Monitoring the observations impact in the short-range forecast

Carla Cardinali

Many Thanks
Mohamed Dahoui, Anne Fouilloux, Alan Geer, Fernando Prates, Tony McNally, Giovanna De Chiara and Peter Bauer

Forecast sensitivity to observation: Equations

J_e is a measure of the forecast error e.g Energ

$$\frac{\partial J_e}{\partial \mathbf{y}} = \frac{\partial \mathbf{x}_a}{\partial \mathbf{y}} \frac{\partial J_e}{\partial \mathbf{x}_a}$$

$$\frac{\partial J_e}{\partial \mathbf{x}_a}$$

Forecast error sensitivity to the analysis
Rabier F, *et al*. 1996
2nd order SG

$$\frac{\partial \mathbf{x}_a}{\partial \mathbf{y}} = \mathbf{K}^T = \mathbf{R}^{-1}\mathbf{H}(\mathbf{B}^{-1} + \mathbf{H}^T\mathbf{R}^{-1}\mathbf{H})^{-1}$$

Cardinali et al 2004, Lupu&Gauthier 2010

+

$$\frac{\partial J_e}{\partial \mathbf{y}} = \mathbf{R}^{-1}\mathbf{H}\mathbf{A}\frac{\partial J_e}{\partial \mathbf{x}_a}$$

Linear System Solver

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Computing the Forecast Error Contribution **δ**J or FEC

$$< \frac{\partial J_e}{\partial \mathbf{x}_a}, \delta \mathbf{x}_a > = < \frac{\partial J_e}{\partial \mathbf{x}_a}, \mathbf{x}_a - \mathbf{x}_b > = < \frac{\partial J_e}{\partial \mathbf{x}_a}, \mathbf{K}(\mathbf{y} - \mathbf{H}\mathbf{x}_b) > = < \mathbf{K}^T \frac{\partial J_e}{\partial \mathbf{x}_a}, (\mathbf{y} - \mathbf{H}\mathbf{x}_b) > = < \frac{\partial J_e}{\partial \mathbf{y}}, \delta \mathbf{y} >$$

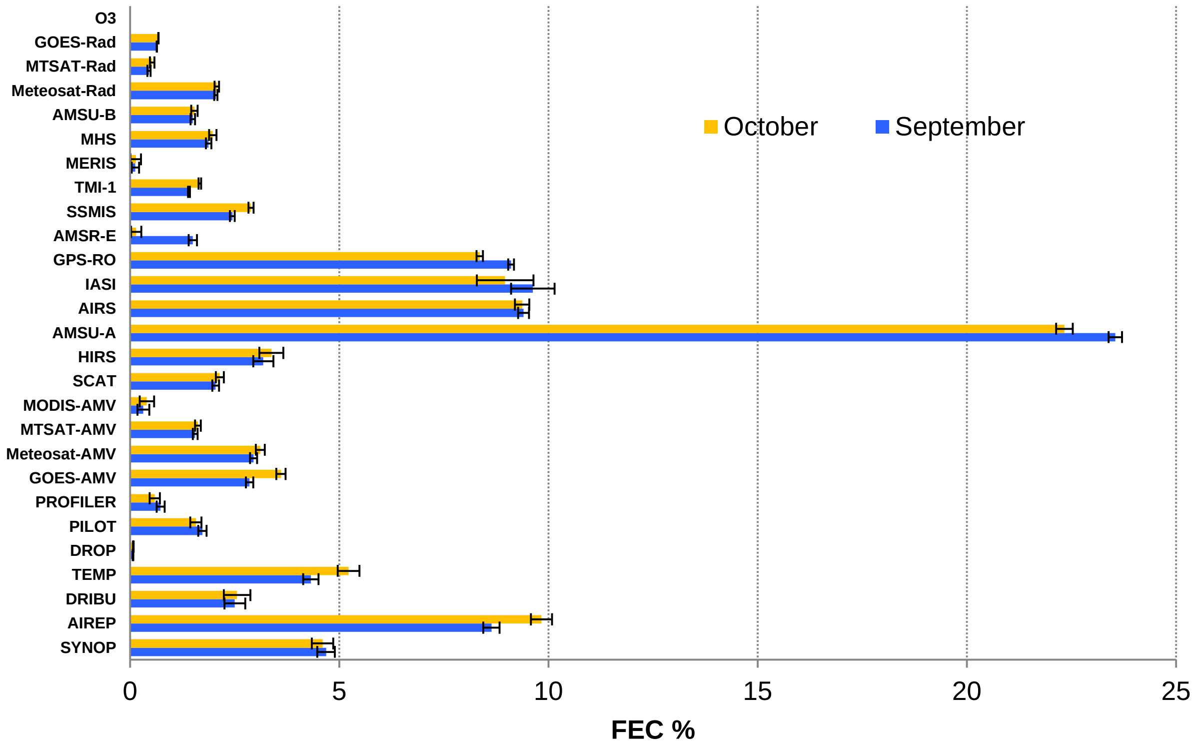
$$\delta J_e = \frac{\partial J_e}{\partial \mathbf{y}}(\mathbf{y} - \mathbf{H}\mathbf{x}_b)$$

Langland&Baker 2004, Zhu&Gelaro 2008, Cardinali 2009

Monitoring the satellite data impact in the 24 h forecast: Global impact of the Observing System September&October

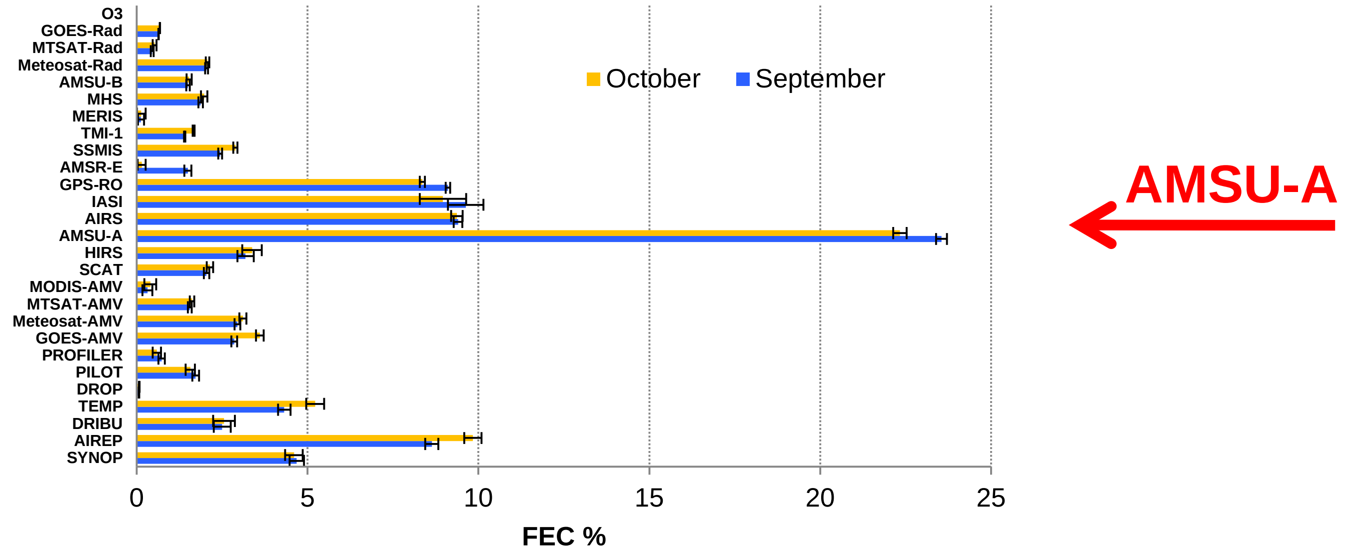
- Forecast sensitivity tool computes the ***variation of forecast error*** due to the assimilated observations
  - ***Positive variation*** means ***forecast error increase***
  - ***Negative variation*** means ***forecast error decrease***
- Forecast error is ***Forecast-Analysis*** → Analysis is a proxy for ***Truth***
- ***Bias*** in the ***Verifying Analysis*** can ***mask*** the observation impact
- ***Linearity assumption*** must be applied therefore only ***24 or 48*** hour forecast can be examined
- ***Interpretation*** of forecast improvement or degradation as depicted by the tool is ***Necessary***

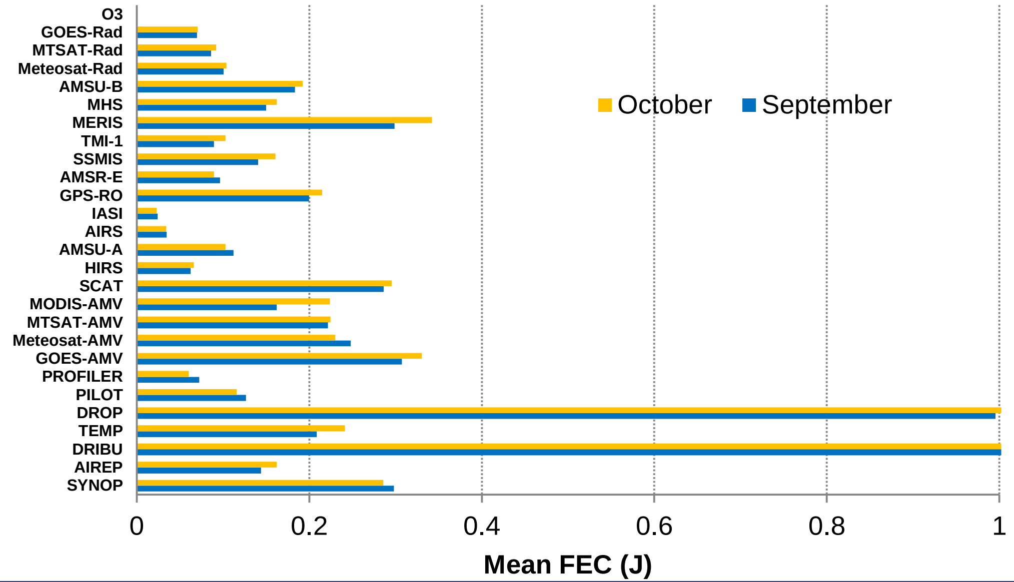
Monitoring the satellite data impact in the 24 h forecast: Global impact of the Observing System September&October



Forecast Error **Assimilation System Adjoint** **Observation Departure**

Monitoring the satellite data impact in the 24 h forecast: Global impact of the Observing System September&October

