GEWEX WCRP

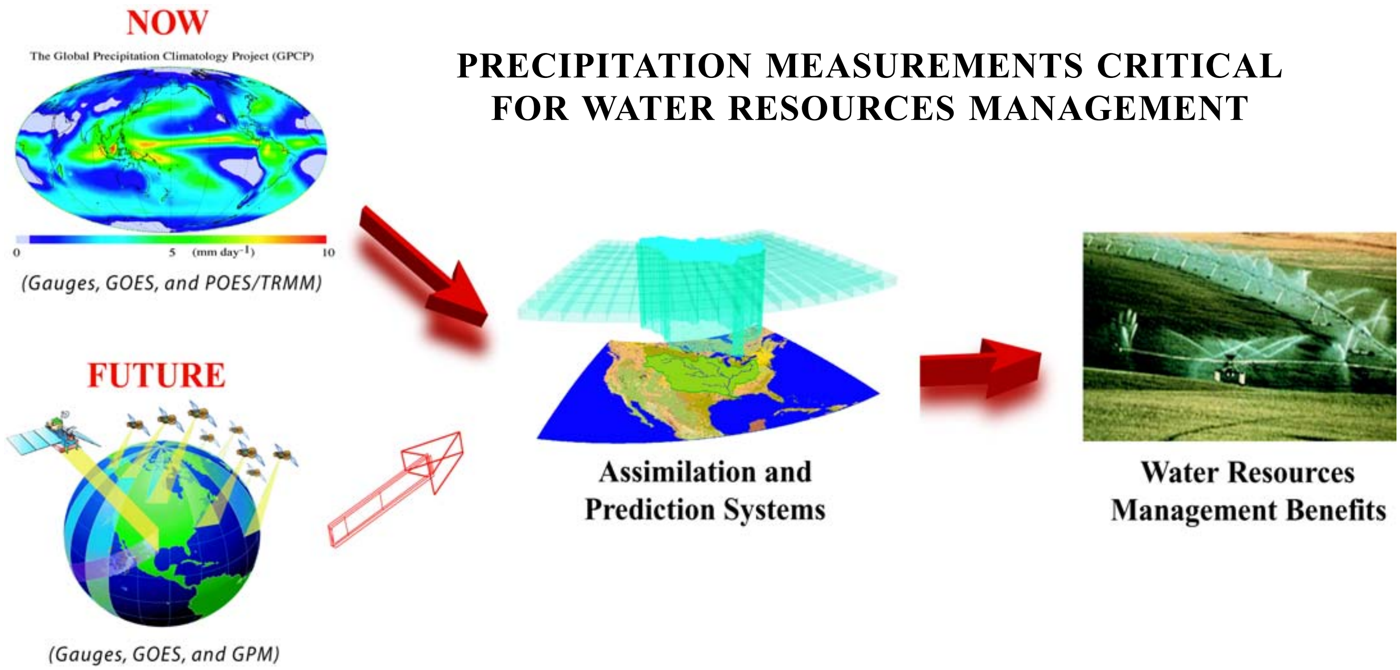
Global Energy and Water Cycle Experiment

