GEWEX WCRP
Global Energy and Water Cycle Experiment
NEWS

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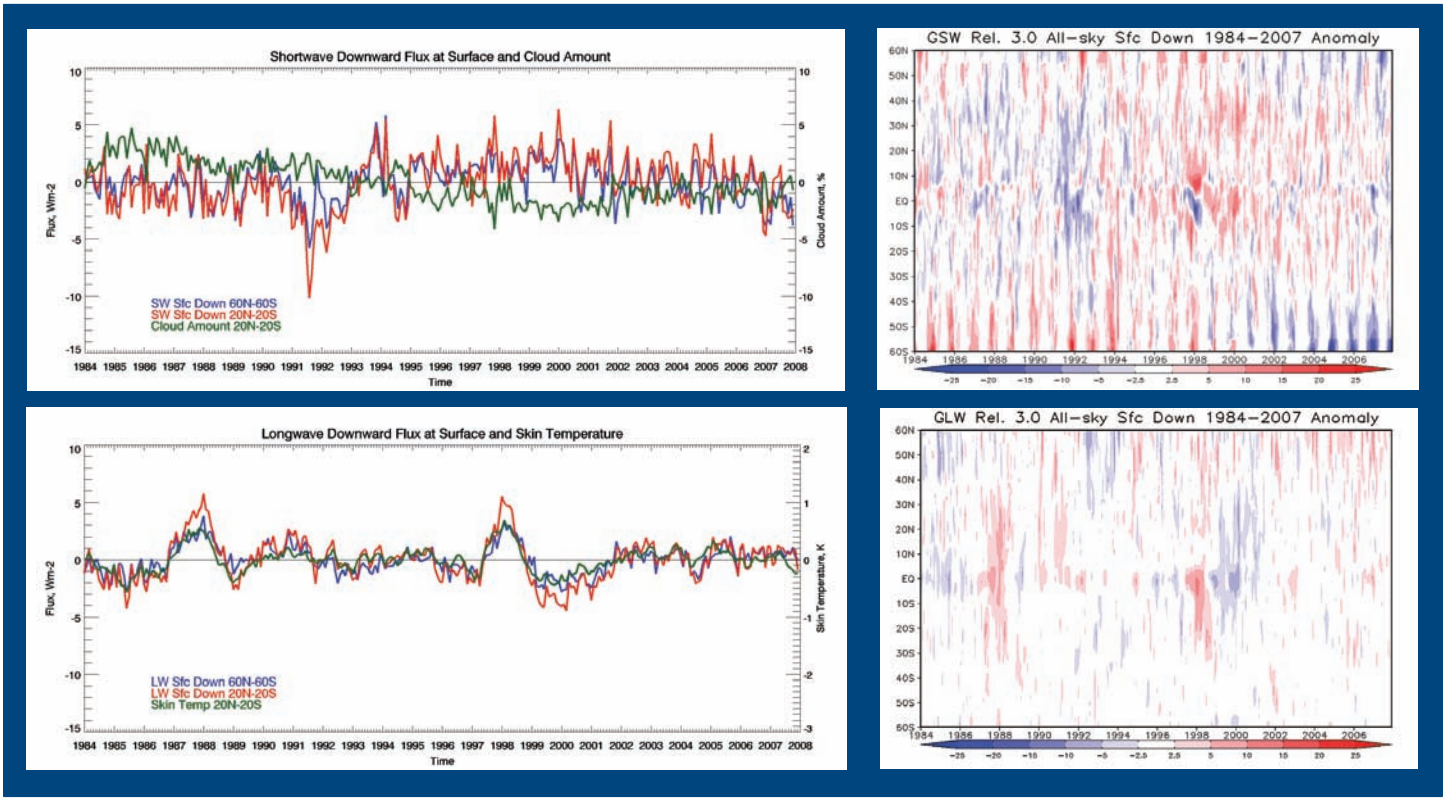
24.5-Year Surface Radiation Budget Data Set Released

Data Show the Larger Variability of Shortwave Downward Fluxes and Latitudinal Propagation of Anomalies from the 1991 Mt. Pinatubo Eruption and the 1987–88 and 1998–99 El Niño Episodes



The panels on the left side present the 24-year time series for the 20°S–20°N and the 60°S–60°N zonally averaged deseasonalized flux anomalies for the shortwave (top left panel) and longwave (bottom left panel). The deasonalized anomalies of the same zones for the cloud amount from ISCCP (top left) and the surface skin temperature from ISCCP and GEOS-4 inputs (bottom left) are added to plots to provide context. The panels on the right show the time-latitude cross-sections (Hovmöller plots) for the deseasonalized SW (top right) and LW (bottom right) anomalies. Interestingly, the 1987–88 and 1998–99 El Niño episodes produce little zonal cloud fraction anomalies (as shown in the top left panel) but significant zonal warming anomalies as shown by correspondence to the skin temperature anomalies. See article by Stackhouse et al. on page 10.

Contents

Commentary

GEWEX 2011

Kevin E. Trenberth
Chair, GEWEX Scientific Steering Group

The New Year has barely begun as I write this commentary, yet it looks as if it will be an especially eventful one for climate science in several respects. The major event this year is the World Climate Research Programme (WCRP) "Open Science Conference: Climate Research in Service to Society" to be held in Denver, Colorado on 24–28 October 2011. The call for abstracts is out with a deadline of 30 April. The Conference will have strong plenary sessions with 29 featured speakers and 12 parallel oral sessions. The 45 poster sessions will be a major highlight. Many of the sessions are being convened by GEWEX scientists on behalf of our many panels and activities. A special GEWEX poster will be highlighted all week, along with those from the other WCRP core projects. With 200 current conveners, this will be a major conference, unlike anything WCRP has done before. We could have a good conference with just the conveners and confirmed invited speakers showing up! That alone hints that we should expect a couple thousand participants and I strongly urge you all to put this Conference on your calendar and fully participate in it. Early career scientists are especially encouraged to attend and should note the opportunity to participate in a special National Center for Atmospheric Research (NCAR)-sponsored workshop prior to the OSC in Boulder on 19–21 October. For details, please visit the Conference website at: *http://conference2011.wcrp-climate.org*.

There are, of course, many other conferences, workshops and meetings of relevance to GEWEX science this year, including the International Union of Geodesy and Geophysics Meeting being held in Melbourne, Australia on 28 June–7 July 2011. The next session of the WCRP Joint Scientific Committee (JSC) will be held on 4–8 April in Exeter, UK. GEWEX has traditionally held its Scientific Steering Group (SSG) meeting in January, as we did in 2010 in New Delhi, India. We also held an SSG meeting in conjunction with the 2nd Pan-GEWEX Science Meeting in late August 2010. This now affords us an opportunity to change the timing of our SSG meetings and to get away from holding them in January, as there are often conflicts with the annual American Meteorological Society meeting. Accordingly, we are planning our next SSG meeting on 14–18 November 2011 in Rome, Italy.

The New Year brought with it some spectacular storms and further discussions about the role of climate change. A very snowy and cold November–December in the United Kingdom and Europe set the stage, and was followed by a major U.S. East Coast snow storm between Christmas and the New Year that paralyzed air traffic and other transportation for many days. Meanwhile, flooding in California from a series of storms continued with complete disregard of the official National Oceanic and Atmospheric Administration (NOAA) forecasts based upon strong La Niña conditions in the tropical Pacific Ocean. The La Niña had already signaled it would be a major climate event right from its rapid onset in July. It no doubt contributed to the flooding events in China and India in July, Pakistan in August, and subsequently to the record-breaking rains experienced by Australia in September. The latter have continued, leading to extensive flooding in Queensland in January of 2011. Very high sea surface temperatures in the Indian Ocean-Indonesia region in August and around northern Australia in December have helped provide ample moisture for these events. Yet they have not been well predicted, and information about them has not been as good as it needs to be to provide information to the public and decision makers.

In the United States, the New Year also brings a new Congress with a number of climate change deniers taking office, and the threat of hearings of various sorts that may well capitalize on the inadequate explanations of the above extremes and the role of both climate variability and change. We can and must do better in explaining, attributing, and forecasting these extreme events. Surely we can, and GEWEX aims to play its role to help coordinate the relevant science and improve information, services, and communication.

As documented in previous newsletters, the SSG is leading an effort to highlight seven scientific imperatives for GEWEX to promote in the years ahead. Planning for the 2013 to 2018 time frame has led to a new draft 40-page document detailing the imperatives, including their rationale, scientific background, and strategic plan, along with the partners with GEWEX in implementing the plan, and as an indication of deliverables and links to other activities. This document will be available on the GEWEX web site in February for a period of open review and commentary, prior to its presentation at the JSC meeting. I hope your New Year's resolution was to take this opportunity to help guide where we are going by providing comments and becoming involved.

Recent News of Interest

Changes in Global Land/Atmosphere System Study (GLASS) Leadership

Dr. Bart van den Hurk of the Royal Netherlands Meteorological Institute in The Netherlands has stepped down as co-chair of the Global Land/Atmosphere System Study (GLASS) Panel. Dr. Martin Best, who has co-chaired GLASS for the past 2 years, will continue, and is joined by Dr. Joseph A. Santanello.

Martin Best

Dr. Best heads the Land-Surface Processes Group at the Joint Centre for Hydro-Meteorological Research in the United Kingdom and is also responsible for the wider coordination of land-surface research within the Met Office. He also is responsibile for the development of the community Joint UK Land Environment Simulator (JULES).

Joseph A. Santanello

Dr. Santanello is a Physical Scientist at the Hydrological Sciences Branch of the National Aeronautics and Space Administration (NASA) Goddard Space Flight Center in Maryland. He specializes in research on land-atmosphere interactions and quantifying the role of the planetary boundary layer in modulating the energy and water cycle. He also leads the GLASS Local Coupled Land-Atmospheric Modeling (LoCo) Project for developing diagnostics to quantify the strength and accuracy of the local land-atmosphere coupling in prediction models.

Terrestrial Regional North American Hydroclimate Experiment (TRACE) Workshop

During the period of 1992 to 2009, land-surface scientists benefited from a number of strong Regional Hydroclimate Projects (RHPs) located in North America. A proposed RHP, TRACE, could reinvigorate this scientific community and be aligned with the goals of GEWEX and the broader goals of its parent organization, WCRP, as well as with those of other programs, such as the North American Carbon Program and the International Geosphere-Biosphere Programme. An open community discussion workshop will be held on 18–20 April 2011 in Silver Spring, Maryland, to examine ideas and issues for TRACE. For more information about this proposed RHP and the Workshop, see: *http://www.trace-rhp.org*.

New GEWEX Hydroclimatology Panel Co-Chair

Dr. Jan Polcher of the Laboratoire de Météorologie Dynamique du Centre National de la Recherche Scientifique in Paris, France, is now co-chairing the GEWEX Hydroclimatology Panel with Dennis Lettenmaier. Dr. Polcher is a land-surface climate modeler and has held many leadership positions within GEWEX, most recently as a member of the Scientific Steering Group. He also coordinated the European African Monsoon Multidisciplinary Analysis Project (AMMA) and developed the Organizing Carbon and Hydrology in Dynamic Ecosystems (ORCHIDEE) land-surface scheme.

Long Time Supporter of GEWEX Retires

Dr. Einar-Arne Herland, who functioned as the European Space Agency (ESA) liaison for GEWEX for the past 9 years, is retiring. Dr. Herland began working for ESA in May 2001 as the Head of the Earth Sciences Division (later renamed the Mission Experts Division and Mission Science Division) at ESA's European Space Research and Technology Centre (ESTEC) in Noordwijk, The Netherlands. In that position, he followed in the footsteps of another GEWEX supporter, Dr. Chris Readings, who helped define Earth observations missions relevant to GEWEX research. In 2007 Dr. Herland moved to ESA's European Space Research Institute in Frascati, Italy, where he headed the Science Strategy, Coordination and Planning Office. As such, he was responsible for coordinating the overall scientific mission of ESA's Earth Observation Programme (EOP), for providing the secretariat of the Earth Science Advisory Committee (ESAC), and for acting as the primary interface for the scientific community and international scientific bodies.

