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NEWS

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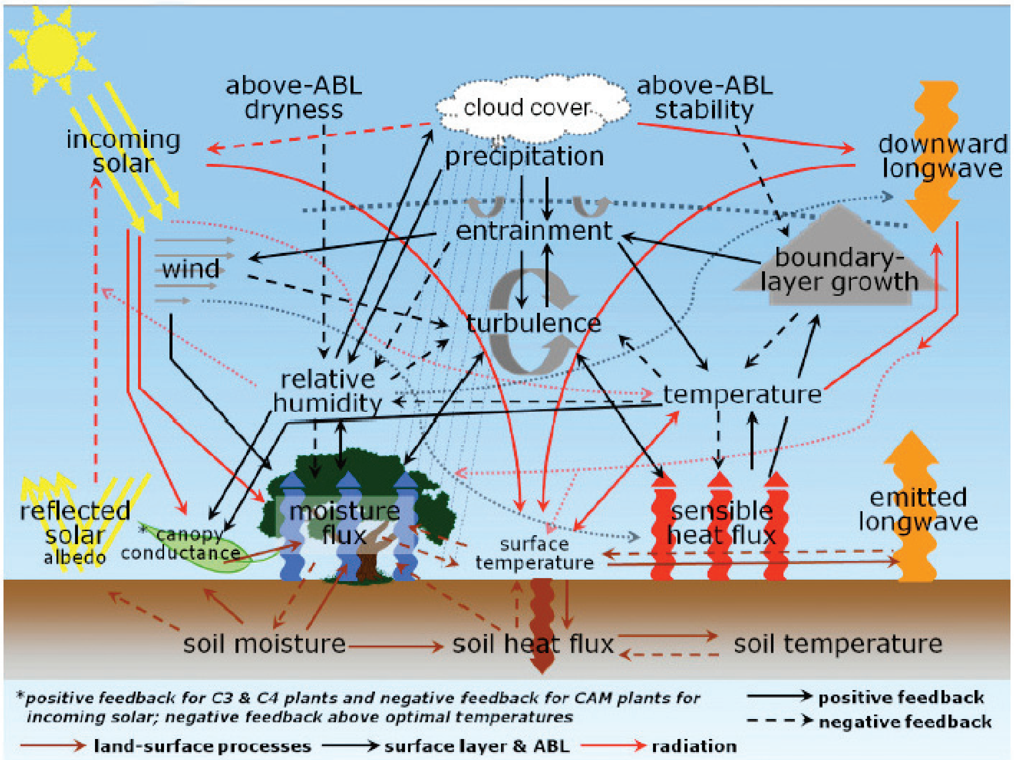
May 2013

Diurnal Land-Atmosphere Coupling Experiment (DICE): A First Attempt to Identify These Complex Interactions *(see page 3)*



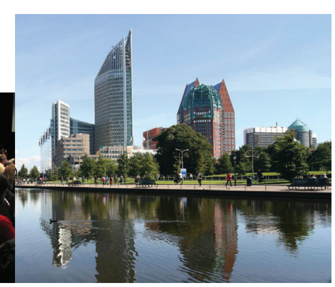
Schematic of the complex interactions between the land surface, atmospheric boundary layer, and radiation via many variables. These interactions are not well understood, in general, and are often poorly represented in numerical models. See article by Martin Best, et al. on page 3. Figure adapted from Ek and Holtslag (2004), courtesy of Mike Ek.

Save the Date!

7th International Scientific Conference on the Global Energy and Water Cycle

The World Forum, The Hague, The Netherlands

14–17 July 2014



The Conference will be preceded by GEWEX summer sessions for early career scientists, and followed by Pan-GEWEX and Pan-CLIVAR meetings.

A call for abstracts will be announced soon.

For Conference updates, see: *http://www.gewex.org*

Commentary

The GEWEX Science Conference: An Opportunity for All

Kevin Trenberth
Chair, GEWEX Scientific Steering Group

Over the past few years, the World Climate Research Programme (WCRP) has taken a hard look at its activities and revamped them with a view to new endeavors between now and about 2020. It has resulted in six Grand Challenges being put forward for the community to take on. GEWEX has also undergone a renewal and we have changed our name to Global Energy and Water Exchanges even as we retained the same acronym. This was accompanied by extensive work on developing a strategic view of GEWEX activities listed as a set of Imperatives, and now published as a 48-page document, "*GEWEX Plans for 2013 and Beyond: Imperatives*." It is available online at *http://www.gewex.org/pdfs/GEWEX_IMPERATIVES_final.pdf*. The Imperatives include aspects related to observations and data set development and assessment, data analysis and generation of products, understanding processes and improving their depiction in models, improving models more generally including for data assimilation and predictions, applications of all sorts, technology transfer into operations or to users, and capacity building of the community and users.

The Imperatives were followed by a careful look at GEWEX Science Questions that are actionable and tractable over the next 5–10 years, published as "*GEWEX Plans for 2013 and Beyond: GEWEX Science Questions*" and available at *http://www.gewex.org/pdfs/GEWEX_Science_Questions_final.pdf*. The GSQs take advantage of various opportunities, including new and expected observations, especially from space, new modeling and processing capabilities, new insights, and potential benefits. Paraphrased, they include:

- **Observations and Predictions of Precipitation**. How can we better understand and predict precipitation variability and changes?
- **Global Water Resource Systems**. How do changes in the land surface and hydrology influence past and future changes in water availability and security?
- **Changes in Extremes**. How does a world that is warming affect climate extremes, especially droughts, floods and heat waves; and how do land processes, in particular, contribute?
- **Water and Energy Cycles and Processes**. How can understanding the effects and uncertainties of water and energy exchanges in the current and changing climate be improved and conveyed?

The GEWEX Science Questions (GSQs) are but part of the WCRP Grand Challenges, which deal with: (i) Actionable regional climate information; (ii) Regional sea level rise; (iii) The cryosphere and changing climate; (iv) Changes in water availability; (v) Aerosol, precipitation and cloud systems; and (vi) Climate extremes. GSQs 1 and 2 feed directly into the fourth WCRP Grand Challenges; GSQ No. 4 is central to WCRP Grand Challenge No. 6 and a part of WCRP Grand Challenge No. 5.

Several small workshops are underway to begin implementation of science to address these questions. However, the main way in which we wish to bring in and fully engage with the science community is via the **7th International Scientific Conference on the Global Energy and Water Cycle to be held in The World Forum, The Hague, The Netherlands 14–17 July, 2014.** It will be preceded by a summer school for early career scientists, and followed immediately by Pan-GEWEX and Pan-CLIVAR meetings held together on 17–18 July 2014. The Pan-GEWEX meeting will include the GEWEX Panels, individually, jointly and in plenary in order to advance the planning and implementation of the plans for addressing the GSQs. The Pan-CLIVAR meeting may start a day earlier and go on in parallel, but also jointly with GEWEX.

It will be nearly 3 years since the WCRP Open Science Conference, held in Denver, launched the new initiatives within WCRP. Many early career scientists attended that meeting and are most welcome at the GEWEX Science Conference. Having such a critical mass of scientists together will promote advances, and this opportunity is not to be missed. Please join us for this exciting scientific conference.

Newsletter Contents

Recent News of Interest

International Hydrology Prize Awarded to Kuniyoshi Takeuchi

Dr. Kuniyoshi Takeuchi, Professor Emeritus of the University of Yamanashi, Kofu, Director of the International Centre for Water Hazard and Risk Management (ICHARM), and former member of the GEWEX Scientific Steering Group, was awarded the 2012 International Hydrology Prize. Professor Takeuchi was recognized for his outstanding contributions to hydrological research, particularly in the field of water resources management; his role in educating young researchers through establishing both national and international academic programs; his international leadership in the field of water sciences, especially related to the International Hydrological Programme; and his extraordinary contributions to hydrological sciences as President of the International Association of Hydrological Sciences, in particular for launching the international decade of Prediction in Ungauged Basins (PUB).

Africa Climate Research Network

The Climate Variability and Predictability Project (CLIVAR)-GEWEX Africa Climate Panel has launched a database that aims to strengthen the network of climate scientists in Africa and to serve as an effective way of communicating relevant news and opportunities. It will be used to distribute the WCRP Africa Newsletter, announcements of the Africa Climate Conference 2013 and other meetings, training opportunities, and more.

To join the network and create your profile with contact details and areas of expertise, see: *http://www.clivar.org/africa/climate-research-network-signup*.

GEWEX Scientists Receive EGU Awards

The 2013 Plinius Medal was awarded to Justin Sheffield for his outstanding research achievements in hydrologic and related aspects of droughts.

