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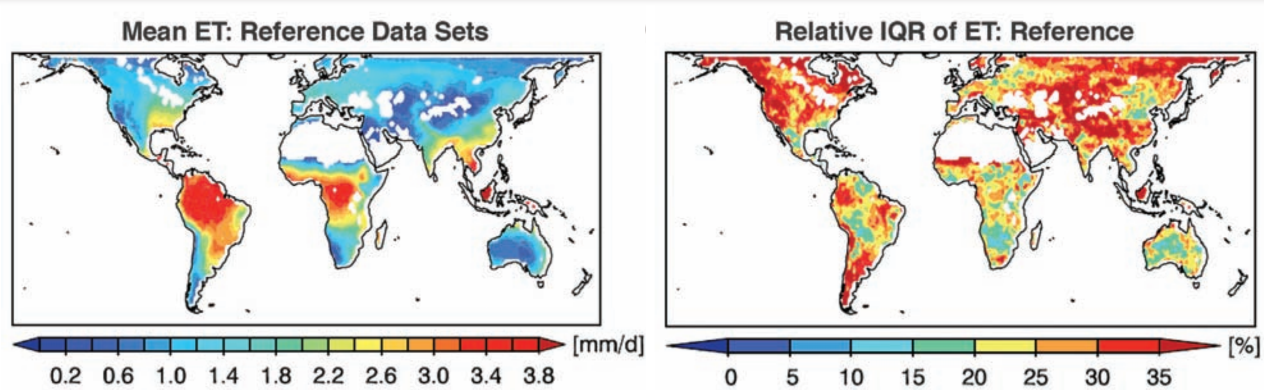
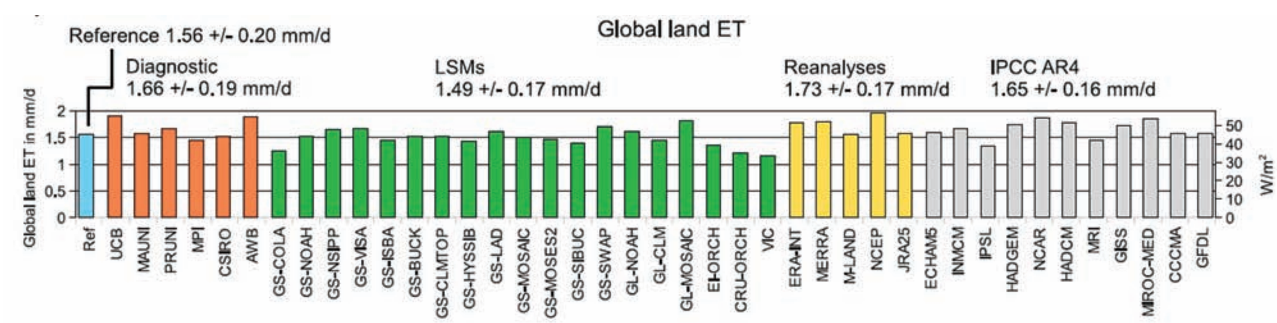
GEWEX LandFlux Project Plans
Global Latent and Sensible Heat Flux Data Sets



The left panel shows the mean of 30 reference evapotranspiration (ET) data sets in mm/d. The data sets include remote-sensing-based estimates, reanalysis data, and output of land-surface models driven with observation-based forcing. The right panel shows the relative Interquartile Range (IQR) of the data sets in percentage. [From Mueller et al., 2011.] The data sets, as well as the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4) simulations, are found to closely agree on the global-scale land ET (see figure below), but large regional differences are apparent. The LandFlux Project is currently preparing a synthesis benchmark data set based on existing global ET products (LandFlux-EVAL), as well as a targeted global GEWEX-based ET product. See article by S. Seneviratne et al. on page 18.



Mean annual global ET estimates in mm/d and W/m² from 30 reference data sets and IPCC AR4 simulations. [From Mueller et al., 2011.]

See These Articles Related to Evapotranspiration

- **Developing a Predictive Capability for Terrestrial Evapotranspiration: Ways Forward?** (page 10)
- **Evapotranspiration as a Regional Climate Priority: Results from a NASA/USDA Workshop** (page 15)
- **LandFlux-EVAL Workshop** (page 18)

Save the Date!