A strong proponent of WCRP and in particular GEWEX, Dr. Herland supported our activities in many ways. He hosted many GEWEX meetings, including the first Pan-GEWEX Science meeting held in October 2006 at ESA-ESRIN. He also helped our project programmatically and was instrumental in establishing the European GEWEX Coordinator position at ESA-ESTEC.

We will miss Einar's presence, his expertise regarding Earth observations and science, and his good humor. In particular, he will be missed at our Scientific Steering Group meetings, which he attended regularly and contributed to actively. We wish Einar much enjoyment in his retirement and thank him for all the support he has given GEWEX.

GEWEX Radiation Flux Assessment Status and Early Results

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[2]NASA/Langley Research Center, Hampton, Virginia, USA

The GEWEX Radiative Flux Assessment (RFA) Working Group was tasked by the GEWEX Radiation Panel (GRP) to conduct a series of assessment activities to analyze and critically review global data sets that provide components related to water and energy cycles within the climate system. This work includes assessing long-term radiative flux data sets at the top-of-atmosphere (TOA) and surface in terms of their current levels and sources of uncertainties. A lead writers' workshop was held on 9–10 December 2010 at the National Aeronautics and Space Administration (NASA) Langley Research Center (LaRC) to collect and organize author contributions and prepare a timetable to complete the work. The international group of 21 scientists agreed to submit a draft document to the GRP later this year. Some preliminary results of the assessment are given below.

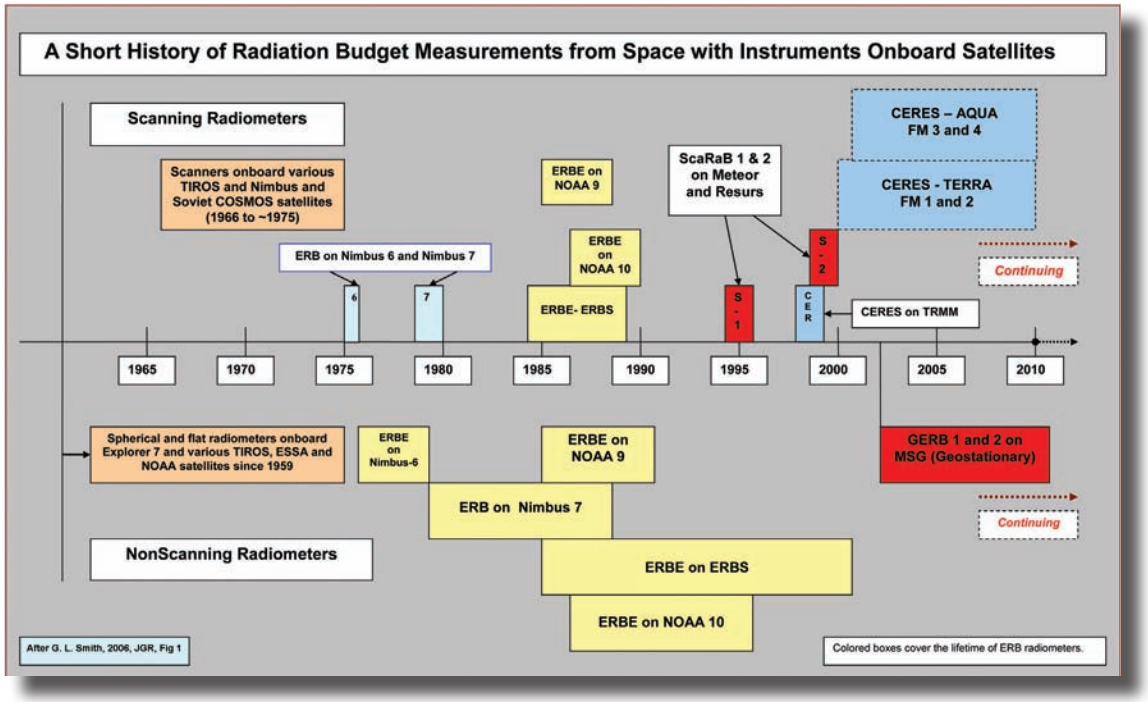
There is an emerging consensus that the value of the Total Solar Irradiance (TSI) at TOA at 1361 Wm^{-2}. However, the computation of the distribution of TSI over the globe, particularly among global models, varies upon the accuracy of assumed astrophysical models, which can lead to relatively large errors in some cases.

Numerous satellite flux data sets were submitted to the RFA archive and compared for the assessment. These include TOA data sets that are derived more directly from satellite measurements, such as the Earth Radiation Budget Experiment (ERBE), the Clouds and the Earth's Radiant Energy System (CERES), and the Scanner for Radiation Budget (ScaRaB). See figure below. Surface flux data sets [e.g., GEWEX Surface Radiation Budget Project, SRB; International Satellite Cloud Climatology Project, ISCCP; Foundation for Research and Technology-Hellas (Greece); University of Maryland; and German Aerospace Center–Irradiance at Surface using ISSCP, DLR-ISIS)] were computed from the satellite measurements combined with a variety of ancillary data products, such as surface albedo, surface temperature, and cloud properties. Although the 4-year global averages show general flux component agreement to about 5–10 Wm^{-2} among the data sets, comparisons at the monthly time scales show significantly larger differences (e.g., more than 50 Wm^{-2} for the upward long-wave radiation flux at the surface) over various regions worldwide.

Clouds are shown to affect the radiative fluxes with different sensitivity. For instance, the relative absorption (i.e., vertical flux divergence) of solar radiation in the atmosphere under cloudy vs. clear-sky conditions varies even in sign depending upon the data set. Regional differences in atmospheric absorbed solar flux range up to +/– 15 Wm^{-2}.

ISCCP and SRB data sets show artifacts in cloud and radiative products, which are due to the changes in reference satellites since 1983 and operational changes due to other input data sets [e.g., changes in the TIROS Operational Vertical Sounder (TOVS) retrievals of air temperature].

Ground-based networks with high quality instruments and data handling, such as the Baseline Surface Radiation Net-



work (BSRN) have been established; however, there are operational uncertainties in these measurements and issues that to some extent limit the use of the data for validation. Assessment and use of older measurements, such as the Global Energy Budget Archive (GEBA), and results from studies using long-term time series to assess regional changes were reviewed.

The comparison of surface measurements to surface fluxes shows generally good agreement with ensemble monthly average root mean square error values around 20 Wm^{-2}. Individual sites produce smaller and/or larger errors, depending upon the physical conditions occurring at the site. The monthly average anomaly of the ensemble shows very good agreement, providing insight into the capture of the month-to-month variability.

Radiation fields, which were produced using the approximately 20 climate models that participated in the Fourth Assessment of the Intergovernmental Panel on Climate Change (IPCC) have been analyzed and compared with collocated surface site networks and "observational data" from CERES, ISCCP, and SRB. Discrepancies between the models were found to be larger than those of other satellite-based data products.

Future efforts will quantify possible improvements and uncertainty limitations that have implications in assessing long-term changes at different space and time scales linked to the physical processes causing these changes. This knowledge will improve the integration of radiation observations with hydrological processes and quantify the usefulness of these data products for verification of climate models.

Participants (in alphabetical order) in the Radiative Flux Assessment include the following.

Richard Bangtes (Imperial College, London), Thomas Charlock (NASA/LaRC), Stephen Cox (Science Systems and Applications, Inc., SSAI/NASA/LaRC), Ellsworth Dutton (National Oceanic and Atmospheric Administration (NOAA/Earth System Research Laboratory), Stuart Freidenreich (NOAA/Geophysical Fluid Dynamics Laboratory), Laura Hinkelman (University of Washington/Joint Institute for the Study of the Atmosphere and Ocean), Seiji Kato (NASA/LaRC), Stefan Kinne (Max Planck Institute), Norman Loeb (NASA/LaRC), Chuck Long (Pacific Northwest National Laboratory), Colleen Mikovitz (SSAI/NASA/LaRC), Rachel Pinker (University of Maryland), Ehrhard Raschke (University of Hamburg, Germany), William Rossow (NOAA Cooperative Remote Sensing Science and Technology Center, CREST, at City College of the City University of New York, CUNY), Jacqui Russell (Imperial College, London), David Rutan (SSAI/NASA/LaRC), Paul Stackhouse (NASA/LaRC), Wenying Su (SSAI/NASA/LaRC), Takmeng Wong (NASA/LaRC), Martin Wild (Swiss Federal Institute of Technology in Zurich), and Yuanchong Zhang (Columbia University/Goddard Institute for Space Studies).

Parameterizing Thermal Roughness Length is Crucial for Dryland Energy Budget Modeling

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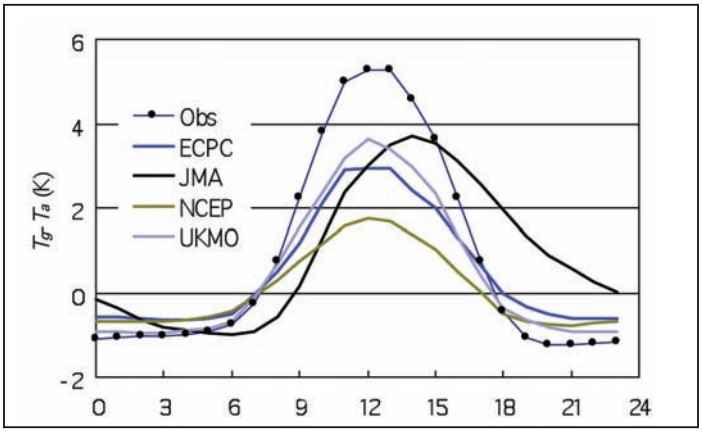
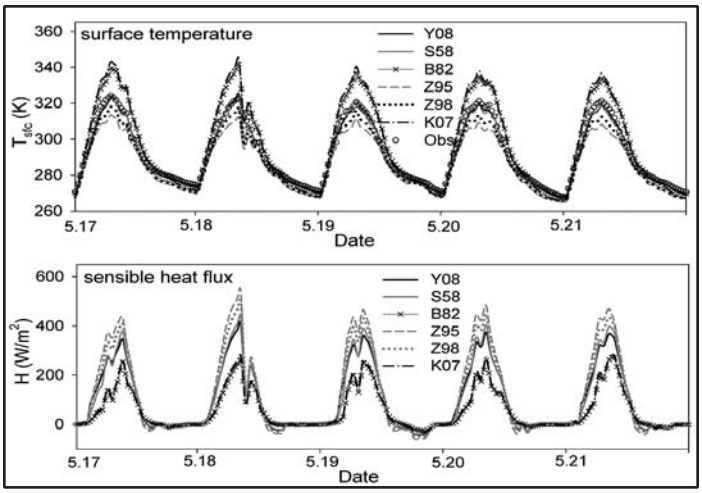
Sensible heat fluxes over land surfaces dominate the surface energy budget in arid regions. The process of parameterizing surface heat transfer resistance in a land-surface model (LSM) still lacks a strict evaluation. Recent studies have shown that the Noah LSM overestimates sensible heat flux and underestimates surface temperature in dry seasons (Hogue et al., 2005; LeMone et al., 2008; Chen and Zhang, 2009). Using Coordinated Enhanced Observing Period (CEOP) data, Yang et al. (2007) observed that many global circulation models (GCMs) systematically underestimate the diurnal range of surface–air temperature differences (see figure below), particularly in arid and semi-arid regions, due to heat transfer resistances being under-predicted.