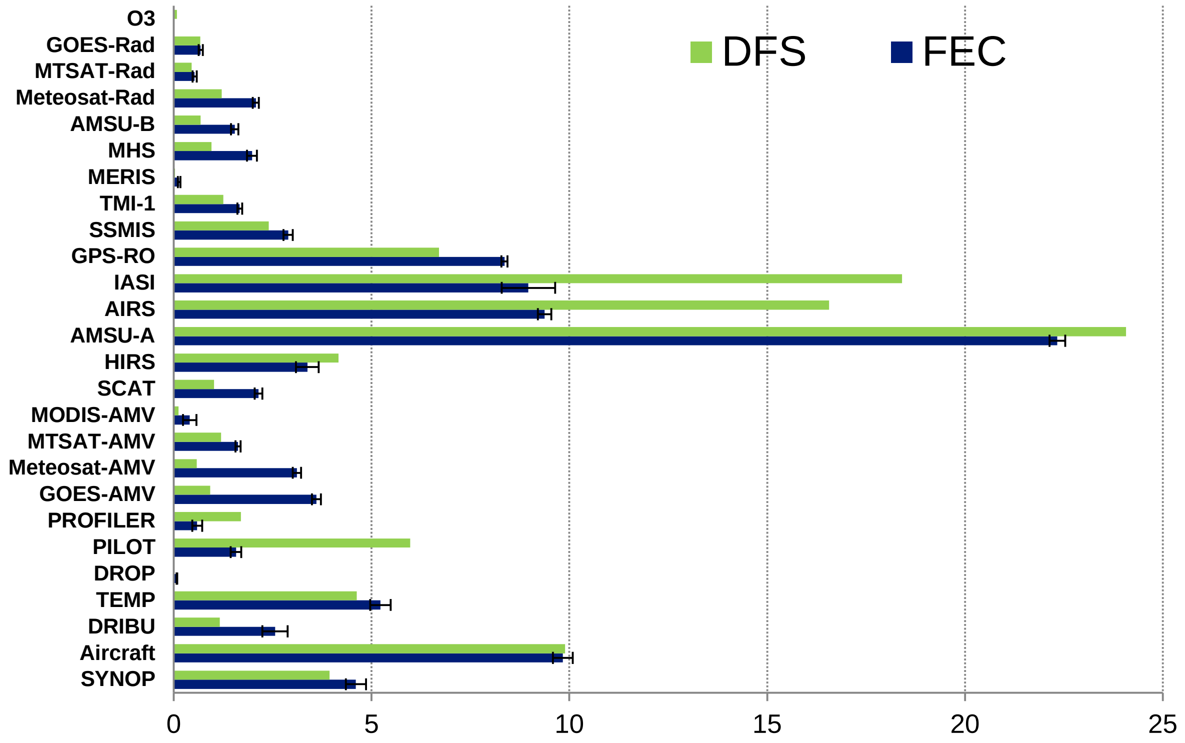




ECMWF

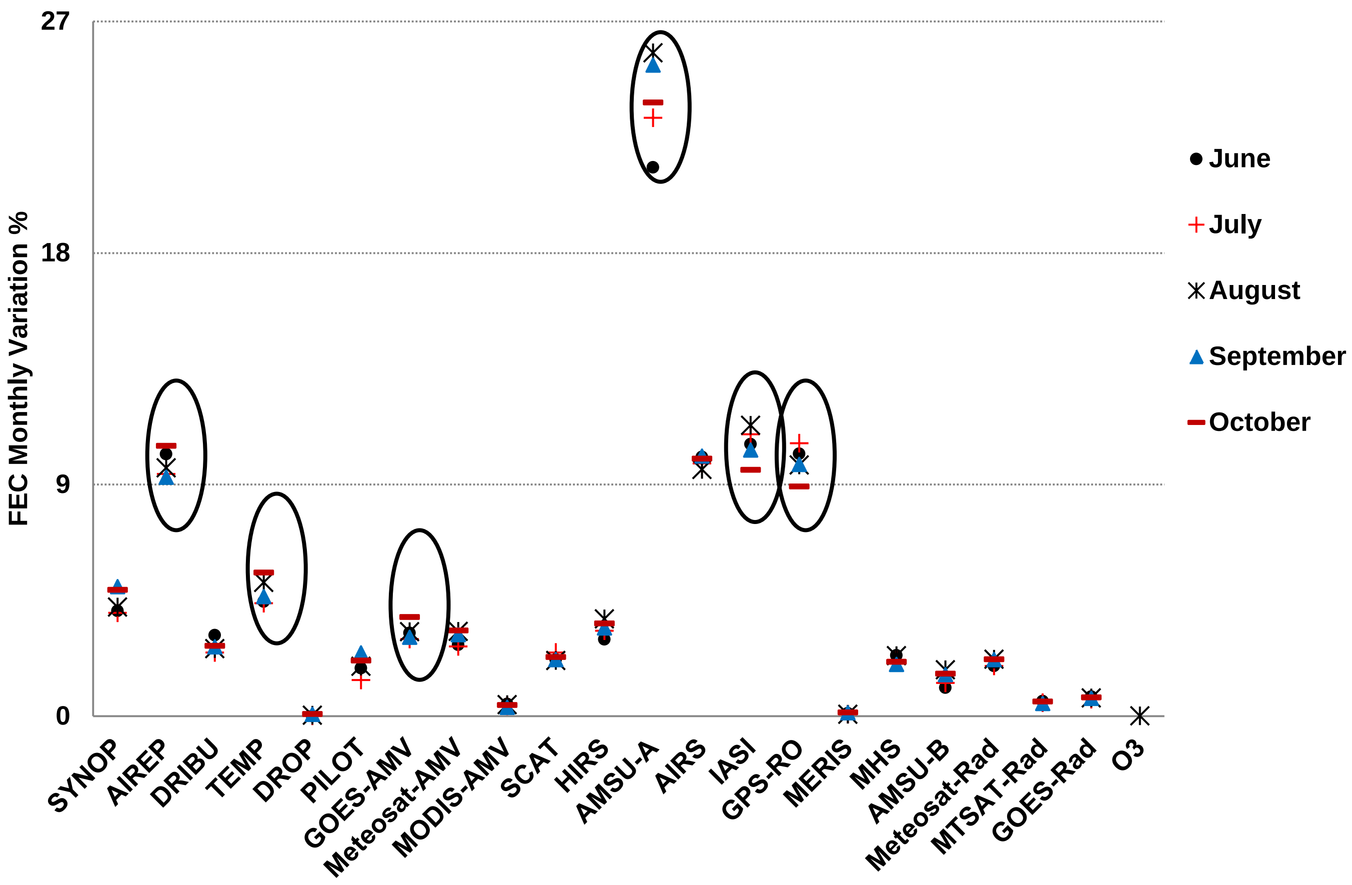
DFS and FEC October 2011

●Forecast sensitivity tool computes the ***variation of forecast error*** due to the assimilated observations: **Forecast Error Contribution FEC** → **K^T,FcE,d**



●**Degree** of **Freedom** for **Signal DFS** quantifies the number of statistically independent directions constrained by each observation. The average can be expressed as **Observation Influence OI** → **K^T**

FEC monthly variation



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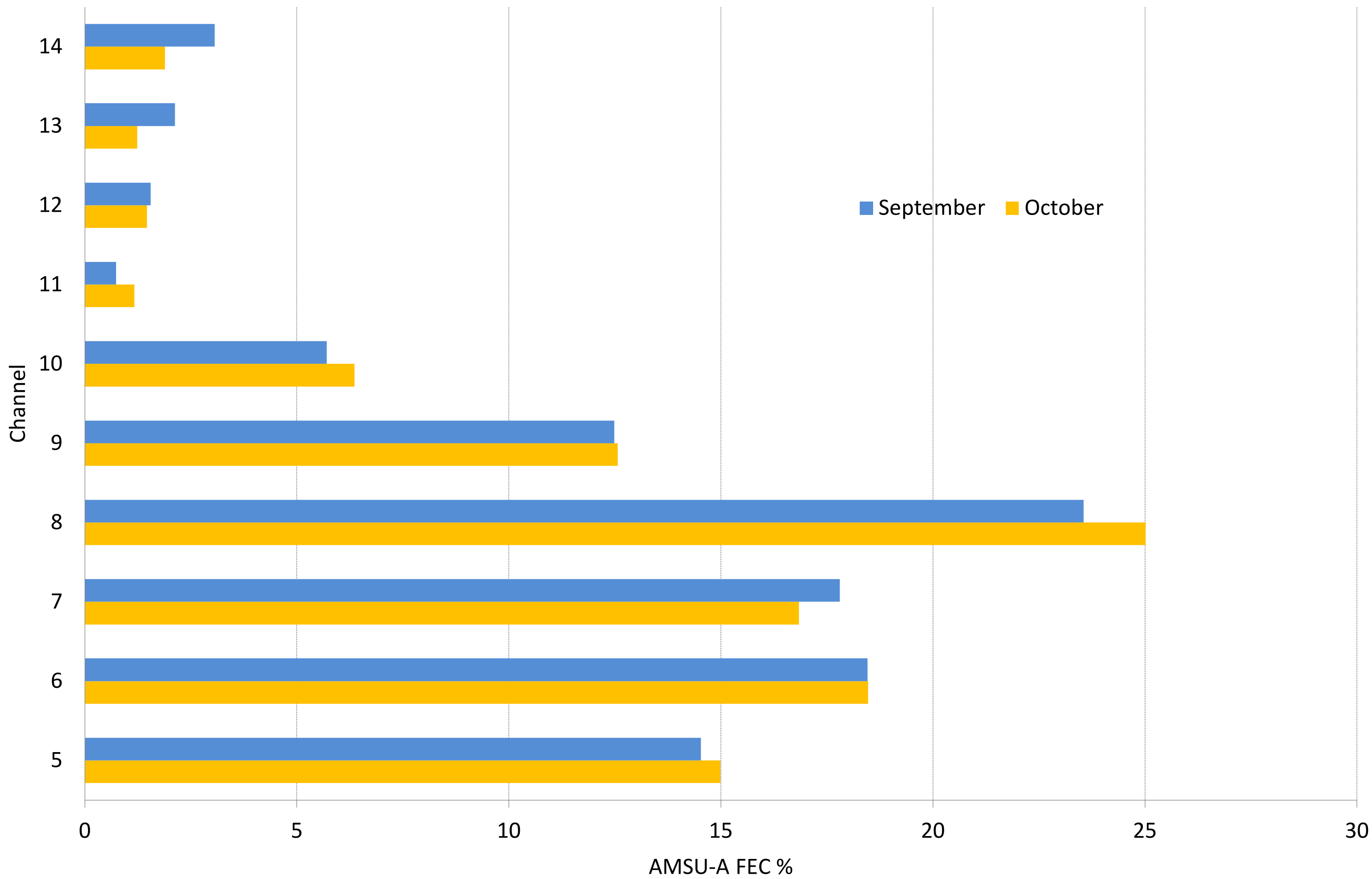
Global AMSU-A forecast impact by Channel



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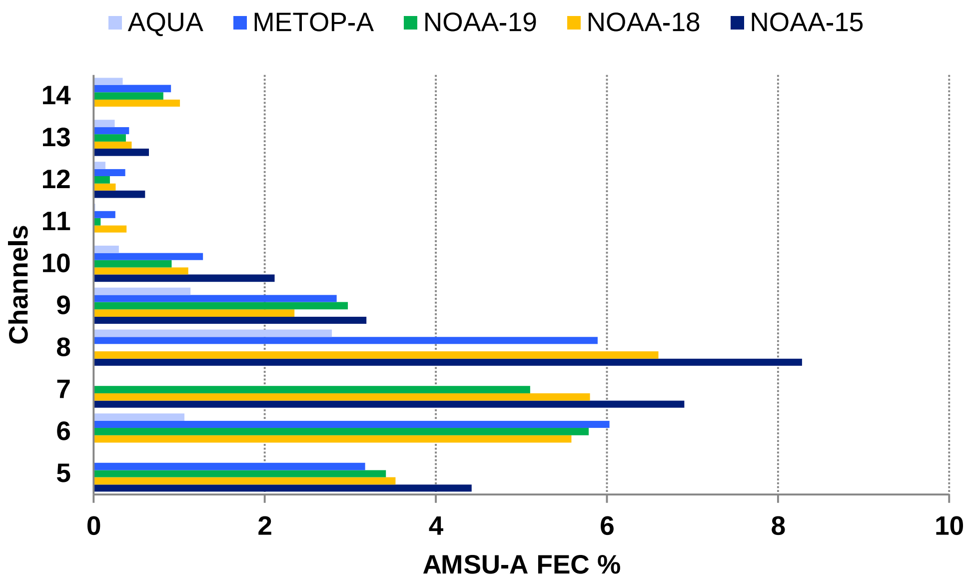
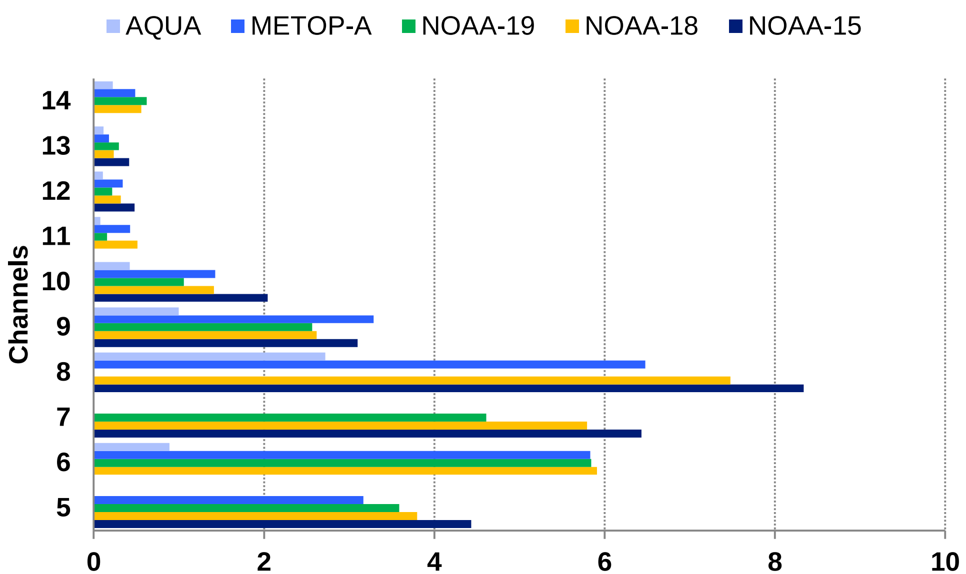
Global AMSU-A forecast impact by Satellite and Channel

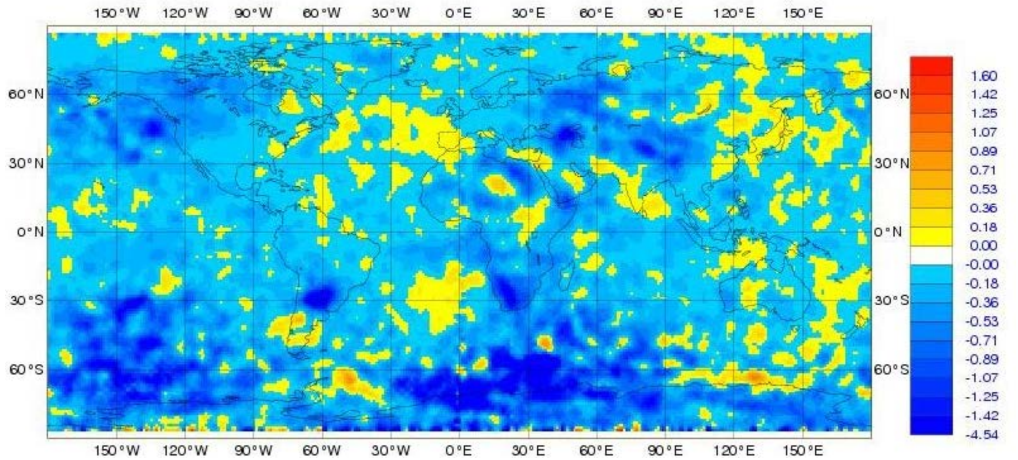


September



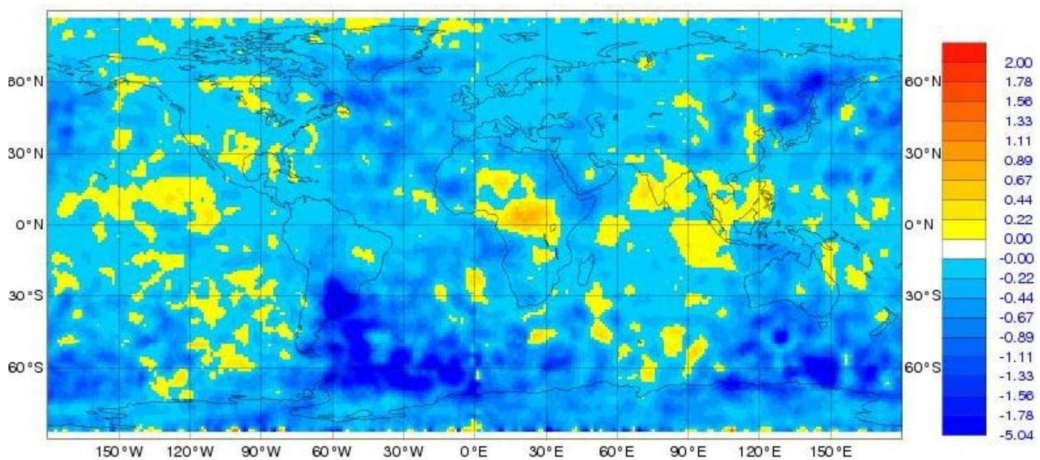
October

AMSU-A Ch8 forecast impact September&October 2011: Geographical mean forecast impact pattern (J)



