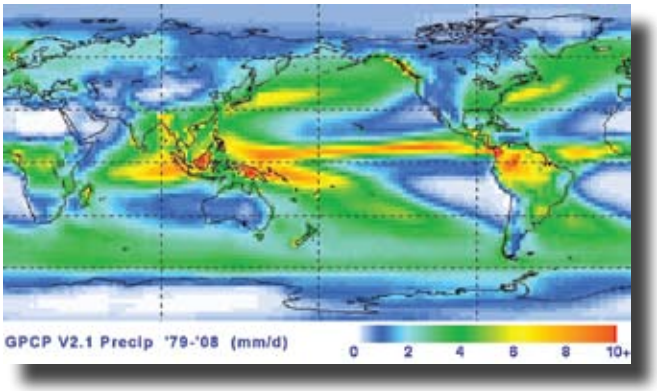
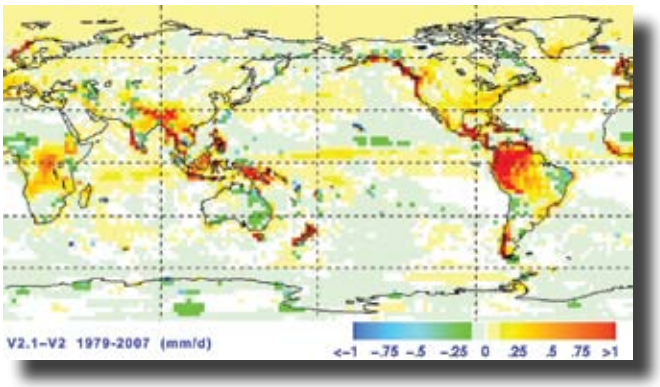
GEWEX WCRP
Global Energy and Water Cycle Experiment
NEWS

Vol. 19, No. 4 | WCRP World Climate Research Programme | WMO | IOC | ICSU International Council for Science | November 2009

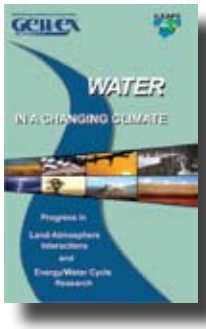
30 Years of Global Precipitation Estimates Completed — A Major Milestone in Creating Long-Term Observational Data Sets for the Water and Energy Cycle *(see page 6)*



Global Precipitation Climatology Project (GPCP) Version 2.1 precipitation climatology, 1979–2008, in mm/day. This combination of satellite estimates based on infrared, microwave, and sounding data, together with gauge analyses, yields a global average of 2.68 mm/day.



Difference between GPCP Version 2.1 and Version 2 precipitation estimates averaged over 1979–2007 in mm/day. The new version is about 2 percent higher, mostly over land, due to a new gauge analysis. Changes over ocean mostly reflect an improved calibration in the first 9 years of data.



Highlights of the 6th International GEWEX Science Conference and Joint GEWEX/iLEAPS Sessions
Melbourne, Australia, 24–28 August 2009
See page 11

Contents

Commentary

A Year in Reflection

Peter J. van Oevelen
Director, International GEWEX Project Office

In the last newsletter of the year it seems customary to look back and reflect, as well as to anticipate the challenges in the coming year. Judging from the feedback received, the 6th International GEWEX Science Conference, co-organized with the 2nd iLEAPS International Science Conference, and held in Melbourne, Australia, was very successful. Almost 400 scientists from 32 countries attended both conferences and joint sessions. Results presented show that GEWEX is turning observations into scientific knowledge to support improved decision making, reduce uncertainty, and facilitate planning and policy. I thank all of you who contributed in one form or another, especially the local organizers, Christian Jakob and Monash University (see page 11 for the conference highlights).

The African Monsoon Multidisciplinary Analyses (AMMA) Project, a GEWEX Regional Hydroclimate Project, held its third international conference in Ouagadougou, Burkina Faso (West Africa) in July (see page 15). AMMA researchers have shown that the formation of cold water in the Gulf of Guinea plays a determining role in the monsoon onset. Similarly, the meteorological conditions in the Mediterranean Sea or in the Indian Ocean are key factors in the variability and the retreat of the monsoon.

Another important event this year was the World Climate Conference-3 (WCC-3), which called for strengthening the essential elements of a global framework for climate services of which the World Climate Research Programme (WCRP) and the Global Climate Observing System (GCOS) will play a key role. The contribution of GEWEX will be based upon the lessons learned from Coordinated Energy and Water Cycle Observations Project (CEOP) activities, such as the former Water Resources Applications Project and its successor, the Hydrological Applications Project. It is evident that many changes will be taking place and that GEWEX will be asked to deliver more specific types of climate information. The increase in the knowledge of the climate system and its processes will not suffice; we have to look at these processes in an Earth system context. Collaboration within WCRP and its projects will be emphasized more strongly, as well as collaboration with other entities outside of WCRP, such as the International Geosphere-Biosphere Programme (IGBP) and Earth System Science Partnership (ESSP).

The GEWEX Radiation Panel (GRP) has begun transitioning some of its data sets into operational status for long- term contributions to climate research and prediction, and has successfully obtained agency funding for the reprocessing of its data sets. GRP has also successfully completed several formal assessments of its data sets and related products, and is establishing a future baseline for development of a scientific consistency among the climate data sets that describe the global energy and water cycles.

This year the Global Precipitation Climatology Project (GPCP) completed 30 years of global precipitation estimates with a new update (see page 6). The availability of reliable global precipitation estimates is of ongoing importance and some of the current problems and issues in providing these data, such as significant bias errors in the precipitation estimates over mid-latitude oceans and higher latitude oceans and land, will be addressed by the planned Global Precipitation Mission (GPM).

The step from precipitation to soil moisture is not too large. The European Space Agency's Soil Moisture and Ocean Salinity (SMOS) mission is scheduled to be launched in November. Many science activities have been generated with the planning of passive microwave soil moisture sensing satellites, such SMOS and the National Aeronautics and Space Administration's Aquarius and Soil Moisture Active-Passive (SMAP) missions. The launch of SMOS should boost the establishment of a global soil moisture *in situ* network, something that the science community has worked towards but not yet achieved.

WCRP has played a prominent role in climate research for over 30 years. Last year a comprehensive review of the Programme was completed and as a result, a new long-term strategy is being developed. On page 4 the Director of WCRP and the Chairman of the Joint Scientific Committee present the new Implementation Plan (IP) and long-term strategy for WCRP. One of the cross-cutting activities identified in the IP is climate extremes. The Drought Interest Group (see page 5) is a new CLIVAR/GEWEX organized activity designed to identify and assess the missing links in drought research, and to coordinate this research at an international level in order to advance the understanding of prediction and predictability of extremes.

Finally, based on the success of the first Pan-GEWEX Meeting held in 2006, a second one is planned for 2010 in Seattle, Washington. It is hoped that by bringing all of its panels and projects together, GEWEX will be able to develop a cohesive response to the new priorities of WCRP.

GEWEX NEWS
Published by the International GEWEX Project Office

Peter J. van Oevelen, Director
Dawn P. Erlich, Editor
Shannon Macken, Assistant Editor

International GEWEX Project Office
8403 Colesville Rd, Suite 1550
Silver Spring, MD 20910, USA

Tel: 1-240-485-1855
Fax: 1-240-485-1818
E-mail: gewex@gewex.org
Web Site: http://www.gewex.org

Recent News of Interest

Call for Papers

Cold Regions Hydrology in a Changing Climate (Session CR12.1/HS13.5) at the European Geosciences Union General Assembly in Vienna, Austria (2–7 May 2010) will address major issues and challenges in cold region hydrology research and applications, such as the changes in the nature, structure, and function of cold region rivers, lakes, and wetlands, and their interactions with human activities and ecosystems. It will also explore and examine the biological, physical, and social impacts of hydrology and climate changes in cold regions. This session welcomes contributions from various research aspects, including field process study, analysis of long-term records, modelling approaches, remote sensing application, and synthesis of major regional and international research projects. Abstracts are due 18 January 2010. For more information, contact Daqing Yang (*daqing.yang@npolar.no*) or Peter van Oevelen (*gewex@gewex.org*).

Call for Proposals: Earth Explorer Opportunity Mission EE-8

As part of its Earth Observation Envelope Programme, the European Space Agency (ESA) announces an opportunity for scientists to make proposals to be assessed as potential Earth Explorer Opportunity Mission EE-8. This mission is intended to be used to conduct research in the field of Earth observation and/or to demonstrate the potential of new innovative Earth observation techniques of relevance to both the scientific and the applications communities. A response to the Call may be made by European or Canadian scientists or teams of scientists, where proposing teams also may include scientists from non-ESA Member States. For more information please see: *http://esaeopus.ejr-quartz.biz/.*

Publications

A Multimodel Analysis for CEOP

Michael G. Bosilovich, et al. 2009. *J. Hydro.*, 10, 912–934.

Summary: Results from a comparison of eight operational global analyses show that the monthly precipitation and outgoing longwave radiation from the multimodel ensemble compares better to the observations than a single analysis.

Uncertainties in Satellite Remote Sensing of Aerosols and Impact on Monitoring Their Long-Term Trend: A Review and Perspective

Z. Li, et al. 2009. *Ann. Geophys.*, 27, 2755-2770.

Summary: Satellite aerosol products assessment in support of the assessment initiative proposed by the GEWEX program to evaluate the quality of existing long-term satellite data products for climate change study and applications.

New Large-Scale Biosphere-Atmosphere Experiment in Amazonia (LBA) Data Sets

1. **LBA-ECO CD-03 Mesoscale Meteorological Data, Santarem Region, Para, Brazil (1998–2006) —** Meteorological data from the Santarem region of Para, Brazil, collected at eight stations for 2002–2005 and at some of the stations from as long as 1998–2006. See: *http://dx.doi.org/10.3334/ORNLDAAC/944*

2. **LBA-ECO CD-03 Cloud Base-Backscatter Data, 67 km Tower Site, Tapajos National Forest—**30-minute averaged cloud base and backscatter profile data from the old-growth forest site located at the forest site located at the 67 km Eddy Flux Tower site, Tapajos National Forest, Santarem, Brazil. See: *http://dx.doi.org/10.3334/ORNLDAAC/942.*

NLDAS-2 Hourly Products Released

The National Aeronautics and Space Administration Goddard Space Flight Center Hydrological Sciences Branch and Goddard Earth Sciences (GES) Data and Information Service Center (DISC) have released North America Land Data Assimilation System Phase 2 (NLDAS-2) data products. The 30-year data set (1979–present) of hourly 1/8° surface meteorology and hydrology data over the continuous United States and parts of Canada and Mexico combines observations from many different sources to generate a surface forcing data set, which is used to drive several different land-surface models. The data, which include both primary and secondary forcing data and Mosaic model outputs are available at: *http://disc.sci.gsfc.nasa.gov/hydrology/data-holdings.*

ALMIP-Phase 2 Participation Requested

The GEWEX community, in particular the Global Land Atmosphere System Study (GLASS), is invited to participate in the African Monsoon Multidisciplinary Analysis (AMMA) Land-surface Model Intercomparison Project (ALMIP)-Phase 2 (see article on page 9). An overview paper of results from the recently completed ALMIP-Phase 1 will soon be published in the Bulletin of the American Meteorological Society. For more information about ALMIP-2, contact Aaron Boone (*aaron.boone@meteo.fr*).

ARM and ASP Merged into Atmospheric System Research Program

The U.S. Department of Energy's Atmospheric Radiation Measurement Program (ARM) and Atmospheric Science Program (ASP) were merged and are now managed under a new name, Atmospheric System Research. To learn more, see: *http://www.arm.gov/news/cms/prog-news/3809.*

WCRP Implementation Plan 2010–2015

Ghassem R. Asrar[1] **and Antonio J. Busalacchi**[2]
[1]Director, World Climate Research Programme (WCRP)
[2]Chair, WCRP Joint Scientific Committee (JSC)

In 2008 the World Climate Research Programme (WCRP) sponsors [International Council for Science (ICSU); World Meteorological Organization (WMO); and Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization (UNESCO)] commissioned an independent review of WCRP. An international panel of experts was appointed to evaluate the extent to which international global change research programs, such as WCRP, add value to their respective areas of research and to the national programs that contribute to them. They asked the panel to answer the question "what do scientists, sponsors and the end-users get out of participating in and supporting these international programs that they would not have gained if the international programs did not exist?" The final report is available at *http://www.icsu.org*.