A recent study (Chen et al., 2010) clarified that these biases are largely due to inappropriate parameterizations of heat transfer resistance over bare soils. The authors selected a very dry surface so that the sensible heat transfer could be separated from complex water transfer processes. In a dry region with negligible water supply, the sensible heat flux and ground heat flux dominate the surface energy budget. In addition to the input forcing data, four parameters in the radiation budget and energy budget equations determine the surface energy partitioning and the surface temperature [albedo, surface emissivity, thermal conductivity, and heat exchange coefficient (C_h)]. The former three can be assumed as a constant for very dry surfaces with low soil moisture and can be reliably specified according to the observed surface radiation budget and soil temperature profile. Therefore, the simulated surface temperature and energy fluxes rely highly on the parameterization of C_h, whose value depends on the aerodynamic roughness length (z_{0m}) and



Composite diurnal variations of surface-air temperature difference from in situ data and GCMs [Experimental Climate Prediction Center (ECPC) of the Scripps Institution of Oceanography, Japan Meteorological Agency (JMA), NOAA National Centers for Environmental Prediction (NCEP), UK Met Office (UKMO)] at 14 CEOP sites for the period of October 2002–September 2003 (after Yang et al., 2007).

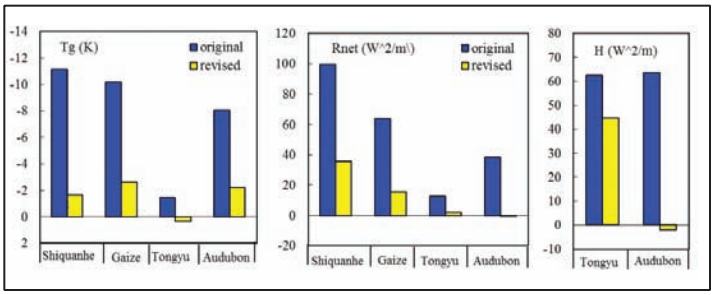


Sensitivity of Noah-simulated surface temperature and sensible heat fluxes to z_{0h} schemes for an arid site, Shiquanhe in western Tibet, during the period of 17–21 May 1998. References: S58 (Sheppard, 1958), B82 (Brutsaert, 1982), Z95 (Zilitinkevich, 1995), Z98 (Zeng and Dickinson, 1998), K07 (Kanda et al., 2007), and Y08 (Yang et al., 2008). See details in Chen et al. (2010).

thermal roughness length (z_{0h}) under the framework of the Monin-Obukhov similarity theory. z_{0m} can be assumed as a constant, whereas z_{0h} or kB^{-1} [defined as ln (z_{0m}/z_{0h})] is more variable and requries parameterization.

Much of the literature has focused on the parameterization of z_{0h}. The figure above shows modeling sensitivity of the surface energy budget and surface temperature to the z_{0h} scheme, after implementing six z_{0h} schemes into Noah LSM at a dry site (Shiquanhe) in western Tibet. Some of these schemes have been widely used in operational models, such as Z95, being embedded in NCEP operational prediction systems since Chen et al. (1997).

Among these schemes, Y08 performs better than the others at this site and thus it was selected to revise the Noah LSM. The original Noah model and the revised one were then applied at two arid sites in Tibet (Shiquanhe and the Gaize CEOP reference site), one arid site in Arizona (Audubon, courtesy of AmeriFlux), and one semi-arid grass site in North China



Mean biases of the original Noah model and the revised one for three arid sites and one semi-arid site during the daytime (0900–1600 LT), calculated from 30-minute observations and simulations. Sensible heat flux was not observed at the Shiquanhe and Gaize sites.

(Tongyu CEOP reference site). The modeling biases are shown at the bottom left of this page. The original Noah LSM commonly underestimates daytime surface temperature by 10 K or more for the three arid sites, whereas the revised one more accurately reproduces the surface temperature at all sites. As the underestimation of surface temperature corresponds to lower upward longwave radiation (and thus high net radiation) and lower ground soil heat fluxes, the underestimated surface temperature implies that sensible heat fluxes are overestimated.

The distinct modeling difference between the revised Noah and the original can be attributed to the diurnal variation of z_{0h} which can be simulated by the revised Noah LSM but not by the original model (see Chen et al., 2010, Figure 6). Actually, diurnal variations of z_{0h} over bare-soil surfaces and grassland surfaces have been reported in several studies.

In summary, the parameterization of z_{0h} is crucial for modeling T_{sfc} and the surface energy budget in arid regions. The revised Noah LSM with a novel z_{0h} scheme that was developed based on experimental data analysis can simulate T_{sfc} and H simultaneously. This success is an example showing the contribution of GEWEX/CEOP field experiments to model development.

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Workshop Is First Step in Improving Accuracy of Estimation of Extreme Climate Events

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[2]World Climate Research Programme, Geneva, Switzerland

Record-breaking flooding in Pakistan, India, and China as well as heat waves and wildfires in Russia during 2010 highlight the extremes of the hydrological cycle. GEWEX plays a leading role in the study of extreme climate events, a cross-cutting activity involving the core projects of the World Climate Research Programme (WCRP).

The WCRP (GEWEX/CLIVAR)-United Nations Educational, Scientific, and Cultural Organization [(UNESCO)/International Hydrological Programme, IHP)] Workshop was held on 27–29 September 2010 at UNESCO Headquarters in Paris, France. The focus of the Workshop, which was co-sponsored by the Willis Research Network, was on the phenomenology and methodological aspects of the quantitative estimation of different climate extremes under observed and future climate conditions using observational and model data.

Part of the rationale for holding the Workshop was related to the recent increase in the number of disparate activities and meetings targeting different aspects of extreme events, which demonstrated the strong need for WCRP and its core projects to develop a consolidated and effective strategy for defining robust and reliable characteristics of extremes and optimal methodologies for their estimation. Thirty-five oral presentations and 72 posters were presented, and 132 scientists from 32 countries participated in the open dialogue between data producers, statisticians, and users as a first step in developing this strategy. Opening remarks were given by Dr. Alberto Tejada-Guibert, Director of the Division of Water Sciences and Secretary of the IHP; by Dr. Jorge Luis Valdes Santurio, Head of the Ocean Science Section of the Intergovernmental Oceanographic Commission; and by Dr. Valery Detemmerman, Senior Scientific Officer of the Joint Planning Staff of WCRP.

The Workshop was organized into five major topical sessions:

1. Hydrological extremes (precipitation, flooding, and river discharge), including compound hydroclimate extremes. This session considered the physics and origins of hydroclimate extremes, observed climate variability in heavy precipitation, and flooding and abilities of climate models to accurately simulate changes in extreme precipitation.
2. Extremes in temperature conditions (heat waves and dry spells). Regional analyses of heat waves and droughts, as well as regional and global studies on attribution of temperature extremes, were included in this session.
3. Extreme tropical and extra-tropical cyclones and associated wind waves and storm surges. Structure and global statistics of tropical and extra-tropical storms were discussed, as well as storm surges, which represent a compound extreme phenomenon originating from many factors.
4. Methodologies for estimation of extremes. Different mathematical aspects of the estimation of the events of rare occurrences were considered in this session, as well as problems in the estimation, including the detection of climate extremes in climate projections and in observations.
5. Risk assessment. This session addressed issues of requirements for decision making, downscaling, and of climate extremes and risks of sea level extremes. Gero Michel reviewed the activities of the Willis Research Network in quantifying risks of different worldwide climate extremes.

The three breakout group (BOG) sessions were opened with keynote speeches (speakers are in parentheses):

- BOG-1. Data requirements and availability, including data policy (Albert Klein Tank);
- BOG-2. Representation of extreme events in climate and operational models, including consideration of scaling and spatial scales of extremes (William Gutowsky); and
- BOG-3. Methodologies for estimation of extremes across areas and disciplines (David Stephenson).

BOG-1 reviewed the need for real-time data for dealing with the impacts of extreme events as they occur, including issues related to the availability of data for use in the analysis of extremes; requirements for homogeneous and interoperable data sets for the analysis and prediction of extremes; and the relative roles of satellites and models in providing data of use in understanding and characterizing extremes. Discussions on these topics resulted in the following recommendations:

- International organizations (i.e., World Meteorological Organization, WMO; Group of Earth Observations, GEO) and nations should undertake studies to assess the value of adding new observations of certain types in data sparse regions on both a global and a regional scale.
- Research organizations should encourage the development of models that can reliably simulate extreme events and test them to see how useful they can be for estimating the occurrence and characteristics of extremes in areas where measurements do not exist.
- A substantial effort should be directed at data rescue for old data sets that are not in digital form with priority given to the most critical records.
- Steps should be taken by WMO and WCRP to develop a comprehensive database of tropical cyclones for assessing the trends in the frequency and intensity of these events.
- Research should be undertaken to explore the feasibility of using mean sea level pressure as a proxy of drought.
- Data requirements should be reviewed to support case studies of extreme events so that steps can be taken in a timely way to ensure that all of the data required to study an extreme event are archived and accessible. Specifically, an overview of the data needed to support the analysis of cryospheric extremes should be undertaken. In addition,

the concerns of the communities dealing with extremes in wind, precipitation, and stream flow should be added to any WMO/WCRP letter that is sent to national hydrological and meteorological services.

- Develop a project involving precipitation radar data that includes intercomparisons and analysis of radar data fields to examine extreme events.
- WCRP, the Committee on Earth Observation Satellites (CEOS) and national space agencies should work together to determine ways in which satellite data sets related to extremes could be refined and made more readily available to users. WCRP could also develop information products, including brochures and articles for its E-zine, that make more people aware of the freely available data sets for studies of extremes.
- Convene a WCRP task group to study possible innovative techniques for the acquiring and distributing of data on extremes and other climate phenomena.

Items addressed by BOG-2 included: (1) comparison of models with observations and appropriate comparisons of model output from grid boxes with observations, whether station (point) or gridded values; (2) consideration of physical processes, which raised questions about the most pressing directions for improving simulation of extremes when updating models; and (3) consideration of scales and physical processes.

BOG-2 had two general recommendations: (1) Evaluations are needed for how well models simulate climatologies of weather variables that yield extremes, including statistics of blocking highs, cut-off lows, frontal systems, extra-tropical cyclones, and monsoons; and (2) Assessments of processes yielding extremes should be included in model development, in addition to the usual efforts to improve means and the variability of fields.

BOG-2 made recommendations in the following three categories, which were directed towards the mission of WCRP for the next 5–10 years to better understand and simulate the physical behavior of climate.

Prediction and Projections

- Develop skillful prediction of El Niño Southern Oscillation (ENSO) time scales of the variability of extremes.
- Assess emerging decadal forecasts for their ability to produce the behavior of extremes.
- Improve initial conditions and forcing data sets for long-term projections of climate with a focus on reducing uncertainties in the evolution of extremes.
- Take steps to understand the impact of new feedbacks on extremes when additional complexity (e.g., socioeconomic processes, agriculture, and ocean biogeochemistry) is added to climate models.

Climate Model Output

- Establish output archives that are more suitable for the analysis of extremes and their processes. This would include establishing requirements for appropriate fields in addition to those already saved, such as probability-distribution functions of key fields, frequency of threshold exceedances, and other complex diagnostics that match observing system output.
- Use a variety of statistical approaches and statistical modeling to reconcile model output with observations.

Participants at the Workshop on Metrics and Methodologies of Estimation of Extreme Climate Events.

Briefing session at the Workshop on Metrics and Methodologies of Estimation of Extreme Climate Events.

Methodologies for Extremes

- Construct appropriate ensembles of simulations for analysis, forecasting, and projection of extremes that account for trade-offs between resolution and the number of ensemble members.
- Learn how to best utilize multi-model ensembles for the assessment of extremes.
- Design data assimilation methods for models and reanalyses to represent extremes, including ensemble approaches to better capture uncertainty.
- Use capabilities of statistical models for a proper physical interpretation of extreme events, better quantification of the nature of errors in model simulations and for making numerical model outputs more applicable for integrated assessment. When considering model uncertainties, account for the error propagation through statistical and dynamical downscaling and through boundary conditions for global and regional models.

