CICS
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COOPERATIVE INSTITUTE FOR
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Scientific Report

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Dr. Phillip Arkin, Director

April 30, 2013

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1 CICS-MD PROJECTS

1.1 Data Fusion and Algorithm Development

- GOES SST Enhanced Cloud Clearing and Accuracy Updates

Task Leader Andy Harris
Task Code AHAH_EGSS11
NOAA Sponsor Tom Schott
NOAA Office NESDIS/OSD/SGSP/SEID
Main CICS Research Topic Data Fusion and Algorithm Development
Percent contribution to CICS Themes Theme 1: 50%; Theme 2: 50%; Theme 3: 0%.
Percent contribution to NOAA Goals Goal 2: 25%; Goal 3: 25%; Goal 4: 25%; Goal 5: 25%
Highlight: A fundamental approach to reduction of forward model bias is to increase the resolution of the input atmospheric profile data. Code for this has been developed, tested and supplied to NESDIS Operations and this improvement is already being assessed for operational implementation

BACKGROUND
In the sea surface temperature (SST) operational processing methodology used to date, the confidence in SST retrieval algorithms (developed by direct regression of satellite-measured radiances against *in situ* observations) is highest where the satellite data have least impact, and lowest where their potential is greatest. During the course of the satellite record, there have been significant changes in the density and spatial distribution of the *in situ* data. These changes may have affected the accuracy of algorithms for different satellites. The effect of aerosols, particularly from the major eruptions of El Chichon (1982) and Mount Pinatubo (1991) have caused significant biases and trends in retrieved SST that far exceed the stringent 0.1 degK.decade^{-1} requirement of climate monitoring. While reprocessing efforts such as AVHRR Oceans Pathfinder have succeeded in removing much of the bias present in operational satellite SST data, they still fall short of requirements in a number of areas; *e.g.*, cloud elimination.

Two issues that go hand-in-hand with the estimation of SST from satellite radiances are those of cloud detection and surface effects. In cloud detection, the use of predetermined thresholds threatens the prospect of the detection/false alarm ratio being influenced by changing cloud regimes, impacting the spatial and temporal retrieval errors. A better approach is to input the level of certainty for each observation into the analysis step, as part of the error limit description for each observation. In this regard, cloud detection errors are generally non-Gaussian and asymmetric and a revised method of analysis is needed in order to produce an optimal result. Surface effects (skin effect and diurnal thermocline) are also asymmetric in their behavior. This asymmetric behavior can be modeled given adequate forcing fluxes.

Another key issue that has arisen is that of radiance bias correction. Any physical retrieval methodology is reliant on accurate forward modeling of satellite-observed radiances. The accuracy requirement for sea surface temperature retrieval is much greater than for sounding. Systematic brightness temperature errors need to be «0.1 degK in order to avoid contributing >0.1 degK to the final retrieval error.

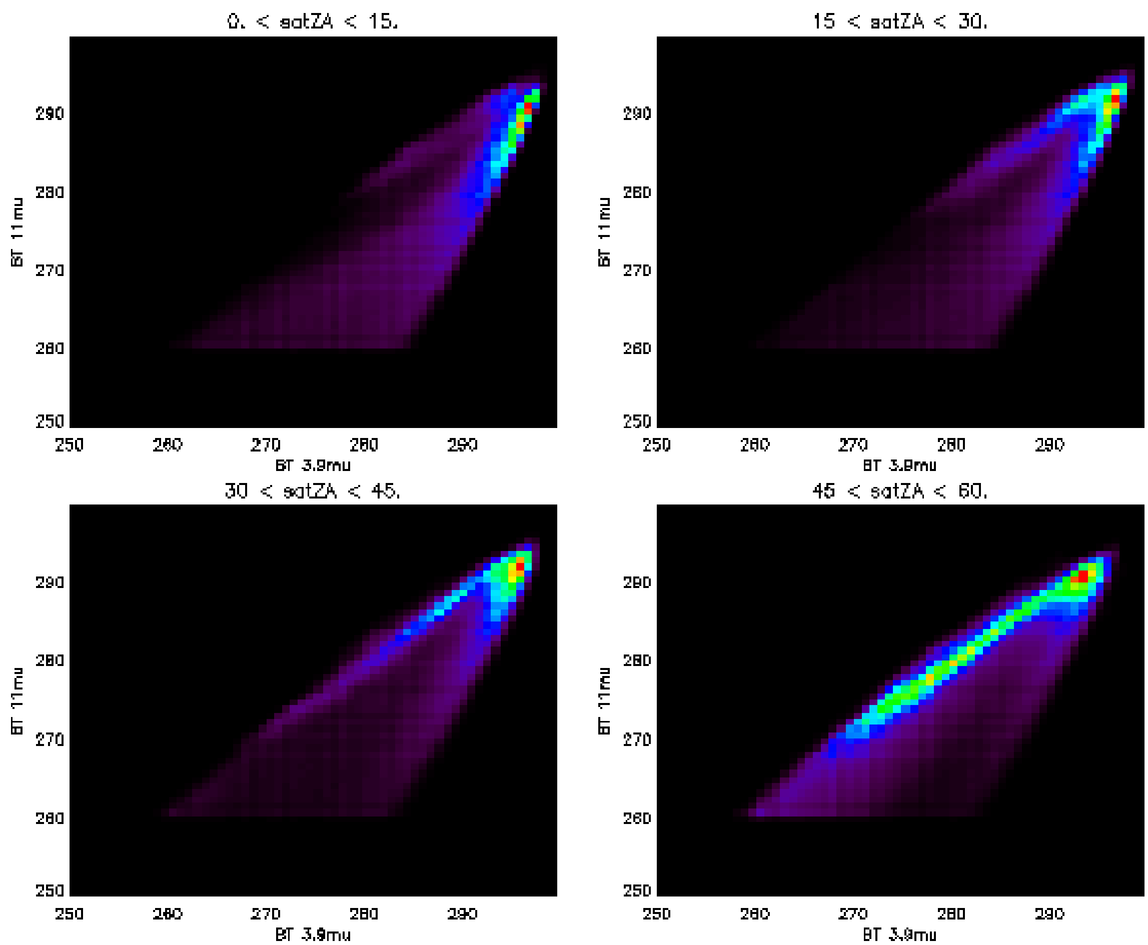


Figure 1 *Example of substantial variation in MTSAT 2-d cloudy brightness temperature PDFs as a function of satellite zenith angle.*

ACCOMPLISHMENTS

A fundamental approach to reduction of forward model bias is to increase the resolution of the input atmospheric profile data. Code for this has been developed, tested and supplied to NESDIS Operations and this improvement is already being assessed for operational implementation. Work has also begun on the development of instrument-specific probability density functions (PDFs) of cloudy pixels. Part of this work includes generating PDFs referenced against matched CALYPSO data but issues with geolocation and timeliness (as well as the CALIPSO sampling itself) render the results rather noisy. This work is continuing with a much larger sample of CALIPSO data but an alternative method has also been explored of extracting subsets using the cloud mask derived from the existing generic PDF information. This has allowed the rapid identification of potential refinements such as variation with satellite zenith angle (see Figure 1).

PLANNED WORK

- The work in this project was due to finish end-June 2012. However, substantial effort had to be expended in supporting the operational implementation of a related project, which resulted in this work being put on hold
- Instrument- and parameter-specific PDFs will be continue to be generated and tested

OTHER

Code to ingest and process higher resolution atmospheric profile data was delivered to OSPO

Performance Metrics	FY12
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	1
# of peer reviewed papers	0
# of non-peered reviewed papers	1
# of invited presentations	0
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	0

- Microwave and Diurnal Corrected Blended SST

Task Leader Andy Harris
Task Code AHAH_MDCB_12
NOAA Sponsor Tom Schott
NOAA Office NESDIS/OSD/SGSP/SEID
Main CICS Research Topic Data Fusion and Algorithm Development
Percent contribution to CICS Themes Theme 1: 50%; Theme 2: 50%; Theme 3: 0%.
Percent contribution to NOAA Goals Goal 2: 25%; Goal 3: 25%; Goal 4: 25%; Goal 5: 25%
Highlight: The experimental version of the 0.05°×0.05° resolution version of the analysis has been successfully transferred to operations. We have also adopted the GHRSST standard 1/20 degree land mask, combined with a refined version of the ocean basins which now includes the Black Sea and Caspian Sea.

BACKGROUND

NESDIS have been in the process of developing a new high-resolution (0.1°×0.1° and 0.05°×0.05°) global SST analyses to replace the previous 100-km, 50-km and 14-km (regional) products. The new scheme, which uses a recursive estimator to emulate the Kalman filter, also provides continuously updated uncertainty estimates for each analysis grid point. Since the analysis is entirely satellite-based, there is no explicit attempt to correct regional biases to an *in situ* standard. However, biases between individual datasets are corrected in a statistical manner, with certain assumptions of persistence and correlation length scale.

Improvements have been made to the analysis by assimilating a thinned version of the RTG_HR as the bias-free dataset to which others are adjusted. The impact of the RTG data is negligible where there is adequate density of other observation. The analysis is performing well with the addition of new geostationary SST data and the recent improvement in resolution from 0.1°×0.1° to 0.05°×0.05° (see Figure 1), particularly with respect to the definition of high-resolution features of oceanographic importance, such as mesoscale and coastal eddies.

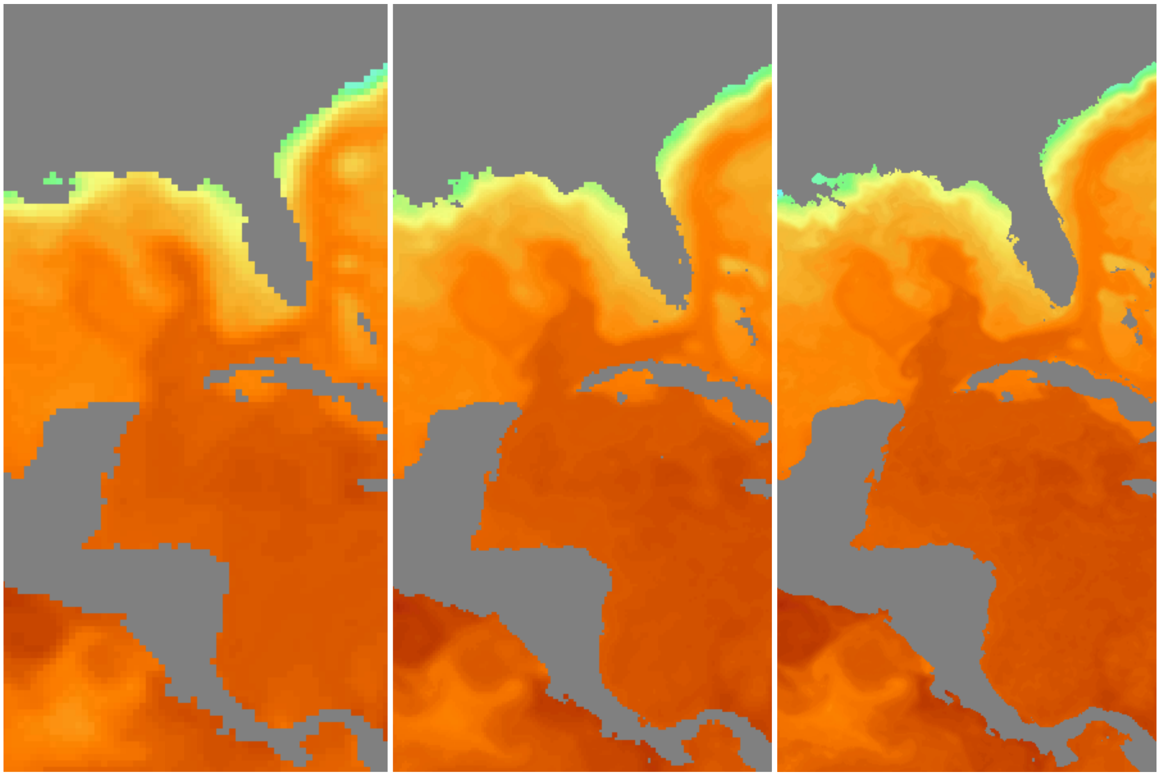


Figure 1 Comparison of Reynolds Daily OI ¼°×¼° SST analysis (left panel), POES-GOES Blended 0.1°×0.1° SST analysis (middle panel) and POES-GOES Blended 0.05°×0.05° SST analysis (right panel). Improved definition of shallow water regions in the vicinity of Abaco and other Caribbean islands, as well as coastal eddies in the Gulf Stream and Loop Current, is evident, particularly in the 1/20 degree product.

PROJECT GOALS

Despite the substantial coverage gains afforded by utilizing carefully bias-corrected geostationary data, there remain significant regions of the world's oceans for which few infrared observations are available. Primarily these are regions of heavy cloud cover which may persist for several weeks or even months. These regions of persistent cloud cover are usually off the west coast of large continental land masses, and are seasonal in nature. Eastern basin currents return cooler water to the Equator and thus are locations for the formation of seasonal marine stratiform cloud as warm continental air passes over the cool water. Classic locations for such persistent cloud cover include off the coasts of California, Peru and Namibia. In such circumstances, the current analysis falls back on the thinned RTG data. However, the RTG analysis itself has to rely on sparse *in situ* data if no cloud-free infrared satellite SST data are available. Thus, despite the fine analysis grid resolution, the actual resolution of SST features may be very coarse indeed. It is to this end that we propose to add microwave SST retrievals from the AMSR-2 instrument to the input datastream for the analysis. This represents a substantial departure, not least because the native resolution of the data is significantly coarser than the grid resolution, and will therefore require different treatment. Secondly, the causes of bias in microwave SST retrievals are rather different from those encountered in infrared SST data and their time-and-space scales will need to be determined. The project originally planned to utilize data from AMSR-E but that instrument's failure in October 2011 prompted a reprioritization of project tasks and this task was originally intended to be tackled in the first year.

ACCOMPLISHMENTS

The experimental version of the 0.05°×0.05° resolution version of the analysis has been successfully transferred to operations. We have also adopted the GHRSST standard 1/20 degree land mask, combined with a refined version of the ocean basins which now includes the Black Sea and Caspian Sea. Various issues with the CoastWatch header information have been resolved. These were primarily due to the legacy nature of the CoastWatch georeferencing system, which was originally intended to map small AVHRR scenes rather than global equal-angle fields.

Additionally, work has been done to improve the algorithm preprocessing and analysis. The ingest routines have converted from Matlab to C which has vastly improved the efficiency of the ingest step. The code has also been modified to read full-resolution AVHRR data, which gives us the opportunity to apply more sophisticated quality control techniques during the super-ob preprocessing stage.

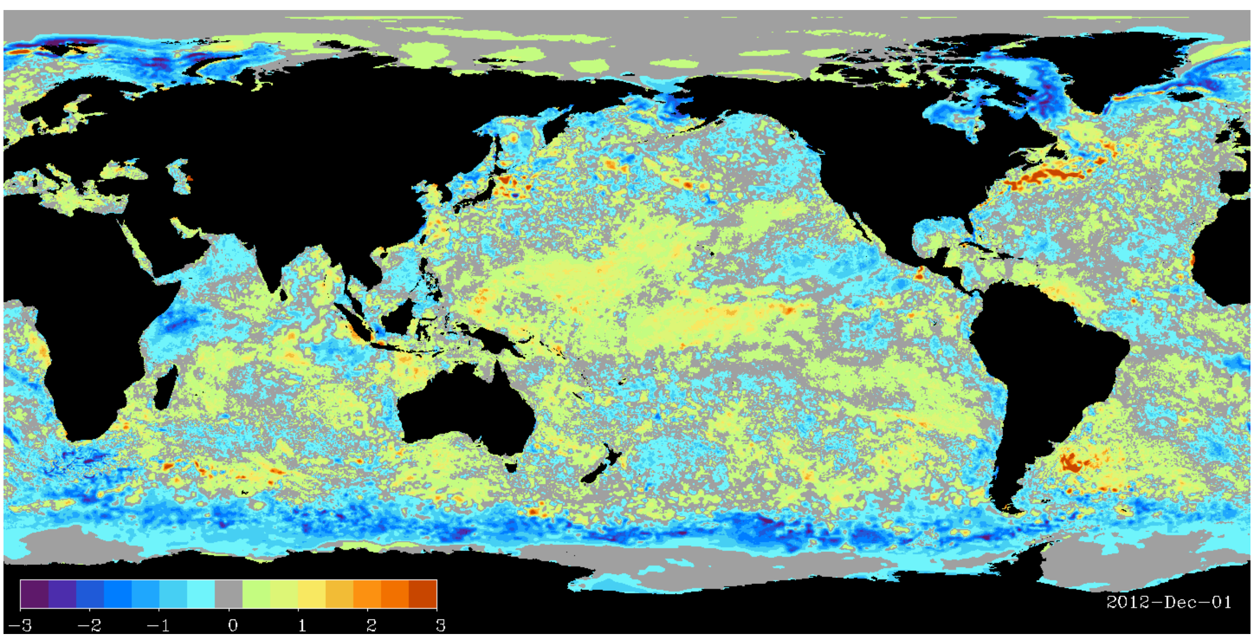


Figure 2 Difference between Geo-Polar 1/20 degree SST analysis and ¼ degree "Daily OI" SST analysis for December 1st 2012

Recent work has indicated that the use of NCEP RTG data for the satellite bias correction stage, whilst providing compatibility w.r.t. other NWS products, may be introducing regional biases. Figure 2 shows a typical difference map for our analysis and the Reynolds "Daily OI" ¼° SST product. The cool bias in the Southern Ocean is a persistent feature of such maps. While NCEP's position is that they consider their analysis to be correct, we started to investigate the use of an independent SST bias correction source to "pre-correct" the RTG SST. Other institutes (particularly European ones) have been using the AATSR on board ENVISAT to bias-correct their other satellite data sources. However, the abrupt failure of the ENVISAT platform forced a restructuring of project tasks as well as a mitigation activity.

Some work has also been directed towards identifying possible improvements to the diurnal correction aspect of the processing. Although this is not due for another year, the demise of AMSR-E necessitated significant restructuring of the project plan. We now plan to take advantage of the NCEP wave model forecast fields to incorporate into the vertical turbulent mixing scheme (see Figure 3). In the meantime, the nighttime-only product has been tested and implemented.

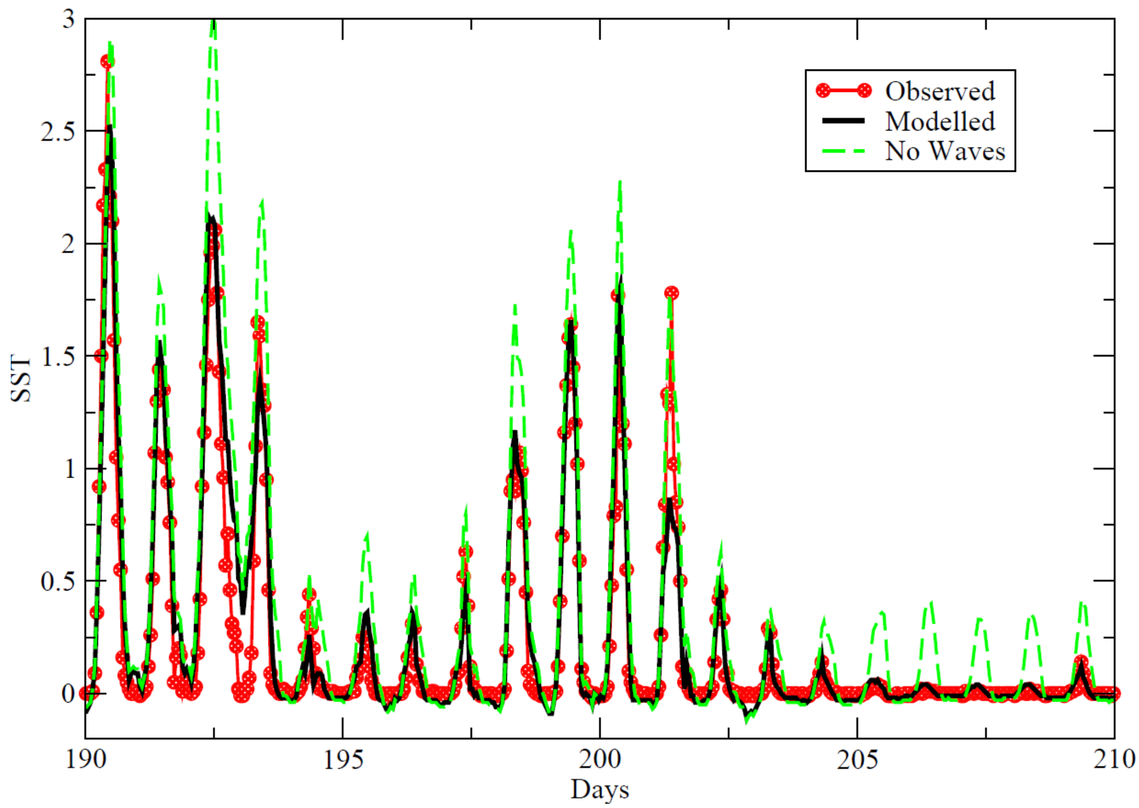


Figure 3 Comparison of observed and modeled diurnal warming results for Arabian Sea mooring. The tendency of the model to over-predict when wave-mixing is not included is evident for both high and low warming cases. (Taken from Janssen, GHRSST, 2011)

PLANNED WORK

- The abrupt failure of AMSR-E on October 4, 2011, necessitated substantial revision of the project schedule. The first phase now incorporates the conversion of I/O intensive ingest routines from Matlab to C, and the production of a nighttime-only SST analysis in support of the NOAA Coral Reef Watch mission. Stage 1 of the project is was complete in September 2012.
- Next year's work includes the inclusion of the diurnal correction estimates and a revised bias correction scheme to mitigate issues with the NCEP RTG SST. Incorporation of microwave SSTs from the Japanese AMSR-2 instrument (when they become available) will be added in the final phase.

OTHER

Operational 1/20 degree nighttime SST analysis system with new C-code ingest routines delivered to OSPO

Performance Metrics	**FY12**
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	1
# of peer reviewed papers	0
# of non-peered reviewed papers	1
# of invited presentations	0
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	0

- Development of a 4-km Snow Depth Product for the Version 3 Interactive Multi-Sensor Snow and Ice System (IMS-V3)

Task Leader Cezar Kongoli
Task Code CKCKIMSS-12
NOAA Sponsor Tom Schott
NOAA Office NESDIS/OSD/SGSP/SEID
Main CICS Research Topic Data fusion and algorithm development
Percent contribution to CICS Themes Theme 1: 70%; Theme 2: 30%; Theme 3: 0%.
Percent contribution to NOAA Goals Goal 1: 20%; Goal 2: 80%

Highlight: A new 4-km global snow depth analysis has been developed and is being integrated into NOAA's Interactive Multi Sensor Snow and Ice Mapping System (IMS). Main utility is ingestion into NWP by NCEP for its GFS land surface initialization.

BACKGROUND

This report summarizes the year-2 work of the ongoing NOAA project entitled "Interactive Multi-Sensor Snow and Ice Mapping System (IMS) Version 3 – Snow depth". A new snow depth analysis has been developed and is being integrated into the daily 4-km IMS. The algorithm framework is an optimal interpolation scheme that blends in-situ and satellite-derived snow depth taking into account the geospatial structure of the data and their relative errors. The final snow depth output also blends snow depth

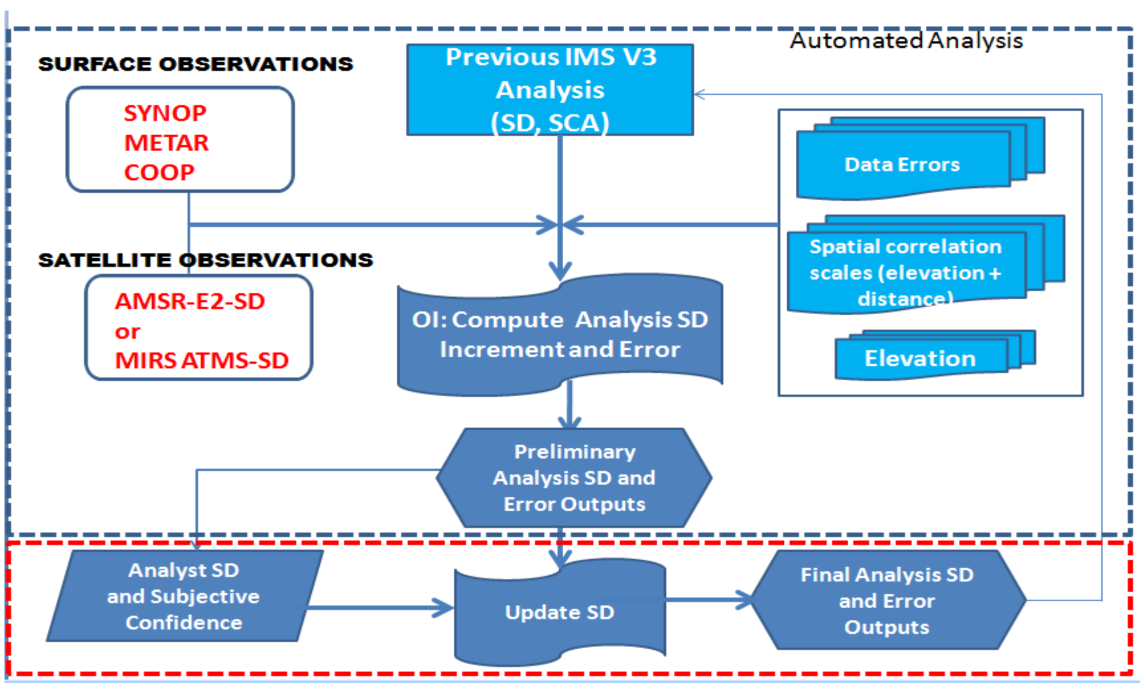


Figure 1. Snow Depth processing system and data flow.

updates made by the analyst interactively. This is a new product being integrated into IMS, and the first-of-its kind to be developed at NOAA. Figure 1 presents high-level design and data flow of the snow depth processing system. Below are the accomplishments during the second year of the project, followed by future plans for third year.

ACCOMPLISHMENTS

The automated algorithm and the software system have been developed. Figure 2 presents an example of the algorithm generating blended snow depth output over the Northern Hemisphere using synoptic snow depth reports and snow depth derived from the NASA's AMSRE Snow Water Equivalent product.

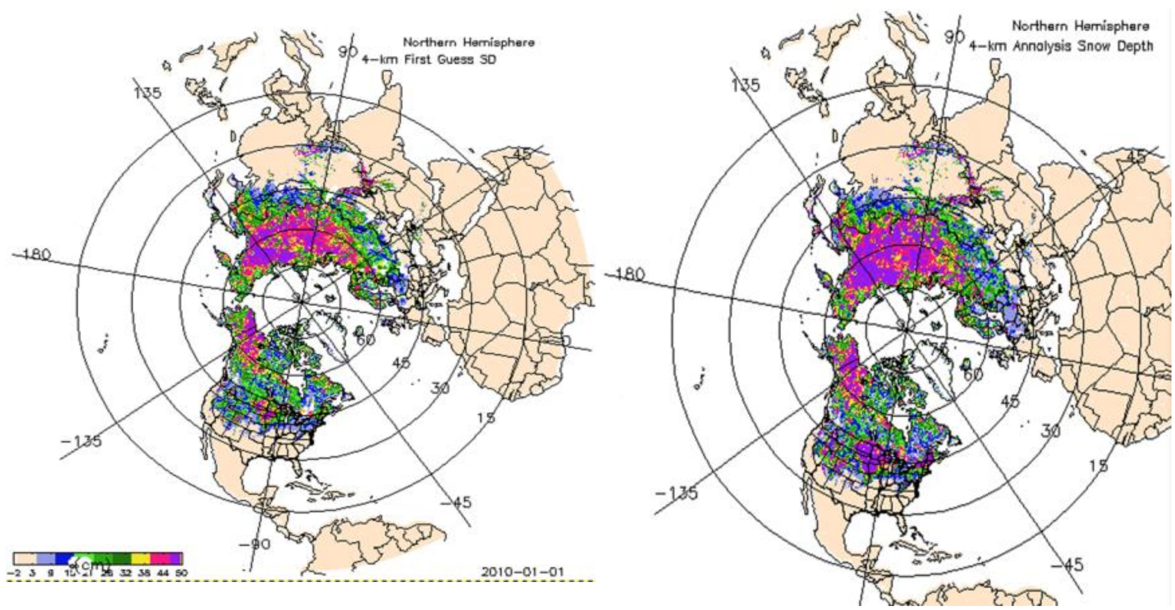


Figure 2: An example of IMS analysis snow depth. The left map shows previous-day analysis on January 1, 2010. The right map shows analysis snow depth on January 2, 2010. The analysis update on January 2 blends the NASA AMSR-E Snow Water Equivalent with in-situ snow depth obtained from synoptic reports.

All project deliverables (documentation and software) and milestones have been accomplished as planned. Currently, the software system is being tested and preparations are under way for the Test Readiness Review (TRR). Three presentations summarizing the algorithm have been made, and another one has been submitted. One journal paper on the microwave retrieval of snow depth related to the project has been published, while another journal publication on the algorithm is under preparation.

PLANNED WORK

- Continue work to assess the performance of the algorithm
- Continue work to refine the algorithm parameters and to improve its performance over high-elevation areas
- Integrate algorithm within IMS Version 3 platform
- Transition algorithm to operations

PUBLICATIONS

Green J., C. Kongoli[1], A. Prakash, M. Sturm, C. Duguay, and S. Li, 2012, "Quantifying the relationships between lake fraction, snow water equivalent and snow depth, and microwave brightness temperatures in an arctic tundra landscape", Remote Sensing of Environment. DOI: 10.1016/j.rse.2012.09.008

PRESENTATIONS

Kongoli C., and T. Smith, Blended Analysis for Snow Depth Using Optimal Interpolation, submitted to Spatial Statistics 2013 Conference, 4-7 June, 2013, Columbus, Ohio.

Helfrich S., and C. Kongoli, Snow and Ice Analysis products, Global Cryospheric Watch Workshop, 28-30 Jan. 2013, Toronto, Canada.

Helfrich S., M. Li, C. Kongoli. 2012 (oral), "The Next Generation of the Interactive Multi-sensor Snow and Ice Mapping System (IMS)", Eastern Snow Conference, June 5-7, 2012

Helfrich S., and C. Kongoli (oral), "Improved monitoring of snow depth combining surface observations from existing stations and newly developed acoustic sensors", International Symposium on Cryosphere and Climate Change (ISCCC) 2012, Manali India, 2-4 April, 2012.

Performance Metrics	FY12
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	1
# of peer reviewed papers	1
# of non-peered reviewed papers	0
# of invited presentations	3
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	0

[1]Corresponding author

- Developing GOES-R Land Surface Albedo Product

Task Leader Shunlin Liang
Task Code DWSLSAWG11
NOAA Sponsor Yunyue Yu
NOAA Office NESDIS/STAR/SMCD/EMB
Main CICS Research Topic Data Fusion and Algorithm Development
Percent contribution to CICS Themes Theme 1: 40%; Theme 2: 40%; Theme 3: 20%.
Percent contribution to NOAA Goals Goal 1: 50%; Goal 2: 50%

Research highlight: We developed and implemented a new methodology of data fusing multiple existing satellite albedo products. The inconsistency and uncertainty of different albedo datasets significantly reduced after the data fusion algorithm was implemented.

BACKGROUND

This work is part of the ongoing NOAA GOES-R project "Developing GOES-R land surface albedo product" and represents a continuation and enhancement of previous activities. The research and development in this project supports the albedo algorithm development of future GOES-R satellites, which would benefit the surface radiation budget estimation and hydrologic cycle modeling.

In our previous reports, we have demonstrated the land surface albedo (LSA) algorithm development and implementation for GOES-R using MODIS and MSG/SEVIRI observations as proxy data. Albedo estimations from the prototype LSA algorithms have been proved to satisfy the accuracy requirement for the GOES-R project. However, there are still limitations of using one sensor to produce complete LSA dataset, such as cloud contamination, atmospheric correction inaccuracy, and sensor failure. Therefore, it is important to combine existing satellite albedo products from different sensors to generate a complete LSA dataset for modeling studies. This task is a continuation of previous efforts on estimating surface albedo from satellite data. The goal of this task is to develop algorithms to fuse multiple existing satellite albedo products to improve the albedo estimation accuracy and reduce data gaps.

To prototype the data fusion algorithm, data from multiple satellites at different spatial resolutions were used. We evaluated these LSA products over different surfaces, analyze the uncertainties, and apply the data fusion algorithm to generate a series of spatially continuous and consistent LSA datasets. This report summarizes our main accomplishments in algorithm development and implementation during the past year.

ACCOMPLISHMENTS

In this proposed task, a data fusion method was prototyped using multi-resolution tree (MRT) models to develop spatially continuous albedo maps from different satellite albedo/reflectance datasets. Data from the Multi-angle Imaging Spectro-Radiometer (MISR), Moderate Resolution Imaging Spectroradiometer (MODIS), and Landsat Thematic Mapper (TM)/Enhanced Thematic Mapper Plus (ETM+) are used as examples.

To implement the MRT using multiple satellite products, we followed several steps. First, the data uncertainties of different satellite products were evaluated and quantified. To do this, the ground measurements of surface albedo are collected to verify the satellite albedo products. An inter-comparison between different satellite datasets was also carried out to assess the products' accuracy. Second, the spatial trend surface for each of the satellite products was extracted such that the de-trended albedo datasets can be used in the data fusion process. Based on the detrended datasets, we calculated

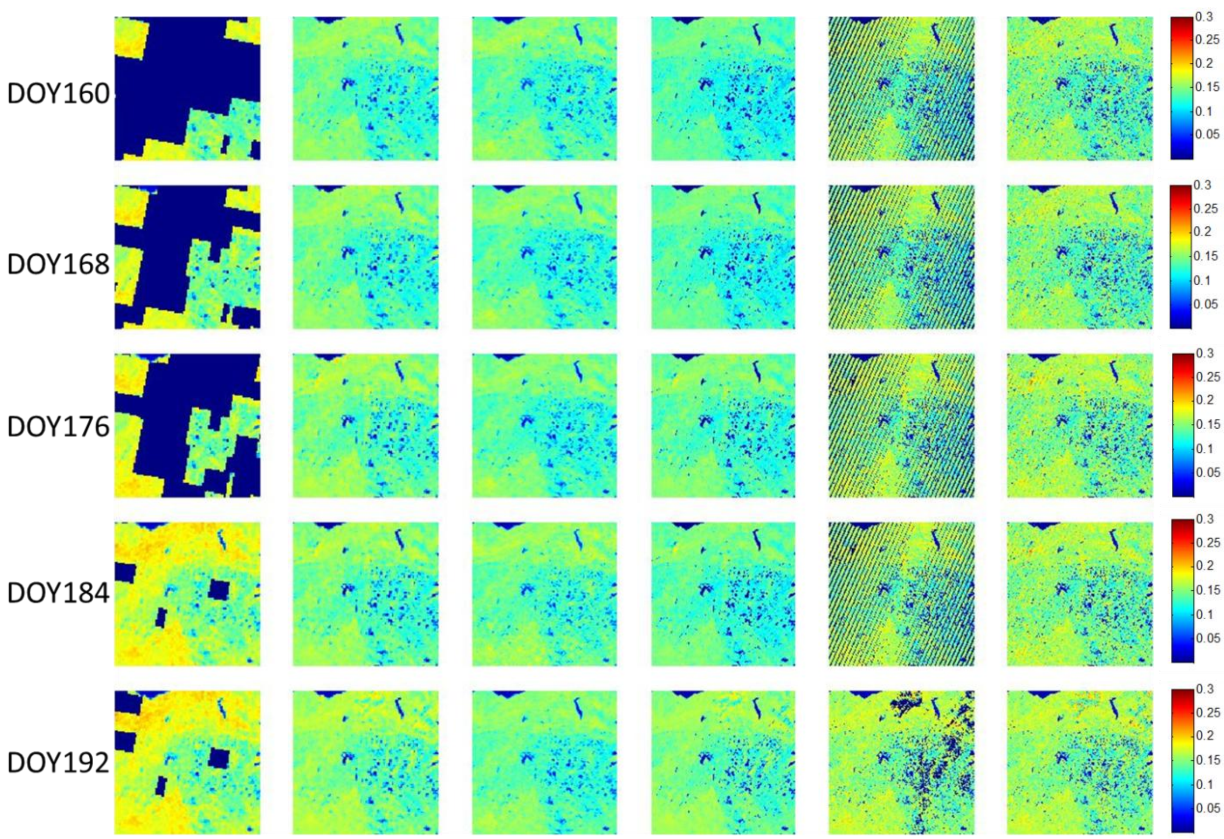


Fig. 1. Time-series comparison of albedo maps before and after MRT (left-to-right order: original MISR albedo, MISR albedo after MRT, original MODIS albedo, MODIS albedo after MRT, original Landsat albedo, and Landsat albedo after MRT); dark blue color (0 value) means no data.

the error variance for different satellite albedo products. We obtained the observational error from validation of the finest resolution data with ground truth. To calculate the observation error of the coarser resolution datasets, we used the aggregated finer resolution data as the "truth". Third, the leaves-to-root Kalman filtering and root-to-leaves Kalman smoothing procedures were implemented to obtain the updated probability estimation of the data at each scale. Finally, the updated spatial residual "albedo" was added back to the trend surface to obtain the actual updated albedo maps at all the scales involved. Some results are shown in Fig. 1.

PLANNED WORK

- Continue to work on the refinement of albedo data fusion algorithm and implement the algorithm to the regional scale.

PUBLICATIONS

He, T., S. Liang, D. Wang, Y. Shuai, and Y. Yu. Fusion of satellite land surface albedo products across scales using a multi-resolution tree method. IEEE Transactions on Geoscience and Remote Sensing, revised

Wu, H., S. Liang, L. Tong, T. He, and Y. Yu, (2012). Bidirectional reflectance for multiple snow-covered land types from MISR products. IEEE Geoscience and Remote Sensing Letters , 9, 994-998

He, T., Liang, S., Wang, D., Wu, H., Yu, Y., & Wang, J. (2012). Estimation of surface albedoand directional reflectance from Moderate Resolution Imaging Spectroradiometer (MODIS) observations. Remote Sensing of Environment, 119, 286-300

Performance Metrics	FY12
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	3
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	1
# of undergraduate students supported by a CICS task	0

- Combining GLM and ABI Data for Enhanced GOES-R Rainfall Estimates

Task Leader Robert F. Adler
Task Code RARA_CGLM_12
NOAA Sponsor Steve Goodman
NOAA Office NESDIS/GOESPO
Main CICS Research Topic/s Data Fusion and Algorithm Development
Percent contribution to CICS Themes Theme 1: 20%; Theme 2: 80%; Theme 3: 0%.
Percent contribution to NOAA Goals Goal 1: 0%; Goal 2: 100%

Highlights: CICS scientists developed and estimated a new satellite rainfall retrieval technique for the use of GOES-R, which uses a combination of IR data and lightning information. The new technique innovatively incorporates the lightning information and significantly reduces biases and uncertainties compared to the infrared technique.

BACKGROUND

This project seeks to enhance precipitation estimates from the future GOES-R by combining information from the Geostationary Lightning Mapper (GLM) with the Advanced Baseline Imager (ABI) to produce a superior combined instrument product. This effort will make the GOES-R precipitation information uniquely important and provide a large step forward in improving satellite rain estimates in the coming decades. This development will provide the National Weather Service (NWS) and other users with timely, more accurate precipitation estimates from geosynchronous satellite data for use in supplementing ground-based estimates, especially in mountainous areas (e.g., western U.S.), surrounding waters, and in Mexico and Central and South America. The resulting improved rainfall estimates will be valuable for nowcasting in general, flash floods in particular, and estimation of rain potential of tropical cyclones.

The project examines lightning-convection-rainfall relations using TRMM data and develops an approach to integrate the lightning information into geostationary IR rain algorithms, including the ABI rainfall algorithm based on SCaMPR (Kuligowski, 2002). The resulting test product shows great benefit of the lightning data and the usefulness of the enhanced product. The final part of the project (third year) will be to further test the algorithm and validate (with field experiment and simulated GOES-R data) the simulated products for the enhanced rainfall product for possible use at GOES-R launch, or shortly thereafter. This work is also combined with Nai-Yu Wang's project (coupling lightning information in microwave rainfall estimate) in the second and third years to take advantage of the synergism between the two efforts.

ACCOMPLISHMENTS

Significant progress has been made during the past year in establishing lightning-rainfall relations using TRMM data in the context of their use in GOES-R-based rain estimation and developing the IR/lightning combined rainfall estimation technique.

Major accomplishments in last year are as follows:

1. Examine lightning-cloud-rain relationships with TRMM observations (Xu et al., 2013, published in JAMC).

Results show that lightning frequency is a good proxy to separate storms of different intensity, identify convective cores and convective rain area, and screen out false convective core signatures in areas of thick anvil debris. The lightning-cloud-rainfall relationships derived provide insights into the best approaches for rain estimation and provide the lightning-rainfall quantitative relations to potentially be used. Specifically, the lightning information has been shown to be useful to aid identification of convective cores in thick anvils missed by the IR technique, eliminate misidentified convective cores, and correctly define convective rainfall volume. These will be key uses of the lightning information as part of a geosynchronous rain estimation technique. In the last few months we have begun to incorporate these findings and relationships to improve the rainfall estimation using IR techniques, using the Convective/Stratiform Technique (CST) of Adler and Negri (1988) as a prototype approach.

2. Develop a rain estimation technique to take advantage of lightning information potential, using TRMM data (Xu et al. 2013, paper submitted to JAMC).

A satellite rainfall estimation technique is developed to combine infrared and lightning information to estimate convective and stratiform precipitation. The algorithm is developed and tested using seven years (2002-2008) of TRMM measurements over the southern United States during the warm season. Lightning information is coupled with a modified IR-based Convective/Stratiform Technique (CST) and produces a lightning-enhanced CST (CSTL). Both the CST and CSTL are then applied to the training (2002-2004) and independent (2005-2008) datasets. In general, this study shows significant improvement over the IR rainfall estimates (rain area, intensity, and volume) by adding lightning information. The CST and CSTL display critical skill in estimating warm season precipitation and the performance is quite stable. The CST can generally catch the heavy (convective) and light rain regions, while CSTL further identifies convective areas that are missed by CST and removes convective cores that are incorrectly defined by CST (a case shown in Fig. 1). Specifically, the CSTL improves the convective cell detection by 5% and reduces the convective false alarm rate by more than 30%. Similarly, CSTL substantially improves the CST in the overall estimate of instantaneous rainfall rates. For example, when compared with passive microwave estimates, CSTL increases the correlation coefficient by 30%, reduces the bias by 50% and RMSE by 25%. Both CST and CSTL reproduce the rain area and volume fairly accurately over a region, although both techniques show overestimation compared to radar estimates.

We are also starting to compare results with the Self-Calibrating Real-Time GOES Rainfall Algorithm (SCaMPR) (Kuligowski, 2002) as part of moving toward examination of the GOES-R Baseline Rain Algorithm (BRA). In the few cases examined the IR-lightning technique (CSTL) shows potential for improvement when compared with the SCaMPR results from GOES matched up in time with TRMM overpasses. A focus for the coming year will be improvement, definition and testing of the lightning-enhanced algorithm and linking to the BRA.

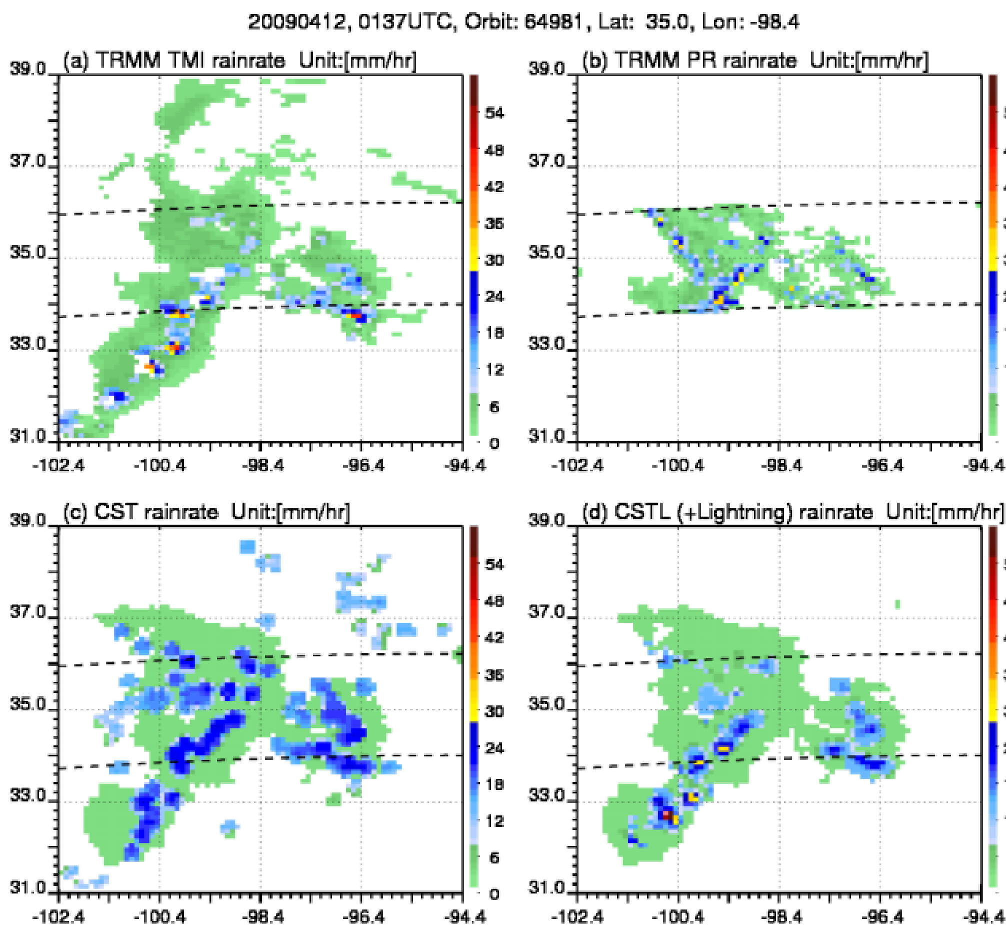


Figure 1. Instantaneous rainfall estimates (10 km resolution) of a MCS: (a) rainrates estimated by TMI 2A12, (b) rainrates estimated by PR 2A25 (c) CST rainrate estimates, and (d) CSTL rainrate estimates. Rainfall rates are indicated by the color bar with unit of mm hr^{-1}.

3. Use of lightning information for improvement of convective-stratiform delineation in passive microwave rain retrievals (Wang et al., JGR).

Passive microwave rain retrievals involve determination of convective-stratiform separation, usually represented as fraction of the microwave satellite pixel area having convection. Since the GOES-R baseline IR algorithm is calibrated using low-orbit passive microwave rain retrievals, an improvement in those retrievals by using lightning information would also improve the IR-based estimates. Upon careful examination the relationships between LIS flash rate, PR reflectivity, and TMI Tb_{85V}, a new microwave convective and stratiform partitioning method that incorporates lightning information into passive microwave observations to delineate convective and stratiform precipitation has been developed as part of this project. LIS lightning occurrence and flash rates (i.e., no flash, 0-1 fl/min, 1-2 fl/min, and > 2 fl/min) are used to classify TMI Tbs into four groups of increasing convective probability. Results indicate that the improvement in microwave retrievals upon incorporating lightning information is most apparent in deep convective systems.

PLANNED WORK

- Final pre-launch statistical evaluation on impact of lightning information on geostationary rain estimation;
- Test and validate algorithm/software using simulated GLM proxy data and real-time GOES data;
- Validate results in form useful for hydrological applications;

PUBLICATIONS

Xu, W., R. F. Adler, and N.-Y. Wang, 2013: Improving Geostationary Satellite Rainfall Estimates Using Lightning Observations: Underlying Lightning-Rainfall Relationships. *J. Appl. Meteor. Climatol.,* **52,** 213-229.

Xu, W., R. F. Adler, and N.-Y. Wang, 2013: Combining Satellite Infrared and Lightning Information to Estimate Warm Season Convective and Stratiform Rainfall. *J. Appl. Meteor. Climatol.,* **to be submitted**.

Wang, N.-Y., K. Gopalan, and R. I. Albrecht, 2012: Application of lightning to passive microwave convective and stratiform partitioning in passive microwave rainfall retrieval algorithm over land from TRMM, J. Geophys. Res., **117**, D23203, doi:10.1029/2012JD017812.

PRESENTATIONS

Xu, W., R. F. Adler, and N.-Y. Wang, 2013: Combining GLM and ABI Data for Enhanced GOES-R Rainfall Estimates. Amer. Meteor. Soc., 93nd Annual Meeting, Jan 2012, Austin, TX.

Xu, W., R. F. Adler, and N.-Y. Wang, 2012: Combining Infrared and Lightning Data for Enhanced GOES-R Rainfall Estimates. CICS-MD science meeting, College Park, MD.

Adler, R. F., W. Xu, and N.-Y. Wang, 2012: Combining GLM and ABI Data for Enhanced GOES-R Rainfall Estimates. NOAA GOES-R Risk Reduction annual meeting, Kansas City, MO.

REFERENCES

Adler, R. F., and A. J. Negri, 1998: A satellite infrared technique to estimate tropical convective and stratiform rainfall. *J. Appl. Meteor.*, **27**, 30-51.

Kuligowski, R. J., 2002: A self-calibrating real-time GOES rainfall algorithm for short-term rainfall estimates. *J. Hydrometeor*, **3**, 112–130.

Performance Metrics	**FY12**
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	2
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	0

1.2 Calibration and Validation

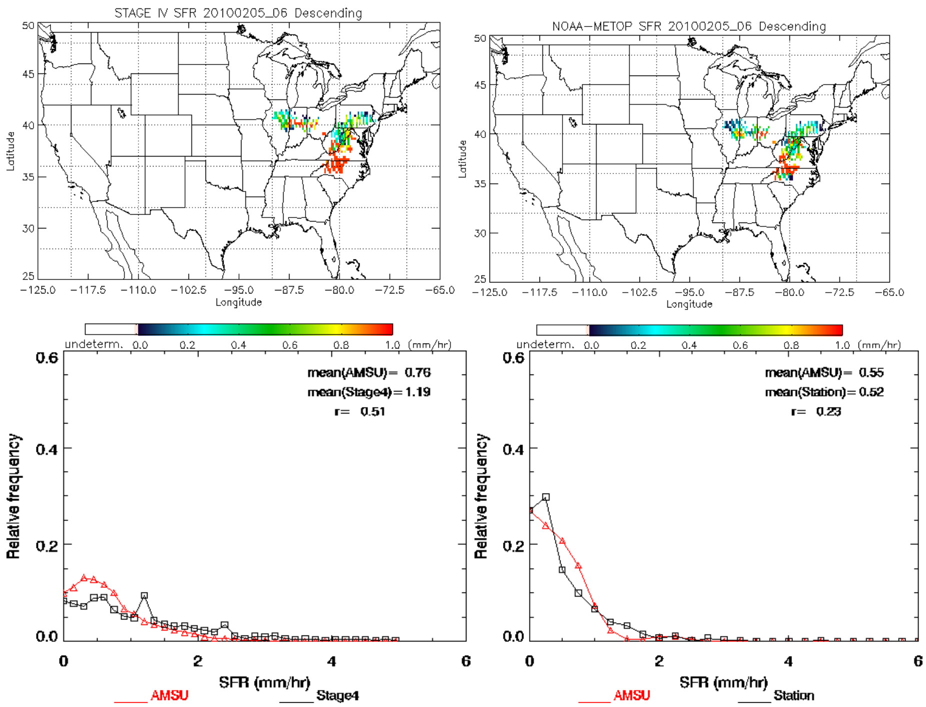
- Satellite Calibration and Validation efforts for STAR Precipitation Products Task

Task Leader Cezar Kongoli
Task Code CKCKCALVA12
NOAA Sponsor Ingrid Guch
NOAA Office NESDIS/STAR/CRP
Main CICS Research Topic Calibration and validation
Percent contribution to CICS Themes Theme 1: 70%; Theme 2: 30%; Theme 3: 0%.
Percent contribution to NOAA Goals Goal 1: 20%; Goal 2: 80%

Highlight: The AMSU snowfall rate product was extensively evaluated with in-situ and stage IV precipitation data. Evaluation results showed reasonable agreement with reference data. The product was approved for operational applications.

BACKGROUND
This work is part of the Cal/Val efforts for quantitative evaluation of the AMSU experimental snowfall rate product and the operational snowfall detection product. Snowfall detection algorithm is based on a decision tree method that takes advantage of the ability of AMSU's high frequency channels to detect falling snow and filter out snow on the ground. The algorithm is integrated into the Microwave Surface Precipitation Product System (MSPPS) and in concert with the snow cover and rain algorithms retrieves snow cover, snowfall extent and rain rate. The experimental snowfall rate algorithm is an inversion of a radiative transfer model that retrieves cloud ice microphysical properties which in turn are used to infer snowfall rate.

ACCOMPLISHEMENTS
Major accomplishment was that the snowfall rate algorithm was evaluated extensively with in-situ and stage IV precipitation data. The algorithm's performance statistics met operational requirements and as a result the product was approved for operational applications at NOAA. In addition, a software system that matches up AMSU/MHS, surface stations and GDAS data was updated and further improved. Next, Stage IV data were collected, aggregated and collocated with AMSU data for NOAA-18, -19 and -MetopA satellites, thus creating a useful tool for potential storm analysis in the future. Figure 1 shows evaluation results with respect to Stage IV and in-situ data. The top two maps show good spatial correspondence and the histograms show similar distribution in snowfall rate. The Table at the bottom presents summary statistics (Bias, RMSE and Correlation) with respect to Stage IV and in-situ data.



Summary Statistics

	Accuracy	Precision	Correlation
StageIV	-0.23	0.67	0.42
Station	0.07	0.72	0.30

- Accuracy is the (sample size) weighted average bias of all events
- Precision is the (sample size) weighted average RMSE of all events
- Correlation is the (sample size) weighted average correlation coefficient of all events

Figure 1. Evaluation results and summary statistics for the AMSU Snowfall Rate Algorithm

PRESENTATIONS

Meng, H., B. Yan, R. Ferraro, and C. Kongoli (oral), "Snowfall Rate Retrieval using AMSU/MHS Measurements", 27th Conference on Hydrology, 93rd American Meteorological Society Annual Meeting, Austin, TX, 6-10 January, 2013

Meng, H. B. B. Yan, R. Ferraro, and C. Kongoli, "Snowfall rate retrieval using passive microwave measurements" (oral), 2012 12th Specialist Meeting on Microwave Radiometry and Remote Sensing of the Environment (MicroRad), Rome, Italy, March 5-9, 2012.

Performance Metrics	FY12
# of new or improved products developed	0
# of products or techniques transitioned from research to ops	1
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	2
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	0

- Evaluation of Megha-Tropiques (M-T) Products

Task Leader Isaac Moradi
Task Code EBEB_EMTP_12
NOAA Sponsor Ralph Ferraro
NOAA Office NESDIS/STAR/CRPD/SCSB
Main CICS Research Topic Calibration and Validation
Percent contribution to CICS Themes Theme 1: 25%; Theme 2: 70%; Theme 3: 5%.
Percent contribution to NOAA Goals Goal 1: 80%; Goal 2: 20%

Highlight: This research aims to evaluate the quality of the satellite data from the SAPHIR and MADRAS instruments aboard the Megha-Tropiques satellite.

BACKGROUND

The hydrological cycle of the Earth is perhaps one of the most complex global feedback mechanisms that impact all living forms on the planet. An accurate description of the global precipitation patterns over an extended period of time is critical to determining any changes in the hydrological cycle. These pattern changes include the frequency, areal extent and duration of extreme weather events (e.g., flash floods, drought, extreme events, etc.) as well as long term shifts of the global rainfall distribution. Such changes have a dramatic impact on the quality of life for all inhabitants on the Earth. Measurements from low earth orbiting (LEO) satellites, in particular, microwave sensors, offer a unique dataset to develop global precipitation retrievals. This project focuses on a new satellite – Megha-Tropiques (M-T) – a joint research mission between India and France (launched in October 2011), and the evaluation of hydrological products generated at NESDIS from the M-T sensors (Brogniez et al. 2012). M-T operates in an orbit very similar to TRMM and covers a latitude band spanning from almost 30° S to 30° N. In particular, a series of products generated through the Microwave Integrated Retrieval System (MiRS; Boukabara et al. 2011).

ACCOMPLISHMENTS

In the first step of this project SAPHIR data are compared with data from the Advanced Technology Microwave Sounder (ATMS) onboard NPP satellite. SAPHIR channels operate at 183.31±0.20, 183.31±1.10, 183.31±2.80, 183.31±4.20, 183.31±6.80, and 183.31±11.0 but ATMS water vapor channels operate at 183.31±7, 183.31±4.5, 183.31±3, 183.31±1.8, and 183.31±1 GHZ. Since none of the SAPHIR and ATMS channels are identical, therefore in this study, we compare similar channels from the two instruments but characterize the systematic differences between the two instruments using radiative transfer calculations. *Although the frequency differences between the SAPHIR and ATMS channels are small, yet these differences will cause a systemic bias between the brightness temperatures from SAPHIR and ATMS.*

Figure 1 shows the comparison between SAPHIR and ATMS channels operating at similar frequencies. The criteria for the collocations were one hour time difference and 30 kilometers spatial distance. Part of the bias observed in Figure 1 is introduced by the frequency difference between the two instruments. The real bias between the instruments can be characterized using the difference between observations from the two instruments and also simulations using a radiative transfer model. This method is known as double difference and is able to identify the real bias (the difference that is not related to the frequency difference between the channels) between the observations.
The results show that observations from the two instruments are generally consistent with a small bias (less than 0.6 K) that is within the range of noise equivalent temperature.

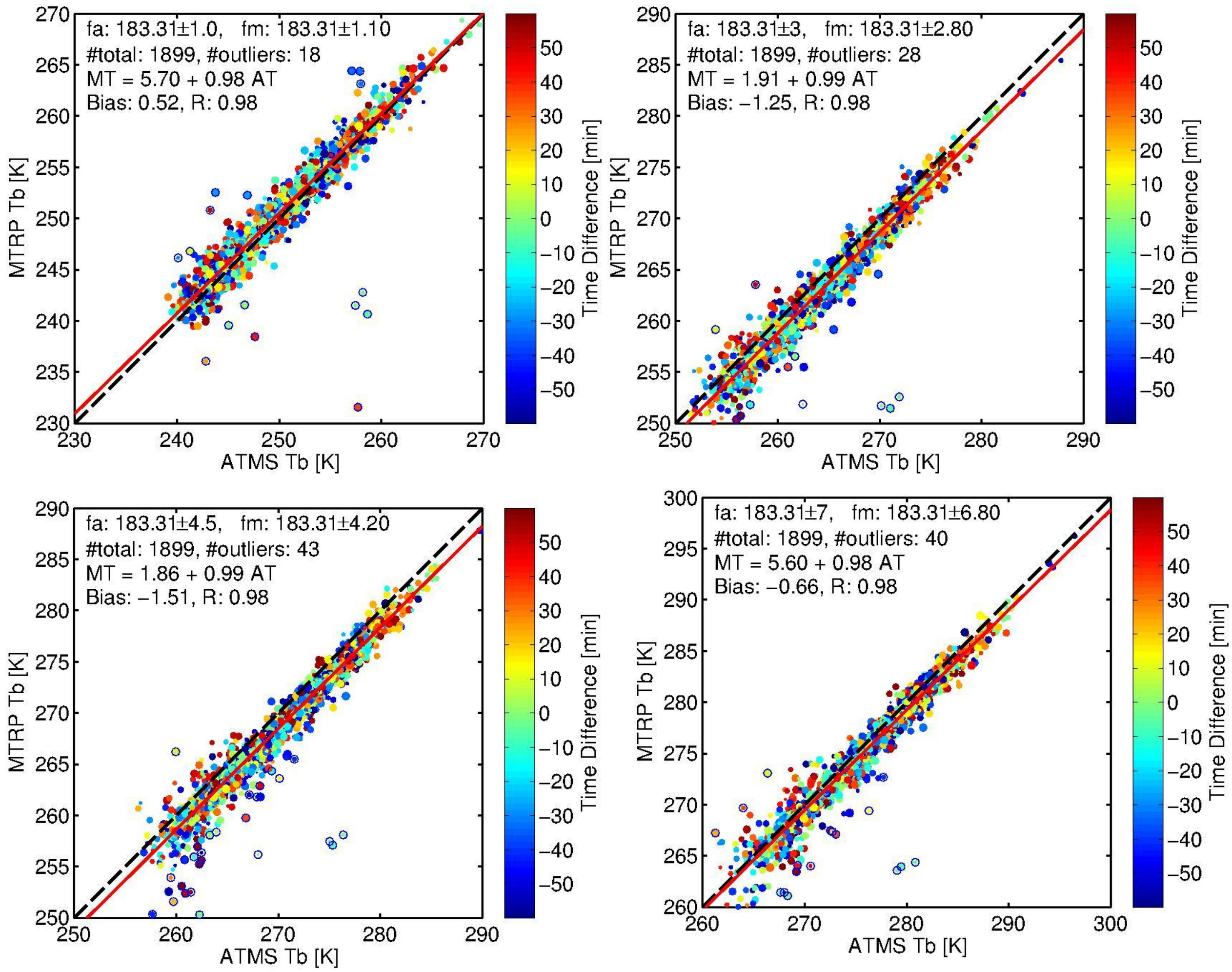


Figure 1: Comparison between SAPHIR and ATMS observations and simulations

During the course of this project, we improve Megha-Tropiques data in terms of calibration and also correcting other biases.

PLANNED WORK

- Evaluate the TB data from MADRAS and SAPHIR through inter-comparisons with similar measurements from other satellites microwave instruments such as MHS and ATMS.
- Evaluating the TB data from the SAPHIR instrument using balloon-borne radiosonde measurements.
- Evaluate the MiRS derived products from M-T through inter comparisons with similar derived products from other satellites such as TMI, SSMIS, AMSU, MHS and ATMS, as well as in-situ data sets.

PRESENTATIONS

Moradi, I., Ferraro, R., et al., 2013. Evaluating Megha-Tropiques SAPHIR products. X-CAL Science Meeting, University of Central Florida, February 21-22, 2013, Orlando, FL.

Performance Metrics	**FY12**
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	1
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	0

- Wind Effects on Estimates of Sea Level Rise Offsite

Task Leader J.A. Carton
Task Code JCJC_WEES_12
NOAA Sponsor Laury Miller
NOAA Office NESDIS/STAR/SOCD/OPB
Main CICS Research Topic: Calibration and Validation
Percent contribution to CICS Themes Task 1: 50%; Task 2: 50%; Task 3: 0%.
Percent contribution to NOAA Goals Goal 1: 20%, Goal 2: 60%, Goal 5: 20%

Highlight: Quantify the impact of components of sea level rise through analysis of coupled atmosphere-ocean-land climate models, observations, and surface forced ocean simulations.

BACKGROUND

This is a proposal to quantify the impact of regional steric and eustatic (including wind-driven) components of sea level rise through analysis of new AR5 coupled atmosphere-ocean-land climate models, observations, and surface forced ocean simulations. Our regions of focus include the waters bordering the continental United States and also the waters at subpolar and polar latitudes. These regions are of interest because of their societal importance and because previous studies have identified them as having large predicted changes. As the timescales increase toward centennial, regional sea level should increasingly resemble the global average sea level and so we begin by considering temporal behavior of the global average.

ACCOMPLISHMENTS

A student, Ben Johnson, working with Eric Leuliette of NOAA, has developed a suite of software to compare satellite altimeter sea level and tide gauge sea level, accounting for such effects as tides, geographic and temporal interpolation. This software allows a continual 'sanity check' on satellite altimetry and thus represents a critical activity associated with monitoring sea level rise. It is available now as an online product at: http://ibis.grdl.noaa.gov/SAT/SeaLevelRise/LSA_SLR_calibration.php. Here is the accompanying description (from the same site):

> "The method of producing estimates of altimeter drift using a global network of tide gauges is described in detail by *Mitchum (2000)*. Briefly, the method works by creating an altimetric time series at a tide gauge location, and then differencing this time series with the tide gauge sea level time series. In this difference series, ocean signals common to both series largely cancel, leaving a time series that is dominated by the sum of the altimetric drift and the land motion at the tide gauge site. Making sepa-

> rate estimates of the land motion rates and combining the difference series from a large number of gauges globally results in a times series that is dominated by the altimeter drift. Since the difference series at separate time gauge locations have been shown to be nearly statistically independent (*Mitchum, 1998*), the final drift series has a variance much smaller than any of the individual series that go into it. Because of the relatively large number of degrees of freedom, this method outperforms calibrations from dedicated calibration sites, although it is only a relative calibration, meaning that it cannot determine any absolute bias. It can, however, detect change in a bias, either a drift or a step change."

The tide gauge locations are shown in Figure 1.

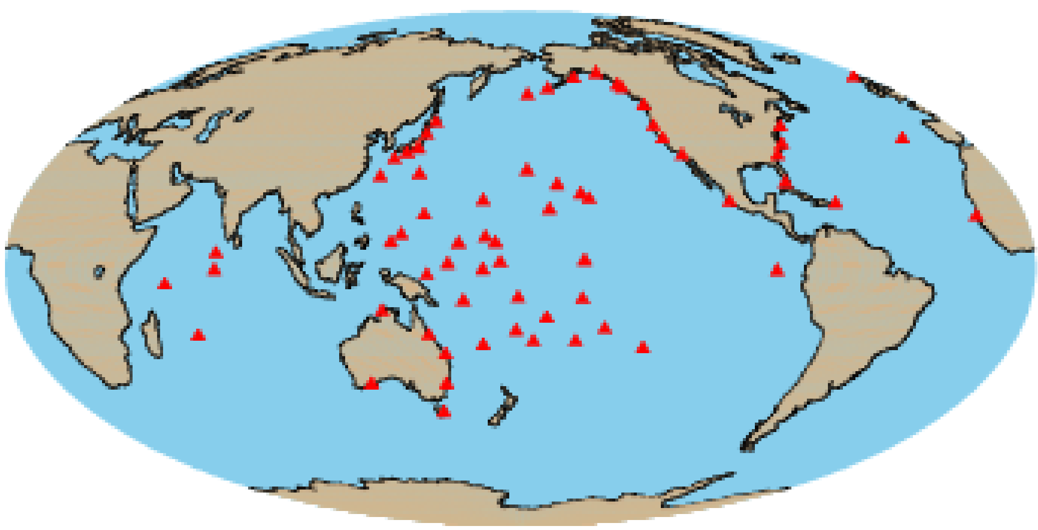


Figure 1: Locations of tide gauges used for the tide gauge altimeter comparisons

The resulting calibration is shown in Figure 2**.** Similar calibrations have been carried out for the other satellites.

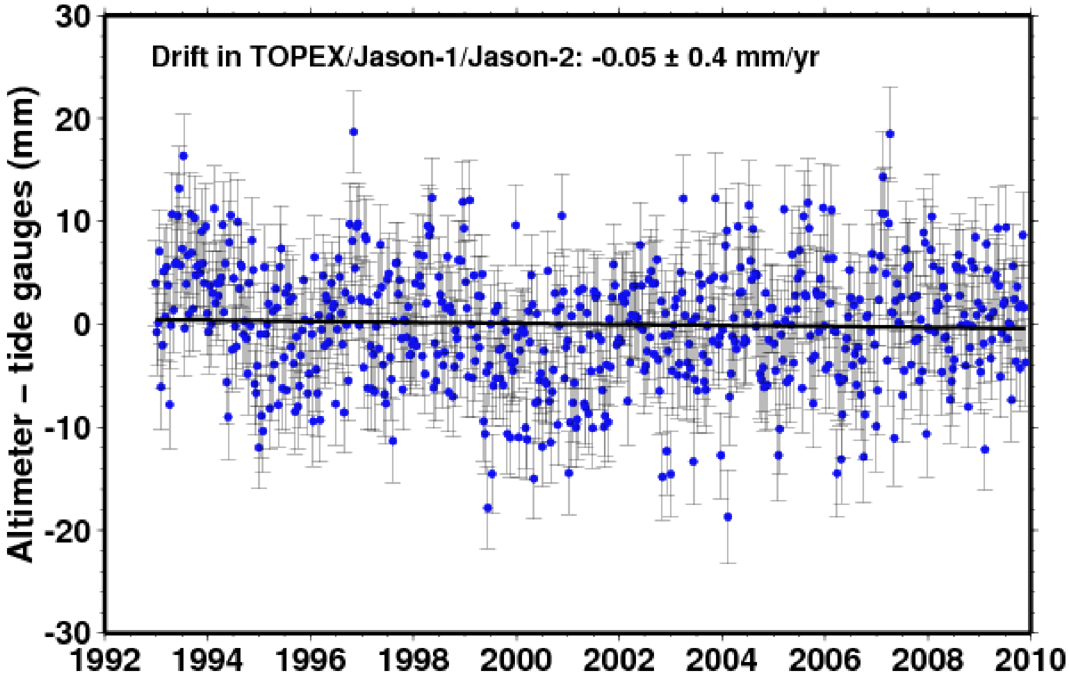


Figure 2 Results of tide gauge station comparison versus JASON2. Note the slight indication of a negative drift.

PLANNED WORK

- The previous work by Douglas and Miller relied on ICOADS wind analyses. Independent studies have shown these to be subject to many errors. We propose to revisit these comparisons using the NOAA ESRL 20th Century Reanalysis, Version 2 (extended, 1871–2010), looking for multi -decadal patterns of surface wind forcing that span the northern hemisphere,
- To complete our documentation of the ocean response to historical surface fluxes, we plan to carry out a series of simulation experiments for the North Atlantic with a POP primitive equation numerical ocean model forced by the 20CRv2 surface forcing. The purpose of this work is to determine the relative sensitivity of regional and coastal sea level to the patterns identified in the ESRL data set

REFERENCES

Mitchum, G.T., Monitoring the stability of satellite altimeters with tide gauges. J. Atmos. Oceanic Tech., 15, 721-730.

Mitchum, G.T., An improved calibration of satellite altimetric heights using tide gauge sea levels with adjustment for land motion. Marine Geodesy, 23, 145-166.

- A Retrospective Analysis of IPCC TAR & FAR Model Projections of Sea Level Rise

Task Leader J.A. Carton
Task Code JCJCSIPCC11
NOAA Sponsor Laury Miller
NOAA Office NESDIS/STAR/SOCD/OPB
Main CICS Research Topic Calibration and Validation
Contribution to CICS Themes Task 1: 50%; Task 2: 50%; Task 3: 0%. (estimated)
Contribution to NOAA Goals Goal 1: 20%, Goal 2: 60%, Goal 5: 20% (estimated)

Highlight: Quantify the impact of components of sea level rise through analysis of coupled atmosphere-ocean-land climate models, observations, and surface forced ocean simulations.

BACKGROUND

Observations of global sea level, available since 1991, have shown a rise of over 3mm/yr, significantly in excess of the 100yr average rise of under 2mm/yr. IPCC projections are quite uncertain, but suggest that these numbers may grow alarmingly in the next century. Part of the concern has to do with the possibility of local regions such as the eastern United States, where sea level rise may substantially exceed the global average due to a combination of post glacial rebound, changing currents, and warming of the mid-depth ocean associated with changes in the meridional overturning circulation (*Yin et al., 2010*). Within NOAA GFDL has extensive commitment to producing coupled climate model projections and are adding physical processes such as those controlling continental ice melt and the ocean freshwater budget for the purpose of providing more accurate sea level projections. Observational data related to sea level is maintained at NOAA's Laboratory for Satellite Altimetry (satellite altimetry), National Ocean Survey (tide gauges), and National Ocean Data Center (subsurface temperature). The purpose of this work is to bring together the model projections and the observations to learn about the processes regulating sea level rise and thus the accuracy of future projections.

ACCOMPLISHMENTS

A comparison has been carried out between sea level from tide gauges and sea level from a set of seven ocean reanalyses/syntheses. The results from different reanalyses/syntheses vary since they may include radically different assumptions, models, and data sets. One such system includes eustatic, loading, and self-gravitation effects. Most, including SODA, currently do not. This paper will compare estimates of sea level and dynamic topography from a variety of ocean reanalyses/syntheses in comparison with observed satellite and gauge sea level records particularly focusing on those reanalyses/syntheses which span multiple decades. A key goal is to explore differing estimates of the geographical variations in the thermosteric and eustatic contributions to sea level and their connections to changes in ocean circulation. Comparing the reanalyses/syntheses to land-based gauges should also lead to independent estimates of GIA and improved estimates of the uncertainties in estimates of centennial trends and acceleration in global sea level. An example of such a comparison is shown in Figure 1 for a tide gauge station at Papeete, French Polynesia in the South tropical Pacific. Note that the highest correlation is not at the actual location of the tide gauge and that the minimum of the RMS difference does not occur at the same location as the maximum correlation.

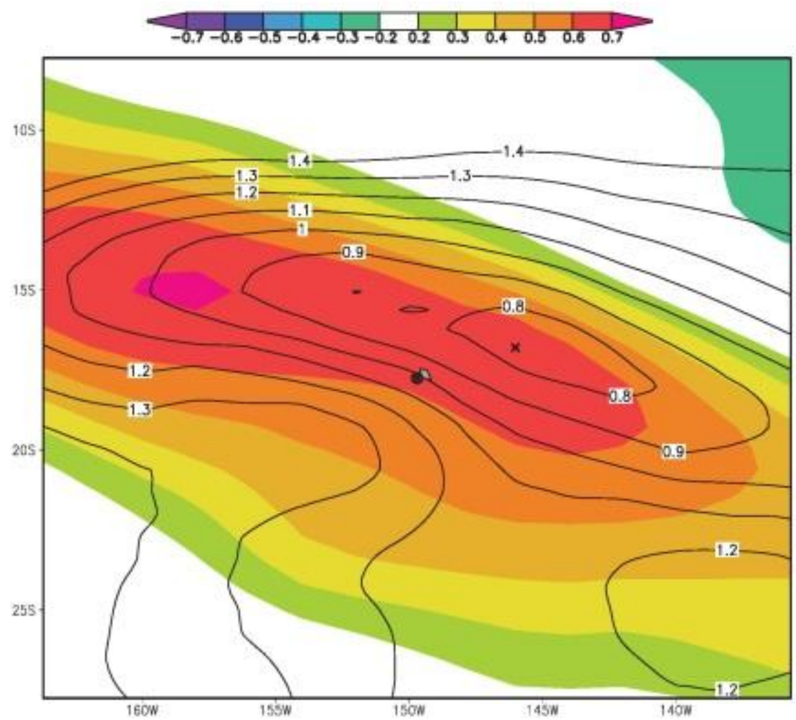


Figure 1: Example of comparison of tide gauge and one of the reanalyses included in our comparison, POAMA, sea level at Papeete, French Polynesia (17.53S, 149.57W). Records have been detrended and the climatological monthly cycle has been removed separately from each time series prior to correlation. Solid circle indicates the tide gauge location. Colors show correlation, while contours show normalized RMS difference. X indicates the POAMA time series location.

We have extended comparisons such as that shown in Figure 1 to a set of 84 gauges distributed throughout the global ocean. In Figure 2, we show such comparisons for gauges distributed along the east coast of North America. The results are generally good which is a very encouraging sign that we can use ocean reanalyses/syntheses to extend the meager tide gauge record to reconstruct global sea level in the era before satellite altimetry.

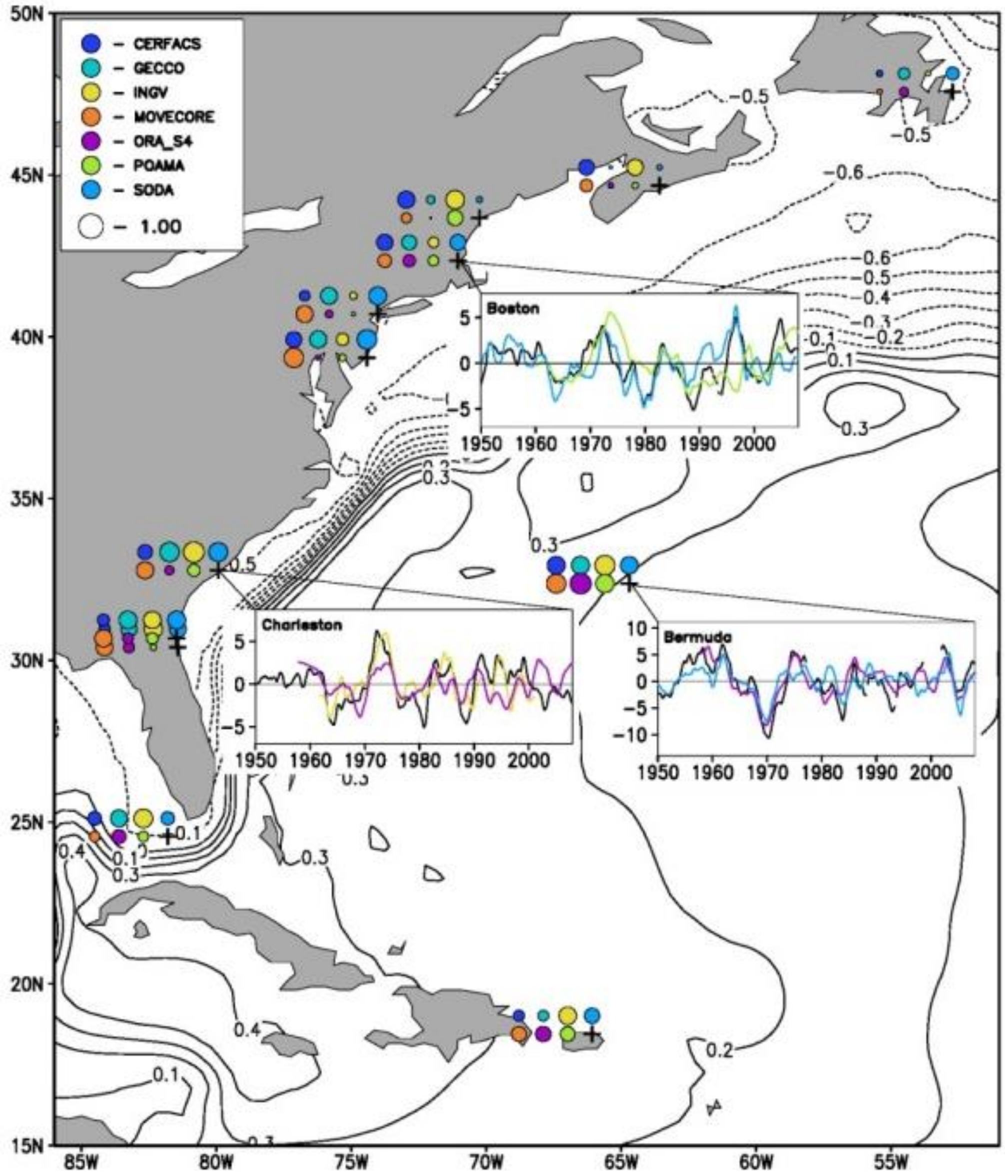


Figure 2: Correlations between tide gauge records and reanalyses in the western North Atlantic. Colors indicate which reanalysis sea level time series is being compared. Radius of each circle is proportional to the strength of the correlation (all correlations are positive). Radius corresponding to a correlation of 1.0 is shown. Detrended time series of tide gauge (black) and the two reanalysis time series that have maximum and minimum correlations (colors) are shown for three stations. Contours show mean sea level (m) (from SODA).

FUTURE PLANS

- Examine the spatial structure of relationship between gauge sea level and altimetry.
- Complete a publication on the altimeter-tide gauge work.
- Explore predictions of regional sea level rise in AR5 coupled general circulation models. In particular we are interested in the impact of circulation changes, AMOC, and clouds and aerosols.

- Global Space-based Inter-Calibration System (GSICS) Framework using CrIS Sensor Data Records (SDR)

Task Leader Likun Wang
Task Code LWLW_EGSB12
NOAA Sponsor Fuzhong Weng
NOAA Office NESDIS/STAR/SMCD/SCDAB
Main CICS Research Topic Calibration and Validation
Percent contribution to CICS Themes Theme 1: 70%; Theme 2: 30%; Theme 3: 0%.
Percent contribution to NOAA Goals Goal 1: 20%; Goal 2: 80%

Highlight: CICS scientists developed methods that use inter-sensor calibration to evaluate and improve radiometric, spectral, and geolocation accuracy of Cross-track Infrared Sounder (CrIS) Sensor Data Records (SDR), which are fundamental for Global Space-based Inter-Calibration System (GSICS) Framework.

BACKGROUND

This work is part of the project "Support for NPP/JPSS Global Space-Based Inter-Calibration System (GSICS)" but emphasizes more on NPP/JPSS Cross-track Infrared Sounder (CrIS) Sensor Data Records (SDR). The goal of this project is to extend the GSICS framework by using CrIS hyperspectral radiance measurements from NPP and JPSS as a benchmark reference for assessing the calibration accuracy and preciseness of operational broad- and narrow-band instruments. To achieve this goal, the first step is to well understand, characterize, and document the data quality of CrIS SDR.

The major methods are to use inter-sensor calibration techniques to evaluating spectral, radiometric, and geolocation calibration accuracy of CrIS SDR and to improve and ensure the data quality of CrIS SDR, including 1) geolocation assessment using collocated Visible Infrared Imager Radiometer Suite (VIIRS) infrared channels; 2) radiometric evaluation through inter-sensor comparison with Atmospheric Infrared Sounder (AIRS), Infrared Atmospheric Sounding Interferometer (IASI), and VIIRS infrared (IR) channels; and 3) data processing quality assurance involving in discovering SDR data processing anomalies, investigating root causes, and providing solutions to CrIS SDR team.

ACCOMPLISHMENTS

In year 2012, we compared CrIS hyperspectral radiance measurements with AIRS on *Aqua* and IASI on *Metop-A* to examine spectral and radiometric consistency and difference among three hyperspectral IR sounders. The newly-launched CrIS on Suomi NPP, combined with previously-launched AIRS and IASI, provides the first-ever inter-calibration opportunity because three hyperspectral IR sounders can observe the Earth and atmosphere at the same spectral regions from different satellites. We directly compared CrIS with AIRS and IASI at orbital crossing points of satellites occurring at high latitudes, the so-called simultaneous nadir overpasses (SNO). The CrIS, AIRS, and IASI spectra are processed at common grids and then the spectral differences are computed. Through inter- and intra-satellite calibration efforts, we can quantify the CrIS calibration bias and uncertainties.

Figure 1 CrIS SDR Geolocation Accuracy Time Series Assessed by VIIRS Band I5. It clearly tracks the variation of CrIS SDR geolocation accuracy caused by software and instrument changes. Based on the above results, the CrIS SDR accuracy is estimated as 0.281 ± 0.110 km in scan direction and 0.276 ± 0.162 km in track direction, and meets the designed specification of less than 1.5 km.

The accomplishments of year 2012 also include assessment of CrIS geolocation accuracy using VIIRS radiance measurements. Just like spectral and radiometric calibration, accurate geolocation is fundamental for CrIS SDR. Given a 14-km CrIS field-of-view (FOV) at nadir, the designed specification of CrIS geolocation is less than 1.5 km - on the order of tenth of CrIS FOV size. However, due to the large FOV size and gaps among CrIS FOVs, it is very hard to assess the sub-pixel geolocation accuracy using a traditional method based on land features. An algorithm has been developed to accurately compute the footprint shapes of CrIS FOVs. The VIIRS pixels are then spatially averaged to compare with CrIS measurements, which are convolved with VIIRS spectral response function to generate VIIRS band radiances. By shifting the VIIRS pixel toward along- and cross-track direction, the perfect collocation position can be indentified to quantify the geolocation accuracy of CrIS FOVs. Shown in Figure 1 is the time series of CrIS SDR geolocation accuracy assessed using VIIRS I5 band, which clearly tracks the variation of CrIS SDR geolocation accuracy caused by software and instrument changes.

In the second part of the inter-comparison of CrIS with VIIRS, we also examined the radiometric consistency between CrIS and VIIRS infrared bands. There are four VIIRS IR channels that are fully covered by CrIS, i.e. M13, M15, M16, and I5. The out-of-band spectral response from VIIRS has been carefully addressed to reduce to comparison uncertainties. The CrIS-VIIRS BT radiance difference is thus examined along with view angles, orbit, scene temperatures, and different FOVs. More important, the third sensor - IASI - is introduced to compare with VIIRS to investigate the root causes of the differences. The scene-dependent feature has been identified for CrIS-VIIRS for VIIRS M15, and the root causes are still under the investigation.

In year 2012, four peer reviewed papers have been published or under review, and two conference proceedings have been published.

PLANNED WORK

- Develop a system to long-term monitoring CrIS SDR stability through inter-sensor calibration.
- Evaluate long-term radiometric and spectral consistency among AIRS, IASI, and CrIS.
- Demonstrate that the CrIS SDR data from NPP and JPSS can serve as a long-term reference benchmark for inter-calibration and climate-related study.

PUBLICATIONS

Raja, M. K. R. V., X. Wu, F. Yu, L. Wang, and G. Rancic, 2012: Evaluation of operational Midnight Blackbody Calibration Anomaly Correction Algorithm Performance Using Global Space based Inter Calibration System. Journal of Atmospheric and Oceanic Technology (Accepted upon revision).

Wang, L., X. Wu, M. Goldberg, and F. Weng, 2013: Effects of Ice Decontamination on GOES-12 Imager Calibration. **IEEE T***ransactions* on Geoscience and *Remote Sensing,DOI:* 10.1109/TGRS.2012.2225839*.*

Wang, L., and Cheng-Zhi, Zou, 2013: Inter-comparison of SSU Temperature Data Records with Lidar, GPS RO, and MLS Observations. Journal of Geophysical Research, DOI: 10.1002/jgrd.50162 (in press).

Yu F., X. Wu, M.K. Rama Varma Raja, Y. Li, L. Wang, and M. Goldberg, 2012: Evaluations of Diurnal Calibration Variation and Scan Angle Emissivity Calibration for GOES Imager Infrared Channels. **IEEE T***ransactions* on Geoscience and *Remote Sensing,* 51, 671-683, doi: 10.1109/TGRS.2012.2197627*.*

Wang L., D. Tremblay, and M.D. Goldberg, 2012: Inter-comparison of NPP/CrIS radiances with VIIRS, AIRS, and IASI: a post-launch calibration assessment", Proc. SPIE 8528, Earth Observing Missions and Sensors: Development, Implementation, and Characterization II, 85280J, doi:10.1117/12.978769

Denis A. T., Y. Han, Y. Chen, X. Jin, L. Wang, 2012: CrIS SDR calibration and validation status and NOAA-STAR related activities",Proc. SPIE 8528, Earth Observing Missions and Sensors: Development, Implementation, and Characterization II, 85280F, doi:10.1117/12.981340.

PRESENTATIONS

Wang, L., F. Weng, and M. Goldberg, 2012: Inter-comparison of CrIS, AIRS, and IASI Radiances Toward Creating Long-term Infrared Hyperspectral Radiance Benchmark Datasets. AOGS - AGU (WPGM) Joint Assembly 2012, August 13 to 17 2012, Singapore.

Wang L., Y. Han, F. Weng et al., 2012: Post-launch Radiometric and Spectral Calibration Assessment of NPP/CrIS by Comparing CrIS with VIIRS, AIRS, and IASI,” 2012 Con-

ference on Characterization and Radiometric Calibration for Remote Sensing, August 27 to 30 2012, Logan, Utah.

Wang, L., Y. Han, F. Weng et al., 2012: Inter-Comparison of NPP/CrIS with AIRS and IASI, 2013 AGU Fall meeting, December 3-7 2012, San Francisco, California.

Wang, L. Y. Han, F. Weng et al., 2013: **Inter-Comparison of NPP/CrIS Radiances with AIRS and IASI**, AMS 93rd Annual Meeting/9th Annual Symposium on Future Operational Environmental Satellite Systems, January 5-10 2013, Austin, Texas.

Wang, L. Y. Han, F. Weng et al., 2013: Assessment of CrIS Geolocation Accuracy using VIIRS, AMS 93rd Annual Meeting/9th Annual Symposium on Future Operational Environmental Satellite Systems, January 5-10 2013, Austin, Texas.

Performance Metrics	**FY12**
# of new or improved products developed	0
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	4
# of non-peered reviewed papers	2
# of invited presentations	5
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	N/A

- A Recalibration of the AVHRR Data Record to Provide an Accurate and Well Parameterized FCDR

Task Leader Jonathan Mittaz
Task Code Shadow award
NOAA Sponsor Jeff Privette
NOAA Office NESDIS/NCDC/RSAD
Main CICS Research Topic Calibration and Validation
Percent contribution to CICS Themes Theme 1: 0%; Theme 2: 100%; Theme 3: 0%.
Percent contribution to NOAA Goals Goal 1: 70%; Goal 2: 30%

Highlight: The AVHRR operational calibration has large (up to 0.5K) biases which are both scene and time dependent and we are deriving a new AVHRR calibration which will significantly reduce these biases. As part of this we are using the IASI and (A)ATSR sensors as accurate top-of-atmosphere (TOA)radiance source and have determined both the accuracy of these sensors as well as corrections to be used so that, for example, the AATSR can be used as a climate TOA reference.

BACKGROUND

The Advanced Very High Resolution Radiometer (AVHRR) is a critical instrument for climate change studies because different versions of the AVHRR sensors have been available continuously for over 30 years and continue to be used to the present day. To use the AVHRR for climate change studies, however, accurate and stable radiances are required, or at the very least the biases and trends have to be well understood. Unfortunately these are not available with the current operational calibration, and work done by us and others has already shown significant biases and errors of up to > 0.5K. Further, analysis done by the University of Miami as part of the Pathfinder project shows that for at least one AVHRR (NOAA-16), significant time varying calibration problems are producing large time variable SST biases. These issues of both large biases and time variable calibration problems will severely limit the use of the AVHRR for climate change studies if left uncorrected.

In order to address the problems with the current AVHRR calibration we have developed a completely new physically based calibration methodology which has been able to find and highlight the complex sources of bias and error in both the pre-launch and in-orbit data for the AVHRR. By including effects such as stray light and instrument temperature drifts we have shown that it is possible to remove much of the source of error seen in AVHRR radiances and under certain circumstances provide a nearly zero bias pre-launch calibration. We have also shown that the new calibration has the capability of predicting instrument gain during times when the on-board calibration data are affected by solar and/or Earthshine contamination - solar contamination has been a significant problem for many NOAA platforms as their equator crossing times drift. The baseline for this new calibration are matches with the (A)ATSR series and we have developed new match code which deals with variations in observed instrument footprints. We are in the process of validating the (A)ATSR series as a top-of-atmosphere reference as well as validating IASI and, in the future, AIRS as accurate references. Finally, we are beginning to move through the AVHRR series starting with the more modern AVHRRs to derive a new calibration scheme to the complete historic AVHRR data record to fix calibration biases and contamination effects and therefore provide an accurate and clean AVHRR FCDR.

ACCOMPLISHMENTS

Much of the work this year has concentrated on validating the AATSR sensor for its use as a TOA reference. This work, though not part of the original proposal, is necessary to ensure that the final AVHRR calibration is referenceable back to an understood and SI traceable source which is what we hope that (A)ATSR series can be. In detail, however, there are issues with the (A)ATSR calibration methodology which give rise to small (up to 0.1K) biases as well as significant problem with the AATSR 12µm channel bias which as of now has no correction or explanation. In order to use the (A)ATSR series as a reference we have therefore had to validate them against another sensor to make sure we understand its possible sources of bias and error and to make sure any problems do not get transferred to the AVHRR recalibration.

In order to measure the accuracy and stability of the IASI and the AATSR their radiances were inter-compared on locations (collocations) that are observed by both the instruments at the same time. To accomplish this, first a collocation algorithm was developed that took IASI and AATSR orbit files as input and identified collocated pixels. An AATSR IASI collocation database was created for the 2008 -2011 period enabling comparisons of AATSR and IASI radiances to be made.

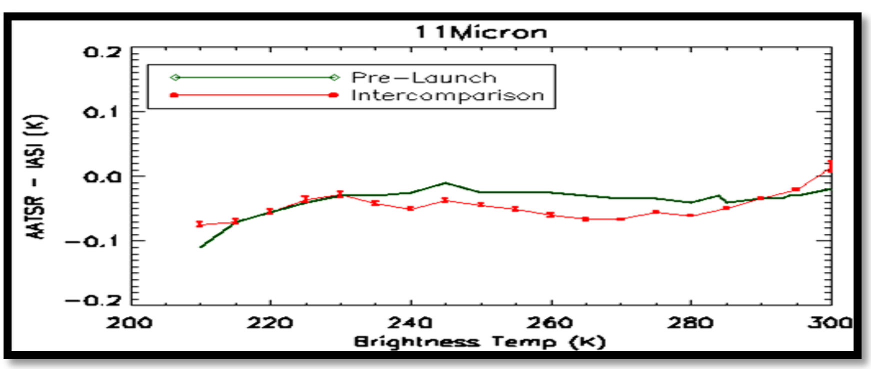


Figure 1. Shows that IASI is nearly as good as a pre-launch reference. The temperature dependence bias of AATSR – IASI is similar to the bias of the AATSR with its pre-launch calibration target.

Figure 1 shows a comparison between the AATSR-IASI bias compared to the pre-launch estimates of the AATSR accuracy and show that in broad general terms the shape of the bias including a increasing negative bias at low (<240K) temperatures exist in both datasets. Apart from the small offset ~0.08K the two datasets agree to within a few hundredths (~0.03K) of a degree implying that the IASI 11µm channel region is actually accurate at a level which is 10 times better than the IASI quoted accuracy. This then shows that both IASI and the AATSR 11µm channel region after minor corrections (an IASI offset and a removal of the small AATSR trends) can be trusted to a few hundredths of a degree relative to pre-launch testing data. This level of accuracy was expected for the AATSR, which was designed as an instrument to be used for climate datasets, but shows that IASI is much more accurate than previously thought.

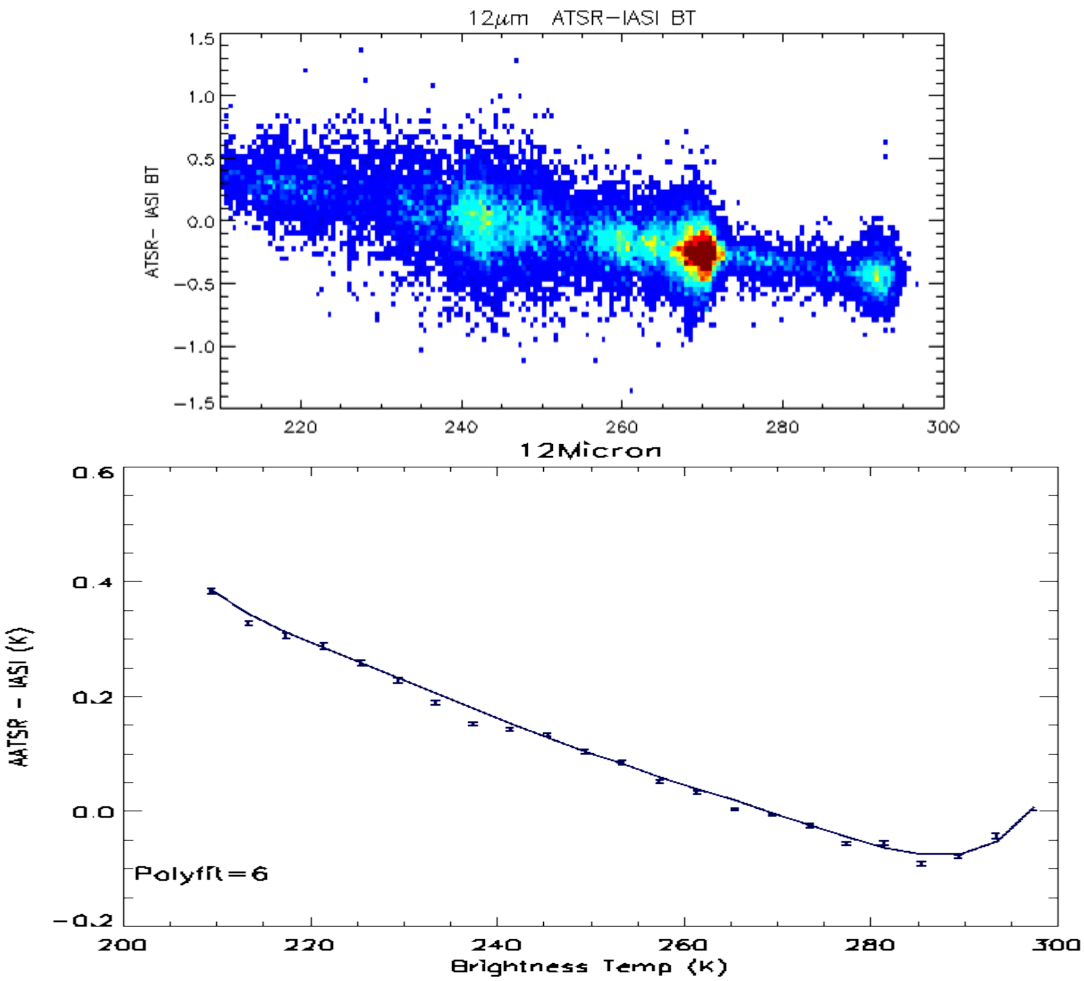


Figure 2. Shows the 12µm channel AATSR-IASI bias and shows a strong temperature dependence. The top panel shows the raw matches while the bottom panel shows a fit to the binned mean values which can be used to correct the data.

The situation is very different for the AATSR 12µm channel which is known to be biased. Most work to date has concentrated on the SST temperature regime and had assumed that the bias was an approximately constant -0.2K bias. We have been able to get collocations over a much wider temperature range and show in Figure 2 what the true bias is. As can be seen, instead of a flat -0.2K bias the AATSR 12µm channel shows a strong temperature dependence from +0.4 to -0.2K. As a first step towards correcting this bias we have fitted a function to the difference which will be used to derive unbiased 12µm AATSR radiance to be used for the AVHRR recalibration

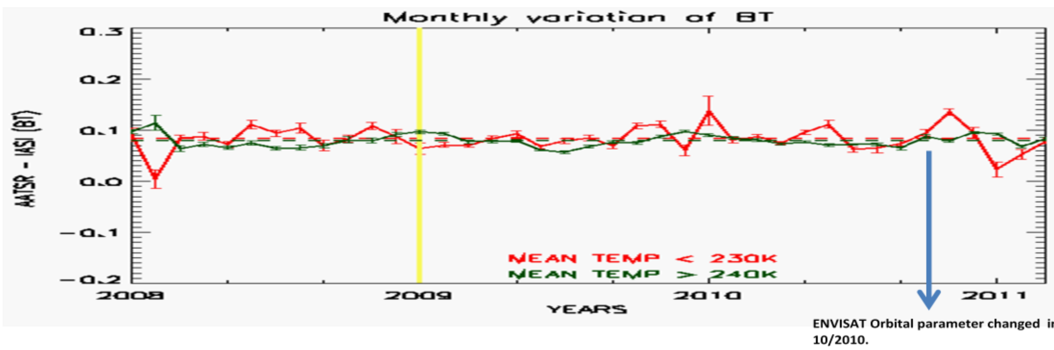


Figure 3. The long timeseries of biases between the AATSR and IASI showing that both instrument are essentially stable at the level of a few hundredths of a degree. There is an apparent variation after Oct. 2010 which is when the ENVISAT orbital parameters changed. Note the constant 0.08K offset between IASI and AATSR.

We have also studied the time stability of the AATSR 11µm channel. Figure 3 shows 3 years of data in two temperature ranges. The >240K regime is where the pre-launch and AATSR-IASI bias is relatively flat while the <230K region is where there is a dip in the bias down to ~-0.1K. As can be seen the AATSR and IASI are stable relative to each other most of the time, though there seems to be AATSR variability after October 2010 in the cold (<230K) temperature range which may be due to a change in the ENVISAT orbit. After October 2010 there is also a change in the temperature dependent bias which can be seen in Figure 4 so it has been decided for the AVHRR recalibration project to ignore AATSR data after Oct 2010 and highlights the need to validate the (A)ATSR sensors for use as a TOA reference.

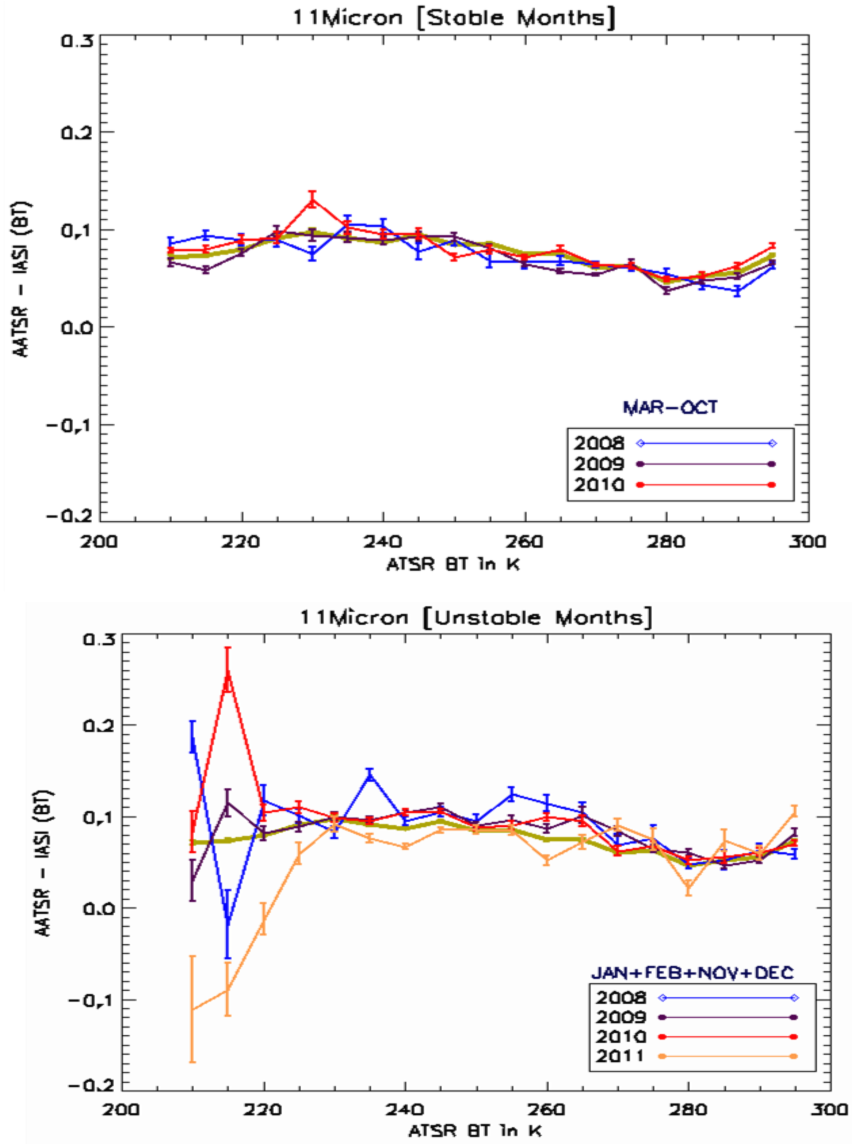


Figure 4. Top panel shows a year by year comparison of the temperature dependent bias between the AATSR and IAS which shows only small deviations from a constant offset. The bottom panel shows the Nov-Feb timeframe for the same years and shows that for 2010-2011 there is a significant change in the temperature dependent bias at low (<230K) temperatures. Data after Oct 2010 (which is when the ENVISAT orbit changed) will be excluded as a TOA reference.

Work has also progressed on understanding the instrument temperature dependent bias seen in the AVHRR relative to the AATSR. More complex thermal models have been looked at and seem to show that when the AVHRR has a simple seasonal instrument temperature dependence and simple thermal model is sufficient whereas when there is a more complex instrument temperature behavior a more complex model might be needed. However, this work was put on hold while the AATSR biases were fully investigated and will continue shortly.

PLANNED WORK

Work will continue investigating the accuracy of the (A)ATSR series by continuing to analyse the AATST and moving onto the ATSR and ATSR-2 satellites. Now that we have checked the accuracy of the AATSR we will resume the calibration of the AVHRR/3 sensors including the instrument temperature dependence and will transition to investigating the AVHRR/2 sensors using the ATSR-2 as a reference together with an analysis of the AVHRR/2 pre-launch data. It is hoped that by the summer the AVHRR/3 data will be available for release using the corrected AATSR (both 11 and 12µm channels) as a reference.

PUBLICATIONS

Bali, M and Mittaz, J: Inter-Comparison of IASI and AATSR IR channels: 2012 EUMETSAT Meteorological Satellite Conference: 3-7, September 2012, Sopot, Poland.

PRESENTATIONS

Mittaz, J., 2012,"IR Calibration of NOAA broad band IR sensors", GHRSST XIII, 4th - 8th June 2012 Tokyo, Japan

Bali, M and J. Mittaz, "Inter-Comparison of IASI and AATSR IR channels", 2012 EUMETSAT Meteorological Satellite Conference: 3-7, September 2012, Sopot, Poland.

Mittaz, J., "A Fundamental Climate Data Record for the AVHRR", 2012 EUMETSAT Meteorological Satellite Conference: 3-7, September 2012, Sopot, Poland.

Performance Metrics	**FY12**
# of new or improved products developed	0
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	0
# of non-peered reviewed papers	1
# of invited presentations	1
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	N/A

-Satellite Calibration and Validation (Cal/Val) efforts for STAR Precipitation Products

Task Leader Matt Sapiano/JJ Wang
Task Code MSMS_SCAV_12
NOAA Sponsor Ralph Ferraro
NOAA Office NESDIS/STAR/CRPD/SCSB
Main CICS Research Topic Calibration and Validation
Percent contribution to CICS Themes Theme 1: 30%; Theme 2: 70%; Theme 3: 0%.
Percent contribution to NOAA Goals Goal 1: 20%; Goal 2: 80%

Highlight: A precipitation Cal/Val center has been established at CICS and is maintained to provide critical validation information on a range of NESDIS datasets including MiRS estimates from several sensors such as ATMS on NPP .

BACKGROUND

A Precipitation Product Cal/Val task has been implemented (task DVDV_STAR10) to evaluate satellite-derived precipitation estimates that are produced by NESDIS/STAR. This task was initiated to provide support to incorporate MiRS precipitation products from the ATMS instrument into the Cal/Val activity.

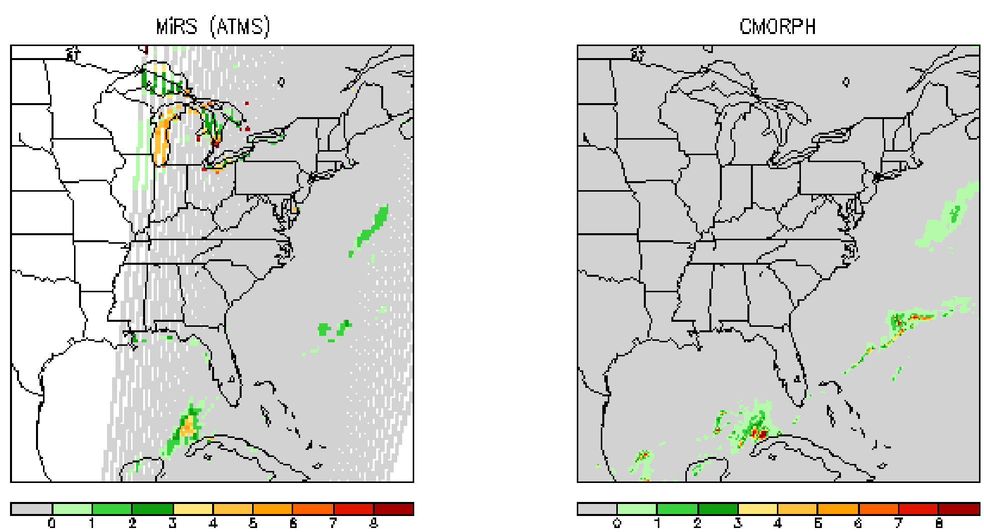


Figure 1. Plot of precipitation (mm hr^{-1}) for MiRS (from ATMS instrument; left) and CMORPH (right) for 8 U.T.C. on January 29, 2012.

ACCOMPLISHMENTS

The Cal/Val webpages have been periodically updated at the usual seasonal (three-month) time period and results have been disseminated to the PREPOP and other

NESDIS data producers for their review and use. As of late 2012, only a few samples of MiRS precipitation products that were derived from the ATMS instrument aboard the NPP satellite were available. The MiRS granule precipitation data for a sample day were obtained and gridded to the 0.25^{o} degree latitude/longitude grid that matches the "Stage IV" radar reference data. These data were plotted at the individual swath level and compared them to independent precipitation analysis (CMORPH) to ensure the data had been correctly processed. The product evaluation software was modified to incorporate the MiRS/ATMS estimates so that when the estimates become available on a routine basis, the evaluation process will be ready to accept them and results can be produced operationally. Figure 1 shows a comparison of the rainfall from MiRS/ATMS and CMORPH for a test case. It is clearly too early to start drawing conclusion regarding the skill of MiRS, the plot shows that the correspondence between the products is generally very good.

PLANNED WORK

We are anticipating the imminent inclusion of MiRS precipitation estimates that were generated from ATMS data into the validation procedure. However, at present, not all MiRS products are included in this validation effort because NESDIS is still checking them out and only samples were distributed.

OTHER

- The Cal/Val website has been updated every three-months with new results; the website has been disseminated to the PREPOP and NESDIS partners
- The software for the Cal/Val website has been updated and prepared for operational processing of MiRS/ATMS when that data becomes available.

Performance Metrics	**FY12**
# of new or improved products developed	0
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	0

- Support for NPP/JPSS Global Space-Based Inter-Calibration System (GSICS)

CICS Task Leader: Zhanqing Li
CICS Co-Investigator: Hu (Tiger) Yang, Wei Han, Zaizhong Ma
Task Code: PAPA_GSIC11 & EBEB_SNPP12
NOAA Sponsor Fuzhong Weng
NOAA Office NESDIS/STAR/SMCD/SCDAB
Main CICS Research Topic Calibration and Validation
Percent contribution to CICS Themes Theme 1: 70%; Theme 2: 30%; Theme 3: 0%.
Percent contribution to NOAA Goals Goal 1: 20%; Goal 2: 80%

Highlight: 1) Performed calibration accuracy evaluation of AMSR2 measurements by using "Double Difference" method; 2) It was found that the scan biases of F-16 and F-18 are dependent on ascending and descending nodes; 3) it is important to add the cloud liquid water contributions for simulating GPS refractivity in cloudy conditions, especially in the Hurricane Genesis stage**.**

BACKGROUND
The AMSR-2 on board GCOM-W will provide unique information on sea surface wind and surface temperature under all weather conditions. The data sets will be critically support NOAA users for improving the severe storm (such as hurricane and winter storm) intensity forecasts through satellite data assimilation into mesoscale and global forecast systems. In addition, NOAA will have better opportunities in developing more advanced products from synergetic uses of both AMSR-2 and ATMS. The synergy of ATMS with AMSR-2 would have significant impacts on improving severe weather forecasts and environmental monitoring.

ACCOMPLISHMENTS
Major achievements made on this project include:

1. Calibration accuracy evaluation of AMSR2 measurements by using "Double Difference" method
The newest version of CRTM2.2 with Fastem5 ocean surface model were used as forward model to simulate satellite observations, with GDAS global 1deg resolution reanalysis data as inputs; simultaneous TMI measurements was used as reference truth to compare with AMSR2 measurements. The calibration accuracy was found range from 2 to 5K, different for each channel. Figure.1 shows the histogram distribution of bias for different AMSR2 channel.

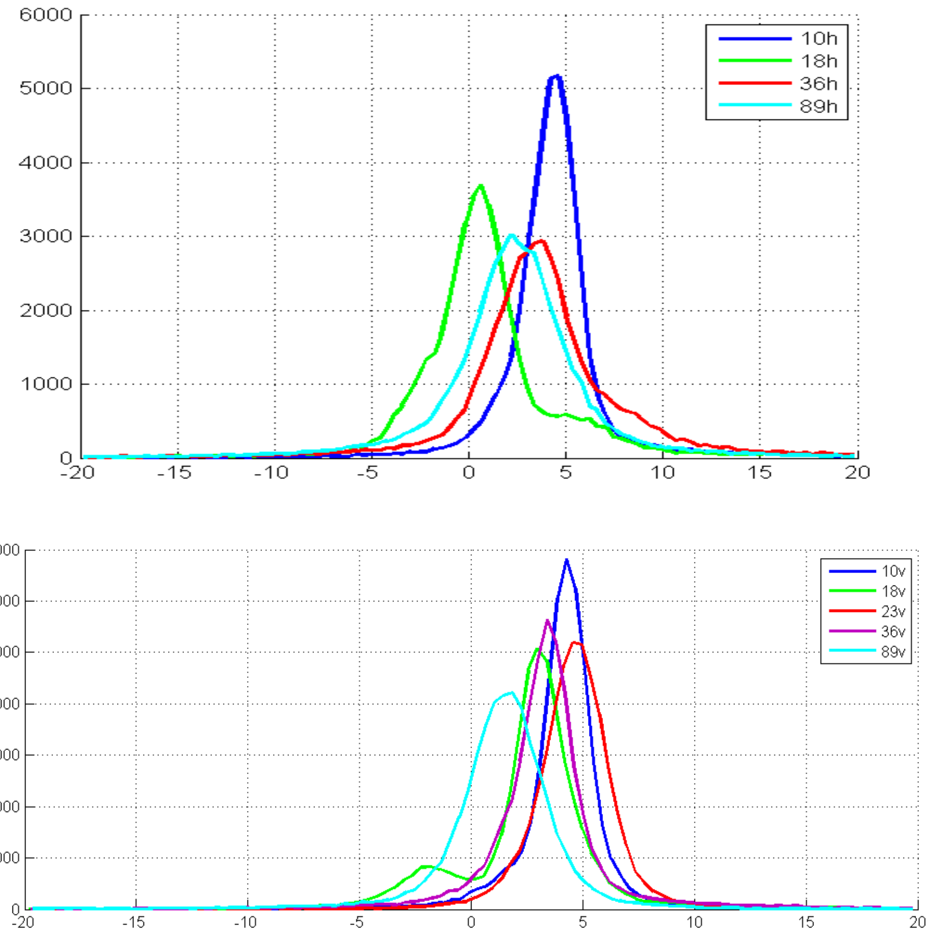


Figure.1 shows the histogram distribution of bias for different AMSR2 channel.

2. Nonliearity correction of AMSR2 measurements

Residual nonlinearity was found in some of channels of AMSR2 level-1 datasets, a physical based model was developed to correct the nonlinearity bias. As shown in Figure.2, after correction, the nonlinearity bias was greatly eliminated. The correction model is believed to be useful in AMSR2 EDR products development.

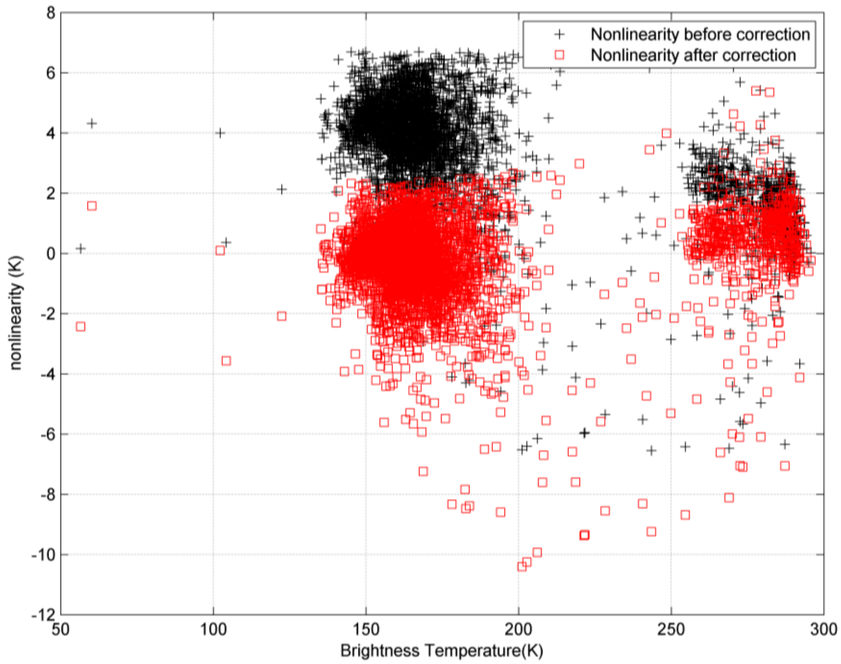


Figure.2 Bias at AMSR2 36.5H channel before (black) and after(red) nonlinearity correction

3. Quality assessments of SSMIS and ATMS data in NWP

It was found that the scan biases of F-16 and F-18 are dependent on ascending and descending nodes. Figure 3 and 4 show that the descending node of F-16 SSMIS O-B for channel 12,13,14 and 15 are biased negatively relative to the ascending node, while the descending node of F-16 SSMIS O-B for channel 16 is biased positively relative to the ascending node. The amplitude of the biases is approximately 0.6K. The biases are not smoothly along scan positions (Figure 3) and there are some agreements in the differences of biases between ascending node and descending node for the 5 imager channels at the same positions (Figure 4). The first guess departures (O-B) with bias correction (Figure 5) agree well with independent conventional data. It is shown that the assimilation of the radiances of DMSP-F16 SSMIS 5 imager channels improves the humidity analysis and the 72h hurricane track and intensity forecast for the Hurricane Sandy.

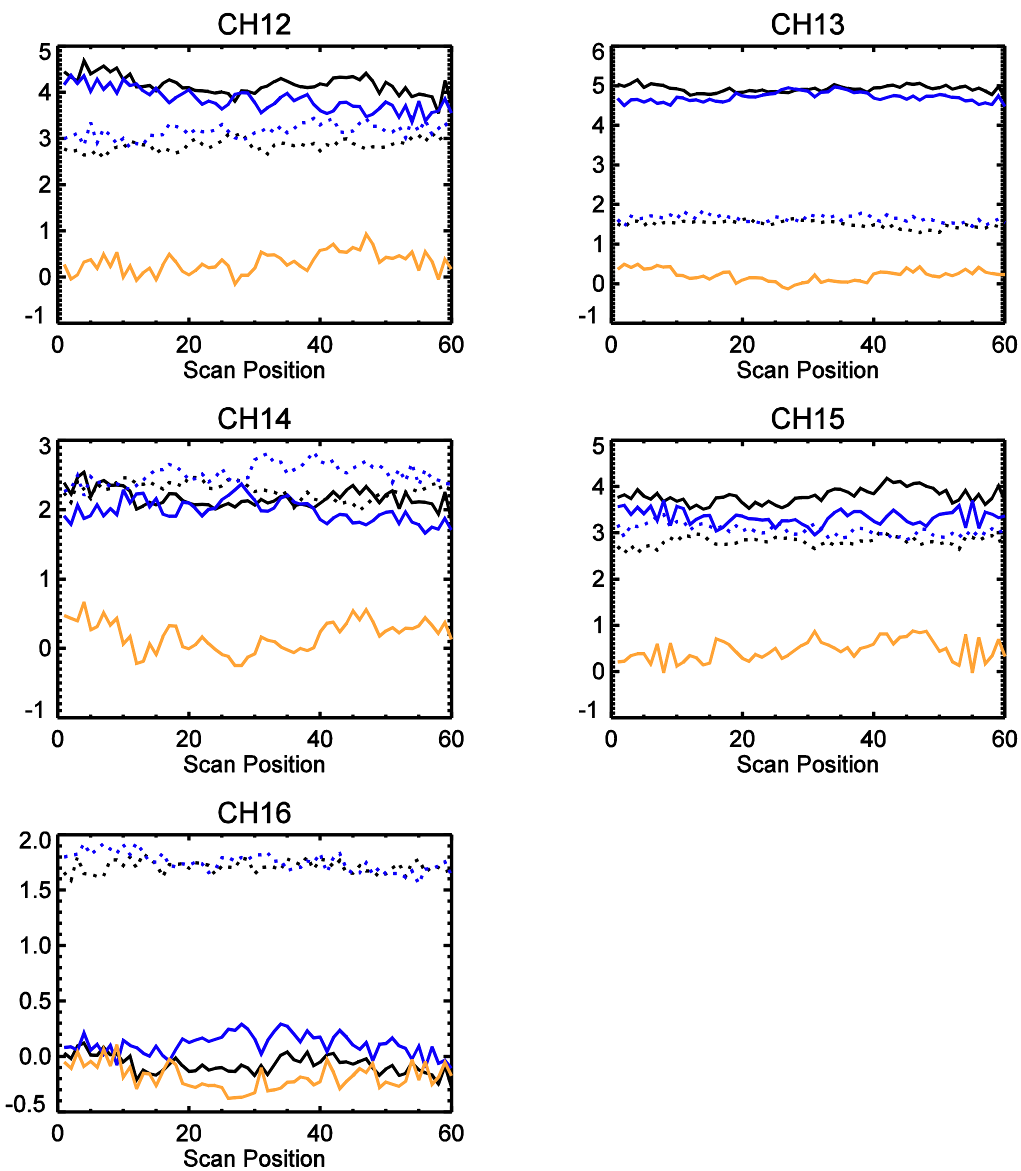


Figure 3 : Regional means and standard deviations (STDs) of O-B as a function of scan position for SSMIS channels 1–6 from DMSP F16 for the period 23–29 October 2012 over the region (125W~42W, 26S~63S). Ascending node (local scan local time at 06:00 PM) and descending node (local scan local time at 05:59 AM) means are plotted by solid black and blue lines , and STDs by black and blue dots, respectively. The differences between means for ascending and descending node (Ascending- Descending) are plotted by solid brown lines.

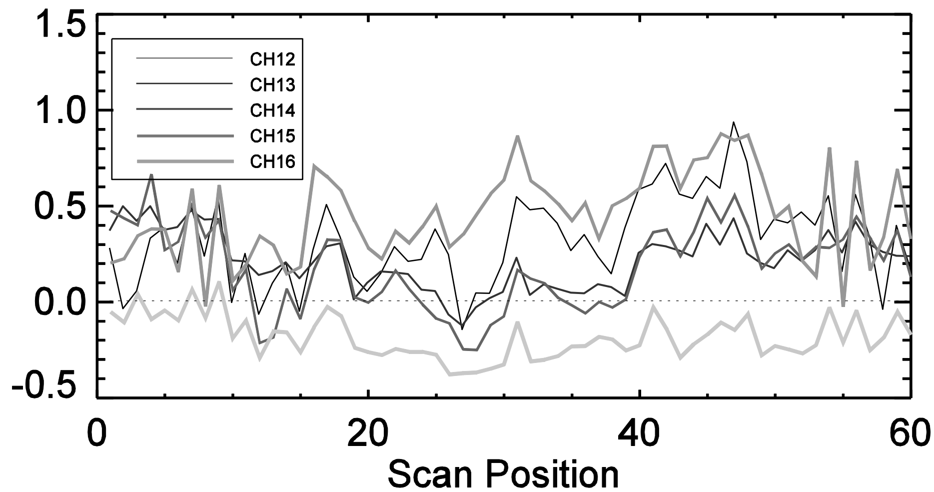


Figure 4: The differences between O-B mean for ascending and descending node of DMSP-F16 SSMIS 5 imager channels at each scan positions for clear sky (Ascending- Descending). Data are drawn from the period 23–29 October 2012 over the region (125W~42W, 26S~63S).

4. Developments of the new GPSRO forward model which will lead better cross-calibration of satellite radiances

Clouds are widespread and very common phenomena, and cover about 60% of the sky. Yet, in the current operational Gridpoint Statistical Interpolation (GSI) data assimilation system, Global Positioning System (GPS) Radio Occultation (RO) refractivity operator didn't include the impact of Cloud Liquid Water (CLW) while simulating GPS refractivity observations. Therefore, it is important to add the cloud liquid water contributions for simulating GPS refractivity in cloudy conditions, special in the Hurricane Genesis stage. After double checking GPS quality control in the GSI system, the contribution from liquid water content (W) has been added into the GPS local refractivity operator:

$$N = 77.6\frac{P}{T} + 3.73\times10^5\frac{P_w}{T^2} + 1.45W \qquad (1)$$

where P is pressure in hPa, T is temperature in K, Pw is water vapor pressure in hPa, and W is the liquid water content in grams per cubic meter.

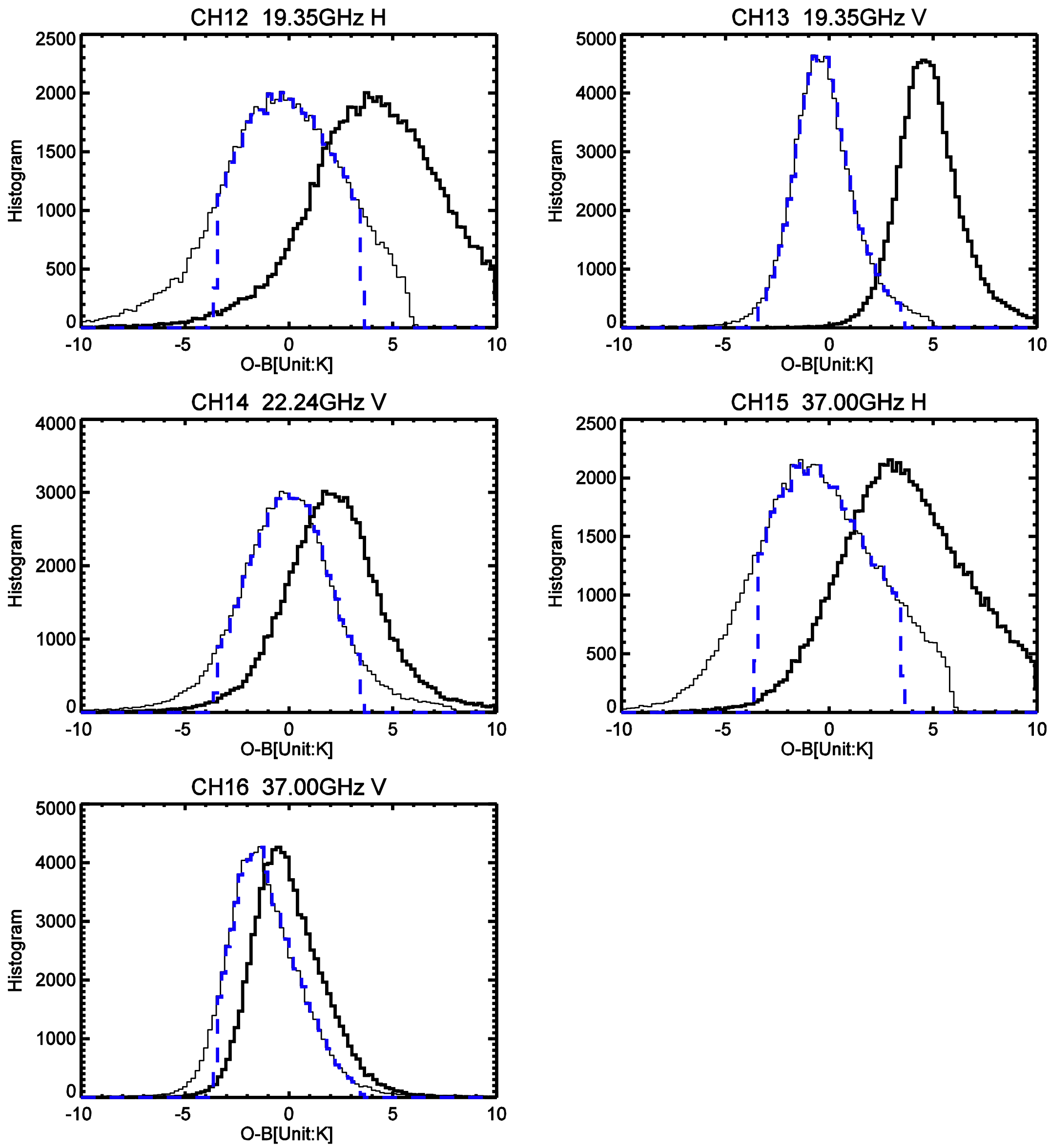


Figure 5: Histograms of DMSP-F16 SSMIS window channels() first-guess radiance departures for samples passed quality control for only clear sky, before bias correction(bold solid), after bias correction(thin solid) and used in analysis (dashed). Data are drawn from the period 23–29 October 2012 over the region (125W~42W, 26S~63S).

Investigation of the impact of Cloud Liquid Water in the GPSRO refractivity operator is based on the 2012 NCEP operational version of Hurricane Weather Research and Forecast system (HWRF). In the past year, our efforts are mainly focused on:

- The model top of HWRF was raised from 50 hPa (operational) to 0.5 hPa and the vertical levels were increased from 43L to 61L;

- Turn on the GSI option. The current NCEP operational HWRF only use GFS analysis field for initialization without performing the further GSI assimilation;
- Replace GFS analysis with WRF-NMM 6h forecast fields as first guess in HWRF system to avoid the double uses of satellite data.
- Implement the GPSRO Refractivity operator with contribution from liquid water content into the HWRF model.

So far, the liquid water content term has been added successfully into the GPS local refractivity operator in the HWRF system. Single GPS profile test has been done for checking the new operator as well (Figure 6). The contribution from liquid water content to refractivity can be found clearly below 4km height. In the future, more sensitivity tests for the cloud liquid water will be focused on the GPSRO refractivity assimilation at the hurricane genesis stage. And more comparison experiments will be designed with/without cloud liquid water contribution as well. And then implementing this new operator into the global option will be considered.

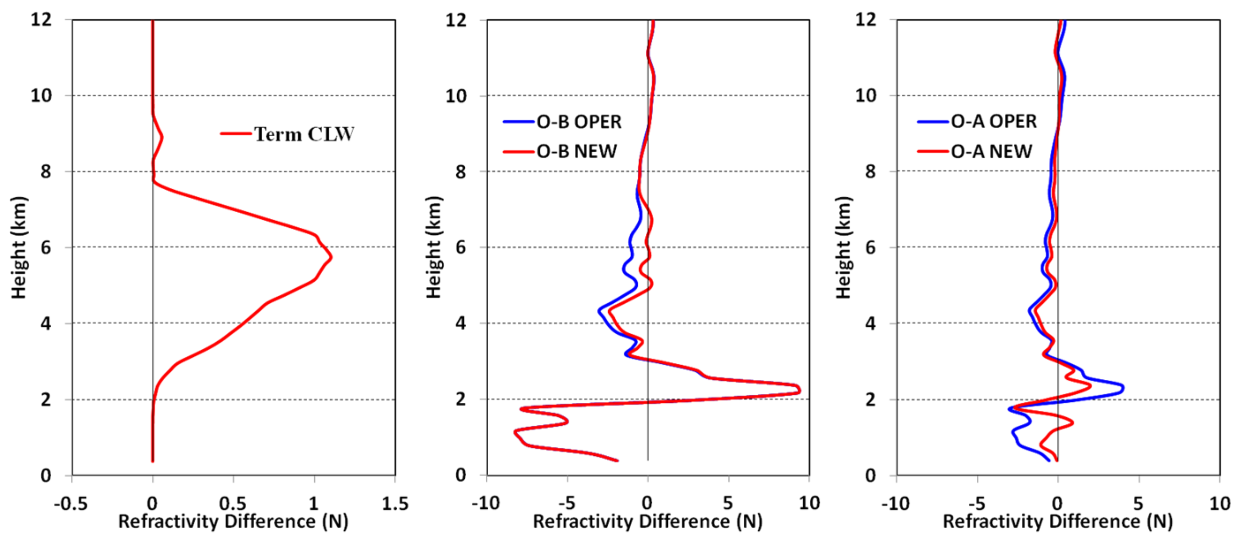


Figure.6. Single GPS profile test. COSMIC GPS observation is located at (29^o N, 65^o W) at 0000 UTC Oct. 23, 2012. Left panel is the distribution of simulated refractivity value with height, contributed only by the liquid water content. The comparison of the observation minus background (O-B) and observation minus analysis (O-A) departures is showed in middle and right panels, respectively.

- Science and Management Support for NPP VIIRS Aerosol Optical Thickness (AOT), Aerosol Particle Size Parameter (APSP), and Suspended Matter (SM)

Task Leader Jingfeng Huang and Ho-Chun Huang
Task Code SKSK_SMSN12
NOAA Sponsor Shobha Kondragunta
NOAA Office NESDIS/STAR/SMCD/SCDAB
Main CICS Research Topic Calibration and Validation
Percent contribution to CICS Themes Theme 1: 50%; Theme 2: 50%; Theme 3: 0%.
Percent contribution to NOAA Goals Goal 1: 20%; Goal 2: 80%

Highlight: CICS scientists at NOAA NESDIS STAR maintained, evaluated, and improved the current operational Suomi-National Polar-orbiting Partnership (S-NPP) Visible Infrared Imaging Radiometer Suite (VIIRS) aerosol products, by closely monitoring global aerosol observations, conducting intense calibration and validation of the products to evaluate data maturity, developing and implementing new schemes to improve global aerosol retrievals, and supporting research and application communities on data use.

BACKGROUND

As a task started in June 2012, this work is part of the NOAA/NASA Suomi-National Polar-orbiting Partnership (S-NPP) operational project “Global Aerosol Environmental Data Record (EDR) from S-NPP Visible Infrared Imaging Radiometer Suite (VIIRS)” under the NOAA NESDIS JPSS program. The work represents a continuation and enhancement of previous early orbit calibration/validation activities after NPP’s successful launch in October 2011. The research and development in this task supports scientific investigations to improve the VIIRS global aerosol EDR data quality, and sustains data management to support scientific and operational data users worldwide in weather forecasting, air quality monitoring and forecasting, climate mitigation studies, and satellite remote sensing. The S-NPP VIIRS provides three aerosol EDRs including aerosol optical thickness (AOT), aerosol particle size parameter (APSP), and suspended matter (SM). The VIIRS aerosol products are important components for the NOAA/NASA’s JPSS program that is dedicated to provide long term continuous comprehensive spaceborne remote sensing capability to monitor global atmosphere, land and ocean environment, and advance weather, climate, environmental and oceanographic sciences.

This particular task is focused on numerous topics related to the development of the VIIRS aerosol products. Through this task, calibration and validation activities of the *VIIRS Aerosol Environmental Data Record (EDR) Products* are conducted by comparing the VIIRS aerosol products to the heritage satellite aerosol products (such as MODIS, MISR, CALIPSO, etc.) and the Aerosol Robotic Network (AERONET) and the Marine Aerosol Network (MAN) in-situ measurements. The task maintains and improves the VIIRS operational aerosol algorithms schemes through research and operational activities by conducting research on anomalous behaviors of global aerosol retrievals, investigating causes and providing code fix to the operational code, and reprocessing aerosol retrievals using the Algorithm Development Library (ADL) for code change and retrieval performance evaluations. The task also supports evaluations of the VIIRS aerosol products for reaching various stages of product maturity (beta, provisional, validated) to meet the JPSS program requirements. Data quality and aerosol event monitoring are also conducted on daily basis in this task to ensure product quality assurance, data delivery and archiving, anomaly discovery, and performance stability etc. CICS scientists from this task also provide any necessary operational services to global data user community to support their scientific and operational use of the VIIRS aerosol products.

ACCOMPLISHMENTS

The main goal of this task is to support the activities of calibration and validation of VIIRS aerosol products at the NOAA/NESDIS/STAR. During the period of this report, some activities had directly/indirectly leaded to the improvements or new developments of VIIRS aerosols algorithms.

Through the intensive calibration and validation (ICV) phase of the VIIRS aerosol products that are conducted by the CICS scientists and supported by this task, VIIRS AOT and AE products reached *beta* version and currently released to public from 05/02/2012. The VIIRS Suspended Matter product is under in-depth evaluation towards beta version. Several critical code changes and improvements were made to the VIIRS AOT retrievals. The team is working towards the evaluation of the VIIRS aerosol products to reach *provisional* maturity status that is planned in May 2013. The results from the VIIRS-AERONET and VIIRS-MAN comparisons, that are critical for VIIRS aerosol products for data maturity evaluation, are shown in the following Figure 1.

An automated data archiving and processing system was developed and implemented to automatically fetch, process, and archive VIIRS aerosol EDR datasets on local disk storage. This system supports the daily activities of data visualization, event monitoring, data reprocessing, and calibration/validation currently performed by members of NOAA/NESIDS/STAR VIIRS aerosol CAL/VAL team. Several algorithms had been created for comparisons between VIIRS aerosol products, i.e., AOT, ASAP, and SM, and those of other satellites or in-situ observations, e.g., MODIS, AERONET, and MAN. The evaluation activities include the AOT and AE comparisons between VIIRS and MOIDS/AERONET over the land and in the coastal areas and the AOT comparison between VIIRS and MAN (Figure 1). The evaluation results had greatly contributed to the beta-maturity review of VIIRS AOT and AE products. The efforts are continue and are expected to significantly contribute to the upcoming provisional-review of the VIIRS aerosol products, as well as the SM beta-maturity review. CICS scientists also performed the massive-data management for the NOAA/NESIDS/STAR VIIRS aerosol CAL/VAL team by removing the duplicate and non-used datasets and reorganizing the structure of data storage. Download special datasets upon the request of NOAA/NESIDS/STAR VIIRS aerosol CAL/VAL team.

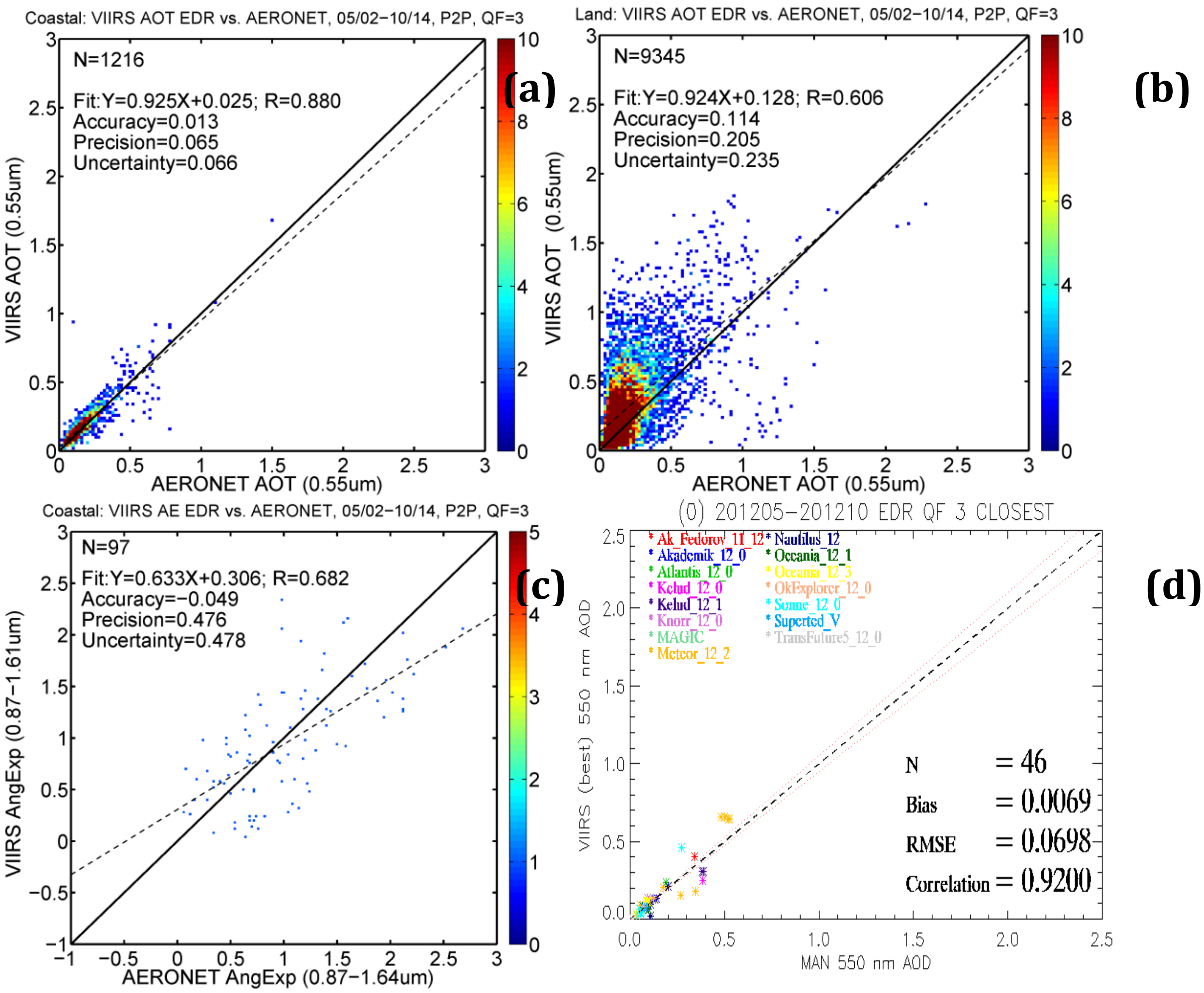


Figure 1. Validation of VIIRS Aerosol AOT and AE against AERONET and MAN: (a) ocean AOT retrievals over AERONET coastal sites; (b) land AOT retrievals over AERONET land sites (the high bias were found and solution proposed and implemented in the operation); (c) ocean AE retrievals over AERONET coastal sites; (d) ocean AOT retrievals against MAN.

An operational anomaly was discovered by the evolution and daily monitoring of VIIRS aerosol products. Further investigation provided by CICS scientists had discovered the anomaly was resulted from a coding error during aerosol AOT code upgrade in October 2012. The bug was caught immediately on the second day of implementation, and it was reported to the task leaders. Additional efforts (participated and presented at several meetings for the code change) had been performed to implement a proposed solution to correct the code error. The Implementation of the correction was applied to the operational code in a timely fashion (on November 2012) and the data loss was kept to a minimum (research to ops #1).

To investigate the possible reasons for the high biases of the VIIRS land aerosol retrievals, CICS scientists also conducted in-depth data analysis on the Terra MODIS AERONET-based Surface Reflectance Validation Network (ASVRN) datasets and diagnosed the seasonal and regional dependence of the surface reflectance ratios in response to the vegetation and surface type changes. This research effort later on lead to more in-depth testing of the relationship using actual VIIRS land aerosol retrievals and the implementation of the updated surface reflectance ratios in the operational aerosol retrieval code by other CAL/VAL team members (research to ops #2). After the update, CICS scientists observed the improvements of the operational VIIRS land AOT retrievals with increasing evidences (improved product #1).

Significant scientific results were presented at AGU Fall Meeting 2012 and AMS Annual Meeting 2013. Positive feedbacks were received from the user communities.

PLANNED WORK

- Continue the intensive Calibration/Validation activities to further improve the VIIRS aerosol products.
- Conduct provisional maturity evaluation of the VIIRS aerosol products.
- Update the VIIRS aerosol Algorithm Theoretical Basis Document (ATBD) and Operational Algorithm Document (OAD).
- Publish and report scientific significant results in journals and at conferences.

PRESENTATIONS

Jingfeng Huang, I. Laszlo, S. Kondragunta, H. Liu, H. Cronk, **H. C. Huang**, L. Remer, S. Jackson, C. Hsu, A. M. Sayer, M. Oo, R. E. Holz, E. J. Hyer, L. Munchak, R. Levy, S. Mattoo, M. Petrenko, and C. Ichoku, Validation of the NPP/VIIRS Operational Aerosol Products Through Multi-Sensor Intercomparisons, Ninth Annual Symposium on Future Operational Environmental Satellite Systems, paper # 659, AMS Annual Meeting 2013, Austin, 5-10 January 2013

Min M. Oo; Robert Holz; Geoffrey P. Cureton; Istvan Laszlo; Shobha Kondragunta; **Jingfeng Huang**; Lorraine A. Remer, Assessment of the Suomi NPP/VIIRS aerosol products using the collocated Aqua/MODIS aerosol products, Eos Trans. AGU, 93, Fall Meet. Suppl., Abstract A13J-0316, San Francisco, 3-7 December 2012.

Hongqing Liu; Istvan Laszlo; *Shobha Kondragunta*; Lorraine A. Remer; **Jingfeng Huang**, Evaluation of Global VIIRS Aerosol EDR Product with MODIS and AERONET, Eos Trans. AGU, 93, Fall Meet. Suppl., Abstract A13J-0317, San Francisco, 3-7 December 2012.

<u>John M. Jackson</u>; **Jingfeng Huang**; Min M. Oo, Overview of NPP VIIRS Aerosol Algorithms and Data Products, Eos Trans. AGU, 93, Fall Meet. Suppl., Abstract A24C-04, San Francisco, 3-7 December 2012.

<u>Ho-Chun Huang</u>*; Istvan Laszlo; Shobha Kondragunta; Hongqing Liu*; **Jingfeng Huang**; *Heather Q. Cronk; Lorraine A. Remer; Andrew M. Sayer*, On the New Satellite Aerosol Measurements for Atmospheric Applications: VIIRS Aerosol Products, Eos Trans. AGU, 93, Fall Meet. Suppl., Abstract A33C-0161, San Francisco, 3-7 December 2012.

<u>Istvan Laszlo</u>; *Shobha Kondragunta; Lorraine A. Remer*, and **VIIRS Aerosol Cal/Val Team**, Initial Assessment of NPP/VIIRS Aerosol Environmental Data, Eos Trans. AGU, 93, Fall Meet. Suppl., Abstract A13J-0314, San Francisco, 3-7 December 2012.

OTHER (e.g., awards; outreach; deliverables…

Software Packages:

- ADL Wrapper for the VIIRS Aerosol Automated Processing
- Visualization Suite for the VIIRS Aerosol Products Visualization and Cal/Val
- VIIRS-AERONET Matchup Tool within the Multi-Sensor Aerosol Products Sampling System (MAPSS) Framework

Performance Metrics	**FY12**
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	2
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of presentations	6
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	N/A

- MSPPS MetOp-B Readiness

Task Leader Huan Meng; Wenze Yang
Task Code WYWY_MOBR_12
NOAA Sponsor Ralph Ferraro
NOAA Office NESDIS/STAR/CRPD/SCSB
Main CICS Research Topic Calibration and Validation
Percent contribution to CICS Themes Theme 1: 100%; Theme 2: 0%; Theme 3: 0%
Percent contribution to NOAA Goal Goal 1: 0%; Goal 2: 100%

Highlight: A scan bias correction scheme for Metop-B AMSU-A window channels has been developed and verified using MSPPS suites. This scheme has been transitioned to operations.

BACKGROUND

Meteorological Operational Polar Satellite-B (Metop-B) of EUMETSAT was launched on September 17, 2012. Two of the onboard sensors are the Advanced Microwave Sounding Unit-A (AMSU-A) and Microwave Humidity Sounder (MHS), which provide global information on atmospheric temperature profile, water vapor, cloud, precipitation, etc. However, a pronounced cross-scan asymmetry of the AMSU-A window channels was discovered from the same sensor onboard NOAA-15, -16, -17, -18, -19 and Metop-A, and it severely impacted water cycle product generation through the operational Microwave Surface and Precipitation Products System (MSPPS). This proposal is to develop post-launch cross-scan asymmetry correction for different channels, and make Metop-B MSPPS suitable for operations.

The goals of this CICS PSDI project are to i) perform scan bias characterization for AMSU-A and MHS window channels; ii) perform scan bias correction for AMSU-A window channels; and iii) assess product performance within the Microwave Surface and Precipitation Products System (MSPPS) product suite.

AMSU-A window channels refer to 23.8, 31.4, 50.3 and 89.0 GHz, i.e. channels 1-3 and 15. Window channels on MHS are the first two channels, i.e. 89.0 and 157.0 GHz. Water vapor channels on MHS are channels 3-5, i.e. 183.3±1, 183.3±3 and 190.3 GHz. These channels are used to retrieve the following MSPPS products: rain rate, ice water path, total precipitable water, cloud liquid water, snow cover, snow water equivalent, sea ice concentration, land surface temperature, and land emissivity at 23.8, 31.4, and 50.3 GHz.

ACCOMPLISHMENTS

Firstly, the cross-scan bias of AMSU-A window channels has been characterized and corrected. The characterization and correction basically followed the method described in Yang et al. (2013) with some modifications. AMSU-A scan bias has been characterized by referencing to simulated brightness temperature (Tb) and taking the difference between observations and simulations over low and mid-latitude oceans (60°S-60°N) under clear sky. The difference is adjusted across scan line by its nadir value and there is no systematic adjustment at nadir. The bias is asymmetric relative to the nadir. The correction method utilizes a three-point correction approach: vicarious cold reference (VCR), average of all ocean observations (ALL), and vicarious hot reference (VHR). It was successfully applied to 23.8 GHz and 31.4 GHz channels.

However, since the coldest Tb at the 50.3 GHz and 89 GHz channels generally occur over land in the Polar Regions, VCR does not represent the lower limit of the Tb dynamic range. To overcome this problem, much similar to using the Amazon area for scan bias correction at the warm end, targeted areas in Antarctica and Greenland were chosen to characterize and then correct bias at the cold end. Other updates to the method described in Yang et al. (2013) include using the numerical weather data NCEP GDAS instead of ERA-Interim, and using AVHRR radiance for cloud clearing instead of Patmos-x. The data used for the characterization spans from mid October to the end of December 2012 due to the time constraint. Figure 1 presents the mean observed brightness temperature under clear-sky over ocean. Figure 2 shows the cross-scan bias characterized by the difference between simulation and observation over ocean. Note the significant scan bias in the 89 GHz channel. Better characterization results could be achieved by using an entire year of data.

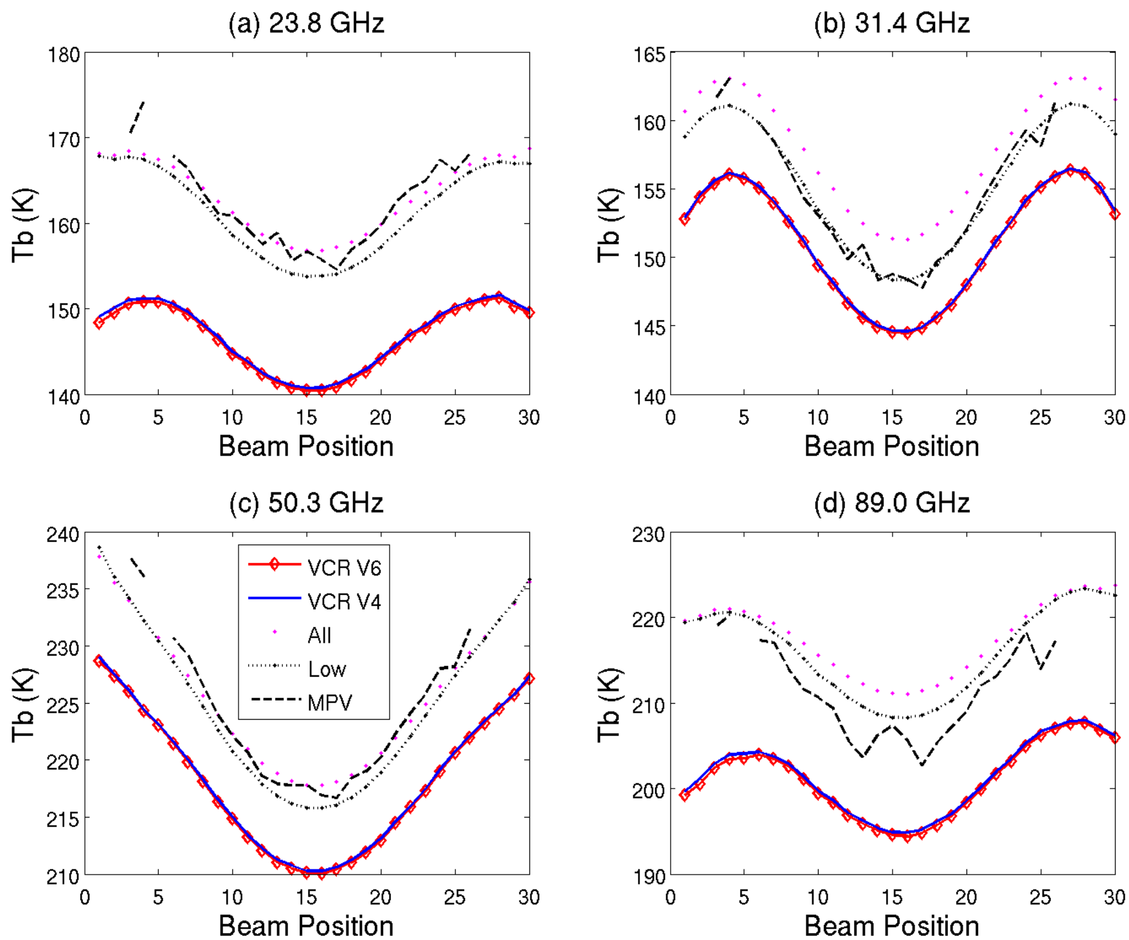


Figure 1. Mid- and low-latitude yearly mean observed brightness temperature at Metop-B AMSU-A (a) 23.8, (b) 31.4, (c) 50.3, and (d) 89 GHz over ocean under clear sky, from mid October to the end of December 2012. The results are for two versions of VCR, all observations (All), stratification results with low sea surface temperature, low precipitable water, and low wind speed (Low) and stratification results with most probable value (MPV).

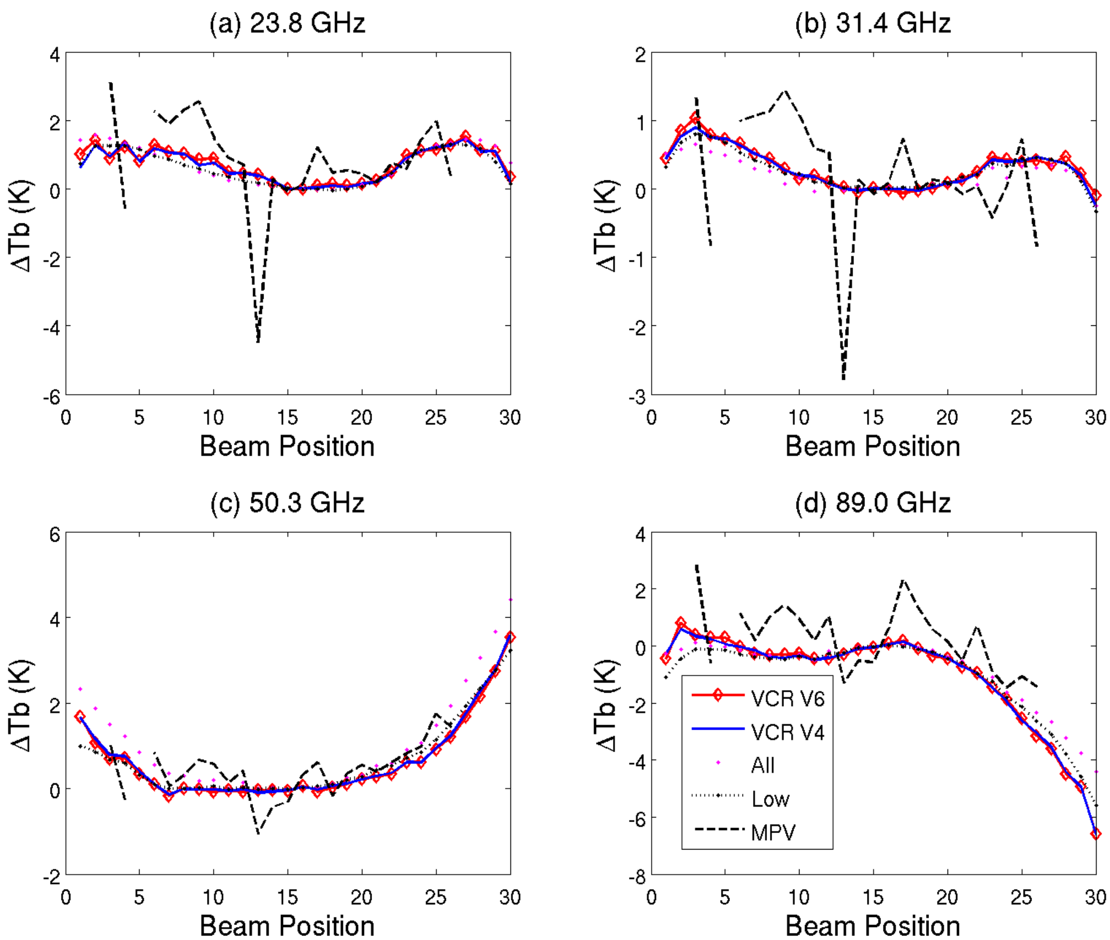


Figure 2. Mean bias of simulated brightness temperature from the observed under clear sky over ocean in mid- and low-latitudes for Metop-B AMSU-A (a) 23.8, (b) 31.4, (c) 50.3, and (d) 89 GHz, from mid October to the end of December 2012. The results are for two versions of VCR, all observations (All), stratification results with low sea surface temperature, low precipitable water, and low wind speed (Low) and stratification results with most probable value (MPV).

Secondly, the correction scheme has been applied to MSPPS for verification purpose. Figure 3 compares the CLW product before and after bias correction to show the effect of such correction. Before correction, the asymmetry effect is clearly seen in the CLW image (Figure 3a) with drier atmosphere at the left edge of the swath and wetter at the opposite edge, which makes the cloud system unrealistic. Comparing the area in the blue boxes in Figure 3a and 3b, the improvement in scan asymmetry is evident after bias correction.

Thirdly, a bias correction package was delivered to NOAA OSPO on January 28, 2013. Support was also provided to the operational team to implement the changes in the MSPPS system.

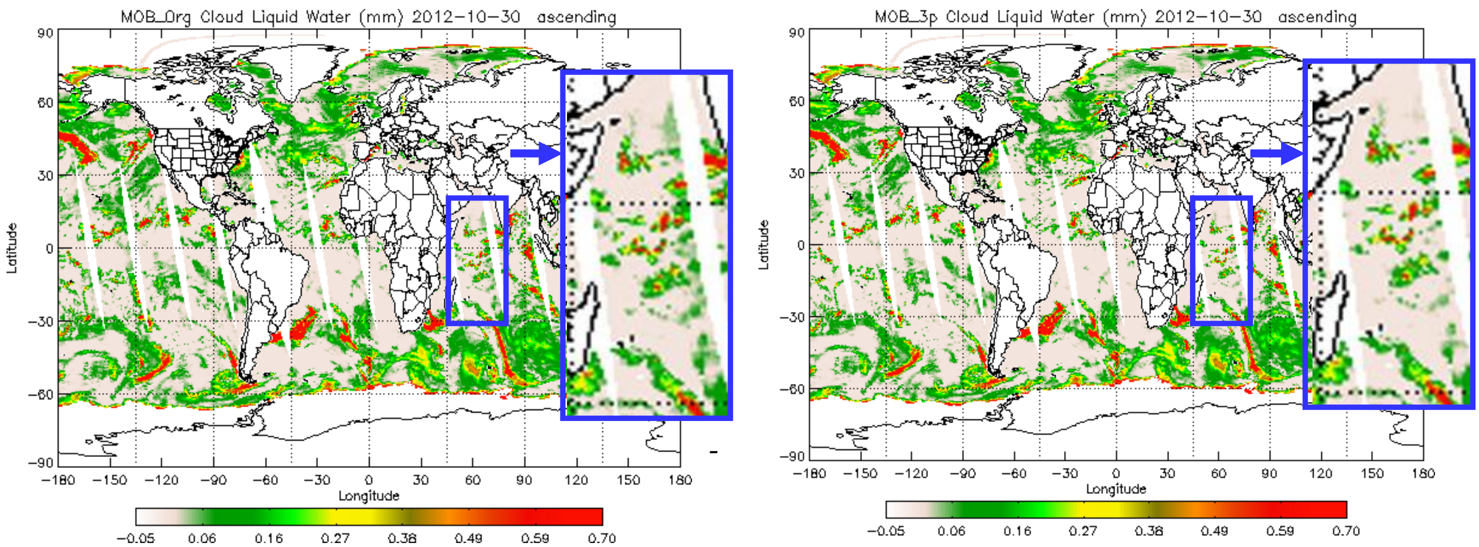


Figure 3. (a) MSPPS Cloud Liquid Water before bias correction; and (b) after bias correction.

PLANNED WORK

In the next phase of the project, we will characterize scan bias for MHS channels. Effort from previous projects will be leveraged to perform this task.

PUBLICATIONS

Yang, W., H. Meng, R. Ferraro, I. Moradi, and C. Devaraj, "Cross scan asymmetry of AMSU-A window channels: Characterization, correction and verification," IEEE Trans. *Geosci. Remote Sens*., doi:10.1109/TGRS.2012.2211884, 2013.

Performance Metrics	FY12
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	1
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	0

- GOES-R Calibration Working Group (CWG) Support

Task Leader Shunlin Liang and Xi Shao
Task Code XSSL_GCWG_12
NOAA Sponsor Changyong Cao
NOAA Office NESDIS/STAR/SMCD/SCDAB
Main CICS Research Topic Calibration and Validation
Percent contribution to CICS Themes Theme 1: 80%; Theme 2: 20%; Theme 3: 0%.
Percent contribution to NOAA Goals Goal 1: 20%; Goal 2: 80%

Highlight: CICS scientists support Calibration and Validation work for GOES-R Advanced Baseline Imager (ABI) instrument through lunar calibration and long-term monitoring of radiometric parameters at desert areas.

BACKGROUND

This work supports the calibration and validation of GOES-R Advanced Baseline Imager (ABI) instrument. The sensor performance of ABI sensor is subject to degradation caused by various post-launch influences, which requires independent calibration and validation activities to satisfy required uncertainty criteria. We support GOES-R ABI cal/val work and assessing sensor variability through on-board solar diffuser monitoring and vicarious calibration using moon, and homogeneous surface on the Earth such as long-term monitoring of desert areas.

Photometric stability of the lunar surface and its smooth reflectance spectrum makes the moon an ideal target for calibrating satellite-based hyper/multi-band visible and infrared imagers. Therefore, lunar calibration for solar bands is an important part of the GOES-R ABI Cal/Val plan. Long-term performance monitoring of ABI instrument using Moon can reveal the degradation of instruments. It can also be used as a framework to compare GOES-R radiometer performance relative to similar radiometers flown on different satellite platforms.

For calibration using desert surface, we focused on the characterization of the atmosphere and surface variability of the Sonoran Desert in Mexico. The Sonoran Desert is one of the best pseudo-invariant sites available in North America which can be observed both from GOES-West and -East. To fully exploit the top-of-atmospheric radiance/reflectance measured at the sensor, understanding of the variability in the surface and the atmosphere above the desert areas is essential.

ACCOMPLISHMENTS

1. Vicarious Calibration using Desert Sites

The atmospheric variability of the Sonoran Desert area has been investigated using various operational satellites such as Landsat 5 Thematic Mapper (Landsat 5 TM) and Moderate Resolution Imaging Spectroradiometer (MODIS) data acquired for more than 10 years. Bidirectional reflectance distribution function (BRDF) of the combined surface and atmosphere has been investigated using the current GOES data. GOES data provide TOA radiance measurements that have unique sun-target-sensor geometry covering a wide range of solar zenith and azimuth angles.

A new methodology for sensor degradation assessment has been developed using time series techniques. Degradation of a space-borne sensor can be estimated by analyzing time series of TOA radiance emitted from pseudo-invariant sites such as desert areas. However, characterization of atmospheric and surface variability is challenging since it is difficult to acquire synchronized meteorological variables as well as exact surface and atmosphere BRDF. The proposed data-driven approach decomposes TOA reflectance time series data of a calibration site into signals of different frequencies, and separates factors that are not directly related to the sensor degradation which usually have a very low frequency. The new methodology successfully extracted long-term sensor degradation pattern from the TOA reflectance time series which exhibit short-term variability stemming from atmospheric and surface instability. Figure 1 shows that the short-term variability in Landsat 5 TM time series has been removed by two time series algorithms; Seasonal trend decomposition (STL) and discrete wavelet transform (DWT).