The 2013 Vladimir Ivanovich Vernadsky Medal was awarded to Albertus (Han) J. Dolman for his important contributions to biogeosciences, in particular to the terrestrial carbon and water cycles, ecohydrology, and interactions with land use and climate change.

A New Community Experiment to Understand Land-Atmosphere Coupling Processes

Martin Best[1], Adrian Lock[1], Joe Santanello[2], Gunilla Svensson[3], and Bert Holtslag[4]

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Motivation for DICE

The Diurnal land-atmosphere Coupling Experiment, or DICE, is a first attempt to identify the complex interactions and feedbacks between the land surface and the atmospheric boundary layer (see the simplified schematic in the figure on the cover). These interactions are not well understood, in general, and are often poorly represented in numerical models.

The Global Land-Atmosphere Coupling Experiment (GLACE) (Koster et al., 2006; Guo et al., 2006) identified land-surface hot spots showing a high coupling strength between soil moisture and precipitation (i.e., between the land surface and the atmosphere). GLACE also showed large differences in the coupling strength between models, even in the hot spot regions. In reality there is only one value for this coupling strength and GLACE served to highlight our limited knowledge of what this coupling strength should actually be.

Subsequent research into the physical mechanisms for the coupling strength used in various models (e.g., Lawrence and Slingo, 2005; Comer and Best, 2012) has shown that it is the interaction between atmospheric parameterizations that determines the land/atmosphere coupling strength rather than the interactions between the land and the atmospheric boundary layer. However, more research is required to fully understand the implications of these findings.

Timescales for variations in the soil moisture at deep layers are on the order of months to years, which means that such variations could be critical for constraining the evolution of seasonal to decadal predictions. However, if the coupling between the land and the atmosphere is not correctly modeled, then such seasonal predictions may not be correctly constrained, leading to reduced quality for these valuable predictions.

Land-atmosphere interactions also play a critical role in determining the near-surface atmospheric states of temperature and humidity throughout the diurnal cycle, particularly during the stable nocturnal boundary layer. During these conditions, subtle interactions between the land and the atmospheric boundary layer can have significant impacts at the near surface and potentially lead to large prediction errors. It is unclear from current research whether these model deficiencies result from the land-surface scheme, the stable boundary layer scheme or the interactions between them. Likewise, the daytime diurnal cycle of surface fluxes and evaporative fraction is tightly coupled to the convective boundary layer heat and moisture budget, which is driven principally by the feedback of entrainment. Studies, such as Santanello et al. (2011, 2013) have shown that the influence of the land versus the boundary layer depends upon the regime of interest (e.g., dry versus wet).

It is difficult to isolate and identify issues related to either the land-surface or atmospheric boundary layer schemes within any particular model. In general this is due to the complexities of the schemes and the resulting large observational data requirements. As such, little progress has been made over the past decade in understanding land/atmosphere feedbacks. The Global Land/Atmosphere System Study (GLASS) Panel has had an activity (LoCo Project) on local coupling between the land and atmosphere for many years, and while the development of an array of diagnostic approaches has been fruitful, progress on a systematic, community-wide experiment, such as GLACE or the Project for the Intercomparison of Land-surface Parameterization Schemes (PILPS), has been slow due to the complexities described above. In parallel, the Global Atmospheric Boundary Layer Studies (GABLS), which is now part of the GEWEX Global Atmospheric System Studies (GASS) community has been evaluating the performance of atmospheric boundary layer models through several intercomparison studies (e.g., Cuxart et al., 2006; Svensson et al., 2011), but relatively little attention has been given to the role of the surface in constraining the surface fluxes. Another objective of the DICE Project is to link these two communities together to bring their combined expertise to bear on this coupled problem.

Within the DICE experiment, a simple methodology for assessing the impact of land/atmosphere feedbacks is proposed by first assessing the individual components constrained by observational data and then identifying changes due to coupling. This is the first step towards understanding the true observed physical feedbacks whilst understanding the impact of parameterization interactions.

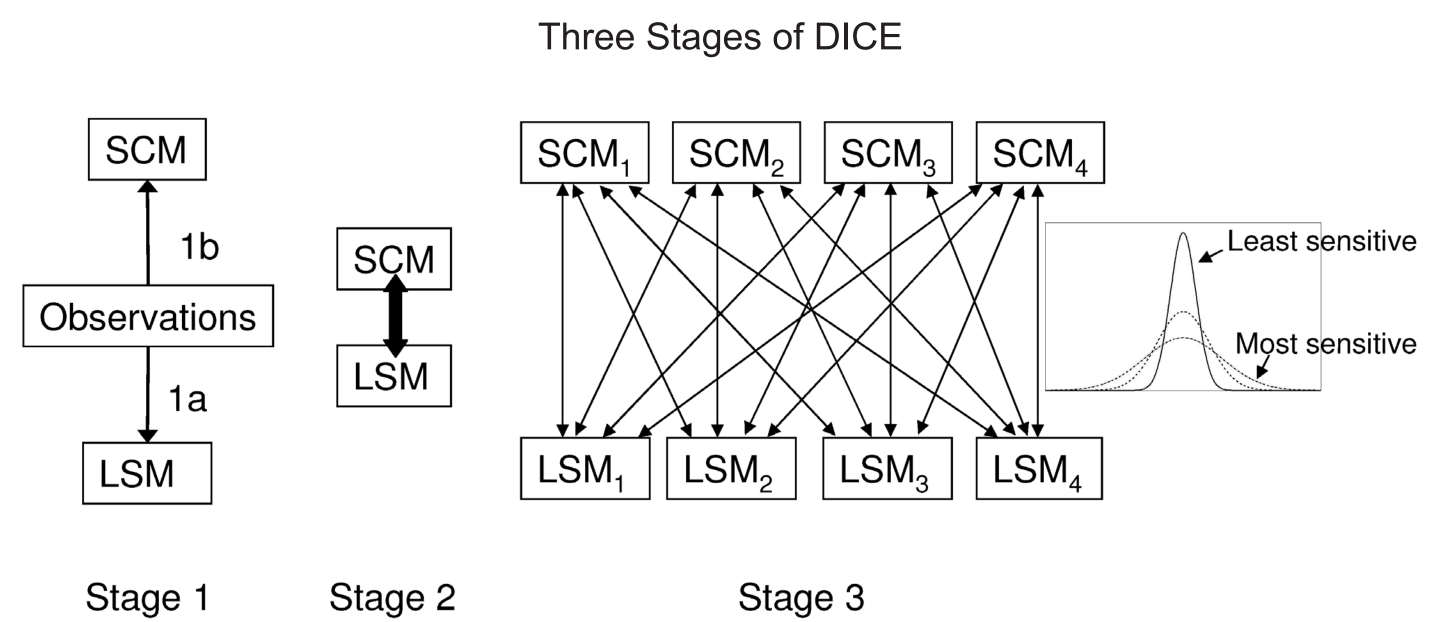
Project Outline

DICE will use data from the Cooperative Atmospheric-Surface Exchange Study-1999 (CASES-99) field experiment in Kansas (37.65°N, 96.74°E) for three days from the afternoon of 23 October through 26 October 1999. The dates chosen have clear skies in the daytime and the three nights are of varying character, such as intermittent turbulence, continuous turbulence and very stable, respectively. Data from this experiment have already been used by the GABLS boundary layer community to assess their models (Svensson et al., 2011). However, within the current project protocol, the boundary layer models (single-column models) will be designed to use observed surface fluxes as their bottom boundary condition, rather than the specified land-surface temperatures used in the previous experiment. This enables a clean split between the land-surface schemes and the atmospheric boundary layer schemes.

DICE will have three stages, which are illustrated in the figure below.

Stage 1

a. The land-surface models will be run using observed atmospheric forcing at a reference height that follows the protocol used for many of the PILPS experiments (e.g., Henderson-Sellers et al., 1993, 2003; Irranejad et al., 2003). The resultant surface fluxes and 2-m screen level data derived by the models will then be compared to the observed values to provide an initial assessment of the model performance.



b. Similarly, the single-column models will be run using the observed surface fluxes as a bottom boundary condition and the large-scale atmospheric forcing provided. The resultant wind, temperature and humidity profiles will then be compared to the observed atmospheric data to provide an initial assessment of the models.

Stage 2

Each modeling group will run its land-surface and single column models coupled to include land/atmosphere feedbacks. The modeled atmospheric profiles of temperature, humidity and wind will be compared to observations, along with the surface fluxes of momentum, heat and moisture, the screen level temperature and humidity, and the 10-m wind speed. Differences between the results from the coupled run and those from the two model components driven by the observed data (Stage 1) will be assessed to investigate the impact of the coupling through feedback processes.

