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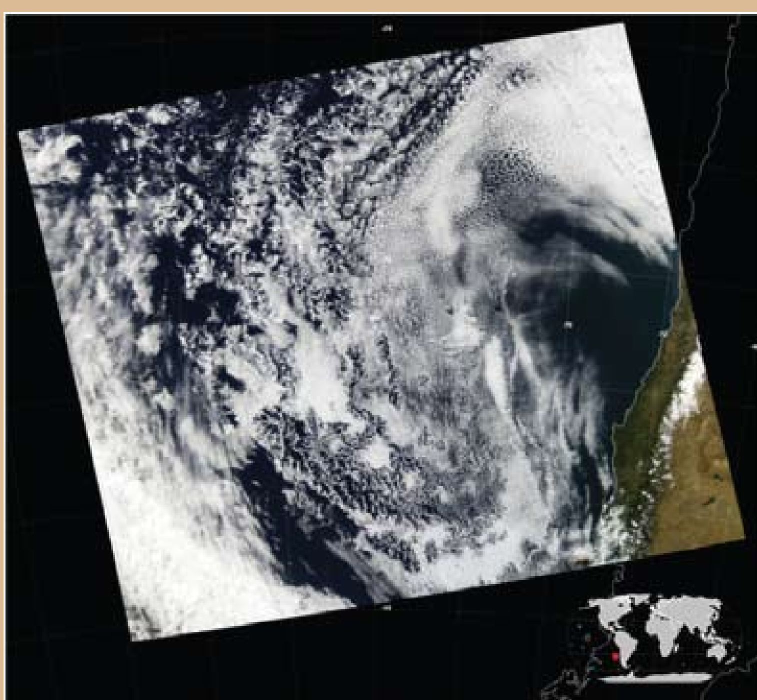
Is There a Missing Low Cloud Feedback in Current Climate Models?

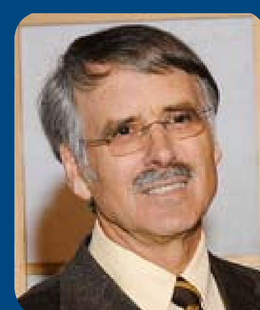
An analysis **by Prof. Graeme Stephens in the article on page 5** suggests that solar radiation reflected by low clouds is significantly enhanced in models compared to real cloud observations. This finding has major implications for the cloud-climate feedback problem in models.



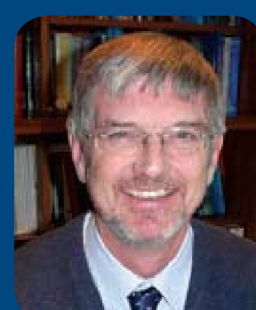
A MODIS false color image of low clouds that formed as part of a larger weather system just west of Chile on 3 June 2007. The properties of the low clouds inferred from MODIS were matched to CloudSat and CALIPSO observations, and other sensor data from the A-Train to provide new insights on the properties of these clouds.

GEWEX Welcomes New Chair and Vice-Chair of the Scientific Steering Group

(See Page 3)



Kevin E. Trenberth
GEWEX SSG Chair



Howard S. Wheater
GEWEX SSG Vice-Chair

Commentary

A Brighter Future Ahead

Peter J. van Oevelen
Director, International GEWEX Project Office

This year kicked off with some exciting prospects for the rest of the year. Unfortunately, Tom Ackerman has resigned as Chair of the GEWEX Scientific Steering Group (SSG) due to obligations at his home institution. I thank Tom for his over 10 years of support and contributions to GEWEX in various roles and capacities, and hope that he will continue to be involved in GEWEX activities so that we may draw upon his valuable experience and insight.

At the 22nd GEWEX SSG Meeting, which was held in New Delhi, India (see summary on pages 8–9), the SSG members unanimously endorsed Kevin Trenberth for SSG Chair and the nomination was approved by the WCRP Joint Scientific Committee in February. Much of Kevin's research has been related to the global energy and water cycle and his long-standing experience in various capacities within WCRP make him an excellent choice to lead GEWEX into the future.

As you may be aware, WCRP is in the process of redefining its long-term functions and structure for the post-2013 era. This restructuring will include a plan for more effective interfacing with the users of climate informational products and a strategy for prioritizing WCRP science that includes its transfer into future societal benefit. At the SSG meeting, plans for GEWEX in this new era were discussed and a draft mission statement and list of imperatives were developed. These will be refined at the 2nd Pan-GEWEX Science Meeting to be held in Seattle on 23–27 August 2010, which will include all of the GEWEX panels, projects and working groups.

In November of last year, GEWEX, together with the European Space Agency, the European Geosciences Union (EGU) and International Society for Photogrammetry and Remote Sensing, held a very successful conference on Earth Observations of the Water Cycle. Nearly 200 scientists from 30 countries attended this conference, which was the first in a series of EGU topical conferences on the hydrological cycle (see summary of the conference on page 15).

The United Nations Climate Change Conference held last December in Copenhagen (*http://unfccc.int/meetings/cop_15/items/5257.php*) was perceived by many as not successful and by some to have failed. I will not give my judgment on that, but I will note that the meeting coincided with very cold weather and was followed by unseasonably cold weather in many parts of the Northern Hemisphere for the rest of the winter. No doubt many of you involved in climate science were asked by neighbors, friends and family, "What happened to global warming?" Maybe it was even followed by a smirk, a comment or even the question "Tell me honestly, is this climate change really happening?" The criticism of the Intergovernmental Panel on Climate Change (IPCC) reports and the review process involved in producing these reports has no doubt contributed even further to raising questions about research related to climate and global change. This form of denial goes further than just the average citizen in the street denying the effects of our changing climate. Even farmers, for example in the Murray Darling Basin in Australia, who are and have been severely impacted by more than 10 years of drought have a hard time accepting the fact that some of the changes in our climate are irreversible and that the ways of the past are not the ways of the future. The human element is probably the most difficult part in dealing with global change and the biggest challenge may be changing human behavior to establish a sustainable society.

As scientists working in this area we have the responsibility to continue to provide the best possible assessments and predictions of changes in our Earth system. Fundamental research is one of the crucial building blocks in that process. With the current emphasis on societal relevance and benefit of our research we have to safeguard that crucial part of science—basic research—where it is so much more difficult to show that direct societal relevance. If we are capable of making progress in these areas, for starters within GEWEX and WCRP, then I am sure a bright future (and not just for climate research) is ahead.

Finally, I wish to express a growing concern of mine, which is the proliferation of meetings, workshops and conferences related to climate research. In particular for hot topics, such as extreme events, the number of meetings is astounding. I do not have a solution to this problem but I will do my best to limit the number of GEWEX-related meetings requiring your participation. I ask that you keep me informed about any meetings you believe are worthwhile and I will include them in our calendar. At the least this will help us to avoid or reduce the number of multiple meetings occurring on the same dates. With that I conclude and look forward to seeing you in Seattle at the 2nd Pan-GEWEX Meeting.

Contents

Changes in GEWEX Leadership

GEWEX Scientific Steering Group

Dr. Kevin E. Trenberth, Head of the Climate Analysis Section at the National Center for Atmospheric Research (NCAR) in Boulder, Colorado, succeeded Dr. Thomas Ackerman as Chairman of the GEWEX Scientific Steering Group (SSG).

Originally from New Zealand, Dr. Trenberth completed a first class honours degree in mathematics at the University of Canterbury, Christchurch, and obtained his Sc.D. in meteorology in 1972 from the Massachusetts Institute of Technology. Following several years in the New Zealand Meteorological Service, he joined the Department of Atmospheric Sciences at the University of Illinois and became a full Professor before moving to NCAR in 1984.

Dr. Trenberth was named a Fellow of the American Meteorological Society (AMS) in 1985, the American Association for Advancement of Science in 1994, the American Geophysical Union in 2006 and an Honorary Fellow of the New Zealand Royal Society in 1995. In 2000 he received the Jule G. Charney award from AMS and in 2003 he was given the NCAR Distinguished Achievement Award.

Dr. Trenberth has served as editor and associate editor for several professional journals and has published over 430 scientific articles, including 45 books or book chapters, and over 185 refereed journal articles. He has also served on a number of national and international advisory committees and panels, including a board of the National Academy of Sciences.