BOG-3 discussed key-issues of methodologies for estimating extremes across areas and disciplines, including: (i) statistical methods used in climate science; (ii) capabilities of simplified indices to capture extremes, and the importance of sampling size and spatial-temporal consideration; and (iii) the transfer of knowledge and wider distribution of advanced statistical methodologies. Recommendations from BOG-3 include:

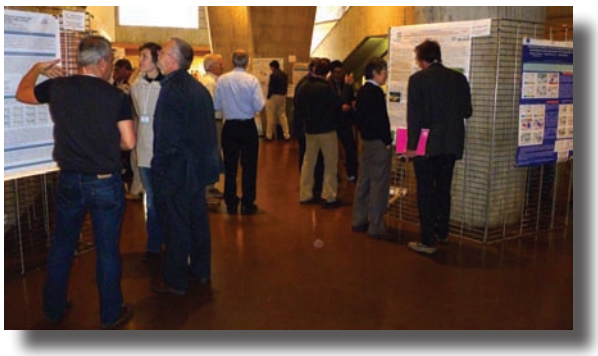
- Develop a statement regarding the problems associated with many of the definitions used now within the community for extreme events (e.g., large meteorological values, rare events in the tail of the distribution, and events that create large losses).
- Engage statisticians to collaborate with scientists in climate research on extremes.
- Develop joint activities on extremes with the World Weather Research Programme (e.g., joint activity on hurricanes and heavy precipitation events).
- Encourage climate centers to produce long control runs for use in detection and attribution studies of extremes and to make these readily available.
- Organize capacity building regional workshops on methodologies for extremes.

During the final session, the recommendations of the BOGs were reviewed, discussed, and consolidated into five general Workshop recommendations.

1. WCRP and its core projects should encourage the development of improved high temporal resolution (sub-daily) data sets that can be used to assess changes in extreme rainfall, drought, heat waves, floods, and storms.
2. In evaluating models, WCRP, together with the CLIVAR Working Group on Coupled Modeling and the two GEWEX modeling panels, should focus on the ability of models to replicate extremes and the comparison of model output with observations.
3. WCRP core projects should concentrate on the determination of the main phenomena responsible for extremes and improve understanding of the relevant physical processes.
4. Robust statistical methods for assessing extremes and methodologies for estimating uncertainties of these methods should be developed and made available for widespread use.
5. An activity for the analysis of extreme events that uses data archived by the WCRP Coupled Model Intercomparison Project should be planned and launched in the near future.

Initial information on the Workshop was published in *EOS Transactions* (Zolina et al., 2010, *Eos*, Vol. 91, No. 51, 21 December). All Workshop presentations and posters are available at: *http://www.extremeworkshop.org*. An extended Workshop report will be prepared as a WCRP report and will be made available on the Workshop website. A white paper will also be prepared with more detailed recommendations based on the workshop discussions and is expected to feed into the larger WCRP cross-cutting effort targeted at climate extremes.

The overall strategy will be discussed in more detail at the upcoming WCRP Open Science Conference (*http://www.wcrp-climate.org/conference2011*) to be held in October 2011.



Workshop poster session.

24.5-Year SRB Data Set Released

Paul W. Stackhouse Jr.[1], Shashi K. Gupta[2], Stephen J. Cox[2], Taiping Zhang[2], J. Colleen Mikovitz[2], and Laura M. Hinkelman[3]

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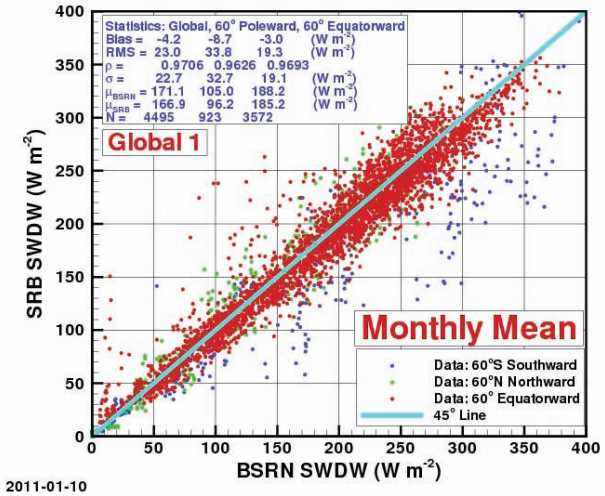
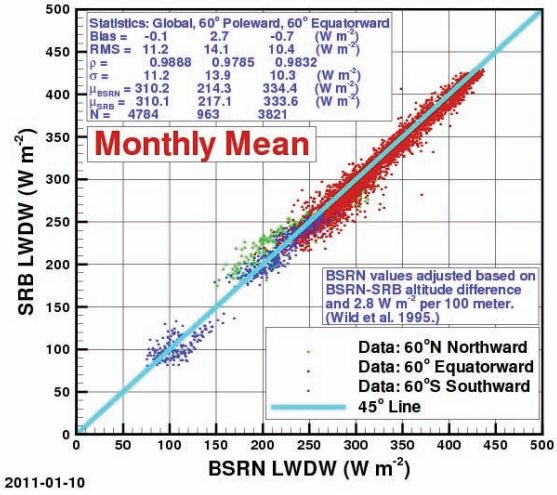
The GEWEX Surface Radiation Budget (SRB) Project at NASA Langley Research Center (LaRC) has completed a 24.5-year (July 1983 to December 2007) data set of surface and top-of-atmosphere (TOA) shortwave (SW) and longwave (LW) radiative fluxes. The data set is produced, archived, and made available to the science community in both a binary and netCDF format by the LaRC Atmospheric Sciences Data Center. It is designated as SRB Release 3.0 and supersedes the 22.5-year SRB Release-2.5/2.81 data set made public 3 years ago (Gupta et al., 2006). The data set is produced on a 1° x 1° global grid using satellite-derived cloud parameters and ozone fields, reanalysis meteorology, and a few other ancillary data sets. Both SW and LW surface fluxes are computed with two sets of algorithms: one designated as primary, and the other as quality-check. TOA fluxes are derived with primary algorithms only. All except the quality-check SW algorithm compute fluxes at a 3-hourly resolution, which are then averaged into daily, monthly, and monthly/3-hourly values. Quality-check SW fluxes are computed at a daily resolution and averaged into monthly values. Surface fluxes from all algorithms have been extensively validated with ground-based measurements obtained from sources that include the Baseline Surface Radiation Network (BSRN), and the Global Energy Balance Archive.

The four algorithms mentioned above are the same as referred to in Gupta et al. (2006), but each has been refined. The primary SW algorithm (Pinker and Laszlo, 1992) has been improved by using a new climatological background aerosol based upon a MATCH aerosol climatology from 2000 to 2005, refining the treatment of clear vs. cloudy skies over bright surfaces, and by changes to the data gap filling strategies. The primary LW algorithm based upon the Fu et al. (1998) radiative transfer model has been upgraded to improve ice cloud radiative properties and water vapor continuum treatments. In addition, data gap filling over sun glint regions was refined and the ozone treatment was corrected. Additionally, the quality-check LW algorithm was improved to correct for the overestimation of downward LW fluxes over desert regions (Gupta et al, 2010). This SRB data set uses the Global Modeling and Assimilation Office (GMAO) Goddard Earth Observing System (GEOS-4) products (Bloom et al., 2005) to provide the temperature and water vapor profiles. Column ozone values use a blending of Total Ozone Mapping Spectrometer (TOMS), TIROS Operational Vertical Sounder (TOVS), and values from the NOAA Stratosphere Monitoring Ozone Blended Analysis (SMOBA) data set in the latest years. All the satellite radiances and cloud properties are derived from International Satellite Cloud Climatology Project (ISCCP) pixel-level (DX) data (Rossow and Schiffer, 1999).

Global annual averages for common TOA and surface parameters for both algorithms are presented in Table 1 on page 11. Present results are compared with corresponding averages from another satellite-based product, the ISCCP-FD (Zhang et al., 2004) data set. The two data sets show very good agreement. Also included is a comparison of the global annual averaged fluxes from Trenberth et al. (2009) and model fluxes produced in Intergovernmental Panel on Climate Change (IPCC) simulations (Wild 2008). The overall agreement is close between these studies, which shows increasingly better understanding of the radiative budget compared to 10 years ago. However, significant differences between the satellite-inferred and model-based fluxes remain for the surface downwelling LW, the net LW, and the total net fluxes. It is noted that due to the nature of the ISCCP cloud detection, the cloud base height estimates contain large uncertainties and are more likely overestimated. Thus, the globally averaged LW downwelling fluxes are more likely underestimated, but this will have to be established with active cloud profile information such as from CloudSat and CALIPSO.





Monthly mean validation of the SRB Release 3 data set for surface downwelling SW (left panel) and LW (right panel) using BSRN measurements from 1992 to 2007. The SW SRB estimates are compared against the Direct + Diffuse measurements (Global 1) from BSRN. Note that SRB LW estimates are adjusted for the elevation difference between the 1°x1° grid box mean elevation and the site elevation.

Flux (Wm^{-2})	NASA/GEWEX SRB Release 3.0 (NASA LaRC) *24-Year Mean (1984-2007)*		Trenberth et al. (2009) CERES/ CCM3	Zhang and Rossow et al. (2004) *21-Year Mean (1984-2004)*	Wild (2008) IPCC AR4 Models
	Main Models	QC Models			
SRF SW Down	188.6	182.1	184	189.2	
SRF SW Net	166.6	159.5	161	165.9	161.8
SRF LW Down	343.8	347.5	333	343.8	337.5
SRF LW Net	-52.6	-51.2	-63	-49.6	-55.6
SRF Total Net	114.0	108.3	98	116.3	106.2
SRF SW CRF	-58.9	-61.9	---	-53.0	-57.2
SRF LW CRF	33.5	34.3	---	29.5	
SRF Total CRF	-25.4	-27.6	---	-23.5	
TOA SW Net	240.4	---	239	236.5	
TOA LW Net	-237.8	---	-239	-233.9	-233.7
TOA SW CRF	-47.5	---	---	-50.0	-50.6
TOA LW CRF	27.4	---	---	25.8	
TOA Net CRF	-20.1	---	---	-24.2	

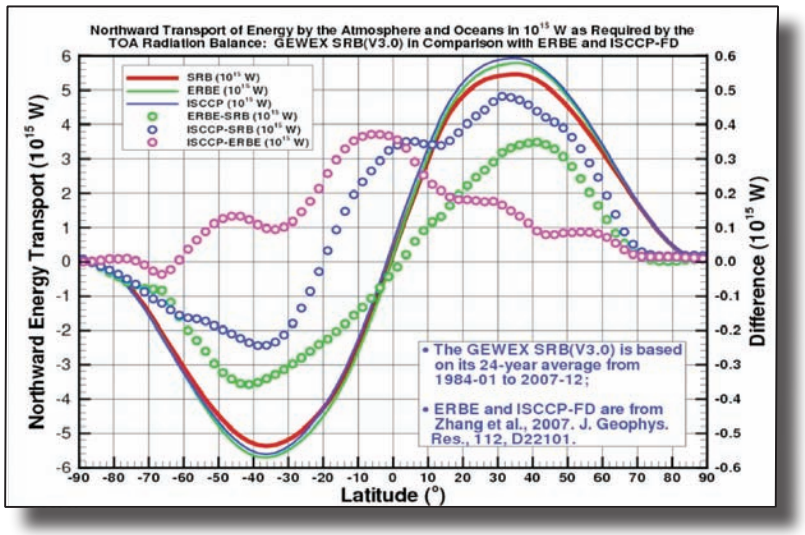
Table 1. *24-year (1984–2007) global averaged radiative flux components at the surface (SRF) and TOA from SRB Release 3.0. The quality-check (QC) algorithms provide estimates of surface fluxes. Fluxes from ISCCP FD (Zhang and Rossow et al., 2004), Trenberth et al. (2009), and Wild (2008) are included for comparison. CRF: Cloud Radiative Forcing. The annual averaged total solar irradiance: F0=S0/4 where S0 is the solar constant. S0=1365 Wm^{-2} for Trenberth et al. results and 1367 Wm^{-2} for all others.*

Validation of monthly average downward SW and LW fluxes (hereafter referred to as DSF and DLF respectively) from the primary algorithms with corresponding averages from a number of BSRN sites is shown on page 10. BSRN measurements originally made at 1-, 2-, 3-, and 5-minute intervals were averaged over the desired temporal resolution and cover the period from 1992 to 2007. Mean bias for SW fluxes is about -4 Wm^{-2} with an RMS difference of 23 Wm^{-2}. An examination of individual sites showed that most of this underestimation arose at polar sites, especially those located on the Antarctic coast, but these are much improved over the previous version. Cloud characterization over likely snow/ice/water-covered surfaces at these sites is generally very difficult and is believed to be the primary reason for these errors. Removing polar points from the plots reduced this bias to about -3 Wm^{-2}. Corresponding bias for the LW fluxes is only about -0.1 Wm^{-2} with an RMS difference of 11 Wm^{-2}. Validation of fluxes of quality-check algorithms provides very similar results. Biases and random errors for all models and at all temporal resolutions are shown in Table 2.