Stage 3

a. The set of surface fluxes derived by each of the land-surface models used in Stage 1(a) will be used as an ensemble of "surrogate observations." Each member of this ensemble will be used by the boundary layer models, analogous to Stage 1(b), to create an ensemble of atmospheric profiles for each boundary layer model. The spread of the ensemble of boundary layer profiles is then compared among the boundary layer models to identify which models have the largest spread and which have the smallest. The models with the largest spread are the ones that are most sensitive to the surface fluxes, whereas the modes with the smallest spread are the ones that are least sensitive to the surface fluxes. Further analysis could then be undertaken to identify the processes responsible for the atmospheric sensitivities to the surface fluxes.

b. The set of atmospheric data, derived by each of the boundary layer models used in Stage 1(b) will be used as an ensemble of "surrogate observations." Each member of this ensemble is used to force the land-surface models, analogous to Stage 1(a), to create an ensemble of surface fluxes, screen level temperature and humidity, and 10-m wind speed for each land-surface model. The spread of the ensemble of surface fluxes and screen level variables will be compared between the land-surface models to identify which models have the largest spread and which have the smallest. The models with the largest spread are the ones that are most sensitive to the atmospheric forcing, whereas the modes with the smallest spread are the ones that are least sensitive to the atmospheric forcing. Further analysis could then be undertaken to identify the processes responsible for the land-surface sensitivities to the atmospheric conditions.

A challenging timescale has been set for the DICE activity, with initial results being shared during a workshop in the fall. The timescales for each part of the experiment are as follows:

- April 2013: Observational data released to participants
- June 2013: Results returned from Stage 1
- July 2013: Results returned from Stage 2
- August 2013: Results returned from Stage 3
- 14–16 October 2013: Workshop on initial DICE results (hosted by the UK Met Office)

Further details of the experiment, along with the observational data and how to contribute, can be found on the project website at: *http://appconv.metoffice.com/dice/dice.html*.

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ISCCP—Recollections of the Early Days

Robert A. Schiffer
Universities Space Research Association, Columbia, Maryland, U.S.A.

For the record, I confess that I have mostly been on the International Satellite Cloud Climatology Project (ISCCP) sidelines since leaving the Earth Science Office at the National Aeronautics and Space Administration (NASA) Headquarters in 2002, although I do continue to be involved somewhat at Universities Space Research Association as the NASA GEWEX Principal Investigator. Accordingly, many of the following comments were liberally adopted from the myriad of ISCCP documents authored by William (Bill) Rossow, myself, and others over the past 33 years.

ISCCP was the culmination of research community thinking about how to address a key obstacle to understanding climate—determining cloud-climate feedbacks (see "ISCCP at 30," *GEWEX News,* November 2012, Vol. 22, No. 4, p. 4). Prior to ISCCP, the community relied on ground-based cloud climatologies. While an important contribution to climate research at the time, these data provided limited geographical and temporal sampling, and did not provide sufficient information on cloud radiative properties.

ISCCP was initially designed to produce a 5-year global cloud climatology using the global coverage provided by the then-planned international array of operational geostationary and polar orbiting meteorological satellites. The first ISCCP global radiance data set was released in 1984. At that time, limitations in the capacity of available data storage media had a profound influence on the initial sampling strategy adopted by the project.

For me, it all began when as a NASA employee, I received an invitation from Bo Doos of the World Meteorological Organization (WMO) in April 1980 to attend a World Climate Research Programme (WCRP)-sponsored cloud climatology international planning meeting in Balatonalmádi, Hungary. This was followed by a June 1980 science planning meeting held near Lake Balaton to translate a recent paper by Vonder Haar and Paltridge on the concept of turning a satellite-based global cloud climatology into a real-time project.

In September 1980, NASA seconded me to WMO on a part-time basis to take the lead in planning and organizing ISCCP. At the 1981 WCRP Joint Scientific Committee (JSC) meeting in Vienna, Austria, ISCCP was approved as the first formal project of WCRP. At the urging of the JSC, I embarked on a global grand tour of the space agencies to sell the project—with mixed results at first.

In 1982, the somewhat complicated initial plan for ISCCP was greatly simplified with assistance from Pierre Morel, the new Director of WCRP. A key element was developing a streamlined method for data handling that was agreeable to the space agencies. Refinements in the specifications had been made earlier at an algorithm workshop held in Hamburg, Germany. I recall that this was a rather contentious meeting with implicit threats of violence, but it did end peacefully with a reasonable consensus on a plan of action. Also, I recall that Bill Rossow's presence at that meeting was an "accident" as Jim Hansen, the Director of the Goddard Institute for Space Studies (GISS), was originally going to attend. Bill came in his place and helped focus the discussion on what was needed to answer the scientific questions. Later, GISS would volunteer to be the central focus for collecting and processing the expected deluge of data and organizing its scientific exploitation, with Bill as the team leader.

Early ISCCP Contributors

Al Arking	Pat Minnis
Andre Berroir*	Pierre Morel
Hans-Jurgen Bolle*	John Morgan*
Chris Brest	Fred Mosher
Garrett Campbell	George Ohring*
Jim Coakley	Garth Paltridge
Michel Desbois	Martin Platt
Yves Desormeaux	Ehrhard Raschke
Leonid Garder	Guy Rochard*
Edward Harrison	Bill Rossow
Garry Hunt*	Eberhard Ruprecht*
E. Jattila*	Bob Schiffer*
Roy Jenne*	Johannes Schmetz
Bob Kandel	Genevieve Seze
Tom Kaneshige	Eric Smith
Kathy Kidwell	Larry Stowe
Edward Kinsella	Tom Vonder Haar*
Julius London	Don Wylie
Gyorgy Major*	

**Balatonalmádi Workshop Attendees, June 1980*

At the time there was no intention to monitor cloud variations on longer time scales to establish climate trends, since it was not clear that the observing system was stable and well enough calibrated for this purpose. The focus of the analysis was on quantifying diurnal, weather scale, and seasonal cloud variations over the entire globe and on obtaining some preliminary information about the magnitude of interannual variations. To achieve its goals, ISCCP needed to address multi-data set (multivariate) retrievals based on rigorous radiative transfer models to account for all factors affecting the satellite-measured radiances and to combine multiple satellite measurements into a comprehensive and homogeneous data product. It was recognized that the process had to be flexible enough to respond to changes in the global observing system due in part to satellite replacements as well as adjustments to external factors such as sensor degradation and satellite orbital precession (see figure at top of page 7). This required developing a radiance calibration standard applied across the entire international constellation of weather satellite imagers, both polar orbiting and geostationary, that is still the only such calibration available.

The challenges faced in successfully achieving such a never-before-attempted consolidation were, and still are, formidable: (i) space agency commitments, (ii) global coverage, (iii) international data processing network, (iv) satellite calibration, (v) cloud retrieval algorithms (mostly a polar problem), (vi) data products, and (vii) verification/validation.

Adjusting to an Ever Changing Observing System

Another challenge was inter-satellite calibration. For the most part, the satellite infrared channels were reasonably calibrated by onboard means. However, the visible wavelength channels, which did not duplicate the identical spectral characteristics among the constellation of ISCCP satellites, were notoriously subject to inconsistent calibration characteristics. The solution consisted of a novel normalization procedure first suggested, as I recall, by Nicholas Beriot, Gerard Therry, and Yves Desormeaux, and refined by Bill Rossow, which capitalized on the relative orbital geometry of the geostationary and polar orbiting platforms.

After considerable negotiations, commitments for operating the Sector Processing Centers (SPC), Global Processing Center (GPC), and Satellite Calibration Center (SCC) were finalized as below.