METOP-A

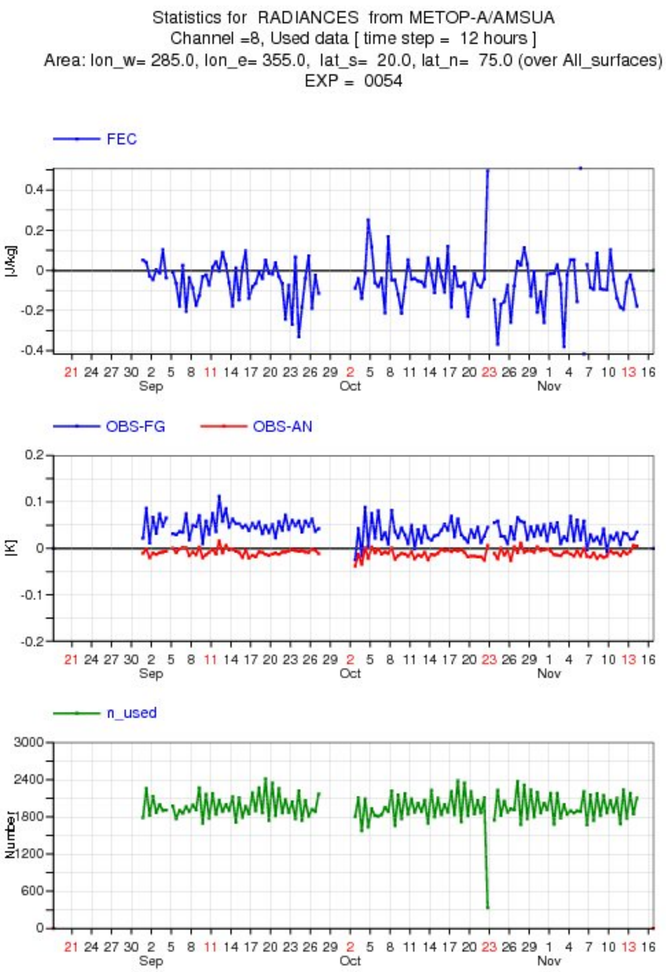
Min=-4.5, Max=2.3, Mean=-0.3

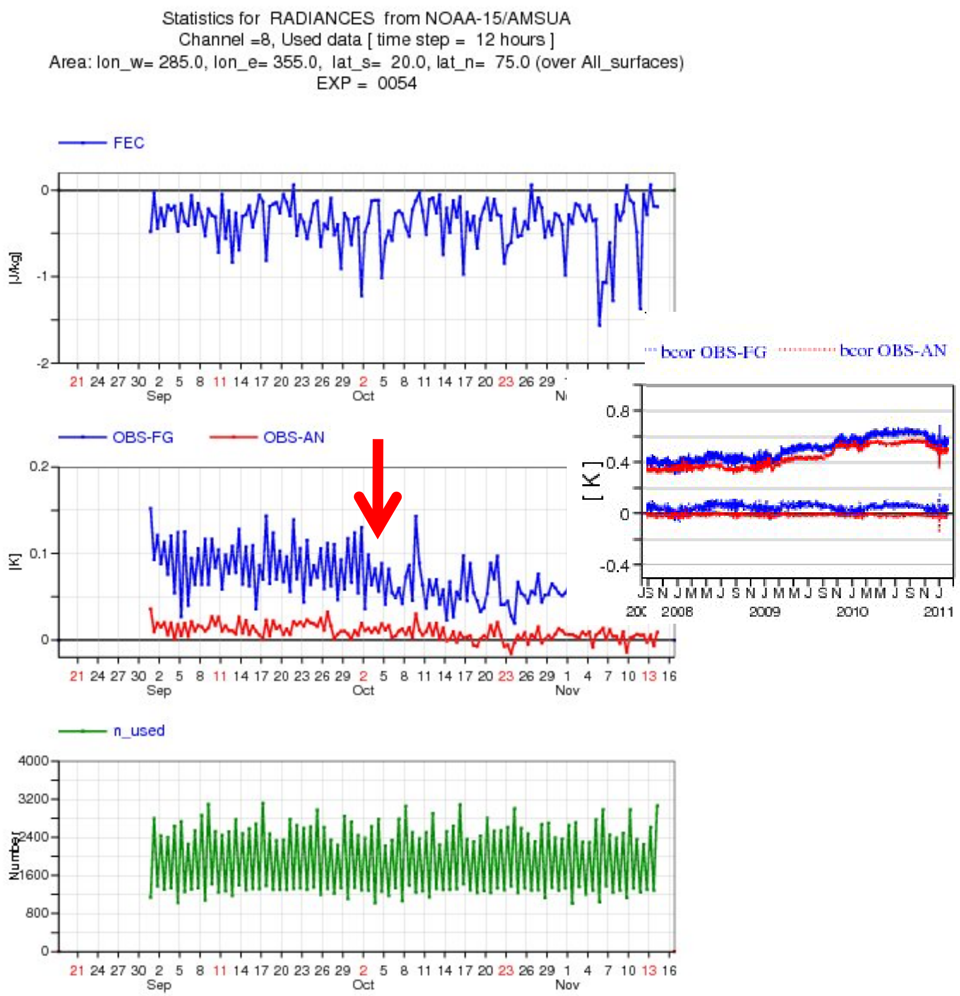


NOAA 15

Min=-5.0, Max=2.0, Mean=-0.3

AMSU-A ch8 Time Series forecast impact over N. Atlantic





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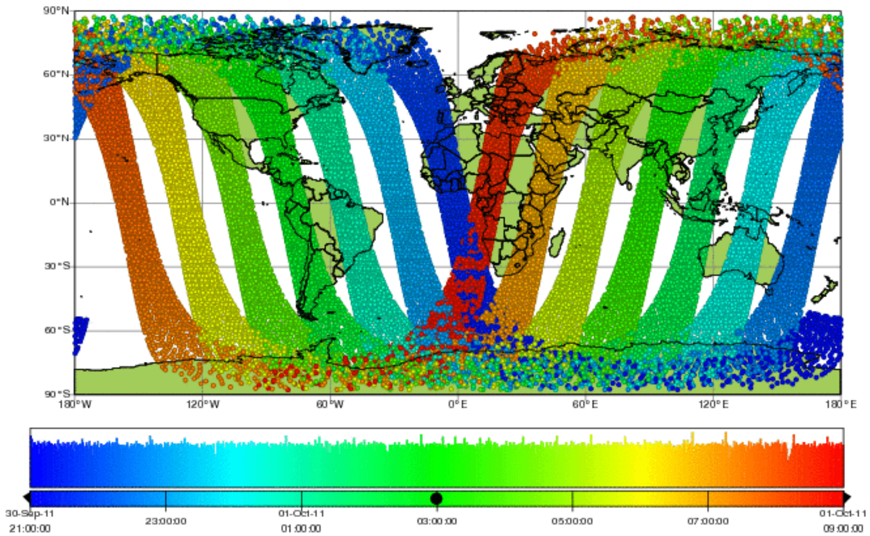
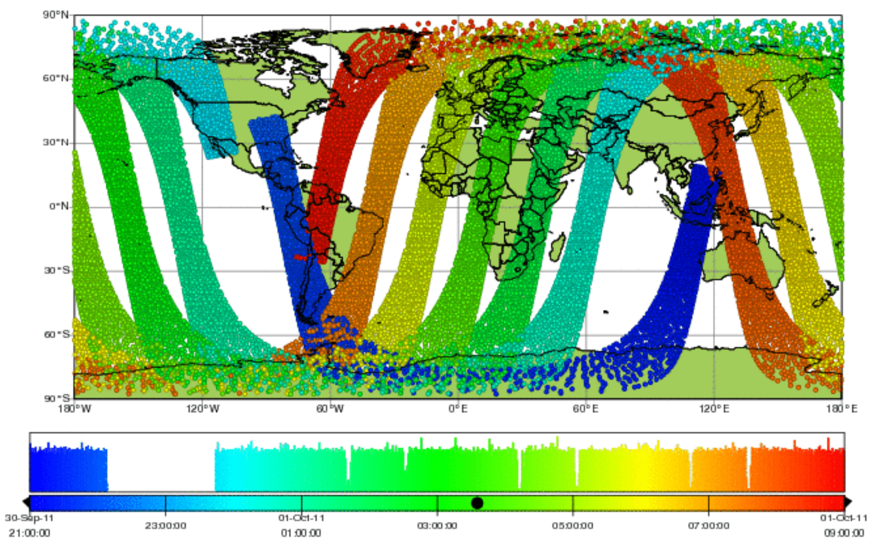
AMSU-A METOP-A versus NOAA-15 orbit over the Atlantic



METOP-A

Observing the Atlantic
at the begin of 4D-Var Window

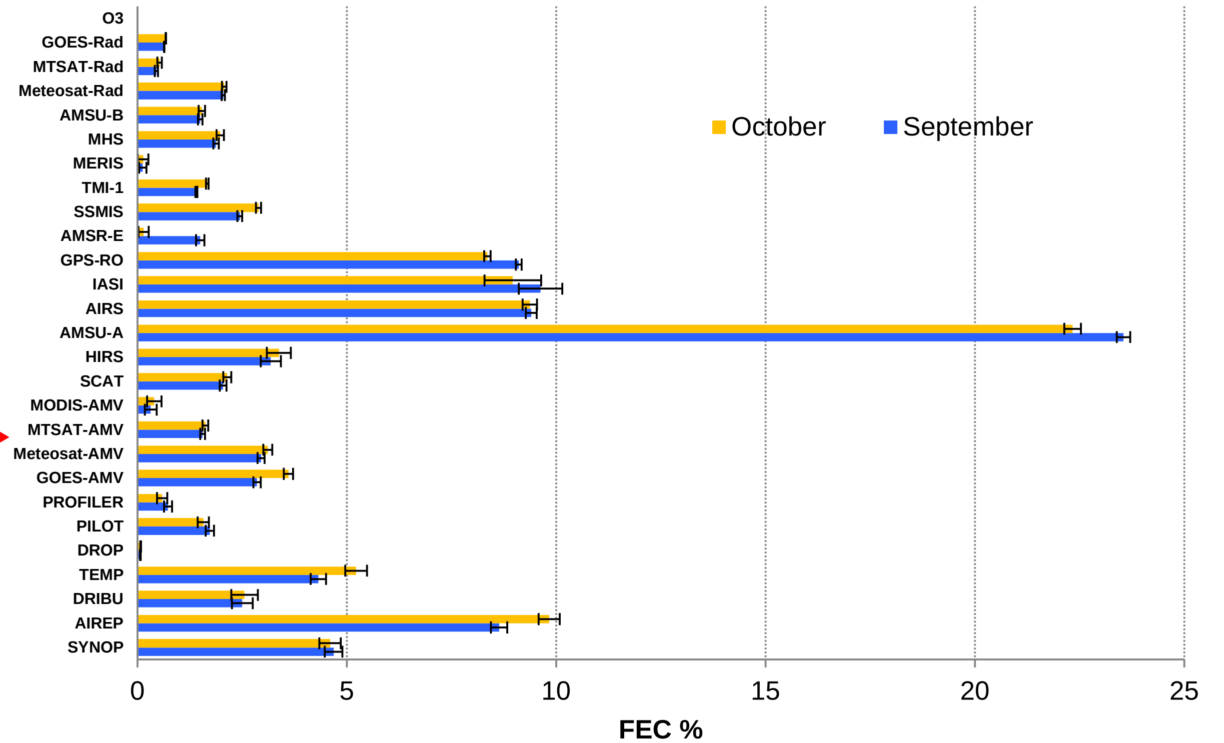


NOAA-15

Observing the Atlantic
at the end of 4D-Var Window

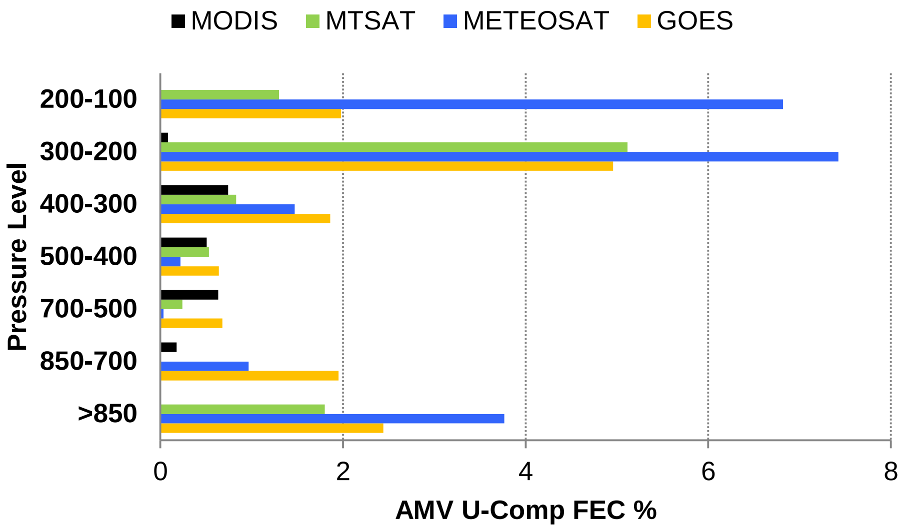
Monitoring the satellite data impact in the 24 h forecast: Global impact of the Observing System September&October