2. *Lunar Calibration Support for GOES-R ABI*

- Developed and refined tools to predict lunar imaging window of opportunity for ABI
- Performed lunar observation and model comparison to benchmark lunar irradiance model. We compared Hyperical and GOES lunar observation with lunar irradiance model such as ROLO and Miller-Turner 2009 models
-

3. *Developing and Refining Satellite Orbit Tracking Software to Support GOES-R Calibration Work*

- Support GOES-R and low-earth-orbiting (LEO) satellite SNO event prediction
- Integrating the satellite orbit prediction with Sun, Moon and Star Orbit Tracking

4. *Developed publication tracking database to support GOES-R CWG:*
http://spp.astro.umd.edu/papers/interface.php

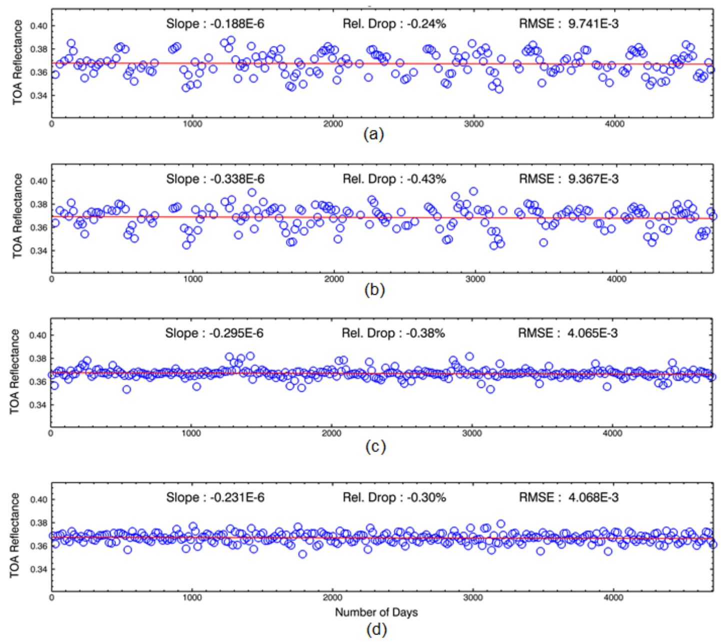


Figure 1: More precise degradation estimates has been obtained by removing short-term variability from (a) original TOA time series based on time series algorithms, (c) STL and (d) DWT. (b) Note that widely used surface BRDF models often fail to remove the variability.

The work based on the time series analysis of long-term sensor radiometric degradation has been presented in 2012 IEEE International Geoscience and Remote Sensing Symposium (IGARSS) and a manuscript was submitted to IEEE transactions on geoscience and remote sensing. The work of supporting lunar calibration of GOES-R ABI has been presented in the 2012 CalCon conference.

PLANNED WORK

- Characterization of BRDF of the Sonoran Desert using current GOES data and airborne hyperspectral data.
- Characterization of atmospheric variability using radiative transfer models.
- Supports lunar calibration of GOES ABI through lunar irradiance model and observation comparison and lunar appearance prediction in the field of view GOES-R ABI.
- Continue to support SNOs and SNOx prediction for cross-calibration between GOES-R and polar orbiting satellite.
- Support solar diffuser calibration of GOES-R ABI through solar diffuser illumination prediction and solar diffuser BRDF evaluation.
- Evaluate and refine radiometric calibration algorithm of GOES-R ABI.
- Support calibration work for GOES-R magnetometer through testing Ground Processing Software and evaluation of Gradiometer Algorithm

PUBLICATIONS

W. Kim, T. He, D. Wang, C. Cao, and S. Liang, “Assessment of long-term sensor radiometric degradation using time series analysis” IEEE Transaction on Geoscience and Remote Sensing (submitted)

PRESENTATIONS

W. Kim, S. Liang, and C. Cao, “On using BRDF models for assessment of radiometric stability of Sonoran Desert,” in 2012 IEEE Int. Geoscience and Remote Sensing Symposium, Munich, Germany, Jul. 22-27, 2012.

Shao X., Cahngyong Cao, Sirish Uprety, Comparing Hyperical Lunar Observed with Model Predicted Irradiances in Support of GOES-R Advanced Baseline Imager (ABI) Calibration, CALCON Technical Conference, Aug., Logan, Utah, p19, 2012.

Performance Metrics	**FY12**
# of new or improved products developed	0
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	1
# of non-peered reviewed papers	0
# of presentations	2
# of invited presentations	0
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	1

- NPP VIIRS Cal/Val Support

Task Leader Xi Shao
Task Code XSXS_NPPV_12
NOAA Sponsor Changyong Cao
NOAA Office NESDIS/STAR/SMCD/SCDAB
Main CICS Research Topic Calibration and Validation
Percent contribution to CICS Themes Theme 1: 90%; Theme 2: 10%; Theme 3: 0%.
Percent contribution to NOAA Goals Goal 1: 20%; Goal 2: 80%

Highlight: CICS scientists support calibration and validation work for NPP VIIRS instrument through developing routine Simultaneous Nadir Overpass predictions web services, performing long-term instrument stability monitoring with lunar and vicarious calibration.

BACKGROUND
VIIRS (Visible Infrared Imager Radiometer Suite) onboard the NPP satellite primarily focuses on clouds and Earth surface variables. VIIRS is designed to provide moderate-resolution, radiometrically accurate images of the globe twice daily. It is a wide-swath (3,040 km) scanning radiometer with spatial resolutions of 370 and 740 m at nadir for I and M bands, respectively. It has 22 spectral bands covering the spectrum between 0.412 µm and 12.01 µm, including 9 reflective solar bands (RSB), 12 thermal emissive bands (TEB), and 1 day-night band (DNB). For the reflective solar bands, the calibration uncertainty in spectral reflectance for a scene at typical radiance is expected to be less than 2%. This performance has been demonstrated in prelaunch testing in the laboratory, but on-orbit performance requires additional efforts in calibration by using the onboard solar diffuser (SD), lunar observations and vicarious methods, as well as inter-comparisons with other instruments.

Our work focuses on providing support to the calibration of RSB, TEB and DNB bands of VIIRS to ensure that the mission requirements are met and the production of high quality radiometrically and geometrically corrected sensor data records for VIIRS.

ACCOMPLISHMENTS
We supported the VIIRS calibration in a broad scope by

- Developing and refining satellite orbit tracking software to provide web-services of predicting SNO and SNOx events, vicarious site overpass, lunar appearance, and solar diffuser illumination.
- Performing lunar irradiance calibration for VIIRS DNB band, and quantifying power outages after severe storms using the S-NPP/VIIRS Day Night Band radiances (Figure 1)

- Monitoring VIIRS stability through vicarious calibration over desert, sea, and Dome C sites using SNO and SNOx techniques.
- Correlational analysis of orbital variation of blackbody thermistor temperature and assessment of its effects on the thermal emissive band calibration.
- Participating write-up of VIIRS radiometric calibration user's guide write-up.

Three web service products to support VIIRS calibration have been developed

- Satellite Simultaneous Nadir Overpass (SNO) Prediction Service for National Calibration Center of NOAA: http://ncc.nesdis.noaa.gov/SNO/SNOs//NCC_SNOs_prediction_service.html
- NPP Satellite VIIRS instrument event log database: http://spp.astro.umd.edu/NPP/interface.php
- VIIRS publication tracking database: http://spp.astro.umd.edu/papers/interface.php

Three publications summarizing our work have been submitted. Two are published and one is currently under review. Two presentations were made in conferences.

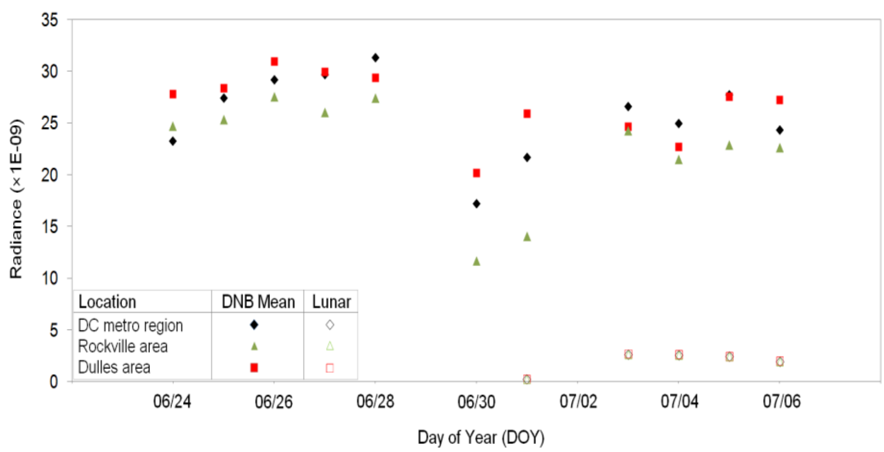


Figure 1: Quantifying power outage detection with VIIRS DNB remote sensing data for 2012 June Derecho storm event in Washington DC area. Time series of corrected mean VIIRS-DNB radiance and corresponding lunar radiance corrections [W/(cm^2-sr)] at selected region of interest (DC metro area size: 40km × 40km; Rockville and Dulles area size: 10km × 10km) during the storm derecho in the Washington DC metropolitan area.

PLANNED WORK

- Continue to provide support to the vicarious calibration of VIIRS RSB and TEB bands.
- Perform vicarious calibration of VIIRS day-night band (DNB) with lunar illumination events and standard light sources.

- Continue to support SNOs and SNOx, vicarious site overpass, lunar appearance prediction web services development for NPP.
- Refine radiometric calibration algorithm and support VIIRS radiometric calibration user's guide and ATBD document development.
- Assessment of VIIRS Calibration Biases with MODTRAN and LBLRTM Modeling

PUBLICATIONS

Slawomir Blonski, Changyong Cao, Sirish Uprety, Xi Shao, Using antarctic Dome C site and simultaneous nadir overpass observations for monitoring radiometric performance of NPP VIIRS instrument. IGARSS : 1061-1064, 2012.

Liu, Quanhua, Kwofu V. Chiang ; Changyong Cao ; Jack Xiong ; Xi Shao; Slawek Blonski ; Fuzhong Weng, Calibration of low gain radiance at VIIRS emissive band (M13) and VIIRS image about moon temperature, Proc. SPIE 8528, Earth Observing Missions and Sensors: Development, Implementation, and Characterization II, 85280O, doi:10.1117/12.979701, 2012.

Cao, Changyong, Xi Shao, and Sirish Uprety, Quantifying Power Outages after Severe Storms using the S-NPP/VIIRS Day Night Band Radiances, submitted to IEEE Geoscience and Remote Sensing Letters, 2013.

PRESENTATIONS

Changyong Cao; Sirish Uprety; Xi Shao, Detecting Power Outages with the VIIRS DNB Images – potentials and challenges, A33M-0322, American Geophysical Union, Fall Meeting, 2012.

Blonski Slawomir, Changyong Cao, Xi Shao, Sirish Uprety, VIIRS Radiometric Calibration for Solar Reflective Bands: Antarctic Dome Site and Simultaneous Nadir Overpas Observations, CALCON Technical Conference, Aug., Logan, Utah, p37, 2012.

Performance Metrics	FY12
# of new or improved products developed	3
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	1
# of non-peered reviewed papers	2
# of presentations	2
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	0

1.3 *Surface Observation Networks*

- Participation in Climate Research Activities at the Air Resources Laboratory NOAA

Task Leader Russ Dickerson
Task Code RDRD_PCAQ12
NOAA Sponsor Richard Artz
NOAA Office OAR/ARL
Main CICS Research Topic **Surface Observing Networks & Climate Research, Data Assimilation and Modeling**
Percent contribution to CICS Themes Theme 2: 50%; Theme 3: 50%
Percent contribution to NOAA Goals Goal 1: 25%; Goal 2: 50%; Goal 3: 25%

Highlight In 2012, CICS hired six research scientists working with NOAA's ARL. They are making air quality measurements and forecasts that complement ongoing atmospheric chemistry studies at UMD.

Link to a research web page http://www.arl.noaa.gov/

Li Pan

Background: In past year, NOAA/ARL (Air Resources Laboratory) provided continuous support of The US National Air Quality Forecasting Capability (NAQFC) 48-hour operational ozone (O_3) concentration forecasting covering US continent (CONUS), Alaska and Hawaii. Our efforts are focused on two aspects: upgrading NOx emission inventory in CONUS and developing 4km forecasting system for megacity areas.

Accomplishments: Nitrogen oxides (NOx = NO + NO_2) are not only the important precursor to catalyze troposphere ozone production, but also sources of ambient aerosols. Based on US Environmental Protection Agency (EPA) 2005 National Emission Inventory (NEI), in US 32% of NOx emission is from on-road mobile source, 30% is from off-road sources such as construction equipment, ships, aircraft and locomotive etc., and 27% from Electric Generating Units (EGU). Although fuel consumptions is generally up in recent years, NOx from vehicle emission including on-road and off-road has decreased since 2007 mainly due to the drastically reducing of NOx emission factor. NOx emissions from power plant are also decreasing since the implementation of pollution controls by utility companies. Therefore, the application of 2005 NOx inventory in NAQFC results in the overestimation of NOx concentration in CMAQ prediction and consequently brings systematical errors into ozone and PM forecasting. In the study of "Impact of NOx emission upgrade on surface O_3 forecast performance of the US National Air Quality Forecasting Capability" we address outdated emission inventories problems in Air Quality

(AQ) forecasting systems. In this analysis, we compared surface NOx and O_3 concentration changes due to two emission scenarios in July of 2011. Model results were verified using ground station observations.

We addressed the following questions through process analysis:

(a) How do NOx emissions change after inventory adjustment?
(b) Is the NOx emission change reasonable and supported by observations?
(c) Does CMAQ performance in NOx prediction improve under such a new inventory?
(d) Does the NOx emission change influenced O_3 predictions?

These answers shed insight on realistic configuration of the emission projection processes for surface level O_3 concentration forecasting.

The second study represents an incremental process in building a limited domain fine resolution air quality forecasting system. One of the most important values of an air quality forecasting system is to predict ground-level ozone concentrations under extreme chemical weather conditions in urban areas and to be able to issue health-related warnings to the public in advance with adequate lead times. The Houston area is well known for its high ozone events that occur frequently in late summer or early fall.

This system consists of coupling the National Weather Service meso-scale NMMB operational weather forecasting model with US EPA Community Multi-scale Air Quality model (CMAQ) in an off-line manner. It has 2-tier nested domains. The CONUS is the parent domain in 12-km resolution and an inner nest over Houston and it surrounding area in 4-km resolution. Model evaluation focused on the inner domain is critical to validate the performance of this modeling system. In this evaluation, we focus on surface ozone and PM2.5 concentrations. Model verification utilized ground stations, aircraft measurements, and satellite-based data. Model performance under different meteorological and emission conditions were identified and studied.

Planned Work

- Continued development of emissions inventories
- Comparison of inventories to DISCOVER-AQ results

Publications: See Kim below.

Paul Kelley

Surface Observing Networks & Climate Research, Data Assimilation and Modeling

Background:

Mercury is an important and poorly understood environmental pollutant. Mr. Kelley is working to support two atmospheric chemists at ARL (Drs. Luke and Ren) and to provide data for model validation for a global mercury model written by Dr. Cohen, also at ARL. One of the major long-term goals is to understand how gaseous elemental mercury (GEM) in the atmosphere is transformed into more highly bio-available reactive gaseous mercury (RGM) and fine particulate mercury (FPM). This involves a complicated cycle of convection of anthropogenic GEM into the free troposphere and lower stratosphere, subsequent oxidation into RGM and FPM, and then wet deposition by deep convective thunderstorms or dry deposition following strong post-frontal subsidence.

Accomplishments:

NOAA / ARL has installed and maintained three ground stations devoted to long term monitoring of speciated atmospheric mercury and operates them according to National Atmospheric Deposition Program sampling protocols (AMNET). The site in Beltsville, MD has a complete, speciated mercury instrument with an inlet at 10 meters. Another site in the Grand Bay National Research Reserve in Grand Bay, MS has a speciated atmospheric mercury instrument, as well as a range of other trace gas instruments (NO, NO_y, SO_2, CO, O_3, black carbon) and standard meteorology instruments. The third site is at the Mauna Loa Observatory (MLO) on the island of Hawaii. ARL currently operates a single, speciated atmospheric mercury system there, along with SO_2 and O_3 instruments, hi-vol particulate sampling.

Mr. Kelley performs weekly maintenance and repair at the Beltsville, MD site to keep it operating according to AMNET protocols. Two trips in the fall of 2012 were made to the Grand Bay, MS site to repair instruments and perform calibrations.

In February 2013, a complete mercury speciation system was installed on the hangar roof of the Submillimeter Array at the summit of Mauna Kea, HI. Additionally continuous monitors for SO_2 and O_3 were also installed on Mauna Kea, as well as a CO monitor and an elemental mercury detector at the Mauna Loa Observatory across the valley. These additional instruments are part of a short-term intensive experiment designed to understand unusually high FPM measurements seen episodically at Mauna Loa over the past two and a half years. During these periods of high FPM we detect lower than normal elemental mercury. It is not clear if this unusual partitioning is due to a matrix effect from nearby volcanic emissions or an artifact of the instrument operating at high altitude.

Planned work:
Mr. Kelley will continue to support on-going atmospheric mercury measurements at three AMNET sites in Maryland, Mississippi, and Hawaii. Additionally he is preparing for the DISCOVER-AQ field intensive in Houston, TX this fall where we will be measuring NO, NO_x, NO_y, SO_2 and O_3.

Presentations:
Ngan, F., M. Cohen, W. Luke, X. Ren, P. Kelley and R. Draxler, 2013: Meteorological Modeling Using WRF-ARW for Grand Bay Intensive. 93th AMS Annual Meeting, Austin, TX

Fantine Ngan

Background: Meteorological data are necessary input for any atmospheric transport and dispersion models. The NOAA dispersion model, Hybrid Single Particle Lagrangian Integrated Trajectory Model (HYSPLIT) can be run offline by utilizing a variety of meteorological data. We developed a model framework such that HYSPLIT is coupled inline with hourly meteorological data from the Advanced Research WRF, WRF-ARW. WRF-ARW produces higher temporal frequency output of the meteorological variables resulting in a more accurate depiction of the state of the atmosphere and, improving the capabilities of the dispersion simulation.

Accomplishments: In this inline version of HYSPLIT, the meteorological variables are updated at the WRF output time steps and kept constant at the HYSPLIT sub-loop time steps. Six episodes of the CAPTEX tracer experiment were simulated and the results were compared to the offline version output. The meteorological simulations used 3-hourly NARR for initial and boundary conditions. The meteorological data were updated every 15 minutes in the coupled WRF-HYSPLIT runs while the standard HYSPLIT used the same but hourly WRF-ARW output that was interpolated to the HYSPLIT integration time step. The results of the inline and the offline simulations were similar. The averaging statistics computed against observations show the inline runs had better figure of merit in space (FMS) than the offline runs. The rank of the in-line simulations was better for CAPTEX #3 and #5 experiments but worse in another two episodes (#2 and #7). A 40-day simulation covering the CAPTEX period has been conducted using inline and offline HYSPLIT. Significant differences between the two HYSPLIT results were observed in the early morning when the rise of PBL height occurs. The offline run trended to accumulate near the surface that leaded the plume moved slower than the inline run.
A manuscript is being prepared to summarize this work for journal publication. For future work, the inline coupled WRF-HYSPLIT will be tested for other domains with complex terrain, urban area and coastal regions. The coupling framework will be advanced

by parallelizing the HYSPLIT model to be consistent with the WRF-ARW domain decomposition.

Planned Work

- Continued development of HYSPLIT products

Publication

Ngan, F., H. C. Kim, P. Lee, K. Al-Wali and B. Dornblaser, 2013: A study on nocturnal surface wind speed over-prediction by the WRF-ARW model in Southeastern Texas. J. Appl. Meteor. Climatol., submitted.

Presentation

Ngan, F., M. Cohen, W. Luke, X. Ren, P. Kelley and R. Draxler, 2013: Meteorological Modeling Using WRF-ARW for Grand Bay Intensive. 93th AMS Annual Meeting, Austin, TX.

Hyun Cheol Kim

Background: NOAA and the EPA use chemical transport models to evaluate abatement strategies, and further our understanding of the fundamental chemistry, physics, and meteorology of air quality. Dr. Kim was involved in three projects using numerical simulations to understand the impact of upwind emissions, synoptic situation, and downscaling on ozone and particulate matter in the US.

1. Impact of Central American Fire Emissions on Springtime Surface Particulate Matter Concentration in Texas

The impact of the transport of Central American fires on United States air quality, particularly on surface particulate matter (PM) concentration in Texas, was investigated. During springtime, smoke plumes from fires over the Yucatan Peninsula and southern Mexico are transported across the Gulf of Mexico to the US, by a southerly flow in a southwestern portion of subtropical high pressure system in the Atlantic Ocean. We utilized surface and satellite measurements (e.g., US Environmental Protection Agency (EPA) AIRNow surface $PM_{2.5}$ data, Moderate-Resolution Imaging Spectroradiometer (MODIS) Aerosol Optical Depth (AOD), Global Fire Emissions Database (GFED), Quick Fire Emission Dataset (QFED)), and modeling outputs (Community Multiscale Air Quality (CMAQ) from National Air Quality Forecast Capability (NAQFC) and Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT)), to show the observational evidence for the detection of fire emissions in the Central American region and to quantify their contribution to US air quality.

Results show that the seasonal variation of unexplained surface PM under-prediction in Texas coincides with the seasonal variation of fire emissions in Central America, implying there are substantial missing PM components in the southern boundary of modeling domain. Analysis of wind direction also supports the hypothesis that the unexplained PM influx is coming from the Central American regions. Compared to US average, the surface PM model bias in Texas is different in its magnitude and its peak timing. Texas PM biases (forecast minus observations) in April and May are -7.88 and -8.2 $\mu g/m^3$, respectively, while average US PM bias is minimal during springtime (± ~1 $\mu g/m^3$) and highest negative bias during summertime (-2.5 $\mu g/m^3$ in July). We further estimated for each month the contributions of southerly to the surface PM in Texas, using backward trajectory simulations. Results show that the estimated contribution from southerly flow to Texas surface PM level, during spring was 15~40%, in 2011. Unlike previous studies using chemistry models with large uncertainty in fire emission assumption, this approach utilizes surface measurement and wind field, so no fire emission estimation is involved in the analysis. We believe this approach can complement previous modeling approaches to provide quantification of out-of-state emissions' impact and guidance to State Implementation Plans. (Presented in 2012 CMAS & Draft in preparation)

2. Impact of global to regional meteorology downscaling on regional air quality simulation.

Three, global (or semi-global) meteorology simulations, for August 2010, were used to initiate regional meteorology simulations, and their impacts on regional air quality simulations were studied. Weather Research and Forecasting (WRF) simulations with the same physical options, but initiated with three different global meteorology model outputs (North American Mesoscale Model (NAM), Global Forecast System (GFS), and Global/Regional Integrated Model system (GRIMs)), were utilized to simulate regional air quality using Community Multi-scale Air Quality/ Sparse Matrix Operator Kernel Emission (CMAQ/SMOKE) modeling system. Variations in key meteorological variables critical to air quality simulation (e.g., surface temperature, wind speed, boundary layer, and cloud fraction) were compared, and their impact on forecast pollutant concentrations was investigated using surface observations from numerous sources, including the Meteorological Assimilation Data Ingest System (MADIS), the EPA AIRNow/AQS, the Interagency Monitoring of Protected Visual Environments (IMPROVE) data. Results show that perturbations in meteorological fields result in distinct sensitivities in regional air quality for different regions. For the California region, a small perturbation in cloud fraction resulted in considerable variation in surface ozone production. For eastern US, variations in surface temperature caused biogenic emission difference in southeastern US region, and resulted in difference in surface ozone concentrations there. Locations of surface temperature bias are also well associated with surface ozone bias, providing a potential explanation for the surface ozone bias during summertime in the southeastern US region. (Presented in 2013 AMS)

3. Assessing the performance of air quality simulations with Spatial Synoptic Classification

Synoptic weather patterns play an important role in regional air quality, especially in the production of daily maximum ozone. We utilized Spatial Synoptic Classification (SSC) data, surface ozone simulations from National Air Quality Forecast Capability (NAQFC) operated by National Oceanic and Atmospheric Administration (NOAA), and surface ozone observations from Air Quality System (AQS) operated by US Environmental Protection Agency (EPA), to investigate the behavior of ozone and air quality model's performance under different synoptic weather patterns, for six air quality air-shed regions in the United States (California (CA), Lake Michigan (MI), the Ohio River Valley (OV), Northeast (NE), Southeast (SE), and Texas (TX)), during summer (May to September) in the years 2009 to 2011. The SSC provides six air mass classifications in the North America: Dry Polar (DP), Dry Moderate (DM), Dry Tropical (DT), Moist Polar (MP), Moist Moderate (MM), and Moist Tropical (MT), based on air mass' thermal characteristics and origins. Results show discrete behaviors of ozone's magnitude and the model's performance in varying air mass types, showing the impact of synoptic weather patterns on regional air quality. The model successfully reproduced these patterns. The MT and DT air mass types are the most important in ozone production through their occurrence frequency and high ozone production efficiency, respectively. The MT air mass also shows the highest mean bias and root mean square error, implying the high uncertainty in model performance due to cloudy condition or unstable atmosphere. While the MT air mass is dominant in all regions except the CA region during summertime, the DT air mass, prominent in CA, SE, and TX, shows the highest ozone production efficiency in all regions. In the DT air mass condition, the chances of ozone exceedance over 75 ppb are 17%, 7%, 16%, 7%, 4%, and 9%, in CA, MI, NE, OV, SE, and TX regions, respectively. (Abstract submitted NATO-ITM and draft in preparation).

Planned Work

- Continued studies of long-range (international) transport on US air quality.
- Continued development and testing of meteorological drivers for CMAQ and SMOKE.
- Completion of analysis of synoptic situation impacts on air quality.

Publications

Choi, Y., **H. Kim**, D. Tong, and P. Lee, 2012, Summertime weekly cycles of observed and modeled NOx and O3 concentrations as a function of satellite-derived ozone production sensitivity and land use types over the Continental United States, Atmos. Chem. Phys., 12, 1585-1611, doi:10.5194/acpd-12-1585-2012.

Ngan, F., D. Byun, **H. Kim**, D. Lee, B. Rappenglueck, and A. Pour-Biazar, 2012, Performance Assessment of Retrospective Meteorological Inputs for Use in Air Quality Modeling during TexAQS 2006, *Atmos. Environ*, doi: 10.1016/j.atmosenv.2012.01.035.

Non-archival publications and presentations

Lee, P., F. Ngan, **H. Kim**, D. Tong, Y. Tang, T. Chai, R. Saylor, A. Stein, D. Byun, M. Tsidulko, J. McQueen, I. Stajner, 2012: Incremental Development of Air Quality Forecasting System with Off-Line/On-Line Capability: Coupling CMAQ to NCEP National Mesoscale Model, *NATO/ITM Air Pollution Modeling and its Application XXI*, Douw G. Steyn & Silvia Trini Castelli (ed.), Springer, Netherlands, pp. 187-192, doi:10.1007/s10652-008-9089-0.

Daewon W. Byun, D.-G. Lee, **H.-C. Kim**, S. Kim, F. Ngan, B. Czader, B. Rappenglueck, S. Kondragunta, and B. Pierce, 2012: Chapter 58. Efficacy of Incremental Reduction of Input Uncertainties to Improve Air Quality Prediction, *NATO Science for Peace and Security Series C: Environmental Security*, Vol. 4, Part 3, 341-346, DOI: 10.1007/978-94-007-1359-8_58.

Kim, H., F. Ngan, S. Hong, and P. Lee, 2013, Impact of global to regional meteorology downscaling to the regional air quality simulation, 93rd American Meteorological Society Annual meeting, Austin, TX.

Chai, T., P. Lee, **H. Kim**, and L. Pan, 2013, Integrating satellite and surface network observations into a 3-D Community Multi-scale Air Quality (CMAQ) Modeling System – a first step towards generating atmospheric chemistry reanalysis field for the continuous United States, 93rd American Meteorological Society Annual meeting, Austin, TX.

Pan, L., P. Lee, D. Tong, F. Ngan, **H. Kim**, T. Chai, 2013, NMMB-CMAQ 4km forecasting system in Houston: model simulation and evaluation, 3rd American Meteorological Society Annual meeting, Austin, TX.

Lee, J.-J., H. C. Kim, C. **H. Kim**, F. Ngan, A. Stein, P. Lee, Wildfire Duration Model for Air Quality Forecast System, 3rd American Meteorological Society Annual meeting, Austin, TX (poster).

Kim, H., F., Ngan, P. Lee, R. Saylor, 2012, Springtime Transport of Central American Fire Emissions to the United States, 4th International Workshop on Air Quality Forecasting Research (IWAQRF), Geneva, Switzerland (poster).

Kim, H., F. Ngan, P. Lee, R. Saylor, 2012, Springtime Transport of Central American Fire Emissions to the United States, 2012 CMAS conference, Chapel Hill, NC.

Lee P., S. Kondragunta, **H. Kim**, Xiaoyang Zhang, Li Pan, Rick Saylor, Tianfeng Chai, Daniel Tong, Ariel Stein, 2012, Fine resolution Air Quality forecasting capability for limited domains over Eastern Texas in support of validation attempt of wild fire emission retrievals by geostationary and polar-orbiting satellites, 2012 CMAS conference, Chapel Hill, NC.

Pan L., D. Tong, P. Lee, **H. Kim**, T. Chai and C. Ding, 2012, How does the concentration of surface ozone change in CONUS due to a new paradigm for emission upgrade for the national forecasting system?, 2012 CMAS conference, Chapel Hill, NC (poster).

Chai T., **H. Kim**, P. Lee, and L. Pan, 2012, Chemical data assimilation with CMAQ and DISCOVER-AQ field measurements, 2012 CMAS conference, Chapel Hill, NC.

Kim, H., S. Hong, F. Ngan, and P. Lee, 2012, Impact of meteorology downscaling to the regional air quality simulation using WRF/CMAQ modeling system, 2012 WRF users workshop, Boulder, CO (poster).

Tianfeng Chai

NOAA Backtracking Support to CTBTO (Comprehensive Nuclear-Test-Ban Treaty) using the HYSPLIT (HYbrid Single Particle Lagrangian Integrated Trajectory) Model

NOAA Associate: Roland Draxler

Background: The National Oceanic and Atmospheric Administration, through the National Weather Service (NWS) with support from the Office of Atmospheric Research (OAR), is one of the WMO designated Regional Specialized Meteorological Centers (RSMC) for transport model products. NOAA backtracking support to the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) started on October 1, 2012 for the implementation of the CTBTO-WMO (World Meteorological Organization) Backtracking Response System required by the CTBTO Verification regime.

Accomplishments: An automated system developed several years earlier has been reinstalled and tested after modifying the system according to the changes of meteorological input data and HYSPLIT model in the past years. This system has the following components.

1. A CTBTO request email triggers a script through ".forward" utility;
2. An email parsing script is run to get the required information;
3. A HYSPLIT control file is written by "set4ctbt" script;
4. HYSPLIT runs with the generated control file in "backward dispersion" mode;
5. Results are then converted to CTBTO format;
6. An output file is uploaded to the CTBTO website using a perl script.

Each component of the system ran successfully for a test request sent in Jul 2012. While the system is still under development, real-time CTBTO requests have been fielded since Feb. 11, 2013

Planned Work: A web-based interface for the CTBTO backtracking HYSPLIT run will be developed. It will allow NCEP Central Operations (NCO) to check inputs before the model run. Model results will be plotted and displayed through the web interface they are uploaded to CTBTO.

A source attribution analysis system will be developed to determine the most likely source location based on monitor data. This system will be transitioned to CTBTO.

Publications

Most are related to the NAQFC project. Not directly linked to the CTBTO project that started from Oct. 2012.

"Evaluation of the United States National Air Quality Forecast Capability experimental real-time predictions in 2010 using Air Quality System ozone and NO2 measurements," by Chai, T., H. Kim, P. Pius, D. Tong, L. Pan, Y. Tang, J. Huang, J. McQueen, M. Tsidulko, and I. Stajner, submitted to Geosci. Model Dev. on Feb. 22, 2013.

"Impacts of transported background pollutants on summertime western US air quality: model evaluation, sensitivity analysis and data assimilation," by Huang, M., G. R. Carmichael, T. Chai, and others, Atmos. Chem. Phys., 13, 359-391, doi:10.5194/acp-13-359-2013, 2013.

Presentations:

"Chemical data assimilation with CMAQ and DISCOVER-AQ field measurements," by Chai, T., H. Kim, P. Lee, and L. Pan, 11th Annual CMAS Conference, Chapel Hill, NC, Oct. 15-17, 2012.

"Chemical data assimilation with CMAQ and MODIS aerosol optical depth observations," by Chai, T., H. Kim, P. Lee, and L. Pan, 4th International Workshop on Air Quality Forecasting Research, Geneva, Switzerland, Dec. 12-14, 2012.

"Integrating satellite and surface network observations into a 3-D Community Multi-scale Air Quality (CMAQ) Modeling System - a first step towards generating atmospheric chemistry reanalysis field for the contiguous Unites States," by Chai, T., P. Lee, H. Kim, and L. Pan, 93rd American Meteorological Society Annual Meeting, Austin, TX, Jan. 5-10, 2013.

"CMAQ Background Error Covariance Estimation and Its Implementation in Chemical Data Assimilation," by Chai, T., Y. Tang, M. Pagowski, and I. Stajner, 92nd American Meteorological Society Annual Meeting, New Orleans, LA, Jan. 22-26, 2012.

Xinrong Ren

Background: According the USEPA "Exposures to mercury can affect the human nervous system and harm the brain, heart, kidneys, lungs, and immune system." The current state of knowledge is inadequate to quantify sources mercury and human exposure.

Accomplishments:

Mercury speciation, including gaseous elemental mercury (GEM), gaseous oxide mercury (GOM) and particulate bound mercury (PBM), trace pollutants, including ozone, SO_2, CO, NO, NO_Y and black carbon, and meteorological parameters have been continuously monitored since 2007 at an Atmospheric Mercury Network (AMNet) site in Grand Bay, Mississippi. Average concentrations and standard deviations were 1.40±0.23 ng m^{-3} for GEM, 5.9±11.4 pg m_{-3} for GOM, and 5.0±10.8 pg m^{-3} for PBM. Diurnal variation of GEM shows slight increase in GEM concentration during the morning, likely due to downward mixing of higher concentrations from the residual layer. Seasonal variation of GEM shows higher levels in winter and spring and lower levels in summer and fall. Both diurnal variations of GOM and PBM show peaks in the afternoon likely due to photochemical oxidation of GEM. Seasonally, PBM measurements exhibit higher levels in winter and spring and lower levels in summer, while GOM measurements show high levels in early summer and late fall and low levels in winter. These data were analyzed using HYSPLIT back trajectory and principal components analysis in order to develop source-receptor relationships for mercury species in this coastal environment. Trajectory frequency analysis shows that high mercury events were generally associated with high frequencies of the trajectories passing through the areas with high mercury emissions, while low mercury levels were largely associated the trajectories passing through relatively clean areas.

Transport from the middle-to-upper troposphere is potentially important in influencing mercury concentrations at the surface. Contributions of both natural and anthropogenic processes can significantly impact burdens of mercury in local, regional, and global scales. To address these key issues in atmospheric mercury research, NOAA Air Resources Laboratory conducted airborne measurements of mercury speciation and ancillary parameters in collaboration with University of Tennessee Space Institute in a region near Tullahoma, Tennessee from August 2012 to February 2013. These airborne measurements included gaseous elemental mercury (GEM), reactive gaseous mercury (RGM) and particle bound mercury (PBM) as well as ozone (O_3), sulfur dioxide ($SO_{2)}$, condensation nuclei, and meteorological parameters. The flights were scheduled to occur one week out of each month to characterize seasonal variations in mercury concentrations. Data obtained from 0–20 kft altitude show that GEM exhibited a relatively constant vertical profile for all seasons with an average concentration of 1.41±0.15 ng m^{-3}. A slight trend of GEM depletion occurs at 4-6 km, suggesting oxidation of GEM in the upper troposphere. Significant seasonal variation of RGM was observed, with highest RGM concentrations up to 100 pg m^{-3} in the summer flights and lowest (0-20 pg m^{-3}) in the winter flights. One of the major findings from this study is that vertical profiles of RGM show the maximum levels at altitudes between 10 and 15 kft (Figure 1). Limited PBM measurements exhibit similar levels of RGM and PBM at all altitudes. High PBM levels (up to 200 pg m^{-3}) were usually associated with cold front passages. These data are currently being analyzed using HYSPLIT back trajectory and source-receptor relationships will be investigated for mercury species in this continental environment.

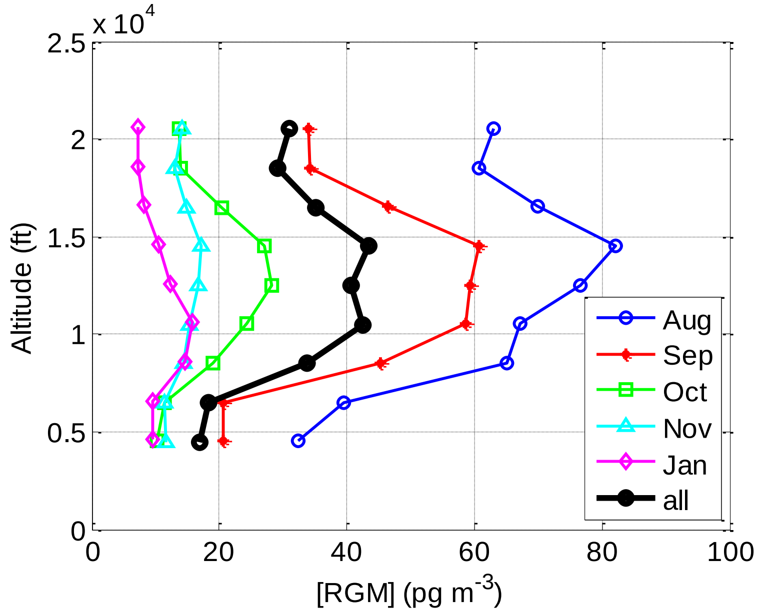


Figure 1. *Monthly mean vertical profiles of reactive gaseous mercury (RGM) during the mercury profiling study in Tullahoma, TN. Overall RGM levels continuously dropped from August 2012 to January 2013. A maximum of RGM level was observed between 10 and 15 kft for each month.*

Planned Work

- Continued measurements of mercury compounds
- Development of an aircraft version of the HONO detector.

Publications

Ren, X., J. Mao, W. H. Brune, C. A. Cantrell, R. L. Mauldin, R. S. Hornbrook, E. Kosciuch, J. R. Olson, James H. Crawford, and Gao Chen, Intercomparison of HOx measurements using laser–induced fluorescence and chemical ionization mass spectrometry during ARCTAS, *Atmos. Meas. Tech.,* 5, 2025–2037, 2012.

Mao, J., X. Ren, L. Zhang, D. M. Van Duin, R. C. Cohen, J.-H. Park, A. H. Goldstein, F. Paulot, M. R. Beaver, J. D. Crounse, P. O. Wennberg, J. P. DiGangi, S. B. Henry, F. N. Keutsch, C. Park, G. W. Schade, G. M. Wolfe, J. A. Thornton, and W. H. Brune, Insights into hydroxyl measurements and the atmospheric oxidation in a California forest, *Atmos. Chem. Phys*., 12, 8009–8020, 2012.

Olson, J. R., Crawford, J. H., Brune, W., Mao, J., Ren, X., Fried, A., Anderson, B., Apel, E., Beaver, M., Blake, D., Chen, G., Crounse, J., Dibb, J., Diskin, G., Hall, S. R., Huey, L. G., Knapp, D., Richter, D., Riemer, D., Clair, J. St., Ullmann, K., Walega, J., Weibring, P., Weinheimer, A., Wennberg, P., and Wisthaler, A.: An analysis of fast photochemistry over high northern latitudes during spring and summer using in-situ observations from ARCTAS and TOPSE, *Atmos. Chem. Phys.,* 12, 6799-6825, doi:10.5194/acp-12-6799-2012, 2012.

Ahlm, L., S. Liu, D. A. Day, L. M. Russell, R. Weber, D. R. Gentner, A. H. Goldstein, J. P. DiGangi, S. B. Henry, F. N. Keutsch, T. C. VandenBoer, M. Z. Markovic, J. G. Murphy, X. Ren, and S. Scheller, Formation and growth of ultrafine particles from secondary sources in Bakersfield, California, *J. Geophys. Res*., 117, D00V08, doi:10.1029/2011JD017144, 2012.

Manuscript submitted:

Ren, X., D. van Duin, M. Cazorla, S. Chen, J. Mao, L. Zhang, W. H. Brune, J. H. Flynn, N. Grossberg, B. L. Lefer, B. Rappenglück, K. W. Wong, C. Tsai, J. Stutz, J. E. Dibb, B. T. Jobson, W. T. Luke, and P. Kelley, Atmospheric oxidation chemistry and ozone production: Results from SHARP 2009 in Houston, Texas, submitted to JGR, 2013.

Presentations

Ren, X. et al. (2012), Atmospheric Oxidation Chemistry and Ozone Production: Results from SHARP, Brown Bag Seminar, Dept. of Atmospheric and Oceanic Science, University of Maryland, College Park, MD, 13 July, 2012.

Zhang, L., J. Mao, X. Ren, W. H. Brune, P. Feiner, and D. Miller, Understanding measurements of OH, HO_2 and OH reactivity in forest environments, AGU 2012 Fall Meeting, San Francisco, CA, December 3-7, 2012.

Ngan, F., M. Cohen, W. Luke, X. Ren, and R. Draxler, Meteorological modeling using WRF-ARW for Grand Bay Intensive, AMS 2013 Meeting, Austin, TX, January 7-11, 2013.

Ren, X. et al. (2013), Airborne Vertical Profiling of Hg Speciation near Tullahoma, TN, Mercury Conference, Dept. of Atmospheric and Earth Sciences, Georgia Tech, Atlanta, GA, 30 January, 2013.

Performance Metrics	**FY12**
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	8
# of non-peered reviewed papers	7
# of invited presentations	13
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	0

- Assessment of Global Oceanic Net Freshwater Flux Products Using Argo Salinity Observations

Task Leader	Li Ren
Task Code	
Sponsor	Anjuli Bamzui
Sponsor Office	NSF
Main CICS Research Topic	Surface Observation Networks
Percent contribution to CICS Themes	
Percent contribution to NOAA Goals	

Highlight: We attempted to evaluate ten E-P sets employing the ocean rain gauge as a valid reference. For the annual mean spatial distribution, the combination of E-P from OAFlux/TRMM has the best agreement with the indirect estimate of E-P according to their spatial pattern correlations and the RMSD. Thus, we recommend this combination for ocean modeling studies. The zonal averaged analysis indicates that direct estimate products likely overestimate in their high value regions.

BACKGROUND

Oceanic evaporation and precipitation are major components of the global hydrological cycle as well as among the most important components of the climate system, with 86% of global evaporation and 78% of global precipitation occurring over the oceans. However, even in the age of satellite observations, measurements of both evaporation and precipitation are still unsatisfactory. In-situ observations of sea surface evaporation and indirect retrievals of evaporation from satellite information are both subject to errors and uncertainties . Oceanic precipitation can be estimated from satellite observations, but the values are subject to significant uncertainties due to the scarcity of calibrating observations and the physical limitations involved.

With the rapidly growing number of ocean salinity measurements in recent years, the concept of “ocean rain gauge” has gained increasing attention. With the expanding salinity measurements by new satellite instruments and in situ technologies our understanding of the global water cycle would be improved. At present there are more than 3200 active Argo floats providing near real time temperature and salinity profiles of the world ocean. Additionally, the NASA Aquarius mission, which was launched in June 2011, is providing global Sea Surface Salinity (SSS) with 150-Km spatial resolution on a 30-day time scale with measurement error estimate to be less than 0.2 psu. This mission, along with the European Soil Moisture/Ocean Salinity (SMOS), provides an unprecedented view of global SSS.

The oceanic salinity budget links salinity to forcing at the ocean-atmosphere interface in the form of E (evaporation) - P (precipitation). However, upper ocean salinity variation is a rather complex process, being additionally influenced by factors including horizontal advection, entrainment, lateral diffusion and mixing. In this study, we take advantage of the rich salinity data employing the “ocean rain gauge” concept according to the ocean salinity budget, to validate the oceanic precipitation and evaporation.

ACCOMPLISHMENTS

The spatial correlations of the E-P products (direct estimate) and the E-P from salinity (indirect estimate) indicates that the set of OAFlux/TRMM yields the highest correlation (0.55), while the second highest is provided by the GSSTF3/TRMM pair (Table 1). The E-P from Liu has the lowest spatial correlations. The Root Mean Square Difference (RMSD) between the direct and indirect methods indicates that OAFlux/TRMM and IFREMER/TRMM have the smallest RMSD (2.30 m year^{-1}). The evaporation and precipitation from RSS has the highest RMSD among the net freshwater products. Therefore, annual mean E-P from OAFlux/TRMM agrees best with the E-P estimated from the ocean salinity budget based on this simple assessment of its high spatial correlation and low RMSD.

	TRMM /OAflux	TRMM/ IFREMER	TRMM/ GSSTF	GPCP/ OAflux	GPCP/ IFREMER	GPCP/ GSSTF	CMAP/ OAflux	CMAP/ IFREMER	CMAP/ GSSTF	Liu	RSS
R	0.55	0.53	0.54	0.52	0.50	0.52	0.50	0.50	0.50	0.49	0.50
RMSD	2.30	2.30	2.38	2.43	2.37	2.45	2.38	2.32	2.50	2.38	2.57

Table 1: Spatial correlation (r) and RMSD between the direct and the indirect estimates of annual mean E-P.

The zonal averages of the annual mean E-P including both the direct and indirect estimates show similar latitude distributions (Figure 1). In the tropics, where precipitation peaks, both the direct and indirect E-P estimates have negative numbers representing precipitation exceeding evaporation. However, most of the E-P sets from direct estimates are lower than the indirect estimate of E-P, except the Liu E-P. Also, the local minimums of the E-P sets are offset slightly north of the indirect estimate of E-P. North of 40°N and south of 40°S, where the secondary precipitation maximum (storm track) appears, both the direct and indirect estimates all have negative numbers. Most of the E-P sets from direct estimates are lower than the indirect estimate of E-P. In the Northern hemisphere subtropics, the indirect E-P estimated is lower than most of the E-P sets except the sets of OAFlux/CMAP and the indirect estimate is almost identical to OAFlux/GPCP in these regions. In the Southern Hemisphere subtropics, local maximums of E-P are offset to the north of the indirect E-P estimate. In summary, the direct estimates of E-P are lower than the indirect estimate in the heavy rain zones possibly due to overestimation of the precipitation and/or underestimation of the evaporation in these products. In the high evaporation zones, the direct estimates are greater than the indirect estimate of E-P possibly due to the overestimation of evaporation and/or underestimation of precipitation in these products.

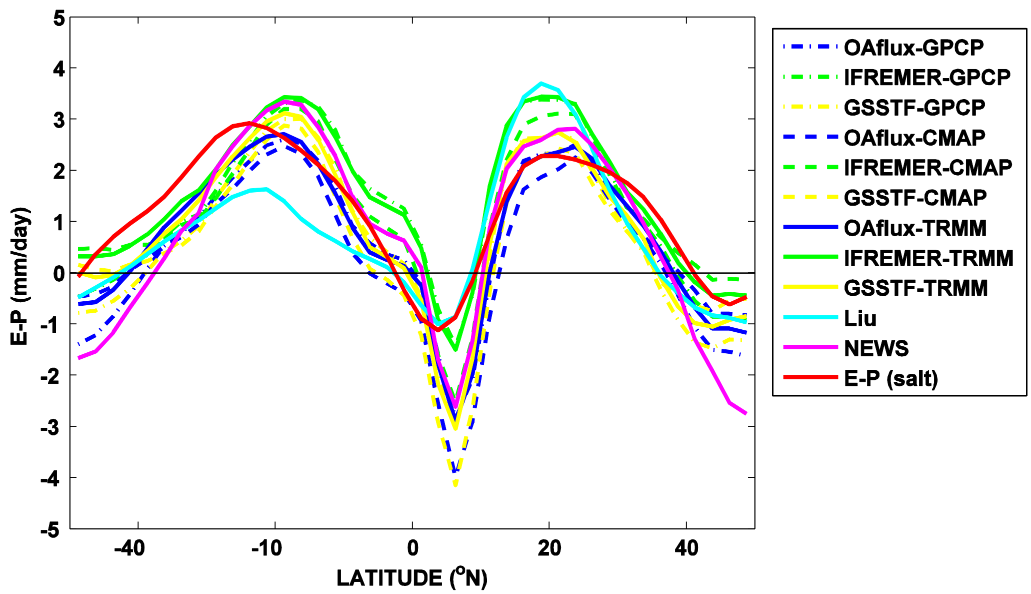


Figure 1: Zonal averages of the annual mean E-P from both the direct (eleven sets) and indirect estimates.

PLANNED WORK

In this analysis, the annual mean evaluation of the ten E-P sets were based on the ocean rain gauge concept. In the next step, we plan to work on this topics for seasonal time scales.

PRESENTATIONS

Ren, L., E. Hackert, A. J. Busalacchi, and P.A. Arkin, Assessment of Global Oceanic Net Freshwater Flux Products Using Argo Salinity Observations, AGU Fall Meeting 2012, San Francisco, 12/2012

1.4 Future Satellite Programs

- Observing System Simulation Experiments for an Early-Morning-Orbit Meteorological Satellite

Task Leader	Sean Casey
Task Code	LPSC_OSSE12
NOAA Sponsor	Lars Riishojgaard
NOAA Office	NWS/OASST
Main CICS Research Topic	Future Satellite Programs
Percent contribution to CICS Themes	Theme 1: 100%; Theme 2: 0%; Theme 3: 0%.
Percent contribution to NOAA Goals	Goal 2: 100%

Highlight: Simulated environment experiments demonstrated that the loss of DMSP/F16 could have significant negative effects on medium-range forecasts, and that two of three proposed follow-on missions would have significant positive impacts.

BACKGROUND

Over the last 10-15 years, Observing System Simulation Experiments (OSSEs) have been conducted assessing the impact of new candidate observing systems on numerical weather prediction applications and for preparing to immediately benefit from observing systems that have already been approved for future deployment. Since 2006, the Joint Center for Satellite Data Assimilation has coordinated Joint OSSE collaboration across a number of groups within NASA and NOAA. The backbone of the collaboration is the shared use of a simulated realization of a long sequence of atmospheric states—the “Nature Run” in OSSE terminology—provided by the European Centre for Medium-Range Weather Forecasts, and coordinated validation, simulation of observations and calibration of the OSSE systems.

The Joint Center has made this Joint OSSE capability available to DWSS for assessment of the expected consequences of a variety of possible programmatic decisions regarding e.g. an instrument payload located in the so-called “early morning orbit” (0530 Local Equatorial Crossing Time). This orbit has traditionally been covered by the Defense Meteorological Satellite Program (DMSP), and was one of the two orbits intended to be covered by the NPOESS program. This projected assesses the expected impact on medium-range forecast skill of the NCEP Global Forecast System. In order to assess this, the following five baseline experiments have been performed:

1. A control run in which all relevant observations from observing systems (conventional and space-based) other than DWSS are assimilated (cntrl)
2. Same as 1., but without any early morning orbit coverage (no NOAA-16/DMSP-F17) (nossmis)

3. Same as 2., but with JPSS (i.e. CrIS and ATMS) added in the early morning orbit (atmscris)
4. Same as 2., but with VIIRS in the early morning orbit (i.e., polar winds) (viirs)
5. Same as 2., but with VIIRS and ATMS in the early morning orbit (atmsvirs)

ACCOMPLISHMENTS

Most of the instruments for which data were simulated for these experiments had real equivalents with available data in May and June 2012. Orbits & Latitude/Longitude information from these two months were used to simulate the instruments that were used for all five experiments, as well as SSMI/S-F16 for the cntrl case. Observations from ATMS & CrIS onboard Suomi/NPP were shifted 120° west in longitude to simulate these observations in the new early-morning-orbit for atmscris (and atmsvirs for ATMS). MODIS observations from Aqua were also shifted 120° west in longitude and used to simulate viirs measurements for cases viirs and atmsvirs. Simulation of radiance was conducted using Community Radiative Transfer Model (CRTM) developed at JCSDA.

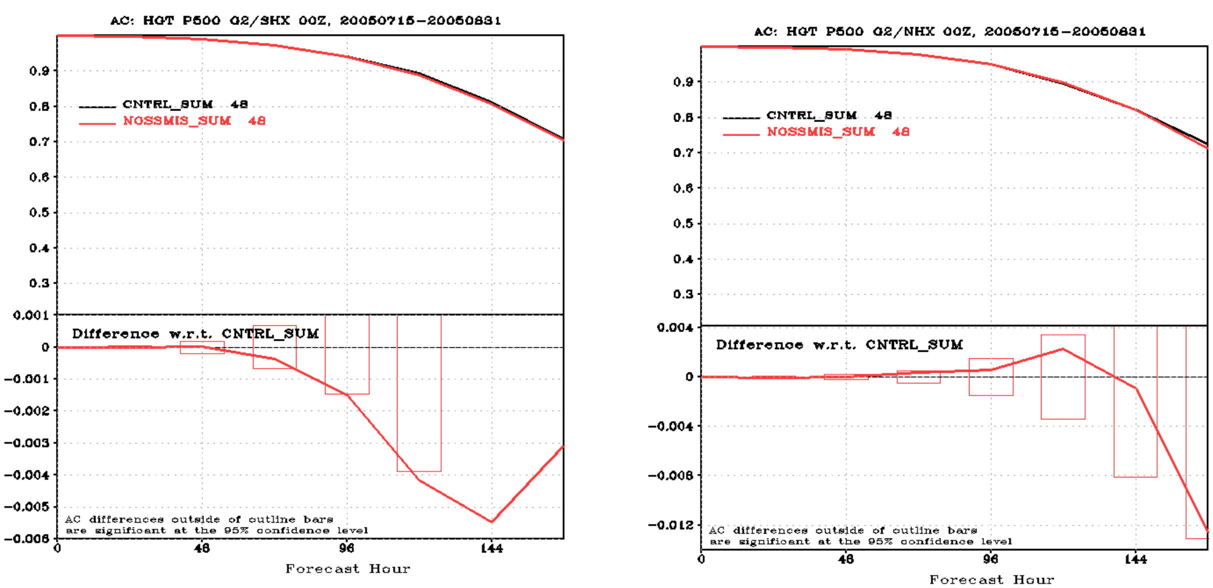


Figure 1. Experiment impacts on 500 hPa anomaly correlation. (left) Northern Hemisphere. (right) Southern Hemisphere.

We use the NCEP GDAS system based on the May 2011 version of GFS, coupled with a May 2012 version of the GSI trunk. While GDAS is currently run operationally at a horizontal resolution of T-574 (roughly corresponding to 25 km), we use here a horizontal resolution of T-382 (or 40 km, the resolution previously used for operations), as we are limited by the T-511 resolution of the current nature run. Two experimental periods were chosen; one encompassing the months of July and August 2005 (_sum) of the nature run, and one encompassing the months of January and February 2006 (_win). Results for the Northern Hemisphere summer period (_sum) are discussed below; results for the second period will be available in the near future. For each period, the first two weeks are discarded as a spin-up period; the experiment then encompasses the remaining 45 days for forecast impact analysis.

To answer whether the lack of early morning sounding coverage affects medium-range weather forecast skill, we first compare experiment nossmis to the cntrl case. Figure 1 shows the impact of the test experiments on 500 hPa Anomaly Correlation (AC) for the Northern (left) and Southern (right) hemispheres. AC is correlation between forecast and the best estimate of truth and varies between 0 and 1. Therefore higher values of AC indicate better forecast. Rectangles in the lower portion of the figures denote the 95% confidence interval; curves above or below these rectangles are said to be statistically significant; curves within the rectangles are considered non-significant to two standard deviations. Some differences are noted in the Northern Hemisphere; however, none of these differences can be considered significant. In the Southern Hemisphere, forecasts 4 and 5 days out (96 & 120 hours, respectively) show significant negative impact following the removal of SSMI/S.

We now want to see which of the three suggested payload configurations for the early morning orbit would have the greatest forecast impact. We now use case nossmis as the base case, and compare the remaining four experiments (cntrl, atmscris, viirs, atmsvirs) to nossmis. Figure 2 shows the 500 hPa AC for the Northern (left) and Southern (right) hemispheres. In the Northern Hemisphere, only atmsvirs has a significant positive impact on the forecast, here for days 6 and 7. All other experiments/forecast times show a non-significant impact. For the Southern Hemisphere, the cntrl case shows a significant impact at days 4 and 5, while no other cases/forecast times show a statistically significant impact.

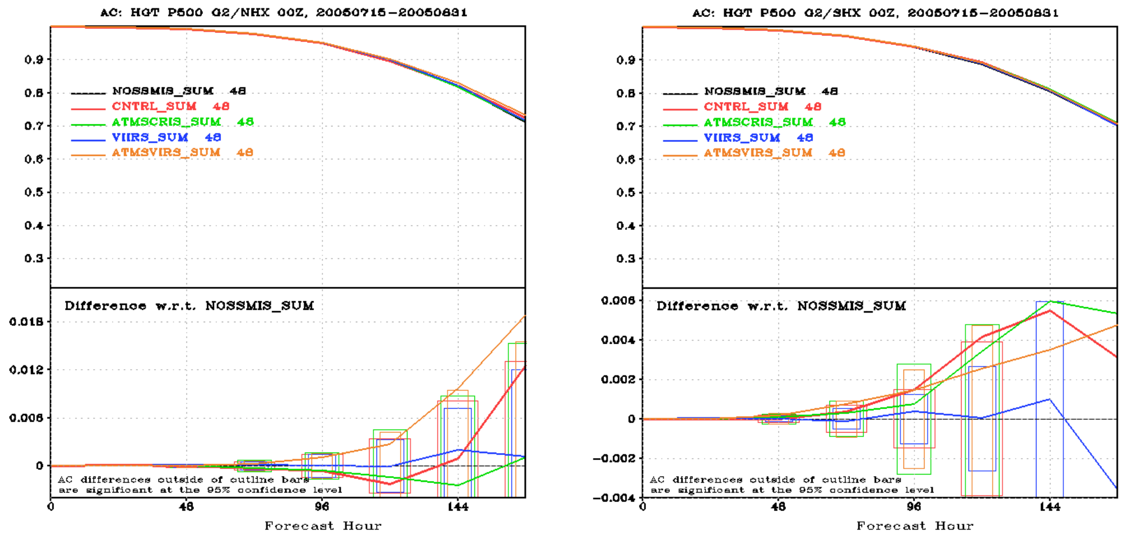


Figure 2. Experiment impacts on 500 hPa anomaly correlation. (left) Northern Hemisphere. (right) Southern Hemisphere.

We derive a comparative metric (TD_{tot}) reflecting cumulative distance from nature run truth between two OSSE experiments, by computing RMSE(nossmis-NR)-RMSE(exp2-NR) formed at each level and gridpoint sampled over some period of time, then horizontally and vertically averaging the gridpoint differences to produce a single composite value:

$$TD_{tot} = \sum_{i=1}^{n} (p_i - p_{i-1}) \frac{[A(p_{i-1}) + A(p_i)]}{2}$$

Here A_i is the global area average of (RMSE(nossmis, level i)-RMSE(experiment, level i)) and p_i is the pressure at level i. We then find the following TD_{tot} values for temperature for all analyses:

- TD_{tot}(atmsvirs)=4.81 K
- TD_{tot}(atmscris)=4.54 K
- TD_{tot}(cntrl)=3.13 K
- TD_{tot}(viirs)=0.4 K

We can also compute TD_{tot} for different analysis times, to see how the different data sources affect the analysis. For example, we can calculate TD_{tot} values for temperature forecasts 96 hours from forecast run time (Day 4):

- TD_{tot}(atmscris)=5.17 K
- TD_{tot}(cntrl)=3.13 K

- TD_{tot}(atmsvirs)=3.01 K
- TD_{tot}(viirs)=0.4 K

PLANNED WORK

- Add analysis of additional forecast cycles (00Z, 06Z, 12Z, 18Z, as opposed to simply comparing 00Z forecasts)
- Add simulated GPS-radio occultation data to experiments
- Simulate, run experiments for January/February (_win) season, compare hemispheric impacts
- (May 2013) Begin OSSE work involving a simulated geostationary hyperspectral infrared satellite, in conjunction with current JCSDA, NOAA/NESDIS/STAR & NOAA/NCEP/EMC partners, in addition to new partners at CIMSS and NOAA/AOML

PUBLICATIONS (Non Peer-Reviewed):

Riishojgaard, L.P., S.P.F. Casey, M. Masutani, J. Woollen, T. Zhu & R. Atlas, *Observing System Simulation Experiments for an Early-Morning-Orbit Meteorological Satellite in the Joint Center for Satellite Data Assimilation: Preliminary Report.* Submitted to Cost Assessment & Program Evaluation Department, Office of the Secretary of Defense, January 2013.

Casey, S.P.F., L.P. Riishojgaard, M. Masutani, J. Woollen, T. Zhu & R. Atlas, *Observing System Simulation Experiments for an Early-Morning-Orbit Meteorological Satellite in the Joint Center for Satellite Data Assimilation.* Extended Abstract, 93rd Annual Conference of the American Meteorological Society, Special Symposium on the Joint Center for Satellite Data Assimilation. https://ams.confex.com/ams/93Annual/webprogram/Handout/Paper219127/OSSE-EarlyMorningOrbit-Summary.pdf

PRESENTATIONS

Casey, S.P.F., L.P. Riishojgaard, M. Masutani, J. Woollen, T. Zhu & R. Atlas, *Observing System Simulation Experiments for an Early-Morning-Orbit Meteorological Satellite in the Joint Center for Satellite Data Assimilation.* 93rd Annual Conference of the American Meteorological Society, Special Symposium on the Joint Center for Satellite Data Assimilation, Austin, TX, January 2013.

Casey, S.P.F., M. Masutani, J. Woollen, L.P. Riishojgaard, T. Zhu & Z. Ma, *Observing System Simulation Experiments for an Early-Morning-Orbit Meteorological Satellite in the Joint Center for Satellite Data Assimilation*. Annual Meeting of the American Geophysical Union, Session on Observing System Simulation Experiments, San Francisco, CA, December 2012 (poster).

Casey, S.P.F., M. Masutani, J. Woollen, L.P. Riishojgaard, T. Zhu & Z. Ma, *OSSEs to assess the impact of early morning orbit coverage.* Conference on Satellite Lidar Winds, Boulder, CO, October 2012 (invited).

Casey, S.P.F., M. Masutani, J. Woollen, L.P. Riishojgaard, T. Zhu & Z. Ma, *OSSEs to assess the impact of early morning orbit coverage.* 10th JCSDA Workshop on Satellite Data Assimilation, College Park, MD, October 2012.

Casey, S.P.F., M. Masutani, J. Woollen, L.P. Riishojgaard, T. Zhu & Z. Ma, *Observing System Simulation Experiments for an Early-Morning-Orbit Meteorological Satellite in the Joint Center for Satellite Data Assimilation*. 1st Annual CICS Science Team Meeting, College Park, MD, September 2012 (poster).

Performance Metrics	**FY12**
# of new or improved products developed	0
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	0
# of non-peered reviewed papers	2
# of invited presentations	1
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	0

- GOES-R/JPSS Proving Ground Support

Task Leader: Michael J. Folmer
Task Code: PAMF_GPGV_12
NOAA Sponsor Steve Goodman
NOAA Office NESDIS/GOESPO
Main CICS Research Topics: Future Satellite Programs (GOES-R and JPSS)
Percent contribution to CICS Themes: Theme 1: 20%; Theme 2: 80%; Theme 3: 0%.
Percent contribution to NOAA Goals: Goal 2: 50%; Goal 5: 50%

Highlight: Michael Folmer has lead the GOES-R and JPSS Proving Ground activities at the NOAA Center for Weather and Climate Prediction since May 2011. Proving grounds provide forecasters and researchers the opportunity to evaluate new satellite technologies in every day operations.

BACKGROUND

The Geostationary Operational Environmental Satellite R-Series (GOES-R) and Joint Polar-orbiting Satellite Services (JPSS) Proving Grounds are a collaborative effort among the GOES-R Program Office, JPSS Program Office, cooperative institutes, weather forecast offices, National Centers for Environmental Prediction (NCEP) National Centers, and National Oceanic and Atmospheric Administration (NOAA) Testbeds across the country. The Proving Ground is a project in which simulated GOES-R and JPSS products can be tested and evaluated before the GOES-R series of satellites are launched. Simulated GOES-R products are generated using combinations of currently available GOES data, along with higher-resolution data provided by instruments on polar-orbiting satellites such as the Moderate Resolution Imaging Spectroradiometer (MODIS) on National Aeronautic and Space Administration's (NASA) Aqua and Terra satellites, the Visible Infrared Imaging Radiometer Suite (VIIRS) on the new Suomi-National Polar-orbiting Partnership (S-NPP), and model synthetic satellite data.

A full-time visiting scientist is required for the GOES-R Proving Ground efforts based at the NOAA National Weather Service (NWS) Hydrometeorological Prediction Center (HPC), Ocean Prediction Center (OPC), National Hurricane Center (NHC) Tropical Analysis and Forecast Branch (TAFB), and National Environmental Satellite, Data, and Information Service (NESDIS) Satellite Analysis Branch (SAB) in College Park, Maryland. This scientist coordinates the evaluation efforts, helps facilitate product availability, generates combined reports in a timely manner, interacts directly with forecasters to help train them on product applications, and provide valuable feedback to product developers.

ACCOMPLISHMENTS

The 2012 GOES-R Proving Ground activities at HPC, OPC, TAFB, and SAB successfully introduced the RGB Air Mass product into operations using the GOES Sounder, the Spinning Enhanced Visible and Infrared Imager (SEVIRI) on Meteosat-9, and MODIS. Approximately 80 forecasters and analysts received product training between 1 January and 30 April 2012 and surveys collected their feedback. Forecasters found the imagery useful for identifying potential vorticity (PV) anomalies and stratospheric intrusions that could lead to explosive cyclogenesis. Some forecasters referenced the imagery in their public text products. During the summer of 2012, GOES-14 was taken out of storage for science testing and the GOES-R Program Office and NESDIS used Super Rapid Scan Operations (SRSO) to provide forecasters with a glimpse of the future GOES-R capabilities. The imagery updated each minute at 1-km resolution, making mesoscale boundaries more noticeable and allowing forecasters and analysts the opportunity to monitor convective and forest fire trends. Forecasters and analysts had the unique opportunity to monitor and evaluate the RGB Air Mass and GOES-14 SRSO imagery in real-time during Hurricane/Superstorm Sandy. Although this was not a formal product demonstration for 2012, forecasters and analysts provided valuable feedback that was collected for a final report.

This Proving Ground also contributed to the National Aeronautics and Space Administration (NASA) Hurricane and Severe Storm Sentinel (HS3) Field Campaign that was based at the NASA Wallops Flight Facility in Chincoteague, VA. The CICS scientist trained forecasters on the products and answered their questions. The RGB Dust and Pseudo-Natural Color products received the most use to monitor the Saharan Air Layer. CICS intends to continue contributions to the 2013 experiment.

The WRF and NAM simulated Advanced Baseline Imagery (ABI) and the Overshooting Top Detection (OTD) products were introduced to forecasters and analysts during late 2012. Demonstrations of these products will continue into 2013 to allow for sufficient evaluation time during significant weather events. Coordination with JPSS started in late summer 2012 to develop a proving ground strategy that would include the introduction of S-NPP products to the four centers. Products from both proving grounds have been ingested using a Local Data Manager (LDM) and FTP scripts. CICS has developed a robust archive of current and proxy satellite products to assist forecasters and scientists with case study development. This has led to multiple collaborations including a NASA DEVELOP project with Saint Louis University (SLU), co-mentoring a Master's Degree student at (SLU), a peer-reviewed paper on RGB Air Mass and AIRS Total Column Ozone Retrievals for use in an operational setting, and a paper in development that highlights satellite usage during Hurricane/Superstorm Sandy. Work has also begun on transitioning some products into AWIPS II by the end of the year. The AWIPS II work is in collaboration with NCEP Central Operations and NASA SPoRT and will compliment a Unidata proposal that seeks to obtain an AWIPS II EDEX server and CAVE client at CICS.

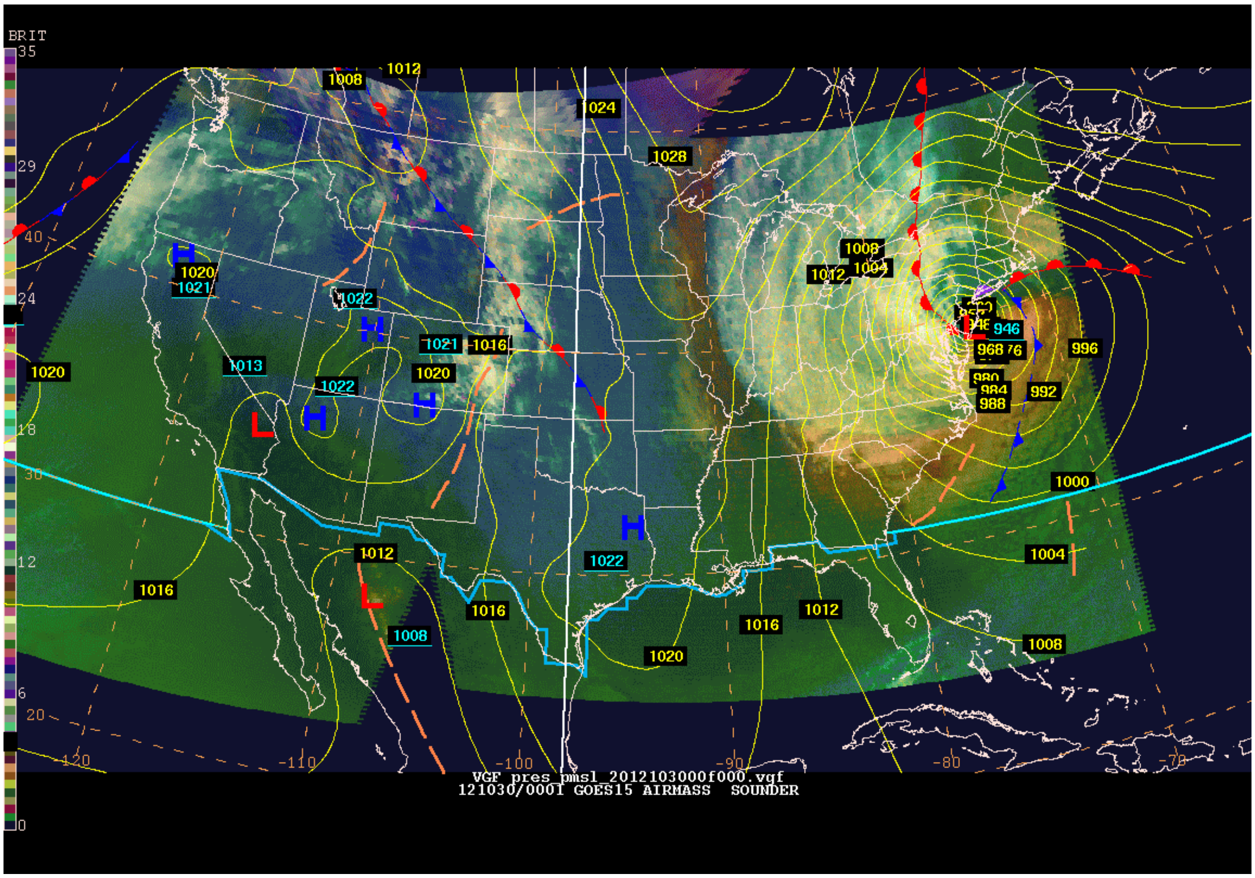


Figure 1: The GOES-Sounder RGB Air Mass product with the HPC 0000 UTC surface analysis overlaid showing Hurricane/Superstorm Sandy arriving on the southern New Jersey coast. The central pressure was analyzed at 946 mb at this time and the orange coloring wrapping around and into the storm is evidence of a stratospheric intrusion (dry, high ozone air) assisting with the transition from tropical to extratropical storm.

Planned Work

- The 2013 GOES-R Product Demonstrations begin around 3/15/13 for the following products:
  - WRF/NAM simulated Advanced Baseline Imagery (ABI)
  - Overshooting Top Detection (OTD)
  - Lightning Density Product (developed as a CICS/NESDIS/OPC collaboration using the Vaisala GLD-360 lightning feed at the NCWCP)
  - GOES-R Convective Initiation
  - Derived Motion Winds
- JPSS products from S-NPP VIIRS will be introduced through the year
  - RGB Air Mass

  - Day-Night Band
  - Longwave IR, Visible
- Work with AWIPS-II experts to display GOES-R/JPSS products
- Participate in the 2013 HS3 field experiment
- Continue research collaborations with CICS scientists and other academic partners

PUBLICATIONS

Zavodsky, B.T., A.L. Molthan, and M.J. Folmer, 2013: Multispectral imagery for detecting stratospheric air intrusions associated with cyclogenesis. Accepted to *National Weather Association Electronic Journal of Meteorology* in December 2012.

Folmer, M., R. Pasken, T. Eichler, G. Chen, J. Dunion, and J. Halverson, 2013: The effect of GPS dropwindsondes from the NAMMA 2006 field campaign on the simulations of two eastern Atlantic tropical cyclones. Submitted to *Journal of Geophysics Research* in February 2013.

PRESENTATIONS

Folmer, M., J. Beven, M. Brennan, H. Cobb, M. DeMaria, J. Knaff, C. Velden, J. Dunion, G. Jedlovec, K. Fuell, 2013: The 2012 Satellite Proving Ground at the National Hurricane Center. 67th Interdepartmental Hurricane Conference, College Park, MD. March 2013.

Kibler, J. and M.J. Folmer, 2013: The Satellite Analysis Branch Hazard Mitigation Programs and Preparing for GOES-R. Second NWS/Eastern Region Virtual Satellite Workshop, College Park, MD. February 2013.

Folmer, M.J., K. Mozer, S. Goodman, J.M. Sienkiewicz, D.R. Novak, H.D. Cobb, and J. Kibler, 2013: GOES-R Convective Product Demonstrations at HPC, OPC, TAFB, and SAB. AMS 93rd Annual Meeting, Austin, TX. January 2013.

Folmer, M.J., K. Mozer, S. Goodman, M. Goldberg, J.M. Sienkiewicz, D.R. Novak, H.D. Cobb, and J. Kibler, 2013: The 2012 HPC/OPC/TAFB/SAB GOES-R/JPSS Proving Ground Demonstrations. AMS 93rd Annual Meeting, Austin, TX. January 2013.

Folmer, M.J., B.T. Zavodsky, and A. Molthan, 2012: Operational use of the AIRS Total Column Ozone Retrievals along with the RGB Air Mass product as part of the GOES-R Proving Ground. AGU Fall Meeting, San Francisco, CA. December 2012.

Folmer, M.J., 2012: The 2012 GOES-R Product Demonstrations for Marine, Precipitation, and Hazardous Weather Applications. 2012 CICS Review, College Park, MD. November 2012.

Folmer, M.J., S. Goodman, A. Orrison, J. Sienkiewicz, and D. Novak, 2012: The 2012 GOES-R Product Demonstrations for Marine and Precipitation Applications. NWA 37th Annual Meeting, Madison, WI. October 2012.

Brennan, M. and M.J. Folmer, 2012: The Use of the RGB Products at the HPC, OPC, NHC, and SAB Proving Grounds. NOAA Satellite Science Week, Kansas City, MO. May 2012.

Sienkiewicz, J., M. Folmer, and H. Cobb, 2012: Atmospheric Motion Vectors Usage at OPC and TAFB. NOAA Satellite Science Week, Kansas City, MO. May 2012.

Folmer, M.J., B. Reed, S. Goodman, J.M. Sienkiewicz, E. Danaher, D.R. Novak, and J. Kibler, 2012: The 2012 HPC/OPC/SAB GOES-R Proving Ground Demonstrations. NOAA Satellite Science Week, Kansas City, MO. May 2012.

Folmer, M.J., A. Orrison, J. Schauer, J. Simko, and B. Kuligowski, 2012: Rainfall Rate / QPE Usage at HPC, TAFB, and SAB. NOAA Satellite Science Week, Kansas City, MO. May 2012.

Folmer, M.J., A. Orrison, M. Bodner, J. Schauer, and J. Dunion, 2012: Imagery and Proxy Imagery UsageAt HPC, OPC, TAFB, and SAB. NOAA Satellite Science Week, Kansas City, MO. May 2012.

Siewert, C., B. Rabin, D. Kingfield, J. Otkin, D. Lindsey, L. Grasso, J. Knaff, M. Folmer, A. Molthan, and S. Weiss, 2012: GOES-R Proving Ground Demonstration of Imagery Products at NOAA's Storm Prediction Center and Hazardous Weather Testbed. NOAA Satellite Science Week, Kansas City, MO. May 2012.

Folmer, M.J., A.L. Molthan, K.K. Fuell, J.A. Knaff, B. Zavodsky, J.M. Sienkiewicz, E. Danaher, J. Kibler, D.R. Novak, B. Reed, J.L. Beven II, and M. DeMaria, 2012: The Use of the RGB Products at the HPC, OPC, NHC, and SAB GOES-R Proving Grounds during the 2011 Atlantic Hurricane Season. AMS 30th Conference on Hurricanes and Tropical Meteorology: Tropical Cyclone Remote Sensing II, Ponte Vedra Beach, FL. April 2012.

Folmer, M.J., 2012: The 2012 GOES-R Proving Ground Activities at HPC, OPC, TAFB, and SAB: An Introduction to the GOES-R Products that will be Demonstrated. Seminar – University of Miami, Rosenstiel School or Marine and Atmospheric Science, Miami, FL. April 2012.

Folmer, M.J., 2012: The 2012 GOES-R Proving Ground Activities at HPC, OPC, TAFB, and SAB: An Introduction to the GOES-R Products that will be Demonstrated. Seminar – National Hurricane Center, Miami, FL. April 2012.

PROPOSALS SUBMITTED

1. 2013 Unidata Community Equipment Awards
2. 2012 GOES-R Risk Reduction Visiting Scientist Proposal

Awards

- NASA SPoRT Satellite Champion of the Year (2012)

Outreach

- Mesonet development project with the Marine Academy of Technology and Environmental Sciences
- Co-mentoring a Master's Degree student at Saint Louis University (SLU)
- Co-mentoring multiple students at SLU during the NASA DEVELOP program

Performance Metrics	FY12
# of new or improved products developed	N/A
# of products or techniques transitioned from research to ops	6
# of peer reviewed papers	1
# of non-peered reviewed papers	1
# of invited presentations	7
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	N/A

1.4a Scientific Support for the GOES-R Mission

- Validation of Cryospheric EDRs GCOM

Task Leader Cezar Kongoli
Task Code CKCK_AMSR12
NOAA Sponsor Ingrid Guch
NOAA Office NESDIS/STAR/CRP
Main CICS Research Topic Scientific Support for the Future Satellite Missions: (i) Scientific support for the JPSS Mission
Percent contribution to CICS Themes Theme 1: 70%; Theme 2: 30%; Theme 3: 0%.
Percent contribution to NOAA Goals Goal 1: 20%; Goal 2: 80%

Highlight: The Advanced Microwave Scanning Radiometer 2 (AMSR2) instrument launched on May 18, 2012 onboard the Global Change Observation Mission 1st - Water "SHIZUKU" (GCOM-W1) satellite. A suite of AMSR2 operational algorithms are being developed for the retrieval of snow cover, snow depth and Snow Water Equivalent using heritage AMSR-E data as proxy.

BACKGROUND

A suite of operational snow algorithms are being developed for the new AMSR2 instrument. The snow cover algorithm is a decision tree classification scheme originally developed for the SSM/I instrument. The algorithm is enhanced with a climatology test which applies snow cover climatology derived from the Interactive MultiSensor Snow and Ice Mapping Unit (IMS). The snow depth algorithm is based on the NASA AMSR-E empirical dynamical approach whereby algorithm regression coefficients are dynamically adjusted (computed from brightness temperatures). SWE is derived from the retrieved SD and climatologically determined snow density.

ACCOMPLISHEMENTS

Snow cover algorithm and code have been developed and its performance tested against IMS snow cover as ground truth reference. Figure 1 presents statistical measures of accuracy with respect to IMS - detection rate and false alarm - which meet operational requirements.

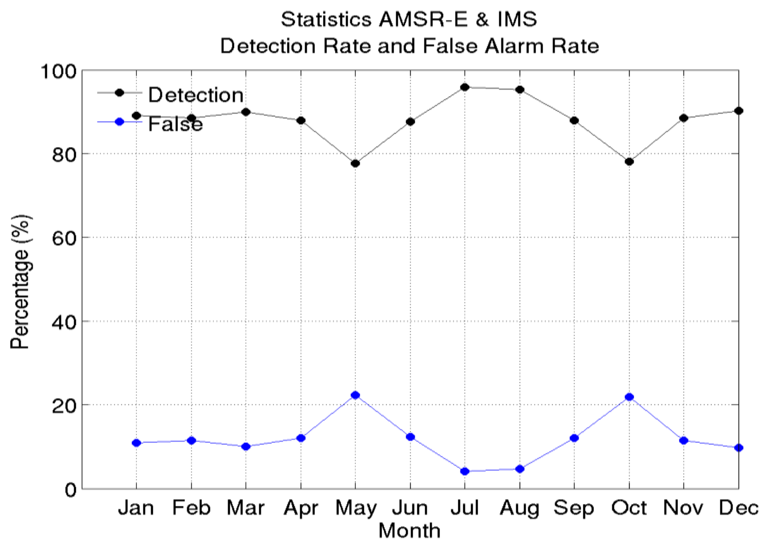


Figure 1. Snow cover algorithm statistics with respect to IMS as reference ground truth

Snow depth algorithm code has also been developed and preliminary testing performed, whereas SWE algorithm is underdevelopment. Table 2 below present performance statistics (standard deviation and bias) with respect to snow depth measurements from in-situ stations (table) and a map of retrieved Snow Depth distribution (right).

	STD (cm)	Bias (cm)	Number of samples
All data	17.97	0.39	130,036
ff=0	17.20	-3.69	69,139
0.0<ff<=0.5	18.26	6.14	35,232
ff>0.5	16.78	3.46	25,665

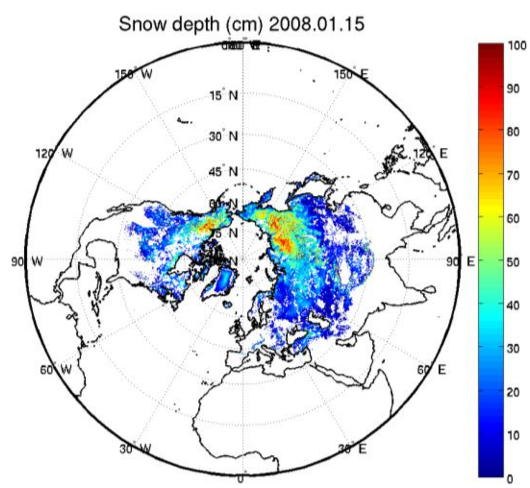


Figure 2. Snow Depth algorithm statistics with respect to in-situ stations (left) and a map of retrieved Snow Depth (right)

PLANNED WORK

- Continue work to develop and test SWE algorithm
- Optimize snow cover algorithm AMSR-E thresholds for improved performance

PRESENTATIONS

Li, J-K., C. Kongoli, J. Key, "Snow cover detection and snow depth algorithms for the Global Change Observation Mission (GCOM) AMSR2 instrument", 2012 AGU Fall Meeting, San Francisco, CA, 3-7 December 2012.

Performance Metrics	FY12
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	1
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	1
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	0

- Application of the GOES-R Land Surface Temperature Product for Snowmelt Mapping

Task Leader Cezar Kongoli
Task Code CKCKLS_R311
NOAA Sponsor Ingrid Guch
NOAA Office NESDIS/STAR/CRP
Main CICS Research Topic Scientific Support for the Future Satellite Missions: (i) Scientific support for the GOES-R Mission
Percent contribution to CICS Themes Theme 1: 70%; Theme 2: 30%; Theme 3: 0%.
Percent contribution to NOAA Goals Goal 1: 20%; Goal 2: 80%

Highlight: A snowmelt detection technique for the future GOES-R ABI sensor has been developed using GOES-13 and VIIRS data as proxy. The NOAA's Snow Data Assimilation System (SNOWDAS) was used as reference to develop and test the algorithm.

BACKGROUND

This report summarizes the year-2 work for the GOES-R3 project entitled "Application of the GOES-R Land Surface Temperature Product for Snowmelt mapping". Land Surface Temperature (LST) derived from the operational GOES-13 algorithm was used as proxy and initially evaluated for its ability to accurately retrieve LST. Figure 1 presents an inter-comparison example. Shown is a scatterplot of GOES-13 retrieved LST versus ground truth LST, the latter estimated from surface radiation data at an AMERIFLUX forested site. As shown, GOES LST performs reasonably well in the surface temperature range between -5 and +5 ^{0}C that is most relevant for wet snow detection. Next, empirically established thresholds were applied to LST for wet-dry snow discrimination of synoptic weather events associated with snowmelt.

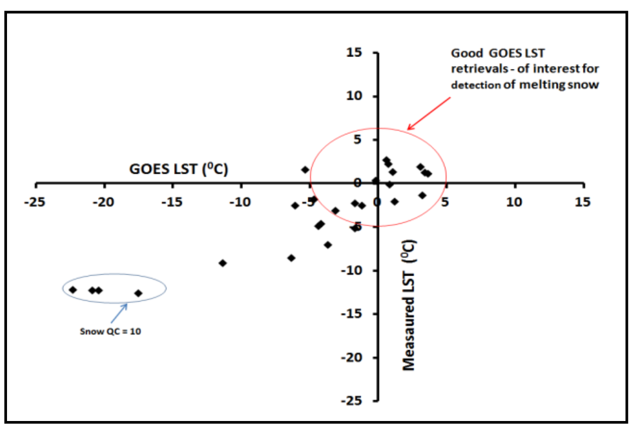


Figure 1. An example of GOES-13 retrieved LST and measured LST (computed from flux radiation data) at an AMERIFLUX site in Michigan during 2012 snow season. The surface type is deciduous broadleaf forest. Surface emissivity is assumed 0.98 for LST calculations. GOES LST performs reasonably well over the surface temperature range between -5 and +5 ^{0}C that is most relevant for wet snow detection.

ACCOMPLISHMENTS

A technique has been developed that flags the melting snow component of the GOES pixel using empirically established LST thresholds. GOES-13 data were collected for weather events over CONUS associated with snowmelt. In addition, VIIRS LST and optical measurements were also collected and examined for their potential to improve daytime snow melt detection. Specifically, VIIRS Normalized Snow Difference Index (NSDI) computed from comparable MODIS bands 4 and 6 was examined in concert with VIIRS derived LST. The NOAA's Snow Data Assimilation System (SNOWDAS) was used as reference to develop and test the algorithm (Figure 2).

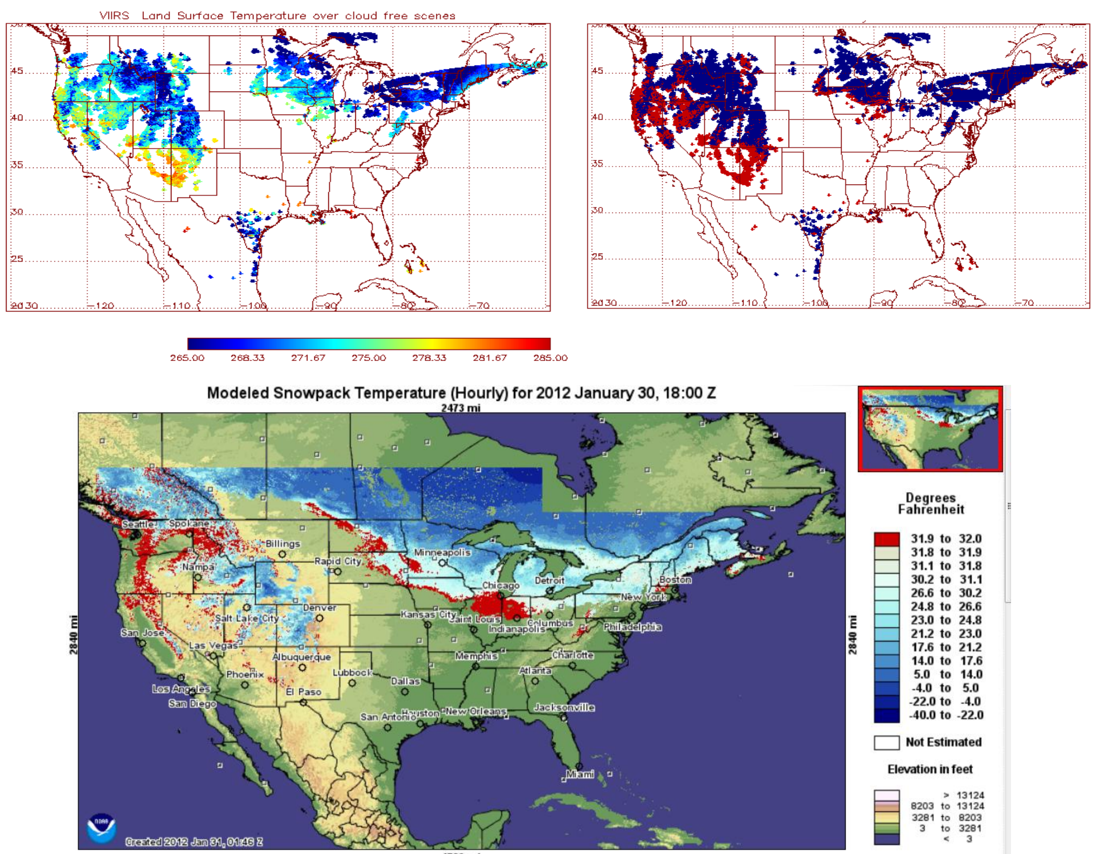


Figure 2. VIIRS LST in Kelvin over clear- and snow-identified scenes (top panel left) and wet/dry snow areas (top panel right) in red and blue, respectively, based on an established LST threshold of 274 Kelvin. Closest-in-time modeled surface snowpack temperature in Fahrenheit over US on January 30, 2012 (bottom), obtained from the 1-km Snow Data Assimilation System (SNOWDAS) of NOAA's National Operational Hydrological Remote Sensing Center (NOHRSC). Note that SNOWDAS reports the modeled snowpack temperature, which refers to the surface temperature of the snow component of the (mixed) surface, not the LST of that particular surface. On the other hand, VIIRS LST refers to the skin temperature of the (mixed) surface. Inconsistencies between the dynamic

snow mask applied by SNOWDAS (on an hourly basis) and the rather static snow mask applied to the VIIRS LST (on a daily basis) can be seen, e.g., no-snow areas by SNOWDAS that are flagged as snow by VIIRS.

PLANNED WORK

- Continue work to make algorithm refinements
- Leverage a remote-sensing land surface energy balance modeling system called TSEB/ALEXI to estimate surface energy balance components including melt occurrence and rates.

PRESENTATIONS

Kongoli, C. Y. Liu, and Y. Ju, “Use of GOES-R proxy data for snowmelt detection” (poster), Ninth Annual Symposium on Future Operational Environmental Satellite Systems, 93rd American Meteorological Society Annual Meeting, 6-10 January, 2013

Performance Metrics	**FY12**
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	1
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	0

- GOES-R Radiometric Calibration

Task Leader Shunlin Liang
Task Code DWSLGOEAB11
NOAA Sponsor Yunyue Yu
NOAA Office NESDIS/STAR/SMCD/EMB
Main CICS Research Topic: Future Satellite Programs; Scientific support for the GOES-R Mission
Percent contribution to CICS Themes Theme 1: 40%; Theme 2: 40%; Theme 3: 20%.
Percent contribution to NOAA Goals Goal 1: 50%; Goal 2: 50%

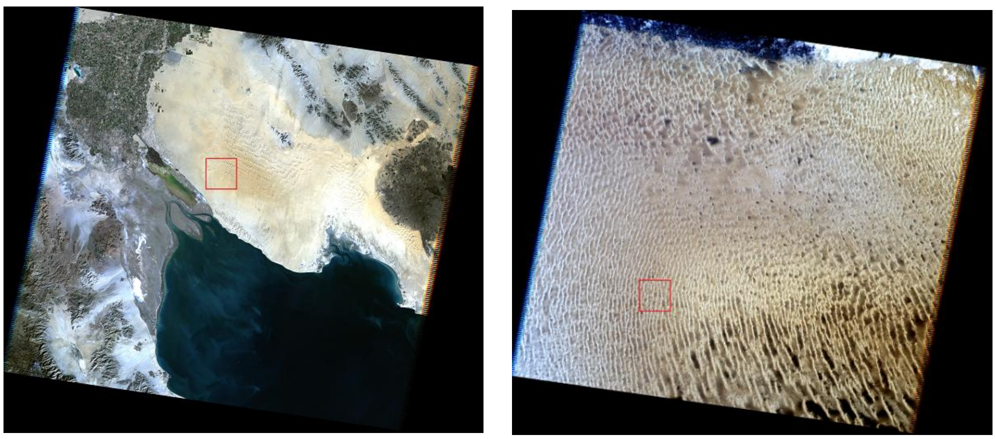
Research highlight: We developed a time-series based algorithm for assessing sensor degradation, which is able to remove the variability in TOA reflectance without using ancillary information.

BACKGROUND

This study is on vicarious calibration of GOES-R Advanced Baseline Imager (ABI). GOES-R is the next generation geostationary satellite series of United States, the launch of which is expected in 2015. Satellite sensors are subject to degradation after launch, due to various reasons such as vibration during the launch, harsh condition in space, and aging. Although an onboard calibration system is planned for ABI to correct such degradation, the onboard calibrator itself is not free from the post-launch changes. Vicarious calibration process provides an independent means of calibration and validation for ABI sensor in GOES-R.

In vicarious calibration, sensors are calibrated based on the signals from exterior reference targets whose reflectance property and illumination condition are well known *a priori*. The Sun, the Moon, stars, and homogeneous Earth surfaces are often used for the reference targets. Among those targets, we focus on investigating temporal stability and variability of the signals from pseudo-invariant calibration sites on the Earth such as deserts. Two types of calibration techniques are available for vicarious calibration – absolute and relative. In absolute calibration, the spectral radiance/reflectance of the site that is acquired at the sensor is calculated by running a radiative transfer model for the atmosphere which requires inputs such as surface bidirectional reflectance function (BRDF) and atmospheric condition (e.g. aerosol loading, water vapor amount). The simulated radiance/reflectance is then compared with the measured radiance/reflectance to compute the degradation of the sensor. In relative calibration, the at-sensor signals need not to be compared with simulated ones, since the degradation is measured by monitoring temporal changes of the at-sensor signals namely top-of-atmosphere (TOA) radiance or reflectance. This relative approach requires an assumption that the signals from the calibration site are temporally stable.

The TOA radiance/reflectance that are measured at the sensor aperture is, however, subject to variability, which is mainly caused by (1) BRDF of surface and atmosphere, and (2) atmospheric variability (e.g. changes in water vapor and aerosol loading). Absolute calibration process takes those impacts into consideration through atmospheric modeling (through radiative transfer model), and the use of atmospheric model can be performed in relative calibration as long as the information on the BRDF and atmospheric condition are available for every at-sensor measurement. However, collection of precise meteorological data and exact surface/atmosphere BRDF that are synchronized with every at-sensor measurement is very challenging and expensive.



(a) (b)

Figure 1: Calibration sites used in this study: (a) the Sonoran Desert, (b) the Libyan Desert

ACCOMPLISHMENTS

In this study, we develop a time-series based algorithm for assessing sensor degradation which removes the variability in TOA reflectance without using such ancillary information. The key idea of the proposed approach is to identify and remove the effect of the two variability sources (BRDF and atmospheric variability) on the TOA reflectance time series by using their differences in frequency. Sensor degradation has usually lower frequency than that of the variability of TOA reflectance.

We used two time series algorithms; seasonal trend decomposition procedures based on loess (STL) and discrete wavelet transform (DWT). The TOA reflectance time series of Landsat 5 Thematic Mapper (TM) are constructed for two calibration sites, the Sonoran Desert and the Libyan Desert (Fig 1.). Seasonal components extracted with the time series algorithms show that the BRDF and atmospheric variability has an approximately annual cycle (Fig 2.). The removal of the seasonal component gives time series with significantly smaller variance, which will consequently result in more precise sensor degradation assessment.

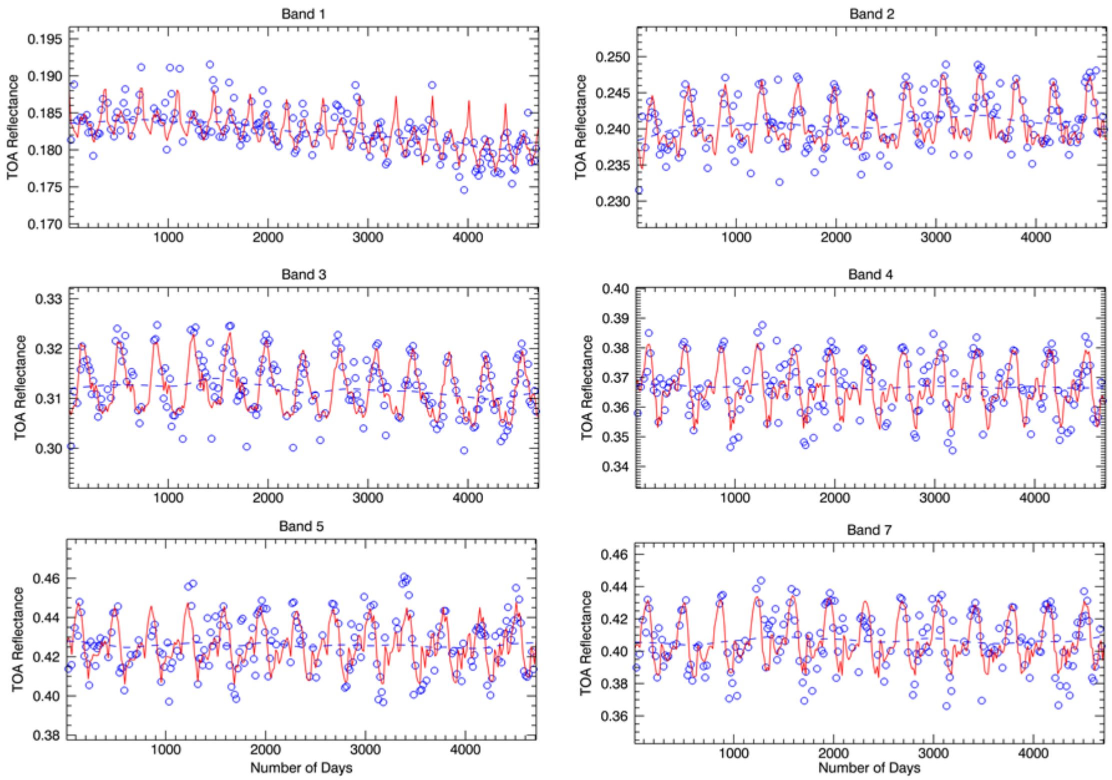


Figure 2: TOA reflectance time series for the Sonoran Desert where the seasonality is estimated by the STL algorithm.

PLANNED WORK

* Characterization of BRDF of the Sonoran Desert using current GOES data and airborne hyperspectral data.
* Characterization of atmospheric variability using radiative transfer models.

PUBLICATIONS

W. Kim, T. He, D. Wang, C. Cao, and S. Liang, "Assessment of long-term sensor radiometric degradation using time series analysis" IEEE Transaction on Geoscience and Remote Sensing (submitted)

PRESENTATIONS

W. Kim, S. Liang, and C. Cao, "On using BRDF models for assessment of radiometric stability of Sonoran Desert," in 2012 IEEE Int. Geoscience and Remote Sensing Symposium, Munich, Germany, Jul. 22-27, 2012.

- Development of Longwave Radiation Budget Products for GOES-R ABI
Task Leader Hai-Tien Lee
Task Code HLHLABAWG11
NOAA Sponsor Istvan Laszlo
NOAA Office NESDIS/STAR/SMCD/EMB
Main CICS Research Topic Future Satellite Programs: Scientific support for the GOES-R Mission
Percent contribution to CICS Themes Theme 1: 80%; Theme 2: 20%
Percent contribution to NOAA Goals Goal 1: 100%

Highlight: The GOES-R ABI longwave earth radiation budget (ERB) products have been implemented in the GOES-R Framework. The offline four-month extended validation for OLR has been performed with results consistent to earlier evaluations but the Deep Dive Validation Tool has demonstrated possibility of catching production errors. GOES-R ABI LW ERB development and validation were currently suspended pending future decision on the Option 2 products.

BACKGROUND
This work supports the GOES-R Algorithm Working Group tasks for the development and validation of three longwave radiation budget (LWRB) products for the Advanced Baseline Imager (ABI) instrument.
The GOES-R LWRB products include the outgoing longwave radiation flux density (OLR) at the top of the atmosphere and the downward and upward longwave radiation flux density (DLR and ULR) at the Earth's surface. FY10 activities include algorithm development, validation, and documentation activity leading up to delivery of an Algorithm Package (AP) to the GOES-R Ground Segment Project (GSP) on September 30, 2010; and Development of product validation "tools" that include those targeted for use in operations (routine tools) and in STAR (deep dive tools).

ACCOMPLISHMENTS
The histogram analysis for domain distribution of OLR differences between the ABI estimated and the reference data sets is a new feature of the Ver.2 Validation Tools. The data from the 4-month extended validation study showed different distributions of the OLR differences. This suggested possible issues in the CERES FM2 OLR product, being inconsistent with the other three instruments: FM1, 3, and 4. The bimodal distribution observed in the OLR differences also suggests the need for multi-mode regression models, for algorithm improvement purpose.

The temporal tracking of mean and standard deviation of OLR differences assesses the performance stability. As seen in Figure 2 that the mean OLR differences between SEVIRI/ABI OLR and CERES has shifted from about 0 Wm^{-2} to about -5 Wm^{-2} starting around mid of April 2007. This is an indication of problems from either or combination of the input, the algorithm, and the reference data sets. The spikes in standard deviation OLR differences indicate transient problems in the product generation or in the reference data source. All these problems require further investigations.

The LW ERB products are the Option 2 products that the development and validation activities were suspended due to GOES-R program funding situation. Efforts were redirect to the validation of the GOES Surface Insolation Product (GSIP) products. Preliminary results using archived GSIP product showed that the data packing precision is too low to serve product accuracy assessment purpose. We are in data collection phase since summer 2012 to accumulate real-time GSIP output that has an improved data-packing format, from a sideline NESDIS ftp server.

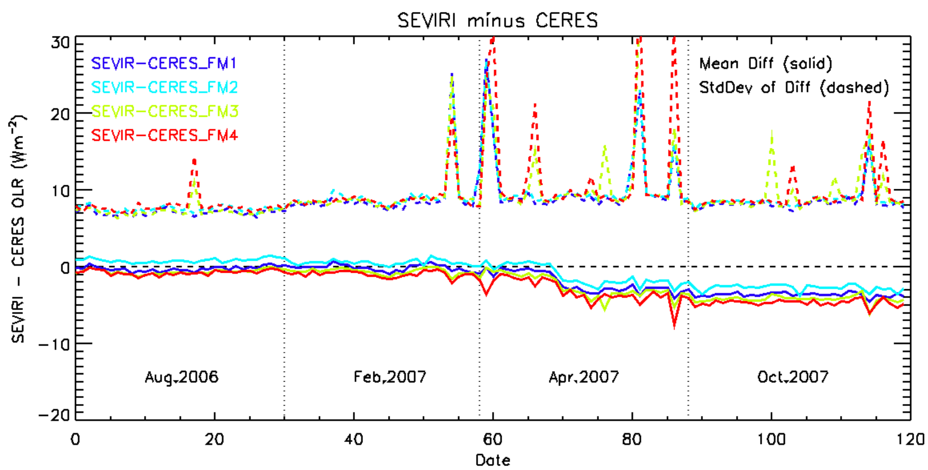


Figure 2 Demonstration of Validation Tools. The time series of full-disk domain mean and standard deviation of daily OLR differences between SEVIRI/ABI and CERES-FM1/2/3/4 for four seasonal months. The change in the mean OLR differences (solid curves) (since mid April 2007 and in Oct 2007) and the spikes in the rms differences (dashed curves) require further investigation in the input data quality.

PLANNED WORK

- Ver.3 Routine and Deep-dive Validation Tool packages (pending).
- Continue to provide Framework and LWRB Algorithm Verification and Validation (V&V) support (pending).
- GSIP products validation for TOA and Surface LW radiative fluxes.

PUBLICATIONS

Lee, H.-T., I. Laszlo, and A. Gruber, 2011: ABI Earth Radiation Budget - Outgoing Longwave Radiation. NOAA NESDIS Center for Satellite Applications and Research (STAR) Algorithm Theoretical Basis Document (ADEB approved)

Lee, H.-T., I. Laszlo, and A. Gruber, 2011: ABI Earth Radiation Budget – Surface Downward Longwave Radiation. NOAA NESDIS Center for Satellite Applications and Research (STAR) Algorithm Theoretical Basis Document (ADEB approved)

Lee, H.-T., I. Laszlo, and A. Gruber, 2011: ABI Earth Radiation Budget – Surface Upward Longwave Radiation. NOAA NESDIS Center for Satellite Applications and Research (STAR) Algorithm Theoretical Basis Document (ADEB approved)

DELIVERABLES

Routine and Deep-Dive Validation Tools Ver.2 packages for LW ERB products (OLR, DLW and ULW).

Performance Metrics	FY12
# of new or improved products developed	0
# of products or techniques transitioned from research to ops	3
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	0

- Land Surface Temperature Diurnal Analysis (Diurnal) to Validate the Performance of GOES-R Advance Baseline Imager

Task Leader Konstantin Vinnikov
Task Code KVKVLSTD_12
NOAA Sponsor Yunyue Yu
NOAA Office NESDIS/STAR/SMCD/EMB
Main CICS Research Topic Future Satellite Programs: Scientific support for GOES-R Mission
Contribution to CICS Themes Theme 1: 75%; Theme 2: 25%
Contribution to NOAA Goals Goal 1: 30%; Goal 2: 70%

Highlight: The work consists of statistical evaluation of angular anisotropy of (LST) Land Surface Temperature, developing of algorithm for correcting GOES-R retrieved LST for angular anisotropy, and testing the algorithm using independent data.

BACKGROUND

Satellite-based time series of land surface temperature (LST) have the potential to be an important tool to diagnose climate changes of the past several decades. Production of such a time series requires addressing several issues with using asynchronous satellite observations, including the diurnal cycle, clouds, and angular anisotropy. This report includes the end of work scheduled for period 7/2011-6/2012 and beginning of work scheduled for period 7/2012-6/2013. The planned work consists of statistical evaluation of angular anisotropy of (LST) Land Surface Temperature, developing of algorithm for correcting GOES-R retrieved LST for angular anisotropy, and testing the algorithm using independent data. The main requirement to the angular correction algorithm is to convert satellite observed directional LST, $T(\gamma,\xi,\beta)$, that depends on satellite viewing angle γ, sun zenith angle ξ, and azimuth β into the scalar, unbiased, energy effective value of LST, ϑ, that can be used in land surface energy balance computation. The main idea of this research is using historical data of multiple instantaneous LST observations at the same surface locations from two geostationary satellites GOES-EAST and GOES-WEST. LST observations of five SURFRAD stations should be used as ground truth for statistical evaluation of the algorithm.

ACCOMPLISHMENTS

We evaluated the angular anisotropy of LST using one full year of simultaneous observations by two Geostationary Operational Environment Satellites, GOES-EAST and GOES-WEST, at the locations of five surface radiation (SURFRAD) stations. We developed a technique to convert directionally observed LST into direction-independent equivalent physical temperature of the land surface. The anisotropy model consists of an isotropic kernel, an emissivity kernel (LST dependence on viewing angle), and a solar kernel (effect of directional inhomogeneity of observed temperature). Application of this model reduces differences of LST observed from two satellites and between the satellites and surface ground truth - SURFRAD station observed LST. The techniques of angular adjustment and temporal interpolation of satellite observed LST open a path for blending together historical, current, and future observations of many geostationary and polar orbiters into a homogeneous multi-decadal data set for climate change research. Detailed description of results is published in scientific paper (Vinnikov et al., 2012) and should not be repeated in this report.

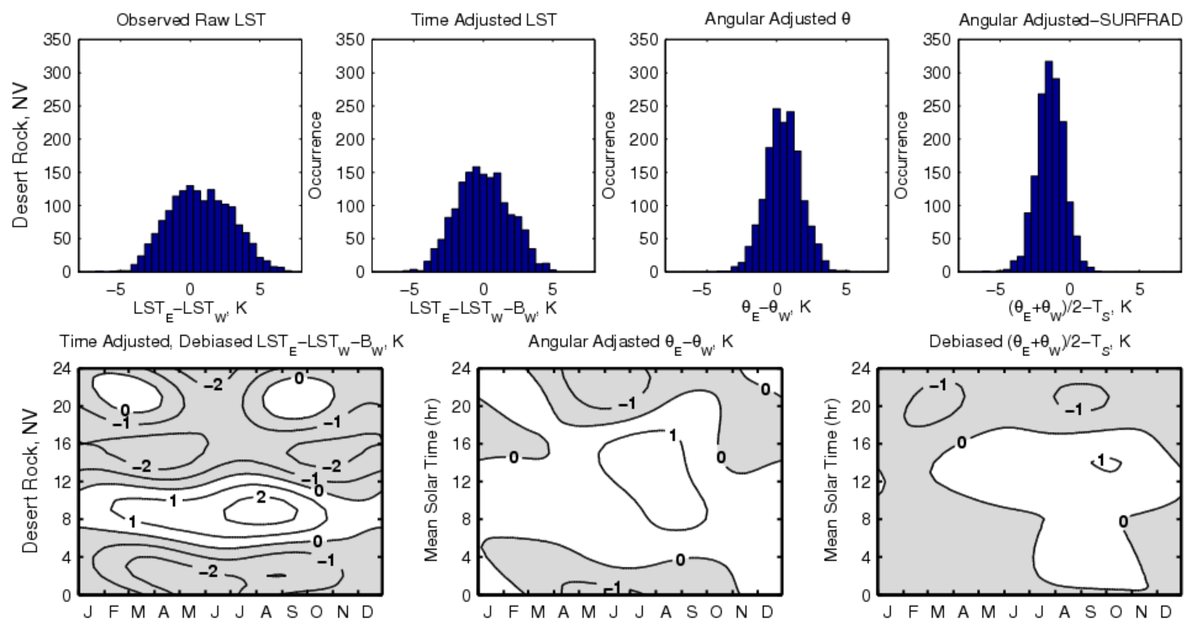


Figure 1. Top panels: progressive narrowing of the statistical distribution of raw differences of GOES-EAST and GOES-WEST observed LST at the location of SURFRAD station Desert Rock, NV as a result of time and angular adjustment. The top panels present the statistical distribution of the difference between satellite- and surface-observed LST. Bottom panels: Seasonal and diurnal variation of time adjusted debiased differences of observed (T_E-T_W-B_W), angular adjusted differences (ϑ_E-ϑ_W), and debiased differences of (ϑ_E+ϑ_W)/2-T_S. T_S here is surface observed LST.

In order to illustrate the overall improvements achieved by the statistical distribution of the difference between LST observed from GOES-EAST and GOES-WEST at Desert Rock, NV, it is presented in the upper row of panels in Figure 1. The first panel displays the initial distribution of the raw differences (T_E–T_W), which contain the 15-minute time mismatch between the observations of the two satellites. After time shift (and constant bias B_W) adjustment, the distribution of (T_E–T_W–B_W) is getting noticeably taller and narrower (second panel). Angular correction makes the distribution (ϑ_E–ϑ_W) significantly taller and significantly narrower (third panel). This progressive narrowing of the statistical distribution proves the effectiveness of the proposed angular adjustment technique. In the third panel a significant part of angular anisotropy is corrected, which mainly leaves the residual random error of satellite-retrieved LST. This random error can be decreased $2^{0.5}$ times by averaging observations of two satellites, $\vartheta_{ave} = (\vartheta_E+\vartheta_W)/2$. The statistical distribution of the difference of ϑ_{ave} and T_S is shown in the top-right panel of Figure 1. T_S here is the *in situ* LST obtained at the SURFRAD station. This distribution has an even sharper shape than the others and has a standard deviation of 1.0 K.

Variations of atmospheric air temperature and water vapor profiles are not the source of these errors since both satellites are looking at the same scene. Systematic seasonal/diurnal pattern of the time adjusted debiased difference (T_E-T_W-B_W) between GOES-EAST and GOES-WEST observed LST at Desert Rock, NV, is shown in the bottom-first-left panel in Figure 1. The bottom-middle panel presents the same difference but for angular adjusted temperatures (ϑ_E-ϑ_W). The main components of seasonal and diurnal cycles have been removed by application of the angular adjustment (16-17). The bottom-right panel displays seasonal-diurnal cycles in the difference between the average of the two angular adjusted satellite temperatures and SURFRAD observed temperatures [$(\vartheta_E+\vartheta_W)/2$-$T_S$]. This pattern clearly shows that the proposed angular adjustment technique removes much of the geometric inhomogeneity of satellite LST.

For independent verification of the model, we also used nighttime LST data for CONUS area retrieved from GOES-11 and GOES-13 satellites for year 2011 using single channel LST retrieval technique (PATMOS-x data provided by Andy Heidinger). We were not able to improve analytical expression for the emissivity kernel, compared to one, recommended in our paper (Vinnikov et al., 2012). Nevertheless we obtained next new empirical estimates of the *A* – emissivity kernel coefficient for different land surface types in the emissivity kernel $\varphi(\gamma)=A(1-\cos(\gamma))$, where γ-satellite viewing zenith angle.

Table 1. Independent estimates of A – emissivity kernel coefficients for different land surface types.

Land Surface Type	Number of observation	Coefficient *A*, K^{-1}
ALL	56360769	-0.0070
WATER	6458435	-0.0067
EVERGREEN_NEEDLE	5036467	-0.0071
DECIDUOUS_BROAD	812628	-0.0058
MIXED_FORESTS	1316597	-0.0077
WOODLANDS	5665168	-0.0063
WOODED_GRASS	5909898	-0.0069
CLOSED_SHRUBS	3699217	-0.0069
OPEN_SHRUBS	11267623	-0.0061

GRASSES	7685795	-0.0096
CROPLANDS	6730964	-0.0079
BARE	1604730	-0.0068
URBAN	169972	-0.0085

All estimated values of this coefficient are noticeable smaller compared to the estimated earlier A=-0.0138 K^{-1} for split-windows technique retrieved LST. This means that angular anisotropy of satellite retrieved LST may be different for different LST retrieval algorithms. Work is in progress.

PLANNED WORK

We will continue our work to test, improve and document the developed algorithm for angular correction of GOES-R retrieved LST.

PUBLICATIONS

Yunyue Yu, Dan Tarpley, Jeffrey L. Privette, Lawrence E. Flynn, Hui Xu, Ming Chen, Konstantin Y. Vinnikov, Donglian Sun, and Yuhong Tian, 2012: Validation of GOES-R Satellite Land Surface Temperature Algorithm Using SURFRAD Ground Measurements and Statistical Estimates of Error Properties. IEEE Trans. on Geosci. Remote Sens. 50 (3), 704-713.

Konstantin Y. Vinnikov Yunyue Yu, Mitchell D. Goldberg, Dan Tarpley, Peter Romanov, Istvan Laszlo, and Ming Chen (2012), Angular anisotropy of satellite observations of land surface temperature, Geophys. Res. Lett., 39, L23802, doi:10.1029/2012GL054059.

Performance Metrics	**FY12**
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	2
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	0

- Aircraft Observations in Support of GOES-R

TASK LEADER Russ Dickerson & Jeff Stehr
TASK CODE RDRDFCAWG11 & RDRDGOESR11
NOAA Sponsor Richard Artz
NOAA Office OAR/ARL
Main CICS Research Topic Future Satellite Programs: Scientific support for the GOES-R Mission; Calibration and Validation
Percent contribution to CICS Themes Theme 1: 75%; Theme 2: 25%
Percent contribution to NOAA Goals Goal 1: 25%; Goal 3: 75%

Highlight: We employed aircraft profiles to determine a relationship between fine particle mass concentrations measured at ground level and satellite aerosol optical depth. Satellite measurements of aerosol optical depth from NOAA satellites can now be used to fill gaps between monitors and between sampling times in the fine particle monitoring network.
Web page: http://www.atmos.umd.edu/~RAMMPP/archives/ArchiveFlightData.html

Background:
Fine particle pollution is both deadly and poorly measured. Current routine monitoring of fine particle concentrations is largely bound to ground level, consisting of filters collected and weighed after 24-hour exposures. For health effects studies and fine particle forecasting, more measurements of fine particle concentrations that are more detailed in space and time are sorely needed. Some headway has been made by using satellite data to fill these gaps. Health effects investigators have used data from the once-daily MODIS satellite overpass to improve the spatial resolution of their exposure models, though the temporal resolution is still limited. Determining the link between column aerosol optical depth and the ground level fine particle concentrations that harm people would be a boon to air quality forecasters and environmental health researchers. In this task, we aim to tie the geostationary observations from GOES and the new GOES-R satellite to particulate concentrations at ground level. To this end, we have measured profiles of fine particle properties from aircraft and found a relationship between satellite aerosol optical depth and ground level fine particle concentrations by using measurements from our aircraft.

Accomplishments:
The University of Maryland light aircraft platform has been upgraded with aerosol instruments and an inlet capable of passing particles up to 5 μm in diameter for this project. The platform can now measure particle scattering, absorption, size distribution, number density, and absorbing particulate (soot) mass. These measurements can then

be used to calculate the mass and garner aerosol type information from the size distribution, absorption and scattering.

We fly our aircraft upwind and downwind of the Baltimore-Washington, D.C. urban corridor in spirals from the ground up to 3000 m altitude over small airports with nearby fine particle monitors. A relationship is then established between the fine particle mass concentrations measured at nearby ground level monitors and the lowest 500 m of an aircraft profile. From this relationship, one can then determine the fine particle loading through the rest of the aircraft column and tie this to satellite results.

Detailed fine particle size measurements during the 2011 DISCOVER-AQ campaign found that most particles in the eastern United States are smaller than 1 μm in diameter. A measurement of fine particle mass fast enough for aircraft use does not currently exist, so faster optical measurements that are closely related to mass must take their place. Fortunately, the small size of the particles in the eastern United States means that they scatter and absorb visible light efficiently. The measurements on board the University of Maryland research aircraft use visible and near infrared light, so these measurements can be expected to correlate with mass near ground level.

Using the lowest portions of University of Maryland aircraft fine particle profiles and nearby measurements of ground level fine particle mass concentrations, our colleagues at NOAA/NESDIS were able to establish a relationship between ground level fine particle mass and GOES aerosol optical depth (Figures 1 and 2).

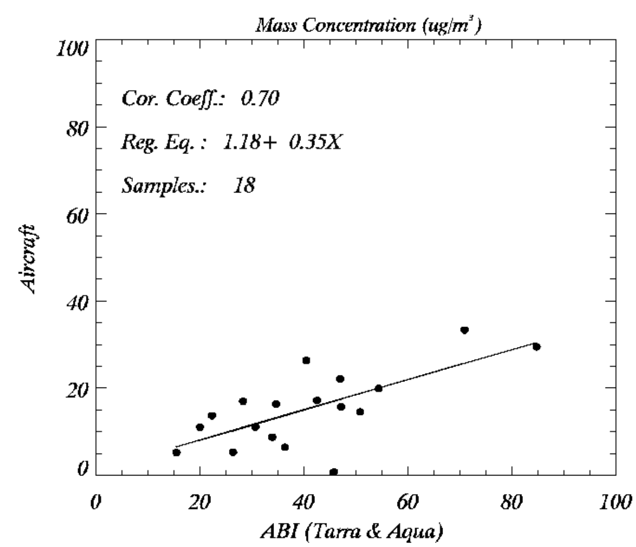


Figure **1**. *Correlation between aerosol mass as calculated from the UMD Aircraft observations averaged over the entire profile column and that from the ABI observations on board Terra and Aqua, assuming water particles. The correlation is good, and the slope will improve substantially when the density assumed for fine particles is increased. Figure courtesy of S. Kondragunta.*

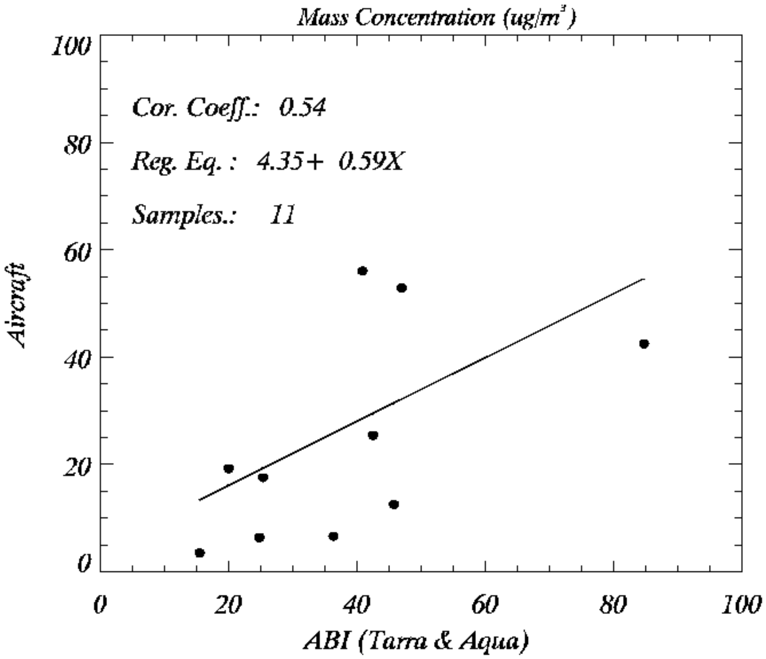


*Figure **2**. Correlation between fine particle mass derived from the UMD light aircraft for water particles when averaged over the lowest 500 m vs. that derived from ABI. Note that the slope improves because the measurements are closer to the ground monitor, and should approach 1 when the density is increased from 1.0 to 1.5. Figure courtesy of S. Kondragunta.*

In Figures 1 and 2, the fine particle size distribution measured by the University of Maryland research aircraft was used to calculate the mass of a spherical particle by first calculating its volume and assuming that it had the density of water. A subsequent literature review has revealed that particle densities in the Eastern U.S. are roughly 50% higher, which would bring the slope of these relationships closer to 1:1, especially that in Figure 2.

These correlations offer promise, demonstrating clear ties between the optical properties of the particles and mass. At this point, the slope calculated above should be taken as a lower limit. The correlations are to be expected, since much of the fine particle load in the eastern United States is sulfate particles and is highly correlated across broad swaths of the eastern U.S., especially in summer. Sulfate particles are nearly spherical, small, and very efficient at scattering light. We expect, therefore, that a measurement of the aerosol optical depth of such particles would correlate with measurements of their mass since they are well-mixed particles that scatter light efficiently in the wavelengths we are using to measure them.

In the future, we hope to determine whether or not these relationships also extend to winter and to days when the fine particle loading is not so severe. It may also be possible to apply techniques used by health effects exposure modelers to the relationship between fine particle mass and aerosol optical properties to produce a tighter correlation.

Planned Work:

- Measurements of fine particle properties near ground level, with emphasis on seasons other than summer
- Measurements under low particle loads would improve the regressions by extending the dynamic range of concentrations

Publications:

He, Hao, J. W. Stehr, J. C. Hains, D.J. Krask, B. G. Doddridge, K. Y. Vinnikov, T. P. Canty, K. M. Hosley, R. J. Salawitch, H. M. Worden, R. R. Dickerson, “Trends in emissions and concentrations of air pollutants in the lower troposphere in the Baltimore/Washington airshed from 1997 to 2011”, *Atmos. Chem Phys. Discuss*. 13, pp. 3135-3178, 2013, doi:10.5194/acpd-13-3135-2013.

Stauffer, R. M., A. M. Thompson, D. K. Martins, R. D. Clark, D. L. Goldberg, C. P. Loughner, R. Delgado, R. R. Dickerson, J. W. Stehr, M. A. Tzortziou, “Bay Breeze Influence on Surface Ozone at Edgewood, MD During July 2011”, *J. Atmospheric Chemistry*, November, 2012 DOI 10.1007/s10874-012-9241-6.

Presentations:

Jeffrey W. Stehr, S. Kondragunta, Daniel Anderson, Heather Arkinson, Lacey Brent, Daniel Goldberg, Hao He, Christina Liaskos, Allison Ring, Russell R. Dickerson, Samantha Carpenter, P. Ciren, C. Xu, "Moving Toward Continuous Satellite Monitoring of PM2.5 Using the GOES Aerosol/Smoke Product (GASP) and Aircraft Profiles", poster presented at the American Geophysical Union Fall Meeting in San Francisco, CA.

Performance Metrics	FY12
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	2
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	1
# of undergraduate students supported by a CICS task	1

- Development of Algorithms for Shortwave Radiation Budget from GOES-R

Task Leader Rachel Pinker
Task Code RPRPDASR12
NOAA Sponsor Ingrid Guch
NOAA Office NESDIS/STAR/CRP
Main CICS Research Topic Future Satellite Programs: Scientific support for the GOES-R Mission
Percent contribution to CICS Themes Theme 2: 100%
Percent contribution to NOAA Goals Goal 1: 100%

Highlight: A collocated database that matches GERB reference observations with the shortwave (SW) radiative flux algorithm products for ABI as driven with MODIS proxy data has been expanded to: addresses issues of angular matching and algorithm evaluation. Visualization tools for validation have been developed and a manuscript detailing the development and evaluation of the ABI SW radiative flux algorithm is in progress.

BACKGROUND

Under the GOES-R activity, new algorithms are being developed to derive surface and Top of the Atmosphere (TOA) shortwave (SW) radiative fluxes from the ABI sensor. This project supports the development and testing of the STAR effort. Specifically, scene dependent narrow-to-broadband (NTB) transformations and angular distribution models (ADMs) are developed to facilitate the use of observations from ABI. The NTB transformations are based on theoretical radiative transfer simulations with MODTRAN-3.7 using 14 land use classifications based on the International Geosphere-Biosphere Programme (IGBP). This represents an improvement over currently available NTB transformations that consider only 4 land use categories. The ADMs are a combination of MODTRAN-3.7 simulations and the Clouds and the Earth's Radiant Energy System (CERES) *(Loeb et al., 2005)* observed ADMs. The radiative transfer simulations provide information that fills in gaps in the CERES ADMs. The NTB transformations and ADMs have been tested using proxy data from multiple satellites to simulate ABI observations. Initial algorithms were delivered in 2010. The current focus is on validation and improvement.

ACCOMPLISHMENTS

Previously a collocation database has been developed for comparison of GERB observations of TOA SW upward fluxes against those produced with the ABI SW radiative flux algorithm, using MODIS proxy data *(King et al., 2002; Ackerman et al., 1998).* Initial studies showed a large negative bias (-15%) in the comparison of the MODIS-based product against the GERB reference data. Some of the bias was to be expected since an in depth evaluation by *Clerbaux et al. (2009)* found that GERB *(Harries et al., 2005)* fluxes were 7.5% higher than values inferred from the Clouds and Earth Radiant Energy System

(CERES) measurements. They attributed this mainly to absolute calibration differences between the GERB and CERES instruments.

To investigate the bias of the MODIS-based fluxes, we first compared the raw radiances from the GERB and MODIS instruments. Figure 1a shows a sample difference field of GERB minus MODIS radiances on 8 July 2006 at 1100 UTC. Figure 1b shows the negative bias in raw radiance was only -7.6 Wm^{-2} (-10%, on par with the CERES-GERB comparison) rather than the -37.5 Wm^{-2} that had been seen in the comparison of fluxes. A substantial variation in the bias of the radiances was observed between different MODIS swaths due to viewing angle. Since the GERB sensor is higher and geostationary, the viewing angle can differ greatly from the MODIS instrument flying on a lower polar-orbiting satellite.

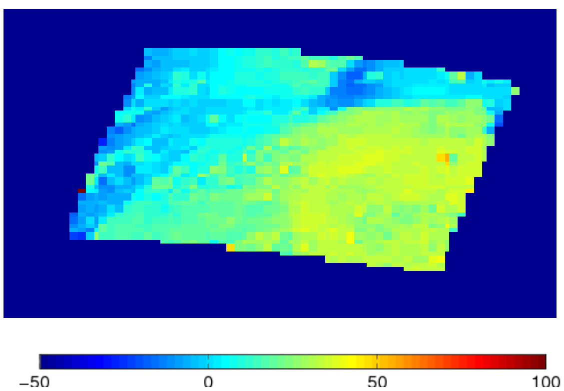


Figure 1a. Difference in radiances ($Wm^{-2}sr^{-1}$) (GERB minus MODIS) on 8 Jul 2006 at 1100 UTC

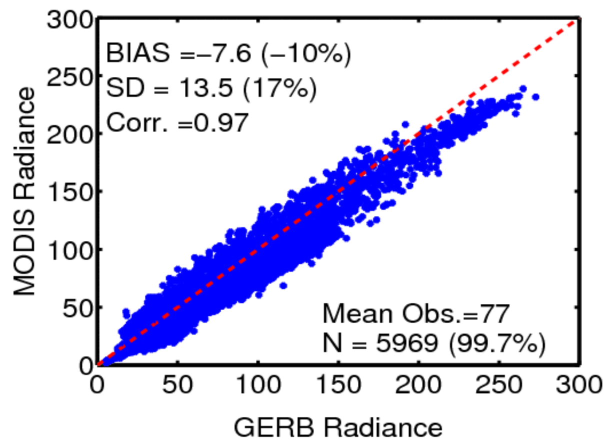


Figure 1b. Comparison of MODIS and GERB radiances ($Wm^{-2}sr^{-1}$) from 4 MODIS swaths on 8 Jul

To separate errors due to viewing angles from those that may be attributed to the ABI SW flux algorithm, we developed procedures to apply a co-angular threshold to ensure the viewing angles of both instruments are within a given range. In their comparison of GERB and CERES radiances, *Clerbaux et al. (2009)* demonstrated that a co-angularity threshold of 8° was sufficient for filtering out radiance differences that could be attributable to view angle. We have built up the collocation database with this additional constraint.

To expedite the evaluation of the ABI SW radiative flux algorithm for comparison to GERB, we have re-written the code that produces the fluxes using MODIS proxy data by applying the NTB transformations and ADMs. The original version of the code written in

FORTRAN ran slowly; we were able to speed-up the process by porting the code to IDL. We have now successfully implemented the NTB transformations and are working to implement the ADMs. We will include an updated version of the ADMs to better characterize scenes where cloud optical depths are larger than 10.

In the *"Deep Dive"* effort of evaluation, we have tested the model sensitivity to different sources of information on aerosols. Used was information as available from MODIS, MISR *(Martonchik et al., 1998; Kahn et al., 2001)* and The Goddard Chemistry Aerosol Radiation and Transport (GOCART) *Chin et al., 2002).* In Figure 2 illustrated are differences in aerosol optical depth between the available information and the impact on surface SW. The evaluation was done against the PIRATA buoys *(McPhaden et al., 1998; Bourle`s et al., 2008)* over the Atlantic Ocean covered well by SEVIRI.

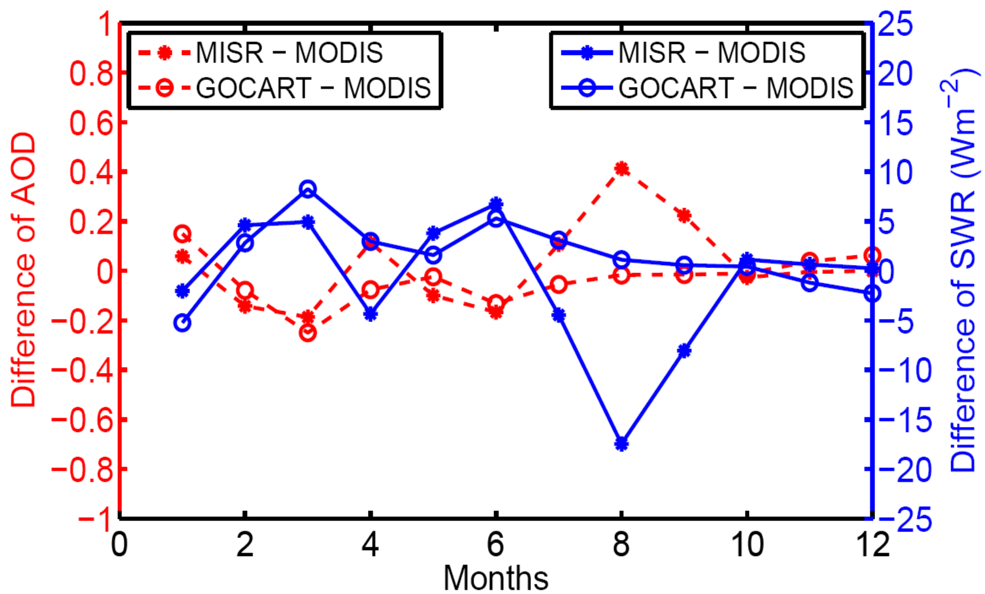


Figure 2. Difference (Δ) in SW fluxes as compared to PIRATA buoy observations ***(blue)*** *due to differences (Δ) in aerosols (MISR, GOCART vs. MODIS)* ***(red)*** *for Feb - Jul 2004.*

PLANNED WORK

• Improve and augment the NTB transformations for water and ice clouds. Additional simulations are needed to more accurately model radiative transfer in atmospheres where water and ice clouds are present.

• Perform additional testing to incorporate view zenith and azimuth angle dependence in the NTB transformations by augmenting the scope of the data base for more robust regression coefficients

• Routine Validation: Generate and visualize comparison statistics with emphasis on stratification for the following categories: clear-sky, cloudy-sky, all-sky, land, water, high elevation, low elevation

- “Deep Dive” validation tool for detailed product analysis
  - Extract all of the information that is pertinent for computing the TOA flux at a point, including: NTB coefficients and ADM correction used, solar and satellite geometry, reflectance in each channel used, surface type, snow cover, cloud amount, cloud type, COD
  - Correlate errors with individual input sources
  - Reprocess fluxes with the ability to change NTB and ADM input values and determine if a better result can be obtained

PUBLICATIONS

Wonsick, M., X. Niu and R. T. Pinker, 2013. Shortwave radiative fluxes from SEVIRI using new algorithms for the Advanced Baseline Imager. In preparation.

PRESENTATIONS

Pinker, R. T., M. M. Wonsick, Y. Ma and I. Laszlo, 2013. Support of Shortwave Algorithms Development for ABI on GOES-R. NOAA Satellite Science Week Virtual Meeting, March 18 – 22, 2013.

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Martonchik, J. V., D. J. Diner, R. Kahn, T. P. Ackerman, M. M. Verstraete, B. Pinty, and H. R. Gordon, 1998. Techniques for the retrieval of aerosol properties over land and ocean using multi-angle imaging, *IEEE Trans. Geosci. Remote Sens.*, 36, 1212–1227.
McPhaden, M. J., et al., 1998. The Tropical Ocean-Global Atmosphere observing system: A decade of progress, *J. Geophys. Res.,* 103, 14,169–14,240.
Pinker, R. T., H. Wang, and S. A. Grodsky, 2009. How good are ocean buoy observations of radiative fluxes?, *Geophys. Res. Lett.,* 36, L10811, doi:10.1029/2009GL037840.

Performance Metrics	**FY12**
# of new or improved products developed	2
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	1
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	0

- GOES-R Active Fire/Hot Spot Characterization - Validation and Refinement of GOES-R/ABI Fire Detection Capabilities

Task Leader Wilfrid Schroeder
Task Code WSWS_VRFD_12
NOAA Sponsor Ivan Csiszar
NOAA Office NESDIS/STAR/SMCD/EMB
Main CICS Research Topic Future Satellite Programs: Scientific support for the GOES-R Mission
Percent contribution to CICS Themes Theme 1: 100%; Theme 2: 0%; Theme 3: 0%.
Percent contribution to NOAA Goals Goal 1: 50%; Goal 2: 50%

Highlight: Deep-dive active fire validation tool is being developed in support of GOES-R/ABI Fire Detection and Characterization (FDC) algorithm. Airborne reference data sets were developed using NASA airborne multispectral sensors flown over fires located in the Western United States.

BACKGROUND

The future GOES-R/ABI fire detection and characterization (FDC) algorithm builds on the Wildfire Automated Biomass Burning Algorithm (WF-ABBA), which originated from GOES VAS data applications [Prins and Menzel, 1992]. The WF-ABBA product provides routine detection and characterization of sub-pixel active fires, serving the fire management community as well as the scientific community. Consequently, WF-ABBA must deliver quality data with well-characterized sources of errors.

Assessment of satellite active fire detection and characterization products requires simultaneous observations in order to reduce the effects of short-term variations in fire conditions [Csiszar and Schroeder, 2008]. Previous studies have used higher spatial resolution satellite data to validate moderate-to-coarse resolution fire products derived from sensors aboard the same orbital platform (e.g., MODIS and ASTER) as well as on separate platforms by limiting the time difference between acquisitions (e.g, GOES and Landsat ETM+) [Schroeder et al., 2008a, b].

By adapting the validation methods developed for GOES and MODIS fire products to GOES-R/ABI data, this project utilizes higher spatial resolution fire reference data to assess and validate the ABI FDC algorithm.

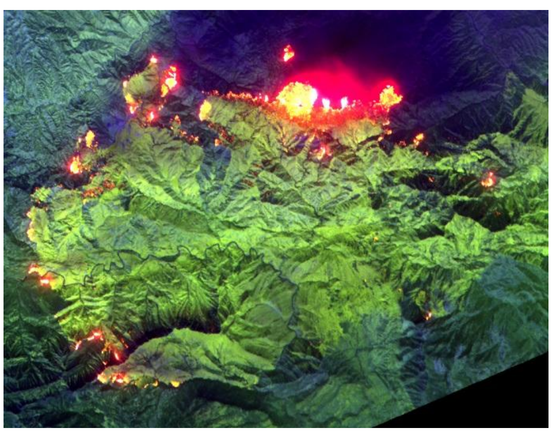
This project is considered highly relevant to the GOES-R mission, as it will allow the refinement of ABI's fire detection product by means of algorithm fine-tuning using independent higher spatial resolution reference data.

ACCOMPLISHMENTS

The main activities implemented under this task were focused on the development of a robust GOES-R/ABI *deep-dive* fire characterization validation methodology using reference data sets derived from multispectral airborne sensors. Reference fire characterization parameters include fire size and temperature, and fire radiative power (FRP).

Previously, fire retrievals were produced for a test reference data set acquired by NASA's Autonomous Modular Sensor (AMS) during a prescribed fire near San Jose, CA in 2011. In order to verify the consistency of those fire retrievals, a new reference data set was obtained from NASA MODIS/ASTER Airborne Simulator (MASTER) for approximately 10 different wildfires in the Western United States. A complete set of MASTER data processing algorithms were developed, along with refined components and data format specifications for the *deep-dive* fire validation tool.

A sample NASA/MASTER image is shown in Figure 1, which depicts the *Day Fire* complex at Los Padres National Forest/CA, 19 September 2006. The subsets show a false color composite of the active fire and background area and the corresponding fire temperature retrieval. Results from the test validation of FRP using GOES Imager data as a proxy for GOES-R/ABI are shown in Figure 2.



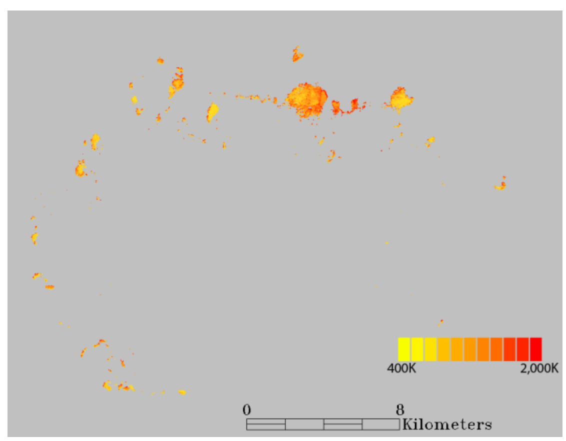


***Figure 1**: Aerial view of the "Day Fire" at Los Padres National Forest in California as imaged by the MASTER sensor onboard NASA's ER-2 high altitude aircraft on 19 September 2006. False color composite depicting fire and background pixels and the corresponding active fire pixel temperature estimates are shown on the left and right panels, respectively.*

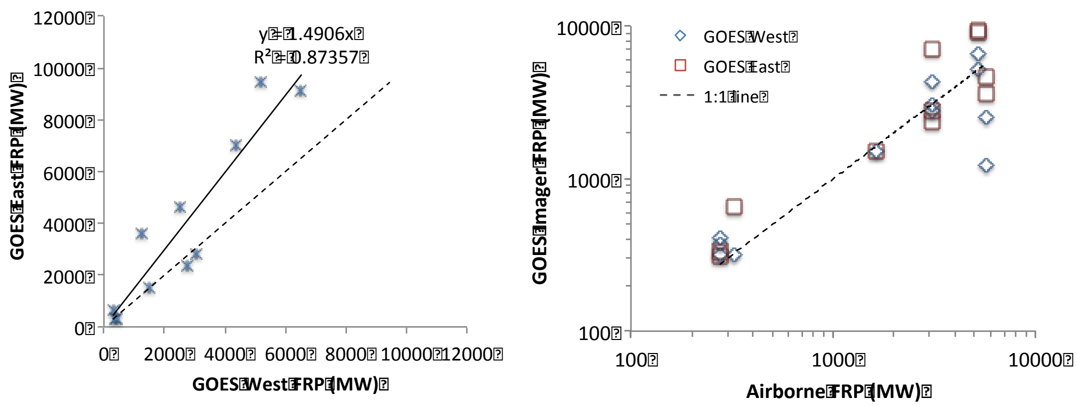


***Figure 2**: Fire radiative power (FRP) retrievals for approximately 10 different wildfires imaged by GOES (East & West) and NASA/MASTER airborne sensor across the Western United States. Scatterplots displaying near-coincident GOES East and West FRP retrieval data (left panel), and near-coincident GOES (East&West) and NASA/MASTER FRP retrieval data (right panel).*

PLANNED WORK

- Develop graphical user interface (GUI) designed to facilitate future operation of validation-tool
- Develop graphical and tabular outputs generated by validation tool
- Validation of ABI's binary active fire data using moderate spatial resolution (e.g., Landsat-class) and airborne imagery: Continue development and testing of fire reference data sets

PRESENTATIONS

Schroeder, W., Csiszar, I., Schmidt, C., 2013. GOES-R/ABI active fire algorithm validation. The 93rd American Meteorological Society Annual Meeting – 9th Annual Symposium on Future Operational Environmental Satellite Systems, Austin/TX, 6-10 January.

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Prins, E., and Menzel, P. (1992). Geostationary satellite detection of biomass burning in South America. International Journal of Remote Sensing, 13, 2783-2799.

Schroeder, W., Prins, E., Giglio, L., et al. (2008a). Validation of GOES and MODIS active fire detection using ASTER and ETM+ data. Remote Sensing of Environment, 112, 2711-2726.

Schroeder, W., Ruminski, M., Csiszar, I., et al. (2008b). Validation analyses of an operational fire monitoring product: The Hazard Mapping System. International Journal of Remote Sensing, 29(20), 6059-6066.

The performance metrics table highlights one new/improved product originated from the fire retrieval algorithm developed for the airborne multispectral sensor data described above.

Performance Metrics	FY12
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	N/A

- Evapotranspiration and Drought Monitoring Using GOES-R Products for NIDIS

Task Leader Christopher Hain
Task Code CHCH_EDMU_12
NOAA Sponsor Xiwu Zhan
NOAA Office NESDIS/STAR/SMCD/EMB
Main CICS Research Topic Future Satellite Programs: Scientific Support for the GOES-R Mission
Percent contribution to CICS Themes Task 1: 50%; Task 2: 50%
Percent Contribution to NOAA Goals Goal 1: 70%; Goal 2: 30%

Highlight: CICS scientists are developing methods to implement the two-source energy balance model, ALEXI, using Meteosat Second Generation data (e.g., LST, LAI, and incoming solar radiation) as a proxy for future GOES-R products to monitor evapotranspiration and drought conditions over Europe.

BACKGROUND

Monitoring evapotranspiration (ET) and the extent and severity of agricultural drought is an important component of food and water security and world crop market assessment. Agricultural systems are climate-sensitive, and conventional surface instrument networks are sparse and report with delays, therefore, satellite remote sensing and modeling play a vital role in monitoring regional water use and providing early warning of impending moisture deficits, and can be used to supplement coarser resolution data from weather and precipitation networks to assess drought conditions. Because land-surface temperature (LST) is strongly modulated by evaporation, thermal infrared (TIR) remote sensing data carry valuable information regarding surface moisture availability and therefore have been widely used to map ET, drought, and vegetation stress. Signatures of vegetation stress are manifested in the LST signal before any deterioration of vegetation cover occurs, for example as indicated in the Normalized Difference Vegetation Index (NDVI), so TIR-based drought indices can provide an effective early warning of impending agricultural drought. Evapotranspiration deficits in comparison with potential ET (PET) rates provide proxy information regarding soil moisture availability, without any need for knowledge of antecedent precipitation. In regions of dense vegetation, ET probes moisture conditions in the plant root zone, down to meter depths. Our group has spearheaded use of anomalies in the remotely sensed ET/PET fraction (f_{PET}) generated with ALEXI as a drought monitoring tool that samples variability in water use, and demonstrating complementary value in combination with standard drought indices that reflect water supply.

Fully automated ALEXI ET and drought monitoring systems have been implemented at 10-km resolution over the continental U.S. using TIR and shortwave information from current GOES instruments. With the launch of GOES-R, our capabilities for ET and drought monitoring will be significantly enhanced due to substantial improvements in spatiotemporal resolution, radiometric accuracy, and cloud-clearing capabilities. With GOES-R, the resolution of ALEXI ESI and ET products can be improved to 2-km. This will significantly improve utility to the drought community and action agencies served by NIDIS, who are demanding drought information at increasingly higher spatial resolution to support decision making at the sub-county scale.

ACCOMPLISHMENTS

During the past year, our research group has collected and archived all necessary MSG-SEVIRI (a GOES-R proxy) input products (e.g., land surface temperature; incoming shortwave radiation; surface albedo; leaf area index) from the Land Surface Analysis Satellite Applications Facility (LSA-SAF) for the year 2012, extending our current climatology to a period of 2007-2012.

All necessary meteorological inputs for ALEXI have also been processed and archived, mainly in the form of daily WRF simulations for each day during the study period. The ALEXI evapotranspiration climatological database (2007-2012) has been processed and archived at 3 km over Europe using the aforementioned input fields. The six-year climatology now serves as the initial period for the computation of the Evaporative Stress

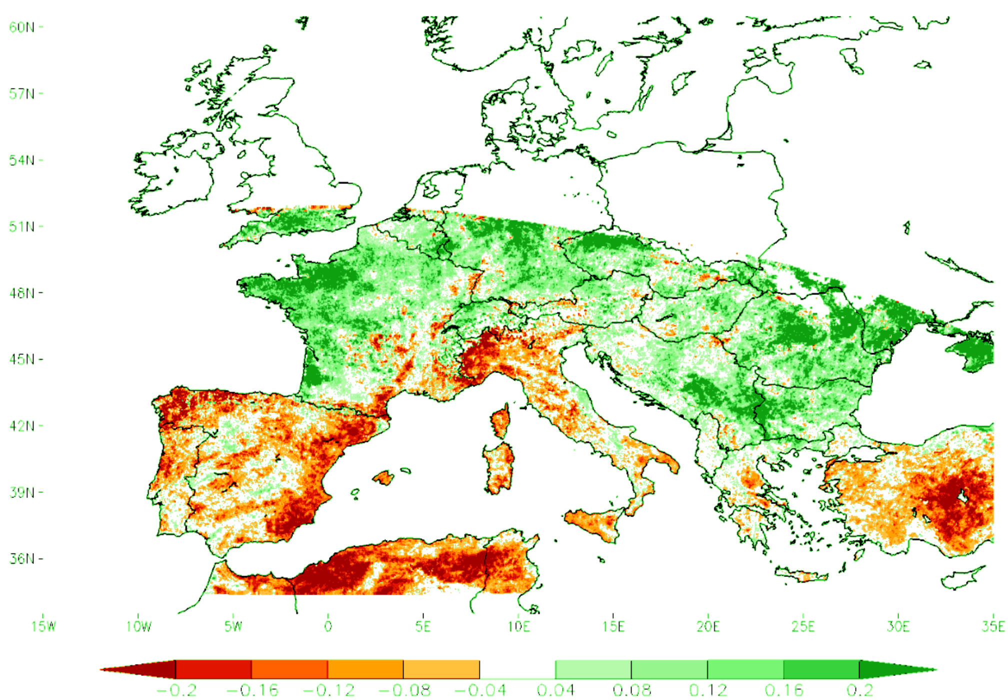


Figure 1. ALEXI Evaporative Stress Index for August 2008

Index (ESI) which has been shown to be an effective drought monitoring tool over the United States. Figure 1 shows the August ESI map, a period where severe drought conditions were observed in the Catalonia Region of Spain (eastern Spain).

ESI shows anomalously dry conditions (evident by negative anomalies in ESI [red shading] over this region. Dry conditions are also observed in ESI in Northern Africa and central Turkey (consistent with documented drought conditions). A significant drought which occurred in Russia during the summer months of 2010 was also captured in this newly developed ESI dataset (Figure 2). This drought largely affected the agricultural portions of Russia and lead to significantly decreased yields in Russia.

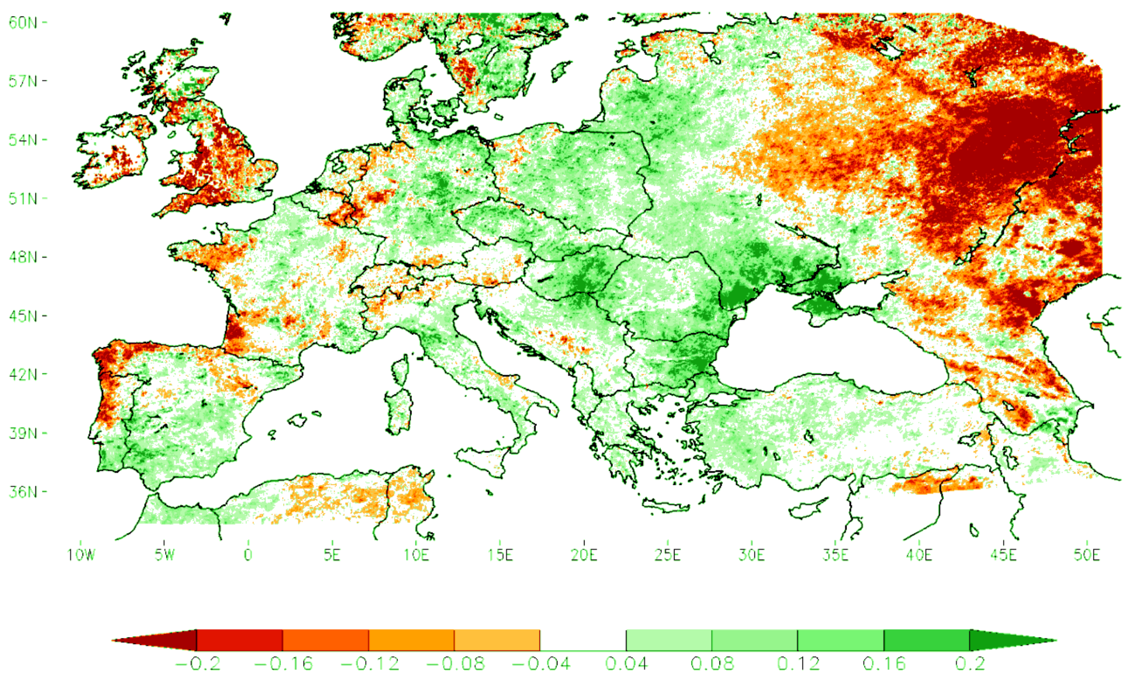


Figure 2. ALEXI Evaporative Stress Index for August 2010.

Assessments of the ESI dataset are currently underway to examine the relationships in ESI with other standard drought metrics such as the Standard Precipitation Index, GLDAS ET and SM products, vegetation indices (e.g., Vegetation Health Index, NDVI), and passive microwave soil moisture products. Also, ESI maps are being compared to drought classification maps produced by the European Drought Observatory. A manuscript is currently is draft form and will be submitted based on these findings.
While ESI (anomalies in actual to potential ET) has been shown to be an important drought indicator, actual evapotranspiration estimates from ALEXI provide a unique opportunity for monitoring actual water use from space. A six-year climatology (coincident with the current ESI climatology) of daily ALEXI ET estimates has also been produced.

Estimates of daily ET from ALEXI is only possible when cloud-free conditions are observed during the morning periods, however, our research group have developed gap-filling methods to estimate ET during cloudy periods. We are currently testing two methods: (a) one that assumes constant evaporative fraction (ET divided by available energy) during cloudy intervals and (b) one that attempts to fit a spline interpolate to the time series of clear-sky evaporative fraction. Assessments of the ALEXI ET dataset are also currently underway using all available eddy covariance flux observations from the FLUXNET database. ALEXI ET is also being compared to model-based ET from the GLDAS project.

PLANNED WORK

A quantitative evaluation of 3-km evapotranspiration and drought products over Europe for 2007-present using ground-based flux observations, other satellite and model-based ET estimates and all available standard drought metrics.

PRESENTATIONS

Hain, C. R., M. C. Anderson, X. Zhan and M. T. Yilmaz. “Monitoring evapotranspiration and water resources with thermal infrared geostationary sensors: An intercomparison with model-based ET predictions and tower observations”, 93nd Annual Meeting of the American Meteorological Society in Austin, TX 6-10 January 2013 [INVITED].

Hain, C. R., M. C. Anderson, X. Zhan and M. T. Yilmaz. “Monitoring evapotranspiration and water resources with thermal infrared geostationary sensors: An intercomparison with model-based ET predictions and tower observations”, American Geophysical Fall Meeting in San Francisco, CA 3-7 December 2012 [INVITED].

Hain, C. R., M. C. Anderson, X. Zhan and W. P. Kustas. "Monitoring evapotranspiration from space: Methodology and Applications", Urban and Rural Meteorology Workshop in Jeju, South Korea 27-29 August 2012 [INVITED].

Hain, C. R., X. Zhan, M. C. Anderson, and J. R. Mecikalski. "Evapotranspiration and drought monitoring using GOES-R proxy data", 2012 NOAA Satellite Science Week in Kansas City, MO 30 April - 4 May 2011.

Performance Metrics	**FY12**
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	4
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	0

1.4b Scientific Support for the JPSS Mission

- Enhancing Agricultural Drought Monitoring Using NPP/JPSS Land EDRs for NIDIS

Task Leader Christopher Hain
Task Code CHCH_EADM_12
NOAA Sponsor Xiwu Zhan
NOAA Office NESDIS/STAR/SMCD/EMB
Main CICS Research Topic Future Satellite Programs: Scientific Support for the JPSS Mission
Percent contribution to CICS Themes Task 1: 33%; Task 2: 33%; Task 3: 33%.
Percent Contribution to NOAA Goals Goal 1: 70%; Goal 2: 30%.

Highlight: CICS scientists are developing methods to implement new Land EDRS from the NPP/JPPS system in the NASA Land Information System to quantify the impacts of these new products towards improving agricultural drought and soil moisture monitoring.

BACKGROUND
Monitoring land surface soil moisture (SM) and the extent and severity of agricultural drought is an important component of food and water security and world crop market assessment. Because agricultural systems are climate-sensitive, and conventional ground instrument networks are sparse and report with delays, satellite remote sensing and modeling play a vital role in monitoring regional water use and providing early warning of impending moisture deficits, and can be used to supplement coarser resolution data from weather and precipitation networks to assess drought conditions. Because land-surface temperature (LST) is strongly modulated by evaporation and vegetation transpiration that are highly dependent on soil moisture conditions, LST remote sensing data carry valuable information regarding surface moisture availability and therefore have been widely used to map ET, drought, and vegetation stress. Land surface albedo (Al), surface type (ST) and green vegetation fraction (GVF) also directly impact the energy balance of land surface, and thus, accurate information of Al, ST and GVF are all critical to the soil moisture estimates and drought monitoring.

Near real time satellite data products of LST, Al, GVF or NDVI, and newer global land cover or surface type maps have been or are becoming available from NOAA AVHRR, NASA MODIS, or NPP/JPSS routinely or operationally. However, none of these valuable data products has been utilized in the routine runs of NLDAS or GLDAS. Therefore, we propose to develop new or examine existing algorithms for assimilating NPP/JPSS LST, Al, GVF/VI and ST data products into NLDAS and GLDAS to enhance the simulations of root-zone soil moisture and in turn to improve the drought monitoring products. As part of the NOAA JPSS program, a soil moisture (SM) EDR will be generated from the second Advanced Microwave Scanning Radiometer (AMSR2) of JAXA's GCOM-W mission that will be launched in early 2012. An ensemble Kalman filter data assimilation algorithm has been tested to assimilate satellite soil moisture data product from AMSR-E and SMOS. Once AMSR2 SM EDR becomes available, it will be assimilated into NLDAS/GLDAS simultaneously as the above NPP/JPSS Land EDRs.

ACCOMPLISHMENTS

The NPP/JPSS land EDRs used in this study are VIIRS surface type (ST; see Fig. 1), land surface temperature (LST), albedo (Al), and vegetation index (VI). The 750 meter resolution data of ST, LST, Al, and VI are extracted from the VIIRS HDF5 files and re-gridded or re-sampled to 0.125 degree lat/lon grids for use in NLDAS and to 0.25 degree grids for GLDAS. All available NPP/JPSS VIIRS data in the project years are currently being processed (Fig. 1). So far about one half year of these land product data files have been collected since September 2012. In addition, the performances of TOC_NDVI and TOC_EVI have been examined with MODIS land products over the same period. These data files of NPP/JPSS surface type, monthly albedo and GVF, daily LST and VIs including NDVI and EVI are being processed and implemented in various land surface models (LSM) in NASA Land Information System (LIS) to assess their impacts on soil moisture simulations, which are essential for drought monitoring.

Accurate information on surface type is critical to the soil moisture estimates and drought monitoring. Regional surface type changes and its potential influence on regional drought-monitoring have begun to be studied. Since China has experienced rapid economic development and made the dramatic land cover change in past 30 years, AVHRR and MODIS land cover are employed to test five sophisticated land surface models (LSMs) performance, including Noah 2.7.1, Noah 3.2, Mosaic, Catchment and CLM 2.0, on surface type changed over China Mainland with in-situ observations of relative soil moisture data. From the comparison, it is apparent that dramatic land cover changes in China have occurred in past 20 years. The land cover from 2007 to 2010 is more homogeneous than it was in the early1990s. In addition, the bare ground area has increased significantly in Northwest China, and Woodland that is defined as trees exceed 5m in height and can be either evergreen or deciduous has replaced by mixed forest defined as forests with interspersed tree mixtures. The dramatic land cover change has a significant effect on the performances of the five aforementioned LSMs (Fig. 2). It is shown that the fives LSMs all have a better performance when driven by MODIS surface type. The relationships for each station between in-situ observational relative soil moisture stations and soil moisture simulated by LSMs are all more reasonable with MODIS land cover than with AVHRR land cover. However, Noah 2.7.1, Noah 3.2, Mosaic and Catchment only have the regional improvement: Catchment, Mosaic and Noah models show better performance in northern China, southern China and central China, respectively. But CLM 2.0 is the most sensitive to change land cover for the entire study domain. This analysis is ongoing and will continue to assess the impact of additional NPP/JPSS VIIRS data on the simulation of soil moisture and surface fluxes over China.

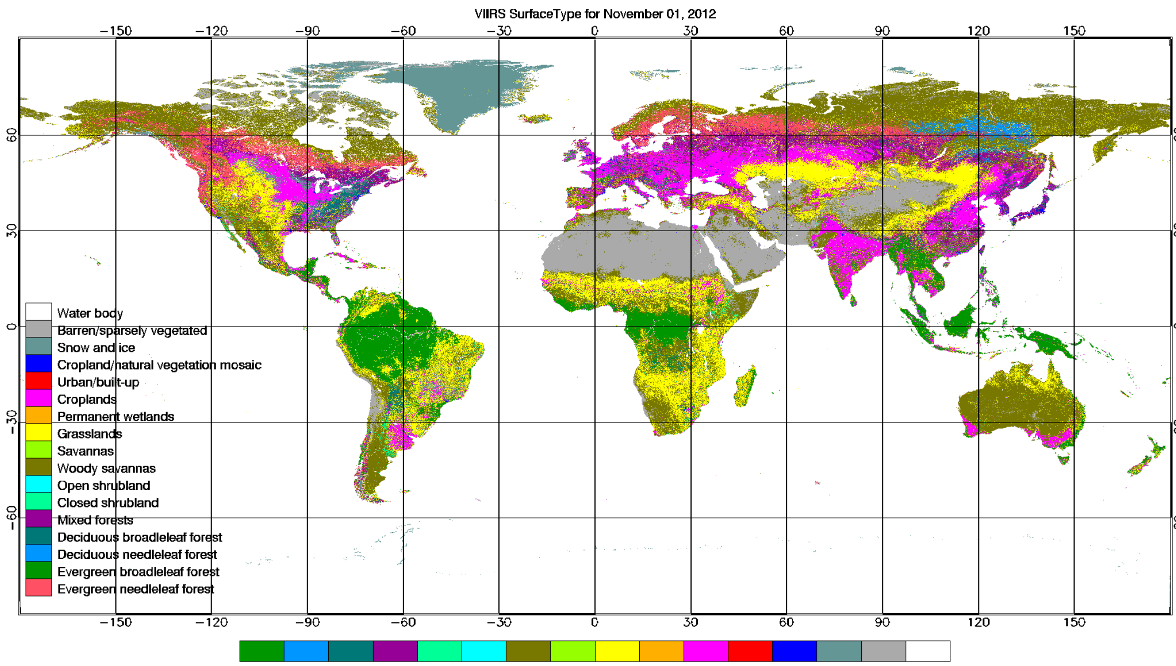


Fig.1 Global VIIRS Surface Type (ST) with 0.25 degree resolution extracted from the 750 meter resolution NPP/VIIRS HDF5 files.