- European Space Agency for Meteosat
- Canadian Atmospheric Environment Service for Geostationary Operational Environmental Satellites (GOES-East)
- Colorado State University for GOES-West
- University of Wisconsin as GOES backup SPC
- EUMETSAT for Meteosat
- U.S. National Oceanic and Atmospheric Administration for the Television Infrared Observation Satellite (TIROS)
- Japan Meteorological Agency for the Geostationary Meteorological Satellite
- U.S. NASA/GISS for the GPC
- MeteoFrance for the SCC
- NOAA and NASA Langley as Archival Centers

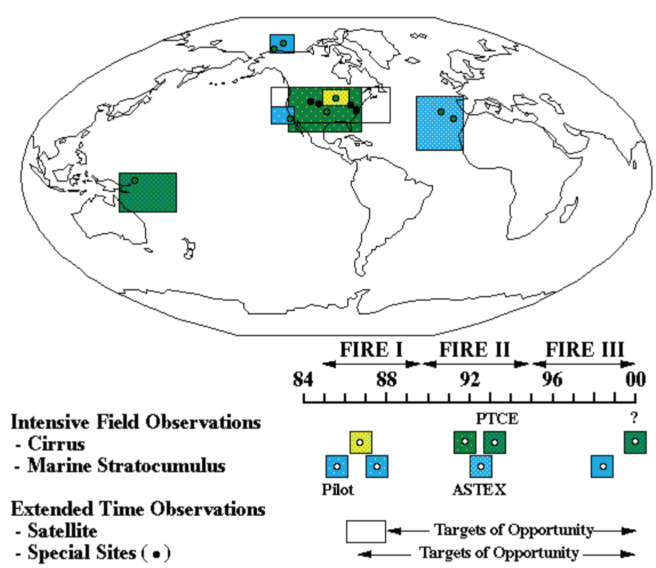
From 1984 to 1990, ISCCP-related field campaigns were organized by NASA at the behest of Vern Suomi, Tom Vonder Haar, and others to further investigate the relationships between differing cloud systems and climate, and to help verify and improve cloud monitoring techniques from satellite platforms. The First ISCCP Regional Experiment (FIRE) consisted of a series of field campaigns at different worldwide locations to study the radiative properties of a variety of cloud systems with the aid of airborne and ground-based instrumentation, as well as high resolution ISCCP data. The figure below shows the geographical distribution of the FIRE campaigns. David McDougal at NASA Langley deserves credit for his important contributions as the FIRE Project Manager.

The ISCCP cloud data sets are now being used to determine cloud effects on the Earth's radiation balance. Clouds play an equally important role in Earth's water cycle as the intermediate stage between the water vapor that evaporates from and cools the surface and the precipitation that heats the atmosphere and returns the water back to the surface. Variations in both the radiation and water cycles help drive the circulations of the atmosphere and oceans. Since it is the motions of the atmosphere that transport water vapor and form clouds and precipitation, understanding both the cloud radiation and the cloud water feedbacks on the climate also requires understanding how atmospheric motions effect cloud properties. To address these considerations, more information is needed on how cloud systems form, evolve, and decay in different meteorological regimes, which requires extending the list of cloud properties that can be measured and organizing the observations in more meaningful terms of the evolution of the dynamics of whole systems, such as the mid-latitude cyclones and tropical mesoscale convective complexes. Research is under way to adapt or extend the ISCCP cloud data sets for this purpose.

In closing, I want to express my deepest appreciation to the ISCCP team, the dedicated staff and management at the satellite operational agencies, to GISS, and especially to Bill Rossow for their dedicated work over the past three decades, without which we would not be celebrating the 30th Anniversary of ISCCP. Even if improvements of the whole satellite observing system someday warrant creation of a "better" cloud product, the ISCCP record will continue as the longest uniform global record of basic cloud properties.

The above comments are an abridged version of a paper presented at the ISCCP at 30 Conference on 22–25 April 2013.

FIRE INTENSIVE FIELD AND EXTENDED TIME OBSERVATIONS



OzEWEX: The Australian Energy and Water Exchange Initiative

Albert van Dijk[1], Gab Abramowitz[2], Brad Evans[3], Ben Gouweleeuw[4], Juan Pablo Guerschman[4], Fiona Johnson[2], Marc Leblanc[5] , Tim McVicar[4], Sandra Monerris[6], Tom Pagano[7], Luigi Renzullo[4], and Bellie Sivakumar[2]

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In October 2012, the Australian research community launched a new initiative aiming to become a new Regional Hydroclimatology Project (RHP) within GEWEX. The Australian Energy and Water Exchange (OzEWEX) Initiative brings together researchers and operational staff from universities, the Commonwealth Scientific and Industrial Research Organisation (CSIRO), and the Australian Bureau of Meteorology (BoM) to collaborate on the measurement, understanding, and prediction of climate- and water-related variables, including vegetation dynamics and ecosystem carbon fluxes. OzEWEX aims to achieve its goals by promoting and facilitating data collection and sharing, collaborative research activities across organizations, and engagement between researchers, research users, and research managers. The initiative's website (*http://www.ozewex.org*) provides information about new events, publications, and data sets, and allows the community to add their own information and post requests.

Why Australia as a Region?

The previous RHP in Australia was focused on the Murray-Darling River Basin (Evans, 2012). In discussing options for a follow-on project, there was general consensus that the scope should be extended to the entire Australian continent. Limiting the geographical scope would narrow the research activities and interests that could be encouraged and coordinated, and be less likely to strengthen Australia's relatively small and widely-dispersed water and energy research community. Further, with the more open sharing of government-collected data and with measurement technology becoming routine and coordinated through existing research networks, the need for field campaigns as a primary means of collaboration appears to have somewhat receded.

An important challenge for the community now is to find and access existing observational data and to collaborate in using these data in research. There are also several research activities central to OzEWEX that are carried out at the continental scale and include a range of climate, water, and carbon modeling projects, and remote sensing-based research. Limiting the project scope to a single region would narrow the opportunities for intercomparison and evaluation, and not make optimal use of national measurement networks. For these reasons, OzEWEX has a national scope. This does not mean that all research will occur at the national scale. For example, intensive regional field measurement campaigns still create a far greater richness and density of observations for research, and some of the supported research activities use a selected set of locations or catchments. Some examples include the following (see figure on next page):

- **OzNet Monitoring Network in the Murrumbidgee Catchment in New South Wales**—extensive field and airborne data collection for the development and validation of soil moisture remote sensing products (Smith et al., 2012, *http://www.oznet.org.au*)
- **Savanna Patterns of Energy and Carbon Integrated Across the Landscape (SPECIAL) Transect in Northern Australia**—contributing to understanding landscape-scale water and carbon fluxes (Beringer et al., 2011)
- **Terrestrial Ecosystem Research Network (TERN) OzFlux Facility**—maintains a network of flux towers to measure energy, water, and carbon exchanges between the land-surface and atmosphere (*http://www.ozflux.org.au*)
- **CosmOz Network** (*http://cosmoz.csiro.au/cosmoz/*)—a near-real-time cosmic ray soil moisture sensor network established by CSIRO in collaboration with universities
- **BoM Reference Data Sets**—select climate and water measurement stations for model development, forecasting, and reporting purposes. Where research has relevance to these operational uses, OzEWEX encourages the same measurement network be used in research.

OzEWEX Working Groups

The six working groups of OzEWEX are summarized in the table on the next page with more details provided below. All working groups combined currently have 96 members from 14 organizations. Anyone inside or outside of Australia interested in joining one of the working groups is warmly invited to contact the relevant working group chairs.

Observational Data Working Group

Finding and sharing observational data has become an important focus of the research community, and includes data from operational and research monitoring networks and programs, as well as from occasional field, airborne, and satellite data collection campaigns. Data types of interest include in situ and remote sensing observations, as well as derived data products.

Examples of relevant in situ observations include precipitation and other meteorological observations at climate stations and flux towers, eddy covariance water and carbon flux data, hydrometric monitoring data (e.g., streamflow, groundwater level), and soil moisture measurements. Examples of remote sensing observations include atmospherically corrected Landsat imagery; optical, thermal, passive microwave, and radar land-surface remote sensing time series; and airborne and satellite hyperspectral and soil moisture data at various resolutions. Some of the derived data products of interest are national-scale dynamic or static land cover change and use, elevation, physical soil properties, and physical vegetation properties.

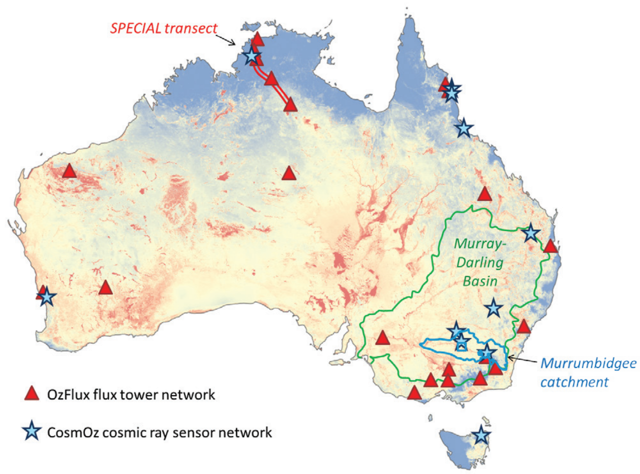
To assist the research community in discovering existing data sources, the Observational Data Working Group is developing a catalogue of currently available data and data portals. It includes climate and water data provided by BoM, CSIRO, state agencies and departments, and flux tower observations, in situ soil moisture data and remote sensing products provided by other research initiatives and projects. Where data are deemed particularly valuable for research but are not easily accessible or future availability is not secure, OzEWEX will advocate for their continued provision. Where necessary, data owners will be encouraged to make the data more widely available. We will also encourage the use of data standards and the provision of uncertainty information.

