GEWEX WCRP NEWS

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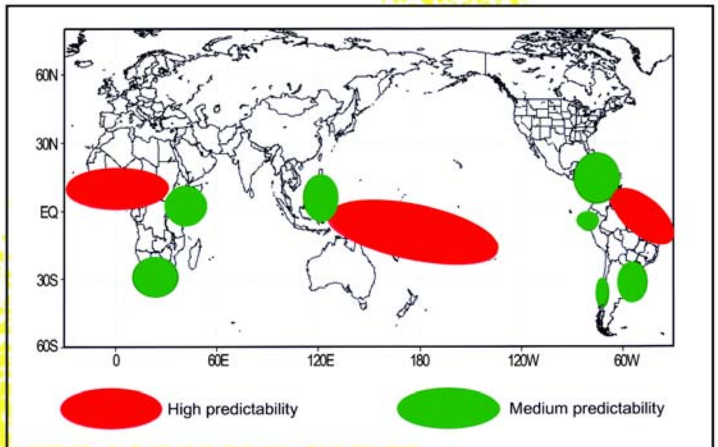
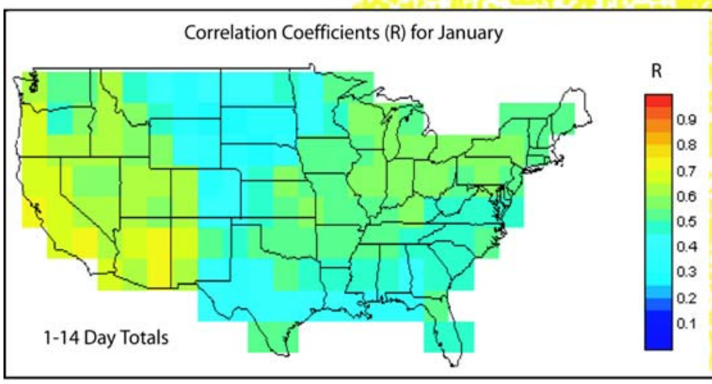
PREDICTION OF PRECIPITATION: AN ELUSIVE GOAL

GEWEX ADVANCES PREDICTION CAPABILITIES BY:

– **Model Intercomparisons**
– **Improved Process Understanding**
– **Improved Data and Data Assimilation**
– **Ensemble Prediction Techniques**



Areas of high and medium predictability of annual precipitation (documented in a multi-model study described on page 6).



Prediction systems are limited by observational inputs and models (examples of correlations between ensemble means and observations). See article on page 10.

Newsletter Contents

COMMENTARY

PREDICTION AND PREDICTABILITY CONCEPTS AND GEWEX

Soroosh Sorooshian, Chairman
GEWEX Scientific Steering Group

Discussions about various interpretations of prediction and predictability concepts have been going on for quite some time but in the past few years have become livelier thanks to the recently announced WCRP strategy, the Coordinated Observation and Prediction of the Earth System (COPES), which has made the topic of predictability and climate prediction its central focus for the 2005–2115 period. A number of definitions have been given for these two concepts. A 2002 United States National Research Council water cycle workshop defined hydrologic predictability as a measure of "*our ability to observe and characterize hydrologic systems and it is bounded by the inherent limits-to-prediction of the system...[which] are intimately tied to the observability of the system and the way in which variability propagates through both the components of the water cycle and across its scales.*" The term "prediction" on the other hand is often used to describe the future state of the climate as it relates to the average conditions and its range of variability and Earth-surface states, such as precipitation, temperature, humidity, and winds.

GEWEX has separated predictability and prediction in the articulation of its objectives. In short, predictability is more theoretical, aiming to push the limits of prediction accuracy towards "perfection," while prediction represents present ability to produce reliable and useful predictions. Models are the main engine in both cases. GEWEX contributes to model improvements through activities led by the three GEWEX panels and the Coordinated Enhanced Observing Period and International Satellite Land-Surface Climatology Project.

GEWEX focuses on those aspects in which it has expertise and relies on other programs for the areas in which more can be accomplished collaboratively. GEWEX has been emphasizing the utilization of higher resolution observations and improving the representation of land-surface processes in models. Our strong working relationship with the Programme on Climate Variability and Predictibility (CLIVAR) in a number of areas includes our reliance on them for global scale predictions where oceans play a dominant role. We look forward to working closely with the new WCRP Modelling Panel that has been established under the umbrella of COPES.

While its contributions to the more theoretical aspects of predictability will be continued, GEWEX has an even more critical role in the current state of the art of climate prediction for use in an increasing range of practical applications and of direct relevance and benefit to society. For this reason GEWEX promotes and works towards an end-to-end prediction system. For example, we now can reasonably predict the onset of El Niño, months (or a season) in advance and with these events have some strong statistical evidence that the Southwestern United States may experience wetter than average winters. This knowledge alone is not sufficient to help water resources and reservoir managers to plan and take operational actions to benefit their system operations. An end-to-end approach requires that longer term predictions be linked to short- term event forecasts and that the uncertainties of these forecasts be specified. We also need to monitor forecast accuracy as a measure of our progress.

In this arena, the challenges are immense and will require close collaboration with other projects and programs. Given the role of uncertainty in observations and prediction systems, it is not surprising that new approaches to prediction such as ensemble techniques are becoming popular since these methods can show the range and variability in forecast outcomes for a particular initial condition. Our promotion and cooperation with the grass roots Hydrologic Ensemble Prediction Experiment (HEPEX) effort addresses this issue. In addition, we have initiated dialogue with a number of international hydrology programs such as the United Nations Environmental, Scientific and Cultural Organization's (UNESCO) Water and Development Information for Arid Lands–A Global Network and the International Association of Hydrological Sciences Project for Ungauged Basins (see my commentary in the May 2005 issue of *GEWEX NEWS*).

The user community is the ultimate judge of our ability to provide useful predictions and relevant information. Hence, climate prediction evaluation tools and hydrologic verification tools are very important. The procedures shown at *http://hydis6.hwr.arizona.edu/ForecastEvaluationTool* are a good example of the former, but the latter has completely been ignored until recently. Hydrologic verification lags far behind verification procedures used for weather forecasts such as skill scores. We rely on our Water Resources Application Panel (WRAP) to take the lead in this area. To encourage this new approach, I plan to propose at the upcoming GEWEX SSG that we change the name of WRAP to the Hydrologic Applications Project (HAP) to more realistically reflect GEWEX contributions to improved hyroclimate predictions.

GEWEX WELCOMES THE NEW DIRECTOR OF WCRP

Beginning January 2006, Prof. Ann Henderson-Sellers will be the new Director of the Joint Planning Staff of the World Climate Research Programme. Prof. Henderson-Sellers, now Head of the Institute for Nuclear Geophysiology under the Australian Nuclear Science Technology Organization, has had a long history with GEWEX as the lead investigator for the Project for Intercomparison of Land-surface Parameterization Schemes (PILPS) and the more recent Isotopes in PILPS (iPILPS).

A mathematician, with a Ph.D. and D.Sc. in atmospheric science, Prof. Henderson-Sellers is an ISI "most highly cited" author of 452 publications, including 13 books. She is an elected Fellow of the American Geophysical Union and the American Meteorological Society and has served on Australia's Science and Technology and Greenhouse Science Advisory Councils, and various international and national committees in climate, environmental policy and Earth sciences. Prof. Henderson-Sellers is also a company director and Fellow of Australia's Institute of Company Directors and Academy of Technological Sciences and Engineering. She was awarded the Centenary Medal of Australia for Service to Australian Society in Meteorology in 2003.

GEWEX/IGWCO MEETING IN UK

A meeting in October was held at the British National Space Centre with Natural Environment Research Council (NERC)-funded researchers to explore possible links between United Kingdom experts and GEWEX, and the Integrated Global Water Cycle Observations (IGWCO) theme. A number of recommendations for collaborations in areas such as soil moisture, observations to support flood forecasting, capacity building and UK Earth observation activities such as the Flow Regimes from International Experimental and Network Data (FRIEND) will be addressed through IGWCO and GEWEX. These activities are expected to support the enhancement of GEWEX activities in Europe.

CAPACITY BUILDING WORKSHOP IN LATIN AMERICA

Buenos Aires was the site of a Latin America Capacity Building workshop on "Earth observations in the service of water management" on October 26 to 28, 2006. The Workshop, which was organized by the Comision Nacional de Activadades Espaciales (CONAE) and the Integrated Global Water Cycle Observations (IGWCO) theme/GEWEX, highlighted applications of Earth observations in the water management sector. Specialists from North America, Japan and Europe in data assimilation, snow observations, remote sensing for hydrology, water quality and applications participated in the workshop and presented overviews of the observation and analysis capabilities in these different areas. Specialists from more than 12 Latin American countries contributed to the discussions and presented research results and descriptions of their observational programs and needs for Earth Observations.

NASA NEWS UPDATE

The National Aeronautics and Space Administration (NASA) Energy and Water Cycle Study (NEWS) held its kickoff meeting in New York on September 7 to 9, 2005 with representatives from 25 newly approved NEWS projects in attendance. Based on the science results and project plans presented at the meeting the NEWS implementation plan is being modified for release in an open forum through the NEWS website at *http://wec.gsfc.nasa.gov/*. The GEWEX community is invited to comment on this plan.

CONTINENTAL-SCALE EXPERIMENTS STRENGTHEN THEIR PROJECT IMPLEMENTATION CAPABILITIES

Dr. Marcus Reckermann has joined the Baltic Sea Experiment Secretariat as a full-time staff member. He is a Biological Oceanographer and his primary field of research is the microbial food web dynamics in the sea. Dr. John Gibson, currently with the Australian Nuclear Science and Technology Organization on secondment from Environment Canada's National Water Research Institute, has joined the Murray Darling Basin Project. He has a background in Earth Sciences and Mathematics with special interests in stable isotope hydrology.