The left panels of the figure on the front cover provide the monthly 24-year time series of the all-sky surface downward deseasonalized SW (left) and LW flux (right) anomalies of the 60°N-60°S and tropical (20°N–20°S) zonal bands. Added to the SW and LW plots are the anomalies of cloud amount determined from ISCCP and the surface skin temperature taken using inputs from both GEOS-4 and ISCCP. The skin temperature is a reasonable proxy of the lower atmospheric temperature, particularly over the oceans which dominate the two zones in the figures. Comparison of the plots show that the variability of SW downward flux is much larger than the variability of tropical LW flux. Also, the tropical anomalies account for the largest portion of the 60°N – 60°S zonal anomalies. The SW monthly variability shows the impact of the Pinatubo eruption (note no cloud amount anomaly) and multi-year oscillations, but at least some of the variability correlates with changes from input data streams. The multi-year variability of downward SW flux corresponds to the variability of the cloud amount. The downward LW variability also shows correspondence to long-term cloud amount changes but more clearly corresponds to anomalies in the surface temperatures. Interestingly, the 1987–88 and 1998–99 El Niño episodes produce little zonal cloud amount anomalies (as shown in the top left panel) but significant zonal warming anomalies as shown by correspondence to the skin temperature anomalies. The right panels show Hovmöller plots of the monthly deseasonalized anomalies of the surface downward fluxes: SW (top) and LW (bottom). These figures show the larger variability of the SW downward fluxes and the latitudinal propagation of anomalies from the Mt. Pinatubo eruption and El Niño events noted above.

Model	3-Hourly (Wm^{-2})	Daily (Wm^{-2})	3-Hourly-Monthly (Wm^{-2})	Monthly (Wm^{-2})
GEWEX SW (V3.0)	-5.91 **(87.9)**	-3.2 **(35.7)**	-6.7 **(41.0)**	-4.2 **(23.1)**
QC SW (V3.0)	----- -----	-5.5 **(38.5)**	----- -----	-6.7 **(23.8)**
GEWEX LW (V3.0)	0.7 **(30.1)**	0.5 **(21.8)**	0.6 **(13.3)**	-0.1 **(11.2)**
QC LW (V3.0)	4.24 **(30.2)**	4.0 **(22.4)**	4.0 **(15.4)**	3.5 **(12.7)**

Table 2. *Bias and RMS (bolded in parentheses) differences of the SRB surface downwelling SW and LW fluxes compared to BSRN measurements from 1992 through 2007 for each of the temporal averaged products.*



The northward-implied transport (10^{15} W) implied by the TOA meridional gradients of the zonal means for SRB Release 3, ISCCP-FD, and ERBE.

The derivation of TOA fluxes enables the computation of the 24-year mean TOA implied energy transport as shown in the figure on page 11. The implied energy transport uses the long-term zonally averaged TOA SW net and LW net fluxes, and contrasts that transport to that implied by ERBE and ISCCP-FD. The largest difference is about 0.5 x 10^{15} W at the latitude of maximum implied transport (30°N), which shows improved agreement relative to the results of Zhang et al. (2007).

Since GEOS-4 ended in December 2007, extension of this data set will require a new source of meteorological profile information. However, ISCCP plans a complete reprocessing in the coming year and thus the SRB data set will also be reprocessed in its entirety with improved algorithms and new meteorological data as the new ISCCP data become available. Reducing the impacts of changes to the input data streams from changing satellite instrumentation and calibration is one the most important objectives of the planned reprocessing. Information about the data set is available at: *http://gewex-srb.larc.nasa.gov.* The data are available at: *http://eosweb.larc.nasa.gov/PRODOCS/srb/table_srb.html.*

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GEWEX Panel Meeting Reports

The GEWEX Panels held individual and joint meetings at the 2nd Pan-GEWEX Science Meeting in Seattle, Washington from 23–27 August 2010. Individual reports from these Panel meetings begin below and continue through page 19. Presentations made during the meetings are available at: *http://www.gewex.org/2010pangewex/Agenda_Pan-GEWEX.pdf.*

GEWEX Radiation Panel Meeting

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Background

The GEWEX Radiation Panel (GRP) was born of a need to understand the short- and longwave energy balance of the Earth System, requiring expertise in satellite and in situ observing systems. Soon after its formation, GRP began developing data sets of global water and energy variables, including surface radiation (Surface Radiation Budget Project, SRB), clouds (International Satellite Cloud Climatology Project, ISCCP), and precipitation (Global Precipitation Climatology Project, GPCP). Later, these were further expanded to complete the flux and forcing terms, including turbulent fluxes (SeaFlux and LandFlux) and aerosols (the Global Aerosol Climatology Project, GACP). These products represent the legacy of GRP.

GRP is conducting an assessment of the state of the water and energy budgets based upon its radiation products, which is intended to document the state of our observing system, and is meant to be the first in a periodic re-evaluation of the state of the water and energy observing system. It will also consist of closure tests on the global scale, temporal variability in the fluxes and states, attribution of changes to observed forcings, and a maturity index of various components based upon ongoing assessments of individual elements of the budget.

Success in this objective allows GRP to expand its scope to certain related areas:

- *Product assessments.* GRP has led a number of assessment activities related to its own products but stands ready to help with future assessments of products related to the water and energy budgets—whether it be its own products or those generated under different auspices.

- *Regional water and energy budget closures through collaboration with the Regional Hydroclimate Projects (RHPs).* These basins are of sufficient size to allow validation of global products and for GRP products to begin serving regional model validation. This collaboration has not been very successful to date as GRP's focus has remained global, but with some stewardship it should produce results quickly.

- *Development of new radiative transfer codes to model and understand forcings in the climate system.* This effort includes an assessment of new potential satellite and in situ observing systems that would help close budgets.

- *Diagnostic and process studies.* The global data products produced under GRP auspices lend themselves to verify not only model output, but also model processes. Successful examples include the ISCCP simulator that allows models to compare their cloud fields directly to ISCCP and thus verify if the right clouds are being produced. Similar simulators have been/are being created for CloudSat and the Tropical Rainfall Measuring Mission. Precipitation databases also let models verify if partitions between cloud- and rainwater correspond to observations. Optimizing these interactions with the climate and cloud scale modeling groups within GEWEX is ongoing.

The GRP meeting focused on reviewing progress in its objectives and individual panel activities, as well as the integrating function led by the Working Group on Data Management and Analysis (WGDMA) to bring the global products into a unified framework to address the current assessment of the global water and energy cycle state. Four new GRP members were welcomed: (1) Prof. Hirohiko Masunaga from the University of Nagoya, with expertise in the areas of clouds, aerosols and precipitation; (2) Dr. Carlos Jimenez, from the Laboratoire d'Etude du Rayonnement et de la Matière en Astrophysique (LERMA), with expertise in land turbulent fluxes (he has also been active in LandFlux assessment activities); (3) Dr. Mark Ringer from the UK Met Office, who will help guide diagnostic activities; and (4) Dr. Enio Pereira from the National Institute for Space Research (INPE), who has expertise in surface radiation measurements.

The first presentation, on the National Climatic Data Center (NCDC), was given by Dr. Kummerow, the GRP Chair, on behalf of Dr. John Bates, and covered: (1) the transition of ISCCP data from a research product to an operational production stream at NCDC; (2) the status of the previous year's request by GRP to NCDC to study the Clouds and the Earth's Radiant Energy System (CERES) FM6 calibration issue; and (3) the recently completed Earth Radiation Budget (ERB) Requirements Workshop. The transition of ISCCP data to an operational product is going smoothly with enough current and planned scientific involvement to ensure long-term care of the product. Calibration changes sought by the CERES team were prioritized for implementation based upon availability of funds, with the highest priority being the changing of the Longwave Window Filter, followed by changes in the Mirror Attenuator Mosaic. Presentations made at the ERB Workshop showed that radiation budget measurements are made by a large number of international agencies and that their coordination is paramount if they are to be optimized.

Dr. Robert Adler reported that Version 2.1 of GPCP data uses a more sophisticated gauge analysis over land and that improvements are particularly noticeable in regions dominated by orographic rain. Uncertainty estimates based upon differences among mature rainfall products have also been added and climate rainfall trends can be obtained from the 30-year record. When volcano and El Niño Southern Oscillation signals are removed, precipitation trends are shown to be 0.0154 mm/day (0.6%) per decade. Preparation of Version 3 is on track to be released in 2011 and will use a new microwave algorithm that produces higher temporal and spatial resolution products. The Global Precipitation Climatology Centre reported that it is producing valuable products and that the breadth of its gauge data record continues to increase.

During the new panel member presentations, Prof. Masunaga presented his science interests, including satellite observations of tropical convection and the large-scale environment. Dr. Jimenez showed his work on model intercomparison studies and observational products comprising land-surface temperature, emissivity, and turbulent fluxes.

Prof. Carol Anne Clayson reported on the 5th SeaFlux Workshop, which was held jointly with the Climate Variability and Predictability Project (CLIVAR) Working Group on High Latitude Surface Fluxes. The Workshop demonstrated the need for improved measurements of near-surface properties in high latitudes where many of the existing flux estimates still diverge. The SeaFlux product itself is being evaluated and appears robust against in situ measurements. All models seem to have large unrealistic latent heat trends, while some of the observationally based trends seem to be correlated to ocean swell with drifts in the Special Sensor Microwave Imager (SSM/I) brightness temperatures through the time series from F08 through F15. Version 2.0 of the SeaFlux product will use a homogeneous time series of SSM/I Tb from Remote Sensing Systems.

Prof. Mathew McCabe reported that there are now at least 12 different candidate global products for the LandFlux data set. While papers are being written about the similarities and differences among these, the main goal of these intercomparisons is to determine the range of uncertainty between them. It is premature to attempt to quantify the absolute accuracy of any of the products or to make claims about the superiority of one over another.

Dr. Paul Stackhouse presented the status of the Baseline Surface Radiation Network (BSRN) for Ellsworth Dutton, and reviewed the SRB Project and Radiative Flux Assessment activities. BSRN has grown to 58 participating sites in 23 countries, with new sites at the Marcos and Cocos Islands, which are very small islands representative of oceanic conditions. Significant progress continues in pyrheliometer instrument comparisons, and in the archive of BSRN data at the Alfred Wegener Institute. Twenty-four years of SRB data are now available (see article on page 10) and are being validated against BSRN and newly processed CERES measurements. The next reprocessing is scheduled to begin in June 2011, following significant improvements in the input data and radiative transfer codes, as well as new ISCCP products. The Radiative Flux Assessment report will be available in 2011 and is intended to be a useful reference for the development of future climate system observation requirements for radiative fluxes and for understanding current data limitations.