- **4th WCRP International Conference on Reanalyses, 7–11 May 2012, Silver Spring, Maryland, USA** (page 13)

GEWEX and ESA Have Developed a Process and an Integrative Platform for Ground-Based Soil Moisture Measurements to Support ISMN

An article profiling the International Soil Moisture Network (ISMN) appeared in the American Geophysical Union's weekly newspaper *Eos*, published on 26 April 2011. The piece covers the importance of soil moisture as an "essential climate variable" and explains the role of ISMN as a repository for standardized soil moisture data across the globe. GEWEX is highlighted as the catalyst for ISMN, developing the network with the support of the Group on Earth Observations (GEO) and the Committee on Earth Observation Satellites (CEOS).

Over 500 Years of BSRN Radiation Data Available

On May 3rd the central archive of the Baseline Surface Radiation Network (BSRN), which is housed at the World Radiation Monitoring Center, received exactly 6000 monthly station-to-archive files. In other words, 500 years of radiation data are now available at: *http://www.pangaea.de/PHP/BSRN_Status.php?q=LR0100*.

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Moustafa Chahine, First GEWEX SSG Chair: An Extraordinary Gentleman and Scientist

Paul Try
International GEWEX Project Office, Silver Spring, Maryland, USA

We recently lost a great leader and scientist who had a significant impact on the GEWEX Project throughout its entire lifetime. Dr. Moustafa (Mous) Chahine, the first Chair of the GEWEX Scientific Steering Group (SSG) and former Chief Scientist at the National Aeronautics and Space Administration (NASA) Jet Propulsion Laboratory, passed unexpectedly in late March of this year. I am sure he would also appreciate being remembered as the always-enthusiastic leader and driving force behind the Atmospheric Infrared Sounder (AIRS) Instrument and Science Team. The quote "always make progress" was his lead-in remark for every AIRS Science Team meeting. While it is difficult to summarize and give credit to one who has had such a long and distinguished career, this article provides key remembrances of his impact on GEWEX, climate science, and the entire Earth science community.

I first met Mous in 1990 when he was chosen as the initial Chair of the SSG and I was asked by NASA to help establish and lead the International GEWEX Project Office. We worked hard to pull together a few existing projects, establish some needed subprojects, and initiate a new large regional field campaign. Since the GEWEX objectives encompassed a very broad aspect of Earth science, Mous was instrumental in providing the necessary focus and organization of the many components that GEWEX managed. Always thinking ahead, Mous pushed us to obtain improved results in everything we were working on. Mous stayed continuously involved and provided direction to essentially all activities of GEWEX during the year between SSG meetings where the general guidance was formulated. His enthusiasm for the science advances he could see coming out of GEWEX was infectious, and he never seemed too busy to delve deeper into the science behind each of the efforts of its many components. Always a gentleman, and with a significant concern for the people behind the extensive efforts within the projects, Mous found ways to instill an urgency in our efforts to keep things on track and energized.

Mous always stayed abreast of GEWEX and its progress, as was shown in his comments for *GEWEX News* just last November, where he was encouraging a greater focus on process studies in the boundary layer and stronger emphasis on improvement in precipitation prediction. His own words —"my research work determines where I am going to be and what I am going to be doing during most of my daily life"—may be an understatement for his continued focus on and contributions to the Earth sciences. We will greatly miss this "Extraordinary Gentleman and Scientist."

Increasing Desertification of Northwestern India Can Adversely Impact the South Asian Summer Monsoon

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Desertification is formally defined as land degradation in arid, semiarid, and dry sub-humid areas resulting from various factors, such as climatic variations and human activities (UNCCD, 2001). It is a complex process, contributed to by interactions among physical, biological, social, cultural, and economic factors. The human footprint is certainly influential, since deforestation, over-cultivation, soil salinization, overgrazing, and over-exploitation of natural resources contribute to land degradation. Desertification has long been recognized as a major environmental problem affecting the living conditions of people in many countries of the world. In India, nearly one-third of the area is undergoing land degradation, and about 25 percent is subjected to desertification.