Dr. Trenberth has been prominent in the Intergovernmental Panel on Climate Change (IPCC) Scientific Assessment activities. He was a coordinating lead author for the 1995 and 2007 scientific assessments and lead author for the 2001 assessment (including the Technical Summary and Summary for Policy Makers in all three), and shared the 2007 Nobel Peace Prize to the IPCC. He served as a member of the National Oceanic and Atmospheric Administration (NOAA) Climate Working Group (from 1987 to 2006), and is a member of NOAA's Climate Observing System Council. He also served on the Joint Scientific Committee of the World Climate Research Programme (WCRP) from 1999 to 2006 and was an officer from 2003 to 2006. He has chaired the WCRP Observations and Assimilation Panel for the past 6 years.

Dr. Howard S. Wheater, Professor of Hydrology and Director of the Imperial College Environment Forum at the Department of Civil and Environmental Engineering of the Imperial College of London, was named the GEWEX SSG Vice-Chair. Prof. Wheater has served as a member of the SSG for a year. His areas of interest are hydrological processes; hydrological and precipitation modelling; flood risk, water resources and water quality management; and arid zone hydrology.

Coordinated Energy and Water-Cycle Observations Project (CEOP)

Dr. Dennis P. Lettenmaier, professor of civil and environmental engineering at the University of Washington, succeeded Dr. Ronald Stewart (see page 9) as the Co-Chair of CEOP.

Dr. Lettenmaier was recently elected to the National Academy of Engineering; and honored for his "contributions to hydrologic modelling for stream water quality and hydroclimate trends and models for improved water management." He was the first Chief Editor of the American Meteorological Society *Journal of Hydrometeorology* and is currently an Associate Editor of *Water Resources Research*. Dr. Lettenmaier is also the President-elect of the Hydrology Section of the American Geophysical Union. He co-chairs CEOP with **Prof. Toshio Kioke** of the Department of Civil Engineering at the University of Tokyo, whose leadership role in CEOP spans nearly a decade.

GEWEX Cloud System Study (GCSS)

Chris Bretherton

Dr. Chris Bretherton is the new GCSS-Co-Chair. He is a professor in the Departments of Atmospheric Science and Applied Mathematics at the University of Washington in Seattle, Washington and directs its Program on Climate Change. He has contributed to the GCSS Boundary Layer Cloud Working Group for 15 years and was its chairman from 2005–2008. Dr. Bretherton is a past Fellow of the American Meteorological Society and Presidential Young Investigator, as well as Editor of the *Journal of the Atmospheric Sciences*. He co-chairs GCSS with **Dr. Pier Siebesma** of the Royal Netherlands Meteorological Institute, who has chaired the Project for the past 3 years.

Pier Siebesma

Recent News of Interest

WCRP Open Science Conference:
Climate Research in Service to Society

Denver, Colorado, USA
24–28 October 2011

The World Climate Research Programme (WCRP) is hosting a major international Open Science Conference (OSC) in 2011 to bring together major disciplines and the leaders of the research community to advance the understanding and prediction of the variability and change in the Earth's climate system. A better understanding of the behavior of the climate system and its interactions with other Earth system components is critical to predicting its future evolution, reducing vulnerability to high impact weather and climate events, and sustaining life.

The conference aims to attract the world's experts to provide a unique synthesis of current research findings on climate variability and change, to identify the most urgent scientific issues and research challenges, and to ascertain how the WCRP can best facilitate research and develop partnerships critical for progress in the future.

The objectives of the OSC are:

- Appraise the current state of climate science, thereby making a measurable scientific contribution to the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC).
- Identify key opportunities and challenges in observations, modelling and analysis towards understanding and predicting the Earth's climate system.
- Facilitate discussion on interdisciplinary research required to understand and predict responses of the Earth as a system to climate variability and change, thus helping chart the path forward over the ensuing decades.
- Highlight priority research in support of the Global Framework for Climate Services initiated at the 2009 World Climate Conference-3.

By entraining early career scientists and students from across the world, especially less-developed and developing nations and regions, the OSC will facilitate growth of the diverse future workforce needed to meet the increasingly complex scientific challenges of the future.

For more information, please visit the Conference web page at: *http://www.wcrp-climate.org/conference2011* or contact the Conference Secretariat (*info.conf2011@wcrp-climate.org*).

International Soil Moisture Network Launched

The Institute for Photogrammetry and Remote Sensing (IPF) of the Vienna University of Technology has announced that the International Soil Moisture Network (*http://www.ipf.tuwien.ac.at/insitu*) is now operational. The Network is an international collaboration to establish and maintain a global database of harmonized in situ soil moisture measurements. The web-based data hosting facility is operated by the IPF and will be a critical resource for the geosciences community in validating and improving global satellite observations and land-surface models. It will also contribute to the establishment of global and regional soil moisture products using both Earth observational as well as in situ data.

This international network was initiated under the auspices of the International Soil Moisture Working Group (ISWMG). The IPF facility was made possible through sponsorship by the European Space Agency as part of their calibration and validation activities of the Soil Moisture Ocean Salinity satellite mission. The network is coordinated by GEWEX through the ISMWG and in cooperation with the Group of Earth Observations and the Committee on Earth Observation Satellites. The success of the International Soil Moisture Network will be based on the voluntary contributions of scientists and networks from around the world.

With this announcement we call upon the scientific community to support this worthwhile initiative. We hope that many more networks are willing to contribute. For further information about this data hosting facility, please contact: Wouter Dorigo (*wd@ipf.tuwien.ac.at*). For information on the activities of the ISMWG contact: Tom Jackson (*Tom.Jackson@ARS.USDA.GOV*) or Peter van Oevelen (*gewex@gewex.org*).

First Results from GLACE-2 Published

Koster, R. D., et al. (2010). Contribution of Land-Surface Initialization to Subseasonal Forecast Skill: First Results from a Multi-model Experiment. *Geophys. Res. Lett.*, 37, L02402, doi:10.1029/2009GL041677.

Abstract: The second phase of the Global Land-Atmosphere Coupling Experiment (GLACE-2) was aimed at quantifying, with a suite of long-range forecast systems, the degree to which realistic land-surface initialization contributes to the skill of subseasonal precipitation and air temperature forecasts. Results, which focus on North America, show significant contributions to temperature prediction skill out to two months across large portions of the continent. For precipitation forecasts, contributions to skill are much weaker but are still significant out to 45 days in some locations. Skill levels increase markedly when calculations are conditioned on the magnitude of the initial soil moisture anomaly.

Is There a Missing Low Cloud Feedback in Current Climate Models?

Graeme L. Stephens
Department of Atmospheric Science, Colorado State University, Boulder, Colorado, USA

Radiative feedbacks involving low level clouds are a primary cause of uncertainty in global climate model projections. The feedback in models is not only uncertain in magnitude, but even its sign varies across climate models (e.g., Bony and Dufresne, 2005). These low cloud feedbacks have been hypothesized in terms of the effects of two primary cloud variables—low cloud amount and cloud optical depth. The basis of these feedbacks relies on the connection between these variables and the solar radiation leaving the planet exemplified in the following simple expressions (Stephens, 2005).

$$F_{obs} = (1 - A_c)F_{clr} + A_c F_{cldy}$$
$$CRE = -(F_{obs} - F_{clr}) = -A_c(F_{cld} - F_{clr}) \quad (1)$$

where F_{obs} is the observed top-of-atmosphere reflected flux, F_{clr} is the clear sky flux, F_{cld} is the cloudy sky flux and A_c is the cloud amount. *CRE* , the cloud radiative effect is also referred to as cloud radiative forcing. This quantity is a measure of the effect of clouds on the reflected solar flux relative to the clear-sky flux. Estimates of the magnitude and sign of the *CRE* from observations was a focus of much research in the 1970s (e.g., see Stephens et al., 1981) but it was not until the launch of the Earth Radiation Budget Experiment (ERBE) in 1984 that we were able to deduce the global value and distribution of *CRE* (Harrison et al., 1990). The global-mean value of the net (longwave plus shortwave) *CRE* is negative and approximately –20 Wm^{-2} (Harrison et al., 1990) implying a cooling effect of clouds on climate. Closer analysis reveals this is dominated by low clouds (e.g., Hartman et al., 1992, and others). One of the more important activities of the GEWEX Radiation Panel is the flux assessment effort that seeks to provide the most authoritative estimates on *CRE* and other components of the global and regional radiative balance.

One of the remarkable findings of the study was that approximately 40 percent of all low clouds observed contain detectable amounts of either rain or drizzle and this in turn affects the radiative properties of clouds.