Model Evaluation and Benchmarking Working Group

Evaluating energy and water balance models against observations is a key part of understanding when model simulations are useful. This working group will develop protocols for the comparison and evaluation of model predictions through the creation of standardized reference experiments. It will address such questions as:

- Which observational data sets and metrics should be used in reference model evaluation experiments?
- How should differences between simulations and observations be interpreted and how does this relate to uncertainty estimation?
- How can expectations of model performance be quantified a priori on the basis of model complexity and the amount of information provided to a model?
- How does model performance vary regionally across Australia and what does this imply about the driving processes?

Biophysical models of particular importance in the Australian research community and the BoM include: the Community Atmosphere Biosphere Land Exchange (CABLE) (Law et al., 2012), the Australian Water Resources Assessment (AWRA) System (Van Dijk and Renzullo, 2011), and the UK Met Office land-surface models (MOSES and JULES) (Best et al., 2011), although this list is not intended to be comprehensive. This working group will build on recent infrastructure, code, and data developed by the CABLE and AWRA teams, and will further develop the Protocol for the Analysis of Land Surface Models (PALS)–a web-based model evaluation and benchmarking tool that is being developed under the auspices of TERN, the Australian Research Council (ARC) Centre of Excellence for Climate System Science, and GEWEX (Abramowitz, 2012).



Some examples of Australia's research and monitoring infrastructure, which includes national and regional networks, as well as full spatial satellite observations and data products. Background shows net land surface-atmosphere water fluxes estimated from remote sensing: blue colors indicate that rainfall exceeds evapotranspiration, red colors the reverse (after Guerschman et al., 2009).

OzEWEX (*Chair: Albert Van Dijk*)

Promote and enhance measurement, understanding, and prediction of the water and energy cycles and related variables over the Australian continent

OzEWEX Working Groups

Working Group 1 - Observational Data
(Co-Chairs: Juan P. Guerschman and Sandra Monerris)
Promote awareness, access, and continuity of existing data sources that are critical for research of the energy and water cycle, and to evaluate new observations

Working Group 2 - Model Evaluation and Benchmarking
(Chair: Gab Abramowitz)
Use observations to evaluate and compare biophysical models and data products describing energy and water cycle components and related variables

Working Group 3 - Data Assimilation *(Chair: Luigi Renzullo)*
Develop successful new approaches for data observation into energy and/or water balance models

Working Group 4 - Trends and Extremes
(Co-Chairs: Marc Leblanc and Bellie Sivakumar)
Describe, analyze, and attribute observed variations, trends, and extremes (such as heatwaves, floods, and droughts) in water-and energy-related quantities

Working Group 5 - Vegetation Processes *(Co-chairs: Tim McVicar and Brad Evans)*
Understand the role of different vegetation types and their function in coupling the energy, water, and carbon cycles through field experiments, analysis of field data, and modeling

Working Group 6 - Hydrological Prediction
(Co-Chairs: Ben Gouweleeuw, Fiona Johnson, and Tom Pagano)
Improve and provide hydrological predictions over time scales of hours to decades

Data Assimilation Working Group

The assimilation of a range of in situ and satellite observations of atmosphere, ocean, and land is a critical factor in the success of weather forecasting. Statistical climate and streamflow predictions also entrain current observations. Retrospective climate analysis (reanalysis) and AWRA model water balance estimation also rely on data assimilation techniques. Flood forecasting currently relies on the implicit assimilation of weather and streamflow observations in the mind of the forecaster, but formal data assimilation procedures are being developed.

Data assimilation is a tremendous challenge, as it requires understanding across a range of areas: observation characteristics and errors; the relationship between observed and modeled quantities; the conceptual structure and equations of the biophysical model; the mathematical assimilation techniques available; and the constraints imposed by the computational software and hardware. As a consequence, the Australian data assimilation community tends to be highly specialized towards specific applications in terms of each of these aspects. This has been an obstacle to the exchange of expertise and to increasing the efficiency of research through collaboration.

The working group on data assimilation aims to strengthen and grow the Australian data assimilation community in the area of climate and water modeling by providing a forum to exchange expertise and collaborate on topics of common interest in the areas mentioned. Experiments are being designed to address questions of common interest, such as the error in particular observations (e.g., remotely sensed soil moisture) or the effectiveness and efficiency of alternative assimilation techniques (e.g., variation versus ensemble techniques). The experiments are likely to be tiered (e.g., be partly continental and partially focused on the Murrumbidgee catchment).

Trends and Extremes Working Group

To manage the impacts of Australia's highly variable climate (including the anticipated impacts of global climate change), it is critical to understand and attribute observed (and projected) variations, trends, and extremes in climate, such as heat waves, floods, and droughts. This working group analyzes climate and water data to improve understanding of land surface-atmosphere interactions and long-term trends in them, and synthesizes existing and new scientific knowledge for use in planning, management, and policy development associated with our water resources and environment. Of particular interest are trends and nonstationarity in rainfall and streamflow, especially their extremes, and the measurement and prediction of their changes. Statistical techniques and nonlinear dynamic methods will be developed to automate the analysis of long-term climate and water data and their updates (e.g., error detection, trend analysis, system dynamic identification).

Another anticipated new activity is to coordinate the search and access to a range of observational time series that possess characteristics (e.g., record length, measurement frequency, currency) that are suitable for analyzing trends and dynamics in climate and water data. This will be done by sharing knowledge between researchers and data custodians, such as BoM.

Vegetation Processes Working Group

Vegetation plays a critical role in modulating the energy, water, and carbon cycles, yet it is vulnerable to the pressures of fire extremes, water availability, management, and anthropogenic land use change. Of particular interest is the role of native dry land and savanna ecosystems and land cover change, for example, through changes in evapotranspiration partitioning and timing, surface roughness, and soil water dynamics. The current generation of models has important deficiencies in describing these processes and critical questions remain, such as:

- How well can changes at the land surface be predicted?
- How does land cover change affect precipitation?
- What is the net warming or cooling impact of vegetation change?
- What are the trade-offs between carbon, water, and energy fluxes involved in land cover change?
- Can vegetation dynamics, structure, and function be predicted from optimality in resource use?
- How will vegetation structure and function change due to global changes in climate and biogeochemical cycles?
- How is atmospheric carbon dioxide changing vegetation function and how will this impact evapotranspiration and water resources?

The activities of this working group include the collation of observational and model data sets to answer specific questions about vegetation structure and function. This includes research data (e.g., from flux towers, ecophysiology, vegetation sampling for mass, biochemistry, isotopes and structure) as well as land cover information derived from remote sensing (e.g., leaf area index, cover fraction, greenness, biomass, land use and structure). Examples of research in this area include model representation of vegetation groundwater uptake, the partitioning of evapotranspiration into transpiration and wet canopy and soil evaporation, and stomatal behavior. The categories of models used in this research include hydrological, land-surface and dynamic vegetation models. Synthesis and review activities will be initiated by researchers or in response to priorities expressed by management and policy organization staff.

Hydrological Prediction Working Group

The aim of this working group is to test existing methods and develop improved methods of hydrological prediction at a wide range of time scales. Of particular interest are streamflow forecasts at daily, seasonal, and decadal time scales. Areas of focus for the working group include forecast initialization, methods to use meteorological forecasts and predictions, and determining prediction skill. Hydrological forecast model initialization can involve assimilation of hydrometric and hydrological remote sensing data and deal with data latency and lead time, for example by combining historic data and short-term forecasts to "nowcast" recent conditions. This also relates to inundation modeling, where near-real-time remote sensing information can be used to constrain hydrodynamic models, which in turn can be run in forecast mode. It is envisaged that activities using weather forecasts and climate predictions will involve improvement of the mechanisms for researchers to access weather forecasts and climate predictions, the research to evaluate the skill of alternative forecast and prediction sources, and the development of ensemble, downscaling, and bias correction procedures for hydrological applications.