The major recommendations from the independent review, together with internal discussions among WCRP leadership, including the Joint Scientific Committee (JSC) that has the overall responsibility for defining, overseeing, and evaluating the scientific and technical activities of WCRP, and the Chairs and Directors of WCRP Core Projects, and Chairs of the Working Groups and Panels (who implement the program activities), resulted in an ongoing program assessment and planning activity. The WCRP team decided to focus its deliberations on two time horizons: an intermediate period (2010–2015), and a long-term period (post 2015). The outline of the intermediate-term plan has been published recently and is available at *http://wcrp.wmo.int/documents/WCRP_IP.pdf*.

The document describes the major research activities and initiatives that WCRP will promote and undertake during the next several years. These activities/initiatives are based on the scientific challenges and opportunities of interest identified by the scientists involved in the Program, as well as on the national and international scientific priorities that would most benefit from WCRP coordination. In addition to the interdisciplinary research and modelling initiatives identified, the themes of regional climate assessments and climate information for decision-makers also emerged from these discussions as requiring special emphasis by WCRP in the intermediate- and long-term timeframes. There were considerable discussions on the means and modes for delivery of climate information to decision-makers and the role that WCRP can and should play in this process. The major issue debated was how best WCRP should spend its limited resources and make use of its network of volunteers in the continuum that begins with observation, research, analysis, modelling, and prediction and ends with the synthesis, assessment, and delivery of the climate information and knowledge to decision-makers.

The general view is that WCRP must continue to support and enable excellence in climate observations and research, but also promote and enable a comprehensive climate information system for timely and efficient delivery of the resulting knowledge to decision-makers. Partnerships are essential to WCRP success in both areas.

The document provides some specific examples of activities and initiatives to be adopted by WCRP and its Core Projects, but it is not a comprehensive compendium of WCRP activities. It tries to convey the solid scientific foundation that WCRP has established during the first 30 years of its research on climate variability and change, which forms the basis for future challenges and opportunities in delivering the resulting information and knowledge to decision makers for developing strategies and options for climate adaptation, mitigation, and risk management across the major social and economic sectors and regions of the globe.

To implement these activities and initiatives, WCRP functions and organizational structure will continue to evolve during the ensuing decade(s). A companion document entitled *WCRP Long-Term Strategy: Functions and Structure* is currently under preparation and will describe in detail the areas of scientific focus and organizational structure for the program beyond the next decade.

AMS AWARDS

The following GEWEX scientists are to be honored at the next American Meteorological Society conference to be held in Atlanta, Georgia on 17–21 January 2010.

Eric F. Wood, Princeton University, New Jersey, will receive the Jule G. Charney Award for pioneering contributions to understanding the role of land-surface heterogeneity in the coupled water and energy balance of the Earth surface.

Timothy Liu, Jet Propulsion Laboratory, California, will receive the Verner E. Suomi Award for research in space-borne measurements of air-sea interactions and the water cycle, and for inspiring progress through interdisciplinary science team leadership.

New Fellows:

- Robert F. Cahalan, NASA/GSFC
- Jack A. Kaye, NASA Headquarters
- James L. Kinter III, IGES/COLA
- Lai-yung Ruby Leung, PNNL
- Johannes K. Schmetz, EUMETSAT

WCRP Drought Interest Group (DIG) — Coordinating Research for Better Regional Drought Prediction

David Legler[1] and Anna Pirani[2] on behalf of WCRP DIG
[1]International CLIVAR Office; [2]U.S. CLIVAR Office

The World Climate Research Programme (WCRP) has identified extreme events as one of its major cross-cutting foci. WCRP research on extreme events includes prolonged drought, cold periods, the intensity of monsoons, the probability of occurrence of short time scale extreme events dependent on mean climate characteristics (e.g., tropical cyclones, mid- and high-latitude storms), severe frosts, air pollution extremes and heavy precipitation. WCRP is developing new projects jointly within its various groups that focus on improving models, assimilation systems, and observing system requirements for predictions that will have enhanced capabilities for forecasting future extreme events. For example, The Observing System Research and Predictability Experiment (THORPEX) is focusing on the predictability of atmospheric extremes. Other activities will focus on improving capacity to measure and describe extremes.

The Drought Interest Group (DIG) is a WCRP extremes cross-cutting activity designed to identify and leverage drought research activities already underway within WCRP, especially under GEWEX and the Climate Variability and Predictability Project (CLIVAR) [e.g., the extremes activity under the GEWEX Coordinated Energy and Water Cycle Observations Project (CEOP), the activities of the CLIVAR Variability of the American Monsoon Systems (VAMOS) Panel, and the US CLIVAR Drought Working Group]. DIG will assess the missing links in drought research, and coordinate drought research at an international level in order to advance the understanding of prediction and predictability of extremes.

DIG Activities and Future Plans

DIG efforts to date have concentrated on the coordination of activities and enhanced cross-fertilization between the GEWEX and CLIVAR Projects. DIG will identify research needs in drought prediction and encourage increased coordination of regional and international drought-research activities. Work has begun on the WCRP White Paper, *Drought Predictability and Prediction in a Changing Climate: Assessing Current Capabilities, User Requirements, and Research Priorities*, which will assess current prediction capabilities against user needs with the aim of identifying areas that would benefit from international coordination.

The White Paper focuses on the following objectives: (1) motivating climate research that targets drought and the need for coordination, (2) summarizing user drought prediction requirements, (3) documenting current drought prediction capabilities, (4) defining research and development needs, and (5) formulating recommendations on research priorities. The White Paper will set the stage for a Pan-WCRP Workshop planned for late 2010. There is a wide-reaching need for drought predictions, and users' requirements for information can be very different depending on the application. The workshop will aim to describe the needs for regional drought information and prediction, and assess our capabilities for meeting these needs, what the current understanding of what is, and what is not, predictable, and how global climate features, such as monsoons, the El Niño-Southern Oscillation, decadal variability, and climate change can influence the nature and severity of regional drought. The timing of the workshop will coincide with the Coupled Model Intercomparison Project Phase 5 (CMIP5) release of the archive and will motivate the coordinated analysis of the archive in terms of drought. The outcomes of the workshop will be made widely available, possibly as a peer-reviewed article.

DIG will survey drought research activities that are ongoing around the world, provide this information on the WCRP Extremes website, and summarize these in a short report. An appendix is planned for the White Paper that will list all the groups within WCRP that are working in the area of drought and will include short statements from each group summarizing their activities. This will complement the effort to assess current drought prediction capabilities and so contribute to the discussion on how to better coordinate an international effort on drought research.

Invitation to Take Part in Future DIG Activities

Because drought is a concern in many regions and each region has a slightly different mix of local climate conditions, there is a demand for drought prediction information and drought forcings at that scale for that specific region. Regional drought researchers and experts interested in improving our capability to predict drought on time scales of weeks to centuries in the future are invited to join DIG. It is hoped that DIG will facilitate communication between specialists knowledgeable in the demands for drought and drought prediction information and those addressing drought predictability, mechanisms, causes, attribution, observations, and prediction. Anyone interested in joining the DIG should contact Anna Pirani (*anna.pirani@noc.soton.ac.uk*).

For further information, please see the following websites:

WCRP Extremes Crosscut and DIG:
http://www.clivar.org/organization/extremes/extremes.php

WCRP-Extremes/Risks (overview):
http://wcrp.wmo.int/ExtremesRisks_index.html

WCRP-Floods/Droughts (overview):
http://wcrp.wmo.int/FloodsDroughts_index.html

GPCP Celebrates 30 Years of Global Precipitation Estimates with a New Update

George J. Huffman[1,2], Robert F. Adler[1,3], and David T. Bolvin[1,2]
[1]NASA/Goddard Space Flight Center, Laboratory for Atmospheres; GPCP Global Merge Center; [2]Science Systems and Applications, Inc.; [3]University of Maryland College Park, ESSIC

The GEWEX Global Precipitation Climatology Project (GPCP) has completed 30 years of global monthly precipitation estimates, covering 1979 through 2008, a major milestone in creating long-term observational data sets for the water and energy cycle. The data set was carried across the 30-year mark as part of a complete reprocessing (Huffman et al., 2009) to accommodate improved precipitation gauge analysis developed by the Global Precipitation Climatology Centre (GPCC), together with a review of the satellite data that provide the bulk of the estimates. The GPCP data are now well into 2009, the data set's 31st year.

The Version 2.1 data set averages 2.68 mm per day worldwide (see upper figure on the cover page). Confidence in the results varies by region, with developed land areas leading in certainty and high-latitude ocean areas trailing. Nonetheless, the integrated global picture is in considerably better shape than before GPCP commenced work some 20 years ago, when the sequence of precipitation in El Niño-Southern Oscillation (ENSO) events was a matter of debate.

The new average is about two percent higher than for the previous data set (Version 2; described in Adler et al., 2003), with essentially all of the change occurring over land, due to the new gauge analysis (see figure on cover). The important point is that the estimated values over particular locations at particular times can vary by a great deal more. Notably higher values are now analyzed in tropical mountain regions (northwestern South America, Papua New Guinea, the Himalayas, and along the east coast of the Bay of Bengal), along the mountainous Pacific coasts of northwestern North America and southern Chile, in New Zealand, and in central Africa. These are all high-precipitation areas that benefited from the improved quantity of input data and the revised analysis approach in the new GPCC data set.

In addition to the 30-year plus monthly product described above, which is provided on a 2.5° x 2.5° latitude/longitude grid, GPCP also computes a daily product on a 1° x 1° grid, starting in October 1996 (Huffman et al., 2001), and a pentad (5-day) product on a 2.5° x 2.5° grid starting in January 1979 (Xie et al., 2003). These products are constrained to approximately add up to the satellite-gauge product, ensuring consistency when the different products are used. All of the GPCP products are updated on a routine basis a few months after real time, and posted for free public distribution. The primary host for the GPCP data sets is the World Data Center A (WDC-A), hosted by the National Climatic Data Center (NCDC) at: *http://www.ncdc.noaa.gov/oa/wmo/wdcamet-ncdc.html*. They are also posted at *http://precip.gsfc.nasa.gov*. Alternative formats are available from the NCDC Thematic Real-time Environmental Distributed Data Services (THREDDS) server: *http://eclipse.ncdc.noaa.gov:9090/thredds/catalog.html*, and an interactive analysis and display capability is provided by the TOVAS website at the Goddard Data and Information Services Center: *http://disc2.nascom.nasa.gov/Giovanni/tovas/*.

The set of GPCP products is developed and maintained as an international activity. Input data sets are provided by several groups. Special Sensor Microwave/Imager (SSM/I, Defense Meteorological Satellite Program, U.S.) data retrievals are provided by L. Chiu (Chinese University of Hong Kong and George Mason University, U.S.) and R. Ferraro (National Environmental Satellite Data and Information Service, NESDIS, U.S.). Merged geosynchronous- and low-Earth-orbit infrared (GEO- and LEO-IR) data are provided by P. Xie (National Oceanic and Atmospheric Administration/Climate Prediction Center, NOAA/CPC, U.S.) using data contributed by NESDIS, the Japanese Meteorological Agency, and the European Organization for the Exploitation of Meteorological Satellites. P. Xie provides the Outgoing Longwave Radiation (OLR) Precipitation Index (OPI) estimates from NOAA LEO-IR data. J. Susskind (National Aeronautics and Space Administration/Goddard Space Flight Center, NASA/GSFC, U.S.) contributes estimates based on the Television Infrared Observation Satellite Operational Vertical Sounder (TOVS, provided by NESDIS) and the Advanced Infrared Sounder (AIRS, provided by NASA). Global precipitation-gauge analyses are provided by B. Rudolf and U. Schneider (GPCC, hosted at the Deutscher Wetterdienst) using data from most countries around the world. The final computations of the monthly and daily products are carried out by the group led by G. Huffman and R. Adler (NASA/GSFC) and the pentad by P. Xie (NOAA/CPC).