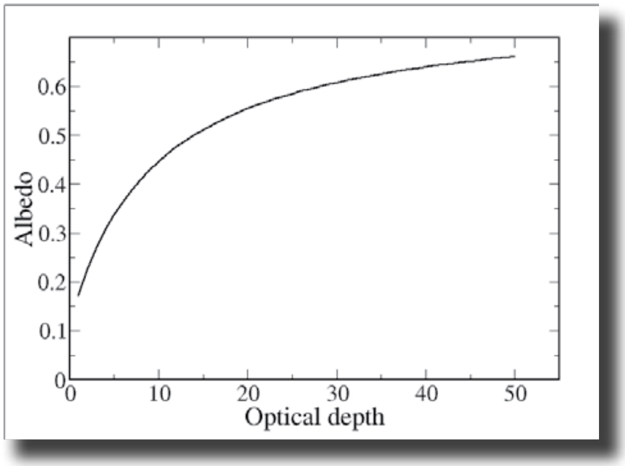
Cloud feedback is often measured in terms of the sensitivity of *CRE* to changing surface temperature that we write as

$$\frac{\Delta CRE}{\Delta T_s} = -\frac{\Delta A_c}{\Delta T_s} F_{cld} - A_c \frac{\Delta F_{cld}}{\Delta T_s} \quad (2)$$

and note it is comprised of two terms. One governed by cloud amount changes such that a decrease in cloud is a positive feedback. The second is governed by the cloud optical depth through its controlling influence on cloud albedo α which in turn determines the cloudy sky flux ($F_{cld} = \alpha F_0$; F_0 is the top of the atmosphere incident solar radiation). Thus an increase in optical depth with an increase in temperature results in an increase in cloud albedo, suggesting a negative feedback. The meaning of the operator is left vague at this point although it is meant to represent a difference of the given variable between one climate state and another.

Low cloud amount is controlled by a number of different pathways that often oppose one another. The result is a feedback that can be complicated with no obvious sign. This is one of the reasons quantifying cloud feedback has been so elusive and is one of the motivating forces behind the GEWEX Cloud System Study (GCSS) activity. Two examples illustrate this complexity. It is well established that the profiles of lower tropospheric temperature, expressed for example by the Estimate Inversion Strength (EIS, Wood and Bretherton, 2006), correlate strongly with low cloud amount. In a warmed climate state, the EIS appears to increase over the subtropical stratiform cloud regions, suggesting cloud amount increases there. This increase further implies a negative cloud amount feedback associated with the warming sea surface temperatures. However, other processes that superimpose on this feedback can oppose these changes, altering the sign of the feedback. For example, changes in the larger scale circulation that result in weakening of the subsidence, which is also predicted in climate warming simulations, may well shift clouds from a stratiform regime to a more convective cloud regime with reduced cloud amount, suggesting a positive feedback.

The second source of feedback is the optical depth feedback associated with the effects of a surface warming on cloud albedo. Paltridge (1980) first introduced the idea of a cloud optical depth feedback. He proposed that a feedback might exist given the association between optical depth and liquid water path introduced earlier by Stephens (1978) and given the expectation that a relation between cloud liquid water path (LWP) and temperature exists (e.g., Betts and Harshvardham, 1987). The early notions of this feedback were simple enough—that warmer clouds are wetter clouds as defined by larger LWPs and thus warmer clouds have larger optical depths. Estimates of the strength of this particular negative feedback based in idealistic climate model simulations suggested this negative feedback might be substantial, capable in reducing the projected global warming of carbon dioxide by a factor of two (Sommerville and Remer, 1984). Attempts to determine if this feedback really operates in the real climate system have been inconclusive (Stephens, 2005). One of the relevant aspects of this feedback is exemplified in the figure on the next page which shows a simple model-based relation between cloud optical depth and cloud albedo. This relation



Calculated relationship between cloud albedo and optical depth based on a simple radiation model where vertically incident sunlight is assumed.

has a simple linear growth regime at low optical depths below about 10 and asymptotes to a limit at high optical depths (the semi infinite limit, Stephens and Tsay, 1990). As a result of this well-known behavior, the sensitivity of cloud albedo to optical depth ($\partial\alpha/\partial\tau$) at τ~8 is about 4-fold greater than is the sensitivity at τ~20–30. These differences are relevant to the discussion below.

Given the complexities described, it is tempting to look to observations alone to diagnose the magnitude and sign of cloud feedbacks [e.g., Clement et al. (2009); Lindzen and Choi, 2009; among many other examples]. However, these studies are subject to greater uncertainty, requiring essential assumptions that have to do with the cause and effect. Quantitative feedback analysis typically requires one to be more precise about what the difference in quantities in (2) represent, and specifically that

$$\frac{\Delta A_c}{\Delta T_s} \equiv \frac{\partial A_c}{\partial T_s} \quad (3)$$

This equality implies that we have to interpret the given observed changes in cloud amount as due solely to the observed surface temperature change, thereby assigning a cause to an effect. Clearly we cannot assert causality without major assumption that is often either not justified or not testable with the observations alone.

One approach to studying feedback is to use observations of present climate and its variability to test the key (physical) mechanisms represented in models. In a recent paper (Stephens et al., 2010) collected low cloud data obtained from A-Train sensors including Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) lidar, CloudSat radar, Moderate Resolution Imaging Spectroradiometer (MODIS) and Advanced Microwave Scanning Radiometer-Earth Observing System (AMSR-E) instrument data. The observations were cast in terms of information about the occurrence of precipitation in low clouds, the cloud LWP, the cloud particle size (effective radius, r_e) and the cloud optical depth. These data were used to evaluate how well models represent low cloud radiative properties, including optical depth.

Table 1 summarizes the oceanic mean values of the low cloud properties observed. **One of the remarkable findings of the study was that approximately 40 percent of all low clouds observed contain detectable amounts of either rain or drizzle and this in turn affects the radiative properties of clouds.** The observations are grouped into four categories—all low clouds (all), clouds containing neither drizzle nor rain (cloud-only), clouds containing drizzle but no rain (drizzle), and clouds that contain rain (rain). The difference between the "all" category and "cloud-only" category thus provides some indication of the effect of drizzle and rain on the global-mean statistics of low cloud properties. The mean LWP of all low clouds is approximately 50 percent higher than the respective cloud only values. The mean effective radius (r_e) of all clouds is also about 15 percent larger than the respective cloud-only values and drizzling and raining clouds are observed to be deeper than non-raining clouds by up to a kilometer in the mean, which is one of the main factors that governs the larger LWPs of these clouds. Although the r_e of drizzling and raining clouds is almost 50 percent larger than the particle sizes of the cloud-only category (21 and 24 µm compared to 14 µm), these larger particle sizes do not offset the effects of the increased water path on optical depth (e.g., Stephens et al., 2008) such that the oceanic-mean optical depth of drizzling or raining low clouds is increased by approximately 25 percent over the cloud-only values. This suggests the presence of drizzle and rain has significant effects on the mean LWP, mean particle sizes and optical depths of all low clouds and therefore this presence exerts a significant influence on the radiative properties of the oceanic low clouds. This effect is rarely included in models.

A comparison of these observed properties to equivalent low clouds properties taken from a weather forecast and climate model is given in Table 2. A number of remarkable differences

Table 1. Seasonal averages of global oceanic-mean properties of low clouds derived from A-Train observations for the period of 2006–2007.

JJA	LWP (gm^{-2})	Optical Depth	r_e (µm)	Cloud Top Height (km)
All	116.0	9.5	15.9	1.44
Cloud-only	78.0	7.5	14.2	1.26
Drizzle	255.1	17.0	21.9	2.02
Rain	303.6	18.9	24.0	2.28
DJF				
All	110.4	9.0	15.0	1.54
Cloud-only	71.2	6.7	13.6	1.35
Drizzle	288.9	19.1	21.4	2.35
Rain	327.3	20.7	22.8	2.54

Table 2. Monthly comparison between observed and cloud properties from two models.

JJA	LWP (gm^{-2})	Optical Depth	r_e (μm)
Observed			
All	116.4	9.5	15.9
Cloud only	78.0	7.5	14.2
ECMWF			
All	224.0	30.0	9.0
Cloud only	161.0	22.0	9.0
CAM3.6			
Cloud only	194.0	20.0	14.0

appear in this simple comparison. The LWPs of the two global general circulation models are significantly higher than the observed values and the differences are significantly greater than any error that can be assumed for the observations. The non-raining cloud LWP of the GCMs, a quantity typically used in radiation schemes to define cloud optical properties, even exceeds the observed values of clouds that include effects of rain and drizzle. A second major model bias evident from this comparison is the difference between the observed and model assumed effective radius values, with model values being much smaller than observed and not reflective of the presence of drizzle or rain.