The Thar (or Great Indian) Desert is located between northwestern India and Pakistan. It receives an average annual precipitation between 150 and 450 mm (west to east), mostly during the summer, and is the most densely populated desert region in the world, generating tremendous stresses on natural resources. This region underwent substantial agricultural expansion in the past decades, largely relying on the withdrawal of groundwater. Despite the weak positive trend in monsoon precipitation over the region, extensive agriculture has resulted in rapid depletion (0.33 m/yr) of groundwater over Northwestern India in recent years (Rodell et al., 2009). This could lead to several consequences, from a shortage of potable water, to a decline in agricultural productivity, to land degradation. Vast areas of Northwestern India are affected by rapid soil degradation and vegetation loss (e.g., Ravi and Huxman, 2009), and soil moisture has been drastically reduced (Singh et al., 2005). The region is under the threat of future desertification (e.g., Goswami and Ramesh, 2008). To the west of the Thar Desert, the relatively green Indus Valley has also been severely degraded and is suffering from water scarcity (WRI, 2003). Overall, the system appears unstable and potentially subject to a collapse in the near future (Tiwana et al., 2007; Tiwari et al., 2009).

Land-surface processes affect climate through the exchange of heat, moisture, and momentum between the Earth's surface and the atmosphere. The impact of vegetation change (due to anthropogenic activities or multidecadal variability) on climate has been widely investigated (Xue and Shukla, 1993; Dirmeyer and Shukla, 1996; Xue and Fennessy, 2002; Oyama and Nobre, 2004; Sen et al., 2004), especially for the Sahel. Vegetation degradation sustains three major regional positive feedbacks on the water cycle (i.e., leading to precipitation reduction which in turn increases desertification):

- Increased surface albedo leads to reduced absorption of solar radiation at the land-surface (which cools) and, other things being equal, to a net radiation loss at the top of the atmosphere. To maintain thermodynamic balance, compensating subsidence is generated (assuming thermal advection is negligible), inhibiting precipitation.

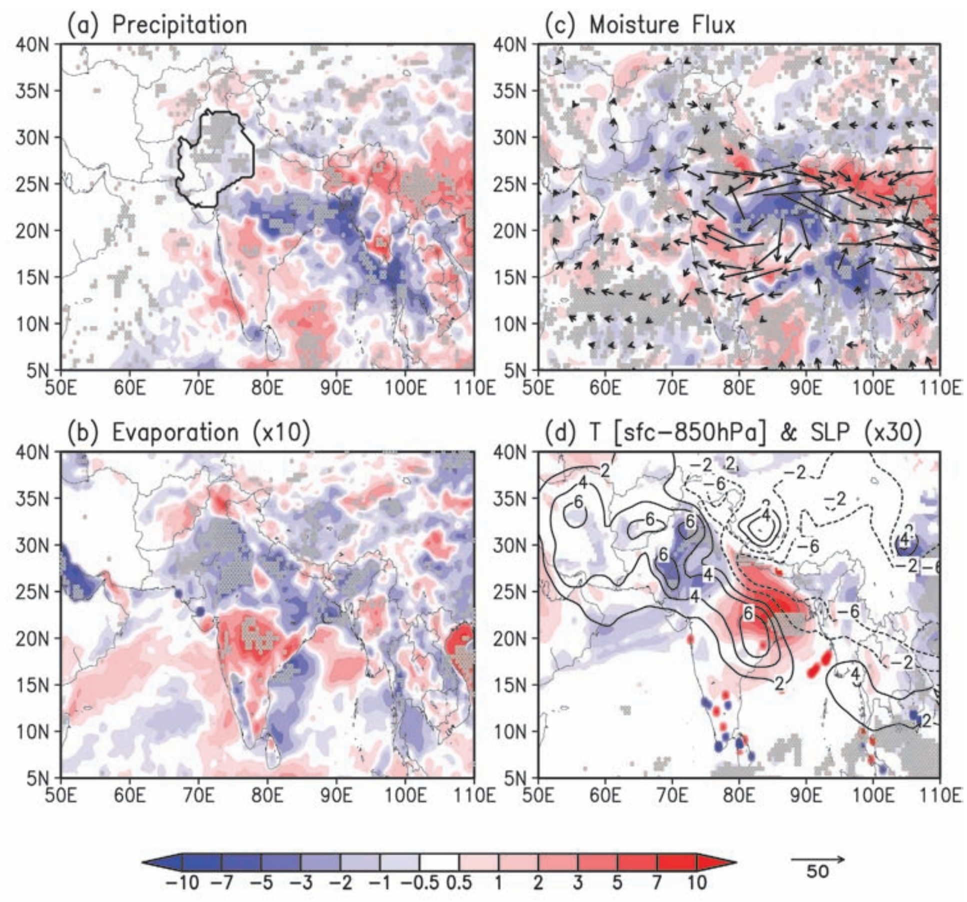
- Decreased surface roughness leads to reduced surface fluxes of heat and moisture, which can also weaken convection and precipitation. Reduced fluxes will, however, lead to surface warming.