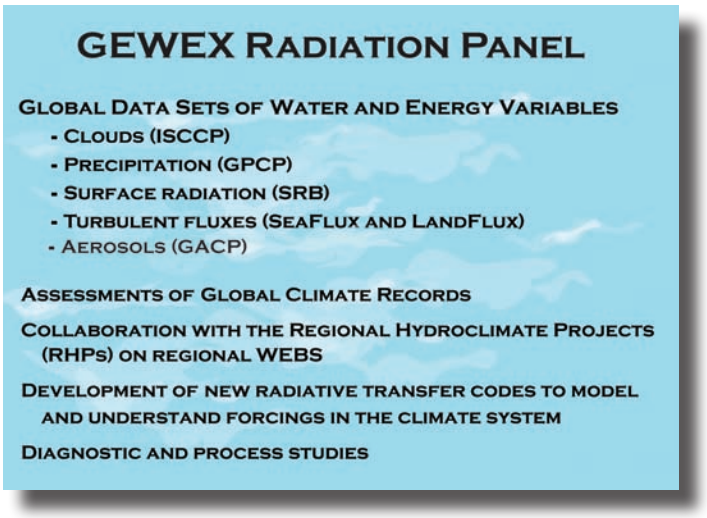
Prof. William Rossow reported on ISCCP and WGDMA. ISCCP cloud products are available through June 2008 and

include cloud radiances (B3 and B1U), DX cloud products at 25 km and 3-hourly resolution, D1/D2 cloud products (280 km, 3hr/monthly), radiative flux products, cloud particle seizes, Lagrangian tracking of mesoscale systems, mid-latitude cycle tracking, and weather states. Current calibration activities include radiance, both in absolute terms as well as calibration transfer schemes between satellites. Product improvements include better polar cloud detection schemes, more realistic surface emissivity for improved surface skin temperatures, and better ice treatment (phase function characterization) in the visible spectrum. Preparations are underway for the reprocessing in 2011 to a new 10 km, 3-hourly global product.

WGDMA coordinates the ancillary data used by the various GEWEX products and only if these are common does it makes sense to integrate the distinct products to produce a unified water and energy budget from these observations. Common ancillary products include a land/water mask with topography, ozone, snow/ice, surface albedo, surface emissivity, surface temperature (over land and ocean), aerosols and atmospheric temperature, and humidity. The latter is deemed the most important for GEWEX products. WGDMA is currently testing the new High Resolution Infrared Radiation Sounder (HIRS) product. Plans were reviewed for reprocessing GEWEX products, which is scheduled to begin in mid-2011. Assessments of Climate Data Records are critical for understanding product strengths and weaknesses, residual uncertainties, and relative differences among parallel climate products. A workshop is planned to elucidate "best practices" in the assessment area and will be hosted by the European Space Agency (ESA) Centre for Earth Observation (ESRIN) in April 2011 in Frascati, Italy.

As reported by Dr. Stefan Kinne, the Cloud Assessment Working Group is assembling all major multi-year data sets of cloud climatologies to produce a concise summary of individual sensor capabilities and their limitations. The assessment will go beyond cloud cover fractions to include cloud optical depth and microphysical properties. An interim result shows that total cloud cover is very sensitive to the instrument being used —ranging from approximately 75% for Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) to 65% for ISCCP. The draft assessment will be completed in 2010 and a summary paper is planned for the *Bulletin of the American Meteorological Society* in 2011.

An update on the aerosol assessment activity was presented by Dr. Paul Stackhouse on behalf of Prof. Sundar Christopher and Dr. Jeffrey Reid. The U.S. National Aeronautics and Space Administration (NASA) established a GEWEX Aerosol Project to examine the most common global aerosol products: Advanced Very High Resolution Radiometer [AVHRR (GACP and NOAA)]; Multi-angle Imaging SpectroRadiometer (MISR), Moderate Resolution Imaging Spectroradiometer [MODIS (Standard and Deep Blue)], Ozone Monitoring Instrument (OMI), and Polarization and Directionality of the Earth's Reflectances (POLDER). The first phase of the Project consists of a comprehensive literature review and evaluation. Deliverables will include a report on the state of the science, the application of satellite aerosol data, the identification of shortcomings, and broad recommendations to the field for future development and verification needs. Early findings show that there is no shortage of validation studies; however, these tend to be direct regression based over limited time periods and/or locations. Hence, they tend to be of limited utility. Even well designed third party studies are generally not utilized or cited by the production teams. While there are many cases of satellite calibration/validation components to field missions, analyses are usually not repeated for new product versions. Over ocean there tends to be remarkable consistency both in aerosol optical depth and in correlated bias across sensors, and over land there are strong regional and temporally correlated biases across both algorithms and sensors.



The GEWEX Water Vapor Assessment is a new activity intended to address the need for a global time series of temperature and humidity profiles for water vapor transport estimates, for use within the derivation of long-term (i.e., 30 years) cloud properties, as well as surface radiation flux data sets and components of the radiation budget climatology. To that end, GRP is organizing an assessment workshop to be held at the ESA/ESRIN in Frascati, Italy on 8–10 March 2011 to review the existing data sets for total column water vapor and water vapor profiles, including an analysis of their appropriateness for long-term climate applications needed by GEWEX.

In a discussion session focused on short-term goals, it was unanimously agreed that the largest single priority for GRP is to finish the individual product improvements and begin reprocessing all the products with a unified set of ancillary data sets. This integrated product forms the heart of GRP's effort to contribute to the understanding of the current observed state of the water and energy budget together with an uncertainty related to our current inability to fully close the water and energy budgets based upon observations alone.

GRP met with the GEWEX Modeling Panel during the 2nd Pan-GEWEX Meeting, to explore issues of joint interest, including the need to foster advanced diagnostic studies. A joint workshop was proposed to explore how to extract relevant

information on the water and energy budget from advanced diagnostics of observations and model results. This would include information on: (i) the interaction between the components of the climate system (e.g., studies exploring local coupling between surface and atmosphere require variables that are integrated somewhere in the Planetary Boundary Layer (PBL) but are sensitive to both surface and atmospheric states and processes), (ii) the conditional skill of models (compositing of cloud data is needed to distinguish between various types of clouds), (iii) the causes of variability (lagged correlations are fairly simple but do not necessarily reveal causal relationships); (iv) techniques like Lagrangian tracking in space or time, or advanced neural networks, give more insights on best estimates of the state of the system (data assimilation increments reveal a lot of information on inherent drifts in data or models). Aside from exploring advanced diagnostics, the workshop would also explore establishing a Working Group on Advanced Diagnostics composed of experts who are not involved with the generation of data sets or model data, but who use both.

Following the joint session with the GEWEX Modeling Panel, GRP met to discuss progress in the Cloud/Aerosol and Precipitation area. Prof. Sue van den Heever led the discussion. She posed a number of broad questions that a combination of global and in situ observations should address, such as: (i) are aerosol responses different under different environments? (ii) what is the relative role of aerosol indirect forcing versus environment? (iii) do precipitation responses to aerosol indirect forcing differ based on storm type? (iv) does the precipitation response to aerosol indirect forcing vary based on when in the storm life cycle it is examined? (v) are raindrops larger, smaller, or the same size in polluted conditions compared with clean conditions? and (vi) is there a dynamic response to aerosol indirect forcing? The discussion focused on examining each of the questions from a GRP and U.S. Department of Energy Atmospheric Radiation Measurement (ARM) Climate Research Facility data perspective to see what data sets could be developed that begin to directly address the above questions.

Jim Mather then gave an update on ARM that included an overview of significant improvements made to the ARM radar facilities that will allow better validation of cloud and precipitation products. The update was received as very positive but some members expressed hope that the high quality data that ARM is known for would not suffer as a result of the greatly expanded observing capabilities.

Dr. Axel Schweigert gave a presentation that summarized some of the GRP priorities in the polar regions. Cloud detection in polar regions is still an issue and he showed examples of cloud amount differences between MODIS and CALIPSO that were clearly dependent on sea-ice concentration. Precipitation in the polar regions, while small, is still important for ice growth and fresh water budgets. In situ observations are few but there are former Soviet ice drifting stations that could be exploited. With regard to turbulent fluxes, he reiterated the need for more open ocean observations at high latitudes.

GRP also met with the GEWEX Hydroclimatology Panel. Both Panels agreed upon using the RHPs as a way of evaluating the global products at the proper regional scales while helping put the regional efforts of the RHPs into the global context afforded by GRP's data sets. The next step in this synthesis will be the selection of the appropriate RHPs for conducting these comparisons. It was felt that the integrated GRP data set should be produced first to get a good estimate of the closure, or lack thereof, in various basins around the world. Dr. Mitch Goldberg gave a presentation on the Committee on Earth Observation Satellites (CEOS) activities related to Environmental Climate Variables in order to ensure that all the products discussed remain consistent with CEOS expectations.

The meeting ended with a discussion of its role in the future of GEWEX and the assignments related to elucidating the GEWEX Imperatives in the next 5–10 years. The outcome of this discussion is embedded in the broader GEWEX plan and Imperatives being prepared by the GEWEX Scientific Steering Group. The next GRP meeting will be hosted by Prof. Masunaga in Tokyo, Japan from 29 August–1 September 2011.

GLASS Panel Meeting

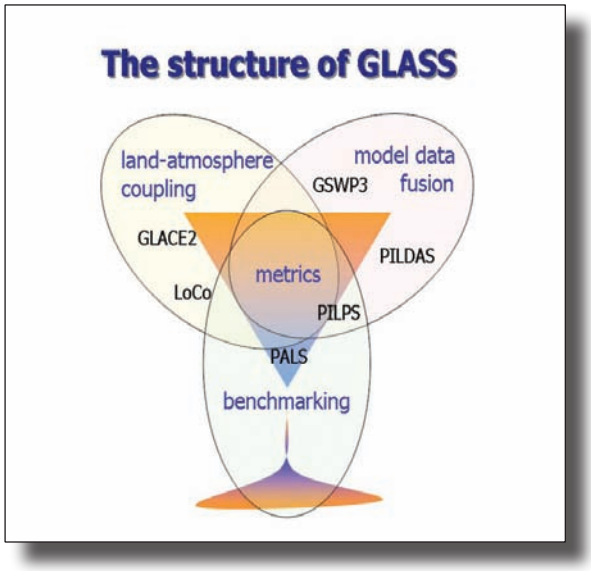
Bart van den Hurk
Royal Netherlands Meteorological Institute, The Netherlands

The Global Land/Atmosphere System Study (GLASS), which had been a project within the former GEWEX Modeling and Prediction Panel, is now a separate panel under GEWEX modeling activities. Bart van den Hurk will step down as Chair in January 2011 and Martin Best of the Joint Centre for Hydro-Meteorological Research at the UK Met Office will continue to co-chair. Joseph Santanello of the Hydrospheric and Biospheric Sciences Laboratory of the National Aeronautics and Space Administration (NASA) Goddard Space Flight Center in Maryland, will also serve as Co-Chair. Gerrit de Rooij, Deputy Head of the Soil Physics Department at the Helmholtz Centre for Environmental Research in Germany and Hyungjun Kim of the University of Tokyo in Japan, were introduced as new Panel members.

Plans for new studies were discussed and included cross-cutting activities with the GEWEX Radiation Panel (GRP) and the GEWEX Hydroclimatology Panel (GHP, formerly CEOP). In light of the Pan-GEWEX Meeting discussions on GEWEX Imperatives, the following mission statement was formulated: *GLASS will support improved estimates and representations of land states and fluxes in models, and the interactions with the overlying atmosphere to maximize the utilized fraction of inherent predictability*. The GEWEX Scientific Steering Group (SSG) recommended that GLASS explicitly promote model development and use of observations, including diagnostics of land-atmosphere interactions based on observations. In addition, the SSG is encouraging GLASS to host a future intercomparison experiment aimed at a new generation of land-surface models with a strongly developed hydrological component.