GPCP is now planning for the next major upgrade to its suite of products, Version 3, which will include improvements in the homogeneity of the long-term record and inclusion of high-time-resolution precipitation estimates as an integral part of this "climate" data set to facilitate research into the typical and extreme precipitation events that many users find essential to their work. Version 3 processing is expected to begin in late 2010 and will also be part of an integrated GEWEX set of climate products dealing with the energy and water cycles.

References

Adler, R. F., G. J. Huffman, A. T. C. Chang, et al., 2003. The Version 2 Global Precipitation Climatology Project (GPCP) Monthly Precipitation Analysis (1979–Present). *J. Hydrometeor.*, **4**(6), 1147–1167.

Huffman, G. J., R. F. Adler, M. Morrissey, D. T. Bolvin, S. Curtis, R. Joyce, B. McGavock, and J. Susskind, 2001. Global Precipitation at One-Degree Daily Resolution from Multi-Satellite Observations. *J. Hydrometeor.,* **2**(1), 36–50.

Huffman, G. J., R. F. Adler, D. T. Bolvin, and G. Gu, 2009. Improving the Global Precipitation Record: GPCP Version 2.1. *Geophys. Res. Lett.,* **36**, L17808, doi:10.1029/2009GL040000.

Xie, P., J. E. Janowiak, P. A. Arkin, R. F. Adler, A. Gruber, R. Ferraro, G. J. Huffman, and S. Curtis, 2003. GPCP Pentad Precipitation Analyses: An Experimental Data Set Based on Gauge Observations and Satellite Estimates. *J. Clim*, **16**, 2197–2214.

10 Years of RAMI: Overview, Achievements and Outlook

Jean-Luc Widlowski and Bernard Pinty
European Commission, Directorate General Joint Research Centre, Institute for Environment and Sustainability, Ispra, Italy

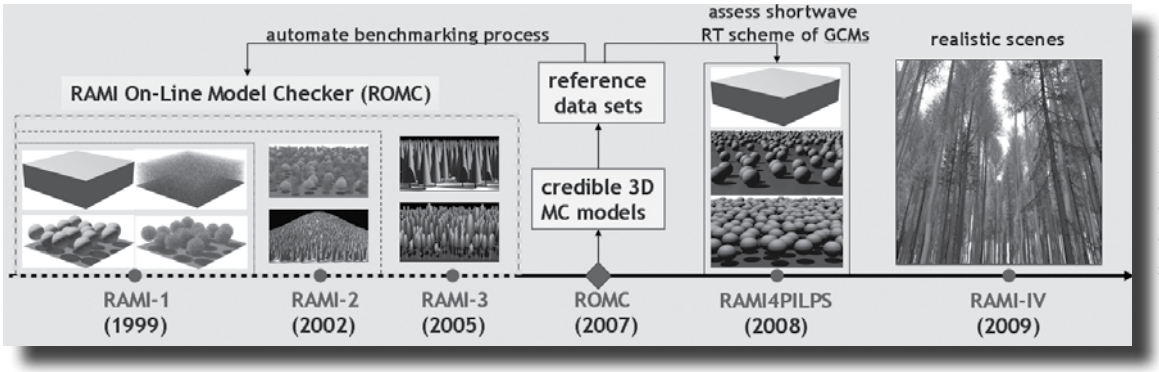
In 1999 the x+ (RAMI) activity was initiated by the European Commission's Directorate General Joint Research Centre to formalize and extend earlier evaluation attempts of canopy radiative transfer (RT) models. These physically based modelling tools simulate the transfer of radiation at or near the Earth's surface, (i.e., in plant canopies and over soil surfaces) and are increasingly used in the quantitative interpretation of remotely sensed data sets. The accuracy and reliability of RT models thus have a direct impact on the quality of the surface products they help retrieve (e.g., Leaf Area Index, Fraction of Absorbed Photosynthetically Active Radiation and albedo) and therefore also on the quality of outcomes generated by applications that assimilate or ingest these products.

As an open-access and community-driven activity, RAMI operates in successive phases, each one aiming at reassessing the capability, performance, and agreement of the latest generation of RT models (*http://rami-benchmark.jrc.ec.europa.eu/*). The results of RAMI-1, a small set of canopy scenarios designed to suit both 1-D and 3-D models, underlined the need for model verification since many of the submitted simulations differed substantially between the eight participating models. During RAMI-2 two new test cases addressing issues of topography and spatial resolution were added to the set of earlier experiments. Thirteen RT models participated and their agreement was much better, especially for the homogeneous canopies. Expanding the set of experiments yet again, RAMI-3 concluded with an unprecedented level of agreement amid its 18 participating RT models for both the homogeneous and heterogeneous canopies.

Within RAMI, models are evaluated in terms of their internal consistency (e.g., energy conservation), their ability to match analytical solutions (where these are available), and by comparison with other RT models (containing fewer assumptions and shortcuts). This strategy is applied to fluxes and directional quantities, to quantities arising from selected orders of scattering of the radiation, and also to scenarios that are physically meaningful but do not necessarily occur on Earth. Using this approach it was possible to identify six "credible" 3-D Monte Carlo models (differing by one percent on average over all the RAMI-3 test cases) and to utilize their simulations to generate a "surrogate truth" community reference data set. This, in turn, led to the development of the RAMI Online Model Checker (ROMC), a web-based benchmarking facility providing quasi-real time evidence of the differences existing between the simulations of a user's canopy RT model and the RAMI-3 "surrogate truth" data set (*http://romc.jrc.ec.europa.eu/*). Currently, over 30 RT models have been registered with the ROMC and several scientific publications use ROMC graphs to provide independent and traceable proof of the quality of a model.

With the availability of the ROMC it became feasible to expand the scope of RAMI and address new issues, such as using "credible" 3-D Monte Carlo models to provide benchmark solutions for shortwave radiative flux formulations in the land surface schemes of Soil-Vegetation-Atmosphere Transfer Models and Global Circulation Models. This activity, known as RAMI4PILPS, was endorsed by the GEWEX Global Land Atmosphere System Study (GLASS) during the 2006 Pan-GEWEX Meeting. In parallel the fourth phase of RAMI was launched (submission deadline January 2010) with a completely new set of test cases. RAMI-IV features very detailed canopy descriptions based on exhaustive field and laboratory measurements and expands the range of simulations beyond spaceborne sensor responses to include passive and active optical instruments used during field and airborne validation campaigns.

By its very nature, RAMI and its sister activity dealing with clouds, the GEWEX Radiation Panel Intercomparison of 3-D Radiation Codes Project (*http://i3rc.gsfc.nasa.gov/*), are both dynamic and evolving activities. As a result, the benchmarks and evaluations issued by the RAMI process must be considered snapshots describing the state of the art at the time of the exercise, and not as a final, absolute and definitive judgment on the worthiness and performance of any particular model. It is through this systematic approach to RT model verification that RAMI contributes to the quality assurance of space-derived information. Expanding RAMI to new thematic areas (soils, coastal zones, urban areas) and/or spectral regimes (thermal, synthetic aperature radar) is very likely. Similarly, the benchmarking of RT model simulations against reference laboratory standards should be addressed if credible RT models are to contribute to a traceable, end-to-end quality assurance system of remotely sensed data and products.



Evolution of RAMI-IV.

Monitoring the Climate from Space: EUMETSAT Satellite Application Facility for Climate Monitoring (CM-SAF)

Jörg Schulz and the CM-SAF Team
Deutscher Wetterdienst, Offenbach, Germany

The demands on the accuracy of satellite-derived climate data increase relative to the length of the time series (Ohring et al., 2005). Some of the satellite data series are approaching 30 years; however, most of these satellites were designed to support weather forecasting and not climate applications.

In 1995 the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) Satellite Application Facility on Climate Monitoring (CM-SAF) was created as a facility for the operational processing of satellite data in near real time under the leadership of Deutscher Wetterdienst (German Meteorological Service) in partnership with the Belgian, Dutch, Finnish, Swedish, and Swiss national meteorological services.

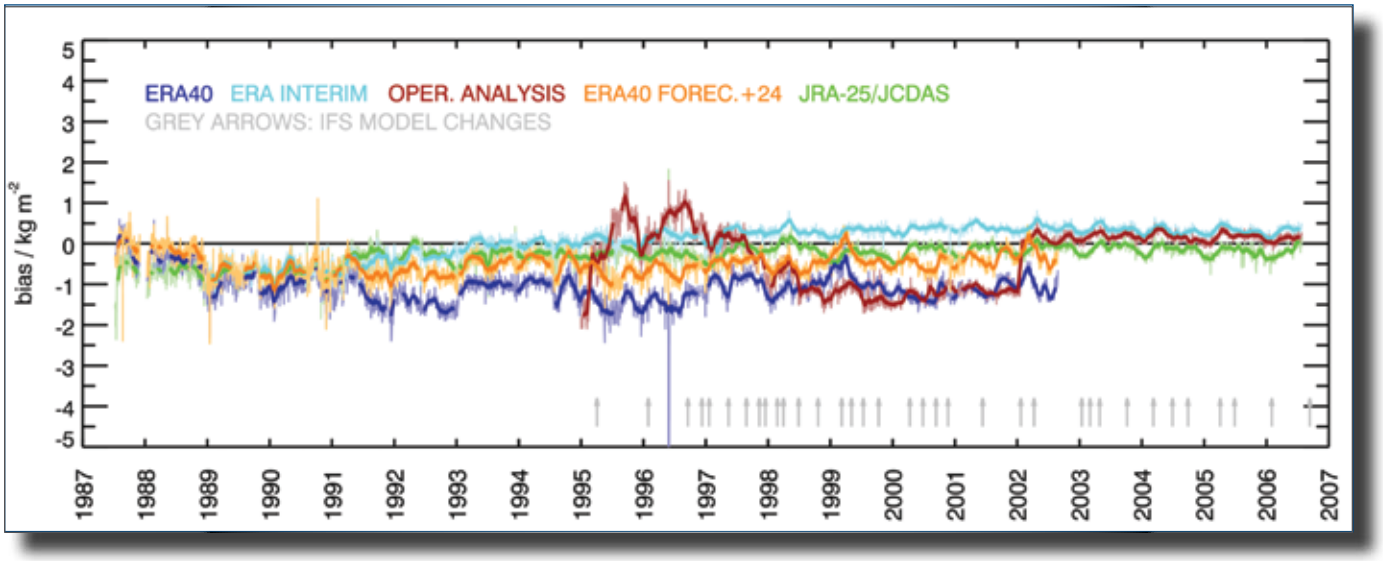
Near real time [Environmental Data Records (EDR)] products are derived from several instruments onboard meteorological operational and research satellites in geostationary and polar orbit, such as Meteosat and EUMETSAT polar system satellites, respectively. The data are archived and made accessible for research via the CM-SAF web site at: *http://www.cmsaf.eu*. EDRs are used for process studies (Roebeling and Meijgaard, 2009) and the validation of global and regional climate models.

CM-SAF also provides satellite-derived geophysical parameter data sets based on inter-sensor calibrated radiances [Thematic Climate Data Records (TCDR)] for the analysis of climate variability on different spatio-temporal scales and climate change. Most of the CM-SAF data sets match the list of Essential Climate Variables as defined and required by the Global Climate Observing System Implementation Plan in support of the United Nations Framework Convention on Climate Change. More information and documentation on the CM-SAF products, algorithms, and validation activities can be found in Schulz et al., 2009, Kaspar et al., 2009, and *http://www.cmsaf.eu*.