- Decreased soil moisture by vegetation reduction affects evapotranspiration and therefore moisture availability in the atmosphere, which in general also negatively impacts precipitation.

The large-scale picture can be complicated as these regional processes interact not only with each other but potentially with larger-scale processes, especially over South Asia where ocean-atmosphere-land coupling plays an important role in summer monsoon evolution. A common aspect of almost all desertification studies is the use of low-resolution general circulation models. More importantly, only Dirmeyer and Shukla (1996) appear to have investigated the effects of desertification over the Indian subcontinent, albeit in an idealized scenario.

Our study (Bollasina and Nigam, 2011) seeks to investigate the impact of the realistic expansion of the Thar Desert on the South Asian summer monsoon hydroclimate, and to elucidate the main physical processes at play. The Weather Research and Forecasting (WRF-ARW) Version 3.1.1 regional climate model was used to conduct ensemble simulations [control (CTL) and sensitivity (DES) experiments] for seven months (February–August) at a 36-km horizontal resolution. Desert conditions were prescribed by changing the distribution of vegetation types and associated parameters (e.g., albedo, vegetation fraction, roughness length) over the most exploited area between Pakistan and northwestern India. The new values do not, however, represent a drastic change with respect to the control experiment since the area is already partially dry and relatively bare at the beginning of the simulation. Initial soil moisture is differently initialized in the two experiments but this difference is not consequential in view of the substantial dryness of the initial state (February/March).

Over the desert area, the atmospheric water cycle weakens (i.e., precipitation, evaporation, and moisture convergence decrease, as well as soil moisture and runoff), further reinforcing the driving mechanism (see the figure at the top of the next page). Air temperature cools due to the overall impact of albedo change and because of the reduction of surface fluxes. Subsidence is generated by thermodynamic balance and increasing sea-level pressure. An anomalous low-level northwesterly flow over the Indo-Gangetic Plain weakens the moisture advection from the Bay of Bengal, leading to a precipitation decrease over Eastern India and consequent cooling of the middle troposphere (but heating of the ground) with the for-

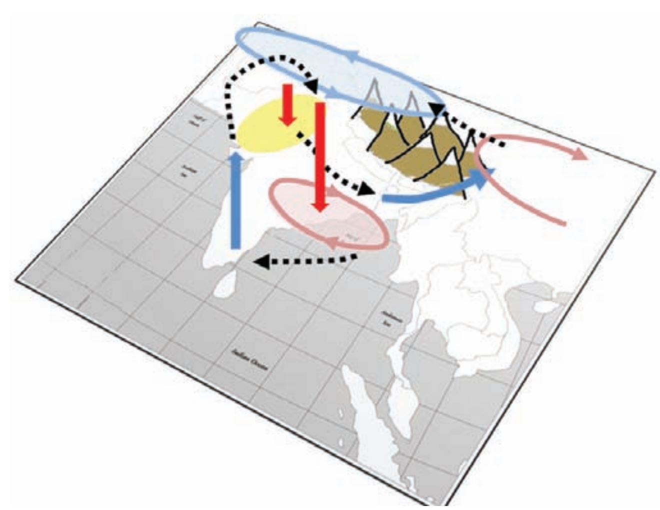


Average difference of the desertification scenario control run (DES-CTL) in June, July, and August for: (a) precipitation (P, mm/day); (b) evaporation (E, x 10 mm/day); (c) vertically integrated mass-weighted moisture flux (kg m/s) and its convergence (shaded, positive red, mm/day); and (d) surface-850 hPa vertically averaged temperature (shaded, °C) and sea level pressure (x30 hPa, contours). The light grey hatching is for statistically significant areas at the 80 percent (a) and 90 percent (b-d) confidence level. The black contour in (a) denotes the area of the expanded desert in DES.