Performance Metrics	FY12
# of new or improved products developed	0
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	1
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	0

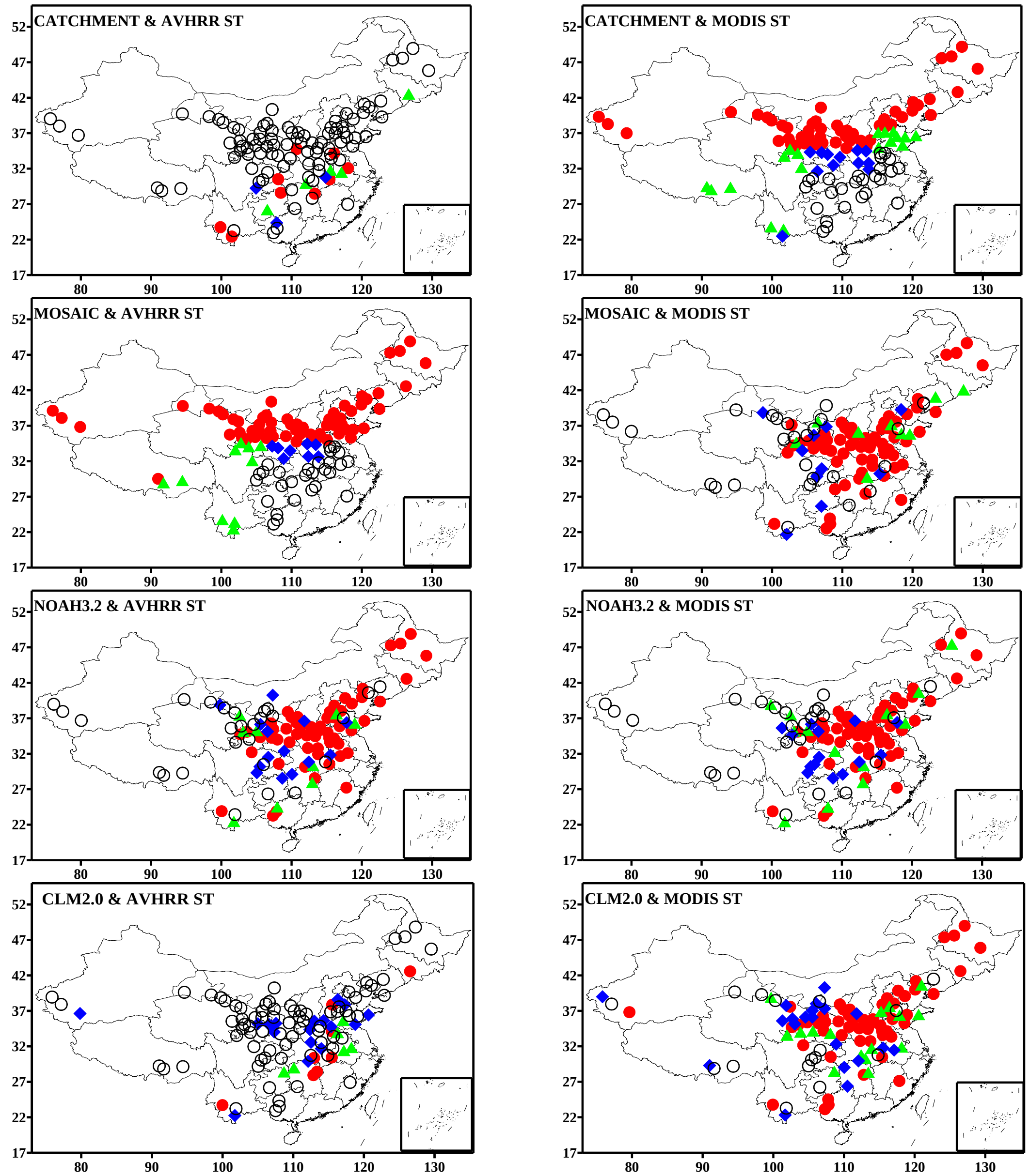


Figure 2. Relationships for each station between in-situ observational relative soil moisture and soil moisture simulated by land surface models with AVHRR and MODIS land cover over China mainland. The samples are 72, since there are 72 ten-days in study period. And the black circle, blue square, green triangle and red dot indicate non-significant and significant with credibility level 0.05, 0.01 and 0.001 separately.

PLANNED WORK

Ongoing and future work will focus on:

- Implement/test data assimilation algorithm in NLDAS;
- Build a climatological database of NLDAS simulations from 2002-present;
- Assimilate the new NPP/JPSS ST, LST, Al, and GVF/VI data products;
- Evaluate assimilation results of soil moistures against ground measurements;
- Generate drought monitoring products from assimilation results and their climatological database;
- Evaluate drought monitoring products against standard drought indices and historical drought records;
- Demonstrate the NPP/JPSS land data assimilation system for drought monitoring to NCEP and NIDIS.

PRESENTATIONS

Zhan, X., **C. R. Hain**, J. Liu, W. Zheng, L. Fang, M. C. Anderson, W. T. Crow, J. Meng, J. Dong and M. Ek. "Preparations for Assimilating Land Surface Observations from GOES-R, NPP/VIIRS and AMSR2 in NCEP NWP Models", 93rd Annual Meeting of the American Meteorological Society in Austin, TX, 6-10 January 2013.

- Development of a snowfall detection and rate algorithm for ATMS

Task Leader Cezar Kongoli
Task Code CKCK_DSDA_12 & CKCK_DSDA_EO
NOAA Sponsor Ingrid Guch
NOAA Office NESDIS/STAR/CRP
Main CICS Research Topic Future Satellite Missions (i) Scientific support for the JPSS Mission
Percent contribution to CICS Themes Theme 1: 70%; Theme 2: 30%; Theme 3: 0%.
Percent contribution to NOAA Goals Goal 1: 20%; Goal 2: 80%

Highlight: A new method for snowfall detection and an improved technique for the retrieval of snowfall rate using ATMS measurements are being developed. The new snowfall detection method uses principal components and logistic regression to compute the probability of snow-fall.

BACKGROUND

This report summarizes the year-1 work for a new proving ground task in support of the ATMS satellite. The goal of this task is to develop a new method for snowfall detection and an improved technique for the retrieval of snowfall rate. Currently, the operational AMSU snowfall detection algorithm makes binary determinations (snowfall versus no snowfall) based on a decision tree classification scheme. The new method will use principal components and logistic regression to compute the probability of snowfall. This work will leverage a dataset matching tool developed for another CALVAL project. The improved snowfall rate algorithm, on the other hand, will leverage a CloudSat database to derive an ATMS brightness temperature-based algorithm for Ice Water Path. Its utility will be initialization of the Radiative Transfer-based inversions for improved retrieval of snowfall rate.

The following is a summary of accomplishments since this project started in January 2013 and future work for the rest of the year.

Accomplishments and future work

- *Ice Water Path Initialization and ATMS TB Simulations for ATMS Snowfall Retrieval (Nai-Yu Wang)*

To accomplish the first guess of ice water path (IWP), coincident CloudSat reflectivity and MHS brightness temperature (TB) observations from winter seasons from 2006 to 2010 are used to develop the relationships between CloudSat derived IWP and MHS TBs. The vertical layer of ice water content (IWC) is estimated by matching the CloudSat observed and simulated reflectivity bin by bin based on the single scattering calculations of non-spherical ice particles and Gamma drop size distribution (DSD). IWP is then obtained by integrating the entire vertical column of IWC. To avoid the ground clutter issue known in CloudSat, bins below 1.2 km are not used in the calculation. In order to investigate the IWP-TB climate regime dependence, surface temperature and specific humidity data from ECMWF ERA 40 are incorporated into the data analysis. If the regime dependence is observed, a regime-dependent (on surface temperature, and/or total precipitable water) IWP-TB relationships will be derived. To extend the AMSU-B/MHS algorithm to the NPP ATMS, clear sky radiative transfer model simulations will be conduct to include the additional ATMS channels.

- *Development of a new ATMS Snowfall Detection method (Cezar Kongoli)*

As part of this project, the new probability-based method is initially being developed for the AMSU-MHS sensor. The goal of this initial step is to a) establish the methodology for the heritage AMSU-MHS sensors (NOAA-18, -19 and MetopA) using an extend dataset, b) apply this methodology to improve the existing operational snowfall detection algorithm, and c) apply this methodology for the ATMS sensor.
The methodology consists of two steps: principal component analysis to determine the most significant uncorrelated components that capture most of the variability in the AMSU/MHS channel measurements, and logistic regression with the principal components as independent variables to the logistic regression model. The training dataset for the AMSU/MHS has been assembled and consists of NOAA-18, -19 and MetopA /MHS measurements and in-situ snowfall station data for the 2009-2010 snow seasons. A total of about 80,000 matched data points have been assembled with a good representation of cold snowfall occurrences, e.g., in Alaska. Principal component analysis is being conducted to establish the optimal configuration that can yield the best performance. Once this methodology is established, it will be applied to ATMS data.

- CrIMSS Rain Flag

Task Leader Wenze Yang
Task Code RFRFJPAT_11
NOAA Sponsor Ralph Ferraro
NOAA Office NESDIS/STAR/CRPD/SCSB
Main CICS Research Topic Scientific Support for the Future Satellite Missions: (ii) Scientific support for the JPSS Mission
Percent contribution to CICS Themes Theme 1: 70%; Theme 2: 30%; Theme 3: 0%
Percent contribution to NOAA Goals Goal 1: 20%; Goal 2: 80%

Highlight: By comparing to a suite of dataset, defects of the CriMSS NGAS EDR rain flag has been found. A reasonable initial and update set of MSPPS-like products for ATMS have been developed, the underlining algorithm will be suitable as a substantial upgrade to the current CrIMSS rain flag.

BACKGROUND

The NPOESS Preparatory Project (NPP) satellite of NOAA was launched on Oct 28, 2011. On-board sensors on this satellite include the Cross-track Infrared Sounder (CrIS) and Advanced Technology Microwave Sounder (ATMS), which together would provide the Cross-track Infrared Sounder Microwave Sounder Suite (CrIMSS) Environmental Data Record (EDR), including atmospheric vertical temperature profile, atmospheric vertical moisture profile, etc. The EDR algorithm was originally developed by Northrop Grumman Aerospace Systems (NGAS) for other similar products. The successful operation of the CrIMSS EDR algorithm is a robust verification of the CrIS and ATMS Sensor Data Records (SDRs). Therefore, a task was proposed as a risk reduction for a) the processing of SDRs and EDRs from the CrIS/ATMS, b) the utilization of high spectral resolution infrared data by Numerical Weather Prediction (NWP) centers and c) validation of CrIS/ATMS SDR/EDR algorithms. This project is a subtask to provide algorithm improvements and validation in the area of clouds and precipitation.

The goals of CICS JPSS effort are to i) perform inter-comparisons between the current CrIMSS ATMS cloud water, ice water and precipitation screens with operational derived products, including the MSPPS and MiRS system; ii) document deficiencies of the current NGAS scheme; iii) develop improved clode/ice water and precipitation schemes for use within CrIMSS; iv) document the improvements through inter-comparisons with NGAS scheme; and v) propose an improved rain algorithm to CrIMSS team.

The current NGAS scheme and MSPPS system are based on AMSU-A/B/MHS radiances, so the update of the algorithm is necessary. Additionally, the NGAS scheme used a very preliminary MSPPS algorithm that is several years outdated.

The rain flag information is obtained from ATMS. Comparing to its predecessor AMSU-A/B/MHS, ATMS has some updates regarding to channel frequency and polarization, in addition to spatial resolution. These updates are summarized in Table 1.

ACCOMPLISHMENTS

Our accomplishments during the first year of the project are as follow:

Firstly, an initial processing of ATMS SDR data was developed, in particular, for channels that are used within the AMSU/MHS precipitation algorithm generated at NESDIS through the Microwave Surface and Precipitation Processing System (MSPPS). A reasonable initial set of MSPPS-like products for ATMS have been developed and compared with those from the Microwave Integrated Retrieval System (MiRS).

Table 1. Frequency and polarization difference between AMSU and ATMS

AMSU			ATMS		
Ch	GHz	Pol	Ch	GHz	Pol
1	22.3	QV	1	22.3	QV
2	31.4	QV	2	31.4	QV
3	50.3	QV	3	50.3	QH
16	89.0	QV	16	88.2	QV
17	150	QV	17	165.5	QH
18	183.31±1	QH	22	183.31±1	QH
			21	183.31±1.8	QH
19	183.31±3	QH	20	183.31±3	QH
			19	183.31±4.5	QH
20	183.31±7	QH	18	183.31±7	QH

Exact match to AMSU
Only Polarization different
Unique Passband
Unique Passband, and Pol. different from closest AMSU/MHS channels

Secondly, investigations were performed for the May 15, 2012 NPP focus day. Here, the CriMSS NGAS EDR rain flag was compared against the NDE MiRS rain rate and our MSPPS ATMS rain rate product (still under development). Further comparisons were made against the TRMM 2A25 product (e.g., precipitation radar product, considered the most accurate space borne rainfall product). The four panel figure below compares the products for the ascending orbits (note that TRMM is not sun-synchronous so here we just show the entire day of data). Some observations are a) the MSPPS and MiRS rain area coverage is very similar; b) the CrIMSS rain flag has serious issues, in particular, it shows virtually no rain in the Inter Tropical Convergence Zone (ITCZ) and very little rainfall over land, this is due to i) the outdated nature of the algorithm used by NGAS; and ii) the algorithm being implemented incorrectly.

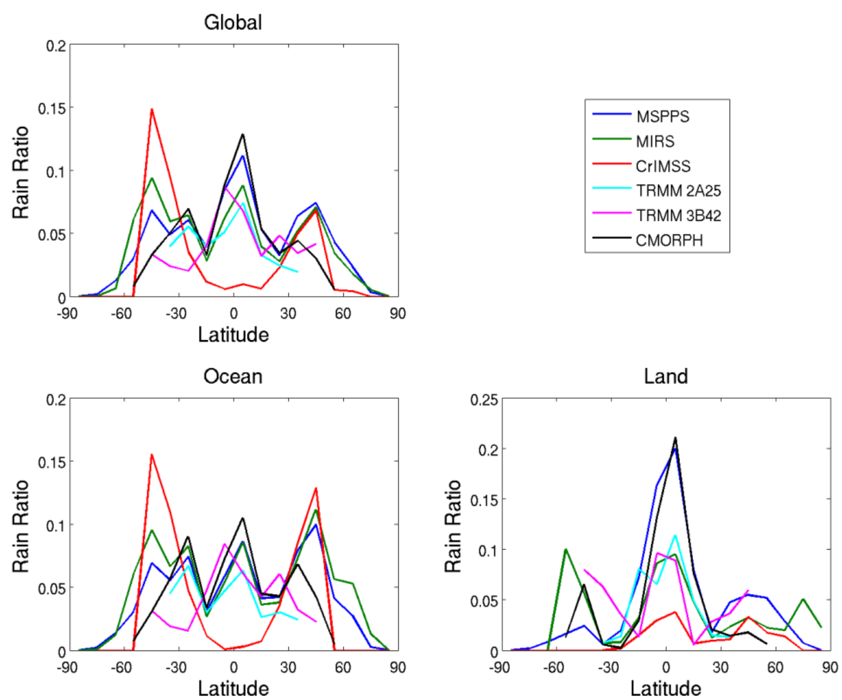


Figure 1. Rain frequency comparison at latitude bands over Global, Ocean and Land using various sets of rain products.

Thirdly, comparisons were made for the May 15, 2012 focus day by adding in additional rainfall product from TRMM and also NOAA's CPC Cloud Morphing Rain Product (CMORPH), as shown in Figure 1. The comparison to the rain frequency of occurrence shown in the figure below confirms previous results, as the TRMM, MiRS, CMORPH and MSPPS products are much more closely related than the current CrIMSS rain flag.

In order to account for sensor differences between AMSU and ATMS (see Table 1), CRTM simulations have been conducted to develop empirical corrections between the two sensors (i.e., make ATMS "look like" AMSU and use directly into the MSPPS rain rate). The largest challenge is the change in the primary polarization. Simulations with the JCSDA CRTM model for clear ocean (Figure 2) and land (Figure 3) scenes reveals that the largest challenges are for the ATMS channel 17 (165.5 GHz) which is one of the more important channels in the MSPPS legacy rain retrieval algorithm. Correction for channel 3 over ocean is also warranted.

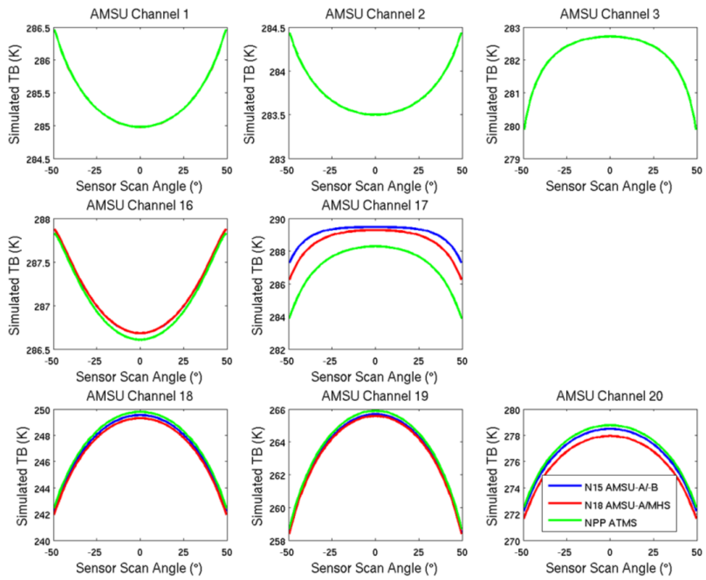


Figure 2. Simulation comparison over ocean of the relative channels among AMSU-A/B, MHS and ATMS.

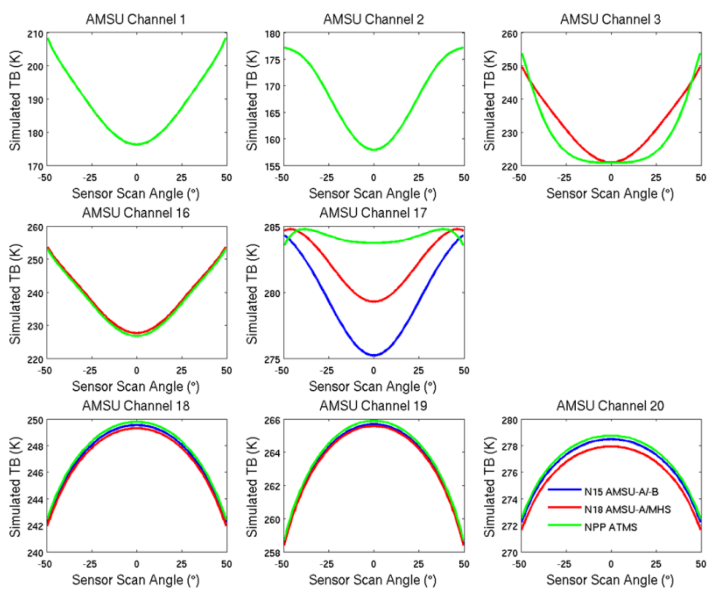


Figure 3. Simulation Comparison over land of the relative channels am among AMSU-A/B, MHS and ATMS.

As a first step to account for these differences, a non-linear fit for channel 3 between the AMSU and ATMS simulations was developed; for channel 17, a non-linear fit that utilizes both channel 16 and 17 was developed is has been tested with fairly good performance; further evaluations will be made in the upcoming quarter. However, it is expected that this algorithm will be suitable as a substantial upgrade to the current CrIMSS rain flag.

PLANNED WORK

Although the improved algorithm developed in the past year is certainly much better than the existing CrIMSS rain flag, Further improvements are planned. We are undergoing final evaluation of the current algorithm; we plan on generating 6 months of swath rain estimates (June – November 2012) from this algorithm and have an independent evaluation and comparison against MiRS and surface rainfall estimates over the CONUS. This work will utilize the STAR Precipitation Cal/Val Center (supported by the STAR Cal/Val program). Upon results that are satisfactory, we will then provide the algorithm to the STAR CrIMSS team who can test it in their parallel system. We would also work with the CrIMSS team in an evaluation of the sounding performances (presumably the ATMS only retrievals) to demonstrate the improvements with the new rain algorithm. The evaluation should include the stratification of the results by land/ocean and different latitude zones where we found the current rain flag to be inadequate.

In the next phase of the effort, an improved algorithm that formulates the use of the ATMS specific channels in the ice water path and diameter size algorithm (the basis for the rain rate algorithm) would be developed and replace the algorithm that uses the proxy channels.

PRESENTATIONS

Yang, W., R. Ferraro, C. Barnet, and M. Divakarla, "Evaluation and improvement of the NPP CrIMSS Rain Flag" (poster), AGU Fall meeting, San Francisco, CA, USA, December 3-7, 2012.

Ferraro, R., W. Yang, C. Barnet, and M. Divakarla, "Evaluation and improvement of the NPP CrIMSS Rain Flag" (poster), 93rd American Meteorological Society Annual meeting, Austin, TX, USA, January 6-10, 2013.

Performance Metrics	**FY12**
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	2
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	N/A

- Satellite Land Surface Temperature and Albedo Development

Task Leader Yuling Liu
Task Code YLYL_TSJL12
NOAA Sponsor Yunyue Yu
NOAA Office NESDIS/STAR/SMCD/EMB
Main CICS Research Topic Future Satellite Programs: Scientific support for the JPSS Mission
Percent contribution to CICS Themes Theme 1: 70%; Theme 2: 30%; Theme 3: 0%.
Percent contribution to NOAA Goals Goal 1: 20%; Goal 2: 80%

Highlight: CICS scientists provided scientific support for Land Surface Temperature and Albedo products, which are the two key environmental data record (EDR) from VIIRS onboard NPP satellite.

BACKGROUND

This work is part of the ongoing Joint Polar-Orbiting Satellite System (JPSS) project "Satellite Land Surface Temperature (LST) and Albedo Development" and represents a continuation and enhancement of previous activities. The research and development in this proposal supports the evaluation and improvement of LST and Albedo Environmental Data Records (EDRs) for the NPP/JPSS mission. The NPP satellite was launched in October 2011, and the first JPSS satellite will be launched in 2016. This project is to provide scientific and technical support on this effort.

The Visible Infrared Imaging Radiometer Suite (VIIRS) provides a majority of the EDRs from the NPP satellite. The VIIRS Land Surface Temperature (LST) which is derived from the VIIRS data collection using a set of dual and split-window regression algorithms, and the VIIRS land surface Albedo which is generated from two types of algorithms as of Dark Pixel Surface Albedo (DPSA) and Bright Pixel Surface Albedo (BPSA), are two of the key EDRs.

This particular task is focused on continuing the post-launch evaluation and refinement of the LST/ Albedo algorithms and to ensure the releases of beta version and provisional version LST/ Albedo products.

ACCOMPLISHMENTS

The NPP VIIRS LST data has been generated since January 2012. A comprehensive assessment of VIIRS LST product has been implemented through the internal evaluation which is focusing on quality flag and metadata check, upstream (SDRs, EDRs and IPs inputs) data check and visualization over space and time; and the external evaluation which focuses on the cross comparison with MODIS LSTs and validation against ground observations collected from *Surface Radiation* Budget Network (SURFRAD), Climate Reference Network (CRN) as well as from China and Africa etc. Some problems have been found and the LST algorithm software and look-up tables (LUTs) therefore have been updated accordingly. In addition, a near real time monitoring is also implemented for LST product under different cloud conditions and surface types. The ground measurements from CRN and SURFRAD are used as reference for the quality monitoring.

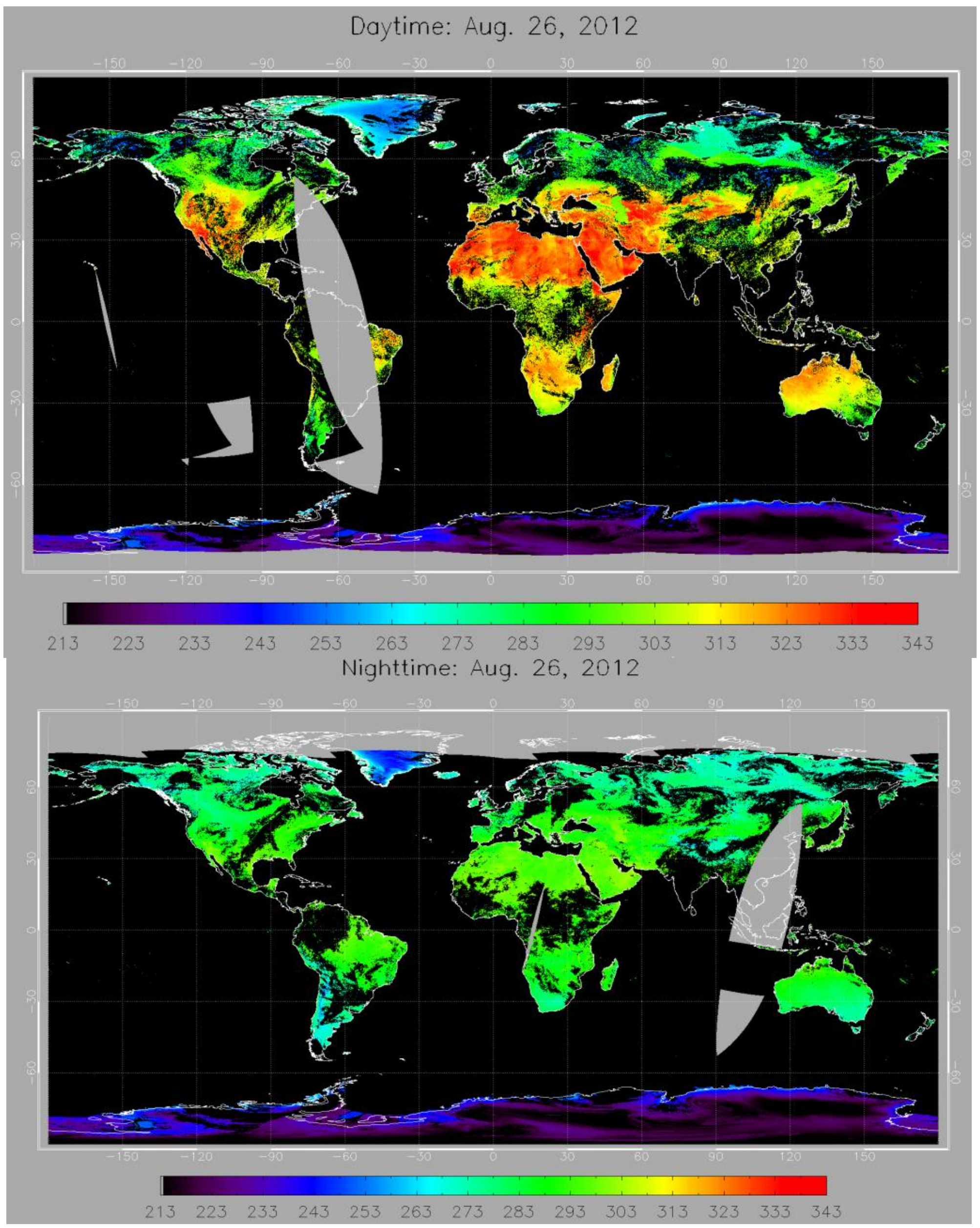


Figure. 1 Suomi NPP VIIRS LST maps for daytime (top) and nighttime (bottom) on Aug. 26,2012

These efforts have finally made the LST product achieve beta maturity in December 2012, which is one of the major milestones for VIIRS LST product. After this, the focus has been turned to improving LST product and supporting tuning for the provisional readiness in May, 2013. The newly generated LUT has been evaluated using ground measurement data and all evaluation results together with radiance based simulation results will be used for corrections of LST algorithm coefficients to achieve a better accuracy. During this period, I finished many technical reports summarizing the findings, issues found and comprehensive evaluation results such as "Report on Beta Release of LST Product" etc. A publication summarizing the evaluations results of VIIRS LST product is under preparation to be submitted to Journal of Geophysical Research-Atmospheres.

PLANNED WORK

- Continue the Evaluation of NPP VIIRS LST/Albedo product
- Improving LST/Albedo product and supporting tuning for the NPP product readiness
- Evaluating the LST/ Albedo product and supporting the development of validation tool
- Update LST/ Albedo software code and ATBD documentation and support the NPP/JPSS Mission Management

PUBLICATIONS

Y. Liu, Y. Yu, D. Sun, D. Tarpley, L. Fang, Effect of Different MODIS Emissivity Products on Land Surface Temperature Retrieval from GOES Series, IEEE Geoscience and Remote Sensing Letters, 2013, 10(3).

Dayong Shen, Yuling Liu, Shengli Huang. Annual Accumulation over the Greenland Ice Sheet Interpolated from Historical and Newly Compiled Observation Data. Geografiska Annaler: Series A, Physical Geography, 2012, 94(3): 377-393. DOI:10.1111/j.1468-0459.2012.00458.x.

Yunyue Yu, Jeffrey P. Privette, Yuling Liu and Donglian Sun, Remote Sensing of Land Surface Temperature, Encyclopedia of Natural Resources (ENR), 2012. (In Press)

Donglian Sun, Yunyue Yu, Li Fang, and Yuling Liu, ''Towards the Operational Land Surface Temperature Algorithm for GOES", Journal of Applied Meteorology and Climatology (In Press)

PRESENTATIONS

Yuling Liu, Yunyue Yu, Dan Tarpley, Xiaolong Wang and Zhuo Wang, "Initial Assessment of Suomi NPP VIIRS Land Surface Temperature(LST) Algorithms", oral presentation at 93rd AMS annual meeting, Jan. 6-10th, 2013, Austin, TX

Cezar Kongoli, Yuling Liu and Yunyue Yu, "Use of GOES-R Proxy Data for Snowmelt Mapping", poster at 93rd AMS annual meeting, Jan. 6-10th, 2013, Austin, TX

Yunyue Yu, Donglian Sun, Li Fang, Yuling Liu, Hanjun Ding, "Developing Operational Land Surface Temperature Product for U.S. GOES Satellites", poster at 93rd AMS annual meeting, Jan. 6-10th, 2013, Austin, TX

Yuling Liu and Yunyue Yu, "Initial Assessment of Suomi NPP VIIRS Land Surface Temperature(LST) Algorithms" , CICS science meeting, Sep.5-7, 2012

Yunyue Yu, Shunlin Liang, Yuling Liu, Dongdong Wang, Ivan Csiszar, "JPSS Land Surface EDRs: Temperature and Albedo", IGARSS 2012 , July 22-27 2012, Munich

Yuling Liu, Yunyue Yu, Sanmei Li, Xiaolong Wang and Dan Tarpley, "Evaluation of the Early Stage NPP VIIRS Land Surface Temperature Product", NPP science meeting, May 10-11, 2012.

OTHER

Certificate of Recognition from JPSS program

Performance Metrics	**FY12**
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	4
# of non-peered reviewed papers	0
# of invited presentations	6
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	0

- Scientific Support for JPSS Instrument Calibration/Cloud Fraction

CICS Task Leader: Zhanqing Li, Hyelim Yoo
Task Code: ZLZL_JPIC11
NOAA Sponsor Fuzhong Weng
NOAA Office NESDIS/STAR/SMCD/SCDAB
Main CICS Research Topic/s Future Satellite Programs: Scientific support for the JPSS Mission
Percent contribution to CICS Themes
Percent contribution to NOAA

Highlight: For a given cloud set of cloud fractions at various model levels, cloud fraction for three representative layers depends on how clouds are arranged vertically. We applied a linear combination of maximum and random overlapping scheme with a weighted factor that is a function of de-correlation length (L_{cf}) and separation distance. The spatial distribution of L_{cf} varies greatly and appears to be a quadratic curve to the total cloud fraction. Use of the observation-constrained L_{cf} leads to an improvement for high-level clouds, has a neutral impact for mid-level clouds and deterioration for low-level clouds.

Task description:

- Median values of de-correlation length for high, mid, low clouds are derived using profiles of cloud fraction obtained from observations.
- Characteristics of changes in cloud fraction of the GFS model due to the application of different cloud overlapping assumptions are described.

Accomplishment in 2012:

- Using CPR cloud mask and radar reflectivity variables from the 2B-GEOPROF product and the cloud fraction field from the 2B-GEOPROF-LIDAR product, de-correlation length for high, mid, low clouds, are calculated.
- Evaluate the impact of cloud overlapping on cloud fraction by applying a linear combination of maximum and random overlapping assumptions with a de-correlation length determined from satellite products
- The data screening for cloud detection is conducted based on a sequence of tests for three conditions.
- A stochastic sub-grid scale cloudy column generator is used to produce synthetic sub-grid-scale columns of cloud by using profiles of cloud fraction derived from observations.

Fifty thousand sub-columns are generated for each cross section of 500 km length. The effective L_{cf} that satisfies the observed cloud fraction is found using Brent's root-finding technique.

Quadratic fits to the curves are $L_{cf\_high} = -4.27C^2+4.60C+0.88$ for high, $L_{cf\_mid} = -9.50C^2+10.72C+1.49$ for mid, $L_{cf\_low} = -5.06C^2+6.40C+0.35$ for low clouds.

Figure 1 illustrates the spatial variation of median values of Lcf for high, mid, low clouds and their variations as a function of total cloud fraction for July 2007. Bottom panel of Figure 1 shows the overall variations of Lcf with total cloud fraction within three representative layers: high, mid, and low. As total cloud fraction changes, the median values of L_{cf} for high and low clouds show a similar pattern that differs from that for mid clouds.

PUBLICATIONS

Yoo, H., and Z. Li, (2012), Evaluation of cloud properties in the NOAA/NCEP Global Forecaster System using multiple satellite product, Climate Dynamics, 10.1007/s00382-012-1430-0

Yoo, H., Z. Li, Y.-T. Hou, S. Lord, F. Weng, H.W. 2013, Barker, Diagnosis and testing of low-level cloud parameterizations for the NCEP/GFS using satellite and ground-based measurements, Climate Dynamics, in revision.

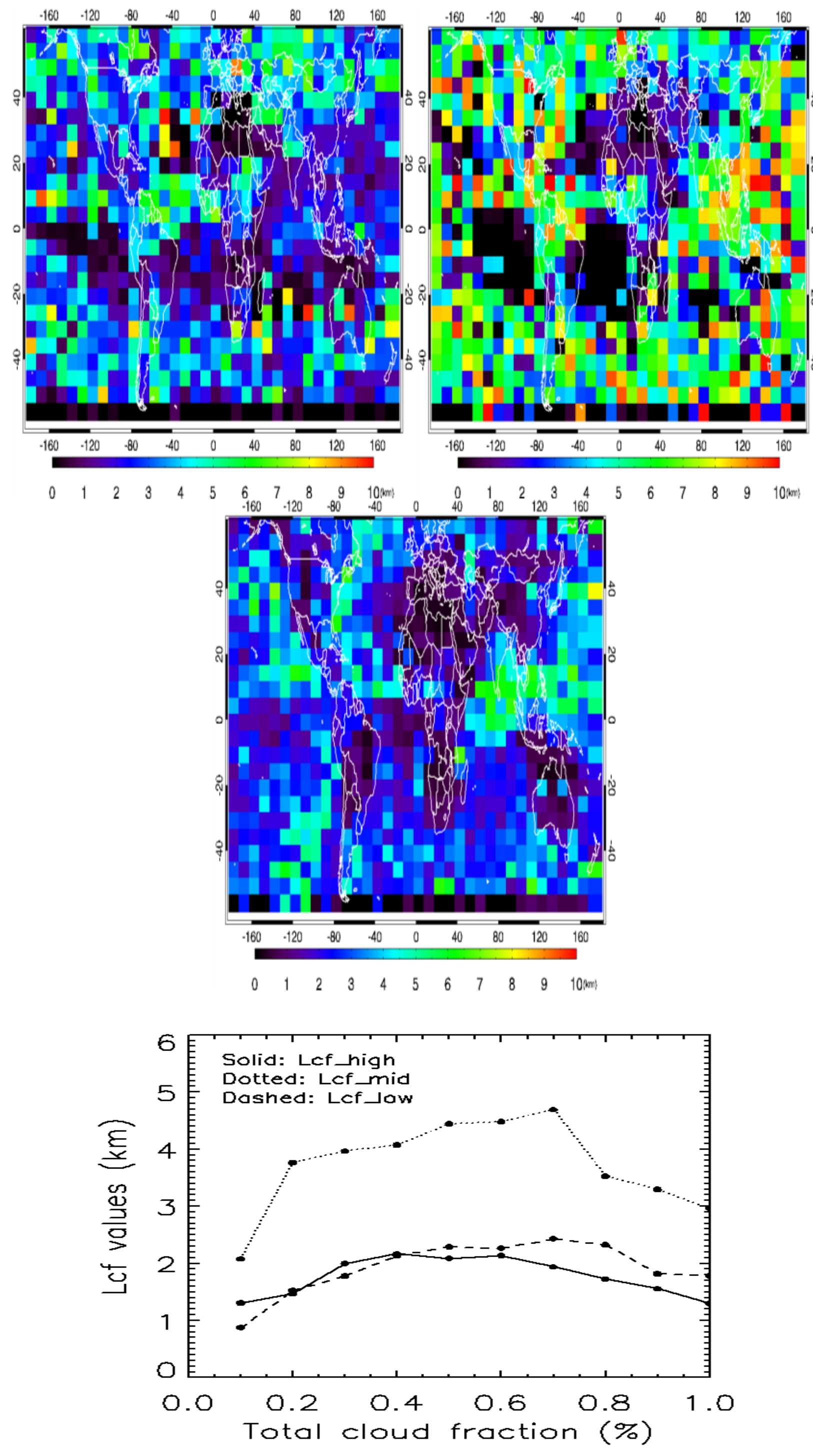


Figure 1. Upper panels: geographic distributions of median values of L_{cf} for high clouds (left), mid clouds (middle), low clouds (right) using a stochastic cloud generator and the C-C data collected in July 2007. Lower panel: median values of L_{cf} for high, mid, low clouds as a function of total cloud fraction.

- Scientific Support for JPSS Instrument Calibration

Task Leader: Zhanqing Li
Task Code: ZLZL_SSJPS12
NOAA Sponsor Fuzhong Weng
NOAA Office NESDIS/STAR/SMCD/SCDAB
Main CICS Research Future Satellite Programs: Scientific support for the JPSS Mission
Percent contribution to CICS Themes Theme 1: 100%
Percent contribution to NOAA Goals Goal 5: 100%

Highlight: Provide NPP/JPSS ATMS SDR calibration/validation support. Develop NPP ATMS instrument performance long-term monitoring and SDR data bias trending system.

Report by Ninghai Sun

BACKGROUND
The Advanced Technology Microwave Sounder (ATMS) onboard the recently launched Suomi-NPP satellite and the future JPSS spacecraft can provide atmospheric vertical profile information to improve numerical weather and climate modeling. ATMS will continue the microwave sounding capabilities provided by its predecessors, the Microwave Sounding Unit (MSU) and Advanced Microwave Sounding Unit (AMSU). Before ATMS data can be ingested into NWP for operations, accurate calibration must be performed.

ACCOMPLISHMENTS
To support NPP ATMS SDR calibration/validation tasks:

- Helped to set up and participated ATMS SDR Cal/Val weekly teleconference
- Generated the first NPP global image
- Generated NPP ATMS instrument quality flag coefficients table for operational IDPS system
- Determined the optimal space view profile
- Provided ATMS channel performance analysis and developed NEDT out-of-spec automatic notification function
- Provided ATMS scan drive main motor current and hundreds of other instrument health status parameter monitoring for anomaly diagnose
- Helped to develop ATMS SDR bias monitoring package
- Developed NPP Spacecraft Status Long-Term Monitoring System
- Ran Algorithm Development Library (ADL) to validate operational ATMS SDR algorithm

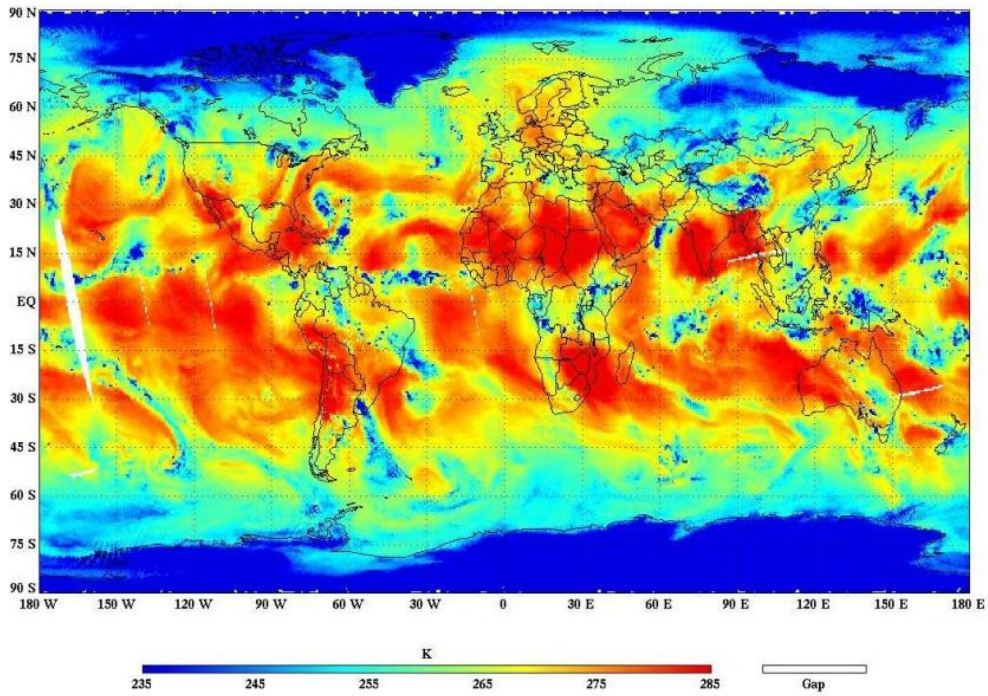


Figure 1: NPP ATMS Channel 18 (183.31±7 GHz) global image, which is the first NPP global image.

ATMS SDR provides instrument health information depending on the on-orbit instrument status trending. An ATMS instrument LTM system is developed to help keep track any anomaly happened in ATMS. The following sample figure is the channel 1 (23.8 GHz) Noise Equivalent Differential Temperature (NEDT), which is the key parameter to assess channel quality.

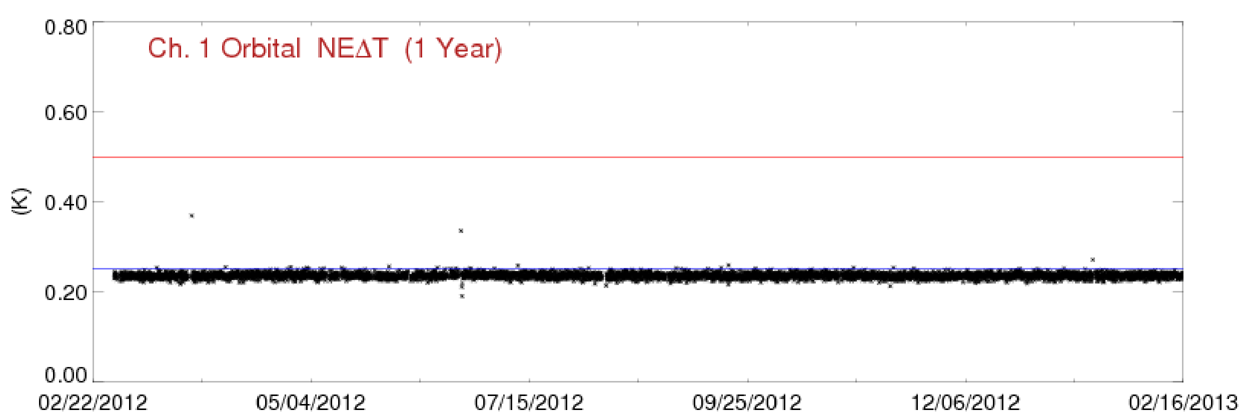


Figure 2: NPP ATMS Channel 1 (23.8 GHz) orbital mean NEdT during the last year

PRESENTATIONS

- NPP/JPSS Instrumental Performance & Data Quality Long-Term Monitoring (LTM) in STAR Integrated Cal/Val System (ICVS), N. Sun, F. Weng, L. Bi, X. Jin, M. Grotenhuis, T. Chang, S. Hu, and L. Qi, AMS Annual Meeting, Austin, TX, 6-10 January 2013

Report by Slawomir Blonski

BACKGROUND

The Visible Infrared Imager Radiometer Suite (VIIRS) is one of the instruments onboard the recently launched Suomi NPP satellite and the future JPSS spacecraft. VIIRS continues and enhances Earth observation capabilities of the AVHRR instruments from the NOAA POES satellites and the MODIS instruments from the NASA Aqua and Terra satellites. Accurate calibration ensures continuity of the satellite measurements for effective applications in weather forecasting and climate change studies.

ACCOMPLISHMENTS

To support calibration of the current and future VIIRS instruments, created and applied software for:

- Monitoring temporal behavior of VIIRS radiometric gain coefficients and signal-to-noise ratios based on onboard calibrator measurements in the reflective solar bands
- Predicting future rate and final effect of the VIIRS telescope throughput degradation occurring due to the tungsten oxide contamination anomaly
- Monitoring stability of VIIRS radiometric calibration using CEOS-selected, pseudo-invariant calibration sites in Sahara (Libya 4) and Antarctica (Dome C)
- Cross-calibration of VIIRS and MODIS using Simultaneous Nadir Overpass (SNO) data

All VIIRS/MODIS SNO measurements acquired during the first year of Suomi NPP operations on orbit were collected and analyzed. Most of the observed biases between VIIRS and MODIS data were within ±2%. Larger biases were investigated using atmospheric radiative transfer modeling with the 6S code and were attributed to the spectral response differences between VIIRS and MODIS. Correlation between the VIIRS-MODIS SNO biases and the changes in the VIIRS SDR radiometric calibration coefficients (the F factors) was also examined: effects of discontinuities in the F factor time series were observed when improvements in the radiometric calibration process were implemented.

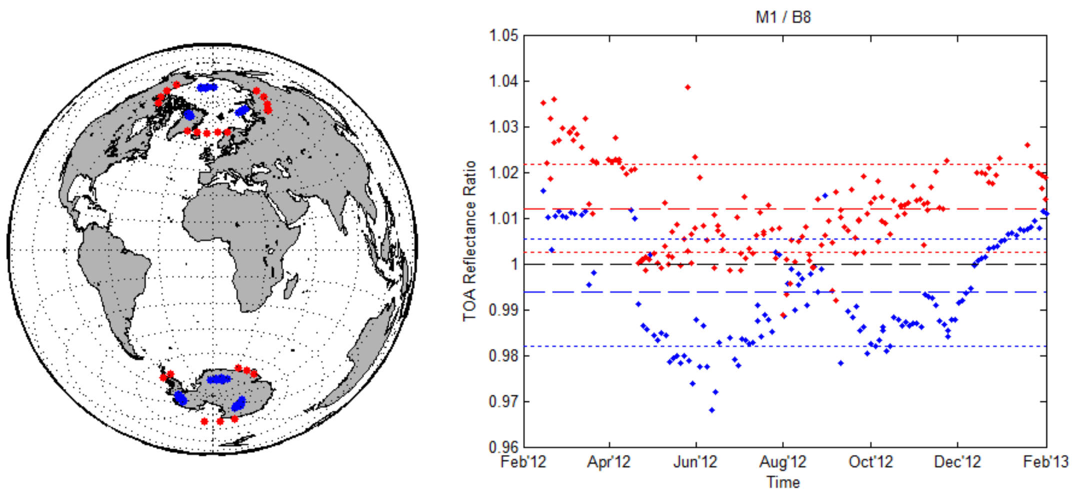


Figure 3: Geographic locations (left) and time series (right) of SNO measurements by Suomi NPP VIIRS and the MODIS instruments on Aqua (blue) and Terra (red). Ratios of top-of-atmosphere (TOA) reflectance measured in VIIRS band M1 and MODIS band 8 (Collection 6) are shown on the graph.

PRESENTATIONS

Using Antarctic Dome C Site and Simultaneous Nadir Overpass Observations for Monitoring Radiometric Performance of NPP VIIRS Instrument, S. Blonski, C. Cao, S. Uprety, and X. Shao, IEEE International Geoscience and Remote Sensing Symposium (IGARSS), Munich, Germany, 22-27 July 2012, pp.1061-1064, doi: 10.1109/IGARSS.2012.6351367

VIIRS Radiometric Calibration for Solar Reflective Bands: Antarctic Dome C Site and Simultaneous Nadir Overpass Observations, S. Blonski, C. Cao, S. Uprety, and X. Shao, Conference on Characterization and Radiometric Calibration for Remote Sensing (CALCON), Logan, Utah, 27-30 August 2012

Continuity of VIIRS/MODIS Radiometric Measurements: Simultaneous Nadir Overpass and Pseudo-Invariant Site Comparisons for Reflective Solar Bands, S. Blonski, C. Cao, S. Uprety, and X. Shao, ASPRS 2013 Annual Conference, Baltimore, Maryland, March 24-28, 2013

Report by Kunghwa Wang

Task description:

- Read VIIRS OBC data and show all user application relative parameters and instrument status parameter on NOAA/NESDIS ICVS web site in near real time.
- Developing and correct coefficients and codes to display the correct parameters of VIIRS.

Accomplishment in 2012:

- Reprocessed all Earth View data from Jun.2012 and generated Specific regional EV image and HDF 5 data set for further research. Generated new EV data in polar area by orbital number instead of daily image for data overlap in polar area.
- Corrected bias in codes and made Auto-execution VIIRS data on OBC, EV data set processing. EV data are processing twice a day, OBC data are executing every four hours to keep latest VIIRS status on web. There are 247 figures generated on ICVS VIIRS web site in each execution circle.
- Read out VIIRS RDR Telemetry data to get more Engineering parameter, which have many parameters not included in OBC SDR data set.
- Corrected offline LUT for Reflectance degradation trend monitoring.
- Move all running jobs to new platform and new disk storage for better performance.
- Daily Maintenance of VIIRS ICVS data products.

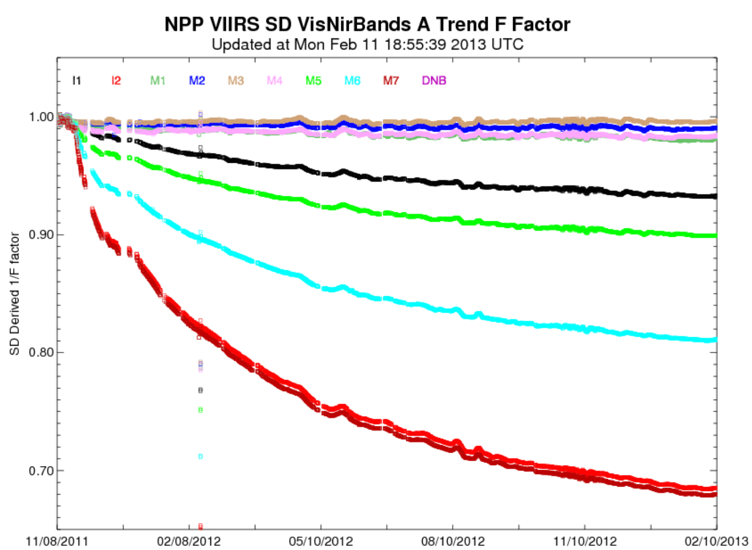


Figure 4: After the LUT was updated in Nov.2012, it shows reasonable trend of Reflectance. Degradation seen in this figure appears significant decay and slow down to flat for VIS band 2 and NIR band 7 since operation started date to present.

Report by Chunhui Pan

The research and development in my work supports the long-term data quality monitoring from OMPS, which from the baseline of sensor parameters to the delivery of the reliable Sensor Data Records (SDRs). Launched on October 28, 2011, OMPS has acquired various types of calibrations images through both the nominal and special calibration activates. With these image data, I have independently gauged the sensor performance through the sensor activation to the current Intensive Cal/val (ICV) operation. My work strategy incorporating initial sensor launch into long term operation focus on the data product quality performance as well as the long-term monitoring of satellite health and status, including evaluated sensor orbital settings and parameters established by NASA**,** monitored and trended sensor important performance parameters, oversight of sensor parameters and algorithms when needed, supported OMPS SDRs Beta and Provision maturity levels. In this report presents the work accomplished from the Early Orbit Checkout (EOC) to the current ICV stage.

Sensor Performance Evaluation and Monitoring
I have developed sensor RDR extract tools and data analysis codes, analyzed and monitored Nadir two sensors (TC and NP) performance parameters, includes electronic bias, system non-linearity, sensor noise, wavelength shift and solar flux, etc. I have complied SDR performance matrix that was used for the OMPS products review.

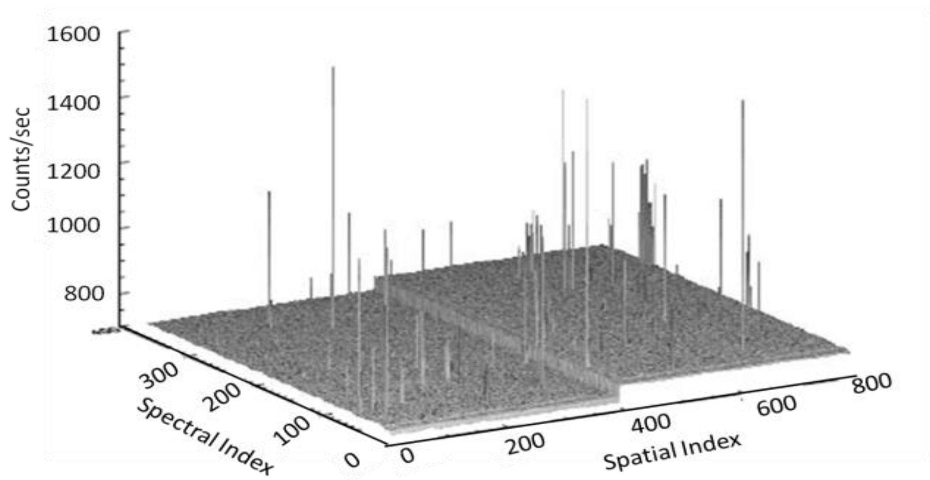
I have followed up closely with NASA’s operation changes in calval. measurement sequences and evaluated that the newly established orbital measurements are also suitable to the fit the sensor behavior. My results show that the sensor performance is stable and match the predicted values and meet the system requirement.

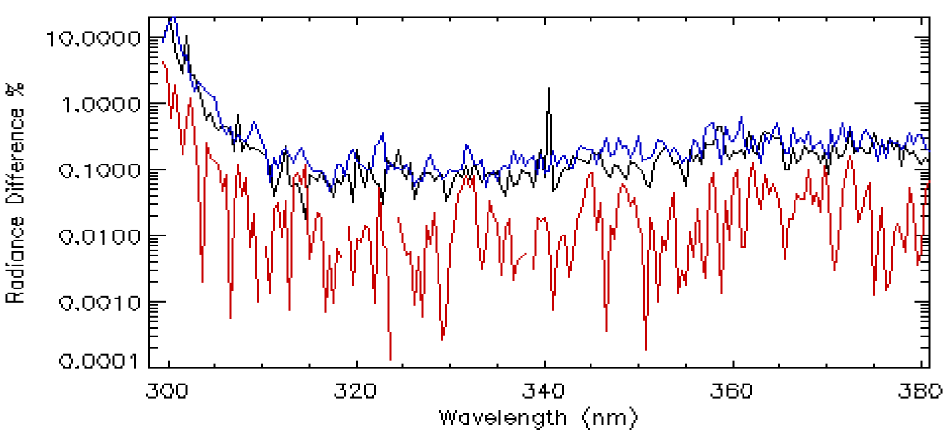
Anomalies’ discovery, identification and solution
I have identify several algorithm discrepancies in the IDPS data processing system and provided suggestions/solutions, such as negative dark, negative smear, transients impact on dark and smear, etc. and worked with team to get some of the issues solved. I also discovered a major operation issue that due to the inappropriate OMPS General Mission Time (GMT) setting, the amount of linearity calibration data excessing the system requirement, and about 40% data was unable to be down linked to the ground – causing RDR truncation.

Sensor Products Evaluation and Monitoring
I have validated SDRs by comparing radiance and geo-location results between IDPS and NASA PEATE; I have evaluated SDRs when a newly derived table was uploaded to the IDPS. I have worked closely with EDR team to improve the SDRs.

Other Activities and Publications

I have supported J1 OMPS pre-launch characterization activities, supported S-NPP project review, project review, and weekly SDR meetings. I also presented my work at several domestic and international conferences, such as Calcon, SPIE, IGARSS, AGU, AMS etc. I have submitted a Journal paper which is in a section revision. I also provided technical consultations to team members.





This figure shows that transients' impact on the SDR products must be corrected in order to meet the OMPS system requirement. The left figure shows a typical example of transients influence to the NM CCD focal plane where multiple spikes are detected by the NM CCD. The right figure shows the radiance error introduced by the transients on the dark image at three different energy levels (blue 3.9, black 3.06, red 2.75 counts/sec) that would reach to 10% high. The short wavelength sensor NP has even worse error. My suggestion was to remove the transients' impact on the dark. The newly established dark calibration removes the transients with a median filter, and the first on-orbit dark was uploaded to the IDPS system recently on January 31, 2013.

1.5 Climate Research, Data Assimilation, and Modeling

- CICS Support of CPC's Climate Monitoring and Prediction Activities

Task Leader: Augustin Vintzileos
Task Code: JJAV_CMPA11
NOAA Sponsor Jon Gottschalck
NOAA Office NWS/CPC/OB
Main CICS Research Theme: Climate Research and Modeling
Percent contribution to CICS Themes: Theme 3 100%
Percent contribution to NOAA Goals: Goal 1 5%. Goal 2 95%

Highlight: Investigated the behavior of NCEP dynamical models during the DYNAMO campaign period and documented differences and proposed some potential reasons for discrepancies from observation. The methodologies developed and knowledge gained are being applied and implemented to support the operational Global Tropics and Benefits Outlook.

BACKGROUND

The Climate Prediction Center (CPC) of NCEP/NWS/NOAA assesses and predicts short-term climate variability and its impact for both the Tropics and the U.S.. The complex nature of the global climate system, and the requirement for continuous improvement in CPC capabilities, makes conducting ongoing collaborative developmental research imperative. This task includes activities of the PI that range from providing improved monitoring products, validation of model forecasts of subseasonal variability and the development of key forecast products to support CPC's operational product suite. Along with the above items, work also includes investigation of the reasons for model forecast successes and failures.

ACCOMPLISHMENTS

During the past year, the PI has continued to collaborate with CPC staff in a number of monitoring, forecasting and diagnostic roles, particularly involving the Madden-Julian Oscillation (MJO) and its impacts on global and U.S. weather statistics at forecast lead times of Week-1 and Week-2. His work evolved along two axes.

(A) Operational processing and forecast tools that were developed during the previous year had to be maintained and migrated to subsequent changed computer infrastructure during the move to the new NCEP building at NCWCP. The PI generalized data acquisition and storing strategies developed and used during DYNAMO. These strategies which optimize post-processing of raw model forecasts were transitioned to the operational CPC environment. He developed new (at this point experimental) tools based on experience gained during the DYNAMO forecast/monitoring support project. One example of such tools is the quantification of forecast stability as a function of lead time from a target week (Figure 1). This tool provides one measure of model forecast uncertainty and is used by the forecaster.

Example of forecast continuity diagrams

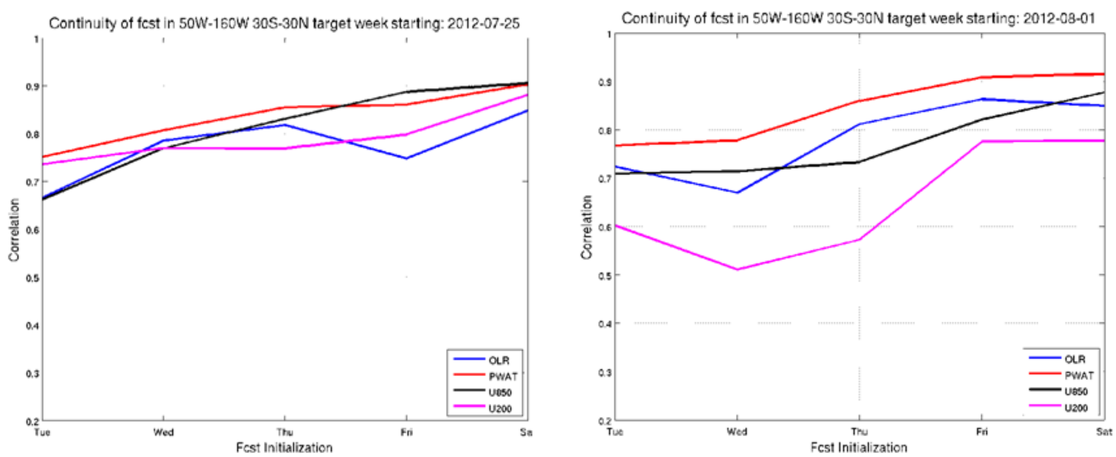


Figure 1: Spatial correlation for critical tropical atmospheric fields as a function of lead time from target forecast week. The left panel shows that the forecast of winds at 200 hPa targeting the week starting on 25 July 2012 presented fewer fluctuations than the forecast targeting the week starting on 1 August 2012.

(B) The PI is conducting work on establishing subseasonal forecast skill of the NCEP dynamical models for several critical fields. The comparative study of forecast skill of different models and the understanding of reasons for forecast skill deviations will not only allow a better understanding of the physics of subseasonal variability, but also feedback to improved operational forecasts via objective weighting schemes for different forecast models. A first important result derived from these investigations follows. The CFSv2 model presented a very significant improvement of forecast skill during the last period of DYNAMO when compared to the GFS and the GEFS (Figure 2). Further study revealed synchronous, constructive variability between SST and the MJO which was absent during the first DYNAMO period. This underlines the importance of coupled ocean – atmosphere models for subseasonal forecasts.

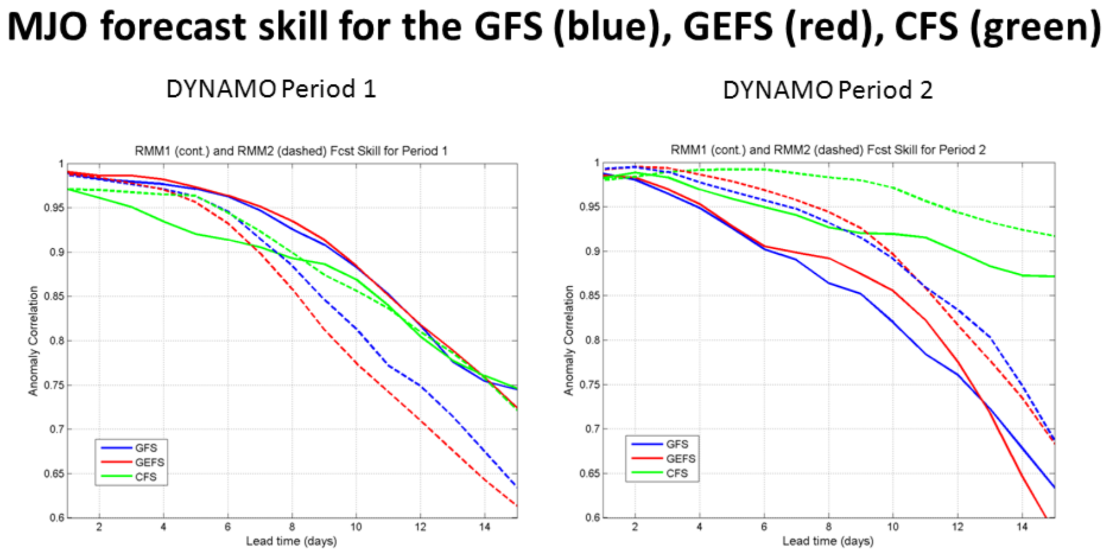


Figure 2: Anomaly correlation between observed and forecast RMMs (RMM1: continuous lines, RMM2: dashed lines). The NCEP models forecast skill GFS (blue), GEFS (red) and CFS (green) show a strong improvement of forecast skill of the coupled CFS during the last DYNAMO period (right panel) in comparison to the first period (left panel).

Planned Work

The work to follow will again evolve along two axes. The proposed strategy optimizes gain of knowledge of physical processes governing weather and climate variability and by consequence the development of novel forecasting methodologies based on this new knowledge:

(A) The forecast data acquisition and storage strategy that the PI developed during DYNAMO was transitioned to CPC operations. Based on this core product, the PI will develop two sets of analysis and visualization packages. The first will aid forecasters by producing routine graphics used in operations. The second package will serve as a workbench for conceiving, developing and testing new forecast tools/products. The PI will use this workbench to conduct collaborative R&D with potential deliverables of extreme heat outlooks for week-2 and beyond in the operational CPC suite.

(B) The PI will continue investigating the behavior of the NCEP dynamical forecast models in the Tropics. This research will help determining physical reasons for successful and unsuccessful forecasts. This work is targeting the *a priori* determination of model weight that will be used in a multi-model forecast first guess context. In parallel, bias correction techniques based on results from retrospective forecasts and the most recent realtime forecast errors will be investigated and transitioned to operations.

PUBLICATIONS

Wen, M., S. Yang, A. Vintzileos, W. Higgins and R. Zhang, R., 2012: Impacts of model resolutions and initial conditions on predictions of the Asian summer monsoon by the NCEP Climate Forecast System. *Wea. and Fore.,* 27, 629-646

Chattopadhyay, R., A.Vintzileos, and C. Zhang, 2013: A Description of the Madden Julian Oscillation Based on Self Organizing Map. *J. Climate,* 26, 1716-1732

Jon Gottschalck, Paul E. Roundy, Carl J. Schreck III, Augustin Vintzileos, and Chidong Zhang , 2012, Large-Scale Atmospheric and Oceanic Conditions During the 2011-12 DYNAMO Field Campaign Submitted to *Mon. Wea. Rev..*

PRESENTATIONS

Augustin Vintzileos, Jon Gottschalck and Ren-Chieh Lien, 2012, Operational forecast support for DYNAMO: The NCEP model suite. AMS 30th Conference on Hurricanes and Tropical Meteorology, Ponte Verda Beach, FL

Augustin Vintzileos and Jon Gottschalck, Global model forecast support for DYNAMO at NCEP, 93rd AMS Annual Meeting, Symposium on Prediction of the Madden-Julian Oscillation, Austin, TX.

Augustin Vintzileos, Jon Gottschalck, 2011, Operational forecast support for DYNAMO: The NCEP model suite. US-THORPEX meeting, College Park, MD.

Augustin Vintzileos and Jon Gottschalck, Coupled versus Uncoupled Forecasts of the MJO during DYNAMO, MJO Field Data and Science Workshop, Hapuna Beach, HI

Other:

The PI is a member of (1) the DYNAMO Science Steering Committee, (2) the US-THORPEX Science Steering Committee and (3) member of the panel for the E.U. funding program ARISTEIA. He serves as assistant editor to the Advances in Atmospheric Sciences of the Chinese Academy of Sciences. He participates in several important new CPC Operations Branch teams which includes the “New GEFS Reforecast Project” and the U.S. Probabilistic Hazards Project”.

Performance Metrics	**FY12**
# of new or improved products developed	4
# of products or techniques transitioned from research to ops	2
# of peer reviewed papers	2
# of non-peered reviewed papers	0
# of presentations	0
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	0

- Use of LETKF sensitivity to detect the origin of the NCEP '5-day forecast dropouts' and improve QC of JPSS polar orbiting instruments.

Task leader	Eugenia Kalnay
Task Code	PAEK_LETKF12
NOAA Sponsor	Mitch Goldberg
NOAA Office	NESDIS/JPSSO
Main CICS Research Topics	Data Fusion and Algorithm Development and Climate Research, Data Assimilation and Modeling
Percent Contribution to CICS Themes	Theme 1: 75%; Theme 2: 25%
Percent Contribution to NOAA Goals	Goal 1: 20%; Goal 2: 80%

Highlight: We developed an accurate Ensemble Forecast Sensitivity to Observations (EFSO). We tested it on the GFS with real observations and showed it can be used to detect observation flaws within 12-24 hr.

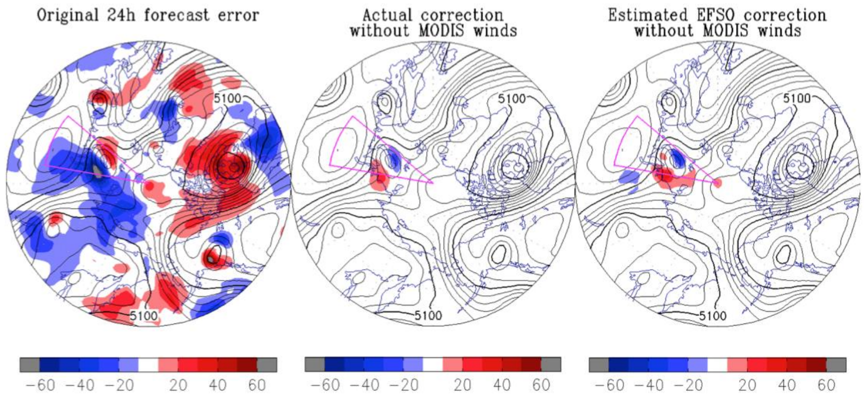
BACKGROUND

Forecast sensitivity to observations has been carried out with adjoint sensitivity (Langland and Baker, 2004, Zhu and Gelaro, 2008) which requires the adjoint of the model and the data assimilation (not available at NCEP). We developed a simpler and more accurate Ensemble Sensitivity to Observations (EFSO) than the original of Liu and Kalnay (2008), and which can be applied to any Ensemble Kalman Filter (Kalnay et al, 2012).

ACCOMPLISHMENTS

We applied the EFSO to one month of data assimilation of all operationally used observations with the GFS coupled to the EnKF used operationally at NCEP since May 2012. The globally averaged results of EFSO are similar to those obtained by the Navy and Goddard using adjoint sensitivity. However, we showed that EFSO can also be used to detect observations that are flawed by detecting that they have a negative impact in forecast skill after 12 or 24hr. This would allow it to perform a "proactive QC", repeating the data assimilation without the flawed observations.

This has two advantages: 1) it avoids accepting observations that are flawed and may cause the 5-day skill dropouts that affected NCEP forecasting systems. 2) It allows collecting the occasionally flawed observations with all needed data to provide the algorithm developers with enough information to determine why the flaws took place and how to correct the problems (Ota et al., 2013).



After identifying with EFSO the observations (MODIS polar winds) producing bad 24hr regional forecasts, the withdrawal of these winds reduced the regional forecast errors by 39%, as estimated by EFSO. (Ota et al. 2013).

PLANNED WORK

- Implement "proactive QC" with the NCEP GFS coupled with the LETKF at UMD, using all operational observations.
- Define uniform regions for EFSO.
- Test 6, 12 and 24 hrs forecasts and the impact of the observations.

Presentations

Kalnay, E., Ota, Y., Miyoshi, T. and Liu, J. 2012. A simpler formulation of forecast sensitivity to observations: application to ensemble Kalman filters. Tellus, 64A, 18462, http://dx.doi.org/10.3402/tellusa.v64i0.18462.

Ota, Y., J C Derber, E Kalnay and T Miyoshi, 2013: Ensemble-based observation impact estimates using the NCEP GFS. Tellus, under review. http://www.aosc.umd.edu/~ekalnay/pubs/FSO_GFSEnKF_20121106.pdf

Performance Metrics	FY12
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	2
# of non-peered reviewed papers	0
# of invited presentations	5
# of graduate students supported by a CICS task	1
# of undergraduate students supported by a CICS task	0

- Participation in Climate Research Activities at the Air Resources Laboratory

Task Leader Russ Dickerson
Task Code PAPA_ARL11
NOAA Sponsor Richard Artz
NOAA Office OAR/ARL
Main CICS Research Topic Climate Research, Data Assimilation and Modeling
Percent contribution to CICS Themes Theme 3: 100%
Percent contribution to NOAA Goals Theme 3: 100%

Highlight: 1) CICS scientists have developed a novel observation-based dust identification approach and applied it to reconstruct long-term dust climatology in the western United States; 2) CICS scientists have successfully proposed to combine the Suomi-NPP ocean color data and NOAA weather forecasting model to develop a new marine isoprene emission product.

BACKGROUND

This work is part of the collaboration between NOAA Air Resources Laboratory (ARL) with UMD to advance climate research. The specific task is to develop high-quality emission datasets and emission algorithms to support air quality and climate models.

ACCOMPLISHMENTS

In past year, I have completed the following tasks on a 50% part-time schedule:

1. NAQFC-related emission tasks:

a) *Emission Inventory Updates*: ARL emission inventories have been updated with the latest emission data, including 2012 non-road update, mobile source projection, point source updates with 2010 Continuous Emission Measurements and 2012 DOE projection, and updates of Canadian emissions (with help from Yunhee).
b) *Operational CONUS Emissions:* Generated emission files for the CONUS domain, including 365-D area source files, 365-D mobile files, ~30 point source files and other ancillary emission files;
c) *Experimental CONUS Emissions:* Generated the similar emission datasets for the Experimental run with CB05 chemical mechanism (total of ~760 files);
d) *Operational Hawaii Emissions:* Generated emission files for the Hawaii domain, including 365-D area source files, 365-D mobile files, ~30 point source files and other ancillary emission files;
e) *Operational Alaska Emissions:* Generated emission files for the Hawaii domain, including 365-D area source files, 365-D mobile files, ~30 point source files and other ancillary emission files (with help from Yunsoo);
f) *Snow/ice dust module*: Developed a module to implement snow/ice effect on fugitive dust for the NAQFC experimental run. Testing is ongoing in conjunction of PREMAQ debugging.

2. Support AQF group research activities:

- *DISCOVER-AQ emissions*: Regenerated 31 days emission datasets for July 2011 for a retrospective CMAQ run for the DISCOVER-AQ simulations;.

3. Grants:

- *PSS Marine Isoprene Project*: Successfully developed a new research project to use NOAA satellite products to dynamically create emission data. Brought in $104K to ARL funding pool.
- *Central America Climate Project*: Contributed a new proposal to USAID, Requesting 935K for ARL.

PUBLICATIONS

Tong, D. Q., Dan, M., Wang, T., and Lee, P.: Long-term dust climatology in the western United States reconstructed from routine aerosol ground monitoring, Atmos. Chem. Phys., 12, 5189-5205, doi:10.5194/acp-12-5189-2012, 2012doi:10.5194/acpd-12-4279-2012.

Tong, D.Q., P. Lee, and R.D. Saylor, 2012. New Direction: The need to develop process-based emission forecasting models, Atmospheric Environment, 47: 560-561..

PLANNED WORK

- Continue working on the FY2013 emission data to support the National Air Quality Forecasting operation;
- Continue developing the NOAA dust storm forecasting system based on CMAQ dust module.

- The Development of AMSU Climate Data Records (CDR's)

Task Leader Wenze Yang
Task Code WYWY_AMSU_12
NOAA Sponsor Ralph Ferraro
NOAA Office NESDIS/STAR/CRPD/SCSB
Main CICS Research Topic Climate Data and Information Records and Scientific Data Stewardship
Percent contribution to CICS Themes Theme 1: 100%; Theme 2: 0%; Theme 3: 0%
Percent contribution to NOAA Goals Goal 1: 50%; Goal 2: 50%

Highlight: Geolocation Correction for all AMSU-A/B/MHS sensors aboard the NOAA POES satellites has been achieved; Cross scan asymmetry for AMSU-A window channels has been characterized, corrected and verified; Inter-satellite calibration is on-going.

BACKGROUND

Current passive microwave sounder data, used in hydrological applications, are derived from POES satellites for which the primary mission is operational weather prediction. These data are not calibrated with sufficient stability for climate applications. A properly calibrated FCDR needs to be developed to enable the utilization of these data for TCDR and Climate Information Records and to extend their application into the JPSS era (e.g., POES/AMSU to NPP/ATMS to JPSS/ATMS). Once developed, TCDR's for water cycle applications (precipitation, water vapor, clouds, etc.) will be developed for use as key components in international programs such as GEWEX, CEOS and GPM.

Passive microwave sounder data have proven their worth in more than just tropospheric temperature and moisture monitoring. NOAA/NESDIS generates operational products from the Advanced Microwave Sounding Unit (AMSU) focused on the hydrological cycle (e.g., rainfall, precipitable water, cloud water, ice water, etc.) through two product systems known as the Microwave Surface and Precipitation Products Systems (MSPPS) and the Microwave Integrated Retrieval System (MIRS) since the launch of NOAA-15 in 1998. These data offer the unique opportunity to develop CDR's that can contribute to other satellite time series with similar capabilities such as the DMSP SSM/I and SSMIS, the TRMM TMI, and Aqua AMSR-E. This project will focus on the development of AMSU FCDR's for the AMSU-A window channels (e.g., 23, 31, 50 and 89 GHz) and the AMSU-B/MHS sensor.

ACCOMPLISHMENTS

Our accomplishments during the third year of the project are as follow: 1. we have finished the geolocation correction for all AMSU-A, AMSU-B, and MHS sensors aboard the NOAA POES satellites (NOAA-15 to -19) (Moradi et al., 2013), and a new dataset corrected for geolocation errors has been generated. The dataset includes latitude, longitude, local zenith angle, and sensor scan angle; 2. finished cross scan asymmetry characterization, correction and verification for AMSU-A window channels, as summarized in Yang et al. 2013 and below; 3. obtained some results on cross scan asymmetry characterization for AMSU-B/MHS window channels, as summarized below; 4. obtained some results on inter-satellite calibration, as summarized below.

A. Geolocation Correction

The methodology for the geolocation correction is published in Moradi et al., 2013. The correction algorithm is schematically explained in Figure 1.

The results show that NOAA-15 AMSU-A2 sensor is mounted about 1.2 degrees negative cross track, and about 0.5 degree positive along track. NOAA-16 AMSU-A1 and -A2 are mounted about 0.5 degree positive along track, and NOAA-18 AMSU-A2 is mounted more than 1 degree positive along track. Table 1 gives the average geolocation error and the Local Zenith Angle (LZA) error caused by geolocation problem for the AMSU/MHS sensors.

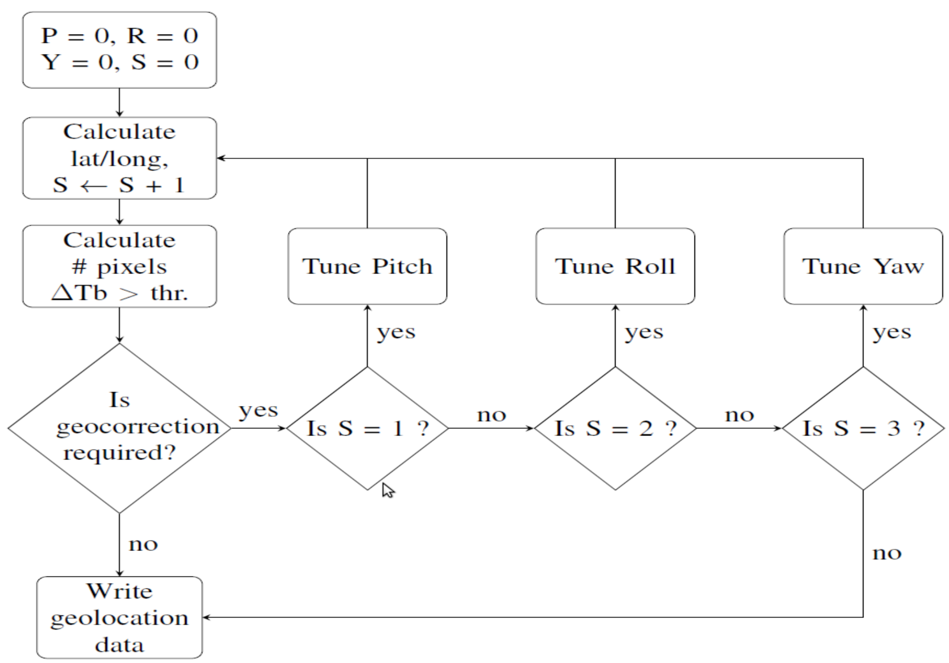


Figure 1. Schematic explanation of the geolocation correction method

Table 1. AMSU/MHS Sensor Geolocation Error (km)/LZA error (deg)

	AMSU-A2 ch1&2	AMSU-A1-2 ch3	AMSU-A1-1 ch15	AMSU-B/MHS
NOAA-15	20/1.2	10/0.15	10/0.15	small/0.15-0.2
NOAA-16	10/0.25	10/0.4	10/0.2	small/small
NOAA-17	5-10/small	-*	-	5-10/0.25
NOAA-18	20/0.2	5-10/small	5-10/0.4	5-10/0.15
NOAA-19	10/0.2	10/0.35	10/0.2	10/0.1

* NOAA-17 AMSU-A1 has a very short record due to instrument failure.

Our geolocation correction method cannot be applied to MetOp-A data as the geometry of the MetOp-A orbit is different from NOAA satellites and our method introduces some extra geolocation error. In addition, our investigations show that the MetOp-A geolocation error is rather small, less than a few kilometers, and does not introduce large error in scan bias or LZA.

B. Cross Scan Asymmetry of AMSU-A Window Channels: Characterization, Correction and Verification

A method has been developed for the characterization, correction and verification of the cross scan asymmetry of AMSU-A window channels (Yang et al., 2013). This method utilizes a three-point correction approach: vicarious cold reference (VCR), most probable

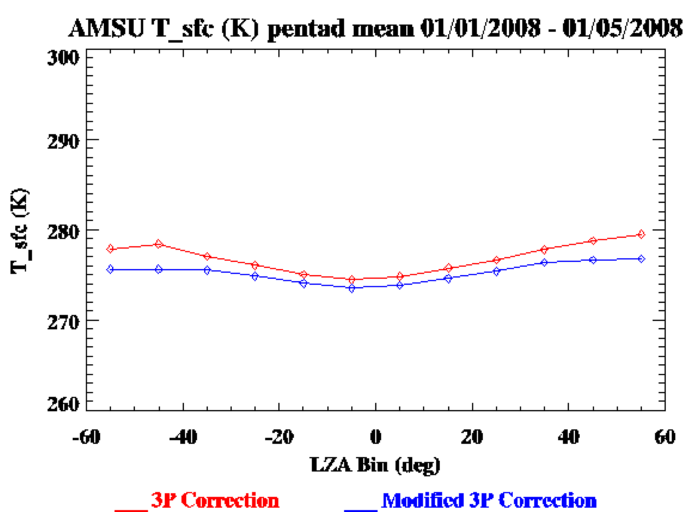


Figure 2. Pentad mean of surface temperature (Ts) vs. local zenith angle (LZA) from Jan 1-5, 2008.Ts is a level-2 product and retrieved using brightness temperatures (Tb) at 23.8, 31.4, and 50.3 GHz. The red curve uses Tb's that are corrected using the 3-point method: VCR, MPV, and VHR. The blue curve uses modified 3-point method where the 50.3 GHz is corrected using polar data, MPV, and VHR.

value (MPV), and vicarious hot reference (VHR). It was successfully applied to 23.8 GHz and 31.4 GHz channels. However, since the coldest brightness temperatures (Tb) at the 50.3 GHz and 89 GHz channels generally occur over land in the polar regions, VCR does not represent the lower limit of the Tb dynamic range. To overcome this problem, much similar to using the Amazon area for scan bias correction at the warm end, targeted areas in Antarctica and Greenland were chosen to characterize and then correct bias at the cold end. Figure 2 presents the pentad means of the cross scan surface temperatures which are retrieved using AMSU-A brightness temperatures including the 50.3 GHz. The curve that used VCR (red) in the asymmetry correction for the 50.3 GHz channel shows more cross scan variation than the one that used polar data (blue) for correction

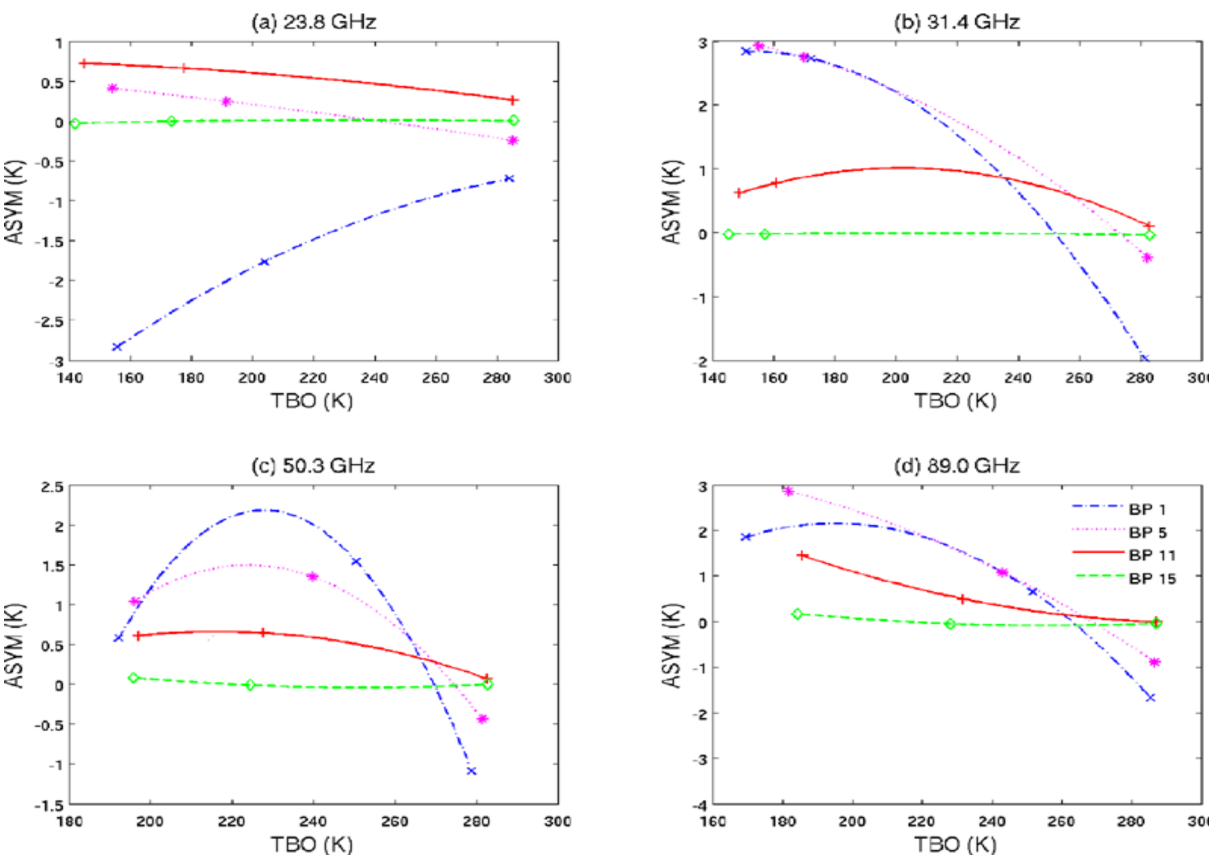


Figure 3. Cross-scan asymmetry (ASYM) as a function of observed brightness temperature (TBO) for NOAA-15 AMSU-A (a) 23.8, (b) 31.4, (c) 50.3 and (d) 89 GHz. For each channel and beam position (BP), the ASYM-TBO relationship is developed at three reference points. For 23.8 and 31.4 GHz, the three points are: vicarious cold reference (VCR), most probable value (MPV) and vicarious hot reference (VHR), with VCR denoting the lowest TBO, and VHR the highest TBO. For 50.3 and 89 GHz, the reference point of VCR is replaced by observations and simulations in polar land areas. Note only 4 out of 30 beam positions are shown for each channel.

Figure 3 shows the correction curves for four beam positions from NOAA-15 AMSU-A window channels, where different methods were used for the characterization of 23.8 and 31.4 GHz channels from those used for 50.3 GHz and 89 GHz channels as discussed above.

C. AMSU-B/MHS Cross-track Asymmetry for the Window Channels

The asymmetry of the AMSU-B and MHS channels were investigated using the differences between the brightness temperatures of right and left sides of the scan. The differences were averaged over the tropical region (ocean for channels 1 and 2, and global for channels 3-5). The results for NOAA-15 AMSU-B are shown in Fig. 3. Note the NEDT specification for both AMSU-B and MHS frequencies is 1 K. As shown in Figure 4, all the channels have a small scan asymmetry close or less than the NEDT early on but started to exhibit sensor degradation as time progressed. By 2009, all channels had scan asymmetry that exceeded the NEDT. For instance, the asymmetry in channel 4 is more than 2 K in 2002, about 6 K in 2005, and 12 K in 2009. The asymmetry plots for NOAA-16 (not shown) also reveal serious degradation issues in the water vapor channels (channels 3-5). However, the asymmetry of NOAA-16 window channels (channels 1 and 2) is within NEDT throughout the years. Likewise, the asymmetry of the rest of the AMSU-B and MHS sensors (onboard NOAA-17, -18, -19 and Metop-A) is less than 1 K for all the channels in the study period with only one exception - Metop-A channels 4 and 5 display clear asymmetry that is not caused by sensor degradation (Figure 5).

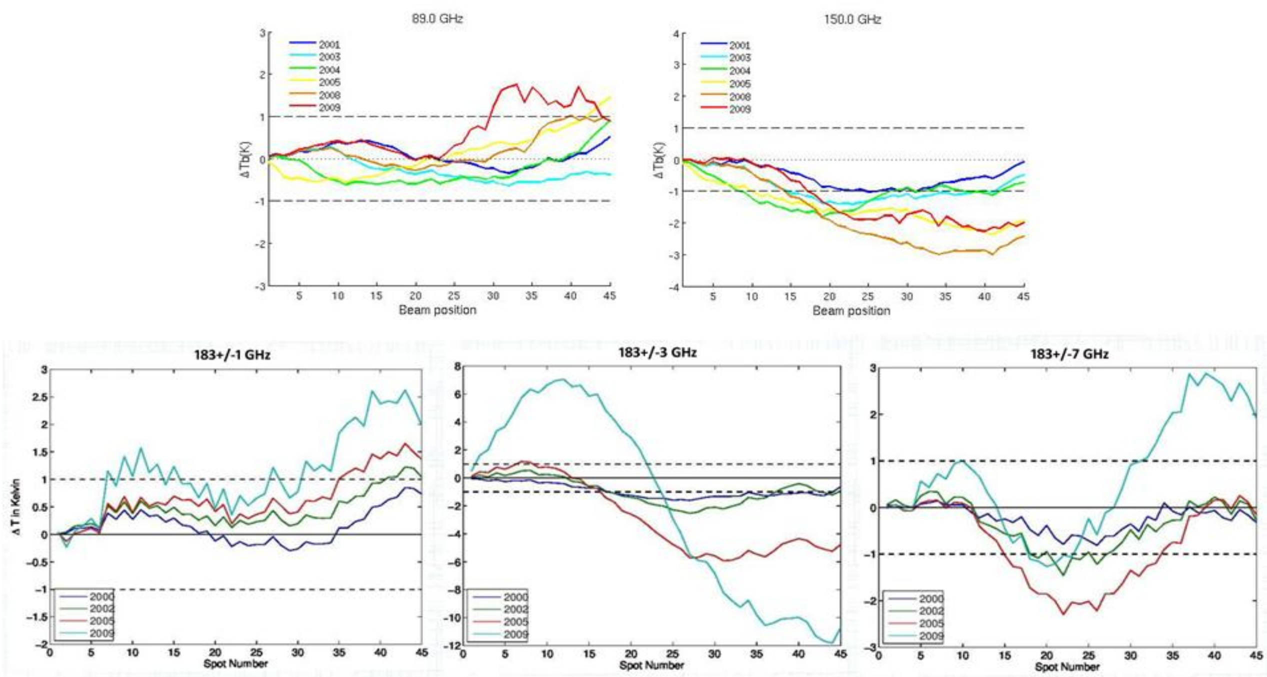
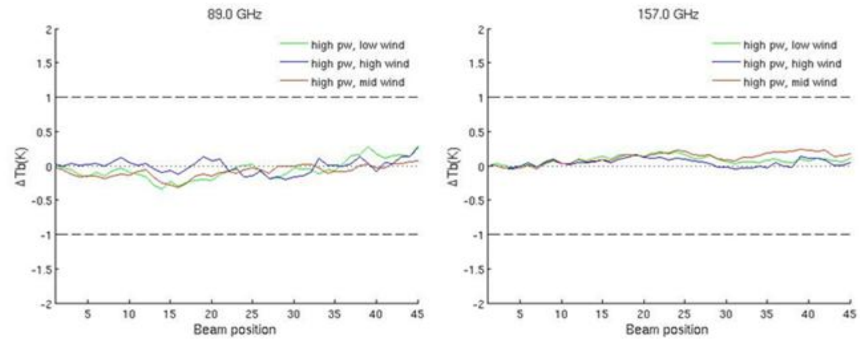


Figure 4. Cross-scan asymmetry of NOAA-15 AMSU-B channels.



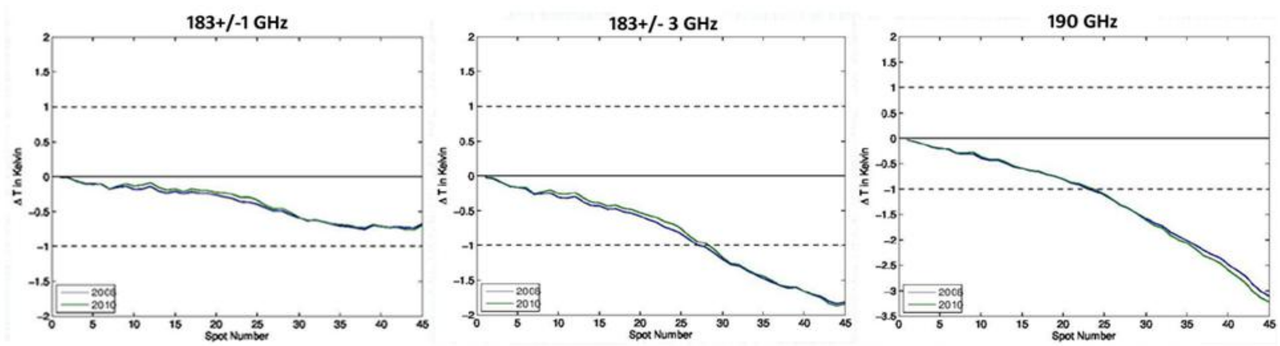


Figure 5. Cross-scan asymmetry of Metop-A MHS channels

D. Inter-Satellite Calibration

Inter-satellite calibration for AMSU-A window channels was started in this period, beginning with the global simultaneous nadir overpass (SNO) method. Most SNO events occur in polar regions. However, global SNO can occur when two satellites take the same equatorial overpass time because of orbital drift. Figure 6 shows the three pairs of satellites that had global SNO during certain periods from 2000 to 2010: NOAA-15 and NOAA-16, NOAA-17 and Metop-A, and NOAA-18 and NOAA-19. For AMSU-A global SNO, the criteria for collocated data are less than 50 s and 50 km apart. One exception is NOAA-18 and -19 for which the distance limit is 75 km due to the scarcity of global SNO data. Figure 7 presents the geographical distribution of the 23.8 GHz Tb difference from the global SNO collocated data set. The Tb differences are generally within 3 K with the extreme values mostly along the coast or in the polar regions.

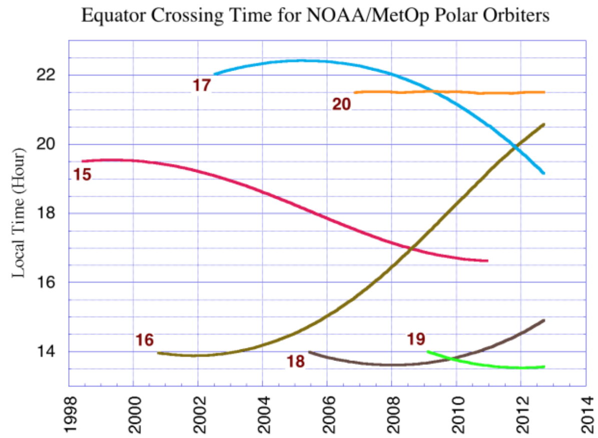


Figure 6. Equatorial crossing times (LST) for NOAA-15 through NOAA-19, as well as MetOp-A (20). This is for ascending nodes.

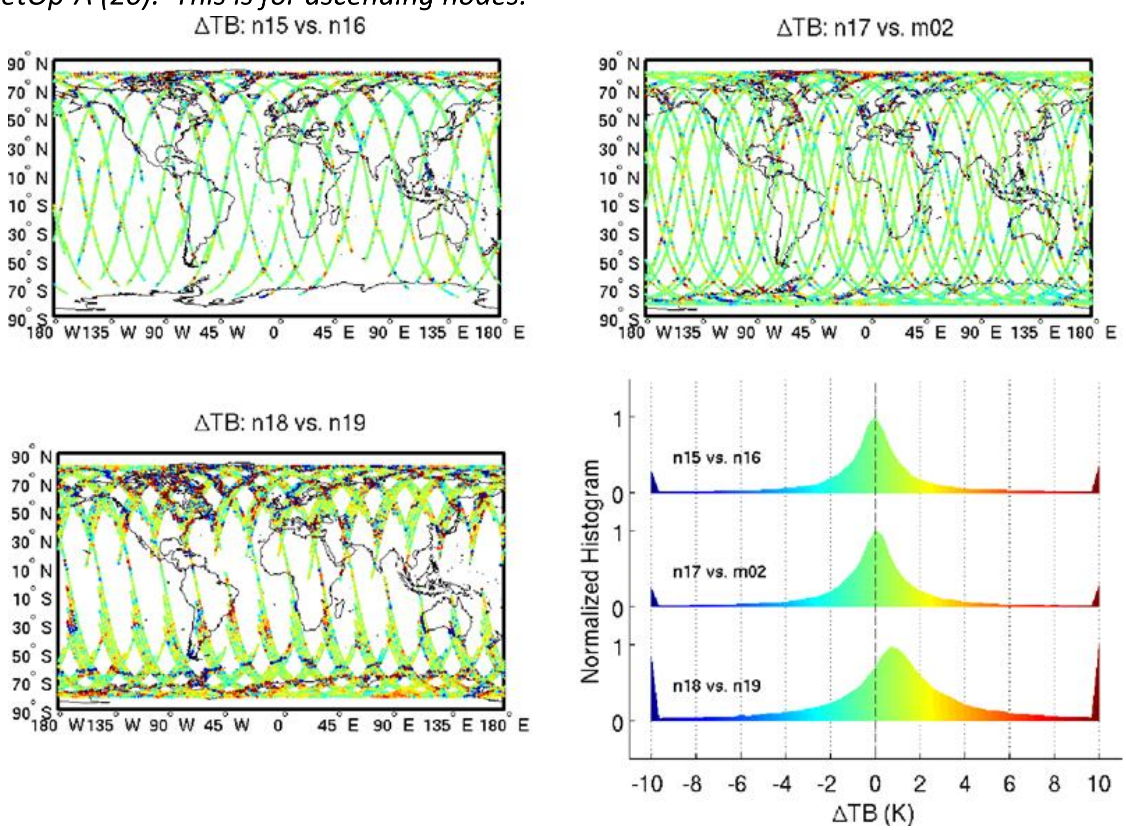


Figure 7. Geographical distribution of the 23.8 GHz brightness temperature difference when global SNO's occurred. SNO is defined as observations from two satellites that are less than 50 s and 50 km apart (the NOAA-18 and -19 pair uses a distance limit of 75 km).

While global SNO allows direct comparison of the observations from two sensors onboard different satellites, the approach is limited to a short time period when the satellites meet due to orbital drift. Polar SNO, on the other hand, provides the means to compare sensors onboard different satellites throughout the sensors' operational lives. The limitation of the polar SNO method is that it only represents sensor differences in certain part of the measurement dynamic range, usually at the lower end. Figure 8 shows the time series of SNO data at the four AMSU-A channels between NOAA-15 and the other satellites, i.e. NOAA-16 to -19 and Metop-A. Figure 8(a) and (b) reveal that NOAA-17 channel-1 and -2 appear to have some quality issues between April 2006 and February 2008. In addition, further study is required to explain the cycles in the NOAA-15/-16 and NOAA-15/-18 time series.

Inter-satellite calibration is also carried out for AMSU-B and MHS sensors using global SNO data. The results show that the Tb difference between the different satellite pairs is a function of frequency. Most Tb differences are less or close to 2 K. The only exception is channel 5 between NOAA-15 and -16 which is as large as 5 K.

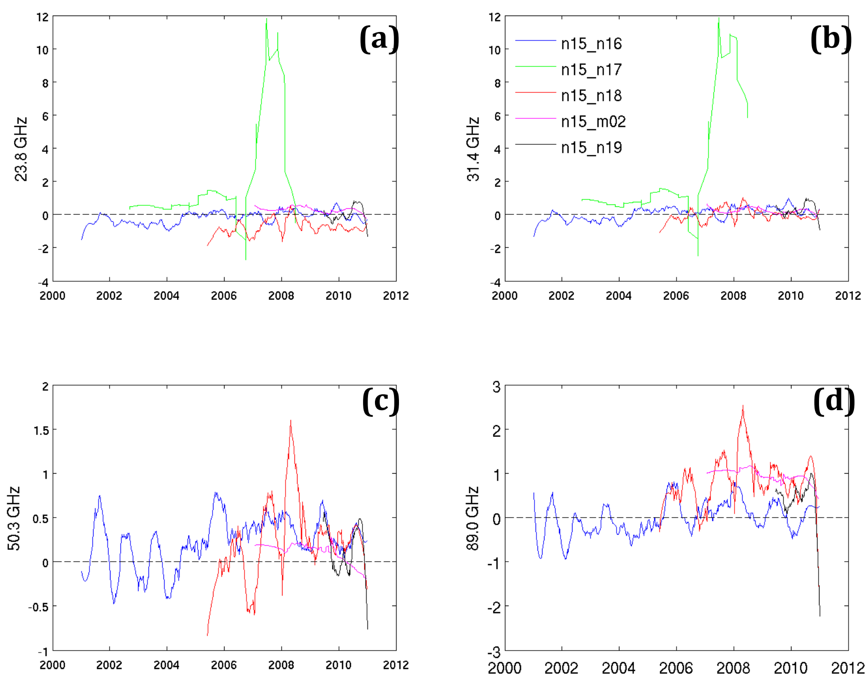


Figure 8. Time series of brightness temperature differences of SNO pairs between AMSU-A onboard NOAA-15 and NOAA-16 through NOAA-19 and Metop-A, (a) 23.8, (b) 31.4, (c) 50.3 and (d) 89 GHz.

PLANNED WORK

The planned work is scheduled in three lines:

- *For AMSU-A window channels*, we have obtained some preliminary results on global and polar SNO. More research is required to answer the following questions: 1) is the SNO pairwise BT difference brightness temperature (BT) dependent in; 2) what is the reason for the trend in the time series of the SNO pairwise BT difference, and how to apply the time series to inter-satellite calibration; 3) how to select a reference satellite; 4) how to characterize and calculate the uncertainty of inter-satellite calibration; etc.

- *For AMSU-B/MHS window channels*, we will develop methods to perform cross scan bias correction and inter-satellite calibration.

- *For AMSU-B/MHS water vapor channels*, preliminary results have shown that inter-satellite calibration is a very complicated issue due to the frequency and polarization differences between AMSU-B and MHS. We will perform further investigation on the task to better understanding of the inter-calibration between the two sets of sensors. The goals for the inter-calibration are: 1) extend to entire dynamic range; 2) no/limited diurnal effect; 3) no/limit weather effect; and 4) eliminate artificial trend, as the impact on sensor calibration is mainly due to orbital drift effect.

We will finish documentation in the proposed period, which will include Algorithm Theoretical Basis Document (ATBD), Operational Algorithm Description (OAD), source code, research papers, etc. So far, two papers summarizing parts of this project have been published. With the progress of the project, more research papers will be prepared, and these publications will contribute to the future documentations.

PUBLICATIONS

Yang, W., H. Meng, R. Ferraro, I. Moradi, and C. Devaraj, “Cross scan asymmetry of AMSU-A window channels: Characterization, correction and verification,” *IEEE Trans. Geosci. Remote Sens*., doi:10.1109/TGRS.2012.2211884, 2013.

Moradi, I., H. Meng, R. R. Ferraro, and S. Bilanow, “Correcting geolocation errors for microwave instruments aboard NOAA satellites,” *IEEE Trans. Geosci. Remote Sens.,* 51 (7), doi: 10.1109/TGRS.2012.2225840, 2013.

PRESENTATIONS

Devaraj, C., W. Yang, I. Moradi, H. Meng, R. Ferraro, “The Development of AMSUB/MHS Fundamental CDR’s” (poster), 18th Conference on Satellite Meteorology, Oceanography and Climatology, New Orleans, LA, January 2012.

Moradi, I., H. Meng, and R. Ferraro, “Geolocation and scan asymmetry correction for the passive microwave instruments” (poster), 18th Conference on Satellite Meteorology, Oceanography and Climatology, New Orleans, LA, January 2012.

Meng, H., W. Yang, I. Moradi, C. Devaraj, R. Ferraro, “Development of AMSU/MHS Climate Data Record” (poster), 12th Specialist Meeting on Microwave Radiometry and Remote Sensing of the Environment, Frascati, Italy, March 5-9, 2012.

Moradi, I., H. Meng, R. Ferraro, W. Yang, C. Deveraj, “Climate Data Records from Microwave Satellite Data: A New High Quality Data Source for Reanalyses” (poster), 4th WCRP International Conference on Reanalyses, Silver Spring, Maryland, USA, May 7-11, 2012.

Yang, W., H. Meng, R. Ferraro, I. Moradi, C. Devaraj, “The Development of AMSU-A Fundamental CDR's” (oral), GPM Xcal meeting, Ann Arbor, MI, July 11-12, 2012.

Yang, W., H. Meng, R. Ferraro, I. Moradi, C. Devaraj, “Cross scan asymmetry of AMSU-A window channels: characterization, correction and verification” (oral), CALCON meeting, Logan, UT, August 26-30, 2012

Moradi, I., H. Meng, R. Ferraro, and W. Yang, “Developing climate data records from microwave satellite data” (oral), AGU Fall Meeting, San Francisco, CA, USA, December 2012. Oral.

Performance Metrics	**FY12**
# of new or improved products developed	2
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	2
# of non-peered reviewed papers	0
# of invited presentations	7
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	N/A

- University of Maryland Center of Excellence in Data Assimilation

Task Leader Jim Carton
Task Code JCJCUMCED11
NOAA Co-Sponsor Al Powell, NESDIS/STAR
NOAA Co-Sponsor Louis Uccellini, NWS (NCEP)
Main CICS Research Topic Climate Research, Data Assimilation, and Modeling
Percent contribution to CICS Themes Theme 1: 0%; Theme 2: 0%; Theme 3: 100%.
Percent contribution to NOAA Goals Goal 1: 20%; Goal 2: 80%
Highlight: The University of Maryland Search Committee is now reviewing applicants for the professorship in data assimilation for the Department of Atmospheric and Oceanic Sciences.

At the end of 2012, Professor Takemasa Miyoshi, who led the University Of Maryland Center Of Excellence in Data Assimilation, left the Department of Atmospheric and Oceanic Sciences (AOSC). He accepted a position with the RIKEN Advanced Institute for Computational Science in Japan to head their Data Assimilation Research Team.

AOSC went through the University process to refill his position. The position was posted as follows:

> The successful candidate is expected to be a leader in the development of advanced computational algorithms in atmospheric, ocean, land surface, and biogeochemical data assimilation, and to develop an independently funded program building on the activities of the thriving interdisciplinary weather and chaos group. Preference will be given to candidates who will further strengthen the strong collaboration between the University and nearby national laboratories including: the NOAA National Weather Service and its National Centers for Environmental Prediction, the National Environmental Satellite, Data, and Information Service and its Center for Satellite Applications and Research, the Joint Center for Satellite Data Assimilation, the NASA Global Modeling and Assimilation Office, and the Naval Research Laboratory.
>
> The candidate should at least demonstrate research accomplishments of originality and depth with the potential to be an international scientific leader in data assimilation. Preference is given to the candidate who also has a strong commitment to the educational mission of the Department, including graduate student mentoring.

The closing date for applications was Friday, April 12, 2013. : The Faculty Search Committee is currently reviewing applicants.

1.6 Climate Data & Information Records/Scientific Data Stewardship

- Reconstruction of Global Phytoplankton Biomass

Task leader Stephanie Schollaert Uz
Task Code ABSURGPB_11
NOAA Sponsor Chris Brown
NOAA Office NESDIS/STAR/CRPD/SCSB
Main CICS Research Topics Climate Data and Information Records, Earth System Monitoring from Satellites
Percent Contribution to CICS Themes Theme 2: 75%; Theme 3: 25%
Percent Contribution to NOAA Goals Goal 1: 25%; Goal 3: 75%

Highlight: Tropical Pacific sea surface chlorophyll concentrations were reconstructed for the period 1958-2008 using physical proxies (SST, SSH, and MLD). Decadal chlorophyll anomalies are dominated by ENSO with some interesting exceptions.

BACKGROUND

This work was part of the NOAA CICS-MD project "Reconstruction of global phytoplankton biomass". The research and development in this project included creating a multi-decadal statistical reconstruction of ocean color surface chlorophyll concentrations in order to characterize low frequency patterns in phytoplankton biomass. While seasonal patterns of blooms are well known, long term patterns are not. Documenting low frequency changes requires long time-series of phytoplankton biomass measurements, yet the best-resolved, large-scale, continuous biological variable (satellite-derived surface chlorophyll concentration) is only 14 years long. In situ data sets have yielded conflicting results.

Canonical correlation analysis (CCA) has successfully reconstructed physical variables, including sea surface temperature and meteorological fields. Because ocean physics controls nutrient availability through upwelling or horizontal advection, to the first order ocean physics controls ocean biology. Multi-decadal data sets of physical variables exist. Sea surface temperature, mixed layer depth, sea surface height, and wind stress curl are variables which reflect vertical exchange processes. Of these, sea surface temperature, mixed layer depth, and sea surface height have been found to correlate best to ocean color chlorophyll. Simple Ocean Data Assimilation (SODA) mixed layer depths and sea surface temperatures are available between 1958-2008.

Now CCA has been applied to a biological data set to extend ocean color chlorophyll concentration back to 1958 using a longer record of physical proxy data in locations where phytoplankton abundance is primarily controlled and predicted by physical forcing. After validating the reconstructed chlorophyll in the tropical Pacific, coherent low frequency climate-scale signals were observed (primarily ENSO, but also PDO). These data are being used to gain insights into phytoplankton biomass pattern changes corresponding to ecosystem regime shifts, among other things.

ACCOMPLISHMENTS

Monthly SeaWiFS chlorophyll concentrations were binned to 2^o and temporally smoothed over three months between September, 1997 through December, 2008, with gaps toward the end of the record filled with MODIS Aqua. Simple Ocean Data Assimilation (SODA) 2.1.6 data are available 1958-2008. The SODA data were binned the same; the land mask was expanded to exclude pixels within 2^o of the coast; the annual cycles were removed; anomalies were demeaned and normalized by standard deviations.

Normalized data were decomposed using Empirical Orthogonal Functions (EOF) that represent the major variations in the data while filtering out noise. The first nine modes account for about 50% of the variability in global CHL and combined SST and MLD or SSH. CCA was first tried at global scale, but the large El Niño signal clearly dominates, so the tropical Pacific between 20^oN-20^oS was isolated. The first nine EOF modes account for 73% of the variability in CHL combined with SST and MLD; 79% of the variability in CHL combined with SST and SSH.

Comparison between the reconstructed CHL and the original CHL confirms that physical processes are mostly controlling phytoplankton abundance in the tropical Pacific. The CHL reconstruction created using SST and SSH as proxies has the highest fidelity along the equator and away from coasts, with the correlation between the original and reconstructed CHL highest just west of the cold tongue: Nino 4 (r = 0.90), Nino 3.4 (r=0.89), and Nino 3 (r=0.86). There is lower coherence in the coastal Nino 1&2 area (r=0.80). Comparing the correlation patterns to the map of the average CHL shows the reconstruction most closely replicates the original CHL in locations where average values are greater than 0.2 mg m^{-3}. The reconstruction was validated against CZCS ocean color data and all available in situ data.

Over the 51 year reconstruction period, low frequency chlorophyll anomalies in the tropical Pacific are dominated by ENSO with some interesting exceptions. During strong El Nino years, negative chlorophyll anomalies are observed in the reconstructions with positive anomalies during strong La Nina years (Figure 1). These observations are consistent with previous studies on the climatic influence of ENSO upon ocean surface chlorophyll. There is no clear coherent trend in ENSO strength or location, but evidence that slower climate oscillations modify ENSO and the associated biological patterns.

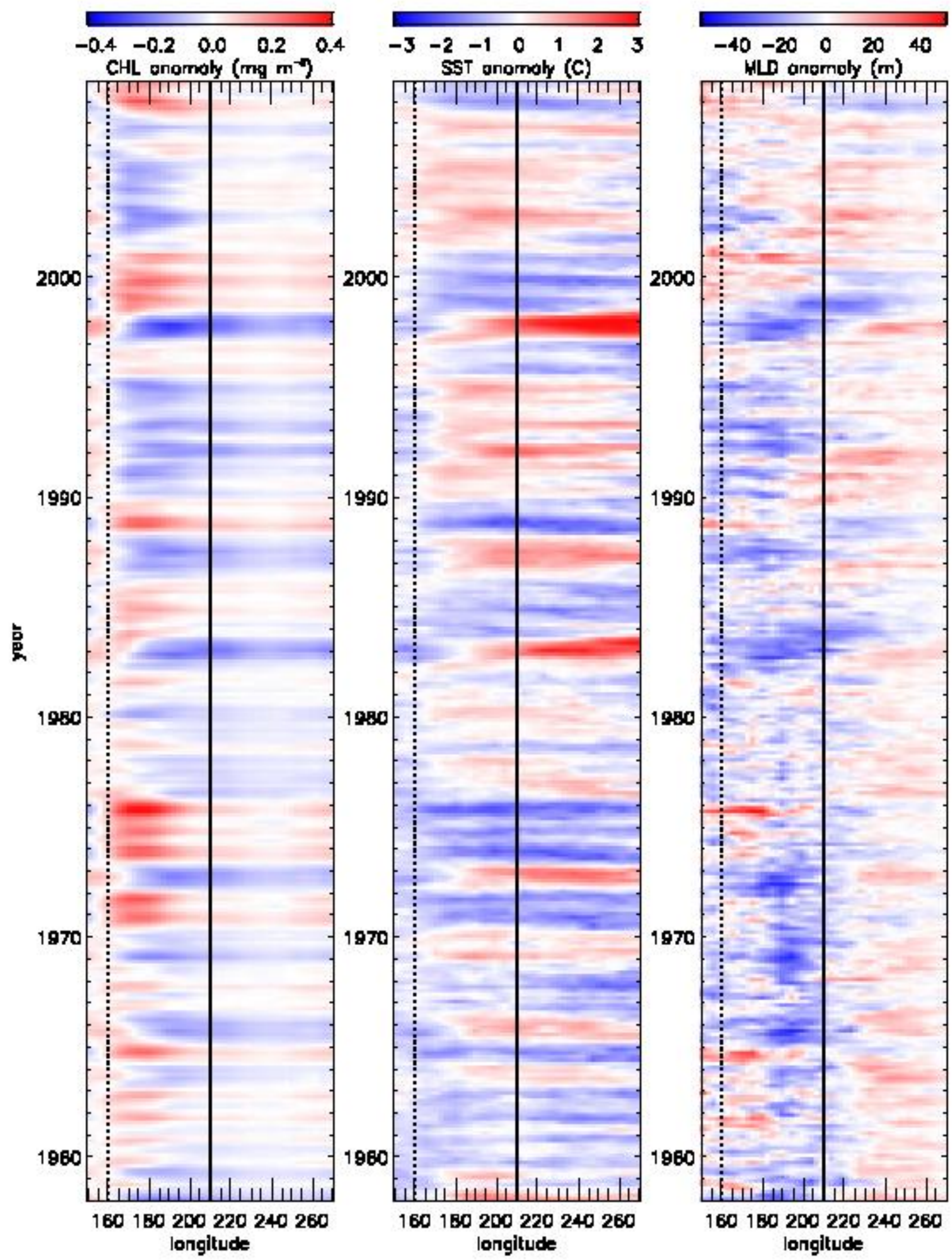


Figure 1: *Longitude-time plot of reconstructed CHL (left), SST (middle), MLD (right) averaged along the equator (+/- 2^o) between 9/1997-12/2008: Nino4 is between the dotted and solid lines; Nino3 is east of the solid line.*

Along a narrow equatorial band east of the dateline, CHL anomalies are dominated by the lower frequency PDO and linked to zonal wind variability more than any other physical variable. There are more negative CHL anomalies during the PDO warm phase, except for the narrow equatorial band which experiences greater positive CHL anomalies and smaller negative CHL anomalies (Figure 2). The CHL difference between regimes is not associated with temperature, but with zonal winds. Anomalous westerly winds result in reduced Ekman transport, reduced equatorial upwelling, and warmer SST. Higher CHL anomalies along the narrow equatorial band during the warm regime are associated with more variable and episodic winds, leading to intermittent nutrient entrainment and blooms. Other studies have noted the predominance of sardines off of South America during the PDO warm phase. This CHL reconstruction offers a link between primary production and higher tropic levels, yet more research is needed to understand why species flourish or collapse with these CHL patterns.

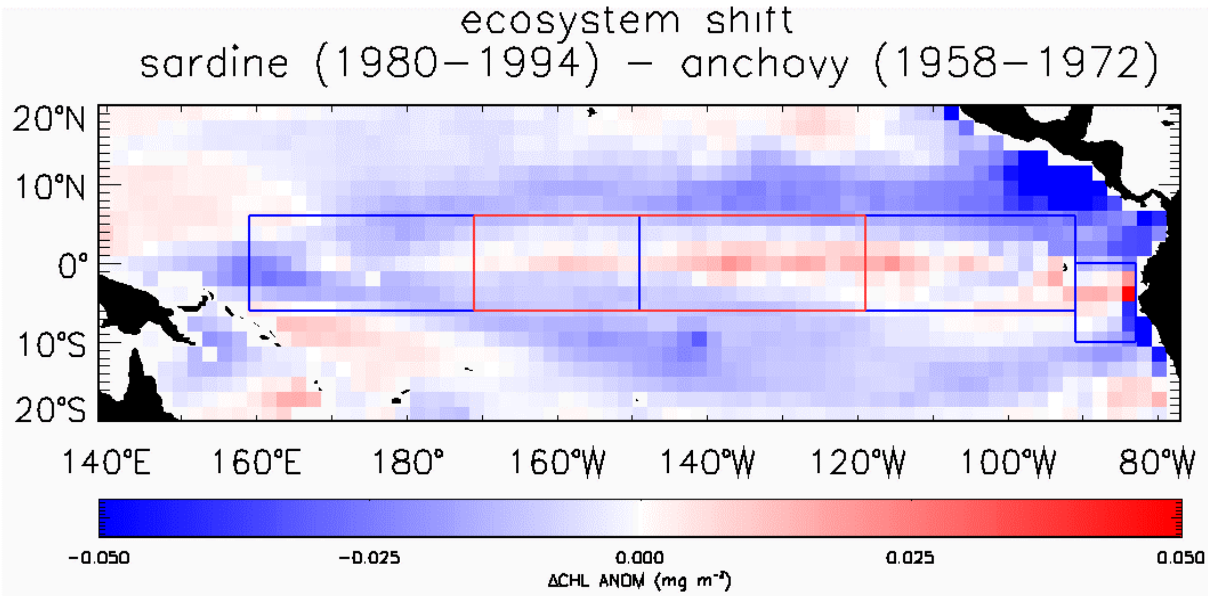


Figure 2: *Difference in reconstructed CHL anomalies between high PDO phase (warm-sardine regime) and low PDO (cool/anchovy regime). Nino regions are delineated.*

PLANNED WORK

- Finish and defend UMD dissertation (anticipate spring/summer, 2013 defense date)
- Publish 3 peer-reviewed manuscripts (*in prep*.)

PRESENTATIONS

Schollaert Uz, S., 'Statistical Reconstruction and analysis of global chlorophyll concentrations using physical proxy data', 2012 Ocean Science meeting, Salt Lake City, UT, Session 044: Advancing Satellite Ocean Color Science for Global and Coastal Research, 8:45am (oral).

OTHER (OUTREACH)

From this research, I wrote the narrative, 'Effects of El Nino/La Nina on phytoplankton and fish' to go with EarthNow visualizations displayed on Science-on-a-Spheres in museums and other locations around the world. The professionally narrated story includes ocean color imagery, with El Nino and La Nina months annotated along with photos of fish and other marine life impacted by El Nino.
ftp://ftp.ssec.wisc.edu/pub/earthnow/rowley/20130312_video.mp4

Performance Metrics	**FY12**
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	3, in prep.
# of non-peered reviewed papers	1
# of invited presentations	1
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	N/A

- The Global Precipitation Climatology Project (GPCP) Data Products – Transfer to Operations at NCDC

Task Leader Robert Adler
Task Code Independently funded NOAA project
NOAA Funder Jeff Privette
NOAA Office NESDIS/NCDC/RSAD
Main CICS Research Topic Climate Data and Information Records and Scientific Data Stewardship
Percent contribution to CICS Themes Theme 1: 0%; Theme 2: 100%; Theme 3: 0%.
Percent contribution to NOAA Goals Goal 1: 50%; Goal 2: 50%

Highlight: Routine production of the well-used and highly cited Global Precipitation Climatology Project (GPCP) V2.2 global precipitation dataset is being transferred from a distributed network of centers to NCDC. At the project's conclusion, NCDC will be the operational producer of GPCP V2.2 at monthly, pentad and daily resolutions and will be able to retrospectively process the entire record.

BACKGROUND

The objective of this work is to successfully transfer the routine production of Global Precipitation Climatology Project (GPCP) products to NCDC from the ad-hoc processing currently performed at several distributed centers. The current monthly (1979-present), pentad (1979-present) and daily products (1997-present) have been developed by research groups over the last 15 years and are produced by a consortium of those groups, funded by various agencies. Transfer of the routine processing of the GPCP products to an operational entity will ensure continuation of these important data analysis sets.

This activity involves the development of a detailed strategy for transfer of scientific knowledge, satellite and other data source accesses, and processing code for successful implementation of an end-to-end processing system that would routinely produce the GPCP current (Version 2) products for archival and dissemination.

The current GPCP processing involves computation of individual intermediate products or data sets by a number of government and university entities and a merger of these products by another group. These codes are being organized, streamlined, updated and documented for product production from the level of the satellite-calibrated radiances to the final merged products. Testing and evaluation of output products from the new system is a key part of this project, as is an evaluation of the feasibility of reprocessing the 30-plus-year-record to make minor upgrades. Maintaining science quality of the output products will be a critical aspect and will require significant on-going effort.

ACCOMPLISHMENTS

The existing algorithms that must be run to produce GPCP V2.2 are being streamlined and re-written where necessary to comply with NCDC coding standards. Each of the three products will be created separately by the Executive Control Package (ECP), a shell script that calls the various elements of the code. Data acquisition will be handled outside of the ECP since this will need to be done on a routine basis. Of the three code elements, the monthly product is the most challenging to implement because it has the most inputs and has the oldest legacy code. In addition, there are several processing streams used to produce the 30-year record. The monthly code package has now completed the design and assembly phases and has been streamlined to run in test mode at UMD. The code for the pentad and daily products is still in the design phase. Figure 1 shows the output from the monthly ECP run at UMD. Some additional testing of the Monthly product is required, but we are close to being able to run the code to produce the full period of GPCP data.

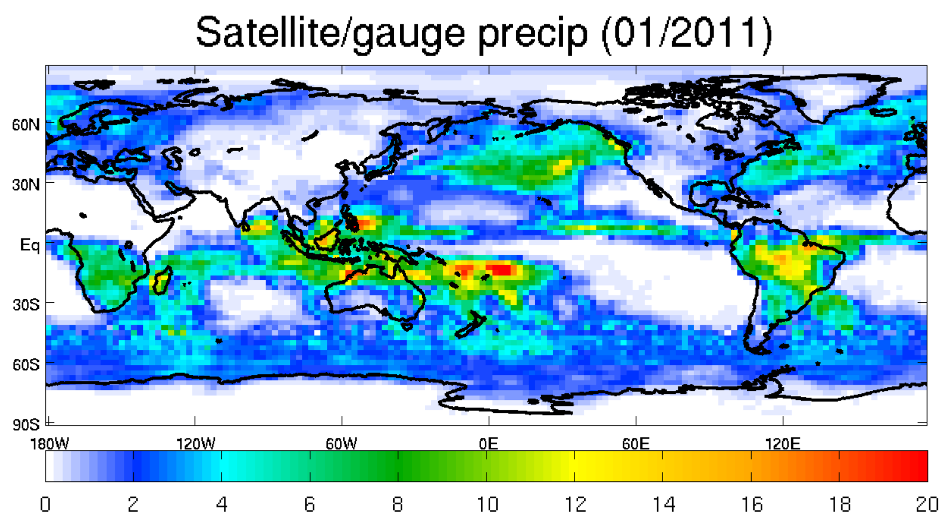


Figure 1: Monthly precipitation for January 2011 produced using the monthly CDR code.

PLANNED WORK

- Finish testing of monthly CDR code and produce full GPCP monthly record at UMD.
- Begin implementation of pentad and daily products
- Implement NetCDF output file formats and liaise with the relevant NCDC contacts to ensure that the standard developed is acceptable

Performance Metrics	FY12
# of new or improved products developed	0
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	4
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	0

- CICS Support for the National Oceanographic Data Center

Task Leader Gregg Foti
Task Code EBEB_NODC12
NOAA Sponsor Terry Tielking
NOAA Office NESDIS/NODC
Main CICS Research Topic Climate Data and Information Records and Scientific Data Stewardship
Percent contribution to CICS Themes Theme 1: 16%; Theme 2: 46%; Theme 3: 38%.
Percent contribution to NOAA Goals Goal 1: 70%; Goal 2: 9%; Goal 5: 21%

Highlight: In 2012 CICS played a significant role in the development of improved satellite data products, working with the ocean science community to provide global and regional ocean data, and by validating new space-based ocean observing technologies. CICS enhanced NOAA's ability to understand, predict and communicate climate variability by data distribution and education through web based satellite data, detailed descriptions of these data and the World Ocean Database.

BACKGROUND:
Coral Reef Temperature Anomaly Database (CoRTAD) Finalization and Release; Processing and Merging of hydrographic data into the World Ocean Database (WOD); Quality Control and Application of Global Salinity Anomaly Fields derived from WOD; and National Oceanographic Data Center Satellite Support; Acquisition of data from Bodega Marine Lab (UC Davis), Integrated Ocean Observing System (IOOS) Regional Association (RA) Mid-Atlantic Regional Association Coastal Ocean Observing System (MARACOOS), IOOS Regional Association (RA) Southeast Coastal Ocean Observing Regional Association (SECOORA), and the NOAA Rolling Deck to Repository (R2R) from the NOAA Office of Marine and Aviation Operations (OMAO); Development of the data quality monitoring systems for Jason-2/3 products, SMOS and Aquarius sea surface salinity data and AVHRR Pathfinder V5.2 sea surface temperature (SST); Development of the data distribution, archive and science stewardship for Jason-2/3 altimetry and MODIS/Aqua Ocean Color Products; Application of the OSTM/JASON-2 Satellite in monitoring of disaster Tsunami and hurricane Events; Ocean acidification data management project development; NODC online submission system development; Transfer of data from the Carbon Dioxide Information Analysis Center (CDIAC) to NODC; Transfer of data
from the Biological and Chemical Oceanography Data Management Office(BCO-DMO); The eXpendable BathyThermograph (XBT) profiles forms an important component of historical subsurface temperature measurements contributing 56% of ocean temperature profiles between 1967 and 2001.

Mathew Biddle (NOAA Collaborators: Dr. Krisa Arzayus, Steven Rutz, Tim Boyer); Gregg Foti (NOAA Collaborators: Dr. Kenneth Casey, Dr. Deirdre Byrne); Liquing Jiang (NOAA Collaborators: Dr. Krisa Arzayus, Dr. Hernan Garcia); Nisha Kurian **(**NOAA Collaborators : Tim Boyer, Sydney Levitus); James Reagan (NOAA Collaborators: Sydney Levitus, Tim Boyer); Yongsheng Zhang (NOAA Collaborators: Dr. Deirdre Byrne, Dr. Eric Bayler);

NOAA's National Oceanographic Data Center (NODC) is an organization (http://www.nodc.noaa.gov/) that provides scientific and public stewardship for national and international marine, environmental, and ecosystem data and information. With its regional branch assets and divisions (http://www.nodc.noaa.gov/General/NODC-About/orgchart.html), NODC is integrated to provide access to the world's most comprehensive sources of marine environmental data and information. NODC maintains and updates a national ocean archive with environmental data acquired from domestic and foreign activities and produces products and research from these data which help monitor global environmental changes.

The satellite team is responsible for the archiving and delivery of ocean data products that are derived from sensors operating in space. These include sea surface temperature, ocean altimetry, ocean vector winds and other products derived from these measurements. The satellite team adds value by providing metadata, making the data discoverable, performing quality assurance and providing scientific and technical support to users of these data (http://www.nodc.noaa.gov/SatelliteData/).
The Coral Reef Temperature Anomaly Database (CoRTAD) product is designed to quantify global-scale stressors that are widely deemed responsible for the decline of coral reefs. A likely candidate is rising sea surface temperature (SST) in much of the tropics. CoRTAD, funded by the NOAA Coral Reef Conservation Program uses SST from NOAA's Pathfinder program to develop weekly SST averages, thermal stress metrics, SST anomalies (SSTA), SSTA frequencies, SST Degree heating weeks and climatologies (http://www.nodc.noaa.gov/SatelliteData/Cortad/).
The World Ocean Database (WOD) is one of the most requested products from the NODC (http://www.nodc.noaa.gov/OC5/WOD/pr_wod.html). It is a vast hydrographic database that includes over 12.8 million profiles dating back to the late 18th century. In order for the WOD to keep growing, and to keep being used by the public for a multitude of different ocean studies, data from the NODC archive must be continually processed and merged into the WOD. This requires that the data be converted into a common format, checked for uniqueness and quality, and merged into the WOD.

The WOD is also used in calculating gridded climatologies of the ocean. The World Ocean Atlas as well as a multitude of regional climatologies (http://www.nodc.noaa.gov/OC5/indprod.html) have been created from the WOD. The climatologies require extensive amounts of quality control to ensure an accurate product. More recently, since the introduction of Argo floats, monthly gridded products have also been able to be produced. One current research project has been to look at gridded monthly salinity anomalies and compare and contrast with the Aquarius Sea Surface Salinity data.

The World Ocean Database was adjusted to calculate a climatology over regional scales. With this adjustment came the expansion of the standard depth levels by which the fields were calculated. The standard fields were increased from 26 depth levels to 102 depth levels. This, in turn, provides a much more robust climatology over depth. Along with the increased depth levels, an increase in the gridding resolution was added. Previously, one-degree grids were used to compute the climatology. Now we have computed the climatology down to 1/10 degree grids, which provide a much higher resolution than ever before.

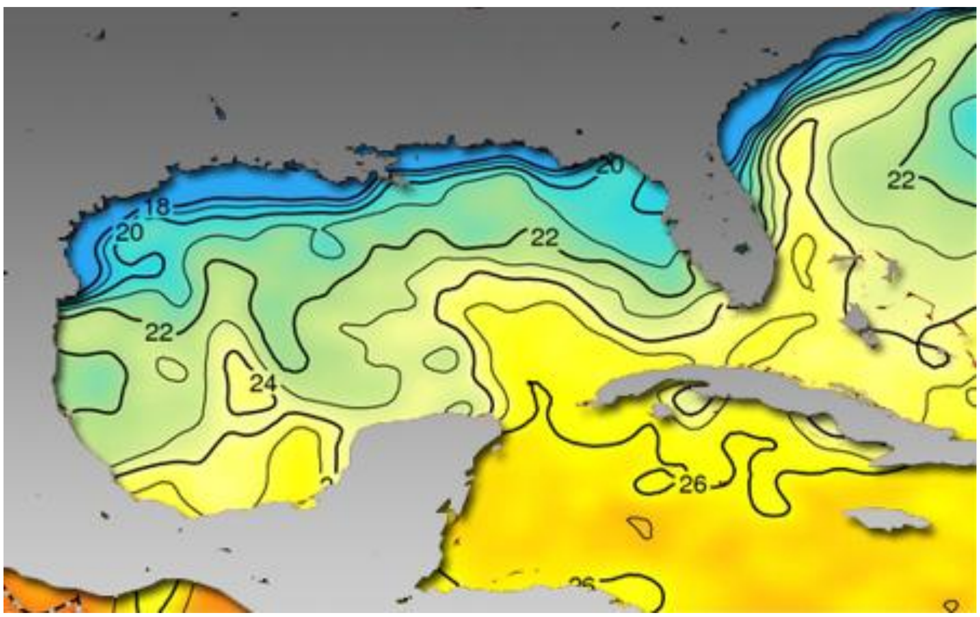


Figure 1. *The first regional climatology using these high-resolution grids was the Gulf of Mexico, found at http://www.nodc.noaa.gov/OC5/regional_climate/GOMclimatology/. CICS staff reviewed these images and added flags to the World Ocean Database to mark "bullseyes", or anomalous data not representative of the climatology.*

CICS staff reviewed and marked appropriate flags for the region. Currently, a sub-regional Arctic climatology is under review by CICS staff and will be marked for appropriate "bullseyes". Continuous updates and reviews have been conducted for each of the regions currently completed.

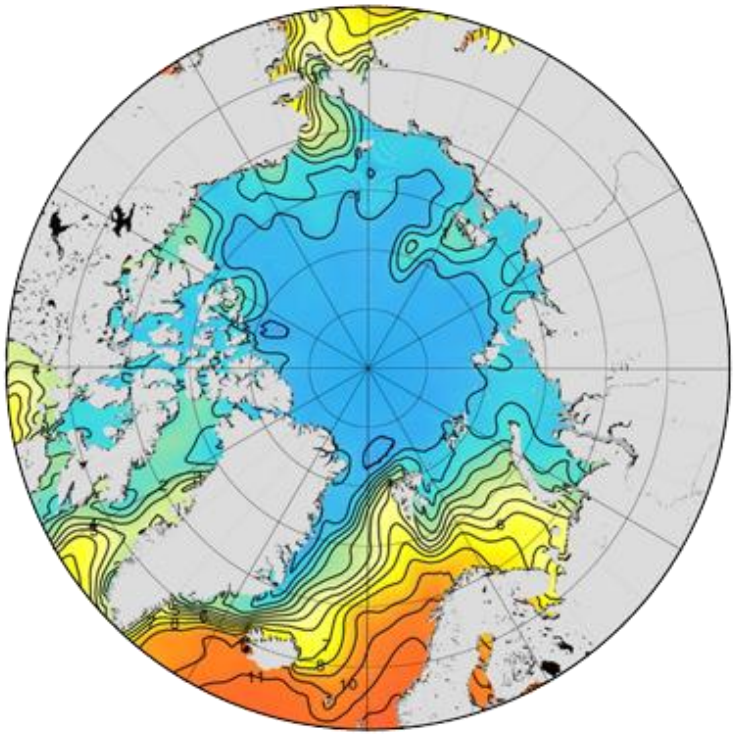


Figure 2. *The second regional climatology was focused on the Arctic, found at http://www.nodc.noaa.gov/OC5/regional_climate/arctic/.*

The ongoing satellite data products are all automatically ingested and placed in the NODC public data area. Here they are made available to the public with an array of online tools including ftp, http, OPeNDAP, THREDDS and our geoportal.

NODC is currently in the process of automating several in-situ datasets as well. CICS staff are currently negotiating with the Integrated Observing Systems (IOOS) Regional Associations MARACOOS and SECOORA to automate the full archive in-situ data. Once the agreement is defined, CICS staff will work with NODC IT staff to implement the automation and archive while providing public access to the in-situ data. These two RA's will be used as test beds and use cases for the remaining 9 observing systems.

NODC is working directly with NOAA Office of Marine and Aviation Operations (OMAO) to automate the archival of Shipboard Computer System (SCS) underway data collected by the NOAA fleet. The agreement has already been established and in-depth discussions about data file formats, documentation, and transfer mechanisms are currently in progress. The OMAO SCS data is part of the NOAA R2R program and this automation will provide a starting point for the rest of the NOAA fleets archival of oceanographic data.

NODC assisted in updating the Global Temperature-Salinity Profile Program (GTSPP) Continuously Managed Database or CMD. The Global Temperature and Salinity Profile Program (GTSPP) is a cooperative international program to develop and maintain a global ocean Temperature-Salinity resource with data that are both up-to-date and of the highest quality. It is a joint World Meteorological Organization (WMO) and Intergovernmental Oceanographic Commission (IOC) program. CICS staff are currently providing support by updating the external access to data from the GTSPP CMD by updating the web images and files discovered at http://www.nodc.noaa.gov/GTSPP/access_data/gtspp-rt.html.

NODC manages and operates the World Data Center (WDC) for Oceanography (http://www.nodc.noaa.gov/General/NODC-dataexch/NODC-wdca.html) in Silver Spring.

In its role as the US archive for oceanographic data, NODC provides near real-time and delayed-mode product distribution, rigorous archive services, and long-term data stewardship for the Jason-2/Ocean Surface Topography Mission (OSTM) and future Jason-3 products. An important component of NODC's data stewardship for Jason-2/3 products is to develop a data quality monitoring system known as the Rich Inventory which provides an important tool to monitor and track the data assurance statistics and metadata attributes in each granule, and to provide those results to the public. This system improves the integrity of the Jason-2/3 archive, thereby enhancing the usefulness and deepening the understanding of the data for climate and other long-term applications. In FY 2012, this work was also extended to establishment similar data quality system for Soil Moisture and Ocean Salinity (SMOS) satellite and Aquarius sea surface salinity data and AVHRR Pathfinder V5.2 sea surface temperature (SST).

Since 1992, the satellite altimetry missions of TOPEX/Poseidon, Jason-1 and Ocean Surface Topography Mission (OSTM)/Jason-2 have provided sea surface heights for determining ocean circulation, climate change and sea-level rise. They have been instrumental in meeting NOAA's operational need for sea surface and wave height measurements necessary for ocean modeling, forecasting El Niño/La Niña events, and hurricane intensity prediction.

Compared to NOAA's other satellites, the Jason-2 altimeter is uniquely designed to observe the sea surface height anomaly and significant wave height on the ocean surface. It can be applied in real-time monitoring of changes of the sea surface across tsunami waves and the wave activities around a hurricane or across tsunami waves. Using Environmental Systems Research Institute's (ESRI's) Geographic Information System (ArcGIS) software, NODC has developed high-quality georeferenced visualizations of Jason-2 data for reveal the sea level and wave changes in the Japanese Honshu Tsunami event and Hurricane Irene. NODC envisions generating this type of scientific application product to correspond with natural disasters and/or extreme weather events, in order to contribute value-added analyses products that can be provided and distributed with data stewarded by NODC.

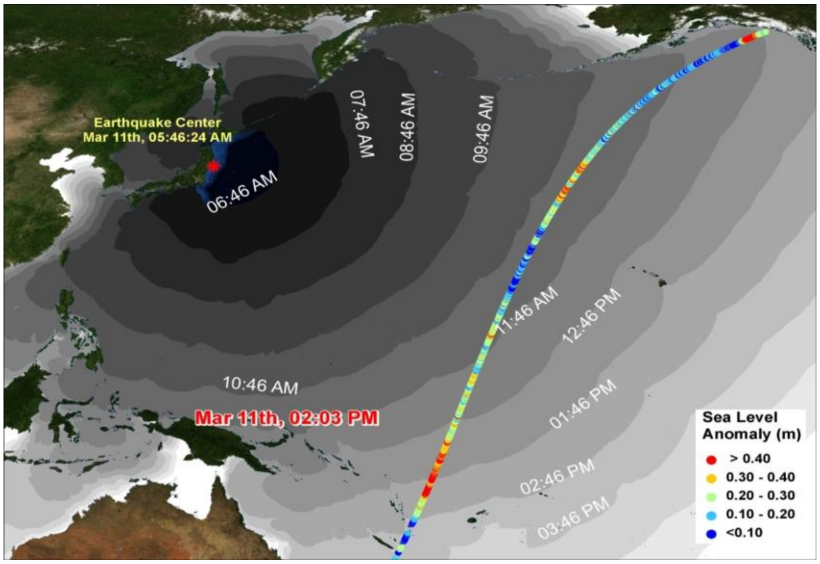


Figure 3. *Sea surface height anomaly observed by Jason-2 satellite (color shading) overlaid onto the first-arrival travel times map of the tsunami (black-white shading to show time) after the March 11, 2011 earthquake near the east coast of Honshu, Japan. Jason-2 satellite successfully captured the sharp rise of the sea level at 02:03 PM, March 11, 2011, 8hour and 17 minutes late after the earthquake in the Southwest Pacific.*

NODC was funded by NOAA's Ocean Acidification Program to manage their data through the Ocean Acidification Data Stewardship (OADS) project. The overarching goal of the OADS project is to serve the OA community by providing dedicated online data discovery, access to NODC-hosted and distributed authoritative data sources, long-term archival, coordinated data flow, and scientific stewardship for a diverse range of OA and other chemical, physical, and biological oceanographic data.

The XBT instrument measures depth using fall rate equation that calculates depth from the time elapsed since the XBT probe entered water. The inter-comparison of the XBT and high-quality hydrographic data suggests that depth-temperature measurements from XBTs to be systematically biased. There have been a number of suggested XBT bias correction algorithms published in the literature. Easy access and use of these correction schemes is important for calculation and comparison of ocean heat content integrals

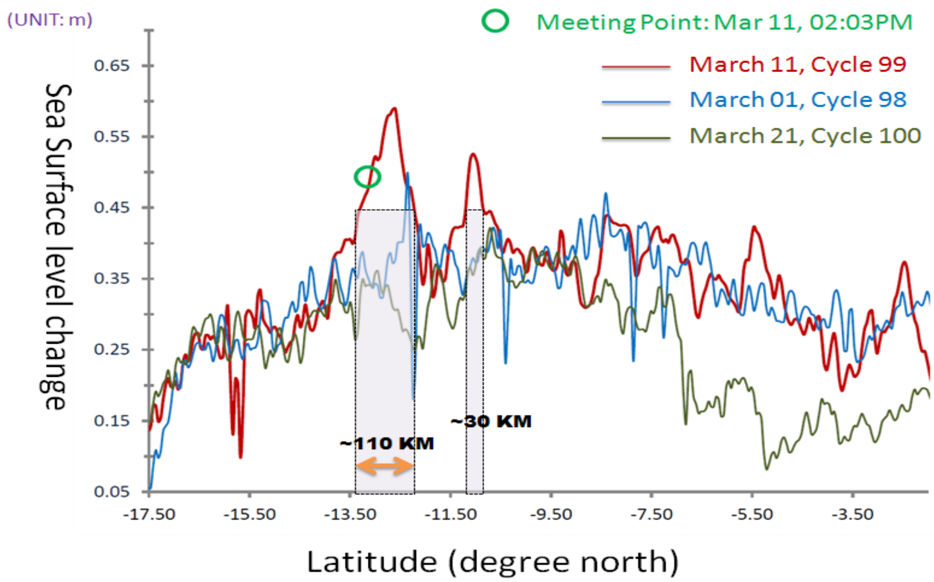


Figure 4*. Changes of the sea surface level (red line) when Jason-2 marches from south (17°S) to north (3.5°N) in the southwest Pacific Ocean to met the Tsunami wave front at 2:03 PM, March 11, 2011. The satellite measured two peaks of the wave with amplitudes over 45 cm on horizontal scales of 100Km and 30 km, respectively. The green and blue lines provide a background of the sea surface change in same location but ten days after/before the Tsunami.*

ACCOMPLISHMENTS

The Coral Reef Temperature Anomaly Database (CoRTAD) version 4 beta has been vetted and released. The NODC provided tools for discovery, outreach, data usage and comprehension of these data. Improvements over previous versions of CoRTAD include:

- CoRTAD 4 is now in NetCDF format, which is preferred by ocean modelers and much of the oceanographic community.CoRTAD 4 contains vastly enriched metadata.
- CoRTAD 4 uses the latest Pathfinder data, version 5.2.
- CoRTAD 4 now goes back to the last 2 months of 1981 and now contains 2010 data.
- CoRTAD 4 has slightly higher spatial resolution at 8192 x 4096 global pixels.
- CoRTAD 4 uses an improved land mask.

The Satellite team has been working with various agencies to evaluate new data products including geostationary and polar satellite SST, Ocean wind and Coastal Ocean Dynamics Applications Radar (CODAR) coastal current with the purpose of reaching agreements to distribute and archive these data.

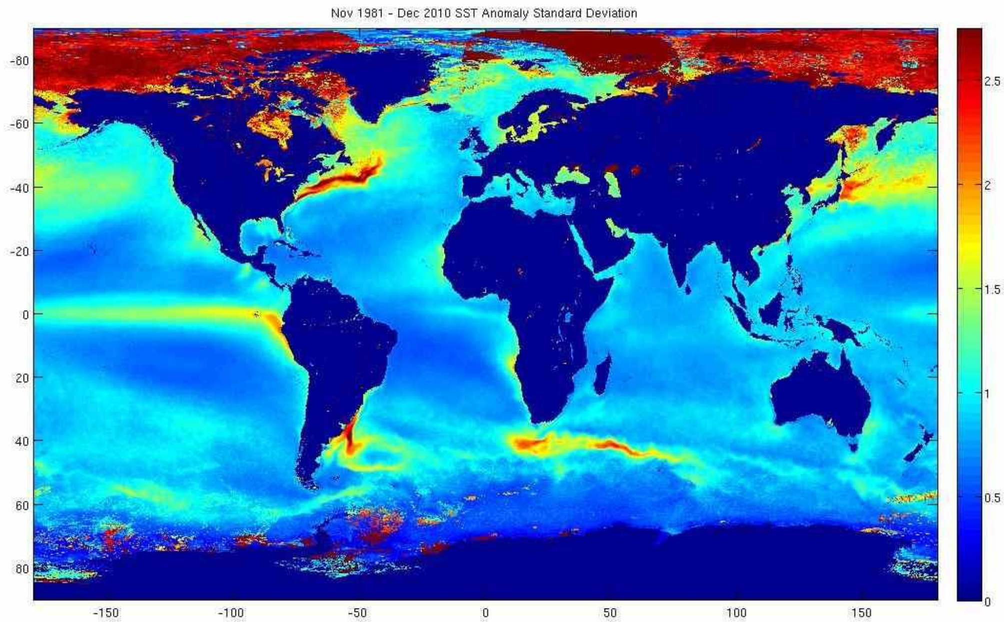


Figure 5. *CoRTAD SST Anomaly Standard Deviation from November 1981 through December 2010.*

Pathfinder, the only Climate Data Record (CDR) for SST was extended from 1981 through 2011.

Conductivity, Temperature, Depth (CTD) and bottle data from the CLIVAR & Carbon Hydrographic Data Office (CCHDO) were processed and merged into the WOD. CTD and bottle data from the International Council for the Exploration of the Seas (ICES) was processed and merged into the WOD. CTD data from the Northeast Fisheries Science Center (NEFSC) was processed and merged into the WOD. Of the 61,966 profiles that were processed, 55,964 were either new or updated profiles and were merged into the WOD.

The World Ocean Atlas 2013 (WOA13) is slated to come out in 2013. The WOA13 will include, in addition to the all-decade climatologies, individual decadal climatologies (beginning 1955) on a quarter degree grid with 102 depths ranging from 0m to 5500m. Multiple runs of quality control have been done, removing bullseyes within the salinity fields. In addition to the quality control of the WOA13 salinity fields, quality control of the one degree seasonal salinity anomaly fields for 2012 has also been performed.

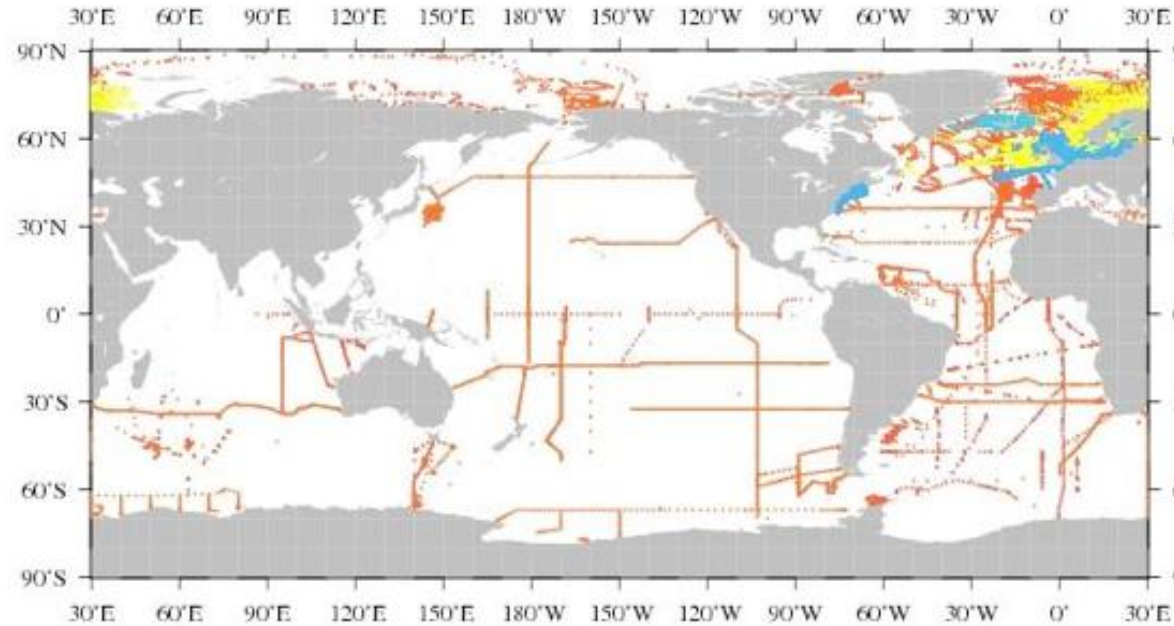


Figure 6. *CTD and bottle observations processed and merged into the WOD from CCHDO, ICES and NEFSC from March 2012 through February 2013. There were a total of 55,964 profiles added or updated in the WOD.*

Ongoing research accomplishments include a comparison analysis between Aquarius monthly Sea Surface Salinity (SSS) products and the NODC monthly SSS products. This has revealed regions of strong similarities and differences. In a very broad sense, coastal regions and regions of very cold water exhibit the strongest differences; however, these are being improved upon with the later releases of Aquarius data. Furthermore, a harmonic analysis was performed on both the NODC and Aquarius data to look at the SSS annual cycle. Preliminary conclusions show that they both exhibit similar annual cycles, especially with respect to the first harmonic.

A relationship and agreement with Bodega Marine Lab for automating the archival of their mooring data and with NOAA's OMAO for automating the archival of their NOAA fleet underway SCS data have been established.

Began building the infrastructure for the Ocean Acidification Data Stewardship (OADS) project, including development of ISO metadata standard for ocean acidification data, interagency ocean acidification parameter list, and data submission guidelines.

NODC is working to create an online data submission system, which will make it easier for data providers to submit their data; and automate a lot of the archiving procedures to reduce the time needed to get data archived. The draft of the requirements for this effort has been completed. An alpha-version was released in November 2012.

The transfer of data from the Carbon Dioxide Information Analysis Center (CDIAC) began. Over 100 accessions to NODC (including data from voluntary observing ships, time-series, and global coastal program) were ingested this year. A similar effort to transfer data from the Biological and Chemical Oceanography Data Management Office (BCO-DMO) has been undertaken.

The NODC created and maintains an active website that provides the bias information of XBT and Mechanical BathyThermograph (MBT) for the oceanographic community at http://www.nodc.noaa.gov/OC5/XBT_BIAS/xbt_bias.html and http://www.nodc.noaa.gov/OC5/mbt-bias/ . These dynamic pages contain a list of peer-reviewed XBT and MBT corrections and are updated as new papers with estimates of corrections are published. It provides an explanation of the corrections detailed, the equations used and the tables used in each study.

The dynamic page http://www.nodc.noaa.gov/OC5/XBT_BIAS/xbt_bibliography.html provides the list of all known research papers that discuss problems with XBTs that lead to measurement uncertainty. It also contains cruise reports, notes and technical reports with references to comparison tests with other instruments, usually Conductivity-Temperature-Depth (CTD) probes. Many of these reports show side-by-side XBT/CTD drops, showing XBT errors against a CTD reference.

The NODC also hosts a WODselect selection tool
http://www.nodc.noaa.gov/cgi-bin/OC5/SELECT/builder.pl
for the World Ocean Database. The WODselect allows the users to download the XBT and MBT data with any of the ten published bias correction applied, as well as without any correction or with only Hanawa et al. (1995) correction applied.

- Regional climatologies for the Gulf of Mexico and the Artic have been produced.
- Implemented routine data archive and access services for real-time Jason-2 products at NODC and improved the data information homepages and related documentations;
- Upgraded the data processing system for data quality monitoring system for new version (from “C” to “D”) Jason-2 Interim Geophysical Data Records (GDRs) and Interim GDRs;
- Generated highly comprehensive ISO 19115 metadata for Jason-2/3 products;
- Finalized application study on application of the OSTM/JASON-2 satellite in monitoring of disaster events;

- Developed tools for calculating and visualizing the QA statistical values for a SMOS Level-2 swath data file;
- Developed automated processing and visualization tools for near-real-time Level-2 SMOS data in swath, daily, 3-day, and monthly mean time frames;
- Performed and developed tools and methods for histogram analyses in comparing the monthly mean sea surface salinity among SMOS, Aquarius, and NODC's objective analysis of *in situ* observations;
- Developed tools for calculating and visualizing the QA statistical values for AVHRR Pathfinder V5.2 SST.

PLANNED WORK

- Continue working with partners to provide global and regional products and climatologies identified as high priority by users, particularly users within NOAA.
- Begin the integration of Quality Monitoring for ocean surface salinity. This endeavor will use data from new salinity sensing satellites as well as in-situ ocean surface salinity products.
- Maintain leading role in world's SST community by operating the Group for High Resolution SST (GHRSST) *Long Term Stewardship and Reanalysis Facility* (*LTSRF*). The NODC LTSRF archives over 30GB of SST data each day. These data are created in the US, Europe, Australia and Japan.
- Develop the next version of Pathfinder as a SST Climate Data Record (CDR)
- Continue operational efforts by conducting scientific records (archive) appraisals for ocean satellite products and accessioning those products assessed as suitable for long-term archive. Products currently undergoing assessment include:
  - Geostationary Operational Environmental Satellites (GOES) SST
  - Polar Operational Environmental Satellites (GOES) SST with AVHRR Clear-Sky Processor over Oceans (ACSPO) processing
  - Merged GOES with Polar orbiting satellite SST products
  - Ocean wind products derived from *synthetic aperture radar (SAR*) instruments.
  - Near shore ocean current products derived from land based High frequency (*HF*) *radar*
- Continue to discover, assess, acquire and archive the wide array of new ocean data as they become available.
- Improve NODC's profile/participation in satellite mission stewardship and satellite data exploitation. Achieve an increased role in defining archive requirements for mission data and routine inclusion of NODC in budget for stewardship of large ocean datasets to be created or acquired by NOAA.
- Continue to archive hydrographic data in the NODC archive.
- Continue to process data for the WOD. This includes CCHDO, ICES, and NEFSC data, as well as other data sets received by NODC.

- Continue to QC WOA13 and other products derived from the WOD.
- Continue to compare and analyze the Aquarius Sea Surface Salinity fields to the WOD calculated SSS fields.
    - Analysis will include a deeper look into the annual cycle
    - Publish results
- Complete the automation of Bodega Marine Lab mooring data.
- Fully automate the archival of IOOS RA data.
- Fully automate the archival of NOAA OMAO data
- Continue to perform quality control for the regional climatologies, specifically sub-regions of the arctic. Identify other regions for climatology.
- Continue updating GTSPP Real-Time data files.
- Continue to implement data archival, distribution, integration, and public access service for Jason-2, SMOS and ocean color satellite products;
- Prepare and participate the acceptance test of NOAA Jason Ground System (NJGS), which is the NOAA next-generation ground system that will support the simultaneous operation of the Jason-2 and Jason-3 ocean surface topography missions;
- Develop Jason-3 data quality monitoring system, phase III;
- Establish data quality monitoring systems for SMOS and Aquarius sea surface salinity and AVHRR Pathfinder V5.2 SST products at NODC;
- Fulfill data archive services and stewardship for NOAA Chlorophyll Frontal Product from MODIS/Aqua and NOAA Sea Level Rise products;
- Continue to develop applications of satellite altimetry data in monitoring of the extreme weather and climate events.
- Continue building the infrastructure for Ocean Acidification Data Stewardship (OADS) project.
- Continue efforts to create an online data submission system.
- Continue effort in automating the transfer of more Carbon Dioxide Information Analysis Center (CDIAC) data.
- Continue effort to automate transfer of data from the Biological and Chemical Oceanography Data Management Office (BCO-DMO);
- Continue updating the XBT, MBT bias pages and XBT-CTD comparison pages as new papers are published.
- Use the XBT data with different corrections applied and the XBT data without corrections applied to understand how it affects the representation of the seasonal and inter seasonal cycle of ocean sub surface temperature.

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Boyer, T.P., S. Levitus, J.I. Antonov, J.R. Reagan, C. Schmid, R. Locarnini (in review) [Subsurface salinity], Global Oceans [in State of the Climate in 2012]. *Bull. Amer. Meteor. Soc.*

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Locarnini, R., S. Levitus, T. Boyer, J. Antonov, A. Mishonov, H. Garcia, M. Zweng, J. Reagan, M. Biddle (2012), World Ocean Atlas 2013: Improved vertical, horizontal, and time resolution, Abstract OS41C-1732 presented at 2012 Fall Meeting, AGU, San Francisco, Calif., 3-7 Dec

Nisha, K., M. Lengaigne, V. V. Gopalakrishna, J.Vialard, S. Pous, A-C. Peter, F. Durand, S.Naik, 2013: Processes of India's offshore summer intraseasonal sea surface temperature variability, Ocean Dyn. (accepted)

Yongsheng Zhang,Y. Li, K. Casey and D. Byrne, 2012: Application of the Ocean Surface Topography Mission/JASON-2 satellite in monitoring of disasters: hurricane and tsunami events. *Earth System Monitor, NODC/NOAA*, 19, 7-10.

PRESENTATIONS

Biddle, M. (2013) The National Oceanographic Data Center's Application of CF Conventions for In-Situ Data, presented at 2013 Winter Meeting, ESIP, Washington D.C., 8-10 Jan.

Biddle, M., K. Arzayus, D. Collins, C. Paver, S. Rutz (2012), Archiving oceanographic data at NOAA's National Oceanographic Data Center: A use-case approach, Abstract IN23C-1514 presented at 2012 Fall Meeting, AGU, San Francisco, Calif., 3-7 Dec.

Reagan, J., T. Boyer, J. Antonov. Comparison analysis between NODC in situ analyzed sea surface salinity and Aquarius sea surface salinity. Poster session presented at: American Geophysical Union Fall Meeting; 2012 Dec 3-7; San Francisco, CA.

Yongsheng Zhang, D. Byrne, Y. Li, K. Casey and S. Phillips, 2012: Progress in OSTM/Jason-2 Science Application Study and Data Discovery/Access Tools Development at NOAA National Oceanographic Data Center (NODC). 2012 Annual Meeting of the Ocean Surface Topography Science Team (OSTST), Sep., 27-28, 2012, Venice, Italy.

AWARDS

Mathew Biddle received a nomination for National Oceanic and Atmospheric Administration's (NOAA) Team Member of the Month award for hiss independent work in documenting and updating NODC's Archive Management Standard Operating Procedures and more optimally utilizing NODC's Wiki system.

Performance Metrics	**FY12**
# of new or improved products developed	7
# of products or techniques transitioned from research to ops	1
# of peer reviewed papers	8
# of non-peered reviewed papers	0
# of invited presentations	1
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	N/A

- Operational Generation of the HIRS Outgoing Longwave Radiation Climate Data Record

Task Leader Hai-Tien Lee
Task Code HLHL_HIRS11
NOAA Sponsor Jeff Privette
NOAA Office NESDIS/NCDC/RSAD
Main CICS Research Topic Climate Data and Information Records and Scientific Data Stewardship
Percent contribution to CICS Themes Theme 1: 10%; Theme 2: 90%
Percent contribution to NOAA Goals Goal 1: 100%

Highlight: NOAA/NCDC CDR Program has acquired the Initial Operational Capability (IOC) for HIRS OLR CDR Product and is moving toward Full Operational Capability (FOC), while CICS continues to take charge of maintaining science integrity and developing QA/QC system. In the coming year, we will be developing the 1°x1° Daily HIRS OLR CDR product in response to the continued requests for an OLR CDR product with higher temporal and spatial resolution.

BACKGROUND

The primary goals of this project are to prototype an operational production system for the outgoing longwave radiation climate data record while continue the improvements and validation efforts for the existing product and algorithms. An end-to-end system has been proposed to produce OLR CDR product using HIRS level-1b data input. The derivation of climate data record involves several careful procedures with OLR retrieval performed for each HIRS pixel, including: applying inter-satellite calibration to maintain continuity; use of diurnal models to minimize orbital drift effects in temporal integral; and consistent radiance calibration. We are also developing OLR algorithms for the operational sounders following the HIRS, including the IASI and CrIS, such that the OLR CDR time series can be extended into the foreseeable future (~2040) without data gaps.

ACCOMPLISHMENTS

HIRS OLR CDR Quality Assurance

As part of the continued validation campaign, the HIRS OLR CDR was compared to the latest CERES Energy Balanced And Filled (EBAF) v2.6 product, a Level4 product that considered to reach the highest scientific integrity (see Figure 1). The results showed very good agreement between HIRS OLR and CERES EBAF products in both absolute radiometric measurement scales as well in the OLR temporal and spatial variations.

Transition from Research to Operation

The HIRS OLR CDR production system has reached Initial Operational Capability (IOC) phase since September 2011. We continue to assist NCDC CDR Program to achieve Full

Operational Capability (FOC) while providing maintenance on the production system.

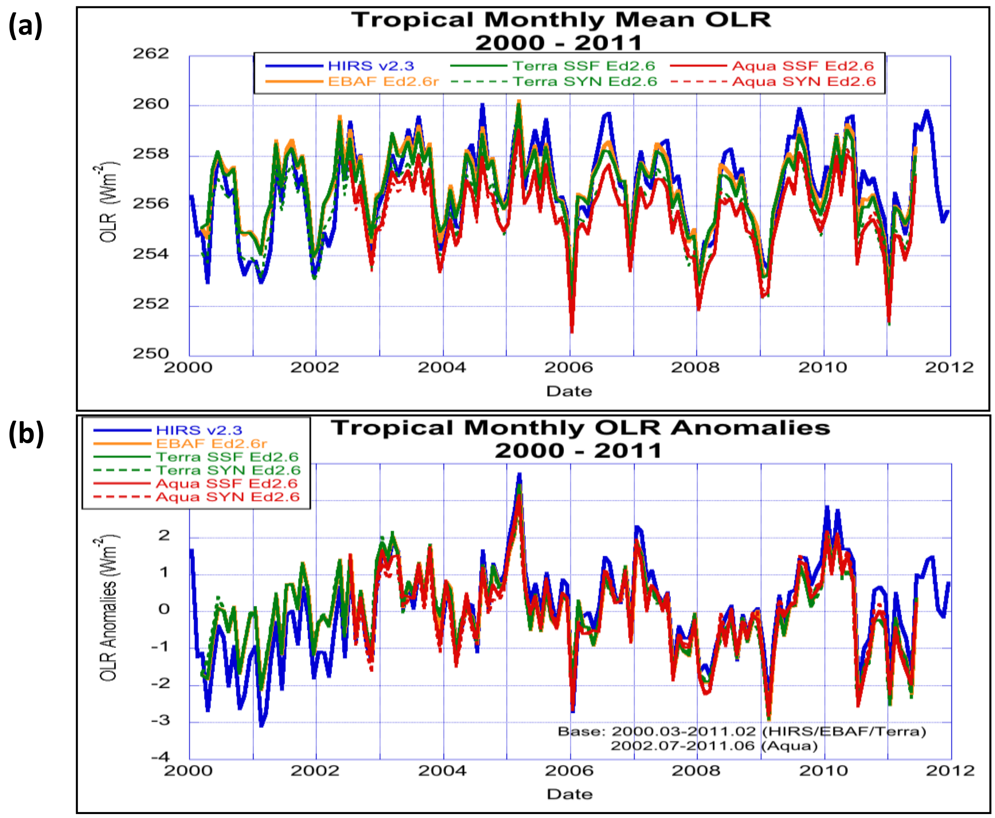

Figure 3. *Validation of the HIRS OLR Climate Data Record with CERES EBAF v2.6 data sets over tropics (20S-20N) for (a) monthly mean OLR, and (b) OLR anomalies. They mean OLR differences are at about 1 Wm^{-2} or smaller with rms differences of about 0.5 to 0.8 Wm^{-2}, both the mean and rms differences are well within the uncertainties of the CERES products. Comparisons of global means have similar results. The discrepancies between HIRS (blue) and Terra (green) in 2000 to early 2002 periods are still under investigation.*

PLANNED WORK

Tasks (April 1 2013 – March 30 2014):

- Develop 1°x1° Daily HIRS OLR CDR production system and documentations
- Set up a near-real time delivery system for 1°x1° Daily HIRS OLR CDR
- Verification of HIRS OLR CDR Operational Production at NCDC
- Running parallel HIRS OLR CDR production system at CICS
- Maintenance of NCDC HIRS OLR CDR Operational Production System - extend v2.2 product to March 2014.