Planned activities include organizing near-real-time research access to forecasts from BoM's numerical weather prediction and seasonal prediction systems, and original or post-processed climate predictions produced in support of the Intergovernmental Panel on Climate Change (IPCC)'s 5th Assessment Report (e.g., the COordinated Regional climate Downscaling Experiment, CORDEX). Existing approaches for making forecasts include a range of simple to complex techniques that may use meteorological forecasts, hydrological models, multivariate statistical techniques, ensemble methods, or a combination of these. There is a need to measure and compare their respective skill. This will require the design of benchmarking experiments and infrastructure to test improvements. Performance evaluation needs to consider accuracy, as well as reliability in the forecasts, and consider unavoidable operational constraints. As the organization responsible for operational forecasting, BoM is a key participant in this working group.

Acknowledgements

Although OzEWEX is newly established, it has already received valuable support from the Australian National University and other universities in Australia, the ARC Centre of Excellence for Climate System Science, TERN; and from BoM and CSIRO, through their joint Centre of Australian Weather and Climate Research (CAWCR) and Water Information Research and Development Alliance (WIRADA).

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Saskatchewan River Basin Regional Hydroclimate Project

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The August 2011 issue of *GEWEX News* reported on an exploratory workshop to develop a GEWEX Regional Hydroclimate Project (RHP) in Western Canada. A formal proposal was made to GEWEX and the Saskatchewan River Basin (SaskRB) Project was approved as an "Initiating" RHP in December 2012. It is currently the only active RHP in North America, but it is hoped that it will provide a stimulus for a broader initiative across North America.

Why the SaskRB Project?

Traversing the three provinces of Alberta, Saskatchewan, and Manitoba, the 336,000 km^2 Saskatchewan River Basin encompasses a large swath of Western Canada. With an area approximately half the size of France, it is one of the world's larger river systems. It experiences one of the most extreme and rapidly changing climates in the world and embodies a set of biomes of major importance to Canada and globally.

The Canadian Rocky Mountains in Alberta are the dominant source of river flow; the Saskatchewan River's two major tributaries flow east from the continental divide. The South Saskatchewan River passes through the Canadian Prairies, a region with high natural climate variability, which is home to 80 percent of Canada's agriculture. While most agriculture in the Saskatchewan River Basin is based on natural precipitation (in which snow plays a major role), the provinces of Alberta and Saskatchewan account for approximately 75 percent of Canada's irrigated agriculture, mostly located in the South Saskatchewan River Basin. Diversions for irrigated agriculture account for about 82 percent of consumptive water use. The North Saskatchewan River passes through Prairie landscapes and Boreal Forest, which is an important global ecosystem and represents 35 percent of Canada's land area. After the confluence of these two major tributaries, the river passes through the Saskatchewan Delta (North America's largest freshwater wetland), marking the downstream limit of the Saskatchewan River Basin catchment, and enters Lake Winnipeg, ultimately discharging its waters into the Hudson Bay.

In addition to irrigation use, the large-scale development of the river includes dams for hydropower, water supply for industry and urban centers, and flood relief. The largest of these is the 225-km long Lake Diefenbaker multipurpose reservoir in Saskatchewan, which stores 9.4 billion m^3 of water.

The climate of the Saskatchewan River Basin is characterized by an extreme temperature range (minus 40 to plus 40 °C), and extreme weather events, which are a defining feature of the Prairie's climate and culture. Recent examples include the major drought of 1999–2004 that has been described as Canada's most costly natural disaster, with a $3.6 billion drop in agricultural production in 2000-2001 and a $5.8 billion decline in Gross Domestic Product. Extensive flooding in 2011 caused widespread damage across the Prairies, with reported costs in Manitoba alone exceeding $800 million.

Concerns include the provision of water resources to three million inhabitants, including drinking water for rural and indigenous communities; balancing the needs for industrial and natural resource development with those of agriculture; issues of water allocation between upstream users in Alberta and downstream users in Saskatchewan and Manitoba; managing risk of flood and drought; and water quality impacts of discharges from major cities and agricultural production. Current pressures are severe: the South Saskatchewan River Basin is fully allocated in southern Alberta and has been described as Canada's most threatened river by the World Wildlife Fund. As noted above, drought in 2000 and flooding in 2011 caused major economic damage, and water quality in Saskatchewan's major reservoir (Lake Diefenbaker) is deteriorating, with increasing concern over eutrophication and water supply.

SaskRB Project Flagship Sites

These pressures are occurring against a background of rapid environmental change. A warming climate is causing Rocky Mountain glaciers to retreat, changing the rain/snow balance and the processes of snow accumulation and melt, thus influencing the magnitude and timing of river flows. In the prairies, changing climate is affecting agriculture, flood and drought risk, and water quality. Farming practices, such as tillage, drainage, and wetland removal, are changing the landscape and the ecological services that it provides. Changes in flow now threaten the Basin's delta, one of Canada's richest regions for its abundant and diverse wildlife, with declining river flows. Transformations in the delta ecosystem are of profound concern to the First Nations peoples who have traditionally occupied the region, affecting hunting, fishing, trapping, and subsistence agriculture.

Superimposed upon these current pressures is the need to understand and manage uncertain water futures, including effects of economic growth and environmental change, in a highly fragmented governance environment. Water planning is based primarily on provincial jurisdictions, but with various responsibilities for the federal government and other agencies, and different legal frameworks for First Nations land and associated water rights, the result is a lack of catchment-based integrated water resources planning and management. The Saskatchewan River Basin thus encompasses many of the challenges faced worldwide in addressing water security.

The Saskatchewan River Basin also poses globally important science challenges due to the importance of, and diversity in, its cold region hydroclimate and ecological zones, the rapid rate of environmental change, and the need for improved understanding, diagnosis, and modeling of change. Biomes of regional and global importance include the Rocky Mountains, boreal forests, and prairies. Key science challenges include the need to improve understanding and modeling of: (i) climate variability and change over the Saskatchewan River Basin; in particular, the extremes of floods and droughts; (ii) effects of land use/management change on environments of regional and global importance; and (iii) societal controls on water management, including operational constraints, water management vulnerabilities, and policy and governance opportunities.

To address these challenges requires integrated, coherent, multiscale, multidisciplinary research. One example is that the cold region environments pose major modeling challenges, and current models have not considered the full range of feedbacks between the atmosphere, hydrosphere, cryosphere, and terrestrial ecosystems. For instance, the North America Regional Climate Change Assessment Program (NARCCAP) simulations of current climate show up to 6°C positive air temperature bias over this region with errors in precipitation ranging from plus 90 to minus 45 percent. Further, limited data and forecasting capability, coupled with effects of climate warming, exacerbated problems with operational management of the 2011 floods.

The SaskRB Project

The SaskRB Project builds upon the fact that in addition to long standing routine monitoring of climate, hydrology, and water quality, the Saskatchewan River Basin contains high quality experimental sites with long-term observational records. Many of these sites were established in conjunction with earlier Canadian GEWEX initiatives, such as the Boreal Ecosystems-Atmosphere Study (BOREAS) and the Mackenzie GEWEX Study (MAGS). With funding from the Canada Excellence Research Chair in Water Security at the University of Saskatchewan and the Canadian Foundation for Innovation, these sites are being expanded and additional sites developed to create a unique set of comprehensive and state-of-the-art field research facilities.

Rocky Mountain research builds on a 50-year history at Marmot Creek, significantly expanded in recent years by John Pomeroy of the University of Saskatchewan. Instrumentation is currently being expanded to develop a more extensive Canadian Rockies Hydrological Observatory. Boreal Forest infrastructure includes an important set of flux tower sites [developed as part of BOREAS, later the Boreal Ecosystem Research and Monitoring Sites (BERMS), with comprehensive flux data from 1994], with new National Aeronautics and Space Administration (NASA) soil moisture instrumentation installed in 2012 for the Airborne Microwave Observatory of Subcanopy and Subsurface (AirMOSS) Experiment.

Prairie sites include St. Denis National Wildlife Area, a classic prairie pothole landscape, and Kenaston, originally established as a soil moisture remote sensing observatory and currently being used for Soil Moisture Active Passive (SMAP) mission development, with major new instrumentation including Community Earth System Models (COSMOS) soil moisture measurement, Sonic Detection And Ranging (SODAR) boundary layer observations, and scintillometry. Additional prairie sites include Smith Creek Research Basin, for investigation of agricultural drainage, and Tobacco Creek, for agricultural beneficial management practices. A major focus for water quality research is Lake Diefenbaker, which is subject to high nutrient loads and increased eutrophication, and its Swift Current Creek tributary, which includes urban as well as agricultural loadings.