ENSEMBLE WEATHER AND CLIMATE PREDICTION

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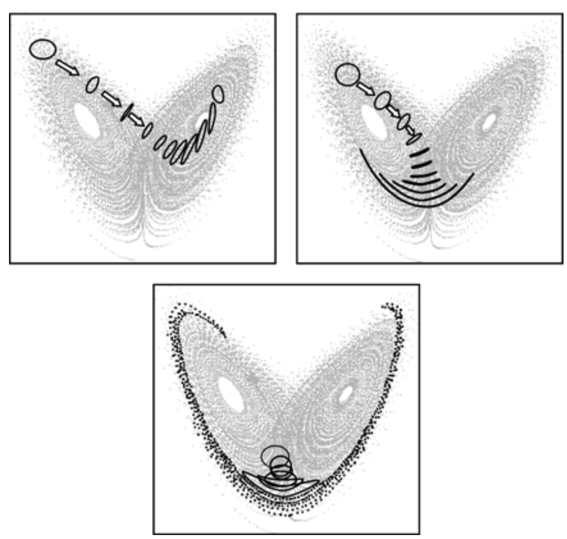
The use of ensemble forecasting techniques has grown enormously in the last few decades. Pioneers such as Ed Lorenz, Ed Epstein and Phil Thompson introduced ideas in the 1960s and 1970s that took root in the 1980s in the area of monthly forecasting (Lewis, 2005). In the 1990s ensemble prediction techniques were used in operational medium-range and seasonal-interannual forecasting. In this decade both short-range and climate-change ensemble forecasts became possible. This article addresses three questions: (1) What is the scientific basis for ensemble prediction? (2) What is the value of ensemble forecasting? (3) What are the important research areas for ensemble prediction, especially with regard to GEWEX science?

Forecasts of weather and climate are inherently uncertain and forecasts with error bars are more valuable than forecasts without them. Although error bars can be estimated from a set of past forecasts, predicting uncertainty using ensemble forecast techniques is more reliable. The reason for making this assertion is that the climate system is non-linear so that the evolution of initial uncertainties depends on the flow; sometimes (and in some places) the flow will be stable and small initial perturbations will grow minimally, while on other occasions (and places) the flow will be unstable and initial perturbations will grow rapidly. This effect of non-linearity can be illustrated using the prototypical Lorenz model (1963). See the figure on this page. Consequently, ensemble prediction systems are practical tools to forecast the flow-dependent predictability of weather and climate. Furthermore, for cases where we cannot estimate error bars from a set of past forecasts, such as in predicting climate change, ensemble prediction techniques are essentially our only chance of estimating forecast uncertainty.

Going from theory to practice is a big step because the underlying uncertainties in making weather and climate forecasts are not fully understood. Many people break the forecast problem down into initial condition uncertainties, model uncertainties and other uncertainties (such as emissions). This is not as meaningful a delineation as it may appear. First, initial conditions are uncertain because the measuring instruments are not perfectly accurate and do not cover the Earth in its entirety. However, initial conditions are also uncertain because the observations, typically point or pixel, are influenced by circulations which the assimilating model is incapable of simulating properly due to truncation (i.e, model) errors. Also, initial conditions are uncertain because assumptions underlying the data assimilation procedures (e.g., gaussianity of error statistics) are uncertain.

In practice, if a researcher deals with only one source of uncertainty, such as developing an ensemble data assimilation system in which random uncorrelated errors are added to the observations, the corresponding forecast ensemble will be underdispersive, and the forecast verification will lie outside the cloud of ensemble members. More dispersive ensembles can be produced by inflating the random observation errors. However, this would be problematic because one would be compensating for an under-representation of one source of error by over-representing another source of error. Operational forecast centres such as the European Centre for Medium-Range Weather Forecasts (ECMWF) and the National Oceanic and Atmospheric Administration's National Centers for Environment Prediction (NCEP) have taken a different approach to representing initial uncertainty by projecting initial perturbations onto patterns of instability of the atmosphere, as determined by techniques known as singular vectors and breeding vectors (Kalnay, 2003).



The scientific basis for ensemble forecasting illustrated by the prototypical Lorenz (1963) model for low order chaos, showing that in a nonlinear system, predictability is flow dependent. Top left: a forecast with high predictability, top right: forecast with moderate predictability, bottom: forecast with low predictability.

The representation of model uncertainty is a developing subject. Currently used methods include multi-model ensembles; perturbed-parameter ensembles; and stochastic physics. Each method is viable but has its own different strengths and weaknesses (Palmer et al., 2005).

The value of ensemble prediction lies in its usefulness for decision makers who can be given forecasts in which the flow-dependent uncertainties are estimated as accurately as possible. Decision makers in weather or climate sensitive areas of activity want to know: what is the risk that tomorrow will be very windy, that the next season will be very wet, or that the Earth will warm up sufficiently to melt the Greenland ice cap? A probability for each event can be estimated from an appropriate ensemble forecast. Providing validation data exists (less so for predictions of climate-change), techniques to estimate the performance of such probability forecasts can be applied to a set of ensemble forecasts (Jolliffe and Stephenson, 2003).

Ultimately the usefulness of ensemble forecasts on weather and climate timescales lies in estimates of value for decision makers (Palmer, 2005). Through institutes such as the London School of Economics and the Oxford Business School, ECMWF is assessing the economic value of ensemble forecasts in weather and climate-sensitive markets such as energy production (Roulston et al., 2003; Taylor and Buizza, 2003).

Three GEWEX-specific activities which link with ensemble-prediction research are given below.

1. *Hydrology*. Hydrology is an application area within the GEWEX Hydrometeorology Panel where ensemble forecast techniques are potentially very valuable. The methodology requires that the applications model is run many times, being forced by each individual member of the weather or climate ensemble. In the case of hydrology applications, the result can be a forecast probability of river discharge based on catchment-basin precipitation forecasts. See related article on the Hydrologic Ensemble Prediction Experiment (HEPEX) on page 10.

2. *Representation of model uncertainty.* Methods to represent model uncertainty in ensemble prediction systems can be developed using cloud-resolving models as truth. For example, by coarse-graining a cloud-resolving model over a General Circulation Model (GCM) grid box, one can compare a GCM-parameterized sub-grid tendency with the "true" sub-grid tendency (Shutts and Palmer, 2005). The work of the GEWEX Cloud System Study (GCSS) is particularly relevant in this respect.

3. *Stochastic land-surface models.* Building stochasticity into Earth-System models is very relevant in the drive to have a full representation of model uncertainty in ensemble systems. There is a need to develop stochastic land models for weather and climate prediction and some early ideas in these areas have been formulated (R. E. Dickinson, personal discussion).

In the 20th century, the study of predictability was considered a rather idealized, ivory-tower pursuit, compared with the more practical process of prediction. However, in the 21st century, predicting predictability, on all timescales from hours to centuries, is just as practical and important as predicting rainfall and temperature on these timescales. This transformation of the notion of predictability, from the ivory tower to the operational forecast centre, has arisen from the development of ensemble prediction systems. However, the development is not complete, and there is much to be done to improve the representation of uncertainty in weather and climate prediction.

References

Jolliffe, I. T., and D. B. Stephenson, 2003. *Forecast Verification,* Wiley 240 pp.

Kalnay, E., 2003. *Atmospheric Modelling, Data Assimilation and Predictability,* Cambridge University Press, 341 pp.

Lewis, J. M., 2005. Roots of ensemble forecasting, *Mon Wea Rev.,* 133, 1865–1885.

Lorenz, E. N., 1963. Deterministic non-periodic flow, *J. Atmos. Sci.,* 42, 433–71.

Palmer, T. N., 2005. Progress towards reliable and useful seasonal and interannual climate predictions, *WMO Bulletin,* 53, 325–332.

Palmer, T. N., G. J. Shutts, R. Hagedorn, F. J. Doblas-Reyes, T. Jung, and M. Leutbecher, 2005. Representing Model Uncertainty in Weather and Climate, *Annu. Rev. Planet Sci.,* 33, 163–193.

Roulston, M. S., D. T. Kaplan, J. Hardenberg, and L. A. Smith, 2003. Using medium-range weather forecasts to improve the value of wind energy production, *Renewable Energy,* 28, 585–602.

Taylor, J., and R. Buizza, 2003. Using ensemble weather prediction in energy demand forecasting. *Intern. J. Forecast.,* 19, 57-70.

Shutts, G. J., and T. N. Palmer, 2005. Statistical fluctuations in convective forcing computed from a cloud-resolving model and their relevance to the parametrisation problem, *J. Clim.* submitted.

GLOBAL CLIMATE PREDICTABILITY AT SEASONAL TO INTERANNUAL TIME SCALES

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Because of non-linear processes in the climate system, deterministic projections of climate variability and change are potentially subject to uncertainties arising from sensitivity to initial conditions or to parameter settings. Such uncertainties can be partially quantified from ensembles of runs from the same model or from ensembles of integrations from different climate models. To make reliable forecasts of weather and climate in the presence of both initial conditions and model uncertainty, it is now common to repeat the prediction many times from different perturbed initial states. This so called multi-initial condition ensemble has been useful in separating interannual climate variability into a chaotic component due to sensitivity to initial conditions, and a potentially predictable component based on the ensemble average (Goddard et al., 2003, Marengo et al., 2003).

Seasonal to interannual and longer climate variability has two components: (1) an externally forced component, which is the response to slowly varying external boundary forcing [sea-surface temperature (SST), sea ice, albedo, and snow coverage] and radiative forcing (greenhouse gases and aerosol concentration); and (2) an internally forced component, which is the atmospheric variability induced by internal dynamics and the weather noise or by strong land-surface feedbacks due to land surface processes (Guo et al., 2005).

The externally forced component is potentially predictable at long range assuming that the forcings themselves are potentially predictable. Predictability of climate at seasonal-to-interannual time scales at both global and regional scales must include an analysis of sources of predictability (boundary conditions versus initial conditions, as well as SST versus land surface boundary conditions), the El Niño/Southern Oscillation (ENSO) induced-predictability, as well as the ENSO induced teleconnections, and the influence of other ocean basins, such as the Atlantic and Indian Oceans. The land-surface potentially provides additional sources of extended predictability for climate. Much of the skill in predicting departures from normal seasonal totals or averages, often associated with atmospheric circulation patterns has its origin in the slowly changing conditions at the Earth's surface that can influence climate.

Simulations using specified SST have an extensive history, and a comprehensive review of relevant work can be found in Shukla et al. (2000) and Goddard et al. (2003), including the Atmospheric Model Intercomparison Project (AMIP) climate simulations. Land surface characteristics and processes also serve as slowly varying boundary conditions on climate simulations. Realistic representation of land-atmosphere interactions is essential to a realistic simulation and prediction of continental-scale climate and hydrology. For example, the interannual changes in snow coverage in the Himalayas plays a role in the onset of the Indian monsoon, while internal oscillations can account for a large part of the simulated monsoon variability. Both in the real world and in the modeling systems, the "memory" associated with continental moisture and the ability to forecast land-surface moisture state is limited. A recent paper by Guo et al. (2005) on the Global Land-Atmosphere Coupling Experiment (GLACE) shows both a wide variation in the strength of land-atmosphere coupling and the ability of soil moisture to affect precipitation. This coupling is examined in two stages: the ability of the soil moisture to affect evaporation and the ability of evaporation to affect precipitation.