- Address the possible intersatellite calibration error due to OLR algorithm channel switch using IASI/HIRS radiance emulation system and continue HIRS OLR algorithm improvements following the nonlinear multi-band regression experiments reported in Lee et al. (2009).
- Prepare journal articles and conference presentations

PUBLICATIONS

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Lee, H.-T., 2011: HIRS Outgoing Longwave Radiation Climate Data Record Algorithm Theoretical Basis Document (C-ATBD) (ftp://ftp.ncdc.noaa.gov/pub/data/sds/cdr/docs/ hirs-olr-catbd.pdf)

PRESENTATIONS

Robertson, F. R. and Hai-Tien Lee, 2012: An Alternative Inter-satellite Calibration of the UMD HIRS OLR Retrievals. AGU Fall 2012. December 3-7, 2012. San Francisco, CA. (Poster)

Lee, H.-T., 2012: HIRS OLR Climate Data Record - Issues and Validation Updates. CICS-MD Science Meeting, University of Maryland College Park, MD. Sept 7, 2012 (Oral)

Lee, H.-T., 2012: Global Long-term Monitoring of Outgoing Longwave Radiation from Operational Environmental Satellites - Review, Today, and the Future. Colloquium in Earth System and Geoinformation Sciences (GGS900), George Mason University, Fairfax, VA. Sept 5, 2012 (Oral, invited)

Lee, H.-T. and R. G. Ellingson, 2012: HIRS OLR Climate Data Record - Production and Validation Updates. International Radiation Symposium 2012. Dahlem Cube, Berlin, Germany, 06–10 August 2012 (Oral)

Lee, H.-T., 2012: Comparisons of Monthly Mean OLR Between HIRS OLR CDR v2.2/v2.3, CERES EBAF/SSF/SYN Ed2.6(r), ERA-Interim, CFSR & Merra Reanalyses. The CERES II Science Team Meeting, May 1-3, 2012 Newport News, VA (Oral)

DELIVERABLES

- HIRS OLR CDR product in NetCDF format, spanning from January 1979 to December 2010.
- HIRS OLR CDR Production System software and document package.

Link to NCDC HIRS OLR CDR Data

http://www.ncdc.noaa.gov/cdr/operationalcdrs.html

Performance Metrics	FY12
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	1
# of non-peered reviewed papers	1
# of invited presentations	4
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	0

1.7 Land and Hydrology

- A GOES Thermal-Based Drought Early Warning

Task Leader	Christopher Hain
Task Code	CHCH_NLDA_12
NOAA Sponsor	Xiwu Zhan
NOAA Office	NESDIS/STAR/SMCD/EMB
Main CICS Research Topic	Land and Hydrology
Percent contribution to CICS Themes	Task 1: 33%; Task 2: 33%; Task 3: 33%
Percent Contribution to NOAA Goals	Goal 1: 70%; Goal 2: 30%

Highlight: CICS scientist are developing a land data assimilation system using the NASA Land Information System (LIS) which assimilates soil moisture retrievals from a thermal infrared methodology (e.g., ALEXI) and from passive microwave sensors (e.g., AMSR-E; Windsat; AMSR2) to improve drought monitoring over the continental United States.

BACKGROUND

Evapotranspiration deficits in comparison with potential ET (PET) rates provide proxy information regarding soil moisture availability. In regions of dense vegetation, ET probes moisture conditions in the plant root zone, down to meter depths. Our group has spearheaded use of anomalies in the remotely sensed ET/PET fraction (f_{PET}) generated with ALEXI as a drought monitoring tool that samples variability in water use, and demonstrating complementary value in combination with standard drought indices that reflect water supply. Additionally, our research group has demonstrated that diagnostic information about SM and evapotranspiration (ET) from microwave (MW) and thermal infrared (TIR) remote sensing can significantly reduce soil moisture (SM) drifts in LSMs such as Noah. The two retrievals have been shown to be quite complementary: TIR provides relatively high spatial resolution (down to 100 m) and low temporal resolution (due to cloud cover) retrievals over a wide range of vegetation cover, while MW provides relatively low spatial (25 to 60 km) and high temporal resolution (can retrieve through cloud cover), but only over areas with low vegetation cover. Furthermore, MW retrievals are sensitive to SM only in the first few centimeters of the soil profile, while in vegetated areas TIR provides information about SM conditions integrated over the full root-zone, reflected in the observed canopy temperature. The added value of TIR over MW alone is most significant in areas of moderate to dense vegetation cover where MW retrievals have very little sensitivity to SM at any depth. This synergy between the two different retrieval techniques should provide a unique opportunity for the development of a dual assimilation system with the potential to improve drought assessments from the NLDAS suite of land surface models.

ACCOMPLISHMENTS

During the past year, our research group has process and generated ALEXI (TIR) soil moisture retrievals for the period of 2000 to 2012 and LPRM (MW) soil moisture retrievals for the period of 2002 to 2011. Unfortunately, the AMSR-E instrument failed late in 2011 and LPRM retrievals are not available for the period of 2012. Therefore, we have made efforts to use MW soil moisture retrievals from the Windsat and SMOS instruments. This work is still ongoing and further testing is needed before we can implement these new MW observations in the assimilation system.

Because NLDAS produces hydrologic products based on static climatological fields, which are not always representative of real conditions, we have tested the impact of using real-time satellite observations of green vegetation cover, albedo and incoming solar radiation. Specifically, monthly MODIS green vegetation fraction and albedo and hourly GSIP insolation to replace the NLDAS insolation (originally extracted from the 32-km Regional Reanalysis dataset). Solar insolation is measured at a number of US Climate Reference Network (USCRN) sites across the continental United States; therefore we sought to analyze the differences between GSIP and NLDAS insolation. We have initially analyzed 7 months in 2009 (April to October) over 115 USCRN sites and have shown the insolation observations from GSIP are closer to observed insolation than NLDAS (NARR). Generally, the improvements in MAE are on the order of 10 to 50 W m^{-2} (referenced to a daily average insolation; see Fig. 1).

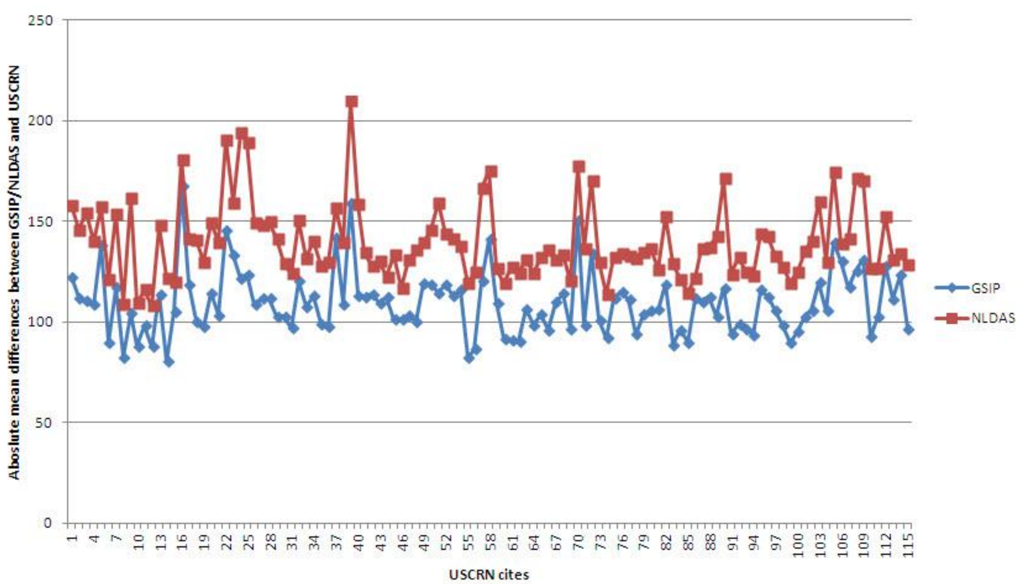

Figure 1. Mean absolute error of GSIP (blue) and NLDAS (red) solar insolation for April to October 2009at 115 USCRN sites.

In order to evaluate the strategy of dual assimilation technique, the data denial framework has been constructed to evaluate the ability of the assimilated TIR and MW retrievals to correct errors introduced by degraded precipitation dataset in comparison with a high quality precipitation dataset. TRMM satellite-based precipitation is used as a degraded dataset in the open loop simulation and NLDAS precipitation, a relatively high quality gauge-based, temporally corrected with radar precipitation dataset, in the benchmark simulation. Before introducing TRMM to land surface model, bias correction was conducted to make TRMM precipitation dataset statistically consistent with NLDAS dataset. We are currently in the process of optimizing the DA framework to assess the impact of single assimilations of ALEXI and LPRM and a dual assimilation of both observations. In general, our initial assimilation experiments show a pattern of general improvement in each assimilation case in 0-10 cm surface soil moisture (improvement quantified as a reduction in RMSE as compared to the open-loop simulation forced with a degraded satellite precipitation dataset [TRMM]; see Fig. 2). The dual assimilation shows a slight increase in the percentage of land pixels which showed improvement over the open-loop simulation. However, the differences are relatively small (compared to the single assimilations of ALEXI and LPMR) due to non-optimal performance of the EnKF, an issue that is currently being address by using more sophisticated methodologies for specification of model and retrieval error covariance.

We have also collected and processed in-situ soil moisture observations from the SCAN network, which provides 4 to 6 layers of soil moisture observations for over 100 sites in the continental US. These observations will be used to assess the impact of the assimilation cases in terms on time series anomaly correlation calculated from long-term time series from the SCAN observations.

PLANNED WORK

Ongoing and future work will focus on:

- Quantitative assessment of data assimilation SM results with in-situ soil moisture observations, NLDAS products and CFSRR forecasts.
- Comparison of data assimilation SM anomalies with the United States Drought Monitors and anomalies in all available standard drought metrics.
- Real-time product delivery of ALEXI SM assimilation drought maps to NIDIS-USDP, CPC and NDMC.

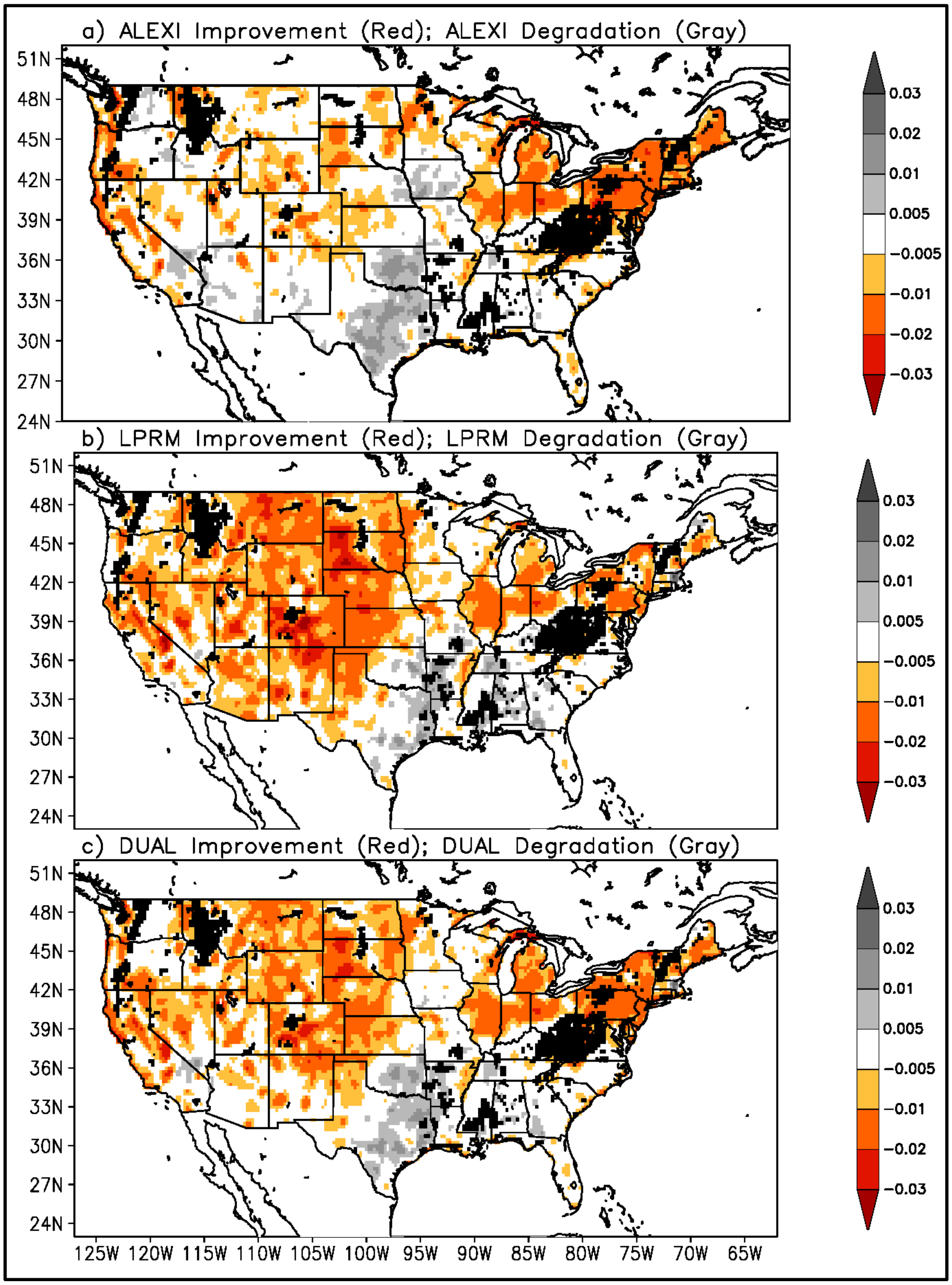

Figure 2. Differences in RMSD between (a) a single ALEXI assimilation, (b) a single LPRM assimilation, and (c) a dual assimilation of ALEXI and LPRM and the OLP (open-loop simulation). Red (gray) shading indicates improvement (degradation). RMSD is computed using the CONTROL (benchmark) simulation.

PUBLICATIONS

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Yilmaz, M. T., W. T. Crow, M. C. Anderson and **C. R. Hain**, 2012: An objective methodology for merging satellite- and model-based soil moisture products, *Water Resour. Res*., 48, W11502, doi:10.1029/2011WR011682.

Anderson, M. C., **C. R. Hain**, B. Wardlow, A. Pimstein, J. R. Mecikalski, and W. P. Kustas, 2012: A drought index based on thermal remote sensing of evapotranspiration. *In Remote Sensing of Drought*, B. Wardlow, M. C. Anderson, and J. Verdin, Eds., Taylor and Francis.

Temimi, M, **C. R. Hain**, X. Zhan, R. Rabin, M. C. Anderson, C. Notarnicola, J. Stepinski, and A. Bonhomme, 2013: On the synergistic use of microwave and infrared satellite observations to monitor soil moisture and flooing, *In Press, In Remote Sensing of Land Surface Turbulent Fluxes and Soil Surface Moisture Content: State of the Art*, Taylor & Francis.

Mishra, V., J. Cruise, J. R. Mecikalski, **C. R. Hain**, and M. C. Anderson, 2013: A remote-sensing driven tool for estimating crop stress and yields, *Submitted to Journal of Remote Sensing*.

Otkin, J. A., M. C. Anderson, **C. R. Hain**, I. E. Mladenova, J. B. Basara and M. Svoboda, 2012: Examining rapid onset drought development using the thermal infrared based evaporative stress index, *Submitted to J. of Hydrometeor.*

Anderson, M. C., **C. R. Hain**, J. Otkin, X. Zhan, K. Mo, M. Svoboda, B. Wardlow and A. Pimstein, 2013: An intercomparison of drought indicators based on thermal remote sensing and NLDAS-2 simulations with U.S. Drought Monitor classification, *Submitted to J. of Hydrometeor.*

PRESENTATIONS

Hain, C. R., M. C. Anderson, W. T. Crow, X. Zhan and J. R. Mecikalski. "Dual assimilation of microwave and thermal infrared satellite observations of soil moisture into NLDAS for improved drought monitoring", 93rd Annual Meeting of the American Meterological Society in Austin, TX 6-10 January, 2013.

Hain, C. R., M. C. Anderson, W. T. Crow, X. Zhan and J. R. Mecikalski. "Dual assimilation of microwave and thermal infrared satellite observations of soil moisture into NLDAS for improved drought monitoring", NOAA's 37th Climate Diagnostic and Prediction Workshop in Fort Collins, CO, 22-25 October 2012.

Hain, C. R., M. C. Anderson, X. Zhan and W. P. Kustas. "Monitoring evapotranspiration from space: Methodology and Applications", Urban and Rural Meteorology Workshop in Jeju, South Korea 27-29 August 2012 [INVITED].

Performance Metrics	FY12
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	7 (3 in review)
# of non-peered reviewed papers	0
# of invited presentations	3
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	0

- Hydrological Support for the Climate Prediction Center

TASK LEADER Li-Chuan Chen
TASK CODE JJJJHYDRO10
NOAA Sponsor Kingtse Mo
NOAA Office NWS/CPC/DB
Main CICS Research Topic Land and Hydrology
Percent contribution to CICS Themes Theme 1: 25%; Theme 2: 25%; Theme 3: 50%
Percent contribution to NOAA Goals Goal 1: 50%; Goal 2: 50%

Highlight: CICS researcher developed the first application product for meteorological drought prediction using the National Multi-Model Ensemble data. The new product has shown higher skill in predicting meteorological drought than that based on single-model forecasts.

BACKGROUND

This work is to support NOAA/NCEP Climate Prediction Center's (CPC's) efforts on drought monitoring and prediction. Tasks include (1) monitoring the production of operational data such as North American Regional Reanalysis (NARR) and North American Land Data Assimilation System (NLDAS) to support U.S. Drought Monitor and Outlook, (2) working on research to advance the science and technology necessary for drought prediction, and (3) developing algorithms and techniques for building a drought early warning system. Three indices: standardized precipitation index (SPI), soil moisture percentile (SMP), and standardized runoff index (SRI) are used in the development of a real-time objective drought prediction system at CPC. SPI, which measures precipitation deficits, is used to identify meteorological drought. SMP, computed based on probability distributions, is used to classify agricultural drought. SRI, similar to SPI and measuring runoff deficits, represents hydrological drought.

ACCOMPLISHMENTS

The CPC SPI Outlooks developed in 2011 based on the NCEP Climate Forecast System version 2 (CFSv2) precipitation forecasts have been expanded to use six climate models from the National Multi-Model Ensemble (NMME), including CFSv2. NMME is a multi-model seasonal forecast system consisting of coupled dynamical models from U.S. and Canada modeling centers, including NOAA/NCEP, NOAA/GFDL, NCAR, NASA, and Canadian Meteorological Centre. Precipitation forecasts from the six NMME models are downscaled to 0.5-degree grids over the Continental United States. For each model, precipitation forecasts are bias-corrected based on their probability distribution functions derived the model hindcasts over a 29-year period (from 1982 to 2010), and then used to calculate the 1-month, 3-month, 6-month, and 12-month SPI forecasts. The ensemble forecast is the equally weighted mean of all model forecasts. Figure 1 shows the 3-month SPI (SPI3) ensemble forecasts for the 2013 FMA season based on NMME forecasts initiated on 1-6 February 2013 as an example. The NMME SPI forecast system became operational in December 2012 and has been used to assist in CPC's monthly drought briefing and outlooks activities. A website to deliver the real-time NMME SPI Outlooks to the public has been created and started in operation on March 1, 2013. The operational NMME SPI Outlooks products are expected to contribute greatly to the drought research and user communities, such as the National Integrated Drought Information System community. Drought is among the costliest natural hazards in the United States. Over the last decade, drought costs have averaged about $4 billion, and the inflation-adjusted cost of the 1988 Midwest drought exceeded $70 billion. Developing a drought early warning system for the U.S. is of critical importance to mitigate the impacts of droughts and reduce losses from such events.

Uncertainties in drought indices derived from the NLDASs operated by NCEP Environmental Modeling Center and the University of Washington (UW) were assessed for the monitoring period of 1979 to 2008. For SMP and SRI, differences are relatively small among different land surface models (LSMs) within the same system; however, the differences of ensemble mean between the two systems are large over the western United States —in some areas exceeding 20% for SMP. The differences are most apparent after 2002 when the NCEP system transitioned to use the real-time NARR data and CPC/Office of Hydrologic Development daily precipitation gauge data as input forcing. Numerical experiments were performed to address the sources of uncertainties. Comparison of simulations using a common LSM (i.e., the Variable Infiltration Capacity (VIC) model) with input forcing of the two systems indicates that the differences in precipitation forcing are the primary source of the uncertainties in SMP and SRI. While forcing differences of temperature, short-wave and long-wave radiation, and wind speed are also large after 2002, their contributions to the differences in SMP and SRI are much smaller than precipitation. Results of this investigation have been published in Journal of Hydrometeorology in June 2012.

In addition, an assessment of the soil moisture and runoff forecasts from CFSv2 has been conducted to evaluate their usefulness for drought prediction using CFSv2 retrospective forecasts from 1982 to 2009. We investigated whether seasonal soil moisture forecasts derived from a land surface model (VIC model) forced by seasonal climate model (CFSv2) forecasts (i.e., hydroclimatic forecasts) are more skillful than the baseline forecasts derived from the same land surface model but with forcing taken from resampled climatological precipitation, surface temperature, and low-level winds. We found that soil moisture prediction based on seasonal climate forecasts is no more skillful than the baseline forecasts for most forecast leads and over the western U.S. For one-month leads, the CFSv2-based hydroclimatic forecasts are skillful when and where

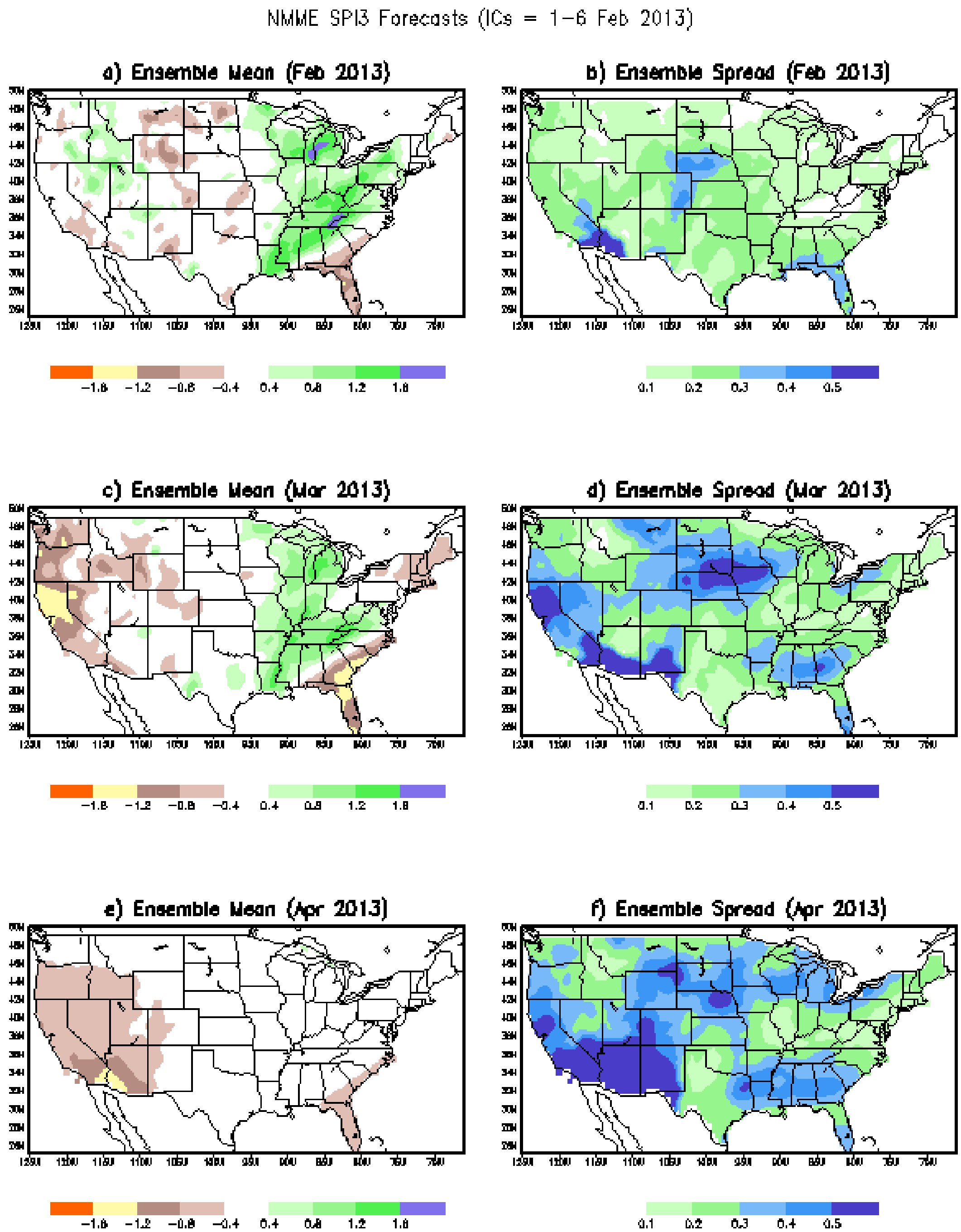


Figure 1: 3-month SPI ensemble forecasts for the 2013 FMA season based on NMME forecasts initiated on 1-6 February 2013.

the precipitation forecasts from the climate model has skill. We further analyzed the runoff forecasts from the same hydroclimate forecast system and found similar results to the soil moisture forecasts, that CFSv2 contributes to the runoff forecasts when and where precipitation forecasts are skillful. However, preliminary results have shown that regional SRI forecasts from a hydroclimate forecast system have higher skill than the baseline forecasts during the transition seasons (e.g., April and October) and where dynamical forcing is active, and demonstrated their potential use for predicting hydrological drought. The results of these studies are published in Geophysical Research Letters in December 2012 and presented in several conferences and meetings, including the CFSv2 Workshop and 2012 AGU Fall Meeting.

PLANNED WORK

- Evaluate the predictive skill of NMME SPI forecasts based on NMME hindcasts from 1982 to 2010.
- Develop a real-time forecast verification system for the operational NMME SPI prediction products at CPC.
- Conduct research to explore the potential of developing an operational probabilistic drought prediction system using NMME forecasts.
- Develop an operational SMP and SRI forecast system and products.
- Design products to provide regional water supply information to the user communities, such as the National Integrated Drought Information System community and NWS River Forecast Centers.

PUBLICATIONS

Mo, K. C., L.-C. Chen, S. Shukla, T. Bohn, and D. P. Lettenmaier (2012), Uncertainties in North American Land Data Assimilation Systems over the Contiguous United States, Journal of Hydrometeorology, 13, 996-1009, DOI: 10.1175/JHM-D-11-0132.1.

Mo, K. C., S. Shukla, D. P. Lettenmaier, and L.-C. Chen (2012), Do Climate Forecast System (CFSv2) forecasts improve seasonal soil moisture prediction? Geophysical Research Letters, Vol. 39, L23703, DOI: 10.1029/2012GL053598.

PRESENTATIONS

Chen, L.-C., K. C. Mo, S. Shukla, and D. P. Lettenmaier (2012), Seasonal Runoff Forecasts Based on the Climate Forecast System Version 2, Abstract H41A-1148 presented at 2012 Fall Meeting, American Geophysical Union, San Francisco, CA, 3-7 Dec.

Chen, L.-C., and K. C. Mo (2012), Runoff Outputs from NCEP Climate Forecast System Reanalysis and Reforecasts, 4th WCRP International Conference on Reanalyses, World Meteorological Organization.

Mo, K. C., and L.-C. Chen (2012), Drought Monitoring and Prediction Based on the Climate Forecast System Reanalysis and Reforecasts, 4th WCRP International Conference on Reanalyses, World Meteorological Organization.

Chen, L.-C., K. C. Mo, S. Shukla, and D. P. Lettenmaier (2012), Prediction Skill of Seasonal Runoff Forecasts From the Climate Forecast System Version 2, Abstract of the CFSv2 Evaluation Workshop, College Park, Maryland.

Mo, K. C., and L.-C. Chen (2012), Agricultural Drought Forecasts Based on the Climate Forecast System Version 2, Abstract of the CFSv2 Evaluation Workshop, College Park, Maryland.

OTHERS (e.g., awards; outreach; deliverables)

Operational NMME SPI Outlooks website at http://www.cpc.ncep.noaa.gov/products/Drought/Monitoring/spi_outlooks_3.shtml

Performance Metrics	**FY12**
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	2
# of non-peered reviewed papers	0
# of invited presentations	2
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	0

- Improvements to the AMSR-E Rain over Land Algorithm

Task Leader Phil Arkin & Hugo Berbery
Task Code PAASMSRE10 and PARF_AMSR_E12
NOAA Sponsor Ralph Ferraro
NOAA Office NESDIS/STAR/CRPD/SCSB
Main CICS Research Topic Land and Hydrology
Percent contribution to CICS Themes Theme 1: 100%
Percent contribution to NOAA Goals Goal 1: 50%; Goal 2: 50%

Highlight: CICS scientists continued to develop improvements to the retrieval of rainfall over land from passive microwave sensors. This past year focused on completing an emissivity study that is contributing to the advancement of the land based retrievals for AMSR-E and other sensors.

BACKGROUND

The hydrological cycle of the Earth is perhaps one of the most complex global feedback mechanisms that impact all living forms on the planet. An accurate description of the global precipitation patterns over an extended period of time is critical to determining any changes in the hydrological cycle. These pattern changes include the frequency, areal extent and duration of extreme weather events (e.g., flash floods, drought, extreme events, etc.) as well as long term shifts of the global rainfall distribution. Such changes have a dramatic impact on the quality of life for all inhabitants on the Earth.

Measurements from polar orbiting satellites, in particular, microwave sensors, offer perhaps the most viable means to develop global precipitation retrievals. This project focuses on the continued development and improvement of the Advanced Microwave Scanning Radiometer on board the Aqua satellite (AMSR-E) L2 and L3 facility precipitation retrieval algorithm. This project focuses on the land portion of the algorithm, which is incorporated within the Goddard Profiling Algorithm (GPROF).

ACCOMPLISHMENTS

An emissivity intercomparison study was completed and is documented in Ferraro et al. 2013. An example of some of the results is presented in Figure 1. The major findings of the study include:

- Confidence in emissivity estimates is greatest in vegetated regions and for frequencies at or below 37 GHz.
- Emissivity can be used explicitly in the precipitation retrievals when the precipitation signal exceeds the surface-related uncertainty. For example, a 3 % uncertainly at 19 or 37 GHz is roughly 10 K in TB, certainly good enough for liquid water computations in heavy rain, but not good enough for discriminating rain/no-rain and retrievals of lighter precipitation.

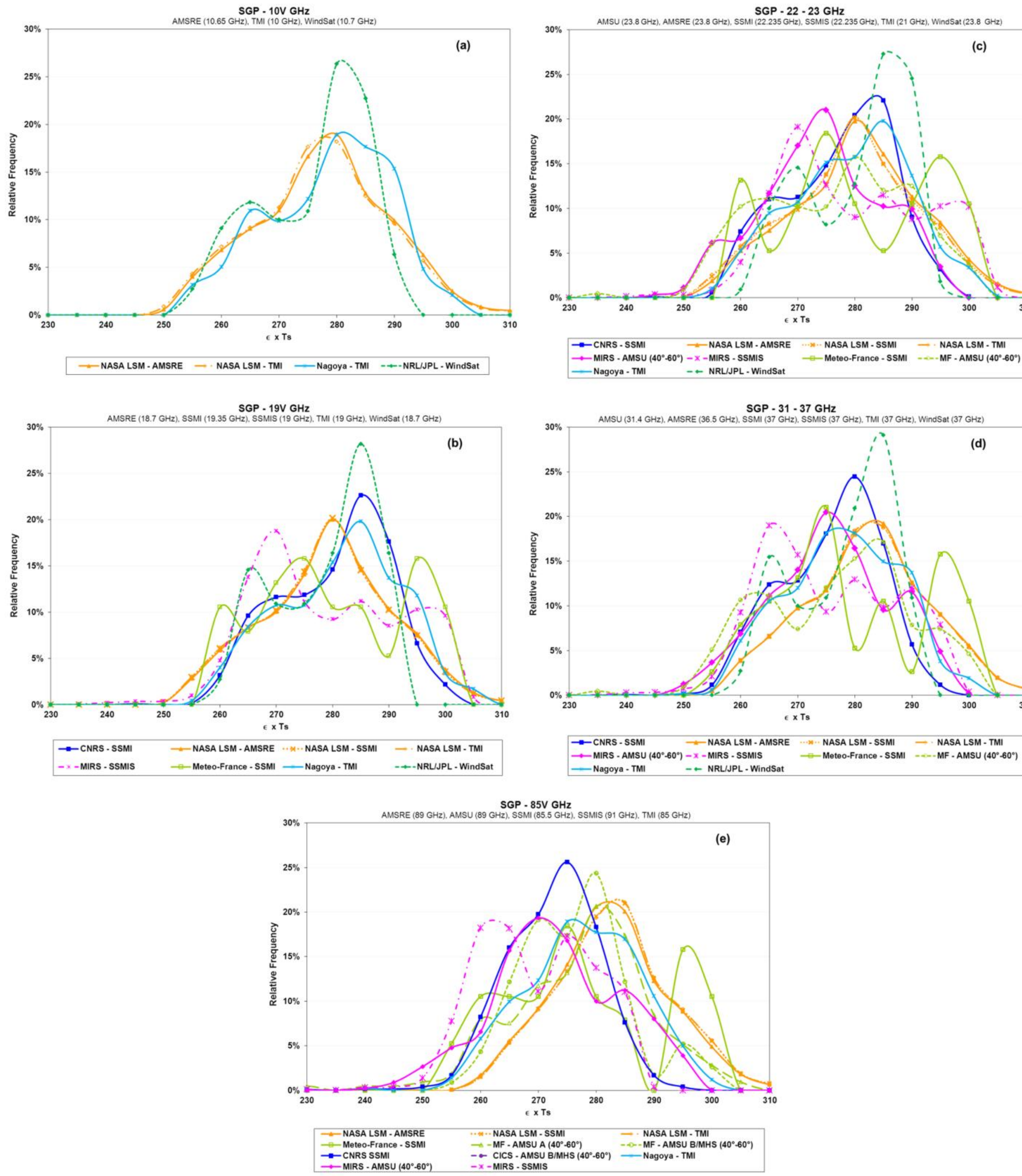


Figure 1: Frequency distributions of the product of emissivity and surface temperature for the Southern Great Plains (SGP) site for a variety of passive microwave frequencies (a through e) and the different retrievals provided by the intercomparison team (different colored lines).

- Although many of the input parameters used by the individual techniques were controlled as much as possible, in many cases large differences were noticed. Since nearly all global emissivities lie within a very small range (a lower bound of roughly 0.2 for 10 GHz H polarization over ocean, to 0.99 over dry bare soils), different external forcings (e.g., surface temperature, atmospheric opacity, cloud/precipitation screening) strongly influence the range of values amongst these datasets.
- Complex surface types. The emissivity variability characteristics of such surfaces are highly variable and affected by smaller scale features (leaf area index, snow grain size, etc.) that are variable both in time and spatially within the large satellite footprint. Additional input information upon the terrain and land cover within the FOV (e.g, elevation, slope, and its variability) and dynamic surface cover (e.g, MODIS snow cover or equivalent) within the LSM approach would allow the retrievals to better identify such complex scene conditions, which would be passed on to the precipitation algorithms.

PLANNED WORK

- Update the current version of GPROF (GPROF2010) for AMSR-E and provide to the NASA/MSFC AMSR-E Science Team
- Evaluate the reprocessed time series from AMSR-E from GPROF2010.

PUBLICATIONS

Ferraro, R., and members of the PMM Science Team Land Surface Working Group, 2013: An evaluation of microwave land surface emissivities over the continental United States to benefit GPM-era Precipitation Algorithms. *IEEE Trans. Geoscience. Rem. Sens.,* DOI: 10.1109/TGRS.2012.2199121.

PRESENTATIONS

Ferraro, R., C. Hernandez, P. Meyers and N-Y. Wang, 2012: Improvements to the AMSR-E Rain Over Land Algorithm. *2012 AMSR-E Science Team Meeting, Portland, OR, September 2012.*

Performance Metrics	**FY12**
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	1
# of non-peered reviewed papers	0
# of invited presentations	1
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	0

- Development of JPSS AMSR-2 Hydrology Products

Task leaders	Patrick Meyers, Jun Park
Task Code	RFRF_JPAM11
NOAA Sponsor	Ralph Ferraro
NOAA Office	NESDIS/STAR/CRPD/SCSB
Main CICS Research Topic	Land and Hydrology
Percent Contribution to CICS Themes	Theme 1: 20%; Theme 2: 80%; Theme 3: 0%
Percent Contribution to NOAA Goals	Goal 1: 20%; Goal 2: 80%

Highlight: Algorithm development for the AMSR2 passive microwave sensor continued, with effort focused on improving retrievals of rainfall over land and implementing new emissivity models for hydrological retrievals over ocean.

BACKGROUND

The hydrological cycle of the Earth is one of the most complex global feedback mechanisms that impact all living forms on the planet. An accurate description of the global precipitation patterns over an extended period of time is critical to determining any changes in the hydrological cycle. These pattern changes include the frequency, areal extent and duration of extreme weather events (e.g., flash floods, drought, extreme events, etc.) as well as long term shifts of the global rainfall distribution.

Measurements from polar orbiting satellites, particularly from microwave sensors, offer perhaps the most viable means to develop algorithms for global retrievals of hydrological parameters. This project focuses on the development of algorithms related to the hydrological cycle for the AMSR2 sensor flown on the GCOM-W1 satellite that was successfully launched by JAXA in May 2012.

AMSR2 will provide a suite of products similar to the EOS Aqua AMSR-E sensor which stopped functioning in October 2011. CICS scientists are focused on retrievals of rainfall rate, total precipitable water, cloud liquid water, wind speed, and sea surface temperature for NOAA/NESDIS GCOM mission.

ACCOMPLISHMENTS

The Goddard profiling algorithm (GPROF) will be used for rainfall retrievals for AMSR2. In a related effort, the final update to the GPROF2010 package for AMSR-E was delivered to NASA/Marshall Space Flight Center in December. This package will be the Day-1 precipitation algorithm for AMSR2. CICS' contributions to the GPROF2010 update focused on improvements to the surface screening procedures over land, where retrievals are susceptible to contamination from misdiagnosed surface conditions. GPROF2010 now utilizes climatological ancillary data to allow empirical flagging of desert, snow, ice, and semi-arid land from brightness temperature measurements. Retrievals from the updated algorithm are verified globally on monthly time scales using Global Precipitation Climatology Project (GPCP) data and instantaneously over CONUS using collocated National Mosaic & Multi-Sensor QPE (NMQ) data (Figure 1).

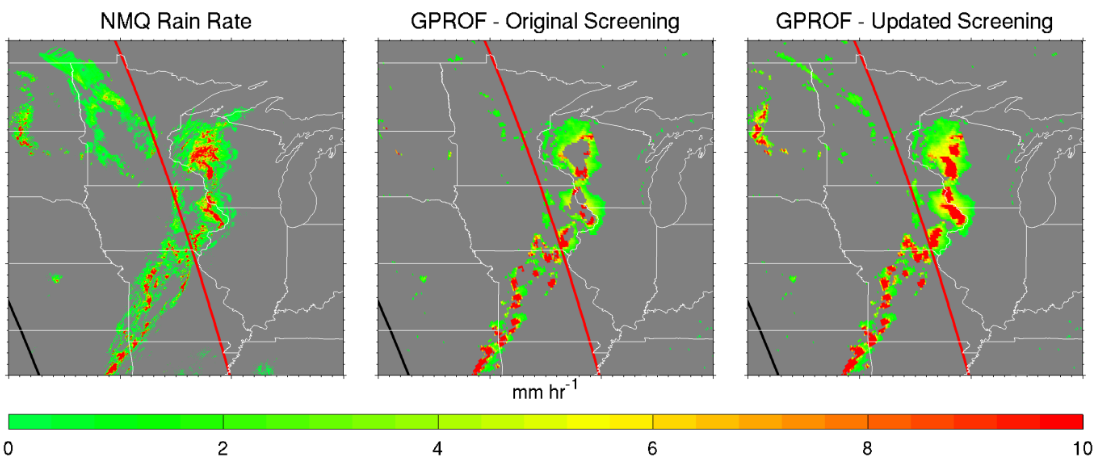


Figure 1 – The original GPROF screening procedures often flagged heavy precipitation as ice (left). Updated procedures (center)use climatology to reduce false flagging as compared to radar-derived NMQ rain rates (left).

Additionally, efforts were made to develop an algorithm for NOAA EDR geophysical retrievals over ocean scenes for sea surface temperature, ocean surface wind speed, total precipitable water, and cloud liquid water (Figure 2). The characteristics of AMSR2 brightness temperatures were studied using inter-satellite calibration with TMI, WindSat, and AMSR-E sensors, and a new ocean surface emissivity model was tested to simulate the brightness temperatures of GCOM-W1 AMSR2 channels.

PLANNED WORK

- Validate AMSR2 EDRs by building collocation dataset using space- and ground-based observations
- Interface with NOAA's GCOM development and integration teams to transition research code into operations

PRESENTATIONS

Meyers, P., et al., Finalizing the Goddard Profiling 2010 (GPROF2010) Rainfall Algorithm for AMSR-E, American Geophysical Union Fall Meeting, December 2012, San Francisco, CA, H33C-1341.

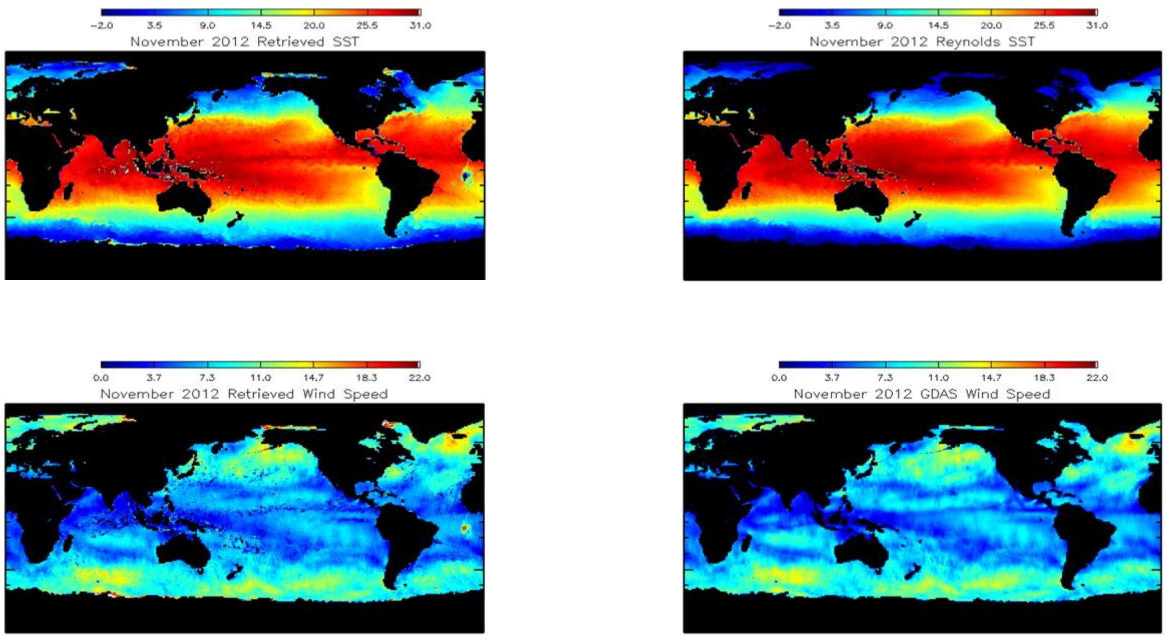


Figure 2: Comparison of one month average of AMSR-2 retrieved SST with Reynolds SST (upper) and AMSR2 retrieved Ocean surface wind speed with GDAS wind speed (bottom).

Performance Metrics	**FY12**
# of new or improved products developed	2
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	N/A

- Modeling Carbon Cycle Variability for the North American Carbon Program

TASK LEADER Ning Zeng
TASK CODE NZNZ_MCCV_12
NOAA Sponsor Ken Mooney
NOAA Office OAR/CPO/ESS/AC4
Main CICS Research Topic Land and Hydrology
Percent contribution to CICS Themes Theme 1: 25%; Theme 2: 25%; Theme 3: 50%
Percent contribution to NOAA Goals Goal 1: 50%; Goal 2: 50%

Highlight: High-resolution simulations (0.125° by 0.125° and 0.5° by 0.5°, both globally) for the VEGAS dynamic vegetation and carbon cycle model were conducted. Sensitivity experiments explore the role of CO2, climate and land use change on the long-term carbon sources and sinks. Land use is identified as crucially important for both mean carbon sink, as well as seasonal amplitude change in atmospheric CO2. Simulations are contributing to IPCC AR5, the Global Carbon Project and the North American Carbon Program.

Background

One of the primary approaches for understanding the past, present, and future role of the terrestrial biosphere in the global carbon cycle is the development and application of terrestrial biospheric models (TBMs). These models estimate carbon fluxes through a set of physical and physiological relationships based on our current understanding of processes controlling carbon exchange. Although models vary in their specific goals and approaches, their central role within carbon cycle science is to address key scientific questions ranging from carbon flux attribution (What are the fluxes?), to diagnosis (What are the processes controlling variability?), and to prediction (How will changes in climate and other factors alter future fluxes?). As such, TBMs are the only tool that directly addresses three of the four main overarching questions of the North American Carbon Program (Denning et al. 2005).

The development of individual TBMs has been supported through a variety of programs both within the United States and globally, including the NASA Terrestrial Ecology program and NASA North American Carbon Program. These modeling efforts have brought to light both the promise of modeling approaches for improving our understanding of the carbon cycle, as well as their challenges and uncertainties. Due to the primary focus of ongoing research on individual models, however, there have been limited organized efforts at comparing predictions across TBMs. The MsTMIP is a project designed to provide a consistent and unified modeling framework in order to isolate, interpret, and address differences in process parameterizations among TBMs. This effort requires the development of consistent and optimal environmental driver datasets, the development of a unified intercomparison protocol, as well as coordination of the intercomparison effort across a large number of institutions.

The multi-scale synthesis and intercomparison project (MsTMIP) is a formal model intercomparison activity with standardized model simulations within an integrated evaluation framework. This task will conduct a series of simulations using the VEGAS terrestrial carbon model developed at UMD, forced by observed climate, land use, CO2, and other datasets. The model results will be analyzed and provided to the North American Carbon Program (NACP) syntheses activities, thus contributing to the MsTMIP overall goal of providing feedback to the terrestrial biospheric modeling community to improve the diagnosis and attribution of carbon sources and sinks across regional and global scales.

Accomplishment

Simulations

We conducted a set of simulations at the global scale:

- Global simulations at 0.5° by 0.5° resolution and the domain will include all land points, excluding Greenland and Antarctica.
- Global simulations at 0.125° by 0.125° to better represent fractional land cover change. This was conducted on the DOE supercomputer Evergreen. The results were then aggregrated to 0.5° by 0.5° resolution

Sensitivity experiments were conducted to identify the effects of CO2, climate and land use change. The ability to partition observed net ecosystem exchange (NEE) among processes such as climate variability, CO2 fertilization, nitrogen limitation, current land management, and the recovery from historical land use and disturbance is fundamental to understanding the terrestrial carbon cycle. Therefore, in combination with the baseline simulations, we ran simulations with (1) recycled climate; (2) land-use and disturbance history; (2) time-varying Atmospheric CO2 concentrations

Table 1: NACP MsTMIP simulations. The VEGAS simulations are highlighted in blue.

Domain	Simulation Name	Climate Forcing	Land-Use History	Atmospheric CO_2	Nitrogen Deposition
Global (0.5° x 0.5°)	RG1	Constant	Constant	Constant	Constant
North America (0.25° x 0.25°)	RR1	Constant	Constant	Constant	Constant
Global (0.5° x 0.5°)	BG1	CRU+NCEP	Time-varying	Time-varying	Time-varying
North America (0.25° x 0.25°)	BR1	NARR[1]	Time-varying	Time-varying	Time-varying

Global (0.5° by 0.5°)	SG1	CRU+NCEP	Constant	Constant	Constant
	SG2		Time-Varying	Constant	Constant
	SG3		Time-Varying	Time-varying	Constant
North America (0.25° by 0.25°)	SR1	NARR[1]	Constant	Constant	Constant
	SR2		Time-Varying	Constant	Constant
	SR3		Time-Varying	Time-varying	Constant

Analysis and Model Evaluation

In the sensitivity analysis, we employ a one-at-a-time (OAT) strategy, where changing one input (such as weather) or turning off other internal process (such as nitrogen deposition) in each simulation. The baseline simulations, as described above, serves as the reference case.

Overall model evaluation we have conducted so far:

- Model-observation comparison of total carbon flux and component fluxes (Fig. 1);

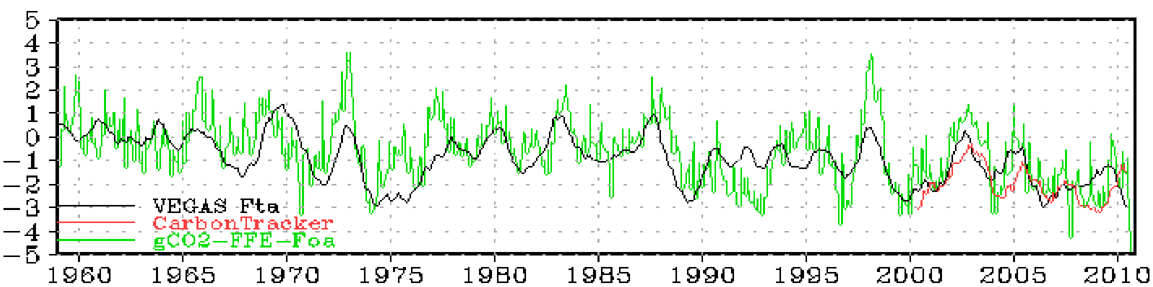


Figure 1. Deseasonalized total land-atmosphere carbon fluxes (Fta) simulated by the VEGAS model (black line), forced by observed climate, land use change and CO_2, compared to atmospheric inversion from CarbonTracker (red). Also plotted is surface flux diagnosed from a budget analysis (green) using Mauna Loa CO_2 growth rate (gCO2) and estimated fossil fuel emissions (FFE) and ocean fluxes (Foa) from the Global Carbon Project (Le Quere et al., 2009 with update in 2012). Sufficient agreement on CO_2 variability now exists between forward and inverse models for meaningful data assimilation and mechanistic interpretation. Uncertainty remains in the long-term carbon sink especially at regional scale that will require correction.

- TBM and inverse intermodal comparisons in terms of amplitude and phase of the seasonal cycle, mean annual estimates of NEE, and inter-annual variability (Figs 1, 2).

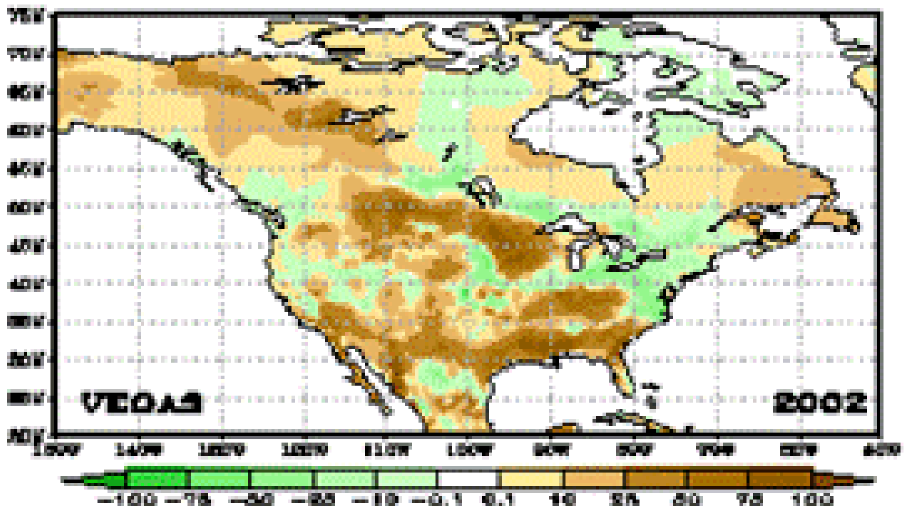


Figure 2. Net land-atmosphere carbon fluxes (gC/m2/y) in 2002, relative to the mean of 2000-2006 simulated by VEGAS, showing the wide spread impact on both natural vegetation and managed cropland during the 2002 North American drought.

PLANNED WORK

- Comparison of transported TBM fluxes to atmospheric CO2 concentration measurements, in collaboration with Scripps Institute of Oceanography, UCSD and Institute of Atmospheric Physics, Chinese Academy of Sciences.
- TBM model-model comparison with other MsTMIP models and component flux data.

PUBLICATIONS

Zeng et al., 2013, Seasonal amplitude increase in atmospheric CO2, a comprehensive analysis, in preparation.

C. Le Quéré, R. J. Andres, T. Boden, T. Conway, R. A. Houghton, J. I. House, G. Marland, G. P. Peters, G. van der Werf, A. Ahlström, R. M. Andrew, L. Bopp, J. G. Canadell, P. Ciais, S. C. Doney, P. Friedlingstein, C. Huntingford, A. K. Jain, C. Jourdain, E. Kato, R. Keeling, S. Levis, P. Levy, M. Lomas, B. Poulter, M. Raupach, J. Schwinger, S. Sitch, B. D. Stocker, N. Viovy, S. Zaehle and N. Zeng. The Global Carbon Budget 1959 - 2011. Earth Syst. Sci. Data Discuss., 5, 1107¿1157, doi:10.5194/essdd-5-1107-2012, 2012. http://www.earth-syst-sci-data-discuss.net/5/1107/2012/

OTHERS (e.g., awards; outreach; deliverables)
Several VEGAS simulations have been provided through NACP MsTMIP, as well as the international project TRENDY, and used in the upcoming IPCC AR5 report, the Global Carbon Project (GCP)'s REgional Carbon Cycle Assessmentand Processes (RECCAP). More than 10 papers using VEGAS results are accepted or in review.

1.8 Earth System Monitoring from Satellites

- Development of Land Surface Characterization for GPM-era Precipitation Measurement

Task Leader Nai-Yu Wang
Task Code NWNW_DLSC_12
NOAA Sponsor Ralph Ferraro
NOAA Office NESDIS/STAR/CRPD/SCSB
Main CICS Research Topic: Earth System Monitoring from Satellites
Percent contribution to CICS Themes Theme 1: 70%; Theme 2: 30%; Theme 3: 0%.
Percent contribution to NOAA Goals Goal 1: 20%; Goal 2: 80%

Highlight: We focused on the construction of an at-launch GPM GPROF database for over land, an important yet tedious work. GPROF relies on a realistic database that presents the microwave radiometer observations of rainfall frequency and intensity. The decision at the GPM Algorithm Team was to construct an at-launch database for land from the empirical databases derived from SSMIS, NOAA NMQ, and MMF CRM simulations.

BACKGROUND
If the Global Precipitation Measurement Mission (GPM) is to meet its requirement of global 3-hourly precipitation, the use of sounders such as AMSU will likely be needed. This project utilizes the "traditional" imager channels in conjunction with high frequency observations from AMSU and SSMIS, cloud resolving models and advanced radiative transfer models to:

- Study the effects of hydrometeors on the 10-183 GHz radiances and utilize them to improve the current Bayesian precipitation retrieval scheme (e.g., GPROF). Focus will be on cold season precipitation systems (e.g., stratiform rain and snowfall) since the present scheme has focused only on tropical rainfall systems.
- Investigate the potential of incorporating microwave sounding channels (50-60 GHz and 183 GHz) to the hydrometeor profile retrieval.
- Improve the current GPROF "surface screening" to remove ambiguity between precipitation and other surface signatures that resemble precipitation through the use of innovative methods such as dynamic land surface data sets available from ancillary data sets (i.e., NWP assimilation fields, emerging emissivity products, etc.).

ACCOMPLISHMENTS

This year I'm tasked to construct a before-launch GPM GPROF database for over land, an important yet tedious work. GPROF relies on a realistic database that presents the microwave radiometer observations of rainfall frequency and intensity. The decision at the GPM Algorithm Team (July 2012) was to construct the at-launch database from the empirical databases derived from TRMM PR/TMI, A-Train CloudSat/AMSR-E, SSMIS, and NOAA NMQ. In the case of over-land database which includes the conventional TRMM TMI TBs and additional high frequency channels on GPM GMI, the observed SSMIS Tbs and NOAA NMQ radar derived rain rates were be paired with CRM profiles from the GSFC MMF simulations that match both the Tb and surface rainfall. This semi-physical database would have the advantage of combining observed Tb and rain rates with CRM profiles that reproduce the right Tb and surface rain and can therefore also be used to generate the constellation databases. It is not fully physical in that there is no guarantee that the clouds extracted from the MMF simulation also match the high resolution radar vertical structure.

The overland database task can be thought of a two-step process : (1) attaching NMQ 0.01 deg resolution (~1km) rain-rates to SSMIS 37 GHz footprint (~27 km X 45 km) (2) matching observation SSMIS/NMQ with model simulations from GSFC MMF/CRM to get complete vertical hydrometeor profiles in order to translate to all constellation radiometers.

For the 1st step of attaching surface rain-rates to satellite radiometer observations, a year of SSMIS orbit TBs and NMQ rain-rates data from December 2009 to November 2010 are processed. The 1-km NMQ rain-rates are convolved to the SSMIS 37 GHz 27km by 45 km footprint based on a two-dimension Gaussian antenna beam pattern

$$g = \exp\left[-\left(\left(\frac{X}{FWHMX}\right)^2 + \left(\frac{Y}{FWHMY}\right)^2\right) \times 4 \times \ln 2\right]$$

Where FWHMX and FWHMY are the full width at half maximum at along track and cross track directions, respectively. Figure 1 shows an example of such an convolution from 1km resolution NMQ surface rain-rates to the 37 GHz footprint size of 27 km by 45 km, based on 833 km SSMIS F17 spacecraft altitude and half power beam widths. The satellite footprint averaging retains the main precipitation features from the finer resolution surface radar rain measurements, but the footprint averaging also smears out the small-scale high surface rain-rates detected by the surface radars.

Figure 1c shows the high frequency 150 GHz measurements from the same SSMIS overpass, which captures the finer details of the precipitating clouds from small ice particle scattering, relative to the 37 GHz.

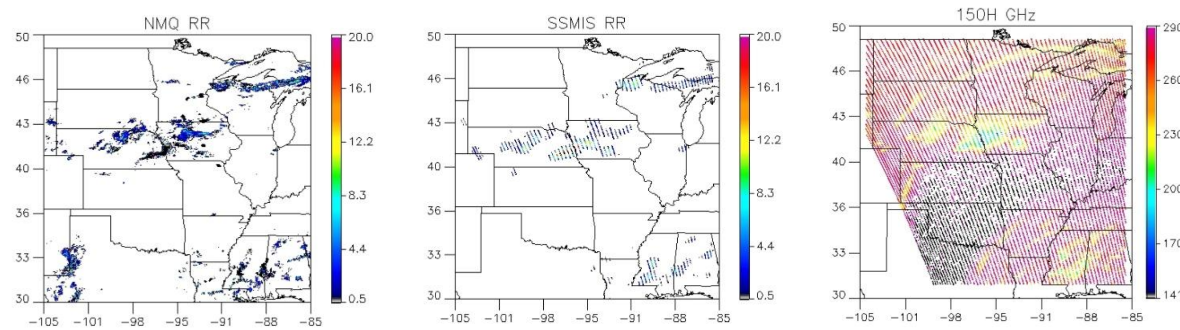


Figure 1. Surface rain-rates from June 1, 2010 from (a) NOAA radar composites NMQ at 1 km resolution (b) same NMQ rain-rates convolved to SSMIS 37 GHz footprint area at the resolution of 27 km by 45 km (c) SSMIS observations of surface rainfall at 150 GHz.

For the 2nd step of matching the SSMIS observed TBs to the CRM simulated TBs. For SSMIS/NMQ matches with the MMF profiles, we would compute a distance between the SSMIS pixel and the MMF simulation. The Total distance $D^2$is

$$D^2 = D_{Tb}^2 + D_R^2 + D_{FL}^2 + D_{FOVCover}^2$$

Where the total distance D^2 is the sum of distances from Tb, rain rate, freezing level, and the fraction of FOV cover. We chose the smallest D that meets the Ts, TPW and emissivity class window. As before, The Ts, TPW, emissivity class, and T_{2m} will added to the empirical database using ECMWF and the surface classification based upon lat/lon and time. The above finds the best profile for the a-priori database for SSMIS for all Ts, TPW and emissivity classes covered by the SSMIS orbit over a year

Figure 2 shows the distribution of the final MMF-SSMIS matched database in each of the surface emissivity class, plotted as a function of surface temperature Ts and total water vapor TPW.

PLANNED WORK

- Now the GPROF 2014 land database is built, one might ask the science questions. How do the radiometer observations depend on climate regime? For example, are there any dependence on TPW and surface temperature for each surface type?
- Work on the manuscript for publication.

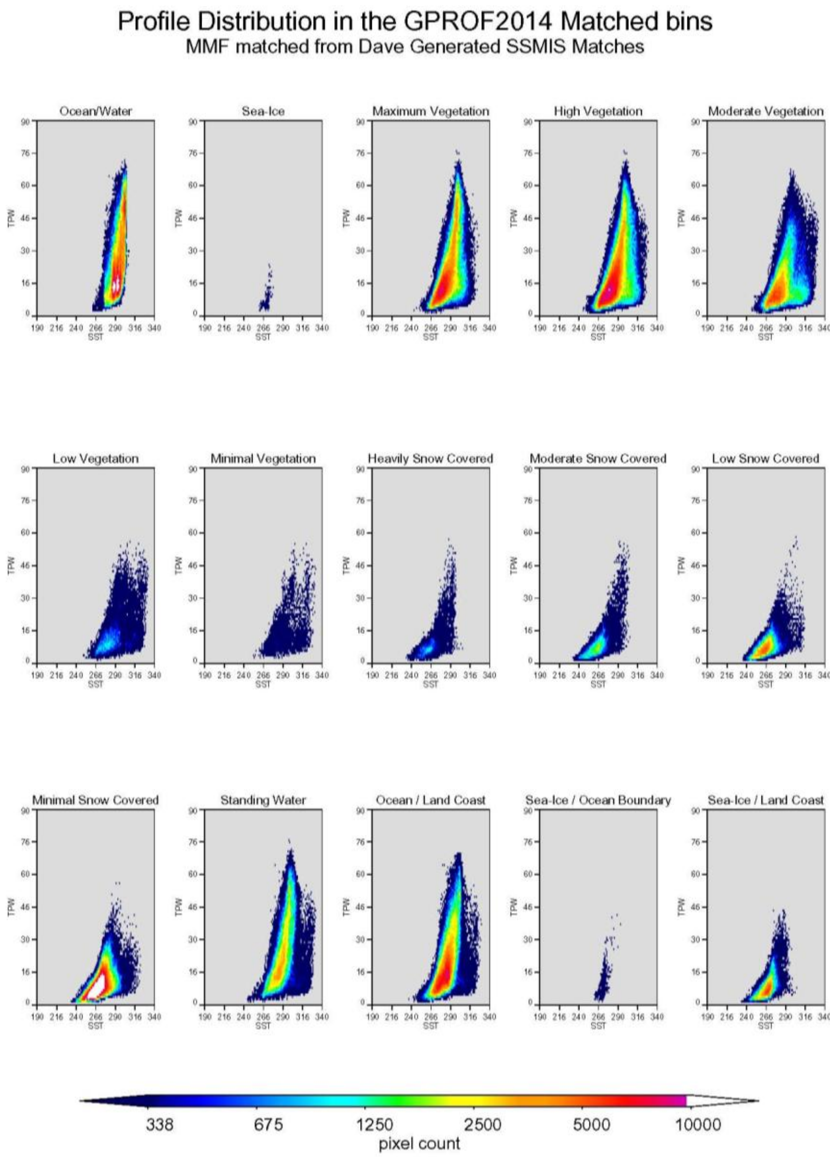


Figure 2. The distribution of the final MMF-SSMIS matched database in each of the surface emissivity class, plotted as a function of surface temperature Ts and total water vapor TPW.

PRESENTATIONS

Kulie, Mark; Wang, Nai-Yu; Bennartz, Ralf and Ferraro, Ralph. Leveraging currently available spaceborne microwave observational datasets for GPM-related algorithm development purposed. AGU Fall Meeting, San Francisco, CA, 3-7 December 2012. American Geophysical Union, Washington, DC, 2012, abstract only.

Performance Metrics	FY12
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	0

- Investigations over Arctic Sea Ice using Satellite and Aircraft Altimetry

Task Leader Farrell, Sinéad L.
Task Code SFSF_CIAS_12
NOAA Sponsor Laury Miller
NOAA Office NESDIS/STAR/SOCD/OPB
Main CICS Research Topic Earth System Monitoring from Satellites; Calibration and Validation
Percent contribution to CICS Themes Theme 1: 30%; Theme 2: 70%; Theme 3: 0%.
Percent contribution to NOAA Goals Goal 1: 50%; Goal 2: 50%

Highlight: The continued decline of Arctic sea ice demands routine monitoring of the ice pack by satellite and aircraft. Key to meeting this need we have assessed the quality and accuracy of data from the ICESat and CryoSat-2 missions via a nested approach that relies on data from the NASA IceBridge mission as well as coincident in situ snow and sea ice thickness measurements.

BACKGROUND

The declining thickness and volume of Arctic sea ice are leading indicators of change in the polar climate system. It is crucial to improve our knowledge of the nature, and variability, of Arctic sea ice and its contribution to the global climate system. Ongoing loss of Arctic sea ice has serious implications for climate change, and will have ecological and socio-economic impacts on the Arctic region. Satellite passive microwave observations show areal shrinkage of the sea ice pack since the late 1970s and an historical minimum ice extent was recorded in September 2012. The latest satellite altimetry observations of sea ice indicate a decline in the thickness and volume of the ice pack since 2003. The greatest losses have been observed in the oldest, multiyear ice, and during the autumn in particular. An extensive monitoring of Arctic-wide sea ice thinning using satellite altimetry is necessary to determine whether such observations are part of a sustained negative trend, or a reflection of the natural, interannual variability of the system. NASA's ICESat ceased operations in October 2009. However ESA's CryoSat-2 radar altimeter satellite, launched in April 2010, continues to monitor sea ice volume change at both poles. NASA plans the launch of ICESat-2 in April 2016, supporting continuity of the time series of Arctic sea ice thickness observations until at least the end of this decade. In addition, NASA's IceBridge mission, which commenced operations in March 2009, continues to conduct airborne altimetry campaigns over Arctic sea ice every March/April. It is essential to validate the capabilities of these altimeter systems via independent aircraft and field experiments.

ACCOMPLISHMENTS

The goal of this investigation is to assess how well Arctic sea ice elevation and ice thickness can be mapped using satellite altimeters including those onboard NASA's ICESat and the European Space Agency's CryoSat-2. The results contribute to a longer-term goal of assimilating satellite estimates of sea ice thickness into Arctic Ocean sea ice forecasts and predictive models. Monitoring ice thickness and volume change is technically challenging due to the small sea ice freeboard signal, and the complex distribution and density structure of sea ice and its snow cover. A number of airborne observing systems are used to validate the satellite altimetry data, in particular NASA's Operation IceBridge.

During the Arctic Spring 2011 IceBridge campaign a coordinated multi-scale, nested approach to mapping snow depth and ice thickness distribution on Arctic sea ice was undertaken. Measurements of snow and ice thickness were collected *in situ* at two sites for the calibration and validation of both the IceBridge and CryoSat-2 data sets. Data was collected across a range of sea ice types at the "ICEX" site, approximately 350 km north of Alaska, and at the CryoVex site, north of Alert, Canada. The analysis of these coincident data sets has enabled use to derive the uncertainty in estimates of snow depth and sea ice thickness derived from remote-sensing platforms, as a function of ice type. Figure 1 illustrates the validation of airborne snow depth estimates at the ICEX and CryoVex survey sites via comparison with snow depth measured *in situ*. Once the uncertainties associated with the airborne data are established, these data are in turn used to validate satellite estimates of sea ice elevation from ICESat and ice thickness from CryoSat-2 (Figure 2).

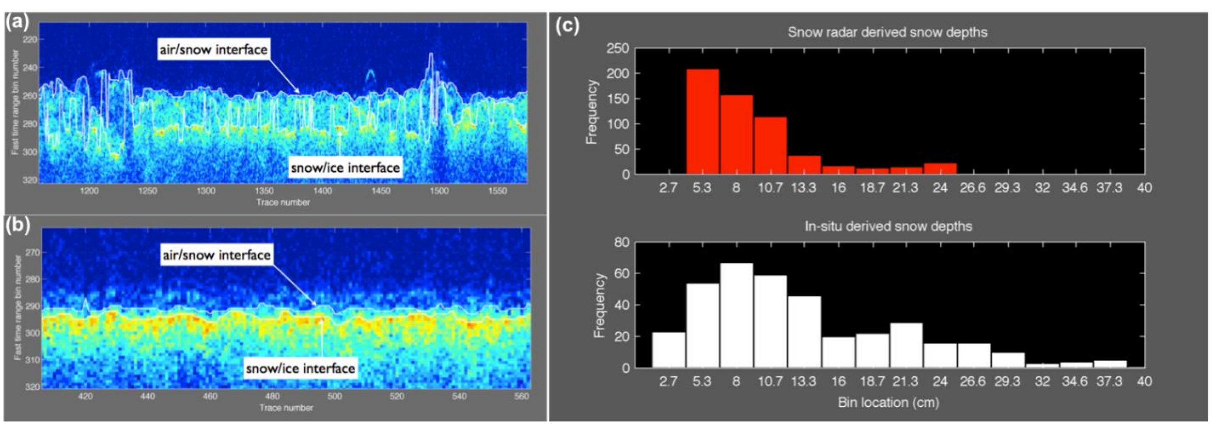


Figure 1: Validation of airborne data with coincident measurements collected in situ. (a) IceBridge snow radar echogram collected over the CryoVex sea ice field survey in April 2011. (b) IceBridge snow radar echogram collected over the ICEX field survey in March 2011. Snow depth on sea ice is derived from the difference between the air/snow and snow/ice interfaces as indicated in both (a) and (b). (c) Histograms of snow depth derived from the IceBridge snow radar (red) and measured in situ (white) at the ICEX survey site.

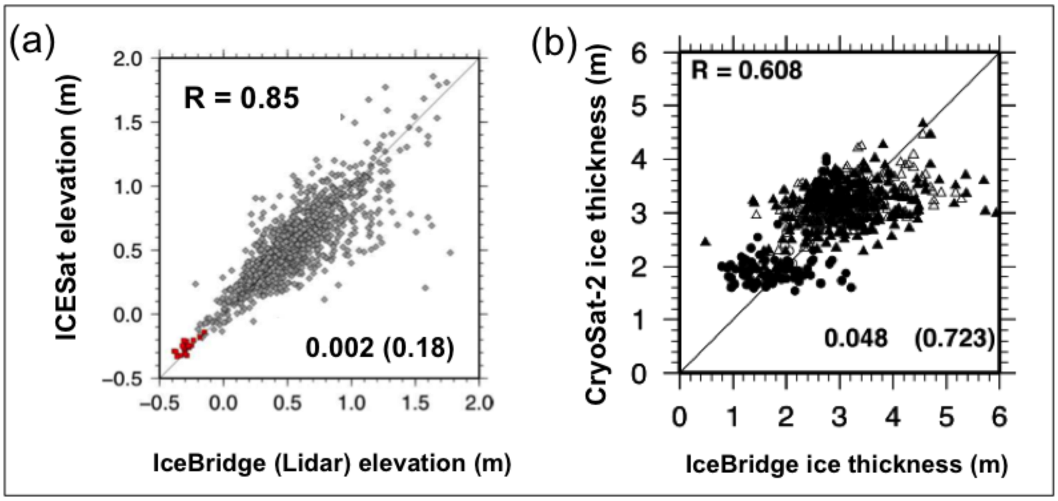


Figure 2: Validation of satellite data with airborne measurements. (a) Connor et al. (2012) found a correlation of 0.85 about a 0.00 m bias, comparing ICESat sea ice elevations with IceBridge data. (b) Laxon et al. (2013) found a correlation of 0.61 about a 0.05 m bias, comparing CryoSat-2 and IceBridge ice thickness estimates.

Our analyses were presented at the American Geophysical Union Fall Meeting 2012 (six presentations), as well as at other national and local meetings at NASA Goddard Space Flight Center (GSFC), the Naval Research Laboratory (NRL), and the University of Maryland. Our results were published in over seven peer-reviewed articles during the reporting year. Under this task we assisted with the production of the 2012 "QuickLook" IceBridge sea ice data products and provided mappings of these data for both the National Snow and Ice Data Center's (NSIDC) Sea Ice News and the SEARCH Sea Ice Outlook web-report. We provided Synthetic Aperture Radar (SAR) processing consultation to our collaborators at NRL and assisted with future NRL airborne survey design over sea ice north of Alaska. Results from our analysis of a 2009 field survey on fast-ice north of Greenland appeared on the cover of the June 2012 (Vol. 50, no. 6) issue of *IEEE Transactions on Geoscience & Remote Sensing.*

Performance Metrics	FY12
# of new or improved products developed	2
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	6
# of non-peered reviewed papers	1
# of invited presentations	7
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	1

PLANNED WORK

- Participation in NASA Operation IceBridge Arctic and Antarctic 2013 airborne campaigns.
- Continue to develop snow thickness uncertainty theory for rough and ridged sea ice surfaces
- Develop an automated snow-layer picking system that can be applied to IceBridge airborne radar data and will include an uncertainty estimate for each snow thickness, with respect to ice type.
- Continued assessment of CryoSat-2 data and development of algorithms to exploit Level 1b waveforms to improve understanding of the impact sea ice ridges and leads on the retrieved CryoSat-2 elevations.
- Continue collaborations with the NOAA Laboratory for Satellite Altimetry, University College London, the European Space Agency, and NASA GSFC focused on the intercomparison of IceBridge and CryoSat-2 data products over Arctic sea ice.

PUBLICATIONS

Kurtz, N., S. L. Farrell, M. Studinger, N. Galin, J. Harbeck, R. Lindsay, V. Onana, B. Panzer, and J. Sonntag (2013a), Sea ice thickness, freeboard, and snow depth products from Operation IceBridge airborne data, *The Cryosphere*, tc-2012-164, under review.

Laxon, S.W., Giles, K. A., Ridout, A. L., Wingham, D. J., Willatt, R., Cullen, R., Kwok, R., Schweiger, A., Zhang, J., Haas, C., Hendricks, S., Krishfield, R., Kurtz, N., Farrell, S. L., Davidson, M. (2013), CryoSat Estimates of Arctic Sea Ice Volume, *Geophys. Res. Lett.*, doi:10.1002/grl.50193.

Kurtz, N., M. Studinger, S. Farrell, J. Paden, J. Richter-Menge, J. Sonntag, and J. Yungel (2013b), IceBridge Airborne Survey Data Support Arctic Sea Ice Predictions, *EOS Trans. AGU*, *94*(4), 41, doi: 10.1002/2013EO040001.

Kurtz, N., S. L. Farrell, M. Studinger, N. Galin, J. Harbeck, R. Lindsay, V. Onana, B. Panzer, and J. Sonntag (2012), Sea ice thickness, freeboard, and snow depth products from Operation IceBridge airborne data, *The Cryosphere Discussions*, 6, 4771-4827, 2012, non peer-reviewed.

Connor, L. C., S. L. Farrell, D. C. McAdoo, W. B. Krabill, and S. Manizade (2012), Validating ICESat over thick sea ice in the northern Canada Basin, *IEEE Transactions on Geoscience & Remote Sensing*, PP 99 (99), 1-13, doi:10.1109/TGRS.2012.2211603.

Onana, V. D. P., N. T. Kurtz, S. Farrell, L. S. Koenig, M. Studinger, and J. P. Harbeck (2012), A Sea Ice Lead Detection Algorithm for use with High Resolution Airborne Visible Imagery, *IEEE Transactions on Geoscience & Remote Sensing*, PP 99 (99), 1-19, doi: 10.1109/TGRS.2012.2202666.

Farrell, S. L., N. Kurtz, L. N. Connor, B. C. Elder, C. Leuschen, T. Markus, D. C. McAdoo, B. Panzer, J. Richter-Menge, and J. G. Sonntag (2012a), A First Assessment of IceBridge Snow and Ice Thickness Data Over Arctic Sea Ice, *IEEE Transactions on Geoscience & Remote Sensing*, *50* (6), 2098 - 2111, doi:10.1109/TGRS.2011.2170843.

Farrell, S. L., D. C. McAdoo, S. W. Laxon, H. J. Zwally, D. Yi, A. Ridout, and K. Giles (2012b), Mean Dynamic Topography of the Arctic Ocean, *Geophys. Res. Lett.*, *39*, L01601, doi:10.1029/2011GL050052.

PRESENTATIONS (April 1, 2012 - March 31, 2013)

Farrell, S.L. (invited): AOSC 401: Global Environment, Aspects of the Cryosphere: Sea Ice and Snow, Guest Lecture for Prof. Zhanqing Li, Dept. of Atmospheric and Oceanic Science, University of Maryland, College Park, MD, 30 Mar., 2012.

Farrell, S. L.: Deriving High Resolution Sea Ice Statistics from Aircraft and Satellite Observations and their use in Model Validation, Presented at the Arctic Ocean Model Intercomparison Project (AOMIP), Woods Hole Oceanographic Institution, Woods Hole, MA, 23-26 Oct., 2012.

Farrell, S. L. (invited), Cryospheric Research at CICS-MD, CICS Midterm Science Review, Earth System Science Interdisciplinary Center (ESSIC), University of Maryland, College Park, MD, 8-9 Nov., 2012.

Kurtz, N. T., S. L. Farrell, J. P. Harbeck, V. Onana, J. Richter-Menge, J. G. Sonntag, M. Studinger, D. Yi (invited): Four years of sea ice thickness and snow depth results from Operation IceBridge: results, accuracy assessments, and future directions, Abstract C11B-01, presented at 2012 Fall Meeting, AGU, San Francisco, Calif., 3-7 Dec., 2012.

Newman, T., S. L. Farrell, J. Richter-Menge, L. N. Connor, N. T. Kurtz, B. C. Elder: An assessment of IceBridge airborne data quality over Arctic sea ice via comparison with in situ measurements gathered in the Beaufort Sea, Abstract C11B-04, presented at 2012 Fall Meeting, AGU, San Francisco, Calif., 3-7 Dec., 2012.

Farrell, S. L., N. T. Kurtz, J. Richter-Menge, J. P. Harbeck, V. Onana: Statistical Analyses of High-Resolution Aircraft and Satellite Observations of Sea Ice: Applications for Improving Model Simulations, Abstract C43A-0590, presented at 2012 Fall Meeting, AGU, San Francisco, Calif., 3- 7 Dec., 2012.

Rose, S. K., L. N. Connor, T. Newman, S. L. Farrell, W. H. Smith, R. Forsberg: Assessment of Lead Discrimination from CryoSat- 2, Abstract C51A-0763, presented at 2012 Fall Meeting, AGU, San Francisco, Calif., 3-7 Dec., 2012.

Laxon, S., K. A. Giles, A. Ridout, D. J. Wingham, R. Cullen, C. Haas, S. Hendricks, R. A. Krishfield, N. T. Kurtz, S. L. Farrell, R. Kwok, A. J. Schweiger, J. Zhang (invited): Sea ice thickness and volume from CryoSat-2, Abstract C54A-04, presented at 2012 Fall Meeting, AGU, San Francisco, Calif., 3-7 Dec., 2012.

Webster, M., I. Rigor, S. V. Nghiem, M. Sturm, N. T. Kurtz, S. L. Farrell, E. Gleason, R. Lieb-Lappen, E. Saiet: Snow conditions near barrow in spring 2012, Abstract A31D-0069, presented at 2012 Fall Meeting, AGU, San Francisco, Calif., 3-7 Dec., 2012.

Brunt, K., S. L. Farrell, V. M. Escobar (invited): ICESat-2: A next generation laser altimeter for space-borne determination of surface elevation, American Meteorological Society, Austin, TX , 05-10 Jan., 2013.

Newman, T., S L Farrell, J. Richter-Menge, N. T. Kurtz, L. N Connor, B. C Elder, J. M. Gardner, J. Brozena, R. Hagen, D. Ball (invited): Snow on Arctic Sea Ice – Assessment of Airborne Experiments for Data Calibration and Validation, New and Emerging Research in Cryospheric studies meeting, Earth System Science Interdisciplinary Center (ESSIC), University of Maryland, College Park, MD, 18 Jan., 2013.

Farrell, S. L.: Overview of Cryospheric Research at ESSIC - Emerging Activities, New and Emerging Research in Cryospheric studies meeting, Earth System Science Interdisciplinary Center (ESSIC), University of Maryland, College Park, MD, 18 Jan., 2013.

Newman, T., S. L Farrell, J. Richter-Menge, N. T. Kurtz, L. N Connor, B. C Elder, J. M. Gardner, J. Brozena, R. Hagen, D. Ball: Snow on Arctic Sea Ice – Assessment of Airborne Experiments for Data Calibration and Validation and forward modeling of the returned radar waveform, Naval Research Laboratory, Washington, DC, 28 Jan., 2013.

Newman, T., S. L Farrell, J. Richter-Menge, N. T. Kurtz, L. N Connor, B. C Elder, J. M. Gardner, J. Brozena, R. Hagen, D. Ball: Comparison of IceBridge airborne data with in situ measurement in the Beaufort Sea, PARCA/OIB Science Team Meeting, NASA Goddard Space Flight Center, Greenbelt, MD, 30 Jan., 2013

Farrell S. L. (invited): The Declining Sea Ice Pack of the Arctic Ocean, Atmospheric and Oceanic Science Departmental Seminar Series, University of Maryland, College Park, MD, 21 Feb., 2013

OTHER

- Dr. Farrell visited the Francis Scott Key Elementary School, 2300 Key Blvd, Arlington, Virginia in March 2012. Working with Specialist Teachers, Ms. Caitlin Fine (science) and Ms. Kerensa McConnell (art), Dr. Farrell delivered a presentation to 2nd graders on the Polar Regions, snow, ice, and the polar environment.
- Dr. Farrell currently serves as a member of the NASA Operation IceBridge Science Team, and the NASA ICESat-2 Science Definition Team, and is a science investigator on the ESA CryoSat-2 Mission.
- The results from our analysis of Operation IceBridge products over an ice camp north of Greenland appeared on the Front Cover on *IEEE Transactions on Geoscience & Remote Sensing*, 50 (6), C1, doi: 10.1109/TGRS.2012.2198310.
- Dr. Farrell co-organized and co-hosted the "New and Emerging Research in Cryospheric Studies" meeting held at the Earth System Science Interdisciplinary Center (ESSIC), University of Maryland, College Park on 18 January 2013.

LINK TO RESEARCH WEBPAGE:
http://ibis.grdl.noaa.gov/SAT/SeaIce/index.php

- Using Satellite Data to Improve Operational Atmospheric Constituents Forecasting Capabilities

Task Leader Xiaoyang Zhang
Task Code SKSK_USDI_12
NOAA Sponsor Shobha Kondragunta
NOAA Office NESDIS/STAR/SMCD/SCDAB
Main CICS Research Topic Earth System Monitoring from Satellites
Percent contribution to CICS Themes Theme 1: 20%; Theme 2: 40%; Theme 3: 40%.
Percent contribution to NOAA Goals Goal 1: 60%; Goal 2: 40%

Highlight: CICS scientists developed a new global biomass burning emissions product. This product blends fire observations from polar orbit satellites and geostationary satellites. It is expected to serve as a significant input to aerosol module (GFS-GOCART) in the next-generation operational weather forecasting system, National Environmental Modeling System (NEMS), for predicting global aerosols

BACKGROUND

The objective of this task is to develop a global biomass burning emissions product required in preparation for operational assimilation of satellite aerosol products (Aerosol Optical Depth, fire emissions) into NOAA NCEP (National Centers for Environmental Prediction) Grid point Statistical Analysis (GSI) data assimilation system. In support of NCEP's GFS-GOCART model development and subsequent operational deployment, NOAA/NESDIS and NASA have developed the datasets of biomass burning emissions that will be transitioned to operations for NCEP's model applications. Particularly, NASA has developed Quick Fire Emissions Data (QFED) from Aqua and Terra MODIS. The QFED dataset offers complete global coverage but observes fires only four times a day (two times for Aqua and two times for Terra, no full diurnal coverage). NOAA/NESDIS/STAR has developed a Global Biomass Burning Emissions Product (GBBEP-Geo) from a network of geostationary satellites (GOES-East, GOES-West, Meteosat-9, and MTSAT). A geostationary satellite observes fires every ~30 minutes (48 times a day) but cannot provide coverage over high latitudes. Therefore, to provide a full coverage (temporally and spatially), the ideal approach would be to combine QFED and GBBEP-Geo datasets.

NCEP carried out the GFS-GOCART runs using GBBEP-Geo and QFED datasets for June-August 2010. Model simulations with fire emissions elevated levels of aerosols near the source regions. However, when model-derived AODs from model runs using QFED and GBBEP-Geo are compared to in situ data from AERONET, the model AODs are lower than AERONET but capture the aerosol peaks associated with the fire events. The bias is because fire size is much smaller than the model grid size and the emissions from these fires are represented in the model as area sources instead of point sources. It is also possible that satellite emissions are biased low due to uncertainties in Fire Radiative Power (FRP) product used in calculating emissions.

To circumvent this problem, NASA has revised its estimate (QFED V2.2) by applying scaling factors. These scaling factors have been derived, for each biome type, by comparing model derived AOD (with original QFED data) and MODIS AOD over a 4-yr time period. Therefore, this proposed activity involves determining scaling factors for GBBEP-Geo using QFED v2.2 methodology before both datasets are combined for operational use at NCEP.

The algorithms and products are being developed in such a way that when new satellites are launched, transition to new datasets is transparent to NCEP. For example, NPP VIIRS AOD and fire emissions are expected to replace MODIS products that are currently available.

ACCOMPLISHMENTS

- Daily biomass burning emissions (GBBEP-Geo) in 2011 were produced from fire FRP that was derived from a set of geostationary satellites (GOES, Meteosat-9, and MTSAT). The emissions were gridded to a 0.25°× 0.3125° resolution grid to meet the GFS-GOCART runs.
- Computer software for processing MODIS biomass burning emissions (QFED v2.2) was converted to NOAA operational codes. The software of QFED V2.2 was originally developed in NASA using Python codes. This software is required to rewrite to meet the operational requirements in NOAA/NESDIS/OSPO. Therefore, the Python codes in NASA were converted to C and Perl codes. The operational QFED codes were tested and the output results were compared with NASA outputs
- Operational computer codes for combining GBBEP-Geo and QFED were developed. Biomass burning emissions from QFED and GBBEP-Geo need to be combined in order to provide a full coverage (temporally and spatially) of biomass burning emissions for GFS-GOCART model. The operational computer codes produce two different types of fire emissions. The blended biomass burning emissions from QFED and GBBEP-Geo are daily data with a spatial resolution of 0.25° × 0.3125° and a data format of NetCDF4. The emission species include BC, CO, CO2, OC, PM2.5, and SO2. Another is GBBEP-Geo emissions product, which contains hourly emissions in fire pixels for FRE, PM2.5, dry mass burned, BC, CO, CO2, OC, SO2, ecosystem types. The software was tested in the local machine.
- Fire energy data from different satellites were compared. The FRP values from GOES-E and GOES-W were investigated and compared. The raw instantaneous FRP observations from GOES-E and GEOS-W are considerably different. However, after simulating using diurnal pattern of FRP, the FRE from these two satellites are comparable with a slope of 1.027. Moreover, GBBEP-Geo emissions (un-scaled to MODIS AOD) were compared with QFED v2 (scaled to MODIS AOD). The scaling factor from

GBBEP-Geo to QFED V2 is 5.89, 4.56, 3.68, 23.21, and 36.50 for North America, South America, Africa, Asia, and Australia, respectively.

- Long-term biomass burning emissions in America were also generated from GOES-E data. GOES-E fire characteristics from 1995-2011 were detected using the updated Wildfire Automated Biomass Burning Algorithm (WF_ABBA V65) in University of Wisconsin. From the updated fire data, biomass burning emissions in America during past 17 years were produced and the results were analyzed.

PLANNED WORK

- Design quality control and monitoring plan for global biomass burning emissions product
- Test and evaluate routine processing of global biomass burning emissions from a local machine
- Complete documents for operation in OSPO
- Finalize operational computer codes and transfer to OSPO
- Evaluate and assess the estimates of biomass burning emissions

PUBLICATIONS

Zhang, X., Kondragunta, S., Ram, J., Schmidt, C., Huang,H-C, 2012. Near Real Time Global Biomass Burning Emissions Product from Geostationary Satellite Constellation. *Journal of Geophysical Research,* doi:10.1029/2012JD017459.

PRESENTATIONS

Kondragunta, S., *Zhang, X.*, da Silva, A., Lu, S., Kim, H.C., 2012, Using Satellite Data to Improve Operational Atmospheric Constituents Forecasting Capabilities**.** *JCSDA 10th Workshop on Satellite Data Assimilation*, 10-12 October 2012, College Park, Maryland, USA.

Hu, Y., Odman, M. T, Russell, A.G., *Zhang, X.*, Kondragunta, S., Yu, H., Remer, L., Bian, H., 2012, Modeling wildfire impacts on air quality during the ARCTAS-CARB campaign: evaluation using surface, airborne and satellite measurements, *11th Annual CMAS Conference*, 15-17 October 2012, Chapel Hill, North Carolina, USA.

Performance Metrics	**FY12**
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	1
# of non-peered reviewed papers	0
# of invited presentations	2
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	0

1.9 National Climate Assessments

- Research, Development and Implementation of National and Regional Physical, Ecological, and Societal Climate Indicators for the NOAA and the USGCRP National Climate Assessment

Task Leader Kenney, Melissa A.
Task Code MKMK_PRESC_12
NOAA Sponsor Eric Locklear
NOAA Office OAR/CPO/ASD
Main CICS Research Topic National Climate Assessments
Percent contribution to CICS Themes Theme 1: 75%; Theme 2: 0%; Theme 3: 25%
Percent contribution to NOAA Goals Goal 1: 85%; Goal 2: 5%; Goal 3: 5%; Goal 4: 5%

Highlight: Kenney is leading the development of an interagency indicator system to bring together data, observations, and indicator products in innovative ways to better assess climate changes, impacts, vulnerabilities, and preparedness.

BACKGROUND
The National Climate Assessment (NCA) is being conducted under the auspices of the U.S. Global Change Research Program (USGCRP), which is required to provide a report to Congress every 4 years. Part of the vision for the NCA process is a system of physical, ecological, and societal indicators that communicate key aspects of the physical climate, climate impacts, vulnerabilities, and preparedness for the purpose of informing both decision makers and the public with scientifically valid information such as the development and implementation of climate adaptation strategies in a particular sector or region.

This particular task is focused on developing recommendations for the USGCRP National Indicator System. The approach brings together over 150+ physical, natural and social scientists from academia, government agencies, and the private sector to develop a theoretical framework, to recommend existing indicators, and to provide near-term and long-term research priorities. There are 15 technical teams, each with team leads or co-leads, and 10-20 team members who will be providing these recommendations. These teams are currently established and regularly meeting to provide the required deliverables -- conceptual model, recommended indicators, and research priorities – by June 2013. These products will be synthesized by Kenney's team and provided to the Indicator Work Group, an advisory board of 25 members will make the final decisions of which indicators to recommend for inclusion in a pilot system on the Global Change Information System (GCIS) in 2014 and which to include in the launch of the system in 2015.

In this report we only focus on the work accomplished since the inception of the task (past 6 months).

ACCOMPLISHMENTS

Since the inception of the task 6 months ago, we have made tremendous progress. One of the major accomplishments was establishing formal and informal support from the federal agencies (e.g., NOAA, NASA, EPA, USGS, USDA, USFS, DOE) and USGCRP Principals, given conversations and formal invited briefings, to develop a robust set of recommendations for a prototype indicators system in collaboration with experts from their agencies and utilizing indicators and data for the system developed by their agencies (listed as priority on pg. 31 of USGCRP FY13 Our Changing Planet). Such support was critical to expand this effort and begin to rally the scientific community to participate in a process to develop the theoretical basis for the indicator system, provide recommendations that leverage existing agency investments in data, observations, and indicator products, and establish near-term and long-term research priorities to better achieve the indicator vision. As a result, we confirmed major leadership in indicators effort (Tony Janetos (system-wide leadership), Deke Arndt (physical indicators), Bob Chen and Richard Moss (societal indicators), and Rich Pouyat (ecological indicators)), technical team leadership for 13 teams and technical team members (approximately 10-20 members per team with each team choosing their "NRC" panel of scientists and senior managers in academia, government, or private sector). Additionally, the National Climate Assessment Development and Advisory Committee (NCADAC) Indicator Work Group (advisory board of the indicators effort, which includes approximately 25 members) established 1) decision criteria for inclusion of indicators in the system, a critical product necessary for the development of a system.

To support the establishment of the system, we have 2) finalized a multi-year implementation plan including the organizational structure, timeline, and deliverables to provide assurance that we can deliver on our ambitious goals, developed a 3) fact sheet, 4) universal slide deck, and 5) other briefing materials to be used by anyone that is part of this effort and provided at the request of NOAA, USGCRP, and other agencies as they develop priorities and want to know more about the development of an indicator system, and 6) drafted initial inventory of physical, ecological, and societal indicators to support the initial work of the technical teams. Additionally, to better support collaboration within and between teams, an Indicator Portal (indicators.globalchange.gov); we worked with NOAA NCDC, who developed the portal, to move the portal from an idea into operation. Finally, we hosted an in-person meeting of indicator team leads at UMD JGCRI to discuss the development of conceptual models and received verbal support for a prospectus to *Proceedings of the National Academy of Sciences* for a special issue on the National Indicator System to be published in 2015.

Over the past 6 months we have given 15 verbal or poster presentations (11 invited) and Kenney has 1 publication in press (unrelated to this project); 2 in review (related to this task), and 4 close to submission (1 related to this task and 3 unrelated). To accomplish our goals, we have mentored early career science policy fellows (5), graduate students (1), and undergraduate students (5) who are learning about science policy research methods and provide unpaid research support. Additionally, Kenney is teaching a climate science policy research course (AOSC 499) for undergraduate Spring 2013 to teach students about science policy research methods by working on the indicators effort.

PLANNED WORK

- Technical teams deliver recommendations (June 2013)
  - conceptual model with supporting documentation
  - candidate indicators with supporting documentation
- Synthesize conceptual models and recommendations. Determine similarities and synergies between recommendations. (Summer 2013)
- Develop pilot survey methods to test the value of information of individual indicators. Explore methods to evaluate the value of an information system. (2013)
- Indicator WG recommends indicators for initial system (Summer/Fall 2013)
- Begin development of evaluation methods for the pilot and full indicator system to better understand information system design and have a quantitative basis for improvement decisions. (2013)
- Technical teams provide near-term and long-term research priorities (September 2013)
- Documentation for each of the indicator that would allow for replication of the product, including data, metadata, transformation, and indicator methodology (end 2013)
- Write and submit manuscripts for special issue of a journal (prospectus to *PNAS*) on the indicator system (drafts due by January 2014; submitted Spring 2014)
- Inclusion of indicators in GCIS release (March 2014)
- Test evaluation methods given the pilot of the indicators on the GCIS. Use lessons learned to improve the methods so that a robust procedure is developed for the launch. (2014)
- NCADAC, internal, and external review of the system – data and methods (2014)
- Work with GCIS team and graphic designers to develop the design of the indicator system (2014)
- Launch indicator system on GCIS (2015)
- Special issue of journal on the national indicator system (2015 with release of indicator system)
- Evaluate and improve the indicator system; pilot indicators from research investments (after 2015)

PUBLICATIONS (since September 2012)

Moss, R., P.L. Scarlett, M.A. Kenney, H. Kunreuther, R. Lempert, J. Manning, B.K. Williams (in review) Decision support: Supporting policy, planning and resource management decisions in a climate change context. 3rd National Climate Assessment (currently draft because in review).

Janetos, A.C. and M.A. Kenney (in review) Indicators of Change and Consequence are Unmet Needs for Climate Change Assessments. Nature Climate Change.

Kenney, M.A., B.F. Hobbs, D. Mohrig, H. Huang, J.A. Nittrouer, W. Kim, G. Parker. (in press) Cost Analysis of Water and Sediment Diversions to Optimize Land Building in the Mississippi River Delta. Water Resources Research. doi:10.1002/wrcr.20139

PRESENTATIONS (since September 2012)

Kenney, M.A. (Spring 2013) Are stream restoration projects worth it? Carnegie Mellon University, Civil and Environmental Engineering Environment Today. Invited Keynote Speaker

Kenney, M.A. (Spring 2013) National Climate Assessment: Science informing policymaking. University of Maryland, School of Public Policy (invited)

Kenney, M.A. (2013) Supporting and Informing Decisions Through Assessments. American Association for the Advancement of Sciences. Boston, MA. (invited)

Janetos, A.C., M.A. Kenney, R. Chen, D. Arndt. (2013) Developing a System of National Climate Assessment Indicators to Track Climate Change Impacts, Vulnerabilities, and Preparedness. NOAA Climate Board. Washington, DC. (invited)

Kenney, M.A. (Fall 2012) Using decision analysis to address complex restoration problems. University of Maryland, Earth System Science Interdisciplinary Center (invited)

Kenney, M.A. and Janetos, A.C. (2012) Recommendations of a Protype National Indicator System for the U.S. Global Change Research Program. Principal's Briefing of the U.S. Global Change Research Program. Washington, DC. (invited)

Janetos, A.C., M.A. Kenney, R. Chen, D. Arndt. (2012) Developing a System of National Climate Assessment Indicators to Track Climate Change Impacts, Vulnerabilities, and Preparedness. Briefing of National Climate Assessment Development and Advisory Committee (NCADAC). Silver Spring, MD. (invited)

Janetos, A.C., M.A. Kenney, R. Chen, D. Arndt, R. Pouyat. (2012) Developing a System of National Climate Assessment Indicators to Track Climate Change Impacts, Vulnerabilities, and Preparedness. National Ecological Observatory Network (NEON). Washington, DC. (invited)

Kenney, M.A., Janetos, A.C., R. Chen, D. Arndt, R. Pouyat. (2012) Developing a System of National Climate Assessment Indicators to Track Climate Change Impacts, Vulnerabilities, and Preparedness. U.S. Global Change Research Program, Interagency National Climate Assessment Task Force. Washington, DC. (invited)

Kenney, M.A., Janetos, A.C., R. Chen, D. Arndt, R. Pouyat. (2012) Developing a System of National Climate Assessment Indicators to Track Climate Change Impacts, Vulnerabilities, and Preparedness. U.S. Geological Society. Reston, VA. (invited)

Hobbs, B.F., M.A. Kenney, D. Mohrig, J. Nittrouer, W. Kim and G. Parker. (2013) What's the Most Efficient Use of our Limited Water and Money? Scale Economy Tradeoffs in Land Building Diversions in the Mississippi Delta. 2013 World Environmental & Water Resources Congress. Cincinnati, OH.

M.A. Kenney. (2012) Testing the Value of Information of Climate Change Indicators that Use Earth Observations. Physical, Ecological, and Societal Indicators for the National Climate Assessment. American Geophysical Union conference. San Francisco, CA. (contributed/invited)

Janetos, A.C., M.A. Kenney, R.S. Chen, D. Arndt, and R. Pouyat. (2013) Developing a System of National Climate Assessment Indicators to Track Climate Change Impacts, Vulnerabilities, and Preparedness. Poster presented at North American Carbon Program. Albuquerque, NM.

Janetos, A.C., M.A. Kenney, R.S. Chen, and D. Arndt. (2012) Developing a System of National Climate Assessment Indicators to Track Climate Change Impacts, Vulnerabilities, and Preparedness. Paper Number: GC11C-1020. Poster presented at American Geophysical Union conference. San Francisco, CA.

Kenney, M.A., A.C. Janetos, R.S. Chen, and D. Arndt. (2012) Developing a System of National Climate Assessment Indicators to Track Climate Change Impacts, Vulnerabilities, and Preparedness. Poster presented at University of Maryland, Earth System Science Interdisciplinary poster session. College Park, MD.

OTHER

- ***Awards:*** Lead Author for Decision Support Chapter of the 2013 National Climate Assessment (2012-2013)
- ***Instructor AOSC 499****:* Special Topics Research – Climate Science Policy, University of Maryland, College Park (2013)
- ***Mentoring:*** 5 undergraduate students (2012-2013), 1 graduate student (2012-2013); 5 early career Ph.D. science policy fellows (2012-2013); Ecological Society of America Mentor for Networking for Students and Early Career Professionals (2012)
- ***Sigma Xi, the Scientific Research Society***: National Qualifications and Membership Committee (2010 – present)
- ***Grant Reviewer for***: Belmont Forum, Freshwater Security (2013); National Science Foundation, SEES Fellows (2013); American Association for the Advancement of Sciences Policy Fellowship (2012)
- ***Reviewer*** : IPCC Working Group II Report (2012); *Environment, Systems, and Decisions* (2013)
- ***Grants submitted:*** Haimin, E., D. DeGroot, **M.A. Kenney**, T. Sheahan. (submitted 2013) RCN-SEES: Sustainable Adaptive Gradients in the coastal Environment (SAGE): Reconceptualizing the Role of Infrastructure in Resilience. National Science Foundation, Research Coordination Network, Science, Engineering and Education for Sustainability. Requested $750,000.

Performance Metrics	FY12
# of new or improved products developed	6
# of products or techniques transitioned from research to ops	1
# of peer reviewed papers	1 in press; 2 in review
# of non-peered reviewed papers	0
# of invited presentations	11
# of graduate students supported by a CICS task	1 (travel support)
# of undergraduate students supported by a CICS task	5 (travel support)

1.10 Education, Outreach, and Literacy

- Program Management at the Climate Program Office

Task Leader	Dan Barrie
Task Code	DBDB_CPO_12
NOAA Sponsor	Eric Locklear
NOAA Office	OAR/CPO/ASD
Main CICS Research Topic	Education, Literacy, and Outreach
Percent contribution to CICS Themes	Theme 1: 0%; Theme 2: 0%; Theme 3: 100%
Percent contribution to NOAA Goals	Goal 1: 85%; Goal 2: 15%

Highlight: Scientific progress has been fostered through new digital outreach techniques in addition to traditional facilitated community meetings. This outreach effort has helped coordinate and maximize the federal climate and Earth system model effort.

BACKGROUND

The NOAA Climate Program Office (CPO) focuses on developing a broader user community for climate products and services, provides NOAA a focal point for climate activities, leads NOAA climate education and outreach activities, and coordinates international climate activities. To achieve these goals, CPO will benefit significantly from a strong partnership with outside investigators. Building this partnership requires the involvement of personnel with strong backgrounds in scientific research in program management positions. This need for scientific expertise within CPO matches well with Dr. Barrie's training, talents, and career interests.

ACCOMPLISHMENTS

Three representative highlights from the task leader's previous year of activity are described below: 1) the success of a webinar series; 2) a NOAA modeling meeting; 3) an interagency/university community meeting on the CMIP experiment.

1) The task leader has organized and hosted a webinar series intend to communicate research results to the broader research and end-user community, connect funded investigators with each other, and to provide updates for program management on the progress of funded projects. In FY12, the webinar series entered its second year. A total of 737 individuals have attended the webinar series, and attendance has grown from the first to second year; current attendance is running 56% ahead of first-year attendance when comparing through the first six webinar sessions. The webinar series is highlighted on a website co-created by the task leader, where information about the series, slides, and recordings are hosted.

2) The task leader organized and hosted leading scientists from NOAA's National Centers for Environmental Prediction (NCEP) and Geophysical Fluid Dynamics Laboratory (GFDL) to discuss common historic, ongoing, and subsequent interests and efforts. Discussions centered on ocean modeling-related topics including GFDL's Modular Ocean Model (MOM), ocean data assimilation efforts at each institution, as well as interests and activities associated with observing system experiments.

A number of initiatives emerged from the meeting, each of which is built off independent work at GFDL and NCEP as well as ongoing collaborations in a variety of areas including Observing System Experiments; use of the Modular Ocean Model, version 3; and the National Multi Model Ensemble. These initiatives are summarized below:

- The latest release of the GFDL ocean model (MOM5) will be migrated to NCEP for operational use.
- NCEP is looking to improve the quality of the modeled daily cycle of ocean temperature near the surface. GFDL indicated that the next major version of MOM, MOM6, may help ameliorate existing issues as resolution can be increased substantially near the surface.
- Both NCEP and GFDL seek to improve the representation and simulation of Arctic ice conditions in their climate models. GFDL is working to incorporate the CICE sea ice model, developed by the Los Alamos National Laboratory, into MOM6.
- NCEP and GFDL will collaborate on linking the WAVEWATCH model with MOM6.
- NCEP/GFDL discussed current joint work with Observing System Experiments and how they plan to jointly explore the value of ocean buoy systems and their role and value as a component of the larger observing system.

During the meeting, more general discussions revolved around how NCEP's operational forecasts could benefit from better performance in simulating particular coupled phenomenon, an area that GFDL, with its research investments in exploring the impacts of model parameters and configurations, can inform. In addition, the group discussed how ocean modeling has an influential role at the interface between long-term climate and shorter climate/weather timescales. Ongoing discussions of a "seamless" prediction system are critically dependent upon ocean modeling efforts and directions, the initial vs. boundary condition problem, and the distinct Earth system timescales GFDL and NCEP orient their activities around. At this interface lies the potential for a great deal of collaboration between these two institutions. Aside from fostering the ongoing collaborations and new initiatives, the two institutions will be more aggressive in collaborating on joint publications and applying for joint funding. GFDL will participate at whatever level is practical and most useful in the development of version three of NCEP's CFS.

3) The task leader organized a meeting on the Coupled Model Intercomparison Project (CMIP). The meeting focused on a number of issues related to CMIP, including:

- Experimental results and the experience of producing, disseminating, and utilizing CMIP, Phase 5 (CMIP5) output with a focus on U.S. laboratory efforts.
- CMIP5 results for North America including model performance relative to the 20th century and CMIP5 as well as 21st century projections.
- The interface with application communities (specifically water cycle and agriculture), including community needs and the role of CMIP experiments as an interface between the climate/modeling/applications communities.

Meeting attendees were drawn from academia as well as federal laboratories and agencies, and a few of the major highlights are given below:

- Model development should be decoupled as much as possible as possible from the IPCC/CMIP cycle.
- There should be a clear timeline for model development ending in a frozen model leading to performance of the experiment and culminating in analysis of the results, all in enough time to allow the community to produce papers for the next IPCC report, assuming the IPCC and CMIP cycles remain coupled; a longer period between CMIPs might result in a more thorough and meaningful process.
- Governance over and enforcement of deadlines should be strengthened.
- The volume of data for a CMIP6 may be unmanageable (estimates range well into the Exabyte scale) with existing data and information systems, so considerable planning and development is needed that draws on accumulated experience to ensure data are universally available and well-documented.
- More server-side capabilities should be provided to reduce the movement of data across the network and to alleviate local data storage and analysis constraints.
- For hindcast runs (e.g., decadal predictions), initialization is of critical importance and should receive greater attention in future CMIPs, particularly for the earlier period where observations are comparatively scant; focusing on a shorter timescale for the hindcast experiments (perhaps five years) may be more advisable from the perspective of the present science and capabilities; the decadal goal may be too far ahead of current capacity.

PLANNED WORK

- Continue growing the webinar series
- Serve as organizer and host for future internal NOAA meetings and discussions
- Develop and implement new outreach activities.

Performance Metrics	FY12
# of new or improved products developed	2
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	N/A
# of non-peered reviewed papers	N/A
# of invited presentations	0
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS theme	3

New and improved products are described in the accomplishments section. Papers and graduate students are not applicable to the task.

- Interpretation of Real-Time Weather and Climate Data for Spherical Displays

Task leader	Stephanie Schollaert Uz
Task Code	EarthNow
NOAA Office	OESD
Main CICS Research Topics	Education, Literacy, and Outreach
Percent Contribution to CICS Themes	0%
Percent Contribution to NOAA Goals	Goal 1: 50%; Goal 2: 25%; Goal 3: 25%

Highlight: By providing audio clips so that narrated visualizations can play in autorun, with or without a live docent present, we increased the visibility of NOAA products at venues where Science-on-a-Spheres are installed world-wide.

BACKGROUND

Because of my experience in Earth Science (oceanography) as well as outreach activities using the portable Magic Planet spherical displays, I was invited to join the EarthNow team in April, after a rigorous application and interview process. The project was in its second year, six months since the launch of its website blog and routine SOS network data, when results of the first formative evaluation were received in April, 2012. Adoption rates were low: only 20% of sites surveyed had used EarthNow in a live presentation. A plan of action was discussed during a full-team conference call in May, including setting up a twitter feed, establishing relationships with several EarthNow model museums, and having team members send the team leader topic and contact suggestions for EarthNow posts.

ACCOMPLISHMENTS

In April, 2012, I began regular visits to Washington, DC area SOS sites to explore current EarthNow utility to them as well as the potential for a summer intern to work with their docents. Over the summer, we hired an AOSC graduate student whom I supervised closely during her regular working hours at the Maryland Science Center and at ESSIC. While her internship was originally intended to involve researching climate topics for EarthNow stories, the team switched her mission to mentoring docents in how to give live EarthNow shows. I coordinated training her in how to prepare and deliver SOS presentation at the National Zoo's SOS (Figure 1). She conducted eight bi-weekly docent training sessions at the Maryland Science Center during her summer internship.

During observations at the National Zoo and Maryland Science Center SOS spaces, I noticed: that live docent shows are rare or nonexistent; that unless a site has the EarthNow feed selected, it will not receive automatic update; that visitors are drawn to the SOS and frequently take pictures of it, but don't stop to watch it if it is only displaying raw data (e.g. temperature anomalies, visible cloud imagery). Discussions with several docents about how they prepare their shows indicated they weren't comfortably changing their show frequently and that, while they liked EarthNow, it didn't necessarily fit into their shows.

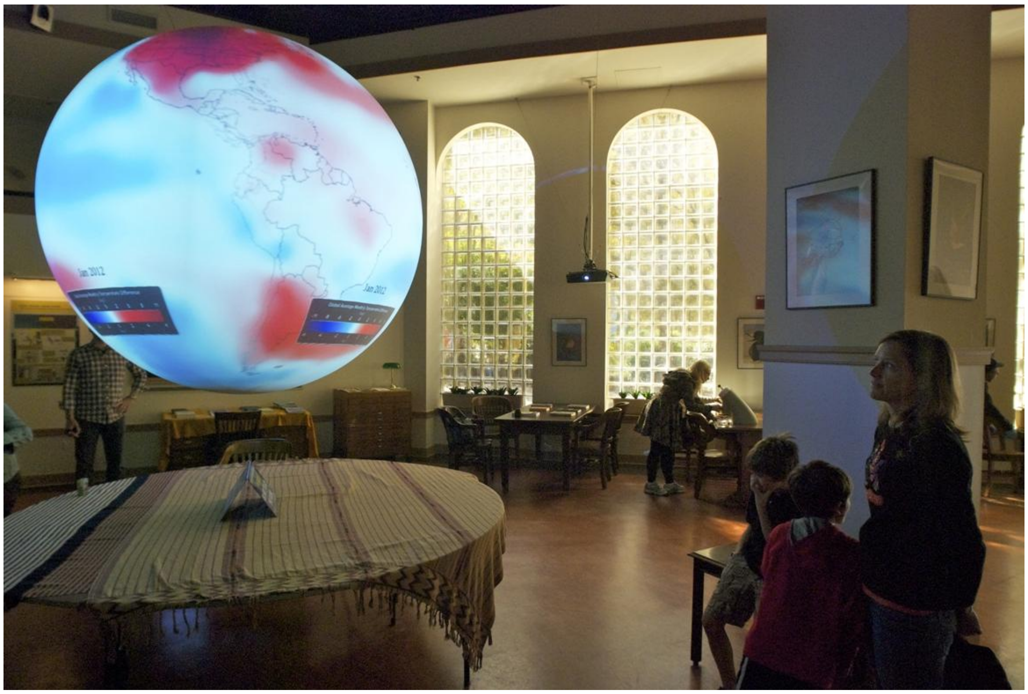


Figure 1: *Science-on-a-Sphere (Amazonia Building) at the Smithsonian National Zoo in Washington, DC.*

Museums most often have their SOS in autorun mode, therefore I began taking the EarthNow visualizations and creating an audio script in which I explain the data and the science: distilling complex Earth weather and climate concepts into a form the public can comprehend. After preparing two initial prototypes of professionally narrated EarthNow segment, I tested them at the Maryland Science Center in October. Feedback received from the museum was used to develop guidelines for regular audio clips to accompany EarthNow posts, to be accessible from the EarthNow website along with instructions and playlists so that museums may incorporate the narrated segments in autorun mode (Figure 2).

The narrated EarthNow stories made their debut at the SOS User's Workshop at the Aquarium of the Pacific, Long Beach, CA in November, 2012. Reviews were instantly favorable. Museums without live staff said this is exactly what they need. Museums with live staff also expressed excitement over the narrated pieces, which they like to use with and without audio.

An additional feature currently being tested at the Maryland Science Center is a handout for docents of 'Questions & Answers' to accompany EarthNow science feature stories. These sheets are intended to facilitate discussion with visitors and school groups, to stimulate deeper thoughts and additional questions, and to provide museum interpreters with a quick reference. This product will make its debut at the Regional SOS Workshop in Baltimore, MD March 18-19, 2013.

Figure 2: *Screen grab of sample EarthNow blog entry, with the option to play a mini video of what the visualization would look and sound like on the SOS. http://sphere.ssec.wisc.edu/20121003/*

PLANNED WORK

- Present EarthNow overview and 'Questions & Answers' capability at SOS regional network meeting, Maryland Science Center, Baltimore, MD, March 18, 2013
- Publish manuscript *In prep*: Schollaert Uz, S., P.A. Arkin, A. Kavvada, D. Pisut, P. Rowley, M. Mooney, S.A. Ackerman. Informal evaluations of near real-time weather and climate stories for spherical displays at museums.

PRESENTATIONS

Hayward, J. and Schollaert Uz, S., 'Implementing EarthNow: formal and informal evaluation activities', 2012 SOS User's Collaborative Network Workshop, Long Beach, CA. (talk)

Rowley, P. and Schollaert Uz, S., 'Implementing EarthNow: real-time data interpretation with new audio narration', 2012 SOS User's Collaborative Network Workshop, Long Beach, CA. (talk)

OTHER:

Links to EarthNow videos for which I researched, developed and wrote audio script:

http://sphere.ssec.wisc.edu/sst/
http://sphere.ssec.wisc.edu/20120910/
http://sphere.ssec.wisc.edu/20120917/
http://sphere.ssec.wisc.edu/20121003/
http://sphere.ssec.wisc.edu/20121023/
http://sphere.ssec.wisc.edu/20121029/
http://sphere.ssec.wisc.edu/20121104/
http://sphere.ssec.wisc.edu/20130104/
ftp://ftp.ssec.wisc.edu/pub/earthnow/rowley/20130312_video.mp4

Performance Metrics	**FY12**
# of new or improved products developed	2
# of products or techniques transitioned from research to ops	1
# of peer reviewed papers	1, in prep.
# of non-peered reviewed papers	0
# of invited presentations	3
# of graduate students supported by a CICS task	1 summer intern
# of undergraduate students supported by a CICS task	N/A

1.11 Geographical Sciences

- A Terrestrial Surface Climate Data Record for Global Change Studies

Task Leader Eric Vermote
Task Code GEOG-01
NOAA Sponsor Ivan Csiszar
NOAA Office NESDIS/STAR/SMCD/EMB
Main CICS Research Topic Calibration and Validation
Percent contribution to CICS Themes Theme 1: 50%; Theme 2: 50%; Theme 3: 0%.
Percent contribution to NOAA Goals Goal 1: 100%

Highlight: A 30+ years of daily surface reflectance and vegetation index data processed in a consistent way is now available from this project (Figure 1). It is generated from data of several AVHRR instruments from 1981 to 1999 and of the MODIS instruments onboard Terra and Aqua from 2000 to 2012. It uses state of the art algorithms for geolocation, calibration, cloud screening, atmospheric and surface directional effect correction to achieve the most consistent data record possible. This dataset is a daily global dataset at the resolution of 0.05 degree of latitude and longitude. This dataset has also been tested prior to release in practical applications of societal benefits such as forest cover change detection over the long term as well as drought monitoring or yield prediction in the context of agricultural production and food security.

BACKGROUND

The overall objective of this project is to produce, validate and distribute a global land surface climate data record (CDR) using a combination of mature and tested algorithms and the best available land imaging polar orbiting satellite data from the past to the present (1981-2011), and which will be extendable into the JPSS era. The data record consists of one fundamental climate data record (FCDR), the surface reflectance product. Two Thematic CDRs (TCDRs) are also be derived from the FCDR, the normalized difference vegetation index (NDVI) and LAI/fAPAR. These two products are used extensively for climate change research and are listed as Essential Climate Variables (ECVs) by the Global Climate Observing System (GCOS). In addition, these products are used in a number of applications of long-term societal benefit. The two TCDRs are used to assess the performance of the FCDR through a rigorous validation program and will provide feedback on the requirements for the Surface Reflectance FCDR.

ACCOMPLISHMENTS

- *Release of the 30+ record*
- *Processing and evaluation of the 1km AVHRR data*
- *Implementation of the LAI code*

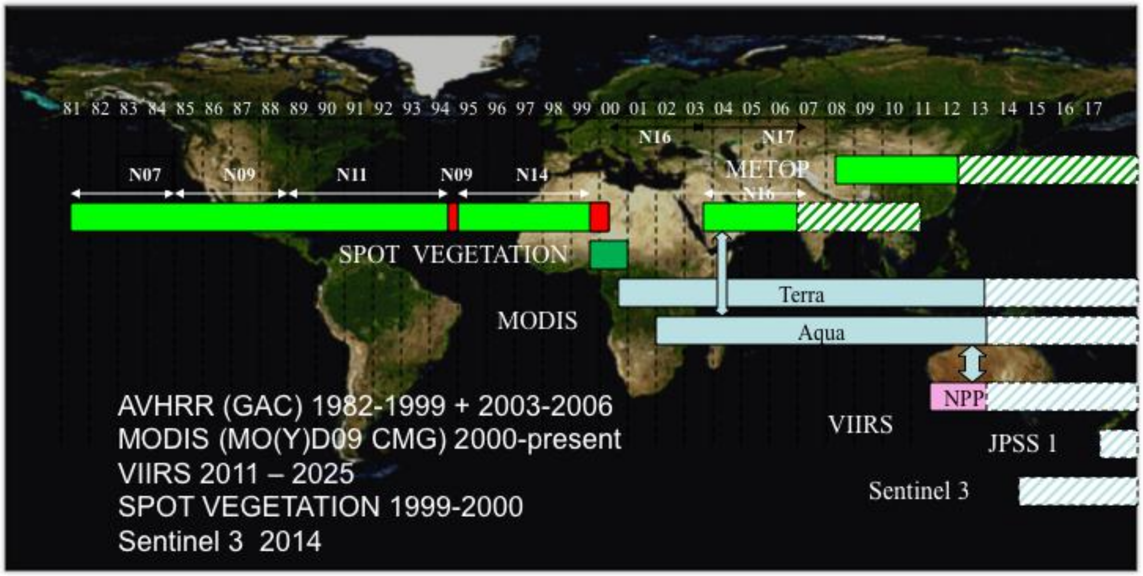


Figure 1: The generation of a Land climate data record (several decade) necessitates the use of multi instrument/multi sensor science quality data record. This record is used to quantify the trend and change in land surface parameter (e.g. Vegetation/Land Cover). A strong emphasis is put on data consistency which is achieved by careful characterization and processing of the original data rather than degrading and smoothing the dataset.

PLANNED WORK

We are planning to make final improvements to the AVHRR atmospheric correction (water vapor and aerosol) that will be possible when the updated calibration of the longwave bands on AVHRR (4,11 and 12 microns) is available.

PUBLICATIONS

Franch B., Vermote E., Sobrino J.A. and Fédèle E. (accepted 2012). Analysis of directional effects on atmospheric correction, Remote Sensing of Environment, (in press)

Breon, F.M., & Vermote, E. (2012). Correction of MODIS surface reflectance time series for BRDF effects. Remote Sensing of Environment, 125, 1-9

Dongdong Wang, Douglas Morton, Jeffrey Masek, Aisheng Wu, Jyoteshwar Nagol, Xiaoxiong Xiong, Robert Levy, Eric Vermote, Robert Wolfe, Impact of sensor degradation on the MODIS NDVI time series, Remote Sensing of Environment, Volume 119, 16 April 2012, Pages 55-61, ISSN 0034-4257, 10.1016/j.rse.2011.12.001.

PRESENTATIONS

Vermote et al., “A Terrestrial Surface Climate Data Record for Global Change studies”, NCDC Climate Data Record (CDR) Third Annual Workshop, National Climatic Data Center in Asheville, North Carolina on July 31rst – August 2nd 2012.

E. Vermote “A Terrestrial Surface Climate Data Record for Global Change Studies”, American Geophysical Union, Fall Meeting 2012.

Eric Vermote and Inbal Becker-Reshef, “A long term terrestrial data record for drought impacts studies”, 4Th International Conference on Drylands, Deserts & Desertification, November 12-15, 2012, Bluastein Institutes for Desert Research, Sede Boqer Campus of Ben-Gurion University, Israel.

Eric Vermote, “BRDF corrections for the use of daily MODIS data”, Regional workshop on Monitoring of Agricultural Production and Land Use Change. Potentials and limitations of remote sensing, September 25-28, 2012, Buenos Aires, Argentina

Eric Vermote, “Review of the state of the art atmospheric correction of remotely sensed data in the solar spectrum”, first international symposium on land remote sensing (ISLRS) ,May 31st to June 1st, 2012,Chengdu, China.

Performance Metrics	FY12
# of new or improved products developed	3
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	3
# of non-peered reviewed papers	0
# of invited presentations	5
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	1

- NPP/VIIRS Land Surface Albedo Validation Research and Algorithm Refinement

Task Leader Shunlin Liang
Task Code GEOG-02
NOAA Sponsor Yunyue Yu
NOAA Office NESDIS/STAR/SMCD/EMB
Main CICS Research Topic Calibration and Validation
Percent contribution to CICS Themes Theme 1: 40%; Theme 2: 40%; Theme 3: 20%.
Percent contribution to NOAA Goals Goal 1: 60%; Goal 2: 40%

Highlight: We evaluated the quality of the current surface albedo EDR data and compare them with the existing products. We updated the BPSA LUT, and the new LUT generated better results. We investigated the angular dependency of BPSA retrievals and proposed methods to reduce the temporal variations.

BACKGROUND

This work is part of the project "NPP/VIIRS Land Product Validation Research and Algorithm Refinement" and particularly focused on the validation and refinement of the NPP/VIIRS land surface albedo algorithm. Land surface albedo (LSA), together with ice surface albedo and ocean surface albedo, are combined into one final product --VIIRS surface albedo EDR. LSA is generated from two types of algorithms: Dark Pixel Sub Algorithm (DPSA) and Bright Pixel Sub Algorithm (BPSA). DPSA uses the MODIS heritage algorithm. BPSA directly estimate broadband albedo from VIIRS TOA reflectance. In addition to land pixels, surface albedo over sea ice pixels is also calculated from a similar direct estimation approach.

This project contains two components: 1) validation of land surface albedo algorithm and data; 2) improvement and refinement of the retrieval algorithm. This report present our work accomplished for the period April 1, 2012 through March 31, 2013.

ACCOMPLISHMENTS

BPSA directly links land surface broadband albedo to TOA narrowband reflectances through extensive radiative transfer simulations and multiple linear regression. The regression coefficients are stored in BPSA LUT. The previous BPSA LUT was built prior to the launch. We designed a simulation process for generating a simulation dataset for the VIIRS albedo study and updated the BPSA LUT with a new set of regression coefficients.

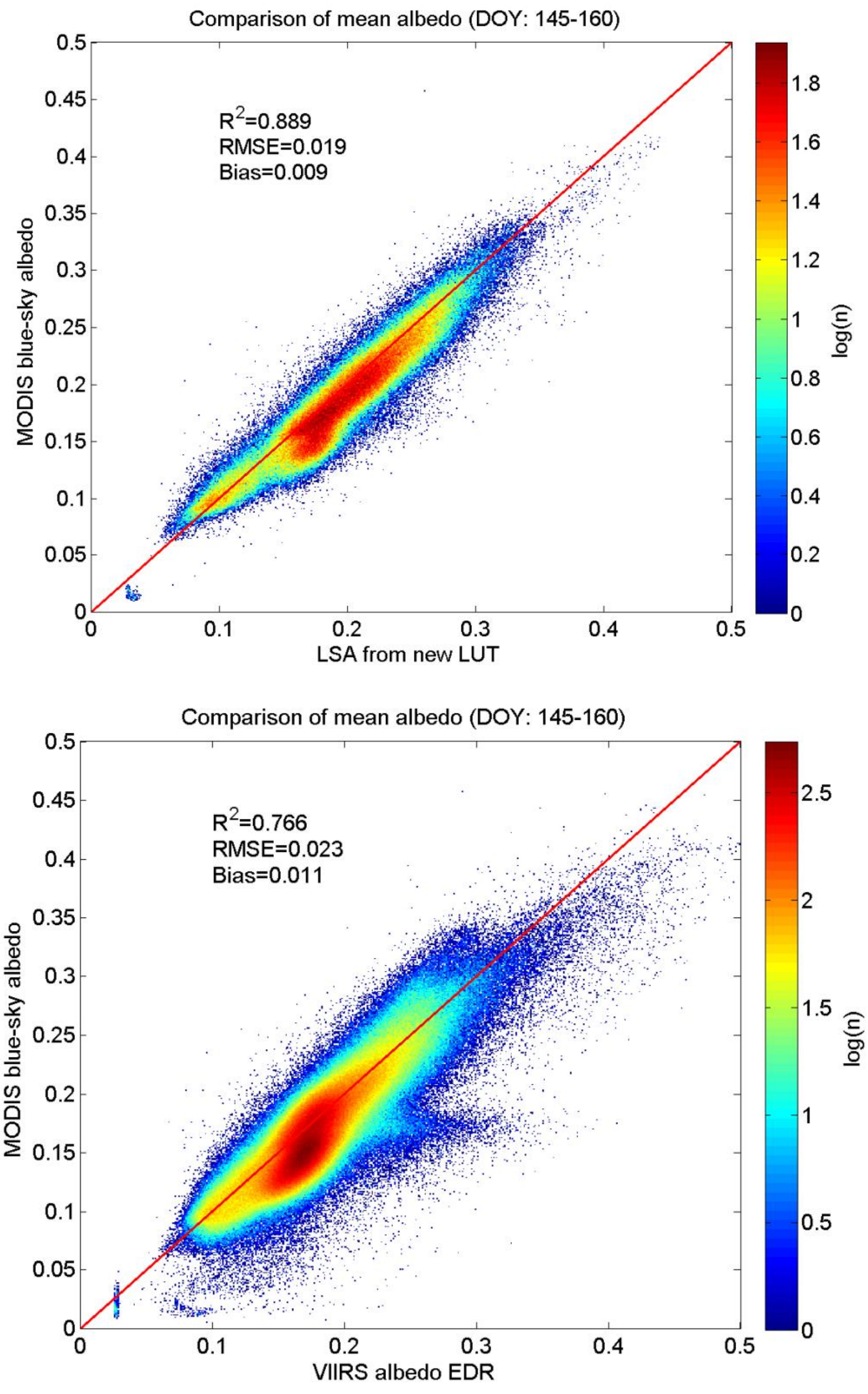


Figure 1. Comparison between VIIRS albedo retrievals and blue-sky albedo calculated from MODIS using data covering US continent from DOY 145-160. The number of available VIIRS clear-sky retrievals is limited to >10 to reduce the impacts of cloud, cloud shadow. Upper panel: The BPSA derived from the updated LUT; Lower panel: The BPSA derived from the current LUT that will be replaced by the new LUT.

The new LUT was used to estimate albedo from VIIRS data over both North America and Greenland. The retrievals from the new LUT and the corresponding VIIRS surface albedo EDR data were compared with the collocated MODIS albedo products (Figure 1). When comparing with the MODIS albedo products, better correlation is seen over the retrievals from the new LUT. The correlation between the retrievals from the new LUT and the MODIS albedo products was dramatically improved after considering the number of clear-sky observations during the 16-day period.

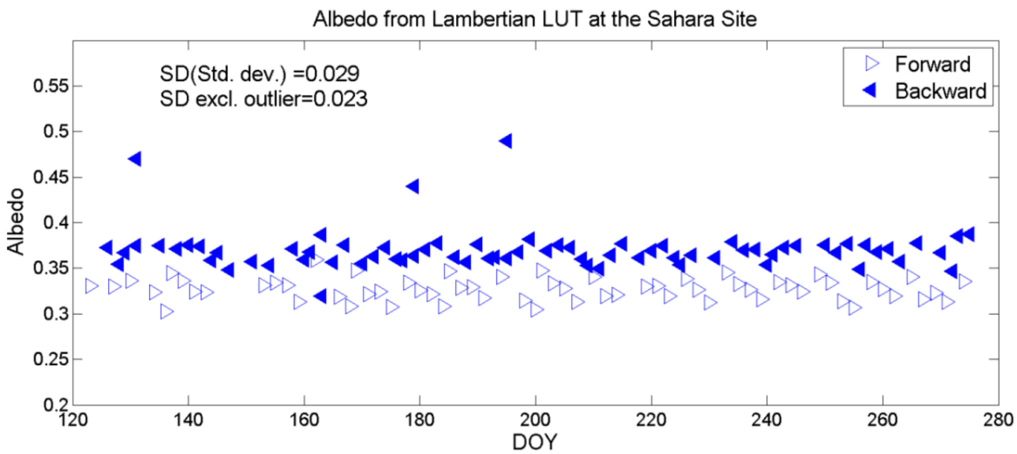
The anisotropy of surface reflectance is not incorporated in the construction of the BPSA LUT (regression coefficients). As a result, individual albedo retrieved from such LUT shows some degree of angular dependency. For example, albedo over stable desert sites shows temporal variations (angular dependency). We proposed two methods to handle the problem: 1) building the BRDF LUT and 2) applying the Lambertian LUT with the BRDF correction.

In the first method, we added the surface BRDF information in the process of building the BPSA LUT. The MODIS BRDF products are used as the inputs to the simulation and generated the training data with BRDF. The second method has two steps: 1)applying the original (Lambertian) LUT and 2) using the pixel-level BRDF information to correct the retrievals from the Lambertian LUT.

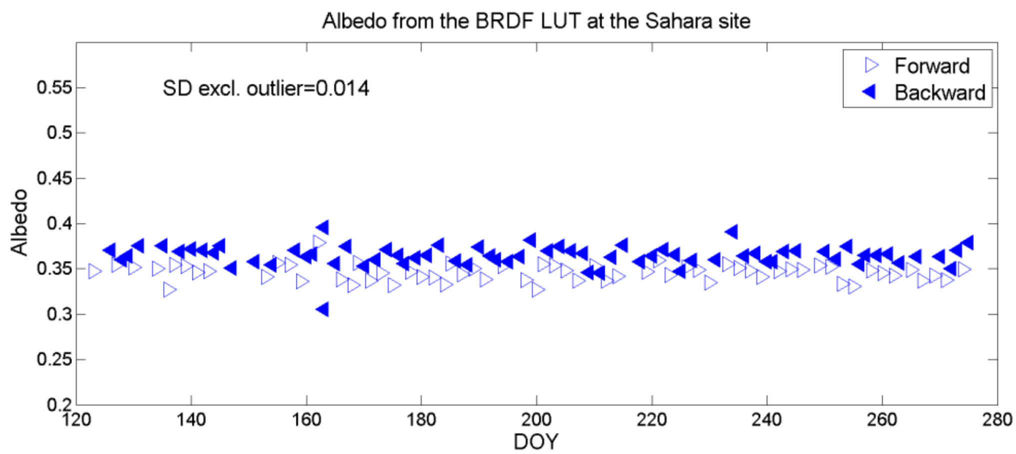
The variations of albedo retrievals from both methods are reduced significantly. Variation still exists even for the two improved methods. The variation is comparable with the reflectance residue of BRDF fitting. Temporal filtering is needed to reduce such residual variations and the influences of cloud and cloud shadow.

PLANNED WORK

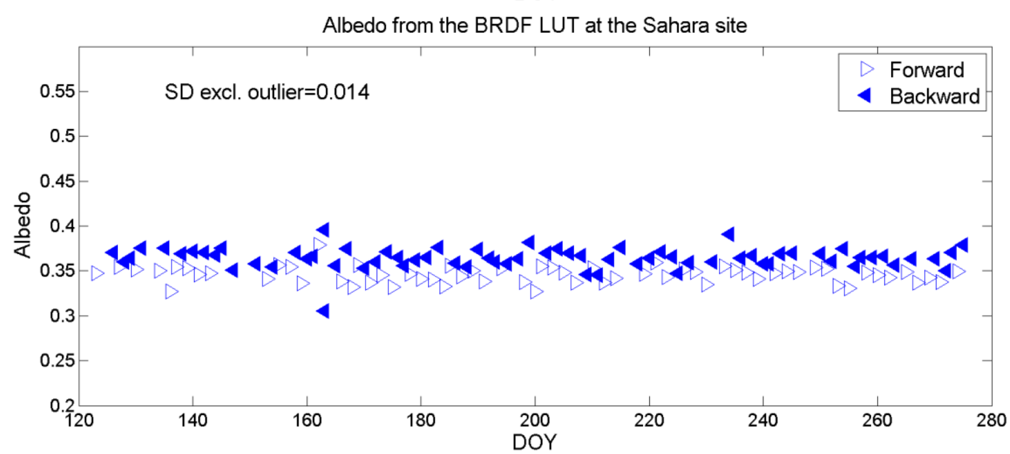
- Continuing to evaluate the Albedo product;
- Improving LSA product and supporting tuning for the NPP product readiness;
- Updating LSA software code and ATBD documentation and support the NPP/JPSS Mission Management



a)



b)



c)

Figure 2. The BPSA albedo retrievals at a desert site. In the original data (a), some temporal variations (angular dependency) exist. Both methods (b: Method 1 and c: Method 2) can reduce the angular dependency significantly.

In terms of Performance Metrics, we developed and delivered a new BPSA LUT, which improves the retrieval accuracy of land surface albedo. Please find details on the publications and presentation in the following sections.

Performance Metrics	FY12
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	6
# of non-peered reviewed papers	0
# of presentations	1
# of graduate students supported by a CICS task	1
# of undergraduate students supported by a CICS task	N/A

PUBLICATIONS

He, T., S. Liang, D. Wang, Y. Shuai, and Y. Yu. Fusion of satellite land surface albedo products across scales using a multi-resolution tree method. IEEE Transactions on Geoscience and Remote Sensing, in revision

Wu, H., S. Liang, L. Tong, T. He, and Y. Yu, (2012). Bidirectional reflectance for multiple snow-covered land types from MISR products. IEEE Geoscience and Remote Sensing Letters , 9, 994-998

He, T., S. Liang, D. Wang, H. Wu, Y. Yu and J. Wang, (2012). Estimation of surface albedo and directional reflectance from Moderate Resolution Imaging Spectroradiometer (MODIS) observations. Remote Sensing of Environment, 119, 286-300

Roman, M., C. K. Gatebe, Y. Shuai, Z. Wang, F. Gao, J. Masek, T. He, S. Liang, and C. B. Schaaf, (2012). Use of in situ and airborne multiangle data to assess MODIS- and Landsat-based estimatesof directional reflectance and albedo. IEEE Transactions on Geoscience and Remote Sensing, accepted

Dongdong Wang, Shunlin Liang, Tao He, Yunyue Yu, Crystal Schaaf, Zhuosen Wang. 2013. Estimating daily mean land surface albedo from MODIS data. JGR-atmosphere. Submitted.

Dongdong Wang, Shunlin Liang, Tao He, Yunyue Yu, Crystal Schaaf, Zhuosen Wang. Direct estimation of land surface albedo from VIIRS data: algorithm and preliminary validation. In preparation.

PRESENTATION

Y Yu, Y Y Liu, D. Wang, S. Liang, P. Guillevic, J. Privette, Z. Wang, C. Schaaf. Evaluation of VIIRS Land Surface Temperature and Albedo EDRs . MODIS Science Meeting

OTHER

A new BPSA LUT was delivered.

- NPP/VIIRS Land Product Validation Research and Algorithm Refinement: Land Surface Type EDR

Task Leader Chengquan Huang
Task Code Task Code GEOG-03 Land Surface Type EDR
NOAA Sponsor Chengquan Huang
NOAA Office NESDIS/JPSSO/GSD
Main CICS Research Topic Future Satellite Programs: Scientific support for the JPSS Mission
Percent contribution to CICS Themes Theme 1: 30%; Theme 2: 40%; Theme 3: 30%.
Percent contribution to NOAA Goals Goal 1: 20%; Goal 2: 20%; Goal 3: 20%; Goal 4: 0%; Goal 5: 40%

Highlight: A thorough investigation of the Suomi-NPP/VIIRS Land Surface EDR products was conducted. The Surface Type EDR algorithm performed as designed. The EDR product achieved *Beta* status in a review conducted last month.

BACKGROUND

The surface type Environmental Data Records (EDR) is an important data product from the Suomi NPP satellite. Using the IGBP land cover classification scheme, it labels the land cover types around the world on a daily basis. It is created from the Quarterly Surface Type (QST) Intermediate Product (IP) and other VIIRS EDR products such as ice/snow EDR and fire EDR.

The QST IP will be created every three months after a full year of VIIRS data has been gathered and calibrated. Before that, the MODIS land cover classification product derived by the Boston University (BU) in 2001 is used as a seed QST IP for the surface type EDR and other NPP EDR algorithms that require QST IP as an input. Development of the MODIS land cover classification has been detailed by Friedl et al. (2002).

This task focuses on development of the QST IP and evaluation of the Surface Type EDR.

ACCOMPLISHMENTS

1. *Evaluation of Surface Type EDR*

Surface Type EDR describes the surface condition at the time of each VIIRS overpass. It is created by remapping the QST IP from the gridded space to the swath space and adding flags for snow/ice based on the Snow EDR and fire based on the Active fire Application Related Product (ARP). We performed comprehensive assessments of surface type EDR products in two aspects. The first is to determine if the QST IP is mapped properly to the swath space. The second is to determine Snow EDR and ARP fire flags have been copied to the Surface Type EDR properly. Our results reveal that the QST IP has been remapped into the swath space for each Surface Type EDR product, although the remapping process often results in pixel shifts of up to 1-2 pixels, which is unavoidable in resampling thematic maps (Figure 1). Fire pixels in the ARP and snow/ice pixels in day time snow EDR products have also been copied to the surface type EDR properly (Figure 2-4). These results indicate that the surface type EDR has reached beta maturity.

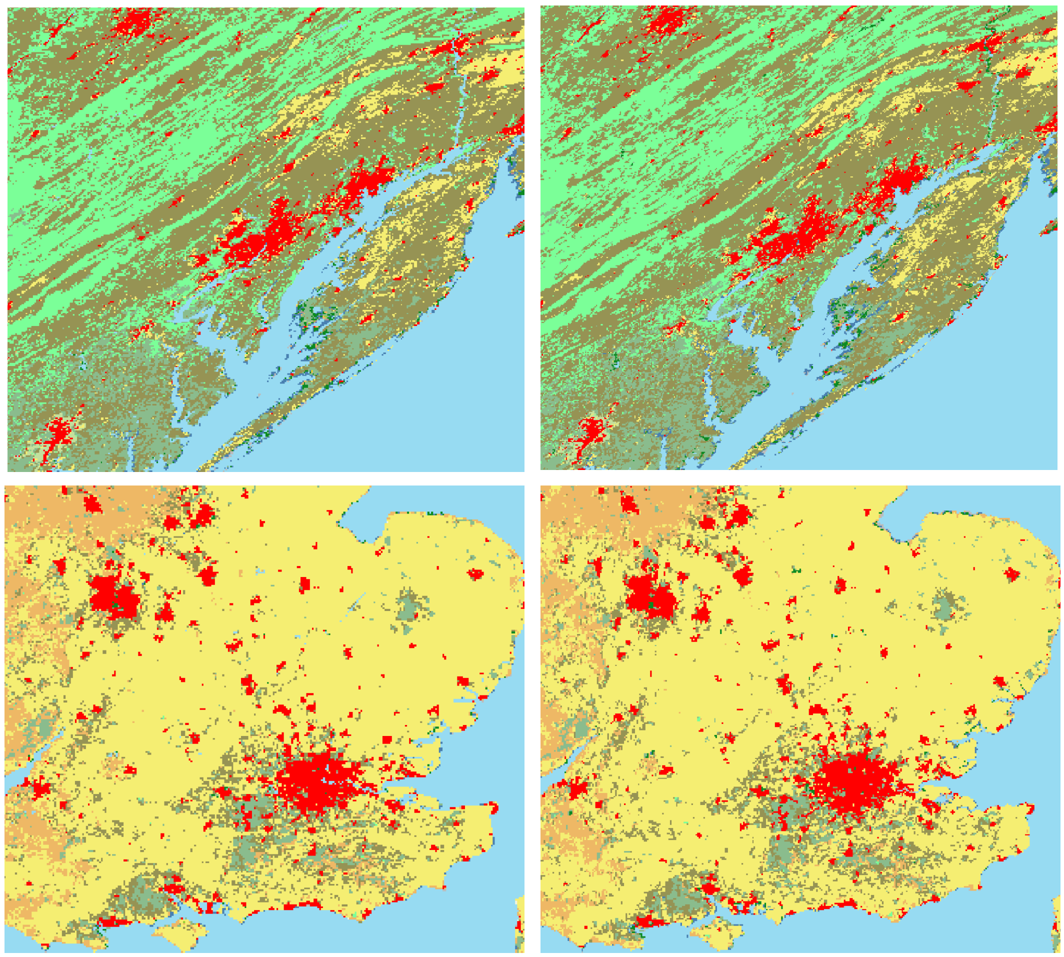


***Figure 1**: Comparison of the QST IP seed product (left) and surface type EDR products (right) shows that the QST IP has been mapped properly into the swath space in Surface Type EDR generation. The top row shows the eastern coast of the US, with the Washington-Baltimore corridor shown in red. The bottom row is for southeastern England.*

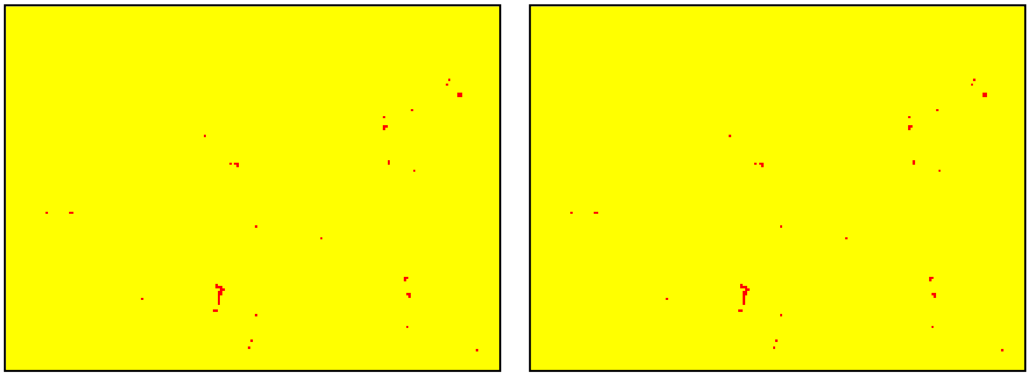


Figure 2: *Fire pixels (red color) in the Fire ARP product (left) and surface type EDR (right) derived using images acquired at 18:08 on 02/05/2013 for an area in El Salvador are identical.*

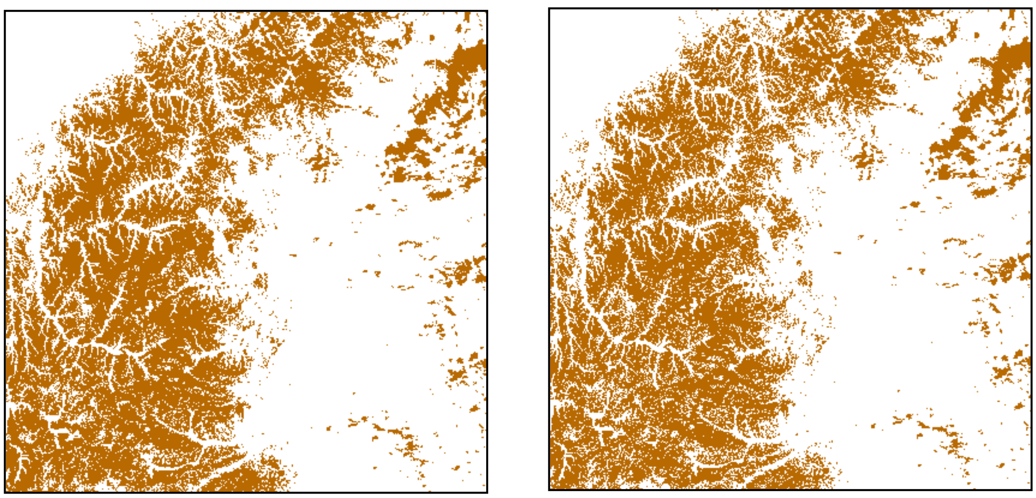


Figure 3: *Snow pixels (white color) in the Snow EDR (left) and surface type EDR (right) derived using images acquired at 04:45 on 02/05/2013 for an area north of Lake Baikal are identical.*

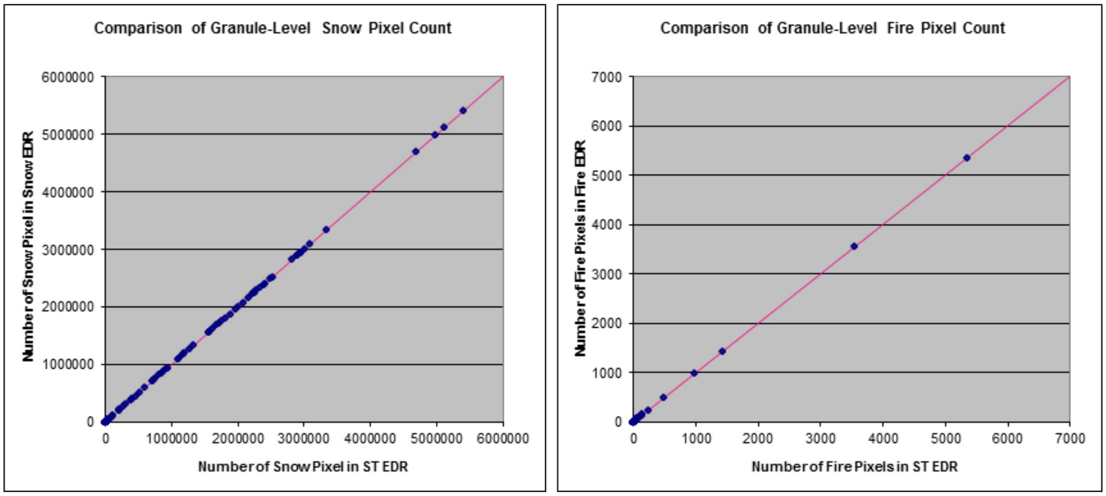


***Figure 4**: A comparison of snow pixel counts in snow EDR and surface type EDR shows that they are near identical for all VIIRS granules acquired on 12/31/2012 (left). Similar, fire pixel counts in the fire ARP and those in the surface type EDR are identical for all VIIRS granules acquired on 02/05/2013.*

2. *Quarterly Surface Type Intermediate Product (QST IP)*

Our goal is to develop high quality QST IP products using VIIRS data. The current QST IP algorithm requires one full year's VIIRS data. Before a full-year VIIRS became available, we tested the QST IP algorithm using MODIS data acquired in different years. We explored different ways to improve the QST IP product, including use of multi-year MODIS data, developing better compositing algorithms to reduce residual cloud/shadow contaminations, use of the advanced support vector machines (SVM) algorithm, and adding more representative training data.

Given the fact that the VIIRS gridding modules were not turned on until very recently, we obtained a gridding tool developed by NASA scientists and used it to grid VIIRS surface reflectance products to create daily, weekly, and monthly composites. Recently, we have downloaded 8-day gridded composites produced by NASA LPEATE and have begun to generate the annual metrics required by the QST IP algorithm.

PLANNED WORK

Algorithm and Product Development:

- Investigate methods for creating night-time snow flags for updating the surface type EDR;
- Change the threshold value for labeling a 750m snow pixel aggregated from 4 375m snow EDR pixels from 0.75 to 0.5;
- Continue to develop and improve QST IP using VIIRS data
    - Download one full year's of VIIRS data
    - Develop high quality monthly composites and annual metrics
    - Increase training data representativeness globally
    - Test different classification algorithms

Performance Metrics	**FY12**
# of new or improved products developed	0
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	N/A

- NPP/VIIRS Land Product Validation Research and Algorithm Refinement: Active Fire Application Related Product

Task Leader Wilfrid Schroeder, Evan Ellicott, Louis Giglio
Task Code GEOG-04 Active Fire Application Related Product (ARP)
NOAA Sponsor Ivan Csiszar
NOAA Office NESDIS/STAR/SMCD/EMB
Main CICS Research Topic Future Satellite Programs: Scientific support for the JPSS Mission
Percent contribution to CICS Themes Theme 1: 0%; Theme 2: 100%; Theme 3: 0%.
Percent contribution to NOAA Goals Goal 1: 50%; Goal 2: 50%

Highlight: A thorough investigation of the Suomi-NPP/VIIRS Active Fire Application-Related Product (AF-ARP) being generated by the Integrated Data Processing Segment (IDPS) was implemented during the initial 12 months of post-launch sensor operation. The active fire product achieved *Beta* status in May 2012, and all major performance anomalies were identified and fixed with the implementation of version Mx6.3 of the IDPS in October 2012. Initial assessment of the VIIRS active fire algorithm was performed using near-coincident Aqua/MODIS active fire data.

BACKGROUND

The Active Fire Application-Related Product (AF-ARP) is generated as part of the Suomi-NPP/VIIRS land product suite, but also serves as input for other key mission products (e.g., cloud mask, land surface type). The AF algorithm implemented in the Integrated Data Processing Segment (IDPS) builds on an earlier version (Collection 4) of the EOS/MODIS *Fire and Thermal Anomalies* algorithm designed to detect and characterize active fires [Giglio *et al*., 2003], allowing for improved data continuity although fire characterization would not be included in the original baseline VIIRS fire product. The MODIS algorithm has since evolved, incorporating additional tests to minimize potential false alarms, implementing a dynamic background characterization, and expanded processing of offshore pixels to allow detection of gas flares. Meanwhile, a new set of revised requirements was implemented for the VIIRS fire product, which included fire characterization retrievals (Fire Radiative Power), and a 2D image classification product flagging fire and non-fire pixels (e.g., fire-free land surface, clouds, water), both mimicking the MODIS fire product.

This task is focused on the development and refinement of the operational IDPS AF product providing the required algorithm support and data analyses, quality assessment and validation.

ACCOMPLISHMENTS

The period following the initial activation of the VIIRS sensor infrared channels on 18 January 2012 was marked by extensive analyses of the operational AF product using near-coincident Aqua/MODIS fire product as a reference data source. Two main VIIRS AF data artifacts were discovered and found to be the result of VIIRS Sensor Data Record (SDR) processing errors, namely the incorrect handling of the M13 channel data aggregation and a dual-gain switch processing error also affecting the M13 channel data (Figure 1). Those problems were reported to the VIIRS SDR team who implemented the appropriate upstream data processing fixes.

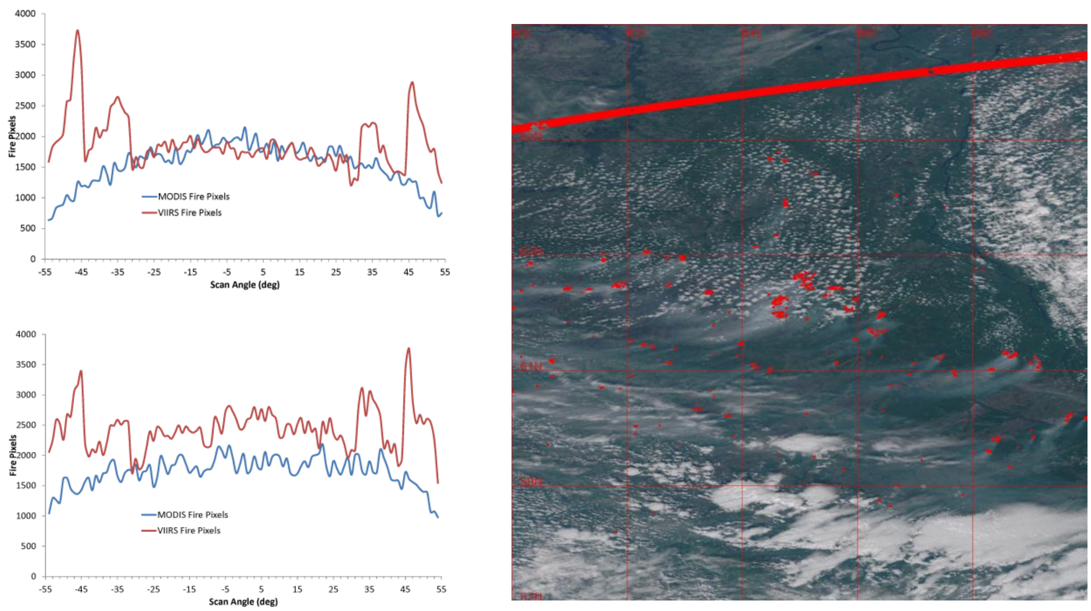


Figure 1*: NPP/VIIRS and Aqua/MODIS fire pixel histogram as a function of scan angle before (top-left panel) and after (lower-left panel) the SDR data aggregation fix; the latter shows increased VIIRS fire detection rates compared to MODIS. Example of M13 channel dual-gain switch anomaly (right panel) leading to spurious fire pixels (band of red-colored pixels) alongside with valid fire detections (sparsely-distributed red-colored pixels).*

The initial performance of the VIIRS AF algorithm was characterized and documented, enabling the product to achieve *Beta* status in May 2012. The SDR data processing fixes impacting the VIIRS AF data were subsequently implemented in October 2012, when the product was freed of most artifacts (Figure 2).

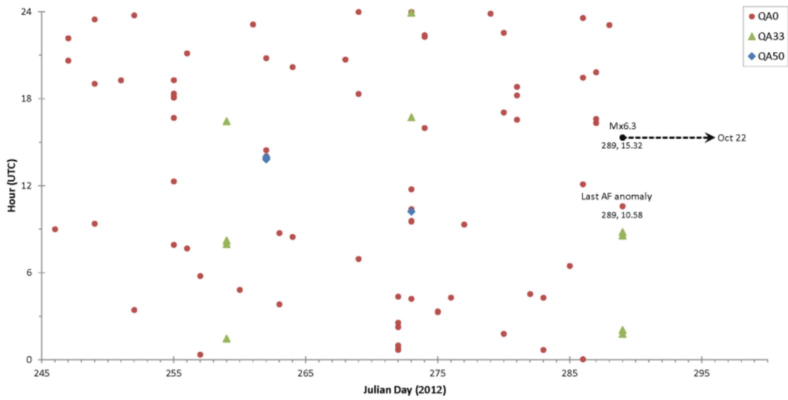


***Figure 2**: Daily occurrence of VIIRS AF data anomalies during September-October 2012 resulting from corrupted SDR M13 data (symbols describe the corresponding SDR quality flags associated with those anomalies). Implementation of IDPS Mx6.3 data processing package fix on 22 October 2012 was confirmed by the immediate reduction in the number of anomalies reported.*

The development and implementation of the replacement code meeting the new VIIRS AF product requirements was initiated in April 2012 with the installation of the Algorithm Development Library (ADL) at our local computing facility at the University of Maryland in College Park/MD. New AF code modules are being developed and tested using ADL and input SDR files generated by IDPS.

The initial quality assessment of the VIIRS AF product was performed using near-coincident Aqua/MODIS fire data. We have analyzed numerous data subsets for different geographic regions and imaging conditions. Initial data validation was performed in collaboration with the USDA Forest Service using reference data sets acquired for different prescribed fires in the southeast and western United States.

PLANNED WORK

Algorithm Development:

- Identify and recommend IDPS VIIRS AF algorithm updates to make it conform to latest MODIS detection code version (C6), including algorithm processing blocks and revised outputs (mask, FRP)
- Propose further IDPS VIIRS AF algorithm modifications to accommodate VIIRS-specific detection tests following detailed algorithm tuning
- Perform algorithm testing using ADL and assist with the code integration into the operational processing chain of IDPS
- Report back to SDR team when VIIRS AF input data quality anomalies are discovered

Algorithm Validation:

- Conduct product inter-comparison using near-coincident Aqua/MODIS data
- Analyses of airborne and available field data in support of fire detection and characterization validation

PRESENTATIONS

Csiszar, I., Justice, C. O., Prins, E., Schroeder, W., Schmidt, C., and Giglio, L., "Fire Monitoring from the New Generation of US Polar and Geostationary Satellites" European Geosciences Union General Assembly, Vienna, Austria, April 22-27, 2012.

Csiszar, I., Justice, C. O., Vadrevu, K., Schroeder, W., Giglio, L., and Ellicott, E., "New Biomass Burning Observing Capabilities from Suomi NPP VIIRS for Continuing Regional Fire Monitoring in Northern Eurasia". ENVIROMIS Conference and NEESPI Workshop, Irkutsk, Russia, June 24 – July 2, 2012.

Csiszar, I., Giglio, L., Schroeder, W., Ellicott, E., and Justice, C. O., "The Suomi NPP VIIRS Active Fire Product Status and Early Evaluation Results". 2012 International Geoscience and Remote Sensing Symposium (IGARSS), Munich, Germany, July 22-27, 2012.

Csiszar, I., Schroeder, W., Giglio, L., Wind, B., Ellicott, E., Justice, C. O., and Vadrevu, K.. "Use of VIIRS Satellite Data for Forest Fire Detection (in Spanish)". 2012 EUMETSAT Meteorological Satellite Conference, Sopot, Poland, September 3-7, 2012.

Csiszar, I., Schroeder, W., Giglio, L., Ellicott, E., Justice, C. O., and Vadrevu, K.. "Use of VIIRS Satellite Data for Forest Fire Detection (in Spanish)". GOFC-GOLD Latin American Regional Network (RedLatif) meeting, Santiago, Chile, October 29-30, 2012.

Justice, C. O., Schroeder, W., Ellicott, E., Giglio, L., Wind, B., and Csiszar, I., "Suomi NPP VIIRS Active Fire Product Status". 2012 Fall Meeting of the American Geophysical Union, San Francisco, CA, December 3-7, 2012.

Justice, C. O., Giglio, L., Davies, D., Csiszar, I., Schroeder, W., and Vadrevu, K., "Monitoring Fires from Space: a case study in transitioning from research to operations". 2012 Fall Meeting of the American Geophysical Union, San Francisco, CA, December 3-7, 2012.

Csiszar, I., Ellicott, E., Schroeder, W., Giglio, L., Justice, C. O., Wind, B., Vadrevu, K., Roohr, P., and Quayle, B., "Fire monitoring from the Suomi NPP Visible Infrared Imager Radiometer Suite" Town Hall Meeting Presentation, 2013 Annual Meeting of the American Meteorological Society, Austin, TX, January 6-10, 2013.

REFERENCES

Giglio, L., Descloitres, J., Justice, C., Kaufman, Y., 2003. An enhanced contextual fire detection algorithm for MODIS. Remote Sensing of Environment, 87, 273-282.

The performance metrics table highlights one new/improved product originated from the improved VIIRS AF data achieved after major anomalies were identified and fixed.

Performance Metrics	**FY12**
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	N/A

- Land EDR Coordination and the Proving Ground Activities

Task Leader Chris Justice
Task Code GEOG-05
NOAA Sponsor Ivan Csiszar
NOAA Office NESDIS/STAR/SMCD/EMB
Main CICS Research Topic Future Satellite Programs: Scientific support for the JPSS Mission
Percent contribution to CICS Themes Theme 1: 40%; Theme 2: 60%
Percent contribution to NOAA Goals Goal 1: 20%; Goal 2: 10%; Goal 3 20%; Goal 5: 50%

Highlight: Land EDR Coordination with NASA Science Team Activites and Proving Ground Activities.

BACKGROUND

The NPP VIIRS instrument is a bridging mission between MODIS and the JPSS VIIRS. A suite of products was developed by the NPOESS Contractor Raytheon and tested by Northrop Grumman. The government has recently taken over the responsibility for the generation of these derived products (Environmental Data Records, EDR's) from VIIRS. NOAA STAR is responsible for stewardship of the VIIRS products and is working the research community with experience in coarse resolution remote sensing and data product generation from MODIS to improve the EDR's. This assistance is focused on three areas: algorithm refinement and improvement, product validation and proving ground activities.

Proving ground activities are aimed at developing pre operational capabilities for the use of VIIRS data by the Fire User community. This work is being led by Evan Ellicott working in close cooperation with Dr. Wilfrid Schroeder at ESSIC.