This infrastructure provides the basis for modeling and analysis at multiple scales, including land surface systems models, and the development of decision support tools for water resources, water quality, and aquatic ecosystem management. The SaskRB Project is developing an information system to support integrated water science and adaptive management, and these activities will address not only the water policy and management needs of the prairie provinces, but also each of the six Imperatives of the GEWEX program. It will develop the ability to close the water and energy budget and its sub-catchments at all temporal scales using observations, models, and data assimilation capabilities, and use these capabilities to predict water cycle variability over the Saskatchewan River Basin.

SaskRB is working to develop its web presence (see *http://www.usask.ca/water/saskrb*) and also to develop a web-based data portal. Collaboration is welcome; for further information, please contact Howard Wheater (*howard.wheater@usask.ca*) or our network manager, Chris DeBeer (*chris.debeer@usask.ca*).

NASA Satellite and Modeling Products Improve the Monitoring of the 2012 Drought

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As the harvest season approached in August 2012, much of the United States remained in the grip of a major drought that threatened global food prices and the U.S. biofuel feedstock. According to the U.S. Drought Monitor (USDM), 52 percent of the U.S. was in moderate or worse drought conditions by August 7, 2012 (see Figure 1a on page 14). Drought areas were concentrated in the agricultural states in the central U.S. Although areas east of the Mississippi River experienced some relief due to Hurricane Isaac, the drought persisted west of the Mississippi River Basin. The U.S. Department of Agriculture (USDA) Economic Research Service reports about 80 percent of U.S. agriculture experienced drought in 2012, making it the most extensive drought since the 1950s. The *Financial Times* reported losses related to the drought at roughly $30 billion dollars.

Drought Monitoring

NASA maintains satellite and modeling capabilities for the assessment of drought severity and extent on a national and global basis. NASA vegetation maps and soil moisture and groundwater products are used in conjunction with data from other U.S. agencies to provide drought information through the USDM (see Svoboda et al., 2002). NASA products have increased the accuracy of USDM drought contours and improved drought detection. The North American Land Data Assimilation System (NLDAS: *http://ldas.gsfc.nasa.gov/nldas/* and *http://www.emc.ncep.noaa.gov/mmb/nldas*) soil moisture and snow cover maps supplement in situ data, especially in data-sparse regions.

Agricultural and Pastureland Drought Monitoring

As of July 29, 2012, the drought had left 48 percent of the corn and 37 percent of the soybean harvests rated as poor or worse, and 33 percent of the nation's cattle were trying to survive in extreme to exceptional drought. The USDA Global Economic Intelligence System provides a global overview of crop production. In 2012, this system used weather data from geostationary satellites, Normalized Difference Vegetation Index (NDVI) data from polar-orbiting satellites, passive microwave soil data, and lake level estimates from radar satellite altimeters to develop monthly U.S. and global updates. Increasingly, U.S. agricultural agencies rely on high resolution VegDRI products (see Figure 1b on this page) to map the drought effects down to 1-km resolution (Wardlow et al., 2012). VegDRI integrates Moderate Resolution Imaging Spectroradiometer (MODIS) data from the Terra satellite observations of vegetation conditions with a modified Palmer Drought Severity Index classification scheme, and the biophysical characteristics of vegetation to produce an estimate of drought stress on vegetation. The eMODIS VegDRI product proved quite valuable because it provided frequent updates during the 2012 drought.

Soil moisture can be used to indicate the availability of water for plant growth and irrigation requirements and as an indicator of the potential for reductions in streamflow and water infiltration. During 2012, soil moisture and surface water storage were estimated from Active/Passive Microwave Sensors, including the Advanced Microwave Scanning Radiometer-Earth Observing System (AMSR-E)/TRMM (Tropical Rainfall Measuring Mission) Microwave Imager (TMI)/Special Sensor Microwave Imager (SSM/I) Radiometers and the QuikSCAT Scatterometer. The Soil Moisture Active Passive (SMAP) mission, which is planned for launch in 2014, will map soil moisture globally and support a range of drought-related applications, including the USDM.

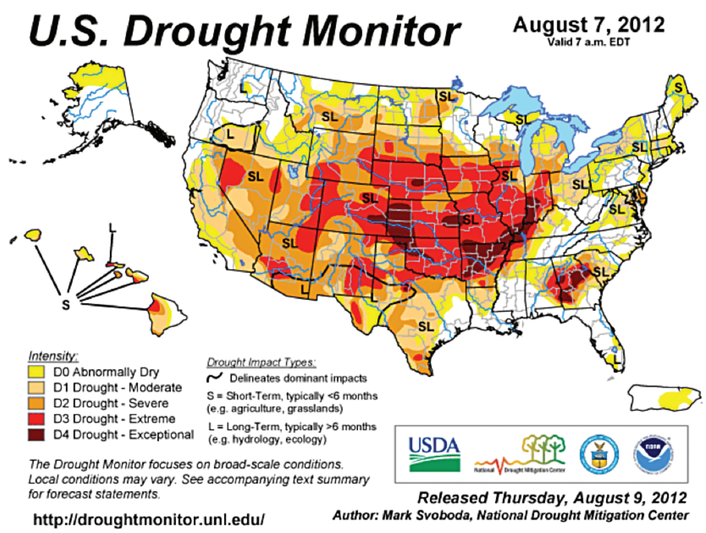
Hydrologic Drought Monitoring

Streamflow and surface water storage were affected by the 2012 drought. In July, almost 80 percent of the contiguous U.S. experienced low streamflows, with Iowa and other central states experiencing flows of less than 25 percent of normal levels, leading to stress on fish and aquatic bird habitats. USDM products provided guidance on the timing of the implementation of federal agricultural drought assistance programs in many states. Due to satellite limitations in measuring flows on smaller rivers and streams, streamflow droughts were assessed using in situ streamflow data operated by the U.S. Geological Survey (USGS) and individual states and from the NLDAS output.

The drought resulted in falling groundwater levels in many central states. A large number of farmers in Indiana and nearby states reported that their wells had failed and spent up to $10,000 each on deepening their wells or drilling new ones. NASA's Gravity Recovery and Climate Experiment (GRACE) mission, combined with other data and a data-assimilating land-surface model, produced useful maps (see Figure 2b on page 15) for assessing drought impacts on groundwater (Rodell, 2012). Weekly national GRACE-based drought maps are available through the National Drought Mitigation Center's website at: *http://drought.unl.edu/MonitoringTools/NASAGRACEDataAssimilation.aspx*. A comparison of the center of drought in Figures 1 and 2 shows that atmospheric, agricultural, and hydrologic drought experience both time and space lags and displacements due to the processes responsible for their manifestations.

Meteorological Drought Monitoring

Prolonged periods without precipitation are the main drivers for drought. Earth observations by NASA that contribute to meteorological drought monitoring include: the Tropical Rainfall Measuring Mission (TRMM) Multi-Satellite Precipitation Analysis (TMPA), measurements of temperature [including the Atmospheric Infrared Sounder (AIRS) temperature], cloud and humidity measurements, Clouds and the Earth's Radiant Energy System (CERES) radiation measurements, and MODIS vegetation measurements. NASA has led the development of Global Precipitation Climatology Project (GPCP) products available at *http://precip.gsfc.nasa.gov/* that provide a



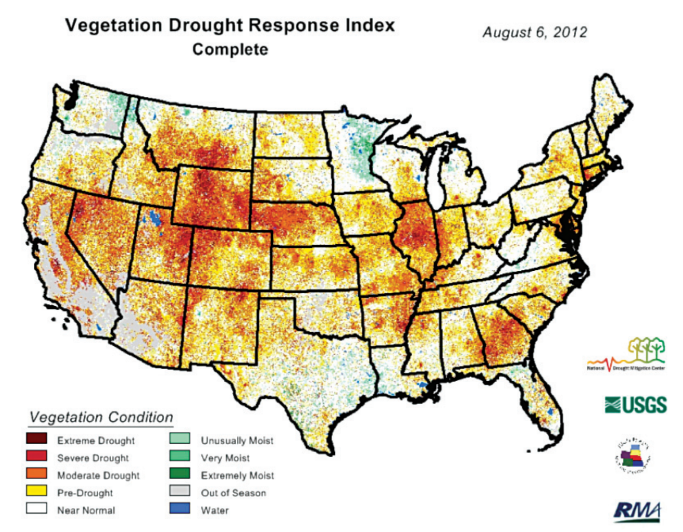


Figure 1a (top) shows the U.S. Drought monitor map for August 7, 2012 and Figure 1b (bottom) shows the VegDRI map for August 6, 2012. The drought severity had migrated eastward (1a) but the impacts were still largest in the western grain producing states (1b).