CM-SAF's expanding suite of products is tailored for applications focusing on key aspects of the Earth's atmospheric water and energy cycles and includes cloud and radiation budget parameters (surface and top of the atmosphere) as well as temperature and water vapor. In the near future CM-SAF will provide precipitation (P) and evaporation (E) data and the resulting E-P.

The Hamburg Ocean Atmosphere Parameters and Fluxes from Satellites (HOAPS: *http://www.hoaps.org*) data set is being developed together with the Max-Planck Institute for Meteorology in Hamburg, Germany and is the first transition of a research data set in an operational framework performed by CM-SAF in cooperation with a research institute.

As a part of the transition of HOAPS into CM-SAF, an approximately 20-year TCDR of total column integrated water vapor from the U.S. Defense Meteorological Satellite Program Special Sensor Microwave/Imager (SSM/I) covering ice free oceans has been released. The data record of SSM/I radiances was homogenized by matching probability density functions (PDFs) of radiances of overlap periods between satellites. The figure below compares this data set to such model-based global reanalysis data as the European Centre for Medium-Range Weather Forecasts (ECMWF) ERA Interim, ERA-40, the operational analyses of ECMWF, and the Japanese JRA-25. The ERA-40 reanalysis has a bias of about 2 kg m^{-2} compared to the CM-SAF data set, whereas the new ERA-Interim data show very little bias. This demonstrates how a high quality and very



Time series of global daily mean biases of the CM-SAF water vapor column product from Special Sensor Microwave/Imager versus different reanalysis data sets. Thin light curves denote daily averages and bold lines denote 30-day moving averages. Arrows at the bottom indicate changes in the ECMWF forecast model.

robust satellite-derived data set can be used to assess the quality of model based reanalysis.

> ***To be at the highest scientific level of these developments, cooperation with GEWEX is of fundamental importance.***

More long time series are planned in cooperation with the National Oceanic and Atmospheric Administration (NOAA) and other institutions in Europe. A global cloud property data set derived from the Global Area Coverage data from the Advanced Very High Resolution Radiometer data using the CM-SAF retrieval schemes is in preparation. From the geostationary orbit the whole series of Meteosat instruments, including the Meteosat visible and infrared imager (MVIRI) and Spinning Enhanced Visible and Infrared Imager (SEVIRI) are being used to derive a climatology of free tropospheric humidity with high temporal resolution. While the MVIRI time series is homogenized, its temporal extension with SEVIRI observations is still under development. Also, a long time series of spectrally resolved solar irradiance from MVIRI is currently under development at CM-SAF. This is complemented by a reprocessing of all EDRs from the SEVIRI and Geostationary Earth Radiation Budget Satellite instruments.

CM-SAF data sets are only produced within a cooperative international research and operational framework. CM-SAF is also contributing to World Meteorological Organization activities such as the Global Space-based Inter-Calibration System (GSICS, *http://gsics.wmo.int*) and to the Sustained Coordinated Processing of Environmental Satellite Data–Climate Monitoring (SCOPE-CM, *http://www.wmo.int/pages/prog/sat/SCOPE-CM.html*). The goal of both activities is improved Fundamental Climate Data Records (FCDRs) and TCDRs from satellite-derived time series. To be at the highest scientific level of these developments, cooperation with GEWEX is of fundamental importance. The GEWEX Radiation Panel with its associated data set projects has the best experience in deriving long-term climate data records from satellite data. CM-SAF activities are based on this experience and provide a sustainable long term option for future climate monitoring based on satellite data.

References

Kaspar, F., et al., 2009. Operational generation of AVHRR-based cloud products for Europe and the Arctic at EUMETSAT's Satellite Application Facility on Climate Monitoring (CM-SAF). *Advances in Science and Research*, **3**, 45–51. *http://www.adv-sci-res.net/3/45/2009/asr-3-45-2009.html.*

Ohring, G., B. Wielicki, R. Spencer, B. Emery, and R. Datla, 2005. Satellite instrument calibration for measuring global climate change. *Bul. Amer. Meteor. Soc.*, **86**, 1303–1314.

Roebeling, R. A., and E. van Meijgaard, 2009. Evaluation of the diurnal cycle of model predicted cloud amount and liquid water path with observations from MSG-SEVIRI. *J. Clim.*, **22**, 1749–1766.

Schulz, J., and Co-authors, 2009. Operational climate monitoring from space: the EUMETSAT Satellite Application Facility on Climate Monitoring (CM-SAF). *Atmos. Chem. Phys.*, **9**, 1687–1709. *http://www.atmos-chem-phys.net/9/1687/2009/.*

AMMA Land Surface Model Intercomparison Project Phase 2 (ALMIP-2)

Aaron Boone[1], Augusto C. V. Getirana[1], Jerome Demarty[2], Bernard Cappelaere[2], Sylvie Galle[3], Manuela Grippa[4], Thierry Lebel[3], Eric Mougin[4], Chris Peugeot[2], and Théo Vischel[3]

[1]GAME-CNRM, Météo-France, Toulouse, France; [2]HSM, Université de Montpellier, France; [3]LTHE, Grenoble, France, [4]CESBIO, Toulouse, France

The goal of the African Monsoon Multidisciplinary Analysis (AMMA) Project is to obtain a better understanding of the intraseasonal and interannual variability of the West-African Monsoon (WAM). The magnitude of the north-south gradient of surface fluxes (related to soil moisture and vegetation) has an influence on the position of the tropical front and the strength of the monsoon. A high priority of AMMA is to better understand and model the influence of the spatial and temporal variability of surface processes on the atmospheric circulation patterns and the regional scale water and energy cycles. This is being addressed through a multi-scale modelling approach using an ensemble of land surface models (LSMs) which rely on dedicated satellite-based forcing and land surface parameter products, and data from the AMMA observational field campaigns (Redelsperger et al., 2006).

The coordination of the land surface modelling activities in AMMA is supported by the AMMA Land surface Model Intercomparison Project (ALMIP) and is being conducted along the same lines as previous GEWEX LSM intercomparison studies, such as the Global Soil Wetness Project (Dirmeyer et al., 2006) and the Project for the Intercomparison of Land-Surface Parameterization Schemes (PILPS, Henderson-Sellers et al., 1995) where an ensemble of LSMs are forced in offline mode by a mix of data from numerical weather analysis and prediction, satellite products, and surface observations. In this sense, the simulations comprise the equivalent of a multi-model reanalysis product.

On the regional scale, 12 international groups performed multi-year offline simulations for the period of 2002–2007 over West Africa using multiple forcing input forcing data sets for the recently completed ALMIP Phase I (Boone et al., 2009). The resulting LSM simulations are being used extensively for hydrological modelling, regional scale water budget estimates, mesoscale atmospheric case studies, and regional atmospheric chemistry modelling. The results are also used for the evaluation of regional and global scale atmospheric models within the AMMA Atmospheric Model Intercomparison Project (AMMA-MIP, Hourdin et al., 2009) and the GEWEX-sponsored West African Monsoon Modelling Evaluation Project (WAMME, Xue et al., 2009).

In ALMIP Phase 2, LSMs will be evaluated using observational data from three heavily instrumented supersites from the AMMA-Couplage de l'Atmosphère Tropicale et du Cycle Hydrologique (CATCH) observing system (Mali, Niger, and Bénin) (see map on page 10). The AMMA-CATCH window covers a north-south transect encompassing a large eco-climatic gradient (Lebel et al., 2009). Two main experiments will be performed with the first one at the mesoscale for each of the three super sites, using a grid resolution between 5 and 10 km.

A second set of experiments will be performed at the local scale for several selected sites within each of the mesoscale squares. The simulations will encompass the 2005–2007 Intensive Observing Period with a special focus on the analysis during the Special Observing Period in 2006. In addition to evaluation using field data, LSM simulations will also be compared to results from detailed vegetation process and hydrological models that have already been extensively validated over this region. The results will be used in conjunction with those from ALMIP-1 in an effort to evaluate the effect of scale change on the representation of the most important processes from the local to the regional scale.

A coordinated set of model experiments over the three AMMA-CATCH sites will provide a good idea of the contrasting characteristics and processes in the Sahel and Soudano-Guinean regions. The typical endorheic nature of the surface hydrology of the two Sahelian sites (Mali and Niger) for which catchments are limited to scales on the order of a few tens of square kilometers, includes both high runoff-prone and infiltration-prone surfaces. This is in contrast to the large hydrological catchments over the Benin site. Each site observing system provides both forcing (i.e., micrometeorological description and soil and vegetation properties) and validation data (surface fluxes, soil moisture, water table, and runoff). In addition, remote sensing images have been processed in order to infer land surface properties at the mesoscale, such as land cover, leaf area index maps, land surface temperature, albedo, and superficial soil moisture.

The Gourma-Mali site located in the northern Sahel (14.8°N–17.3°N) is a typical rangeland region, covered with semi-arid natural vegetation. LSM simulations will be focused on the Hombori super site, a 50 x 50 km area which extends over the central Sahel where most of the *in situ* instrumentation is concentrated (Mougin et al., 2009). The rainy season is short, lasting from late June to mid-September, with an average annual precipitation recorded at Hombori over 1950–2007 of 370 mm. The site is characterized by three soil types over which two different hydrologic systems operate. Vegetation comprises a herbaceous layer almost exclusively composed of annual plants, among which grasses dominate, and scattered bushes, shrubs, and low trees.

The South-West Niger site (13°N–14°N) is typical of the central Sahel conditions with average annual rainfall decreasing from 570 mm in the south to 470 mm in the north (1990–2007 average). The mesoscale site is located near Niamey, generating heavy demographic pressure, including intensive agricultural usage and wood cutting for fuel. The area is now essentially composed of millet fields, fallows, and tiger bush (Cappelaere et al., 2009). Simulations will be performed for a 1-degree square (2-3°E; 13–14°N) characterized by a typical semi-arid tropical climate with a long dry season (from October to May) followed by a wet season of 4 to 5 months.

The third site is the Ouémé-Benin site (9°N–10.2°N; Guyot et al., 2009) where annual rainfall averages 1200–1300 mm. The vegetation is wooded savannah with interspersed crops including maize and niébé. Simulations will focus on the upper Ouémé watershed (14,600 km²). The rainy season lasts from April to October. Contrary to the two other Sahelian sites, river runoff is structured by an arborescent drainage network, and sustained by the drainage of water-tables. The vegetation cover is patchier than on the other sites, with forest clumps scattered in mixed fields and fallow landscape.

ALMIP-2 is tentatively scheduled to begin in early 2010 and results collected by June 2010, with analysis undertaken during the June–August 2010 period. A workshop is planned for the end of the year. The development and results of ALMIP-2 will be supported and advised by the GEWEX Global Land Atmosphere System Study (GLASS). ALMIP-2 is open to the land surface and hydrological modelling community at large and interested researchers are encouraged to participate. For more information about ALMIP, see: *http://www.cnrm.meteo.fr/amma-moana/amma_surf/almip/.*

References

Boone, A., et al., 2009. The AMMA Land Surface Model Intercomparison Project. *Bull. Amer. Meteor. Soc.* (in press).

Cappelaere, B., et al., 2009. The AMMA-CATCH experiment in the Sahelian area of south-west Niger – Investigating water cycle response to a fluctuating climate and changing environment. *J. Hydro*, 375, 34–51.

Dirmeyer, P. A., X. Gao, M. Zhao, Z. Guo, T. Oki, and N. Hanasaki, 2006. GSWP-2: Multi-model Analysis and Implications for Our Perception of the Land Surface. *Bull. Amer. Meteor. Soc.*, 87, 1381–1397.

Guyot, A., J.-M. Cohard, S. Anquetin, S., and C. R. Lloyd, 2009. Combined analysis of energy and water balances to estimate latent heat flux of a Sudanian small catchment. *J. Hydro*, 375, 227–240.

Henderson-Sellers, A., A. J. Pitman, P. K. Love, P. Irannejad, and T. Chen, 1995. The project for intercomparison of land-surface parametrization schemes (PILPS): Phase 2 and 3. *Bull. Amer. Meteo. Soc.*, 76, 489–503.