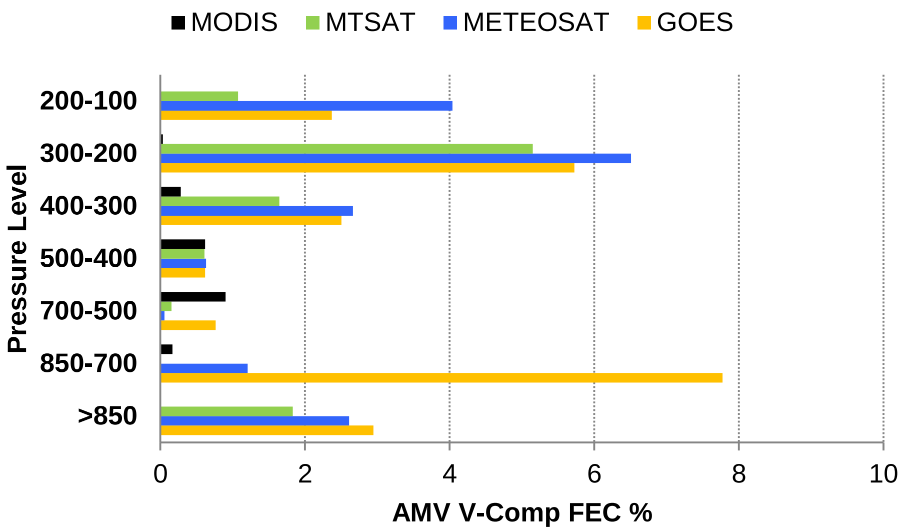
AMV



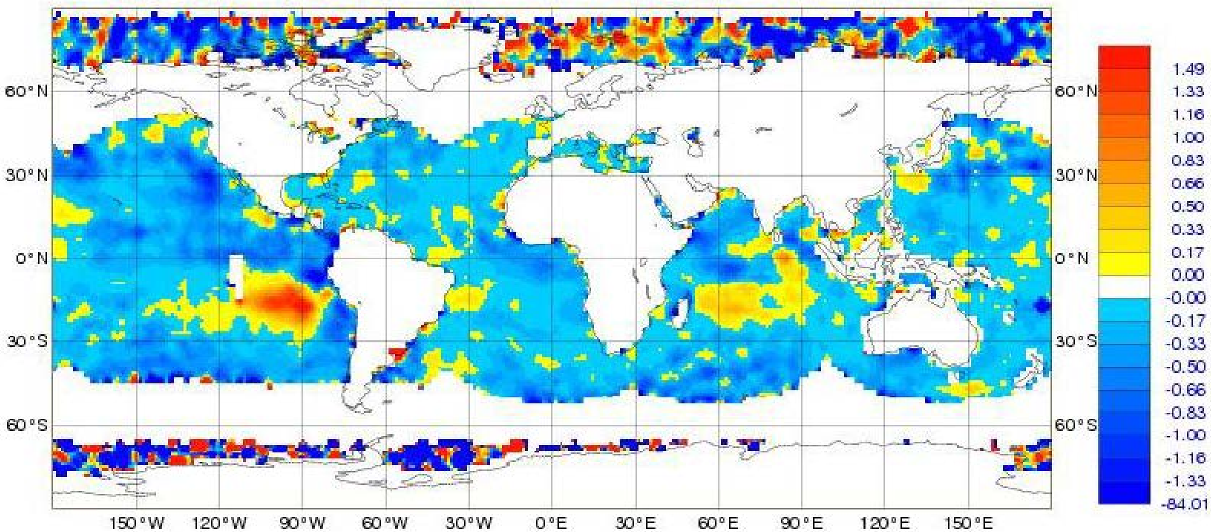
ECMWF

AMV FEC September by Satellite and Pressure Level



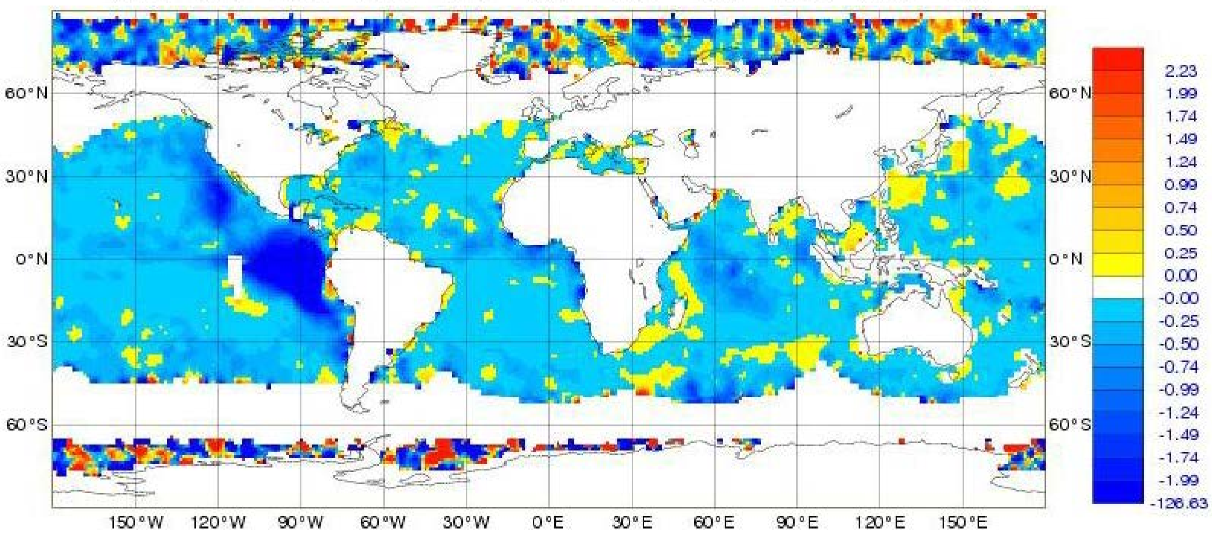


AMV Mean FEC September-October 2011 700-1100 hPa



U-Comp

Min=-84, Max=65, Mean=-0.15

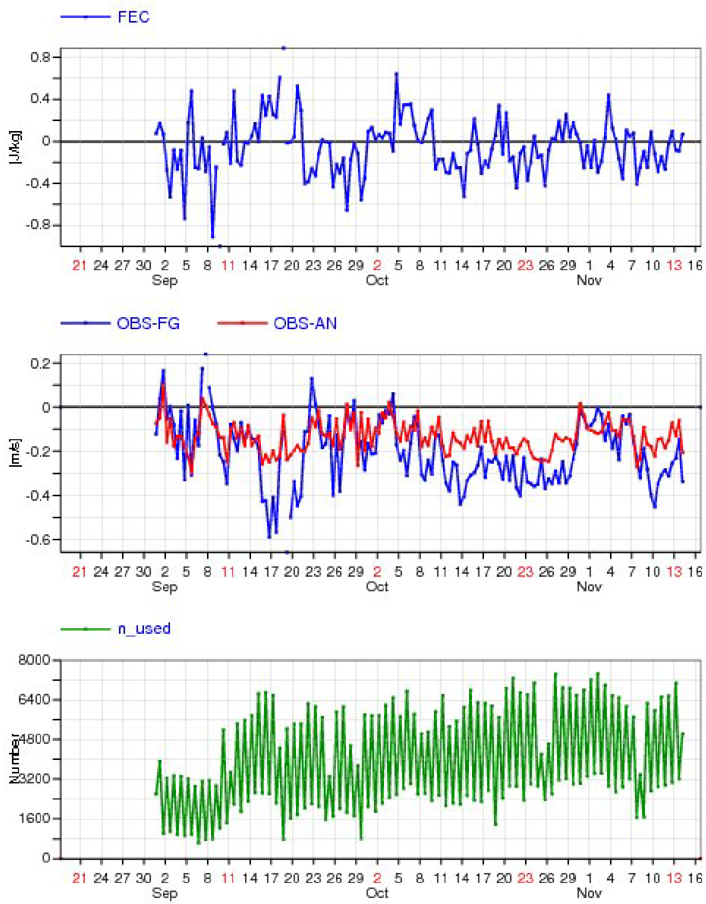


V-Comp

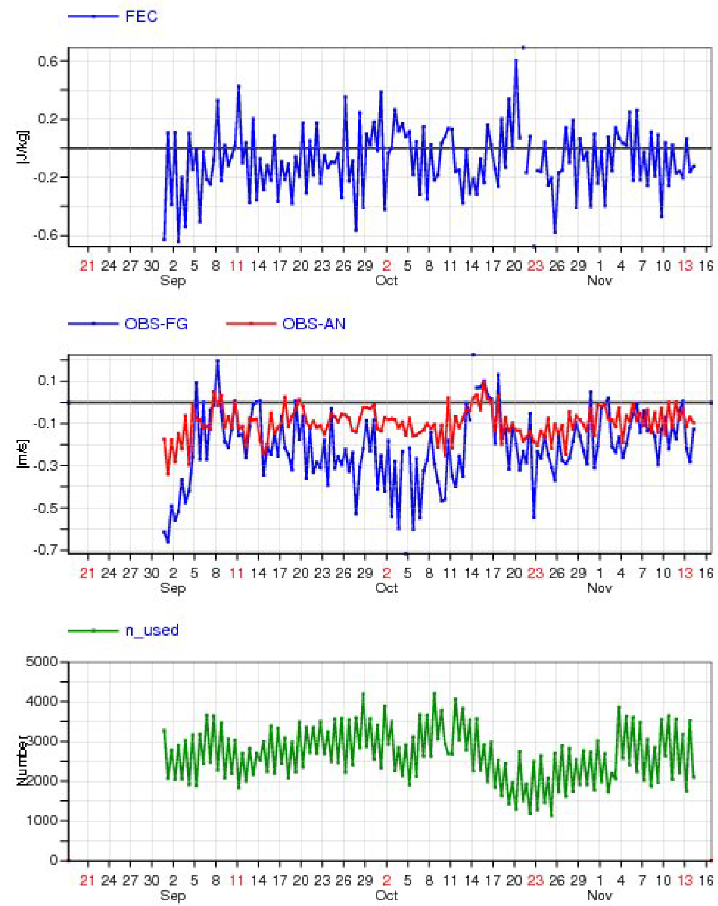
Min=-127, Max=59, Mean=-0.24

AMV FEC Time Series 700-1100 hPa

GOES-13

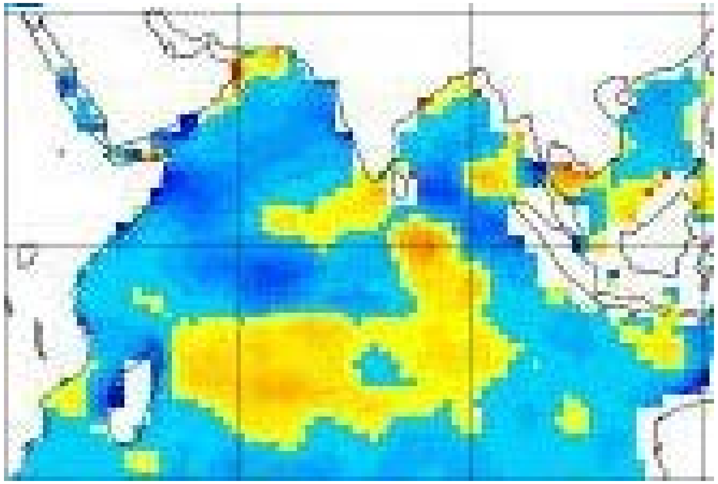


Meteosat-7

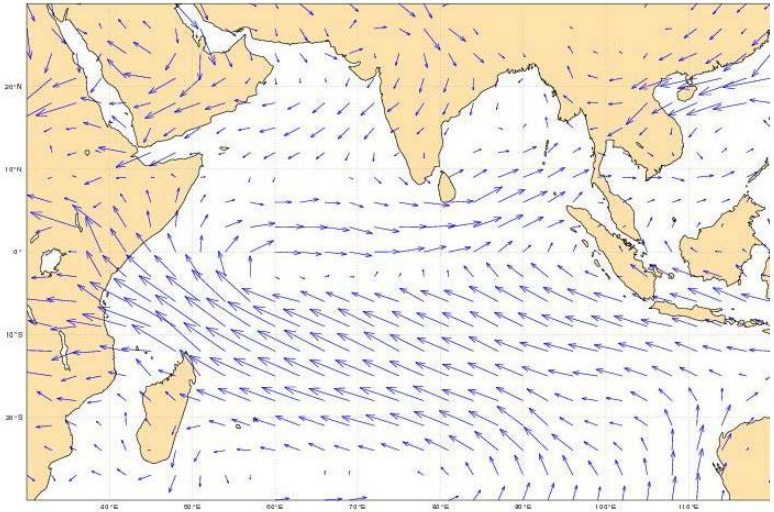


AMV METEOSAT 7 Degradation investigation: September-October OSE NOAMV-CNTR 700-1000hPa