30-year climatology of precipitation as well as a benchmark for drought monitoring. Integrated precipitation products such as the Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks (PERSIANN), which is derived from TRMM, the Distributed Model Intercomparison Project (DMIP), and National Oceanic and Atmospheric Administration (NOAA) geostationary satellite data, is widely used for monitoring precipitation at higher resolutions.

The water stress produced by drought affects evapotranspiration (ET) and its role in the local water budget. The 2012 drought was monitored by using Atmosphere-Land Exchange Inverse (ALEXI), a thermal approach (Anderson et al., 2011) to drought monitoring supported by USDA and NASA. This inverse modeling technique combines clear-sky fluxes from Landsat Thermal Infrared Radiometer (TIR) with coarse (5–20 km) satellite data [AIRS, the Geostationary Operational Environmental Satellite (GOES), the Meteorological Satellite Second Generation (MSG)], moderate (1 km) resolution [MODIS, the Advanced Very High Resolution Radiometer (AVHRR), the Along Track Scanning Radiometer (ATSR)] and high (90–120 m) resolution [Atmosphere Surface Turbulent Exchange Research (ASTER), Landsat] to produce multiscale ET, drought monitoring, and soil moisture maps. Peters-Lidard et al. (2011) showed that improved estimates of ET arose from the assimilation of AMSR-E soil moisture, leading to optimism that SMAP soil moisture data will produce significant improvements when they become available in 2014.

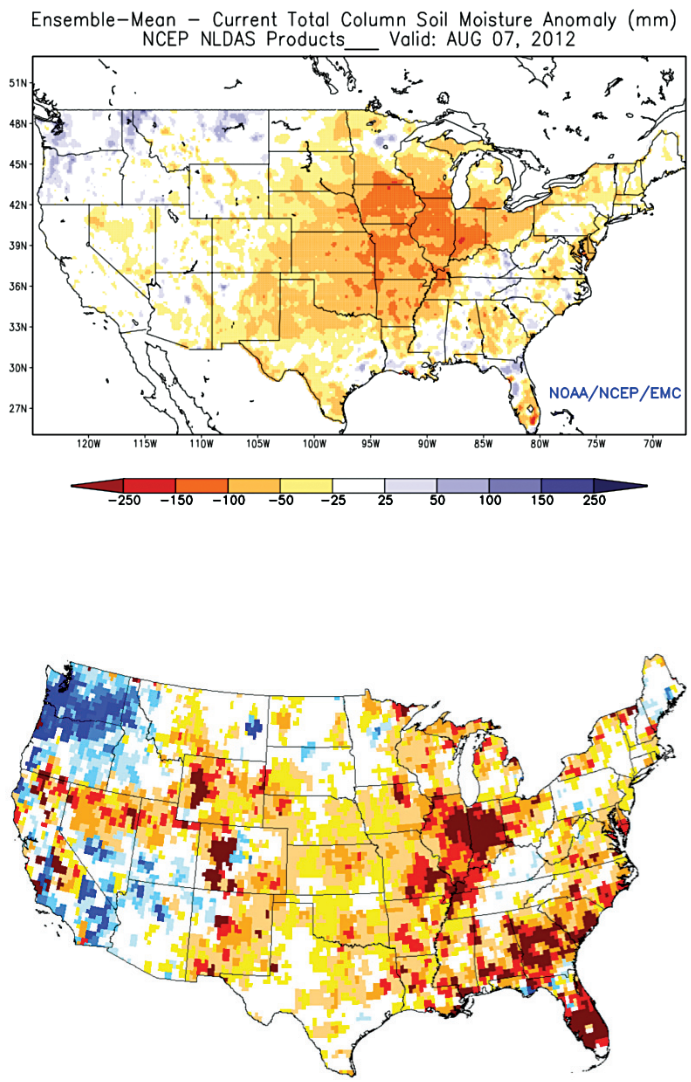


Figure 2: Soil moisture outputs including (top) the total column soil moisture anomaly on August 7, 2012 from a NLDAS four land-surface model (LSM) ensemble mean (see Xia et al., 2012) and GRACE data for August 12, 2012 (bottom).

Drought Prediction

Access to reliable forecasts of a drought's onset, persistence, and termination is necessary to mitigate its impacts. Drought predictions rely on comprehensive observations of surface conditions on oceans and land. Forecasts can be improved with higher resolution LSMs that use NASA high resolution data products (Cai et al., 2011) and improved soil moisture information, which has a significant impact on streamflow prediction and drought monitoring (Koster et al., 2011).

Ensemble forecasts can increase confidence in drought predictions (Schubert and Koster, 2012). They were used by the NASA Global Modeling and Assimilation Office (GMAO) to forecast precipitation and soil moisture deficits. Ensemble forecasts for July 30 initialized in early May, early June and early July all have some skill (see: *http://gmao.gsfc.nasa.gov/research/climate/US_drought*). At local scales, the climate extension of the Weather Research and Forecasting (CWRF) model has been used to show that model downscaling reduces forecast errors of seasonal mean precipitation and produces greater skill for heavy rainfall predictions (Yuan and Liang, 2011).

Communicating information on drought to end users remains a challenge. Options for doing this more effectively include:

1. Using organizations and groups as intermediaries between scientists and users;
2. Holding user workshops to train users on ways to apply drought information;
3. Developing capacity and applications for users and data providers; and
4. Improving strategies for coping with and adapting to drought based on access to better monitoring and prediction information.

Summary

Through its unique Earth science program, NASA provided important contributions to the U.S. government's response to the 2012 drought. NASA satellites provide global high resolution measurements and data assimilation systems to integrate these data with in situ data and model outputs. In addition, NASA supports global drought monitoring activities by providing maps for the evaluation of current conditions; tools for customized and interactive visualization; analysis and data downloading; multi-sensor, multi-source data integration; and the integration of drought-related data products.

Two ways that NASA might strengthen its support to drought preparedness are:

1. Reducing the time required for data acquisition, download, processing, and distribution, thereby substantially increasing the potential benefit of its products for its users; and

2. Continuing to make the strongest possible case for relevant Earth observations and science to support all aspects of drought preparedness as a priority for the NASA budget. This should be done within a broader integrated Earth, climate and water framework that includes all hydrometeorological extremes as well as their causitive factors such as climate and land use change, demographics and water resource development.

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GEWEX/WCRP Calendar

For the complete Calendar, see the GEWEX website: http://www.gewex.org/

3–5 June 2013—GASS/MJO Task Force Meeting on the Heating and Moistening Processes of the MJO—Centre for Climate Research, Singapore.

5–7 June 2013—WCRP Strategy Workshop for Global Water Resource Systems—Sasakatoon, Canada.

10–14 June 2013—7th Study Conference on BALTEX—Borgholm, Sweden.

10–14 June 2013—CFMIP/EUCLIPSE Meeting on Cloud Processes and Climate Feedbacks—Hamburg, Germany.

24–27 June 2013—WWRP Polar Workshop—ECMWF, Reading, UK.

27–28 June 2013—WCRP Strategy Workshop on Observations and Predictions of Precipitation—Ft. Collins, Colorado, U.S.A.

1–3 July 2013—Satellite Soil Moisture Validation and Application Workshop—ESRIN, Frascati, Italy.

6–7 July 2013—2013 Gordon Research Conference and Gordon Seminar on Radiation and Climate—Colby-Sawyer College, New Hampshire, U.S.A.

15–17 July 2013—Workshop on Using GRACE Data for Water Cycle Analysis and Climate Modeling—Pasadena, California, U.S.A.

18–19 July 2013—Planning Workshop for a GEWEX Regional Hydroclimate Study on the Hydrology of the Lake Victorian Basin (HyVic)—University of Reading, UK.

22–26 July 2013—IAHS/IAPSO/IASPEI Joint Assembly—Gottenburg, Sweden.

28–31 July 2013—AGU Chapman Conference on Seasonal to Interannual Hydroclimate Forecasts and Water Management—Portland, Oregan, U.S.A.

23 August–2 September 2013—SOLAS Summer School—Xiamen, China.

2–6 September 2013—Joint GEWEX Hydroclimatology (GHP)/Data and Assessments (GDAP) Panel Meetings—Rio de Janeiro, Brazil.

9–11 September 2013—Global Soil Wetness Project-3 Meeting—Tokyo, Japan.

9–13 September 2013—13th European Met Society Annual Meeting and 10th European Conference on Applied Climatology—Reading, UK.

9–13 September 2013—ESA Living Planet Symposium—Edinburgh, UK.

GEWEX NEWS

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