The first cross-cutting session was held with GRP and revealed two primary areas of common interests: (1) the LandFlux Project; and (2) the area of advanced diagnostics for model quality. The LandFlux Project provides a valuable data set for testing and benchmarking land-surface models and the data from the Global Soil Wetness Project (GSWP) would be a valuable addition to the LandFlux archive. There is shared interest in expanding the current metrics of model quality or system states by developing advanced diagnostics that give information on items such as the nature and strength of coupling between land and atmosphere, including the causes of observed variability of system components (attribution), and the conditional performance of models or process representations. Bart van den Hurk (GLASS) and Carlos Jimenez (Landflux) are joint conveners of a dedicated poster session on advanced land-surface diagnostics at the World Climate Research Programme (WCRP) Open Science Conference in Denver, Colorado, on 24–28 October 2011.

Two broad areas of common interests were identified in the GLASS/GHP cross-cutting session: (1) modeling activities; and (2) the role of land-surface characteristics on precipitation in the West African Monsoon. Martin Best (GLASS) and Dennis Lettenmaier (GHP) were tasked with defining a joint hydrological modeling project. Yongkang Xue (GLASS) and Toshio Koike (GHP) will develop a local coupled land-atmospheric Modeling-African Monsoon Multidisciplinary Analysis Project (AMMA) type experiment that is suitable for identifying the relationships between surface properties and precipitation variability.



Organization of the GLASS Panel

PILDAS

A pilot phase of a Project for the Intercomparison of Land Data Assimilation Schemes (PILDAS) was discussed. NASA and MeteoFrance are foreseen as initial partners (with more organizations invited to participate in the second phase). The goal of PILDAS is to organize a community effort through GLASS that provides a framework for comparing and assessing land-surface data assimilation systems. PILDAS-1 will focus on the assimilation of synthetic observations of surface soil moisture in preparation for the use of such data from the European Space Agency's Soil Moisture and Ocean Salinity (SMOS) Mission and NASA's Soil Moisture Active and Passive (SMAP) Mission. The initial design would be for a multi-year period with a limited domain (e.g., Red Arkansas River Basin).

LoCo and LIS

The Land Information System (LIS) contains a myriad of land-surface models, including the European Centre for Medium-Range Weather Forecasts' land-surface scheme (HTESSEL), the Joint UK Land Environment Simulator (JULES), and a data assimilation feature and standardized verification system. The first order Local Coupled land-atmospheric Modeling (LoCo) Experiment is now testing a wide range of land-atmosphere coupling diagnostics, such as: (i) traditional mixing diagrams; (ii) lifting condensation level (LCD) deficit quantifying the impact of land perturbations on the planetary boundary layer (PBL); (iii) Findell-Eltahir diagnostics of triggering of convection; (iv) revised relative humidity tendency variables; and (v) the McNaughton coupling coefficient. One paper has been been submitted (Santanello et al., *Journal of Hydrometeorology*), and three papers are in preparation that describe the set-up of the software and diagnostics: (i) Santanello et al: Coupling indicators on the southern Great Plains site using LIS-WRF; (ii) Jacobs et al: Coupling indicators diagnosed from reanalysis datasets; and (iii) Ek et al.: Derivation of the diagnostics and sensitivity formulations.

The experiments focus on daytime studies when the first-order impact of the land-surface conditions through turbulent fluxes is at a maximum. Now that verification data are available over West Africa, the relative contributions in the parameterizations of the local variability of rainfall or convection can be evaluated.

GSWP-3/CHEESE

A Global Soil Wetness Project-2 (GSWP-2) follow-on project (with the suggested name of CHEESE, for the Coupled Hydro-Energy-Eco System Experiment) was proposed at a dedicated workshop held in Tokyo in June 2010. CHEESE would cover 1979–present, a period during which interesting global trends occurred, such as regionally different temperature increases and trends in (pan) evaporation and atmospheric dimming/brightening. Carbon models would be used to explore possible carbon-related effects or changes in ecosystem functioning related to these trends and uncertainties in forcings (e.g., precipitation) with multiple data sets. In addition, simulations using Coupled Model Intercomparison Project–Phase 5 (CMIP5) models for both present day and future conditions would be used with a routing scheme, such as the Total Runoff Integrated Pathways (TRIP), as a standard diagnostic tool.

Results of pilot error propagation analysis were presented by Hyungjun Kim showing that the spread between the different land models was generally larger than in the precipitation forcings, which indicates model dependent sensitivity on evaporation and runoff. A white paper on experimental protocol is currently in preparation by Taikan Oki and Kim. The

GLASS Panel recommends that the project focus on climate experiments using CMIP5 forcings for present day climate conditions (uncertainty propagation, trend attribution, hydrological modeling, vegetation and carbon processes).

PALS and Benchmarking Activities

The development of a beta version of the Protocol for the Analysis of Land Surface Models (PALS, *http://pals.unsw.edu.au*) is underway. PALS is a web application for evaluating land surface models and the observed data sets used to test them. The PALS website is designed to analyze in a standard way uploaded single site model simulations with FLUXNET observations. Extensions to other data sets and creation of benchmarking tests is under development. Synchronization with components of the land information system (e.g., the verification package) is being considered. A number of suggestions were presented and discussed, including a presentation given by Bill Rossow on advanced diagnostics in the plenary session. A new benchmarking subgroup led by Christa Peters-Lidard will focus on how to promote the use of benchmarks in land-surface model development and testing. Projects like the International Land-Model Benchmarking (ILAMB) Project, GSWP-3/CHEESE, and the AMMA Land-Surface Model Intercomparison Project (ALMIP-2) are good candidates to serve as a test bed.

ALMIP-2

The goal of ALMIP-2 is to provide parameterizations of runoff scaling and it is being planned with higher spatial resolution (5 km) than ALMIP-1. It will focus on subtle hydrology and vegetation processes (e.g., very large rooting depths, land use change, sloping bedrocks removing water from the catchment, strong variability in runoff). The study will cover a 4-year period and will use a blend of in situ and radar data, and Landsat and other satellite data. The call to participate will come soon (via *GEWEX News*) and results are expected by the end of 2011.

GLACE-2

Results from the second Global Land Atmosphere Coupling Experiment (GLACE-2) show that skill in temperature and precipitation increases mainly in areas where the precipitation forcing quality is high (high station density gives better initial soil moisture data), when soil moisture is relatively extreme, and where potential predictability is high. A longer experiment is needed to capture the extreme conditions leading to better skill in some areas not showing a large skill right now (e.g., Europe). Eric Wood and Luofeng Luo are planning an extension of GLACE-2 to examine the degree to which more accurate initialized forecasts can lead to better hydrological forecasts by hydrological models driven by the GLACE-2 models.

GLASS Meetings in 2011

The next GLASS Panel meeting is planned adjacent to the WCRP Open Science Conference in Denver, Colorado. A small subgroup of GLASS members will meet in Barcelona at the time of the WCRP Workshop on Drought Predictability and Prediction in a Changing Climate in March 2011.

GCSS/GABLS Panel Meeting

Christian Jakob
Monash University, Melbourne, Australia

Several breakout sessions of the GEWEX Cloud System Study (GCSS) and GEWEX Atmospheric Boundary Layer Study (GABLS) were held during the 2nd Pan-GEWEX Science Meeting and the discussions focused on three subjects: (i) the removal of the GEWEX Modeling and Prediction Panel (GMPP) layer in the GEWEX structure; (ii) reorganization of GCSS and GABLS; and (iii) a proposal for an extended tropospheric physics and dynamics research framework for the post 2013 World Climate Research Programme (WCRP) structure.

Prior to the Pan-GEWEX Meeting, discussions via e-mail set the stage for the modeling discussions in Seattle; in particular, the desire of the Chair of GMPP to step down and his proposal to remove the reporting layer of GMPP, as well as the need to address the future structure of GEWEX modeling. The proposal to replace GMPP with two panels, the Global Land/Atmosphere System Study (GLASS) Panel and GCSS/GABLS Panel, both of which both report directly to the GEWEX Scientific Steering Group (SSG), was positively received and this new structure was later approved by the SSG.

As a part of the organizational changes, GCSS will abandon its current working group structure and will instead operate through projects, which can be initiated by any member of the community. Members of a GCSS/GABLS Science Steering Committee (SSC) will provide oversight of the program, including the approval of proposals for new activities. GABLS activities will be fully integrated into this structure through specific projects as well as GABLS membership on the SSC.

There was much discussion at the meeting regarding the proposal for a new post-2013 activity called the Framework for Atmospheric Model Enhancement (FAME), which would improve the representation of physical and dynamical processes in the troposphere in models for all purposes, and especially weather and climate services. Its main focus would be the improvement of the representation of clouds and precipitation in atmospheric models, which can only be achieved by improving our understanding of the intricate coupling of physical and dynamical processes associated with clouds and precipitation at various scales.

FAME was proposed in recognition of the need expressed by the Intergovernmental Panel on Climate Change (IPCC) in several reports, which highlighted the significant shortcomings in models of the simulation of clouds and precipitation with consequences for the simulation of important climate feedbacks and climate sensitivity. Other important factors included the recent revolution in the ability to observe clouds and precipitation, especially from space, and improvements in ability to model the processes involved at the process scale. The experience of more than 15 years of the GCSS project and almost 10 years of the GABLS project makes the time right for

a more concerted effort in atmospheric model improvement that builds on the existing strengths and adds to them the important new research area of physics-dynamics coupling.

The envisaged components of FAME would be programs on the planetary boundary layer (GABLS), clouds, convection and precipitation (GCSS), radiation (currently residing in GRP and the Stratospheric Processes and their Role in Climate, SPARC), coupling to dynamical processes (new), and potentially also coupling to numerics (new). FAME will be built around the core approaches identified by the WCRP Joint Scientific Committee (JSC), including observations, modeling, data analysis and model diagnosis, and process studies. Through the direct involvement of operational modeling centers in FAME, as well as through the engagement of scientists throughout the world, the activities in FAME could make major contributions to capacity building and services.

As FAME is tightly focused on providing a means for the improvement of the representation of core physical processes in atmospheric models, it would partner with many other programs to contribute to the research on phenomena that go beyond the physics-dynamics coupling in the atmosphere. Those include partnerships with GLASS and the GEWEX Hydroclimatology Panel (GHP) (land); Climate Variability and Predictability (CLIVAR) (oceans); the Aerosols, Clouds, Precipitation and Climate Initiative (ACPC); the Integrated Land Ecosystem-Atmospheric Processes Study (iLEAPS) (aerosols); SPARC and International Global Atmospheric Chemistry (IGAC) (atmospheric chemistry); SPARC (stratosphere); and CliC (cryosphere). Necessarily, these go well beyond GEWEX alone.

FAME could be seen as a natural extension to the existing GCSS/GABLS panel described above. This would maintain continuity, provide close links to the land and limited area modeling communities, and ensure FAME's natural focus on the energy and water cycles. These activities were originally grouped together to provide a focus on relatively "fast processes" as compared with those involving the ocean or cryosphere. FAME could also make a major contribution to a potential cross-WCRP effort on atmospheric model development.

This proposal was discussed by the SSG, which strongly recommend keeping FAME within the post-2013 GEWEX structure. Whether it would be a panel or working group are questions to be addressed. Many of the other modeling activities within WCRP are under working groups. The CLIVAR Working Group on Seasonal to Interannual Prediction (WGSIP) is an example of a working group that reports to the CLIVAR SSG but acts on behalf of WCRP to deal with seasonal to interannual prediction. A new group, integrating FAME and possibly called WGAP, short for Working Group on Atmospheric Processes and modeling for climate, could operate similarly within the post-2013 era of GEWEX. However, as the activities relate to the established working groups, especially the World Meteorological Organization Commission for Atmospheric Sciences/JSC Working Group on Numerical Experimentation (WGNE), this aspect has yet to be decided after broad consultation with the community.