NEWS

Vol. 14, No. 2 May 2004

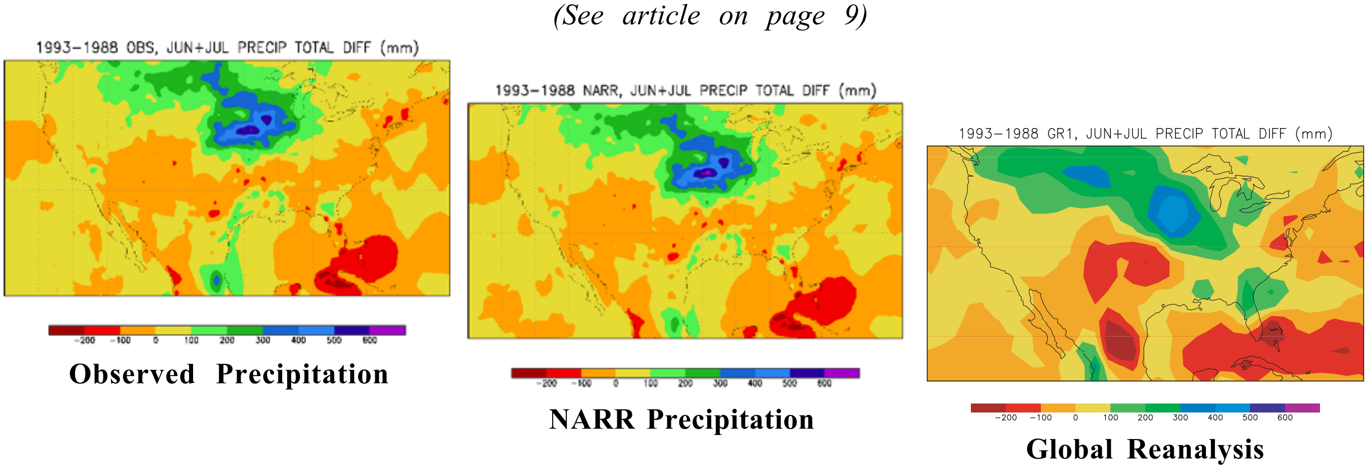
World Climate Research Programme–WCRP

PRECIPITATION MEASUREMENTS CRITICAL FOR WATER RESOURCES MANAGEMENT



NCEP 25-YEAR NORTH AMERICAN REGIONAL REANALYSIS SHOWS SIGNIFICANT IMPROVEMENT FROM PRECIPITATION ASSIMILATION

(See article on page 9)



The 1993 minus 1988 difference in June plus July total precipitation (mm) from gauge observations (left), North American Regional Reanalysis (NARR) (middle) and Global Reanalysis 1 (right).

What's New

COMMENTARY

GEWEX AT THE 2004 JOINT SCIENTIFIC COMMITTEE MEETING

Soroosh Sorooshian, Chairman
GEWEX Scientific Steering Group

This edition of *GEWEX News* focuses on precipitation issues. Precipitation is a central GEWEX issue for a number of reasons. It is the critical link between the atmosphere and the surface that drives most water resource applications. Furthermore, scenarios of precipitation changes from climate models remain one of the areas of greatest uncertainty. We need to improve our understanding of how clouds produce precipitation, procedures for reducing precipitation measurement and estimation errors at watershed scales, the use of precipitation in improved model parameterizations, and strategies for improving the ability to predict precipitation on all time scales. Future newsletters will focus on other science themes that are central to GEWEX. We will be carrying this approach through to our meetings, as well as with more in-depth focus on specific science issues.

At the Joint Scientific Committee (JSC) meeting (see report on page 13) in March, we received support for our plan for a precipitation cross-cut activity. The JSC also expressed their expectations for GEWEX support of other priority areas. In particular, the JSC expects GEWEX to contribute to the next Intergovernmental Panel on Climate Change (IPCC) assessment through its global data sets and expertise. GEWEX could help to strengthen the links between continental-scale experiments and national hydrological prediction services and to contribute effectively to the Global Water System Project (GWSP) that will likely be approved this summer. The Climate Variability and Predictability (CLIVAR) Programme, the Working Group on Coupled Modelling (WGCM) and Working Group on Numerical Prediction (WGNE) all focus on the development of better modeling capabilities and model intercomparison studies while GEWEX continues to be the main source of research leading to improvements in land-surface and macroscale hydrologic models. We need to ensure that these research groups make full use of GEWEX innovations and encourage them to ensure that their developments contribute to a framework that will enable us to support the development of improved hydrometeorological service capabilities.