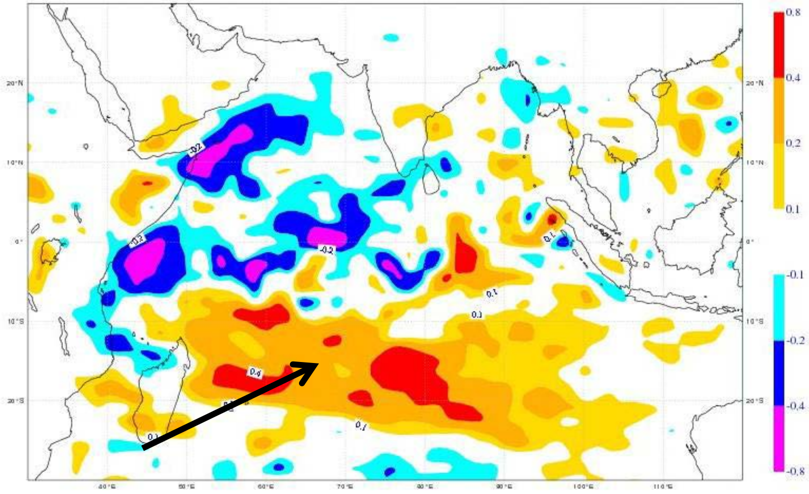
FEC METEOSAT Degradation



Mean Wind field

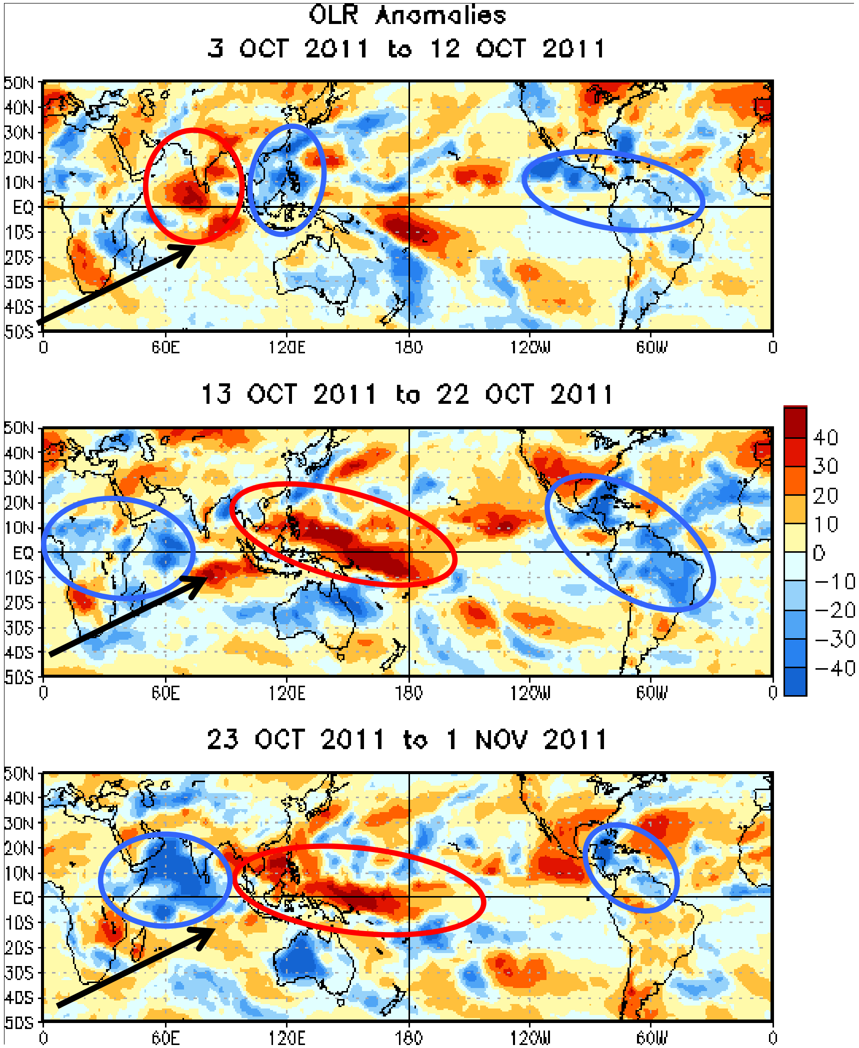


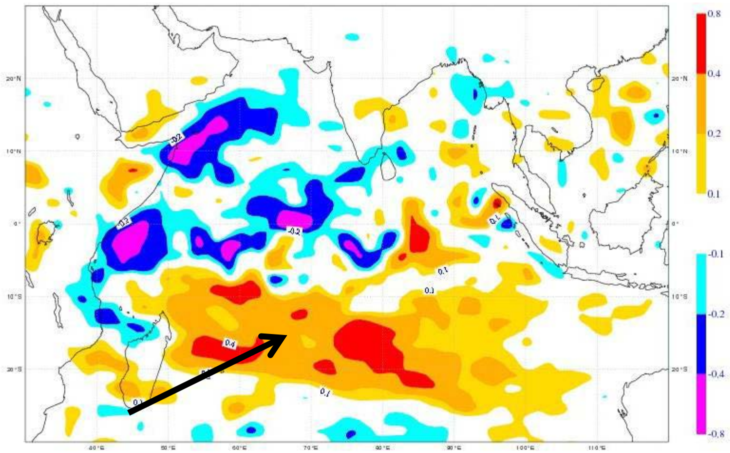
NOAMV-CNTR mean analysis difference



AMV observations reinforce the zonal circulation

AMV OSEs MJO Activity in October





Red Circle: suppressed convection
Blue Circle: Enhanced convection

MJO pattern over Indian ocean justifies a reinforcement of the zonal circulation

AMVs increase the zonal circulation

ECMWF

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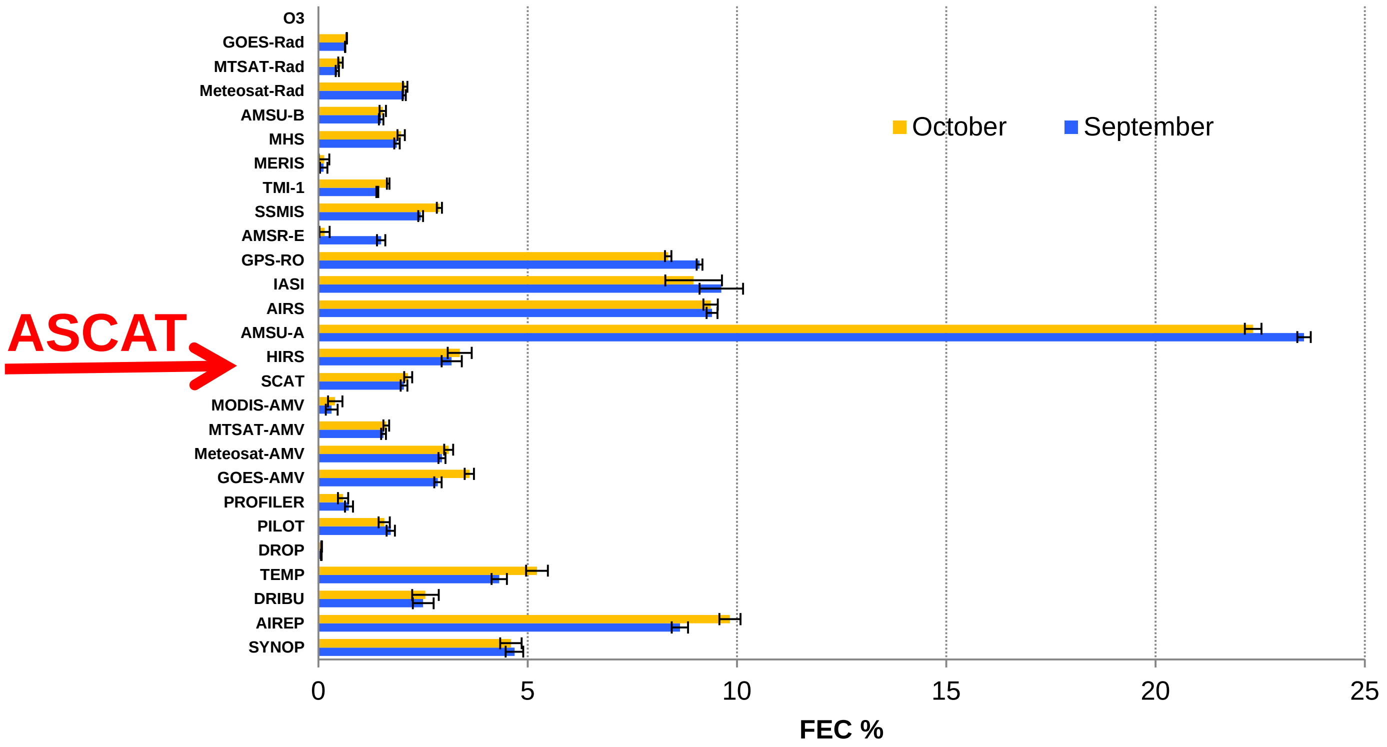
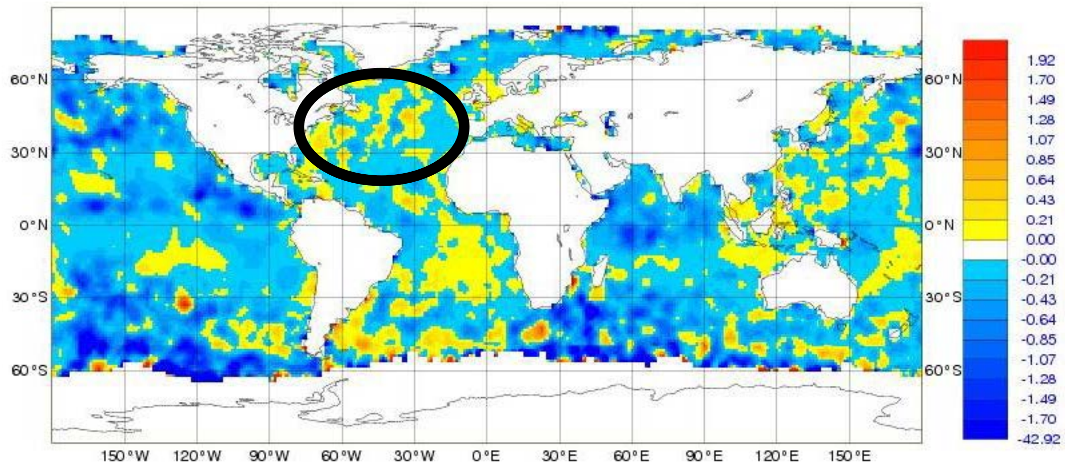
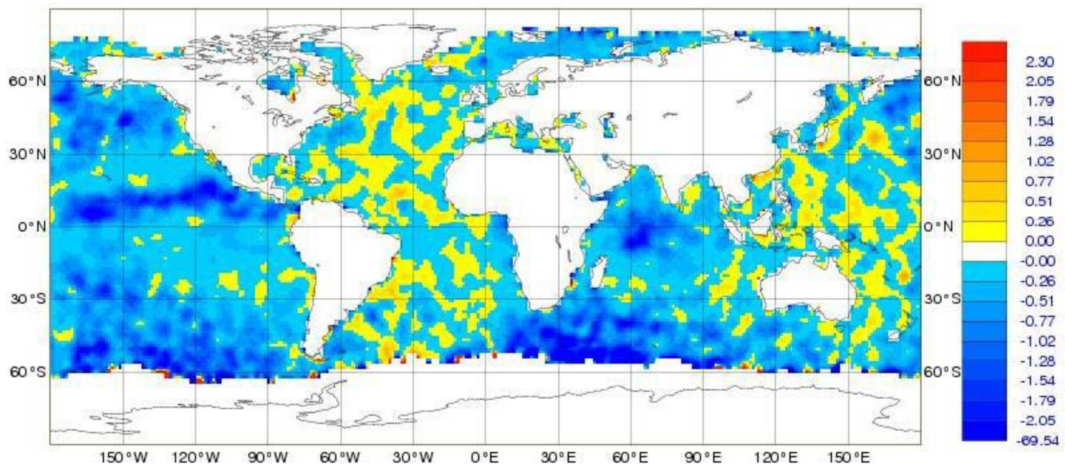