The net consequence of these biases is that the optical depth of low clouds in GCMs is more than a factor of two greater than observed, resulting in albedos of clouds that are too high. This model low-cloud albedo bias is not a new finding and is not a feature of just these two models. The study of Allan et al. (2007), for example, also noted how the reflection by low-level clouds in the unified model of the UK Meteorological Office is significantly larger than matched satellite observations of albedo, suggesting that this bias also exists in that model. The mean LWP of model clouds that contributed to this in the most recent Intergovernmental Panel on Climate Change assessment is close to 200 g/m^2, which is also nearly a factor of two larger than observed.

The implication of this optical depth bias that owes its source to biases in both the LWP and particle sizes is that the solar radiation reflected by low clouds is significantly enhanced in models compared to real clouds. This reflected sunlight bias has significant implications for the cloud-climate feedback problem. The consequence is that this bias artificially suppresses the low cloud optical depth feedback in models by almost a factor of four and thus its potential role as a negative feedback. This bias explains why the optical depth feedback is practically negligible in most global models (e.g., Colman et al., 2003) and why it has received scant attention in low cloud feedback discussion. These results are also relevant to the model biases in absorbed solar radiation discussed recently by Trenberth and Fasullo (2010) and as explored in more detail in Stephens et al. (2010).

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Highlights of the 22nd Session of the GEWEX SSG

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International GEWEX Project Office

The 22nd Session of the GEWEX Scientific Steering Group (SSG) was hosted by Dr. Kapil Dev Sharma of the Government of India's National Rainfed Area Authority (NRAA) in New Delhi, India on 25–29 January 2010. Dr. J. S. Samra, the Chief Executive Officer of NRAA and Dr. Ghassem Asrar, Director of the World Climate Research Programme (WCRP) provided opening remarks. Special presentations included: Cold waves, heat waves and droughts (J. Samra); Integrated information base—savior of water sector (A. Gosain); Plan of Indian satellites in understanding the science of tropical weather and climate (P. Pal); and Formulation of a global model as a tool for forecasting, geo-engineering and climate change (O. Sharma).

During the agency presentations, Dr. Einar-Arne Herland presented European Space Agency (ESA) plans to establish long-term alliances with major international Earth system science programs. The Water Cycle Multi-Mission Observation Strategy (WACMOS) funded by ESA and supported by GEWEX, is the first of many such planned. Initial results of this project were presented during a Water Cycle Science Conference held in November 2009 (see page 15 for details).

After the review of ongoing activities of the three GEWEX panels (hydroclimate, radiation, modelling; see highlights in following paragraphs), the SSG members discussed how GEWEX will contribute to the World Meteorological Organization global framework for climate services and developed a draft statement of GEWEX contributions. After a discussion of how the GEWEX Phase II objectives and activities could best evolve into the new post-2013 WCRP organizational structure, the SSG developed a draft mission statement for GEWEX post 2013 with a list of imperatives. The imperatives will be further refined at the 2nd Pan-GEWEX Science Meeting to be held 23–27 August 2010 in Seattle, Washington.

The Cold Regions Study and several Regional Hydroclimate Projects (RHPs) of the Coordinated Energy and Water-Cycle Observations Project (CEOP), are coordinating activities with the WCRP Climate and Cryosphere (CliC) Project to produce a solid precipitation data set. This process includes integrating satellite, model and in situ data from CEOP cold region sites in different RHPs. The characteristics of the CliC cold regions data archive and in situ data set have been defined to include snow cover and frozen ground from Asian regions that can and are now being compared with CEOP sites. In addition, information, data and analyses taking place within the activities of the Glacier Group of Asia-CliC and CliC are being gathered and formatted for application toward meeting the goals of the CEOP Cold Regions Study. The Baltic Sea Experiment (BALTEX) is contributing to this effort through a national activity to calculate radar-based daily precipitation accumulation maps in a limited area at the CEOP Sodankylä site.

The CEOP High Elevations (HE) Regional Study requires globally integrated analyses of CEOP reference sites data, remote sensing observations, and models analysis and application. For this reason HE enlisted the support of a number of groups, including members of the CEOP RHPs and representatives from other GEWEX Panels, as well as from CliC to provide input and review of the CEOP HE Science Plan. A special HE poster session was also organized at the GEWEX/iLEAPS Joint Conferences held in August 2009 in Melbourne, Australia. A number of posters highlighted collaborative initiatives related to water and energy budget studies, aerosols and extreme events in high elevation regions, as well as multidisciplinary topics related to climate changes in mountain areas that support ecosystems sensitive to global change. CEOP HE is also cooperating with the Coordinated Asia-European long-term Observing system of Qinghai–Tibet Plateau hydrometeorological processes and the Asian-monsoon systEm with Ground satellite Image data and numerical Simulations (CEOP-AEGIS) in the planning of the 2nd International Workshop on Energy and Water Cycle over the Tibetan Plateau and High-Elevations to be held in Lhasa, China, 19–21 July 2010.

Participants at the 22nd Session of the GEWEX Scientific Steering Group.

The GEWEX Radiation Panel (GRP) showed excellent progress in many of its activities (see page 11). The final report of the Cloud Assessment Project is scheduled for completion in mid-2010. It reviews existing long-term climatologies and compares these to data from the improved complement of satellite-flown instruments. Climatological averages, as well as their regional, seasonal and diurnal variations are presented, and differences between results from the various data sets are discussed.

The GRP/SeaFlux Version 1.0 data set has been completed for the period of 1998–2005. LandFlux produced an inventory of available global surface latent and sensible heat flux products. First results from global, monthly (1993–1995) comparisons indicate that overall geographical patterns are consistent among data sets (dry vs wet regions), but there exists a large range between data sets in some regions, in particular in tropical rainforest areas. GRP is planning a "state-of-the-art" suite of global energy and water cycle products with error bars for closing the global water and energy budgets for the period 1980 to 2010.

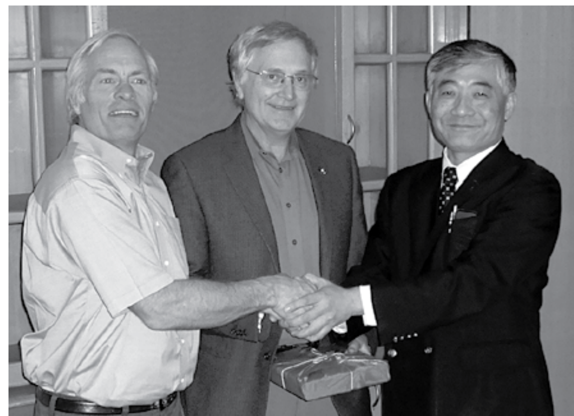
The GEWEX Modelling and Prediction Panel (GMPP) and the Working Group on Numerical Experimentation (WGNE) initiated and conducted a WCRP-wide survey on model development across all application areas. The survey went out to the community in August 2009 and response has been good. The main areas for future model development that were highlighted in an early analysis of the responses to the survey included: (i) Tropical biases and errors in tropical variability often associated with the representation of tropical deep convection; (ii) cloud-climate feedbacks; (iii) the carbon cycle; and (iv) the representation of physical processes in high-resolution models. The analysis of the responses is ongoing and a second distribution of the survey that includes the World Weather Research Programme THe Observing System Research and Predictability Experiment (THORPEX) community went out in early December. The results of the survey will serve as the foundation for a workshop on "physical processes in Earth-system models" planned for early 2011.

GMPP/Global Land/Atmosphere System Study (GLASS) has reorganized into three focus areas: (1) Benchmarking; (2) Data Assimilation; and (3) Land-Atmosphere Coupling. For details see the GLASS meeting report in the November 2009 issue of *GEWEX News*. First results from the Global Land-Atmospheric Coupling Experiment (GLACE-2) have been published in the American Geophysical Union Geophysical Research Letters (see page 4) and show that there is a significant impact of land-surface initialization for large anomalies. The GEWEX Clouds System Study (GCSS) continues its strong research activity with more than 300 researchers involved. One of the successes this year is the approval of a new European Union Seventh Framework Project called EU-CLIPS that concerns cloud intercomparisons, process studies and evaluation. In 2009 the GEWEX Atmospheric Boundary Layer Study (GABLS-3) presented results of the experiment at a successful workshop (see related article in November 2009 issue of *GEWEX News*). In the future GABLS will focus more on regional models/modelling as well and there are plans to include some tagged on experiments in conjunction with the Intergovernmental Panel on Climate Change Fifth Assessement Report (AR5).