GEWEX is also being asked to contribute to the WCRP Coordinated Observation and Prediction of the Earth System (COPES), which will be facilitating the prediction of climate variability and change for use in an increasing range of practical applications of direct relevance, benefit and value to society. Based on the current structure of COPES, it seems that the Coordinated Enhanced Observing Period (CEOP) is very well positioned to be a central contribution.

We have 10 months to work on these ambitious goals before the next JSC meeting. I am counting on your help to ensure that research results that relate to GEWEX goals are used in an effective way in IPCC, the ad hoc Group on Earth Observations (GEO), GWSP and the many other activities that benefit from our efforts. As an important step in this process I would encourage you to participate in the Fifth International Scientific Conference on the Global Energy and Water Cycle being planned for California in June 2005.

Contents

5TH INTERNATIONAL SCIENTIFIC CONFERENCE ON THE GLOBAL ENERGY AND WATER CYCLE

The Fifth Conference will be held in Orange County, California, June 20–24, 2005. Results from field experiments, new developments in theory, and modeling and observational capability that are being undertaken in the context of the World Climate Research Programme, GEWEX and other related activities, are expected to be reported. Particular emphasis will be on the linking of disciplines such as coupled atmospheric and land-surface models, and cross-discipline studies. The advances in scientific knowledge presented will provide new information to assess the impact of climate on water resource management. In focusing on priority GEWEX science areas, there will be six interrelated sessions, each addressing one of the following scientific themes.

- The role of clouds and their effects on radiation budgets in climate prediction.
- Use of predictions of water cycle variables in water management.
- Data and analysis for understanding feedback processes in the water and energy budgets.
- The role of modeling predictability and prediction studies.
- New strategies for characterizing and predicting energy and water budgets.
- Measuring precipitation from space and on land.

Call for Papers

Contributed papers covering work on the Conference themes will be accepted for oral or poster presentation. Potential contributors must submit an abstract for consideration. All abstracts will be limited to 400 words and cannot contain formulae, figures, or non-English text. Abstracts cannot be accepted if they do not include all required information, such as authors and their affiliations, the presenter's name and contact information, and the abstract text. We strongly encourage electronic submission of abstracts.

For more information about submitting abstracts, deadlines, and other Conference specifics, see the Conference web site at: **http://www.gewex.org/5thconf.htm**.

RECENT NEWS OF RELEVANCE TO GEWEX

GEO Framework Adopted

Significant progress was made on the Global Earth Observing System of Systems (GEOSS) at the Earth Observation Summit Ad-hoc Group on Earth Observations (GEO) meeting and Earth Observation Summit (EOS-II) in Tokyo in April 2004. The framework report was unanimously adopted by all participating countries and a strategy for the development of a 10-year implementation plan was tabled. Dr. Toshio Koike, the senior scientist for the Coordinated Enhanced Observing Period (CEOP), will be one of four people leading the preparation of the 10-year implementation plan for the Global Earth Observing System of Systems (GOESS). In addition, national plans, such as a U.S. GEOSS, are also being developed.

IGOS Global Water Cycle Theme Report Completed

The Integrated Global Observing Strategy (IGOS) Global Water Cycle Observations (IGWCO) theme report has been printed by the European Space Agency and distributed to participants at the fourth meeting of the Ad-hoc Group on Earth Observations (GEO) and the second Earth Observation Summit (EOS-II) held in Tokyo, Japan, in April 2004. Individuals wishing to obtain a copy of the report should contact Rick Lawford (gewex@gewex.org) or Einar-Arne Herland (Einar-Arne.Herland@esa.int).

Director for GWSP Appointed

The Global Water System Project (http://www.gwsp.org) has established its new office in Bonn, Germany. Dr. Eric Craswell has been appointed as the Director of the Project Office. He brings extensive research experience in tropical soil and water management, and nutrient cycling to the position. He has worked for many international organizations, including 5 years as Director General of the International Board for Soil Research and Management in Bangkok, and has recently co-authored a paper on ecological and policy aspects of global nutrient flows in trade. He can be contacted at eric.craswell@uni-bonn.de.