This article reviews issues related to seasonal to interannual climate prediction and predictability during the summer rainy season at a global scale. We refer to the experiences in seasonal climate predictability at two of the World Meteorological Organization World Data Centres: the Center for Weather Forecasts and Climate Studies (CPTEC) in Brazil and the International Research Institute (IRI) in the United States. The dynamical climate predictions at IRI are currently made with six different atmospheric general circulation models. CPTEC runs the CPTEC/Center for Ocean-Land-Atmosphere Studies (COLA) Atmospheric General Circulation Model (AGCM) at T62 (Marengo et al., 2003). Each month, these models are run 10 times forming an ensemble (nine members at CPTEC), with one or two possible scenarios for the global SST, one to three seasons (3 to 9 months) into the future. In each set of ensemble runs for a given SST scenario, the only difference between each run is the initial atmospheric state (the current weather) at the beginning of the run.

We examine the statistical patterns of rainfall fields from seven models for the 1950–2000 period and assess the skill of the models for summertime at global scale, using the anomaly correlation score. Other skill scores such as Relative Operation Characteristics (ROC) and Ranked Probability Skill Score (RPSS) have been also explored, and since they show similar information we have chosen the anomaly correlation for the predictability analyses. One of the regions with the highest predictability is Northeast Brazil, while the central and southern Europe regions have low predictability (Marengo et al., 2003). The figure on the right side of page 1 shows the observed and simulated (CPTEC/COLA AGCM) annual cycle of rainfall for Northeast Brazil and Southwest Europe. Areas in red indicate higher predictability; areas in green indicate medium predictability, and lower predictability elsewhere. High predictability is defined in regions where anomaly correlation is larger than 0.6, medium predictability is defined for correlation values between 0.3–0.5, and lower predictability is defined for correlation values below 0.3. In Northeast Brazil the seasonal cycle is well reproduced even though the model systematically overestimates precipitation, while in Southwest Europe the seasonal cycle is not well simulated.

In Northeast Brazil the interannual variability is very well simulated, with the dry ENSO years in 1983, 1987, 1990–92 and 1998 accurately produced very low scatter among members. On the other hand, the interannual variability in Southwest Europe is not well simulated by the model and the scatter among members is quite large.

The figure below suggests indicators of regions with different levels of skill for seasonal climate predictions from seven models for the summer season. Regions were defined based on the values of the correlations. During the summer, tropical regions and some subtropical regions near the oceans have high and medium predictability, while low predictability for rainfall is found over the continental regions in both hemispheres, including the monsoon regions.

In summary, the skill scores from seven AGCMs indicate that in some regions, simulation of seasonal and interannual variations of rainfall remains problematic. Some of this lack of skill in simulating rainfall in these regions arises from the strong effects on internal atmospheric variability, possibly due to land-surface feedback mechanisms or the representation of sub grid scale processes, as discussed by Koster et al. (2000). In tropical regions much of the predictable atmospheric variability on interannual time scales is driven by SST anomalies, with the most important source of variability being El Niño. Other factors beyond the external forcing arising from SST anomalies may be important in other year-to-year climate variability, suggesting other limitations on climate predictability in these regions.

References

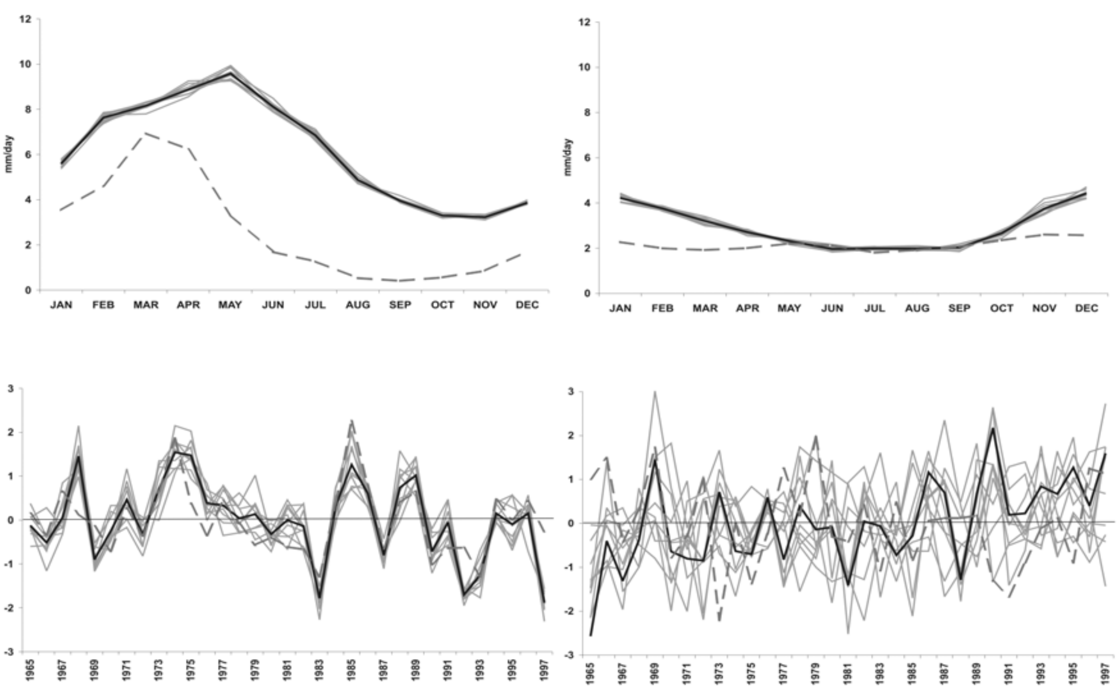
Goddard, L., A. G. Barnston, and S. J. Mason, 2003. Evaluation of the IRI's "Net Assesment" seasonal climate forecasts: 1997–2001, *Bull. Amer. Meteor. Soc.*, 84, 1761–1781.

Guo, A. Z., P. Dirmeyer, R. Koster, G. Bonan, P. Chan, P. Cox, et al., 2005. GLACE: The Global Land-Atmosphere Coupling Experiment Analysis (Submitted, *J. Hydromet.*).

Koster, R., M. J. Suarez, and M. Heiser, 2000. Variance and predictability of precipitation at seasonal-to-interannual timescales. *J. Hydromet*, 1, 26–46.

Marengo, J. A., I. F. A. Cavalcanti, P. Satyamurty, C. A. Nobre, J. P. Bonatti, et al., 2003. Ensemble simulation of regional rainfall features in the CPTEC/COLA atmospheric GCM. Skill and Predictability assessment and applications to climate predictions. *Climate Dynamics*, 21**,** 459–475.

Shukla, J., D. A. Paolino, D. M. Straus, D. De Witt, M. Fennessy, J. L. Kinter III, L. Marx, and R. Mo, 2000. Dynamical seasonal prediction with the COLA atmospheric model. *Q. J. Roy. Met. Soc.*, v. 126, p. 2265–2291.



Seasonal cycle (top) and interannual variability of rainfall in Northeast Brazil (left side) and Southwest Europe (right side). The dashed lines represent the observations (from CRU) and the thick black lines represent the mean of the members. The lighter lines represent each one of the individual members of the ensemble.

NCEP IMPLEMENTS MAJOR UPGRADE TO ITS MEDIUM-RANGE GLOBAL FORECAST SYSTEM, INCLUDING LAND-SURFACE COMPONENT

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Prediction systems often rely on physical process research to realize the model improvements needed to improve forecast skill. This article details recent improvements in the National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Prediction (NCEP) global model that have been derived in part from GEWEX research.

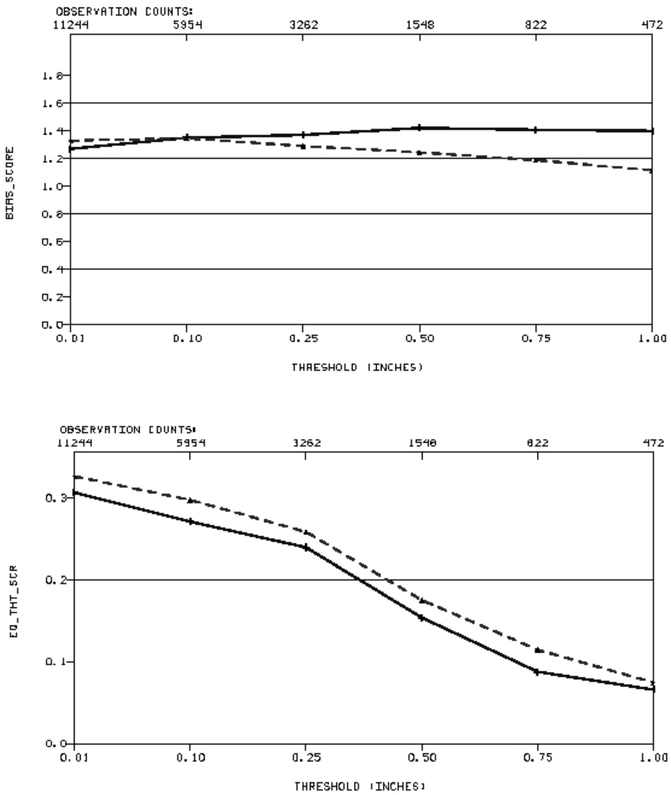
On 31 May and 14 June 2005, NCEP extensively upgraded the land-surface component of its Global Forecast System (GFS), including its Global Data Assimilation System (GDAS). Other substantial GFS upgrades were also implemented on May 31, including increased horizontal resolution from about 50 km (T254) to about 35 km (T382), a new sea-ice model, enhanced mountain blocking in the gravity-wave drag, modified vertical diffusion, and upgrades to the objective analysis in the GDAS (more satellite radiance data, enhanced quality control, and improved emissivity calculations over snow and sea ice). All the upgrades and names of the many contributors are given in the NCEP technical bulletin at: *http://www.emc.ncep.noaa.gov/gc_wmb/Documentation/TPBoct05/T382.TPB.FINAL.htm*.