GMPP remains at the heart of the implementation of the model development activities in WCRP, and GMPP study groups form the core of a new expert group on parameterization within WMO under the auspices of WGNE. The role of this group is to advise all WMO activities in the area of parameterization and to set the agenda for parameterization development activities.

The 22nd SSG meeting laid some of the foundation necessary to prepare GEWEX and the activities it represents for its long term future. As such it provides a good starting point for the 2nd Pan-GEWEX Meeting where the GEWEX science community will be consulted and asked to endorse the plans to shape the future of GEWEX.

Ronald Stewart Honored by CEOP



Dennis Lettenmaier (left), Ronald Stewart (center) and Toshio Koike (right).

Prof. Ronald Stewart concluded his term as Co-Chair of the Coordinated Energy and Water-Cycle Observations Project (CEOP) at the SSG Meeting and was honored for his leadership and long history of support to CEOP, the GEWEX Hydroclimate Panel, and the former CEOP (the Coordinated Enhanced Observing Period. Prof. Stewart and his Co-Chair, Dr. Toshio Koike, were largely responsible for the successful merger and complex reorganization of the GEWEX Hydrometeorology Panel (GHP) and the Coordinated Enhanced Observing Period into the current GEWEX Hydroclimate Panel or "new" CEOP. Prof. Stewart chaired the GHP from 1998–2003.

Prof. Stewart is the Head of the Department of Environment and Geography at the University of Manitoba in Winnipeg, Canada and is a Fellow of the Royal Society of Canada. He will continue to provide strong scientific direction and support to CEOP and WCRP through his role as the leader of the CEOP Extremes Project and as a member of the WCRP Extremes Working Group. In addition, Prof. Stewart is a member of the GEWEX SSG, where he will continue to apply his unique leadership skills toward shaping the future of the overall international framework of GEWEX.

Dr. Dennis Lettenmaier, also a long time contributor to GEWEX, was endorsed by the SSG to take Prof. Stewart's place as the CEOP Co-Chair (see page 3).

Meeting/Workshop Reports

7th WGDMA Meeting

College Park, Maryland
16–18 September 2009

William B. Rossow
CREST at The City College of New York, NY, USA

The Working Group on Data Management and Analysis (WGDMA), which was hosted by the Earth System Science Interdisciplinary Center at the University of Maryland, met to review the status and plans for GEWEX data products. Global Precipitation Climatology Project (GPCP) products have been delivered through June 2009; International Satellite Cloud Climatology Project (ISCCP) products through June 2008; Surface Radiation Budget (SRB) products through 2007; and Global Aerosol Climatology Project (GACP) products through June 2005. For more details about these and other GEWEX products see the GEWEX Radiation Panel (GRP) report on page 11.

Many of the data records are approaching three decades in length, and a new goal of producing "climate data record" quality products has recently been adopted. GEWEX data projects were not designed for producing "climate data record" quality products. Their original goal was to produce data products that would be useful for the study of key climate processes with an emphasis on global, relatively long-term coverage. These projects pioneered the analysis of satellite observations for this purpose. It has now become critical to the quality of these products that the various ancillary data sets used in their processing be of similar quality over the whole time period. Moreover, as the GRP works towards the goal of completing the quantitative description of the global energy and water cycle, the physical consistency of the data products, including their ancillary inputs, becomes vital.

The projects are working together to review the available products that could be used in the reprocessing. Comparison studies and evaluations have been completed for topography/land-water mask and ozone; preliminary studies have been completed for sea ice. After comparing the NOAA National Geophysical Data Center ETOPO2v2 Global Gridded 2-minute database and USGS GTOPO30 products with the Shuttle Radar data set and the AVHRR project land-water mask, the GTOPO30 reconciled with the AVHRR land-water mask was selected for use. A new merged Shuttle Radar and Atmosphere Surface Turbulent Exchange Research (ASTER) product has just been released and will be evaluated as well. Based on literature evaluations, as well as the length and continuity of its time record and its spatial resolution and coverage, the Total Ozone Mapping Spectrometer (TOMS) product was selected as the basic ozone product. However, this product has some significant gaps, including missing data for 1995 and part of 1996, and the data set ends in 2005. TOMS was replaced by the ozone monitoring instrument (OMI) product. An interpolation procedure was developed by the ISCCP group, as a refinement of one developed by the SRB group, for merging several data sets to provide complete coverage of the globe [the TIROS operational vertical sounder (TOVS) is the only ozone product for polar night] and the whole time period. This product was specifically checked for inhomogeneities over the record. Three satellite sea ice products were compared—the National Snow and Ice Data Center (NSIDC) Bootstrap, the NASA/Goddard Space Flight Center (GSFC) Bootstrap, and the NASA Team products. The NASA/GSFC Bootstrap product was selected because it seems less affected by summertime surface meltwater; however this product will be further evaluated by comparison with a NOAA compilation that combines satellite and conventional observations. There is only one long-term snow-cover data set, the NOAA operational product.

A final selection for aerosols and atmospheric temperature/humidity was not made, although a preliminary conclusion was reached that the "best" tropospheric aerosol product would probably be a merger of the GACP ocean-only product with the AEROCOM "model-median" result over land, augmented by the Stratospheric Aerosols and Gas Experiment (SAGE) for the stratospheric component. This merger will have to be checked for consistency at the coastlines. The currently available data sets for atmospheric temperature-humidity profiles are unsatisfactory in many ways, in terms of time period covered and in terms of their homogeneity over the time record. No product has been shown to be superior to the operational TOVS product used by ISCCP, even though it has many noticeable flaws. Work is underway by ISCCP in collaboration with NOAA/NCDC to reprocess the High Resolution Infrared Radiation Sounder (HIRS) record up to sufficient quality to reduce the known problems with respect to TOVS and other products. The aerosol and atmospheric temperature-humidity analysis should be completed by mid-2010.

The clouds, aerosols and radiation projects have agreed to use the same solar "constant" data set that includes the 11-year solar cycle variations. The composite record is based on the Solar Radiation and Climate Experiment (SORCE)/Total Irradiance Monitor (TIM) Total Solar Irradiance (TSI) values.

The contents of the energy and water cycle data product, which is to be produced by merging all the global GEWEX products with additional data sets, will include all parameters reported by the various separate products, together with a collection of new joint histograms made possible by the merger. The basic format will be one-degree equal-area mapping and 3-hour (or one day) time intervals, binary coding, fixed variable array in netCDF4. Two specific aspects of these data sets were discussed at the meeting. The first aspect concerned whether the values reported at each 3-hour time step should represent "instantaneous" samples or averages. Moreover, it was realized that traditional precipitation data sets report values based on the precipitation accumulated over a time interval beginning at the nominal time (e.g., 0300), whereas the clouds and radiation data sets are reported for 3-hour intervals centered on the nominal time. It was decided that the "flux" data sets, including precipitation, would report both instantaneous and 3-hour-average values, whereas the "physical variable" data sets would report instantaneous time samples as they currently do. Further testing is planned to decide whether the other "flux" data sets can shift their time interval to begin at the nominal time rather than 1.5 hours prior. The second aspect concerned how to deal with missing data and it was decided that all products would "fill" missing values so that the global and temporal coverage would be complete. These "fill" values will be labeled in the data sets to distinguish them from actual observations.

Each project has specific plans for study activities to make final revisions before starting reprocessing. The primary GPCP activities include: (1) implementing a modern microwave algorithm; (2) incorporating the "full" gauge data analysis (Version 4), which will further improve results in mountainous terrain; (3) developing an analysis procedure for AVHRR infrared data to fill in for missing geostationary data in the earlier part of the record; and (4) implementing a snow/rain discrimination based on near-surface air temperatures.

The primary ISCCP activities before reprocessing are: (1) refining the radiance calibrations; (2) refining polar cloud detections; (3) refining treatment of ice clouds; (4) adding aerosols in the retrievals; (5) implementing more complete treatment of surfaces; and (6) reducing angle dependence in results.

The primary GACP activities are to extend the current product through June 2008 (or 2009 if the ISCCP results become available) and to continue evaluation of available aerosol products, including working on a merged GACP-AEROCOM product.