ASCAT Mean FEC   September & October



ASCAT U-Comp

Min=-43, Max=34, Mean=-0.3

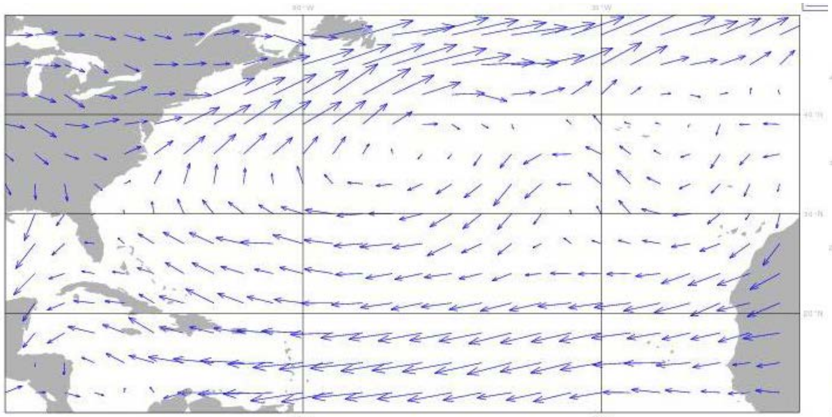


ASCAT V-Comp

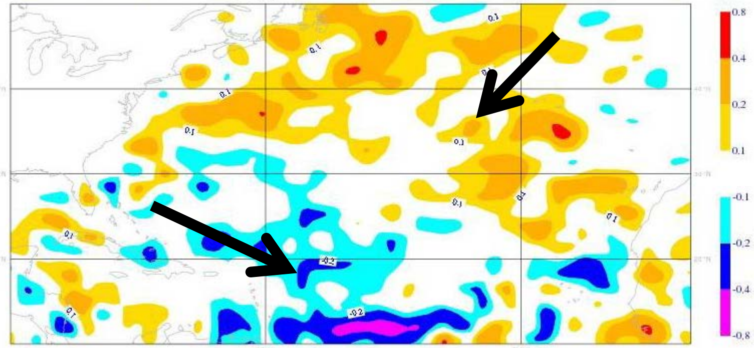
Min=-70, Max=55, Mean=-0.4

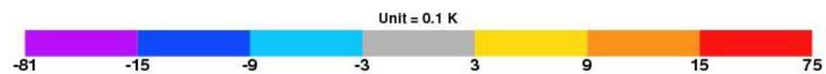
ASCAT September&October Degradation over N. Atlantic
OSE NOSCAT-CNTRL 850-1000hPa

Mean Wind field



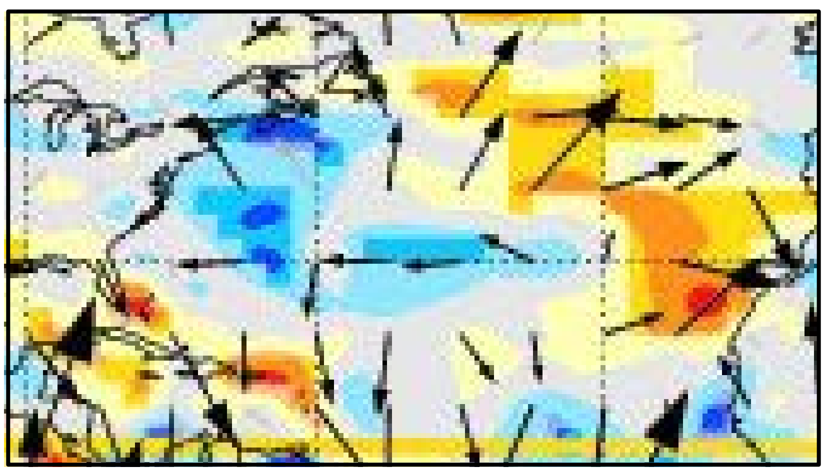
NOSCAT-CNTRL Mean Analysis Differences

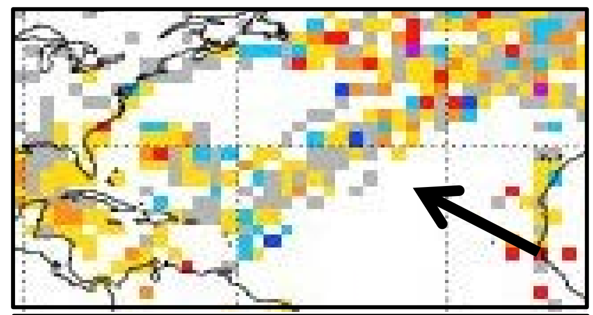




ASCAT data weaken the circulation

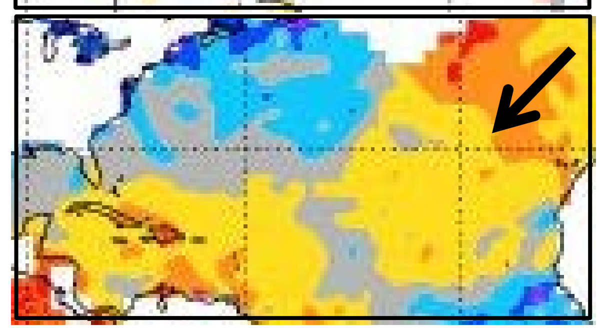
Mean Analysis Increments





TEMP U-Comp FG-dep

reinforce the circulation



AMV U-Comp FG-dep

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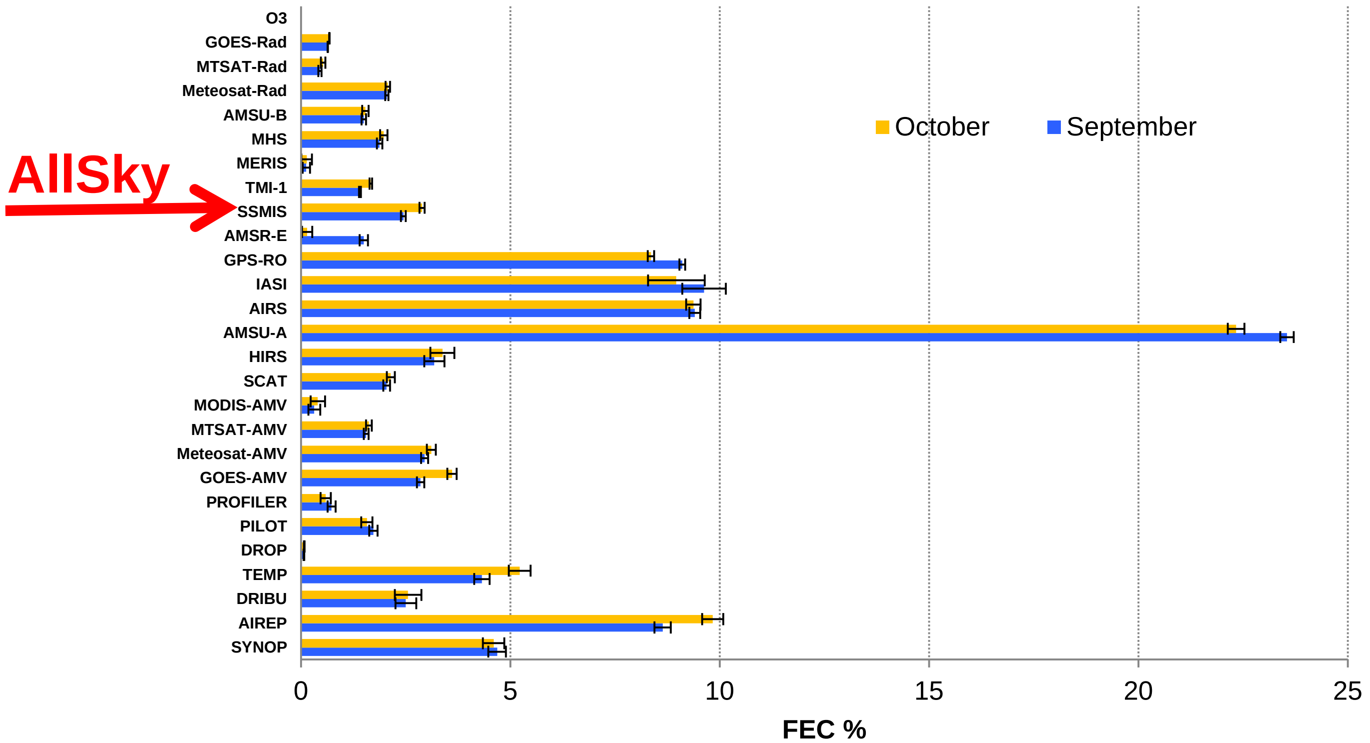

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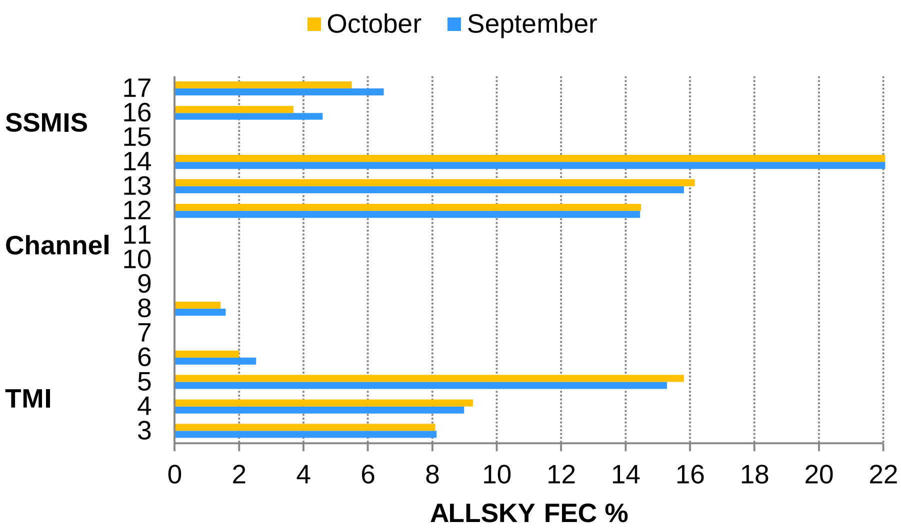
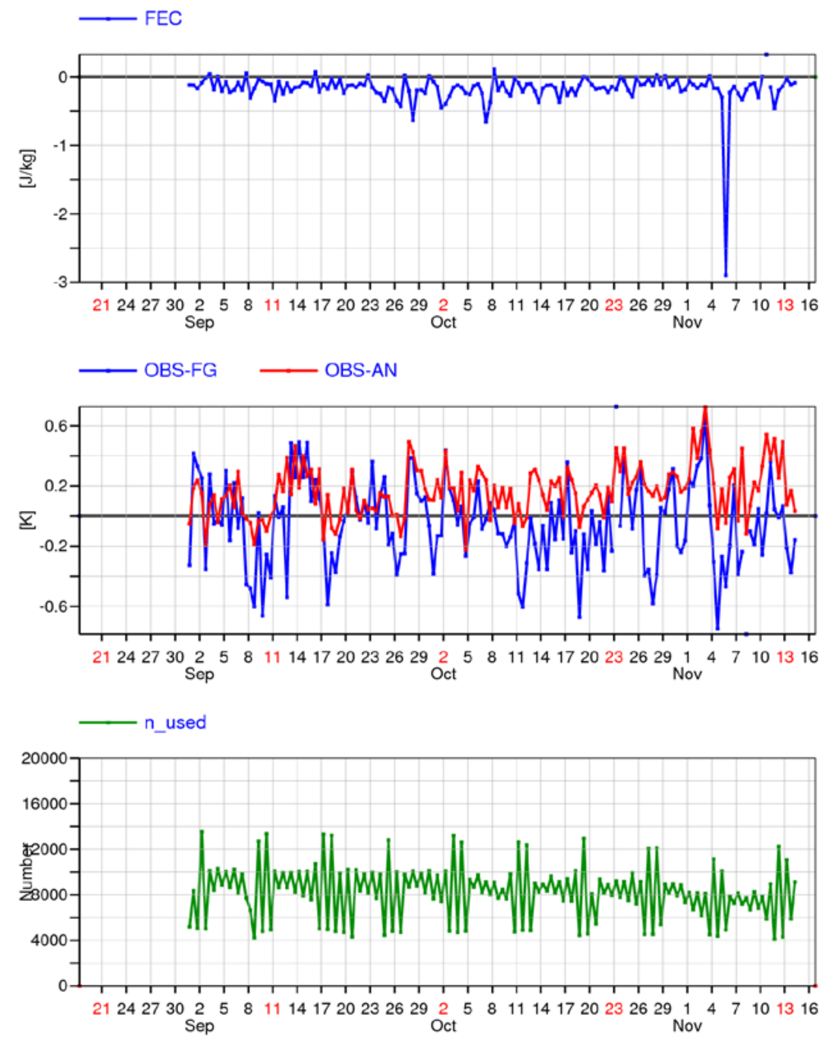
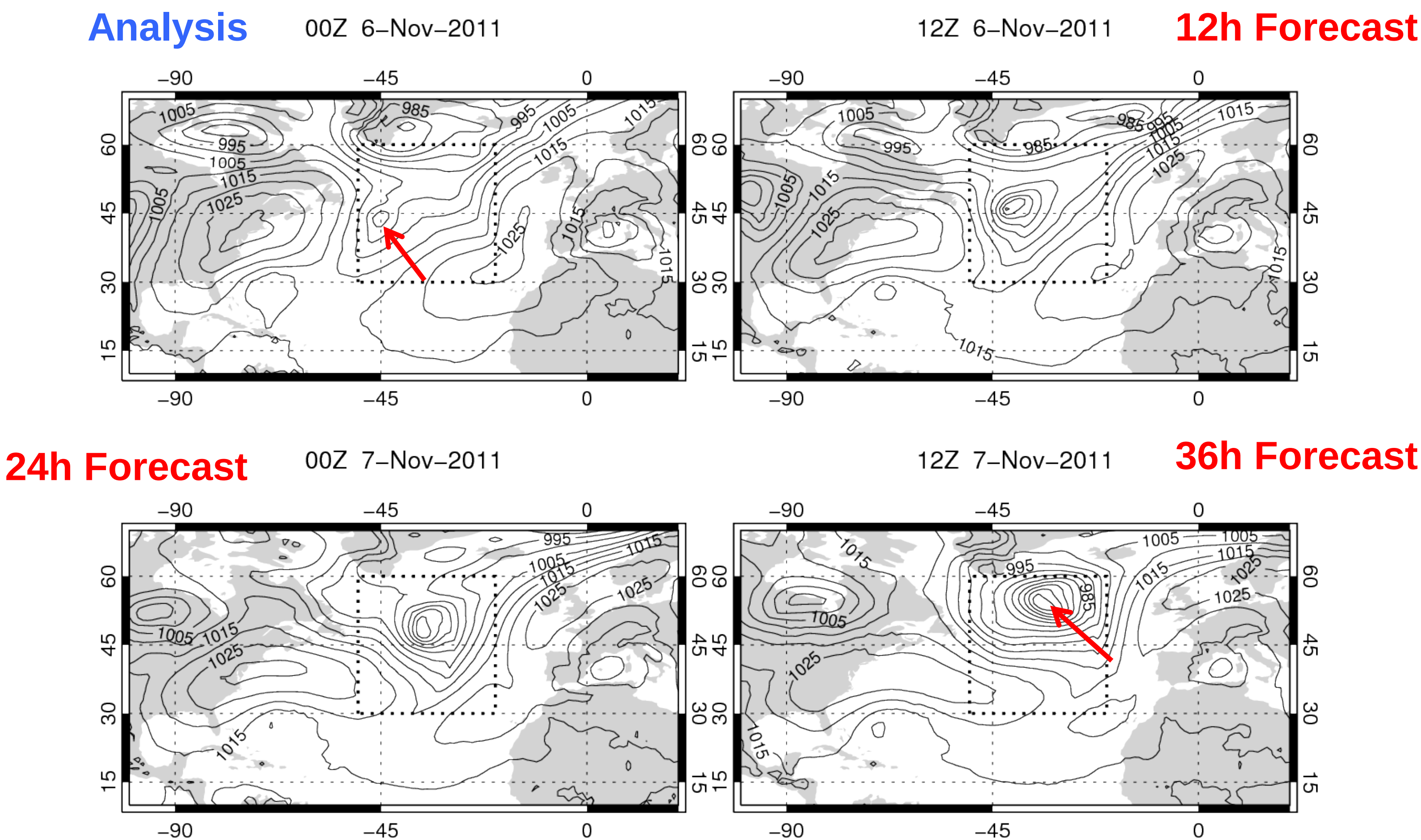
SSMIS FEC North Atlantic November 2011 Case Study