This article describes the land surface model (LSM) upgrade, wherein the NCEP Noah LSM (Version 2.7.1) replaced the Oregon State University (OSU) LSM, which had been operational in the GFS since the mid-1990s. The Noah LSM embodies about 10 years of upgrades (see Chen et al., 1996; Koren et al., 1999; Ek et al., 2003) to its ancestor, the OSU LSM. These upgrades were developed and tested by the Environmental Modeling Center (EMC) Land Team, assisted by many collaborators, including the National Weather Service Office of Hydrological Development, National Environmental Satellite Data and Information Service Office of Research and Applications, National Center for Atmospheric Research, National Aeronautics and Space Administration, OSU, and university principal investigators of the GEWEX Americas Prediction Project, which is sponsored by the NOAA Office of Global Programs (OGP).

The Noah LSM upgrade includes an increase from two (10, 190 cm thick) to four soil layers (10, 30, 60, 100 cm thick), addition of frozen soil physics, new formulations for infiltration and runoff (giving more runoff for unsaturated soils), revised physics of the snowpack and its influence on surface heat fluxes and albedo, tuning and adding canopy resistance parameters, allowing spatially varying root depth, revised treatment of ground heat flux and soil thermal conductivity, reformulation for dependence of direct surface evaporation on first layer soil moisture, and improved seasonality of green vegetation cover. The frozen soil physics includes soil heat sinks/sources from freezing/thawing and influences vertical transport of soil moisture, soil thermal conductivity and heat capacity, and surface infiltration. The prognostic states of snowpack depth and liquid soil moisture were added to the already present prognostic states of snowpack water-equivalent (SWE), total soil moisture (liquid plus frozen), soil temperature, canopy water, and skin temperature. SWE divided by the snowpack depth gives the snowpack density. Total soil moisture minus liquid soil moisture gives the frozen soil moisture.

To provide initial values of soil moisture/temperature, the Noah LSM land states cycle continuously in the coupled atmosphere/land global model of the GDAS. These land states respond to the global model's predicted land-surface forcing (precipitation, surface radiation, near-surface air temperature, humidity, and wind speed). Since the land component of the GDAS is forced by model prediction rather than observed precipitation, we avoid undue drift by nudging soil moisture towards a monthly global climatology (in GDAS only, not in forecast).

For some years, the GFS had manifested two prominent biases in land-surface processes: 1) an early depletion of snowpack; and 2) a high bias in both surface evaporation and precipitation in the warm season in non-arid mid-latitude regions. The Noah LSM upgrade greatly reduces the early depletion of snowpack and the warm-season high bias in both surface evaporation and precipitation in mid-latitudes. (In the *online technical bulletin* cited earlier, figures 1 and 2 show the significant reduction of early snowpack depletion and figure 44 illustrates the reduced warm-season surface evaporation.) The top panel of the figure on the next page shows the reduced high bias in precipitation over the



Bias (top panel) and equitable threat score (bottom panel) as a function of 24-hour precipitation threshhold (inches) for 60–84 hour GFS forecasts from 00Z over eastern half of CONUS during 12–31 May 2005 (solid line represents the old GFS and the dashed line represents the new GFS). Labels at the top of the panels show counts of observed grid points in the verifying analysis at or above given threshold. Bias is ratio of forecast to observed count (bias=1 means no bias).

eastern two-thirds of the Continental United States (CONUS) during May 2005 in the new, versus old, GFS for the 60–84 hour forecast range. The bottom panel also depicts an increase in the precipitation forecast skill in the new, versus old, GFS. Precipitation results for other GFS forecast lengths and other regions (western CONUS, Amazon River basin) are given in figures 45–48 of the *online technical bulletin*. While the increase in precipitation forecast skill is likely due as much to the increase in model resolution as to the land surface model upgrade, the reduction of the positive precipitation bias is largely due to the LSM upgrade (see figure above).

Extensive pre-implementation testing of the Noah LSM upgrade by itself in the GFS was carried out, but at substantially lower spatial resolution (T62) to facilitate efficient execution of multi-year tests of the continuously cycled GDAS. Given the "long-memory" nature of land states, such multi-year tests with continuous cycling are critical for proper assessment of major land-surface upgrades, to allow sufficient spin-up of the land states under the physics/parameters of the new land model. GFS tests (not shown) with the new Noah LSM initialized from GDAS tests of insufficient length manifested significantly different land surface fluxes than those from GDAS/Noah-LSM tests that had cycled for more than one annual cycle.

Of additional note, when full resolution testing (T382) of the Noah LSM commenced in the GFS, it was found that tuning of several canopy resistance parameters (e.g., minimal stomatal resistance) was required to achieve the desired reduction in the high bias of GFS warm-season surface evaporation in mid-latitudes over non-arid regions. Figures 44–48 in the *online technical bulletin* cited earlier provide examples of GFS performance before and after the tuning of canopy resistance parameters. These examples show a direct link between the reduced surface evaporation and the reduced high bias in precipitation.

The Noah LSM had been previously implemented in NCEP's mesoscale Eta model and its data assimilation system (EDAS), and in NCEP's 25-year North American Regional Reanalysis. The implementation of the Noah LSM in NCEP's GFS positions the Noah LSM for inclusion in the next-generation upgrade of NCEP's ocean/atmosphere/land Coupled Forecast System (CFS) for seasonal forecasting. At NCEP, the atmosphere/land component of any future CFS upgrade for seasonal forecasting is unified with the atmosphere/land component of a recent operational version of the GFS for medium-range forecasting. Assessing the Noah LSM as the land component of the next-generation CFS is now a major thrust of the NOAA Climate Test Bed at NCEP, co-sponsored by NOAA OGP.

References

Chen, F., K. Mitchell, J. Schaake, Y. Xue, H.-L. Pan, V. Koren, Q.-Y. Duan, M. Ek, and A. Betts, 1996. Modeling of land-surface evaporation by four schemes and comparison with FIFE observations, *J. Geophys. Res.*, 101, No. D3, 7251–7268.

Ek, M. B., K. E. Mitchell, Y. Lin, E. Rogers, P. Grunmann, V. Koren, G. Gayno, and J. D. Tarpley, 2003. Implementation of Noah land-surface model advances in the NCEP operational mesoscale Eta model, *J. Geophys. Res.*, 108, No. D22, 8851, doi:10.1029/2002JD003296, 2003.

Koren V., J. Schaake, K. Mitchell, Q.-Y. Duan, F. Chen, and J. Baker, 1999. A parameterization of snowpack and frozen ground intended for NCEP weather and climate models, *J. Geophys. Res.*, 104, No. D16, 19569–19585.

THE HYDROLOGIC ENSEMBLE PREDICTION EXPERIMENT (HEPEX)

John Schaake[1], Kristie Franz[2], Allen Bradley[3], and Roberto Buizza[4]

[1]NOAA/National Weather Service, [2]University of California, Irvine, [3]University of Iowa, [4]European Centre for Medium-Range Weather Forecasts

Users of hydrologic predictions need reliable, quantitative forecast information, including estimates of uncertainty, for lead times ranging from less than an hour during flash flooding events to more than a year for long-term water management. The Hydrologic Ensemble Prediction EXperiment (HEPEX) is an international effort that brings together hydrological and meteorological communities to develop advanced probabilistic hydrologic forecast techniques that use new weather and climate ensemble forecasts. HEPEX will demonstrate how to produce reliable hydrological ensemble predictions that can be used with confidence to make decisions that have important consequences for the economy, environment, public health and safety.

The key science issue for HEPEX is reliable quantification of hydrologic forecast uncertainty. HEPEX plans to address the following key questions: (1) What are the adaptations required for meteorological ensemble systems to be coupled with hydrological ensemble systems? (2) How should the existing hydrological ensemble prediction systems be modified to account for all sources of uncertainty within a forecast? and (3) What is the best way for the user community to take advantage of ensemble forecasts?

HEPEX is a global project affiliated with GEWEX that helps GEWEX meet its water resource applications objectives. Also, it is an important GEWEX contribution to the over-arching WCRP Coordinated Observation and Prediction of the Earth System (COPES) initiative. HEPEX will rely on the International Association of Hydrological Sciences (IAHS) Predictions for Ungauged Basins (PUB) initiative for contributions of new science and data sets, and expects PUB to participate in its test bed projects. A brief description of HEPEX was recently published in *EOS* (Franz et al., 2005).

Participation in HEPEX is open to anyone wishing to contribute to its objectives. HEPEX activities include test bed projects, development of supporting data sets, development of components of a Community Hydrologic Prediction System (CHPS), and sponsorship of workshops and special sessions at scientific meetings. HEPEX test bed projects will be used to develop CHPS components and to meet the HEPEX demonstration goal. CHPS is expected to have an open systems architecture that will easily accommodate new forecast components and greatly accelerate infusion of new hydrologic science into hydrologic forecast operations. HEPEX invites potential forecast users to participate in HEPEX activities and the "Users Forum," which helps oversee activities to assure user needs are being addressed.

HEPEX builds upon two international planning workshops: the first was hosted by the European Center for Medium-Range Weather Forecasts, March 8–10, 2004, where the HEPEX science agenda was established and the second one was held at the National Center for Atmospheric Research, July 19–21, 2005, where several test bed projects were initiated.

HEPEX will interact with GEWEX by demonstrating how to use improved climate forecast products that GEWEX will help to produce. This could include developing a seamless approach to the application of weather and climate forecasts through collaboration with The Observing System Research and Predictability Experiment (THORPEX) Interactive Grand Global Ensemble (TIGGE) Project. TIGGE is expected to provide an ensemble of 2-week forecast inputs that can be used for hydrologic ensemble prediction.

Biases in weather and climate forecasts must be removed and the forecasts must be downscaled for hydrologic application. This requires an archive of forecasts and corresponding observations that can be used to estimate parameters of the hydrologic ensemble preprocessor. The archive of ensemble forecasts from the National Weather Service Global Forecast System for the period 1979 to the present is an important initial global source of meteorological ensemble forecasts to study this issue. A measure of the potential importance of the ensemble precipitation forecasts is the correlation between the ensemble mean and the corresponding observation. The high correlation for 14-day total precipitation (see figure on the left side of page 1) for most of the United States, and the eastern/midwestern United States and the mountainous west in particular, demonstrates their potential for improving hydrological predictions. For more information see the HEPEX website at http://hydis8.eng.uci.edu/hepex.