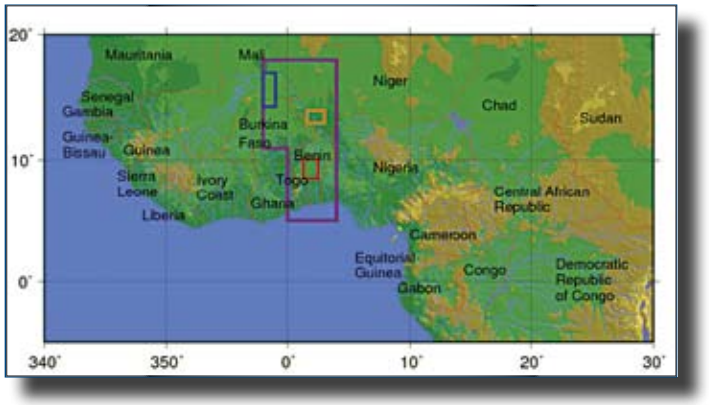
Hourdin, F., F. Guichard, and F. Favot, et al., 2009. AMMA-Model Intercomparison Project. *Bull. Amer. Meteor. Soc.* (accepted).

Lebel, T., et al., 2009. AMMA-CATCH studies in the Sahelian region of West Africa: An overview. *J. Hydro*., 375, 3–13.

Mougin, E., et al., 2009. The AMMA-CATCH Gourma observatory site in Mali: Relating climatic variations to changes in vegetation, surface hydrology, fluxes and natural resources. *J. Hydro*, 375, 14–33.

Redelsperger, J.-L., et al., 2006. AMMA: An international research project and field campaign. *Bull. Amer. Meteor. Soc.*, 87, 1739–1746.

Xue, Y., et al., 2009. The West African Monsoon Modeling and Evaluation project and its First Model Intercomparison Experiment. *Clim. Dyn*. (under revision).



The regional domain shown above extends from –20° to 30°E, and –5° to 20°N and was used in ALMIP-1 Experiment (at a 0.5 degree spatial resolution). The ALMIP-2 study region is in the subregional domain outlined in violet (mesoscale; 0.10 degrees spatial resolution). Ouémé (red), Niamey (orange), and Gourma (blue) are local scale data sites.

Highlights from the 6th International Scientific Conference on the Global Energy and Water Cycle

Peter van Oevelen and Dawn Erlich
International GEWEX Project Office, Silver Spring, MD, USA

Almost 400 scientists from 32 countries gathered in Melbourne, Australia from 24–28 August 2009 to attend the 6th International GEWEX Science Conference, held in parallel with the 2nd Integrated Land Ecosystem-Atmosphere Study (iLEAPS) Science Conference. Both conferences were organized together and around a central theme, *Water in a Changing Climate—Progress in Land-Atmosphere Interactions and Energy/Water Cycle Research,* to emphasize the unique aspects of the GEWEX and iLEAPS programs, while highlighting the overlap in their scientific communities. Joint oral and poster sessions were held that combined the mutual scientific interests and subject matter of both programs. The 150 oral and 250 poster presentations given during the conferences showed that the mutual science from both international frameworks has already led to new and interesting collaborations and insights.

Opening remarks at the Plenary Session were given by the following dignitaries: Bruce Stewart, President of the World Meteorology Organization (WMO) Commission for Hydrology, who spoke on behalf of Michel Jarreaud, Director General of WMO; Carlos Nobre, Chairman of the International Geosphere-Biosphere Programme (IGBP) Scientific Committee; Ghassem Asrar, Director of the World Climate Research Programme (WCRP); Antonio Busalacchi, Chair of the WCRP Joint Scientific Committee; Pavel Kabat, iLEAPS Conference co-chair and iLEAPS Scientific Steering Committee co-chair; and Soroosh Sorooshian, GEWEX Conference co-chair and former chair of the GEWEX Scientific Steering Group. **The opening remarks touched on the significant progress that has been made in climate research and emphasized the important role that GEWEX and WCRP as a whole have played in this, including their contributions to the Intergovernmental Panel on Climate Change process.** With future developments on the horizon resulting from United Nations Climate Change Conference (COP 15) held in Copenhagen this year and the recent addition of climate services as a WCRP goal, the GEWEX role has become even more vital.

Roger Pielke, Jr.

Five keynote speakers presented their ideas on the state of climate change research. The first keynote speech was delivered by Piers Sellers, U.S. astronaut and former GEWEX chairman of the International Satellite Land-Surface Climatology Project. His presentation focused on opportunities and challenges in the climate science arena, in particular for the U.S. program. John Thwaites, Professorial Fellow of Monash University and Chair of the Monash Sustainability Institute in Australia, emphasized the regional and practical aspects of climate change and water management from his personal experience as former Minister of Water in Victoria, Australia. In his presentation, **Prof. Thwaites demonstrated that a robust planning framework for conservation of water resources and planning is necessary, even if the climate change predictions and assumptions regarding climate change and its impact on water resources are incorrect.** This point was strengthened by the presentation of Roger Pielke, Jr., professor and Fellow of the Cooperative Institute for Research in Environmental Sciences (CIRES) and former Director of the Center for Science and Technology Policy Research at the University of Colorado at Boulder. Because most hydrological processes are of a non-stationary nature, he urged the scientific community to focus on not just improving predictive capabilities with increasingly complex models but also to come to robust decisions in crafting policy with simple models based on what is possible rather than what is probable.

John Thwaites

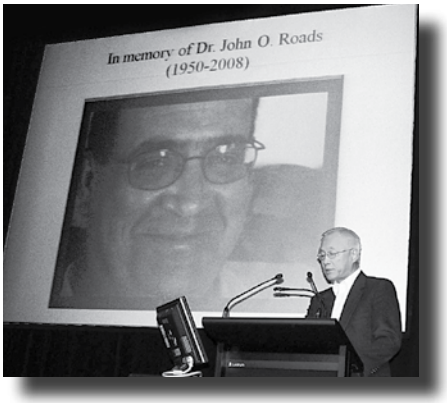
Paulo Artaxo, Professor of environmental physics at the University of São Paulo, Brazil, reflected on the challenges in unveiling the links between climate's scientific aspects and climate's socioeconomic aspects, which are as important as physics, chemistry, and biology. He concluded with a strong plea for combining biogeophysical and socioeconomic systems research. Will Steffen, Executive Director of the Climate Change Institute at The Australian National University, expanded on this theme, stating that we are now living in the "anthropocene" and that societal transformation at a global scale is necessary for survival. The challenge for research is to provide the knowledge base to support that transformation.

After the Plenary Session, iLEAPS and GEWEX began their parallel sessions. The first GEWEX session focused on *Regional Forecasting and Predictions for Hydrological Applications in Arid Zones*, where Soroosh Sorooshian gave a concise overview of the issues in arid- and semi-arid zone hydrology. He indicated, as did other presenters in this session, that **changes in precipitation patterns (timing and intensity) and vegetation cover have great implication on the magnitude of ground water recharge, runoff, and flooding. Satellite observations on both precipitation and ground water are proving to be invaluable in hydrologic forecasting and predictions and much progress has been made in this area.**

In the GEWEX session on *Rainfall Variability and Drought in Australia*, Harry Hendon presented a provocative paper on why it would be difficult, if not impossible, to predict Australian summer monsoon rainfall. Other authors were more op-

timistic, such as Carsten Frederiksen, who showed the relative importance of slow and intraseasonal processes in Australian rainfall variability and predictability.

The GEWEX *John Roads Memorial Symposium* was held on Tuesday in honor of John Roads, who had been committed to closing water and energy budgets. Masao Kanamitsu began the Symposium with an overview of John's contributions to GEWEX, and many presenters paid similar tribute by speaking of the influence John had had on their own work. In the first session of the Symposium, *Analyses of Water and Energy Cycles*, Richard Lawford emphasized the societal importance of many aspects of GEWEX research. For example, **through GEWEX studies, hydrologic models have been developed that require less calibration than lumped models. They utilize the extensive distributed information available through remote sensing. These models have been easier to interface with atmospheric models and have become central to land data assimilation activities.** Other speakers underscored the importance of regional data, such as the Coordinated Energy and Water Cycle Observations Project's (CEOP) evaluation of various energy and water cycle products. Michael Bosilovich stressed this point with respect to evaluation of reanalysis data.



Masao Kanamitsu

The session on *Climate Prediction Systems* featured papers on the various aspects of skill of the current climate models. **Most authors indicated that the skill in forecasts of precipitation leaves much to be desired, whereas skill in temperature forecasts is, as to be expected, performing better.** The intermediate results from the second Global Land Atmospheric Coupling Experiment (GLACE-2) experiment presented by Bart van den Hurk also showed this and indicated that the initialization impacts on skill increase dramatically when conditioned on the size of the initial local soil moisture anomaly.

In the *Regional Downscaling* session, Jack Katzfey's overview on regional climate modelling emphasized the considerable progress made over the past 20 years and that a high and growing demand exists for detailed regional climate change information. However, questions persist on explaining the differences between regional and global climate models. Regional climate models at the moment may best be a tool to explore the issues of effects of increased resolution for global models.

In the last session of the Symposium, *Regional Hydroclimate Projects (RHPs) and Studies*, Hans von Storch (presented by Hans-Joerg Isemer) demonstrated how the Baltic Sea Experiment (BALTEX) has progressed from a regional project, initially focused on energy and water cycle observations, to a broader ecosystems approach. This successful transition is laid out by the report "BALTEX Assessment of Climate Change for the Baltic Region" and was condensed into a paper for the Helsinki Commission, a Baltic Sea Region environmental policy maker. This session could only highlight a few of the many diverse activities ongoing in the RHPs within CEOP, such as the progress in water isotope modelling and the assessment on how reliable climate variability estimates are in predicting extreme precipitation.

On Wednesday three joint GEWEX-iLEAPS sessions were held. In the first, *Land in the Climate System*, Paul Dirmeyer concluded that although climate is sensitive to the land surface state and its variations, it may not be useful for climate prediction. Thus, the assessment of the quality of climate models is very important. Eleanor Blythe presented a method for accomplishing this. Dennis Baldocchi showed the progress that FLUXNET has made over the years, especially regarding the availability and quality of data. The importance of global-covering flux observations and *in situ* data are essential when examining Earth system vulnerabilities through carbon-climate interactions, as Michael Raupach presented.

In the joint session on *Aerosol, Cloud, Precipitation and Climate Interactions*, **Terruyuki Nakagima showed that the surface cooling loop for precipitation change by aerosols provides a link between cloudiness and precipitation.** Anders Engstrom demonstrated that the effect of aerosols on convective precipitation at a much larger scale was not evident.

In the last session, *The Future Generation of Integrated Observation and Modelling Systems*, Adrian Simmons gave an overview of the current and future integrated observation and modelling systems for meteorology and atmospheric composition by a major numerical weather prediction center. **Kevin Trenberth advocated for a climate information system as part of an integrated Earth information system.** Eric Wood showed that an assimilated global water budget with closed budgets is now feasible and that it is also possible to compute a continental-to-global scale budget with discharge as a residual, solely from remotely sensed observations.


Left to right: G. Asrar, S. Sorooshian, A. Busalacchi and R. Lawford

GEWEX Parallel sessions resumed on Thursday with *Observing Surface Fluxes: From Local to Global Scales*. **Bill Rossow concluded that within the next 2 years we will have completed the global energy and water cycle budget from space-borne observations (i.e., produced an integrated and consistent**

global energy and water cycle observations data set). John Finnigan, who chaired this session, concluded that some big questions still persist, such as how to close the global energy budget when all the terms are estimated and cannot account for the fact that atmospheric transport of both latent and sensible heat is always low.