The primary SRB activities are: (1) improving the treatment of land surfaces; (2) improving the representation of cloud microphysical properties; (3) reducing angle dependence in results; and (4) upgrading the radiative transfer code to handle more detailed representations of cloud and aerosol properties.

The primary SeaFlux activities are: (1) extending the Version 1 product back to 1987 and comparing this new product with all of the previous products; (2) developing an improved sea surface temperature product; and (3) continuing comparisons with products produced from newer satellite instruments.

The primary LandFlux activities are to continue evaluation of the first global latent heat flux products and to develop sensible heat flux products. The ISCCP, SRB and SeaFlux groups will collaborate on the evaluation of atmospheric temperature-humidity data sets, including producing a unified surface skin temperature retrieval.

Data reprocessing will begin in 2010 and will be performed in reverse chronological order starting with 2009. Products for 2010 will be processed last. Tasks to be completed in 2010 include: (1) production of a new HIRS-based atmospheric temperature-humidity data set (or selection of a reanalysis product for use); (2) production of a combined GACP/AEROCOM aerosol climatology; (3) beginning the ISCCP and SRB reprocessing; (4) beginning the GPCP and SeaFlux reprocessing; (5) conducting the first complete LandFlux processing. All of the project reprocessing and production of the merged energy and water cycle data set should be completed in 2011.

20th Session of the GEWEX Radiation Panel

13–16 October 2009
Rostock, Germany

Christian Kummerow
Colorado State University, Fort Collins, CO, USA

This Session of the GEWEX Radiation Panel (GRP) was hosted by Dr. Jörg Schultz, Deutscher Wetterdienst (DWD) and chaired by Dr. Christian Kummerow. The meeting opened with an update on the activities of the World Climate Research Programme (WCRP) and included a specific recommendation to GRP to consolidate and strengthen its focus as a user and promoter of observations, as well as its support of the Global Climate Observing System (GCOS).

The work being done by the Climate Monitoring Satellite Applications Facility (CM-SAF), an operational facility under the leadership of DWD, was introduced (see article in November 2009 issue of *GEWEX News)* and included a presentation on the CM-SAF approach to deriving the Earth's radiation budget from satellite data. It was shown that data from SOVA1/DIARAD instruments on the International Space Station should be as accurate in their measurements of total solar irradiance as the Total Irradiance Monitor (TIM) on the Solar Radiation and Climate Experiment (SORCE). Instead, there are differences of 1–2Wm^{-2} between the instruments that have yet to be resolved. CM-SAF is proposing that the Sun Earth IMBAlance Radiometer (SIMBA) should make direct flux measurements; however challenges for this method are daunting for both instrument and orbit.

A presentation about merging Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO), CloudSat, Clouds and the Earth's Radiant Energy System (CERES) and Moderate Resolution Imaging Spectroradiometer (MODIS) data for a simultaneous cloud, aerosol and radiative flux profile retrieval clearly showed the advantages of using A-Train observations to overcome some of the historical difficulties of retrieving individual parameters from single sensors.

Agency reports were given by the European Space Agency (ESA), the Japan Aerospace Exploration Agency (JAXA), the Japan Meteorological Agency (JMA), the National Oceanic and Atmospheric Administration (NOAA), and the Brazillian National Institute for Space Research (INPE). A number of ESA Earth Explorer Missions are highly relevant to GRP objectives, including the Cold Regions Hydrology High-resolution Observatory (CoReH2O), which is one of the candidates for the 7th Explorer Mission. The JMA Multifunctional Transport Satellite-2 (MTSAT-2) is ready to go operational once MTSAT-1 is decommissioned. JAXA is planning to launch the Global Change Observation Mission-Water satellite (GCOM-W) in 2013. The NOAA-19 High Resolution Infrared Radiation Sounder (HIRS) is performing. Key National Polar-orbiting Operational Environmental Satellite System (NPOESS) instruments have been reinstated and the NOAA/National Climatic Data Center (NCDC) participated in a Joint NASA/NOAA Working Group to assess options to recover climate capabilities and develop climate-quality data products from NPOESS.

Routine International Satellite Cloud Climatology Project (ISCCP) data set production is being transferred to NOAA/NCDC, which will ensure its long-term archival. The ISCCP cloud product has almost too many satellites, with seven geostationary and three polar orbiters providing data. Because all the information should be captured despite the overlap, ISCCP is considering delivering a gridded product that can be separated for individual satellites. A particle size product is nearly complete and a paper on this is almost ready for journal publication.

The Global Precipitation Climatology Project (GPCP) Interim Version 2.1 was produced to exploit the latest analysis from the Global Precipitation Climatology Centre (GPCC) and shows significant improvement in regions of orographic rain. The 2008 data show record low global mean precipitation and oceans showed the normal decrease due to La Niña; however, land did not compensate for that effect. In the reprocessed GPCP trend analysis, global linear trends still show an increase in tropical oceans and decrease in subsidence zones. In terms of global trends, there is still very little change as the decrease over land compensates for the increase over oceans.

GPCP is focusing much of its efforts on getting Version 3 ready and improving error estimates. The Version 2.1 data set averages 2.68 mm per day over the whole globe. Confidence in the results varies by region, with developed land areas leading in certainty and high-latitude ocean areas trailing. Version 3 plans still include higher time and space resolutions (approximately 3 hr 25 km) for part of the period, using a new passive microwave algorithm (GPROF) and new passive microwave data [AMSR-E, Tropical Rainfall Measuring Mission (TRMM), AMSU]. This will be integrated with previous longer-term, coarser time/space resolution. Rain and snow discrimination (by temperature) will be added.

Version 3.0 (July 1983–June 2007) of the Surface Radiation Budget (SRB) Project data is now available and new energy budgets have been produced. There are differences with the ISCCP data but they are probably due to differences in surface temperature. There are significant differences (15 Wm^{-2}) when compared to other analyses, but overall the data are in better agreement with new and active missions (e.g., CloudSat, CALIPSO).

Aside from validation against the Baseline Surface Radiation Network (BSRN), the current focus is assessments aimed at understanding the causes of discrepancy, with investigations underway involving clear skies and completely cloudy skies to find the root of the biases. Upcoming activities are related to the joint product reprocessing starting in late 2010, which requires the evaluation and homogenization of SRB inputs and ancillary data.

Global Aerosol Climatology Project (GACP) data processing is idle. Aerosol product generation has some funding for current NASA missions, but GACP is not funded. Current progress involves comparing the existing product with newer ones. Assessment reports have claimed that MODIS and the Multi-angle Imaging SpectroRadiometer (MISR) data are each good to 0.05 in aerosol optical depth (AOD). However, comparisons between MODIS and MISR show disagreements are much larger than that. Retrieval depends on the properties of the aerosol. The largest uncertainty comes from an inability to properly clear clouds out of the scenes.

The data show that AOD has dropped over time, posing the question of whether this is a real result or an artifact. Two different products agree, but both use the Advanced Very High Resolution Radiometer (AVHRR). Issues concerning the difficulty of distinguishing stratospheric aerosols from other aerosols are now arising because of the loss of SAGE. Since GACP is ocean-only, discussions focused on the possibility of using aerosol source and dynamics type models such as Spectral Radiation-Transport Model for Aerosol Species (SPRINTARS) to complete the global aerosol picture.

Version 1.0 of SeaFlux data (1998–2005) is complete. A robust diurnal variability was developed using the Clayson and Curry algorithm, which includes SRB solar radiation and NOAA blended winds. SeaFlux is working with Colorado State University to get an intercalibrated data set from the Special Sensor Microwave/Imager (SSM/I), which will enable completion of Version 1 back through 1987. Version 2.0 is in preparation and will include improved sea surface temperature, diurnal cycle and better aerosol effects.

The LandFlux activity is proceeding extremely well with participation from the satellite, in situ and modelling communities. Estimates are being compared to Intergovernmental Panel on Climate Change (IPCC) models to ensure that the models are within the observation envelope. First results show that overall geographical patterns are consistent among data sets (dry vs. wet regions) but a large range exists between data sets in some regions, in particular tropical or rainforest areas. The main conclusion is that differences among observationally based estimates of fluxes are on the same order of magnitude as differences between existing model-based estimates.

GRP is working on a series of white papers to help define its future directions. The White Paper on Water Vapor recommends that GRP initiate a new water vapor assessment activity to determine the strengths and weaknesses of different products now available and to recommend appropriate combinations for use within the GRP community. Accurate water vapor profiles are needed for the ISCCP and SRB data, as well as for determining water vapor transport for closing water budgets. Data products are now available from multiple sensor types that have 3-D associated wind fields for consistent transport. These products and new assimilation techniques in NWP have really opened doors.