Reference

Franz, K., N. Ajami, J. Schaake, and R. Buizza, 2005. Hydrologic Ensemble Prediction Experiment Focuses on Reliable Forecasts, *Eos*, Vol. 86, No. 25.

CONTRIBUTIONS OF GAME AND CEOP TO OPERATIONAL PREDICTION SERVICES IN JAPAN

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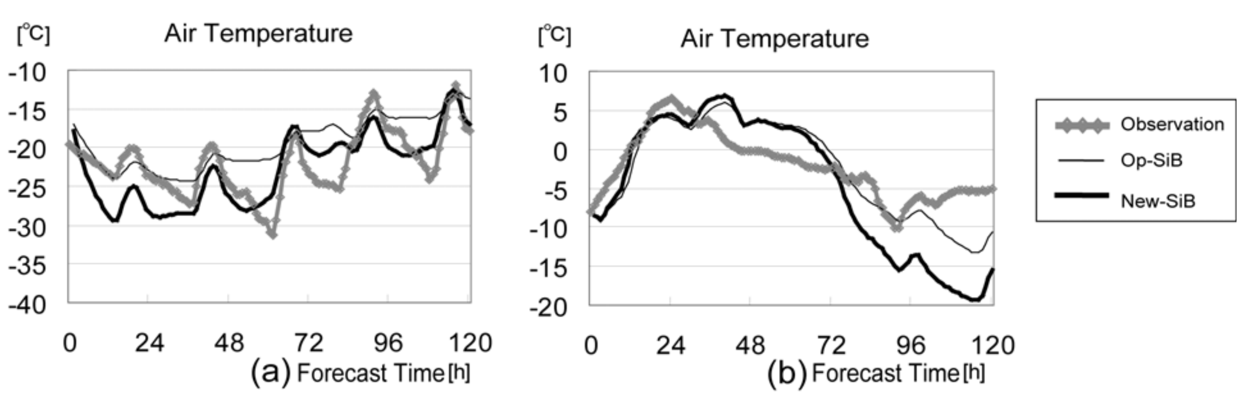
The GEWEX Asian Monsoon Experiment (GAME) was implemented in 1996 to understand the role of the Asian monsoon in the global climate system and improve long-range forecasting. The GAME reanalysis conducted by the Japan Meteorological Agency's (JMA) Meteorological Research Institute and Numerical Prediction Division (NPD) uses four-dimensional data assimilation (4DDA) to integrate operational and experimental observation data to produce a more comprehensive data set from the atmosphere and land surface hydrology. Phase I of GAME was successfully completed in 2001, the same year the Coordinated Enhanced Observing Period (CEOP) was launched. Under CEOP, collaboration with JMA's operational activity was extended. This article reviews the GAME reanalysis and collaborative activities carried out by JMA under GAME and CEOP.

In the summer of 1998 GAME conducted intensive sonde observations at the same time as the South China Sea Monsoon EXperiment (SCSMEX). All available off-line data observed in GAME and SCSMEX were analyzed using the operational JMA forecast model with T213 horizontal resolution (about 60 km resolution) and 30 vertical layers. The Prognostic Arakawa-Schubert convection scheme and 3D optimal interpolation assimilation schemes were also used in the model.

Two-dimensional precipitation and radiation fields, as well as fundamental atmospheric fields are provided at 1.25 by 1.25 degrees and 2.5 by 2.5 degrees globally. For the Asian and Pacific regions (30E-180W, 80N-30S), atmospheric fields were provided at a higher resolution (0.5 by 0.5 degree). GAME Reanalysis data are available at: *gain-hub.mri-jma.go.jp/GAME_reanal.html* for the 7-month period of 1 April to 31 October 1998 in 6-hour intervals.

A comparison of the GAME reanalysis and the Tropical Rainfall Measuring Mission (TRMM) precipitation is shown in the upper left figure on page 20. The left two, middle two and the right two groups show biases [root mean square error (RMS) in millimeters calculated daily] and correlation coefficients (multiplied by 100) between daily time series from each of three reanalyses (JMA, European Centre for Medium-Range Weather Forecasts, US National Centers for Environmental Prediction), analyzed precipitation and TRMM, respectively. Each value is averaged over 2.5 by 2.5 grids with TRMM Precipitation Radar (PR) estimates for a day. The Asian region is shown on the left-hand side and global coverage (0º–360, 30ºS to 40ºN) is shown on the right. Evaluation of the RMS error and time correlation show that precipitation from the GAME reanalysis is very reliable when compared to other reanalyses and operational analysis. Since precipitation is related to atmospheric divergence, good reproduction of precipitation implies high quality divergent fields.

Many process studies have used GAME reanalysis data. Research by Ueda et al. (2003) showed the



(a) 2-m surface temperature validation results for the CEOP Asia-Australia Monsoon Project (CAMP)/Inner Mongolia using 120-hr forecast time (FT) initialized for 1 January 2003 shows better diurnal temperature ranges from the new experimental Simple Biosphere (SiB) model than from the operational SiB when compared to observations. (b) Snowpack formation for BALTEX/Lindenberg shows the snowpack forming at 72 hrs FT. After that, the temperatures from the new SiB model are colder than the observations and the results of the operational SiB.

importance of pre-monsoonal latent heating in addition to conventional sensible heating around the Tibetan Plateau. Using an isotope circulation model forced by the GAME reanalysis data, Yoshimura et al. (2003) reproduced observed precipitation isotope variations. They found that transport and mixing process are important for 1–10 day variability of precipitation isotopes. Yokoi and Satomura (2005) used the GAME reanalysis data and other observational data and showed that the 10–20 day variation associated in Thailand precipitation is similar to an equatorial Rossby wave and has distinctive vertical structures. Yasunari and Miwa (2005) documented the large diurnal cycle of convection and circulation over the Tibetan Plateau that occasionally plays an important role in the development of mesoscale cloud systems in the Meiyu front over China.

In 2001, JMA began a joint Japanese Reanalysis project (JRA-25) with the Central Research Institute of Electronic Power Industry for the period of 1979 to 2004. JRA-25 uses 3DVAR data assimilation with an improved forecast model compared to the GAME reanalysis. JRA-25 includes GAME Intensive Observation Period sonde data and is considered to be an updated version of the GAME reanalysis for 1998.

JMA has supported CEOP through NPD which is providing operational products to the CEOP data archive. Furthermore, the Climate Prediction Division provides JRA-25 to this archive. NPD is using *in situ* observation data from the CEOP reference sites for global model validation, especially in the development of new land surface models.

Through these experiences, we have recognized the importance of model performance for accurate data assimilation. As shown here, model validation with observational data is an effective way to improve model performance. As CEOP provides useful integrated data sets for validation, cooperation with CEOP is one of the most important activities for model development at JMA.

References

Ueda, H., et al., 2003. Seasonal contrasting features of heat and moisture budgets between the eastern and western Tibetan Plateau during the GAME IOP. *J. Climate*, 16, 2309–2324.

Yasunari, T., and T. Miwa, 2005. Convective cloud systems over the Tibetan Plateau and their impact on mesoscale disturbances in Meiyu/Baiu frontal zone. *J. Meteorol. Soc. Japan* (in revision).

Yokoi S., and T. Satomura, 2005. An Observational Study of Intraseasonal Variations over Southeast Asia during the 1998 Rainy Season. *Mon. Weather Rev.*: Vol. 133, No. 7, pp. 2091–2104.

Yoshimura K., et al., 2003. A quantitative analysis of short-term variability with a Rayleigh-type isotope circulation model. *J. Geophys. Res.*, 108, 4647, doi:10.1029/2003JD003477.

DO DYNAMICAL MODELS PICK UP PAN-ARCTIC TELECONNECTIONS?

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Although our knowledge and understanding of the pan-Arctic climate system has improved in recent years, the existence and degree of pan-Arctic climate connectivity, and hence predictability, is not well known. Teleconnection patterns imply that the state of the atmosphere, ocean, and land surface at remote locations (from the mid-latitudes to the tropics) can impact conditions at high northern latitudes; and conversely, the state of the pan-Arctic domain can influence regions further to the south. These teleconnections are characterized by strong statistical relationships between climates in different regions that provide useful information for seasonal predictions, the study of large-scale land-surface-atmosphere interactions, and understanding atmospheric moisture/energy transport pathways.

Snow constitutes one of the most prominent and transient features of the pan-Arctic domain. Fluctuations in snow cover extent vary considerably in both space and time, especially during the transition seasons of spring and fall. Continental-scale snow anomalies substantially affect the surface radiation and water budgets, particularly during spring and early summer that appear to impact remote locations through large-scale teleconnections. There is a substantial body of research that has investigated a number of snow-related teleconnections including a relationship between Eurasian snow cover extent anomalies and the Indian summer monsoon; the role of boreal summer/fall snow cover extent anomalies in Eurasia and the Arctic Oscillation and the North Atlantic Oscillation and to wintertime storminess over N. America; and potential intercontinental teleconnection between simulated spring snow water equivalent (SWE) and soil moisture anomalies in Eurasia and meteorological fields in N. America.

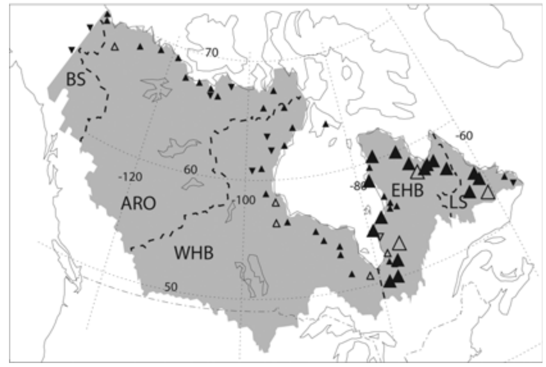
These studies provide evidence that Eurasian snow cover extent anomalies play a key role in pan-Arctic climate connectivity. However, the degree to which the Eurasian snow anomalies affect the terrestrial water budget in Canada remains unknown. Recent work by the authors is designed to explore the relationship between measured Eurasian snow cover extent anomalies and observed Canadian SWE and river discharge anomalies. Three independent data sets are used to investigate pan-Arctic climate connectivity: (1) monthly mean snow cover extent for

Eurasia covering the period 1973–2003 from the National Oceanic and Atmospheric Administration (NOAA); (2) N. American monthly mean SWE (in millimeters) gridded data at a resolution of 0.3° from the Canadian Meteorological Centre for the period 1980–1997 (Brown et al., 2003); and (3) daily streamflow records from the Water Survey of Canada's Hydrometric Database for 64 major rivers of northern Canada (Déry and Wood, 2005). The Eurasian snow cover extent anomalies are then correlated to the North American SWE anomalies to river discharge anomalies in 64 basins of northern Canada. Time lags or leads (from 0-12 months) are imposed in the calculations to determine possible causal relationships and only correlation coefficients with $p < 0.05$ are considered statistically significant. Déry et al. (2005) provide details on the data and methodology.