DIURNAL VARIATION OF PRECIPITATION MEASURED BY THE TRMM TMI

Kenji Nakamura

Hydrospheric Atmospheric Research Center, Nagoya University

Observation of rain distribution on a global scale is essential for understanding the Earth's climate system. Both visible/infrared and microwave radiometers are used to infer precipitation on geostationary and polar orbiting spacecraft. The visible/infrared radiometers on geostationary satellites typically use a rain retrieval technique known as the Global Precipitation Index, which utilizes statistical relationships between cloud top infrared radiation and rain, and observations at hourly or less than hourly intervals. The relationship between cloud top height and rain varies regionally and seasonally. Microwave radiometers, such as the Defense Meteorological Satellite's Special Sensor Microwave/Imager have the capability to observe precipitation more directly because it uses the microwave emissions from the precipitation particles. Rain retrieval using microwave radiometers generally works best over the ocean, which has a low microwave emission. However, the microwave rain retrieval needs a model of precipitation system structure and the estimated rain is dependant on the model. A systematic bias of rain estimation over mid-latitude regions is attributed to the error in the specification of the rain height (Masunaga et al., 2002; Ikai and Nakamura, 2003).

The Tropical Rainfall Measuring Mission (TRMM), launched in November 1997, is equipped with a Visible/Infrared Radiometer (VIRS), the TRMM Microwave Imager (TMI), and a Precipitation Radar (PR), the first spaceborne rain radar. The three sensors observe precipitation systems almost simultaneously, although the coverage is limited to plus or minus 37 degrees due to the inclination of the TRMM orbit. Thus, TRMM provides a unique opportunity to compare rain retrieval from each sensor. TRMM has led to a remarkable understanding of the microwave radiometer (i.e., Viltard et al., 2000; Shin and Kummerow, 2003) and hence in our understanding of rain measurement.

TRMM's specific combination of sensors together with the low-altitude, non-Sun-synchronous, highly precessing orbit provides a unique insight into the diurnal variability of precipitation. It is well known that precipitation has a significant diurnal variation, particularly over tropical land and coastal areas. The diurnal variation of clouds is studied by visible/infrared radiometers rather than direct rain measurements. Though the PR observes precipitation directly, the observation suffers from poor sampling due to the PR's narrow swath. Although the TMI has a swath that is about three times wider, measurements have an accuracy problem over land.

A comparison of the PR and TMI rain rate over land was performed and it was found that generally, both are in good agreement; however, there are small, but systematic differences for low cloud systems, where the TMI rain rate is smaller than the PR rain rate. Conversely, for high cloud systems, the TMI rain rate is stronger (Furuzawsa and Nakamura, 2004). Based on the TMI rain rate characteristics, a global diurnal rain map was compiled from the TMI data. Since TMI sampling is about three times more frequent than the PR, the sampling errors are significantly reduced. The figure at the bottom of page 16 shows the distribution of the local time when summer rain amount is maximum. The color indicates the peak local time, and the intensity (saturation) denotes how distinct the peak is (intense color and pale color mean strong and weak diurnal variation, respectively). The global image at the bottom of page 16 shows that the diurnal variation is strong over maritime continents and over tropical or sub-tropical lands. However, some regions show clear morning rain even over land, for example, the southern foothill of Himalayas. The peak local time of TMI is a few hours behind the PR peak local time over some of the land regions. This may reflect sensitivity of TMI rain estimates to anvils that persist after the mature stage of the precipitation systems. Further study of the diurnal variations in precipitation using TRMM and other data sources directly supports the major focus of GEWEX Phase II on improving our understanding and representation/prediction of the atmospheric diurnal cycle.