The White Paper on Data Set Assessments concludes that assessments are the only straightforward way for unbiased information about data products to be communicated to climate and model evaluation communities. When done properly, they should include a description of retrieval algorithms and references, averages and distributions of the key variables and time variability and uncertainty/biases. More importantly, they should attribute differences to basic causes, such as percent cloudiness being related to instrument sensitivity. Finally, assessments should lead to the establishment of databases that can be used for future benchmarks so that new products can immediately be compared to previous assessment results.

The White Paper on GRP's role in Climate Model Validation concludes that current tests of Global Climate Models (GCMs) quality of present climate simulations are insufficient. This leads to suboptimal models, suggesting that higher order tests are needed to examine model physics. Observationally based data sets needed to make these higher order tests feasible exist today. Many of these tests have been published in the literature and tested on GCM output but have not been widely adopted or standardized. The white paper outlines specific tests, such as the "the global annual and seasonal exchanges of water and energy between the surface (separately or ocean and land) and the atmosphere."

The White Paper paper on Cloud, Aerosol and Precipitation (CAP) products is examining what role GRP should play in contributing effectively to the understanding of CAP processes? Much of our current lack of understanding is related to three areas: (1) aerosol indirect effects; (2) cloud processes controlling surface precipitation; and (3) cloud processes associated with latent and radiative heating. Combining data from various satellites, such as TRMM and CloudSat, has already contributed to our understanding of the CAP problem. GRP therefore supports the collection and analysis of data taken with current and future (e.g., Global Precipitation Mission) satellites and encourages the development of a unified global data set containing cloud products, aerosol products, actual and derived precipitation measurements and atmospheric conditions at co-located points.

While data stewardship is not a formal white paper, GRP recommends that sensor calibration, intercalibration and stewardship be performed within a global framework with common metrics and goals. WCRP could aid in this and prevent the splintering of this activity into competing or isolated, agency centric activities.

The next meeting of the GRP will occur in conjunction with the Second Pan-GEWEX Science Meeting in Seattle, Washington on 23–27 August 2010.

GWSP Science Committee Meeting

18–20 October 2009
Stellenbosch, South Africa

Richard G. Lawford
International GEWEX Project Office

The Global Water System Project (GWSP), one of four interdisciplinary global projects under the Earth Science System Partnership (ESSP), held its annual science committee meeting following the Biodiversity Congress in Cape Town, South Africa. The GWSP has undergone a number of changes during the past year as a result of renewed support from the German Government. The International Project Office has recently been staffed with a new director, Dr. Janos Bogardi; scientific officer, Dr. Konrad Vielhauer, and administrative officer, Gisela Ritter Pilger.

Janos Bogardi

GWSP is now in the fifth year of its 10-year implementation plan. The current middle phase is focused on the delivery of short- and medium-term projects that were launched in the first phase of the Project and on preparing for legacy activities that will be undertaken in the final phase of the project. During the Data Synthesis and Application phase, emphasis will be given to the preparation of synthesis documents and related legacy activities. GWSP has been pursuing initiatives and activities to strengthen its links with other global change projects and is also supporting the Integrated Global Water Cycle Observations Community of Practice through the development of "State of the Global Water System" products.

The meeting in Stellenbosch attracted a number of South African scientists who presented reports on local water issues. The committee received extensive reports from the leaders of the individual GWSP projects as well as shorter reports on related projects including ESSP, GEWEX, the International Human Dimensions Programme, and the Group on Earth Observations Water Societal Benefit Area.

In terms of past products, the Digital Water Atlas has been a major GWSP success. This atlas, which is accessible through the GWSP web site, has more than 100 registered users and has had more than 25,000 visits since being placed online in 2008.

NOAA/NCEP Climate Forecast System Reanalysis (1979–2010) Now Available

http://cfs.ncep.noaa.gov

CFS was developed at the NOAA/NCEP Environmental Modelling Center and is a fully coupled model representing the interaction between the Earth's oceans, land and atmosphere.

Three major themes form the backbone of the GWSP. The Global Scale Initiative has three subthemes, including efforts to develop: (1) global estimates of major changes in the global water system; (2) interdisciplinary indicators of global water resource stress; and (3) global analysis and mapping of major agents of change. The Global Catchment Theme is carrying out an analysis of how water managers in large river basins use monitoring and prediction information in decision-making. Some of these large basins coincide with the GEWEX/Coordinated Energy and Water Cycle Observations Project (CEOP) Regional Hydroclimate Project areas. As a result of this meeting, this theme added its first North American basin, specifically the Lake Winnipeg Basin, which is also the GEWEX Drought Research Initiative area.

The Global Water Needs Initiative, the third major GWSP theme, is developing a global consensus on assessment of environmental flow needs, estimating the value of freshwater ecosystem goods and services and devising strategies for harmonizing the water needs of humans and nature. Progress has also been made on some of the GWSP's cross-cutting activities, including global governance and capacity building [in collaboration with the Global Change SysTem for Analysis, Research and Training (START) and NuWater].

During the breakout session, four new priority initiatives were identified: (1) water constraints on new energy developments; (2) water indicators; (3) water indicators and health; and (4) water and migration. Workshops or other activities will be developed around each of these initiatives. Efforts are underway to find funding for these new proposals and to develop a plan for the second half of the GWSP initiative. In addition, plans are under development for a GWSP Science Conference in 2011. Open questions requiring further discussion involve the GWSP legacy and plans for the next phase of the Project.

GWSP has a number of common interests with GEWEX, particularly in the area of Hydrologic Application Working Group and some of the GEWEX data projects. It is anticipated that over the coming years several joint projects between GWSP and GEWEX will be launched to enhance the development of these bonds and to allow the GWSP activities to take full advantage of the support that can be provided by GEWEX and related WCRP projects.

31-Year (1979–2009) NLDAS-2 Forcings and Multi-Model Outputs Now Available

http://www.emc.ncep.noaa.gov/mmb/nldas

In collaboration with the Climate Prediction Program for the Americas (CPPA) Project, the NOAA/NCEP Environmental Modelling Center developed the North American Land Data Assimilation System-Phase 2 (NLDAS-2) of forcing, water fluxes, energy fluxes, and state variables from four land-surface models.

ECMWF/GLASS Workshop on Land Surface Modelling, Data Assimilation and the Implications for Predictability

9–12 November 2009
Reading, United Kingdom

Anton Beljaars[1], Gianpaolo Balsamo[1], Patricia de Rosnay[1], Bart van den Hurk[2], and Martin Best[3]
[1]ECMWF, Reading, UK; [2]Koninklijk Nederlands Meteorologisch Instituut (KNMI), De Bilt, The Netherlands; [3]Met Office, Joint Centre for Hydro-Meteorological Research, Wallingford, UK

The European Centre for Medium-Range Weather Forecasts (ECMWF) and GEWEX Global Land/Atmosphere System Study (GLASS) Workshop reviewed recent research on land-atmosphere modelling, land data assimilation, new observations and the role of soil moisture and snow in predictability in the subseasonal time range. Quality assessment of models by standardized procedures for model verification and benchmarking was also addressed. It is clear that a wide range of physical processes at the land-surface is relevant to improving predictability. Following the presentations, four working groups gave their recommendations on priorities for further research by ECMWF and the GLASS community and these are summarized below.

The **Working Group on Land-Surface Modelling and Applications** reported that representation of lakes and rivers in hydrological models is necessary for accurate land-atmosphere and land-ocean water flux predictions. The inclusion of cold processes (particularly snow accumulation and melting in heterogeneous terrain) and warm processes (e.g., evaporation and soil heat transfer) would provide the greatest potential for improvement in Numerical Weather Prediction (NWP) and climate forecasts. Land-surface models will benefit from the increasingly higher spatial resolution of remotely-sensed Earth observation data and will help to establish process-oriented schemes to replace those based on effective parameters or dominant land-use type. Finally, interactive vegetation and carbon processes should be included to bridge the gap between NWP land-surface schemes and Earth system models.

The **Working Group on Land-Surface Data Assimilation** noted that current improvements in surface data assimilation systems open a wide range of possibilities to take advantage of past, current and future satellite data. Exploiting synergies between the different types of data (soil moisture, vegetation, snow, albedo and land-surface temperature) has been identified to be of high importance for land-surface analysis activities. To achieve this, ECMWF is in a very good position to implement a multi-variate land-surface data assimilation system for NWP. A posteriori diagnostics on the land data assimilation system would be important for evaluating the self-sensitivity of different observation types.