The figure on the top right side of page 20 shows the correlation coefficient between Eurasian snow cover extent anomalies in August and annual maximum SWE anomaly over Canada the following winter for the period 1980–1997. There also exist ($p < 0.05$) positive (negative) correlations between spring and summer Eurasian snow cover extent anomalies and northeastern (northwestern) Canada maximum SWE anomalies the following winter. There is a decline in the strength of the correlations when computed with the October Eurasian snow cover extent anomalies. No significant correlations are observed in southern Canada or the United States.

The figure on this page presents the annual Eurasian snow cover extent anomalies correlated to the annual streamflow anomalies of 64 rivers of northern Canada for which hydrometric data are readily available (Déry and Wood, 2005). The results suggest that river discharge into the Labrador Sea and Eastern Hudson Bay is strongly influenced by the preceding year Eurasian snow cover extent anomalies. Nineteen rivers of northern Québec and Labrador, draining an area > 0.6×10^6 km^2 and with a mean annual total discharge of 320 km^3 yr^{-1} show statistically significant positive correlations. These rivers exhibit a spatially coherent response to the Eurasian snow cover extent anomalies.

Simulations of the 20th century from eleven different dynamical climate model/configurations were obtained from the Intergovernmental Panel on Climate Change 4th assessment. The number of ensembles available varied across the models and ranged from 1 to 9 with the ensemble mean of each available model used in the following analysis. Correlations were computed between August Eurasian snow cover extent and following winter maximum SWE, and the results are shown for four represented models (see figure at the bottom of page 20). As can be seen, the models



The correlation coefficient between the Eurasian annual snow cover extent anomalies and the annual discharge anomalies for 64 rivers of northern Canada (gray shading) the following year, 1973–2003. Positive (negative) correlations are denoted by upward (downward) triangles, with statistically significant correlations (p < 0.05) denoted by larger symbols. Open triangles denote rivers affected by major dams, diversions, and/or reservoirs. The symbols are located at the coordinates of the measuring gauge of each river nearest the outlet to high-latitude oceans. Dashed lines denote five regional basins of northern Canada (LS, Labrador Sea; EHB, Eastern Hudson Bay; WHB, Western Hudson Bay; ARO, Arctic Ocean; BS, Bering Strait).

show statistically significant correlations over the study region, but the patterns are significantly different from the correlation patterns based on observations.

The above result has implications regarding current and future climate projections and predictions based on coupled climate models. The results in the figure at the bottom of page 20 show consistency across three of the models in that they have statistically significant correlations with SWE in the mountainous regions of the Canadian west coast and in the western US, which is absent in the observationally based correlations. This implies a teleconnection not supported by observations. Seasonal prediction skill by dynamical models requires that teleconnections and connectivity patterns be well simulated and be confirmed through observations. Ultimately, procedures for merging (skill-weighted) predictions from statistical models with those from dynamical models are needed to provide the most enhanced prediction product.

References

Brown, R. D., B. Brasnett, and D. Robinson, 2003. Gridded North American monthly snow depth and snow water equivalent for GCM evaluation. *Atmos.-Ocean*, 41, 1–14.

Déry, S. J., and E. F. Wood, 2005. Decreasing river discharge in northern Canada, *Geophys. Res. Lett.*, 32, L10401, doi: 10.1029/2005GL022845.

Déry, S. J., J. Sheffield, and E. F. Wood, 2005. Connectivity between Eurasian snow cover extent and Canadian snow water equivalent and river discharge. *J. Geophys. Res.*, in press.

GEWEX RELEVANT PUBLICATIONS OF INTEREST

Fundamental Challenge in Simulation and Prediction of Summer Monsoon Rainfall

Reference: B. Wang, Q. Ding, X. Fu, I.-S. Kang, K. Jin, J. Shukla, and F. Doblas-Reyes, 2005. *Geophys. Res. Letters, Vol.*. 32, L15711.

Summary/Abstract: The scientific basis for two-tier climate prediction lies in the predictability determined by the ocean and land-surface conditions. The authors show that the state-of-the-art atmospheric general circulation models (AGCMs), when forced by observed sea-surface temperature (SST), are unable to simulate properly Asian-Pacific summer monsoon rainfall. All models yield positive SST-rainfall correlations in the summer monsoon that are at odds with observations. The observed lag correlations between SST and rainfall suggest that treating a monsoon as a slave possibly results in the models' failure. They demonstrate that an AGCM, coupled with an ocean model, simulates realistic SST-rainfall relationships; however, the same AGCM fails when forced by the same SSTs that are generated in its coupled run, suggesting that the coupled ocean-atmosphere processes are crucial in the monsoon regions where atmospheric feedback on SST is critical. The present finding calls for reshaping of current strategies for monsoon seasonal prediction.

Long-Range Predictability in the Tropics. Part I: Monthly Averages

Reference: T. Reichler and J. O. Roads, 2005. *J Climate*: Vol. 18, No. 5, pp. 619–633.

Summary/Abstract: The sensitivity to initial and boundary conditions of monthly mean tropical long-range forecasts (1–14 weeks) during the N. Hemisphere winter is studied with a numerical model. Five predictability experiments with different combinations of initial conditions and prescribed ocean boundary conditions are conducted in order to investigate the temporal and spatial characteristics of the perfect model forecast skill. It is shown that initial conditions dominate a tropical forecast during the first 3 weeks and that they influence a forecast for at least 8 weeks. The initial condition effect is strongest over the E. Hemisphere and during years when the El Niño–Southern Oscillation (ENSO) phenomenon is weak. The relatively long sensitivity to initial conditions is related to a complex combination of dynamic and thermodynamic effects, and to positive internal feedbacks of large-scale convective anomalies. At lead times of more than 3 weeks, boundary forcing is the main contributor to tropical predictability.

WORKSHOP/MEETING SUMMARIES

1ST POST-GAME PLANNING WORKSHOP

28 August 2005
Kyoto, Japan

Jun Matsumoto
University of Tokyo, Japan

The First International Post-GEWEX Asian Monsoon Experiment (GAME) Planning Workshop was held at Kyoto International Community House with the support of the Ministry of Education, Culture, Sports, Science and Technology of Japan, the Hydrospheric Atmospheric Research Center, Nagoya University, the Research Institute of Humanity and Nature, and Kyoto University Active Geosphere Investigation. Forty participants from ten countries met to discuss the objectives, key scientific questions, expected achievements, international cooperation strategies, regional structures and schedule for a post-GAME program.

The post-GAME program will aim to improve the prediction of the Asian monsoon and its hydrological cycle, focusing on establishing a scientific basis for predicting the hydroclimate monsoon system with a special emphasis on intraseasonal to seasonal time-scale, including developing prediction systems for droughts and flood conditions of regional river basins and similar areas in Asia. It will target processes in the Asian summer and winter monsoon. Its spatial coverage will include the tropics from the maritime continent to South and Southeast Asia, Tibet/Himalaya, East Asia, and Northeast Asia. More emphasis will be placed on the air-land-ocean interactions, the role of aerosols on monsoons, monsoon predictability, and flood/drought predictions.

It is planned that this program will undertake an essential role in the WCRP research strategy—the Coordinated Observation and Prediction of the Earth System (COPES)—and will contribute to other related international initiatives, such as the Global Earth Observation System of Systems (GEOSS), the Coordinated Enhanced Observing Period (CEOP), The Observing System Research and Predictability Experiment (THORPEX), the International Hydrology Programme (IHP)-Project for Ungauged Basins (PUB), the SysTem for Analysis, Research and Training (START), and the Global Water System Project (GWSP). A special observation period may be planned in conjunction with the International Polar Year in 2008.

U.N. SYMPOSIUM ON SCIENCE AND OBSERVATIONS IN SUPPORT OF PROTECTING AND RESTORING WATER RESOURCES

13–16 September 2005
Graz, Austria

Rick Lawford
International GEWEX Project Office

The United Nations Office for Outer Space Affairs (UNOOSA) and the European Space Agency held a symposium at the Austrian Academy of Sciences to explore the possible applications of satellite data for protecting and restoring water resources around the world as part of a mission to develop an "Earth Observation-enabled society." Approximately half of the 75 participants came from countries in Africa, the Middle East and Eastern Asia, thus ensuring that the Workshop had a good balance of viewpoints from both the developed and the developing world.

Presentations reviewed the applications of remote sensing data for protecting and restoring water resources in a number of regions including central America, the Caucasus mountains, the Lake Chad drainage basin in Africa, northern Viet Nam and the countries of Morocco and Uzbekistan. This led to the identification of information and data needed for efficient regional and national water resource management. In particular, near-term benefits could result from using forecast information on floods to take mitigating actions, such as draining reservoirs in advance of a flood event and using geological mapping techniques and satellite data to map groundwater potential.

Subsequent discussions dealt with the development of low cost methods and technologies in using Earth observations, such as telecommunications and mapping software to address water challenges in the developing world. As a service to the community, UNOOSA has established an expert committee to assist groups in the developing world develop proposals for new projects that exploit Earth observations.

A discussion of water-related disasters, including floods and droughts, demonstrated the opportunities for using remote sensing to benefit society. Examples

(Continued on page 19)

11TH ANNUAL MEETING OF THE GHP

26–29 September 2005
Melbourne, Australia

John Roads
Scripps ECPC, UCSD
La Jolla, California

The 11th meeting of the GEWEX Hydrometeorology Panel (GHP), chaired by John Roads, was hosted by Alan Seed at the Bureau of Meteorology Research Center in Melbourne, Australia. The BMRC is the numerical weather prediction center associated with the Murray Darling Basin (MDB) Continental Scale Experiment (CSE). The objective for this GHP meeting was to review the past year's progress and refocus objectives to meet the GEWEX Phase II objectives, which have been modified to reflect the recent WCRP strategy for international research and collaboration efforts—the Coordinated Observation and Prediction of the Earth System (COPES). Future GHP activities are being increasingly focused on developing a regional to global hydrometeorological analysis and predictive capability and developing applications of GEWEX science for operational hydrology.