ACCOMPLISHMENTS

2.1 Land EDR Coordination with NASA Science Team Activities – Dr. Chris Justice

Dr. Justice continued to work with the VIIRS Land Lead and the NASA VIIRS Land Science Team, providing outreach to the science and applications user communities and working with START to continue to provide liaison to other compatible instruments through the GTOS GOFC-GOLD Program. Dr. Justice is the land lead for the NASA VIIRS instrument. The NASA Science Team is undertaking research to develop science quality products from NPP VIIRS. This involves evaluating the EDR's generated by the IDPS and suggesting improvements to the algorithms. This is being undertaken with the NASA Land PEATE. A close working relationship between STAR Scientists and Algorithm Support Team, Cal/Validation scientists and the NASA Land Science Team is needed. As the NASA Land Discipline lead for VIIRS, Dr. Justice provided liaison between the teams. Coordination activities involved: participation in land telecons, developing a coordinated land program between the NASA Science Team and the NOAA VIIRS Land Team, outreach and presentations on VIIRS Land capabilities. Specifically Justice worked with Miguel Roman (NASA Validation Lead) and Ivan Csiszar JPSS Land Lead to develop a white paper on the status of the VIIRS EDR Evaluation and the development of science enhanced code being developed by the NASA Science Team running at the Land PEATE. Justice presented an overview of the VIIRS land activities at the CICS Maryland External Review, at the Applied Sciences Working group, at two GEO Agricultural Monitoring Task Regional Meetings and presented an overview of the VIIRS Fire Program at the AGU. On-going activities include the development of a review paper on the Land EDRs with contributions from the NOAA and NASA EDR evaluation teams.

1.2. Proving Ground Activities for Fire – Evan Ellicott

1.3. Proving Ground Activities for Fire – Evan Ellicott

Proving ground activities are aimed at developing pre operational capabilities for the use of VIIRS data by the Fire User community. This work is being led by Evan Ellicott working in close cooperation with Dr. Wilfrid Schroeder at ESSIC and the VIIRS Fire Team. As part of this effort, on-going coordination with the US Forest Service and National Weather Service has yielded value-added products and information. For example, a website was developed to provide VIIRS information for the user-community, images of representative fires from around the globe, a contact page to pose questions and provide feedback, and a Google-based interactive map of CONUS fire activity. The last component also incorporates download capabilities and archival database (Fig. 1). Based on user feedback we've incorporate KMZ files for users to directly import VIIRS AF locations into Google Maps and Google Earth.

PLANNED WORK

Dr. Justice will continue to work with the VIIRS Land Team, providing outreach to the science and applications user communities and working with START to continue to provide liaison to other compatible instruments through the GTOS GOFC-GOLD Program. Dr. Justice is the land lead for the NASA VIIRS instrument. The NASA Science Team will be undertaking research to develop science quality products from NPP VIIRS. This will involve evaluating the EDR's generated by the IDPS and suggesting improvements to the algorithms. This will be undertaken primarily on the NASA Land PEATE. A close working relationship between STAR Scientists and Algorithm Support Team, Cal/Validation scientists and the NASA Land Science Team will be highly desirable. As the NASA Land Discipline lead for VIIRS Dr. Justice will provide liaison between the teams. . Activities involve: participation in land telecons, coordinating joint team workshops and meetings e.g. developing a coordinated land program for the NASA Science Team meeting, outreach and presentations on VIIRS Land capabilities.

Future Proving Ground Work will be funded under the continuation of Task 7.

Figure 1: Screen shot of the data delivery interface on the VIIRS Active Fire website

Performance Metrics	FY12
# of new or improved products developed	0
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	1

- Implementation and support of a VIIRS Near-Real Time Rapid Fire System for Fire Monitoring at the US Forest Service

Task Leader: E. Ellicott
Task Code: GEOG-07
NOAA Sponsor Ivan Csiszar
NOAA Office NESDIS/STAR/SMCD/EMB
Main CICS Research Topic Data Fusion and Algorithm Development
Contribution to CICS Research Themes: Task 1: 25%; Task 2: 75%
Contribution to NOAA goals: Task 3: 50%; Task 5: 50%

Highlight: The goals of the VIIRS AF PGRR project are product evaluation and improvement and the development of a near-real-time enhanced product delivery system to support fire management and NOAA operations.

Background
The VIIRS Active Fire product is critical for disaster and resource management. The product is expected to be used by real-time resource and disaster management; air quality monitoring; ecosystem monitoring; climate studies, etc. The JPSS PGRR program's primary objective is to maximize the benefits and performance of SNPP data, algorithms, and products for downstream operational and research users (gateways to the public). The goals of the VIIRS AF PGRR project are product evaluation and improvement and the development of a near-real-time enhanced product delivery system to support fire management and NOAA operations.

Accomplishments
The VIIRS AF website saw major improvements, including an interactive map, data dissemination and archiving, and user-feedback form (Fig 1.) These improvements have greatly enhanced our ability to reach out to end-users, providing background information, data, and a forum for product evaluation.
The VIIRS "C6" code, a VIIRS-adapted version of the current MODIS Collection 6 (C6) algorithm, was delivered to NASA's Direct Readout Laboratory (DRL). The DRL tested the new code and delivered the package to its alpha-testers, including the US Forest Service Remote Sensing Applications Center (RSAC). VIIRS active fire detections based on the standard IDPS "C4" code are now available to end-users (Fig. 4) while the C6 code is still being tested at the RSAC and should be available to users in the coming weeks.
Two fire complexes from this past fire season (2012), the Whitewater-Baldy (NM) and Seeley (UT), were examined to assess the VIIRS active fires product accuracy (e.g. Fig. 5). We've evaluated the VIIRS product for each fire incident to encompass the bulk of fire activity (typically 3-4 weeks) using a combination of fire progression maps generated by the Incident Management Teams, AF detections and burned area from MODIS, and near-infrared imagery produced by the National Infrared Operations (NIROPS) program.

We are also investigating the value-added benefits of using the experimental VIIRS I-band fire detections.

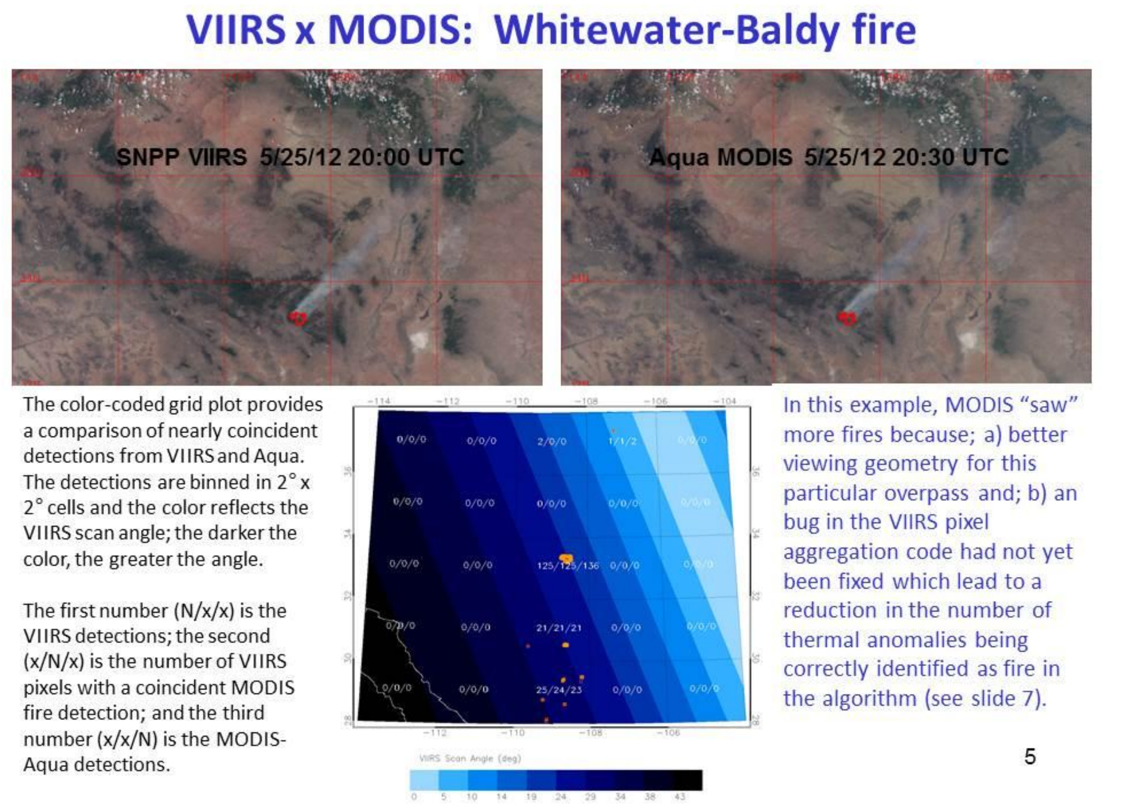


Figure 2: VIIRS x MODIS intercomparison. A tool was developed to allow users to search for a particular event, download and ingest VIIRS and Aqua-MODIS AF data, and perform a qualitative analysis.

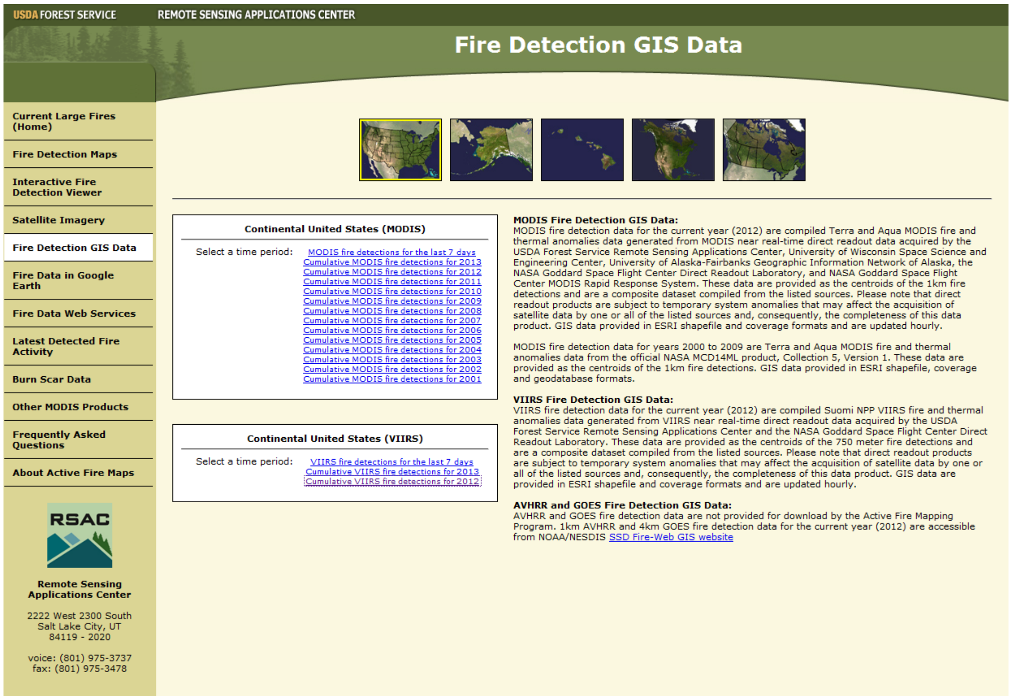


Figure 4: An example of some of the VIIRS Active Fire DB data provided by RSAC.

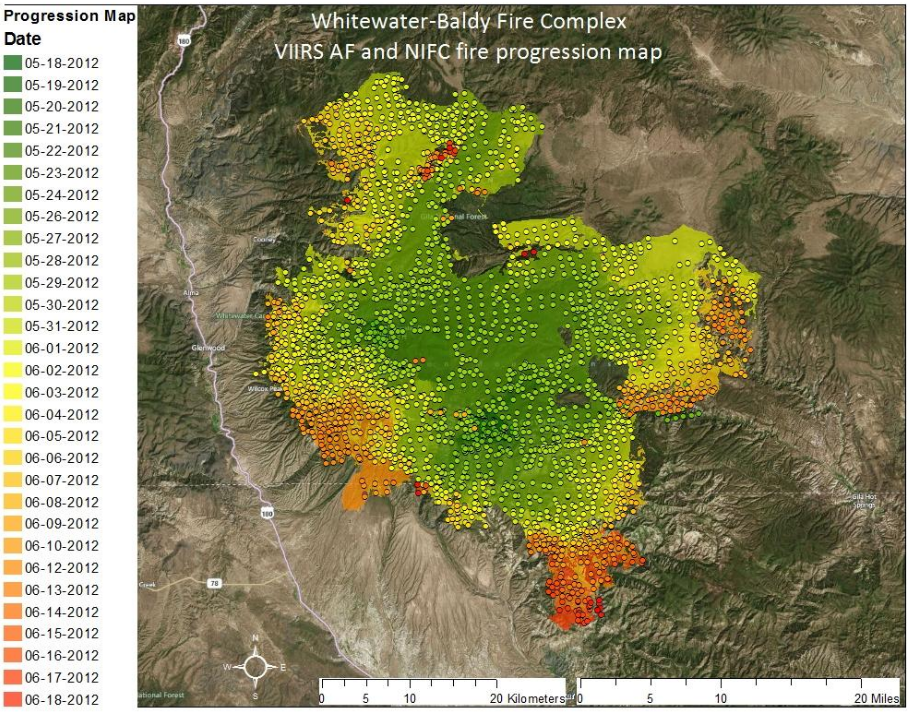


Figure 5: Example of thematic overlay of VIIRS AF detections (small color-coded circles) and National Interagency Fire Center (NIFC) fire progression map for the Whitewater-Baldy fire complex, (NM).

Performance Metrics	FY12
# of new or improved products developed	2
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	2
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	1

Planned Work

- Work with end-users to evaluate VIIRS AF product in operational scenarios. For example, engage IMETs on how to obtain and visualize VIIRS AF data, product characteristics, and VIIRS x MODIS comparisons.
- Continue detailed *a posteriori* analysis of select fires in the 2012 fire season, which was particularly active over the Conterminous United States.
- The system is currently being augmented to distribute data from a science code that includes the latest MODIS algorithm components, a full spatially explicit fire mask, and Fire Radiative Power.
- Science support and coordination is also being provided to the domestic and international direct readout user community, which is incorporating VIIRS fire data into near-real-time applications.
- Implement necessary adjustments into the IDPS operational algorithm based on evaluation results
- Work with GOFC-GOLD Regional fire networks to identify end users and establish feedback mechanisms

Presentations

Justice, C., W. Schroeder, E. Ellicott, L. Giglio, B. Wind, and I. Csiszar; Fall Meeting of the American Geophysical Union, San Francisco, CA, December 7th, 2012 “Suomi NPP VIIRS active fire product status”

W. Schroeder, I. Csiszar, L. Giglio, E. Ellicott, and C. Justice; Fall Meeting of the American Geophysical Union, San Francisco, CA, December 7th, 2012, “Assessment of polar orbiting and geostationary satellite active fire retrievals using a suite of ground, airborne and spaceborne reference data sets”.

E. Ellicott, I. Csiszar, W. Schroeder, L. Giglio, B. Wind, and C. Justice; Tactical Fire Remote Sensing Advisory Committee (TFRSAC) Fall Meeting, NIFC Boise, ID, November 8th, 2012, “VIIRS active fire product: Current status and developments”.

Csiszar, I., L. Giglio, W. Schroeder, E. Ellicott, and C.O. Justice, “The Suomi NPP VIIRS Active Fire Product Status and Early Evaluation Results”. 2012 International Geoscience and Remote Sensing Symposium (IGARSS), Munich, Germany, July 22-27, 2012.

E. Ellicott, I. Csiszar, W. Schroeder, L. Giglio, B. Wind, and C. Justice; Tactical Fire Remote Sensing Advisory Committee (TFRSAC) Spring Meeting, Washington, DC, March 20th, 2012, “VIIRS active fire product: Current status and future plans”.

- NPP/VIIRS Land Product Validation Research and Algorithm Refinement:

Task Leader Chris Justice**,** Dr. Eric Vermote
Task Code GEOG-10
NOAA Sponsor Ivan Csiszar
NOAA Office NESDIS/STAR/SMCD/EMB
Main CICS Research Topic Calibration and Validation
Percent contribution to CICS Themes Theme 1: 50%; Theme 2: 50%; Theme 3: 0%.
Percent contribution to NOAA Goals Goal 1: 50%; Goal 5: 50%

Highlight: CICS scientists have made great progress in the evaluation of the VIIRS cloud Mask (VCM) and VIIRS surface reflectance. The VIIRS surface reflectance resp. VCM will be promoted to beta resp. provisional status shortly. The methods and metrics for evaluation are well in place.

BACKGROUND

This subtask support an evaluation of the accuracy of select operational algorithms for NPP/VIIRS land products. The work includes analysis of the land surface reflectance product, analysis and impact evaluation of the VIIRS SDR and VIIRS cloud mask.

ACCOMPLISHMENTS

We have developed VIIRS vicarious cross-calibration with Aqua over desert/bright sites. This method has been routinely applied to the data stream in order to provide near-real time monitoring of the VIIRS calibration focusing in the reflective domain (Figure 1). We focused in particular on the red and near-infrared bands (I1,I2 M5 and M7) which are critical for downstream products such as Vegetation indices which are used in near time for the monitoring of vegetation and agriculture area, for detecting climate induced anomaly (e.g. drought) and assessing impact on production and forecasting yields.

We have performed preliminary inter-comparison of MODIS Aqua and VIIRS surface reflectance, aerosol and cloud mask products using the Climate Modeling Grid (CMG) dataset developed for MODIS and VIIRS by our science computing facility. This activity has enabled to diagnose very rapidly issues with the VIIRS aerosol, cloud mask and reflectance algorithm on a global and continuous basis which is complementary with the detailed analysis performed on a limited amount of instrument sites (see next paragraph on the validation subset).

We have performed preliminary evaluation of VIIRS aerosol and surface reflectance products on validation subsets. This evaluation will be done by the use of the AERONET data collected at those sites which provide with the 6S radiative transfer code an independent basis to generate surface product and assess the properties of the aerosols.
We have derived a first set of VIIRS surface reflectance product performance (accuracy, precision and uncertainty, APU). This analysis has focused primarily on the validation subset (see previous bullet) and also applied to the MODIS data.
We have acted as the Land Point of Contact with the VIIRS calibration and cloud mask (VCM) teams in particular attended the weekly/bi weekly teleconferences organized by those teams and reported the land perspective. We participated to calibration and cloud mask product re-

view and contributed to the assessment of product maturity (beta, provisional, validated stage 1-3)

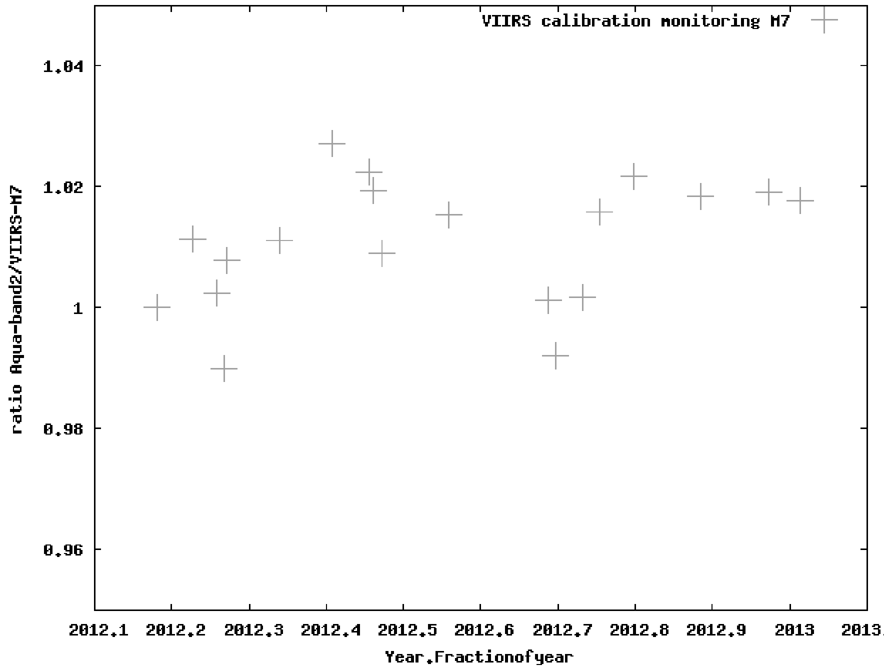


Figure 1: VIIRS calibration monitoring

Performance Metrics	FY12
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	5
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	1

PLANNED WORK
Continue the Calibration monitoring and validation of the reflectance product and cloud mask over land surfaces.

PRESENTATIONS
Presentations at various VIIRS Telecons/Meetings/Reviews

1.12 Consortium Projects

- Howard University Support of NOAA's commitment to the Global Climate Observing System (GCOS) Reference Upper Air Network (GRUAN)

Task Leader Belay Demoz
Task Code Howard
NOAA Sponsor Howard Diamond
NOAA Office NESDIS/NCDC
Main CICS Research Topic Calibration and Validation
Percent contribution to CICS Themes Theme 1: 70%; Theme 2: 30%; Theme 3: 0%.
Percent contribution to NOAA Goals Goal 1: 20%; Goal 2: 80%

Highlight: weekly radiosonde releases will be timed to match Suomi National Polar-orbiting Partnership (NPP) overpass times and data will be used for ground validation purposes.

BACKGROUND

The Howard University Beltsville Research Site as part of the Beltsville Center for Climate System Observation is one of the original international sites selected as a GRUAN site as documented on the GRUAN web site at http://gruan.org. The proposed project will facilitate the activities at Howard University Beltsville Campus that pertain to satisfying the GRUAN station measurement requirements. GRUAN sites are required to collect a monthly reference radiosonde profile capable of capturing moisture signal in the upper troposphere and lower stratosphere to the best level possible launched in tandem with a weekly Vaisala RS-92 radiosonde.

The goal of this project is to continue to enable the Howard University site to be an active participant in the international GRUAN program by providing them the necessary resources to take vertical reference measurement profiles using the Cryogenic-Frost point Hygrometer (CFH) radiosondes. The weekly radiosonde releases will be timed to match Suomi National Polar-orbiting Partnership (NPP) overpass times and thus the data will be used for ground validation purposes.

ACCOMPLISHMENTS

- Data collection coordinated with NPP overpass has commenced. Vaisla radiosonde balloon sounding is collected weekly during a high elevation NPP nighttime overpass. Co-located Beltsville remote sensing is being archived at Beltsville and has been communicated with scientists at NESDIS/STAR and collaborative efforts of preliminary data analysis discussion have commenced.
- Raman lidar data is sporadically being collected together with the RS92 Sounding and assessment of short term atmospheric variability during overpass times quantified.

- More than 30 coordinated RS92 flights have been coordinated with NPP overpass times.

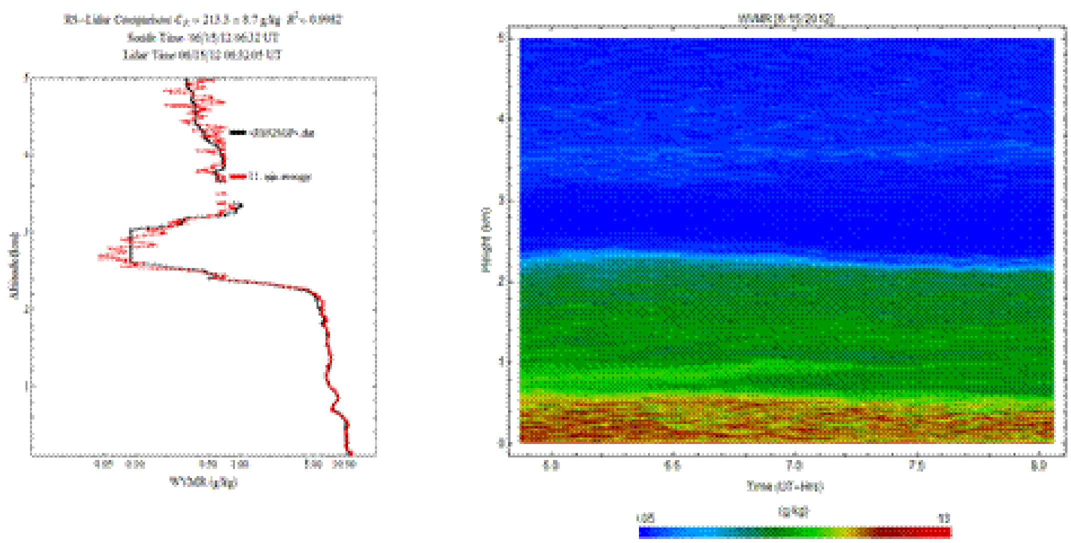


Figure 1: *An example of a coordinated Raman lidar and radiosonde profile measurement during NPP overpass at the Howard University Beltsville Campus on 06/15/2012. NPP overpass at the site was at 07:02 UTC.*

Performance Metrics	FY12
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	0

PLANNED WORK

- Preparation and commencement of Cryogenic Frost Point Radiosonde launches during NPP overpass.

- Coordination with NESDIS/STAR scientists for NPP-Sonde analysis and comparisons and quantification of correlation between satellite and sonde data.

- Commence Delivery of Data to the GRUAN data base.

- CIMMS and Texas Tech University Support to GOES-R Risk Reduction

Task Leader Eric Bruning
Task Code EBEBGOESR11
NOAA Sponsor Steve Goodman
NOAA Office NESDIS/GOESPO
Main CICS Research Topic Future Satellite Programs: Scientific support for the GOES-R Mission
Percent contribution to CICS Themes Theme 1: 90%; Theme 2: 10%; Theme 3: 0%.
Percent contribution to NOAA Goals Goal 2: 10%; Goal 3: 75%; Goal 4: 15%

Highlight: Three Lightning Mapping Arrays now cover a greater than 600 km continuous swath from West Texas through Oklahoma. These networks serve as an important GOES-R GLM validation resource. Examination of average local flash areas from these arrays suggests flash area is related to electrical energetics and the energy of the convection that drives electrification.

BACKGROUND

This task supports GOES-R GLM needs for proxy data, validation datasets, and operational demonstrations of total lightning data (in the GOES-R Proving Ground) thorough sustaining support for the Oklahoma and West Texas Lightning Mapping Array (OKLMA and WTLMA, respectively). Detection of total lightning in the new WTLMA will complement the OKLMA, creating a unique regional-scale domain where total flash rates can be retrieved for larger mesoscale storm complexes and other severe weather outbreaks that are frequent producers of damaging wind and tornadoes. The continued operation of this network will allow for the determination of instantaneous local flash rates and a regional total lightning climatology that will serve as validation datasets for the GOES-R GLM.

This is the final year of this task. A final report on this task has been submitted, and this report summarizes the most recent findings from that report.

ACCOMPLISHMENTS

Lightning Mapping Array Infrastructure and Data Processing

Funds from this task supported the PI, technical staff and students in deploying the WTLMA, arranging real-time communications, and maintaining the operation of the WTLMA and OKLMA. Initial site survey work for the WTLMA began in Fall 2010. Work continued throughout 2011 to deploy the network. The first successful data collection was on 21 November, 2011 with a preliminary 7-station network. Continuous data collection with a 9-station network began on 18 Feb 2012, with a 10th station added on 25 May 2012. Figure 4 shows the final 10-station WTLMA network configuration, and its overlap with the extension in southwest Oklahoma.

Much of the work during early 2012 was focused on implementing real-time communications with each station over the Internet, which began regular operations on 25 April, and includes a web-based graphical archive and real-time display at http://pogo.tosm.ttu.edu/wtlma. Data are also processed and delivered in a real-time streaming mode with 1 second latency to the LiveLMA GUI display written by New Mexico Tech. WTLMA ASCII source data are also available from TTU's Local Data Manager (LDM) feed. Recipients of WTLMA data are NWS Southern Region and its Lubbock local forecast office, the National Severe Storms Laboratory and NOAA Hazardous Weather Testbed, and GOES-R3 partners in Huntsville, AL including the SPoRT group. Data from the WTLMA and OKLMA contributed to the National Lightning Jump Field Test conducted by the National Weather Service.

Operational use of the WTLMA data at the Lubbock forecast office is supported by the NOAA/NSSL HWT. After receiving the WTLMA data, the HWT (Kristin Calhoun and Darrel Kingfield) produces AWIPS-II ready flash extent density and flash initation density grids at 1km / 1 min resolution, and ships them to the Lubbock forecast office. Interaction with the forecast office has been supported by these funds as well as a UCAR/COMET project dedicated to training of forecasters in use of the data.

Research Activities

At OU, funds have supported a part-time research scientist to complete an analysis of the conditions under which lightning occurs far downstream in thunderstorm anvils (Weiss et al. 2012) and to analyze the range dependence of the Lightning Mapping Array for use in GOES-R proxy data sets and for climatological studies. The latter work is ongoing.

A manuscript has been submitted describing results of a study of eight hours of data from two supercell cases from 2004 in central Oklahoma (Bruning 2013). An energetically scaled flash size spectrum (Figure 5a) shows a linear power-law scaling regime with a -5/3 slope in the same range of scales where a -5/3 inertial subrange would be expected in deep convection. The paper considers the role of convection as the source of electrical energy in the storm, and argues that the turbulent structure of the convection controls the extent of regions of electrical potential discharged by lightning. The paper introduces three ways of looking at total lightning data (Figure 5b-d.) that emphasize regions of electrical stress (flash origin density), the extent of potential reservoirs (mean flash area) and a combination of the both properties (flash extent density).

One of the early severe storm cases collected by the WTLMA occurred on 18-19 March 2012, and is being analyzed by a graduate student (Plourde et al. 2013). During this case, a quasi-linear convective system (QLCS) formed as a cold front overtook a dryline, leading to a narrow, 400 km-long line of storms centered on the WTLMA. One cell embedded in the QLCS had a weak tornadic circulation. Operational WSR-88D and research Ka-band radar data will be compared trends in flash rate, extent, and area plots along the line to understand cellular cycling relative to total lightning properties.

The WTLMA contributed to the Deep Convective Clouds and Chemistry field program in summer 2012, which will help constrain NOx emissions from lightning and provide improved understanding of how to use total lightning data, including data from the GOES-R Geostationary Lightning Mapper, in constraining the natural NOx source in air quality models. The DC3 program is also expected to lead to improved understanding of electrical behavior in various mesoscale thermodynamic environments (Bruning et al. 2012), of relevance to setting expectations that condition operational interpretation of total lightning and ground strike data.

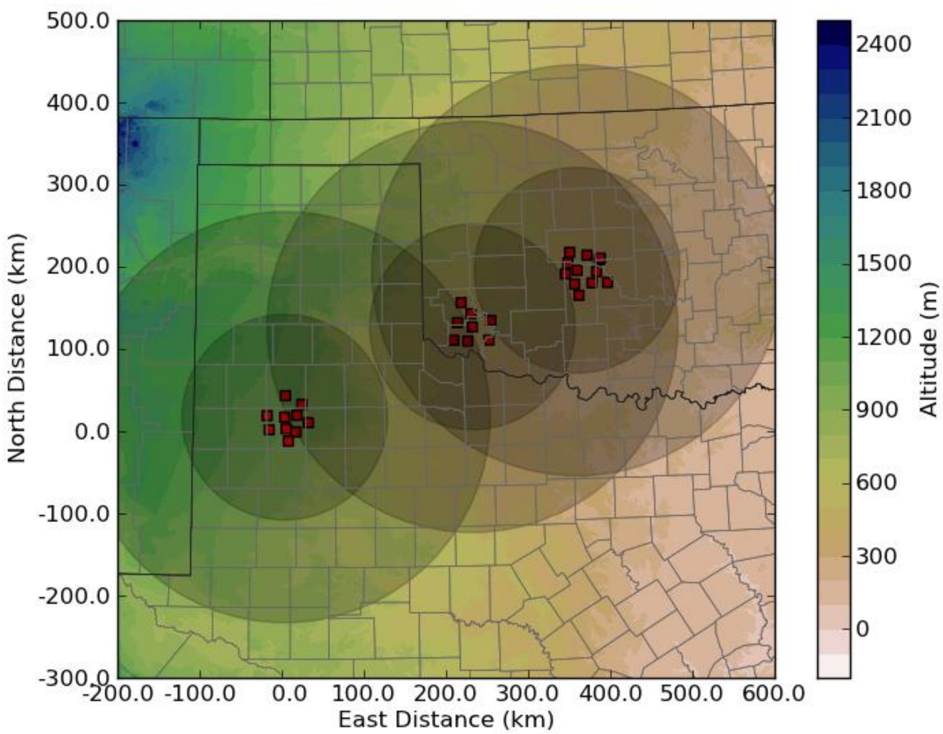


Figure 4 The combined coverage of the West Texas and Oklahoma Lightning Mapping Array installations. Sensor locations are indicated by red squares. Range rings indicate the nominal 3D and 2D coverage areas at 125 km and 250 km range from each network center. The coordinate center is Lubbock, TX.

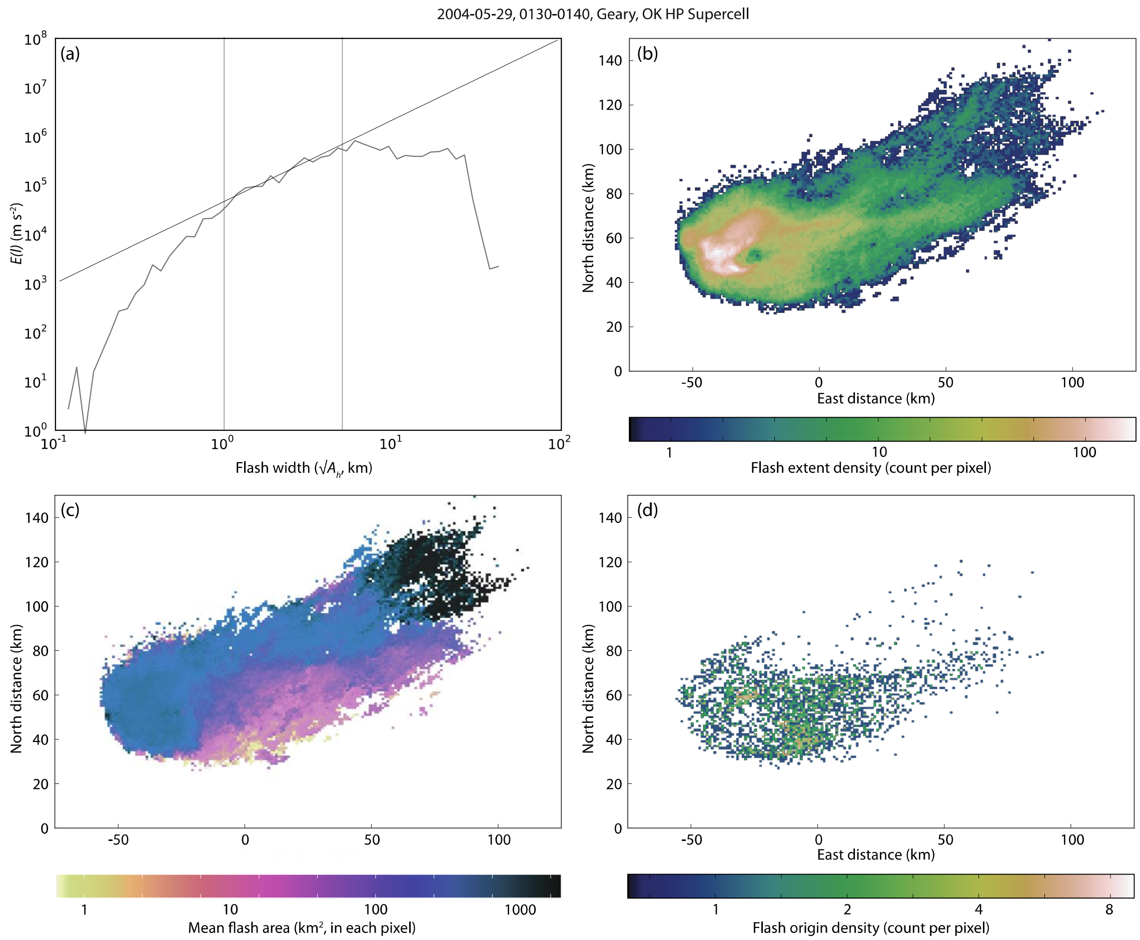


Figure 5 (a) Whole-storm energetically-scaled lightning flash size spectrum and a line representing a 5/3 power law relationship with the length scale for 0130-0140 UTC on 30 May 2004 in central Oklahoma. (b--d): Plan views of (b) lightning flash extent density, (c) mean flash size per pixel, and (d) flash origin density at 1 km resolution. Vertical gray lines indicate the region between 1 and 5 km where the rate of change in flash counts is stable across algorithm configurations.

Performance Metrics	**FY12**
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	1
# of peer reviewed papers	3
# of non-peered reviewed papers	0
# of invited presentations	1
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	0

Bruning provided an invited status update to the GLM Science Team Meeting in Huntsville, AL on 19 September 2012. Three other, non-invited talks are listed below. A technique using average flash size to monitor convective cycling has been transitioned to operations at WFO LUB.

PLANNED WORK

* Final report. No further work is planned on this task.
* GOES-R GLM support for the OKLMA and WTLMA continues through other funding routes.
* Investigation of the relationship of flash size and flash rate to thunderstorm processes continues.

PUBLICATIONS

Bruning, E. C. and D. R. MacGorman, 2013: Theory and observations of lightning flash size spectra. *J. Atmos. Sci.*, in review.

Weiss, S. A., D. R. MacGorman, and K. M. Calhoun, 2012: Lightning in the anvils of supercell thunderstorms. *Mon. Wea. Rev.*, in press, 10.1175/MWR-D-11-00312.1

Bruning, E. C., S. A. Weiss, and K. M. Calhoun, 2012: Continuous variability in thunderstorm primary electrification and an evaluation of inverted-polarity terminology. *Atmos. Res.*, in press, doi:10.1016/j.atmosres.2012.10.009.

PRESENTATIONS

Bruning, E. C., 2012: West Texas LMA: Operational and Research Use. *GLM Science Team Meeting,* Huntsville, Al, September 19.

Calhoun, K. M., E. C. Bruning, D. M. Kingfield, S. D. Rudlosky, C. W. Siewert, T. Smith, G. T. Stano, and G. J. Stumpf, 2013: Forecaster use and evaluation of pGLM data at the NOAA Hazardous Weather Testbed and GOES-R Proving Ground. *Preprints, Sixth Conference on the Meteorological Applications of Lightning Data*, AMS Annual Meeting, Austin, TX, USA.

Plourde, C. M. and E. C. Bruning, 2013: An investigation of lightning behavior during the QLCS in Northwestern Texas on March 18 & 19. *Preprints, Sixth Conference on the Meteorological Applications of Lightning Data*, AMS Annual Meeting, Austin, TX, USA.

Cobb, S., J. Jordan, E. Bruning, and J. Daniel, 2012: Early results of operational use of total lightning data from the West Texas Lightning Mapping Array. *26th Conference on Severe Local Storms, Nashville, TN*, submitted.

- Princeton: Prototype Development of a Microwave Radiometer Simulator for Land Surface and Precipitation Characterization

Task Leader Eric Wood
Task Code EWPRINC11
NOAA Sponsor Al Powell
NOAA Office NESDIS/STAR
Main CICS Research Topic **Earth System Monitoring from Satellites**
Percent contribution to CICS Themes Theme 2: 50%; Theme 3: 50%.
Percent contribution to NOAA Goals Goal 2: 100%

Highlight: The CRTM model used AMSR-E brightness measurements to assess the land surface microwave emissivity. The CRTM had good performance and its sensitivity to input data has been analyzed.

BACKGROUND

The poor progress in developing algorithms to characterize land emissivity has limited the assimilation by weather forecast models of space-borne microwave radiometers and sounders over land, especially at lower microwave frequencies. This has also impacted the development of advanced satellite precipitation retrieval algorithms. The project brings together an inter-disciplinary team for an exploratory effort in developing a land-to-space microwave emission forward modeling capability. The goals of the project are (i) to evaluate the Community Radiative Transfer Model (CRTM) ability to characterize surface emissivity, clouds and precipitation when compared to satellite-based observations and retrieved microwave products from selected case studies, and (ii) to assess the feasibility of developing a microwave radiometer forward model based on a coupled modeling package (e.g. WRF-CRM/Noah/CRTM). In the exploratory project, an uncoupled analysis will be done where Noah LSM will be run off-line using NLDAS forcings with the atmospheric variables based on either satellite retrievals (e.g. AIRS) or NWP models (e.g. NARR).

The project will utilize the extensive data base at CREST/CUNY of satellite observations of surface emissivity, surface temperature, cloud and atmospheric water and temperature profiles. This data base will be used to select case studies that span conditions that will include clear sky, non-precipitating clouds, precipitating warm clouds and precipitating cold clouds. Snow covered conditions aren’t included at this stage. The surface hydrologic conditions will utilize NCEP’s Noah LSM, which solved the surface energy and water budgets and provides surface temperature and soil moisture as prognostic variables. These can be used in the CRTM to predict surface emissivity, which will be compared to observed values from CUNY’s data base.

ACCOMPLISHMENTS

During the last year, we used the Community Radiative Transfer Model (CRTM) in order to evaluate its performance in estimating the Top Of Atmosphere (TOA) Brightness Temperature (Tb) and to analyze how this estimation is impacted by various land and atmospheric conditions at lower microwave frequencies (e.s. 23.8V GHz channel).

The CRTM has been fed with the atmospheric variables provided by the Atmospheric Infra-Red Sounder (AIRS) and the Advanced Microwave Sounding Unit (AMSU) instruments, aboard NASA's Aqua satellite. From AIRS-AMSU data product, we used data for surface skin temperature, atmospheric profile temperature at 24 pressure levels and atmospheric water vapor at 12 pressure levels.
For land use types, we mapped the MODIS data, based on the International Geosphere Biosphere Programme (IGBP) scheme, to the CRTM land use types. The soil and vegetation moisture are taken from the Variable Infiltration Capacity (VIC) land surface model and the AMSR-E based Vegetation Optical Depth (VOD) datasets respectively.

We performed a total of ten experiments over the entire continental USA during the period between April and October 2007. Each experiment included simulations for AMSU 23.8V GHz frequency channel since this channel can be used for rainfall retrievals due to the higher sensitivity to the atmospheric water vapor but may be contaminated by surface conditions. We used the control experiment, where all the input variables dynamically vary over space, to evaluate the performance of CRTM by comparing the TOA T_b with the observed T_b from AMSR-E. Additional nine experiments were conducted to study the sensitivity of the CRTM results to atmospheric profile temperature and water vapor, soil moisture, vegetation water content and surface skin temperature.

We focused our attention over the study area shown in Figure 1 and we used AMSU Level-3 daily fractional cloud cover data to separate the CRTM simulated results into clear and cloudy conditions.

As shown in Figure 1, over the Eastern USA, CRTM estimated higher TOA T_b almost everywhere as compared to those observed by AMSR-E. The coastal regions showed differences of more than 12 K. But, those grids may be contaminated due to the proximity to the water body and the coarse grid resolution (1 degree). Higher T_b estimation in CRTM may have risen from various sources such as the uncertainties in input land parameters and atmospheric variables, mapping of input MODIS vegetation map classes to CRTM vegetation classes, using of standard atmosphere for the entire simulation and non-inclusion of other atmospheric absorber particles like CO_2, CO, CFC and aerosols in CRTM simulations.

Focusing on the study area, the comparison between the TOA Tb CRTM estimations and the AMSR-E observations, under clear sky conditions (Figure 2a), showed that both the datasets match very well with each other. There is a marginally positive mean bias (1.41 K), the root mean squared difference is found to be 3.37 K and the Pearson correlation is high (0.90). This suggests that CRTM is able to simulate comparable TOA T_b with the provided input surface and atmospheric inputs. Under cloudy conditions (Figure 2b), we noticed large discrepancies between the two datasets unlike the case in clear sky condition. These results suggest that the presence of atmospheric water vapor has a very significant contribution towards the CRTM TOA T_b estimates.

The additional nine experiments carried out to evaluate the sensitivity of the CRTM to the input variables showed that the atmospheric profile water vapor and the surface skin temperature have significant contribution towards the estimation of TOA Tb, while the surfaces soil moisture and vegetation water content have very little or no contribution to the CRTM simulated TOA T_b estimates at 23.8V GHz frequency.

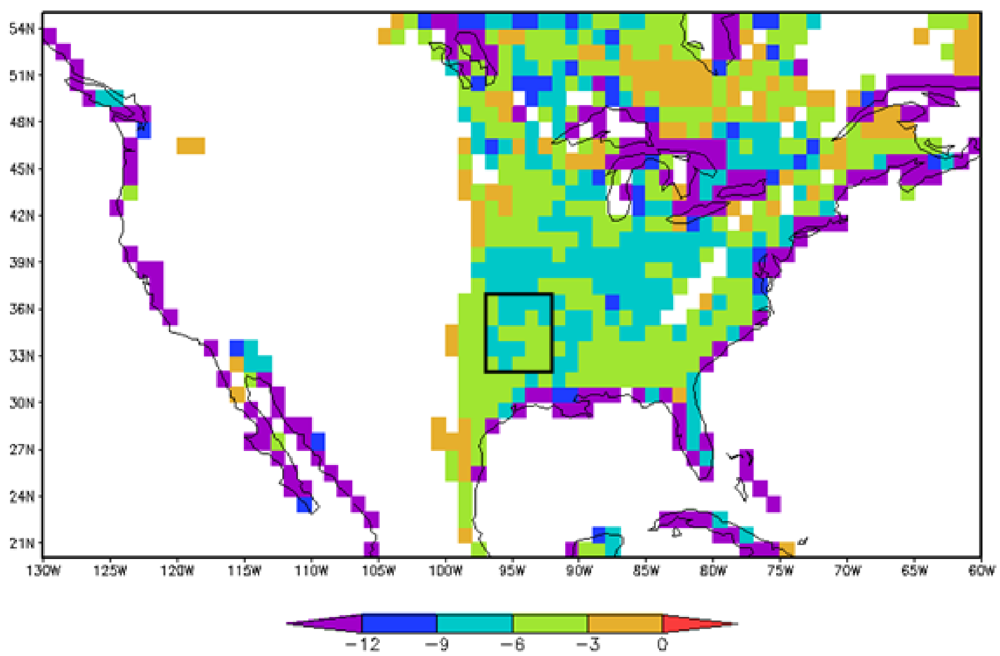


Fig. 1. The mean spatial difference TOA Tb map between CRTM estimates and AMSR-E observed values (AMSR_E – CRTM) over the USA, calculated from the entire study period (April to October, 2007). The data over the Western USA is not considered here, since the CRTM predictions might carry large uncertainties due to non-availability of input atmospheric profile temperature at 1000 hPa. The study area (97 to 92 W and 32 to 37 N) is shown on the map here.

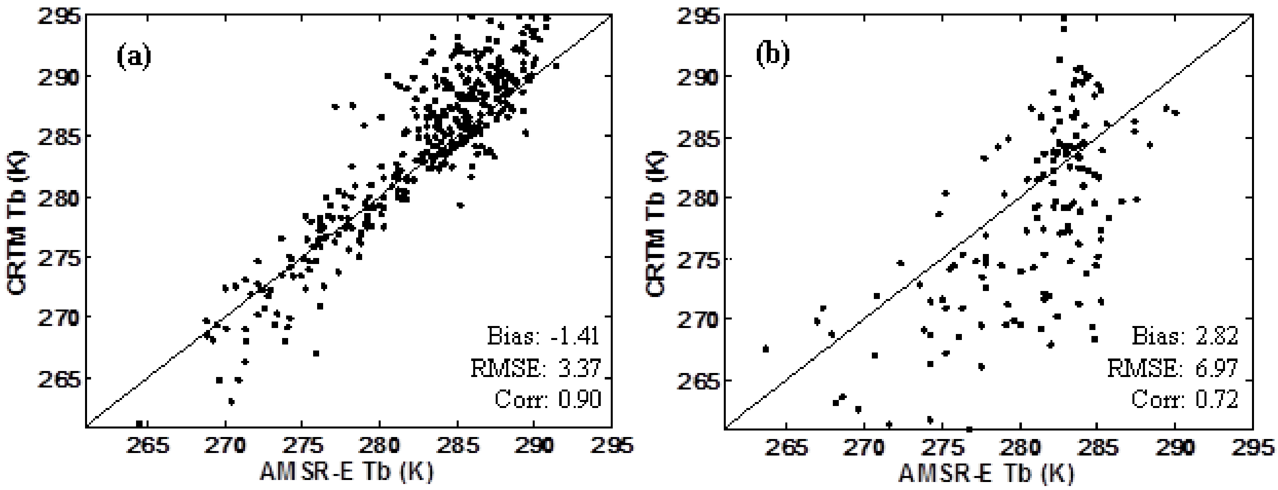


Fig. 2. The comparison of CRTM simulated TOA Tb against AMSR-E observed values at 23.8V GHz frequency channel, (a) in clear sky condition and (b) under cloudy condition for the entire study period.

Performance Metrics	FY12
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	0
# of non-peered reviewed papers	1
# of invited presentations	0
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	0

Planned work

The data set has been completed and will be shared with the PMM land surface characterization working group

2 CICS-NC PROJECTS

2.1 Administrative

Administrative or Task I activities provide a central set of shared resources for the CICS staff and partners. Activities include institute administration, office administration, accounting and finance, proposal development/support, contracts & grants management, human resources, information technology, international linkages, and education and outreach.

The North Carolina Institute for Climate Studies (NCICS) is formed through a consortium of academic, non-profit and community organizations. It is an “inter institutional institute” within the University of North Carolina system hosted by NC State University for the UNC General Administration. It is the UNC System face of the Cooperative Institute for Climate and Satellites –North Carolina (CICS-NC). CICS-NC is part of the Cooperative Institute for Climate and Satellites led by the University of Maryland, College Park (UMCP) and North Carolina State University (NCSU) on behalf of the University of North Carolina (UNC) System. The host institutions for CICS-MD and CICS-NC are UMCP and NCSU, respectively, with CICS-MD located on the Research Park campus of UMCP adjacent to the NOAA Center for Weather and Climate Prediction, and CICS-NC collocated within the National Climatic Data Center in Asheville, NC.

CICS-NC/NCICS administrative activities are currently led by Dr. Otis B. Brown, Director, and are implemented and executed by the following administrative team:

Janice Mills, Business Manager
Jenny Parmar Dissen, Director of Climate Literacy, Outreach and Engagement
Geraldine Guillevic, Communications Specialist
Jonathan Brannock, Network/Systems Analyst
Scott Wilkins, Operations/Systems Specialist

- Information Technology Systems Improvement, Management, and Maintenance

Task Leader Jonathan Brannock, Lou Vasquez, and Scott Wilkins
Task Code NC-ADMIN-01-NCICS-JB_LV_SW
Main CICS Research Topic Task I Support
Percent contribution to CICS Themes Theme 1:33.3%; Theme 2:33.3%; Theme 3:33.3%
Percent contribution to NOAA Goals Goal 1:50%; Goal 2:50%

Highlight:
The CICS staff requires technological infrastructure and resources at a variety of levels. This task supports those needs by providing modern approaches to keep CICS at the competitive edge of technology, as well as maintaining core technologies as a stable base for CICS staff operations. These systems range from scientific computing to medium scale office oriented services.

Critical issues with the storage system hardware were debugged and resolved, assisting vendor in product improvement. Distributed file system controllers were upgraded to support redundancy and higher throughput. An additional, more modern, compute cluster was installed, while other computing environment improvements were made through OS and server upgrades. All servers, and most user operating systems, were upgraded to support latest capabilities.

Building WIFI implementation was re-designed and completed for full user coverage in all desired spaces. Server virtualization was implemented, with multiple services migrated and specialized user tasks supported. Video conferencing solution was obtained, installed and is in use with desktop, mobile and multi-head conference room support. Monitoring was completed and enhanced to support real-time server availability, IT staff notification, and real-time user status updates. Data ingest systems were updated to support quadrupling of data flow and support of data pull model.

BACKGROUND

The CICS-NC network provides a distributed file system for concurrent system-wide access to high-speed storage. The Quantum Stornext file system is attached to three Promise SANs providing 425 Terabytes of online disk storage. This offers our users high-speed redundant storage for large projects and data sets. Of the total disk storage, 330 Terabytes is managed using Quantum's Storage Manager which makes two copies of the data to separate tapes, providing recovery capability for project data.

High performance computing is available via a cluster system supporting research tasks for both CICS-NC and NCDC. We currently have 10 blade centers with 600 processing

cores and 2.3 terabytes of memory. Each of the processors have access to all of the distributed storage space. The head node provides access to a large variety of software as well as command and control tools to push tasks into the cluster. Users may execute tasks using multiple approaches, including but not limited to batch mode processing and OpenMPI.
A building-wide wireless network was created to provide both CICS and other partners in the building with strong-signal, fast wireless coverage. This allows CICS to quickly integrate and work side by side with our NCDC partners.

The CICS network (see figure 1) is simple yet fast, providing 10 Gigabit per second connectivity though the core of the network to our Internet service provider and to NCDC. This allows users to fully utilize the high performance computing cluster as well as the building wireless network. It also gives CICS and our partners an environment where they can quickly perform research tasks as well as testing and development.

Video conferencing by Vidyo is available through CICS-NC. This provides users with the ability to quickly and easily set up virtual meetings where they can share video, audio and desktop content. It provides a method to effectively work with off-site employees, teleworkers, and people on travel. It also provides a means to collaborate and attend meetings hosted by other organizations, including NCSU and NOAA.

CICS-NC IT supports a variety of system services required for data, computing, user and administrative needs. These include: Local Data Manager (LDM), a field standard service for real-time transfer of weather data; Web service for external visibility and collaborator interfacing; FTP for external data sources; and collaboration tools for administrative and internal office oriented interaction.

ACCOMPLISHMENTS
A critical storage hardware issue due to a bug in manufacturer firmware was debugged and resolved. The problem would cause severe data loss on CICS SAN when using a disk size of 3TB. We pinpointed and demonstrated the cause of the error to the manufacturer who, using this information, was able to correct their code for our system as well as all global users of this storage solution.

Upgrades were made to distributed file system controllers. The Stornext metadata controller was migrated to high availability servers with failover capability. This provides greater throughput and real-time failsafe for the scientific computing environment.

The computing environment was upgraded to the latest server hardware, OS, and software tools. A new IBM Bladecenter was added to the compute cluster. This addition provides access to more powerful CPU’s, more memory per CPU, and faster disk and network access than is available on the previous systems.

Building wide WIFI access was planned, updated, and deployed. WIFI coverage was improved from 9 access points covering 75% of two floors to 19 access points covering 100% of two floors and select areas on 3 other floors. Heat maps and simulations were used to place the access points in optimal locations. We also upgraded the wired network with a 10 Gb/s uplink and improved POE switches to support the expanded wireless network.

Virtualization was implemented to support development, management, and efficient use of resources. This provides CICS with a flexible and expandable Linux server environment. We have migrated multiple services, including redundant DNS, Web, FTP, and LDM from OS X and OpenVZ to virtualization on Linux KVM. The virtual environment also supports several development systems that have been requested by our users.

Significant operating system upgrades were performed in various computing categories. This is critical to users for stability, security, and deployment of the most recent computing techniques. Linux servers were migrated from Redhat 5.4 to Redhat 6.2 or newer. OS X Servers were migrated from Snow Leopard to Lion. All user systems, including desktops and mobile platforms, were updated to Lion or Mountain Lion.

A video teleconferencing solution by Vidyo was planned, installed, and is in operation. This included two servers for the user portal and legacy h323/sip gateway. We also outfitted our conference room with dual 55" screens and a high definition camera to support group meetings. Upgrades were made to the firewall topology, including setting up a DMZ to safely accommodate a wider range of video capabilities.

Multiple tools were implemented and are in use to daily monitor the network and systems. Nagios is used to monitor systems, services and connections, automatically sending problem notifications to IT staff. Ganglia monitors utilization and performance characteristics of our computing cluster and related servers. Cacti monitors network utilization and maintains historical data for future analysis. We also obtained and set up an external third party service that monitors our publicly accessible services, sending notification if issues arise. An internal web page has been setup to keep CICS-NC users informed about current problems, disk utilization, and service availability. We leverage these tools daily to proactively identify and manage problems.
The Local Data Manager (LDM) server was reconfigured and upgraded to ingest and store weather, forecast, and model data. We have quadrupled the amount of data ingested, decoded, and stored within the timeframe of this report. This provides our scientists with a rich set of current data to choose from. All data is available directly from local CICS servers. This data is also being used to feed the local weather and regional radar maps generated on the CICS development web page. As our scientists identify re-

quired data feeds, we add the necessary components and place the data where they can access it.

We maintain three data subscriptions from NCDC's Comprehensive Large Array-data Stewardship System (CLASS) that provide VIIRS and AVHRR data to our collaborators in Miami. We have completely redesigned the processes for moving this data, as prior provider (NOAA/CLASS) will no longer be able to push the files to us. This redesign resulted in a 50% reduction in the amount of data we are required to transfer and store.

A backup solution has been implemented supporting versioned backups of all server user home directories. This solution provides versioned backups of each server and virtual machine, as well as any supplemental directly attached storage as necessary. The distributed file systems are copied to tape twice for redundancy as versioned backups are not practical at scale.

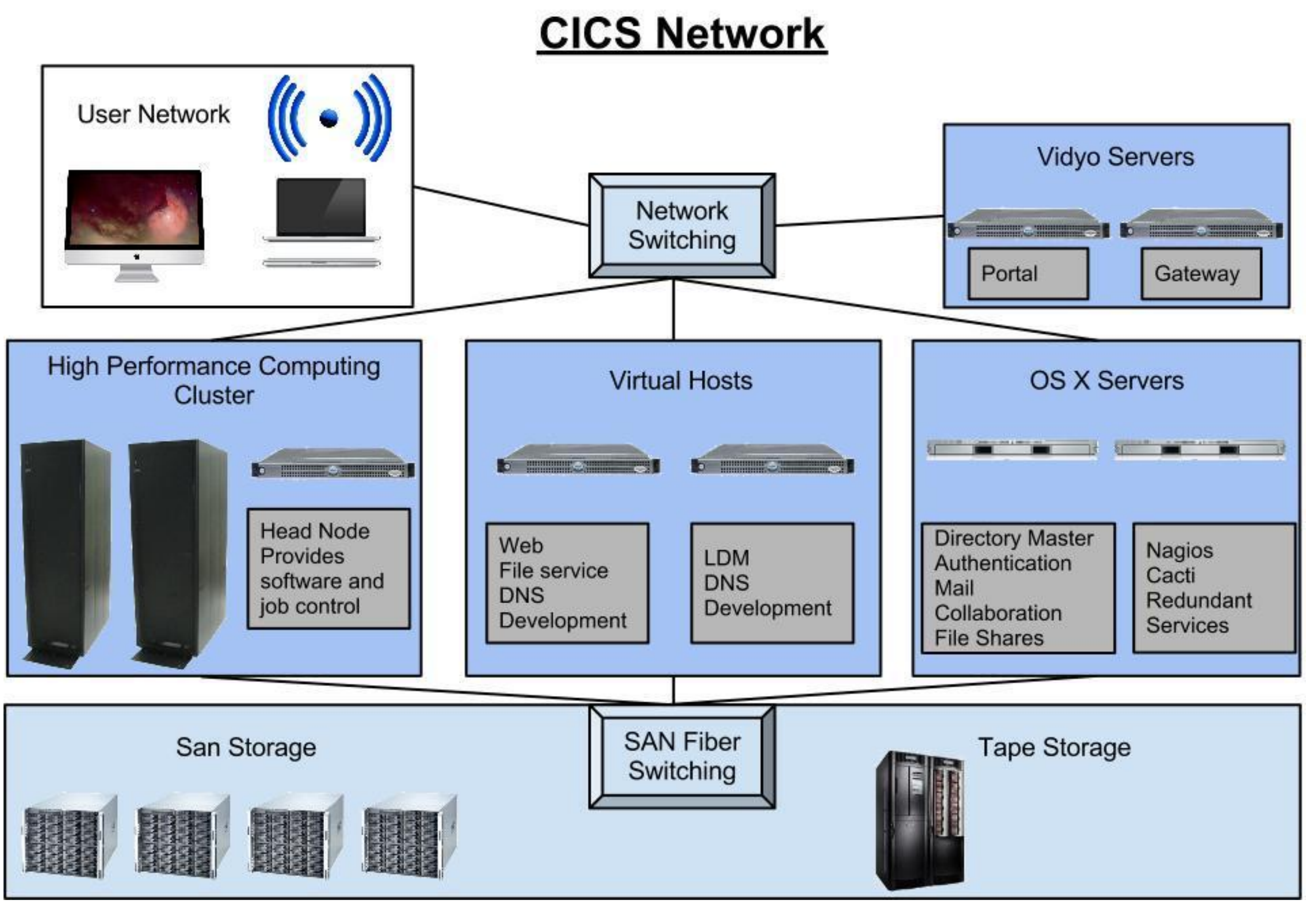


Figure 1: Upgraded network, and system diagram.

Performance Metrics	FY12
# of new or improved products developed	10
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	1

PLANNED WORK

* Migrate services including Open Directory and Mail to the latest version, OS X Server 10.8.
* Network and wireless network security improvements through the use of 802.1x and WPA2 Enterprise.
* Replace aging Desktops and Servers.
* Major upgrade of our current distributed file system from version 4.2.2 to 4.3.7, including conversion of the metadata database format.
* Develop virtual failover solution to resolve current file system limitations.

PUBLICATIONS

N/A

PRESENTATIONS

N/A

2.2 Climate Literacy, Outreach, and Engagement

Climate literacy efforts are focused on improving public knowledge and understanding of climate change, its impacts, and options for adaptation and mitigation.

Background

Over the last decade or so, understanding changes in our climate has emerged as one of the most important areas of scientific endeavor. There is a rapidly increasing realization that profound changes in the Earth climate system are already occurring and will impact nearly everyone, either directly or indirectly. It is well recognized globally that there is a need to mitigate the effects of climate change by reducing greenhouse emissions. The magnitude and scale of climate change and its impact are unpredictable, arguably underestimated, and certain to intensify as past emission levels impact the weather patterns today and into the future. As the discussion on reducing emissions shifts into mainstream awareness, considered as climate mitigation pathways, the question still remains on understanding the inevitable impacts that are already occurring and how we can strategically adapt to adverse conditions.

Anticipated climatic changes, which vary by regions, can include more intense precipitation events, warmer temperatures, shorter snow seasons, and changes in growing seasons, among many others. Collecting and processing the fundamental data on climatic conditions, developing the models and algorithms to simulate natural cycles, assessing the possible projections, and communicating the information are critical activities in building resiliency.

CICS-NC supports NOAA's commitment to the development of a society that is environmentally responsible, climate resilient, and adaptive, and which utilizes effective, science-based problem-solving skills (e.g. STEM based learning) in education. The CICS-NC team participates in various climate education programs to advance the development of strong and comprehensive education and outreach activities about climate and oceanic and atmospheric sciences.

Through CICS education, literacy, and outreach activities, CICS-NC participates in a number of activities that enable a variety of stakeholders to understand the large volumes of climate data that NOAA collects about the Earth. Working collaboratively with other academic and public partners, stakeholders, and the private sector, CICS-NC supports and engages in various educational, engagement, and outreach-related activities to advance the following areas:

- Advancing climate literacy for the education communities, including those in the K-12, undergraduate, and graduate levels and other organizations (e.g. Boy Scouts)

- Advancing climate literacy for private sector partnerships through interdisciplinary activities, including outreach to energy industry, insurance industry, plant-based sector, and executive roundtable sessions
- Outreach to local and national TV meteorologists and other media interested in climate information through CICS-NC partners
- Providing operational support to activities in NOAA organizations like NCDC in advancing their outreach with the Sectoral Engagement Team, communication with the Communications Officer, and literacy with the Education Lead
- Advancing outreach and engagement activities to public policy groups and economic development groups

- Highlighting 150 Years of Weather Observations in Asheville

Task Leader Michelle Benigno and Dr. Teresa H. Cowan
Task Code NC-CLOE-01-NCSU/TSH
Main CICS Research Topic Climate Literacy
Percent contribution to CICS Themes Theme 1: 100%; Theme 2: 0%; Theme 3: 0%
Percent contribution to NOAA Goals Goal 1: 0%; Goal 2: 100%

Highlight
The Science House of NCSU provides K-12 educational outreach for climate and Earth system science in partnership with NOAA's NCDC and CICS-NC. Educational support materials will be created for a museum exhibit called: "Highlighting 150 Years of Weather Observations in Asheville". The Science House is collaborating with NCDC on building curriculum and methodologies for using climate data in the classroom.

BACKGROUND
The Science House is an educational outreach arm of NC State University that serves over 5,000 teachers and over 36,000 students annually from six offices spread across the state. The mission of The Science House is to:

- Cultivate and diversify the pool of students pursuing degrees and careers in STEM (Science, Technology, Engineering, and Math) fields.
- Improve the quality of teaching and learning in STEM education.
- Communicate innovative scientific and educational research to the public.

The Science House's Mountain Office programs are guided by the best research and practices in STEM education. In addition, they lead the K-12 outreach projects for several multi-university STEM research centers that are at the cutting edge of their disciplines.

The Science House increased the number of students served during the 2010-11 school year by 57% and increased the number of teachers and administrators reached by 70%.

ACCOMPLISHMENTS
Climate science education is a crucial part of the work of The Science House. The Science House leads teacher professional development sessions that focus on understanding the Earth system, the changing nature of the climate and its impacts, resource management, and sustainability. The Science House supports students and teachers by providing climate materials, teaching techniques, and sharing cutting edge research from climate scientists. Laboratory equipment is loaned out to participating teachers at no cost. Students can use this equipment to collect local data, which can then be compared with various data from the National Climatic Data Center.

The Science House partners with CICS-NC and collaborates with NOAA's NCDC to out-reach to K-12 students and teachers which now includes instruction with a visualization tool, The Magic Planet. Part of this outreach included collaboration on an exhibit that will be erected at Asheville's Colburn Earth Science Museum showcasing the history of the people who supported the weather and climate community since 1857.

Figure 1: The Magic Planet - Captivates Participants

The Science House is currently collaborating with CICS-NC and NCDC to develop an educational activity for K-12 teachers related to NCDC climate datasets. This activity builds curriculum modules for teachers using climate datasets as a mechanism for teaching students climate science information. This activity will become a methodology and a teaching exercise for teachers across the U.S. on using the NCDC climate dataset as one teaching activity in climate science.

PLANNED WORK

- Educational activities and materials were developed by The Science House to ehance the exhibit, “Highlighting 150 Years of Weather Observations in Asheville” that will be erected at Asheville's Colburn Earth Science Museum. This specific project has been completed.
- Overall collaboration between CICS-NC/NCICS, NCDC and The Science House will continue:
    - Currently in the process of developing the educational curriculum and methodologies for teachers across the U.S. for using climate data in the classroom.
    - Continue climate education outreach to K-12 population and continue collaborations on various Earth system educational opportunities.

OTHER

- Dr. Teresa H. Cowan became the Mountain Office Outreach Director of The Science House on February 1, 2013.
- Michelle Benigno was awarded the Outstanding Extension Service Award for 2010 by NC State University.

Performance Metrics	FY12
# of new or improved products developed	0
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	0

- Stakeholder Engagement to Better Understand Climate Information Needs I

Task Leader	George Briggs
Task Code	NC-CLOE-02-NCAS
Main CICS Research Topic	CICS Stakeholder Engagement
Percent contribution to CICS Themes	Theme 1: 100%; Theme 2: %; Theme 3: %
Percent contribution to NOAA Goals	Goal 1: 40%; Goal 2: 40%; Goal 5:20%

Highlight: Professional business sectors and cultural institutions with key risk factors related to climate change are now engaged and building specific adaptation and education strategies

BACKGROUND

The North Carolina Arboretum, as an affiliate entity of The University of North Carolina system, has supported the goals and objectives of the National Climatic Data Center for many years. As NCDC and NOAA have continued to build stakeholder engagement in a wide variety of sectors and constituencies, The North Carolina Arboretum (the NC Arboretum) and its Executive Director have utilized a unique familiarity with the traditional green industry, the US botanical garden community, and other related business sectors to leverage progress toward NOAA goals.

ACCOMPLISHMENTS

Following successful leadership and engagement in the completion of a June 2011 Letter of Intent between NOAA and the American Public Gardens Association (APGA), the following accomplishments have occurred:

A. The NC Arboretum has fostered a relationship between APGA and NOAA that has now produced further engagement of the zoos and nature centers via *Youtopia*, a program partnership with ecoAmerica that greatly leverages the goals of the Letter of Intent. Through these partnerships, NOAA is able to expand educational capacity through training of professional staff in these cultural institutions, with the goal of reaching approximately 200 million people who annually visit American botanical gardens, arboreta, zoos, and nature centers.

B. In partnership with the Institute for Global Environmental Strategies (IGES), the Arboretum recruited participation and assisted in hosting and conducting *A Growing Interest 2: Climate and Economic Impacts on the Plant Sector*. Key conclusions of the workshop:

a. Monetizing the value of plants is a game changer; effectively articulating the value of plants will largely determine the continued survival of the sector. Climate information can play a critical role in enabling the resiliency of the sector.

b. Climate data and information are still relatively unknown, and as a result, not easily accessible to most users.
c. To facilitate the delivery and use of NOAA science, data, and information, a sustained dialogue between NOAA and the plant sector is essential to better understand sector trends and concerns and where NOAA data and information products can be most useful.
d. A need exists to better communicate and describe "climate" data and information to the plant sector. For example, a user may not readily recognize how climate data and information may be useful to their operations. However, if communicated in terms of long-term forecasting for weather and water, such information may be more understandable and useful.
e. The plant sector is uniquely positioned to engage the public in climate change issues.

B. In April 2012, the Arboretum assisted IGES in hosting "Executive Roundtable on Climate, Private Sector Engagement, and Strategic Forecasting." This workshop brought to Asheville and in connection with NCDC business leaders from a variety of sectors across the United States. The workshop planning was coordinated to some extent with the NCDC/CICS-NC sponsored Normals Workshop that focused on the energy sector.

a. Credible data is absolutely essential for both climate service providers and for the users.
b. Improving communication to the general public is of benefit to the entire emerging Enterprise. The approach should seek to emphasize how climate impacts individuals, local communities, and businesses, and the value of climate information.
c. NOAA is uniquely positioned and committed to continue acting as a source and steward of these data.
d. Numerous opportunities exist for improved engagement between the public and private sectors in the provision of climate services — from identifying user needs across various economic sectors to adding value to climate data in support of effective decision-making.
e. The long-term success of the Climate Enterprise will depend on continued, open dialogue between the private, public, and academic sectors.

PLANNED WORK

A. In partnership with the Institute for Global Environmental Strategies (IGES), the Arboretum recruited participation and assisted in hosting and conducting *A Growing Interest 2: Climate and Economic Impacts on the Plant Sector*. This specific project is complete.

Overall collaboration between CICS-NC/NCICS, NCDC and the NC Arboretum will continue:

B. Planning for certification of public gardens professionals in climate science. Working with IGES and selected major public gardens across the US, the Arboretum is collaborating to create a focused strategy toward certified climate training and instruction that will benefit K-12 students, particularly those in underserved constituencies. Two NSF proposals have been completed – the first was not funded; the second has been modified according to NSF input and is being prepared now for submission. The Arboretum has been responsible for program design collaboration and for recruiting participants, and will serve as the host site for initial profession training. The Arboretum's executive director will chair the project's advisory panel.
C. Assisting with CICS-NC planning for professional educational opportunities for industry leaders. As a member of the Steering Committee for these efforts, the Arboretum's executive director provides input from a community and appropriate sector perspective.
D. Continuing to develop strategies in concert with NCDC to advance climate literacy in the plant and related economic sectors.

PRESENTATIONS

- Frequent reference to these activities in the normal course of speaking at Arboretum events and to civic, economic, and cultural groups.

OTHER

- The Arboretum periodically hosts public officials and groups who are interested in the location and functions of the Bierbaum Station, the first instrument in the NOAA Climate Reference Network dedicated at the Arboretum in 2000.

Performance Metrics	**FY12**
# of new or improved products developed	
# of products or techniques transitioned from research to ops	
# of peer reviewed papers	
# of non-peered reviewed papers	
# of invited presentations	2
# of graduate students supported by a CICS task	
# of undergraduate students supported by a CICS task	

- Stakeholder Engagement to Better Understand Climate Information Needs II

Task Leader Nancy Colleton
Task Code NC-CLOE-03-IGES
Main CICS Research Topic CICS Stakeholder Engagement
Percent contribution to CICS Themes Theme 1: 70%; Theme 2: 10%; Theme 3: 20%
Percent contribution to NOAA Goals Goal 1: 60%; Goal 2: 10%; Goal 4: 10%; Goal 5: 20%

Highlight: This project engaged different U.S. business communities, such as the plant sector, to assess their climate information needs and identify opportunities for NOAA and the private sector to meet them.

BACKGROUND
Recent record-breaking extreme weather and climate events have highlighted a strong linkage between environmental changes and the national economy. This forces the following questions:

- How can U.S. business, and the economy as a whole, be better prepared for weather and climate changes that may take place in the future?
- How can NOAA provide improved information products for U.S. business, thus protecting and growing the economy?
- What are the opportunities for the U.S. private sector in developing and delivering these long-term forecasting products?

To address these, the Institute for Global Environmental Strategies (IGES) implemented the *Stakeholder Engagement to Better Understand Climate Information Needs* project. It was developed to examine the climate – or long-term forecasting – information needs of the U.S. private sector and how NOAA can better facilitate the development of an emerging Climate Services Enterprise (CSE) in which the public and private sector together collaborate to meet growing demand.

ACCOMPLISHMENTS
This project focused on implementing the following activities:

1. Executive Roundtable on Climate, Private Sector Engagement, and Strategic Forecasting

General Description
The *Executive Roundtable on Climate, Private Sector Engagement, and Strategic Forecasting* met on April 25-26, 2012, in Asheville, N.C. Leaders from the public, private and

academic sectors came together to assess the latest thinking and pending issues related to the CSE.

Participants engaged with NCDC/NOAA officials and shared candid insights on how to improve collaboration between the three sectors and how to better define actionable information. Key themes as well as observations of the group on pressing challenges and solutions are captured on the *Executive Roundtable* final report.

Milestones and Deliverables

April 25-26, 2012	Convened the Executive Roundtable on Climate, Private Sector Engagement and Strategic Forecasting
May 10, 2012	Provided the meeting summary via http://strategies.org/environmental-information/stakeholder-engagement- climate-information/executive-roundtable/
July 20, 2012	Executive Roundtable Final Report submitted. Available at: http://strategies.org/wp-content/uploads/2012/03/Executive-Roundtable_F.pdf

2. A Growing Interest 2: Climate and Economic Impacts on the Plant Sector

General Description

A Growing Interest 2: Climate and Economic Impacts on the Plant Sector took place on March 21-22, 2012 in Asheville, N.C. Workshop participants heard from National Climatic Data Center (NCDC) experts on the latest climate change science while also sharing observations and data on the impacts of climate change in their specific communities. A follow up to the 2008 *A Growing Interest* workshop, the meeting served as a forum to assess what has changed since then in the climate and climate change literacy of the different plant sector communities, as well as to identity the long-term forecasting information priorities of this critical sector and how improved communication and cooperation can enable NCDC to meet these needs.

The *A Growing Interest 2* final report captures key themes that resonated throughout the discussion as well as the observations of the group on pressing challenges and solutions.

Milestones and Deliverables

March 21-22, 2012	Convened Plant Sector Workshop
March 30, 2012	Provided meeting summary via http://strategies.org/environmental-information/stakeholder-engagement-climate-information/a-growing-interest-2/

July 12, 2012 A Growing Interesting 2 Final Report Submitted. Available at: http://strategies.org/wp-content/uploads/2012/03/A-Growing-Interest-2_F.pdf

3. Assessment of Public-Private Partnerships

General Description
Government as well as private sector capabilities will be needed to meet growing demand for climate information. NOAA has initiated discussions with the private sector to better understand how it can contribute to structuring the CSE. Of particular interest is the debate over how the public and private sector will interact in the provision of these services.
Building upon previous work in this area, IGES analyzed recent developments on public-private engagement and conducted a series of interviews with key NOAA/NCDC officials and private sector representatives to gain additional insights on how NOAA might move forward with the CSE.

To better understand the maturity of the U.S. private companies involved in climate services, some of which were referenced in the NOAA Science Advisory Board's Climate Partnership Task Force (CPTF) report, IGES conducted a series of informal interviews with companies involved in climate services to identify the challenges they face and their take on the future of the market. *Attachment A* lists the participating companies, questions asked, and findings derived from these interviews, which took place from October 2012 to November 2012.

The results of this assessment are captured in *Climate Services and Approaches for Public-Private Engagement.*

Milestones and Deliverables
April 25, 2012 Initial assessment provided at the Executive Roundtable (Presentation available at: http://strategies.org/wp-content/uploads/2012/04/DelgadoLopez_Roundtable.pptx)
November 20, 2012 Report submitted. Available at: http://strategies.org/wp-content/uploads/2012/12/CICS_PPP_F_small1.pdf
December 28, 2012 Private Sector Interview summaries submitted with final project letter

4. Further Defining Actionable Information

General Description
In order to further define actionable climate information and build upon the findings of the *Executive Roundtable on Climate, Private Sector Engagement, and Strategic Fore-*

casting, IGES convened leaders in the public, private and international arenas during a Town Hall session at the American Meteorological Society (AMS) 2013 Annual Meeting, as part of a National Climate Assessment Special Session. Participants were also asked to consider how actionable information can be delivered and used to better manage risk and guide adaptation.
Details about the town hall, including background, list of participants and key observations derived from the discussion, are captured in a session report.

Milestones and Deliverables
January 9, 2013 Convened Town Hall session
January 30, 2013 Report submitted. Available at:
http://strategies.org/environmental-information/stakeholder-engagement-climate-information/defining-actionable-information/

Performance Metrics	FY12
# of new or improved products developed	4
# of products or techniques transitioned from research to ops	N/A
# of peer reviewed papers	1
# of non-peered reviewed papers	5
# of invited presentations	2
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	N/A

PLANNED WORK
This project has been completed.

PUBLICATIONS
Peer-reviewed:

Goldstein, W., N. Colleton, S. Rientjes, F. Hesselink, C. Phillips, J. Zeidler, J. Braby, and K. Wheeler, August 2012. Creating Pathways for Positive Change. S.A.P.I.E.N.S., 5 (2), 13 –26.

Non peer-reviewed:

Executive Interview: Environmental Intelligence Important for the Economy. *Imaging Notes,* Volume 28, Number 1, Winter 2013.

Colleton, N. January 2013. Hurricane Sandy, Protecting America, and Bipartisanship Beyond a Hug. *The Washington Post*.

Colleton, N. December 2012. Industry Insights: U.S. Environmental Intelligence Efforts Need Leadership, *Earth Imaging Journal,* 9 (6).

Colleton, N. 9 September 2012. Environmental intelligence, basic thermodynamics, and extrem weather. *Physics Today*, 65 (9), 8.

Colleton, N., 6 September 2012. Weather: A hot topic for the next Administration. *The Washington Post.*

PRESENTATIONS

- Presentation at the CDR Applications panel, NOAA's Annual Climate Data Records Conference, Stakeholder Engagement, Asheville, N.C. August 2012.

- Keynote Speech – Emerging Aerospace and Defence Green Technology & Environmental Sustainability Conference, The Role of Space Assets in Environmental Issues, Montreal, Quebec, Canada, 20 - 22 June 2012.

- CICS Support of Climate Kits and Climate at the Keywall (Year 3)

Task Leader	Heidi Cullen
Task Code	NC-CLOE-04-CC
Main CICS Research Topic	Outreach
Percent contribution to CICS Themes	Theme 1: %; Theme 2: %; Theme 3: 100%
Percent contribution to NOAA Goals	Goal 1:40%; Goal 2:40%; Goal 5: 20%

Highlight: The ultimate goal of this program is to establish the routine relevancy of climate science information and provide the climate context to extreme weather events. Climate Central also seeks to raise climate literacy by showcasing the findings of the upcoming National Assessment report. We do this by highlighting NCDC products and showcasing the expertise of NOAA scientists.

BACKGROUND

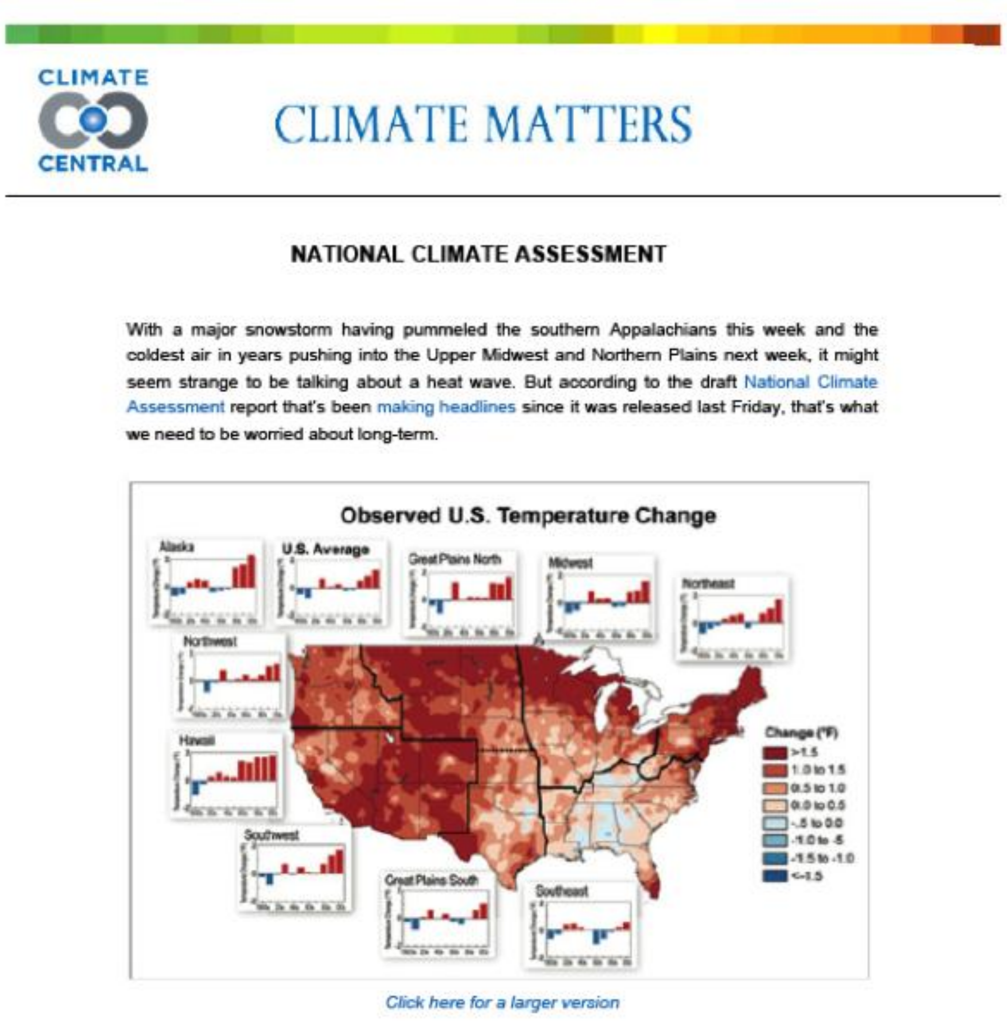
In Year 3, we focused on extreme weather, adaptation strategies, and content distribution across all media platforms. Climate Central highlights how NCDC data and tools can be used to better understand and manage climate and weather-related risks on seasonal to decadal and longer timescales through two video series. Our content routinely utilizes the data, maps, and forecast products produced by NCDC scientists.

ACCOMPLISHMENTS

- Provided expertise/b-roll/graphics/photos and facilitated collaboration of monthly video segments featuring Deke Arndt (screenshot - The Weather Channel). Marketed videos to outlets with broad distribution including The Weather Channel/weather.com (weather) and Weather Underground/wunderground.com (See Figures 1 and 2).
- Surveyed local TV partners and obtained direct feedback to NCDC to better understand the separate technical, pedagogical, and content knowledge (aka "TPCK") barriers for distributing climate information. Provided summary of feedback and requirements from local TV partners with suggestions on how to improve the barriers for distributing climate information.
- Tailored NCDC's monthly graphical products for our local TV partners and assisted with reaching media markets through social media tools, leveraging Climate Central's existing assets and experience. (Climate Central employee Dennis Adams-Smith attended NCDC's Dataset Discovery Day.)
- Assisted in the dissemination of key messages from the National Climate Assessment (NCA) across multiple platforms both at the local and national level (see Figure 3).

Figure 1: Weather 101 video featuring NCDC's Deke Arndt appeared on The Weather Channel /weather.com.

Figure 2: Tell Me Why video featuring NCDC's Tom Peterson appeared on Weather Underground/ weatherunderground.com.



CLIMATE CENTRAL

CLIMATE MATTERS

NATIONAL CLIMATE ASSESSMENT

With a major snowstorm having pummeled the southern Appalachians this week and the coldest air in years pushing into the Upper Midwest and Northern Plains next week, it might seem strange to be talking about a heat wave. But according to the draft National Climate Assessment report that's been making headlines since it was released last Friday, that's what we need to be worried about long-term.

Click here for a larger version

Figure 3: Example of content produced for local TV meteorologists drawing from the National Climate Assessment (NCA).

PLANNED WORK

Climate Central will complete work on this project by 30 June 2013.

PUBLICATIONS

E. Maibach, X. Zhao, J. Gandy, H. Cullen, J. Witte, K. Rowan, B. Klinger, (in review): TV Weathercasters as Climate Educators: Results of a Field Experiment, *Bulletin of the American Meteorological Society*.

Anderson, A. A., Myers, T. A.; Maibach, E. W.; Cullen, H.; Gandy, J.; Witte, J.; Stenhouse, N.; & Leiserowitz, A. (in review): If they like you, they learn from you: How a brief weathercaster-delivered climate education segment is moderated by viewer evaluations of the weathercaster, *Weather, Climate & Society*.

Performance Metrics	FY12
# of new or improved products developed	> 15
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	2
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	0

- Research Activities in Advancing Climate Literacy and Outreach across Public, Private and Academic Institutions

Task Leader	Jenny Dissen
Task Code	NC-CLOE-05-NCICS-JD
Main CICS Research Topic	Literacy, Outreach, and Engagement
Percent contribution to CICS Themes	Theme 1: %; Theme 2:100%; Theme 3: %.
Percent contribution to NOAA Goals	Goal 1:40%; Goal 2:40%; Goal 5: 20%

Highlight: CICS-NC engages in the various formal and informal interdisciplinary education approaches to advance climate literacy for climate-adaptive society. The literacy, outreach and engagement activities are broadly grouped within K-12 Education, Undergraduate and Graduate Education, Private Sector Engagement, partnering with NCDC's Sectoral Engagement team, and other stakeholder groups (e.g. policy makers or economic development coalitions).

BACKGROUND

Education, literacy, and outreach are all important elements of the broader CICS mission. CICS-NC engages in the improvement of both formal and informal education approaches to a variety of stakeholders and the public, ultimately to advance climate information and support a climate-adaptive society. These activities are broadly grouped within K-12 Education, Undergraduate and Graduate Education, Private Sector Engagement, and partnering with NCDC's Sectoral Engagement team for outreach to various industries.

There is a need to advance climate science and climate change literacy for decision-makers as they explore practical and cost-effective approaches to leverage available resources. Provision of climate data for applications and decision capabilities, which can factor into strategic, planning, and operational decisions, requires partnerships across public, private, and academic organization. CICS-NC engages in several meaningful climate literacy and outreach activities to the private sector as well as the general public. These activities are often in conjunction with CICS-NC partners who have particular areas of expertise. Key highlights of accomplishments in literacy and outreach are framed under these areas:

- Increase awareness of climate science and changes in the climate system
- Grow the understanding of how climate data is collected, observed, analyzed, and used in research purposes
- Increase awareness of climate datasets and products, and how educational teachers/professors can make use of climate data products for teaching climate science

- Demonstrate capacity building on the various impacts of climate change across public, private, and academic arenas
- Increase private sector understanding and use of climate data and information for their strategic and operational use.

Climate literacy activities require developing frameworks, delivering presentations, engaging in relationship-building and capacity-building activities, enabling catalytic support of innovation in uses of climate data, engaging in individual and executive-level roundtable discussions, as well as providing ongoing operational support to NOAA organizations like NCDC, NODC, and CPC.

ACCOMPLISHMENTS

To advance climate literacy activities across public, private, and academic partners on climate data, information, and application opportunities, there were several activities accomplished during April 2012 to end of March 2013. These include developing frameworks, delivering presentations, engaging in relationship building and capacity- building activities, enabling catalytic support of innovation in uses of climate data, and ongoing operational support to NCDC. Key highlights of accomplishments in literacy and outreach are framed under these key themes:

- Growing climate literacy with and for education/academic purposes and partners, including K-12 and undergraduate/graduate levels
- Advancing climate literacy for private sector partnerships through interdisciplinary activities
- Providing operational support to NCDC's activities in advancing their outreach with the Sectoral Engagement Team, communication with the Communications Officer, and literacy with the Education Lead
- Conducting outreach and engagement activities to other stakeholder communities (e.g. public policy/legislative groups, or Chamber of Commerce / Economic Development Coalition)

K-12 Education

CICS reaches out through various activities to K-12 students to help advance climate science, literacy, and education particularly focusing in on STEM skillsets. Over the past several years, I, along with CICS-NC scientists, have given presentations, led lectures, taught courses, developed curricula, lent equipment, and mentored high-school students.

CICS-NC partners with NOAA's NCDC and the NC State University Science House to provide K-12 educational outreach for climate and Earth system science. The Science House serves over 5,000 teachers and over 36,000 students annually from six offices spread across the state of North Carolina.

I collaborate and coordinate proposal activities with The Science House that involve the development of an educational curriculum using NCDC's climate data, where specific climate datasets will be used for teaching exercises for teachers across the U.S. Through this educational engagement, CICS-NC also hopes to increase their understanding of teachers' needs for climate information so they can effectively teach climate science to their students.

In collaboration with The Science House Mountain Office, I participated as a local woman in STEM in one of their flagship events *Expanding Your Horizons,* held April 7, 2012. This event that encourages young women to pursue science, technology, engineering and mathematics (STEM) careers. The goal was to motivate girls to become innovative and creative thinkers ready to meet 21st Century challenges by providing STEM role models and hands-on activities for middle and high school girls. Approximately 60 seventh grade students participated. My specific role was to 1) share my knowledge of local STEM careers, 2) guide girls through a hands-on activity that helps them understand more about one area of STEM, and 3) encourage our young women to pursue STEM pathways.

Partnering with CICS-NC scientist Jim Biard, I have given a Climate Change Overview presentation to a class of 8th graders who are part of the AIG group at the Asheville Middle School. The presentation aimed to fulfill some of the requirements for the North Carolina Essential Standards for 8th grade (section 8.E.1) that stated "**Understand the hydrosphere and the impact of humans on local systems and the effects of the hydrosphere on humans. "**

Figure 1: Jim Biard and Jenny Dissen, along with teacher Mary Elston and her 8th grade AIG students from the Asheville Middle School, Asheville, NC.

Continuing to build the literacy at the K-12 level and the community, Jared Rennie and I presented for the Asheville Boy Scout Troops, Troop 8, on two topics, which provide information to the troops for merit badges on those topics. The topics included “Weather/Climate” and “Environmental Science.” This engagement effort has raised the question of whether a climate badge could become a required badge. There are plans to collaborate with the Boys Scouts group at the national leadership level to revisit the program on climate and reshare the information requirements.

Figure 2: Boys Scouts, Troop 8 of Asheville, North Carolina with Jenny Dissen (CICS-NC) and Jared Rennie (CICS-NC).

CICS-NC supports undergraduate student research activities and student internships. Currently, an undergraduate research project in the Applied Mathematics program is being overseen. CICS-NC has also undergraduate student internship programs where two UNC Asheville students have been engaged in supporting CICS staff over the 2011-2012 academic year.

CICS also engaged in interdisciplinary activities for education and outreach support to other academic institutions. I served on a panel on energy, environment, and climate at Harvard University for their Science Policy Careers Symposium, held on May 2, 2012, to provide support and share career experience with postdoctoral students about careers in science policy. The outcome of this participation has enabled many of their post-doc students to contact CICS-NC for discussions in career opportunities in climate, science and policy. It has also enabled opportunities to provide their program with contacts of other science and policy experts working in science policy.

Collaborating with other NCDC contract partners in outreach, I supported the planning of an outreach activity for NASA as part of the NASA's DEVELOP Student program. The NASA DEVELOP

Program focuses on environmental research conducted through the use of NASA, NOAA, and USGS data and information, as well as international remote sensing satellites. The activity included supporting students in this program to present their research and application projects at NCDC; CICS-NC team members were asked to review and provide insights to the students' presentations. The topics of the presentations include:

1. Ecological Forecasting and Agriculture in Rwanda,
2. Flood Risk Mapping in the Coahuila District of Mexico, and
3. Air Quality in Virginia, Comparison of Coal Burning Technologies.

CICS-NC supported a unique seminar series discussion with Dr. Michael Mann, a well known scientist from Pennsylvania State University who visited the Asheville area and gave talks on climate change and perceptions of the how the confusion on the topic evolved. CICS-NC led in the organization of the seminar discussions at NCDC and NC State University and supported the planning of seminars at Warren Wilson and UNC Asheville for their students.

Outreach and Engagement through Interdisciplinary Activities

Over the past few years, CICS-NC has established a relationship with Duke Energy to help them understand the impacts of changing climate normals on their energy load forecast. This interaction spurred a research activity in developing profiles of optimal climate normals for each climate division in North Carolina, which has enabled further dialogue with the company on impacts to their operational activities. The engagement with Duke Energy led to the development of a workshop on Alternative Climate Normals that I led, managed, and helped facilitate. The workshop took place April 24-25, 2012, where regulatory agencies, the science community, and business leaders discussed the impacts of changing normals on business and opportunities, and of potentially enabling change in current regulations to allow flexibility for businesses to apply alternative normals. Information on this workshop can be found at this website: http://cicsnc.org/meetings/cnws/.

The ongoing interaction with Duke Energy also resulted in a discussion on climatic trends in the Carolinas with their System Planners, and Director of Transmission, Distribution and Substation, and Policy. CICS-NC Director Otis Brown, Ken Kunkel, and I presented on "Advancing Climate Literacy for the Energy Industry."

As the engagement with the energy industry builds, I was invited to serve as a panel moderator for the *Energy Risk* conference in Houston, TX to moderate a panel titled "Weather risk management and hedging strategies." The engagement with the participants and the panelists enabled a series of follow-on opportunities. I was asked to participate and present on CICS-NC and NCDC's outreach activities at the inaugural and annual Energy Summit, hosted by Statweather, a climate forecasting company based out of Florida. The intent was to disclose and share how research advancement is being shared with the business industries. *Energy Risk* published information in their magazine on climate information and engaged in an interview with Dr. Ken Kunkel for more information on how extreme weather and climate trends are impacting the industry.

Figure 3. Weather risk management panel at Energy Risk Conference, Houston, Texas, May 15 - 16 – L-R: Jenny Dissen (CICS-NC / National Climatic Data Center), Lynda Clemmons, James Gooding (Black & Veatch), Ria Persad (StatWeather), Tom Paylor (RenRe Energy Advisors).

Additional engagement with the energy industry and other industry executives continued at the other forums and seminars:

- Fortune Brainstorm Green Event, taking place in April 2012
- Harvard Business School Executive Education Global Energy Seminar

As CICS-NC represents one way to communicate and represent a bridge to private sector understanding of climatic risks, I was invited to participate and engage in the half-day business workshop on the climate risk and resilience project organized by the Center for Climate and Environment Studies that took place in Washington D.C. on November 14, 2013. C2ES is undertaking a research project exploring the extent to which companies consider their vulnerabilities to and opportunities from extreme weather and a changing climate, and how those considerations may be incorporated into business planning and decision-making. As a result of this engagement with C2ES, CICS-NC is serving as a peer reviewer for C2ES' report on building business resilience to the impacts of extreme weather and climate change. The report, which includes six case studies, will also likely be useful for the CICS-NC activity "Executive Forum on Business and Climate."

To continue to build literacy on climate data and information and the availability of products provided by NCDC to the private sector, I gave webex presentations for Booz Allen Hamilton to their Climate Change Community of Practice and the Sustainability Community of Practice. These discussions were in partnership with NCDC's Sectoral Engagement Coordinator, Tamara Houston.

Collaborating with NOAA / NCDC

In collaboration and partnership with NCDC's Climate Services and Monitoring Branch, I lead the development of an ongoing framework and approach for advancing climate data applications through a new workshop engagement activity called "Dataset Discovery Day." This is a two-day workshop interaction focused on informing users of NCDC data and information on sector-specific needs in climate information. As part of the workshop, participants will engage in specific sectors that use climate and environmental information and explore potential future research needs. The workshop will bring together business leaders, decision-makers, entrepreneurs, in-

novators, and scientists to discuss NCDC's climate data, applications of the data, and future uses of climate information. Through this collaborative discussion, we hope to uncover innovative opportunities for the market and research needs that can be provided to the scientific and academic community.
The first workshop focused on Storm Data and Severe Weather Data Inventory and took place on November 28 and 29, 2012. Additional information on the workshop is available at: http://cicsnc.org/events/ddd/agenda-nov-2012/.

The second workshop is scheduled for March 20-21, 2013 and is focused on frost and freeze data and applications. For example, frost and freeze information is useful in assessing the risk of operations where the risk of crop production is associated with planting dates, the length of the growing season, and potential destruction of immature and/or tender vegetation. The outcomes of the first workshop included collecting a set of requirements from the user community. This was shared with the NCDC leadership which enabled further discussions on opportunities to respond to those requests.

Additional information on Frost and Freeze Data Users Workshop can be found on the CICS-NC website: http://cicsnc.org/events/ddd/.

Figure 4. Dataset Discovery Day workshop on Storm and Severe Weather Data, November 28-29, Asheville, NC.

In addition, I supported the NCDC Sectoral Engagement efforts in the planning and execution of the NCDC led workshop activity "U.S. Disaster Reanalysis Workshop."

Integral to outreach activities is the communication of climate information to various stakeholders. In collaboration with NCDC's Communications Coordinator, I support the planning and management of a Communications Training proposal that is geared towards providing media and communications training to NOAA scientists in effective engagement with media. The training includes three workshops at three of the NOAA locations: College Park, Maryland, Boulder, Colorado, and Asheville, North Carolina. These workshops are planned in coordination with NOAA's Communications and Public Affairs and Outreach/Education leads across all three locations.

Legislative / Policy Making Community

I was selected to participate as a volunteer to Climate Science Day on Capitol Hill, which took place

February 26-27, 2013. The purpose of the visits is to provide Members of Congress with the best possible access to scientific information on climate science when making policy decisions. This non-partisan event, organized by the Climate Science Working Group (CSWG), included training on effective communication and individual meetings with various Senators and Congressman from North Carolina. The legislative offices that I met with included the following:

- Senator Hagan
- Representative Price and his aides
- Representative Hudson and his aides
- Representative McHenry and his aides

Figure 5: As part of Climate Science Day on Capitol Hill, Washington D.C., February 26-27, 2013, interacting with NC Senator Hagan (left) and Congressman David E. Price, US House of Representative District #1 North Carolina. Left photo L-R: DeWayne Cecil, GST; Jenny Dissen, CICS-NC; Senator Hagan, North Carolina; Susan Hassol, Climate Communications; Richard Smith, SAMSI.. Right photo: L-R: Jenny Dissen, CICS-NC; DeWayne Cecil, GST; Congressman David Price, 4th District of North Carolina; Susan Hassol, Climate Communications; and Richard Smith, SAMSI.

Innovation and Economic Development

The overall NOAA strategy for climate information products assumes that the private sector will provide most derived climate products (also termed climate analyses, decision support information, and/or climate information records). At the moment private investment in such activities is in its infancy and needs significant nurturing to flourish at the levels needed for the national climate enterprise. CICS-NC collaborates with NCDC and other Economic Development groups to assist in the incubation of such activities.

CICS-NC outreach and engagement activities are under the purview of NC State's Office of Research, Innovation, and Economic Development. To that end, I collaborate with the Asheville Chamber of Commerce and the Buncombe County Economic Development Coalition to identify and support opportunities in growing the region with STEM skills and capabilities, particularly in climate science. I supported and led a discussion with various business leaders in the growth of the science and technology sector in the Western North Carolina region, specifically in the weather/climate sciences arena. Along with Dr. Otis Brown, I gave a presentation that portrayed CICS-NC as an example of an entity in climate activities. The discussion covered the following topics: CICS-NC's growth, our technological and community needs, and our approach for future stability. We discussed key capabilities, a community of practice, and infrastructural support as examples of critical ingredients that would need to be available to attract other start-ups to this location.

Performance Metrics	FY12
# of new or improved products developed	0
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	1
# of non-peered reviewed papers	0
# of invited presentations	8
# of graduate students supported by a CICS task	1
# of undergraduate students supported by a CICS task	0

PLANNED WORK
* Conduct the Executive Forum on Business and Climate activity
* Continue to build and grow the outreach capabilities in K-12 by partnering with the Science House
* Assess the possibility of creating a required merit badge in climate studies through our collaboration with the Boy Scouts
* Assess the options for a recurring outreach set of discussions on climate and climate change for the legislative and policy-making community
* Attend and speak at the upcoming NOAA Satellite Conference on examples of uses and application of climate satellite data
* Develop a center-wide outreach and engagement strategy with NCDC for NCDC, which includes more workshops under the Dataset Discovery Day umbrella on various climate data products

* Participate in Climate Leadership Conference through the Association of Climate Change Officers

PUBLICATIONS

Arguez, A., R. Vose., and J. Dissen. (in review) *Alternative Climate Normals: Impacts to the Energy Industry*. Bulletin of American Meteorological Society

PRESENTATIONS

- Brown, O., K. Kunkel, J. Dissen. (2012), Advancing Climate Literacy for Duke Energy Executives, Presentation to Duke Energy,Duke Energy Headquarters, Charlotte, NC. April 2012
- Dissen, J. (2012), Executive Forum on Climate and Business: Overview for Weather Summit, Presentation to the Weather Summit. Houston, TX. September 2012
- Arguez, A. and J. Dissen. *"Climate Normals and Engagement with the Energy Industry"* The 93rd American Meteorological Society's Annual Meeting, 22nd Symposium on Education and Fourth Conference on Weather, Climate and New Energy Economy. January 6th – 10th, 2013, Austin, Texas.
- Dissen, J. and T. Houston. (2013), Climate Data to Decision: NCDC/CICS-NC Approach to Outreach, Presentation to Booz Allen Hamilton Sustainability Community of Practice, Webex, 18 January 2013.
- Biard, J., Dissen, J. (2013), Climate Science and Climate Change Overview, Presentation to the 8th Grade Academically and Intellectually Gifted (AIG) class at Asheville Middle School, Asheville, NC, 7 February 2013.
- Dissen, J. and T. Houston. (2013), NOAA's National Climatic Data Center: An Overview, Presentation to Booz Allen Hamilton Climate Change Community of Practice, Webex, 11 February 2013.
- Dissen, J. and J. Rennie. Weather and Climate Science Overview. Asheville Boy Scouts Troop 8. February 2013.
- Brown, O. and J. Dissen. CICS-NC: A Prototype. Asheville Chamber of Commerce and Buncombe County Economic Development Coalition. March 2013.

OTHER

- Facilitator of group discussions in the first Dataset Discovery Day workshop focused on Storm and Severe Weather Data
- Key participant in the and a voting member of AMS Energy Committee and the new member of the newly proposed AMS International Committee
- Integrally involved in assembling and completing the CICS 5-Year Review Process
- Completed Global Energy Seminar at Harvard Business School Executive Education (received scholarship stipend) (November 2012)

2.3 Climate Data and Information Records and Scientific Data Stewardship

Climate Data Records (CDRs) provide climate quality satellite and *in situ* observing datasets that document the Earth's climate.

Background

CICS–NC supports efforts at the National Climatic Data Center (NCDC) for the development and transition from research to operations (R2O) of Climate Data Records. While some of this effort is in–house, a significant part of it is accomplished by CICS partner institutions, which include some of the leading climate science practitioners in the nation working in basic and applied research endeavors.

Work Plan

CDR's primary aim is to develop and sustain as complete and consistent a climate record as possible from remotely sensed and in situ measurements in order to provide users with climate quality data and information products. Support of these activities requires the highly specialized scientific and technical experience that is currently assembled in CICS–NC.

CICS–NC staff of climate and instrument researchers and scientific support staff at the senior, mid–career, and junior levels as well as post–doctoral and graduate students in climate science and related areas work under the direction of the CICS Director and in coordination with the NCDC project leader and his staff and provide necessary skills in the following areas:

- Expertise needed to coordinate the development of calibration and validation activities and approaches for high quality baseline climate data sets from satellite and in situ observations relevant to documentation and detection of climate change in the land, ocean, and atmosphere.
- Expertise needed to develop, refine, and implement algorithms for a daily, global, multi–sensor, optimally interpolated Climate Data Records (CDR), and to characterize the sources and magnitudes of errors and biases in the CDR and develop methodologies for the reduction of these errors and biases.
- Expertise needed to develop high quality baseline climate data sets from satellite and in situ climate data, and develop the relationship(s) between the observed tropospheric and stratospheric trends from the ground–based network with those observed from satellite.
- Development of scientifically–based quality control algorithms for in situ climate data of various time scales (hourly, daily, monthly, annually), methods to detect and adjust for inhomogeneities due to issues such as instrumentation changes or observing station relocations, and scientific analyses of structural uncertainty due to these methods.

- Expertise needed to ensure that research to operation transitions occur between data set development activities and the operational use of these data sets in activities such as climate monitoring and climate research, as well as performing research documenting climate variability and change using the observed record and climate model simulations.
- Expertise needed to support the stewardship of archival and current climate observations.

- Suomi NPP VIIRS Land Surface Temperature EDR Validation

Task Leader Pierre Guillevic
Task Code NC-CDR-01-NCICS-PG
Main CICS Research Topic Climate Data and Information Records and Scientific Data Stewardship
Percent contribution to CICS Themes Theme 1: 10%; Theme 2: 80%; Theme 3: 10%
Percent contribution to NOAA Goals Goal 2: 20%; Goal 5: 80%

Highlight: Research was conducted to evaluate the quality of LST products derived from the VIIRS sensor onboard the NPP satellite using ground-based measurements.

BACKGROUND

NOAA will soon use the new Visible Infrared Imager Radiometer Suite (VIIRS) on the Suomi National Polar-orbiting Partnership (NPP) and future Joint Polar Satellite System (JPSS) platforms as its primary polar-orbiting satellite imagers. NOAA will generate a series of Environmental Data Records (EDRs) – or level 2 products – from VIIRS data. For example, the VIIRS Land Surface Temperature (LST) EDR will estimate the surface skin temperature over land surfaces and provide key information for monitoring Earth surface energy and water fluxes. Because both VIIRS and its processing algorithms are new, NOAA is conducting a rigorous calibration and validation program to understand and improve LST
product quality.

The objective of this work is to evaluate quantitative uncertainties in LST products derived from VIIRS using ground-based measurements currently made operationally at many field and weather stations around the world, and contribute to improving the retrieval algorithm. Until now, validation of thermal infrared satellite products at moderate resolution was mostly performed over homogeneous surfaces such as lakes and deserts. Actually, for most vegetated landscapes composed of various land cover types or soils, the LST measured by a station at one specific location – i.e., a point measurement – does not represent the surrounding area that is part of the coarser satellite sensor pixel. Furthermore, depending on illumination and viewing directional configurations, satellites measure different surface radiometric temperatures, especially over sparsely vegetated regions with directionally varying radiometric contributions from soil and vegetation. I have developed two new methodologies to account for both spatial variability of LST around ground stations (Guillevic *et al.*, 2012) and directional viewing and illumination configuration effects (Guillevic *et al.*, 2013) when validating LST satellite products.

ACCOMPLISHMENTS

Over heterogeneous areas, the LST spatial variability is mainly due to changes in surface types, biophysical parameters, or soil moisture. I have developed a validation methodology that employs a physically-based approach to scaling up in situ measurements (Fig. 1). We use vegetation density information at higher resolution than the thermal infrared data (e.g., MODIS NDVI at 250m) or surface emissivity from ASTER at 100m to describe the spatial variability in surface biophysical parameters. Then, the SETHYS land surface model is used to merge information collected at different spatial resolutions, describe the LST distribution around the station, and fully characterize large area (km x km scale) satellite products (Guillevic *et al.*, 2012). The approach can be used to explore scaling issues over terrestrial surfaces spanning a large range of climate regimes and land cover types, including forests and mixed vegetated areas.

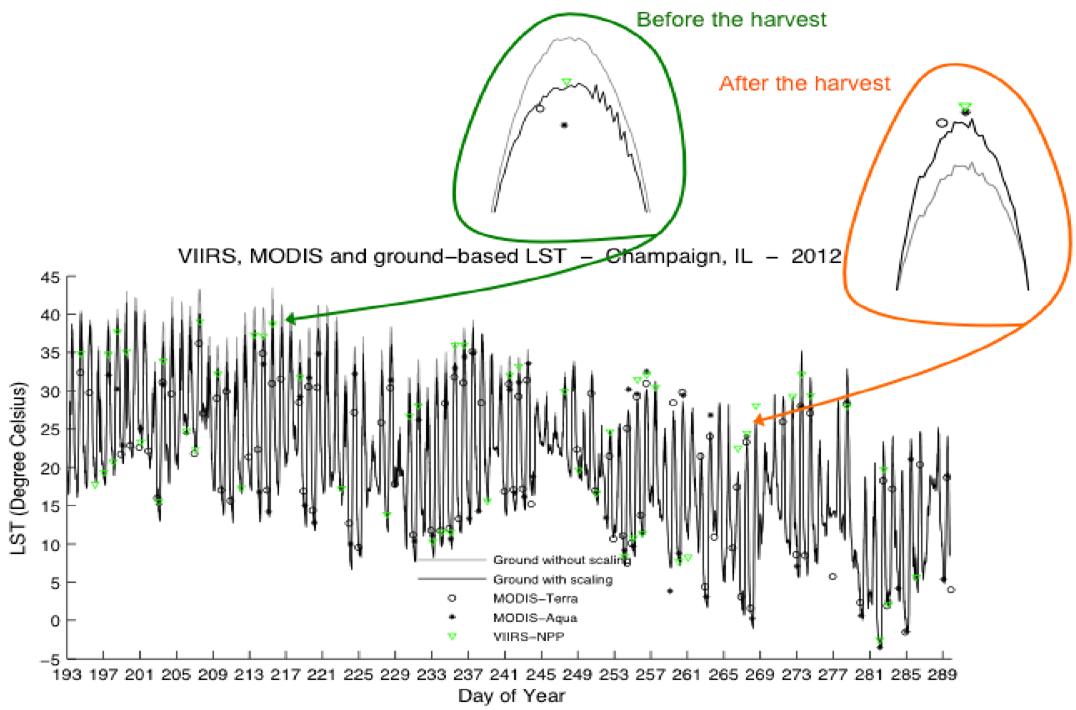


Figure 1: LST derived from VIIRS and MODIS satellite sensors and from ground-based measurements with and without scaling over an agricultural landscape near Champaign, IL. For this site, the effect of spatial variability around the station depends on the season and/or land use.

For sparsely vegetated areas, such as woodlands or open forests with low tree coverage, I have developed an approach that combines local field radiometric measurements and a 3-D radiative transfer model to characterize illumination and viewing directional effects on LST standard products. We use the Discrete Anisotropic Radiative Transfer (DART) model to estimate the radiometric contribution of the different surface components, i.e. tree canopy and understory/soil fractions in shaded and sunlit areas, for a given illumination and viewing geometry (Fig. 2). Remotely sensed data are then represented by a linear combination of surface component ground-based radiometric temperatures weighted by the fraction of each component viewed by the sensor.

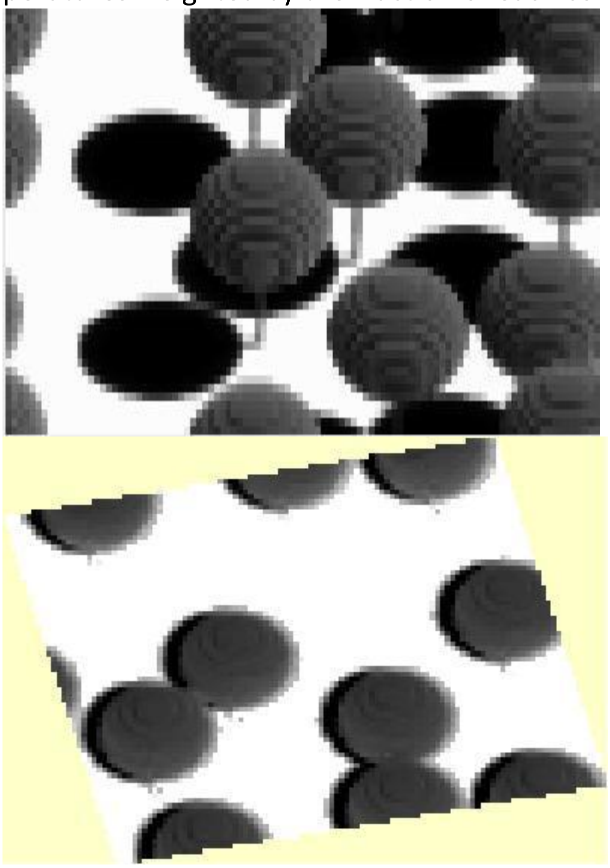


Figure 2: Directional images of a 50mx50m woodland area near Evora, Portugal simulated by the DART model – the illumination configuration is for day of year 211 at 12:30PM. Simulated images for MODIS viewing configuration (left – viewing zenith and azimuth angles are 62˚ and 270˚) and Meteosat/SEVIRI viewing configuration (right – viewing zenith and azimuth angles are 45˚ and 167˚) illustrate shadow effects on satellite LST products.

We have selected 51 validation sites worldwide to represent a large range of climate regimes and land cover types, including forests and mixed vegetated areas. The stations are part of operational networks, e.g. the Surface Radiation Budget (SURFRAD) network, US Climate Reference Network (USCRN), and Ameriflux, or are specifically designed for the validation of LST products derived from other satellite sensors: the Moderate Resolution Imaging Spectroradiometer (MODIS), the Spinning Enhanced Visible and Infrared Imager (SEVIRI), or the Along Track Scanning Radiometers (ATSR). Depending on spectral characteristics of the thermal infrared sensors, different protocols are defined to retrieve precise LST values from thermal infrared radiances collected by different ground stations.

Performance Metrics	FY12
# of new or improved products developed	0
# of products or techniques transitioned from research to ops	1
# of peer reviewed papers	2
# of non-peered reviewed papers	0
# of invited presentations	1
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	0

PLANNED WORK

* Fully evaluate the precision/accuracy of VIIRS LST products using worldwide ground observation networks.
* Define a protocol to enhance the radiometric skin temperature made by the NOAA's USCRN stations for satellite LST product validation. The goal is to retrieve precise LST values from thermal infrared radiances collected by field measurements, depending on spectral characteristics of the Apogee thermal infrared sensors installed at each USCRN station.
* Participate to the EarthTemp international initiative on earth Surface temperature which main goal is to develop more integrated, collaborative approaches to observing and understanding Earth's surface temperatures. The goal in 2013-2014 is to provide a description of the recommended methodology for performing LST validation using various approaches. The recommendations are based on previous experience of the LST validation community. A first collaborative work will be presented at the IEEE International Geoscience and Remote Sensing Symposium (IGARSS) in July 2013. The reference of the submitted communication is: Guillevic, P.C., Privette, J.L., Yu, Y., Goettsche F.M., Hulley, G., Olioso, A., Sobrino, J., Meyers, T., Ghent, D., Bork-Unkelbach, A., Courault, D., Román, M.O., Hook, S., and Csiszar, I. NPP VIIRS Land Surface Temperature product validation using worldwide observation networks. IEEE International Geoscience and Remote Sensing Symposium (IGARSS), Melbourne, Australia, July 2013.

PUBLICATIONS

Guillevic P., Bork-Unkelbach A., Goettsche F.M., Hulley G., Gastellu-Etchegorry J.P., Olesen F. and Privette J.L. (2013). Directional viewing effects on satellite Land

Surface Temperature (LST) products over sparse vegetation canopies – A multi-sensors analysis. Accepted for publication to *IEEE Geoscience and Remote Sensing Letter* – Special stream on *Biophysical variables and spatial heterogeneities in agricultural landscapes*.

Guillevic P., Privette J.L., Coudert B., Palecki M. A., Demarty J., Ottlé C. and Augustine J.A. (2012). Land Surface Temperature product validation using NOAA's surface climate observation networks – Scaling methodology for the Visible Infrared Imager Radiometer Suite (VIIRS). *Remote Sensing of Environment,* 124, 282-298.

PRESENTATIONS

- Guillevic P. and Privette J.L. (2013). NPP VIIRS Land Surface Temperature ERD validation using NOAA's observation networks. Oral presentation at the *American Meteorological Society* (AMS) annual meeting. Austin, TX. 6-10 January 2013.
- Guillevic P. and Privette J.L. (2012). NPP VIIRS Land Surface Temperature ERD validation using NOAA's observation networks. Oral presentation at the *American Geophysical Union* (AGU) fall meeting. San Francisco, CA, USA. 3-7 December 2012.
- Guillevic, P., and Privette, J. (2012). NPP VIIRS Land Surface Temperature EDR validation using NOAA's observation networks. *EarthTemp international initiative on Earth surface temperature Workshop*. Edinburgh, UK, June 2012.
- Yu, Y., Liu, Y.Y., Wang, D., Liang, S., Guillevic, P., Privette, J., Wang, Z., Schaaf, C. (2012) Evaluation of VIIRS Land Surface Temperature and Albedo EDRs. *MODIS Science Meeting.* Silver Spring, MD, USA, May 2012.
- Guillevic, P., and Privette, J. (2012). NPP VIIRS Land Surface Temperature EDR validation using NOAA's observation networks. *VIIRS Science Team Meeting*. Greenbelt, MD, USA, May 2012.

OTHER

- Member of the Cooperative Institute for Climate and Satellites (CICS) Council of Fellows, primary scientific planning and consultative body of CICS.
- Member of the EarthTemp international initiative on Earth surface temperature
- Participant in the European Space Agency (ESA) Glob Temperature initiative on satellite products users for environmental studies

- Suomi-NPP VIIRS Climate Raw Data Record Production Software Development

Task Leader	Jim Biard
Task Code	NC-CDR-02-NCICS-JB
Main CICS Research Topic	Climate Data and Information Records and Scientific Data Stewardship
Percent contribution to CICS Themes	Theme 1:100%
Percent contribution to NOAA Goals	Goal 5:100%

Highlight: Development of the VIIRS Climate Raw Data Record production software entered the testing phase.

BACKGROUND

The Climate Raw Data Record (C-RDR) Project is a part of the Climate Data Record Program. The C-RDR Project is responsible for developing a system to acquire, reformat, and enhance the Suomi National Polar-orbiting Partnership (NPP) Raw Data Records (RDRs) and support data to facilitate the production of Climate Data Records (CDRs).

CDRs are fully-calibrated, long-term time series of climate variables that have the consistency and continuity required for the climate research community. The production of CDRs requires the reprocessing of extensive data sets as algorithms are improved and the sensor performance is better understood. To produce CDRs**,** the raw data are required as input for each iteration of the reprocessing.

The goal of the C-RDR system is to provide the Suomi-NPP raw data and supporting data in a format that is enhanced for utilization in research, the production of CDRs, and long term stewardship. There will be a C-RDR for each science instrument on the Suomi-NPP satellite. The C-RDRs contain the raw measurements from the RDRs, decoded and decompressed so they are easily accessible. Each C-RDR file also contains extensive provenance, discovery, and usage metadata. The C-RDR files use the established, platform-independent, community standard netCDF-4 data format.

The C-RDR system will produce C-RDRs from NPP RDRs on an operational basis for the life of the NPP mission. The C-RDR files will be archived and made available to the user community.

The C-RDR for the Visible Infrared Imaging Radiometer Suite (VIIRS) instrument was the first one chosen for development.

ACCOMPLISHMENTS

During the last year I completed the coding of the application that produces C-RDR files from VIIRS RDR files. I also completed the coding of three applications that will be used in verifying the correctness of the VIIRS C-RDR files.

The primary application for VIIRS C-RDR production is the VIIRS C-RDR packer application. This application is built on the Joint Polar Satellite System (JPSS) Application Development Library (ADL). ADL is a port of the Interface Data Processing Segment (IDPS) software that is used for the operational processing of the data streams from the Suomi-NPP satellite. It allows an individual to run any of the applications that run in the real-time IDPS system in a standalone fashion, and to develop new applications that will run in the full IDPS environment. ADL provides me, as a developer, with all of the data structures and I/O functions that are needed to interact with the Suomi-NPP input and output data products. The VIIRS C-RDR packer differs from a standard ADL application in that it is generating a netCDF-4 file as its output, which is not a feature provided by ADL.

Figure 1 depicts the transformations to data which occur when generating a VIIRS C-RDR file using ADL and the VIIRS C-RDR packer application. The input to the process is a Hierarchical Data File 5 (HDF5) format file obtained from the NOAA Comprehensive Large Array Storage System (CLASS), which is the archive and dissemination system being used by the Suomi-NPP project for all IDPS data products. A VIIRS HDF5 RDR file contains up to four VIIRS Science RDR granules and up to nineteen Spacecraft Diary RDR granules. Each granule contains a group of CCSDS downlink data packets that contain raw measurements for that granule's type and collection period. Each HDF5 RDR file also contains metadata that specify details - such as the acquisition time range - for each granule. An ADL-provided HDF5 unpacker application is used to extract the RDR granules and metadata and store them as separate files. There is one metadata file for each RDR granule file. The RDR granule files are "binary blob" files, meaning that their internal structure does not conform to any standard file format (such as HDF5 or netCDF-4).

Once the RDR granules and associated metadata have been extracted from the HDF5 file obtained from CLASS, the VIIRS C-RDR packer application ingests these files, organizes the data into collections of individual raw measurements, and writes these raw measurements to a netCDF-4 C-RDR file as variables. Granule-level and file-level metadata is written to the C-RDR file as file-level attributes, and measurement-level metadata extracted from Suomi-NPP project documentation is written to the C-RDR file as variable-level attributes.

Once a C-RDR file has been produced, the operational C-RDR processing system will then verify its correctness. Verification is accomplished by "unpacking" the contents of the C-RDR file and producing binary-blob intermediate data product files normally generated by the IDPS during VIIRS data processing. These intermediate files, known as VIIRS Verified RDR (VRDR) files, are the inputs used by the IDPS for generating all higher-level VIIRS data products. If the VRDR files produced from a C-RDR file match the VRDR files generated by the ADL software from the same group of RDR files used to produce the C-RDR file, then the C-RDR file is considered to be verified.

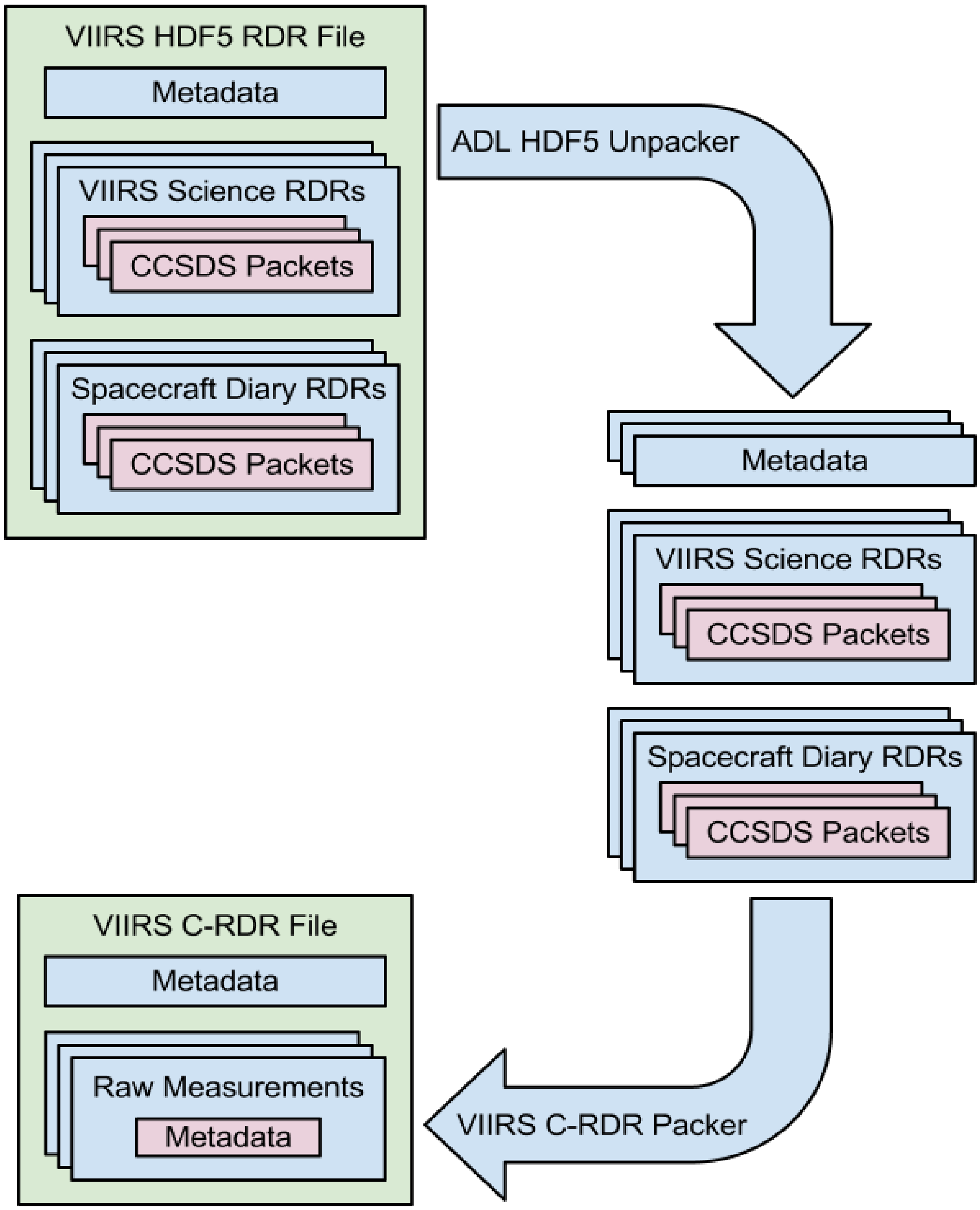


Figure 1: Flow of Data from a VIIRS HDF5 RDR file to a VIIRS C-RDR file.

The VIIRS C-RDR Unpacker application, which is built on ADL just as the VIIRS C-RDR Packer application is, reads in the contents of a VIIRS C-RDR file and writes out binary-blob VIIRS VRDR files, binary-blob Spacecraft Diary RDR files, and the ASCII metadata files that accompany each VIIRS VRDR and Spacecraft Diary RDR file.

There are three parts to the verification process. The VRDR files produced by the VIIRS C-RDR Unpacker must be compared with VRDR files that were produced as a byproduct when the VIIRS C-RDR Packer was run, the Spacecraft Diary RDR files produced by the VIIRS C-RDR Packer must be compared with the Spacecraft Diary RDR files that were used as inputs when the VIIRS C-RDR Packer was run, and the ASCII metadata files produced by the VIIRS C-RDR Unpacker must be compared with the those associated with the corresponding “original” RDR files.

Comparing the different types of files is handled by three different applications. The VIIRS VRDR Comparator application (developed by Linda Copley), the Spacecraft Diary RDR Comparator application, and the ASCII Metadata Comparator application. Once a VIIRS C-RDR file has been produced, it will be used as input to the VIIRS C-RDR Unpacker. These three applications will then be run, and the results of the comparisons will used to determine whether or not the VIIRS C-RDR file is considered verified.

Coding of all of the applications described above was completed during this fiscal year. Operational testing has begun using several previous months of VIIRS RDR files. There are currently only two open issues, neither of which should prevent a transition to operations in the first quarter of FY 2013.

Performance Metrics	**FY12**
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	0

PLANNED WORK
* Complete the operational testing of VIIRS C-RDR production applications.
* Transition to VIIRS C-RDR operational production.

* Automate the handling of support data files for VIIRS C-RDRs. This is currently a manual process.

PUBLICATIONS

N/A

PRESENTATIONS

- Biard J. (2012). Using ADL for NPP Climate Raw Data Record Production. Oral presentation at the JPSS Data Products Engineering (DPE) Algorithm Development Library (ADL) 4.0/4.1 User Workshop. Lanham, MD. 14-15 November 2012.
- Biard J., Copley L., Baldwin D., Saunders D., and Privette J.L. (2013). The VIIRS Climate Raw Data Record: An Easy-to-use Raw Data Set (Level 1b) for the Suomi-NPP Visible Infrared Imaging Radiometer Suite. Oral presentation at the *American Meteorological Society* (AMS) annual meeting. Austin, TX. 6-10 January 2013.
- Biard, J., Dissen, J. (2013), Climate Science and Climate Change Overview, Presentation to the 8th Grade Academically and Intellectually Gifted (AIG) class at Asheville Middle School, Asheville, NC, 7 February 2013.

OTHER ACTIVITIES

- Provided support for the development and verification of Climate Data Record (CDR) metadata for the NCDC CDR Program Office.
- Provided support for the development of NCDC metadata standards with the NCDC Metadata Working Group (NMWG).
- Provided support for the design of the NOAA Comprehensive Large Array Storage System (CLASS) common ingest interface that is currently under development.
- Supporting Pierre Guillevic in the VIIRS LST Cal/Val work.
- Supporting Jenny Dissen's K-12 outreach efforts.

- Optimum Interpolation Sea Surface Temperature (OISST) Transition to Operations

Task Leader	Art Burden
Task Code	NC-CDR-03-NCICS-AB
Main CICS Research Topic	Climate Data and Information Records and Scientific Data Stewardship
Percent contribution to CICS Themes	Theme 1: 50%; Theme 2: 50%
Percent contribution to NOAA Goals	Goal 1: 100%

Highlight: NCDC's Optimum Interpolation Sea Surface Temperature software is being refactored in order to meet CDR Program requirements for operational readiness

BACKGROUND

A primary requirement in bringing Climate Data Records (CDRs) to operational readiness within NCDC is that the software is stable, reproducible, portable, and efficient. The CDR Program works with the Principal Investigator to ensure that incoming CDR software meets these goals for long-term stewardship and transparency. To that end, the Optimum Interpolation Sea Surface Temperature (OISST) product has been selected as a pilot case for investigating the feasibility of refactoring scientific software to meet CDR program requirements while keeping costs manageable.

The OISST software was originally written by CICS staff scientist Dr. Richard Reynolds, and currently runs operationally within the Center. OISST is a high quality product with many end users in the scientific community. While the software runs efficiently, its source code contains a large amount of redundancies, difficult to follow 'spaghetti' code, and incomprehensible variables. In addition, it is written in a proprietary language package, has many hard-coded paths, and requires data inputs retrieved via ftp from permission-based sources, all of which affect the portability of the OISST software.

The OISST refactor project has consisted of several scheduled phases conducted by four part-time to full-time NCDC staff. These phases include a Technical Assessment Review, source code refactoring, control script refactoring, operational framework integration, Test Readiness Review/system testing, and Operational Readiness Review. In addition, the OISST software lacks an Operation Algorithm Document (OAD), which is necessary for NCDC staff to document for NCDC staff, as well as CDR customers wishing to reproduce OISST results.

ACCOMPLISHMENTS

Prior to making any software improvements, it was necessary to perform a technical assessment, followed by an open review, in order to determine the initial state of the OISST source code and present recommendations on how to best proceed. Based on this assessment, we determined that the original source code was of sufficient quality

and functionality to be improved through refactoring, or modifying the code, rather than through a wholesale rewrite in either Fortran or other computer language.
Since the OISST refactor project is a pilot study meant to help determine if and how CDR software may be brought to operational readiness, it was necessary to build an initial framework for how one should perform such an endeavor. Two internal NCDC wiki pages have been developed to document methods and tools that may be used for this type of project in general, as well as a comprehensive list of methods and tools that we chose specifically for improving the OISST software. Because the OISST software is written in Fortran, the wiki pages may be useful for anyone refactoring software written in that computer language. The wiki pages are located at https://local.ncdc.noaa.gov/wiki/index.php/Fortran_Refactoring and https://local.ncdc.noaa.gov/wiki/index.php/OISST_Refactor_Tasks, respectively.

The first step in the refactoring was to build a baseline version of the software in a separate location from the operational software and process test data to reproduce the operational results. This working version of the software was built in a 64-bit bcs container with CentOS 6.0, and uses a 30-day test dataset. The source code was also placed under version control. Daily meetings and code reviews have been utilized to ensure that project goals are being met appropriately.

Most of the source code refactor task has been completed. Below are some of the improvement highlights:

- Converted all source code from fixed-format Fortran 77 to free-format Fortran 95.
- All source code has been checked using static analysis tools throughout the refactor to eliminate syntax issues and ensure that the modified software meets Fortran 95 standards.
- The modified software has also been written to conform with the CDRP General Software Coding Standards (CDRP-STD-0007). Case-by-case exceptions have been documented.
- The software was originally written in Lahey Fortran 77, which is not easily ported. It has been converted to gfortran 95, which is readily available on Linux systems.
- The original code volume has been reduced substantially by removing redundancies and combining similarly functioning subroutines.
- Several hundred 6-character variable names have been replaced with variable names that reflect intent.
- The original source code contained as many as 19 parameters for a single subroutine. The number of subroutine parameters was reduced to conform with the CDRP Coding Standard of seven or fewer.

- GOTO and label-branch statements contribute greatly to issues with code readability. All GOTO and label-branch statements were removed from the source code, making it much more linear and easier to follow.
- The cyclomatic complexity of software represents the number of unique paths through the code. The higher this metric is, the more difficult it is to maintain and test. The CDRP Coding Standard calls for a maximum cyclomatic complexity of 15. The original OISST software contained source code with values as high as 85. A concerted effort was made to reduce the number of unique paths - in the case of the main OISST code, the cyclomatic complexity was reduced by over 60%.
- Unit testing can be incorporated into source code in order to ensure that the code performs as expected when changes are made. We performed a case study for implementing unit testing with the OISST source code and found that, while a significant need exists for this type of checking, the cost of introducing unit testing into previously-written code made it too expensive for the project. To meet the goal of code reliability part-way, we significantly increased the amount of I/O error checking and made substantial improvements to information and error logging in the OISST source code.

Performance Metrics	**FY12**
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	0

PLANNED WORK

* The remaining tasks in the OISST refactor project include: a small amount of source code refactoring, control script refactoring, implementation of Operations Branch ingest, processing, and dissemination procedures, system and acceptance testing.

* The OAD for OISST needs to be written based on a template to be provided by the CDR Program.
* netCDF outputs need to be upgraded to netCDF-4 Classic format and modified to conform with Climate & Forecast (CF) Metadata Conventions

- Suomi-NPP VIIRS Climate Raw Data Record System Infrastructure Development

Task Leader	Linda Copley
Task Code	NC-CDR-04-NCICS-LC
Main CICS Research Topic	Climate Data and Information Records and Scientific Data Stewardship
Percent contribution to CICS Themes	Theme 1: 100%; Theme 2: 0%; Theme 3: 0%
Percent contribution to NOAA Goals	Goal 5: 100%

Highlight: The VIIRS C-RDR processing framework is being integrated with inputs from the NPP mission routed through the NOAA Comprehensive Large Array-data Stewardship System (CLASS) and archived to the Hierarchical Data Storage System (HDSS) at NCDC

BACKGROUND

The Climate Raw Data Record (C-RDR) Project is a sub-system of the Climate Data Record (CDR) Project. The C-RDR Project is responsible for developing a system to acquire, reformat, and enhance the Suomi National Polar-orbiting Partnership (NPP) Raw Data Records (RDRs) and support data required for the production of Climate Data Records (CDRs).

CDRs are fully-calibrated, long-term time series having the consistency and continuity required for the climate research community. The production of CDRs requires the reprocessing of extensive data sets as algorithms are improved and the sensor performance is better understood. To produce CDRs**,** the raw data are required as input for each iteration of the reprocessing.

The goal of the C-RDR system is to provide the NPP and JPSS raw data and supporting data in a format that is enhanced for utilization in research, the production of CDRs, and long-term stewardship. The C-RDRs contain the raw measurements from the CCSDS packets, decoded and decompressed so they are easily accessible in an established data format, netCDF-4. The C-RDRs are quality controlled and assembled into data files, which include information for the computation of earth location and calibration values.

The C-RDR system will reformat the NPP and JPSS raw measurements and support data into easily accessible C-RDR files. The C-RDRs will contain the information required for the production of CDRs and Climate Information Records (CIRs). The C-RDR system will disseminate these C-RDRs to the user community on a routine and operational basis. This task is focused on developing the system infrastructure to support the production of C-RDRs. The Processing Director system will control the flow of ingested Raw Data Records (RDRs) from the NOAA CLASS archive, set up the processing into C-RDRs, as well as track and report on the status of processing. The system is being developed with a generic architecture to provide a framework that allows other processing streams to be inserted into the workflow in place of the C-RDR.

ACCOMPLISHMENTS

The production of the VIIRS C-RDR has been integrated in a test environment with RDRs received from NOAA's Comprehensive Large Array-Data Stewardship System (CLASS), and the C-RDR product archived to the Hierarchical Data Storage System (HDSS) at NCDC. Additional testing has been completed to demonstrate the distribution of C-RDRs through the Unidata Local Data Manager (LDM).

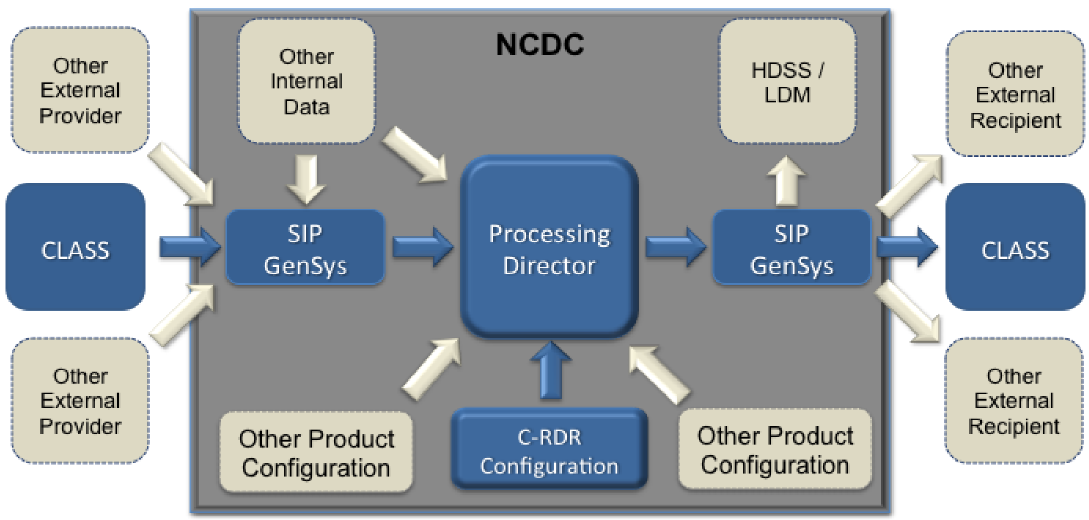


Figure 1: C-RDR Processing Director Context

The C-RDRs were developed based on the pre-launch Suomi National Polar-orbiting Partnership (NPP) system design documents. The application support data formats were validated based on files obtained post-launch from the NPP satellite, and the formats were updated in the application.

A comparator tool has been created to validate that the raw data contained in the RDR is faithfully replicated in final C-RDR product. This comparison tool has been integrated into the product workflow so that each C-RDR is validated prior to archive.

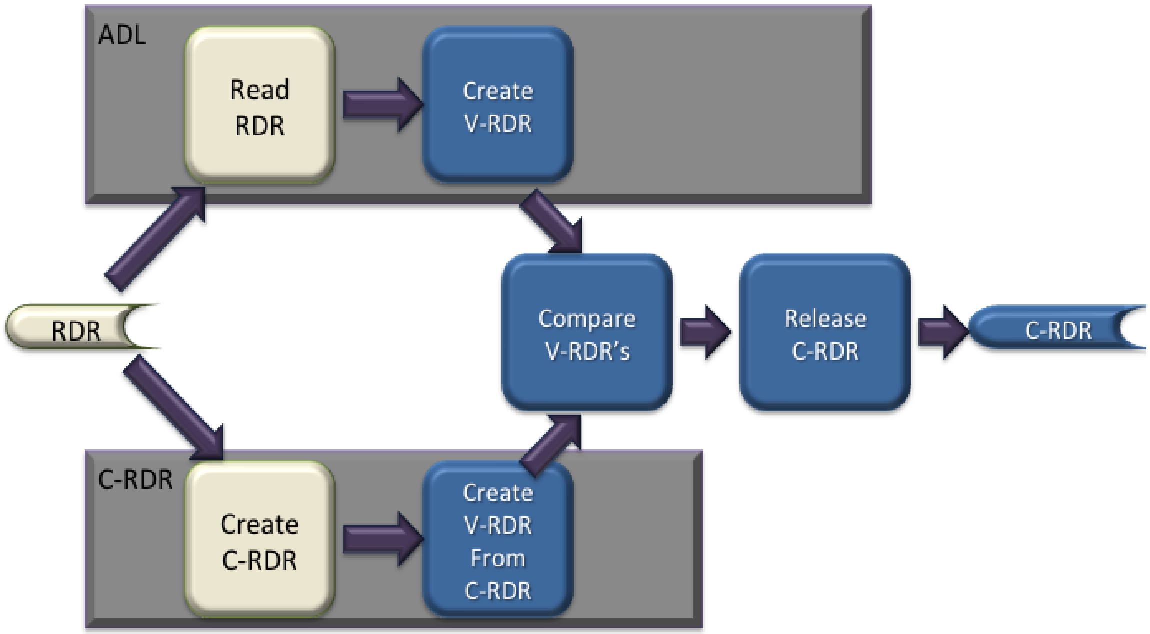


Figure 2: C-RDR Validation Processing Model

During the integration of the system we were able to begin to collect processing statistics. The ingested RDRs average 226 Mb each, and are received at an average rate of 11 files per hour, for a total ingest rate of 264 files or 58 Gb per day. Independent of ingest, we are able to process approximately 1728 C-RDRs per day without data validation, or 528 files per day with validation. With the current combination of hardware and software architecture, the C-RDRs can be processed at a rate of 6.5 days of data per day without validation, or 2 days of data per day with validation.

This project serves as a demonstration project for developing the Standard Operating Procedure for the transition of software into operations. As part of the project, we defined the exit criteria required to move a development project into the testing and operations environments. Draft System Acceptance Test, Software Coding Standards, and Code Review Guidelines were developed for use in this project, and for adaptation into the standards that will be adopted by the Operations Branch within NCDC.

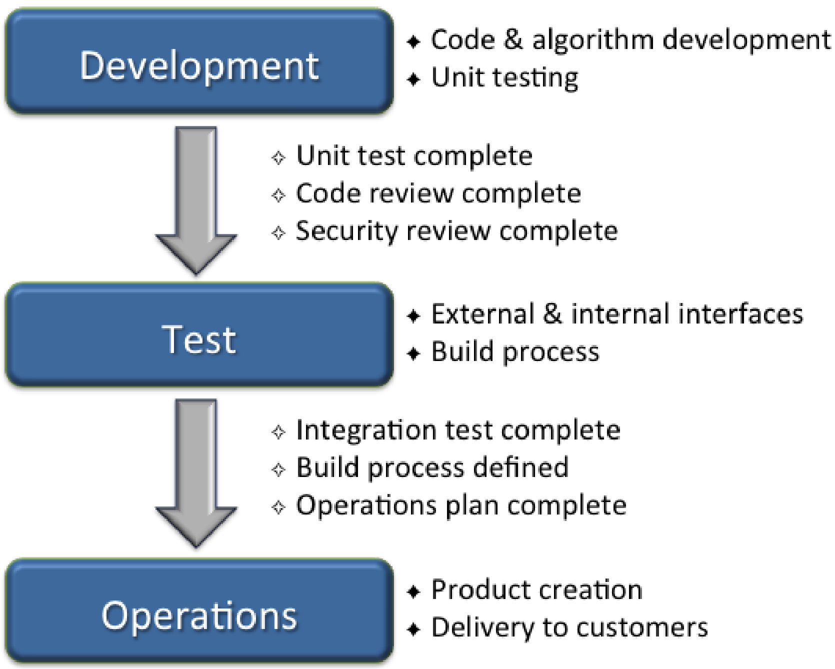


Figure 3: C-RDR 3-Tiered Development Model

Performance Metrics	FY12
# of new or improved products developed	5
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	0

PLANNED WORK

* Complete transition of VIIRS C-RDR into operations.
* Coordinate and complete Standard Operating Procedure for transition of products into operations at NCDC.
* Refine the Processing Director system for controlling the processing of data sets prior to archive.

* Develop operations status and reporting functions for the Processing Director.

OTHER

- Database architect and database developer for Submission Information Package Generation System (SIPGenSys) configuration sub-system.
- Member of NCDC Metadata Working Group (NMWG). Member of Data Governance Tiger Team, and Metadata Versioning and Control Tiger Team. Contributed to NCDC End-to-End Process development and pilot project. Lead for development of Research-to-Operations SOP and Operations SOP.

- Transfer NOAA/NASA AVHRR Pathfinder SST Processing to NODC

Task Leader Robert Evans; (NOAA Collaborator: Kenneth Casey)
Task Code NC-CDR-05-UM
Main CICS Research Topic Climate Data and Information Records and Scientific Data Stewardship
Percent contribution to CICS Themes Theme 1: 0%; Theme 2: 100%; Theme 3: 0%
Percent contribution to NOAA Goals Goal 1: 100%; Goal 2: 0%

Highlight: The Pathfinder SST time series has been extended to include NOAA-19 observations. This is a continuation of the previously submitted time series that covered the AVHRR sensors NOAA-7 through NOAA-18. In addition, the coverage period of NOAA-7 was expanded to include September and October of 1981 through cooperative work with NCDC/RSAD and NODC to provide the augmented Reynolds OI reference SST fields that are required to process the Pathfinder time series.

BACKGROUND
The primary goal of this work is to assemble AVHRR SST retrieval algorithms into a robust code package to produce a Climate Quality data Record (CDR) for the AVHRR SST time series, NOAA-7 (September 1981) through NOAA-19 (2013) and deliver the package to NODC to support on-going production of the AVHRR Pathfinder SST time series. This work is based on the Pathfinder 5.2 approach, originally published in Kilpatrick et. al, 1999 (Pathfinder 5.0) and updated to 5.2 with the inclusion of an updated land mask, use of the Reynolds ¼ degree, daily OI analysis enhanced with rivers and lakes and inclusion of ancillary fields required by the GHRSST Version 2.0 file specification and formatted in the GHRSST NetCDF4 files format.

ACCOMPLISHMENTS
Accomplishments during the period April 1, 2012 to March 31, 2013 include:
- Implementation of updated AVHRR SeaDAS 6.4 retrieval codes.
- Update of AVHRR processing to support NOAA-19
- Update of ATBD to reflect inclusion of NOAA-19 processing support
- Addition of Pathfinder 5.2 SST fields for NOAA-7 beginning with observations from September and October 1981. These dates were not originally processed due to non-availability of the Reynolds OI SST reference fields.
- Addition of Pathfinder 5.2 SST fields for NOAA-19 beginning with observations from 2011 through Sept 2012.
- Transfer of NOAA-7 and NOAA-19 Pathfinder 5.2 data set to NODC for conversion to GHRSST format NetCDF fields.
- The NODC group performed extensive checking of the Pathfinder data products and delivered the entire time series to NCDC for archive

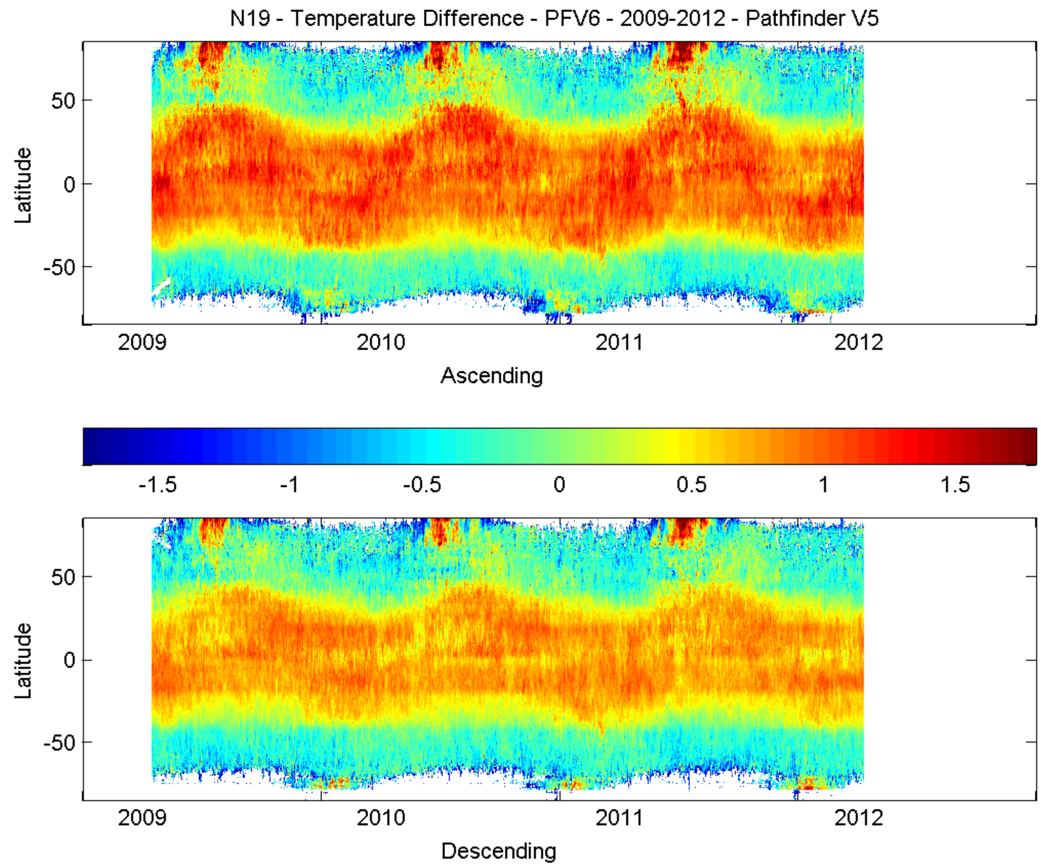


Figure 1: Pathfinder 5.2 Latitude-Time plot of NOAA-19 residuals with respect to the Reynolds ¼ degree, daily global SST reference fields. Each data point is a daily, ¼ degree average of the best quality 4km residuals found within the ¼ box. Top plot, Ascending, is the daytime field while the Bottom plot shows the nighttime residuals.

Performance Metrics	FY12
# of new or improved products developed	2
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	0

PLANNED WORK
* Transfer of Pathfinder SeaDAS 6.4 implementation to NODC and NCDC
* Continued production of NOAA-19 Pathfinder 5.2 SST dataset.
* Transfer of updated NOAA-19 dataset to NODC for NetCDF file conversion.
* Transfer of Pathfinder on-going production to NODC.

PUBLICATIONS
N/A

PRESENTATIONS
N/A

OTHER
N/A

- Detection of Aerosol Signal from Geostationary Imager Visible Channel

Task Leader	Anand Inamdar
Task Code	NC-CDR-06-NCICS-AI
Main CICS Research Topic	Climate Data and Information Records and Scientific Data Stewardship
Percent contribution to CICS Themes	Theme 1:30%; Theme 2:35%; Theme 3:35%
Percent contribution to NOAA Goals	Goal 1:30%; Goal 2:70%

Highlight: A novel approach has been proposed for the retrieval of aerosols from the geostationary orbits (GEO) around the world, through combining GEO visible data with AVHRR mid infrared channel information. This has the potential to produce long time series of Climate Data Records (CDR) of aerosols over the earth's land surface.

BACKGROUND

Aerosol retrieval has been normally confined to polar orbiters such as the Advanced Very High Resolution Radiometer (AVHRR) and Moderate Resolution Imaging Spectroradiometer (MODIS) instruments, etc. and mostly over the ocean regions. While the multi-channel configurations of polar orbit sensors offer the best potential for aerosol retrieval, they lack the detection of diurnal sampling offered by the geostationary meteorological satellites. Diurnal variation becomes vital in the study of forest fires, biomass burning, dust outbreak episodes, air pollutant transport, and aviation. Geostationary satellites, with their long time history of measurements, provide the best opportunity in the study of evolution of aerosols and their radiative forcing over time in different regions of the earth. Earlier attempts of aerosol retrieval (Knapp, 2008; Knapp et al, 2005) from GEO employed observations from GOES-8 over the North American continent only. The present study exploits the recently re-calibrated ISCCP B1 data and extends analysis over the entire globe.

ACCOMPLISHMENTS

The possibility of aerosol retrieval over diverse areas of the world has been assessed by comparing cloud-free reflectance observed by the GEO visible channel with ground measurements of aerosol optical depth (AOD). Such observations are available from hundreds of sites all over the globe with the Aerosol Robotic Network (AERONET), equipped with sun-sky radiometers reporting measurements at regular intervals during the day. Linear correlations found over most of sites studied (example sites shown in Fig. 1) reveal a very good potential for aerosol retrieval.

However, presence of an aerosol signal is not sufficient for aerosol retrieval. One needs to apply atmospheric correction through radiative transfer, and estimation of surface reflectance is an integral part of the retrieval process. Past studies have utilized 30-day clear-sky composites of visible imagery to retrieve the surface reflectance. This method has been found to have several limitations. In the present study, the AVHRR mid-IR (3.75 mm) channel has been found to be well correlated with the surface reflectance after correcting for the thermal emission component (Fig. 2), and shows great promise for the estimation of accurate surface reflectance.

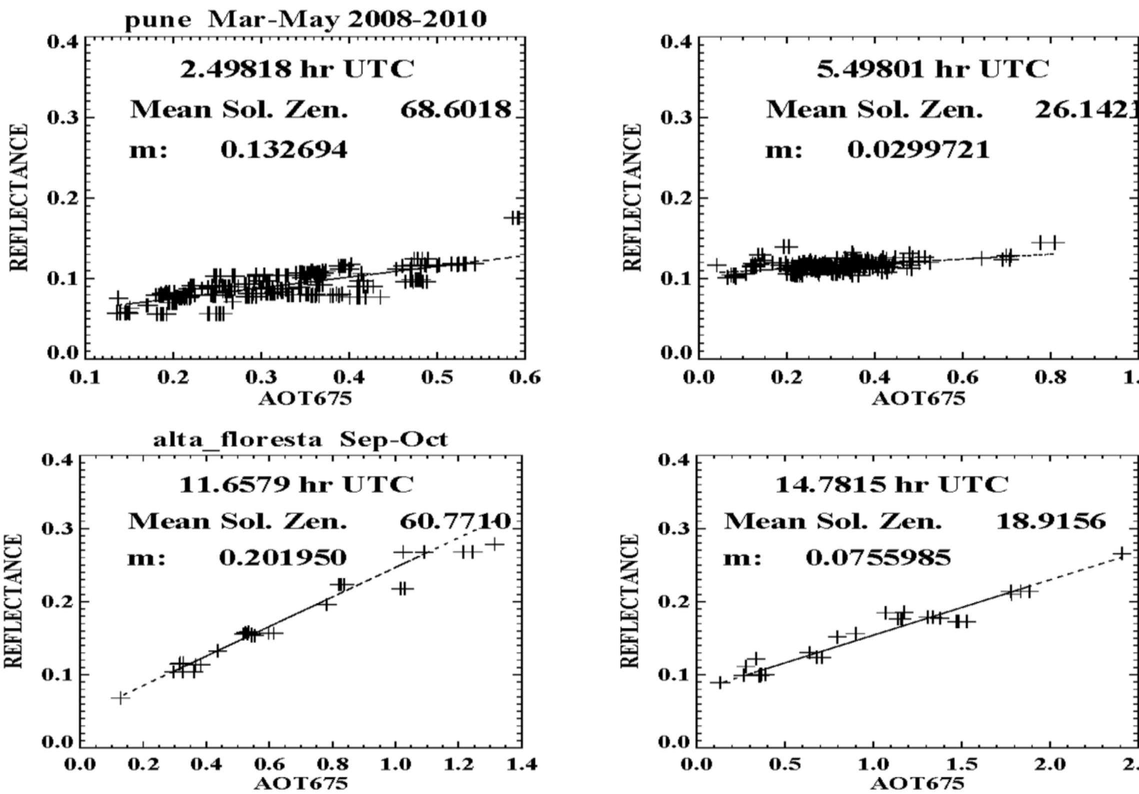


Figure 1: Calibrated Metesat-7 reflectance versus AERONET-measured AOD at 0.675 micron at Pune (upper panel) station, 100 km inland of West Coast of India. The bottom panel shows GOES-8 observed reflectance at the Alta_Floresta site which experiences prolific deforestation fires during Sep-Oct period.

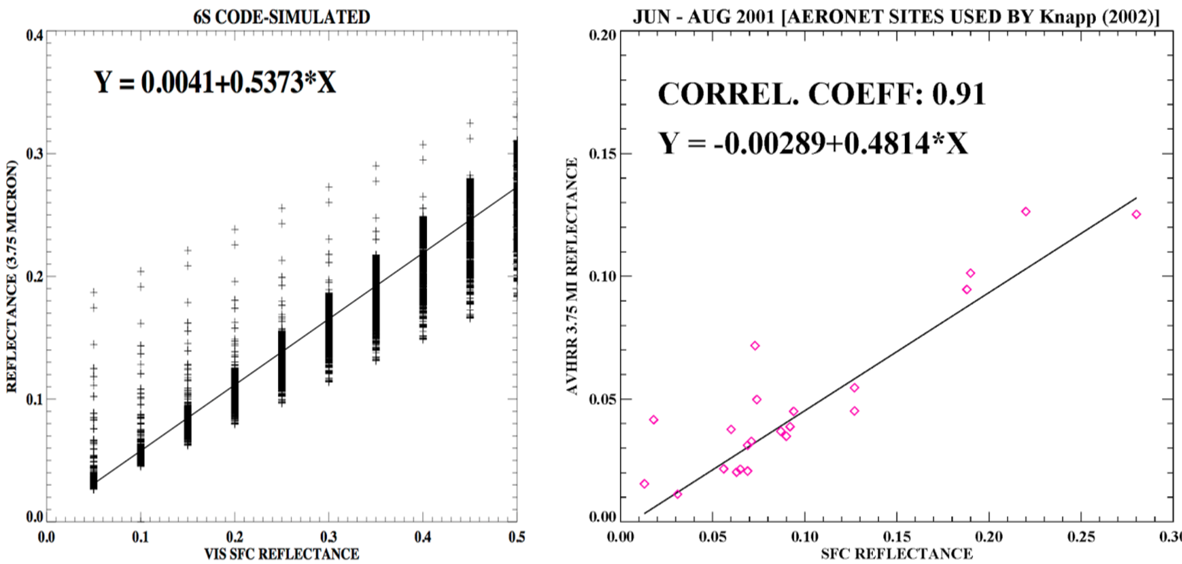


Figure 2: Results from both theoretical (left) and observation-based studies over the North American region (right) indicate consistent correlations implying a great potential for the retrieval of surface reflectance in the GEO visible range.

Performance Metrics	FY12
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	
# of peer reviewed papers	
# of non-peered reviewed papers	1
# of invited presentations	
# of graduate students supported by a CICS task	
# of undergraduate students supported by a CICS task	

PLANNED WORK

* Surface reflectance values from the AERONET-based surface reflectance validation network (MODASVRN product) will be used to determine correlations between the reflective part of the AVHRR-observed mid-IR spectrum and surface reflectance, to produce a global map of surface reflectance in the GEO visible spectrum.

* Employ the retrieved surface reflectance in aerosol retrieval and compare with MODIS, LANDSAT, etc.
* A peer-reviewed manuscript on the new approach is planned within the next two months.

PUBLICATIONS

Non Peer-reviewed:

Inamdar, A. K., and K. Knapp, 2013: 'Detection of aerosol signal from geostationary satellite imagery'. Fifth Symposium on Aerosol-Cloud-Climate Interactions. Proceedings of the 93rd American Meteorological Society Annual Meeting.

PRESENTATIONS

- Inamdar, A. K.: 'Detection of aerosol signal from geostationary satellite imagery'. Fifth Symposium on Aerosol-Cloud-Climate Interactions. 93rd American Meteorological Society Annual Meeting, Austin 7 Jan 2013.

- Improvements to the Calibration of the Geostationary Satellite Imager Visible Channel in the ISCCP B1 Data

Task Leader Anand Inamdar
Task Code NC-CDR-07-NCICS-AI
Main CICS Research Topic Climate Data and Information Records and Scientific Data Stewardship
Percent contribution to CICS Themes Theme 1: 30%; Theme 2: 35%; Theme 3: 35%
Percent contribution to NOAA Goals Goal 1: 50%; Goal 2: 50%

Highlight: Further improvements to the calibration of Geostationary Satellite (GEO) Imager visible channel have been implemented following suggestions from the ISCCP processing group led by Dr. William Rossow. Separately, the pre-GVAR GOES data has been reprocessed to conform to a more consistent format with less noise, and these reprocessed data files will soon replace the present ISCCP B1 data in the archive.

BACKGROUND

The ISCCP (International Satellite Cloud Climatology Project) B1 data represents geostationary imagery at 3 hourly and 10 km spatial resolution retrieved from the suite of geostationary meteorological satellites all over the world. It will soon be employed in the reprocessing of the ISCCP Cloud Climatology, surface radiation budget, and aerosol retrieval at higher spatial resolution. For accurate retrieval of these geophysical parameters, it is vital to have a good calibration. The visible channel calibration is currently managed by the Meteorological Center in France through normalization with the concurrent Advanced Very High Resolution Radiometer (AVHRR) solar channel on the afternoon NOAA polar-orbiting satellite at the same viewing geometry. However, there are several gaps in the present calibration, such as prior to the year 1983, and it suffers from too much noise for certain GEO sensors. The main objective of the present project is to fill in these calibration gaps and perform a uniform calibration for all the geostationary satellite visible channels from 1979 until present, through cross-calibration with the MODIS-quality AVHRR visible channel Climate Data Record (CDR) product available at NOAA/NCDC.

ACCOMPLISHMENTS

The implementation of the cumulative histogram matching technique to perform the cross-calibration of the GEO visible channel with the AVHRR PATMOS-x data was reported last year. However, only the time series of the calibration slope was used as a measure of degradation of the sensor. Following extensive exchanges with the ISCCP processing group, the calibration formulae have been revised through introducing a nonlinear variation among slope, intercept (as derived through the cumulative histogram matching for each month) and annual degradation in terms of the time lapsed since the launch of the satellite. Thus, L, radiance in W m-2 micron-1 ster-1 is expressed as,

$L =$

$(a0 + a1 * X) * (g0 + g1 * Y + g2 *$

$Y2.)$, where a0, a1, g0, g1, and g2 are constants and Y *is the number of years since launch, and X is the digital count value measured by the detector.*

The resulting final calibration performs much better and minimizes noise. Examples are shown in Figs. 1 & 2 below for GOES-12 and MSG-1 satellites.