In the session *Multiscale Properties of the Tropical Energy and Water Cycles: From Thunderstorms to Monsoons,* George Huffman, using Tropical Rainfall Measuring Mission (TRMM) multi-satellite precipitation analysis, demonstrated how a weather regime classification may be useful in classifying typical extremes behavior. In the session *Advances in the Representation of the Energy and Water Cycle in Models*, **Sigfried Schubert demonstrated that in a multi-model assessment of the impact of sea-surface temperature anomalies and land-atmosphere feedbacks on drought, there is general agreement among models on global response, but that substantial differences exist at regional scales.** It was surprising, given its importance to climate processes, to see the relatively limited amount of accomplishments presented in cloud climate feedbacks during the session devoted to that topic.

The session on *The Role of Integrated Observing Systems in Closing Regional and Global Energy and Water Budgets* featured comprehensive space agency overview presentations by Jack Kaye for NASA and Taikan Oki for the Japan Aerospace Exploration Agency. Both agencies show strong continued support for research activities and dedicated climate research missions along with a commitment to activities and services based on their proven value to observations of the global energy and water cycles. Bob Su presented the European Space Agency's Water Cycle Multi-mission Observation Strategy (WACMOS) for establishing a solid scientific basis for the creation of coherent long-term data sets of water-relevant geo-information.

Olga Zolina

Presentations given at the last GEWEX session, *Climate Change and Global Precipitation*, focused on the issue of bias errors in precipitation estimation products that need to be reduced in coming years, particularly in mid-latitude ocean and high-latitude ocean and land areas. For example, Cloudsat (and follow-ons) could be used to address missed light rain and the planned Global Precipitation Mission for the mid-latitude ocean and high-latitude ocean and land areas.

To view the conference presentations, please see: *http://gewex.org/2009gewex_ileaps_conf.html*.

Meeting/Workshop Reports

GEWEX Atmospheric Boundary Layer Study (GABLS) Workshop

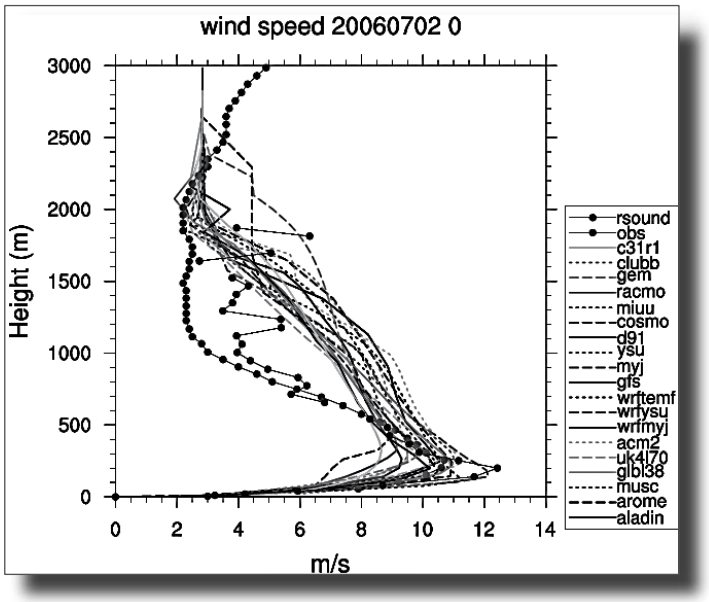
26–27 June 2009
Boulder, Colorado, USA

Bert Holtslag[1] **and Gunilla Svensson**[2]
[1]Department of Meteorology and Air Quality, Wageningen University, The Netherlands; [2]Department of Meteorology, Stockholm University, Sweden

About 40 scientists met to review GABLS-3 results at a workshop held at the National Center for Atmospheric Research (see program at *http://www.met.wau.nl/projects/Gabls/index.html*). The workshop was organized in connection with the annual Weather Research and Forecasting (WRF) Conference to attract these participants to the GABLS Workshop.

The aim of the GEWEX Atmospheric Boundary Study (GABLS) is to enhance the understanding and to improve the representation of the atmospheric boundary layer in weather forecast and climate models on a variety of scales, which should benefit atmospheric chemistry and Earth system studies as well as other applications, such as wind energy resource estimation (Holtslag, 2006). The first study (GABLS-1) covered a simplified case for a stable boundary layer with moderate geostrophic forcing and prescribed surface temperature over ice, in which single column models (SCMs) were compared with an ensemble of Large Eddy simulation (LES) models' results. The second intercomparison case (GABLS-2) dealt with the representation of the diurnal cycle over land in comparison with observations from the Cooperative Atmosphere-Surface Exchange Study 1999 (CASES-99) (Svensson and Holtslag, 2007; 2009). The third case (GABLS-3) extends the previous work for SCM and LES models and uses the extensive data gathered around the 213-m Cabauw tower in the Netherlands.

The first session of the workshop focused on presenting the results of the participating SCM and LES models for the Cabauw site. Fred Bosveld [Koninklijk Nederlands Meteorologisch Instituut (KNMI)] presented the set-up for the SCM study and Sukanta Basu (Texas Tech) presented the LES set up and results. The Cabauw site is situated in a flat environment dominated by grassland. On many nights a low level jet (LLJ) develops as an inertial oscillation initiated by the evening decoupling. Thus, the scientific question of GABLS-3 is how well the SCMs represent the transitions between daytime and nightime conditions, including the development of LLJs. For a fair comparison with the Cabauw observations, a relatively ideal, baroclinic night (1 July 2006) was selected from the multi-year data archive of Cabauw. Detailed dynamic forcings and surface conditions were prescribed on the basis of local observations and the outcome of 3-D-atmospheric mesoscale models.



GABLS-3 nightime wind speed profiles calculated with various SCMs in comparison with the 213-meter tower and wind profiler observations at Cabauw and the radio sounding in De Bilt, The Netherlands (Courtesy of Fred Bosveld, KNMI).

In total, 12 institutes with 18 models cooperated in the GABLS-3 SCM evaluation and intercomparison study and were able to run their SCMs with interactive land surface through their own soil-vegetation scheme. Evaluation shows that most models follow the basic observations (temperature, temperature and moisture) much better than in the previous GABLS-2 intercomparison study with prescribed surface temperature. The figure above gives the nighttime wind speed profiles as calculated with various SCMs in comparison with the 213-m tower and wind profiler observations at Cabauw and the nearby radio sounding in De Bilt. It shows that the models do have difficulty in representing the magnitude and shape of the sharp LLJ. A more detailed analysis is currently performed on model performance for the evolution of the LLJ during the night, the influence of the onset of decoupling at sunset, the onset of convection at sunrise, and other aspects.

In addition, the intercomparison of LES models is based on the same night with a particular focus on the nighttime stable conditions and early morning transition period, building on the achievements of the GABLS-1 intercomparison study. More than ten groups from around the world participated in the intercomparison study. In the presentation, the setup of the GABLS-3 LES intercomparison case was given with a selection of the many results. Emphasis was given to the evolution of the LLJ and the morning transition as well as the impact of subgrid closures.

An overview was given on the current status of modelling the atmospheric boundary layer at regional and larger scales by Wayne Angevine (National Oceanic and Atmospheric Administration; NOAA), Gunilla Svensson (Stockholm University), and John Edwards (UK MetOffice). From the presentations it is clear that the performance of boundary layer schemes within weather forecast and climate models still needs improvement, but progress is being made. We now better understand why operational models show boundary layers that are too deep in stable conditions and why this results in the erosion of LLJs and underestimation of the turning of wind with height. John Edwards showed the significant improvement in the UK MetOffice model performance after including non-local momentum mixing for unstable conditions, and using shallow mixing formulations for stable cases (in agreement with the GABLS-1 results).

The impact of subgrid closures in LES studies of slope flow was presented by Bryan Burkholder and surprisingly, the traditional Smagorinsky closure is performing very well overall. Subsequently, a new perspective of the problem of so-called run-away surface cooling and collapse of stable boundary layers was presented by Sukanta Basu.

The workshop also focused on alternate ways of evaluating boundary-layer models with observations. Rather than using a single "golden" case, it was argued that it may be beneficial to compare models with a "composite" case as constructed from observations using several similar cases in the Cabauw database (work by Peter Baas and colleagues, as presented by Fred Bosveld). In addition, SCMs can also be evaluated on a routine basis in an operational setting by doing short range forecasts with some nudging to the observations (Cabauw testbed work by Roel Neggers and colleagues at KNMI as presented by Bert Holtslag).

An overview of the Local-Coupled (LOCO) model study was presented with a new way of quantifying the atmosphere-land coupling (Joe Santanello). In addition, results from the Arctic Model Intercomparison Project (ARC-MIP) were presented to show how models can be evaluated on a larger time and spatial scale and how the process performance of boundary-layer schemes can be evaluated (Michael Tjernström).

Participants at the GABLS-3 Workshop.

It is clear that with GABLS-2 and -3 we have moved towards more realistic and more difficult cases of atmospheric boundary layers. However, we are still struggling with optimal case design in terms of boundary conditions and other forcing. Participants suggested further issues to be investigated for GABLS-3, including a consistency test on the variety of results, the impact of the initial conditions, and exploration of the impact of the low level jet of the previous night on the momentum mixing in the morning. It was also suggested that the SCMs be run in exactly the same set-up as the current LES study to facilitate a more direct comparison. Before this can be released as a new intercomparison experiment further analysis and testing are needed.

It was also suggested that an intercomparison of mesoscale and regional models for GABLS-3 be organized [some runs are available now for the Regional Atmospheric Climate Model (RACMO), the WRF Model, the High Resolution Limited Area Model (HIRLAM), and Regional Atmospheric Modelling System (RAMS)]. A more detailed case study using the Cabauw data set focusing on the evening transition was also considered to be useful, in particular if it includes mixing of passive tracers. Another idea is to define a GABLS activity as a tag-on project to the regional modelling that will be performed as preparation for the Intergovernmental Panel on Climate Change Assessment Report No. 5. Current plans involve running regional models for several different climate zones both for historical and future climates to identify a number of locations where we have longstanding boundary layer observations (such as Cabauw). Participating modelling centers would be requested to save adequate model output for this location, allowing for a thorough investigation of the planetary boundary layer model performance.

The next GABLS workshop is planned to be held in connection with the American Meteorological Society Meeting on Boundary Layers and Turbulence in the summer of 2010.

Acknowledgements: we thank the participants for their presentations and contributions, as well as the Mesoscale and Microscale Meteorology Division (MMM) of the National Center for Atmospheric Research (NCAR) Earth and Sun Systems Laboratory and the World Climate Research Programme for providing facilities and funds for the organization of the workshop. We also acknowledge Wayne Angevine (NOAA) and Sudie Kelly (NCAR-MMM) for their help in the local organization of the workshop.

References

Holtslag, A. A. M., 2006. GEWEX Atmospheric Boundary Layer Study (GABLS) on stable boundary layers. *Bound.-Layer. Meteor.*, 118, 243–246.

Svensson, G., and A. A. M. Holtslag, 2007. The diurnal cycle–GABLS Second intercomparison project. *GEWEX News*, Vol. 17, No. 1, February 2007, 1, 9–10.

Svensson, G., A. A. M. Holtslag, et al., 2009. Evaluation of the diurnal cycle in the atmospheric boundary layer over land as represented by a variety of single column models with same forcing (in preparation).

Third International AMMA Conference

20–24 July 2009
Ouagadougou, Burkina Faso

Jean-Luc Redelsperger[1] and Chris Thorncroft[2]
[1]Météo-France, Toulouse, France; [2]University at Albany, SUNY, New York, USA

Almost 500 scientists participated in the third international conference on the African Monsoon Multidisciplinary Analysis Project (AMMA). Results presented from the AMMA field campaigns showed significant advances in the knowledge of monsoon mechanisms and will pave the way for improvement of forecasts and their applications, in particular for early warning systems. Scientific achievements of AMMA were presented within three themes: (1) understanding the monsoon system and its variability; (2) predictability and prediction of weather and climate; and (3) society-environment-climate interactions.