Two of the CSEs, the GEWEX Asian Monsoon Experiment (GAME) and Mackenzie GEWEX Study (MAGS) are ending this year. In addition, both the Baltic Sea Experiment (BALTEX) and the Large-scale Biosphere Atmosphere Experiment in Amazonia (LBA) have now completed their Phase I activities.

A follow-on project for GAME is planned with the objective to improve the prediction of the Asian monsoon and its hydrological cycle (see the post-GAME workshop report on page 15). Wrap-up activities for MAGS will include preparation of a data DVD, a book on cold regions hydroclimate science based on MAGS research and a monograph on applications and knowledge transfer.

The BALTEX Phase II science plan has been published and the implementation plan will be completed this year. One of the major activities of LBA Phase II will be the Regional Atmospheric Carbon Budget in Amazonia (BARCA), which will address the basin-wide budgets of CO_2, CH_4 and water.

The GEWEX Americas Prediction Project (GAPP) plans to continue as part of the Coupled Prediction Project for the Americas (CPPA). Through GAPP, numerous operational model upgrades have improved the Environmental Modeling Center global forecast system, resulting in reduced high precipitation bias (see article on page 8).

Draft implementation plans for the MDB and the La Plata Basin (LPB) projects are still under development and will be available soon. An operational center has been established for the African Monsoon Multidisciplinary Analysis (AMMA) Project. The AMMA implementation plan will be presented at the 1st International AMMA Conference on the West African Monsoon to be held in Dakar, Senegal on 28 November – 2 December 2005.

A presentation on the Northern Eurasian Earth Science Partnership Initiative (NEESPI), an interdisciplinary program that includes the Former Soviet Union, Northern China, Mongolia, and Eastern Europe was given. If NEESPI can meet the GHP criteria, it will be proposed at the next GHP meeting as the newest CSE.

Updates on the GHP affiliated global projects and programs were provided for the Global Precipitation Climatology Centre (GPCC), the Global Runoff Data Centre (GRDC), the International Satellite Land-Surface Comparison Project (ISLSCP), the Coordinated Enhanced Observing Period (CEOP) and the International Association of Hydrologic Sciences (IAHS).

The GHP working groups and global projects are conducting specific studies relevant to hydrometeorology research and applications. These groups will be developing white papers summarizing their activities.

The Water and Energy Budget Study (WEBS) is assessing the uncertainties in observing and simulating water and energy budgets over the CSEs in particular, and global land in general, using model output and in the future, GEWEX global data sets.

The Worldwide Integrated Study of Extremes (WISE) working group is determining the extent to which processes responsible for extremes are similar in different regions, to understand the processes that link extremes in different regions, and to assess how they may be changing. One of the first tasks for WISE is to develop a database of extreme events starting with the CEOP time period and extending back in time using the WEBS data set.

The Stable Water Isotope Intercomparison Group (SWING) has almost completed its analysis of the first common SWING simulations under present-day boundary conditions using three different state-of-the-art isotope global circulation models. In the near-future SWING will prepare a summary of Phase I results, evaluate new global circulation model (GCM) model results, and determine the focus for Phase II. The isotopes in the Project for Intercomparison of Land-surface Parameterization Schemes, a GEWEX Global Land-Atmosphere System Study project has strong linkages to SWING and MDB.

The Transferability Working Group (TWG) is facilitating the development of regional models and climate simulations. Of particular note, is the Inter-CSE Transferability Study (ICTS), a joint project under TWG and CEOP, to study the performance of regional climate models over all of the CSEs. The TWG agreed at the meeting to participate in the ongoing GEWEX Cloud System Study (GCSS) Pacific Cloud Transect Study.

The Water Resources Application Project (WRAP) is redefining its role by adopting a focus on hydrometeorological applications. Examples of initiatives with promising links to WRAP include the Hydrologic Ensemble Prediction Experiment (HEPEX), the Project for Ungauged Basins (PUB) and THe Observing system Research and Predictability EXperiment (THORPEX). HEPEX, a new GHP affiliated global project is described on page 10.

The Data Management Group (DMG) continues to provide links to the CSE data sets and archives and serves as the *in situ* data archive for CEOP. It is currently developing globally relevant regional data sets.

The next GHP meeting will coincide with the other GEWEX panel meetings at the Pan-GEWEX Meeting tentatively planned for October 2006 in Italy.

Attendees at the 11th annual GHP meeting included (front, left to right): T. Koike, J. Huang, J. Matsumoto, G. Sommeria, D. Erlich, B. Rockel, A. Seed, J. Roads, T. Satomura; (back, left to right) B. Croke, M. Werner, A. Hall, R. Lawford, S. Williams, H. Berbery, L. Martz, R. Stewart, J. Gibson, C. Jones, H. Isemer, S. Sorooshian, E. Takle, and P. Van Oevelen.

16th ANNUAL MEETING OF THE GRP

3–6 October 2005
Paris, France

William B. Rossow
NASA Goddard Institute for Space Science
New York, USA

The GEWEX Radiation Panel (GRP) meeting was held at the Observatoire de Paris. Key goals for this meeting were to review and evaluate global data collection and analysis activities, review on-going study activities and plan new initiatives concerning remote sensing of atmospheric water vapor, ocean and land surfaces, precipitation and aerosols.

Discussion of WCRP activities focused on the on-going development of the Coordinated Observation and Prediction of the Earth System (COPES) infrastructure, particularly the plans of the WCRP Observation and Assimilation Panel to foster a co-operative approach to calibration of the whole satellite constellation and to encourage a coordinated re-processing of global, long-term data products.

Special reports highlighted the activities of the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) Climate Monitoring Satellite Application Facility (CM-SAF), analyses of high-time-resolution radiation budget data from the Geostationary Earth Radiation Budget instrument on METEOSAT-8 and the release of advanced radiation budget products from the Clouds and the Earth's Radiant Energy System using new angle dependence models.

The Surface Radiation Budget (SRB) Project is in its 20th year and will have released all products for 1983–2001 by the end of this year. Comparison of downwelling fluxes from SRB and the Baseline Surface Radiation Network (BSRN) shows shortwave/longwave biases <10 / <5 Wm^{-2} and root mean square differences of about 25/15 Wm^{-2} for monthly mean values. BSRN is in its 11th year and is composed of 38 sites (with 12 provisional sites) collecting the full set of radiative flux and meteorological measurements and has completed its first year as the radiation reference network for the Global Climate Observing System. The Global Precipitation Climatology Project is in its 21st year and has produced global precipitation products covering the period from 1979 to April 2005. Improvements have begun for a third version of the products, including implementing a microwave analysis method based on the Tropical Rainfall Measuring Mission (TRMM) results and adding an explicit snow discrimination algorithm. The Global Aerosol Climatology Project (GACP) is in its 8th year and has produced a monthly mean product over the global oceans for the period from 1981 through 2004. The International Satellite Cloud Climatology Project is in its 24th year and has produced global cloud and radiation products covering the period of 1983 through 2004. New products include a method for analyzing the joint histograms of cloud top pressure and optical thickness to identify distinct weather states, a composite survey of the cloud, radiation and precipitation associated with midlatitude cyclones and a survey of twice-daily retrievals of cloud particle sizes for both liquid and ice clouds. The Precipitation, Radiation and Cloud Assessment activities have completed a first round of workshops.

Globally complete water vapor data sets are available from the National Oceanic and Atmospheric Administration (NOAA) operational analysis of the High Resolution Infrared Radiation Sounder/ Microwave Sounding Unit and from the several weather reanalyses of conventional observations, supplemented by several Special Sensor Microwave Imager-based analyses and a merged product the National Water Vapor Project produced as a pilot study under GRP. There are also experimental products produced from the Global Positioning System, as well as various new infrared and microwave instruments. Given activities reported at CM-SAF, NOAA and the reanalysis centers, these efforts appear to be sufficient to produce better long-term, global water vapor data sets.

The Working Group on Cloud and Aerosol Profiling is comprised of nine "high-end" cloud and aerosol profiling sites and has held two workshops towards providing conversion software to allow for reformatting of data products from all these sites into each other's formats. The International Radiation Commission's 3-Dimensional (3D) Working Group (3DWG) reported that the focus of activities is shifting from testing models and schemes to account for 3D effects of solar radiation in clouds to similar studies of the interactions of radiation with 3D vegetation canopy structure and of radiation scattered between the surface and cloudy atmosphere. The 3DWG is also developing and releasing common codes for calculating 3D radiative fluxes and radiances. The plan for a Continuous Intercomparison of Radiation Codes (CIRC), which combines the synthetic radiation code test cases of the Intercomparison of Radiation Codes in Climate Models activity with observation-based test cases [drawn from the Atmospheric Radiation Measurement Program (ARM)] on a web site hosted by ARM, was discussed. The initial cases should be released early next year. The GRP recommended holding a workshop in 2006 to foster use of this facility and that CIRC be operated as a hybrid of open and closed cases with all results attributed to specific codes. A relationship with the Intergovernmental Panel on Climate Change (IPCC) will also be explored so that the radiation codes in the climate global circulation models used for IPCC scenarios are evaluated against the CIRC cases and standards.

The SeaFlux activity has been reactivated and a workshop is planned for early March 2006 to complete the planned comparison of products in the common year 1999, with an emphasis on products using "older" instruments (visible, infrared, passive microwave) and products using "newer" instruments (including scatterometers and altimeters).

Discussion on the GRP-proposed LandFlux initiative and the role of the International Satellite Land Surface Climatology Project (ISLSCP) under GRP led to two recommendations: (1) continuing with a planned joint GRP/Global Soil Wetness Project (GSWP) workshop to evaluate GSWP model inputs and outputs necessary to define the remote sensing tasks needed to complete the characterization of the global energy and water cycle; and (2) making the primary goal for the next phase of ISLSCP the development of global data products for the turbulent fluxes of energy and water over land. As practical steps towards this goal, ISLSCP could follow a course parallel to SeaFlux, including "cleaning up" the radiances to be used for remote sensing of the main relevant land parameters (albedo, skin temperature, fire occurrence, vegetation index, soil wetness index), producing an extensive compilation of *in situ* land-surface flux measurements, evaluating available satellite-based products, and developing methodologies for inferring these fluxes.

GRP endorsed a new initiative for comparing the new, high space-time resolution precipitation products and an international workshop to evaluate possible snow algorithms. GRP will organize a working group on Precipitation Radar Networks to foster the dissemination and use of this type of data.