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GEWEX PRECIPITATION PRODUCTS

George J. Huffman[1], Arnold Gruber[2], Robert Adler[3], and Bruno Rudolf[4]

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One of the major goals of the Global Precipitation Climatology Project (GPCP) is to develop a more complete understanding of the spatial and temporal patterns of global precipitation. Data from over 6,000 rain gauge stations, and infrared and passive microwave observations from geostationary satellites have been merged to estimate monthly rainfall on a 2.5 degree global grid from 1979 to the present. GPCP currently provides three global precipitation products based on multiple sensors. The project is supported by the Global Precipitation Climatology Center (GPCC), which produces precipitation products based on gauge data.

Various steps are taken to ensure consistency between the products. For example, the pentad and daily GPCP products are adjusted to approximately sum to the monthly product. The full archives, including supporting documentation, individual input data sets, and key intermediate data sets, such as random error estimates for the monthly data, are available at http://www.ncdc.noaa.gov/oa/wmo/wdcamet-ncdc.html and through http://precip.gsfc.nasa.gov. The GPCC monitoring products (gauge only) are accessible at http://gpcc.dwd.de, while the full must be requested by e-mail to gpcc@dwd.de.

Product Name	Version 2 Monthly Satellite-Gauge	Pentad	1° Daily	GPCC Gauge
Space/Time Grid	2.5°/Monthly	2.5°/5-day	1°/daily	1° and 2.5°/month
Areal Coverage	Global	Global	Global	Global
Period of Record	January 1979-present	January 1979-present	October 1997-present	January 1986-present (monitoring) 1986-1997 (full)
Update Frequency	Monthly	3 Months	Monthly	Monthly (monitoring)
Latency	3 Months	3 Months	3 Months	2 Months (monitoring)
Input Data	1/79-12/85: GPCP-OPI, gauge; 1/86-6/87, 12/87: GPCP-OPI, GPI, gauge; 7/87-present except 12/87: SSM/I, GPI, gauge, TOVS	OPI, SSM/I, GPI, MSU (1979-1994), gauge, SG	SSM/I, GEO-IR, LEO-IR, SG	Up to 7,000 gauges (monitoring) Up to 30,000 gauges (full)
Reference	A	B	C	D

GEO-IR — Infrared data observed from geosynchronous orbit
GPCP-OPI — OPI calibrated to the SG
GPI — Geosynchronous Operational Environmental Satellite (GOES) Precipitation Index
LEO-IR — Infrared data observed from low Earth orbit
MSU — Microwave Sounding Unit
OPI — Outgoing Longwave Radiation (OLR) Precipitation Index
SG — Satellite-Gauge
SSM/I — Special Sensor Microwave/Imager
TOVS — Television-Infrared Observation Satellite (TIROS) Operational Vertical Sounder

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CONTRASTING WINTER AND SUMMER PRECIPITATION VARIABILITY OVER EUROPE

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Changes in precipitation patterns over Europe have serious consequences for a wide range of human activities in this densely populated region. For example, during the 2002 Summer, extremely dry conditions in central European Russia resulted in extensive forest fires, while anomalously high precipitation caused floods in central-eastern Europe and the southern part of European Russia. On the other hand, in July through early August 2003, almost all of western-central Europe suffered from deficient precipitation and extremely high temperatures that caused catastrophic forest fires in southern France, Spain and Portugal. Thus, in successive years both deficient and excessive precipitation resulted in significant damage to many European economies. Despite the above facts, little attention has been given to summer climate variability in the Atlantic-European sector.

A gridded monthly and pentad precipitation product for 1979–2001 from the Climate Prediction Center (CPC) Merged Analysis of Precipitation (CMAP) data set (Xie and Arkin, 1996) and terrestrial monthly gauge-based precipitation from the Climatic Research Unit (CRU), University of East Anglia (CRU) data set (New et al., 1999) were used to investigate and to compare winter and summer precipitation variability over Europe.

Prominent seasonal differences are detected both in precipitation climatologies and in characteristics of precipitation variability. Figure 1 depicts winter (DJF) and summer (JJA) seasonal mean precipitation climatologies, their interannual standard deviations (STDs) and ratios between seasonal climatologies and STDs.