Understanding the Monsoon System and Its Variability

Several key features of the monsoon are now better understood than before, including the cold tongue, the Saharan heat low, and the St. Helena anticyclone, all of which play a role in determining the evolution of the monsoon and its onset. Major advances have been achieved regarding the characterization and understanding of monsoon variability at intraseasonal timescales, which is critical for agriculture in the Sahel. The impact of the Madden-Julian Oscillation on wet and dry spells has been clarified and other modes of variability have been identified for the first time, including one that varies biweekly. Evidence has also been found for significant land-atmosphere coupling on spatial scales of 10 km upwards, and timescales from hours to days. Mesoscale patterns of soil moisture have been shown to be important with initiation of convection favored over drier soils.

The skill of today's land surface models in simulating upper soil layer wetness at regional scales, given the correct forcings, has been evaluated through the AMMA Land Model Intercomparison Project (ALMIP; see page 9). Consistency between ALMIP models and data from the National Aeronautics and Space Administration Gravity Recovery and Climate Experiment (GRACE) for continental water has been obtained over the Sahel region, in contrast with some discrepancies over the Guinean and Saharan regions.

The water cycle has been studied from local to regional scales. At the regional scale, a hybrid method that combines satellite, model output, and reanalysis products has been developed to better estimate the atmospheric water budget. It allows us to determine more precisely the origin of the West African Monsoon (WAM) water vapor and its different sources and sinks.

The sensitivity analysis of the hydrologic response to atmospheric models has been explored at the mesoscale level with rain fields predicted by ten atmospheric simulations over the Benin AMMA mesosite for one case study. The rainfall fields

shared a few similarities at the synoptic scale but none of the simulated rain fields really compared well with observations at the mesoscale. The hydrologic response to these model products was realistic as long as the overall statistical properties of the observed field were reproduced regardless of the location of rainfall cells. This effort to determine land-atmosphere coupling at the mesoscale is taking place parallel to studies that compare the different evapotranspiration estimates with the AMMA surface flux station network and ALMIP results.

Among many results obtained from the Aerosols-Chemistry-Land-Atmosphere couplings, it was shown that dust emission is a function of the amount of vegetation residue, which depends on the previous year's precipitation and also on the frequency and characteristics of convective systems (e.g., surface winds in front of these systems) at the beginning of the rainy season.

Predictability and Prediction of Weather and Climate

A major challenge for AMMA is to channel the increased knowledge gained in its first phase toward improving weather and climate predictions. AMMA coordinates many activities on weather to climate scales. Most of them are included in international programs, such as THe Observing System Research and Predictability Experiment (THORPEX) for weather. AMMA is a a key component of the Africa-THORPEX Program and the Climate Variability and Predictability Project (CLIVAR) for climate. AMMA was approved in January 2005 by the GEWEX Scientific Steering Group as a GEWEX Regional Hydroclimate Project.

Reanalysis and data impact studies have been performed in collaboration with the Numerical Weather Prediction Centers. Assimilation of both AMMA unbiased radiosoundings and satellite microwave radiances over land, such as the Advanced Microwave Sounding Unit-B have been shown to improve short range forecasts over West Africa and the Atlantic and Europe.

Examination of the predictability of the monsoon at intraseasonal timescales has just started. However, we do know that dynamical models have difficulty representing the key coupled ocean-atmosphere-land interactions needed to skillfully predict the occurrence of wet and dry spells or monsoon onset. AMMA is also promoting efforts to develop statistical prediction of intraseasonal variations and to determine how this impacts monsoon onset.

Analysis of Intergovernmental Panel on Climate Change (IPCC) model runs over the AMMA region have shown that the response of WAM precipitation to anthropogenic climate change is unclear, with prediction of a precipitation increase by some model systems and a decrease by others. Characterization of West African rainfall errors in climate models and their relationship with dynamical fields has highlighted strong deficiencies in the representation of teleconnections.

Seasonal, decadal, and climate simulations have all exhibited similar systematic errors. One of the most important of these is the warm bias in the Tropical Atlantic Ocean, but others exist (e.g., heat low strength, rainfall amounts, and location). These biases must be prioritized in future coordinated research efforts.

Working with CLIVAR, AMMA has made recommendations to improve the observing system over the Atlantic and continues to provide long-term observations and land-surface products over the land.

Society-Environment-Climate Interactions

About one-third of the Conference presentations were concerned with this theme. The impacts of environmental change over Africa, particularly in its Sahel-Saharan region, are already being felt, as reflected in climate extremes, the associated impacts on land surface conditions, and the loss of biodiversity. AMMA has built a multidisciplinary community that works on the societal impacts of climate variability.

The AMMA models for land productivity exhibit better performance and more flexibility than operational ones used in the early warning systems for food security. At the same time, our understanding of the main drivers of land productivity has improved significantly (e.g., role of the distribution of rainfall events within the season; monsoon onset date; effects of dry spells on vegetation growth and yields).

Historical climate and hydrological data analysis on catchments of various scales has shown a deep modification of runoff regimes: over the Sahel, runoff coefficients increased at small scales whereas over the Sudan, a sharp decrease of the streamflow was observed from the small scale to the mesoscale. The impact of land use on hydrological processes has been revealed for the Sahel region. Thanks to AMMA, the West African community of hydrological scientists has been significantly strengthened through better organization, links with the weather and climate communities, and doctoral training for young African scientists. In addition, natural resource management has been studied from national to local scales in Mali (e.g., the public politics, the environmental vulnerability, the impact on the population mobility and migration).

A combination of ground and satellite observations and modelling has allowed major advances on four health issues related to climate: malaria (malaria dynamical model forced by seasonal forecast, observations and bio-statistical modelling of malaria in four representative sites in Mali), rift valley fever (correct cartography of water bodies representing breeding sites, first environmental risk maps combining remote sensing and *in situ* data), meningitis (better understanding of aerosol-climate relationships using geophysical and epidemiological datasets on local and regional scales), and pollution in four African cities (e.g., creation of a unique database, integrated environmental and health modelling).

The Conference presentations and book of abstracts are available at: *http://www.amma-international.org/*. The October issue of the AMMA newsletter is dedicated to the synthesis of the conference results.

Third Annual Meeting of the Coordinated Energy and Water Cycle Observations Project (CEOP)

19–21 August 2009
Melbourne, Australia

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

The annual CEOP meeting was hosted by the Bureau of Meteorology (BoM) of Australia and focused on organizational and implementation activities. Introductory comments by Dr. Sue Barrow, Deputy Director of BoM, Melbourne Head Office and Dr. Helen Cleugh, Theme Leader of Climate and Atmosphere at Australia's Commonwealth Scientific and Industrial Research Organization (CSIRO), acknowledged the importance of the integrated approach being undertaken by CEOP. By combining the CEOP Regional Hydroclimate Projects (RHPs) with the use of data and model prediction schemes, CEOP can study global scale phenomena and apply new tools and improved knowledge to regional scientific climate issues in areas especially sensitive to climate change, while extending this knowledge to the global scale such as in semi-arid, cold and high latitude regions. CEOP extremes studies were also mentioned as areas in need of further study, especially work that encompasses drought, heavy precipitation, floods, low flows, and related features.

The Director of the World Climate Research Programme (WCRP) was unable to attend the meeting but sent his comments, which noted that one of the WCRP mission objectives described in the *WCRP Strategic Framework 2005–2015*, is to "support climate-related decision making and planning adaptation to climate change by developing the science required to improve climate predictions, the understanding of human influence on climate, and the use of this scientific knowledge in an increasing range of practical applications of direct relevance, benefit and value to society." CEOP has developed a research framework and integrated data sets necessary to address these issues.

The general agreement of those at the meeting was that the strength of the CEOP approach was that its focus on regional basins and climatically sensitive regions of the world encourages researchers to study these areas, understand their regional hydrological and radiation budgets, and ensure that these are well represented in global climate system models.

Below is a brief summary of the main items discussed at the meeting:

- *A Multimodel Analysis for CEOP* was published by M. Bosilovich et al., in the August 2009 issue (Vol. 10) of the *Journal of Hydrology*.
- A summary of activities clarifying the CEOP strategy for bridging the RHPs needs and applications and the CEOP global observation and prediction activities, is planned for publication in 2010.
- A global high elevation observing period and a joint CEOP/China semi-arid region study are planned.
- CEOP studies on extreme weather events will focus on drought, heavy precipitation, floods and low stream flows.
- The CEOP Cold Regions Study and several RHPs are now coordinating activities with the WCRP Climate and Cryosphere (CliC) Project.
- Water and Energy Budget Studies (WEBS) have been expanded to understand average conditions during the entire CEOP period, including the influence of aerosols and a study of water isotopes.
- CEOP modelling studies now include explicit global, regional, land-surface, and Hydrologic Applications Project efforts, as well as researching international models related to the CEOP reference sites.
- In order to better utilize available CEOP data sets for bridging the gap between the global and regional aspects of CEOP research, opportunities are being explored to integrate these efforts with other planned or ongoing initiatives in the broader climate research community, such as the WCRP initiated COordinated Regional climate Downscaling EXperiment (CORDEX) effort.
- A CEOP satellite data set has been populated with data from instruments flown on Japan Aerospace Exploration Agency, European Space Agency and National Aeronautics and Space Administration spacecraft. Tools for handling historical data were provided by the National Oceanic and Atmospheric Administration.

The latest version of the CEOP Strategic Implementation Plan is available at: *http://www.ceop.net*.

Participants of the Third Annual CEOP Meeting.

Annual Meeting of the Global Land/Atmosphere System Study (GLASS)

22 August 2009
Melbourne, Australia

Bart van den Hurk
Koninklijk Nederlands Meteorologisch Instituut (KNMI), De Bilt, The Netherlands

The GLASS meeting focused on the progress of three new working groups: (1) Benchmarking Land-Surface Models and Data Working Group; (2) Land Surface Data Assimilation Working Group; and (3) the Land-Atmosphere Coupling Working Group.

The **Benchmarking Land-Surface Models and Data Working Group** reported on the July benchmarking workshop held in Exeter, United Kingdom. Representatives attending the workshop included the Carbon Land Model Intercomparison Project (C-LAMP; two U.S. carbon models led by Forrest Hoffman) and the International Land-Atmosphere Model Benchmarking Project [I-LAMB; European land surface models (LSMs) under the auspices of the European Union's Integrated Project Water and Global Change (WATCH) Project].

Two benchmarking systems are being developed for carbon fluxes that include a suite of LSMs that are confronted with Fluxnet observations and are evaluated against statistical performance criteria. During the Exeter workshop, specific criteria were targeted to serve different stakeholder communities (e.g., numerical weather prediction centers, climate modellers, impact modellers, hydrologists), although the overlapping interests and techniques of these communities make a strict separation difficult. We envisage a benchmarking system that would ultimately consist of performance metrics, where a score (red, orange, green) is assigned at a level that has been weighted according to agreed-upon factors. The benchmarking levels may vary from basic performance indicators (sensible seasonal cycle, balance closure) via levels of agreement with observations within observational accuracy to demonstrated added value compared to empirical models driven solely by observed forcings. An online benchmarking web server is being developed where modellers can upload output from LSMs, beginning with local Fluxnet data and fast processes (net ecosystem exchange, sensible heat flux, latent heat flux) that would be evaluated using standard statistical measures. This would ensure that the evaluation data are not used by the models for calibration.

Other promising activities in this area include possible contributions to the GEWEX Radiation Panel's LandFlux Project (see page 19). A set of offline land surface simulations driven by observed meteorological forcings would complement the existing and planned observational data sets within LandFlux. Developments by the University of Tokyo, the European Union WATCH Program, and the Land Information System (LIS) will be monitored and if possible combined to contribute a range of LSM simulations extending beyond the Global Soil Wetness Project-2 (GSWP-2) timeframe.