CEOP/GHP Meeting

Sam Benedict
International GEWEX Project Office, Silver Spring, Maryland, USA

The Coordinated Energy and Water-Cycle Observations Project (CEOP) meeting included more than 40 international participants. In response to a series of questions posed before the meeting, project representatives presented status reports that included strategies for activities for the next 3 years. Additionally, the participants were challenged to address the changes needed to be responsive to the GEWEX Imperatives.

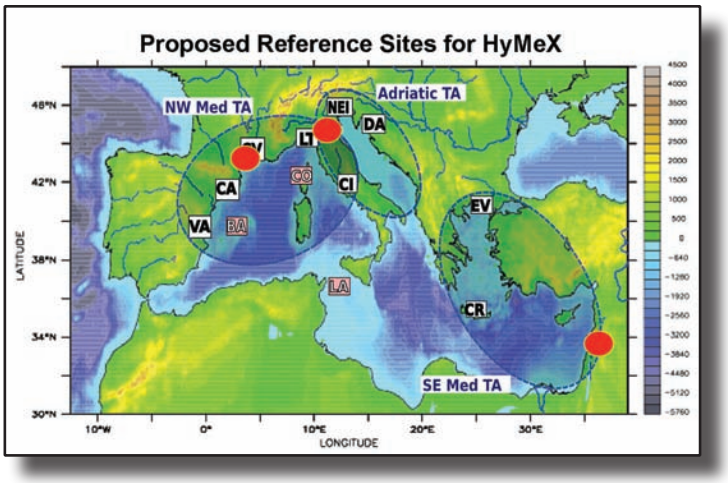
The new Co-Chair, Dennis Lettenmaier, with the support of the GEWEX Scientific Steering Group (SSG) and those present, agreed to take on more activities related to the expansion of regional land-surface models within the Regional Hydroclimate Projects (RHPs). To delineate this shift in focus and to preserve the legacy of CEOP as a separate but important contribution to GEWEX, the GEWEX Hydroclimatology Panel (GHP) was formed to replace CEOP. The main actions undertaken or planned for implementation by the co-chairs of GHP with respect to the comments and advocacy of the participants and the mandates of the SSG are included in the text below.

A special GHP advisory group of 8–10 members will be established and it is anticipated that the members within this group will assist in broadening the interdisciplinary scope of GHP. In addition, an RHP "Council" is planned to ensure stronger dialogue within the RHPs and will have representation on the GHP advisory group.

A draft GHP Terms of Reference (TOR) was developed at the meeting and will be reviewed and refined, first by the Panel members and then by the broader GHP community, before it is presented to the SSG for final approval.

An updated set of performance criteria for RHPs was established and presented in draft form for further review and iteration by the GHP/RHP community. The objectives and performance of all of the RHPs will be reviewed in the context of these "new" criteria, including those already within the GHP framework, those just newly established, such as the HYdrological cycle in the Mediterranean Experiment (HyMeX, see figure on next page), and those in the process of being established. These criteria will be used to determine at what level all the RHPs are or will be contributing to the most important GEWEX (and by association the World Climate Research Programme) science and technical issues as expressed in the new GEWEX Imperatives. The RHP review/evaluation process will evolve over time, since the Imperatives themselves are still being expanded and formalized for full implementation post 2013.

To take advantage of the extensive data management activities that began under CEOP, especially the satellite and in situ data collection and quality verification process (beginning



Proposed reference sites (red circles) within three target areas (TA) for Phase I of HyMeX, the new Mediterranean GHP Regional Hydroclimate Project. Hydrometeorological sites (white boxes) and atmospheric upstream sites (pink boxes). See HyMeX website at: http://www.hymex.org.

as far back as 2001), it was recommended that an advisory group be established within GHP to provide guidance on developing a 10-year GHP data set. An existing white paper on the topic has already gone through an initial review and been updated to include plans for selection of sites from within GEWEX established networks and the FLUXNET Project.

The GHP Co-Chairs were asked, along with other key individuals, to provide details to the GEWEX Imperatives in the next step toward production of a GEWEX "next phase" Implementation Plan. Specifically, GHP was asked to take this action with respect to the "Application" Imperative.

A GHP working group was formed to review options for integrating the Coordinated Regional Cimate Downscaling Experiment (CORDEX) into GEWEX and to make a recommendation for GEWEX membership in the WCRP Task Force on Regional Climate Downscaling. Because of the extensive expertise that GHP has in regional climate downscaling (RCD) techniques and since CORDEX is aimed at improving coordination of international efforts in RCD research, GHP agreed to take a lead role in this work on behalf of GEWEX.

Other items discussed at the meeting included:

- GHP involvement in the planning of a model error analysis workshop with the GEWEX modeling community.
- The engagement of the RHPs in a joint GEWEX Radiation Panel/GHP project to evaluate water and energy cycle data products using RHP data sets.
- Nomination of a representative of GHP to attend the Global Land/Atmosphere System Study (GLASS) meetings and investigate the feasibility of a joint GHP/GLASS initiative built upon GLASS expertise in land-surface studies and the GHP/RHPs focus on application models.

GWSP Conference and SSC Meeting

Rick Lawford[1] and Olga Zolina[2]
[1]International GEWEX Project Office, Maryland, USA
[2]Meteorological Institute, University of Bonn, Germany

The Global Water System Project (GWSP) Scientific Steering Committee (SSC) meeting was held in Bonn, Germany, on 9–10 December 2010, and was preceded by a 3-day Conference on the Global Catchment Initiative (GCI). The Conference attracted almost 110 scientists who presented studies related to international river basins, and many of these reports involved basins in Africa and other less industrialized parts of the world. A wide range of Global Climate Model outputs, hydrologic models, and analytical approaches are being used in these studies. There is evidence that the primary cause of changes in many basins is related to the increasing level of industrial development, including land use and hydropower development, followed by other factors such as climate change. A number of the studies were directed towards looking at environmental services, governance options, ethics, and legal frameworks for managing water at local to global scales.

Some of the GCI basin studies, such as the Danube Basin in Europe, the Volta Basin in Africa, and the Murray Darling Basin in Australia, overlap GEWEX Regional Hydroclimate Project (RHP) areas. Two presentations that had existing or potential connections to GWSP included one on hydrological indicators of drought based on the Canadian Drought Research Initiative, and one related to the Lake Winnipeg drainage basin (which includes elements of a new RHP in Canada that is under consideration).

The GWSP SSC meeting featured a number of presentations, including related activities by the United Nations and the European Union (EU), reports on the use of Earth observations in water management, teleconnections between global basins through virtual water flows, water and governance issues, water management in India, and capacity building activities in Southeast Asia.

Olga Zolina, on behalf of the GEWEX Scientific Steering Group and the International GEWEX Project Office, presented the status of GEWEX, which included planning now underway for the post-2013 era. Her presentation also highlighted potential areas for GEWEX/GWSP collaboration, including the role GWSP could play in defining requirements for information on model outputs and observations, and the feasibility of incorporating GEWEX data sets into the GWSP Digital Water Atlas. The GWSP International Project Office (IPO) indicated that they would seek guidance on the level of resources available for the Atlas before advancing any collaborative activities.

Some of the GWSP highlights in 2010 included: (1) a paper in *Science* entitled "Rivers in Crisis," that summarizes the results related to the use of indicators in the GWSP Global Scale Initiative; (2) results from the GWSP/Integrated Project Water and Global Change (WATCH) Initiative Water Model Inter-

GWSP Conference and SSC Meeting

Continued from page 19

comparison Project (WaterMIP); (3) the launch of Twin2go, a EU-funded project that partners basins in Europe to basins outside Europe to study both natural science issues and policy issues; and (4) a workshop on water governance, of which the results will be reported in a special issue of the Global Environmental Change Journal, *Ecology and Society*. The GWSP IPO has also taken the lead in studying the effect of water on human migration. Preliminary results suggest that human migration is dominated by social issues rather than physical factors, such the effect of climate change on water resources.

GWSP activities for 2011 include developing plans for a science conference for 2013 and another GCI conference/workshop, the launching the Energy and Climate Study, and possibly hosting a Water and Health Workshop. GWSP is also exploring options for a joint GWSP/GEWEX event. Other activities discussed at the SSC included hosting a workshop on attributes of non-linear processes and preparing a synthesis article on global drought. Claudia Pahl-Wostl, Co-Chair of the SSC and Rick Lawford, a member of the SSC, agreed to advance a second phase of GCI that would attempt to standardize approaches and explore a range of issues on the science policy interface, including risk management approaches.

The GWSP project is scheduled to end in 2014 with funding for its project office ending in 2012. An initial plan for a synthesis based on mapping GWSP activities against the organization's framing questions was tabled. The form of the synthesis (book or a series of refereed articles) was also discussed, as was the GWSP follow-on. In summary, it is the view of the authors that GWSP has made significant progress over the past year and has taken some encouraging steps to engage a broader cross section of experts in the dialogue on the role of humans in the global water system.

For the answers to the 20th Anniversary Crossword in the November 2010 newsletter issue, see: http://www.gewex.org/gewex_nwsltr.html

GEWEX NEWS

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GEWEX/WCRP Calendar

For the complete listing, see the GEWEX web site: http://www.gewex.org

2–4 March 2011—WCRP Workshop on Drought Predictability and Prediction in a Changing Climate—Barcelona, Spain.

8–10 March 2011—GEWEX/ESA DUE GlobVapour Workshop on Long Term Water Vapour Data Sets—ESRIN, Frascati, Italy.

12–15 March 2011—GTN-H and IGWCO Meetings—Tokyo, Japan.

22–25 March 2011—Sentinel Products for Land, Ocean and Cryosphere: Assessment and Consolidation Workshop—ESRIN, Frascati, Italy.

30 March 2011—Workshop: Saskatchewan River Basin Regional Hydroclimate Project—National Hydrology Research Centre, Saskatoon, Canada.

3–8 April 2011—EGU General Assembly—Vienna, Austria.

4–8 April 2011—WCRP Joint Scientific Committee Session—UK Met Office/Hadley Centre, UK.

5–7 April 2011—Evapotranspiration Workshop—Silver Spring, MD, USA.

8–9 April 2011—LandFlux Workshop—ETH, Zurich, Switzerland.

11–12 April 2011—NASA Drought Monitoring Workshop—Hilton Washington DC/Silver Spring, Maryland, USA.

11–13 April 2011—EUMETSAT/ESA Scatterometer Science Conference 2011—Darmstadt, Germany.

18–20 April 2011—Community Discussion Workshop: Planning a New Terrestrial Regional North American Hydro-Climate Experiment (TRACE)—Silver Spring, MD, USA.

3–5 May 2011—SMAP/Cal-Val and ISMWG 4—Oxnard, CA, USA.

16–18 May 2011—YOTC Int'l Science Symposium—Beijing, China.

16–20 May 2011—5th HyMeX Workshop—Punta Prima, Menorca, Spain.

31 May 2011—Adapting to Climate Change - Case Studies from the Baltic Sea Region—Hamburg, Germany.

6–10 June 2011—EUCLIPSE/GCSS/CFMIP Meeting on Cloud Climate Feedback—Met Office,Exeter, UK.

28 June–7 July 2011—IUGG XXV General Assembly—Earth on the Edge: Science for a Sustainable Planet—Melbourne, Australia.

1–5 August 2011—IGARSS 2011—Sendai, Japan.

30 Aug.–2 Sept. 2011—GEWEX Radiation Panel Meeting—Tokyo, Japan.

18–23 September 2011—3rd iLEAPS International Science Conference—Garmisch-Partenkirchen, Germany.

24–28 Oct 2011—WCRP Open Science Conference: Climate Research in Service to Society—Denver, Colorado, USA.

28–30 Oct 2011—GEWEX Executive Meeting—Denver, Colorado, USA.

29 Oct 2011—GLASS Meeting—Denver, Colorado, USA.

7–10 Nov 2011—ECMWF-GABLS Meeting—Reading, UK.

14–18 Nov 2011—24th GEWEX SSG Meeting—CNR, Rome, Italy.