Stand-alone (without atmospheric analysis) and offline (forced by atmospheric fields) surface analyses are under development at ECMWF and these procedures will be of great interest for seasonal forecast and reanalysis activities, as well as for research and development. In this context, the first Project of Intercomparison of Land Data Assimilation Systems (PILDAS) was suggested as a new GLASS activity.

The **Working Group on Observations for Terrestrial Surfaces** noted the importance of investigating the benefit of assimilating albedo, vegetation parameters, land-surface temperature and snow cover extent using satellite data. Physiographic information (e.g., land-use and elevation maps) is also important to take into account in land-surface modelling and data assimilation systems.

Validation and benchmarking activities should consider both ground-based and satellite data. Comparing established observation networks [e.g., the Flux Tower Network (FluxNET), the GEWEX Coordinated Energy and Water Cycle Observations Project (CEOP), and Snopack Telemetry observations (SNOTEL)] with model and data assimilation results could be very useful. ECMWF was encouraged to create a structured set of ground data to verify land-surface modelling and analysis results on a systematic basis. Satellite data provides two-dimensional information that is relevant for verification of radiative and evaporative fluxes as well as land-surface temperature.

Global meteorological forcing data sets are crucial to support coordinated activities such as land-surface model intercomparison projects. Modern reanalyses [e.g., ECMWF ReAnalysis-Interim (ERA-Interim)] with appropriate bias corrections for precipitation are suitable for this purpose and should be extended to cover multi-decadal periods.

The **Working Group on the Contribution of Land-Surface to Predictability** reported that research efforts to improve long-term prediction across several NWP and climate research centers have indicated the crucial role of the land-surface. This is associated with the slow surface processes for which initial anomalies persist through the forecast (due to memory effects) for days and weeks. Large multi-model projects such as the GEWEX Global Land-Atmosphere Coupling Experiment (GLACE) provided evidence of strong coupling between soil moisture and precipitation in mid-latitude and tropical areas. Results from GLACE-2 helped to quantify the predictability gain coming from accurate land-surface initial conditions up to two months in the future.

More accurate snow cover and snow depth are also considered to be a high priority for model initialization. Snow processes have an impact on temperature profiles in northern latitudes and teleconnections with large-scale circulation patterns, such as the Indian monsoon. It would be highly beneficial to investigate both local and remote impacts of snow through GLACE-type exploratory experiments.

Reports on the working group discussions will be published in the forthcoming proceedings together with short papers on the individual contributions. Workshop presentations are available at: *http://www.ecmwf.int/newsevents/meetings/workshops/2009/Land_surface_modelling/presentations.html*.

Conference on Earth Observation and Water Cycle Science: Towards a Water Cycle Multi-Mission Observation Strategy

ESA-ESRIN, Frascati, Italy
18–20 November 2009

Peter van Oevelen
International GEWEX Project Office

Nearly 200 scientists from 30 countries assembled at this Conference to assess state-of-the-art observations and scientific research for characterizing global water cycle variability and identifying the main needs in modelling and data assimilation to improve our knowledge and ability to quantify future changes in water cycle variables. Organized by the European Space Agency (ESA), GEWEX, the European Geosciences Union (EGU), and International Society for Photogrammetry and Remote Sensing, this was the first in a series of EGU topical conferences on the hydrological cycle.

The plenary discussions focused on current gaps in water cycle research and provided valuable input to the strategy and future directions of global climate research programs, such as GEWEX. Presentations were given on current and planned space missions, precipitation, clouds and water vapor, turbulent energy fluxes, evapotranspiration, floods and droughts, modelling the water cycle, and soil moisture. In addition, Dr. Yann Kerr, the lead investigator for the recently launched Soil Moisture and Ocean Salinity Mission, unveiled the first data sets from the satellite.

Round table discussions focused on the main gaps and scientific challenges ahead to better observe, monitor and characterize the different components of the water cycle in view of improving our ability to cope with water management and governance in a world where water is more and more at the center of international law, policy and conflicts. Also discussed were the challenges and opportunities in water cycle science in reducing uncertainties in water-related climate change impacts and adaptation strategies in water resources. The Conference recommendations represent a major step for a scientific roadmap that outlines the main priorities for the development of new global geo-information data products, improved models and effective data assimilation systems.

Earlier this year, ESA initiated, as a part of its new Support To Science Element Program and in collaboration with GEWEX, the Water Cycle Multi-Mission Observation Strategy (WACMOS). This project supports the development of novel techniques to study the water cycle using satellite-derived Earth observations. WACMOS is carried out by an international team of experts led by the International Institute for Geo-Information Science and Earth Observation (ITC) located in The Netherlands. The WACMOS team presented preliminary results of its activities addressing key elements of the water cycle, including global evapotranspiration, soil moisture, clouds and water vapor. This project, among others, as well as the Conference results, represents ESA's contribution to the international coordination effort carried out by GEWEX to better understand, describe and predict the global water cycle.

Mark Your Calendar for These Events

2nd Pan-GEWEX Science Meeting
Seattle, Washington, USA
23–27 August 2010

The Meeting will bring together the project and working group members of the three GEWEX Panels [GEWEX Radiation Panel (GRP), GEWEX Modelling and Prediction Panel (GMPP), Coordinated Energy and Water Cycle Observations Project (CEOP)] to develop a plan for GEWEX science post-2013. The meeting will address how the GEWEX panels and their projects will achieve their Phase II goals over the next 2 years, while also setting the stage for new directions and initiatives in 2013 and beyond that fit within the new World Climate Research Programme structure.

WCRP-UNESCO (GEWEX/CLIVAR/IHP) Workshop on Metrics and Methodologies of Estimation of Extreme Climate Events
UNESCO Headquarters, Paris, France
27–29 September 2010

The Workshop will focus on phenomenology and the methodological aspects of quantitative estimation of different climate extremes under observed and future climate conditions using observational and model data. The goal of the Workshop is to facilitate an open dialogue between climatologists from different research areas (meteorology, hydrology, oceanography), data producers (in situ, satellites, numerical weather prediction, climate model community), and statisticians on a future strategy for the development of robust and reliable characteristics of extremes and the optimal methodologies for their estimation. An important issue, the estimation of extremes—metrics, methodologies, and uncertainties—is a critical gap that prevents their accurate quantification and prediction, and will be a focus of the workshop.

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GEWEX/WCRP Calendar

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

13–16 April 2010—11th 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.

28–30 April 2010—Workshop on Cold Regions Hydrology—Innsbruck, Austria.

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

10–13 May 2010—IGBP/AIMES Earth System Science: Climate, Global Change and People—Edinburgh, UK.

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

19–21 May 2010—SORCE Science Meeting–Solar and Anthropogenic Influences on Earth—Keystone, Colorado, USA.

31 May–2 June 2010—UNESCO/IOC International Symposium on Boundary Current Dynamics—Qingdao China.

8–10 June 2010—4th HyMEX Workshop—Bologna, Italy.

8–10 June 2010—IPY Oslo Science Conference—Norway.

14–16 June 2010—Regional Climate Modelling Workshop—Lille, France.

14–18 June 2010—6th Study Conference on BALTEX—Miedzyzdroje, Island of Wolin, Poland.

22–25 June 2010—2nd Hydrology delivers Earth Stystem Science to Society Int'l Conference—Tokyo, Japan.

22–25 June 2010—Joint Meeting for GSWP/GLASS, AsiaFlux/FLUXNET, and LandFlux-EVAL—Tokyo, Japan.

22–25 June 2010—GEWEX Cloud Assessment Workshop—Berlin, Germany.

28–30 June 2010—15th Int'l Symposium for the Advancement of Boundary Layer Remote Sensing—Paris, France.

28 June–2 July 2010—13th Conference on Cloud Physics and Atmospheric Radiation—Portland, Oregon, USA.

29 June–1 July 2010—International Climate Change Adaptation Conference Gold Coast—Queensland, Australia.

29 June–1 July—Tenth IHP/IAHS George Kovacs Colloquium: Hydrocomplexity: New Tools for Solving Wicked Water Problems—UNESCO, Paris, France.

19–21 July 2010—Second International Workshop on Energy and Water Cycle over the Tibetan Plateau and High-elevations—Lhasa, China.