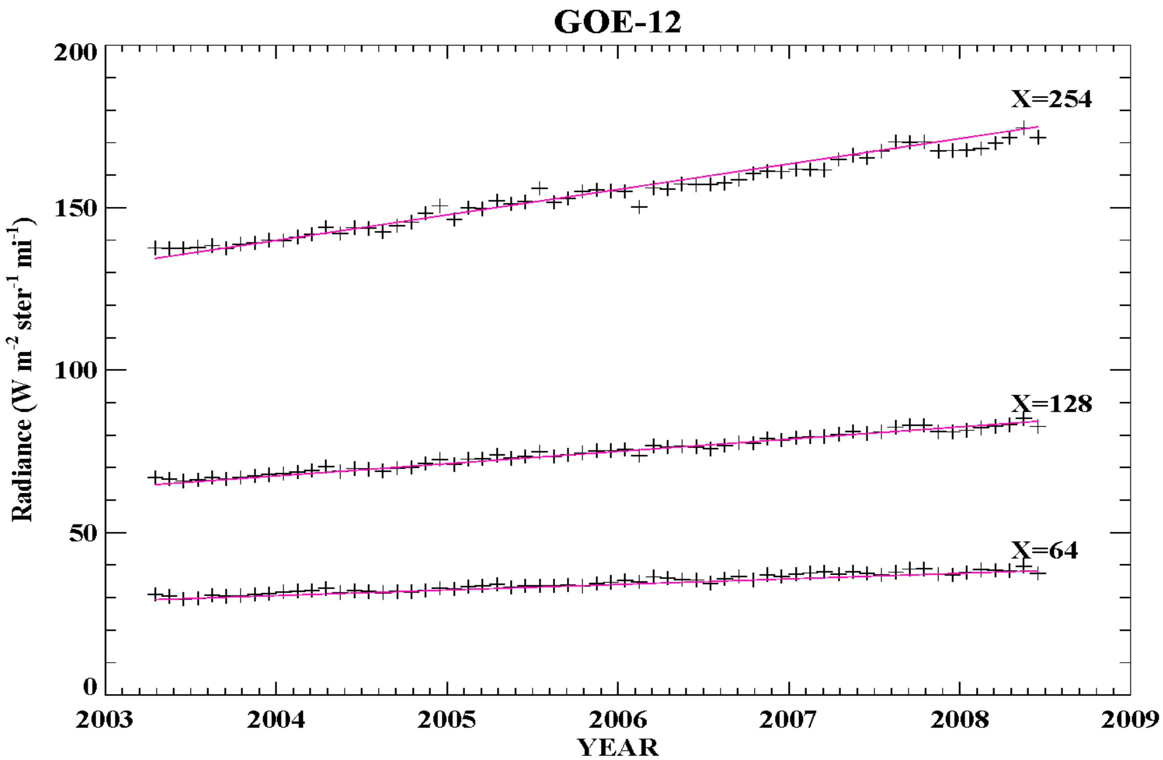


Figure 1: Measured radiance as a function of the number of years since launch for GOES-12 for count values (8-bit) of X=64, 128 and 254. The symbols represent ISCCP calibration and the magenta-colored line refers to the present calibration.

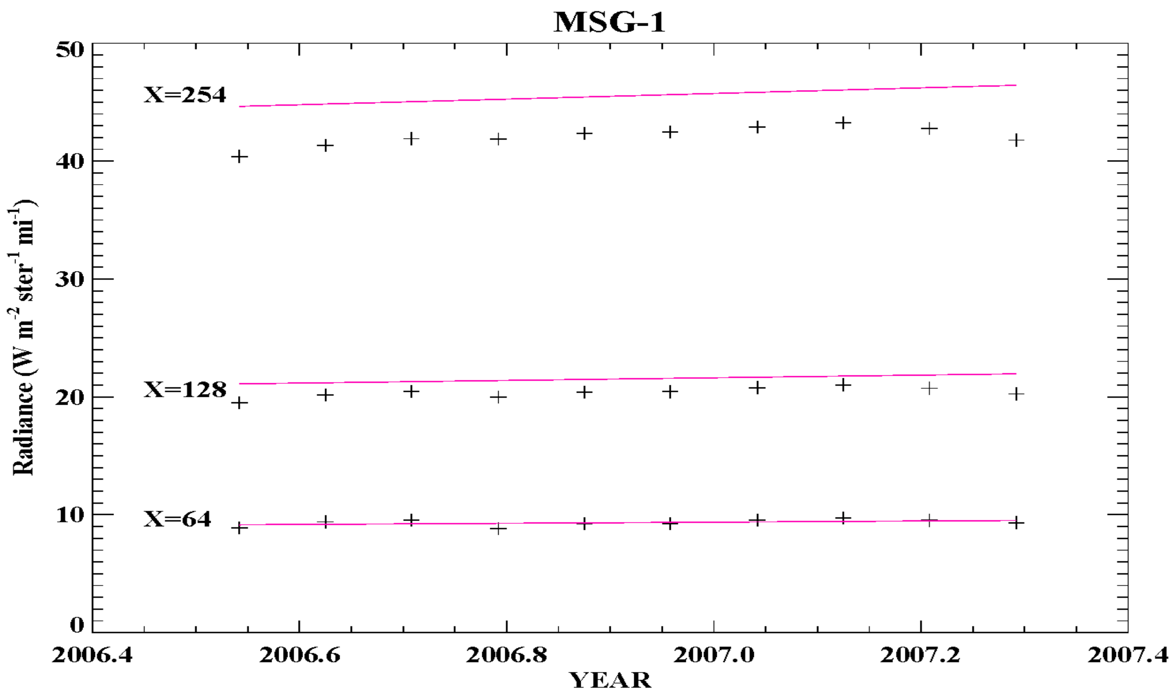


Figure 2: Same as in Fig.1, but for Meteosat Second Generation (MSG-1) satellite.

Performance Metrics	**FY12**
# of new or improved products developed	2
# of products or techniques transitioned from research to ops	
# of peer reviewed papers	
# of non-peered reviewed papers	1
# of invited presentations	
# of graduate students supported by a CICS task	
# of undergraduate students supported by a CICS task	

PLANNED WORK

* A manuscript for submission to a peer-reviewed article relating to calibration is under preparation and will soon be submitted.
* The reprocessing of the GOES (pre-GVAR and GVAR) ISCCP B1 data will be completed, after filling in the existing data gaps. The reprocessed ISCCP B1 data will re-place the existing version in the archive and represent larger amount of data with more uniform and consistent formatting with better calibration.

PUBLICATIONS

Non-peer reviewed:

Inamdar, A. K., and Ken Knapp, 2012: Assessment of Calibration Performance of the Geostationary Satellite Image Visible Channel in the ISCCP B1 Data., 18th Conference on Satellite Meteorology, Oceanography and Climatology/ First Joint AMS-Asia Satellite Meteorology Conference, Proceedings of the 92nd AMS Annual Meeting, New Orleans Jan 25, 2012.

PRESENTATIONS

- Inamdar, A. K., and Ken Knapp, 2012: Assessment of Calibration Performance of the Geostationary Satellite Image Visible Channel in the ISCCP B1 Data., 18th Conference on Satellite Meteorology, Oceanography and Climatology/ First Joint AMS-Asia Satellite Meteorology Conference, 92nd AMS Annual Meeting, New Orleans Jan 25, 2012.

- Implementation of Geostationary Surface Albedo (GSA) Algorithm with GOES data

Task Leader	Jessica Matthews
Task Code	NC-CDR-08-NCICS-JM
Main CICS Research Topic	Climate Data and Information Records and Scientific Data Stewardship
Percent contribution to CICS Themes	Theme 2:100%
Percent contribution to NOAA Goals	Goal 1:100%

Highlight: The GSA algorithm is being implemented as the American contribution of an international collaboration between Europe, Japan, and the US to produce a joint Climate Data Record

BACKGROUND

Surface albedo is the fraction of incoming solar radiation reflected by the land surface, and therefore is a sensitive indicator of environmental changes. To this end, surface albedo is identified as an Essential Climate Variable (ECV) by the Global Climate Observing System (GCOS). In support of the Sustained, Coordinated Processing of Environmental Satellite Data for Climate Monitoring (SCOPE-CM), we are implementing the GSA algorithm for GOES data on behalf of NOAA to contribute to an international effort in collaboration with EUMETSAT and JMA. This effort signifies the first such attempt to use the same core algorithm across internationally operated geostationary satellites to produce a climate data record for this variable. Currently, the GSA algorithm generates products operationally at EUMETSAT using geostationary data from satellites at 0° and 63°E and at JMA using 140°E geostationary data. To create the stitched global Level 3 product as illustrated in Figure 1, NCDC is tasked with implementing the algorithm for GOES-E (75°W) and GOES-W (135°W).

Previously the GSA algorithm was run with GOES data only for viability studies with 10 days of data. To effectively and efficiently generate products with this algorithm over large time periods, much effort was extended to understand the application to GOES data specifically. The effort may be divided into two general categories: Operations and Science. Examples of Operations tasks include: porting code developed in the EUMETSAT computing environment to be functional in the NCDC computing environment, code development to work with GOES data format imagery, code development for ancillary NWP input data, etc. Examples of Science tasks include: evaluation of the effect of different spatial and temporal resolutions of GOES as compared to the resolutions of EUMETSAT and JMA satellites, validation of the algorithm as applied to GOES data with external data sets, development of uncertainty bounds for the product, etc.

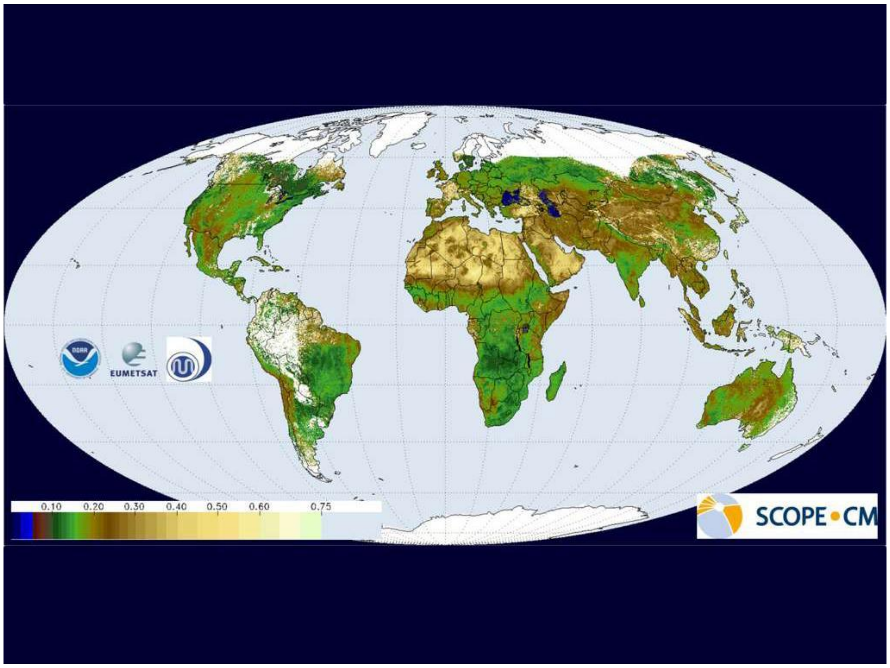


Figure 1: Broadband black sky albedo spatial composite product for the period 1-10 May 2001.

ACCOMPLISHMENTS

To date, much of the effort for this project has been directed towards implementation of an operational algorithm at NCDC. The 32-bit core algorithm has been successfully ported to the 64-bit computing environment at NCDC. We have developed a code package to convert GOES formatted imagery into the required binary input for the core algorithm, to accept NCEP inputs for total column water vapor and ozone, and to process in parallel on the computer cluster infrastructure. And, we have developed a preliminary code package to convert the binary product output into netCDF4 format for archival.

In April and August 2012 Jöerg Schulz, of the team of collaborators from EUMETSAT, visited NCDC. During these visits a number of items were discussed. We updated on the status of Level 2 processing at NCDC, discussed future plans for joint Level 3 product generation, and begin initial discussions about the future of GSA in Phase-2 of SCOPE-CM.

In September 2012, we delivered all products for GOES-E and GOES-W for the SCOPE-CM requested period of 2000-2003. This is the largest reprocessing of GOES data undertaken at NCDC, working with 45 TB of input data. The work made use of the CICS computing facility, processing in only weeks, using nearly 70 parallel streams. We are currently analyzing the resultant products.

A letter of intent was submitted to SCOPE-CM in January 2013 to continue and extend the international collaboration of the GSA project into Phase 2. This second phase is planned to last 5 years and includes activities such as: a common cloud mask approach, a common intercalibration method, exploration of different temporal resolutions and formats of output, and validation of Level 2 products.

Performance Metrics	FY12
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	1
# of peer reviewed papers	1
# of non-peered reviewed papers	
# of invited presentations	3
# of graduate students supported by a CICS task	
# of undergraduate students supported by a CICS task	

PLANNED WORK

* Submit full proposal to SCOPE-CM for Phase 2 work.
* Validation of GSA products with MODIS and in situ observational data.
* Pending validation, the algorithm will be implemented for the entire historical record of GOES data (1979-present).
* Evaluate and extend the uncertainty analysis technique implemented by the GSA algorithm.
* Research possible angular and seasonal patterns in RPV parameters.

PUBLICATIONS

Lattanzio, A., Schulz, J., Matthews, J., Okuyama, A., Theodore, B., Bates, J.J., Knapp, K.R., Kosaka, Y., Schueller, L. (2012) Land surface albedo from geostationary satellites: a multi-agency collaboration within SCOPE-CM. Bulletin of the American Meteorological Society, doi:10.1175/BAMS-D-11-00230.1.

PRESENTATIONS

- Matthews, J.L., Lattanzio, A., Hankins, W., Knapp, K., and Privette, J. (2012), Land surface albedo based on GOES geostationary satellite observations. Poster presented at AGU Annual Meeting, December 3-7, 2012, San Francisco, CA.

- Matthews, J.L. (2012), A SCOPE-CM Initiative: Surface albedo from the geostationary constellation. Presented at NOAA's Annual Climate Data Record Conference, July 31-August 2, 2012, Asheville, NC.
- Lattanzio, A., Theodore, B., Schulz J., Scheuller, L., Matthews, J., Knapp, K., Okuyama, A., Kosaka, Y. (2012), Land surface albedo retrieval within the SCOPE-CM initiative. Presented at IGARSS, July 22-27, 2012, Munich, Germany.

OTHER

- The products from GOES-E and GOES-W for 2000-2003 were delivered to EUMETSAT in September 2012.

- Uncertainty Quantification for Climate Data Records

Task Leader	Jessica Matthews
Task Code	NC-CDR-09-NCICS-JM
Main CICS Research Topic	Climate Data and Information Records and Scientific Data Stewardship
Percent contribution to CICS Themes	Theme 3: 100%
Percent contribution to NOAA Goals	Goal 1: 100%

Highlight: Uncertainty quantification in climate research is a multidisciplinary area of increasing importance

BACKGROUND

Observations are key to uncertainty quantification in climate research because they form the basis for any evidence of climate change and provide a corroborating source of information about the way in which physical processes are modeled and understood. However, observations themselves possess uncertainties originating from many sources including measurement error and errors imposed by the algorithms generating derived products (see Figure 1). Over time global observing systems have undergone transformations on pace with technological advances and these changes require adequate quantification of resultant imposed biases to determine the impact upon long term trends. The uncertainties in climate observations pose a set of methodological and practical challenges for both the analysis of long-term trends and the comparison between data and model simulations.

The data flow for a climate data record, illustrated as a “fountain” in Figure 1, shows that at each level of climate data manipulation, additional uncertainties are introduced. At the premier level, raw data is affected by measurement errors. During the quality control procedures of the next level, uncertainty may be introduced when correcting the geolocation of measurements and identifying inconsistent measurements. The homogenization methods used to remove systematic bias and data artifacts at the next level may introduce additional uncertainty. Finally, both the choice of dataset to use as input and the forward model algorithms applied to generate derived products may introduce another layer of uncertainty. The typical climate data user gathers records from the “pool” at the bottom of this “fountain”, thereby realizing the total sum of uncertainties from all the preceding levels.

ACCOMPLISHMENTS

The mission of communicating the statistical needs of CICS-NC/NCDC to the larger community was addressed by attending and organizing multiple conferences. We attended the Society for Industrial and Applied Mathematics (SIAM) conference on Uncertainty Quantification In April 2012, chaired a session at the Statistical and Applied Mathematical Sciences Institute (SAMSI) Massive Dataset Program opening workshop in September 2012, and organized the Workshop on Massive Datasets in Environment and Climate in February 2013. Additionally, a synopsis paper of outcomes of the CICS-NC-organized 2012 Uncertainty Quantification for Climate Observations workshop was accepted by BAMS.

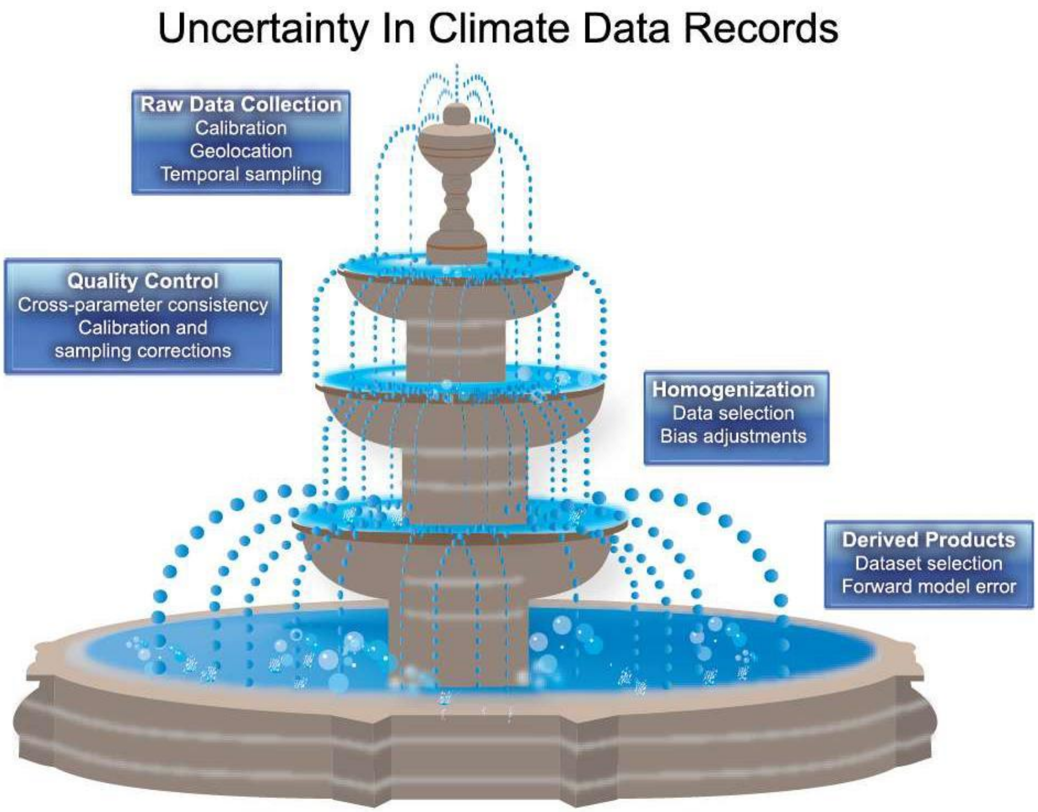


Figure 1: Uncertainty in climate data records: it is necessary to understand all the uncertainties in the observing system and data manipulation processes. Additional uncertainties are introduced at each level leading to an uncertainty cascade.

Further, as chairperson of the Climate Working Group for SAMSI's 2012-13 Program on Statistical and Computational Methodology for Massive Datasets, beginning in September 2012 virtual weekly meetings are organized and held throughout the academic year. The participants in the working group include graduate students, postdocs, and scientists from various governmental agencies and academic institutions across the country and world. This activity has introduced CICS-NC as an entity in the mathematics/statistics for climate community network. Project topics being researched by the working group include: detection and attribution when comparing climate model output with observational data, uncertainty quantification for the global carbon cycle, spatial statistics on distributed data, and determining an optimal method to analyze citizen science classifications of tropical cyclones.

A collaboration with Sandia National Laboratories, CICS-NC, and CICS-MD was formalized with the submittal of a letter of intent in February 2013 for a multi-year project: "Estimating uncertainties in satellite measurements of outgoing longwave radiation (OLR)". OLR is recognized as an essential climate variable, and NCDC's Climate Data Record (CDR) Program offers an operational OLR product. This CDR does not yet have a full end-to-end quantification of the product uncertainties. Our goal is to demonstrate uncertainty quantification in the OLR CDR product, thus improving the overall confidence and applicability of the dataset. Pending successful implementation of UQ methodologies to the OLR CDR, we hope to encourage the CDR Program to more formally assess uncertainties on other operational and developmental datasets.

Performance Metrics	**FY12**
# of new or improved products developed	
# of products or techniques transitioned from research to ops	
# of peer reviewed papers	2
# of non-peered reviewed papers	
# of invited presentations	1
# of graduate students supported by a CICS task	
# of undergraduate students supported by a CICS task	

PLANNED WORK

* Continue to bridge between NCDC and the largely academic mathematical and statistical communities.
* Evolve the Uncertainty Quantification for Climate Observations workshop, like the one co-organized by CICS-NC and held at NCDC in 2012, into a regular event to facilitate continued cooperation and communication within the science.
* Submit a full proposal for the UQ for CDR project.

PUBLICATIONS

Matthews, J.L., E. Mannshardt, and P. Gremaud (2012), "Uncertainty Quantification for Climate
Observations", *Bull. Amer. Meteor. Soc.*, doi: 10.1175/BAMS-D-12-00042.1.

Matthews, J.L., R.C. Smith, and E.L. Fiscus, (in press) Confidence interval estimation for an empirical
model quantifying the effect of soil moisture and plant development on soybean (Glycine max (L.) Merr.) leaf conductance, *International Journal of Pure and Applied Mathematics*.

PRESENTATIONS

- Najm, H. (2012), Uncertainty quantification in processed data products, NOAA's National Climatic Data Center, Asheville, NC, 18 September 2012.

OTHER

- Chairperson of the Climate Working Group for SAMSI's 2012-13 Program on Statistical and Computational Methodology for Massive Datasets
- Session chair and panel moderator at SAMSI's Massive Dataset Program opening workshop, Research Triangle Park, NC, September 9-12, 2012
- Organizer for Workshop on Massive Datasets in Environment and Climate, Boulder, CO, February 13-15, 2013

- Maintenance and Production of CDRs for MSU/AMSU Atmospheric Temperatures and SSM/IS Brightness Temperatures

Task Leader Carl Mears
Task Code NC-CDR-10-RSS
Main CICS Research Topic Climate Data and Information Records and Scientific Data Stewardship
Percent contribution to CICS Themes Climate and Satellite Observations and Monitoring: 100%
Percent contribution to NOAA Goals Goal 1: 100%

Highlights: MSU/AMSU brightness temperatures transferred to CDR Archive at NCDCSSM/I Version 7 brightness temperatures transferred to CDR Archive at NCDC

BACKGROUND

NOAA's National Climatic Data Center (NCDC) Climate Data Record Program (CDRP) leads NOAA's development and provision of authoritative satellite climate data records (CDRs) for the atmosphere, oceans, and land. This project addresses CDRP's current need to sustain and maintain two specific CDRs derived from satellite microwave radiometers:

1. Atmospheric temperatures at multiple layers derived from the Microwave Sounding Units (MSUs) and Advanced Microwave Sounding Units (AMSUs)
2. Top of the atmospheric (TOA) brightness temperature (TB) derived from the SSM/I on the F15 spacecraft and from the SSM/IS on the F17 spacecraft

The air temperature measurements began in late 1978 with the launch of the first Microwave Sounding Unit (MSU), and the SSM/I brightness temperature measurements began in 1987 with the launch of the first SSM/I on the DMSP F08 spacecraft. Both types of measurements will continue to be recorded with the ongoing operation of various Advanced Microwave Sounding Units (AMSUs) on NOAA, NASA, and EUMETSAT platforms and with the four SSM/IS on F16, F17, F18, and F19.

These measurements have been an important part of national (CCSP) and international (IGPP) assessments of climate change, as well as providing a basis for a number of independent studies of climate change. The continuation, validation, and improvement of these datasets are thus of fundamental importance to our ability to continue to monitor long-term changes in atmospheric temperature. The goal of this proposal is to ensure the continued production of high quality CDRs from both MSU/AMSU and SSMI/SSMIS.

ACCOMPLISHMENTS

The main focus of this project to date has been to transition the MSU/AMSU and SSM/I brightness temperature products from research to operations. In the two sections below we summarize progress to data on each of the data products.

MSU/AMSU

We have completed the following tasks for MSU/AMSU:

· Completion and Approval of the Submission Agreement for this dataset.

· Transfer to NCDC of a documented version of the source code used to generate the MSU/AMSU dataset.

· Conversion of the dataset to netcdf4 with approved, CF 1.6 compliant metadata.

· Begun routine transfer of the MSU/AMSU data to NCDC on a monthly basis.

· On-going data production for AMSU instruments on NOAA-15, NOAA-16, NOAA-18, NOAA-19, METOP-A, and AQUA satellites.

An example of the monthly atmospheric temperature anomalies from this dataset is shown below.

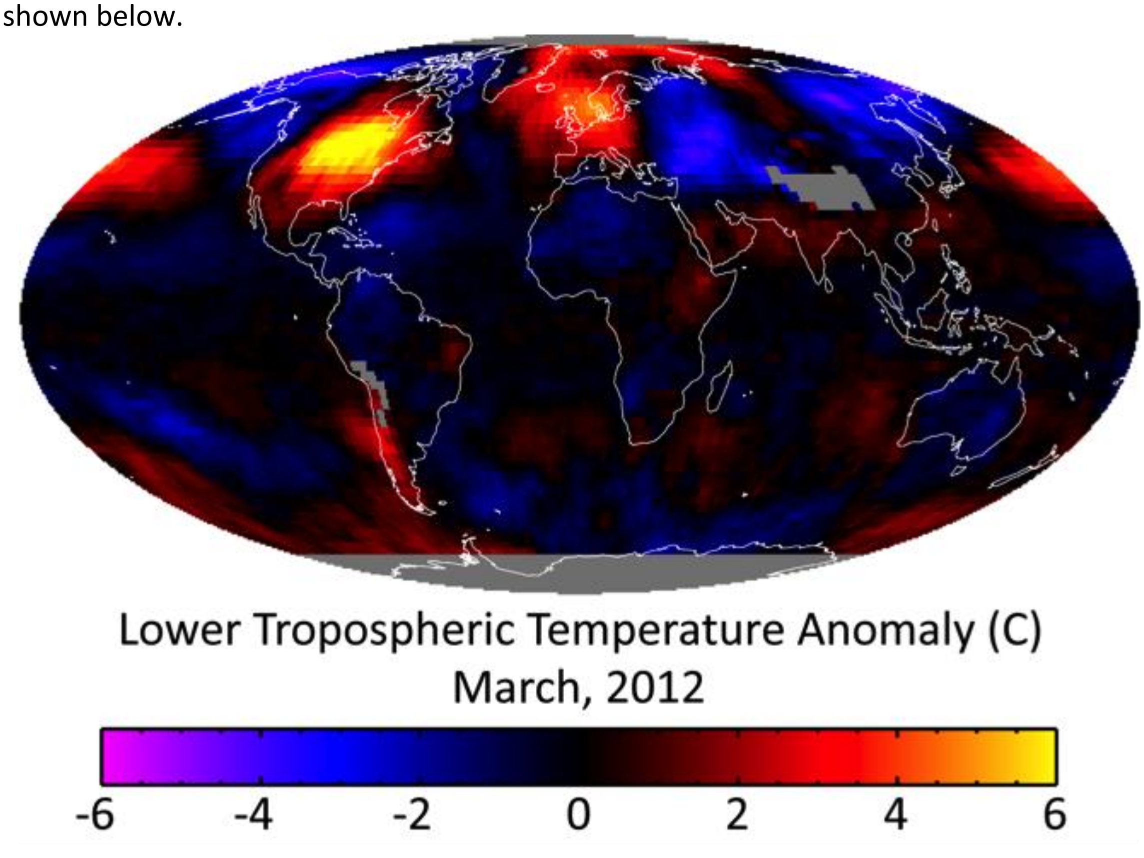


Figure 1: Temperature Anomaly in the lower troposphere for March, 2012. The large positive anomaly over the Central and Eastern United States corresponds to the record-setting surface temperatures observed during this period

SSM/I – SSMIS

We have completed the following tasks for SSM/I – SSMIS.
· Completion and Approval of the Submission Agreement for this dataset.
· Conversion of the dataset to netcdf4 with approved, CF 1.6 compliant metadata.
· Transfer of the historical (1987-2011) SSM/I brightness temperature data to NCDC.
· Submission of a detailed calibration report to NCDC.
· On-going production of data from F17

A daily map of the 37 GHz H-Pol brightness temperatures is shown below.

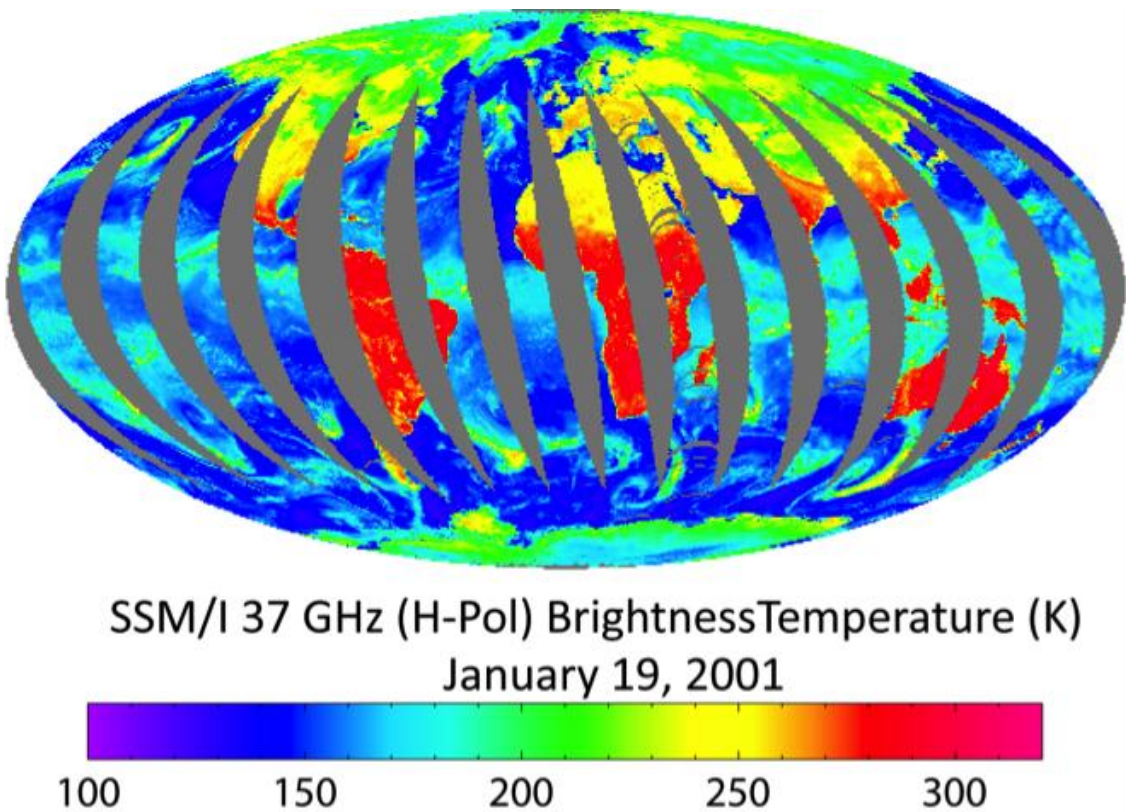


Figure 2: SSM/I 37 GHz H-Pol brightness temperatures for January 19, 2001. These data were obtained from the DSMP F13 satellite. Variations in the brightness temperatures are due to a combination of surface (temperature, emissivity) and atmospheric (water vapor, clouds, and rain) effects.

Performance Metrics	FY12
# of new or improved products developed	0
# of products or techniques transitioned from research to ops	2
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	0

PLANNED WORK

* Develop simple validations tools for both MSU/AMSU and SSM/I brightness temperatures
* Write code to convert SSMIS F17 data to netcdf4 with appropriate metadata.
* Work with NCDC to approve format for SSMIS F17 files.
* Begin routine monthly transfers of SSMIS F17 data to the CDR archive at NCDC.

PUBLICATIONS

Wentz, Frank J. "SSM/I Version 7 Calibration Report." RSS Technical Report 011012. Submitted to NCDC 12/2012.

- Evaluation and Characterization of Satellite Products

Task Leader	Ge Peng
Task Code	NC-CDR-11-NCICS-GP
Main CICS Research Topic	Climate Data and Information Records and Scientific Data Stewardship
Percent contribution to CICS Themes	Theme 1: 10%; Theme 2: 90%; Theme 3: 0%
Percent contribution to NOAA Goals	Goal 1: 85%; Goal 5: 15%

Highlight:

- Evaluation and characterization of the NOAA/NSIDC passive microwave sea ice concentration climate data record
- Evaluation of the NCDC satellite-based blended sea winds product
- Scientific stewardship of NPP Cal/Val data

BACKGROUND

The primary object of this task is to evaluate, validate, and characterize satellite-based products that have been either transitioned to operation from research or are being developed at NCDC.

The evaluation and characterization of the satellite product will provide a baseline and additional quality information for users and identify areas for product improvement.

The valuation and characterization effort during this period has been focused on the passive microwave sea ice concentration climate data record (CDR) that has been R2O-ed (Research to Operations) with IOC (Initial Operation Capability) in FY 12 under a joint effort between the NCDC CDR program and the National Snow and Ice Data Center (NSIDC) and on the NCDC blended sea winds product that has been developed at the NCDC Remote Sensing Satellite Application Branch as a research product.

ACCOMPLISHMENTS

1. Evaluated the NOAA/NSIDC sea ice concentration CDR via comparison with other passive microwave sea ice concentration products. The CDR product compares well with well-established and -validated NASA Goddard-based products (Fig. 1), with no significant difference in trends and interannual variability. Two papers will be submitted to a special issue of “Polar Science and Polar Data” under a joint effort between the Earth System Science Data journal and the Polar Research journal at the end of March 2013.

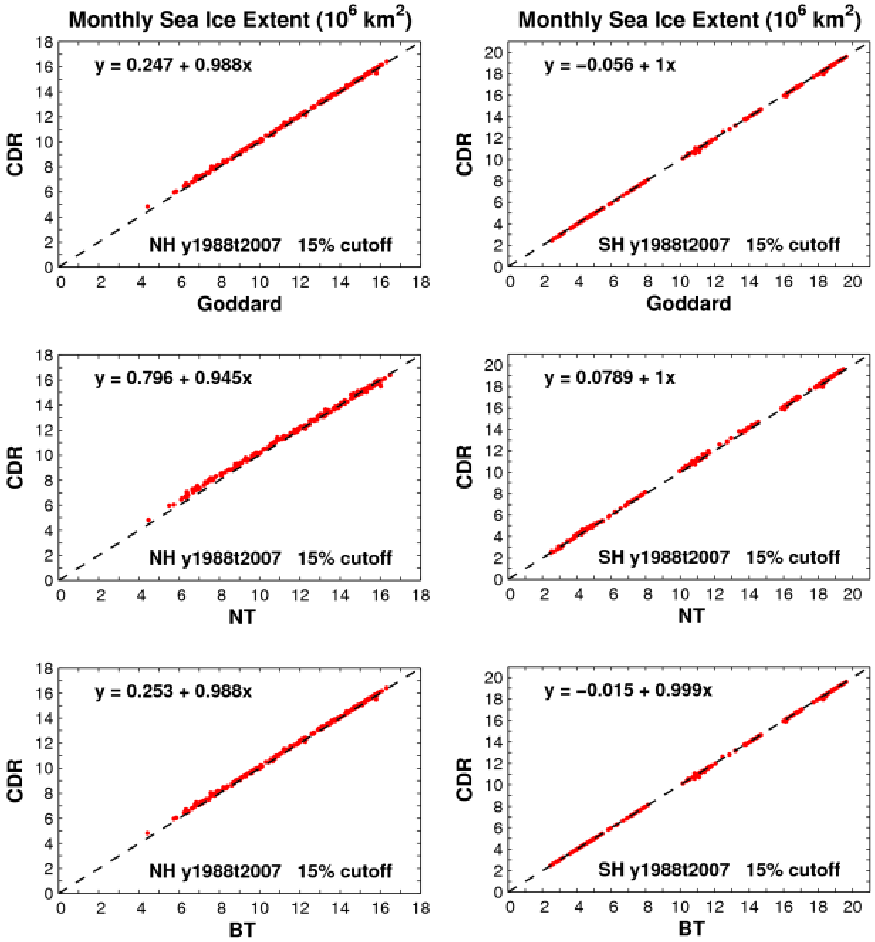


Figure 1: The scatter-diagram of monthly sea ice extents (10^6 km^2) from monthly CDR and Goddard data (top); CDR and NASA Team (NT) data (middle); and CDR and Bootstrap (BT) data (bottom) (20 years from January 1988 to December 2007). Left panel is for the North and the right is for the South Hemisphere.

2. Evaluated the NCDC satellite-based blended sea wind product and wind forecasts from three international numerical weather prediction (NWP) centers and NOAA/NCEP reanalysis with high quality in situ data (OceanSITES) (Fig. 2).

- A peer-reviewed sea wind products evaluation paper is accepted pending revision by AMS Weather and Forecasting.
- The deficiencies of the blended sea winds revealed in this work are useful in identifying areas of improvement for the sea wind product - development of next version of the NCDC blended sea wind product is planned.
- Wind directional irregularity initiated by the results from the evaluation paper, was uncovered at a TAO station in the central equatorial Pacific (0^oN, 170^oW) for a period of November 2008 to January 2010. It was re-

ported to PMEL, which has led to re-characterization of data using quality flag for the station for this deployment period after further investigation of the sensor performance by the PMEL TAO group.

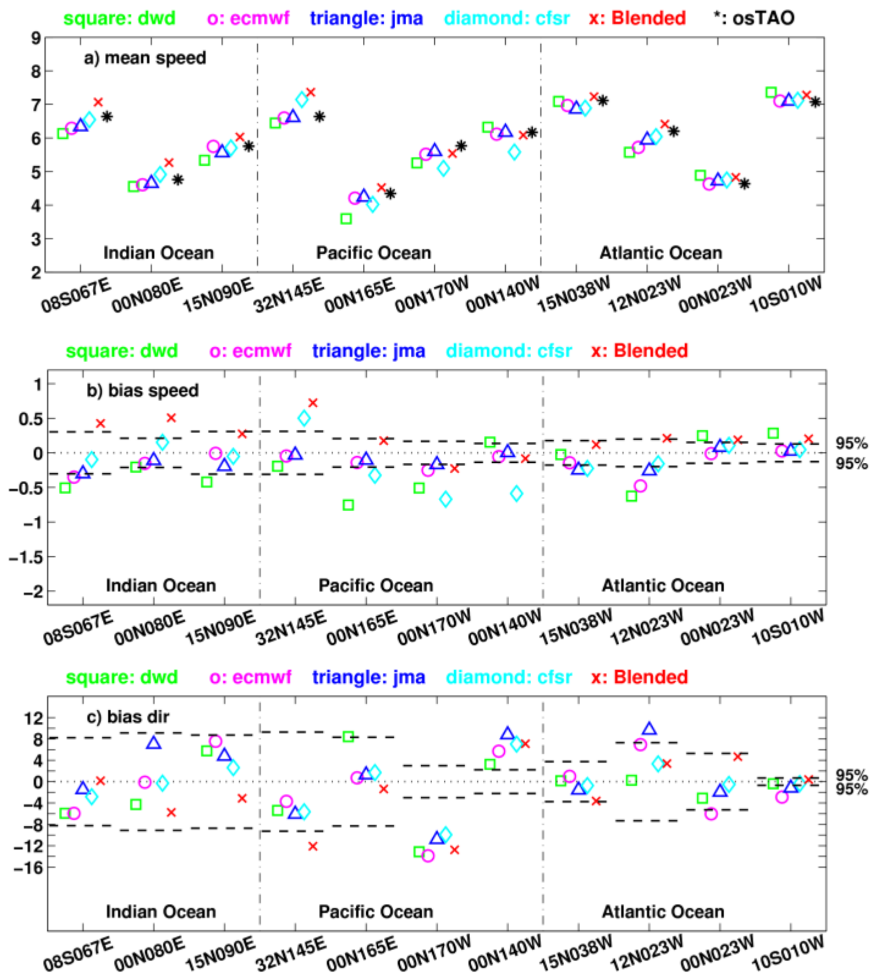


Figure 2: Speed mean (a) and bias (b) and directional bias (c) of 2009 surface winds. The weak winds (wind speed < 3 m/s) are not included in the calculations of directional bias. Bias values outside of the dashed lines for each station are significant at the 95% confidence level. dwd: short-range NWP forecast 10-m winds from the German Weather Service "Deutscher Wetterdienst"; ecmwf: short-range NWP forecast 10-m winds from the European Centre for Medium-Range Weather Forecasts; jma: short-range NWP forecast 10-m winds from the Japan Meteorological Agency; cfsr: 10-m winds from NCEP Climate Forecast System Reanalysis; blended: NCDC blended sea surface winds, and osTAO: OceanSITES buoy winds.

3. Provided a new perspective to the NESDIS IRMT metadata group that helped in identifying areas of potential improvement for the NOAA/NGDC Rubric tool to be more resili-

ent to different structural choices that metadata managers can make, based on a use-case study. (The Rubric tool is recommended by NOAA to quantitatively measure the quality of an ISO metadata record.) It has helped the Rubric developers to refine the tool - a new and improved version has been released.

Performance Metrics	F2
# of new or improved products developed	
# of products or techniques transitioned from research to ops	
# of peer reviewed papers	1
# of non-peered reviewed papers	
# of invited presentations	
# of graduate students supported by a CICS task	
# of undergraduate students supported by a CICS task	

PLANNED WORK

* Continue to evaluate and characterize the NOAA/NSIDC passive microwave sea ice concentration CDR, focusing more on regional and seasonal variability.
* Define the scope and the framework of long-term scientific stewardship for CDRs.

PUBLICATIONS

Peng, G., H.-M. Zhang, H.P. Frank, J.R. bidlot, M. Higaki, S. Stevens, and W.R. Hankins, 2013: Evaluation of remotely-sensed and model surface wind forecast and reanalysis products with OceanSITES buoy measurements. *Resubmitted to Weather and Forecasting – accepted pending revision.*

Peng, G., W.N. Meier, D. J. Scott, and M. Savoie, A Long-Term, Reproducible Satellite-Based Passive Microwave Sea Ice Concentration Data Record for Climate Study and Monitoring. *Submitted to the Earth System Science Data Journal*.

Meier, W.N., G. Peng, D. J. Scott, and M. Savoie, 2013: Evaluation of a passive microwave sea ice concentration climate data record. *Submitted to Polar Research*.

PRESENTATIONS

Conference Presentations and Posters

- Peng, G., M. Denning, D. Saunders, M. Iwunze, R. Ullman, and J. Privette, 2012: A Low-Cost and Efficient Way to Archive Calibration/Validation Findings for Satellite Data, Abstract A33M-0333, Poster, 2012 AGU Fall Meeting, San Francisco, CA, 3 – 7 December.

- Meier, W., G. Peng, and D. Scott, 2012: Evaluation of a passive microwave sea ice concentration climate data record, Abstract C34B-05, 2012 AGU Fall Meeting, San Francisco, CA, 3 – 7 December. Invited talk.
- Vasquez, L., G. Peng, M. Urzen, B. Hankins, and H.-M. Zhang, 2012: A Near Real-Time Monitoring System for NWP Forecast and Satellite-Based Products, Abstract IN31C-1504, Poster, 2012 AGU Fall Meeting, San Francisco, CA, 3 – 7 December.
- Zhang, H. -M., G. Peng, W. Hankins, and S. E. Stevens, 2012: A Facility and Examples for Evaluating Surface Fluxes from Models and Observations, AMS 18th Conference on Air-Sea Interaction, 9 – 12 July 2012, Boston, MA.

Other Presentations

- Peng, G., 2012: NOAA/NSIDC passive microwave sea ice concentration climate data record, v1.0.
  Presentation to NCDC User & Engagement Service Branch, 19 July 2012.
- Peng, G. and J.-R. Bidlot, 2012: Systematic wind directional bias between ECMWF and buoy 51010 from Nov 2008 to Jan 2010. Presentation sent to PMEL TAO group, 11 September 2012.
- Peng, G., 2012: A use-case study of utilizing NOAA/NGDC Rubric Tool and Oxygen XML Editor in improving NCDC ISO collection-level metadata records. Presentation to the NESDIS IRMT (International Records Management Trust) metadata working group, 15 October 2012.
- Peng, G., 2012: Assessment of CDR IOC Readiness - Cryosphere Bundle. Presentation to NCDC CDR program and branch management, 29 November 2012.

OTHER

- Led the initial assessment effort of the CDR FY13 IOC readiness for cryosphere bundle and made presentation and recommendations to the NCDC CDR program and branch management
- Reviewed four NPP Cal/Val findings of beta characterizations and provided recommendation to GRAVITE and NPP Cal/Val program on their readiness for archive as NPP Cal/Val findings in CLASS
    - NPP CrIS SDR beta
    - NPP OMPS SDR beta
    - NPP VIIRS Non-NCC beta
    - NPP VIIRS NCC Imagery EDR beta
- Participated in the NCDC collection-level metadata tiger team that has developed the center-wide guidelines for standard and optional elements of collection-level metadata records

- Updated ISO 19115 compliant collection-level metadata records for NPP gridded and non-gridded retained intermediate products (RIPs) and submitted the up-dated records to the NCDC metadata reviewing board

- Characterization of Precipitation Features in the Southeastern United States Using a Multi-sensor Approach: Quantitative Precipitation Estimates

Task Leader	Olivier Prat
Task Code	NC-CDR-12-NCICS-OP
Main CICS Research Topic	Climate Data and Information Records and Scientific Data Stewardship
Percent contribution to CICS Themes	Theme 1:20%; Theme 2:75%; Theme 3:5%
Percent contribution to NOAA Goals	Goal 1:20%; Goal 2:80%

Highlight: We use a multi-sensor approach to characterize precipitation features at high spatial and temporal resolution. Focused over the Southeastern United States, this work represents a first step toward the development of rainfall climatologies at high spatial and temporal resolution. More broadly, this work is part of an on-going effort to provide high-resolution precipitation estimates for hydrological applications and to derive trends in the evolution of precipitation patterns over time

BACKGROUND

The primary goal of this project is to investigate long-term precipitation characteristics in the Southeastern United States at fine spatial and temporal resolution using a multi-sensor approach. The frequency and spatial distribution of precipitation extremes are evaluated using an ensemble of satellite and radar rainfall estimates. We use the precipitation reanalysis from the National Mosaic and Multi-Sensor Quantitative precipitation Estimates (NMQ/Q2) in order to derive yearly, seasonal, and sub-daily precipitation trends at high resolution (1-km/5-min) for the period 1998-2010, with an attention to intense precipitation events.

This particular task is focused on the intercomparison of satellite observations from the Tropical Rainfall Measurement Mission (TRMM) and ground based (Q2) precipitation estimates in terms of precipitation intensity, accumulation, diurnal cycle, event duration, precipitation type (stratiform/convective), and precipitation systems (localized thunderstorms, mesoscale convective systems, tropical storms). In addition we investigate the impact of the spatial and temporal resolutions on each of these quantities, as well as the ability of satellite products to capture extreme precipitation events.

ACCOMPLISHMENTS

1. Previous work concerned the development of long-term (1998-2010) precipitation datasets at fine scale using the National Mosaic and Multi-Sensor QPE reanalysis (NMQ/Q2: 1km/5min) and satellite products TRMM Precipitation Radar (TPR 2A25: 5km/daily) and TRMM Multisatellite Precipitation Analysis (TMPA 3B42: 25km/3hr). Subtasks included: (A) The derivation of yearly, seasonal, and diurnal precipitation trends from both datasets (TPR 2A25 and TMPA 3B42) (Prat and Nelson 2013a); (B) The

quantification of the rainfall contribution originating from tropical cyclones (Prat and Nelson 2013b).

2. Completed the comparison between TRMM satellite data versus NMQ/Q2 reanalysis over the Carolinas. Figure 1 displays the daily average rainfall derived from the different sensors (Q2: Fig. 1a, TPR: Fig. 1c, TMPA: Fig. 1e) for summer (JJA).

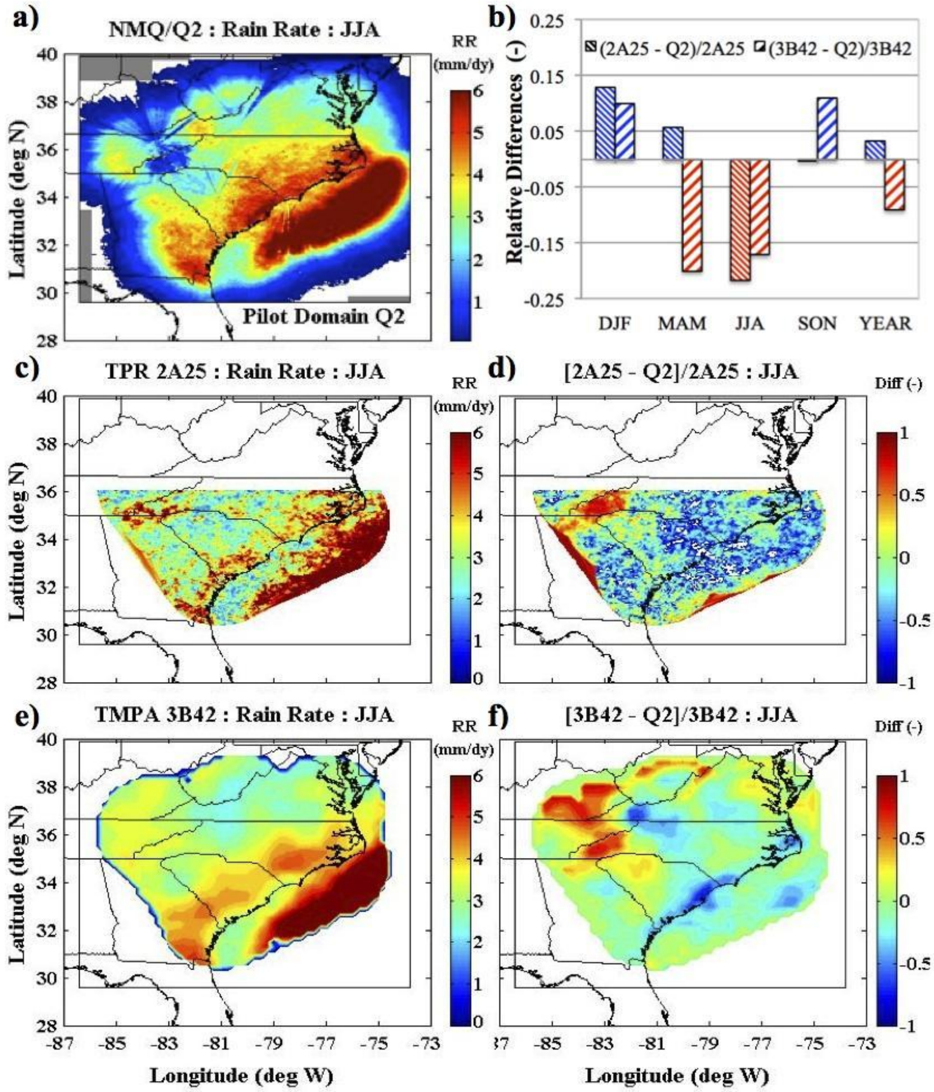


Figure 1: a-c-e) Mean precipitation derived from NMQ/Q2 (1km), TPR 2A25 (5km), and TMPA 3B42 (25km) respectively. b) Seasonnal differences between TRP 2A25 and NMQ/Q2 and TMPA 3B42 and NMQ/Q2. d-e) Difference between TPR 2A25 and NMQ/Q2 (5km) and TMPA 3B42 (25km) for summer (JJA).

Over the Southern Appalachians, we observe important local differences between Q2 and satellite estimates due to beam blocking effects, causing Q2 to underestimate rain-fall because neither of the two radars located in TN and SC is able to fully capture rainfall events (Fig. 1d,f). Along the coast, Q2 displays higher average daily precipitation for summertime due to the fact that the higher spatial and temporal resolution of Q2 allows it to better resolve the diurnal cycle of precipitation, which is dominated by afternoon events (sea breeze effect). We also note a higher rainfall accumulation over the ocean (Gulf Stream). Figure 1b presents the seasonal and annual differences between the satellite estimates TPR 2A25 (5km) and TMPA 3B42 (25km) and NMQ/Q2 regridded at the same resolution. Over the pilot domain, satellite estimates (TPR and TMPA) tend to produce higher daily average rain rates than NMQ/Q2 during the cold season (or transition to/from the cold season: SONDJF or DJFMAM). On the oppositive, rainfall retrieved from NMQ/Q2 is higher than satellite estimates during the warm season (or transition to/from the warm season: MAMJJA or JJASON) because the higher spatial and temporal resolution of NMQ/Q2 allows capturing short-lived localized precipitation events that occur during the warm season. On an annual basis, NMQ/Q2 averaged rain rates fall between rainrates retrieved from TMPA 3B42 (lower) and TPR 2A25 (higher).

Performance Metrics	**FY12**
# of new or improved products developed	
# of products or techniques transitioned from research to ops	
# of peer reviewed papers	3
# of non-peered reviewed papers	
# of invited presentations	2
# of graduate students supported by a CICS task	
# of undergraduate students supported by a CICS task	

PLANNED WORK

* Shorter-term goal includes extending the domain of study for CONUS using the available NMQ/Q2 for the period 2009-2012. Longer-term goal is to perform the same comparison for the period 1998-present using the using the reanalysis currently underway.
* Continue the intercomparison effort using Stage IV data with a focus on extreme events (extreme rainfall, droughts).

PUBLICATIONS

Prat, O.P., and B.R. Nelson, 2013a. Yearly, seasonal, and diurnal precipitation trends in the Southeastern United States derived from long-term remotely sensed data. *Atmospheric Research.* Conditionally accepted.

Prat, O.P., and B.R. Nelson, 2013b. Precipitation contribution of tropical cyclones in the Southeastern United States from 1998 to 2009 using TRMM satellite data. *Journal of Climate.* 26, 1047-1062.

PRESENTATIONS

- Prat, O.P., B.R. Nelson, and S.E. Stevens 2012. Characterization of precipitation features in the Southeastern United States using high spatial and temporal resolution quantitative precipitation estimates derived from National Mosaic and Multi-sensor QPE (NMQ/Q2). *ERAD 2012: 7th European Conference on Radar in Meteorology and Hydrology*, June 25-29 2012, Toulouse, France.
- Nelson, B.R., O.P. Prat, and S.E. Stevens, 2012. Diurnal cycle of precipitation using high spatial and temporal resolution quantitative precipitation estimates and radar-reflectivity products derived from National Mosaic and Multi-sensor QPE (NMQ/Q2). *2012 AGU fall meeting*, December 3-7 2012, San Francisco, CA, USA.

OTHER

- Chair: Session on Scaling and Fractals in Climate, Hydrology, and Exploration Geophysics (I), *2012 AGU Fall Meeting*, December 3-7 2012, San Francisco, CA, USA.
- Reviews for Journal of Atmospheric and Oceanic Technology, Water Resources Research, Tropical Cyclone Research and Review.
- Prat, O.P., A.P. Barros, and F.Y. Testik, 2012. On the influence of raindrop collision outcomes on equilibrium drop size distributions. *Journal of the Atmospheric Sciences.* 69(5), 1534-1546.

- Mapping the World's Tropical Cyclone Rainfall Contribution Over Land Using Satellite Data: Precipitation Budget and Extreme Rainfall

Task Leader	Olivier Prat
Task Code	NC-CDR-13-NCICS-OP
Main CICS Research Topic	Climate Data and Information Records and Scientific Data Stewardship
Percent contribution to CICS Themes	Theme 1:50%; Theme 2:50%; Theme 3:0%
Percent contribution to NOAA Goals	Goal 1:30%; Goal 4:70%

Highlight: This work examines the over-land rainfall contribution originating from tropical cyclones for basins around the world for the period 1998-2009. Using the global database IBTrACS and satellite precipitation data from the Tropical Rainfall Measuring Mission (TRMM) Multi-satellite Precipitation Analysis (TMPA) product 3B42, the precipitation budget and extreme rainfall were determined for different TC basins around the world

BACKGROUND

Tropical cyclones (TC) constitute one of the major natural disasters around the world as well as an important source of fresh water over areas prone to tropical cyclones. Annually, an average of 119 million people are exposed to tropical cyclone hazards (United Nation Development Program 2004). This exposure is explained by the fact that about half of the world population is living within 200-km of a coastline, with some of the most cyclone-prone coastal domains coinciding with highly populated areas. While previous studies that investigated TC rainfall contribution and their hydrological impacts have focused mainly on North America, East Asia, or over entire TC basins, the present study focuses on over-land and coastal areas of the different TC basins around the world.

In this study, precipitation associated with tropical cyclones for the different basins around the world is quantified in terms of spatial distribution and average contribution to the total precipitation budget on an annual and monthly basis for the period 1998-2009. Furthermore the relationship between tropical cyclone activity and extreme precipitation events is also investigated. The precipitation data are taken from the TRMM Multi satellite Precipitation Analysis (TMPA) 3B42 (Huffman et al. 2007). TMPA 3B42 provides 3-hourly/0.25-degree precipitation estimates, which allow deriving annual, seasonal, monthly, and daily precipitation trends. The TC track information is taken from the IBTrACS database that provides the location of the center of the TC every 6 hours (Knapp et al. 2010). A simple linear interpolation is performed to derive the position of the TC center every 3 hours. Finally, the tropical-cyclone-related rainfall was identified as TMPA 3B42 pixels found within a 500-km radius from TC center (Prat and Nelson 2013a among others).

ACCOMPLISHMENTS

1. *Tropical Cyclone Contribution* (Prat and Nelson 2013b): From 1998 to 2009, rainfall data, showed that TCs accounted for 8%, 11%, 7%, 10%, and 12% of the annual over-land precipitation for NCA, EAS, SWA, OCE, and EAF respectively, and that TC contribution decreased importantly within the first 150-km from the coast. At the local scale, TCs contributed on average to more than 40% and up to 77% of the annual precipitation budget over very different climatic areas with arid or tropical characteristics (Fig. 1).

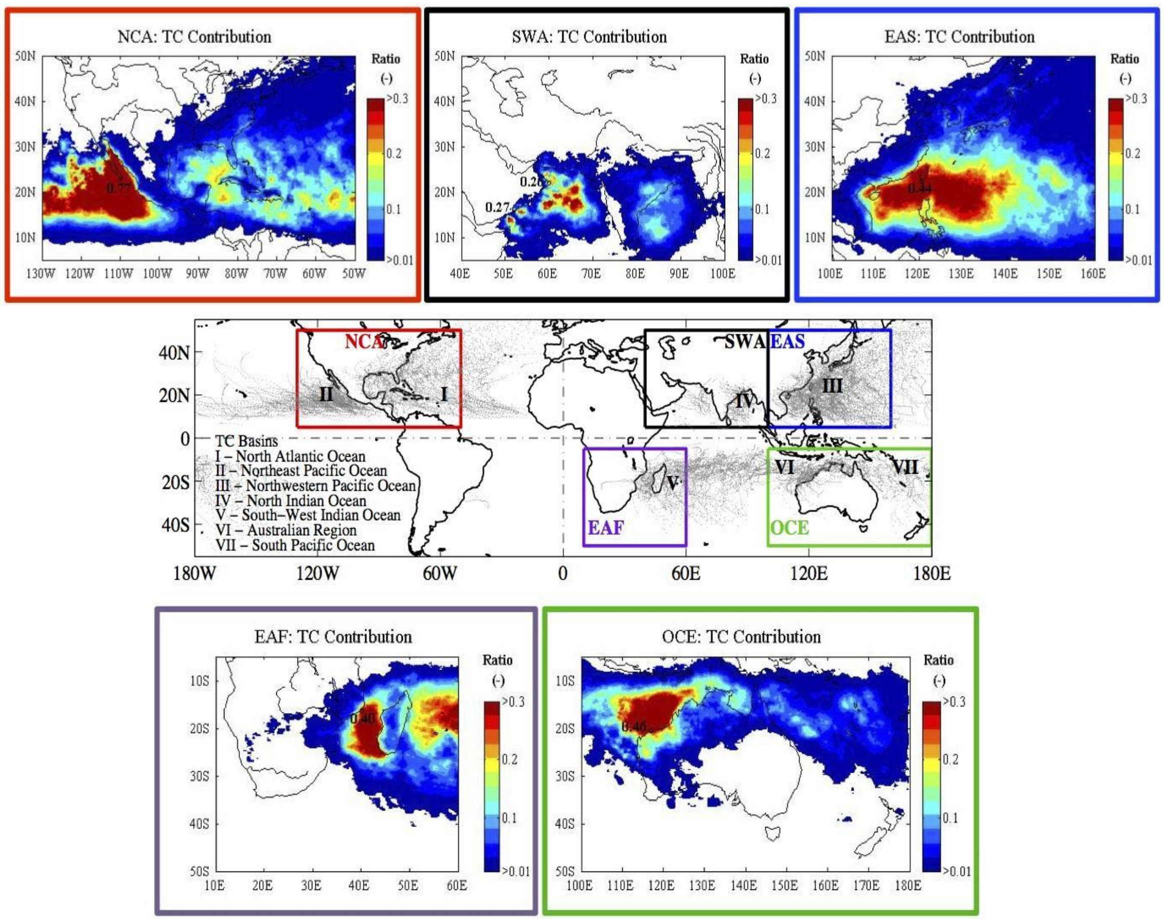


Figure 1: TC contribution for North and Central America (NCA), East Asia (EAS), South and West Asia (SWA), Oceania (OCE), and East Africa (EAF) for 1998-2009. The TC tracks are from the IBTrACS database (Knapp et al. 2010).

The EAS domain presented the higher and most constant TC rain (170±23%-mm/yr) normalized over the area impacted, while the EAF domain presented the highest variability (130±48%-mm/yr), and the NCA domain displayed the lowest average TC rain (77±27%-mm/yr) despite a higher TC activity. The maximum monthly TC contribution (9-13%) was found later in the season and was a conjunction between the peak of TC activity, TC rainfall, and the domain annual antagonism between dry and wet regimes if any.

2. *Link Between Tropical Cyclones and Extreme Rainfall* (Prat and Nelson 2013c): Results showed that while TC days that accounted globally for 2±0.5% of all precipitation events for all basins, they represented between 11-30% of rainfall extremes greater than 4inches/day (>101.6mm/day: EPD4) (Fig. 2). In addition, an important spatial variability was observed in the repartition of TC-related precipitation extremes, with over 70% of extreme rainfall (>4in/day) for NCA (Baja California, FL, NE), EAS (Taiwan, coastal China), EAS, NW Australia, and EAF (Madagascar, La Réunion, Mozambique Coast) associated with TC rainfall.

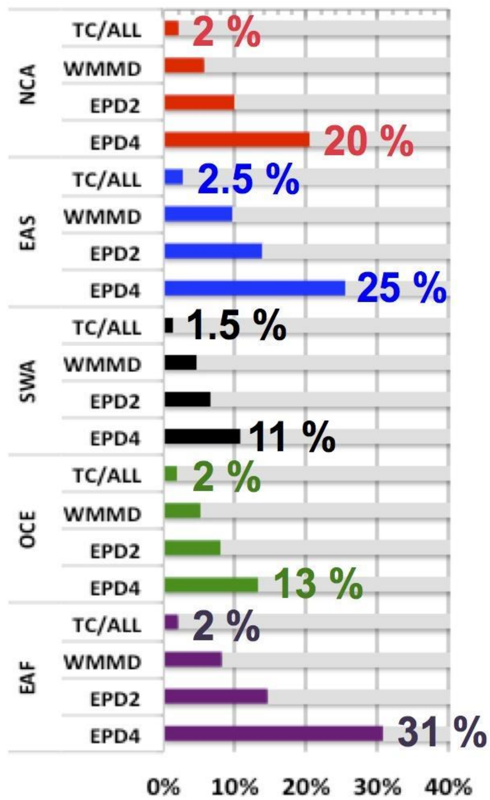


Figure 2: Percentage of extreme rainfall originating from TCs for different metrics: WMMD (Wet Millimeter Days), EPD2 (daily accumulation > 2inches/day) and EPD4 (daily precipitation >4inches/day). Data are for each domain overland: NCA (North and Central America), EAS (East Asia), SWA (Southwest Asia), OCE (Oceania), and EAF (East Africa).

PLANNED WORK

- The main part of the data and results analysis for this task is completed. The current work includes addressing reviewers comments (Prat and Nelson 2013b) and finalizing the third publication to be submitted shortly (Prat and Nelson 2013c).

PUBLICATIONS

Prat, O.P., and B.R. Nelson, 2013c. On the link between tropical cyclones and extreme rainfall for hurricane basins around the world. *Natural Hazards and Earth System Sciences*. To be Submitted.

Prat, O.P., and B.R. Nelson, 2013b. Mapping the world's tropical cyclone rainfall contribution overland using TRMM precipitation data. *Water Resources Research*. Under revision.

PRESENTATIONS

Prat, O.P., and B.R. Nelson, 2012. Mapping the world's tropical cyclone contribution overland using TRMM satellite data: precipitation budget and extremes rainfall. 2012 AGU fall meeting, December 3-7 2012, San Francisco, CA, USA.

OTHER

Prat, O.P., and B.R. Nelson, 2013a. Precipitation contribution of tropical cyclones in the Southeastern United States from 1998 to 2009 using TRMM satellite data. Journal of Climate. 26, 1047-1062.

Performance Metrics	**FY12**
# of new or improved products developed	
# of products or techniques transitioned from research to ops	
# of peer reviewed papers	2
# of non-peered reviewed papers	
# of invited presentations	1
# of graduate students supported by a CICS task	
# of undergraduate students supported by a CICS task	

- High Resolution SST Analysis

Task Leader Richard W. Reynolds
Task Code NC-CDR-14-RR
Main CICS Research Topic Climate Data and Information Records and Scientific Data Stewardship
Percent contribution to CICS Themes Theme 1: 50%; Theme 2: 50%; Theme 3: 0%
Percent contribution to NOAA Goals Goal 1: 100%

Highlight: A 2-stage analysis SST has been developed to best utilize the improved coverage of low resolution microwave satellite data along with the restricted coverage and high resolution of infrared satellite data. An objective method was designed compare two analyses and to improve the signal-to-noise ratio of the final 2-stage product.

BACKGROUND

In the last progress report, work had begun on a 2-stage optimum interpolation (OI) analysis procedure with a high-resolution step built on top of a low-resolution step. For this effort, microwave satellite data were used in the low-resolution analysis on a 28 km grid. The high-resolution analysis used infrared data on a 4.8 km grid. Furthermore, when the analysis procedures push the feature resolution beyond the spatial and temporal resolution limitations of the input data, the apparent small-scale features in the SST analysis are very likely noise

ACCOMPLISHMENTS

During the past year work was completed to show how space-time distributions of satellite SST data impact high-resolution analyses. This work has been accepted by the Journal of Climate for publication in 2013 and is a joint effort by US and UK scientists. Ocean model SST fields are used in this study to simulate "true" SST data and are subsampled based on actual infrared and microwave satellite data coverage. The subsampled data are used to simulate sampling errors due to missing data. Two different SST analyses are considered and run using both the full and the subsampled model SST fields, with and without additional noise. The results are compared as a function of spatial scales of variability using wavenumber auto- and cross-spectral analysis. Comparisons of the two analyses (both having grid sizes of roughly 1/20°) show important differences. One analysis tends to reproduce small-scale features more accurately when the high-resolution data coverage is good but produces more spurious small-scale noise when the high-resolution data coverage is poor. Analysis procedures can thus generate small-scale features with and without data but the small-scale features in an SST analysis may be just noise when high-resolution data are sparse. Users must therefore be skeptical of high-resolution SST products, especially in regions where high-resolution (~5 km) infrared satellite data are limited due to cloud cover.

One of the analyses considered in the paper was the 2-stage OI analysis. The two stages (see Figure 1) both use an optimum interpolation (OI) procedure. The first stage consists of a low-resolution analysis that has been described in Reynolds et al. (2007). The low-resolution analysis impacts the high-resolution analysis through the low-resolution first guess. However, the high-resolution analysis has no effect on each low-resolution analysis, i.e., the link between the two stages is only one-way. The 2-stage processing is designed to have the high-resolution analysis relax to the low-resolution analysis in the absence of any high-resolution data.

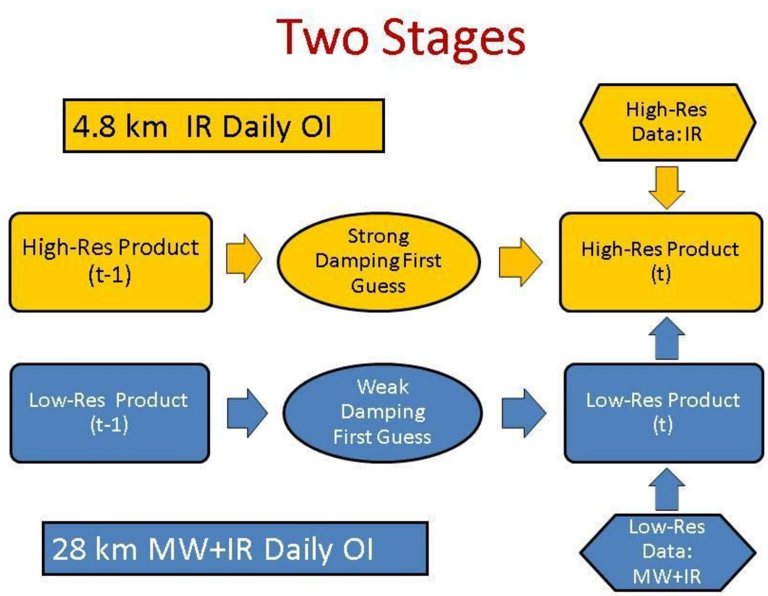


Figure 1: Figure 1. Schematic of high (yellow) and low (blue) resolution 2-Stage OI processing. The first stage consists of a low-resolution analysis using both microwave (MW) and infrared (IR) satellite data. The second stage uses only high-resolution infrared data. The low-resolution analysis impacts the high-resolution analysis through the low-resolution first guess; the high-resolution analysis does not impact the low-resolution analysis. The high-resolution analysis relaxes to the low-resolution analysis in the absence of any high-resolution data.

The simulated SST data used in the study discussed above can be used to improve analyses. This is possible because the analysis can be done using the data reduced by actual coverage and then compared with the full data coverage. The parameters used in the analysis can then be adjusted objectively. Although the 2-stage analysis was designed so that if there are no data, the high-resolution second stage reduces to the low-resolution first stage, problems were found when data coverage was sparse. In that case the second stage overemphasizes the sparse data. This is shown clearly in Figure 2. Note in particular the dipole that occurs in in the reduced data near 39°N and 62°W. This dipole does not occur in the full data set and is caused by the reduced sampling. The analysis in the bottom left panel faithfully uses the sparse data to produce a dipole in the analyzed product. However, in the lower right panel the analysis was modified to treat sparely sampled data as nosier than data in well-sampled regions. This is done formally in the OI by increasing the noise-to-signal ratio when the local data density is low. This change (note the lower right panel) reduces the impact of sparse data. The spectral results (note shown) clearly indicate that the analysis small-scale noise is reduced by an order of magnitude with this modification.

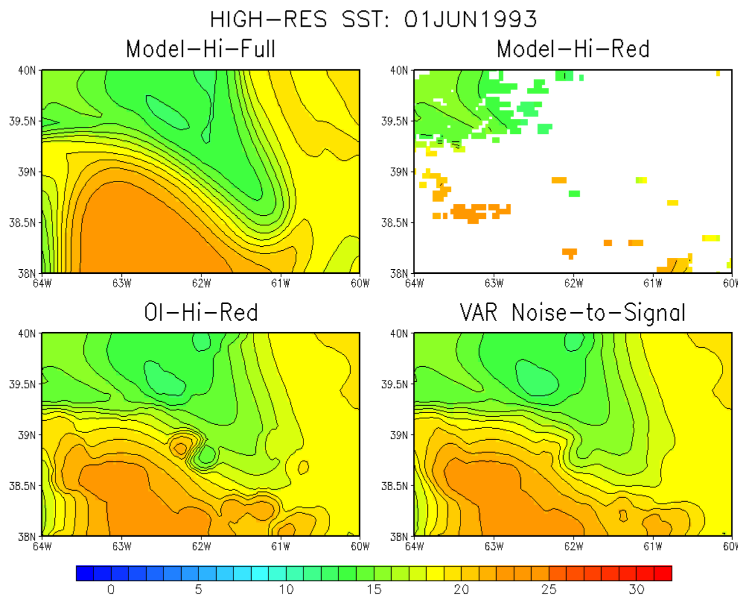


Figure 2: SST model data and SST analyses for 1 June 1993 for the Gulf Stream. The top left panel shows the full high-resolution model data. The top right panel shows the high-resolution model data reduced by the actual satellite coverage. Note the artificial dipole in the reduced data near 39°N and 62°W caused by the reduced sampling. The bottom left panel show the second high-resolution stage of the 2-stage OI using the reduced model. The bottom left panel shows the same analysis with the noise-signal ratio increased as a function of the reduced coverage. The color scale is in °C.

PLANNED WORK

* During the coming year work thee 2-stage analysis will be produced from 2003 through 2010 using the modified noise procedure. The codes and scripts will be documented and the analysis will be made available for real-time processing.

PUBLICATIONS

Reynolds, R. W., D. B. Chelton, J. Roberts-Jones, M. Martin, D. Menemenlis and C. Merchant (2013), Objective determination of feature resolution in two sea surface temperature analyses. *J. Climate*, **26**, in press.

PRESENTATIONS

- "Objective Determination of Feature Resolution in an SST Analysis." was presented at the NCDC Remote Sensing and Applications Division weekly seminar series in Asheville, NC, February 12, 2012.

OTHER

- Reynolds, R. W., T. M. Smith, C. Liu, D. B. Chelton, K. S. Casey, and M. G. Schlax, 2007: Daily high-resolution blended analyses for sea surface temperature. *J. Climate*, **20**, 5473-5496.

Performance Metrics	**FY12**
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	2
# of non-peered reviewed papers	0
# of invited presentations	1
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	0

- Identifying Tropical Variability with CDRs

Task Leader	Carl Schreck
Task Code	NC-CDR-15-NCICS-CS
Main CICS Research Topic	Climate Data and Information Records and Scientific Data Stewardship
Percent contribution to CICS Themes	Theme 1: 0%; Theme 2: 50%; Theme 3: 50%
Percent contribution to NOAA Goals	Goal 1: 0%; Goal 2: 100%

Highlight: Climate Data Records are being leveraged to develop new diagnostics for tracking and predicting the MJO and equatorial waves. These diagnostics are tested in near-real time on monitor.cicsnc.org/mjo where they are served to hundreds of users in the public and private sectors every month.

BACKGROUND

The Madden–Julian Oscillation (MJO), equatorial Rossby waves, and Kelvin waves are the dominant sources of synoptic-to-subseasonal variability in the tropics. The divergent circulations from their convection can influence tropical cyclones and other weather patterns around the globe. Identifying and predicting these systems remains a major research problem, however. This project endeavors to meet this need by developing new diagnostics that are based on Climate Data Records (CDRs).

ACCOMPLISHMENTS

A climatology of the MJO and equatorial waves was published in the Journal of Climate using a recently developed Climate Data Record of homogenized upper tropospheric water vapor (UTWV) from the high-resolution infrared radiation sounder (HIRS). The MJO and equatorial Rossby waves are associated with a greater fraction of the total variance in UTWV than in outgoing longwave radiation (OLR). In the subtropics, UTWV identifies the subsidence drying that occurs poleward of the MJO's convection. These signals are absent from OLR, but they can be valuable for identifying which MJO events change the weather patterns over North America and which do not.

The DYNAMO field campaign was conducted over the Indian Ocean from October 2011 to March 2012. The goal of this campaign was to understand the MJO's initiation in that region. Most MJO diagnostics are global in nature, which might not be suitable for working with in situ campaign data. To bridge this disconnect, we proposed using time series of OLR anomalies associated with the MJO and equatorial waves averaged over the DYNAMO sounding array. These local indices will give DYNAMO investigators a clearer picture of the large-scale state within which their observations were taken.

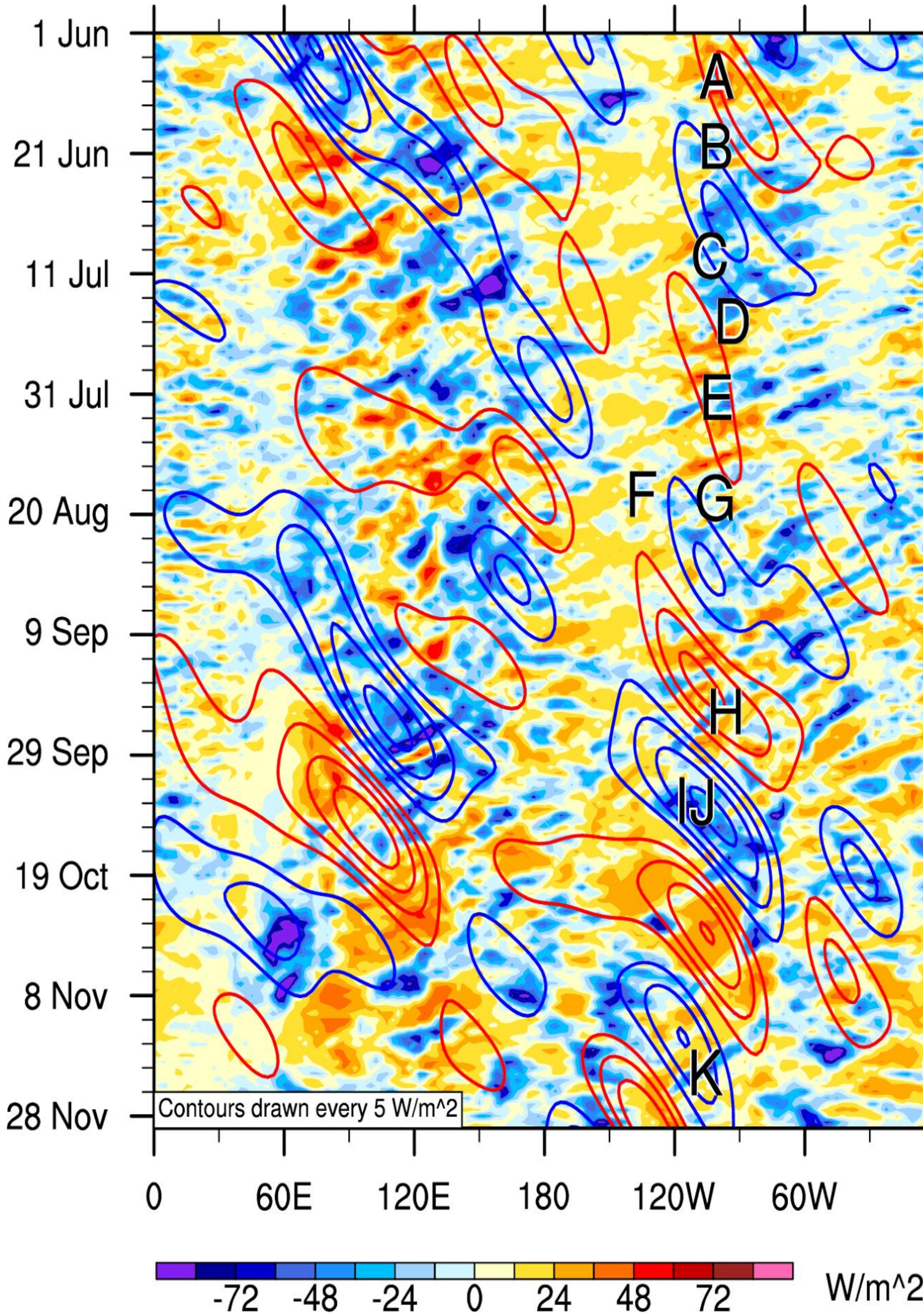


Figure 1: Hovmöller of OLR anomalies from a daily climatology (shading) and MJO-filtered anomalies (contours) averaged 10°N–20°N. Letters indicate the genesis of eastern North Pacific tropical cyclones. Adapted from Kruk et al. (2012).

Monitor.cicsnc.org/mjo serves CDR-based diagnostics of the MJO and other tropical weather systems to hundreds of unique users every month, including NOAA's Climate Prediction Center and forecasters in the energy industry. This service continues to grow and evolve to meet the needs of those users. This year, we added more diagnostics related to the Wheeler–Hendon Real-time Multivariate MJO (RMM) index. We also include new diagnostics for examining the interactions between tropical convection and the extratropical waves that affect our weather in the United States.

The MJO affects tropical cyclone activity around the globe, particularly over the eastern North Pacific. Figure 1 highlights these impacts in the 2011 hurricane season. Due to the La Niña that year, conditions were generally unfavorable for tropical cyclogenesis during that year. However, the MJO provided periods of enhanced convection (blue contours) within which most of the tropical cyclones formed. Irwin, Jova, and an unnamed tropical depression formed within a particularly strong MJO event during October 2011.

PLANNED WORK

* Explore the benefits of the proposed daily OLR CDR for identifying the MJO and its impacts.
* Update and expand monitor.cicsnc.org/mjo.

PUBLICATIONS

Schreck, C. J., L. Shi, J. P. Kossin, and J. J. Bates, 2013: Identifying the MJO, Equatorial Waves, and Their Impacts Using 32 Years of HIRS Upper-Tropospheric Water Vapor. *J. Climate*, **26**, 1418–1431, doi:10.1175/JCLI-D-12-00034.1.

Aiyyer, A., A. Mekonnen, and C. J. Schreck, 2012: Projection of Tropical Cyclones on Wavenumber–Frequency-Filtered Equatorial Waves. *J. Climate*, **25**, 3653–3658, doi:10.1175/JCLI-D-11-00451.1.

Kruk, M. C., C. J. Schreck, and Hennon, Paula A., 2012: [The Tropics] Eastern North Pacific basin [in “State of the Climate in 2011”]. *Bull. Amer. Meteor. Soc.*, **93**, S105–S107.

Ventrice, M. J., C. D. Thorncroft, and C. J. Schreck, 2012: Impacts of Convectively Coupled Kelvin Waves on Environmental Conditions for Atlantic Tropical Cyclogenesis. *Mon. Wea. Rev.*, **140**, 2198–2214, doi:10.1175/MWR-D-11-00305.1.

PRESENTATIONS

Invited:

- Schreck, C. J., 2012: The Madden–Julian oscillation and hurricanes. Energy and Environmental Systems Department, North Carolina Agricultural and Technical State University, Greensboro, NC, 2 April 2012.

Other presentations:

- Schreck, C. J., 2013: Comparing MJO diagnostics during DYNAMO. *MJO Field Data and Science Workshop*, 4-8 March 2013, Kohala Coast, HI.

- Schreck, C. J., J. P. Kossin, and L. Shi, 2012: The MJO and the 2005 hurricane season. *30th Conf. on Hurricanes and Tropical Meteorology*, 15-20 April 2012, Ponte Vedra Beach, FL, Amer. Meteor. Soc., 5B.5.

OTHER

- (product) monitor.cicsnc.org/mjo expanded to include diagnostics of tropical–extratropical interactions.
- (product) Local indices of MJO and equatorial waves developed for the DYNAMO field campaign sounding array.
-

Performance Metrics	FY12
# of new or improved products developed	2
# of products or techniques transitioned from research to ops	1
# of peer reviewed papers	4
# of non-peered reviewed papers	0
# of invited presentations	1
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	0

- Reanalyzing Tropical Cyclone Imagery with Citizen Scientists

Task Leader	Carl Schreck and Scott Stevens
Task Code	NC-CDR-16-NCICS-CS_SS
Main CICS Research Topic	Climate Data and Information Records and Scientific Data Stewardship
Percent contribution to CICS Themes	Theme 1: 0%; Theme 2: 100%; Theme 3: 0%
Percent contribution to NOAA Goals	Goal 1: 0%; Goal 2: 100%

Highlight: CycloneCenter.org is a web-based interface that enables the public to help analyze the intensity and structure of past tropical cyclones. It has already produced more than 150,000 classifications since launching in September 2012.

BACKGROUND

The global record of tropical cyclones contains uncertainties caused by differences in analysis procedures around the world and through time. Patterns in storm imagery are best recognized by the human eye, so we are enlisting the public. Interested volunteers will be shown one of nearly 300,000 satellite images. They will answer questions about that image as part of a simplified technique for estimating the maximum surface wind speed of tropical cyclones.

ACCOMPLISHMENTS

Scientists from CICS-NC worked with the *Citizen Science Alliance* to develop CycloneCenter.org. This process involved distilling the Dvorak technique down to a series of questions that were simple enough to be answered by the public. We also developed a new Dvorak color scale that is more intuitive and can easily be analyzed by even color-deficient volunteers. Nearly 300,000 images were created for analysis using NCDC's HURSAT dataset.

Figure 1 shows an example of one question that a volunteer might be asked. The volunteer is presented with an image, Hurricane Katrina (2005) in this case, and they are asked to pick which of the images below are the closest match. The volunteers are encouraged to pick this match based on the colors and the shape of the storm.

This question gives information about the developmental stage of the storm and an initial estimate of its strength. The volunteers can then opt in for a "detailed classification" where they will be asked more questions that are needed to approximate the Dvorak analysis.

The website launched 27 September 2012, and it has already produced more than 150,000 classifications by over 3,000 unique volunteers. The majority of those volunteers do less than 10 classifications, but most of our data actually comes from the small fraction of dedicated volunteers who have done hundreds of classifications. One volunteer in particular, bretarn, has done over 11,000 classifications, or more than 7% of the data collected so far.

While we have done some preliminary analysis, this project is still in the data collection stage. Our ultimate goal of more than one million classifications will take some time to achieve. We have worked to improve our volunteer base through a number of traditional and social media outlets. Notably, we published a summary of the project in AGU's Eos. We also presented this project at three major scientific meetings, including an invited talk at the AAAS Annual Meeting.

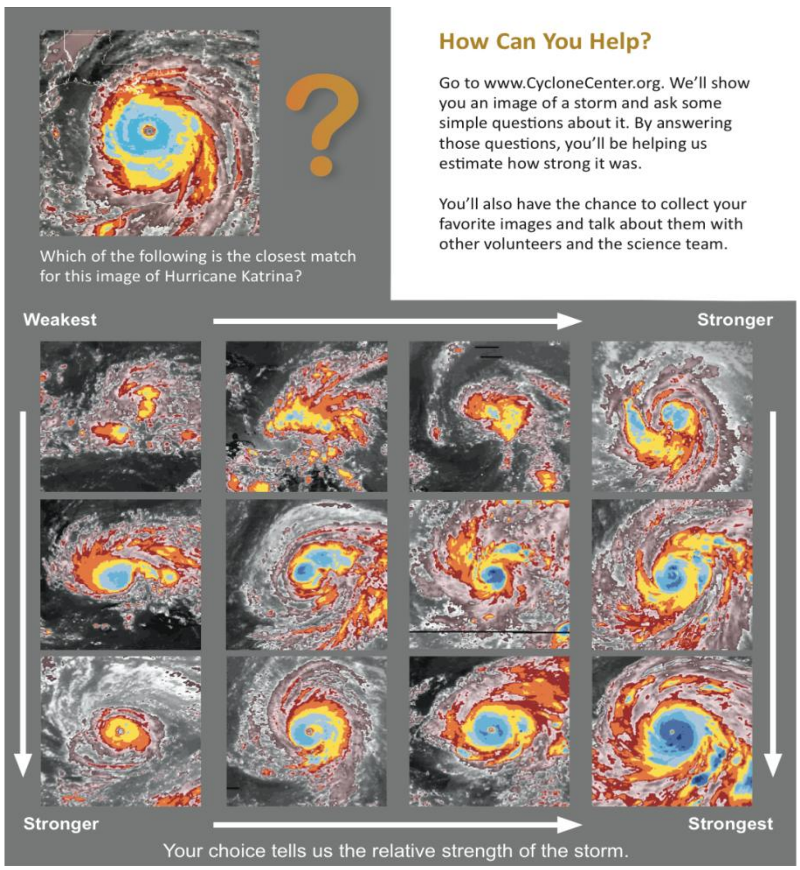


Figure 1: Illustration from one of our promotional flyers showing one question that volunteers may be asked on CycloneCenter.org.

PLANNED WORK

* Continue promoting this project through a variety of media outlets, particularly during the 2013 Atlantic Hurricane Season.

* Collaborate with researchers from Statistical and Applied Mathematical Sciences Institute (SAMSI) to begin analyzing the classifications and investigate methods for weighting our volunteers.
* Develop the educational aspect of CycloneCenter.org

PUBLICATIONS

Non-Peer Reviewed

Hennon, C. C., 2012: Citizen scientists analyzing tropical cyclone intensities. *Eos, Transactions American Geophysical Union*, **93**, 385–387, doi:10.1029/2012EO400002.

PRESENTATIONS

Invited

- Stevens, S. E., C. J. Schreck, C. C. Hennon, and K. R. Knapp, 2013: CycloneCenter: Harnessing the Power of Citizen Science to Analyze Hurricane Imagery (Invited). AAAS Annual Meeting, 14-18 February 2013, Boston, MA.

Other Presentations

- Knapp, K. R., C. C. Hennon, C. J. Schreck, and S. E. Stevens, 2013: Citizen scientists and tropical cyclone activity. *25th Conference on Climate Variability and Change*, 5-10 January 2013, Austin, TX.
- Schreck, C. J., C. C. Hennon, K. R. Knapp, and S. E. Stevens, 2012: Reanalyzing tropical cyclone intensities with citizen scientists. *AGU Annual Meeting*, 3-7 December 2012, San Francisco, CA.
- Schreck, C. J., J. P. Kossin, K. R. Knapp, and Hennon, Paula A., 2012: Global tropical cyclone climatology using IBTrACS. 30th Conf. on Hurricanes and Tropical Meteorology, 15-20 April 2012, Ponte Vedra Beach, FL, Amer. Meteor. Soc., 1B.4.

OTHER

- (Product) CycloneCenter.org website developed.

Performance Metrics	FY12
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	0
# of non-peered reviewed papers	1
# of invited presentations	1
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	0

- Satellite Data Support for Hydrologic and Water Resources Planning and Management

Task Leader Soroosh Sorooshian
Task Code NC-CDR-17-UCI
Main CICS Research Topic Climate Data and Information Records and Scientific Data Stewardship
Percent contribution to CICS Themes Theme 1: 75%; Theme 2: 25%; Theme 3: 0%
Percent contribution to NOAA Goals Goal 1: 25%; Goal 2: 75%

Highlight: UCI CHRS researchers developed an approach to generate near global daily precipitation from 1980 to 2009 using geostationary imagery (ISCCP GridSat-B1 IR) and monthly Global Precipitation Climatology Project (GPCP) data. The new product can be used for hydro-climatological studies.

BACKGROUND

The project emphasizes the reconstruction of long-term daily precipitation measurement at 0.25-Lat-Long degree for extreme event (flood and drought) studies. Specific tasks are added to the development and evaluation of a climate data record (CDR) of high-resolution precipitation estimates.

ACCOMPLISHMENTS

This project emphasizes the reconstruction of a precipitation CDR at daily and 0.25^{o} Lat/Long scales covering 60^{o}S to 60^{o}N. During the project period, the daily precipitation CDR over the time period of 1980 and 2009 were processed using the PERSIANN model and GridSat-B1 IRWIN data and then adjusted by GPCP data at monthly scale. Evaluations of daily precipitation CDR are ongoing. Figure 1 shows the time period daily precipitation data is processed and the monthly precipitation (before and after GPCP adjustment) over the 0-30^{o}N and 0-30^{o}S.

Some gaps are shown in the graphs in Figure 1 where questionable IRWIN data files produced erroneous results. In addition to the gap periods shown, many other IRWIN data files in many of the years on record have patches of IRWIN data that were found to be outside of the range of expected cloud-top temperatures (< 170 deg Kelvin), including large patches of data values below 140 deg Kelvin. The GridSat-B1 IRWIN data producers believe that they have solved these known problems and will be reprocessing that data set in the near future. We will reprocess PERSIANN-CDR for the new version of the GridSat-B1 IRWIN data set with previous errors corrected and apply additional filters to remove those values that are out of range.

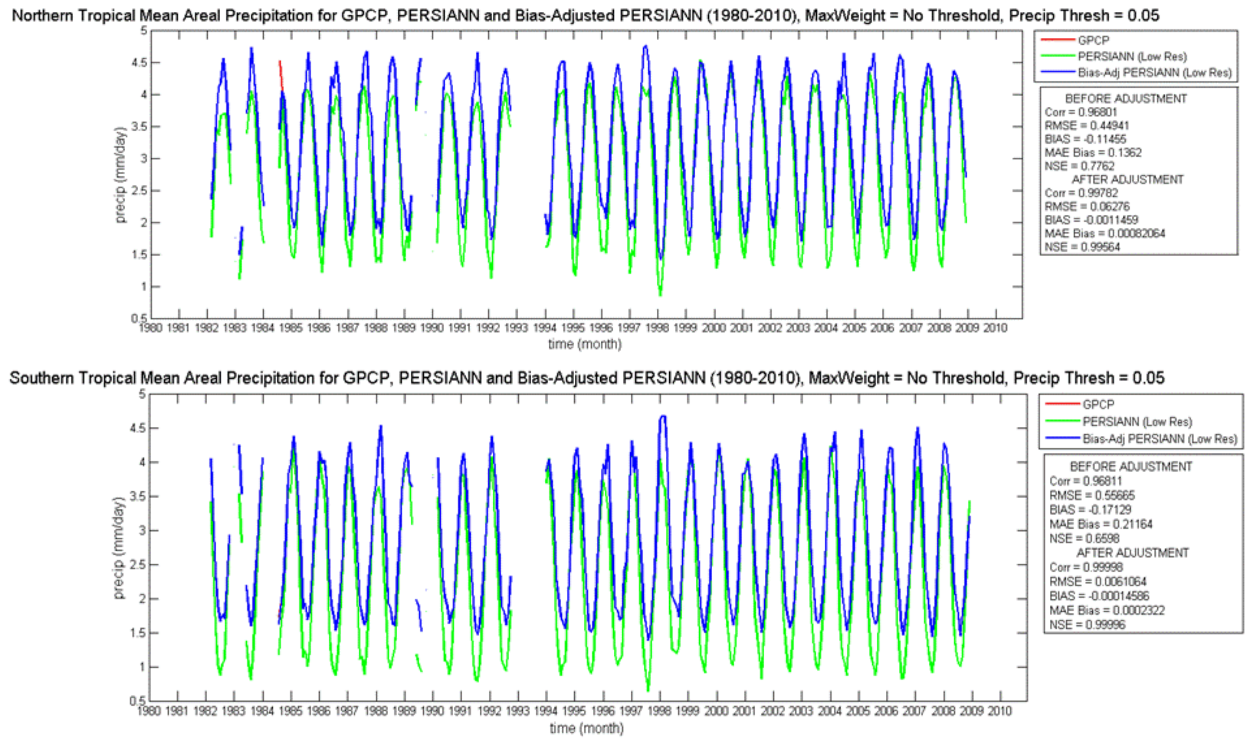


Figure 1: Comparing Mean Areal Precipitation (MAP) for Northern (0-30N, top figure) and Southern (30S-0, bottom figure) Tropical Regions. MAP calculated from GPCP Monthly product (red), Original PERSIANN (green), and Bias-Adjusted PERSIANN (blue).

Figure 2 is the Daily comparison of mean areal precipitation (MAP) for Northern (0o-30oN) and Southern (0o-30oS) tropical regions for the period of 1997-2009. It shows that the Bias-Adjusted PERSIANN data matches well with the GPCP-1DD data (daily 1ox1o) scale for the period of 1997—2009. It is also suggested that the PERSIANN daily precipitation CDR may be able to produce consistent data quality for the period of 1980—1997 for which GPCP-1DD data have not been made available. A publication summarizing the PERSIANN daily precipitation CDR activities is under preparation for submission to a peer-reviewed journal.

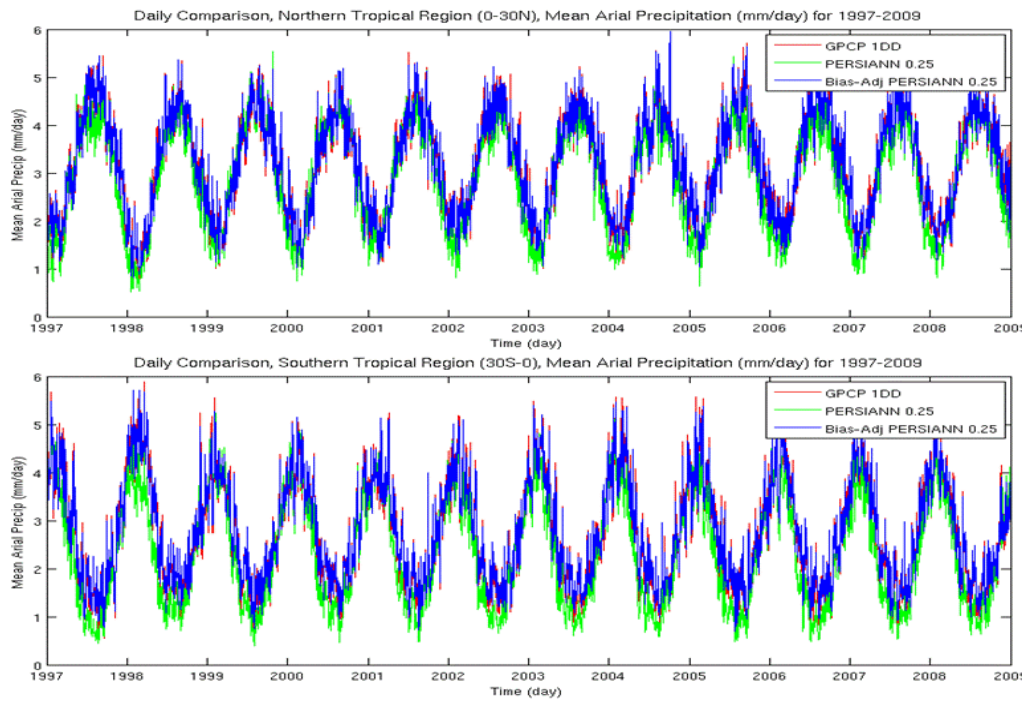


Figure 2: Daily comparison of mean areal precipitation (MAP) for Northern (0-30N, top figure) and Southern (30S-0, bottom figure) tropical regions for the period of 1997-2009. MAP calculated from GPCP-1DD (red), Original PERSIANN (green), and Bias-Adjusted PERSIANN (blue) (Ashouri et al., 2012).

PLANNED WORK

* Rerun PERSIANN-CDR for the new version of the GridSat-B1 IRWIN data set with known errors corrected and apply additional filters to remove those areas of input values that are out of range.
* Perform quality control measures on the outputs to find any anomalous or inconsistent results.
* Evaluate the PERSIANN daily precipitation CDR product against stage IV radar and gauge estimations in U.S., TMPA (3B42) data, and GPCP-1DD.
* Assess the uncertainty of PERSIANN daily precipitation CDR (error bar).

PUBLICATIONS

Nasrollahi, N., A. AghaKouchak, J. Li, X. Gao, K. Hsu, and S. Sorooshian, 2012. Assessing the impact of WRF precipitation physis in hurricane simulation, *Weather and Forecasting*, 27, 1003-1016.

Nasrollahi, N., K. Hsu, and S. Sorooshian, Reducing false alarm in satellite precipitation products, *Journal of Hydrometeorology*. (Submitted)

Zahraei, A., K. Hsu, S. Sorooshian, J.J. Gourley, Lakshmanan, V., Y. Hong, and T. Bellerby, 2012. Quantitative precipitation nowcasting: A Lagrangian pixel-based approach, *Atmospheric Research*, 118, 418-434, 2012.

Zahraei, A., K. Hsu, S. Sorooshian, J.J. Gourley, Y. Hong, and A. Behrangi, 2013. Short-term quantitative precipitation forecasting using an object-based approach, *Journal of Hydrology*, 483, 1-15, 2013.

PRESENTATIONS

- Ashouri H., K. Hsu, S. Sorooshian, D. Braithwaite, 2012, "A Satellite-based High Resolution Precipitation Product for Studying Climate Extremes", American Geophysical Union Fall Meeting, San Francisco, California, December 3-7, 2012.
- Ashouri, H., K. Hsu, and S. Sorooshian, Reconstruction of Daily Precipitation for Climate Trend Detection and Extreme Precipitation Analysis, AMS Meeting, 22-26 January, 2012. New Orleans, LA. 2012.
- Hsu, K. (Invited), A Machine Learning Approach for Precipitation Estimation from Multiple Satellite Information. American Meteorological Society Annual Meeting, 22-26 January, 2012. New Orleans, LA. 2012.

Performance Metrics	**FY12**
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	3
# of non-peered reviewed papers	0
# of invited presentations	3
# of graduate students supported by a CICS task	1
# of undergraduate students supported by a CICS task	0

- Precipitation Re-analysis using NMQ/Q2

Task Leader	Scott Stevens
Task Code	NC-CDR-18-NCICS-SS
Main CICS Research Topic	Climate Data and Information Records and Scientific Data Stewardship
Percent contribution to CICS Themes	Theme 1: 50%; Theme 2: 50%; Theme 3: %
Percent contribution to NOAA Goals	Goal 1: 50%; Goal 2: 50%

Highlight: Have successfully completed radar mosaics for continental United States by optimizing usage of the CICS computing cluster. Results have been compared to output from National Severe Storms Laboratory for quality assurance. Processing has begun on hydrological phase of reanalysis to produce meaningful precipitation data.

BACKGROUND

The National Mosaic and Multisensor QPE (NMQ/Q2) reanalysis represents a significant improvement in the spatial resolution and temporal frequency of gridded precipitation products. At present, the highest-quality product maintained by the meteorological community provides precipitation information at a scale of roughly 4 km, on a timescale of three hours. The NMQ/Q2 process will instead provide 1-km resolution, on a timescale of only five minutes.

ACCOMPLISHMENTS

The software is logically divided into two phases. The first performs radar preprocessing, quality control, and regridding from polar coordinates to cartesian. This phase of the processing has been largely successful in its completion, comparing well to output from the National Severe Storms Laboratory in Norman, OK, where the software was developed. The latest version of the hydrological phase of the software has recently been acquired and is being developed to run in a concurrent processing setting, in order to fully capitalize on available resources.

Figure 1 shows a high-resolution map of composite radar reflectivity for the central Great Plains, during a severe thunderstorm event over Kansas and Oklahoma. These reflectivities will serve as the primary input to the hydrological phase of processing, which will provide high-resolution gridded precipitation information in a clean, NetCDF format.

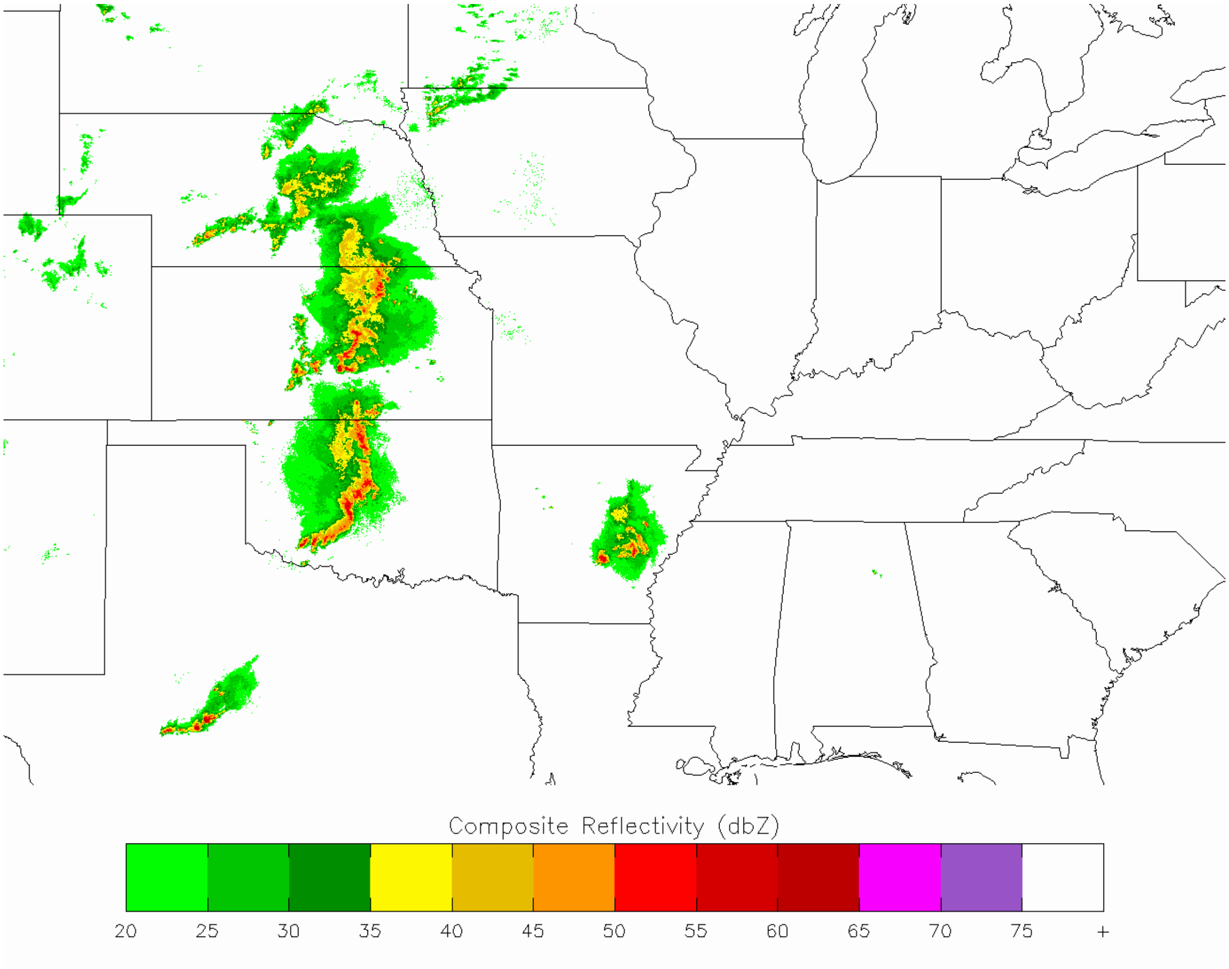


Figure 1: Gridded composite radar reflectivity for the central Great Plains during a thunderstorm event on 02 Apr 2006.

PLANNED WORK

* Continue testing of hydrological software to ensure consistency with analysis taking place at NSSL
* Optimize processing for use on CICS computing cluster. The process is presently run in real-time at NSSL on single machines, so the process will continue to be adapted for running several hundred instances simultaneously.
* Improve processing workflow for ease of automation. At present, some NEXRAD data files have been found to be corrupt, and the software is unable to catch all instances. This can cause problems in processing, so an effort is planned to improve the rate at which corrupt data are detected and removed.

PRESENTATIONS

- Stevens, S.E., B. Nelson, C. Langston, and Y. Qi (2012), Poster: Steps toward a CONUS-wide reanalysis with archived NEXRAD data using National Mosaic and Multisensor QPE (NMQ/Q2) algorithms; AGU Fall Meeting, San Francisco, CA, Dec 6, 2012

Performance Metrics	FY12
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	
# of peer reviewed papers	
# of non-peered reviewed papers	
# of invited presentations	1
# of graduate students supported by a CICS task	
# of undergraduate students supported by a CICS task	

- Satellite Product Evaluation and Near Real Time Monitoring

Task Leader	Lou Vasquez
Task Code	NC-CDR-19-NCICS-LV
Main CICS Research Topic	Climate Data and Information Records and Scientific Data Stewardship
Percent contribution to CICS Themes	Theme 1:0%; Theme 2:100%; Theme 3:0%
Percent contribution to NOAA Goals	Goal 1:0%; Goal 2:100%

Highlight: Significant improvements were made to anomaly detection and filtering capabilities of Satellite Product Evaluation Center (SPEC), an operational near-real-time product evaluation system. Also provided continued implementation support and modifications to manifest generation in Simple Ingest Protocol Generation System (SIPGENSYS), NCDC's most recent ingest system upgrade. Other tasks included support and directional oversight to CICS IT in support of the CICS Asheville high performance computing environments, network, and offices.

BACKGROUND

Satellite Product Evaluation Center (SPEC) is a product evaluation system with the capability to ingest data of various types, co-locating fields in time and space, and providing users with easy to access analyses and visualizations. It is in use, operationally monitoring NWP Forecast and Satellite-Based Products, and designed to be readily applied to a wide scope of data products for validation of near-real-time data streams.

Simple Ingest Protocol Generation System (SIPGENSYS) is the most recent iteration, and a critical component of the NCDC data ingest process. It is designed to ingest and archive multiple disparate data streams in real time. Manifest generation, the primary involvement for this task, allows the system to follow standardized conventions for interoperation with multiple archive locations, while enabling tracking and replay of ingest at a later point.

ACCOMPLISHMENTS

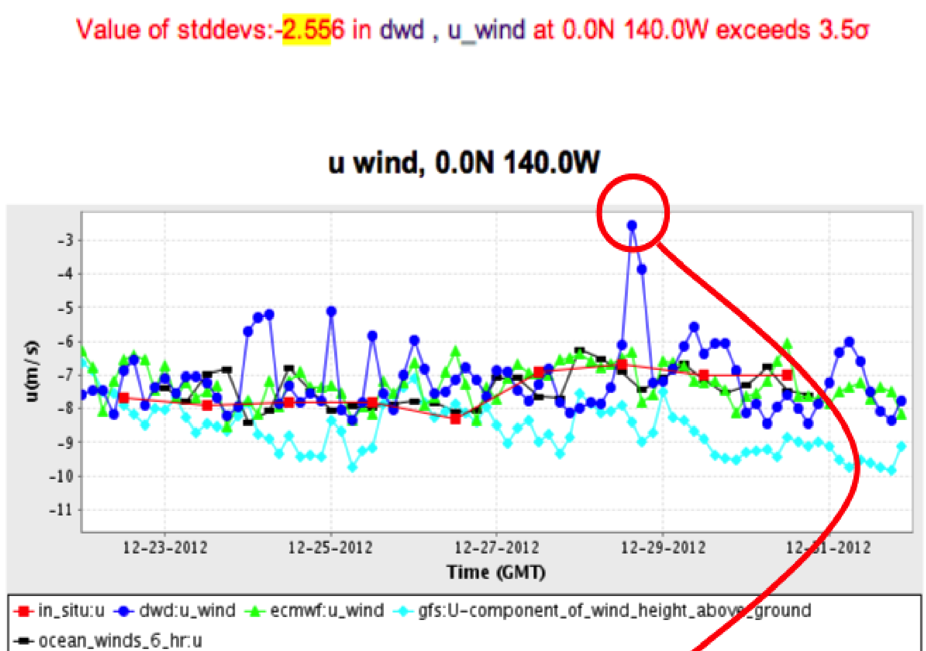
Implementation of SPEC conversion was completed from DB based data to NetCDF file based "Nuggets", a standardized means of creating product subsets for future re-analysis and sharing of commonly used locations to external users for comparison. This feature expands the potential user base of the SPEC product while reducing necessary ongoing support.

A generalized SPEC alert mechanism was designed and implemented, providing simple user control over anomaly detection for any product comparison, or internal metric.

This capability significantly improves the flexibility of the system and its scope of use, while providing a consistent, human readable indication of alert and its cause.

Filtering capability was added to SPEC system, permitting quality control data to be applied post subset, during analysis phase. This allows late in the process user management of results based on variety of possible quality flags or metrics.

The first full release of SPEC was created, with version controlled subset, statistical tools, and documentation in shareable package. Release was applied for first official operational deploy monitoring numerical weather prediction forecast and satellite-based products using Surface Flux Analysis (SURFA) data.



Source	Var	Control ID	Inherent					Relative to (in_situ,u)			
			POINTS	MIN	MAX	MEAN	STD_DEV	USED	BIAS	RMSE	NRMSD
in_situ	u	wnd0n140w	9	-[illegible].300	-6.700	-7.456	0.559	9	0.000	0.000	0.000
dwd	u_wind	wnd00n140w	592	-[illegible].440	-2.556	-6.924	0.969	432	0.327	0.738	0.125
ecmwf	u_wind	wnd00n140w	592	-8.531	-6.057	-7.249	0.592	432	0.220	0.464	0.188
gfs	U-component_of_wind_height_above_ground	wnd00n140w	692	-11.250	-6.530	-8.416	0.816	408	-1.022	1.323	0.280
ocean_winds_6_hr	u	wnd00n140w	144	-8.421	-6.243	-7.515	0.533	144	0.003	0.340	0.156

Figure 1: Satellite Product Evaluation Center (SPEC) alert from detection of anomaly. Human readable text of alert above; additional output below with value causing alert highlighted, and data plot for visual inspection by user.

Subset and analysis systems were merged to provide a single repository for both, with compilation and packaging tools included. Additional features were added, including static versus automated location definition, user defined acceptable data limits, and ID grouping of data plots for multi-location visualization.

New requirements were designed into and applied to the SIPGENSYS manifest, including tag additions, specialized information parsing, and containment, as well as modifications to the command line interface. Legacy code performing reformat of non-standard block compressed data was rewritten for the latest system environment. General support is also provided on this project for design decisions.

PLANNED WORK
* Further development and deployment of SPEC tool.
* Meet with NCDC branches to present and plan SPEC deployment for applicable data products.

PUBLICATIONS
N/A

PRESENTATIONS
- Vasquez, L., G. Peng, M. Urzen, B. Hankins and H.-M. Zhang, 2012: A Near Real-Time Monitoring System for NWP Forecast and Satellite-Based Products, Abstract IN31C-1504, Poster, 2012 AGU Fall Meeting, San Francisco, CA, 3-7 December.

Performance Metrics	FY12
# of new or improved products developed	2
# of products or techniques transitioned from research to ops	1
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	1
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	1

- Providing SSM/I Fundamental Climate Data Records to NOAA

Task Leader	Frank Wentz
Task Code	NC-CDR-20-RSS
Main CICS Research Topic	Climate Data and Information Records and Scientific Data Stewardship
Percent contribution to CICS Themes	Theme 2: 100%
Percent contribution to NOAA Goals	Goal 1: 100%

Highlight: Delivery of 25-years of Updated Version 7 SSM/I Climate Data Records for all 6 SSM/Is.

BACKGROUND

The Special Sensor Microwave Imagers (SSM/I) are a series of 6 satellite radiometers that have been in operation since 1987. These satellite sensors measure the natural microwave emission coming from the Earth's surface. These emission measurements contain valuable information on many important climate variables including winds over the ocean, the moisture and rain in the atmosphere, sea ice, and snow cover. However, the extraction of this information from the raw satellite measurements is a complicated process requiring considerable care and diligence. The first step in the process is the generation of Fundamental Climate Data Records (FCDR) of the sensor measurements in term of antenna temperatures and brightness temperatures. Since the first SSM/I was launched in 1987, Remote Sensing Systems (RSS) has been providing SSM/I data to the research and climate communities. The RSS SSM/I datasets are generally recognized as the most complete and accurate SSM/I FCDR available.

ACCOMPLISHMENTS

The primary objective of this investigation is to make a high-quality SSM/I FCDR, with supporting documentation, more widely and easily available to the User Community. This is being accomplished by converting the RSS data to a netCDF4 format and then providing it to NCDC/NOAA for archiving and distribution. The bulk of this investigation was the Year-1 work described in our previous Progress Report. In this year (Year 3), we are providing the following: (1) the continued processing of the F15 SSM/I, (2) a complete reprocessing of all SSM/I data to Version 7, (3) converting the RSS binary format into the netCDF4 format, and (4) supporting users inquiries and feedback and attending meetings and conferences. Whereas the generation of the V6 FCDR was part of RSS's commercialization program, the development and generation of the V7 FCDR was mostly paid for by NASA. This NASA support is acknowledged here and will be acknowledged on the NCDC/NOAA web site hosting the V7 FCDR.

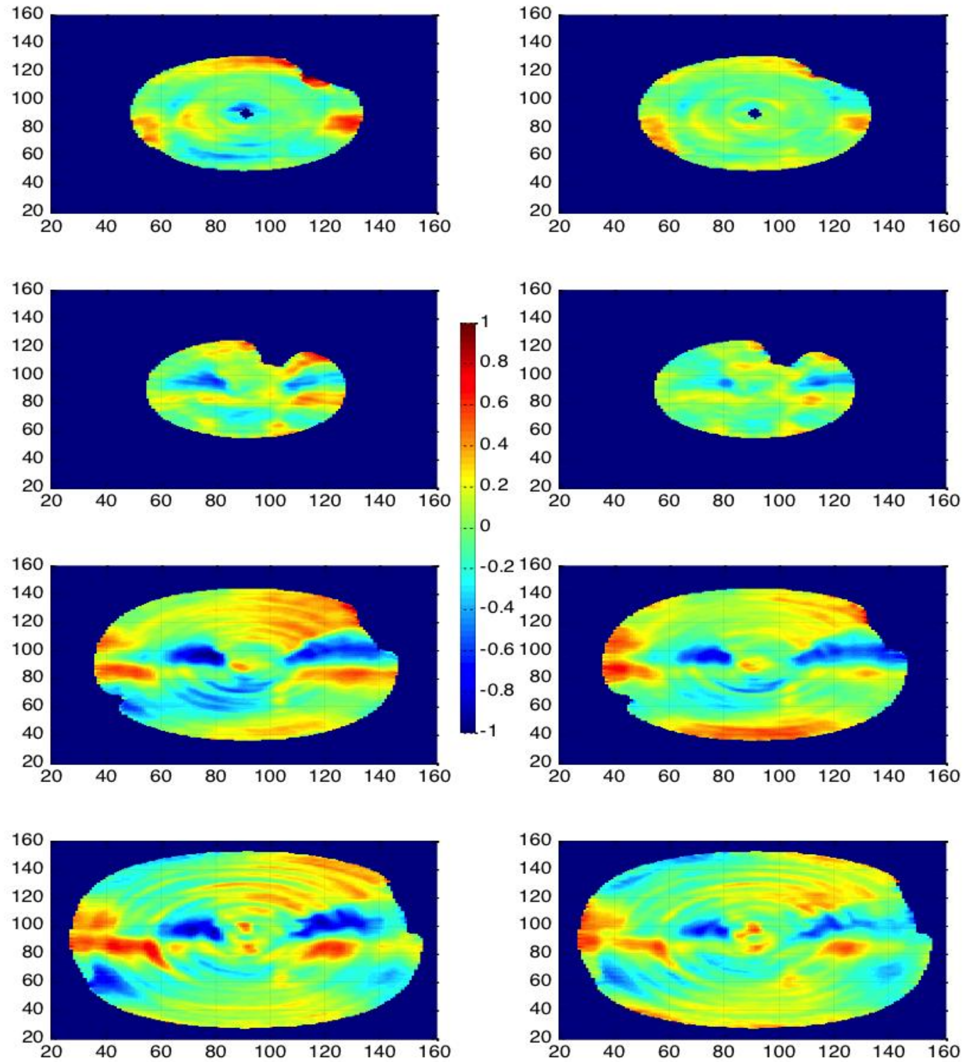


Figure 1. This is an example of the advanced calibration methods applied to the 6 SSM/I satellite sensors. The images show the adjustment to the hot target temperature to account for solar heating of the hot target. The two columns correspond to the adjustment applied to the 19/22 GHz channels and the 37/85 GHz channels. The 4 rows correspond to F11 through F15 SSM/Is. This adjustment is not used for F08 and F10. The x-axis is the sun azimuth angle α and the y-axis is the sun zenith angle β relative to spacecraft coordinates. The color bar goes from −1 K to +1 K.

PLANNED WORK
* This is the final year of this investigation. No further work is planned under this investigation.

PUBLICATIONS

Wentz, F. J., SSM/I Version-7 Calibration Report, RSS Tech. Rpt. 010112, 44 pp, Remote Sensing Systems, Santa Rosa CA, January 2013

Performance Metrics	FY12
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	0
# of non-peered reviewed papers	1
# of invited presentations	1
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	0

2.4 National Climate Assessment

National Climate Assessment efforts support interagency activities for national and regional assessments of climate change.

Background

NOAA has a number of national, regional, and sectoral level climate assessment activities underway and an emerging activity to support overall “Assessment Services”. NOAA is also participating in the high–level, visible, and legally mandated National Climate Assessment (NCA) process, which will be responsive to greater emphasis on user–driven science needs under the auspices of the US Global Change Research Program (USGCRP). National climate assessments, based on observations made across the country in comparison to predictions from climate system models, are intended to advance the understanding of climate science in the larger social, ecological, and policy systems to provide integrated analyses of impacts and vulnerability.

NOAA's National Climatic Data Center (NCDC) and many parts of NOAA have provided leadership on climate assessment activities for over a decade. A renewed focus on national and regional climate assessments to support improved decision–making across the country continues to emerge. Decisions related to adaptation at all scales as well as mitigation and other climate sensitive decisions will be supported through an assessment design that is collaborative, authoritative, responsive, and transparent. NOAA will be working through an interagency process and will be investing in partnerships across many scales to support this comprehensive assessment activity. The agency will also be looking to invest in core competencies including modeling, data management, visualization, communication, web management, and other expertise.

To support these activities, CICS has instituted an assessment task group. This consists of a senior scientist providing oversight for the full NOAA assessment activity with two deputies – a deputy with a support team focused on technical and science support coordination and a second deputy with a smaller support team focused on assessment media coordination. The Senior Lead Scientist is actively engaged in Assessment efforts and CICS will complete hiring of the technical/science deputy (Assessment Program Coordinator) and some of the technical/science support team by the beginning of the next contract cycle.

- National Climate Assessment Scientific Support Activities

Task Leader Kenneth E. Kunkel
Task Code NC-NCA-01-NCIS-KK
Main CICS Research Topic National Climate Assessments
Percent contribution to CICS Themes Theme 1: 0%; Theme 2: 0%; Theme 3: 100%
Percent contribution to NOAA Goals Goal 1: 100%; Goal 2: 0%

Highlight: A series of nine NOAA Technical Reports (NESIDS 142-Parts 1 through 9) was published to support the authors of the Third National Climate Assessment Report. These reports involved 35 co-authors (including 5 CICS scientists) and went through an extensive review process including 20 external reviewers and a thorough internal NOAA review. In addition, CICS scientists were lead authors on 4 chapters of the draft Third Assessment Report.

BACKGROUND

NOAA is participating in the high-level, visible, and legally mandated National Climate Assessment (NCA) process, which will be responsive to greater emphasis on user-driven science needs under the auspices of the US Global Change Research Program (USGCRP). National climate assessments are intended to advance the understanding of climate science in the larger social, ecological, and policy systems to provide integrated analyses of impacts and vulnerability. NOAA's National Climatic Data Center (NCDC) and many parts of NOAA have provided leadership on climate assessment activities for over a decade. A renewed focus on national and regional climate assessments to support improved decision-making across the country continues to emerge. Decisions related to adaptation at all scales as well as mitigation and other climate-sensitive decisions will be supported through an assessment design that is collaborative, authoritative, responsive, and transparent. NOAA is working through an interagency process and investing in partnerships across many scales to support this comprehensive assessment activity.

To support these activities, CICS has partnered with NOAA to form a technical support unit (TSU). Within the TSU, a group focused on scientific support has been assembled, consisting of a lead senior scientist, a deputy scientist, a climate scientist with extensive experience in the IPCC, a support scientist, and a software engineer. The Lead Senior Scientist provides scientific oversight for the development of NOAA's assessment services, focusing on a contribution to the National Climate Assessment and, in support of the National Climate Assessment and in conjunction with NOAA and other agency expertise, providing scientific oversight and guidance to coordinate and implement distributed and centralized high-resolution modeling capabilities.

ACCOMPLISHMENTS

An analysis of historical climate variations and trends was completed, focused around eight U.S. regions defined for the Third National Climate Assessment report. This analysis examined trends in mean temperature and precipitation, metrics of extreme temperature and precipitation, freeze-free season length, and variables of more regional interest, such as lake ice in northern regions. In addition to the historical analysis, climate model simulations of the 21st Century for the A2 and B1 scenarios were analyzed and summarized for use by the authors of the 2013 report. Nine documents were prepared, summarizing the historical data analysis and the analysis of the climate models. The preparation of these documents was led by Kenneth Kunkel and Laura Stevens and included 33 additional co-authors (3 of whom are CICS scientists). The documents were subjected to review by 20 external reviewers. They were then reviewed internally by NOAA to insure that we responded adequately to the external reviews. These documents were published as NOAA Technical Reports (NESDIS 142-Parts 1 through 9) and were used extensively by the chapter authors of the Third National Climate Assessment (NCA3) Report.

Two CICS scientists (Kunkel and Thorne) served as lead authors on four sections of the draft NCA3 Report: (a) Chapter 2 – Our Changing Climate; (b) Chapter 29 – A Research Agenda for Climate Change Science; (c) Appendix 1 – NCA Climate Science-Addressing Commonly Asked Questions from A to Z; and (d) Appendix 2 – The Science of Climate Change. These sections were completed and represent about 20% of the full report. In addition to these contributions, the scientific support group also provided a number of analyses and graphics for other chapter author teams.

An analysis of the potential effects of climate change on Probable Maximum Precipitation (PMP) was completed. PMP is the greatest accumulation of precipitation for a given duration meteorologically possible for an area. The potential effects of climate change on increasing PMP were analyzed, in particular, maximization of moisture and persistent upward motion, using both climate model simulations and conceptual models of relevant meteorological systems. Climate model simulations indicate a substantial increase in mean and maximum water vapor concentrations during the 21st Century. For the RCP8.5 scenario, the changes in maximum values for the continental United States are approximately 20-30% by 2071-2100. The magnitudes of the maximum water vapor changes follow approximately a Clausius-Clapeyron relationship with temperature changes. Model-simulated changes in maximum values of vertical and horizontal winds are too small to offset water vapor changes as the dominant contributor to PMP. This leads to the conclusion that the most scientifically sound projection is that PMP values will increase in the future due to higher potential levels of moisture content and flux convergence.

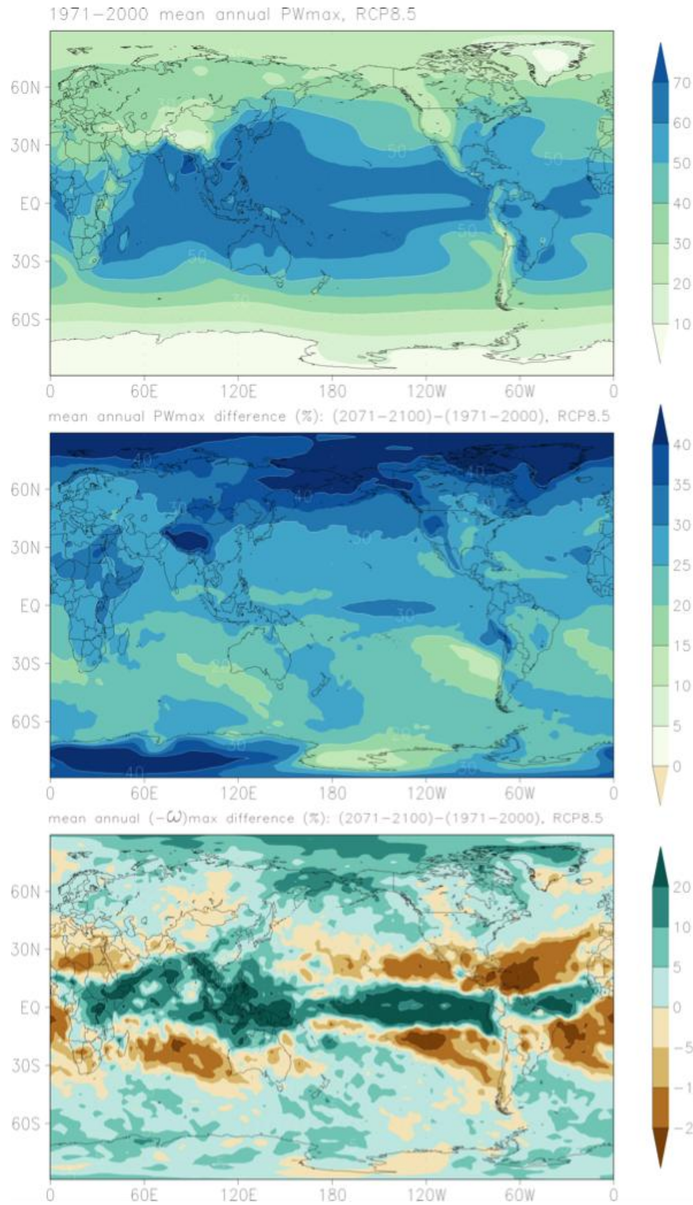


Figure 1: Fractional changes (%) of maximum annual precipitable water (PWmax) and upward vertical motion [(-ω)max]projected by seven CMIP5 climate models. These are multi-model mean differences (future minus present) in the 30-yr average annual maximum values under the RCP8.5 scenario, for 2071-2100 relative to the 1971-2000 reference value for 12-hr precipitable water (middle) and 6-hr vertical motion (bottom). The top panel shows mean annual maximum precipitable water for 1971-2000 (mm), averaged over the same seven climate models.

Performance Metrics	FY12
# of new or improved products developed	9
# of products or techniques transitioned from research to ops	
# of peer reviewed papers	17
# of non-peered reviewed papers	0
# of invited presentations	11
# of graduate students supported by a CICS task	
# of undergraduate students supported by a CICS task	

PLANNED WORK

* Respond to review comments (public and from the National Research Council) on the 4 sections of the draft Third National Climate Assessment Report on which CICS scientists served as lead authors
* Publish a comparative analysis of CMIP3 and CMIP5 climate models simulations following the material in NOAA Technical Report NESDIS 142-Parts 1 through 9.
* Complete papers on analysis of historical observations, including the probability distribution of monthly temperature, time of observation effects on extreme precipitation trends, day of the week signals in extreme precipitation, and the effect of the changeover to MMTS on extreme temperature trends.

PUBLICATIONS

Kunkel, K.E., 2012: Uncertainties in Observed Changes in Climate Extremes. In *Extremes in a Changing Climate – Detection, Analysis & Uncertainty*. A. AghaKouchak, D. Easterling, K. Hsu, S. Shubert, and S. Sorooshian (Eds.), Springer, 423pp, 287-307

Karl, T.R. B.E. Gleason, M.J. Menne, J.R. McMahon, R.R. Heim, Jr, M.J. Brewer, K.E. Kunkel, D.S. Arndt, J.L. Privette, J.J. Bates, P.Y. Groisman, and D.R. Easterling, 2012: U.S. temperature and drought: Recent anomalies and trends. EOS, 93, 473-474.

Kunkel, K.E., T.R. Karl, D.R. Easterling, K. Redmond, J. Young, X. Yin, and P. Hennon (in review) Probable maximum precipitation (PMP) and climate change. *Geophys. Res. Lett*.

Wuebbles, D.W., G. Meehl, K. Hayhoe, T. R. Karl, K. Kunkel, B. Santer, M. Wehner, B. Colle, E. M. Fischer, R. Fu, A. Goodman, E. Janssen, H. Lee, W. Li, L. N. Long, S. Olsen, A. Seth, J. Sheffield, and L. Sun (in review) CMIP5 climate model analyses: Climate extremes in the United States. Bull. Amer. Meteor. Soc.

Vose, R.S., S. Applequist, M.A. Bourassa, S.C. Pryor, R.J. Barthelmie, B. Blanton, P.D. Bromirski, H.E. Brooks, A.T. DeGaetano, R.M. Dole, D.R. Easterling, R.E. Jensen, T.R. Karl, R.W. Katz, K. Klink, M.C. Kruk, K.E. Kunkel, M.C. MacCracken, T.C. Peterson, K.Shein, B.R. Thomas, J.E. Walsh, X.L. Wang, M.F. Wehner, D.J. Wuebbles, and R.S. Young (in review) Monitoring and understanding changes in Extremes: Extratropical storms, winds, and waves. *Bull. Amer. Meteor. Soc.*

Peterson, T.C., R.J. Heim, Jr., R. Hirsch, D.P. Kaiser, H. Brooks, N.S. Diffenbaugh, R.M. Dole, J.P. Giovannettone, K. Guiguis, T.R. Karl, R.W. Katz, K.E. Kunkel, D. Lettenmaier, G.J. McCabe, C.J. Paciorek, K. Ryberg, S. Schubert, V.B.S. Silva, B.C. Stewart, A.V. Vecchia, G. Villarini, R.S. Vose, J. Walsh, D. Wolock, K. Wolter, C.A. Woodhouse, M. Wehner, and D. Wuebbles (accepted) Monitoring and understanding changes in heat waves, cold waves, floods and droughts in the United States: State of knowledge. Bull. Amer. Meteor. Soc.

Kunkel, K.E., T.R. Karl, H. Brooks, J. Kossin, J. Lawrimore, D. Arndt, L. Bosart, D. Changnon, S.L. Cutter, N. Doesken, K. Emanuel, P.Ya. Groisman, R.W. Katz, T. Knutson, J. O'Brien, C. J. Paciorek, T. Peterson, K. Redmond, D. Robinson, J. Trapp, R. Vose, S. Weaver, M. Wehner, K. Wolter, D. Wuebbles, 2013: Monitoring and understanding changes in extreme storms: state of knowledge. *Bull. Amer. Meteor. Soc*., in press.

Liang, X.-Z., M. Xu, X. Yuan, T. Ling, H.I. Choi, F. Zhang, L. Chen, S. Liu, S. Su, F. Qiao, Y. He, J.X.L. Wang, K.E. Kunkel, W.Gao, E. Joseph, V. Morris, T.-W. Yu, J. Dudhia, and J. Michalakes, 2012: Regional Climate-Weather Research and Forecasting Model (CWRF). *Bull. Amer. Meteor. Soc.* 93, 1363-1387.

Kunkel, K.E, L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, J. Rennells, A. DeGaetano, and J.G. Dobson, 2013: Part 1. Climate of the Northeast U.S., NOAA Technical Report NESDIS 142-1, 80 pp.

Kunkel, K.E, L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, C.E. Konrad II, C.M. Fuhrman, B.D. Keim, M.C. Kruk, A. Billet, H. Needham, M. Schafer, and J.G. Dobson, 2013: Part 2. Climate of the Southeast U.S., NOAA Technical Report NESDIS 142-2, 95 pp.

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Kunkel, K.E, L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, K.T. Redmond, and J.G. Dobson, 2013: Part 6. Climate of the Northwest U.S., NOAA Technical Report NESDIS 142-6, 76 pp.

Stewart, B.C., K.E. Kunkel, L.E. Stevens, L. Sun, and J.E. Walsh, 2013: Part 7. Climate of Alaska, NOAA Technical Report NESDIS 142-7, 61 pp.

Keener, V.W., K. Hamilton, S.K. Izuka, K.E. Kunkel, L.E. Stevens, and L. Sun, 2013: Part 8. Climate of the Pacific Islands, NOAA Technical Report NESDIS 142-8, 45 pp.

Kunkel, K.E, L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, and J.G. Dobson, 2013: Part 9. Climate of the Contiguous United States, NOAA Technical Report NESDIS 142-9, 78 pp.

PRESENTATIONS

-Kunkel, K.E. (2013): Regional Climatology and Outlooks for the Northeast and Southeast, invited talk, webinar organized by U.S. Environmental Protection Agency and U.S. Department of the Interior, 29 January, 2013.

-Kunkel, K.E. (2013): Assessing Changes in Extreme Weather and Climate Events, invited talk, Annual Meeting of the American Meteorological Society, Austin, TX, 9 January, 2013.

-Kunkel, K.E., L. Stevens, and G. Dobson (2013): Uncertainties in Regional Simulations of the U.S. Climate in the 20th and 21st Centuries, Annual Meeting of the American Meteorological Society, Austin, TX, 8 January, 2013.

-Kunkel, K.E. and D.R. Easterling (2013): Observed Increases in Potential Maximum Precipitation over Global Land Areas, Annual Meeting of the American Meteorological Society, Austin, TX, 8 January, 2013.

-Kunkel, K.E. (2013): Stan Changnon: A Renaissance Man of (Atmospheric) Science, invited talk, Annual Meeting of the American Meteorological Society, Austin, TX, 7 January, 2013.

-Kunkel, K.E. (2012): Heavy Precipitation Events: Past Trends, Causes, and Future Trends, invited talk, Water Research Foundation Educational Forum: Uranium Mining and Drinking Water Supplies, Richmond, VA, 11 December, 2012.

-Kunkel, K.E. (2012): CMIP5 Projections of Temperature and Hydrologic Extremes for the U.S., invited talk, 2012 Fall Meeting of the American Geophysical Union, San Francisco, CA, 3 December, 2012.

-Kunkel, K.E. (2012): Heavy Precipitation Events: U.S. Trends and Causes, invited talk, Duke University, Durham, NC, 7 November, 2012.

-Kunkel, K.E. (2012): National Climate Assessment Technical Support Unit, CICS program review, Asheville, NC, 6 November, 2012.

-Kunkel, K.E. (2012): U.S. Trends in Weather and Climate Extremes – An Updated Assessment, invited talk, Department of Marine, Earth, and Atmospheric Sciences, North Carolina State University, Raleigh, NC, 15 October, 2013.

-Kunkel, K.E. (2012): Observed Trends and Model Projections of Extreme Precipitation Events, invited talk, NOAA-GLERL Workshop on Methods of Projecting the Hydrologic Impacts of Climate Change, Muskegon, MI, 27 August, 2012.

-Kunkel, K.E. (2012): RCC/SC Involvement in National Climate Assessment, invited talk, Annual Meeting of the American Association of State Climatologists, Destin, FL, 12 July, 2012.

-Kunkel, K.E. (2012): Historical Trends and Future Projections of Extreme Precipitation in the Contiguous U.S., invited talk, webinar, U.S. EPA Office of Water, 21 June, 2012.

-Kunkel, K.E. (2012): Climate Trends and Outlook for the Gulf Region, invited talk, Gulf of Mexico Climate Outreach Community of Practice Workshop, New Orleans, LA, 16 April, 2012.

-Kunkel, K.E. (2012): Climate Trends, Duke Energy, Charlotte, NC, 13 April, 2012.

- Trends in Extratropical Cyclone Occurrence

Task Leader Kenneth E. Kunkel
Task Code NC-NCA-02-NCICS-KK
Main CICS Research Topic National Climate Assessments
Percent contribution to CICS Themes Theme 1: 0%; Theme 2: 0%; Theme 3: 100%
Percent contribution to NOAA Goals Goal 1: 100%; Goal 2: 0%

Highlight: An extensive analysis of potential biases in the temporal trends of ETCs was completed and found that the observed increases in input data over time are likely to cause an artificial downward trend in ETC counts. Thus, the observed upward trends are likely a robust finding and not an artifact of inhomogeneities in data availability.

BACKGROUND

ETCs are large-scale, non-tropical low-pressure storm systems that typically develop along a frontal boundary between air masses of contrasting temperature. The ETC is the principal atmospheric phenomenon through which sensible and latent heat fluxes are exchanged between the subtropical and polar regions. These large-scale cyclonic storms are the major feature of mid-latitude weather during the colder times of the year and often have severe weather associated with them. These storms can produce large snowfall amounts, which, together with high winds, result in blizzard conditions, large waves leading to coastal erosion, and severe convective events with lightning and tornadoes. In fact, these storms (or their absence in the case of drought) are responsible for many of the extreme weather types experienced at mid- and high-latitudes. ETCs are ubiquitous throughout the year, but tend to be stronger and located more equatorward in the cold season. Future changes in extreme weather in mid to high latitudes will likely involve changes in the frequency, intensity, and tracks of ETCs.

A number of recent studies focused on the Northern Hemisphere have documented a significant poleward shift of the storm track in both the Pacific and Atlantic ocean basins, a decrease in ETC frequency in mid-latitudes, and a corresponding increase in ETC activity at higher latitudes for the latter half of the 20th century. Future climate warming may lead to a decrease in polar low activity. A new analysis of surface pressure data has extended the availability of pressure field data from the mid-20th century as used in previous studies, back to the late 19th Century. We have used this new 20th Century Reanalysis (20CR) data set to extend the analysis of ETC occurrence in the Northern Hemisphere to the period 1871-2007.

ACCOMPLISHMENTS

Figure 1 shows the distribution of ETC activity by latitude and region for each year and how that distribution has changed over the 140-year reanalysis period. From 1871 to 2010, statistically significant trends in high latitude ETC activity (top panels) were found in the Pacific sector (downward) and in the Europe and Asia sectors (upward). The shorter records have no significant trends. Conversely, upward statistically significant trends were found for all mid-latitude sectors (bottom panels) over the longer period, but a downward trend was found in the North American sector on the short term. These results imply a substantial equatorward shift over the North American and Pacific sectors

The change in the number and locations of surface pressure observations during the reanalysis period adds a layer of uncertainty to the reanalysis data, and therefore to the ETC climatologies we have generated. The sparseness of digital observations for some regions early in the record, most notably the Pacific Ocean prior to 1925, raises legitimate questions about the accuracy of the 20CR dataset, and by extension the number of ETCs analyzed and their trends. Given that there is an overall upward trend in ETC activity, the central question is whether the reanalysis, with fewer observations, generates fewer ETCs in the early part of the record, resulting in an artificial upward trend. To investigate this issue, the reanalysis system was re-run without any pressure observations. Comparing the 20CR results in these regions of high confidence to the AMIP run, ETC activity is significantly increased when unconstrained by surface pressure observations. The mid-latitude North America and Europe sectors increase by 25% and 20%, respectively. This demonstrates a bias toward more, rather than less, ETC activity in the reanalysis dataset in the absence of observations. Therefore, since few observations are digitally available prior to 1900, the early 20CR values in both Pacific sectors, if biased, would be artificially too high, as seen in the right-most panels of Fig. 3. Elimination of these years would make the upward trend in the Pacific mid-latitudes even more pronounced while diminishing the downward trend in the Pacific polar sector. This reinforces our conclusion that since 1871 ETC activity has increased and shifted equatorward.

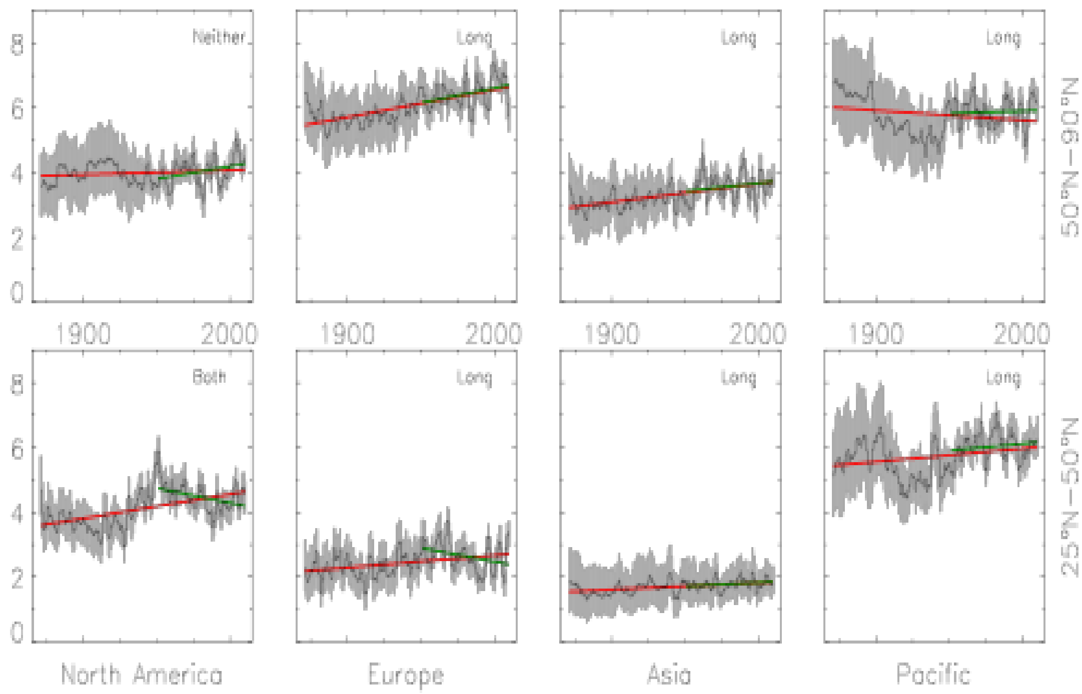

Figure 1: Annual time series of number of occurrences of cold season (Nov-Mar) ETC centers in regional sectors for North America (130°W-40°W), Europe (40°W-50°E), Asia (50°E-140°E), and Pacific (140°E-130°W). In each panel, for each year the number of ETC occurrences, in hundreds, is plotted with a solid black line. Shading indicates the range between the 2nd and 55th sorted ensemble members. Solid red and green lines are the Kendall-Theil robust line fits for the periods 1871-2010 ("Long") and 1951-2010 ("Short"), respectively. The annotation in the upper right corner indicates which of these periods has a slope significantly different from zero.

Performance Metrics	**FY12**
# of new or improved products developed	0
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	1
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	0

PLANNED WORK

* Create a website showing tracks of all ETCs identified in this study, along with ETC characteristics
* Investigate potential teleconnections with observed trends
* Respond to reviewer comments on submitted manuscript

PUBLICATIONS

Applequist, S., D.R. Easterling, K.E. Kunkel, G.P. Compo, P.D. Sardeshmukh, and K.C. McColl, 2013: 20th Century trends and uncertainties in Northern Hemisphere extratropical cyclone activity. *J. Geophys. Res*., submitted.

PRESENTATIONS

N/A

- National Climate Assessment Technical Support Unit Program Support Activities

Task Leader	Paula Ann Hennon
Task Code	NC-NCA-03-NCICS-PH
Main CICS Research Topic	National Climate Assessments
Percent contribution to CICS Themes	Theme 1: %; Theme 2: %; Theme 3: 100%
Percent contribution to NOAA Goals	Goal 1: 100%; Goal 2: %

Highlight: Developing the TSU's business process model and building a supportive workforce was a primary accomplishment in 2012. Identifying, onboarding, and managing the growing TSU team, coordinating team activities and developing necessary technical and process interfaces, all the while facilitating purposeful interaction between CICS-NC, NOAA NCDC, and the USGCRP are ongoing activities.

BACKGROUND

In its third year at NCDC, NOAA's Assessment Technical Support Unit (TSU) continued to provide critical input and support to the National Climate Assessment (NCA), a premier activity of the U.S. Global Change Research Program. The NCA is being conducted under the auspices of the Global Change Research Act of 1990, which calls for a report to the President and Congress that evaluates, integrates, and interprets the findings of the federal research program on global change (USGCRP) every four years. As the agencies comprising USGCRP seek to establish an ongoing, sustainable assessment process, as well as deliver a timely report in 2014, NCDC's TSU and the staff at USGCRP work in concert to provide coordination and technical support to a wide network of interagency and external groups and individuals.

ACCOMPLISHMENTS

The editorial team, responsible for translating the scientific text and assessment information contributed by the authors into a non-scientific, public facing document readable by the Congress and the general public, has achieved a significant milestone with the release of the draft 2014 report to the public for comment and review.
(http://ncadac.globalchange.gov/)

The web development team is scoping the deliverables for the interagency "Global Change Information System" initially focused on providing web access to the NCA, but also ensuring robust traceability of sources, connection to other climate and environmental information across the Government and elsewhere, and using cutting edge data access methods. This web-focused activity of the NCA will serve as a key component of the ongoing, sustainable process.

Production planning of the final report, including incorporating written draft materials from more than 240 authors and managing the input from public and agency reviews and comments is underway. The Graphical Design Team is currently developing the workflow for producing printed materials as well as an on-line magazine-style version so the final report and its accompanying enhanced visualizations can be distributed in multiple formats.

The TSU has also coordinated and facilitated several meetings of the National Climate Assessment and Development Advisory Committee – the federal advisory committee for the NCA – as well as a series of author team meetings to facilitate writing the report.

Performance Metrics	**FY12**
# of new or improved products developed	3
# of products or techniques transitioned from research to ops	1
# of peer reviewed papers	n/a
# of non-peered reviewed papers	n/a
# of invited presentations	n/a
# of graduate students supported by a CICS task	n/a
# of undergraduate students supported by a CICS task	n/a

PLANNED WORK

* Strategic planning for the NCA TSU's sustained process
* Continue to manage the overall team, their activities and milestones, and provide general management oversight of the report completion process

- National Climate Assessment Technical Support Unit Software Engineer

Task Leader Andrew Buddenberg
Task Code NC-NCA-04-NCICS-AB
Main CICS Research Topic National Climate Assessments
Percent contribution to CICS Themes Theme 1: 0%; Theme 2: 0%; Theme 3: 100%
Percent contribution to NOAA Goals Goal 1: 100%; Goal 2: 0% (Adaptation and Mitigation)

Highlight: CICS technical support staff have applied the best practices of software engineering to the scientific research workflow.

BACKGROUND

The National Climate Assessment integrates, evaluates, and interprets the findings of the U.S. Global Change Research Program (USGCRP) into a single cohesive report for policymakers and private entities to inform their decision-making and planning for the future. The far-reaching effects of this report demand the highest levels of traceability and reproducibility of the datasets and scientific analyses that operate upon them.

Given that almost all of these analyses are implemented with computer software, this task focuses on ensuring the integrity and portability of the programs developed for the NCA and assisting the lead scientist in their creation and development. In addition, to facilitate the overall business of the NCA and its integrity, ancillary software tools must be created and continue to be developed as part of the continuing assessment process.

ACCOMPLISHMENTS

Version control for both datasets and source code has been implemented for those that we developed or to which we had access. The Python programming language with the Scientific Python, (SciPy), NumPy (Numerical Python), and Climate Data Analysis Tools (CDAT) packages have been introduced to meet best practices for portability and maintainability for scientific code. The example below was used in the 2013 NCA Draft. Efforts to transition legacy FORTRAN77/95 code to Python, where appropriate, are ongoing.

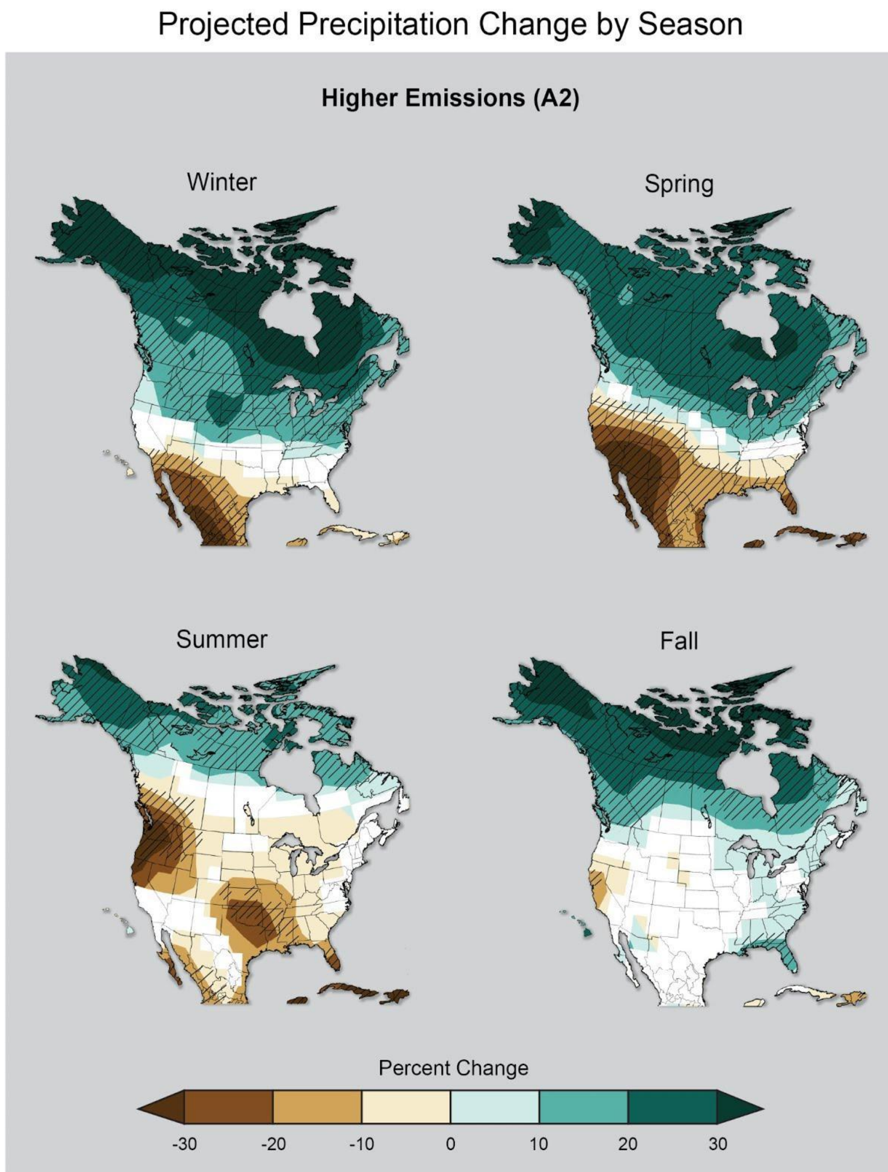

Figure 1. Projected Precipitation change by season for the A2 (higher emissions) scenario.

A large part of ensuring traceability and accountability for the NCA depends on acquiring, processing, and disseminating metadata about the data used in analyses. To support these efforts, a relational database has been developed to provide a common repository for metadata. Various tools that operate with the database to provide access and ingest metadata have also been created.

The initial implementation focused on supporting some of the input documents to the NCA--those with available metadata; efforts are underway to build a general metadata database to support all of the NCA and the GCIS.

Performance Metrics	FY12
# of new or improved products developed	8
# of products or techniques transitioned from research to ops	1
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	0

PLANNED WORK

* Continue development of metadata database and supporting technologies.
* Continue transitioning legacy research code to operations.
* Continue assisting lead scientist and associates with scientific programming tasks.

PUBLICATIONS

N/A

PRESENTATIONS

N/A

- Development of decision support tools using geospatial visualizations, digital resources, and facilitation processes for the National Climate Assessment

Task Leader	James Fox
Task Code	NC-NCA-05-UNCA/NEMAC
Main CICS Research Topic	National Climate Assessment
Percent contribution to CICS Themes	Theme 1: 100%; Theme 2: 0%; Theme 3: 0%
Percent contribution to NOAA Goals	Goal 1: 70%; Goal 5: 30%

Highlight: Staff from UNC Asheville's NEMAC created maps and products for draft chapters of the Third Climate Assessment; co-developed digital resource environments for the authors and users of the Climate Assessment; and presented a decision framework for use by the Climate Assessment. These new products support the overall advancement and progression of the National Climate Assessment program.

BACKGROUND

The University of North Carolina Asheville's (UNCA) National Environmental Modeling and Analysis Center (NEMAC) has assisted CICS and the NOAA Assessments Technical Support Unit (TSU) thorough the provision of expertise, staff time, and technical resources.

The University of North Carolina Asheville's (UNCA's) National Environmental Modeling and Analysis Center (NEMAC) specializes in using science communication and delivery to develop decision-making tools for local and regional planners, decision makers, and the public. UNCA's NEMAC's staff members have expertise in visualization, geographic information systems (GIS), programming, multimedia, marketing, community engagement, outreach, meeting facilitation, and environmental science. Located in Asheville, site of NOAA's National Climatic Data Center and NOAA's Cooperative Institute for Climate and Satellites, UNCA's NEMAC is uniquely situated to address the needs of NOAA's Assessments Technical Support Unit (TSU) through the provision of expertise, staff time, and technical resources.

NEMAC provides its expertise and resources to initially address three task areas:

- Geographic Information Systems/Climate Projections Resource Development
- Co-Development of Digital Resource Environment for the National Climate Assessment/Global Change Information System
- Decision Support

ACCOMPLISHMENTS

Geographic Information Systems/Climate Projections Resource Development

CMIP3 and NARCCAP datasets were processed based on data updates and a series of maps were generated in support of “Regional Climate Trends and Scenarios” publications that the Third Assessment authors then were able to utilize in their draft chapters of the Third Climate Assessment. This was an update to datasets and maps that had been processed and generated in the previous project year. Particular updates included the mapping data uncertainties for all of the CMIP3 and NARCCAP data in the form of hatching, overlays, and color. Final maps were exported in high resolution and multiple formats to support the NCA graphics team needs. Of these sets of final maps, 96 were published in the “Regional Climate Trends and Scenarios” publications, and three were included in draft chapters of the Third National Climate Assessment.

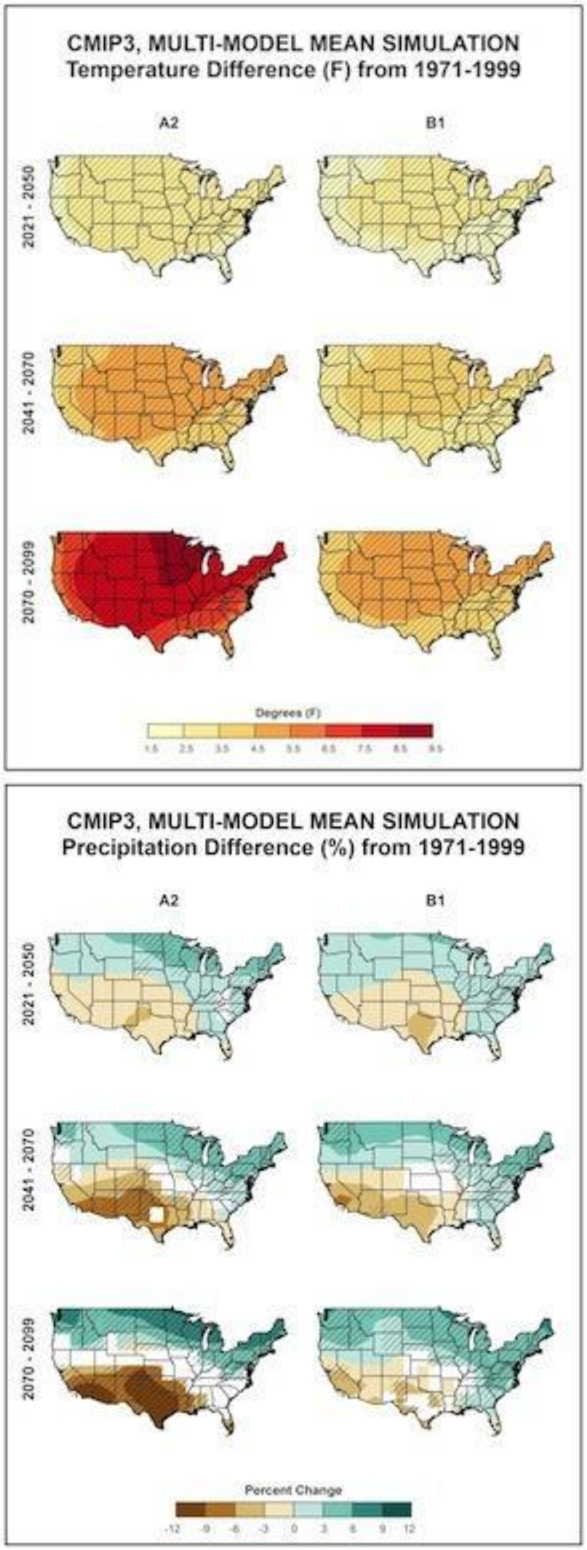

Figure 1. Maps created for "Regional Climate Trends and Scenarios" publications for the Third Climate Assessment.

CMIP5 data was delivered in spring 2012. NCA TSU staff and other Assessment authors requested a set of initial maps of this new data in order to get a sense for differences between it and CMIP3 data. The CMIP5 data were processed and mapped following CMIP3 data processing and mapping procedures. However, for preliminary purposes, only the US region was processed and mapped.

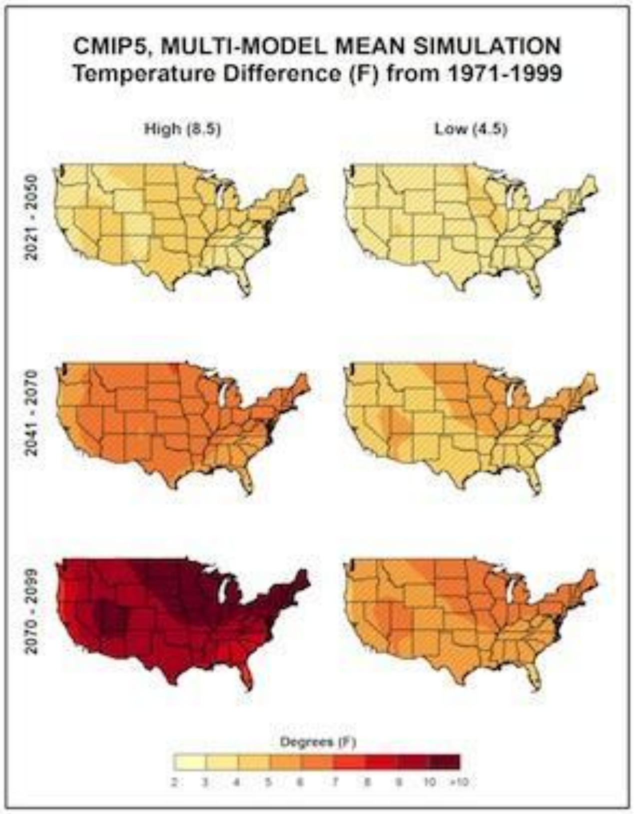

Figure 2. Map created using CMIP5 dataset.

NEMAC staff has worked closely with NCA TSU staff in the development of appropriate metadata to collect from all authors who submitted maps for the "Regional Climate Trends and Scenarios". This included not just usual metadata information, but also color scheme information for data classifications, which followed the Color Brewer color standards. In addition, NEMAC staff has been testing the re-creation of maps based on data and metadata submitted. Finally, all of the data and layers that were used in the creation of the maps that NEMAC has been responsible for (the 96 maps referenced above) have been provided as individual data packages (for each map figure) to the scenarios.globalchange.gov website as a download option so that anyone could essentially download the data and re-create the maps for their own purposes.

Co-Development of Digital Resource Environment for the National Climate Assessment/Global Change Information System

Mark Phillips and Caroline Dougherty provided programming and design support for the 2013 National Climate Assessment review and comment system, built in Drupal 7, as well as assistance to NOAA's April Sides in her development of the site and in launching the site to full production in January 2013. Caroline provided a look and feel to match Globalchange.gov's current design, as well as a secondary design to match Globalchange.gov's new design, to be launched in 2013.

Caroline Dougherty designed the public-facing Drupal site for Scenarios for Climate Assessment and Adaptation, formatting it primarily to be a data library system that is easily accessible and able to support a large amount of data. The site is mobile-responsive and reflects the colors used in designing the National Climate Assessment's Authorship Portal. Mark Phillips developed methodology to conduct a mass upload of data to the site, all of which was cross-linked to corresponding NCA report(s) and relevant region(s).