mation of an anomalous anticyclone. The cooling over Northwestern India extends throughout the troposphere, and the upper-tropospheric Tibetan High weakens as a result of the anomalous subsidence over the desert area. On the east, the anomalous flow from the Indo-Gangetic Plain intensifies and deviates toward the Eastern Himalayas and Southern China, producing more precipitation by orographic uplift (see figure at right).

Decreasing evaporation over the desert should contribute to controlling the cooling due to the increase in albedo. Interestingly, this feedback appears to be marginal over this region.

In a holistic investigation of the changing monsoon, the changes brought about by the expansion of the Thar Desert can interact with other large-scale changes induced by other forcings (e.g., aerosol loading over South Asia, greenhouse gas warming), leading to amplification or dampening of the desert related effects. Our findings nonetheless suggest that increasing desertification of northwestern India and the related expansion of the Thar Desert can profoundly impact the summer monsoon hydroclimate and circulation over the Indian subcontinent, potentially redistributing precious water over South Asia.



A schematic picture of the average circulation anomalies (DES-CTL) in June, July, and August over the Indian Subcontinent induced by the expanded desert (represented by the yellow area). The Himalayas and Tibetan Plateau are also drawn. Colored circular areas represent high (red) and low (blue) pressure. Large-scale vertical motion is indicated by red (subsidence) and blue (ascent) thick arrows. Black dotted arrows represent approximately horizontal winds (i.e., mainly associated with horizontal transport).

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Developing a Predictive Capability for Terrestrial Evapotranspiration: Ways Forward?

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In April 2011, two workshops were held that focused on the development of improved observation and modeling capabilities for terrestrial evapotranspiration (ET). The workshop held in Silver Spring, Maryland (see page 15) focused more on regional ET issues related to water availability, while the Vienna, Austria workshop (see page 18) focused on ET issues as an integral component of the global water and energy budgets. Reading the reports, two challenges emerge for the community: (1) how can irrigated agriculture and water management be improved through better, real-time information on ET, and what data and ET modeling systems need to be developed? and (2) given the central role of ET in the climate system, are quality data sets available for the development of ET as an Essential Climate Variable (ECV) for the Global Climate Observing System (GCOS) that allows for "climate trend quality" ET estimates for climate studies? Neither challenge can be solved easily, but community collaboration and space agency cooperation can take us a long way towards meeting both.

Meeting the first challenge requires data at the sub100 m scale—farm-scale irrigation management to 1–2 km for irrigation district water management. Most ET algorithms for irrigation and water management over large areas are based either on land-surface temperature (LST) data from the highest resolution thermal satellite sensors available (e.g., Landsat) or on shortwave vegetation indices (VIs) that are used to specify crop coefficients applied to a reference or potential ET and adjusted by crop type. While some algorithms have gained acceptance within the user community, widespread application of these methods has not yet taken hold. VI methods typically require extensive local calibration and are unable to handle transient stress conditions, while the accuracy of water-use estimates from LST-based methods is hampered by lack of high spatial and temporal resolution radiation and LST data available in near real time, and by reasonable confidence in continuity. Both funding agencies and users (irrigation districts, water managers) need to commit to programs in a sustained manner for progress. Future technical advances in merging data sources from in situ to satellites at multiple scales offer potential improvements, but require support from sustained research and application programs.

Meeting the second challenge is equally complicated. ET algorithms depend on radiation, meteorological, and biospheric data. Current data sets continue to have issues that preclude them from achieving "climate quality," and ECVs (e.g., albedo) are fraught with temporal quality problems making derived ET uncertain. The LandFlux-EVAL Workshop report on page 18 shows a high level of coordination among the input data set providers and the ET product producers, as well as intercomparison studies of climate-scale ET data sets. Continued progress and success will depend on international program support for accelerating the development of the underlying ECVs on which any ECV ET product must depend.