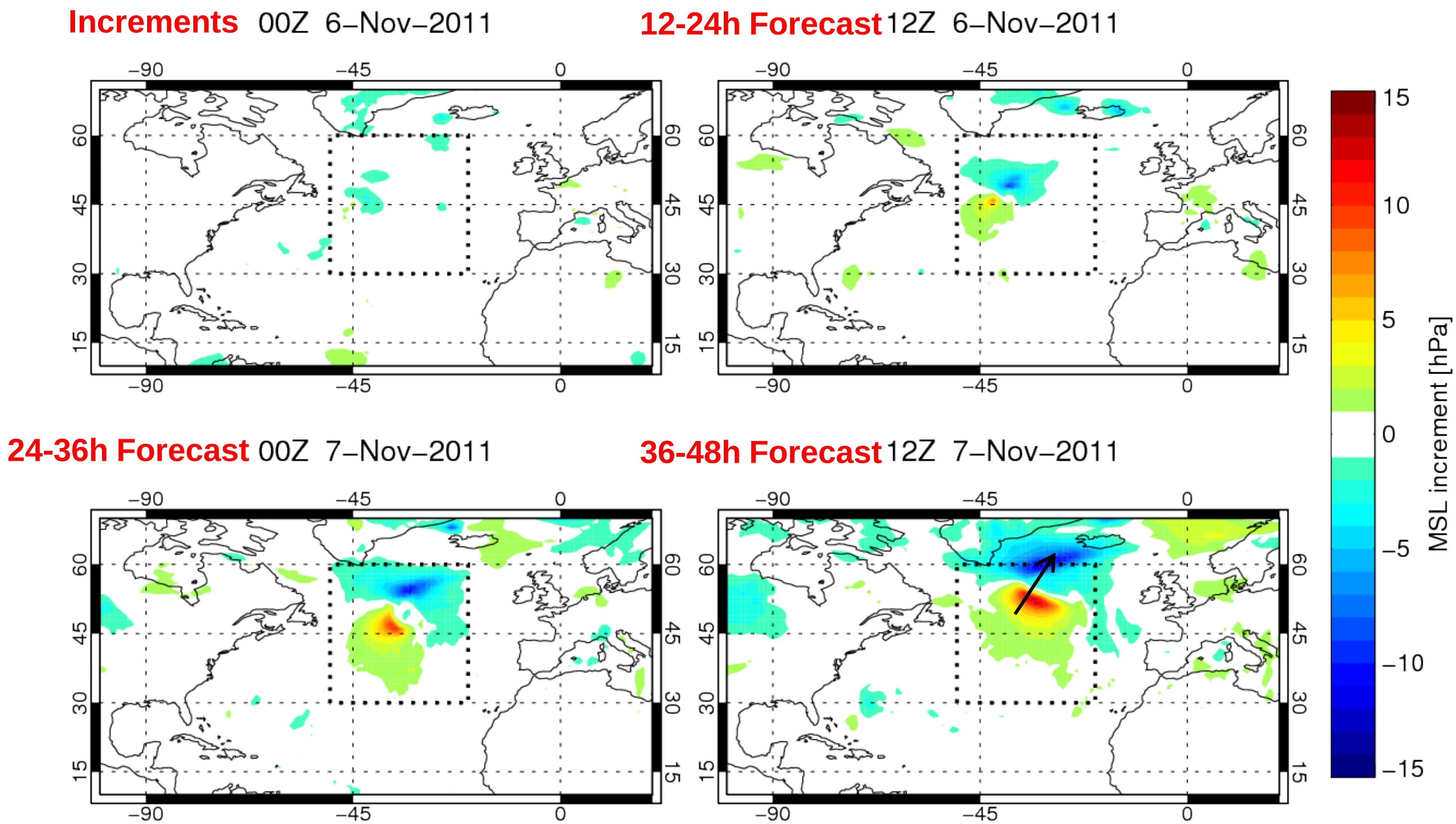


6th November: Case of a rapidly developing cyclogenesis



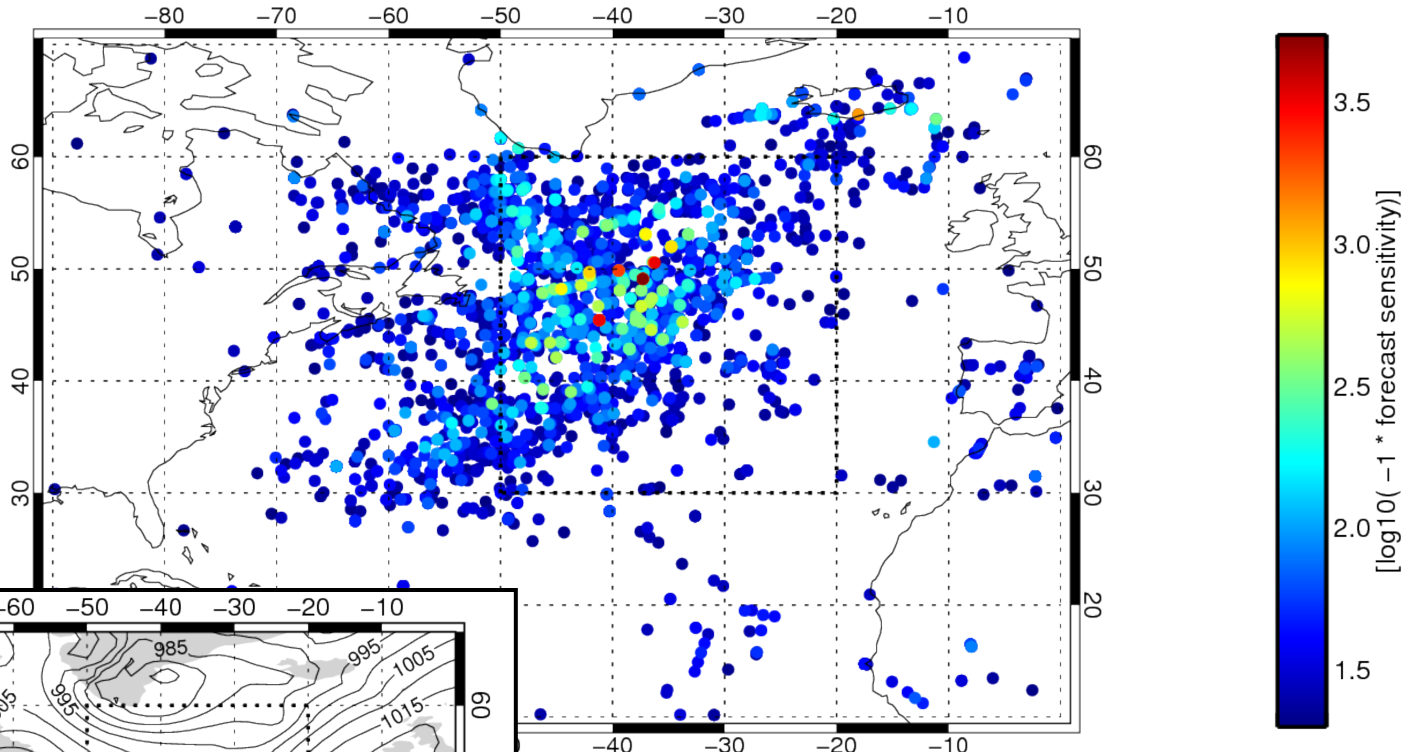
Minimum pressure from 990 to 950 hPa between 00Z 6/11 and 18Z 7/11

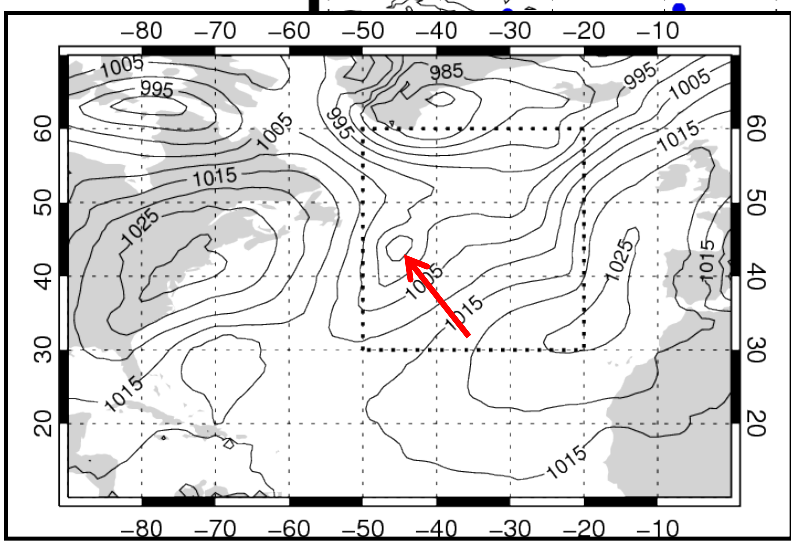
Mean sea level pressure: Evolved increments
Forecast valid at the same time and initiate from subsequent analyses



00Z 6th Nov analysis shifts the storm North West

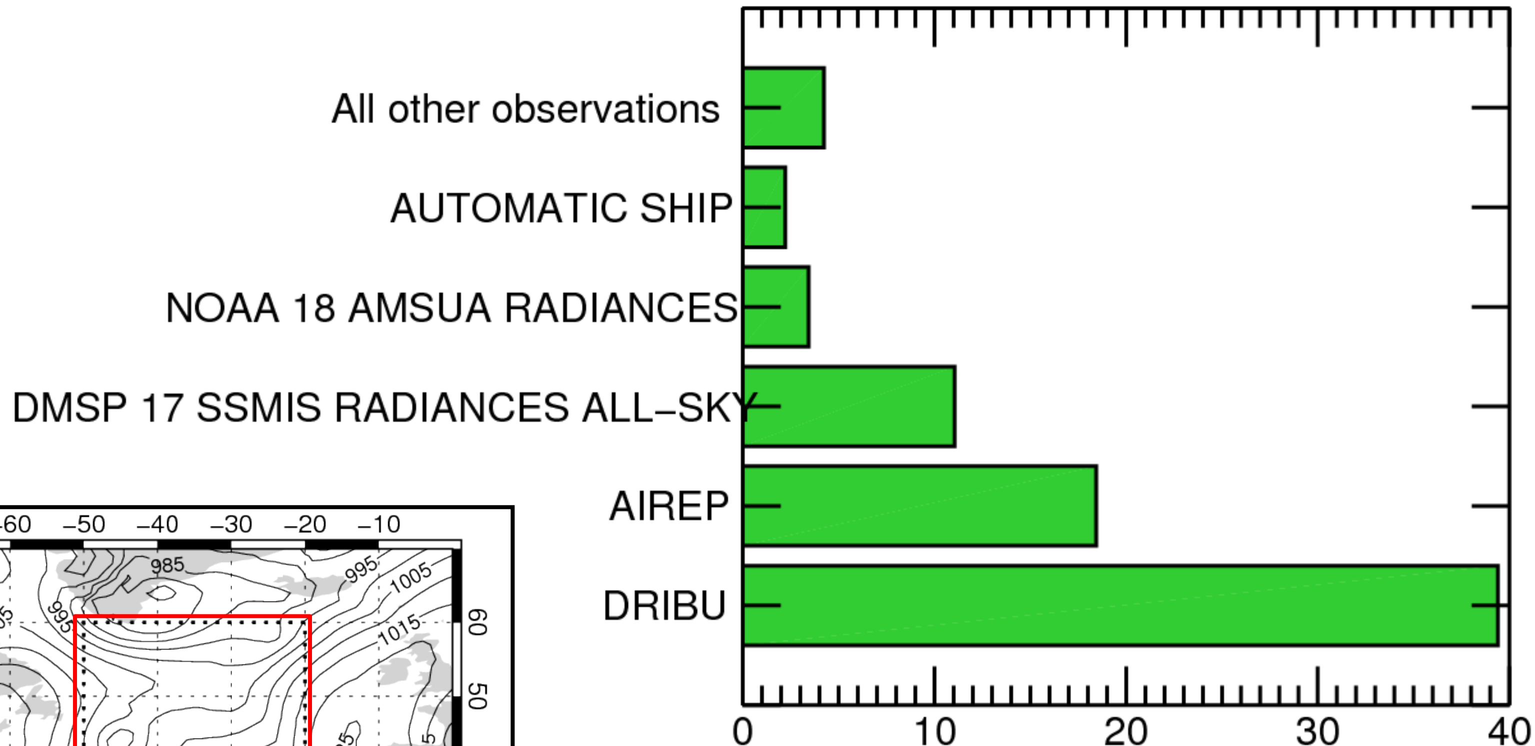
00Z 6th November FEC
All observations with FEC < -20 J