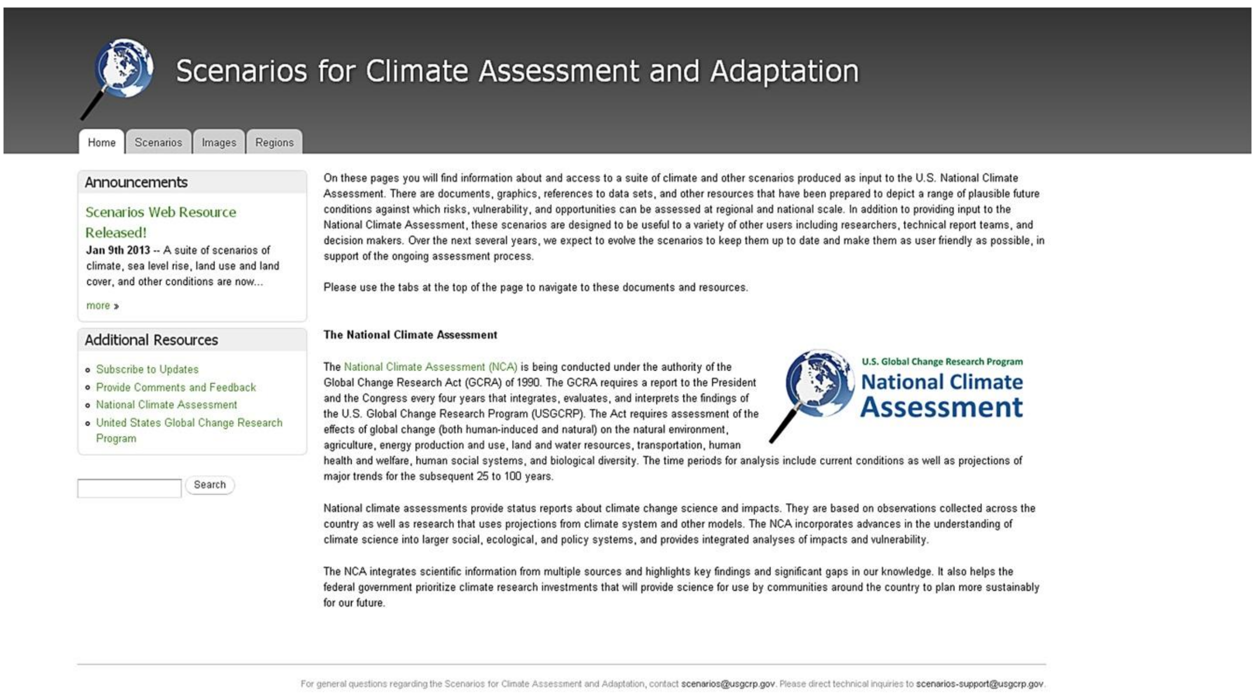

Figure 3. Screenshot of Scenarios for Climate Assessment and Adaptation Drupal site.

Caroline Dougherty worked with NOAA's Melissa Kenney and developed a site in Drupal for the National Climate Assessment Indicators authors to come together and collaborate on their report, estimated to be published in 2015. The site is based on a similar design as the National Climate Assessment Authorship Portal, and it is capable of supporting hundreds of users in distinct workgroups and assisting with their drafting processes necessary in developing the indicators report. The site archives files uploaded into three categories across 16 workgroups and allows team leaders to mark goals and milestones met as the assessment process progresses.

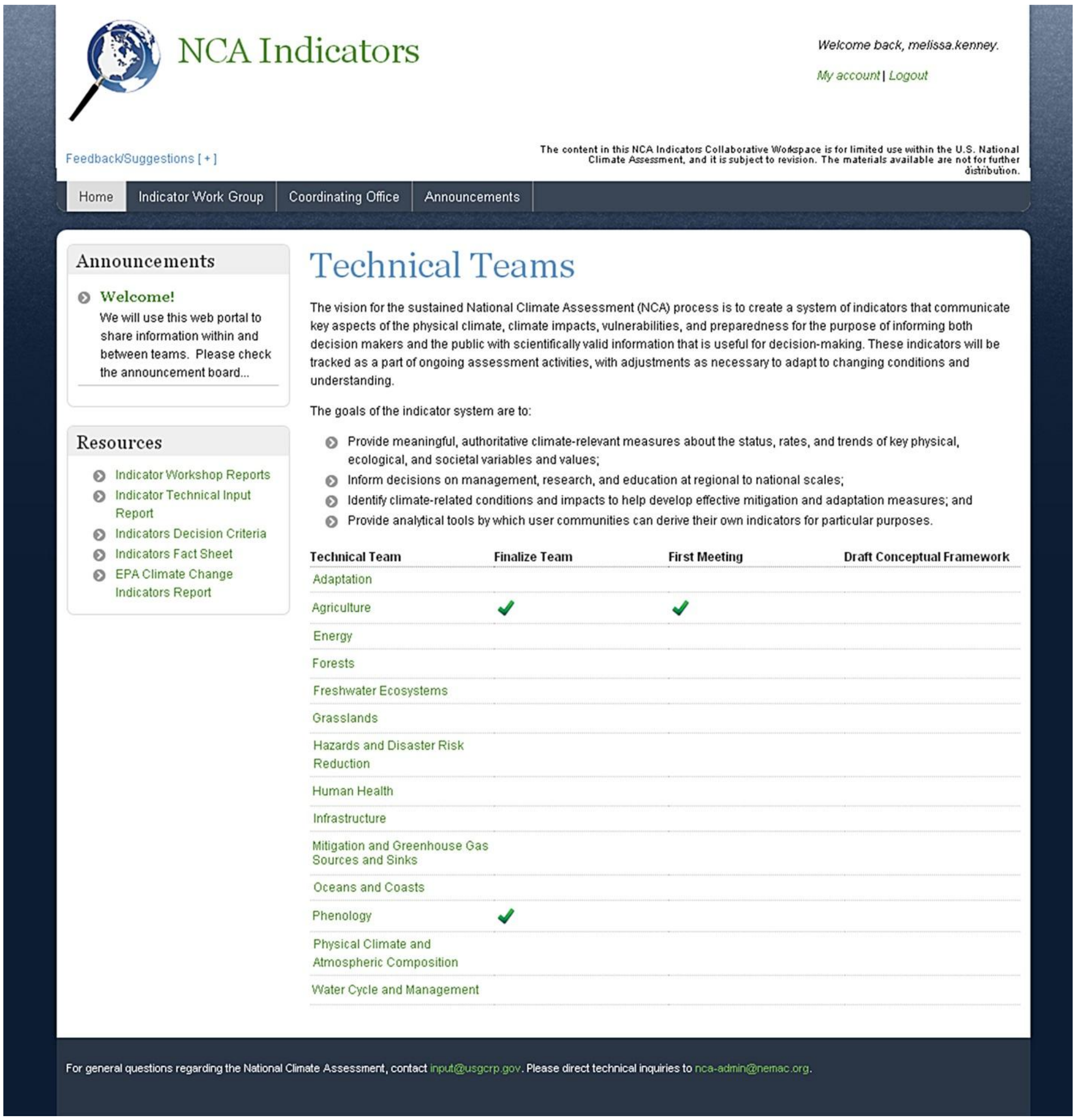

Figure 4: Screenshot of NCA Indicators site.

Other Digital support

Caroline Dougherty and John Frimmel worked with NOAA's Jessica Blunden to develop a portal system for BAMS State of the Climate editors and to support their efforts in putting together the State of the Climate report for 2014. The portal's capabilities were originally based in Oracle and were converted to Drupal. It supports 13 workgroups and their team members on varying levels of site administration, and allows team leaders to mark goals and milestones met as the editing process progresses. The site's look and feel has been designed to provide an accessible, clean interface for the workgroups.

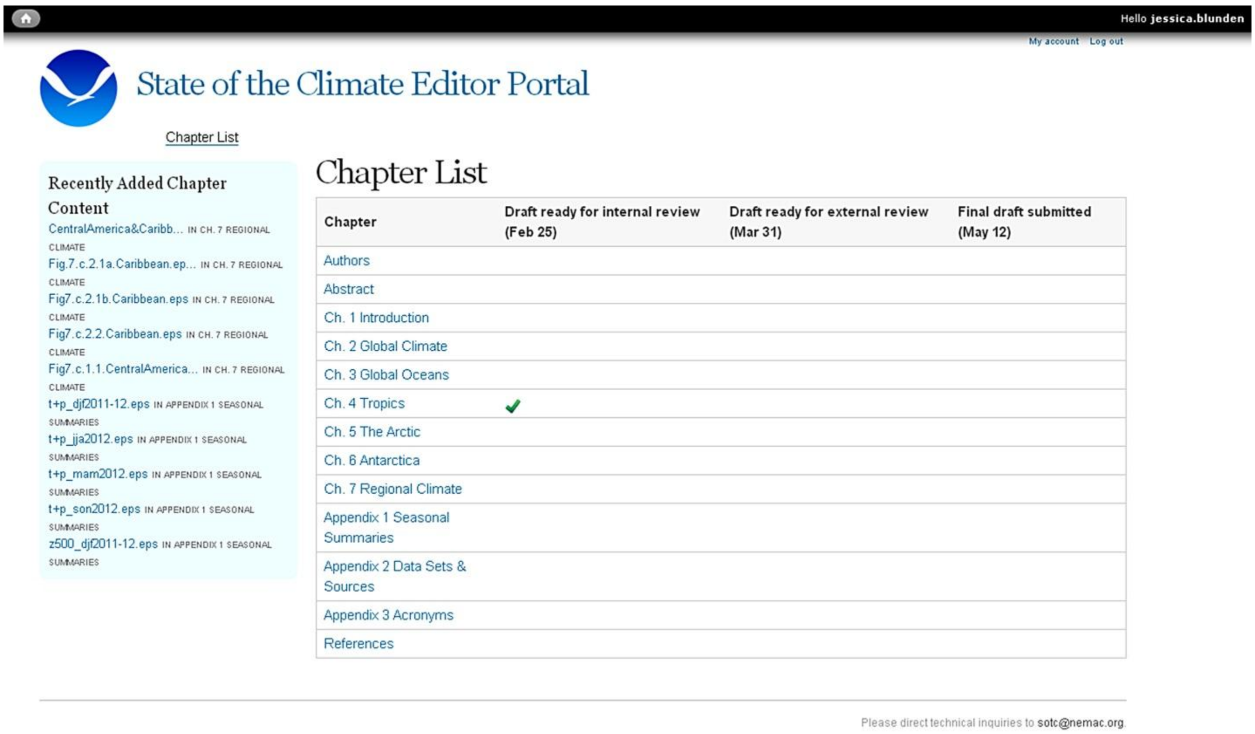

Figure 5: Screenshot of State of the Climate Editor Portal.

Decision Support

NEMAC has worked with a variety of NOAA and NCA team members to begin the scoping of the workshops with NCANET and their stakeholders. Anne Waple has attempted to set up a scoping telephone conference during February, but her imminent departure has made it difficult to coordinate. Jim Fox has created a proposed outline for the workshops that includes scenario planning and other tools. NEMAC has worked on climate adaptation workshops with a variety of stakeholders during this year (funded from other sources) and therefore brings expertise and experience.

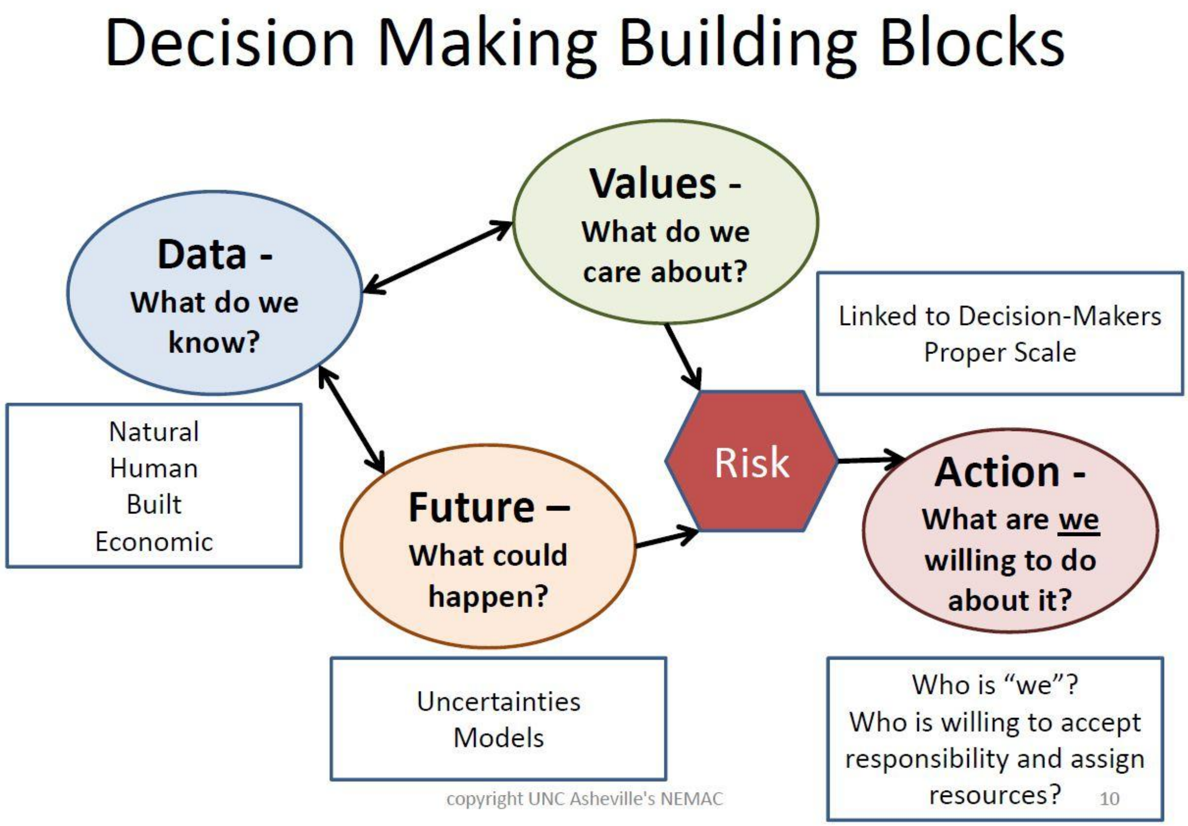

Figure 6. Graphic illustrating decision-making process presented at Data Discovery Days (J. Fox, November, 2012).

NEMAC has added data from the National Climate Assessment chapters to a local decision support system being used by the Mountain Resource Commission of the State of North Carolina (funded outside this work). NEMAC utilized the published reports from earlier workshops from NCA to insure that local decision makers are using the data the proper way.

To advance this NCA work program, Jim Fox and Greg Dobson have participated in two Data Discovery Days with another one planned for late March 2013. Mr. Fox presented at the last workshop on the decision support techniques that NEMAC is employing through other projects. This presentation led to more in depth discussions with two of the companies that attended the workshops.

In addition, NEMAC has started discussing their decision support approach with the group that is developing content on this topic for Climate.gov. David Herring has requested a follow-up planning meeting to ensure coordination between the workshops for NCANET and his group. This coordination will help in the creation of the Visualization tool for NCANET and the integration of this tool into other NOAA websites and outreach materials.

Project Management

NEMAC held regular meetings with staff associated with each product mentioned above. Project meetings were also held with Anne Waple and Ana Privette at the UNC Asheville RENCI Engagement Site on August 30th, 2012; October 15th, 2012 and February 5th, 2013. NEMAC Staff in attendance during those meetings included Jim Fox, Karin Rogers, Mark Phillips, Greg Dobson, and Caroline Dougherty.

Performance Metrics	**FY12**
# of new or improved products developed	100
# of products or techniques transitioned from research to ops	100
# of peer reviewed papers	7
# of non-peered reviewed papers	0
# of invited presentations	4
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	3

PLANNED WORK

Planned work for the remainder of this fiscal year (through June 30, 2012) includes the following tasks:

* Continued maintenance and upkeep of the Indicator and Scenario sites, the Review and Comment system and the BAMS State of the Climate Editor Portal
* Provide cartography and mapping services for the Third Climate Assessment, as needed
* Scope needs for decision support workshops with NCA staff
* Coordinate and host decision support workshops, as planned with NCA staff
* Present decision support approach at Data Discovery Days, March 2013 (Jim Fox)

PUBLICATIONS

Kunkel, K.E, L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, J. Rennells, A. DeGaetano, and J.G. Dobson. 2013. “Regional Climate Trends and Scenarios for the U.S. National Climate Assessment.” Part 1. Climate of the Northeast U.S., *NOAA Technical Report NESDIS* 142-1, 79 pp.

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Kunkel, K.E, L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, S.D. Hilberg, M.S. Timlin, L. Stoecker, N.E. Westcott, and J.G. Dobson. 2013. “Regional Climate Trends and Scenarios for the U.S. National Climate Assessment.” Part 3. Climate of the Midwest U.S., *NOAA Technical Report NESDIS* 142-3, 95 pp.

Kunkel, K.E, L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, M.C. Kruk, D.P. Thomas, M. Shulski, N. Umphlett, K. Hubbard, K. Robbins, L. Romolo, A. Akyuz, T. Pathak, T. Bergantino, and J.G. Dobson. 2013. “Regional Climate Trends and Scenarios for the U.S. National Climate Assessment.” Part 4. Climate of the U.S. Great Plains, *NOAA Technical Report NESDIS* 142-4, 82 pp.

Kunkel, K.E, L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, K.T. Redmond, and J.G. Dobson. 2013. “Regional Climate Trends and Scenarios for the U.S. National Climate Assessment.” Part 5. Climate of the Southwest U.S., *NOAA Technical Report NESDIS* 142-5, 79 pp.

Kunkel, K.E, L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, K.T. Redmond, and J.G. Dobson. 2013. “Regional Climate Trends and Scenarios for the U.S. National Climate Assessment.” Part 6. Climate of the Northwest U.S., *NOAA Technical Report NESDIS* 142-6, 75 pp.

Kunkel, K.E, L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, and J.G. Dobson. 2013. “Regional Climate Trends and Scenarios for the U.S. National Climate Assessment.” Part 9. Climate of the Contiguous United States, *NOAA Technical Report NESDIS 142-9*, 77 pp.

PRESENTATIONS

- Dobson, J.G., Morgan, J.D., Kunkel, K.E., and L.E. Stevens. *“The Use of GIS and Python Scripting for Processing and Mapping National and Regional Climate Data Simulations.”* The 93rd American Meteorological Society’s Annual Meeting, Third Symposium on Advances in Modeling and Analysis Using Python. January 6th – 10th, 2013, Austin, Texas.
- Fox, J.F., Dobson, J.G., Rogers, K.L., and M.W. Hutchins. *“Towards a Scalable Climate Adaptation Approach – It’s all about the Decision.”* The 93rd American Meteorological Society’s Annual Meeting, 8th Symposium on Policy and Socioeconomic Research. January 6th – 10th, 2013, Austin, Texas.

- Dobson, J.G. and J.F. Fox. *"Using 3D Visualization Tools for Integrated Decision Making and Risk Characterization."* 4th Annual Southeast Florida Regional Climate Leadership Summit. December 6th- 7th, 2012, Jupiter, Florida.
- Fox, J.F., "Decisions and System Thinking", Data Discovery Days, November, 2012, NCDC, Asheville, NC

OTHER

Service

- Dobson, J.G., North Carolina Center for Geographic Information and Analysis, 2013 NC GIS Conference Program Committee, April 2012 – February – 2013.
- Dobson, J.G., Session Moderator, *Apps, Apps, and More Apps*, Track 3 – GIS: Vision in Action. 2013 North Carolina GIS Conference, February 7th – 8th, 2013, Raleigh, North Carolina.

- National Climate Assessment Technical Support Unit Graphical Services

Task Leader Jessicca Griffin
Task Code NC-NCA-06-NCICS-JG
Main CICS Research Topic National Climate Assessments
Percent contribution to CICS Themes Theme 1: 0%; Theme 2: 0%; Theme 3: 100%
Percent contribution to NOAA Goals Goal 1: 100%; Goal 2: %

Highlight: CICS staff provided editorial, graphics, and production support for the National Climate Assessment, making significant contributions to the release of a draft NCA in January 2013.

BACKGROUND

The National Climate Assessment (NCA) is intended to provide the President, Congress, other stakeholders, and the general public with a report on the current state of climate change science, the impacts of climate change, and the effectiveness of mitigation and adaptation efforts. Given the intended audience, it is essential that the report is written and graphically represented in clear language that is easily understood by a broad audience while maintaining the highest possible standards of accuracy and transparency.

ACCOMPLISHMENTS

Graphic design support services were provided for the development of the National Climate Assessment draft report. Tasks included basic image editing as well as more extensive editing and new creations to improve readability and ensure accuracy. Production services included preparing graphics for various pre-release drafts, as well as the final PDFs released to the public and NRC for review in January 2013. With tight deadlines and short turnaround times, delivery of that public review draft also required successful integration of the functions of multiple staff members within the TSU and effective coordination between the TSU staff and the USGCRP office in Washington, D.C.

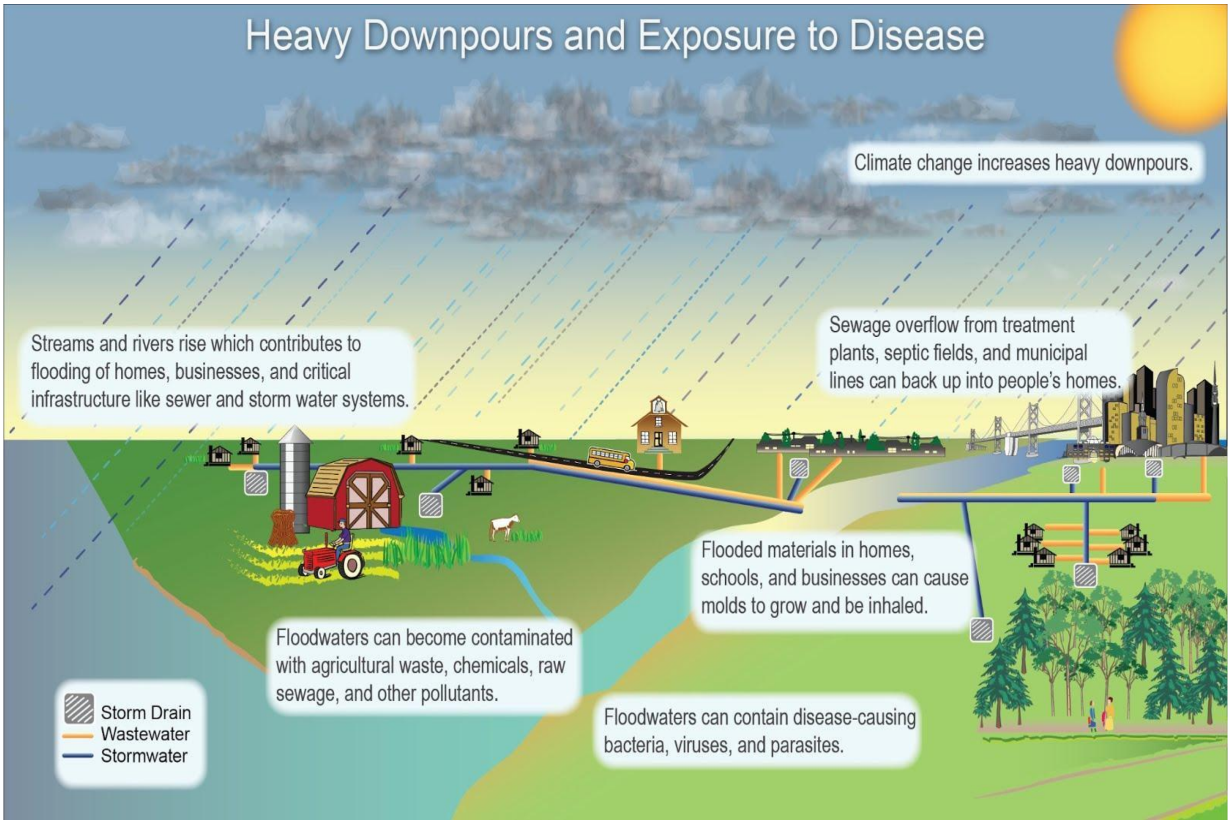


Figure 1: Heavy Downpours and Exposure to Disease - Health Chapter: National Climate Assessment

Performance Metrics	**FY12**
# of new or improved products developed	N/A
# of products or techniques transitioned from research to ops	N/A
# of peer reviewed papers	N/A
# of non-peered reviewed papers	N/A
# of invited presentations	N/A
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	N/A

PLANNED WORK

* Develop graphics for the shorter "Companion" version of the NCA, which will be the only printed version and will be the basis of an interactive eBook version of the Assessment.
* Develop and design the multiple platforms for the NCA
  Full report: Interactive PDF and eBook
  Companion report: Print, Interactive PDF, and eBook
* Continue with iterative graphical editing tasks for subsequent drafts of the NCA.
* Contribute to the development of various supplemental products, online content, and interactive products

- Web Development for National Climate Assessment

Task Leader Angel Li
Task Code NC-NCA-07-NCICS-AL
Main CICS Research Topic National Climate Assessments
Percent contribution to CICS Themes Theme 1: %; Theme 2: %; Theme 3: 100%
Percent contribution to NOAA Goals Goal 1: 100%; Goal 2: %

Highlight:
Designed and implemented a new web site for CICS-NC. Concluded a performance evaluation of the NCA Comment and Review system. Completed web development support for Dataset Discovery Days and the Executive Forum on Business and Climate websites.

BACKGROUND

The National Climate Assessment integrates, evaluates, and interprets the findings of the U.S. Global Change Research Program (USGCRP) into a single cohesive report for policymakers and private entities to inform their decision-making and planning for the future. As print media is being phased out, the web is now a much more vital resource for reports such as the National Climate Assessment report. As tablet sales continue to outpace personal computer sales, the e-Book version of the report is also just as important.

ACCOMPLISHMENTS

A new web site for CICS-NC was developed and launched: it was developed as a prototype to explore user-device independent viewing, which is needed for NCA publications. The website is “responsive”, i.e., it is designed to be viewed on smaller mobile devices as well as desktop computers.

The NCA Comments and Review system launched in January but benchmarking of the site revealed poor performance under medium load. A duplicate of the C&R system was copied to a local machine to facilitate performance tuning. So far, there have been no solutions to the performance bottleneck.

Performance Metrics	FY12
# of new or improved products developed	N/A
# of products or techniques transitioned from research to ops	N/A
# of peer reviewed papers	N/A
# of non-peered reviewed papers	N/A
# of invited presentations	N/A
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	N/A

PLANNED WORK
* Launch new CICS-NC web site
* Work on web presence for the NCA
* Author front-end for the NCA images metadata.
* Contribute to CICS-NC outreach efforts

PUBLICATIONS
N/A

PRESENTATIONS
- Responsible for design and deployment of CICSNC website: http://cicsnc.org

OTHER
- Attended the ESIP Federation Winter meeting in Washington DC

- Copy Editor for the National Climate Assessment

Task Leader	Thomas Maycock
Task Code	NC-NCA-08-NCICS-TM
Main CICS Research Topic	National Climate Assessments
Percent contribution to CICS Themes	Theme 1: %; Theme 2: %; Theme 3:100%
Percent contribution to NOAA Goals	Goal 1:100%; Goal 2:0%

Highlight: CICS staff provided editorial, graphics, and production support for the National Climate Assessment, making significant contributions to the release of a draft NCA in January 2013.

BACKGROUND

The National Climate Assessment (NCA) is intended to provide the President, Congress, other stakeholders, and the general public with a report on the current state of climate change science, the impacts of climate change, and the effectiveness of mitigation and adaptation efforts. Given the intended audience, it is essential that the report is written in clear language that is easily understood by a broad audience while maintaining the highest possible standards of accuracy and transparency.

ACCOMPLISHMENTS

Copy editor support services were provided for the development of the draft National Climate Assessment report. Tasks included basic editing for grammar, punctuation, and style, as well as more extensive editing to improve readability and ensure accuracy. Development of a style sheet for the NCA helped to ensure consistent use of terminology, style, and formatting throughout the report. Production services included preparing documents for various pre-release drafts, as well as the final PDFs released to the public and NRC for review in January 2013. With tight deadlines and short turnaround times, delivery of that public review draft also required successful integration of the functions of multiple staff members within the TSU and effective coordination between the TSU staff and the USGCRP office in Washington, D.C.

Performance Metrics	FY12
# of new or improved products developed	N/A
# of products or techniques transitioned from research to ops	N/A
# of peer reviewed papers	N/A
# of non-peered reviewed papers	N/A
# of invited presentations	N/A
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	N/A

PLANNED WORK

* Contribute to the development of the shorter “highlights” version of the NCA, which will be the only printed version and will be the basis of an interactive eBook version of the Assessment.
* Assist in verifying and maintaining the extensive list of references and sources used in the NCA
* Continue with iterative editing tasks for subsequent drafts of the NCA
* Contribute to the development of various supplemental products, online content, and interactive products

PUBLICATIONS

N/A

PRESENTATIONS

N/A

OTHER

- Attended the November 2012 meeting of the NCADAC (the Federal Advisory Committee overseeing the NCA), which provided an opportunity to meet with USGCRP staff as well as many of the committee members and authors, and to learn about the NCADAC governance process.

- Data Management for the NCA

Task Leader	Ana Pinheiro Privette
Task Code	NC-NCA-09-NCICS-APP
Main CICS Research Topic	National Climate Assessments
Percent contribution to CICS Themes	Theme 1: %; Theme 2: %; Theme 3: 100%
Percent contribution to NOAA Goals	Goal 1: 100% Goal 2: %

Highlight: The design and the implementation of the National Climate Assessment (NCA) Review and Comment System were completed. This system is currently hosting the 2013 NCA draft report and two IPCC draft reports. The development and implementation of four additional web-systems that support the NCA process was also completed.

BACKGROUND

CICS-NC is supporting the National Climate Assessment by providing leadership on the data management aspects of the program. This role is fulfilled by the Data Manager/Coordinator (Ana Pinheiro Privette), whose responsibility is to lead the design of the NCA data management strategy and help identify the tools required to support that strategy. Specific responsibilities include defining NCA's data policy and ultimately ensuring NCA's compliance with the Information Quality Act (IQA) and the Office of Management and Budget (OMB) requirements. To accomplish this goal, the TSU is leading the creation of the NCA data policy, which includes defining metadata standards, best practices for data archiving and data servicing to the public, and scientific data stewardship procedures. The long-term goal of the NCA is to provide reproducibility of all images in the NCA report, and a strategy to achieve that goal is required. In order to align the NCA data management vision with the NOAA data management strategy, the NCA Data Manager is the NCA representative on the NOAA Data Management Integration Team, and is part of the NCDC Metadata work Team.

ACCOMPLISHMENTS

Accomplishments in the last year can be summarized in two different categories: 1) NCA Data Management, and 2) GCIS Support

NCA data management

Several systems were developed to implement appropriate data management. The systems developed can be divided into three categories:

1. NCA Collaborative Tools: These are tools that promote a more effective collaboration process between the different players of the NCA process and include the *NCA Authors Workspace* (completed) and the *NCA Indicators Workspace* (completed).

2. NCA Information Dissemination Tools: These include tools that make the NCA related content available to the public such as the *Scenarios Webpage* (developed).
3. NCA Input Tools: These include tools that allow for public participation into the NCA process such as the *NCA Technical Input Upload System* (completed) and the *Review and Comment System* (completed).

NCA Authors Workspace: This system was designed, developed, and implemented by the TSU with coding support from the National Environmental Data Analysis Center (NEMAC). This workspace helped to promote a collaborative process among authors in the creation of the NCA draft report. The system is structured by chapter, with an additional dedicated space for the Report Integration Team. Users are able to upload and download files, access relevant documents, and request graphic support for images.

NCA Indicators Workspace: This system was designed, developed, and implemented by the TSU with coding support from NEMAC. This workspace supports the work of the NCA Indicators management team and working groups. The system allows for upload and download of document files and images, organized in a structured way with selective privileges assigned to different users depending on their membership status. The system is intended to support the creation of documents related to the NCA Indicators program.

Scenarios Webpage: This system was designed, developed, and implemented by the TSU with coding support from NEMAC. The Scenarios web portal was created to host the NCA Scenarios Reports and associated information. The system allows users to download the nine (9) Climate Outlook report documents and the Sea Level report, as well as access the majority of images included in those reports (and related metadata). An extensive effort was conducted, and is still under way, to identify the processes and datasets that underlay the creation of the images included in these reports, and make that information available to the public (to increase usability and transparency of methods and sources).

NCA Technical Input Upload System: This system was designed, developed, and implemented by the TSU with coding support from NEMAC. This was the web interface for the public to submit technical inputs to the 2013 NCA report.

NCA Review and Comment System: This system was designed, developed, and implemented by the TSU. This web system is hosting the 2013 NCA draft report for public/expert commenting and reviewing. It is also hosting three reports for the Intergovernmental Panel on Climate Change, in collaboration with the U.S. GCRP and the U.S. State Department. The system was designed to allow for enough flexibility as to be able to host different types of comments (online and offline submissions) and review processes (open review, invited review, etc). Given the high visibility and short time for implementation (6 months), particular attention was given to the project management strategy for the creation of this tool, and a detailed project plan, time line and milestones were implemented to accomplish the desired outcome of a user friendly, robust and flexible system.

Support to the USGCRP Global Change Information System:

The USGCRP Global Change Information System (GCIS) is an unified, web-based source of authoritative, accessible, usable, and timely information about climate and global change for use by scientists, decision-makers, and the public. In its first stage of development the GCIS will adopt the NCA to prototype its vision within the globalchange. gov web site. The TSU is participating in the development of the vision and implementation of the system as an element of the GCIS Core Integration team, and further supporting the GCIS data management activities by being the lead for the GCIS Data Management work team, and a member of the GCIS Interagency Working Group.

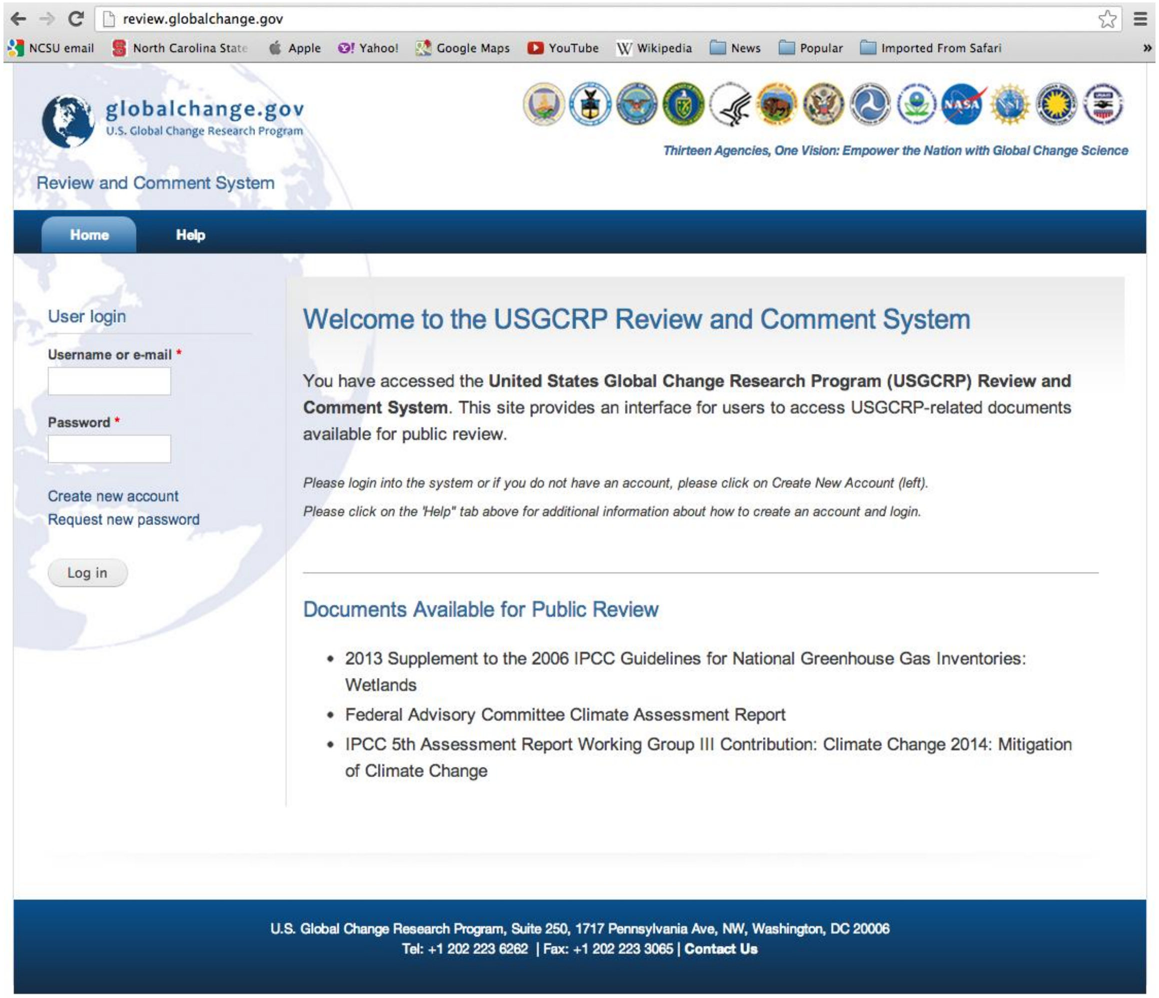


Figure 1: USGCRP Review and Comment System.

Performance Metrics	**FY12**
# of new or improved products developed	5
# of products or techniques transitioned from research to ops	
# of peer reviewed papers	1
# of non-peered reviewed papers	
# of invited presentations	4
# of graduate students supported by a CICS task	
# of undergraduate students supported by a CICS task	

PLANNED WORK

* Continue to develop the NCA Data Management strategy.
* Develop a maturity Matrix, in collaboration with John Bates, to evaluate the maturity of the datasets supporting the NCA 2013 report.
* Lead the process for exploring the incorporation of satellite products into the NCA process, in collaboration with the NCDC CDR program.

PUBLICATIONS

Curt Tilmes, Peter Fox, Xiaogang Ma, Deborah McGuinness, Ana Pinheiro Privette, Aaron Smith, Anne Waple, Stephan Zednik and Jin Zheng (accepted for publication), Provenance Representation for the National Climate Assessment in the Global Change Information System, *IEEE TGRS*.

PRESENTATIONS

-Pinheiro Privette, Ana (2012): *National Climate Assessment Data Management Vision*, Interagency National Climate Assessment (INCA) Meeting, USGCRP Office, Washington DC, August 9th 2012.

-Pinheiro Privette, Ana (2012): *The GCIS Review and Comment System*, Interagency National Climate Assessment (INCA) Meeting, USGCRP Office, Washington DC, August 9th 2012.

-Pinheiro Privette, Ana (2012): *National Climate Assessment Metadata Needs*, NCDC Metadata Workshop (side meeting), NOAA's National Climatic Data Center, Asheville, NC, August 16th 2012.

-Pinheiro Privette, Ana (2013): *National Climate Assessment Data Management Vision*, NCDC Metadata Working Group Meeting, NOAA's National Climatic Data Center, Asheville, NC, January 28th 2013.

- Assessment Science Support: Analysis of Observational and Modeled Climate Data

Task Leader	Laura Stevens
Task Code	NC-NCA-10-NCICS-LES
Main CICS Research Topic	National Climate Assessments
Percent contribution to CICS Themes	Theme 1:0%; Theme 2: 0%; Theme 3: 100%
Percent contribution to NOAA Goals	Goal 1: 100%; Goal 2: 0%

Highlight: Processing and analysis of several observational and modeled climate datasets has been performed for the ongoing National Climate Assessment, as well as the ad hoc creation of graphics for the draft Third National Climate Assessment report.

BACKGROUND

The National Climate Assessment (NCA) is an important resource for understanding and communicating climate change science and impacts in the United States. It informs the nation about already observed changes, the current status of the climate, and anticipated trends for the future. The Global Research Act of 1990 mandates that a national climate assessment be conducted every four years, resulting in a report to the President and Congress. The draft Third National Climate Assessment report has just been released for public review and comments.

Primary science and technical support is being provided to NOAA and the NOAA Technical Support Unit (TSU) of the National Climate Assessment. This includes the processing and analysis of observational and modeled climate data, ad hoc graphical support for the NCA report, and research on Assessment-relevant topics.

ACCOMPLISHMENTS

A nine-part NOAA Technical Report, created as input to the Third National Climate Assessment, has recently been published. The report, entitled "Regional Climate Trends and Scenarios for the U.S. National Climate Assessment", was produced in collaboration with the TSU lead scientist, Kenneth Kunkel, other CICS scientists, and climate experts from across the U.S. The report contains two components for eight regions of the United States and the contiguous U.S. The first component is a description of the historical climate conditions in the region; the second component is a description of the climate conditions associated with two future pathways of greenhouse gas emissions based on IPCC emission scenarios. It is hoped that this research is of direct benefit to decision-makers and communities seeking to use this information in developing adaptation plans

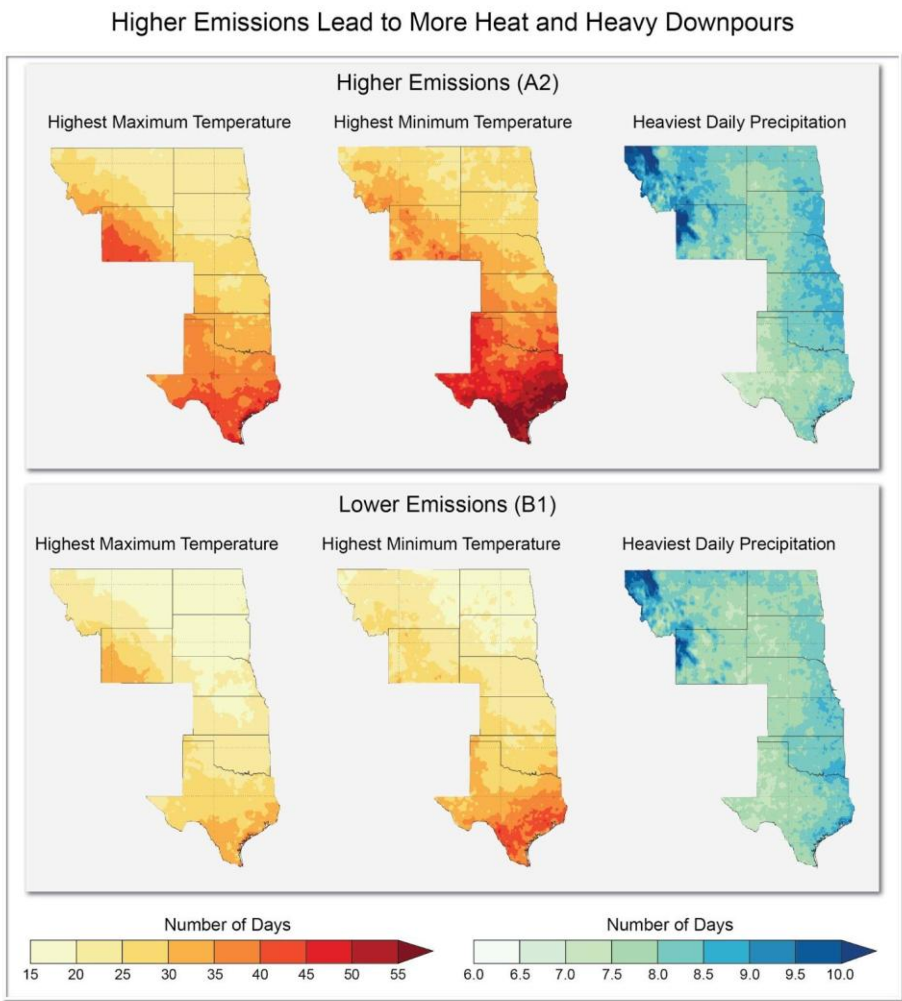


Figure 1: Maps indicating the number of days in which the highest maximum temperature (left), highest minimum temperature (middle), and heaviest daily precipitation (right) in 2041-2070 is projected to exceed what was observed on just 2% of the days each year in the U.S. Great Plains between 1971 and 2000, for both the A2 (top) and B1 (bottom) emissions scenarios. These projections are multi-model means from CMIP3 daily statistically-downscaled simulations. Additional graphical work courtesy of Jessicca Griffin.

The core data set used for analysis of the historical climate was that of the National Weather Service's Cooperative Observer Network (COOP). Trends in temperature and precipitation metrics were analyzed for the period of 1895-2011, including: annual and seasonal temperature and precipitation anomalies; the length of the freeze-free season; heat and cold waves; and extreme precipitation events.

Three model datasets were primarily used for the analysis of future regional climate scenarios, based on the IPCC A2 and B1 emissions scenarios. Data from the Coupled Model Intercomparison Project phase 3 (CMIP3) and North American Regional Climate Change Program (NARCCAP) were used to create multi-model mean maps, as well as to calculate probability density functions of various temperature and precipitation metrics for three future time periods (2021-2050, 2041-2070, and 2070-2099), relative to a historical reference period (e.g., 1971-2000). The CMIP3 daily statistically-downscaled data set was also used, along with NARCCAP data, to calculate spatially-averaged values of temperature and precipitation thresholds (e.g., the number of days with a maximum temperature greater than 95°F), as well as other metrics such as the length of the freeze-free period and heating/cooling degree days.

In addition to the NOAA Technical Report, analyses of the aforementioned data sets were also carried out in order to produce ad hoc figures for the draft Third National Climate Assessment report. With the assistance of Jessicca Griffin and the NCDC Graphics Team, 22 figures were created for inclusion in 11 different chapters of the NCA report, an example of which is given in Figure 1.

The development of figures for the NCA report also led to the creation of a "white paper" summarizing the importance of using color-blind friendly climatological color schemes. Information contained in this paper was subsequently used in the development of NCA guidance documents provided to authors of the report.

Performance Metrics	**FY12**
# of new or improved products developed	N/A
# of products or techniques transitioned from research to ops	N/A
# of peer reviewed papers	9
# of non-peered reviewed papers	1
# of invited presentations	2
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	N/A

PLANNED WORK

* As part of a sustained assessment approach, information contained in the NOAA Technical Report will be updated as new model results are available and as new climate scenario needs become clear.

* Once the NCA public review comment period has ended for the NCA draft report it is likely that there will be a need for additional analyses and revision of figures using the various observational and modeled climate data sets described above.
* Ongoing research will be performed using the latest available historical and future climate data sets, including comparative analyses between data set versions (e.g. CMIP3 vs CMIP5).

PUBLICATIONS

Kunkel, K.E, L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, J. Rennells, A. DeGaetano, and J.G. Dobson (2013), *Regional Climate Trends and Scenarios for the U.S. National Climate Assessment. Part 1. Climate of the Northeast U.S.*, NOAA Technical Report NESDIS 142-1, 79 pp.

Kunkel, K.E, L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, C.E. Konrad II, C.M. Fuhrman, B.D. Keim, M.C. Kruk, A. Billet, H. Needham, M. Schafer, and J.G. Dobson (2013), *Regional Climate Trends and Scenarios for the U.S. National Climate Assessment. Part 2. Climate of the Southeast U.S.*, NOAA Technical Report NESDIS 142-2, 94 pp.

Kunkel, K.E, L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, S.D. Hilberg, M.S. Timlin, L. Stoecker, N.E. Westcott, and J.G. Dobson (2013), *Regional Climate Trends and Scenarios for the U.S. National Climate Assessment. Part 3. Climate of the Midwest U.S.*, NOAA Technical Report NESDIS 142-3, 95 pp.

Kunkel, K.E, L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, M.C. Kruk, D.P. Thomas, M. Shulski, N. Umphlett, K. Hubbard, K. Robbins, L. Romolo, A. Akyuz, T. Pathak, T. Bergantino, and J.G. Dobson (2013), *Regional Climate Trends and Scenarios for the U.S. National Climate Assessment. Part 4. Climate of the U.S. Great Plains*, NOAA Technical Report NESDIS 142-4, 82 pp.

Kunkel, K.E, L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, K.T. Redmond, and J.G. Dobson (2013), *Regional Climate Trends and Scenarios for the U.S. National Climate Assessment. Part 5. Climate of the Southwest U.S.*, NOAA Technical Report NESDIS 142-5, 79 pp.

Kunkel, K.E, L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, K.T. Redmond, and J.G. Dobson (2013), *Regional Climate Trends and Scenarios for the U.S. National Climate Assessment. Part 6. Climate of the Northwest U.S.*, NOAA Technical Report NESDIS 142-6, 75 pp.

Stewart, B.C., K.E. Kunkel, L.E. Stevens, L. Sun, and J.E. Walsh (2013), *Regional Climate Trends and Scenarios for the U.S. National Climate Assessment. Part 7. Climate of Alaska*, NOAA Technical Report NESDIS 142-7, 60 pp.

Keener, V.W., K. Hamilton, S.K. Izuka, K.E. Kunkel, L.E. Stevens, and L. Sun (2013), *Regional Climate Trends and Scenarios for the U.S. National Climate Assessment. Part 8. Climate of the Pacific Islands*, NOAA Technical Report NESDIS 142-8, 44 pp.

Kunkel, K.E, L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, and J.G. Dobson (2013), *Regional Climate Trends and Scenarios for the U.S. National Climate Assessment. Part 9. Climate of the Contiguous United States*, NOAA Technical Report NESDIS 142-9, 77 pp.

Stevens, L.E (2012), Climatological Color Schemes Suitable for Color-blind Readers, CICS-NC (white paper).

PRESENTATIONS

- Stevens, L.E and K.E Kunkel (2012), Regional Climate Trends and Scenarios for the United States: Input to the National Climate Assessment, AGU Fall Meeting 2012, San Francisco, CA, 3 Dec 2012.
- Stevens, L.E (2012), Regional Climate Trends and Outlooks for the United States. Systemic Impacts of Climate on Transportation Workshop, Washington, D.C., 11 Oct 2012.

OTHER

- Attended the NCA Convening Lead Authors/NCADAC Meeting, Washington, D.C., 12-15 June 2012.
- Attended the Alternative Climate Normals Workshop, Asheville, NC, 24-25 April 2012.

- Science Editor/Publication Support for National Climate Assessment TSU

Task Leader	Brooke Stewart
Task Code	NC-NCA-11-NCICS-BS
Main CICS Research Topic	National Climate Assessments
Percent contribution to CICS Themes	Theme 1: %; Theme 2: %; Theme 3: 100%
Percent contribution to NOAA Goals	Goal 1: 100%; Goal 2: %

Highlight: CICS staff provided editorial, graphics, and production support for NOAA's Technical Support Unit to the National Climate Assessment, making significant contributions to the release of a draft report in January 2013.

BACKGROUND

The National Climate Assessment (NCA) is being conducted under the auspices of the Global Change Research Act of 1990, which requires a report to the President and the Congress that evaluates, integrates and interprets the findings of the U.S. Global Change Research Program every four years.

National climate assessments act as a status report on climate change science and impacts. They are based on observations made across the country and compare these observations to predictions from climate system models. The NCA aims to incorporate advances in the understanding of climate science into larger social, ecological, and policy systems, and with this provide integrated analyses of impacts and vulnerability.

The NCA will help evaluate the effectiveness of our mitigation and adaptation activities and identify economic opportunities that arise as the climate changes. It will also serve to integrate scientific information from multiple sources and highlight key findings and significant gaps in our knowledge. The NCA aims to help the federal government prioritize climate science investments, and in doing so will help to provide the science that can be used by communities around the Nation as they try to create a more sustainable and environmentally-sound plan for the future.

In support of the next National Climate Assessment, NOAA has established a Technical Support Unit (TSU) at its National Climatic Data Center. The TSU provides a variety of support to the NCA including editorial, graphics, and production support.

ACCOMPLISHMENTS

Overall leadership and coordination of the TSU's editorial, graphics, and production efforts for the draft assessment report resulted in the successful and timely incorporation of input from a variety of sources (staff and management at USGCRP and TSU, authors, scientists, and federal advisory committee members) to aid production of over 300 figures for the draft report. Extensive editing was performed to help ensure scientific accuracy and consistency throughout the draft report. Scientific editorial support was provided, primarily focused on figures and their captions and titles. The work was coordinated closely with staff at USGCRP and TSU to meet tight deadlines for report production, ultimately leading to the public release of a draft report in January 2013. The report will be available for public comment until April 2013.

Developed a NOAA Technical Report for the Alaska region in collaboration with TSU lead scientist, Kenneth Kunkel and other climate experts. The report was developed as part of a nine-part series entitled "Regional Climate Trends and Scenarios for the U.S. National Climate Assessment". The report contains two components: a description of the historical climate and projections for the future based on two IPCC emissions scenarios. The hope is that this research is of direct benefit to decision-makers in the development of adaptation plans.

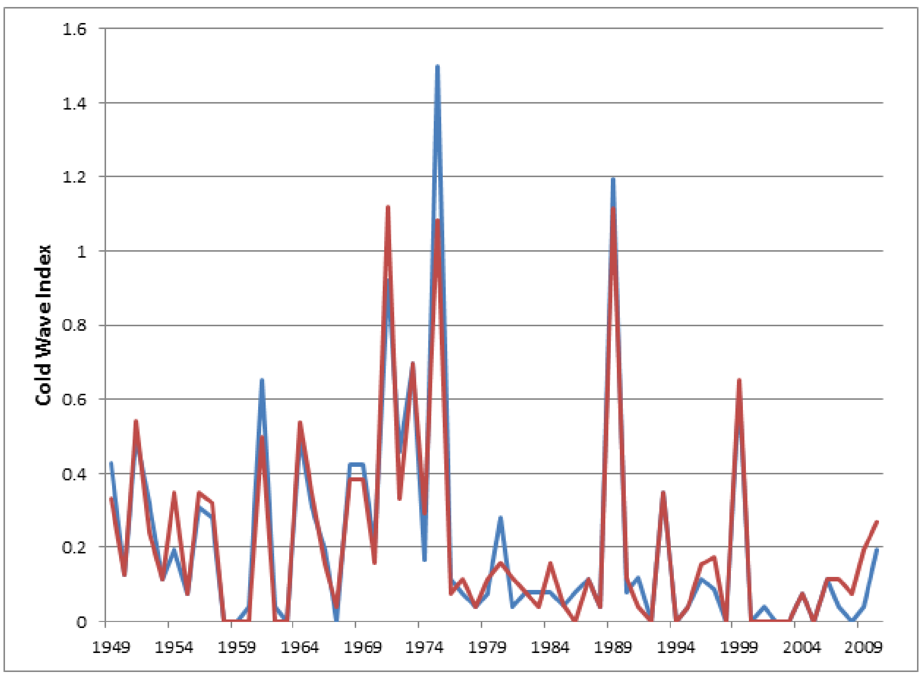


Figure 1: Time series (1949-2010) for Alaska of an index for the occurrence of cold waves defined as 4-day periods (blue) and 7-day periods (red) that are colder than the threshold for a 1-in-5 year recurrence. Based on data from the National Climatic Data Center First-Order Surface Weather Observing Stations and based on methods from Kunkel et al. (1999).

Performance Metrics	FY12
# of new or improved products developed	N/A
# of products or techniques transitioned from research to ops	N/A
# of peer reviewed papers	2
# of non-peered reviewed papers	0
# of invited presentations	N/A
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	N/A

PLANNED WORK

- Work with staff at TSU and USGCRP to coordinate response efforts to public comments
- Coordinate efforts between staff, scientists, authors, editors, federal advisory committee members, and graphic designers to make changes to report figures in response to public comments
- Continue to provide scientific editorial support for future drafts of report, helping to ensure scientific accuracy and consistency
- Continue to coordinate TSU editorial, graphics, and production support of assessment report

PUBLICATIONS

Stewart, B.C., K.E. Kunkel, L.E. Stevens, L. Sun, and J.E. Walsh, 2013: Part 7. Climate of Alaska, NOAA Technical Report NESDIS 142-7, 61 pp.

Peterson, T.C., R.J. Heim, Jr., R. Hirsch, D.P. Kaiser, H. Brooks, N.S. Diffenbaugh, R.M. Dole, J.P. Giovannettone, K. Guiguis, T.R. Karl, R.W. Katz, K.E. Kunkel, D. Lettenmaier, G.J. McCabe, C.J. Paciorek, K. Ryberg, S. Schubert, V.B.S. Silva, B.C. Stewart, A.V. Vecchia, G. Villarini, R.S. Vose, J. Walsh, D. Wolock, K. Wolter, C.A. Woodhouse, M. Wehner, and D. Wuebbles (accepted) Monitoring and understanding changes in heat waves, cold waves, floods and droughts in the United States: State of knowledge. Bull. Amer. Meteor. Soc.

PRESENTATIONS

N/A

- National Climate Assessment Scientific Support Activities

Task Leader	Liqiang Sun
Task Code	NC-NCA-12-NCICS-LS
Main CICS Research Topic	National Climate Assessments
Percent contribution to CICS Themes	Theme 1: 0%; Theme 2: 0%; Theme 3: 100%
Percent contribution to NOAA Goals	Goal 1: 100%; Goal 2: 0%

Highlight: Processing and analysis of observational and model data has been performed to support the development of the NOAA Technical Reports and the Third National Climate Assessment Report. An ongoing research of climate changes in the Southern Plains indicates that the CMIP5 models are capable of reproducing the frequency of observed precipitation events, but fail to capture the intensity of the observed precipitation events. This finding has important implications for development of new and improved climate products.

BACKGROUND

The Development of the Third National Climate Assessment (NCA) report is being conducted under the auspices of the Global Change Research Act of 1990. The NCA reports provide information about state-of-knowledge of climate change science and impacts. The NCA aims to incorporate advances in the understanding of climate science into larger social, ecological, and policy systems, and with this provide integrated analyses of impacts and vulnerability. A sustained assessment process will be providing support for special reports and for the future NCA reports required by the 1990 Research Act.

The Technical Support Unit (TSU) at NCDC develops state-of-art scientific products that support the development of the Third NCA Report and future reports. The CMIP5 model simulations provide the future focus for analysis of potential changes during the 21st Century. Compared to the CMIP3 model simulations, these simulations are generally of higher spatial resolution and using models with more advanced representation of physical processes. Therefore, we expect they provide more reliable simulations of the future climate system. An analysis of these simulations is a priority for the continuing assessment process.

Assessing the potential causes of observed climate change and evaluating the ability of CMIP5 models to simulate key processes are fundamentally important for the development of robust and reliable climate projections at regional scales from imperfect models over the United States.

ACCOMPLISHMENTS

An analysis of CMIP5 temperature and precipitation was completed for the scenarios of rcp8.5, rcp6.0, rcp4.5, and rcp2.6. This analysis examined changes in mean temperature and precipitation during the 21st Century. A preliminary comparison between CMIP5 and CMIP3 model projections and the analysis of the uncertainties of future U.S. projections at regional scales were completed for use by the authors of the 2013 report. In collaboration with CICS scientists, the analysis of the CMIP3 model simulations with dynamically and statistically downscaled data were also completed for use by the NOAA Technical Report (NESIDS 142-Parts 1 through 9).

The ability of climate models to simulate the historical and present climate conditions in the Southern Plains is examined. The multi-model ensemble mean of the annual precipitation obtained from the CMIP5 model historical simulations does not reproduce the observed upward trend during the past 60 years. Further analysis of daily precipitation events indicates that the models also fail to reproduce the observed upward trends in the frequency of heavy precipitation events. However, the models can capture the observed upward trend of the frequency of rainy days (Fig. 1). The frequency of rainy days increased 1.82 and 1.37 days per decade from observations and model simulations, respectively. Both trends are statistically significant at the 95% confidence level. This may imply that the models are capable of initiating convection, but that the model convection schemes have a large bias in their simulation of precipitation intensity.

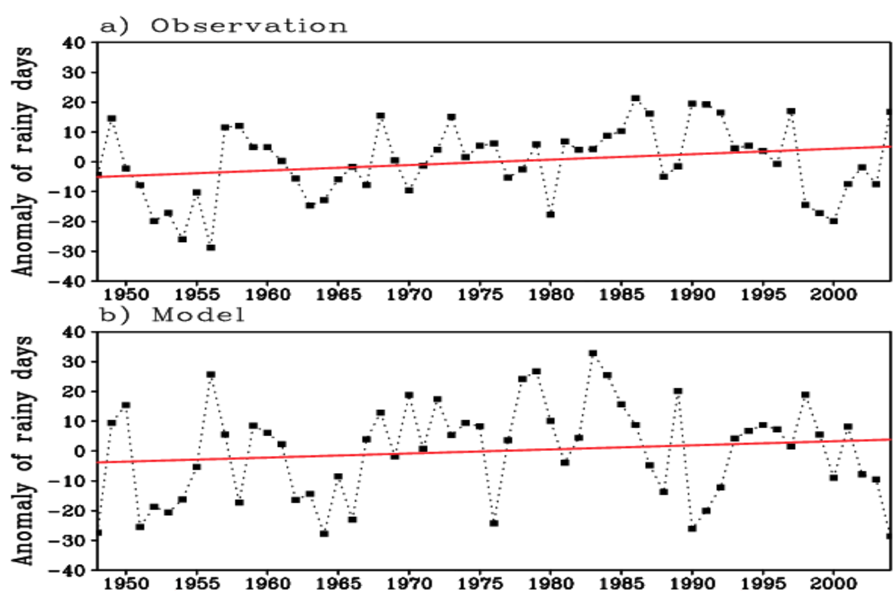


Figure 1: Anomaly of the number of rainy days (deviations from the 1948-2004 average), for the Southern Plains: a) observations from NOAA NCEP CPC Regional US Mexico daily gridded data, and b) CMIP5 model simulations (GFDL-CM3 and NCAR CCSM4).

Performance Metrics	FY12
# of new or improved products developed	
# of products or techniques transitioned from research to ops	
# of peer reviewed papers	2
# of non-peered reviewed papers	9
# of invited presentations	2
# of graduate students supported by a CICS task	
# of undergraduate students supported by a CICS task	

PLANNED WORK

* Continue ongoing analysis of CMIP5 model simulations to support various activities of the National Climate Assessment
* Continue ongoing research on the mechanism study of climate change in the Southern Plains
* Conduct dynamical downscaling of the CMIP5 simulations over the U.S.

PUBLICATIONS

Wuebbles, D.W., G. Meehl, K. Hayhoe, T. R. Karl, K. Kunkel, B. Santer, M. Wehner, B. Colle, E. M. Fischer, R. Fu, A. Goodman, E. Janssen, H. Lee, W. Li, L. N. Long, S. Olsen, A. Seth, J. Sheffield, and L. Sun (in review) CMIP5 climate model analyses: Climate extremes in the United States. Bull. Amer. Meteor. Soc.

Kwon, H.-H., de Assis de Souza Filho, F., Block, P., Sun, L., Lall, U. and Reis, D. S. 2012: Uncertainty assessment of hydrologic and climate forecast models in Northeastern Brazil. *Hydrol. Process.*. doi: 10.1002/hyp.8433

Kunkel, K.E, L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, J. Rennells, A. DeGaetano, and J.G. Dobson (2013), *Regional Climate Trends and Scenarios for the U.S. National Climate Assessment. Part 1. Climate of the Northeast U.S.*, NOAA Technical Report NESDIS 142-1, 79 pp.

Kunkel, K.E, L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, C.E. Konrad II, C.M. Fuhrman, B.D. Keim, M.C. Kruk, A. Billet, H. Needham, M. Schafer, and J.G. Dobson (2013), *Regional Climate Trends and Scenarios for the U.S. National Climate Assessment. Part 2. Climate of the Southeast U.S.*, NOAA Technical Report NESDIS 142-2, 94 pp.

Kunkel, K.E, L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, S.D. Hilberg, M.S. Timlin, L. Stoecker, N.E. Westcott, and J.G. Dobson (2013), *Regional Climate Trends and Scenarios for the U.S. National Climate Assessment. Part 3. Climate of the Midwest U.S.*, NOAA Technical Report NESDIS 142-3, 95 pp.

Kunkel, K.E, L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, M.C. Kruk, D.P. Thomas, M. Shulski, N. Umphlett, K. Hubbard, K. Robbins, L. Romolo, A. Akyuz, T. Pathak, T. Bergantino, and J.G. Dobson (2013), *Regional Climate Trends and Scenarios for the U.S. National Climate Assessment. Part 4. Climate of the U.S. Great Plains*, NOAA Technical Report NESDIS 142-4, 82 pp.

Kunkel, K.E, L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, K.T. Redmond, and J.G. Dobson (2013), *Regional Climate Trends and Scenarios for the U.S. National Climate Assessment. Part 5. Climate of the Southwest U.S.*, NOAA Technical Report NESDIS 142-5, 79 pp.

Kunkel, K.E, L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, K.T. Redmond, and J.G. Dobson (2013), *Regional Climate Trends and Scenarios for the U.S. National Climate Assessment. Part 6. Climate of the Northwest U.S.*, NOAA Technical Report NESDIS 142-6, 75 pp.

Stewart, B.C., K.E. Kunkel, L.E. Stevens, L. Sun, and J.E. Walsh (2013), *Regional Climate Trends and Scenarios for the U.S. National Climate Assessment. Part 7. Climate of Alaska*, NOAA Technical Report NESDIS 142-7, 60 pp.

Keener, V.W., K. Hamilton, S.K. Izuka, K.E. Kunkel, L.E. Stevens, and L. Sun (2013), *Regional Climate Trends and Scenarios for the U.S. National Climate Assessment. Part 8. Climate of the Pacific Islands*, NOAA Technical Report NESDIS 142-8, 44 pp.

Kunkel, K.E, L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, and J.G. Dobson (2013), *Regional Climate Trends and Scenarios for the U.S. National Climate Assessment. Part 9. Climate of the Contiguous United States*, NOAA Technical Report NESDIS 142-9, 77 pp.

PRESENTATIONS

- Sun, L., M. Rodrigues, and E. Martins (2013): The Science and Practice of Seasonal Climate Prediction at FUNCEME, invited talk, 15th Semi-Arid Northeast Brazil Climate Outlook Forum, Fortaleza, Brazil, 23-25 January 2013.

-Sun, L., C. A. S. Coelho, and L. T. Fortes (2013): Development of a National Multi-Model Ensemble System for Operational Seasonal Climate Forecasts in Brazil, invited talk, Climate Prediction Committee Meeting, Fortaleza, Brazil, 21-22 January 2013.

-Sun, L. (2012): CMIP5 Projections of Temperature and Precipitation for the U.S., AgMIP North America Workshop, Ames, IA, 7-9 September 2012.

-Sun, L. (2012): NOAA Technical Support Unit: Deliver and Improve Climate Science for National Climate Assessment, 2012 U.S. CLIVAR Summit, Newport Beach, CA, 17-20 July 2012.

2.5 National Climate Model Portal

The National Climate Model Portal (NCMP) activities are facilitating access to climate projections and forecasts for the general public and the scientific community.

Background

The National Operational Model Archive and Distribution System (NOMADS) is a Web-services based project providing both real-time and retrospective format-independent access to climate and weather model data. NOMADS was established to specifically address the growing need for this remote access to high volume numerical weather prediction and global climate models and data and to facilitate climate model and observational data intercomparison issues.

The National Climate Model Portal (NCMP) continues to be developed to extend the technologies and capabilities currently operational in NOMADS. NCMP, in close coordination with the NOAA Climate Service Portal (NCSP) will serve as an on–line resource to both improve models for modelers, and to convey key aspects of complex scientific data in a manner accessible to both climate and weather modelers and to non–specialists or other particular user communities.

NCMP activities include: 1) continuing development of a requirements specification process, functional requirements, and preliminary design document; 2) additional proof of concept model-to-observational capability using existing but enhanced tools and applications; 3) a downscaling proof-of-concept capability; 4) a user interface portal and community workspace into NOAA's suite of Climate and Weather Models; and (5) the development of online climate model diagnostic tools and resources.

To support these activities, CICS has instituted a task group consisting of a senior scientist and an NCMP technical support staff member. The senior scientist provides scientific oversight for the NCMP development and applications infrastructure. The NCMP Analyst/programmer provides expertise focused on application and development of methods and tools for scientific data access and interoperability.

- NOAA's National Climate Model Portal (NCMP)

Task Leader	Justin Jay Hnilo
Task Code	NC-NCMP-01-NCICS-JH
Main CICS Research Topic	National Climate Assessments, Data fusion and algorithm development.
Percent contribution to CICS Themes	Theme 1:20%; Theme 2:0%; Theme 3:80%
Percent contribution to NOAA Goals	Goal 1:50%; Goal 2:50%

Highlight: It is projected that model-based data will be the largest segment of NCDC's data holdings very soon. These data are becoming too large to continually transfer in whole. We have developed tools to help scientists perform calculations and off-load smaller more meaningful data for direct examination.

BACKGROUND

The National Operational Model Archive and Distribution System (NOMADS) is a Web-services based project providing both real-time and retrospective format independent access to climate and weather model data. NOMADS was established to specifically address the growing need for this remote access to high volume numerical weather prediction and global climate models and data and to facilitate climate model and observational data inter-comparison issues. The National Climate Model Portal (NCMP) continues to be developed to extend the technologies and capabilities currently operational in NOMADS. NCMP, in close coordination with the NOAA Climate Service Portal (NCSP) will serve as an online resource to both improve models for modelers, and to convey key aspects of complex scientific data in a manner accessible to both climate and weather modelers and to non-specialists or other particular user communities. NCMP activities in the coming contract year will include: 1) continuing development of a requirements specification process, functional requirements, and preliminary design document; 2) additional proof of concept model-to-observational capability using existing but enhanced tools and applications; 3) a downscaling proof-of-concept capability; 4) a user interface portal and community workspace into NOAA's suite of Climate and Weather Models; and (5) the development of online climate model diagnostic tools and resources.

Initial work emphasizes the development of diagnostic tools. In this initial phase we have developed tools that regrid, extract average annual, seasonal, diurnal cycles from data as well various statistical measures, and extract station data equivalents from gridded data. Other capabilities we are developing are the examination of anomalies, measures of extreme events, climate sensitivity, decadal trends, ratios of variances, and station data binning.

ACCOMPLISHMENTS

We have implemented a set of first look diagnostics that allow one, for example, to simply run a python script and extract station data equivalents from large gridded data (e.g., CFSR). As our website (and climate.gov site) continues to evolve we will be serving such scripts and showing small plots of the output. These tools can be readily applied to both observational estimates (e.g., re-analyses) as well as model data. From models, we have started to calculate derived values and diagnostics from the large IPCC (e.g., AR4) data holdings and have started to serve these calculated values on the website. We have used these tools to support both the US National Assessment and continuing sectoral engagements at NCDC.

Our open source tool development and implementation goes beyond regular large-scale climate calculations. In support of both Obs4Mip and the US National Climate Assessment, we have implemented a routine whereby one can put the daily Global Historical Climate Network (GHCN) version 3 station data on any rectilinear grid and additionally specify the use of all stations or a limited selection of stations. Our initial procedure is a simple binning approach utilizing lat/lon bounds as sorting criteria, and the code is written so that the grid resolution can be readily changed. To date, the data available on a uniform grid in CF compliant NetCDF are not publicly available at NCDC. We have also designed various tools around these data, which can utilize the temporally changing missing value masks, thereby allowing a matching of spatio-temporal sampling.

Figure 1 shown below is an example of these tools. On the right we show the GHCN daily maximum temperature for June 1st, 2012, gridded to a 2.5 degree grid. On the left is the NCEP/NCAR reanalysis daily maximum surface temperature for the same day (June 1st 2012). The reanalysis data has been regridded to a common grid, and then the missing value mask from the GHCN for June 1st 2012 is applied to the data. When examining these two plots side by side, it appears the reanalysis data has many of the fine spatial structures shown in the GHCN station data. We hope to be including these data as part of NCDC's submissions to the Obs4Mip effort and to offer the code freely via the web. Our hope is that these will be of interest to the community, facilitating direct spatio-temporal subsampling and intercomparisons of such data and specifically advancing adaptation and mitigation efforts.

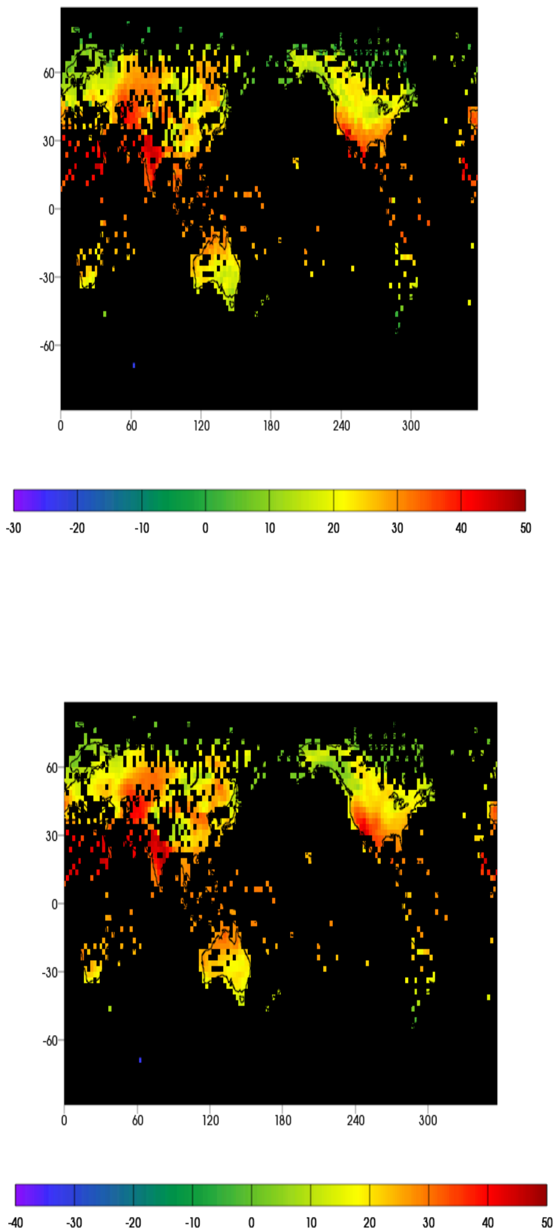


Figure 1: The Global Historical Climate Network Version 3 maximum surface temperature (in degrees C) for June 1st 2012 on left and spatio-temporal subsampled NCEP/NCAR reanalysis data for June 1st 2012 on the right.

Performance Metrics	FY12
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	6
# of peer reviewed papers	
# of non-peered reviewed papers	
# of invited presentations	1
# of graduate students supported by a CICS task	
# of undergraduate students supported by a CICS task	

PLANNED WORK
* Serve a gridded version of the daily GHCN for all variables.
* Continue to work on the ability to extract shapefile regions from gridded data
* Expand data holdings to AR5 data.

PRESENTATIONS
- Computational Data Analysis in the era of Peta-Scale Digital Archives: Advancing Web Services to Reduce Data Access Latencies, Justin Hnilo, Glenn Rutledge and Dean Williams American Meteorological Society. Austin, TX. January 2013

2.6 *Surface Observing Networks*

Surface observing network efforts address sustaining and improving the quality of *in situ* climate observations and observing networks.

Background

The National Climatic Data Center (NCDC) along with NOAA partner institutions leads two new climate–observing programs, the U.S. Climate Reference Network (USCRN) and the U.S. Historical Climatology Network–Modernized (USHCN–M). NOAA's U.S. Climate Reference Network (USCRN) consists of over 110 stations across the continental United States collecting sustainable observational climate data to provide a 50–year picture of climate change. Deployment of additional stations in Hawaii and Alaska and a new network of regional stations are in progress to provide for the detection of regional climate change signals under the management of NCDC in partnership with the National Weather Service and NOAA's Atmospheric Turbulence and Diffusion Division. The USHCN–M has been initiated with a pilot project in the Southwest, and expansion into other regions of the U.S. will follow. USHCN–M stations are being deployed at finer spatial resolution to provide for the detection of regional climate change signals.

NCDC also manages a number of other climate network initiatives, including the Global Historical Climatology Network (GHCN) and the Hourly Precipitation Data (HPD) Network, and archives and maintains observational data for such systems as the Hydrometeorological Automated Data System (HADS) and the Automated Surface Observing Systems (ASOS). Primary activities associated with these programs and systems include (1) collection and analysis of observations of soil moisture and soil temperature, (2) climate related studies and analyses involving climate change and variation, climate monitoring, and visualization, and (3) development of quality control processes to ensure the fidelity of the climate record.

To support these activities, CICS has instituted a task group of a senior scientist and several junior level research scientists supporting various climate observing network initiatives. The senior scientist is currently supporting international initiatives while the junior level research scientists are providing key support to the USCRN, USHCN–M, and other climate observing network programs managed or maintained by NCDC. This proposal seeks to continue the activities initiated in the previous year and build on this experience to refine quality control processes to ensure active and archival data remain robust.

- Validation of US Climate Reference Network (USCRN) Soil Moisture and Temperature

Task Leader	Jesse Bell
Task Code	NC-SON-01-NCICS-JB
Main CICS Research Topic	Surface Observing Network
Percent contribution to CICS Themes	Theme 1:50%; Theme 2:50%; Theme 3:0%
Percent contribution to NOAA Goals	Goal 1:20%; Goal 2:80%

Highlight:
Research was conducted to improve the quality assurance of USCRN soil observations. In addition to the near real-time quality control of the soil products, post-processing statistics were developed to automatically run evaluations of soil moisture/temperature measurements on a monthly basis. Three manuscripts explaining USCRN soil observations and data were accepted for publication.

BACKGROUND
The US Climate Reference Network is a series of climate monitoring stations maintained and operated by NOAA. To increase the network's capability of monitoring soil processes and accurately estimating drought, it was decided to incorporate soil observations to the list of USCRN instrumentation. In the summer of 2011, the USCRN team completed the installation of all soil observational probes in the contiguous US. Each station, along with traditional measurements of surface air temperature, precipitation, infrared ground surface temperature, wind speed, and solar radiation, now also transmits relative humidity, soil temperature, and soil moisture measurements every hour. The data is maintained and stored at NOAA's National Climatic Data Center, while installation and maintenance is performed by NOAA's Atmospheric Turbulence and Diffusion Division (ATDD).

The task of this project is to produce high-quality soil datasets and use these data to research the relationship of soil observations to spatial change and develop drought-monitoring products. To ensure the network is providing quality data, there are a series of quality checks that must be performed before the data are made available to end-users. One task of this project is to improve the current quality assurance method to accurately determine faulty sensors for removal from the final soil products. Exploring the data record and researching ways to identify erroneous changes in the time series is the best way of improving the quality assurance procedure. In this report we will explore ways that we have improved the soil observations' quality assurance and promoted the network's abilities to potential users.

ACCOMPLISHMENTS

The completion of the network in 2011 required implementation of improved soil quality assurance. As the soil observations are transmitted hourly from 114 stations on a near real-time basis via the GOES satellite, there are large amounts of data to observe for occurrences of faulty periods. The first step was to automate the initial quality assurance process and decide the proper checks to determine sensor health. After a thorough investigation, the decision was to proceed with certain quality checks to ensure the automatic ingest could instantaneously flag and remove faulty time periods. After an evaluation of the near real-time quality control procedure, it was determined that an additional post-processing would be necessary to eliminate all erroneous periods of record.

We investigated a series of statistical tests (noise test, spike test, jump test, etc.) for determining when sensors are recording specious values. Initial statistics were evaluated by the ability to report on commonly found errors in the data record. We determined the specific statistical test that identify common errors, but the processing could not be implemented on a near real-time basis and must occur at regular time intervals. These statistics are now automated on a monthly basis and the report is sent to a group of individuals. We then manually inspect all time periods that do not pass the statistical checks and add malfunctioning sensors to the "exclusion list". The "exclusion list" is a list of sensor time periods that are removed from the final products because these periods are not reliable.

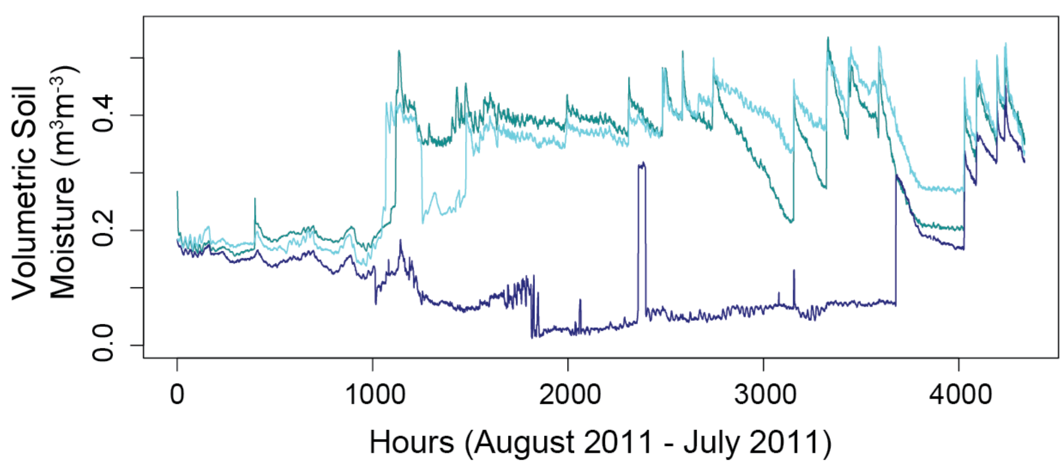


Figure 1: USCRN triplicate redundancy allows for quick identification of faulty sensors. Here is an example using triplicate redundancy at the USCRN Lincoln 8 site to determine a malfunctioning sensor. The data series for probe 1 (light blue) and probe 2 (green) probes are greatly different from probe 3 (dark blue) in the middle of the time series. After probe 3 was replaced near the end of the time series, the three probes go back to agreement with each other. Note: Although each probe is in fairly close prox-

imity to one another, the individual response to drying and wetting is variable even for functional probes.

In addition to improving the quality assurance of these data, we are examining uncertainty of the relationships that may assist in understanding the changes that occur between sensors (fig. 1). These relationships will not only help improve quality assurance, but also assist the scientific community in understanding spatial relationships of soil moisture and temperature (fig. 2).

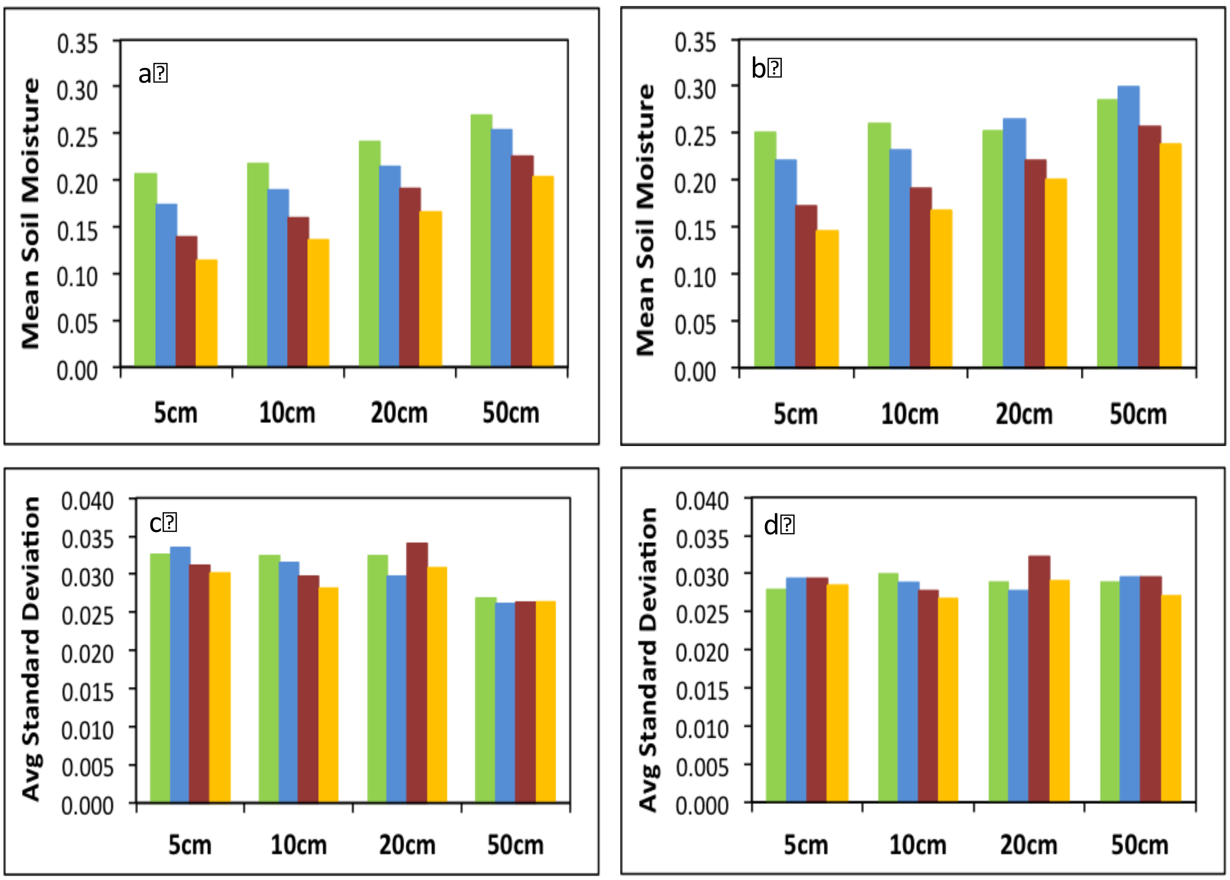


Figure 2: USCRN network-wide mean monthly soil moisture (m^3m^{-3}) for: (a) 2011 and (b) 2012. USCRN network-wide monthly average of the hourly standard deviation of three independent measurements of soil moisture (m^3m^{-3}) for: (c) 2011 and (d) 2012. The bars in each group from left to right represent April (green), May (blue), June (red), and July (orange).

Performance Metrics	FY12
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	2
# of peer reviewed papers	3
# of non-peered reviewed papers	0
# of invited presentations	2
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	0

PLANNED WORK

* Continue soil observation quality assurance.
* Use USCRN observations for drought monitoring and soil moisture spatial representativeness.
* Continue to work on research manuscripts with USCRN data.

PUBLICATIONS

Palecki, M.A., and J.E. Bell. U.S. Climate Reference Network: soil moisture variability and uncertainty. *Vadose Zone Journal*. Accepted.

Bell, J.E., M. Palecki, C. Baker, W. Collins, J. Lawrimore, R. Leeper, M. Hall, J. Kochendorfer, T. Meyers, T. Wilson, and H. Diamond. US Climate Reference Network soil moisture and temperature observations. *Journal of Hydrometeorology*. Accepted.

Diamond, H., Karl, T., Baker, C., Bell, J., Leeper, R., Easterling, D., Lawrimore, J., Meyer, T., Helfert, M., Goodge, G., and Thorne, P. U.S. Climate Reference Network after one decade of operations: status and assessment. *Bull. Amer. Meteor. Soc.* doi:10.1175/BAMS-D-12-00170.

PRESENTATIONS

- Bell, J.E. and M.A. Palecki. U.S. Climate Reference Network SMAP Preparation. SMAP Cal/Val Workshop. Oxnard, CA. November 2012
- Bell, J.E. U.S. Climate Reference Network: Soil Observations and Applications. North Carolina State University, Raleigh, NC. February 2013.

OTHER

- SMAP cal/val effort to understand spatial representativeness of sparse data networks is being planned between USDA, CICS-NC, CREST, and NOAA.

- Comparison of ground based temperature measurements with satellite-derived phenology

Task Leader	Jesse Bell and Jessica Matthews
Task Code	NC-SON-02-NCICS-JB_JM
Main CICS Research Topic	Climate Data and Information Records and Scientific Data Stewardship
Percent contribution to CICS Themes	Theme 1:70%; Theme 2:30%; Theme 3:0%
Percent contribution to NOAA Goals	Goal 1:60%; Goal 2:40%

Highlight:
This research is a comparison of satellite derived phenology measurements with ground based temperature metrics. The goal of this project is to determine if air or soil temperatures are better for estimating the growing season and will serve to improve USCRN drought monitoring.

BACKGROUND

Climate observations of growing season are essential for understanding plant phenology and physiological development. Air temperature, as it is one of the most commonly recorded climate variables, is traditionally used to define the onset and end of the growing season when phenology measurements are not available. Because belowground activity has been shown to be a predominant indicator of vegetative growth, research was conducted to determine if soil temperature is a better metric for calculating plant phenology than air temperature. Using start of season (SOS) estimates derived from remotely-sensed MODIS normalized difference vegetation index (NDVI) data, comparisons were made with SOS estimates derived from air and soil temperature as measured by the U.S. Climate Reference Network (USCRN).

ACCOMPLISHMENTS

Different temperature thresholds were investigated to determine which *in situ* temperature variable (of air, surface, or soil) and which threshold (of 0°C, 5°C, or 10°C) provides the most accurate correlation with the start date of the growing season. Our approach includes an investigation of 39 USCRN stations that have two complete years (2010-2011) of air, surface, and soil (5, 10, 20, and 50 cm) temperature data.

16-day MODIS NDVI data at 250-meter spatial resolution, from both AQUA and TERRA, were used to estimate SOS for each USCRN station in the study. The pixels containing each station were examined for all of 2010 and 2011. Figure 1 illustrates the NDVI data for the Manhattan, Kansas USCRN station in 2010 along with an indication of the definition of SOS for our purposes. Two different methods for calculating SOS were applied to the NDVI data: a local threshold based on yearly minimum and maximum NDVI values (ratio) and slope based estimates from exponential functional fits to NDVI data (exponential).

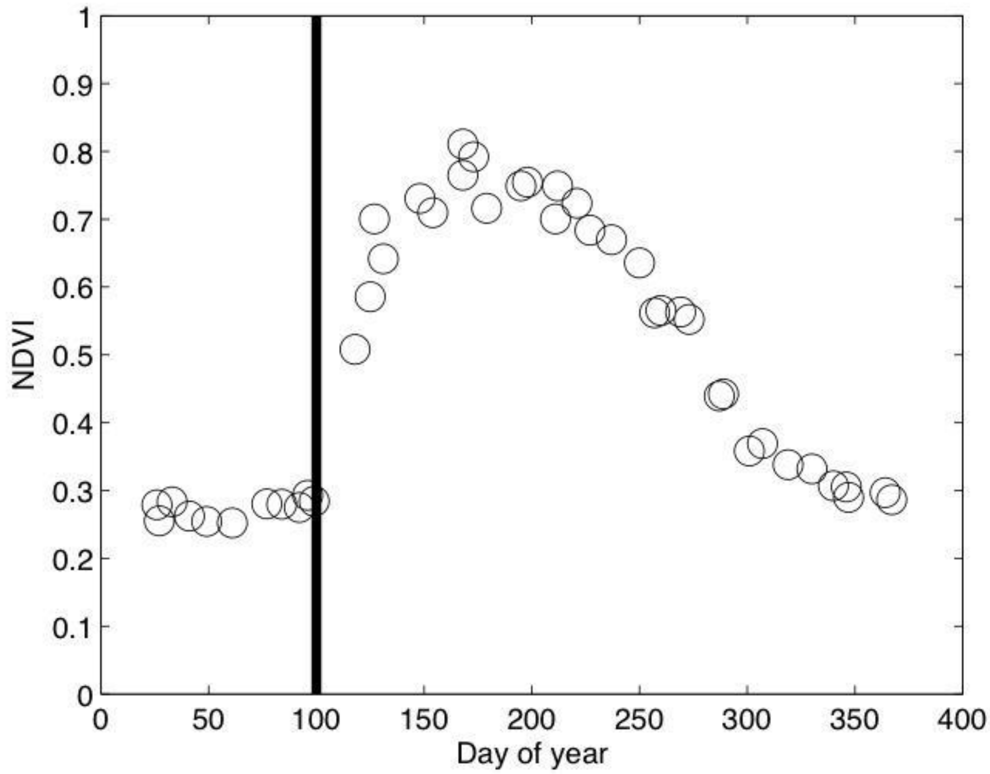


Figure 1: MODIS NDVI data (circles) for the pixel containing the Manhattan, Kansas USCRN station in 2010. The vertical line indicates our definition of onset of growing season.

The NDVI-based SOS estimates were then compared to the SOS estimates for each of the air and soil temperature thresholds from the ground-based measurements. The best RMSE correlations were with the soil temperature thresholds at 5°C and the exponential method (see Figure 2). Assuming that the NDVI-based SOS using the exponential method is a surrogate for truth in the absence of actual phenology data, these results are the first to show large-scale patterns of soil temperature thresholds as an indicator of phenological development. This research provides a new methodology for determining the climatic growing season that will assist in more accurate predictions of plant growth and development for monitoring and modeling purposes.

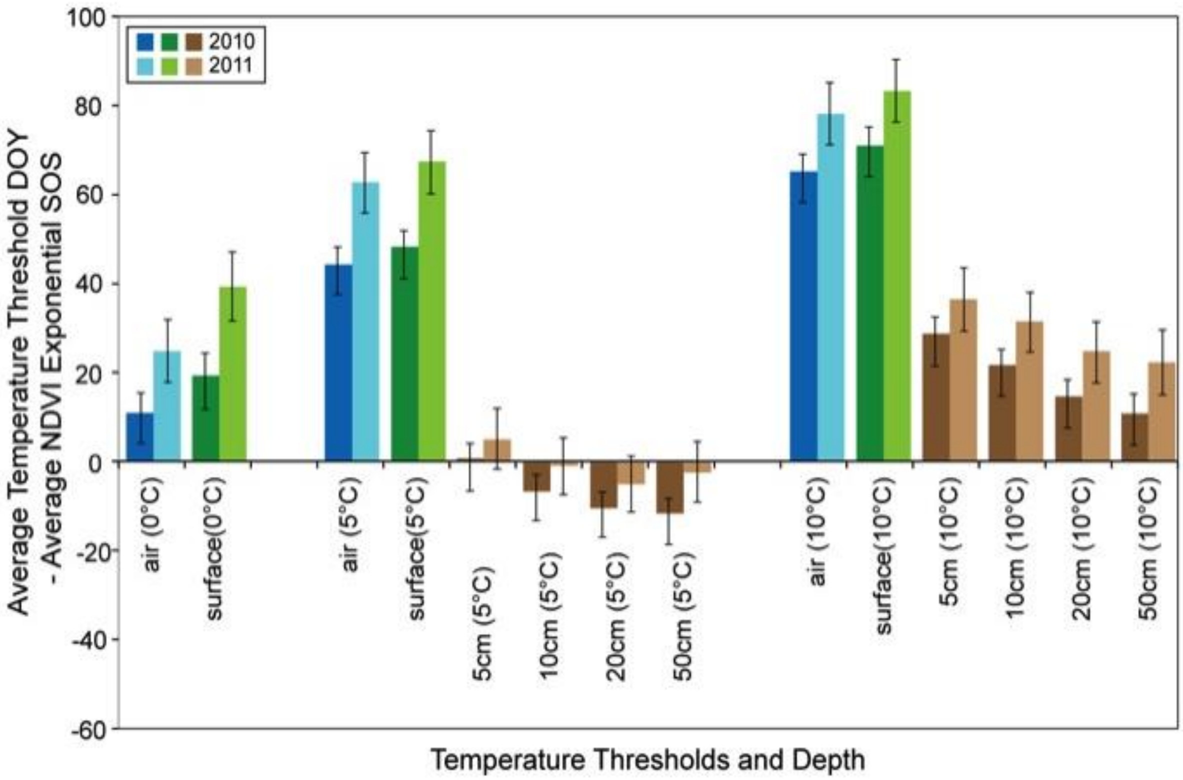


Figure 2: Comparison of the average difference between temperature-derived SOS at various depths and temperature thresholds with NDVI-derived SOS using exponential method. Dark bars indicate 2010 and light bars indicate 2011. Soil temperatures using the 5oC threshold are the closest to the NDVI-derived SOS.

Performance Metrics	**FY12**
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	1
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	1

PLANNED WORK

* Extend the analysis for 2012, where there were 114 USCRN stations with complete soil temperature data profiles.
* Examine other phenology metrics such as end of growing season, peak of growing season, etc.
* Utilize USCRN soil moisture data as an additional metric to predict phenology.

PUBLICATIONS

Bell, J.E. & J.L. Matthews. Evaluation of air and soil temperatures for determining the onset of the growing season. Submitted

PRESENTATIONS

- Bell, J.E. and J.L. Matthews. Comparison of In Situ Temperature Measurement and Remotely-Sensed Phenology. American Meteorological Society. Austin, TX. January 2013
- Bell, J.E. and J.L. Matthews. Comparison of In Situ Temperature Measurement and Remotely-Sensed Phenology. Phenology Conference. Milwaukee, WI. September 2012

OTHER

- The analysis for 2012 is being performed by UNC-A undergraduate mathematics major Jennifer Meyer.

Climate Monitoring and Research Services to the Atmospheric Turbulence and Diffusion of NOAA's Air Resources Laboratory

Task Leader	Mark Hall
Task Code	NC-SON-03-ORAU
Main CICS Research Topic	Surface Observing Networks
Percent contribution to CICS Themes	Theme 2: 100%
Percent contribution to NOAA Goals	Goal 1: 100%

Highlight: Installed three additional USCRN sites in Alaska in 2012. Sites installed near King Salmon, Gustavus, and Metlakatla.

BACKGROUND

ATDD is one of three field divisions of the NOAA's ARL. Through ATDD*,* ORAU works closely with NOAA to perform lower atmosphere research in the areas of air quality, contaminant dispersion, and climate.

ATDD's objectives are to:

- develop better methods for predicting transport and dispersion of air pollutants
- improve modeling of air-surface exchange of water, energy, and carbon so that their effect(s) on the earth's climate may be better understood
- make high-quality measurements in support of these efforts toward increased understanding
- install and maintain a long-term, self-consistent system to monitor climate across the United States.

ATDD's staff has historically consisted of Federal civil servants from NOAA and personnel from ORAU . These personnel contribute 100% of their time in support of ATDD's mission, work toward goals set by the ATDD Director, and are co-located with the NOAA personnel.

One of the primary focii for the ATDD/ORAU partnership has been sustaining NOAA's climate observing systems and developing research efforts that will enhance our understanding of a changing environment in the different ecosystems within the United States.

ACCOMPLISHMENTS

The installation of three additional CRN stations in Alaska brings the total Alaska installs to 12. Two of the stations installed in the summer of 2012 are remotely powered sites, using both solar and a methanol fuel cell for power production. As more remote locations are instrumented in Alaska, the use of alternate energy becomes not only important, but essential. One of these stations is the most remotely located CRN site installed to date. This site is located in Katmai National Park and is a forty minute bush plane flight from King Salmon. The equipment for this install had to be transported the last segment of the trip by helicopter.

In addition to the additional station installs in Alaska, maintenance was performed for 217 climate stations during this period. Maintenance includes calibration of sensors, collection of metadata for each site, and performing system updates and repairs as needed.

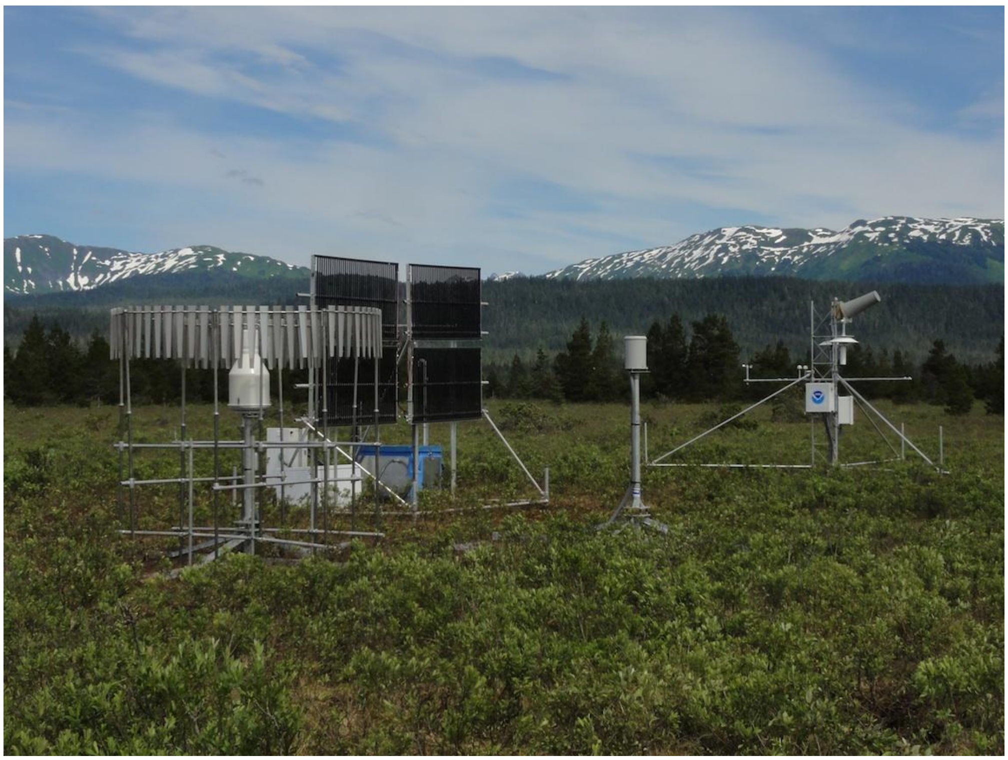


Figure 1: Gustavus Alaska CRN Site

Performance Metrics	FY12
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	1
# of peer reviewed papers	2
# of non-peered reviewed papers	0
# of invited presentations	1
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	0

PLANNED WORK

* Two additional stations are to be installed in Alaska this summer. These stations will be in remote locations and powered by alternate energy sources. The final locations are still being discussed but the most likely sites are Nowitna National Wildlife Refuge and BLM property near Glennallen.
* Maintenance will continue for the network of 220 existing stations in the networks.

PUBLICATIONS

Jesse E. Bell, Michael A. Palecki, C. Bruce Baker, William G. Collins, Jay H. Lawrimore, Ronald D. Leeper, Mark E. Hall, John Kochendorfer, Tilden P. Meyers, Tim Wilson, Howard J. Diamond. U.S. Climate Reference Network Soil Moisture and Temperature Observations. *Journal of Hydrometeorology*

Howard J. Diamond, Thomas R. Karl, Michael A. Palecki, C. Bruce Baker, Jesse E. Bell, Ronald D. Leeper, David R. Easterling, Jay H. Lawrimore, Tilden P. Meyers, Michael R. Helfert, Grant Goodge, Peter W. Thorne. U.S. Climate Reference Network after One Decade of Operations: Status and Assessment. *Bulletin of the American Meteorological Society*

PRESENTATIONS

- John Kochendorfer, NOAA, Oak Ridge, TN; and C. B. Baker, E., J. Dumas Jr., D. L. Senn, M. Heuer, M. E. Hall, and T. P. Meyers: Biases Associated with Air Temperature Measurements near Roadways and Buildings, Presented at the 93rd Annual AMS meeting, Austin, TX, 6-10 January 2013.

- Investigating the hydrological effects of Tropical Cyclones over the Carolinas from observational and modeling based perspectives.

Task Leader	Ronald Leeper and Olivier Prat
Task Code	NC-SON-04-NCICS-RL_OP
Main CICS Research Topic	Surface Observing Network and Earth System Monitoring from Satellites
Percent contribution to CICS Themes	Theme 1:5%; Theme 2:40%; Theme 3:55%
Percent contribution to NOAA Goals	Goal 1:60%; Goal 4:40%

Highlight: Five Tropical cyclones (Floyd 1999, Isabel 2003, Frances 2004, Alberto 2006, Irene 2011) that impacted the Carolinas were simulated using the Weather Research and Forecasting model (WRF) for an ensemble of microphysical parameterizations. Modeling results were compared against surface and remotely sensed observations to assess the model's ability to capture such extreme events and their impacts on local communities.

BACKGROUND

The Carolinas are prone to tropical cyclone (TC) activity and can be impacted in many different ways depending on storm track. Regardless of where landfall occurs, TCs are often associated with intense precipitation and strong winds triggering a variety of natural hazards that can impact coastal and interior communities (Prat and Nelson 2012). The assessment of societal and environmental impacts of TCs requires a suite of observations. However, the scarcity of station coverage, sensor limitations, and rainfall retrieval uncertainties are issues limiting the ability to assess accurately the impact of extreme precipitation events.

Numerical methods provide an additional tool for investigating these hydrological events at regional and local scales and bridge the gap between observations. Models, such as the Advanced Hurricane Weather Research and Forecasting (AHW) model, support of variety of physical parameterizations and modeling options to fully investigate TCs.

The methodology used in this work is as follows:

1. A handful of selected TCs, based on their track, were grouped into direct hit, indirect hit, and near-miss categories and modeled using WRF.
2. For each TC, an ensemble consisting of commonly used microphysics options were simulated and evaluated (storm evolution, hourly-daily-total precipitation amounts, and rainfall field) against TRMM satellite observations and rain gauge data (COOP and USCRN).

3. For near miss and direct hit TCs (Floyd 1999, Isabel 2003, Irene 2011), WRF simulations were used (10-meter average wind-speed, sea level pressure) to force a storm surge model.

ACCOMPLISHMENTS

For selected storms, model performance was evaluated based on TC center, wind speed and pressure against the IBTrACS database. For Irene 2011 (figure 1), ensemble members' wind speed and pressure were all within 5 to 20% of IBTrACS.

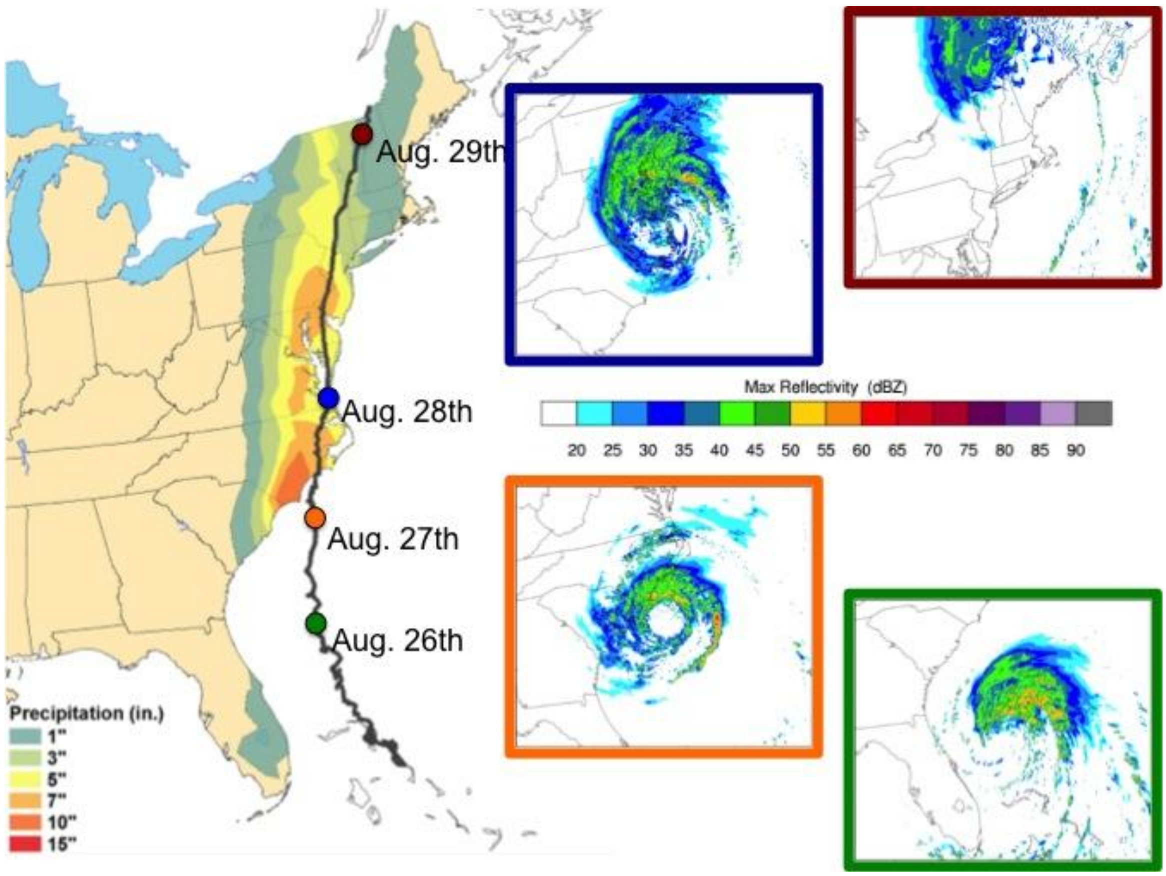


Figure 1: WRF simulations for Hurricane Irene (2011). Results are obtained with the Morrison microphysical scheme and the YSU-PBL. Snapshots of simulated reflectivity are given at 1200UTC for the corresponding day.

Model performance was sensitive to microphysical parameterization and storm track. Simulated precipitation fields of accumulated rainfall (rainfall intensity, location of the maximum precipitation), varied ($0.31<R2<0.87$) with regards to the microphysical parameterization and storm characteristic. For instance, a greater variability among ensemble members was found for Frances (curved track over complex terrain) than Irene (curved track over coastal area).

In general, WRF simulations were in good agreement with surface based observations. This was particularly true in the case of tropical storm Frances, as model results were able to capture precipitation patterns observed over mountainous terrain better than satellite based measurements (figure 2). Among the TCs selected in this study, ensemble mean was more consistently in better agreement with observations than any of the eight of microphysical options.

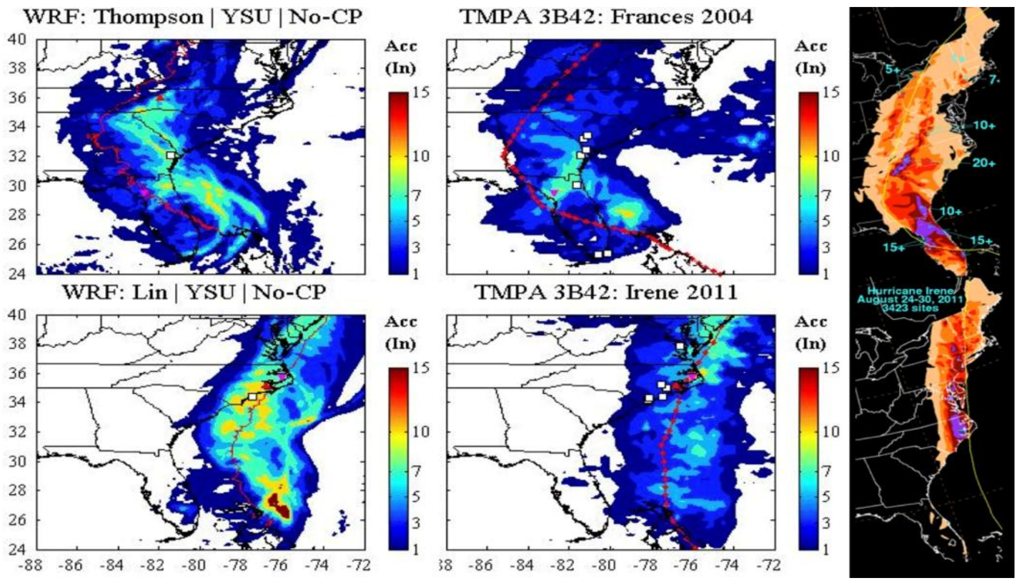


Figure 2: Modeled (WRF; left), remotely sensed (TMPA 3B42; middle), and measured (right) rainfall accumulation for hurricane Frances (2004; top) and hurricane Irene (2011; bottom). Locations of the ground based (red triangle), remotely sensed (pink triangle) and modeled maxima (white squares)

Performance Metrics	**FY12**
# of new or improved products developed	
# of products or techniques transitioned from research to ops	
# of peer reviewed papers	
# of non-peered reviewed papers	
# of invited presentations	2
# of graduate students supported by a CICS task	
# of undergraduate students supported by a CICS task	

PLANNED WORK

* Further evaluate the fitness of WRF simulations by including more observations such as US Climate Reference Network (USCRN) stations (accumulation and timing), COOP rain gauge stations, TRMM Precipitation Radar (TPR 2A25), Stage IV data, and possibly rainfall estimates from the National Mosaic and Multi-sensor QPE (NMQ/Q2).
* Results from the high-resolution WRF simulations, including the average wind-speed and the sea level pressure, will be used with the ADCIRC storm-surge and wave-model (Westerink et al, 2008) to simulate storm surge and waves along the Carolinas coast for near-miss and direct TCs along the coast.

PUBLICATIONS

N/A

PRESENTATIONS

- Leeper, R.D., O.P. Prat, and B. O. Blanton. Understanding the hydrological effects of Tropical
  Cyclones over the Carolinas from an observational and modeling based perspectives. American Meteorological Society. Austin, TX. January 2013
- Leeper, R.D., O.P. Prat, and B.O. Blanton. Assess the hydrological impacts of tropical cyclones on
  the Carolinas; An observational and modeling based investigation. American Geophysical Union. San Francisco, CA. December 2012

OTHER

- This project is conducted in collaboration with Brian O. Blanton (Renaissance Computing Institute) for high performance computing and for the storm surge modeling.

- Development and verification of US Climate Reference Network (USCRN) Quality Assurance Methods

Task Leader	Ronald Leeper
Task Code	NC-SON-05-NCICS-RL
Main CICS Research Topic	Surface Observing Network
Percent contribution to CICS Themes	Theme 1: 0%; Theme 2: 100%; Theme 3: 0%
Percent contribution to NOAA Goals	Goal 1: 20%; Goal 2: 80%

Highlight: The USCRN highlighted a decade of accomplishments since commission with two publications featuring a description of the network in BAMS and a soils-focused manuscript in the Journal of Hydrometeorology. In addition, the recently developed new precipitation algorithm was deployed against archived data for all USCRN stations. Comparisons indicated the new QA approach was less sensitive to gauge evaporation and sensor noise, resulting in an increase of network calculated precipitation of 2.5%.

BACKGROUND

The US Climate Reference Network (USCRN) is one of the first climate-monitoring networks designed to detect and attribute climate trends. Since the network's commission in 2004, the USCRN has deployed over 124 climate-monitoring stations across the US, including Alaska and Hawaii. Stations were placed in locations that were carefully chosen by a site selection committee based on representivity and longevity. Temperature and precipitation observations are taken from state-of-the-art instruments calibrated to NIST traceable standards and annually maintained. Data quality and continuity were preserved by installing sensors in triplicate within well-shielded environments to improve the detection of sensor malfunctions.

As part of the USCRN development plan, network quality assurance (QA) strategies are routinely reviewed with recommendations proposed. A recent review of USCRN precipitation QA methodology revealed that non-precipitating processes (gauge evaporation, sensor noise, and station exposure) could dampen algorithm performance. An additional QA algorithm was proposed to 1) mitigate the impact of non-precipitating processes on QA performance and 2) implement an algorithm with a more straightforward calculation of precipitation.

ACCOMPLISHMENTS

The USCRN team developed a new precipitation algorithm that incorporates redundant measures of precipitation to detect and reduce the impact of gauge noise. Additional QA methods and policies were adopted to minimize the effects of gauge evaporation, station maintenance, and station exposure on the quality of precipitation observations. Field and artificial algorithm comparisons revealed the new QA strategy was less sensitive to sensor noise and gauge evaporation (see figure 1a-b), resulting in an increase in accumulated precipitation of 2.5%.

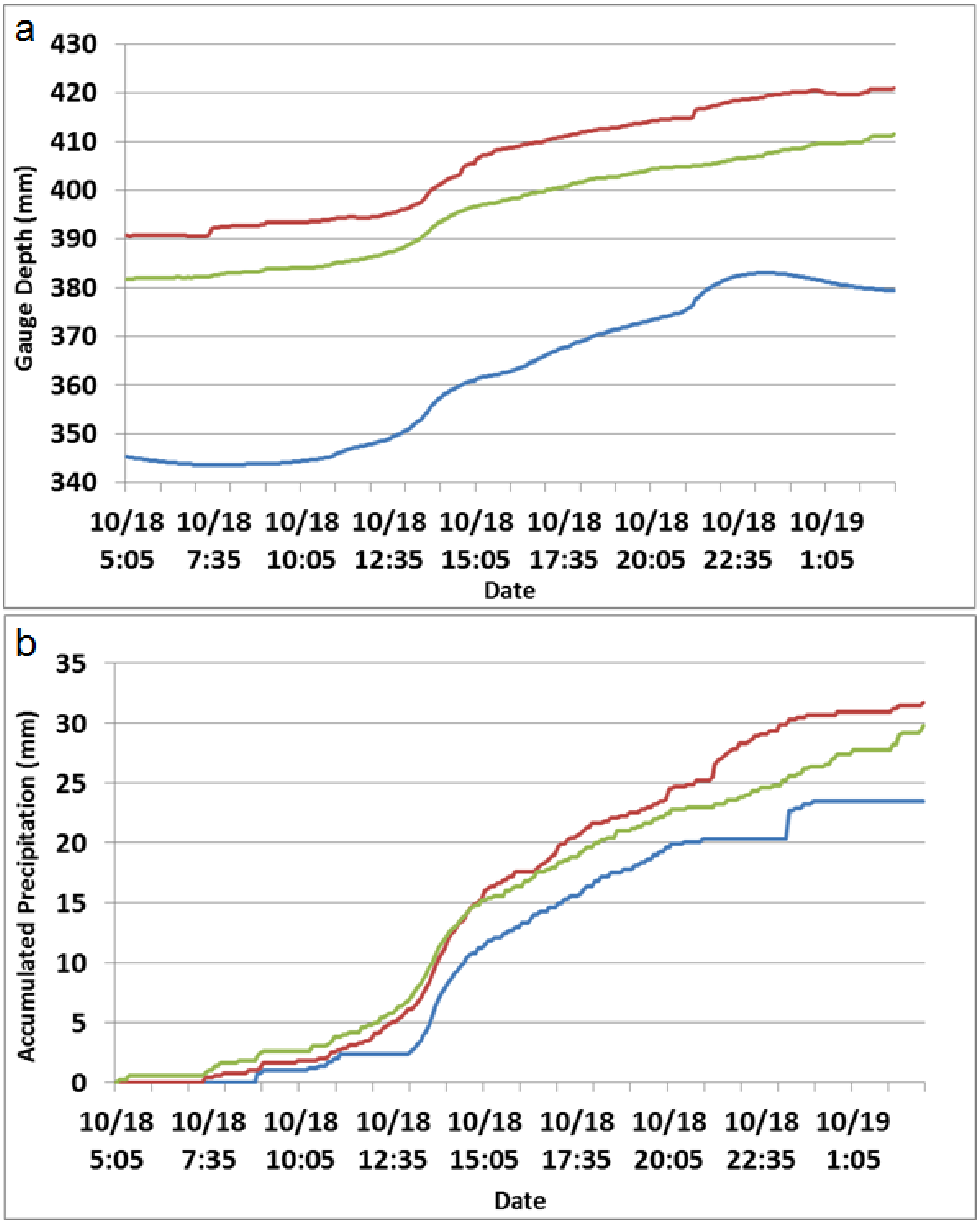


Figure 1: Geonor (a) gauge depths for the three wires and (b) calculated precipitation for (red) newly developed QA methodology, (blue) current QA approach, and (green) tipping bucket for a precipitation event at the Quinault, WA USCRN station.

The new algorithm was deployed across archived data for all USCRN and sister network (US Regional Climate Reference Network) stations. Results from this deployment were stored in a new database to improve the efficiency of algorithm comparisons, which is a necessary step before becoming fully operational.

An additional branch of the new QA methodology was developed to better handle cases when auxiliary measures of wetness from a disdrometer were considered suspicious. Deployed disdrometers were found to exhibit different modes of behavior during precipitation events based on hydrometeor type. For liquid hydrometeors, the detection of wetness was persistent throughout the precipitation episode. However, frozen hydrometeors that can bounce or be blown off the sensing plate resulted in an intermittent pattern of wetness during an event.

Performance Metrics	**FY12**
# of new or improved products developed	
# of products or techniques transitioned from research to ops	
# of peer reviewed papers	2
# of non-peered reviewed papers	1
# of invited presentations	1
# of graduate students supported by a CICS task	
# of undergraduate students supported by a CICS task	

PLANNED WORK

* Evaluate USCRN disdrometer responses to varying hydrometeor types using mounted cameras
and optical based disdrometers deployed at USCRN Marshall Testbed
* Conduct a precipitation survey using field observations to further assess QA performance
relative to manual inspection.
* Present the new QA methodology to the USCRN Advisory Board for operational approval

PUBLICATIONS

Bell, J.E., M. Palecki, C. Baker, W. Collins, J. Lawrimore, R. Leeper, M. Hall, J. Kochendorfer, T. Meyers, T. Wilson, and H. Diamond. US Climate Reference

Network soil moisture and temperature observations. *Journal of Hydrometeorology*. Accepted.

Diamond, H., Karl, T., Baker, C., Bell, J., Leeper, R., Easterling, D., Lawrimore, J., Meyer, T., Helfert, M., Goodge, G., and Thorne, P. U.S. Climate Reference Network after one decade of operations: status and assessment. *Bull. Amer. Meteor. Soc.* doi:10.1175/BAMS-D-12-00170.

PRESENTATIONS

- Leeper, R. D., Michael, P., and Egg, D. USCRN Precipitation Algorithm. Atmospheric Turbulent Diffusion Division. Oak Ridge, TN. December 2012.

-Leeper, R. D. and Michael, P. Wetness sensor performance during snowy conditions. Atmospheric Turbulent Diffusion Division. Oak Ridge, TN. December 2012.

- Collocated US Climate Reference Network (USCRN) and Cooperative Observer network (COOP) Comparisons

Task Leader	Ronald Leeper
Task Code	NC-SON-06-NCICS-RL
Main CICS Research Topic	Surface Observing Network
Percent contribution to CICS Themes	Theme 1:0%; Theme 2:80%; Theme 3:20%
Percent contribution to NOAA Goals	Goal 1: 30%; Goal 2: 70%

Highlight: Closely collocated USCRN and COOP observations of temperature and precipitation were sensitive to station design (shielding, sensor redundancy, and QA strategies). Temperature biases were generally more pronounced during lighter wind conditions, and greater for maximum than minimum temperatures. Precipitation bias was primarily driven by gauge shielding, which affected observations of frozen hydrometeors more so than liquid.

BACKGROUND

The USCRN was specifically engineered to detect and attribute climate signals over the next 50 years. From station placement, sensor selection and shielding, calibration standards, and redundancy, this network was designed to limit the effect of observational biases on data records. As USCRN data becomes increasingly utilized in climate focused tasks, differences between traditional COOP and USCRN networks and the role of network architecture on observations and commonly used climate metrics will become increasingly relevant.

The purpose of this study is to compare USCRN and COOP temperature and precipitation measurements and attribute observational discrepancies to station architecture. Selected station pairs must be collocated within 500 meters to limit the impact of local land-cover, elevation, and sitting impacts on observations. Days where either network had missing observations were excluded from daily comparisons. Additionally, USCRN hourly data were aggregated over daily time scales in such a way that observations were within daily observation times for COOP.

ACCOMPLISHMENTS

As a result of well-shielded and aspirated thermistors, USCRN daily maximum and minimum temperatures were on average cooler and warmer than COOP observations respectively. Minimum temperature bias varied little from season to season; however, USCRN cool maximum temperature bias was generally amplified during summer months. These temperature biases resulted in a slight increase in USCRN-based growing degree-days and growing season length. In addition, the last-day-of-frost (occurring later in USCRN) was found to be more sensitive to temperature biases than the first-day-of-frost, which on average occurred sooner for USCRN (figure 1).

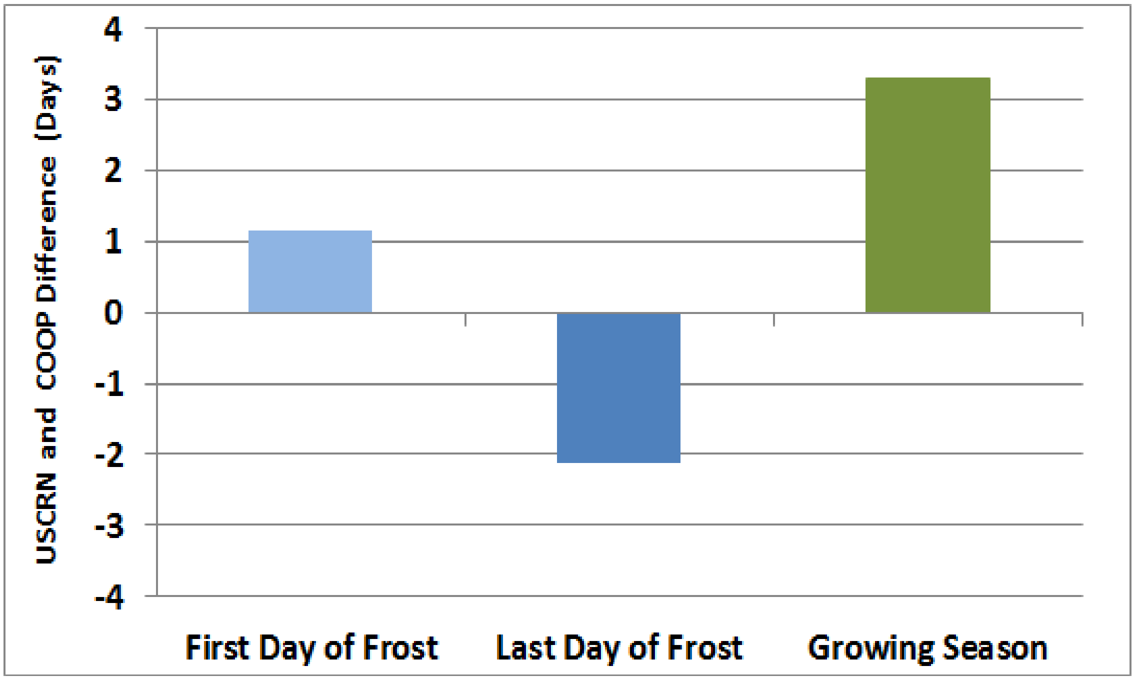


Figure 1: Average of first-day of frost, last-day of frost, and growing season change computed as USCRN minus COOP

Daily precipitation comparisons were strongly influenced by time of observation (TOB) bias. However, precipitation events, which by design were less sensitive of TOB, revealed that gauge shielding contributed to a 2.6% increase in USCRN precipitation over COOP. This precipitation bias was more pronounced for colder than warmer months, indicating the effect of shielding was greater for frozen hydrometeor types (figure 2).

Several COOP observations of precipitation that significantly differed from USCRN were additionally analyzed. Based on radar measurement, some of these anomalous events were identified as suspicious. Currently, over 64 mm of false precipitation have been removed from COOP archives at NCDC, which further illustrate the value of USCRN as a "reference" network.

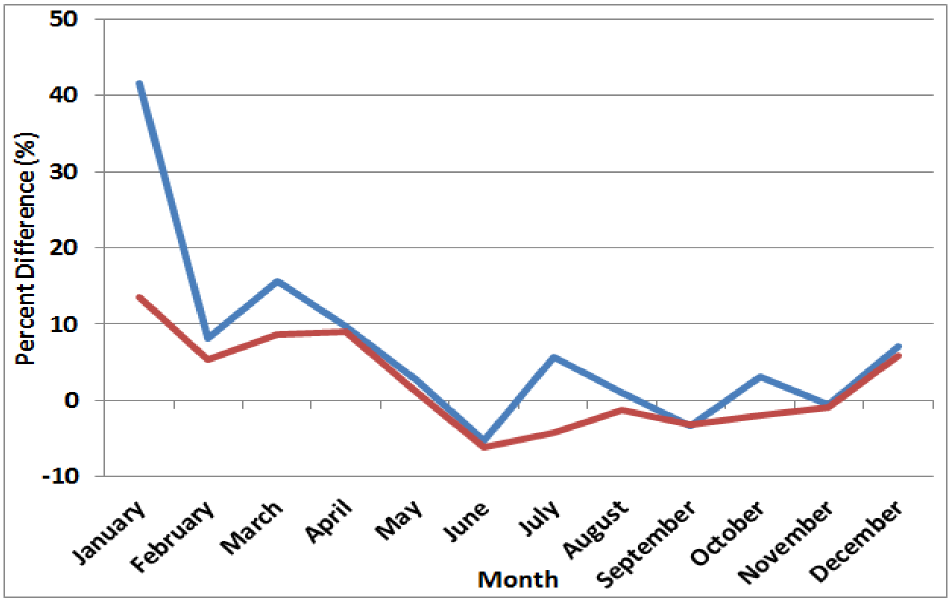


Figure 2: Monthly average (blue) and median (red) USCRN and COOP precipitation differences

Performance Metrics	**FY12**
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	
# of peer reviewed papers	
# of non-peered reviewed papers	
# of invited presentations	1
# of graduate students supported by a CICS task	
# of undergraduate students supported by a CICS task	

PLANNED WORK

* Complete additional comparisons between networks including temperature extremes, standard precipitation index, and palmer drought index

* Incorporate additional radar based estimates of precipitation as a reference point in scenarios where USCRN and COOP measures of precipitation diverge significantly.

PUBLICATIONS
N/A

PRESENTATIONS
- Leeper, R. D. Impact of network design on daily temperature and precipitation and their application: USCRN and COOP. American Meteorological Society. Austin, TX. January 2013

- Maintenance and Streamlining of the Global Historical Climatology Network – Monthly (GHCN-M) Dataset

Task Leader	Jared Rennie
Task Code	NC-SON-07-NCICS-JR
Main CICS Research Topic	Surface Observing Network
Percent contribution to CICS Themes	Theme 1: 50%; Theme 2: 50%; Theme 3: 0%
Percent contribution to NOAA Goals	Goal 1: 90%; Goal 2 10%

Highlight: The International Surface Temperature Initiative has released its new land surface temperature databank, containing over 30,000 stations, and provides better means of versioning control and data provenance. The databank will lay the groundwork for the next iteration of GHCN-M version 4, which will include updates to its quality assurance and bias correction algorithms.

BACKGROUND

Since the early 1990s, the Global Historical Climatology Network-Monthly (GHCN-M) dataset has been an internationally recognized source of data for the study of observed variability and change in land surface temperature. Version 3, which marks the first major revision in over ten years, became operational in 2011 and provides monthly mean temperature data for 7280 stations from 226 countries and territories. This version introduces a number of improvements and changes that include consolidating duplicate series, updating records from recent decades, and the use of new approaches to homogenization and quality assurance. Since its initial release, GHCN-M version 3 has undergone minor updates to incorporate monthly maximum and minimum temperature, as well as improve processing run time.

While there have been tremendous advances in the understanding of climate change since its release, there remain substantial spatial and temporal gaps in GHCN-M due to deficiencies in global collections of data. In addition, there has been limited success at completely documenting the provenance and implementing version control from the point measurement through dissemination and data sharing pathways, quality control, bias correction, and archive and access. More can be done to improve practices to ensure full openness, transparency, and availability of data and the details associated with each processing step.

To address these concerns, scientists from both CICS-NC and NCDC, as well as international partners, established the International Surface Temperature Initiative (ISTI) in 2010. Since its inception, the initiative has worked to create a single, comprehensive global databank of surface temperature observations in a consistent and traceable manner. The databank is version controlled, and has data provenance flags appended to every single value, in order to remain open and transparent. There are multiple stages of the databank, including the original paper record, keyed data in its native format, and a merged dataset with duplicate source data reconciled. All data, along with its underlying code, is available to the public free of charge.

ACCOMPLISHMENTS

Multiple sources of data, on monthly, daily, and sub-daily timescales, have been submitted to NCDC and uploaded to the Databank FTP site. Some sources contain digital images of the original paper copy (known as Stage 0), while all should contain keyed data in its native format (Stage 1). Data is then converted into a common format and data provenance flags are added to every single observation (Stage 2). These flags are determined based upon information provided by the data sender. Some examples include whether an original paper copy is available, and if any quality control or homogenization was applied to the dataset prior to submission. At the time of writing there are 31 daily sources and 23 monthly sources that have been converted to Stage 2. In addition, all daily sources were converted into monthly averages, in order to make the monthly version of the databank more robust.

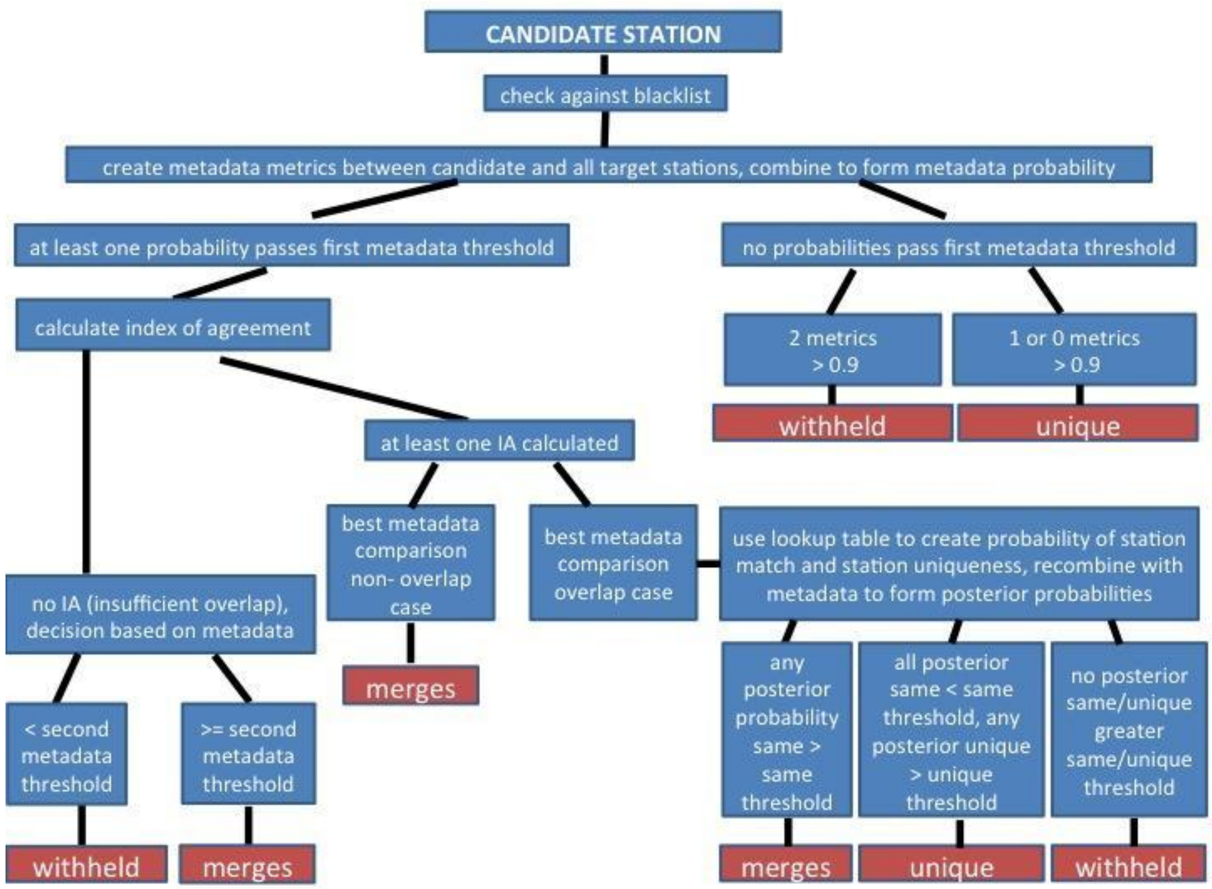


Figure 1: Work flow chart of the merge algorithm.

Because many sources may contain records for the same station, an algorithm was developed to create a consolidated dataset (known as Stage 3). The algorithm attempts to identify and remove duplicate stations, merge identical stations to produce a longer station record, add stations considered unique, and withhold records where it is unclear whether to merge the record or create a new unique record. Using a probabilistic approach, the algorithm attempts to mimic the decisions a hand analyst would make, consisting of metadata matching and data equivalence criteria (see Figure 1). Candidate stations in question are first matched through their metadata characteristics such as station latitude, longitude, elevation, name, and the year the data record began. If a plausible match is made, the station data is then compared using a "goodness-of-fit" measure known as the index of agreement. Using user defined thresholds, a candidate station works through the flowchart above and its fate is to either merge with an existing station, become unique in its own right, or be withheld for future research. The algorithm contains eight user-defined thresholds. Changing these thresholds can significantly alter the overall result of the program. Therefore the Stage 3 product contains a dataset recommended and approved by ISTI, along with variants in order to characterize the uncertainty of the algorithm.

In October of 2012, the Stage 3 databank was released in beta form to the public. All data and code are provided to the public through the Databank FTP, in order to be open and transparent. Numerous suggestions and bug fixes were sent and a second beta went out in December of 2012. Currently the product is in its final revisions for a version 1 release in March 2013, and a landmark paper describing its methods has been submitted to a major science journal. The recommended Stage 3 product contains 32,222 unique stations, over four times as many stations as GHCN-M version 3. Since 1850, there consistently are more stations in both the recommended merge, along with all variants, compared to GHCN-M version 3 (see Figure 2).

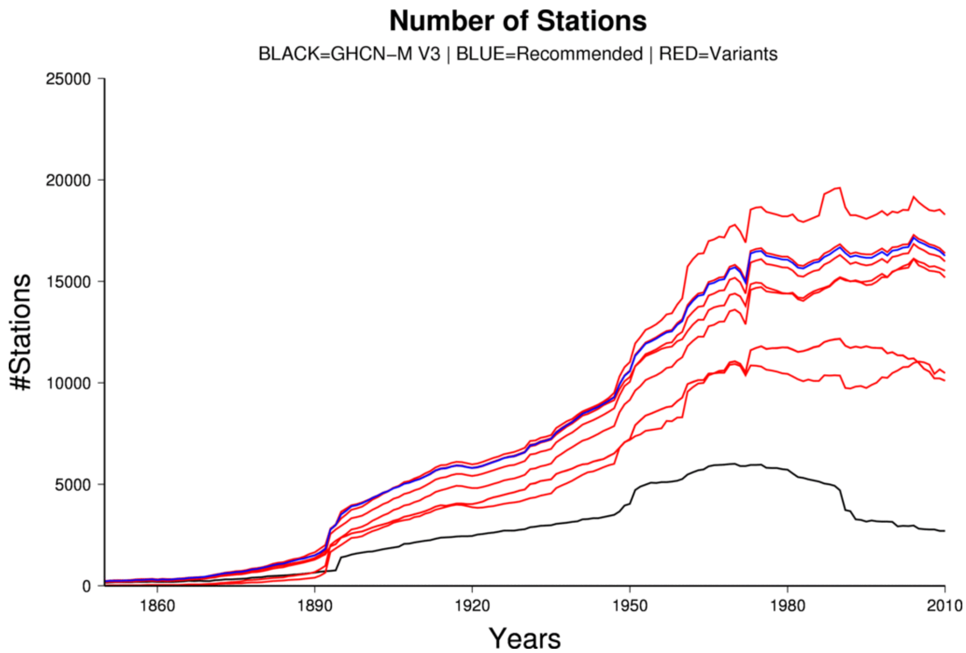


Figure 2: Station count by year from 1850-2010, compared to the unadjusted GHCN-M version 3 (black), recommended merge (blue), and merge variants (red).

Work is underway to develop the next iteration of GHCN-M, with the operational recommended merge as its starting point. Using monthly updates to the Stage 3 product, quality control will be applied, along with running NCDC's pairwise homogeneity algorithm, in order to detect inhomogeneities. Updates to these algorithms are being tested in order to account for the large increase in number of stations. In addition, new quality assurance procedures will be tested and applied, including a spatial quality control check and statistical tests for variance.

Performance Metrics	**FY12**
# of new or improved products developed	2
# of products or techniques transitioned from research to ops	1
# of peer reviewed papers	1
# of non-peered reviewed papers	1
# of invited presentations	1
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	2

PLANNED WORK

* Create update system for the databank, where new data will be added to existing stations on a monthly basis, and new stations will be added on a quarterly basis.
* Engage with the public on suggestions to databank design and merge algorithm. Provide updates with changes to versioning control as needed.
* Update quality control and bias correction algorithms used in GHCN-M version 3 to account for an increase in number of stations from the databank recommended merge
* Establish end-to-end-process for GHCN-M version 4.0 production
* Release GHCN-M version 4.0 to the public

PUBLICATIONS

Lawrimore, J. H., Rennie, J.J., and Thorne, P.W., An International Response to the Need for Better Global Temperature Data. Submitted to AGU's EOS, published Feb 5th, 2013 (http://onlinelibrary.wiley.com/doi/10.1002/eost.v94.6/issuetoc)

Rennie, J.J. and coauthors (2013), The International Surface Temperature Initiative's Global Land Surface Databank: Monthly Temperature Data Version 1 Release Description and Methods. Submitted to Geoscience Data Journal

PRESENTATIONS

- Rennie, J.J. (2013) Development of the International Surface Temperature Initative's Global Land Surface Databank, 20th Conference on Applied Climatology, AMS Annual Meeting, Austin, TX, 9 Jan 2013 (https://ams.confex.com/ams/93Annual/webprogram/Paper218960.html)

OTHER

- Location of latest GHCN-M version 3 dataset: http://www.ncdc.noaa.gov/ghcnm/v3.php
- The International Surface Temperature Initiative: www.surfacetemperatures.org
- FTP site of the Global Databank: http://www.gosic.org/GLOBAL_SURFACE_DATABANK/GBD.html

- Regional and Decadal Analysis of the Air Freezing Index

Task Leader Jared Rennie, Jesse Bell, Ge Peng, Laura Stevens
Task Code NC-SON-08-NCICS-JR_GP_LES
Main CICS Research Topic Surface Observing Network
Percent contribution to CICS Themes Theme 1: 40%; Theme 2: 40%; Theme 3: 20%
Percent contribution to NOAA Goals Goal 1: 80%; Goal 20%

Highlight: Work is underway to develop a climatology of the Air Freezing Index using long term COOP stations in the United States. Using statistical measures, results will highlight the annual, decadal, and regional variability of this product and its effect on soil characteristics.

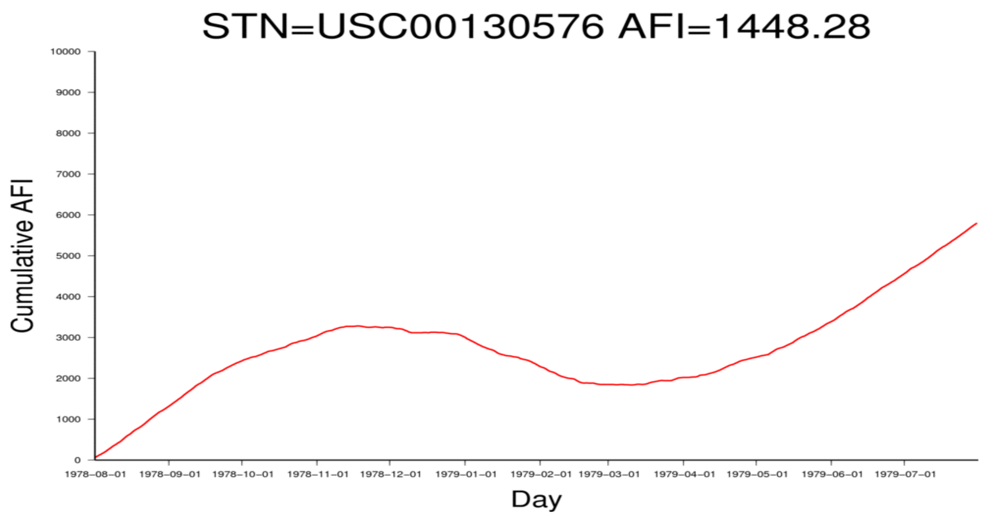
BACKGROUND

Climate observations of frost and its effect on soil have many applications in agriculture and civil and transportation engineering. Many metrics have been calculated using air temperature to characterize frost, including growing degree days, frost depth penetration, and length of freeze season. Another metric, the Air Freezing Index (AFI), calculates frost-depth for mid latitude regions using air temperature. Daily AFI is defined as the departure of the daily mean temperature above or below 32°F. In other words, the daily AFI is the calculated difference between the daily mean temperature and the freezing point of water. Daily values are then accumulated over a winter season, and its yearly accumulation represent the seasonal magnitude and duration of below freezing air temperature. This is important for agencies in agriculture and construction, whose day to day operations rely heavily on soil temperature.

Since AFI is based upon daily average air temperature, a variable commonly reported in the United States, it makes sense to create a national database. Using long-term stations in the United States, Annual AFI will be calculated and research will be performed to highlight its decadal and regional variability. In addition, the AFI will be tested against other metrics more widely known, in order to determine performance.

ACCOMPLISHMENTS

Using observations from the Global Historical Climatology Network - Daily (GHCN-D) dataset, stations were selected that had 90% of non-missing data spanning at least 80 years. Using the daily maximum and minimum temperature, averages were generated and departures from freezing (32°F) were accumulated over a winter season, defined as August 1st - July 31st. An annual curve is generated, and the difference between its peak and valley is used to create the annual AFI (see FIgure 1). Work on this project began late 2012, and talks are underway to develop a methodology of statistical measures. First, the resulting AFI will be tested against other metrics, such as length of freeze season, in order to measure goodness-of fit. Also, decadal trends will be analyzed, in order to characterize AFI and its effect on soil in a changing climate. Work will also be conducted on the regional scale, since temperature characteristics are highly variable in different sections of the United States. Regions selected for the National Climate



Assessment are used for consistency.

Figure 1: Example of calculating AFI from Bedford, Iowa during the 1978-1979 winter season. Daily departures from the mean are calculated and accumulated over time (red curve above) The Annual AFI is then calculated using the difference between the curves peak (3285.90 on Nov 18th, 1978) and valley (1837.62 on March 10th, 1979).

Performance Metrics	FY12
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	1
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	0

PLANNED WORK

* Update Air Freezing Index dataset to contain data up to the 2012-2013 Winter Season
* Compare against other metrics to determine goodness-of-fit
* Calculate decadal trends, and produce regional analysis of Air Freezing Index
* Write paper on methods and results
* Work on modeling AFI and compare against CMIP5 output

PRESENTATIONS

- Rennie, J.J. (2013) Regional and Decadal Analysis of the Air Freezing Index, Frost and Freeze Data Workshop, Asheville, NC, 21 Mar 2013

- Assessments, improving understanding of historical observations and instigation of future reference observations

Task Leader	Peter Thorne
Task Code	NC-SON-09-NCICS-PT
Main CICS Research Topic	Surface Observing Network
Percent contribution to CICS Themes	Theme 1:20%; Theme 2:70%; Theme 3:10%
Percent contribution to NOAA Goals	Goal 1:90%; Goal 2:10%

Highlight: Work continued in support of next generation surface temperature products with Jared Rennie and NCDC colleagues. Further work on drafting of the IPCC AR5 WG1 contribution including contributions to cross-chapter box on the 'warming hiatus' and also the NCA climate change chapter, appendix, and CAQ. Work on detection and attribution of free atmosphere temperatures, surface humidity homogenization, quality control of surface synoptic measurements, and the statistical properties and probability of the long-duration upper tercile streak in USHCN temperatures over 2011/12. Oversight of GRUAN and ISTI activities.

BACKGROUND

Activities under this area can be broadly grouped into three categories:

1. *Assessment activities*. Both the IPCC and NCA reports will be completed in calendar year 2013. As a Lead Author on both activities input to the drafting process has taken up a substantive proportion of the reporting period activities. Editorial support role continues for the annual state of the climate report global chapter.

2. *Analysis activities.* This is primarily in support of the broader NCDC efforts to improve all aspects of the surface temperature records used for operational monitoring and research applications. Further, projects relevant to NCDC's mission are undertaken as resources and priorities dictate.

3. International coordination. Through (co-) chairmanship of the International Surface Temperature Initiative and the GCOS Working Group on the GCOS Reference Upper Air Network, substantive international outreach and coordination is achieved. Reciprocal positions on the steering committees of the Earthtemp network and the Network for the Detection of Atmospheric Composition Change ensure reach into these activities. During the FY12, a role was also taken on the steering committee of a workshop on the detection of climate extremes held under the auspices of the UK Foreign and Commonwealth Office at Oxford University.

ACCOMPLISHMENTS

For assessment activities all required inputs have been delivered to responsible parties on time and in full. The IPCC chapter section on observed temperatures, for which I am responsible, netted 1,000 comments in the first review round and 700 in the second.

These were all responded to. Graphics and analysis support was extended to all temperature and many hydrological section analyses and code and data prepared for release. At the final Lead Author meeting, I was drafted onto a team to address the hot-button topic of the warming hiatus and its causes. Several original section submissions were made to the NCA activity. Thereafter, several requested reviews of relevant materials were undertaken prior to public release. The state of the climate report was published on schedule and support was given to editing, crafting the introduction, and layout of the Global chapter.

For scientific data analysis the global land surface databank first version release was developed alongside CICS and NCDC colleagues and released in beta form and a paper published in EOS. After four years of collaborative effort with staff at NCDC and the UK Met Office, a quality controlled meteorological database covering 1973 on – HadISD – was published and is now updated annually. From this product a novel application of the PHA system used to create GHCNM adjustments was applied to create a new updateable land surface humidity product – HadISDH. This is now in re-review in COPD. Following media attention surrounding the streak of USHCN upper-tercile months arising from the June monitoring report from NCDC, work with Jessica Matthews has enlisted some of the foremost experts in time series analysis to write a paper on this event which is in draft presently. A number of papers and analyses have been undertaken on detection and attribution with a focus upon upper air temperature trends. Several additional papers upon this topic are under preparation / review.

For international activities the global databank is the first demonstrable outcome of the International Surface Temperature Initiative. Work on the creation of a set of analogs for benchmarking and comparison is underway and attention has started to turn to engaging third parties to provide additional realizations of global / regional time series from the databank and participating in the benchmarking activities.

The GCOS Reference Upper Air Network added a station in Ny Alesund and increased the volume of reference quality radiosonde data being served through NCDC. Work progressed on regulatory materials and the development of new data streams from lidars and frostpoint hygrometers. A new Implementation Plan covering 2013-2017 was drafted, circulated to the working group, and signed off by GCOS. In recognition of work on GRUAN, I was a keynote plenary speaker at an EU workshop on the future of the European Observing system in December 2012 in Brussels.

Other international activities included:
- Participation in Earthtemp steering committee activities and attendance at the first meeting in Edinburgh.
- Participation in steering committee for workshop on event attribution in Oxford

- Participation in NDACC steering committee activities and contribution to their newsletter.

Performance Metrics	FY12
# of new or improved products developed	3
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	10
# of non-peered reviewed papers	2
# of invited presentations	3
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	0

PLANNED WORK

* Completion of activities on IPCC AR5 and the 2013 NCA report and support for roll out as requested by these organizations.
* Completion of BAMS State of the Climate report global chapter
* Roll out of the first version of the global land surface databank
* Development and roll out of GHCNv4 and support to paper drafting
* Support to development and roll out of ERSSTv4 and MLOSTv4
* Management of GRUAN and ISTI processes and related activities for Earthtemp, NDACC and GCOS.
* Work on detection and attribution
* Completion of analysis of USHCN upper tercile streak characteristics and publication thereof
* Publication of new homogenized surface humidity product
* Further research opportunities as they arise.

PUBLICATIONS

Diamond, H. J. et al. (2013), U.S. Climate Reference Network after One Decade of Operations: Status and Assessment Bull. Amer. Meteor. Soc , http://dx.doi.org/10.1175/BAMS-D-12-00170

Lott, F. et al. (2013), Models versus Radiosondes in the Free Atmosphere: A New Detection And Attribution Analysis of Temperature, JGR, DOI: 10.1002/jgrd.50255

Santer, B. D. et al. (2013) Identifying human influences on atmospheric temperature PNAS, 110, 26-33, doi:10.1073/pnas.1210514109

Jay Lawrimore, Jared Rennie and Peter Thorne (2013) Responding to the Need for Better Global Temperature Data, EOS, 94 (6), 61–62 DOI: 10.1002/2013EO060002
Dunn, R. J. H., Willett, K. M. et al. (2012) HadISD: a quality-controlled global synoptic report database for selected variables at long-term stations from 1973-2011. Clim. Past, **8**, 1649-1679 doi:10.5194/cp-8-1649-2012
Blunden, J., and D. S. Arndt, Eds., (2012) State of the Climate in 2011. Bull. Amer. Meteor. Soc., **93** (7), S1-S264.
Mears, C. A., Thorne, P. et al. (2012) "Assessing the value of Microwave Sounding Unit-radiosonde comparisons in ascertaining errors in climate data records of tropospheric temperature" J. Geophys. Res., 117, D19103, doi:10.1029/2012JD017710.
Vose, R. S, Appelquist, S. et al. (2012) "An Intercomparison of Temperature Trends in the U.S. Historical Climatology Network And Recent Atmospheric Reanalysis" Geophys. Res. Lett., 39, Art. No. L10703 doi:10.1029/2012GL051387
Chandler, R. E., Thorne, P. W. et al. (2012) "Building trust in climate science: data products for the 21st century" Environmetrics, 23, 373-381
Willett, K. M. et al. (2013), "HadISDH: An updateable land surface specific humidity product for climate monitoring" Clim. of the Past, in press

PRESENTATIONS

- Thorne, P.W., (2012). "International Surface Temperature Initiative and Globtemperature", GlobTemperature user consultation by the European Space Agency (ESA), Edinburgh, UK.
- Thorne, P.W., (2012). "Uncertainty in Observational Records", Frontiers in Attribution Science, Banff, Alberta.
- Thorne, P.W., (2012). "Observational Record of Extremes: State of the Art, Challenges and Uncertainties", Attributing Climate Extremes Meeting, Oxford, UK.
- Thorne, P.W., (2012). "Optimizing the Scientific and Economic Value of Observations for all: A tiered System of Systems approach", Towards an Integrated Atmospheric Observing System in Europe, Brussels, Belgium.

OTHER

- 2 NASA review panels
- Proposal review for NSF
- Attendance at NDACC Steering committee 10/12
- EU Workshop on the future of the European Observing System
- Principal organizer of GRUAN Implementation and Coordination Meeting, De Bilt, 2/25-3/1
- Organizer first Earthtemp meeting, Edinburgh, 6/12
- Organizer, meeting on frontiers in event attribution, Oxford, 9/12
- Chair, International Surface Temperature Initiative
- Owner, surfacetemperatures.org and associated blog

- Co-Chair GCOS WG-GRUAN
- Reviews for GRL, JGR, Nature Climate Change, Nature Geosciences, IJOC, J. Clim, BAMS, and several other journals

2.7 Workforce Development

NCDC has a continuing number of research and workforce requirements that necessitate collaboration with the best climate science practitioners in the nation. This requires the hiring of outstanding scientific staff with unique skills and backgrounds in Earth System Science and the use of observations for defining climate and its impacts. To meet this demand, CICS-NC has hired an initial cadre of dedicated research staff and is also actively working to identify and train the next generation of scientifically and technically skilled climate scientists. Junior and/or aspiring scientists, including students and post-doctoral researchers, play an important role in the conduct of research at CICS- NC. While consistent funding remains a challenge, CICS-NC is nevertheless working to identify prospective future scientists, to nurture interest in climate applications and to provide opportunities for training and mentorship on various levels.

Four CICS-NC staff hold research faculty positions in the Marine, Earth and Atmospheric Sciences Department (MEAS) at NCSU and provide mentorship to junior scientists and students both in CICS-NC and MEAS. CICS-NC scientists are also engaged in various outreach activities to promote awareness and pique interest in science and climate studies at the K-12 level.

Other 2012/2013 CICS-NC workforce development activities involve the following:

- Brady Blackburn

CICS-NC intern, Brady Blackburn, is a senior at Asheville High School with an interest in pursuing a degree in environmental science. CICS-NC is helping Mr. Blackburn explore that interest by contributing to tropical cyclone research through Cyclone Center. He examines the classifications provided by Cyclone Center's volunteer users, and compares them with the actual satellite images. In particular, Mr. Blackburn seeks to understand why a volunteer might mistakenly classify a storm as having an eye when it does not. His work will help us develop an objective method for evaluating the classifications, which will improve our future analysis.

- Jennifer Meyer

Jennifer Meyer is projected to graduate in May 2013 as an Applied Mathematics major from the University of North Carolina - Asheville. As an undergraduate CICS-NC intern, she is gaining a greater understanding of the applications of mathematics to the field of climatology. In particular, Ms. Meyer is working with CICS-NC scientists, Drs. Jessica Matthews and Jesse Bell, on the "Comparison of ground based temperature measurements with satellite-derived phenology" task. She is applying the methodology developed for 2010-2011 to the 2012 datasets. This experience is furthering math skills learned in the classroom and providing an outlet to use these skills to solve real world problems. In addition to advancing her mathematical skills, Ms. Meyer is also improving her programming skills, particularly in utilizing Matlab. Her contribution to the CICS-NC project is providing an additional year of analysis, where only two years were previously accomplished.

- Andrew Rogers

Andrew Rogers joined CICS-NC as an intern in March 2013 and will work with CICS-NC and NCDC staff to further the development of the International Surface Temperature Initiative's (ISTI's)

Global Land Surface Databank. Work is envisaged to include in depth analysis of a recently developed algorithm to merge temperature stations using advanced statistical measures. Particular attention will be paid to classifying problematic stations and working on optimized solutions using both qualitative analysis and software development. Mr. Rogers has a Bachelor Degree in Meteorology from the University of North Carolina - Charlotte, and hopes to take what he learns from this internship and apply it to graduate school in the Fall of 2013.

- Wei Liu

Dr. Wei Liu completed his Ph.D. in 2012 at the University of Wisconsin-Madison. In his dissertation, he studied the stability of the Atlantic Meridional Overturning Circulation (AMOC) using the NCAR CCSM3 model. Dr. Wei Liu proposed and developed an indicator that correctly monitors the AMOC stability in CCSM3. More generally, he has broad interests in physical oceanography and climate dynamics and has studied internal wave breaking and associated diapycnal mixing in the interior ocean by using direct numerical simulation. Dr. Liu joined CICS-NC as a post-doctoral research scholar in March 2013 where he will support the development of a next generation integrated global surface temperature analysis and provide inter-comparison analysis and development of scenarios for specific datasets as part of the Global Surface Temperature Portfolio team.

2.8 Consortium Projects

- Year 1 CICS Support to NC State University: Maps, Marshes, and Management Application: Ecological Effects of Sea-Level Rise in North Carolina

Task Leader	Allen, Tom
Task Code	NC-CONSO-01-ECU/TA
Main CICS Research Topic	Climate Research, Data Assimilation and Modeling
Percent contribution to CICS Themes	Theme 1: 10%; Theme 2: 40%; Theme 3: 50%
Percent contribution to NOAA Goals	Goal 1: 30%; Goal 2: 10%; Goal 3: 10%, Goal 4: 50%

Highlight: Project researchers have assimilated data, conducted exploratory and scoping workshops, concluded a needs assessment, and begun providing a draft online portal for sea-level rise maps and associated coastal geospatial data. A partnership has developed out of the initiative to establish a North Carolina Digital Coastal Atlas, with this online infrastructure rapidly being implemented.

BACKGROUND

Coastal managers are increasingly calling upon scientists to provide information on sea-level rise. Toward this, the NOAA-supported North Carolina Ecological Effects of Sea-Level Rise (NCEESLR) project measured processes and rates of relative sea-level rise, producing important baselines and model simulations to estimates of wetlands responses to sea-level rise. Maps, shoreline and wetland change trends, and observations of estuarine system evolution were developed.

This task aims to synthesize funded research results, geospatial data, and maps for coastal management decision-making and communications for sea-level rise (SLR) in North Carolina. Towards this, researchers have conducted scoping workshops with potential data partners, and an assessment of the needs of target users. The development of the North Carolina Coastal Atlas, a partnership project with close ties to the NC Division of Coastal Management, NC Sea Grant Extension has arisen from this effort. Results of scoping have been used to begin a draft online portal using sea-level rise and associated geospatial data. Coastal managers, policy analysts, and communicators are linked to the project with parallel awareness and communications activities. In this report, we present the first year of activity for this project, including the development of geospatial and visualization tools, the results of scoping workshops, and the needs assessment and results of marsh vulnerability modeling.

ACCOMPLISHMENTS

1. Developing Geospatial Data and Visualization Tools

Our progress on the geospatial data acquisition has focused on available SLR geospatial data and associated layers and review and design of a map-centric portal for a community of users. Prior to prescribing the most elementary near-term geospatial maps and simply posting them to an online map portal, we hosted a workshop in February 2012 at East Carolina University (ECU), soliciting needs, potential uses, and community suggestions from a focus group. Participants (17) included extension staff (NC Sea Grant), State government managers (ND DENR), Division of Coastal Management policy staff, coastal-marine research scientists (ECU and UNC), and risk communications faculty at ECU. This group recommended scaling-up the activity to a broader base, such as a digital coastal atlas. Concurrently, the project had been evaluating which mapping platform to choose for hosting the project (ESRI vs. several open source software options). The workshop also brought in the strong interest of DCM and possible operational support and sustainability. The group also recommended approaching the project with more than one use case scenario (e.g., estuarine shoreline erosion and sea-level rise vulnerability).

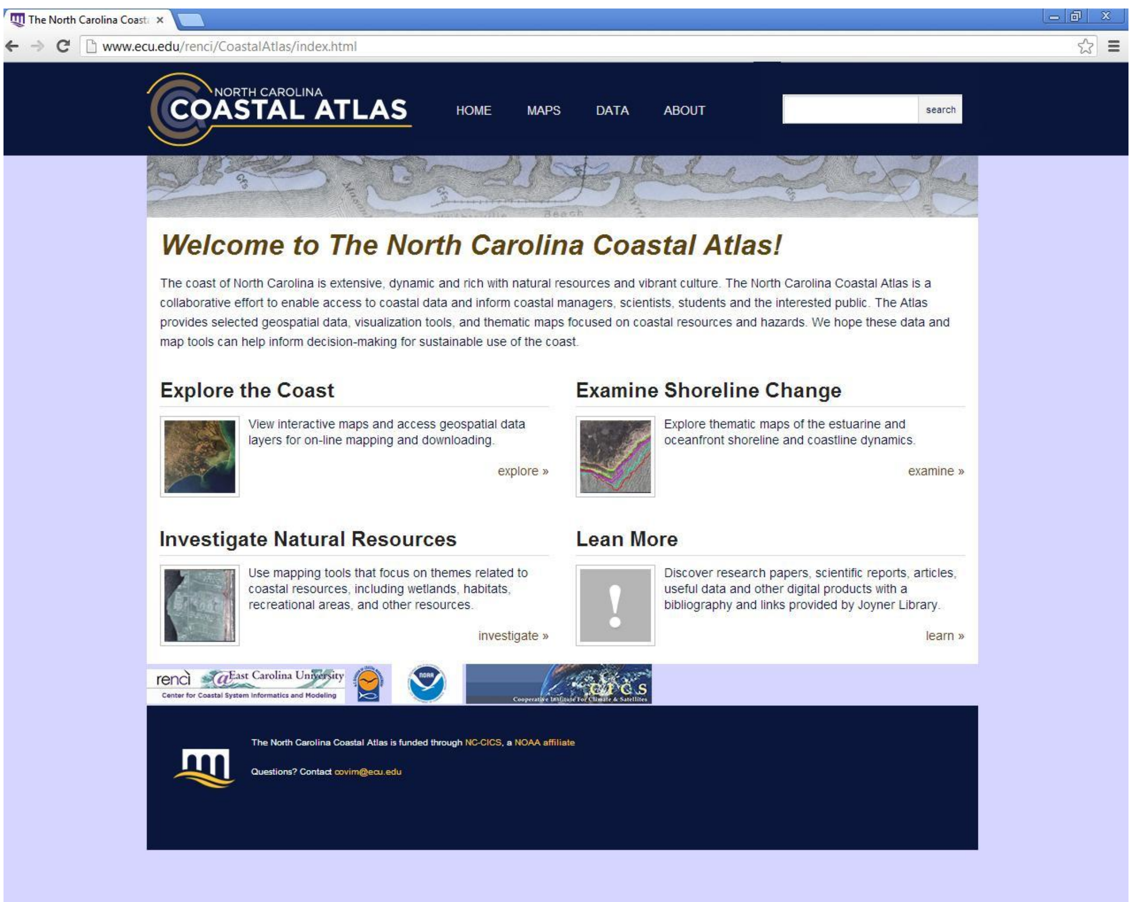


Figure 1. Draft portal and current working page.
http:***//www.ecu.edu/renci/coastalatlas/***

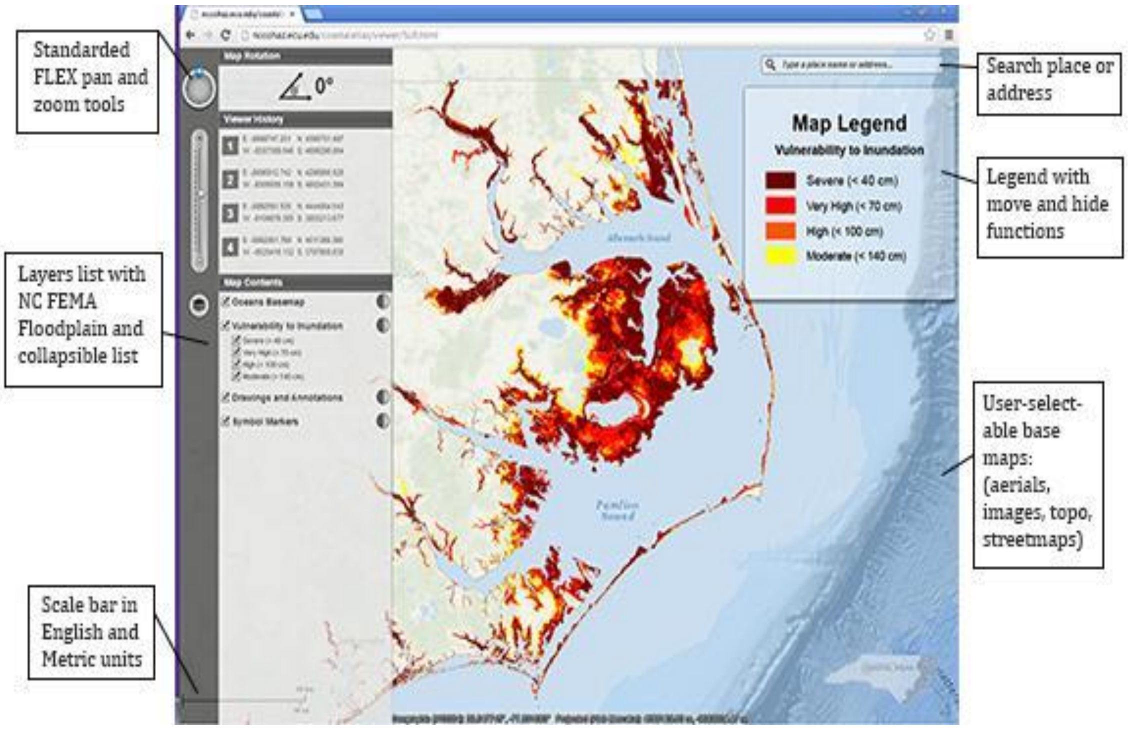


Figure 2. ESRI ArcGIS Server portal and core elements. http://nccohaz.ecu.edu/flex/

2. Needs Assessment

In September 2012, we conducted an assessment of stakeholder needs. It was conducted using the internet-based survey tool, Qualtrics, hosted by East Carolina University. The survey was distributed to key coastal managers, who were asked to re-distribute the link to their list of contacts. It is unknown how many individuals received an invitation to participate. Eighty-five people completed the survey including planners, project managers, biologists, natural resources managers, engineers, and real estate agents. Almost all the participants lived in the region and most were employees of government at the federal, state or local level. Most considered themselves at a mid-level of GIS skill, and only 7 described themselves as GIS experts.