The **Land Surface Data Assimilation Working Group** presented a system intercomparison study that uses four different LSMs to generate synthetic time series of surface soil moisture. These time series were subsequently assimilated into the four land surface models and performance metrics for the potential to reconstruct a (synthetic) truth were compared. The models appear more accurate when they assimilate the synthetic time series generated by the model itself, pointing to an overestimation of the skill of the data assimilation system using so-called "twin experiments." It was also shown that a stronger coupling between the surface and the root zone soil moisture yielded better results.

Multiple data assimilation centers (in Europe and Japan, notably) are organizing idealized land data assimilation experiments. Analyses of effects on variables other than soil moisture (e.g., surface fluxes) and other observations [e.g., Gravity Recovery and Climate Experiment (GRACE) irrigation data] will be considered in the near future.

The **Land-Atmosphere Coupling Working Group** reported progress in two areas: (1) assembling a range of suitable diagnostics for coupling, from the local to the continental scale; and (2) planning the 2nd Global Land-Atmosphere Coupling Experiment-2 (GLACE-2). The WATCH Program held a workshop in July about conducting an inventory of coupling diagnostics, ranging from diurnal cycles of T/q via correlation of fluxes, and convective triggering metrics to Planetary Boundary Layer (PBL) feedback indicators. We plan to apply all the diagnostics to a set of Regional Climate Model simulations over the African Monsoon Multidisciplinary Analysis Project (AMMA) region (see page 9). Some of these simulations were carried out in the European ENSEMBLES Project and others will be done in the context of the WATCH Program.

Six model ensembles have been submitted and analyzed for GLACE-2. The experiment aims at verifying better initial soil moisture conditions to provide better precipitation/temperature skill in GCMs on a seasonal time scale. As expected, skill improvement in the United States is better for temperature than for precipitation, but rapidly declines after a couple of weeks. However, conditioning the ensemble results on extreme soil moisture conditions (very wet or very dry) considerably increases the skill, which agrees with the fact that soil moisture is not always informative but can be in an extreme part of the range. This may be of particular interest for a newly planned GLACE-type experiment aiming at checking coupling hotspots under future climate conditions.

GLASS has focused on coordinating different groups, rather than launching new model evaluation or comparison projects. This approach has proved successful in producing useful scientific results. An ECMWF/GLASS Workshop on Land Surface Modelling and Data Assimilation and the Implications for Predictability on land data processes will be held in Reading, UK on 8–11 November 2009.

LandFlux Workshop

23 August 2009
Melbourne, Australia

Matthew McCabe[1], Sonia I. Seneviratne[2], Carlos Jimenez[3], and William Rossow[4]
[1]School of Civil and Environmental Engineering, University of New South Wales, Sydney, Australia; [2]Institute for Atmospheric and Climate Science, ETH, Zürich, Switzerland; [3]LERMA, Observatoire de Paris, Paris, France; [4]NOAA/CREST, City College of New York, NY, USA

The GEWEX Radiation Panel (GRP) LandFlux Initiative is developing an approach for the routine production of a multi-decadal global land based surface flux data set. As a part of this effort, a 1-day workshop was held to bring together researchers with expertise and interest in the estimation of land surface turbulent fluxes of heat and water to: (1) review and discuss the current state of the art in global flux estimation techniques; (2) identify available global surface heat flux products, spanning observationally based (*in situ* and satellite), model based, and mixed observation-model approaches; (3) develop a program for systematic intercomparison of these different approaches; and (4) identify options for an operational approach and the necessary protocols in producing such data sets. The focus of the workshop was on three broad topics that encompass a range of flux estimation and evaluation efforts currently being developed within the research and operations community: (1) remote sensing-based data sets and approaches; (2) model-based estimation techniques; and (3) validation data sets and intercomparison efforts.

In the session on remote sensing-based approaches a variety of satellite-based estimation techniques were presented, including empirical and statistical approaches, as well as more physically based energy balance techniques. A number of the speakers presented results from global flux data sets that were recently produced for selected periods across a range of spatial and temporal resolutions, illustrating that the development of a multi-decadal product is progressing.

Model-based estimation techniques reviewed included ongoing efforts by groups within the National Aeronautics and Space Administration (NASA) and meteorological operational centers to produce and assess information on global water and energy cycles. Multi-model analyses and ensemble approaches, global land data assimilation schemes and systems, and new reanalysis products were reviewed. The synergy between remote sensing and other model-based approaches was highlighted, particularly with regard to the capacity of both approaches to inform and improve each other.

In the session on validation data and product intercomparisons, presentations underscored some of the recent developments with Fluxnet data and a new data set derived from the upscaling of Fluxnet measurements. Initial results were presented of a intercomparison exercise of global data sets submitted by a number of participants prior to the workshop and plans outlined for the new LandFlux-EVAL activity.

Discussions during each of the sessions were active, with participants offering perspectives from research areas spanning *in situ* measurement, land surface model output, and remote sensing estimation approaches. There was clear recognition that a global land surface product would fill a critical gap in advancing our knowledge of the global water and energy cycle behavior. In identifying a path forward to achieving this, it was apparent from the initial intercomparison exercise that a comprehensive evaluation and intercomparison of presently available products is a priority. This will be undertaken as part of the LandFlux-EVAL activity.

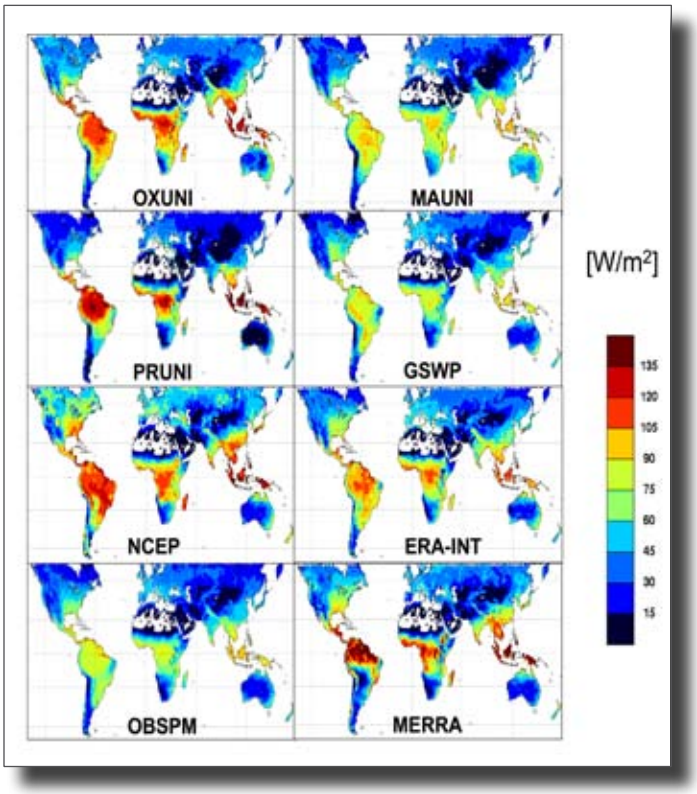
The preliminary intercomparison of the submitted global products, based on analyses of the Observatoire de Paris (1993–1994) and ETH Zurich (1989–1995/2006), proved to be an extremely interesting and valuable exercise, particularly in identifying consistencies and disparities between remote sensing and other model-based estimation approaches. While there is generally good agreement between spatial patterns among the various approaches, there is also a large range in values across many regions of the world (see figure on page 20). Identifying the causes and mechanisms producing these differences, model dependencies, and sensitivities and the complicated issue of how to actually evaluate global products remains a major challenge. The LandFlux-EVAL intercomparison effort will shed more light on addressing these important issues.

A key outcome of this workshop was the recognition that a number of groups are already independently pursuing global scale estimation of flux components. These products vary in terms of the forcing data used, the governing equations employed, and the spatial and temporal scales of their application. The GEWEX LandFlux activity will provide a framework for undertaking coordinated evaluation and assessment of these various products, ultimately identifying and delivering a robust procedure for operational production of a global land surface flux data set to improve climate scale water and energy cycle characterisation. A plan for product development and the identification of specific activities and tasks required to achieve this was discussed in the final session of the workshop. Key action items included:

- Initiate working groups to focus on: (1) remote sensing-based approaches; (2) land-surface model estimates; and (3) forcing and evaluation data sets (including radiation, meteorology, vegetation, and landscape characteristics). The working groups will assist in identifying approaches for product development, examining uncertainty in forcing data, and establishing protocols for multi-model output.
- Expand the workshop-based intercomparison exercise into a focused activity (LandFlux-EVAL) that will include multi-scale (spatial and temporal) data sets, assessment over longer time-periods, and identification of specific regions for focused analysis. ETH Zurich and the Observatoire de Paris are the contact institutions for this activity (see *http://www.iac.ethz.ch/url/LandFlux-EVAL*).

LandFlux Workshop

(Continued from page 19)



Yearly averaged latent heat fluxes for 1993 from a suite of different products: (a) four remote sensing products from Oxford University (OXUNI, provided by Joshua Fisher), the University of Maryland (MAUNI, provided by Kaikun Wang), Paris Observatory (OBSPM, by Carlos Jimenez), and Princeton University (PRUNI, by Justin Sheffield and Eric Wood); (b) land surface model estimate from the GEWEX Global Soil Wetness Project-2 multi-model ensemble; (c) three reanalysis estimates (MERRA, NCEP-DOE, and ERA-INTERIM). These data represent a subset of products considered as a part of LandFlux-EVAL.

- Identify regional scale test-beds over which detailed assessment can be undertaken. The collection and compilation of data to evaluate and assess model output is a major task. The GEWEX Coordinated Water and Energy Observations Project (CEOP) Regional Hydroclimate Projects (RHPs) provide an obvious focus for evaluation efforts. Acquiring the needed forcing and validation data over these RHPs will be critical in advancing the LandFlux product. Contact with CEOP and RHP coordinators will be made to access these data sets.

The amount of activity in this area should soon provide well-evaluated global products of land surface turbulent fluxes of heat and water. It is anticipated that these activities will culminate in the development of a GEWEX LandFlux data set, completing the suite of GRP water and energy cycle products and providing a new source of information with which to better understand climate scale interactions within the Earth system.

GEWEX/WCRP Calendar

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

30 November–1 December 2009—Asian Monsoon Year (AMY) Workshop—Kunming, China.

2–4 December 2009—Conference on the Human Dimensions of Global Environmental Change—Earth System Governance: People, Places and the Planet—Amsterdam, the Netherlands.

9 December 2009—14th GEOSS Workshop XXXII—Water Cycle—San Francisco, California, USA.

14–18 December 2009—NEESPI Science Session, Fall AGU Meeting—San Francisco, California, USA.

17–21 January 2010—90th Annual American Meteorological Society Meeting—Atlanta, Georgia, USA.

25–29 January 2010—GEWEX Scientific Steering Group Meeting—New Delhi, India.

2–3 February 2010—SMAP Science Definition Team Meeting—Pasadena, California, USA.

4–9 February 2010—6th Session of the Climate and Cryosphere (CliC) Scientific Steering Group—Valdivia, Chile.

15–19 February 2010—AGU Chapman Conference on Complexity and Extreme Events in Geosciences—Hyderabad, India.

16–18 February 2010—31st Session of the Joint Scientific Committee for WCRP (with joint session with the Commission for Climatology)—Antalya, Turkey.

16–18 February 2010—Technical Conference on Changing Climate and Demand for Climate Services for Sustainable Development—Antalya, Turkey.

24–26 March 2010—International Drought Symposium—Riverside, California, USA.

13–16 April 2010—Eleventh Science and Review Workshop for the Baseline Surface Radiation Network (BSRN)—Queenstown, New Zealand.

19–23 April 2010—5th International CLIVAR Climate of the 20th Century Workshop (C20C)—Beijing, China.

2–7 May 2010—EGU General Assembly— Vienna, Austria.

19–21 May 2010—CLIVAR Scientific Steering Group Meeting—Boulder, Colorado, USA.

31 May – 2 June 2010—International Symposium on Boundary Current dynamics: Its connection with open-ocean and coastal processes and responses to global climate change— Qingdao China.

31 May – 4 June 2010—International Symposium on Sea Ice—Tromsø, Norway.