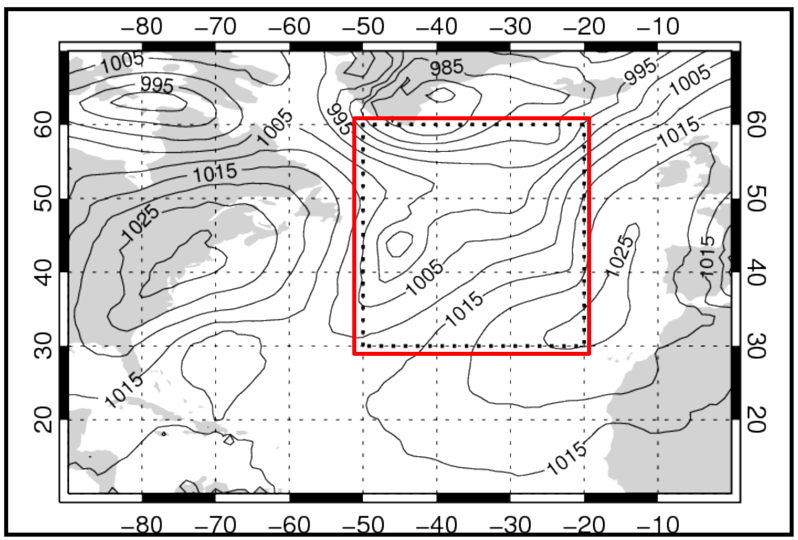




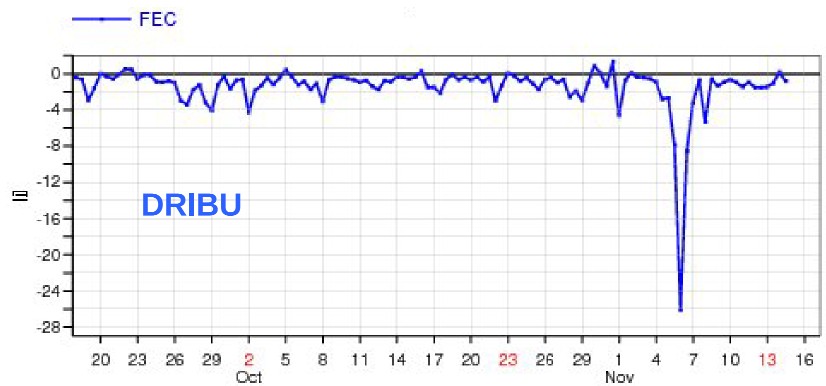
MSL pressure

00Z 6th November FEC in the 30° x30°

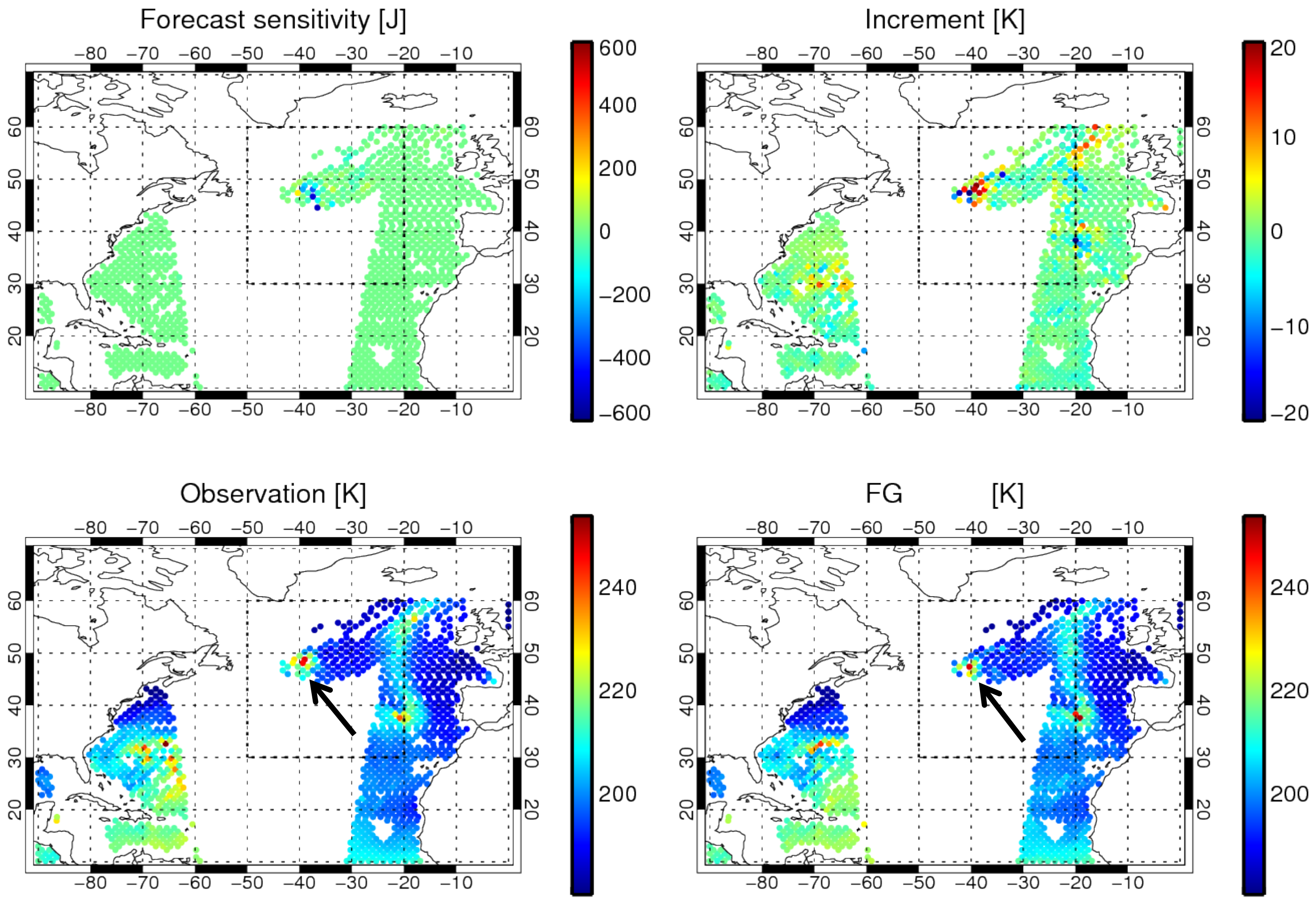




MSL pressure



All-sky SSMIS: channel 19v

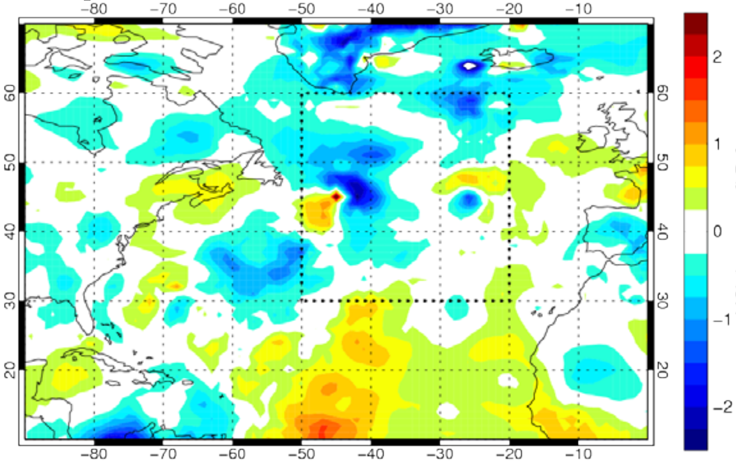


Cloud and precip shifted ~250km to the NW in accordance with obs

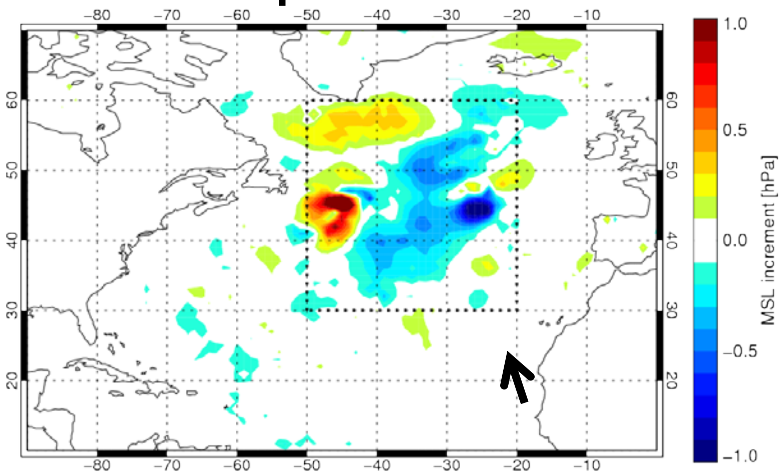
Denial OSEs vs. Operations

Mean sea-level pressure increment at 00Z, 6^{th} November

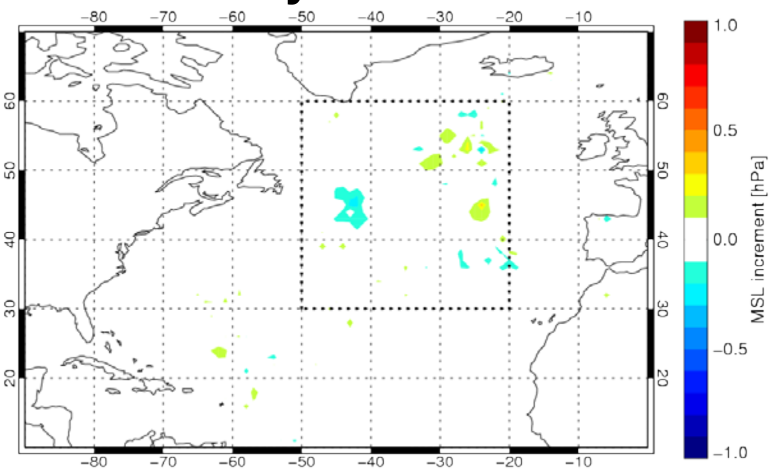
Operations: total increment



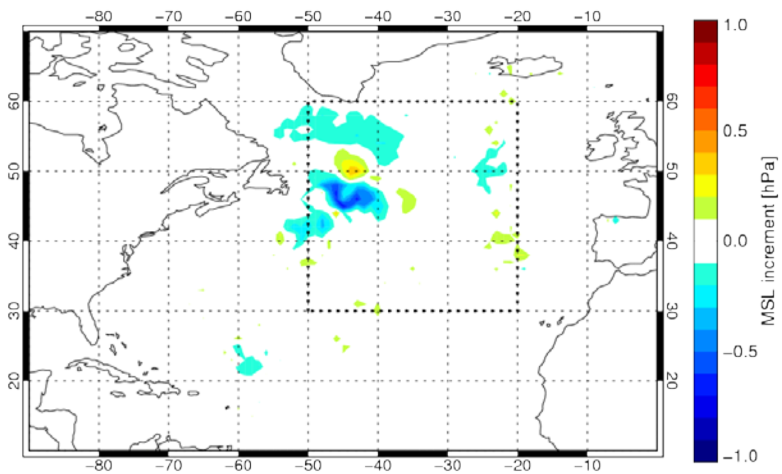
Ship and DRIBU



All-sky SSMIS F-17



AIREP



Conclusions

- Use of Forecast Error Contribution of the Observing system components at ECMWF has been demonstrated
- The observation impact is daily monitored
- Illustrative examples include:
  - ➢ Impact of AMSU-A
    - NOAA and METOP-A
  - ➢ Impact of AMV
    - METEOSAT-7 over Indian Ocean: Degradation related to model bias
  - ➢ Impact of ASCAT
    - North Atlantic Degradation related to underestimation of observed wind speed
  - ➢ Allsky Forecast Improvement Case study
- Potential and Limitation of the diagnostic tool have been shown