There was a diverse list of ways that respondents anticipated using the Atlas. Most people selected all of the listed ways in which the atlas could be used and 13 additional uses were named. Using the atlas to view historic information and communication information to others were the most popular uses. Priority themes were also identified. Shoreline change, wetlands, water bodies, topography and flood plains/hazards were among the map layers identified as most essential. Functions and tools such as downloading data, print to a PDF, and zoom by address were also identified as important to users. The most preferred atlas viewers were the Flex interface (example -Maryland Coastal Atlas), and the ArcGIS server interface (example - Washington Coastal Atlas).

3. Spatially-Enabling MEM II for Marsh Vulnerability

This portion of the project aimed to inform coastal managers about the utility of restoration and climate change adaptation projects with useful data and analytical tools, including the MEM II model developed by Morris. Discussions early in the project revealed two stumbling blocks. First, the model had not been ported to a programming platform immediately available to a webmap environment. Second, questions of severe uncertainty of the model's potential performance were raised, absent local process rate data which is not available. Given these dual constraints, the MEMII modeling application was postponed for later evaluation. Since Fall 2012, discussions on this application have progressed. Dr. Jim Morris and a doctoral student at University of South Carolina are now cooperating on the vulnerability assessment of salt marshes to SLR using coastal LiDAR and hypsometric models of their position on the tidal frame. Further analysis warranted by the non-tidal, wind-driven regime of the Albemarle-Pamlico system has been outlined, now aiming for development of a marsh vulnerability layer. Additional research funding for this task has been acquired by the South Atlantic Landscape Conservation Cooperative (SALCC), with the aim of disseminating maps and data on the Atlas. The product will be updated high- and low-marsh maps and vulnerability scales for NC, SC, and GA. The NC area data will be hosted on the coastal atlas, and the SC and GA data will be shared with collaborators in SECOORA and the respective coastal atlas archives. All data will be available for download or real-time webmap services streaming, including the development of specific, cartographic maps. Interactive marsh symbology and model parameters are being evaluated for inclusion in this decision support tool, and a preliminary presentation will be made at a March 2013 workshop for the NOAA NC Sentinel Sites program in Beaufort, NC.

In the interim, the project focused on available estuarine erosion rates and GIS data for TNC's desired adaptation suitability decisions. A series of suitability models for living shorelines were developed from a database of NOAA EESLR project and other data sources. The models will eventually be published and freely available, and the maps will be incorporated into a site-specific tool in the atlas.

PLANNED WORK

* Implementation of a high profile NC Coastal Atlas website and updated server (machine, networking, and transition to ArcGIS Server 10.1 and related FLEX and open geospatial standards)
* Focus theme for SLR maps on the new mapserver (collaboration workshop in March 12-13, NOAA NC Sentinel Sites program, Beaufort)
* Estuarine erosion tools on the mapserver (collaboration at the NC Estuarine Shorelines Workshop with NC Division of Coastal Management in May/June)

* Documentation of use case scenarios (May-July)
* Participate in workshops for SLR communicators and use results to inform map improvements (April-May)

PUBLICATIONS

Allen, T.R., Y. Wang, and B. Gore. (2013), Coastal wetland mapping combining multi-date SAR and LiDAR in North Carolina. *Geocarto International* (in press)

Allen, T.R., S. Sanchagrin, and G. McLeod. (2013), Visualization for hurricane storm surge risk awareness and emergency communication. In: Tiefenbacher, J., Ed., *Approaches to Disaster Management- Examining the Implications of Hazards, Emergencies, and Disasters* (forthcoming)

PRESENTATIONS

- Allen, T. R. (2013), North Carolina Coastal Atlas, 2013 NC GIS Conference, Raleigh, NC February 7-8
- Allen, T.R. (2013), NOAA Sentinel Sites Workshop NC, Beaufort, NC, March 12-13. (pending)
- Allen, T.R. (2013), Maps, Marshes, and Management Decision Support for North Carolina, Association of American Geographers Annual Meeting, Los Angeles, April 9-13. (pending)
- Allen, T.R (2013), NC Coastal Atlas Update and Stakeholder Feedback, NC Estuarine Shorelines Summit, location and date May-June TBD

Performance Metrics	**FY12**
# of new or improved products developed	2
# of products or techniques transitioned from research to ops	2
# of peer reviewed papers	2
# of non-peered reviewed papers	0
# of invited presentations	2
# of graduate students supported by a CICS task	2
# of undergraduate students supported by a CICS task	1

- Radar-based SPI to Support NIDIS

Task Leader Ryan Boyles
Task Code NC-CONSO-02-NCSU/SCO
Main CICS Research Topic Land and Hydrology
Percent contribution to CICS Themes Theme 1: 50%; Theme 2: 50%; Theme 3: %
Percent contribution to NOAA Goals Goal 1: 100%; Goal 2: 0%

Highlight: With support from a USDA NIFA grant, Boyles is implementing estimates of Standardized Precipitation Index using gauge-calibrated radar estimates of precipitation for the CONUS region. Support from NIDIS via CICS is enabling these data to be made available in an operational environment using THREDDS data servers and OpenDAP protocols. Once complete, high resolution gridded SPI will be available for direct access and display on Drought.gov and for use by NIDIS and US Drought Monitor authors.

BACKGROUND

Radar-based estimates of rainfall provide high temporal (hourly) and spatial (5km) resolutions, but few drought indices use these valuable data as input. In response to the need for improved local objective measure of drought severity, USDA funded Nielsen-Gammon, Boyles, and Niyogi to develop and evaluate drought monitoring tools and local triggers derived from multi-sensor precipitation estimates (MPE). As part of this effort, Boyles is responsible for operational implementation of software to generate MPE-based SPI and development of a web interface to allow users to access and visualize SPI over the targeted geographies of Texas, North Carolina, and Indiana. As part of this effort, we plan to operationally generate 5km gridded SPI at 1-month through 36-month lags using MPE as the input. The methodology for this is described in “McRoberts, D. Brent, John W. Nielsen-Gammon, 2012: The Use of a High-Resolution Standardized Precipitation Index for Drought Monitoring and Assessment. *J. Appl. Meteor. Climatol.*, **51**, 68–83.”

To support the needs of NIDIS and drought.gov to also provide local-scale estimates of drought severity, Boyles is building a web services framework that will allow for NIDIS and drought.gov to directly access the high resolution SPI products currently under development by Nielsen-Gammon, Boyles, and Niyogi.

ACCOMPLISHMENTS

Routine SPI products have been developed and implemented in a test environment using THREDDS data servers and OpenDAP protocol. Hardware and software have been implemented and are tested for stability and robust services.

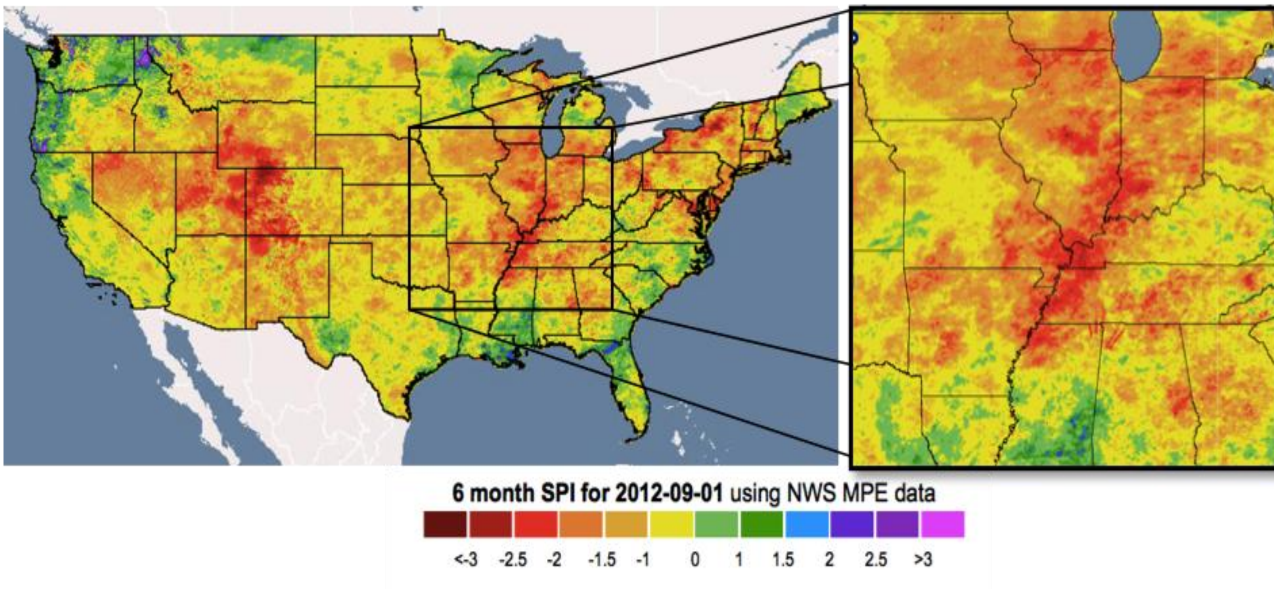


Figure 1: 6-month Standardized Precipitation Index based on Multi-sensor Precipitation Estimates (MPE) at 5 km horizontal resolution.

Performance Metrics	FY12
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	0

PLANNED WORK

* Testing of operational THREDDS service with full SPI historical grids (back to 2005).
* Test drought.gov web service connections to THREDDS service (with M. Brewer)
* Final implementation for drought.gov

PUBLICATIONS

N/A

PRESENTATIONS

N/A

OTHER

- SPI development is supported as a sub-award to Boyles and NCSU from Texas A&M University under USDA NIFA award 2011-67019-20042 to Dr. John Nielsen-Gammon, PI.

- Programming and Applications Development for Climate Portal

Task Leader	James Fox
Task Code	NC-CONSO-03-UNCA/NEMAC
Main CICS Research Topic	Climate Research, Data Assimilation and Modeling
Percent contribution to CICS Themes	Theme: 100%; Theme 2: 0%; Theme 3: 0%
Percent contribution to NOAA Goals	Goal 1: 0%; Goal 5: 100%

Highlight: Staff from UNC Asheville's NEMAC assisted with the enhancement of data visualization capabilities with the Global Climate Dashboard, specifically with the development of Multigraph and the Climate Explorer prototype. These new products support the overall advancement and progression of the NOAA's Climate Services Portal (NCSP) program.

BACKGROUND

There is an increasing need within NOAA's online climate services for greater collaboration to incorporate climate services across NOAA and enhance NOAA's web presence in response to customer requirements. NOAA's Climate Services Portal (NCSP) is envisioned to be the "go-to" website for NOAA's climate data, products, and services for all users. Towards this end, the NCSP has had a need for expertise and resources to support programming work for applications development and data visualization in support of the Global Climate Dashboard, the new Climate Conditions section, the Data section, and other sections of the Portal.

This work addressed NCSP's immediate needs in the following three task areas: a) enhancement of current data visualization capabilities (Multi-Graph, etc); b) enhancement of current on-line mapping (GIS-based) applications; and c) Past Weather Widget replacement and related activities.

ACCOMPLISHMENTS

Enhancement of current data visualization capabilities (Multigraph, etc)

Multigraph is a software library, developed at NEMAC, that supports the creation of interactive data graphs in web pages and web-based applications. It has been in use for several years on NCDC's web site and on climate.gov.

In the period covered by this report:

- Mark Phillips, John Frimmel and Danielle Betke (NEMAC Intern) wrote a new version of Multigraph using JavaScript and HTML5. The previous version was written in Adobe Flash and does not work on mobile devices (phones, tablets, etc); the new version runs on mobile devices as well as desktops. The new version of Multigraph was released in December, 2012 and is available from http://multigraph.github.com

- Semmy Purewal, UNC Asheville Computer Science Professor, worked with Mark and John during the summer of 2012 (May-August) on the development of the new version of Multigraph.

- Mark developed a Drupal module that works with the new version of Multigraph to facilitate the creation of interactive graphs using Multigraph in a Drupal web site; this module has been deployed to the new Drupal version of climate.gov.

Global Climate Dashboard

The "Global Climate Dashboard" is a web application that provides the user an interactive view of several global climate data sets such as temperature, carbon dioxide, arctic sea ice extent, etc., which are key to understanding climate change trends. The current Dashboard application was written by NEMAC in 2011 and has been deployed on the home page of climate.gov since October of that year.

In the period covered by this report:

- Mark Phillips provided a set of scripts to automatically fetch new data for the dashboard as it becomes available.
- Mark worked with the climate.gov Dashboard Team (including Viviane Silva, David Herring, Dave Eslinger, LuAnn Dahlman, Christina Lief, Ned Gardiner) to implement a new Flash version of the Dashboard that matches the new Drupal site design for climate.gov (Figures 1 and 2).
- NEMAC student intern Jonathan Marchesoni developed a Drupal module to facilitate deploying and updating the Dashboard in the new Drupal site.
- Mark worked with Jon Burroughs, Jack Roche, Charlie Roberts, to deliver the new Dashboard Drupal module to the Squishy Media Drupal development team for inclusion in the new site.
- Mark worked with the climate.gov Dashboard Team to design and implement a prototype of a new JavaScript/HTML5 version of the Dashboard, using the new JavaScript/HTML5 version of Multigraph. This version will replace the Flash version in the spring of 2013.

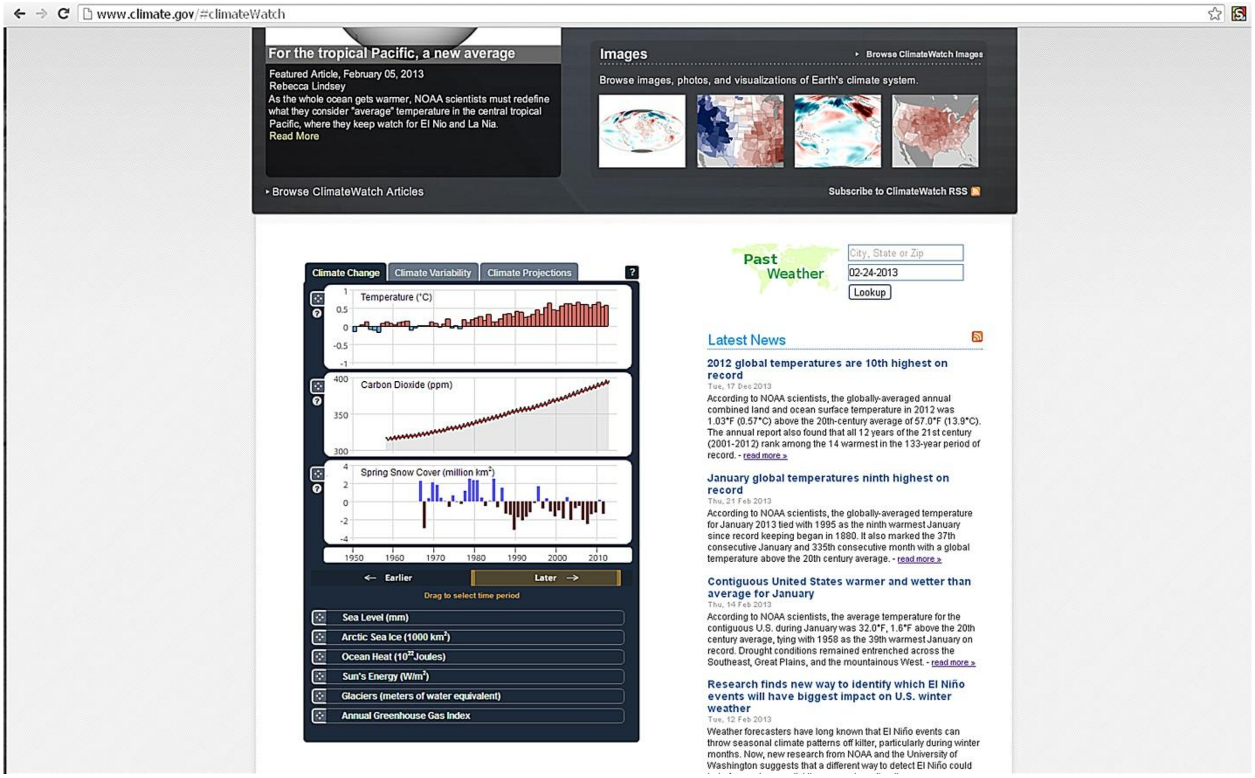


Figure 1. Screenshot of Climate Dashboard version 1.0

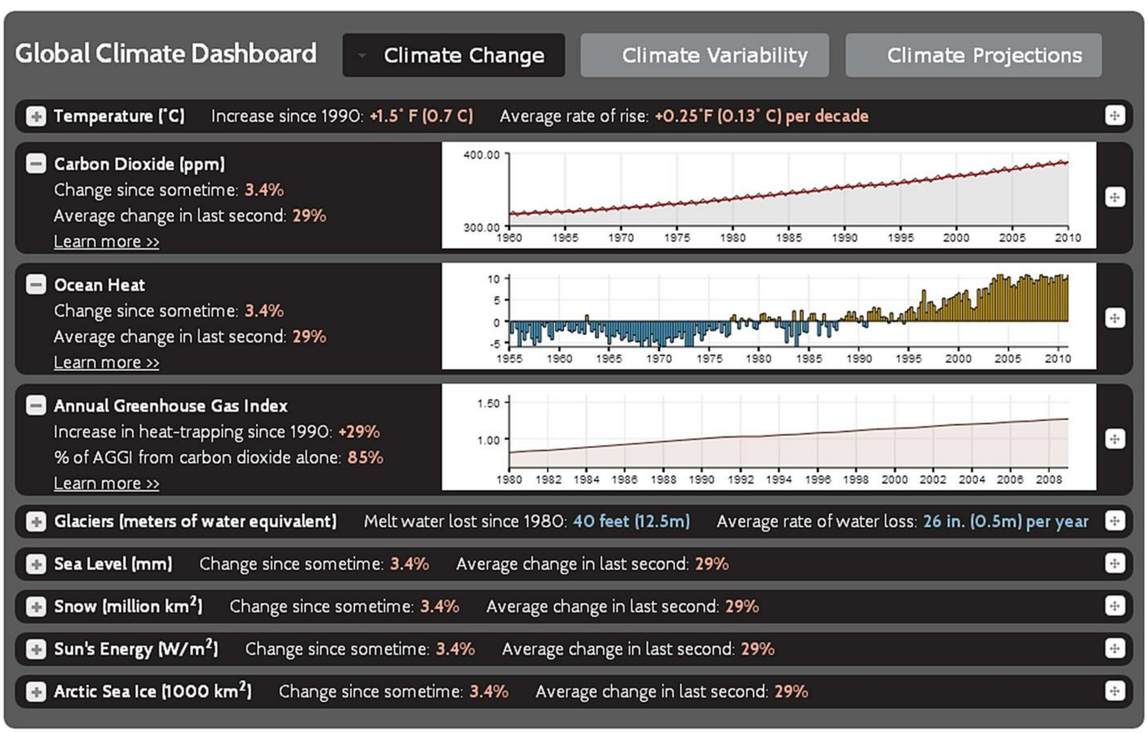


Figure 2. Screenshot of Climate Dashboard version 2.0

Climate Explorer (replacement for “Past Weather Widget”)

The “Climate Explorer” is a web application in the early stages of development, whose purpose is to facilitate the viewing historical weather data in the context of long-term climate. It is intended in some sense to be a replacement for the current “Past Weather Widget” of climate.gov, which allows users to call up a text display of past weather conditions at any location in the United States (see below). The Climate Explorer, however, will provide a more in-depth and graphical display of historical weather, in the context of the long-term climate conditions of the location.

During the period of this report:

- Mark Phillips worked with John Keck, Sam McCown, and David Herring to scope and design a prototype of the application.
- Mark Phillips, Derek Morgan, and John Frimmel developed an initial working version of the application (Figure 3). The application provides intuitive graphical access to daily observed temperature and precipitation records from roughly 9000 GHCN stations, as well as the 1981-2010 daily climate normals.
- The Climate Explorer uses the new JavaScript/HTML5 version of Multigraph, together with the open source OpenLayers web mapping library, to provide support for mobile devices as well as desktop platforms.

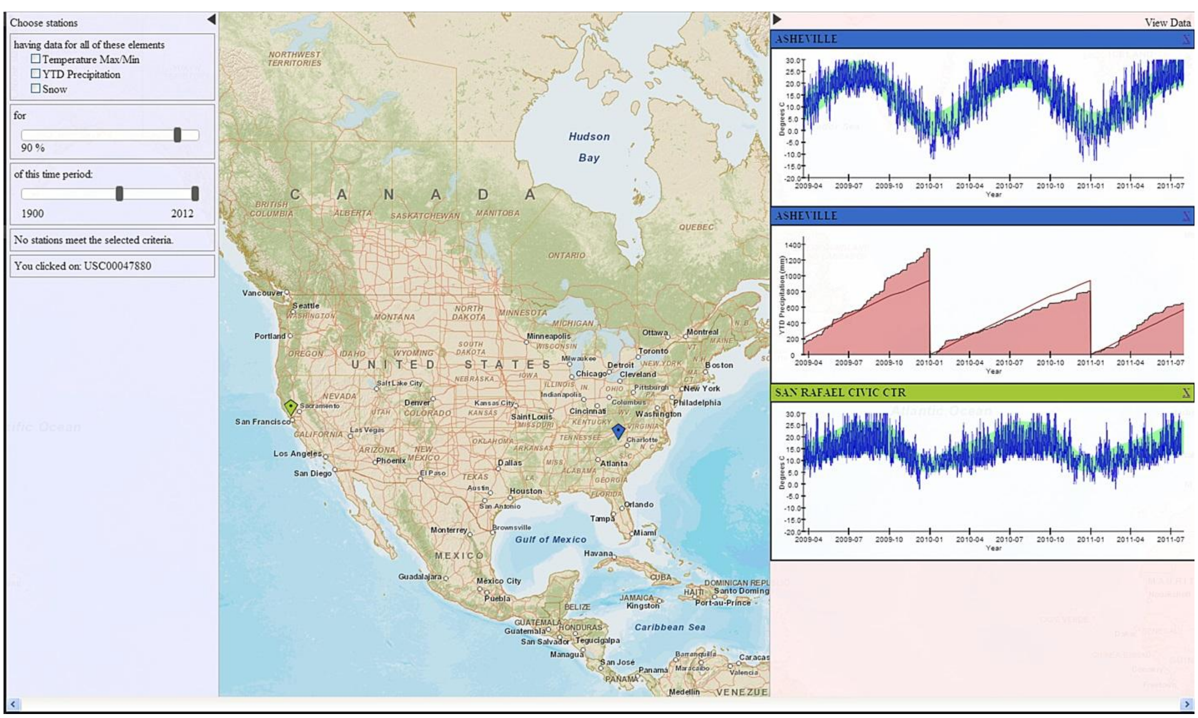


Figure 3. Screenshot of Climate Explorer prototype.

The “Past Weather Widget” is a web application that will allow users to call up a short graphical summary of the climate of a given location. It is somewhat similar in concept to the Climate Explorer application, but is intended to be used as a small “widget” that takes up a much smaller region of the screen, and for displaying information from only one location at a time.

The Climate Widget will be built in late spring /early summer 2013 by leveraging components of the JavaScript/HTML5 version of Multigraph and the Climate Explorer application described above.

Performance Metrics	**FY12**
# of new or improved products developed	3
# of products or techniques transitioned from research to ops	1
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	1
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	3

PLANNED WORK

Anticipated work for the remainder of this fiscal year (through June 30, 2012) includes the following tasks:
* Maintenance towards new version of Multigraph software (JavaScript/HTML5)
* Further development of Climate Explorer application
* The Climate Widget will be built using the JavaScript/HTML5 version of Multigraph.

PUBLICATIONS

N/A

PRESENTATIONS

- Shrestha, S.R, Marshall, J., Steward, J., Ansari, S., O’Brien, K., Phillips, M., and D. Herring. “Towards Interoperable Data Access through Climate.gov”, American Geophysical Union, 2012, San Francisco, CA, IN44A-06.

- Prototypes of Weather Information Impacts on Emergency Management Decision Processes

Task Leader	Jessica Losego and Burell Montz
Task Code	NC-CONSO-04-UNCA/RENCI_ECU/BM
Main CICS Research Topic	Data Fusion and Algorithm Development
Percent contribution to CICS Themes	Theme 1: 100%
Percent contribution to NOAA Goals	Goal 2: 100%

Highlight: Team members evaluated the effectiveness of the experimental Impact-Based Warnings, a Weather-Ready Nation initiative. Actionable findings and recommendations were provided to NWS Central Region HQ as they expand the experiment from five to 38 offices.

BACKGROUND

This work results from collaboration between University of North Carolina at Chapel Hill, Institute for the Environment and the Renaissance Computing Institute, the HQ of the National Weather Service Office of Science and Technology, and East Carolina University Department of Geography, and Arizona State University Decision Theater. The goal of the research is to understand how to improve NWS weather and climate decision support to the emergency management (EM) community to save lives and protect property. This project has goals to infuse social science research into NWS operations to 1) to understand the EM decision processes for risk and crisis management, 2) to understand what is effective translation of scientific information into knowledge for decision making, 3) to understand how collaborative technologies can facilitate knowledge exchange and situational understanding, and 4) to demonstrate prototyping methods fusing together social sciences, physical sciences, and technological advances to advance decision support. To accomplish our work, we employed an incremental and iterative research and development process with EM decision-makers guiding the process.

The work of this past year focused on the evaluation of the effectiveness of the experimental Impact-Based Warnings (IBW) that were tested in five NWS Central Region forecast offices. The evaluation used the Risk Paradigm as the linking mechanism between the National Weather Service and EM. Critical information elements, such as timing and location, were ranked within the Risk Paradigm to determine priority issues that NWS should focus on to improve decision support to the EM community. We applied the 4-Step Method developed during year one to understanding NWS-EM processes for a severe weather event in general and the use of IBW specifically. The method uses social sciences to understand decision making contexts, identify gaps and needs in current practices, explores improvements to product and services through prototyping, and validates findings to make recommendations for operational changes.

ACCOMPLISHMENTS

This year's work continued to build on the use of the Risk Paradigm, which was introduced last year, and the 4-Step iterative method developed in year 1. The Risk Paradigm links the NWS to the EM community through the common goal of managing risk. It provides a framework in which to evaluate the effectiveness of NWS products, such as the Impact-Based Warnings (IBW) that were tested in five Central Region NWS forecast offices and that we were asked to evaluate. The 4-Step Method is iterative and includes these steps: 1) identify the context and timelines of critical decision making, 2) identify current practices of preparing and gathering critical knowledge to make decisions, and identify gaps of needs, 3) prototype approaches and products that improve knowledge transfer between the NWS and EM communities, and 4) validate new products and services in operations.

A main accomplishment of this year was the thorough and successful evaluation of IBW that provided NWS with tangible, actionable findings and recommendations that will be used to improve IBW as it expands from five to 38 offices this spring. Examples of findings and recommendations for three of the 10 risk paradigm components include:

Risk Paradigm Component	Finding	Recommendation
Hazard	a. There are 6 critical elements that EMs need to know to understand risk and make decisions. EMs currently do not receive all of this information. If they do receive it, it can be difficult to interpret and apply to operations. 1. Threat/magnitude 2. Timing 3. Location 4. Duration 5. History 6. Forecaster confidence b. IBW gives forecasters a way to express their confidence and anticipated severity, which a standard warning does not allow.	a. Time, location, duration have a significant impact on EMs understanding of risk and therefore their preparedness and response. These parameters are not addressed in IBW. These need to be addressed as the next level of priority. Example: Forecasters should use pathcasts in warnings or develop another tool to communicate time, location, and location. Issuing discrete timing and location information is not necessary; issuing approximate timing and location information is acceptable.

Impact	a. In the limited number of events in 2012, many forecasters stated that they thought the impact statements should be examined and adjusted. Many were not sure if all of the impacts described were commensurate with the potential of the storm, especially on the low end (base and significant) impact statements. b. EMs think that the impact statements are more useful for the public than they are for EMs, as currently written. EMs like the impact statements for the purpose of informing the public. c. EMs prefer to get a “best guess” from NWS and then a qualitative description of the uncertainty.	a. Impact statements need to be more thoroughly examined to make operationally useful for EM and forecasters
Vulnerability	a. Vulnerability is not explicitly addressed by NWS, so EMs can have difficulty connecting the information NWS does provide to vulnerability and risk. b. There is disagreement amongst personnel on where NWS’s job in describing vulnerability ends and the EMs job begins. c. Data sets to assess vulnerability or risk are not readily available to EM or NWS (e.g., population and critical infrastructure)	a. For effectiveness, EMs and NWS need to dialog on how to connect specifics to vulnerability to determine risk. Hazard and impacts need to be characterized better to get to vulnerability.

Another important finding was that NWS should consider the development of a graphical tornado warning that would communicate the six critical elements of information that EMs need to make decisions. Figure 1 is a prototype mock-up of this idea that is under consideration.

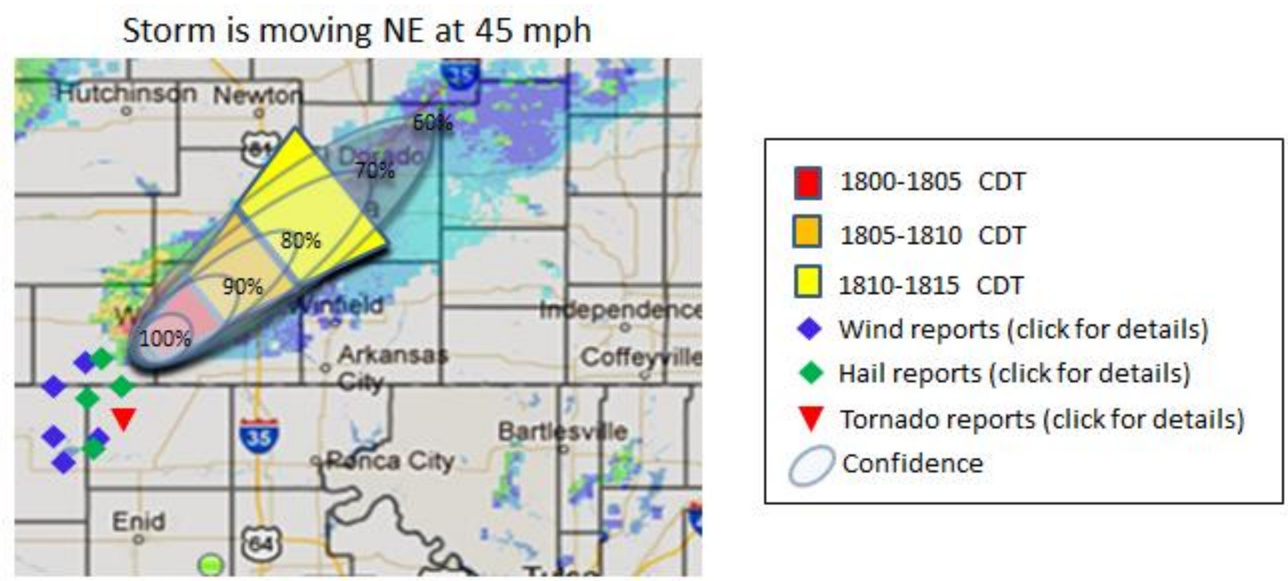


Figure 1: Prototype mock-up of a graphical tornado warning that communicates what the hazard is, timing, location, duration, history, forecaster confidence.

Performance Metrics	FY12
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	1
# of peer reviewed papers	1 (2 in prep)
# of non-peered reviewed papers	0
# of invited presentations	3
# of graduate students supported by a CICS task	1
# of undergraduate students supported by a CICS task	0

PLANNED WORK

This project is complete.

PUBLICATIONS

Heard, J., S. Thakur, J.L. Losego, and K.J. Galluppi. (2013). *Big Board: Teleconferencing Over Maps for Shared Situational Awareness.* Journal of Computer Supported Cooperative Work. (Manuscript accepted for publication).

PRESENTATIONS

- Hudson, M., P.A. Browning, K. Galluppi, J.L. Losego, K. Runk, K. Harding, B.E. Montz, K.J. Mulder, Early Findings and Results from the Central Region Impact-Based Warnings Demonstration, National Weather Association 37th Annual Meeting, October 2012, Madison, WI.
- Goldhammer, R., C. Maier, Galluppi, K., Losego, J.L., NWS Weather-Ready Nation: Improving Decision Support to Emergency Managers, 60th Annual International Association of Emergency Managers Conference, October 2012, Orlando, FL.
- Browning, P.A., M. Hudson, K. Runk, K. Harding, K. Galluppi, J.L. Losego, B.E. Montz, K.J. Mulder, Early Findings and Results from the Central Region Impact-Based Warnings Demonstration, 26th Conference on Severe Local Storms, American Meteorological Society, November 2012, Nashville, TN.
- Losego, J.L., K. Galluppi, B. Montz, Effective Communication Within the Integrated Warning Team, NWS Raleigh Integrated Warning Team Meeting, December 2012, Greensboro, NC. *(invited)*
- Galluppi, K.J., J. Losego, B. Montz, Using the Risk Paradigm to Link Weather to Emergency Management Decisions, Society for Risk Analysis Annual Meeting 2012, December 2012, San Francisco, CA.
- Losego, J.L., K. Galluppi, B.E. Montz, M. Hudson, P.A. Browning, K. Runk, K. Harding, Central Region Impact-Based Warnings Demonstration: Evaluation of IBW Products, 93rd American Meteorological Society Annual Meeting, January 2013, Austin, TX.
- Hudson, M.J., P.A. Browning, K. Runk, K. Harding, K. Galluppi, J.L. Losego, and B.E. Montz, Central Region Impact-Based Warnings Demonstration: Helping to Build a Weather-Ready Nation, 93rd American Meteorological Society Annual Meeting, January 2013, Austin, TX.
- Galluppi, K., Decision Processes: Key to Effective “Decision Support”, NWS Southern Region Science and Operations Officers Virtual Conference, February 2013. *(invited)*
- Montz, B.E., K. Galluppi, J.L. Losego, J. Correia, R. Riley, Social and Behavioral Influences on Weather-Driven Decisions, National Tornado Summit, March 2013, Oklahoma City, OK. *(invited)*

OTHER

- Deliverable to NWS Office of Science and Technology – Final Report: Weather for Emergency Management Decision Support (January 2013)
- Deliverable to NWS Central Region Headquarters - Evaluation of the Effectiveness of the Central Region Impact-Based Warning Conducted by Weather for Emergency Management Decision Support (March 2013)

- Production mechanism, number concentration, size distribution, chemical composition, and optical properties of sea spray aerosols

Task Leader Nicholas Meskhidze
Task Code NC-CONSO-05-NCSU/MEAS
Main CICS Research Topic Climate Data and Information Records and Scientific Data Stewardship
Percent contribution to CICS Themes Theme 1: 33.33%; Theme 2: 33.33%; Theme 3: 33.33%
Percent contribution to NOAA Goals Goal 1: 100%

Highlight: Conducted a workshop that addressed the most urgent open science questions for improved quantification of sea spray aerosol-radiation-climate interactions.

BACKGROUND

Sea spray emission and its influence on global climate remains one of the most uncertain components of the aerosol-radiation-climate problem, but has received less attention. The workshop placed special emphasis on the production flux of sea spray aerosol particles, their number concentration, and chemical composition and properties. The workshop's small size helped facilitate interactive discussion, often lost in big meetings, which: 1) identified the most important questions that can be addressed given the current technology; 2) decided on which questions the community is best suited to tackle; and 3) created a prioritized research agenda and identified areas of investigation in which additional work can close the most significant knowledge gaps in understanding sea spray generation, atmospheric distribution, and lifetime.

ACCOMPLISHMENTS

We conducted a small workshop (roughly 40 invited participants) to identify the most critical open questions and developed a strategic prioritization program for conducting and facilitating novel research regarding oceanic aerosol, with special emphasis on the production mechanism, concentration number and mass size distribution, and chemical properties of sea spray aerosol. Additionally, we identified the pressing science questions and ranked them by their highest impact on reducing the current uncertainty ranges for different processes (i.e. sea spray production, direct effects, indirect effects, and climate predictions). We further prioritized the research agenda and identified areas of investigation by the magnitude of their impact on proposed science questions. The difficulty/feasibility was ranked for resolving each process using currently available measurement and remote sensing techniques and modeling approaches. We identified future strategies, including new measurement techniques and long-term clean oceanic atmospheric aerosol measurements, which can provide significant constraints on different processes.

Performance Metrics	FY12
# of new or improved products developed	0
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	1
# of non-peered reviewed papers	0
# of invited presentations	40
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	0

PLANNED WORK

* Publish a white paper summarizing the results of this conference to be made available to the scientific community.

PUBLICATIONS

Meskhidze, N., Meskhidze, N. M. D. Petters, K. Tsigaridis, T. Bates, C. O'Dowd, J. Reid, E. R. Lewis, B. Gantt, M. D. Anguelova, P. V. Bhave, J. Bird, A. H. Callaghan, D. Ceburnis, R. Chang, A. Clarke, G. de Leeuw, G. Deane, P. J. DeMott, S. Elliot, M. C. Facchini, C. W. Fairall, L. Hawkins, Y. Hu, J. G. Hudson, M. S. Johnson, K. C. Kaku, W. C. Keene, D. J. Kieber, M. S. Long, M. Martensson, R. L. Modini, C. L. Osburn, K. A. Prather, A. Pszenny, M. Rinaldi, L. M. Russell, M. Salter, A. M. Sayer, A. Smirnov, S. R. Suda, T. D. Toth, D. R. Worsnop, A. Wozniak, and S. R. Zorn, (2013), Production mechanisms, number concentration, size distribution, chemical composition, and optical properties of sea spray aerosols, Atmos Sci Lett, submitted.

PRESENTATIONS

- Workshop Website:
http://www4.ncsu.edu/~nmeskhi/Marine_Aerosol_Workshop/WEBSITE.html

- Spatio-Temporal Patterns of Precipitation and Winds in California

Task Leader	Dr. Sandra Yuter, North Carolina State University
Task Code	NC-CONSO-06-NCSU/MEAS
Main CICS Research Topic	Surface Observing Networks
Percent contribution to CICS Themes	Theme 1: 100%; Theme 2: 0%; Theme 3: 0%
Percent contribution to NOAA Goals	Goal 1: 0%; Goal 2: 100%

Highlight: The predictability of flooding associated with atmospheric river storms in California is dependent on the repeatability of the spatial pattern of precipitation as a function of environmental characteristics that can be reliably forecast. Analysis indicates considerable variability in the spatial distribution of precipitation frequency among atmospheric river storms with similar environments.

BACKGROUND

Atmospheric rivers (ARs) are narrow corridors of enhanced water vapor transport within extratropical cyclones. When they arrive in California, ARs contribute significantly to the water supply and flood generation in the State. Although focused research during the last few years has yielded quantitative linkages between ARs and both regional water supply and extreme precipitation events, questions remain regarding the modification and redistribution of water vapor and precipitation in ARs by California's coastal mountains and Sierra Nevada. Previous work indicates that all recent flooding events on the US west coast were associated with an AR but not all ARs yielded flooding. Several factors can potentially turn an AR event into a flooding event. There is limited understanding of the relative roles of atmospheric stability, barrier jets, and small-scale ridges along the windward slope on watershed precipitation totals.

A key-missing piece on the role of ARs in flooding events is knowledge of the detailed spatial distribution of precipitation over the windward slopes of the Sierra Nevada for each AR event and for groupings of AR events with similar environmental variables. The proposed work will utilize operational radar data from six National Weather Service WSR-88D radars (KBHX, KBBX, KRGX, KDAX, KMUX and KHNK) to construct a radar echo precipitation climatology of AR events for a 10 year period. A long-term radar echo climatology is needed since existing rain gauges provide only incomplete information on precipitation in this region, particularly over rugged mountainous terrain.

ACCOMPLISHMENTS

We have completed National Weather Service WSR-88D radar data processing for all 64 atmospheric river storms during the period from 2005 - 2010 for which archived radar data are available for at least KBBX and KDAX. A methodology was developed to "stitch" together precipitation frequency maps from the multiple radars to obtain regional maps.

Upper air soundings were analyzed from two California sites to characterize the range of environments of AR events; 439 soundings from KDAK (Oakland, CA; soundings every 12 hours during AR events from Oct 1997 – Apr. 2011) and 68 soundings from KLHM (Lincoln, CA; soundings ~4-6 hours during events from Dec. 2010 – Mar 2011). Typical AR storms, (between the 25th and 75th percentiles) are stable, have cross-barrier wind speeds of 0 to 7 m/s and freezing level heights between 2.5 and 4 km. Higher freezing levels > 4 km are associated with higher stability and higher cross-barrier wind speeds.

We have cross-referenced AR storms with environmental variables and also with Sierra Barrier Jet characteristics such as jet height and strength. Individual storms with similar environmental and Sierra Barrier Jet characteristics can have very different regional patterns of precipitation (Fig.1).

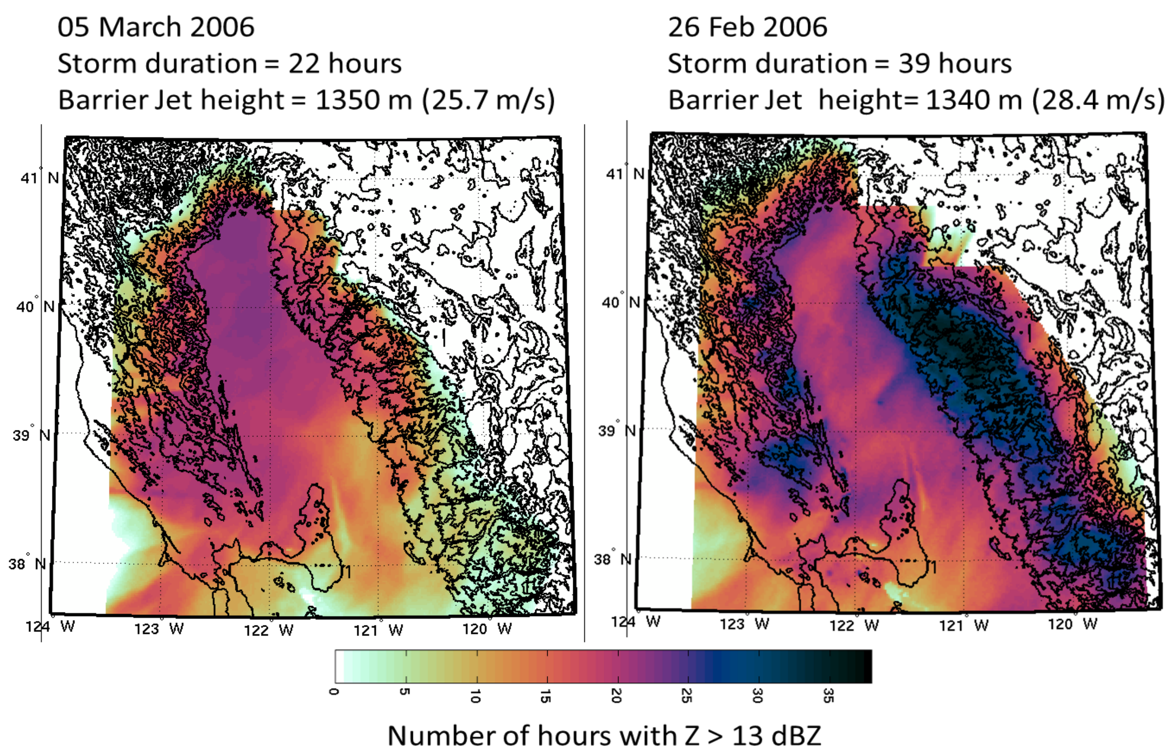


Figure 1: Northern California regional maps of storm precipitation frequency Z > 13 dBZ (~ 0.2 m/hr) for two storms with similar Sierra Barrier Jet characteristics.

Performance Metrics	FY12
# of new or improved products developed	0
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	1
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	1
# of undergraduate students supported by a CICS task	2

PLANNED WORK

* Complete analysis of precipitation frequency regional maps relative to environmental variables and Sierra Barrier Jet characteristics.
* Use Multivariate Analysis of Variance (MANOVA) to test for statistical significance.
* Write up results for publication

PUBLICATIONS

Kingsmill, D. E., P. J. Neiman, B. J. Moore. M. Hughes, S. E. Yuter and F. M. Ralph, 2013: Kinematic and thermodynamic structures of Sierra barrier jets and overrunning atmospheric rivers during a land-falling winter storm in northern California. *Mon. Wea. Rev.,* in press.

PRESENTATIONS

N/A

OTHER

N/A

2.9 Other CICS PI Projects

- Water Sustainability and Climate Change: a Cross-Regional Perspective

Task Leader	Kenneth E. Kunkel (Co-PI)
Task Code	NC-PIOT-01-NCICS-KK
Main CICS Research Topic	Land and Hydrology
Percent contribution to CICS Themes	Theme 1: 0%; Theme 2: 0%; Theme 3: 100%
Percent contribution to NOAA Goals	Goal 1: 100%; Goal 2: 0%

Highlight: This is a multi-institutional research project that has just begun. A post-doctoral research associate has been hired and plans for analysis of CMIP5 decadal hindcasts have been developed.

BACKGROUND

Water resource availability varies across the Sunbelt of the United States with a sharp East-West transition at 105° W. Arid regions west of the 105th Meridian produce less runoff. On the other hand, humid regions in the east produce greater than 40 cm of mean annual runoff. Consequently, reservoirs in the west are over-year systems holding multiple years of inflows, whereas reservoirs in the east are within-year storage systems with the need to refill the system in the beginning of spring. Accordingly, water policies also differ substantially with western states pursuing "prior appropriation" and the eastern states following "riparian rights" for allocation. These contrasting strategies also impact freshwater biodiversity with the ratio of non-native to native fish species being nearly 6 times higher in the West compared to the East. In spite of these cross-regional differences, both regions face two common stressors: (a) uncertainty in available water arising from global climate change and (b) increased human demand due to population growth and consumption. Consequently, there is an ever-increasing need for an integrated assessment of fresh water sustainability under these two stressors over the planning horizon (10-30 years). The main objective of this study is to understand and quantify the potential impacts of near-term climate change and population growth on freshwater sustainability – defined here as integrating daily to annual flows required to minimize human vulnerability and maximize ecosystem needs (including native biodiversity) for freshwater – by explicitly incorporating the feedbacks from human-environmental systems on water supply and demand. Using retro-analyses involving CMIP5 multimodel climate change hindcasts, we will revisit how freshwater sustainability could have been better achieved over the past five decades across the Sunbelt. To couple the hydroclimatic and hydro-ecological system dynamics with the management of water infrastructure systems, a two-level agent-based modeling framework will explicitly simulate adaptive behaviors and feedbacks between policy and consumers.

This interdisciplinary project involves collaboration between three universities, North Carolina State University (NCSU), Arizona State University (ASU), and Florida International University (FIU). Findings from the CMIP5 retro-analyses will evaluate and recommend societal options (i.e., supply augmentation vs. demand reduction) for promoting future (2015-2034) freshwater sustainability across the Sunbelt. Cross-regional synthesis of policies and media sources for the targeted basins will identify de/centralized adaptive strategies that have been employed independently and collectively to maintain flows, increase supplies, or reduce demands. Utilizing the near-term hydroclimatic projections, we will quantify how current policies on reservoir operations and groundwater extraction could impact the reliability of future water supplies for cities and also alter the key attributes of hydrographs that are critical for maintaining freshwater biodiversity. In doing so, the project will also investigate the degree to which regions have pursued 'hard path' (i.e., supply augmentation) vs. 'soft path' (i.e., demand reduction) strategies by explicitly modeling potential societal interventions for water sustainability.

ACCOMPLISHMENTS

The inaugural project team meeting was hosted by CICS-NC at NCDC and was attended by all of the project leaders (the Principal Investigator, co-Principal Investigators, and co-Investigators). This successful 2-day meeting resulted in decisions about specific aspects of the research and established project tasks for the immediate future. Since this inaugural meeting, regular (once every 3 weeks or so) conference calls have been held.

A central responsibility of CICS-NC is the analysis of CMIP5 decadal hindcast simulations. This analysis has been initiated.

Performance Metrics	FY12
# of new or improved products developed	
# of products or techniques transitioned from research to ops	
# of peer reviewed papers	
# of non-peered reviewed papers	
# of invited presentations	
# of graduate students supported by a CICS task	
# of undergraduate students supported by a CICS task	

PLANNED WORK
* Perform analysis of the 30-yr (1980-2009) hindcast simulations from CMIP5 and compare with observed trends in selected extreme event types
* Collaborate with project PI on the development of statistically downscaled climate data for the selected river basins

PUBLICATIONS
N/A

PRESENTATIONS
N/A

- Developing of a Western Hemisphere MJO Index for the Energy Sector

Task Leader	Carl Schreck
Task Code	NC-PIOT-02-NCICS-CS
Main CICS Research Topic	Climate Data and Information Records and Scientific Data Stewardship
Percent contribution to CICS Themes	Theme 1: 0%; Theme 2: 50%; Theme 3: 50%
Percent contribution to NOAA Goals	Goal 1: 0%; Goal 2: 100%

Highlight: CICS scientists developed an index for determining which Madden–Julian Oscillation events will impact North American temperatures and which will not. Real time monitoring of this index helps the industry anticipate energy demand.

BACKGROUND

Energy demand is driven in large part by changing temperatures. Forecasting those temperatures as far in advance as possible is a top priority for energy companies. Numerical models are useful for the first week or so, but their skill drops off after that. At these longer leads, forecasters in the energy sector often rely on statistical techniques and historical analogs.

Climate Data Records (CDRs) are ideal inputs into those statistical models. Because CDRs have been homogenized, forecasters can be assured that changes in the data through time will not affect the model. Satellite proxies for tropical rainfall, like outgoing longwave radiation (OLR), are particularly valuable. They can identify patterns in the tropics that drive a significant part of the global circulation. These patterns also evolve slowly enough to provide skill at the longer lead times needed by the energy sector.

ACCOMPLISHMENTS

Tropical convection associated with the Madden–Julian Oscillation (MJO) can affect extratropical Rossby waves around the globe. These waves can in turn influence temperature patterns over North America. The extratropical impacts of the MJO change from event to event, but no previous methodology existed for identifying these changes. To fill that gap, CICS scientists collaborated with researchers from EarthRisk Technologies to develop a new index, termed the Multivariate Pacific–North American (MVP) index. This index proved to be a useful discriminator of the extratropical impacts associated with different MJO events.

Figure 1 shows an example of how the MVP can be used to anticipate weather patterns over the United States. Tropical convection is identified by the shaded OLR anomalies, while the extratropical response is shown by the contours of 200-hPa streamfunction. Both composites are for the same phase of the MJO, as indicated by the large area of

convection near the Maritime Continent. However, they are subdivided by the phase of the MVP.
When the MVP is negative (bottom), a secondary maximum in convection appears near Hawaii. This convection is associated with an extratropical wave train (contours) that leads to warm temperatures over the eastern United States. Such a pattern is expected for this phase of the MJO. However, this pattern is strikingly absent when the MVP is positive (top). Even though the forcing from the MJO is similar in both patterns, the MVP identifies which set of dates produces the expected extratropical response and which does not.

Combinations of the MJO and the MVP can influence North American temperature patterns for as long as 20 days. For this reason, the MVP has been added to a suite of other CDR-based diagnostics on monitor.cicsnc.org/mjo, which serves hundreds of unique users and the public and private sectors every month.

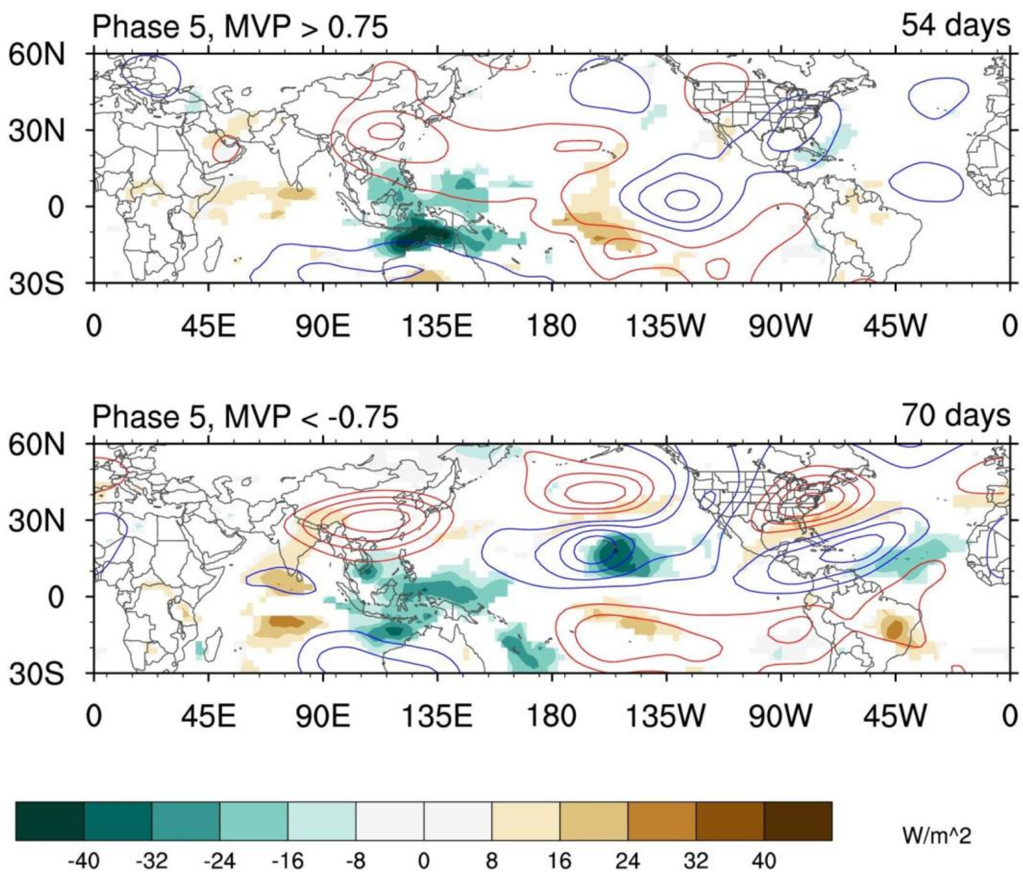


Figure 1: Composites of OLR (shading) and 200-hPa streamfunction anomalies. Both composites show the same phase of the MJO but different phases of the MVP.

Performance Metrics	FY12
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	1
# of peer reviewed papers	0
# of non-peered reviewed papers	1
# of invited presentations	1
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	0

PLANNED WORK

* Submit the MVP index for peer-reviewed publication.
* Investigate the extratropical impacts associated with discrete MJO events.

PUBLICATIONS

Non Peer-reviewed:

Schreck, C. J., and D. Margolin, 2013: The multivariate PNA index: A new index for identifying MJO impacts over North America. *Climate Prediction Science & Technology Digest*, *NWS Science & Technology Infusion Climate Bulletin*, NOAA's National Weather Service, 72–75.

PRESENTATIONS

Invited:

- Schreck, C. J., 2012: Identification and impacts of tropical variability (invited). Second Workshop on Medium/Long Range Weather Forecasting and Subseasonal Atmospheric Drivers, La Jolla, CA, 22 May 2012.

Other presentations:

- Schreck, C. J., and D. Margolin, 2012a: An MJO index for the Western Hemisphere: Identifying the MJO's impacts over North America. *AGU Fall Meeting*, 3-7 December 2012, San Francisco, CA, A138–0220.
- Schreck, C. J., and D. Margolin, 2012b: The multivariate PNA index: A new index for identifying MJO impacts over North America. *37th NOAA Climate Diagnostics and Prediction Workshop Digest*, 22-25 October 2012, Fort Collins, CO, 72–75.

OTHER

- (product) Multivariate Pacific–North American (MVP) index developed.

(research to operations) Multivariate Pacific–North American (MVP) index placed into operational monitoring on monitor.cicsnc.org/mjo

3 CUNY-CREST PROJECTS

3.1 Data Fusion and Algorithm Development

- Improving Monitoring of Tropical Forests and their Characterization in NCEP Models Using GOES-R ABI Land Products

Task Leader Peter Romanov (Co-I), PI: Y. Tian, IMSG Inc
Task Code CUNY
Main CICS Research Topic Data Fusion and Algorithm Development
Percent contribution to CICS Themes Theme 1: 100%; Theme 2: 0%; Theme 3: 0%.
Percent contribution to NOAA Goals Goal 1: 20%; Goal 2: 80%

Highlight: Within this project support has been provided to the PI, Dr. Tian of IMSG. We continued collection of Meteosat Second Generation data for the study of Tropical Forests. Collected data include SEVIRI full disk observations at 30 min interval in shortwave and infrared spectral bands. In house collection of MSG data is needed due to complexity of the access to this data through the EUMETSAT ordering system.

BACKGROUND
This is a small task in support of Dr.Tian's investigation on the potential use of GOES-R ABI data to improve characterization of tropical forests. Responsibilities of P. Romanov (who is the Co-I in this project) consist in collecting and maintaining a set of Meteosat Second Generation (MSG) SEVIRI data for use in the study. The task assumes the total effort of about one week per year.

ACCOMPLISHMENTS
During this year the collection of data for Dr.Tian's research has continued. The dataset includes MSG SEVIRI images at 30 minute interval in several selected bands needed for land surface characterization. These bands are visible (ch.1 at 0.6 µm), near infrared (ch. 2 at 0.9 µm), shortwave infrared (ch.3 at 1.6 µm), middle infrared (ch.4 at 3.9 µm) and far infrared split-window bands (ch.9 at 10.8 µm and ch.10 at 12.0 µm). The data collection is performed automatically. We conduct routine checks on the quality of the data and make sure that the dataset is complete.

Performance Metrics	FY12
# of new or improved products developed	0
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	N/A

PLANNED WORK

This was the last year of the project implementation. No further work is planned.

- Development of Algorithm & Software to Validate Snow Cover Product from VIIRS NPP

Task Leader Peter Romanov
Task Code CUNY
Main CICS Research Topic Data Fusion and Algorithm Development
Percent contribution to CICS Themes Theme 1: 100%; Theme 2: 0%; Theme 3: 0%.
Percent contribution to NOAA Goals Goal 1: 20%; Goal 2: 80%

Highlight: The performance of the JPSS VIIRS operational snow cover algorithm and the snow cover product during the first year of the instrument operation has been examined. The quality of the product has gradually improved in the course of the year mostly due to improvements introduced to the VIIRS cloud mask. The accuracy of the current VIIRS snow cover product is very close to specifications. The agreement of VIIRS snow maps to NOAA interactive charts in cloud clear portions of the VIIRS imagery exceeds 95% most of the time.

BACKGROUND

The Binary Snow Cover and the Snow Cover Fraction are among the suite of land surface products derived from observations of the 22-band Visible/Infrared Imager/Radiometer Suite (VIIRS). VIIRS instrument onboard the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP) was launched in October 2011. Other VIIRS instruments onboard the JPSS (Joint Polar satellite System) platform will be launched in 2014 and 2021.

The objectives of this project include the development of algorithms and software to assess the quality of snow cover retrievals from VIIRS, routine monitoring of the VIIRS Snow cover product accuracy, identification of particular issues with the snow product and providing recommendations on how to improve the product. The work on the project during the last year period was concentrated on the post-launch monitoring of the algorithm performance and of the product accuracy.

ACCOMPLISHMENTS

The VIIRS snow cover validation tools developed during the previous years of the project implementation have been applied to routinely evaluate the accuracy of VIIRS snow cover product. The tool incorporates scripts and codes which (1)regrid daily global VIIRS data to a Platte Carree grid at 1, 5 and 10 km spatial resolution, (2) acquire NOAA Interactive Snow and Ice charts (IMS) from National Snow and Ice Data Center and resample them to 5 km resolution lat-lon grid (3) compare VIIRS snow cover maps with the IMS product. We also routinely compare VIIRS snow maps with surface observation data over Continental US territory.

With the developed system we routinely monitor the accuracy of the VIIRS snow cover product. Global VIIRS snow maps are generated and compared with the NOAA IMS product every three days. It was found that the rate of agreement of the latest VIIRS snow cover products to the IMS snow charts exceeds 97% (see Fig . 1). Commission and omission errors in the VIIRS snow product are well balanced and do not exceed 2%. The high accuracy of the snow mask can be partially explained by a very conservative cloud mask which tends to interpret many land scenes having a partial snow cover as "cloudy". Changes that made the cloud mask to become much more conservative occurred in November 2012. Prior to this change the cloud mask algorithm mapped about 20% more VIIRS pixels as cloud-clear and the accuracy of the snow map was equal to about 95%.

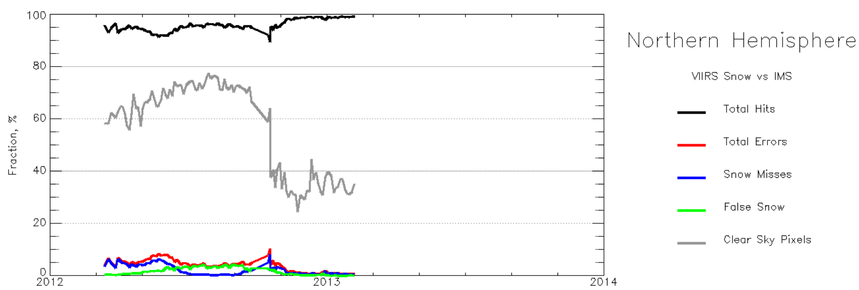


Figure 1: Accuracy and errors of VIIRS-identified snow cover in 2012 and in the beginning of 2013. IMS interactive snow charts are taken as "truth". Gray line presents the fraction of land cover pixels (%) identified as "cloud clear" in the VIIRS snow map and therefore used in the comparison with the IMS product.

Performance Metrics	FY12
# of new or improved products developed	0
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	1
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	N/A

The project does not require the development of new products. At this time there are no plans for implementation of the validation system operationally. The results of this work were presented at the 2012 IGARSS meeting in Munich, Germany, at the EUMETSAT meeting in Gdansk, Poland and was included in an invited lecture titled "Snow Mapping and Monitoring: Techniques, Products, and Applications" presented at International Training Seminar on Snow Remote Sensing and Impact to Water Management" (Istanbul, Turkey, April 2012).

PLANNED WORK

* Continue monitoring of the VIIRS snow product accuracy. Determine the typical observing and environmental conditions when the product fails. Provide accuracy estimate of the VIIRS snow maps over Northern Hemisphere.
* Evaluate the performance of the algorithm generating VIIRS gridded IP snow product and the accuracy of the product. Propose a way to improve the current gridded IP snow product to make it better represent the current status of the global snow cover.
* Examine the quality of the VIIRS snow fraction algorithm and product.
* Document all findings and report to the JPSS Program Office.

PRESENTATIONS

- Romanov P. (2012) Snow Mapping and Monitoring: Techniques, Products, and Applications. International Training Seminar on Snow Remote Sensing and Impact to Water Management", Istanbul, Turkey, April 18-20, 2012.
- Romanov P., I. Appel (2012) Mapping of snow cover with NPP VIIRS: First results. 2012 EUMETSAT Meteorological Satellite Conference. Sopot, Poland , September 3-7, 2012
- Romanov P., I. Appel (2012) Snow cover products from NPP VIIRS: Current Status and Potential Improvements. IEEE Geoscience and Remote Sensing Symposium, Munich, Germany, July 22-27, 2012

- Uniform Multi-Sensor Algorithms for Consistent Products: Snow Cover

Task Leader Peter Romanov
Task Code CUNY
Main CICS Research Topic Data Fusion and Algorithm Development
Percent contribution to CICS Themes Theme 1: 100%; Theme 2: 0%; Theme 3: 0%.
Percent contribution to NOAA Goals Goal 1: 20%; Goal 2: 80%

Highlight: The development of an improved snow identification and mapping algorithm for NPP VIIRS has started. The algorithm will incorporate a two-stage image classification procedure. First, "potential snow" will be identified with threshold-based tests which use the scene spectral response. At the second step all "potential snow" pixels will be subjected to a series of consistency tests to identify "spurious snow" that occurred due to clouds missed by the cloud mask algorithm. The performance of the algorithm and the quality of the new VIIRS snow map will be assessed by the visual analysis of the VIIRS imagery and by comparing the VIIRS snow product with ground truth data and other independent satellite-based products.

BACKGROUND

NPP satellite was successfully launched in October 2011. Information from VIIRS instrument on NPP satellite is used to routinely generate global maps of snow cover. The algorithms to identify snow cover in VIIRS imagery and to generate snow cover maps have been developed by Raytheon Company and Northrop Grumman Corporation. These algorithms are similar to the algorithms developed and implemented by NASA to identify snow cover from the data from Moderate Resolution Spectroradiometer (MODIS) onboard Terra and Aqua satellites. Preliminary analysis of the VIIRS snow product has revealed a number of problems, which include in particular, frequent snow misses in forested areas and spurious snow identifications in the areas with extensive cloud cover. These problems may be partially associated with the general weakness of the developed snow identification algorithm.

The objective of this project consists in the development of a new improved snow cover mapping algorithm for VIIRS data and implementation of this algorithm within the prototype VIIRS data processing and product generation system at NESDIS STAR. The work will include a thorough analysis of the existing algorithm and the snow product, development and testing of the new algorithm and code and documenting the algorithm and the code according to STAR requirements. The new snow mapping algorithm should satisfy the requirement of at least 90% accuracy of snow identification. Validation of the product will be performed through its comparison to ground-based observations of snow cover, to NOAA interactive snow cover charts and to other available automated satellite-based snow cover products. The period of the project implementation is three years.

ACCOMPLISHMENTS

The work on the project started in the end of 2012. During the preceding several months period of time we have developed software tools to acquire and process VIIRS observation data, snow retrievals, navigation data and quality information from the dataset maintained an NESDIS/STAR. The developed software also allows for re-gridding and resampling of all VIIRS data. These tools will be heavily used in the development and validation of the new VIIRS snow cover algorithm and snow product.

The current VIIRS snow maps have been thoroughly examined to identify their main problems . The maps revealed a considerable number of false snow identifications that occur mostly due to missed. Clouds missed by the cloud masking algorithm and hence propagating into the snow detection algorithm are very likely to be interpreted as "snow". An example of such "spurious snow" in the VIIRS snow product is shown in Fig.1. This is one of the primary weaknesses of the current VIIRS snow cover that the new algorithm is targeting. Another weakness consists in frequent snow misses in densely forested areas. The tree canopy masking the snow cover changes the spectral response of the scene and complicates proper identification of snow. It appears that a set of additional threshold-based spectral tests is needed to specifically identify snow in forested regions. Comparing the current VIIRS snow cover maps with maps generated interactively by NOAA IMS system we have identifies areas where snow misses occur most frequently. These are located mostly in southern and central Siberia and in the boreal forest region in Canada.

At this time we have not yet fully assess the performance of the VIIRS snow detection algorithm during the spring time. Identification of snow in forests during spring snowmelt is further complicated by the forest litter that ads to the masking effect of the tree canopy. Therefore other areas where snow identification is unreliable may appear.

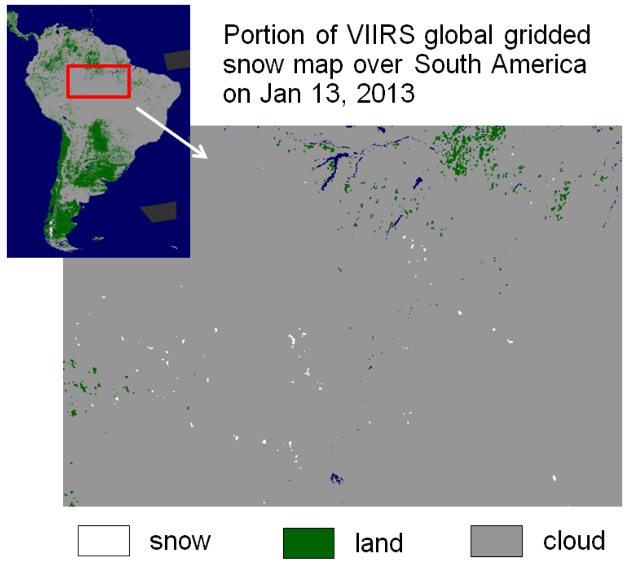


Figure 1: Example of snow commission errors in the current VIIRS snow cover product. Commission errors are most clearly seen as spurious snow mapped in the areas where snow cover is never observed (e.g., in equatorial and tropical plain areas of South America and Africa).

Performance Metrics	FY12
# of new or improved products developed	0
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	N/A

The work on the project has yet started. Therefore the results have not yet been published or presented anywhere.

PLANNED WORK

* Development of the first version of the algorithm. Testing the algorithm with VIIRS data.
* Evaluate the algorithm accuracy and weaknesses.
* Prepare materials for the algorithm technical reviews (Critical Design Review , CDR and Technical Readiness review (TRR). Prepare other technical documentation as required by STAR.

- Development of an Upgraded Southern Hemisphere Automated Snow/Ice Product

Task Leader Peter Romanov
Task Code CUNY
Main CICS Research Topic Data Fusion and Algorithm Development
Percent contribution to CICS Themes Theme 1: 100%; Theme 2: 0%; Theme 3: 0%.
Percent contribution to NOAA Goals Goal 1: 20%; Goal 2: 80%

Highlight: A new upgraded Automated Multisensor Snow and Ice Mapping System for Southern Hemisphere has been developed and is being implemented at NOAA OSPO and National Ice Center. Within the system snow cover is mapped daily at 2 km spatial resolution. The new product provides a much more detailed and accurate characterization of the snow cover distribution in the Southern Hemisphere for NCEP NWP models as compared to the currently used US AFWA snow cover product resolved on a 50 km grid.

BACKGROUND

This work is part of the ongoing NESDIS efforts to upgrade the Global Automated Snow and Ice Mapping System. The previous version of the system used data from older generation visible/infrared and microwave satellite sensors (NOAA AVHRR, DMSP SSMI). The primary objective of these efforts consist in incorporating in the system observations from newer generation satellite sensors (METOP AVHRR, DMSP SSMIS, MSG SEVIRI) along with upgrading the snow detection and mapping algorithm. The new system provides global snow and ice cover maps at the nominal spatial resolution of 2 km, which is 2 times higher than the resolution of the older automated snow/ice product. The planned completion of the task is in April 2013.

In this report we present the work accomplished during the first year and a half of the project execution.

ACCOMPLISHMENTS

During the first two years of the project implementation we have developed and tested a new algorithm for mapping snow cover. The algorithm was used with METOP AVHRR data and applied over land areas in the Southern Hemisphere. Maps of snow cover are generated at 2 km nominal spatial resolution over areas affected by seasonal or perennial snow cover. These areas include South America west of 60°W, South Africa south of 24°S, New Zealand and Australia south of 25°S and east of 140°E. the Antarctic continent is assumed snow covered all year round, therefore snow cover is not mapped there. During the last year the system was complemented with observations in the microwave spectral bands from SSMIS instruments onboard DMSP F-16, F-17 and F-18 satellites. Microwave observations are used to map ice cover in Southern Ocean. The main products generated by the system include (1) the daily snow cover map, where all METOP AVHRR observations over land surface are classified into three categories, snow, snow-free land and clouds/undetermined (2) Daily blended snow and ice cover map, where each land pixel is characterizes as either snow covered or snow-free and each water pixel is characterized as ice covered or ice free, (3) The date of last update for each pixel of the map and (4) support information that includes quality control flags and quality control information.

The upgraded snow and ice mapping system has been tested in a quasi-operational mode for about 6 months time period to identify possible weaknesses in the algorithm and in the data processing setup.

No serious issues with the system performance have been observed. The product accuracy can not be quantitatively estimated since there is no ground truth data available for the comparison. Qualitatively the derived snow and ice distribution agrees well to the snow and ice cover patterns seen in METOP AVHRR and MODIS Terra and Aqua false color imagery.

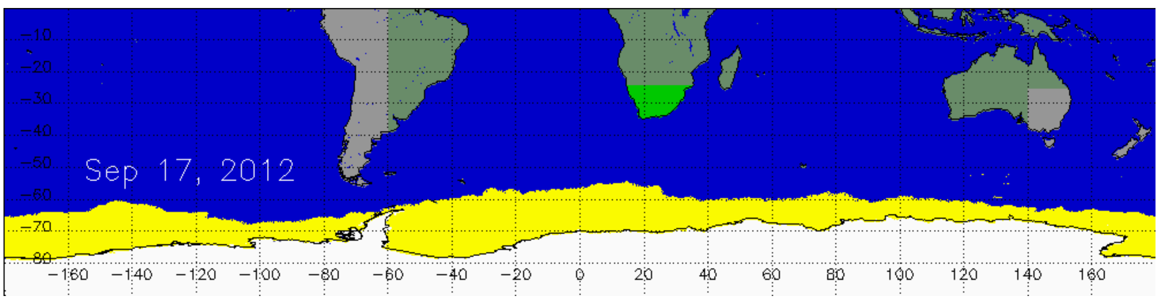


Figure 1: Example of the daily Southern Hemisphere snow and ice map based on observations from METOPA AVHRR and DMSP SSMIS. Snow is shown in white; ice is yellow, light green color shows areas in South America, Africa, Australia and New Zealand where snow cover is mapped.

The code of the system has been delivered to NESDIS OSPO for operational implementation at OSPO and at NOAA National Ice Center (NIC). As of February 2013 the system has been installed on an operational NIC server and is being tested by OSPO and NIC personnel.

Within the project the improved product has been developed. At this time the product is being transitioned to operations. As part of the project we developed support documentation as required by NESDIS OSPO. This documentation includes the Operations Manual, System Description Document, Interface Control Document, System Maintenance Manual and User Manual. The results of this work were included in an invited lecture titled “Snow Mapping and Monitoring: Techniques, Products, and Applications” which was presented at International Training Seminar on Snow Remote Sensing and Impact to Water Management” (Istanbul, Turkey, April 2012)

Performance Metrics	FY12
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	1
# of peer reviewed papers	0
# of non-peered reviewed papers	4
# of invited presentations	1
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	N/A

PLANNED WORK

* Work with the NESDIS OSPO and NOAA NIC operational support to finalize implementation of the new system at OSPO and NIC and put it into operations.
* Finalize support documentation for the system and delivering all documents to NESDIS OSPO.
* Introduce modifications to the system that allows for its easy switch to processing data from forthcoming satellite sensors METOP-B AVHRR and DMSP F-19 SSMIS.

PRESENTATIONS

- Romanov P. (2012) Snow Mapping and Monitoring: Techniques, Products, and Applications. International Training Seminar on Snow Remote Sensing and Impact to Water Management", Istanbul, Turkey, April 18-20, 2012.

- Convective Storm Forecasting 1-6 Hours Prior to Initiation

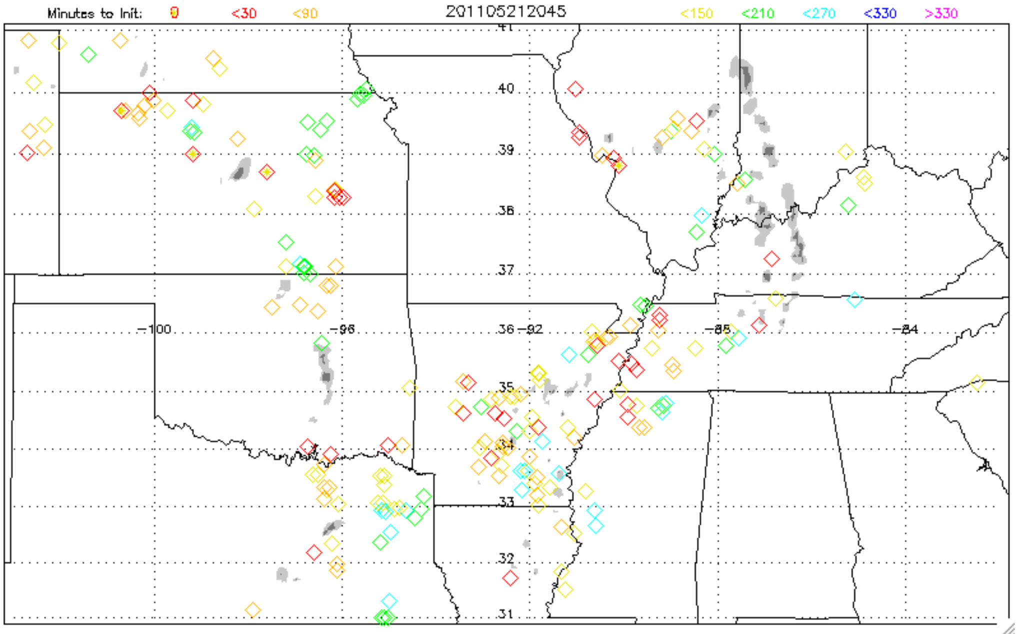
Task Leader: Brian Vant-Hull, CREST, CUNY
Task Code:
Main CICS Research Topic: Data Fusion and Algorithm Development
Percent Contribution to CICS Research Themes: 100% Theme 1
Percent Contribution to NOAA Goals: 100% Goal 2

Highlight: By providing back trajectories of Convective Initiation at several different altitudes, validation is provided for a set of pre-convective initiation algorithms.

Background: : This work outlines the CREST-led evaluation component of the larger project to predict the development of convective initiation (CI) that includes workers from CIRA, CIMMS, NSSL and UAH. The main thrust is to develop indicators of future convective activity based on low-level water vapor convergence, either detected by satellite or projected by numerical weather modeling. Since the goal is to predict convective initiation up to 6 hours in the future, any evaluation component must take existing convection and create back trajectories up to 6 hours in the past.

Accomplishments: A back trajectory algorithm has been created that detects Convective Inititiation from Radar data and advects it back in time 6 hours using NAM data starting at 950 mb, 850 mb, and 750 mb. These trajectories are provided in gridded and graphical format, coded to represent the time remaining to convective initiation. The algorithm has been tested on a 2 day period of active storms over the Great Plains in May 2011. An example is shown in the figure below, showing a snapshot in time with current rainfall in shades of gray and backtrajectory locations color coded by time to initiation. Such images and associated grids are provided every 5 minute interval, so that products with coarser time resolution can always find a validation grid close to their time step.

Performance Metrics	FY2012
# of new or improved products developed	1
# of products transitioned from research to ops	0
# of peer reviewed papers	0
# of non peer reviewed papers	0
# of invited presentations	0
# of graduate students supports by CICS task	0
CICS tasks	1



In the figure above, current precipitation is shown in shades of gray. Diamonds mark locations of backtrajectories from future initiation points: red is 30 minutes from initiation, orange is 30 to 90 minutes from initiation, yellow is 90 to 150 minutes initiation, etc. Red filled with yellow is an initiation point, several are evident in Kansas.

Planned Work:

- Apply the algorithm to detect CI and create back trajectories for 4 months in 2012 over the Great Plains
- Disseminate this validation data to other partners.

Publications

Presentations: "Convective Storm Forecasting 1-6 Hours Prior to Initiation.", poster presentation, 2012 AMS annual meeting

3.2 Calibration and Validation

- Analysis and Validation of Snowpack Grain Size, Density and Temperature using Snow Physical Model

Task Leader Tarendra Lakhankar
Task Code PAPANCREP11
Main CICS Research Topic Calibration and Validation
Percent contribution to CICS Themes Theme 1: 90%; Theme 2: 10%; Theme 3: 0%.
Percent contribution to NOAA Goals Goal 1: 20%; Goal 2: 80%

Highlight: CREST-SAFE field experiment is carried out throughout the winter seasons (2011-12 and ongoing this winter), to measure the snow grain size, and snow density at CREST-SAFE site along with other microwave and meteorological measurements

BACKGROUND

This proposal is the extension of previous projects carried out by PIs on development and improving current algorithm for estimation of snowpack properties using satellite microwave remote sensing data. The continuation of long term observations of in situ snow properties combined with microwave radiances will facilitate the assessment of current snow retrieval algorithms and their capability to infer snow properties under different meteorological conditions.

The research and development in this proposal is to analysis and validation of simulated snow grain size, density and snowpack temperature using SNTHERM (SNow THERmal Model) with measured snowpack properties at CREST-SAFE site. SNTHERM is a one-dimensional mass and energy balance model used to simulate the snow grain size, density and snowpack temperature. The simulated snow grain size, density and snowpack temperature from SNTHERM can be used as an input to microwave emission models such as: Community Radiative Transfer Model (CRTM) and Helsinki University of Technology (HUT) snow emission model to accurately retrieve the brightness temperatures and emissivities from snow covered area.

ACCOMPLISHMENTS

In this particular task, field experiment is carried out throughout the winter season, to measure the snow grain size, and snow density at CREST-SAFE site along with other microwave and meteorological measurements. Observations of the temperature vertical distribution in the snowpack were measured with a specially developed temperature profiler. This instrument was built with 16 Watlow Rigid Sheath Thermocouples placed at 5 to 10 cm intervals.

The meteorological parameters which will be needed to input for SNTHERM model, including incident and reflected solar radiation, upwelling and down-welling longwave radiation, air temperature, relative humidity, wind speed and direction, soil moisture, soil temperature, snow depth, and snow surface temperature were measured through the winter at site. .
Initialized the SNTHERM model using meteorological and snowpack data collected on site and simulated the snowpack temperature, snow grain size, and snow density.

The first manuscript on this research is published on 22 February 2013 Hydrology and Earth System Sciences. Please see citation below.

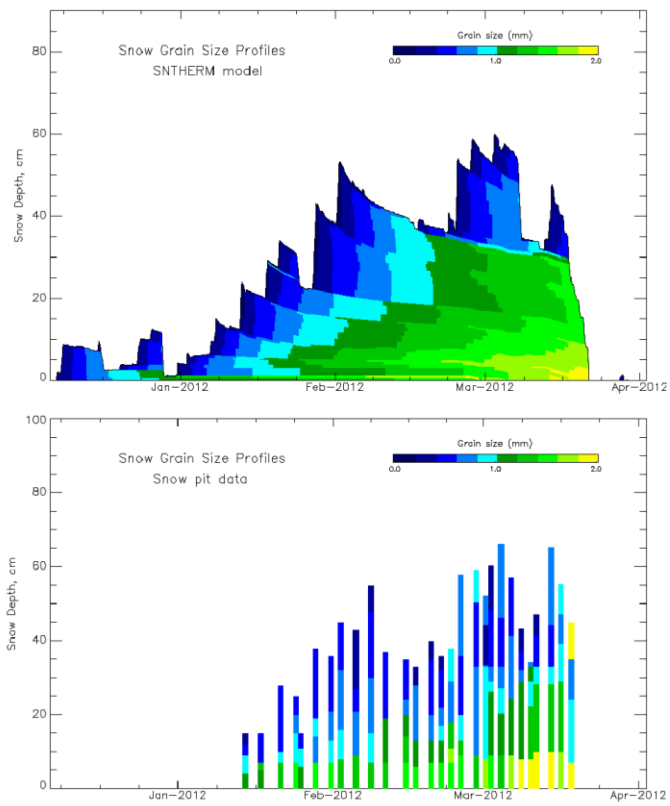


Figure 1: Comparison of in situ and simulated snow grain size at CREST-SAFE experiment site during
2011-12 winter season

Figure 1 Field experiment (a) sampling and (b) measuring snowpack properties including snow grain size, snow density and snow pack temperature of samples taken from different depth of snow pit at CREST-SAFE site at Caribou ME.

Performance Metrics	**FY12**
# of new or improved products developed	0
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	1
# of non-peered reviewed papers	2
# of invited presentations	0
# of graduate students supported by a CICS task	1
# of undergraduate students supported by a CICS task	1

PLANNED WORK

- Compare and evaluate the simulated snowpack temperature, snow grain size, and snow density with observed in-situ data.
- Analyze the snowpack properties for time categories includes: early, mid-winter, spring (melt-freeze period), and melting period.

PUBLICATIONS

- Lakhankar, T., Muñoz, J., Romanov, P., Powell, A. M., Krakauer, N. Y., Rossow, W. B., and R. M. Khanbilvardi (2013) CREST-Snow Field Experiment: analysis of snowpack properties using multi-frequency microwave remote sensing data, Hydrology Earth System Science, 17, 783-793, doi:10.5194/hess-17-783-2013.

- Munoz J., J. Infante, T. Lakhankar, N. Krakauer, R. Khanbilvardi and Al Powell (2013) Synergistic Use of Remote Sensing for Snow Cover and Snow Water Equivalent Estimation, ***submitted*** to British Journal of Environment and Climate Change.

PRESENTATIONS

- Lakhankar T., J. Muñoz, P. Romanov, R. Khanbilvardi, and A. Powell (2013) CREST-Snow Analysis and Field Experiment (CREST-SAFE): Continuous In Situ Observations of Snow Physical Properties and Microwave Emission, 27th Conference on Hydrology, American Meteorological Society Annual Meeting, 6–10 January 2013 in Austin, TX.

- Munoz J., Lakhankar T., P. Romanov, and R. Khanbilvardi (2012), CREST-Snow Field Experiment: analysis of snowpack properties using multi-frequency microwave remote sensing data, presented at The 69th Annual Meeting of the Eastern Snow Conference Claryville, New York, June 5-7, 2012.

- Munoz J., Lakhankar T., P. Romanov, A. Powell and R. Khanbilvardi (2012), CREST-Snow Analysis and Field Experiment (CREST-SAFE): Continuous In Situ Observations of Snow Physical Properties and Microwave Emission, presented at Microwave Remote Sensing of Snow II, American Geophysical Union, C21A-0560, San Francisco, CA, December 2012.

3.3 Future Satellite Programs

- Cloud-top Relief Spatial Displacement Adjustments for GOES-R Images

Task Leader Mahani
Task Code REF043
Main CICS Research Topic/s Future Satellite Program (i)
Percent contribution to CICS Themes Theme 1: 90%; Theme 2: 10%; Theme 3: 0%.
Percent contribution to NOAA Goals Goal 1: 50%; Goal 2: 50%

Highlight: An algorithm, based on using corresponding GOES-East and –West Infrared images and stereoscopic principals to estimate cloud-top height and its associated spatial displacement to adjust/improve GOES-R IR images.

BACKGROUND

The proposed project is an effort to spatially improve the quality of GOES-R infrared channels by removing cloud-top relief spatial displacements and to estimate Could-Top Height (CTH). A method based on stereoscopic (3-D) principles using simultaneous corresponding cloud infrared images from two GOES-East and –West has been used. The developed 3-D based algorithm can compute Cloud-Top relief spatial Displacements (CTD), adjust CTD from each GOES IR image, and compute CTH using the x-parallax of CTD. Hence, to fulfill the objectives of this study, two relationships of CTD-CTH and CTD-IR (or CTH-IR) have been derived. The CTD-CTH relationship mostly depends on geometry of satellite and cloud such as satellite navigation parameters, cloud location, and CTH. The CTD-IR relationship is associated with cloud type, topography, climate, and season. This relationship needs to be updated/modified for each case study. To update CTD-IR relationship at least two simultaneous corresponding GOES-E and -W IR images need to be used but to implement the algorithm there is no need for availability of simultaneous corresponding IR images from two GOES-E and –W satellites. The IR-CTH relationship is a piecewise linear approximation that is derived using the optimization scheme of Shuffled Complex Evolution (SCE-UA) developed by Qingyun Duan at the University of Arizona. The derived CTD-IR relationship is tested and improved using multi GOES IR channels to be able to implement it for CTD adjustment of multi-IR channels of GOES-R satellites. Model output, CTH, is validated against CALIPSO-CTH and the CTH from GOES-R Algorithm Theoretical Basis Document (ATBD). GOES-11 (-West) and GOES-13 (-East) are used as proxy for GOES-R data in this study.

ACCOMPLISHMENTS

The developed CTD and CTH relationship using 3-D principle and GOES-11/13 IR images and their navigation parameters has been use for deriving and studding the relationship between CTH and cloud-top IR brightness temperature for different topography and seasons, following procedures:

- The same time simultaneous and corresponding IR images from GOES-11 and GOES-13 channels-4 and -5 IR data and CLALIPSO-CTH have download and been processed for study cases over mountainous region (Colorado), flat area (Texas/Oklahoma and southwest of US), and coastal area (northeastern US) in summer 2010 and 2011 for model development and validation.

- Derive the relationship between x-parallax of CTD and IR, utilizing 3-D principals from scan-synchronous GOES-13 and -11 IR channel-4 Images and optimize the parameters of the relationship using the SCE-UA approach for four study cases. Following table shows the average of optimized 6 parameters, which are h_0 (height for the an initial point with IR brightness temperature (BT) of 280 K), T_1 and T_2 (IR-BT of the joint points between the 3 pieces of lines of the CTH-IR relationship) and l_1, l_2, and l_3 (slopes of the 3 pieces of lines of the relationship) for flat and mountainous areas. According to these values there are not much changes between the similar parameters for different topography for July storms.

Optimized Parameters	h_0 *(Km)*	T_1 *(K)*	T_2 *(K)*	l_1 *(Km/K)*	l_2 *(Km/K)*	l_3 *(Km/K)*
Flat Study Areas	2.4	245	220	0.125	0.115	0.13
Mountainous Study Area	2.6	242	225	0.15	0.105	0.14
Northeastern US, July 2011	2.45	240	221	0.125	0.115	0.13

- CTD adjustment of IR channel-4 of GOES-11 and -13. Correlation coefficients and RMSE of GOES-11 pixels versus their corresponding pixels from GOES-13 were improved 15% and 50% in average, respectively for images that were used in model development. Comparison between a couple of corresponding the same time of original GOES-E and –W images, before any adjustment (Figure 1, the left two images) and between the same images after CTD adjustment (Figure-1, the right two images) show improvement on spatial displacements between corresponding cloud cell.

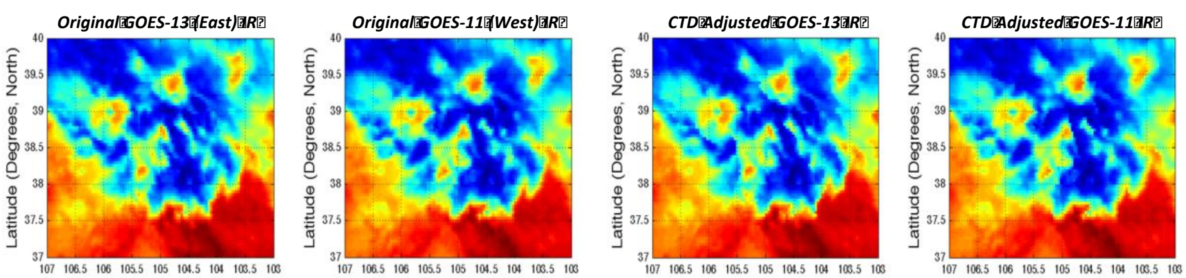


Figure 1: Comparison between original corresponding the same time GOES-West and GOES-East cloud-top IR (the two left images) the same images after spatial adjustment.

- Validate adjustment of CTD using the derived relationships. Each CTD-IR was implement for another type of topography and land for evaluating adjusted GOES images. Correlation coefficient and RMSE of GOES-11 pixels versus their corresponding pixels from GOES-13 were improved 10% and 25% in average, respectively.

- Estimate CTH and evaluate estimated CTH against CALIPSO-CTH product. This comparison shows underestimation of the model estimates with average correlation coefficient of 0.61 and average RMSE of 0.58 (Km) in average.
- Because of the narrow swath of CALIPSO not many common cloud cells could find over each IR image and correlation varied from one image to another particularly for mountainous study cases. Hence, validation of the estimated CTH from the developed model against CALIPSO needs to be tried for much more study cases. In average the correlation coefficient for coastal and flat areas is 0.71 and for mountainous area is 0.59. More study cases need to be used for validation against CALIPSO.
- A draft of the first paper about application of stereoscopic principal on CTH estimates and CTD adjustment of GOES IR images has been prepared and it is ready for submitting to a peer-reviewed journal for publication.
- Investigate CTH-IR relationship with 4 pieces of lines and 8 parameters which are: h_0 (height for 270 K), T_1, T_2 and T_3 (IR-BT of the joint points between the 4 pieces of lines of the CTH-IR relationship) and l_1, l_2, l_3 and l_4 (slopes of the 4 pieces of lines of the relationship). The 8 parameters of the derived the CTH-IR piecewise linear relationship for flat and mountainous areas are compared in the following table.

Optimized Parameters	h_0 (Km)	T_1 (K)	T_2 (K)	T_3 (K)	L_1 (Km/K)	L_2 (Km/K)	L_3 (Km/K)	L_4 (Km/K)
Flat Study Areas	3.8	255	236	212	0.13	0.124	0.104	0.137
Mountainous Study Area	4.05	253	232	209	0.151	0.12	0.138	0.161

- Validate adjustment of CTD and estimated CTH using the derived CTH-IR relationships with 8 parameters and compare with the similar results using the CTD-IR relationship with 6-paramers. Figure 2, demonstrate a sample for spatially improvement of a corresponding couple of the same time GOES-IR images from GOES-11 and -13 for a study case that was used for model development (calibration case) the left two plots and for an independent validation case, the two right plots. In each case the left image represents the correlation between corresponding GOES images before adjustment and the right image are for correlation between the same images after adjustment of could relief spatial displacements from both images. These figures shows higher correlation after spatial adjustment.

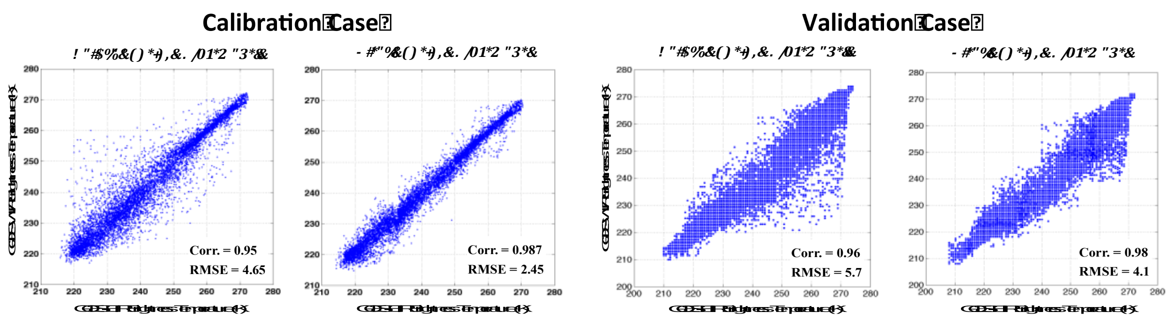


Figure 2: Comparison between GOES-West cloud-top IR vs. its corresponding the same time GOES-East IR before and after spatial adjustment for a calibration case and a validation case for the selected mountanous region.

- GOES IR band-5 has been selected for deriving the CTH-IR relationship for CTD adjustment and CTH estimation. The results will be compared with the similar ones using GOES IR band-4 to understand which IR channel or may combination of them work better.
- Validation of the CTH estimates from the developed model output against GOES-R ATBD algorithm has been postponed due to un-availabity of this data and the undergraduate student for a few months.

Performance Metrics	FY12
# of new or improved products developed	2
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	0 (about this project)
# of non-peered reviewed papers	1
# of invited presentations	1
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	1

PLANNED WORK

Planned Tasks for FY13:

- Continuation of investigating the improvement of the developed algorithm using combination of multi GOES IR channels.
- Validate the CTH from model output against GOES-R ATBD algorithm that has been started due to un-availabity of this data and the undergraduate student for a few months.
- Continuation of investigating the impacts of seasonal, and storm types on model parameters of CTD-IR relationship and modify model for each.
- This algorithm is planned to work operationally at CREST and its outcomes, which are the spatially adjusted current GOES-IR images and CTH product will be posted and available at CREST website. GOES-IR data will be transited to GOES-R IR after launch of this satellite.
- Preparing the second article about CTH and adjustment of associated spatial displacement from GOES-R IR images using combination the validation against ATBD algorithm.

PUBLICATIONS

PRESENTATIONS

Mahani, S. E.; *"Cloud-top Relief Spatial Adjustment of GOES-R Images"*; Oral presentation NOAA Satellite Science Week, Kansas City, May 02,2012.

- Development of validation tools and proxy data for GOES-R ABI Air Quality Proving Ground for the Northeast (NY Metro Region)

Task Leader Barry Gross
Task Code CUNY
Main CICS Research Topic Support for Future Satellite Programs
(i) Scientific support for the GOES-R Mission
Percent contribution to CICS Themes Theme 1: 50%; Theme 2: 50%; Theme 3: 0%.
Percent contribution to NOAA Goals Goal 1: 0%; Goal 2: 100%

Highlight:
*Development of PROXY datasets that can be used to test GOES-R ABI algorithms as assessment
* Preliminary PM2.5 estimator combining MODIS and CMAQ data.

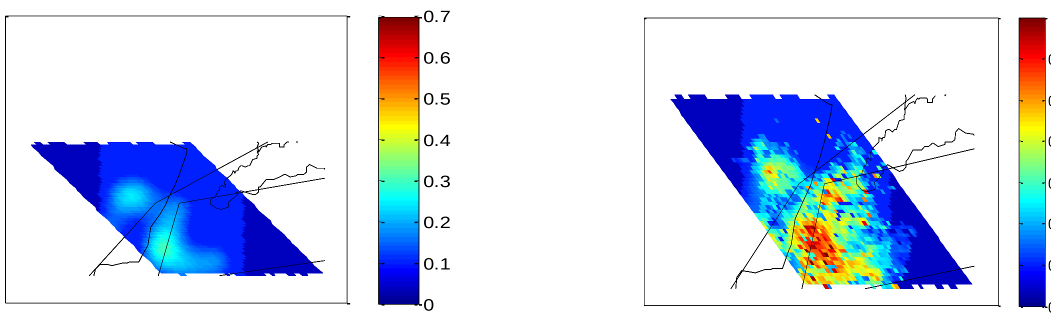
BACKGROUND

The AQPG has been developed as a means to test current ABI aerosol algorithms and to demonstrate performance based on realistic proxy datasets. It is also the case that aerosol retrievals are most complex over brighter surfaces and in particular urban centers. This difficulty is particularly a concern due to population impacts and local sources making monitoring more critical. In particular, the aerosol retrieval product for GOES-R ABI builds on the heritage of the MODIS algorithm and therefore suffers some of the difficulties that MODIS has in retrieving aerosols over urban areas. In particular, the current surface parameterizations cannot be considered optimal and more regional algorithms are needed to assess the GOES-R ABI algorithm. The purpose is therefore to create the most realistic proxy datasets on the ABI channels that can provide robust tests of the algorithm in the NYC area.

ACCOMPLISHMENTS

In order to make an assessment, we have constructed TOA radiances using the 6SV radiative transfer code for the current MODIS bands (B1,B3,B5,B7) but using the GOES-R ABI geometry in an urban region to assess the performance of planned aerosol retrieval algorithms using realistic urban aerosol fields. The aerosol model was chosen to be urban fine mode and the AOD spatial distribution was chosen to model realistic emission sources that might occur (figure E3a). The surface albedo model was taken from season averaged MODIS-ASRVN retrievals (no simulated clouds however).

The MODIS TOA reflectance data were then ingested into the MODIS operational inversion algorithm (IMAPP) and the MODIS AOD's were calculated. The results (figure E3b)



demonstrate that the current retrieval algorithm at high resolution (2km) leads to significant over biases that would lead to strong overestimates of surface PM2.5. We have recently run the 6SV code to generate LUT's for the GOES-R ABI spectral channels. Efforts to include land classification data into the MODIS data stream are being tested and can remove much of the over-biased observed.

Figure 1: Assessment of errors using GOES-R ABI PROXY data sets. a. Input Aerosol Optical Depth Input Distribution , b. Retrieved using current MODIS C005 surface parameterization.

In addition, we have modified the spectral channels to be overlapped with the ABI and have delivered similar GOES-R ABI data . Finally, the results of comparisons between satellites and the CMAQ model are given in figures 3 for EPA region 2 for the correlation in comparison to satellite estimates . It is clear that the CMAQ PM2.5 forecast is superior to either the MODIS or the GOES AOD retreival although the MODIS AOD in summer is quite competative with the CMAQ outputs. Note also that the GOES retreivals are much poorer due to inherent SNR in the geostationary platform.

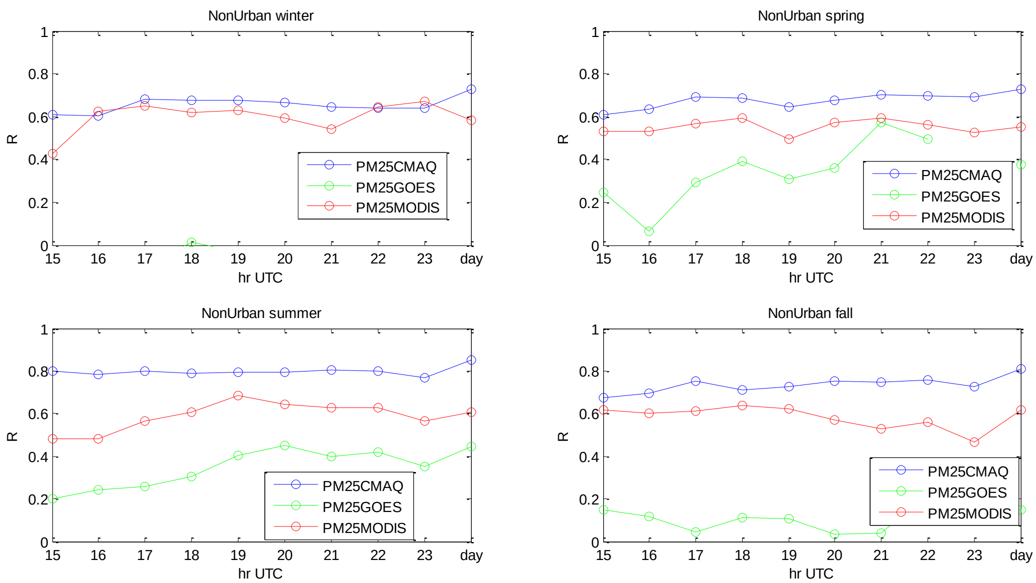


Figure 2. Hourly performance of correlation between CMAQ, MODIS and GOES satellite estimates during daytime hours for Non-Urban locations. a) Winter b) Spring c) Summer d) Fall

Performance Metrics	FY12
# of new or improved products developed	0
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	0
# of non-peered reviewed papers	1
# of invited presentations	0
# of graduate students supported by a CICS task	1
# of undergraduate students supported by a CICS task	0

PLANNED WORK

* Explore performance of satellite retrievals on surface PM2.5 with a special focus on the need for GOES-R ABI high temporal resolution to resolve diurnal variations in PM2.5 signals.

PUBLICATIONS

PRESENTATIONS

- L.Cordero, N. Chowhury, B. Gross, F.Moshary S. Ahmed , "Assessment of Satellite AOD estimates of PM2.5 in comparison to CMAQ PM2.5 estimates ", CMAS meeting Oct 2012

- Quantitative Image Restoration

Task Leader Irina Gladkova
Task Code CUNY
Main CICS Research Topic Future Satellite Programs (Scientific support for the GOES-R Mission)
Percent contribution to CICS Themes Theme 1: 70%; Theme 2: 30%
Percent contribution to NOAA Goals Goal 1: 20%; Goal 5: 80%

Highlight: We have developed a model for simulating ABI potential damage based on ABI onboard resampling procedure; developed a software implementing possible damage simulator for 2 damage scenario classes; evaluated simulated damage for different bands and adapted QIR algorithm to work with ABI simulated damage including preliminary restoration results.

BACKGROUND

One of the NOAA's mission support goal is to "Provide a Continuous Stream of Satellite Data and Information with the Quality and Accuracy to Meet Users Requirements for Spatial and Temporal Sampling and Timeliness of Delivery". The intrinsic risks of damaged to sensors associated to launching and operating satellites in the hostile environment of space continuously threaten NOAAs critical priority of maintaining a continuous stream of accurate and high quality satellite data and information. Such risks are not specific to GOES-R, but given the essential role GOES-R will play for NOAA, it is critical that techniques be in place and ready to mitigate any potential risk from temporary or permanent non-functional detectors. Even when the detectors are partially function, artifacts such as stripes can present severe problems.

The real possibility of such problems is clear as seen in SEVERI striping abnormalities on the MSG, or the large number of damaged detectors in band 6 of Aqua (MODIS). Fortunately there are powerful statistically sound methods of estimating the missing data. While none would suggest such estimations can completely replace the missing data, they can mitigate the risk by using all available data to provide a high quality estimation of the missing data. This project reduces risk to the GOES-R program through development of the statistically sound and high performance quantitative image restoration algorithm targeted to the Advanced Baseline Imager (ABI).

ACCOMPLISHMENTS

We have considered two classes of damage scenarios. In the first class of scenarios we assumed that detectors, which are deemed bad or damaged, are simply dropped. Each regridded pixel is computed using the sinc kernel on distance from several raw detector measurements, properly weighted. Thus, if one of these values is not available then the weighting scheme may mean that the value in the regridded image is minimally affected. Figure 1 (left) shows that with 10% of dropped detectors there is minimal effect to the final image. In the second class of scenarios we assume that rather than being completely dead some detectors are corrupted with additive Gaussian noise. Once again, if the noise is relatively small and effects only 10% of the detectors, there is little effect on the overall image as shown in Figure 1 (right).

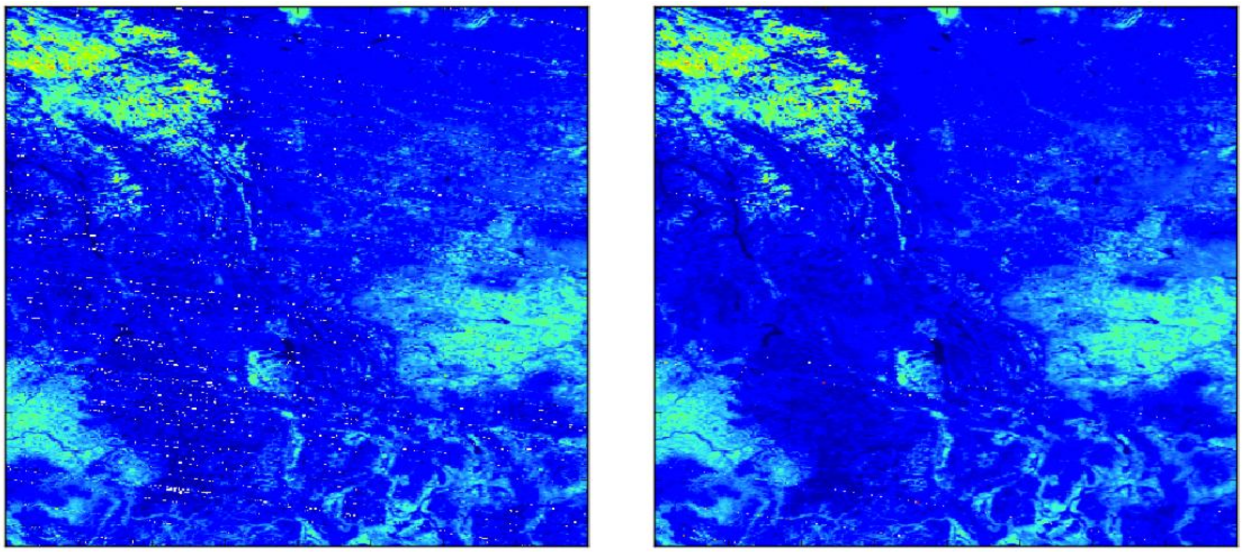


Figure 1: Simulated resampled 2.2 micron ABI band with 10 percent of the detectors damaged. The image on the left is with the noisy detectors used in the resampling. The image on the right is obtained by dropping the damaged detectors from the resampling procedure.

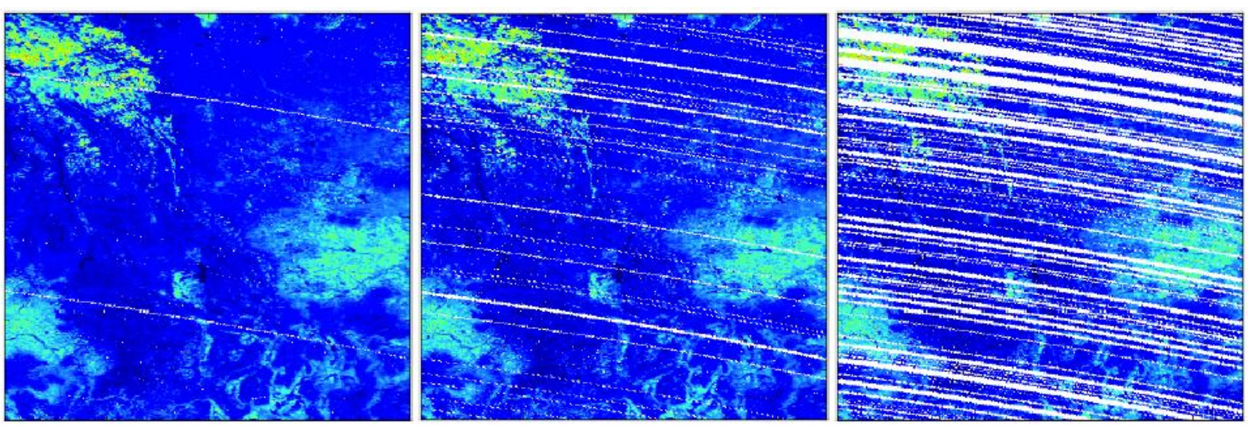


Figure 2: Simulated resampled 2.2 micron ABI band with 25, 50 and 75 percent of the detectors damaged obtained by dropping the damaged detectors from the resampling procedure.

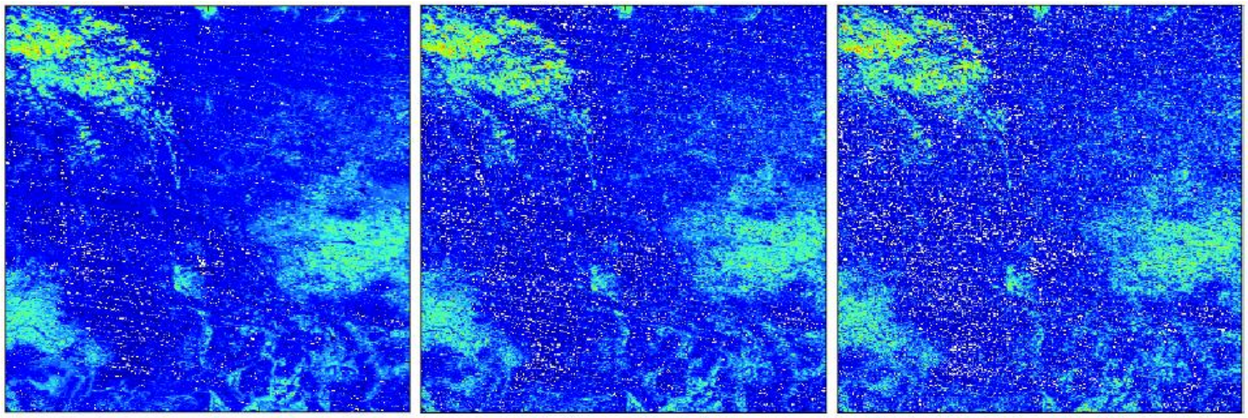


Figure 3: Simulated resampled 2.2 micron ABI band with 25, 50 and 75 percent of the detectors damaged with noisy detectors used in the resampling.

As more detectors are affected and the noise level increases, the quality of the image degrades rapidly.
This can be seen in Figure 2 below which shows dropped pixels for 25% (right), 50% (middle), and 75%
(left) of the detectors. Note that the level of 75% dropped detectors is the level currently experienced by MODIS/Aqua band 6. We also simulate the damage due to noisy pixels corrupting the final regridding. We have performed evaluation varying the noise level. Figure 3 shows the results for the SNR level of 1.5, where the percentage of the pixels corrupted is 25% (left), 50% (middle), and 75% (right). Our analysis indicates that the impact of keeping the noisy values in the interpolation has a much larger effect on image degradation than simply dropping the values produced by damaged detectors.

We have modified our QIR algorithm so that is does not assume that the damage is aligned to scan lines, but is able to replace missing values as produced by the ABI damage simulator. Preliminary results are excellent and comparable to our earlier result with MODIS on Aqua although due to the specific ABI interpolation there are some points, which are falling out of range. We are developing methods to account for this.

Performance Metrics	**FY12**
# of new or improved products developed	0
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	2
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	0

PLANNED WORK

- Improve regression with inclusion of 2nd order terms in the regression
- Evaluate against ABI simulated data to determine statistical confidence of restoration
- Develop integrated software library implementation for producing restored bands and confidence of restoration at each pixel

PUBLICATIONS

I. Gladkova, M. Grossberg, G. Bonev, P. Romanov, F. Shahriar, 2012: Increasing the Accuracy of MODIS/Aqua Snow Product Using Quantitative Image Restoration Technique, IEEE Geoscience and Remote Sensing Letters, vol.9, no.4, pp.740-743

I. Gladkova, M. Grossberg, G. Bonev, P. Romanov, G. Riggs, D. Hall, 2012: A full snow season in Yellowstone: A database of restored Aqua Band 6, IEEE Geoscience and Remote Sensing Letters, vol. 10, no. 3, pp. 553-557

- Coastal Site Data Uncertainties and In situ Validation

Task Leader Samir Ahmed
Task Code CUNY
Main CICS Research Topic B (ii) Scientific support for the JPSS Mission
Percent contribution to CICS Themes Theme 1: 0%; Theme 2: 100%; Theme 3: 0%
Percent contribution to NOAA Goals Goal 3: 20%; Goal 4: 30%; Goal5: 50%
Highlight: VIIRS Ocean Color data quality of coastal regions has been evaluated through AERONET – OC and MODIS data. A novel algorithm for the better estimation of water leaving radiance data from above water measurements was developed and validated based on LISCO data.

BACKGROUND

The satellite OC EDR products are derived from sensor SDR level data which is continuously adjusted with the calibration gains acquired based on the on-board temporal calibration measurement trends. In addition, vicarious calibration procedures are also usually required for SDR to OC EDR processing to minimize biases due to residual atmospheric correction or absolute calibration errors, and to maximize spectral consistency. The related vicarious calibration factors are derived from various reference sources (e.g. Marine Optical Buoy (MOBY) data, sea surface reflectance model and climatology of chlorophyll-a concentration). As the consequence, the consistency and validity of these overall calibration processes for the broad range of conditions need to be assessed and evaluated. Moreover, the overall optical complexity of the atmospheric-water system in coastal zones makes observation from space highly challenging, particularly for the atmospheric correction step, nevertheless, optical remote sensing of coastal waters is of paramount importance for monitoring global water quality and assessing anthropogenic impacts. Thus, the reliability of satellite observations of coastal zones, along with related atmospheric corrections, need to be regularly assessed and validated against high quality in situ measurements.

This work is a part of the ongoing NOAA-Navy-NASA activity “Calibration/Validation of JPSS – VIIRS Sensor, and represents a continuation and enhancement of previous undertakings on generation of quality assured in-situ OC data obtained at the Long Island Sound Coastal Observatory (LISCO) site for JPSS-VIIRS cal/val activities. LISCO is uniquely equipped with collocated multi – spectral SeaPRISM and hyper – spectral HyperSAS instruments and is an integral part of the Aerosol Robotic Network (AERONET-OC). The quality assured LISCO data are actively used by the validation team at NRL SSC to establish post-launch gains at near real time based on coastal site data.

ACCOMPLISHMENTS

- Maintained suite of LISCO instruments and carried out instrument calibrations to ensure delivery of high-quality in-situ data to the JPSS-VIIRS cal/val team.

- Continuously providing a consistent stream of data from the SeaPRISM instrument on Long Island Sound Coastal Observatory (LISCO) to NASA – AERONET and NRL SSC and from the hyperspectral HyperSAS to the CCNY server.
- Develop/maintain a Webtool for the matchup of satellite, SeaPRISM and HyperSAS data.
- With the use of the LISCO's quality assured collocated multi - and hyper – spectral data, a novel algorithm that takes into account the polarization state of the incident skylight for better estimation of water leaving radiance data from in-situ above water measurements, was developed and validated (Appl. Optics, 2012).
- The quality assured in-situ OC data stream of LISCO enabled us to evaluate the quality of VIIRS retrieved OC products for typical coastal waters conditions. Through statistical analysis carried out between the VIIRS, MODIS and AERONET-OC data, the impacts of the different processing schemes (particularly for the respective roles of the vicarious calibration procedures) on the VIIRS's OC data retrievals are scrutinized in order to aid the scientific community to better interpret the physical or biogeochemical meaning of VIIRS data in coastal areas (A journal article is in preparation with this study).

VIIRS (both initial and latest version 12.2), in-situ SeaPRISM and MODIS nLw(λ) spectra recorded at the LISCO site are presented in Fig. 1 exhibiting the consistencies in the overall seasonal average values, spectral shape and ranges for nLw data of all satellite sensors and in-situ SeaPRISM.

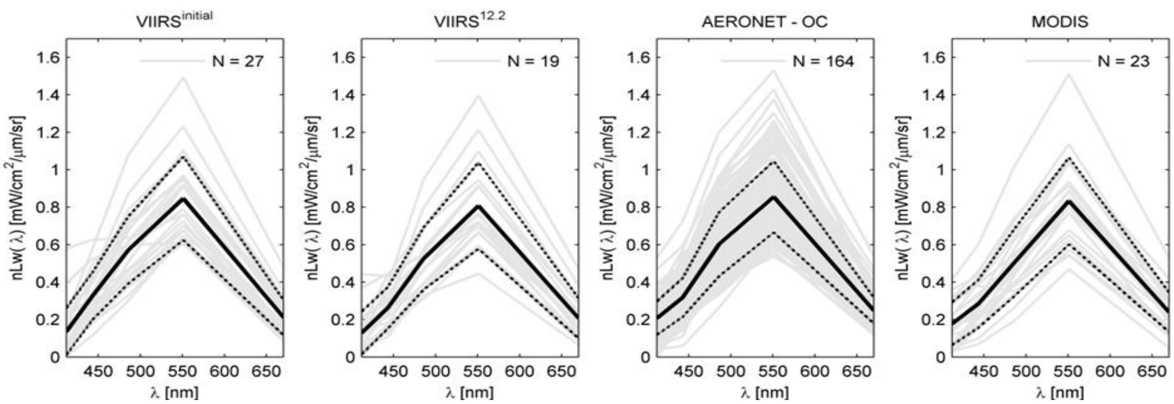


Figure 1. nLw(λ)match-up spectra of VIIRS^{initial}(1stcolumn), VIIRS$^{12.2}$(2nd column), SeaPRISM (3rd column) and MODIS (4th column) for the LISCO site. N is the total number of spectra for each sensor. Grey lines represent the individual spectra. Thick black solid lines indicate average and thick dashed lines indicate ± one standard deviation).

Performance Metrics	FY12
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	1
# of non-peered reviewed papers	2
# of invited presentations	2
# of graduate students supported by a CICS task	1+3 leveraged
# of undergraduate students supported by a CICS task	1 leveraged

PLANNED WORK

- Continue providing stream of data on the LISCO instruments for the calibration/validation of VIIRS sensor and other OC satellites.
- Field measurements in the area of the platform to provide additional matchups for validation VIIRS sensor and other OC satellites.
- Continue work on the improvement of data quality for the satellite – in-situ matchups.
- Assess the impact of atmospheric conditions on the accuracy of retrievals and explore the implementation of approaches to minimize errors and uncertainties in satellite OC retrievals for coastal waters.

PUBLICATIONS

1. Tristan Harmel, Alexander Gilerson, Alberto Tonizzo, Jacek Chowdhary, Alan Weidemann, Robert Arnone, and Sam Ahmed, "Polarization impacts on the water-leaving radiance retrieval from above-water radiometric measurements," Appl. Opt. **51**, 8324-8340 (2012).
2. S. Ahmed, A. Gilerson, T. Harmel, S. Hlaing, A. Tonizzo, A. Weidemann, and R. Arnone, "Evaluation of atmospheric correction procedures for ocean color data processing using hyper- and multi-spectral radiometric measurements from the Long Island Sound Coastal Observatory," Proc. SPIE 8372, Ocean Sensing and Monitoring IV, 83720M (June 11, 2012); doi:10.1117/12.919900.
3. S. Ahmed, A. Gilerson, S. Hlaing, I. Ioannou, A. Tonnizo, A. Weidemann, R. Arnone, "Evaluations of the Performance of the VIIRS Sensor in a Coastal Water Environment at the Long Island Sound Coastal Observatory Site," Ocean Optics XXI Conference, Glasgow, Scotland, October 2012.

PRESENTATIONS

1. S. Ahmed, "Optical Remote Sensing at CCNY," Rutgers University, April, 2012 (**invited**).
2. A. Gilerson, A. Ibrahim, T. Harmel, A. Tonizzo, S. Ahmed, "Retrieval of coastal water properties using polarization sensitive instruments" NASA Workshop "Remote Sensing of Coastal and Inland Water: Challenges and Recommendations for the Future," NASA Workshop, Madison, WI, June 2012 (**invited**).
3. S. Ahmed, A. Gilerson, T. Harmel, S. Hlaing, A. Tonizzo, A. Weidemann, and R. Arnone, "Evaluation of atmospheric correction procedures for ocean color data processing using hyper- and multi-spectral radiometric measurements from the Long Island Sound Coastal Observatory," SPIE, Baltimore, Maryland, April 2012.

4. S. Ahmed, A. Gilerson, S. Hlaing, I. Ioannou, A. Tonnizo, A. Weidemann, R. Arnone, "Evaluations of the Performance of the VIIRS Sensor in a Coastal Water Environment at the Long Island Sound Coastal Observatory Site," Ocean Optics XXI Conference, Glasgow, Scotland, October 2012.
5. S. Hlaing, I. Ioannou, A. Gilerson, S. Ahmed, A. Weidemann, R. Arnone, “Assessments of the retrieval performances of JPSS-VIIRS sensor in coastal water environment through time-series measurements at Long Island sound coastal observatory site and heritage ocean color satellite missions”, AMS 93rd annual meeting, Austin, Texas, January 2013.

- Development of Neural Network algorithms for retrieval of chlorophyll-a in the Chesapeake Bay and other coastal waters based on JPSS-VIIRS bands

Task Leader Alex Gilerson
Task Code CUNY
Main CICS Research Topic B (ii) - Scientific support for the JPSS Mission
Percent contribution to CICS Themes Theme 1: 0%; Theme 2: 100%; Theme 3: 0%.
Percent contribution to NOAA Goals Goal 3: 20%; Goal4: 80%

Highlight: NN approach is explored together with other available algorithms to retrieve chlorophyll and mineral concentrations, CDOM absorption in Chesapeake Bay and potentially other coastal waters for the JPSS/VIIRS sensor

BACKGROUND

Chlorophyll-a concentration [Chl] is one of the main products retrieved from the ocean color satellite imagery which is then used in the estimation of the ocean productivity, modeling of ecosystems, climate studies, evaluation of water quality, and detection of algal blooms. The accuracy of standard blue-green ratio algorithms decreases significantly in the coastal waters because of contamination of the blue and green reflectance signals from CDOM absorption and mineral scattering especially in such complex waters as Chesapeake Bay. CCNY group recently developed a Neural Network (NN) algorithm which showed good performance in coastal waters. In addition, it allows separation of CDOM and mineral absorptions because of the latter's relationship with mineral scattering. This work is aimed at utilizing this NN approach to retrieve chlorophyll and mineral concentrations, CDOM absorption in Chesapeake Bay and potentially other coastal waters for the JPSS/VIIRS sensor. The project started in July 2012, funding – in October 2012.

ACCOMPLISHMENTS

- Available literature is analyzed to determine range of water parameters in the Chesapeake Bay and its main parts as well as characteristics of water components which can be further used in the bio-optical model.
- Atmospheric correction limitations were evaluated based on the comparison of aerosol optical thicknesses and Angstrom coefficients measured by SeaPRISM instrument and Ocean Color (OC) satellites (MODIS, MERIS and VIIRS) on the Long Island Sound Coastal Observatory (LISCO) site. It was shown that Angstrom coefficients distribution from SeaPRISM and OC satellites are different which can require broader range of aerosol models for coastal sites.
- Several sets of satellite and field data were downloaded, organized, filtered and analyzed to provide further high quality matchups and retrievals. These include: MODIS Aqua reflectance data and corresponding retrievals from SWIR-NIR atmospheric correction (Son, Wang, Rem. Sens. of Env. 2012);

MODIS Aqua reflectance data and corresponding retrievals from NIR atmospheric correction (Son, Wang, Rem. Sens. of Env. 2012); Field data for Chesapeake Bay (www.chesapeakebay.net/wquality.htm) separated into Upper, Middle and Lower Bay - these data were filtered to avoid areas near shore, shallow waters, rivers for which satellite data can be inaccurate due to the land impact and difficulties with atmospheric correction (further "WQuality"); MERIS Reduced Resolution (RR) for Chesapeake Bay reflectance data and associated retrievals for the length of the mission; MERIS Full Resolution (FR) reflectance data and associated retrievals for the length of the mission; NASA Bio-Optical Marine Algorithm Data set (NOMAD) for the Bay which includes above water reflectance data, measured water inherent optical properties (IOPs), [Chl], TSS, etc.
- New Neural Network (NN) algorithms were developed based on MODIS bands and global NOMAD data for [Chl] retrieval which include training on NOMAD reflectance data and reflectance data combined with some of retrieved IOPs.

- Several matchups between retrieved and field data were tested and compared with the standard blue-green OC3 algorithm. These include: MODIS SWIR-NIR corrected data - NN retrieved [Chl] (with and without IOPs addition) with "WQuality"; MODIS NIR corrected data - NN retrieved [Chl] (with and without IOPs addition) with "WQuality"; NOMAD reflectance data - NN retrieved [Chl] with NOMAD [Chl]; MERIS RR reflectance data - MERIS NN retrieval (Algal2 algorithm based on NN); MODIS NIR reflectance data - NN retrieval of algal absorption at 443 nm (NN algorithm, Ioannou et al, 2011) with NOMAD [Chl]; MERIS RR reflectance data and two- and three red/NIR bands algorithms (Gilerson et al, 2010) with "WQuality" data.
As a result it is shown that while OC3 retrievals have $R^2 < 0.4$ and lower, some algorithms can retrieve [Chl] with R^2 near 0.9.

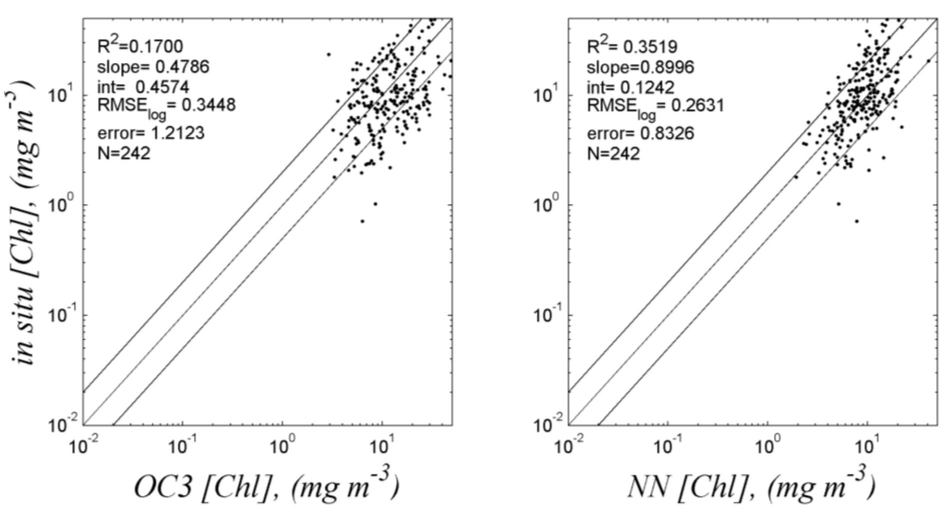


Fig. 1 Retrieval from NOMAD reflectance: OC3 (left), NN algorithm (right), Chesapeake Bay area.

Performance Metrics	FY12-13
# of new or improved products developed	0
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	1
# of non-peered reviewed papers	0
# of invited presentations	1
# of graduate students supported by a CICS task	1
# of undergraduate students supported by a CICS task	1 (leveraged)

PLANNED WORK

- Develop first approximation of the bio-optical model for the Bay and new synthetic dataset for training and testing of NN algorithms.
- Developed algorithms will be further validated on satellite (MODIS, MERIS) and NOMAD, “WQuality” data.
- Impact of atmospheric correction on retrieval in such special coastal area as Chesapeake Bay will be further evaluated.

PUBLICATIONS

1. Ioannis Ioannou, Alexander Gilerson, Barry Gross, Fred Moshary, and Samir Ahmed, "Deriving ocean color products using neural networks," Remote Sensing of Environment, 2013, accepted.

PRESENTATIONS

1. A. Gilerson, “Remote Sensing of the Ocean and Coastal Waters: Novel Algorithms and Instrumentation,” NRL-DC, Sept. 2012 (invited).

3.4 Land and Hydrology

- CICS Support to the NESDIS Cooperative Research Exchange Program

Task Leader Dr. Naira Chaouch
Task code
Main CICS Research topic: Land and Hydrology
Percent Contribution to CICS Themes: Theme1:100%
Percent Contribution to NOAA Goals: Goal 1: 50 % , Goal 2: 50% (estimated)

Highlight This work proposes the development of a new data product that provides information on inland ice (lakes and major rivers) which constitute principal components of hydrological processes in northern watersheds.

BACKGROUND
The proposed research is an expansion of an ongoing work, which has been supported by NWS Eastern Region Hydrologic Services Division, for the mapping of ice in the Susquehanna River which is one of the major ice-flood prone rivers in the U.S. A first application was already developed using MODIS data and a preliminary version of an operational web tool, CREST River Ice Observation System (CRIOS) (http://water.ccny.cuny.edu/crios) was implemented with a particular focus on the Susquehanna River (Chaouch *et al*. 2012). CRIOS allows end-users, NOAA managers, reservoir managers, and the general public, to interactively examine and assess ice conditions over the entire river.
The advent of new satellites like VIIRS will expand the capabilities of the developed systems. The availability of images from VIIRS will complement information derived from MODIS and reduce through image compositing the impact of could obstruction augmenting therefore the chances to obtain larger cloud free scenes during the day.
This work directly addresses the JPSS Proving Ground and Risk Reduction program's primary objective. The generation of this additional data product will greatly maximize the benefit of the mission which fulfills the goal of its risk reduction program. Second, the developed ice maps will be ingested into land surface and river routing models to assess the improvement in their performances. River and lake ice product will be tested into river routing models like HEC-RAS which is in use in Northeast River Forecast Center. It is expected that including ice in the modeling of river hydraulics will significantly improve the accuracy of these models and their capabilities to reproduce the river stage and to forecast the river discharge.

ACCOMPLISHMENTS
The first goal of this research is to expand the existing operational river ice tool (CRIOS) through the integration of VIIRS data. In addition, the intention is also to geographically

expand CRIOS to include additional rivers in Alaska along with the already covered rivers in the northeast like the Susquehanna and the Mohawk Rivers. In this perspective, CREST team members have already established a contact with NOAA National Weather Service team at the River Forecast Center in Anchorage. Specific River branches where the NWS RFC has great interest in monitoring river conditions have jointly identified. Necessary GIS manipulations have been conducted to develop appropriate land masks for the identified rivers sections in Alaska in order to delineate the different regions of interest and apply those masks automatically to the acquired VIIRS images.

With respect to the data acquisition aspect, routines have been developed to acquire automatically VIIRS data from CLASS and process them at CREST. Meanwhile, coordination is ongoing with the manager of the CREST satellite receiving station to acquire data through direct readout from the CREST antenna which will cover mostly the northeast region. This will allow us to have direct access to data with the near real time delivery of the product. This reduced latency is very important for our partners in the Northeast River Forecast Center in Tauten, MA. The river ice product over Alaska will be subject to the latency of CLASS data portal.

PLANNED WORK

We will pursue the adaptation of the developed routines to automatically ingest VIIRS images, identify clouds, and apply the land mask in order to delineate river branches identified by our partners in Alaska.

An image fusion concept will be considered using the color composite technique for visual identification of the ice and qualitatively evaluates image classification results. This technique assigns the visible and near infrared channels to the additive primary colors red, green and blue colors. Hence, near infrared channel will be assigned to the red and green channels whereas visible will be assigned to the blue channel.

We will provide end-users with two products; first, land masked RGB images where NWS managers can visually inspect river section and identify ice coverage. Second, the automatic approach that we have developed for the MODIS images will be adapted to classify VIIRS scenes and develop daily, running and weekly composites. Specifically, the running composite will be of great importance as it is meant to keep the latest cloud free observation.

PUBLICATIONS

Naira Chaouch, Marouane Temimi, Peter Romanov, Regina Cabrera, George Mckillop, Reza Khanbilvardi. (2012). An Automated Algorithm for the Monitoring of River Ice over the Susquehanna River Basin using MODIS data. Hydrological Processes. DOI: 10.1002/hyp.9548.

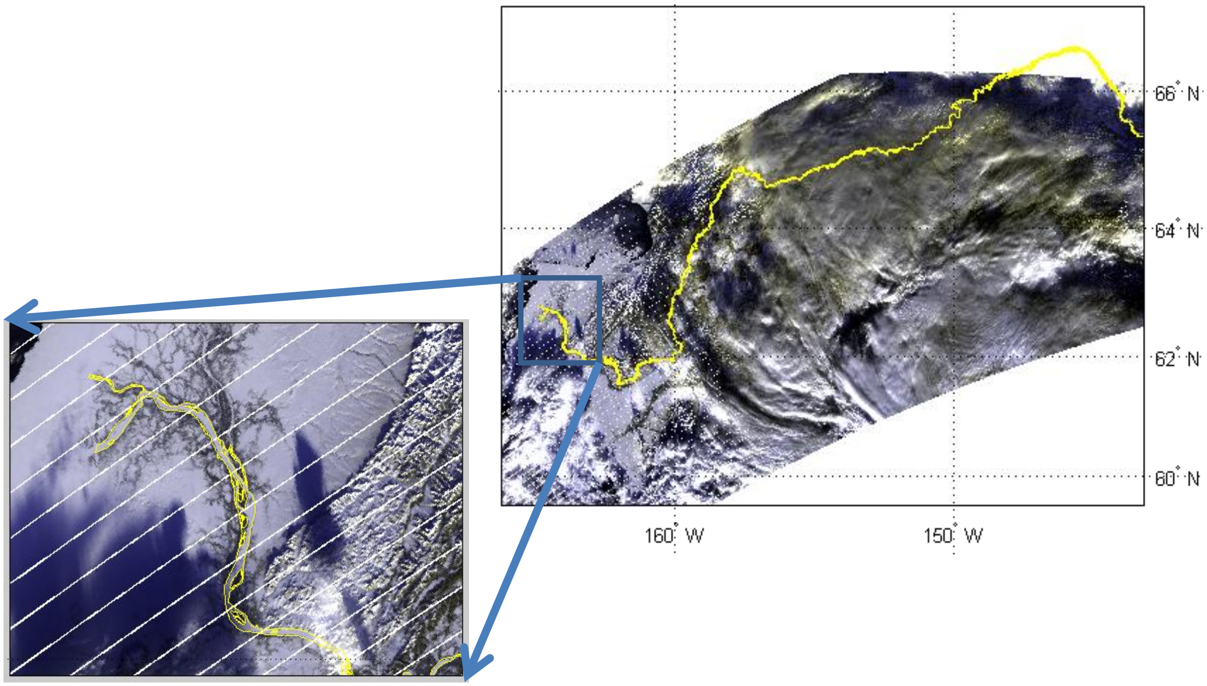


Figure1: *RGB VIIRS image of the Yukon River in Alaska acquired on 01/03/2013 showing ice presence on the river and its tributaries*

Performance Metrics	**FY12**
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	1
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	0

3.5 Earth System Monitoring from Space

- NOAA-CREST Land Emissivity Products From Passive Microwave Observations

Task Leader Dr. Marouane Temimi, NOAA-CREST
Task Code
Main CICS Research Topic Earth System Monitoring from Satellites
Percent contribution to CICS Themes Theme 2: 30%; Theme 3: 70%.
Percent contribution to NOAA Goals Goal 1: 20%; Goal 2: 80%

Highlight: NOAA-CREST scientists have developed a global land emissivity product from AMSR-E observations. The product is available at http://water.ccny.cuny.edu/research-product/emissivity/. The product addresses the effect of discrepancies between microwave and thermal temperatures in the retrieval of emissivity.

BACKGROUND
Passive microwave observations are routinely used to estimate rain rate, cloud liquid water, and total precipitable water. In order to have accurate estimations from microwave, the contribution of the surface should be accounted for. Over land, due to the complex interaction between the microwave signal and the soil surface, retrieval of land surface emissivity and other surface and subsurface parameters is not straightforward. Several microwave emissivity products from various microwave sensors have been proposed. However, lack of ground truth measurements makes the validation of these products difficult.

In addition, microwave remote sensing has a great potential in understanding the geophysical and atmospheric phenomena. To understand the atmospheric phenomena such as rain rate, cloud liquid water, and total precipitable water the contribution of the surface should be accounted and be removed from the microwave signal. On the other hand, to extract geophysical information such as snow, soil moisture, vegetation structure, and sea ice the effect of the atmosphere should be removed. Therefore disaggregating the effect of these two sources (i.e. atmosphere and the surface) is important, and directly using the brightness temperature in these applications without removing the effect of the other does not give accurate results. Over the ocean with approximately spatially homogeneous surface properties microwave radiation can be approximated more routinely. However, over land, the surface contribution depends on the vegetation type and water content, soil moisture, soil texture, and surface roughness. These properties are highly variable spatially over land, which makes the modeling of the passive microwave much more complicated than over ocean. This problem gets more complicated when the microwave information are used in atmospheric retrievals with strong emission by the land surface, and leaves smaller fraction for the atmosphere. Therefore, accurate estimation of the surface effect in shape of land surface emissivity is very crucial.

ACCOMPLISHMENTS

More than six years of land surface emissivity estimates from AMSR-E have been produced. The effect of penetration depth has been considered in these estimates using a novel idea of diurnal cycles of brightness temperatures. More detail of this product can be found at (Norouzi et al. 2012; Norouzi et al. 2011). The monthly estimates using monthly composite mean of instantaneous estimates are calculated and the product is currently available at NOAA-CREST website (at http://water.ccny.cuny.edu/research-product/emissivity/). The second portion of this study addresses the inter-comparison of different land surface emissivity products from various microwave sensors. The selected products are based on observations from the Advanced Microwave Scanning Radiometer for EOS (AMSR-E), the Special Sensor Microwave Imager (SSM/I), and TRMM Microwave Imager (TMI). The AMSR-E product is from our NOAA-CREST emissivity product, SSM/I product is provided by CNRS (Prigent et al. 2006; Prigent et al. 1997, 1998). TMI emissivity product is from Nagoya University (Furuzawa, personal communication 2012). In the retrieval of emissivities from these sensors different methods and ancillary data have been used. Some inherent discrepancies between the selected products can be introduced by as the difference in geometry in terms of incident angle, spectral response, and the foot print size which can affect the estimations. Moreover, ancillary data especially skin temperature and cloud mask cover can cause significant discrepancies between various estimations. The time series and correlation between emissivity maps are explored to assess the consistency of emissivity variations with geophysical variable such as snow, precipitation and drought. It's worth noting that the TMI product is limited to +/- 38 degree latitude as TMI sensor is not a sun-synchronous sensor.

For relatively smooth bare soils, land surface emissivity is smaller in horizontal polarization compared to vegetated areas in all products. For instance, in North Africa and Saudi Arabia, which are mostly dominated by bare soil and desert, a noticeably smaller emissivity can be seen compared to highly vegetated regions such as Amazon or Congo, which exhibit relatively larger emissivities. Generally, they show smaller emissivity values in arid and semi-arid regions (North Africa and Australian desert). This is also observed in Australia, where smaller emissivities are obtained in deserts, whereas the vegetated western coast shows larger horizontal emissivity values. The results at vertical polarization are the opposite, with the largest emissivity values found in desert areas. This behavior is due to the different response of horizontal and vertical polarization emissivities to the dielectric constant. Also, seasonal variation of emissivity has been seen at some places such as in Russia where emissivities show large differences in January and July with land and snow cover changes (not shown here).

To investigate the dynamics of emissivities and the relations between different emissivity products, we calculated the correlation between emissivity maps of pairs of products for six years. The highest correlations in six years are seen between AMSR-E and SSM/I products at all land classes and lowest correlation is between TMI and AMSR-E estimates.

A blended product that minimizes the differences among all products is proposed using an average of all products. This product might be useful for application that more than one sensor is considered such as soil moisture product from multiple sensors. An Example of this from AMSR-E

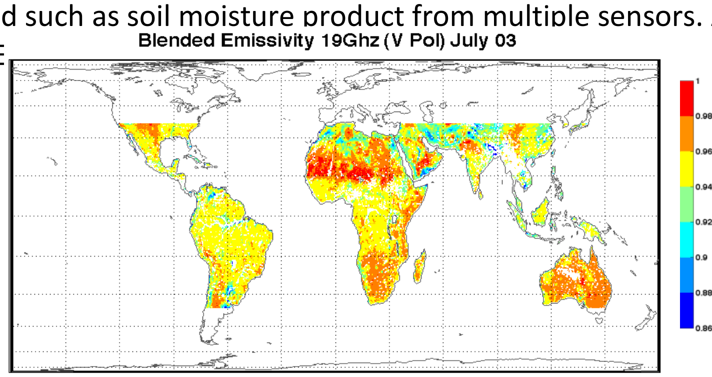


Figure 1: Blended emissivity product for 19 GHz Vertical polarization for July 2003

Performance Metrics	**FY12**
# of new or improved products developed	1
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	2
# of non-peered reviewed papers	0
# of invited presentations	1
# of graduate students supported by a CICS task	0
# of undergraduate students supported by a CICS task	0

PLANNED WORK

We intend to develop a statistically weighted global land emissivity product that merges observation from different sensors according to their sensitivity to land surface conditions. In addition, we will work on developing a model to interpolate between land emissivity values across different frequencies and angles values.

PUBLICATIONS

Norouzi, Temimi, et al. Intercomparison of global land surface emissivity products. IEEE Transactions (in preparation).

Hamidreza Norouzi, William Rossow, Marouane Temimi, Catherine Prigent, Marzieh Azarderakhsh, Sid Boukabara, Reza Khanbilvardi. (2012). Using microwave brightness temperature diurnal cycle to improve emissivity retrievals over land. Remote Sensing of Environment, Volume 123, August 2012, Pages 470-482.

Norouzi, H., Temimi, M., Rossow, W. B., Pearl, C., Azarderakhsh, M., and Khanbilvardi, R. (2011). The sensitivity of land emissivity estimates from AMSR-E at C and X bands to surface properties, Hydrol. Earth Syst. Sci., 15, 3577-3589, doi:10.5194/hess-15-3577-2011, 2011.

PRESENTATIONS

Norouzi, H., M. Temimi, W. Rossow, M. Azarderakhsh, R. Khanbilvardi, “Introduction to CREST Land Emissivity Product”, AMS Annual Meeting, New Orleans, Jan 2012.

Khanbilvardi, R., Temimi, M., McDonald, K., Lakhankar, T., Norouzi, H., “The NOAA CREST Microwave Observation Unit for the Monitoring of Soil Moisture and Snow in Northeastern U.S”, Hawaii, Jan 2012.

Norouzi, H., M. Temimi, W. Rossow, M. Azarderakhsh, R. Khanbilvardi, "Generating an Effective Temperature To Improve Microwave Land Surface Emissivity Retrievals", AGU Fall meeting, San Francisco, CA, 2012.

- Assessment of assimilating NPP/JPSS ATMS land surface sensitive observations in the NOAA data assimilation system

Task Leader Dr. Marouane Temimi, NOAA-CREST
Task Code
Main CICS Research Topic Earth System Monitoring from Satellites
Percent contribution to CICS Themes Theme 2: 30%; Theme 3: 70%.
Percent contribution to NOAA Goals Goal 1: 20%; Goal 2: 80%

Highlight: NOAA-CREST scientists run several simulations with the NOAA NCEP GFS to assess the assimilation of window channels microwave observation from the recent ATMS sensor.

BACKGROUND

The latest GSI was implemented into the existing NOAA/NCEP forecast system in 2007. The new system formulates the analysis in a new grid point system which offers more flexibility to the operational global data assimilation system (GDAS) as well as to regionals systems (Kleist et al., 2009). A new hybrid version is scheduled to be implemented operationally in the spring of 2012. This version combines Ensemble Kalman filter approach for the dynamic covariance matrices, and the variational assimilation (EnKF/Var).

The new version has provided a noticeable improvement in the performance of the system particularly with respect to the quality of short-term forecast. However, assuming that the resolution of the system is high enough to properly define the boundary condition layer, parameters at/near the surface have never been assimilated. The current NCEP GSI system does not include any near-surface model (Lee et al., 2011). As it was pointed out by various researchers further improvements are still to be done in order to achieve higher level of performance.

Since the implementation of the new GSI based version o the NCEP forecast system, various studies have addressed the integration of surface parameters in the NCEP operational observation database to improve the quality of the forecasts. Recently, Bi et al. (2011) assimilated ASCAT surface wind retrieval in the NCEP GSI 3D-VAR system.

This study assesses the impact of assimilating near-surface radiances in the Global Forecast System (GFS). Particular attention was given to the newly deployed ATMS window channels and their impacts on the forecast skills.

ACCOMPLISHMENTS

The primary objective of assimilating surface-sensitive ATMS radiances over land into NOAA's data assimilation suit is to improve forecast skills. Recent studies indicate that, forecast skills are further improved by assimilating surface-sensitive radiances in numerical weather prediction (e.g. Karbou et al., 2006; Gerard et al., 2010).

From august 2012 to February 2013, the satellite data assimilation team at the NOAA CREST Institute worked on the assessment of the performance of the NCEP NWP model when observations from the NPP ATMS sensors are assimilated. We used the Hybrid-GDAS (EnKF filter with 3D VAR) with T574L64 (~25 km) resolution for the test runs on the S4 platform (JCSDA's computer system). Moreover, the DTC (Developmental Testbed Community) version of GSI was download and run successfully on our own platform. An emphasis however is placed on the S4 hosted version to run tests. Each test run contains an 'Experimental' and 'control' run. The 'Experimental' runs were GFS runs with all ATMS channels except channel 15 on whereas the 'Control' runs were GFS runs without the ATMS channels. Both 'Experimental' and 'Control' runs share the same observation and satellite measurement data sets (including AIRIS, IASI, GPSRO, SBUV/2 OZONE, GOME OZONE, GOES SOUNDER, GOES IMAGER, AVHRR and radar data) other than ATMS channels. Moreover the 'Experimental' and 'Control' runs share the same initial static files. Using these input data and initial static files, the model simulates the different atmospheric and surface profile fields.

We assessed the improvement in the forecast of extreme events like major hurricane and the prediction of their tracks. Amongst others, simulations for Hurricane Isaac and Hurricane Sandy cases have been conducted (Table 1). Although, these simulations have been completed successfully, the assimilated ATMS channels seem to have neutral effect (Figure 1). An in-depth analysis of the obtained results is necessary to assess the exact impact of assimilating ATMS channels.

The overall assessment was based on evaluating the spatial distribution of atmospheric parameters, such as geopotential height, wind speed and relative humidity at different pressure levels. Statistical error analysis such as ACC (Anomaly Correlation Coefficient), CC (Correlation Coefficient) and BIAS were also used to compare the 'Experimental' against the 'Control' run. These results were evaluated for different regions of the world (Northern Hemisphere, Southern Hemisphere, Global, and Pacific and North America). The VSDB analysis tool, developed at NCEP was used to plot and analyze the comparison between the 'Experimental' and 'Control' runs. There are several versions of VSDB analysis tool available on the S4 system. Version 10 is tested and worked across different platforms (e.g. S4, Jibb and Zues), and hence we used this version for our validation work.

Depending on the out come of a recently submitted proposal to the JCSDA, we will further continue our studies on the impact of assimilating surface sensitive microwave channels in the GFS.
A summary of the recent results was presented at the last 10th workshop of JCSDA on Satellite Data Assimilation. NOAA CREST scientists have been regularly participating in

the Global Assessment of Advanced satellite Data Assimilation (GAADA) meetings and teleconferences.

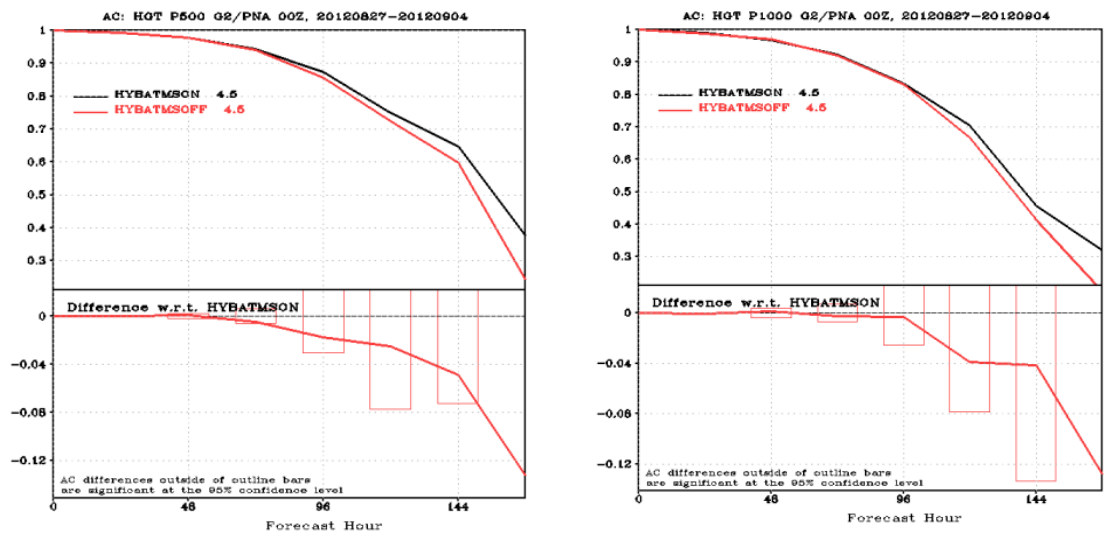


Figure 6 Anomaly correlation maps for Hurricane Isaac at 500 and 700 hPa pressure levels. The black lines are the experimental runs and the red lines are the experimental runs.

*Table 2 Test Runs for assimilating ATMS channels into the Hybrid-GDAS. The first two tests were conducted to lean how the Hybrid-GADS system works. *TESTs were runs to check how the hybrid_GDAS/GFS works.*

Name of Exp.	Version of HYBRID GSI	Specifics	STDATE	EDATE	REMARK
TEST1	DTC	TEST*	20111003	20111010	NO ATMS
TEST2	NCEP	TEST*	20120204	20120211	NO RESULT
TEST3	JCSDA		20120825	20120904	H. ISAAC
TEST4	JCSDA		20120204	20120211	
TEST5	JCSDA		20121026	20121103	H. SANDY

Performance Metrics	FY12
# of new or improved products developed	0
# of products or techniques transitioned from research to ops	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	1
# of graduate students supported by a CICS task	N/A
# of undergraduate students supported by a CICS task	0

PLANNED WORK

In subsequent steps we propose improving brightness temperature simulation in desert areas and accounting for the difference in the phase and amplitude of the diurnal cycles of the LST and the simulated microwave temperatures. Assuming that LST and microwave temperatures are perfectly in sync may lead to biases in Tb and therefore to the rejection of assimilated satellite brightness temperatures. This will build upon our previous findings using window channels onboard AMSR-E. We will place a particular focus on northern regions where soil alternates frequently between frozen and thawed states. The advent of new missions like SMAP (P-I of the freeze/thaw product: K. McDonald) will allow for better monitoring of the soil moisture phase (liquid or frozen). Information on freeze/thaw state and the extent of frozen ground will be assimilated using a simplified EnKF in the GFS through a coupling with the Noah land surface model. The impact of the proposed improvements will be assessed using observations from ATMS and AMSU-A window channels, available from the NOAA-CREST Satellite Receiving Station.

PRESENTATIONS

Kibrewossen Tesfagiorgis, Marouane Temimi, Hamidreza Norouzi, Sid Boukabara, Al Powel, Reza Khanbilvardi (2012): Assessment of assimilating NPP/JPSS ATMS land surface sensitive observations in the NOAA data assimilation system. 10th JCSDA Workshop on Satellite Data Assimilation, College Park, MD. Oct 10-12, 2012**.**

3.6 Education, Literacy, and Outreach

- CUNY High School Weather Camp

Task Leader Brian Vant-Hull
Task Code CUNY
Main CICS Research Topic Outreach
Percent contribution to CICS Themes
Percent contribution to NOAA Goals Goal 2: 100%

Highlight: Seven High school Students spent two weeks intensively studying weather and climate using hands-on activities. The first week was on the campus of the City University of New York, the second week was at the NWS office on Long Island

Background
This high school summer weather camp has been running since 2009 in partnership with the local National Weather Service office on Long Island. The goal is to provide in depth exposure to meteorology/climatology to between 6 and 15 students a year, selected by application. The first week is a day camp on the campus of the City College of New York featuring discussions, hands-on demonstrations, and presentations by specialists in various fields. The second week moves to Long Island to be near the NWS office at Brookhaven. Camping in the local state park gets the largely city raised teenagers directly into the environment they are studying, with daily visits to the NWS office for lectures, demonstrations, and field observations. A night is spent in a hotel for access to a conference room with a career seminar.

Early Career Summer Exchange Program
In Summer 2012, Juan Pinales visited Earth System Research Laboratory (ESRP) during the week of July 30, 2012 to August 4, 2012. ESRL located in the David Skaggs Research Center in Boulder, Colorado. The goal of my visit was to become familiar with the ESRL Global Monitoring Division's Carbon Cycle Greenhouse Gases Group (CCGG), which is dedicated to the analysis, characterization, and modeling of the emissions of greenhouse gases commonly associated with the carbon cycle.

During his visit, Juan was introduced to CCGG members, Drs. John Miller and Lori Bruhwiler. During our meeting, they explained the broad underpinnings of the group's approach. Aggregating measurements from discrete sampling networks, on-site long-term observatories, aircraft-based campaigns, as well as satellite data, the group attempts to improve current understanding on the effect that compounds like CO_2, CO, H_2, N_2O, and specifically CH_4 have on the composition of the atmosphere, and how said changes result in seasonal variability in the biogeochemical cycles that affect ecosystems at the local, regional, and global scales. Ideally, the approach of the group consists of the utilization of data assimilation and inverse modeling techniques to determine the emitters or reservoirs from which the gases originate based on measurements of atmospheric concentrations and the behavior of the winds. However, forward modeling, can also be utilized to improve upon the estimates of concentration. Utilizing what are called “first-guesses”, i.e., input estimates or known quantities based on the system’s previous behavior, it is possible to predict the sources and/or sinks responsible for these methane concentrations/fluxes in the atmosphere. Once these initial concentrations are inputted, physical models involving atmospheric physics, chemistry, and meteorology are used to predict the behavior of the winds and other atmospheric transportation systems.

Juan was also introduced to another model for the characterization of methane emissions called the Kaplan-LPJ model. This model is a simpler parameterization of the emissions of methane based on the input of static GIS data sets that represent the following variables: labile carbon content, maximum wetland extent, surface air and soil T, as well as soil moisture. Knowing that natural wetlands are the single biggest sources of methane, the Kaplan-LPJ model works to characterize methane emissions on a global scale as the summation of the atmospheric release of methane produced by these ecosystems. The scheme bins global wetlands into two categories: floodplains (generally found in the tropics and temperate climates) and peatlands (generally found in temperate to boreal climates). Tropical wetlands are created, expanded, or otherwise altered as a result of the seasonal flooding that occurs in these regions, resulting in high interannual variability in the area occupied by these ecosystems. These changes in the surface inundation levels cause a spike in the regional and global atmospheric distribution of methane because the increased water content in the ground creates highly favorable (anoxic) conditions for the production of methane. On the other hand, peatlands are more seasonally stable ecosystems, having a constant cycle of high wetland extent during the summer period, with a reduced presence during the winter months. Because of the purported lack of sudden shifts in surface inundation and temperature, peatlands generally tend to be seen as quantitatively smaller sources of methane than their tropical counterparts. In other words, boreal wetlands tend to have a more constant surface inundation and water table depth during the more biogeochemically conducive months, resulting in methane emissions of lesser magnitude stretched over a longer period of time. Understanding these two types of ecosystems, we can determine the surface state variables upon which methane production is dependent. The model does have some limitations. For instance, it is spatially static, i.e., it assumes that over time there is no significant change in parameters like surface water fraction. The introduction of datasets of the surface inundation fraction with higher spatial and temporal resolution would give a better picture of what the behavior of global wetlands during their methane producing seasons.

Finally to conclude Juan also learned about interpolation, regridding, and some other useful techniques of data manipulation techniques. All in all, he found this exchange a very satisfactory experience. Juan intends to visit ESRL again in Summer 2013 to continue his Experiential research opportunities with John Miller and his team. Juan will graduate this summer and plan on continuing his doctoral research as CREST fellow.

Annual Colloquium: Due to budget constraints – the Annual CoRP symposium was cancelled in Sumer 2012. However, it is being proposed to organize the symposium in summer 2014 in CIMSS, Wisconsin. CREST plans on sending a few graduate and post-doctoral scientist to this even I summer 2014.

3.7 Climate and Satellite Observations and Monitoring

- NOAA CREST Satellite Receiving Station Upgrade

Task Leader **Dr. Reza Khanbilvardi**
Main CREST Research Topic **Climate and Satellite Observations and Monitoring**
Highlight: CREST scientists developed and implemented a new tools and approaches to various climatic and environmental topics with the use of satellite remote sensing products from polar and geostationary satellites.

BACKGROUND
The Center's research and training focuses on all aspects of remote sensing including: sensor development, satellite remote sensing, ground-based field measurements, data processing and analysis, modeling, and forecasting. The center's research is primarily remote sensing of the earth. This is aided by data from polar and geostationary satellites from NOAA and NASA.

CREST Satellite Receiving Station (SRS) consists of two separate antennas and direct broadcast acquisition systems. Data types that can be received and processed are from X-band transmitting polar orbiting satellites, Terra and Aqua, both equipped with Moderate Resolution Imaging Spectroradiometer MODIS instruments, and L-band data from the geostationary (GEOS-12, GOES-13) satellite. The Receiving Station is tasked with acquisition, processing and storage of all data products generated from both antennas.

To enhance CREST Research as well as meet NOAA Goals and objective, Data is very vital and important. NASA in collaboration with NOAA and other agencies recently launched the Suomi National Polar-orbiting Partnership Spacecraft with is part of NASA's Earth Observing System (EOS). Satellites such as Terra and Aqua carry the MODIS Instrument are also part of the EOS program that provide scientist with critical data about the earth including clouds, oceans, vegetation, ice, and atmosphere

Suomi NPP as it is called is the next generation satellite system to replace the current EOS fleet (Terra and Aqua) as they are slowly phased-out and retired. Suomi NPP will carry a suite of different instruments to help scientists at CREST. Instruments such as the Advanced Technology Microwave Sounder (ATMS), the Cross-track Infrared Sounder (CrIS), the Ozone Mapping and Profiler Suite (OMPS), the Visible Infrared Imaging Radiometer Suite (VIIRS), and Clouds and the Earth's Radiant Energy System (CERES) will help scientist to monitor the earth's different characteristics as well as provide improvements for both short and long term forecasting.

SCOPE OF WORK

The scope of work is to upgrade the current capabilities of the CREST SRS to acquire data from Suomi NPP Spacecraft. This requires upgrades to both hardware and software components of the SRS Antenna and processing units.

This requires the installation of an X Band receiver module, CDA Frame sync and cabling. The installation of a new processing machine is also required to handle the large amount of data generated during both MODIS, NPP pass across New York region. It is estimated processing
and storage space required to be about 1TB.(3 Day NPP CSPP Pass gives 50GB per pass, 4 passes per day = 600GB. Additional Operating System, TerraScan and Userspace is about 400GB)

The Software upgrades requires an upgrade to the current TerraScan Software license and software used for the acquisition of MODIS. CREST currently runs software version 3.2 which needs to be upgraded to version 4. A Linux operating system upgrade is also required.

PROGRESS REPORT

SeaSpace Inc., has been notified about upgrades to our existing infrastructure. We have face a lot of difficulty in the last few month because of HURRICANE SANDY. The Satellite Receiving Station sustained heavy damage as a result.

The team at CREST in collaboration with SeaSpace engineers is currently in the process of repairing the damages and brings both X Band and L-Band Antennas to operational mode before the upgrades can commence.

The repairs are still on-going as the location of the antennas is on the roof of the NAC Building at the City College of New York. Repairs remain slow due to in-consistent winter weather on the eastern coast of the U.S but should be complete by the end of March 2013.