From a climate perspective, the interest in aerosols concerns their direct radiative effects and the consequences of their interactions with clouds. Thus, aerosol measurements at the surface without BSRN-class radiative flux and meteorology measurements are of much less value. Currently there is no existing or planned measurement system that directly observes the interaction of aerosols and clouds. GRP recommends reconciling the differences among advanced aerosol products to allow extension of the longer-term AVHRR-based record to land areas and to provide overall calibration of this record, building an advanced aerosol network by augmenting the BSRN network to include aerosol measurements, and beginning an investigation of how ARM-like sites might be instrumented to attack the aerosol-cloud interaction problem.

In summary, the key outcomes of this meeting are: (1) The global data projects and their assessments are on track with the exception of aerosols. (2) GACP can be re-invigorated to foster reconciliation of the available satellite aerosol products to allow for calibration and extension of the long-term record to land areas. (3) There does not appear to be a need for a special water vapor project at this time. (4) Working Groups and Study Projects are progressing well and an action is now underway to organize a Working Group on Precipitation Radar Networks. (5) GRP asked its Working Group on Data Management and Analysis to formulate specific plans for a coordinated reprocessing of the GRP data products to be reported at the next GRP meeting.

Attendees at the 16th annual GRP meeting included (front, left-right): E. Dutton, R. Adler, R. Cahalan, G. Sommeria, Z. Li, J. Bates, W. Rossow, C. Prigent and J. Schulz; (back, left to right): T. Ackerman, N. Loeb, L. Machado, M. Mishchenko, J. Roads, T. Koike, T. Hayasaka, and T. Iguchi.

U.N. SYMPOSIUM ON SCIENCE AND OBSERVATIONS

(Continued from page 15)

of uses of satellite data were given for floods in central Viet Nam and the Mekong River Basin, for floods associated with hurricanes such as Hurricane Mitch, and for fire hazards in forests in Africa arising from prolonged droughts. More indirect applications of remote sensing data in water management were provided for India where a sophisticated information flow network has been established for communicating technical information and forecasts to villagers through videoconferencing at local centers. This network benefits the implementation of the Millenium Development goals related to sanitation and access to clean drinking water as well as supporting the dissemination of climate and hazard information.

Other issues addressed at the workshop included capacity building through training programs, opportunities for better telecommunications and ways to enhance the participation of women in decisions related to water resources. In summary, within the UN context, along with climate, the theme of water continues to provide an effective way for GEWEX research and Earth observations to contribute to policy. Capacity building also provides many opportunities for GEWEX applications to address the needs of the developing world.

GEWEX/WCRP MEETINGS CALENDAR

For a complete listing of meetings, see the GEWEX web site (http://www.gewex.org)

2–4 November 2005—ASIAN WATER CYCLE SYMPOSIUM, Tokyo, Japan.

7–9 November 2005—5TH INTERNATIONAL PLANNING WORKSHOP ON GLOBAL PRECIPITATION MEASUREMENTS, Tokyo, Japan.

14–17 November 2005—3RD GRP WGDMA MEETING, Darmstadt, Germany.

15–18 November 2005—INTERNATIONAL WORKSHOP ON LAND SURFACE MODELS AND THEIR APPLICATIONS, Zhuhai, Guangdong Province, China.

22–25 November 2005—MAGS LAST ANNUAL MEETING, Ottawa, Canada.

28 November–2 December 2005—FIRST INTERNATIONAL AMMA CONFERENCE ON THE WEST AFRICAN MONSOON, Dakar, Senegal.

5–8 December 2005—AMERICAN GEOPHYSICAL UNION FALL MEETING, San Francisco, California, USA.

26–28 December 2005—1ST INTERNATIONAL CONFERENCE ON WATER RESOURCES IN THE 21ST CENTURY, Alexandria, Egypt.

9–13 January 2006—GEWEX SSG-18, Dakar, Senegal.

21–26 January 2006—1ST ILEAPS SCIENCE CONFERENCE, Boulder, Colorado, USA.

26–28 January 2006—FLUX MEASUREMENTS IN DIFFICULT CONDITIONS, A SPECIALIST WORKSHOP, Boulder, Colorado, USA.

29 January–2 February 2006—86TH ANNUAL AMERICAN METEOROLOGICAL SOCIETY MEETING, Atlanta, Georgia, USA.

29 February–3 March 2006—5TH CEOP IMPLEMENTATION PLANNING MEETING AND 2ND IGWCO WORKSHOP, Paris, France.

6–11 March 2006—27TH SESSION OF THE JOINT SCIENTIFIC COMMITTEE, Pune, India.

13–16 March 2006—ESA SYMPOSIUM – 15 YEARS OF PROGRESS IN RADAR ALTIMETRY, Venice, Italy.

16–22 March 2006—FOURTH WORLD WATER FORUM: LOCAL ACTIONS FOR A GLOBAL CHALLENGE, Mexico City, Mexico.

2–7 April 2006—EUREOPEAN GEOSCIENCES UNION 2006 GENERAL ASSEMBLY, Vienna Austria.

19–21 April 2006—WORKSHOP ON ASSESSMENT OF GLOBAL CLOUD CLIMATOLOGY PRODUCTS, Ft. Collins, Colorado, USA.

24–28 April 2006—8TH INTERNATIONAL CONFERENCE ON SOUTHERN HEMISPHERE METEOROLOGY AND OCEANOGRAPHY, Foz do Iguacu, Brazil.

29 May–2 June 2006—9TH MEETING OF BSRN, Lindenberg, Germany.

4–6 June 2006—SECOND INTERNATIONAL SYMPOSIUM ON QUANTITATIVE PRECIPITATION FORECASTING AND HYDROLOGY, Boulder, Colorado, USA.

11–17 June 2006—7TH INTERNATIONAL SYMPOSIUM ON TROPOSPHERIC PROFILING, Boulder, Colorado, USA.

2–13 July 2006—IUGG XXIV GENERAL ASSEMBLY, Perugia, Italy.

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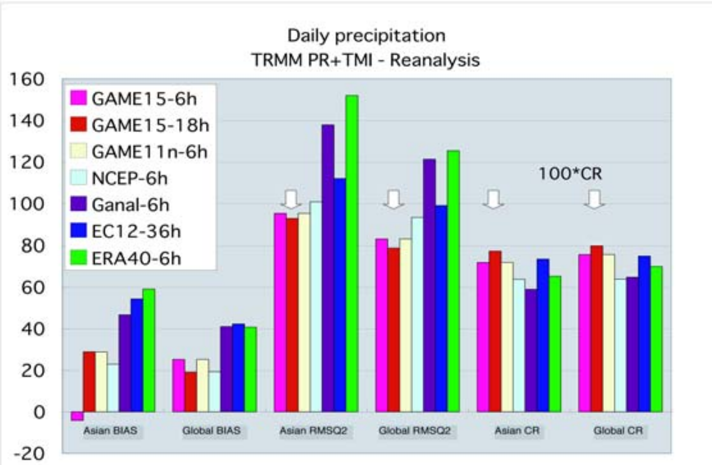
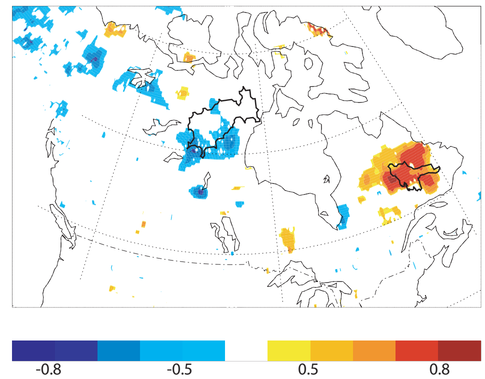
JMA/GAME REANALYSIS COMPARES WELL WITH OTHER REANALYSES PRODUCTS



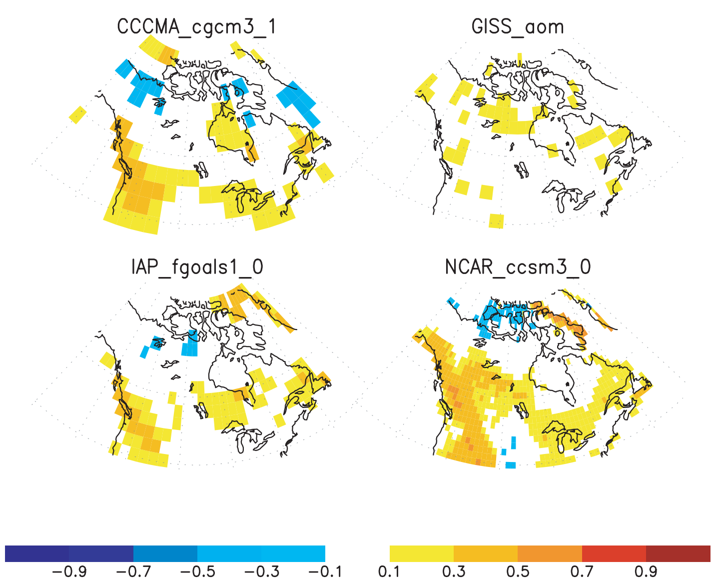
Validation of precipitation estimated from different reanalysis products against the TRMM PR and TMI combined (3G68) in April to October 1998. GAME reanalysis version 1.5 with 0 to 6 hour forecast (pink), 18 to 24 hour forecast (red), earlier GAME Reanalysis version with 0 to 6 hour forecast (yellow), NCEP/NCAR reanalysis (light blue), operational JMA with 0 to 6 hour forecast (purple), operational ECMWF (blue), ERA40 with 12 to 36 hour forecast (green). See article on page 11.

TELECONNECTIONS MAY ACCOUNT FOR LAGGED CORRELATIONS IN SNOW OBSERVATIONS



Correlation coefficient between observed August Eurasian snow cover extent and the maximum SWE in Canada the following winter, 1980–1997. All correlations shown are statistically significant at the $p < 0.05$ level. Thick black lines delineate the Churchill River and the Chesterfield Inlet Basins. See article on page 12.

CLIMATE MODELS RESULTS SHOW DIFFERENT CORRELATIONS THAN OBSERVATIONS FOR SOME SNOW TELECONNECTIONS



Correlation coefficient between ensemble mean August Eurasian snow cover extent and the maximum SWE in Canada the following winter (all available years between 1850–2003) from four representative dynamical climate models. All correlations shown are statistically significant at $p < 0.05$ level. See article on page 12.

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