The climatological winter precipitation pattern (Figure 1a) demonstrates relatively large values (2–5 mm/day) of precipitation over western Europe. Evidently, coastal orography greatly affects the climatology of winter precipitation. Lower (1-1.5 mm/day) precipitation is observed over eastern Europe-European Russia. Interannual variability (expressed by STDs) of winter precipitation (Figure

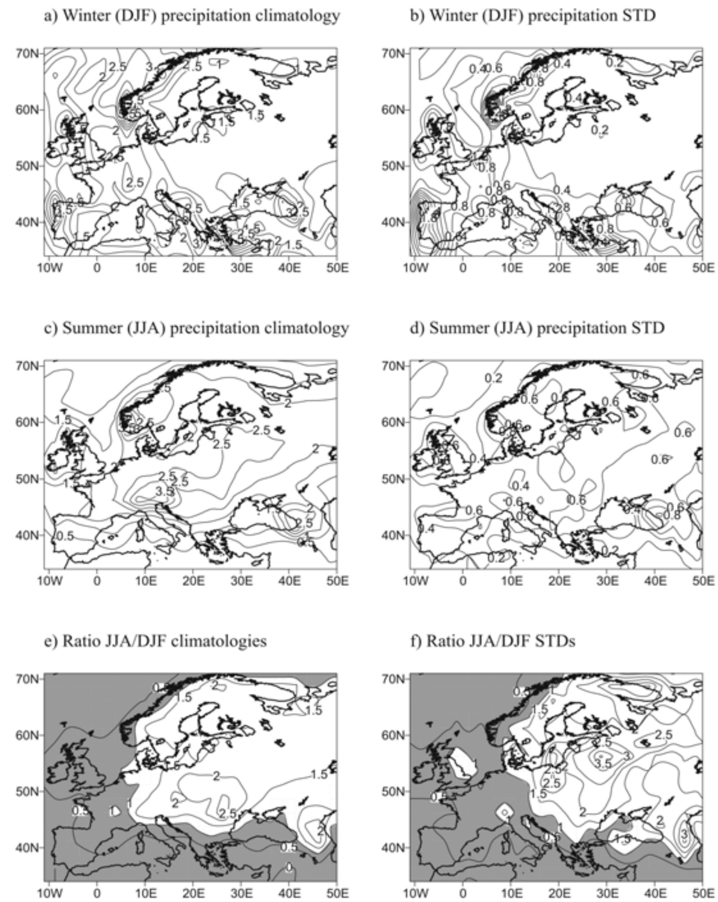

Figure 1. Climatologies (a,c), standard deviations (b,d), and ratios (e,f) of the winter (a,b) and summer (c,d) CMAP precipitation (1979–2001). Climatologies and standard deviations are presented in mm/day. In e) and f) shading indicates regions where the summer characteristics are lower than the winter ones.

1b) is large (0.6–1.8 mm/day) over the regions of greater precipitation (e.g., western Scandinavia, Portugal), and is lower (0.2–0.4 mm/day) over the regions with lower precipitation (Figure 1a). In general, the winter STD pattern is very similar to that of the winter precipitation climatology.

The climatology of the summer precipitation over Europe is depicted in Figure 1c. The largest precipitation amounts, exceeding 2.5 mm/day, are found over the Alps, western Scandinavia and the Caucasus. Enhanced precipitation is also detected over central-eastern Europe. In general, distribution of summer precipitation is more zonal compared to that of the winter season (Figure 1a). Also, the pattern (Figure 1c) features some continentality of the summer precipitation, showing large precipitation over the central part of the region, and lower precipitation at the periphery (e.g., Mediterranean region, Scandinavia except its western part). The largest precipitation variability (STDs reaching 0.8 mm/day) is detected over western Scandinavia, the British Isles, and the Caucasus. Over the major portion of Europe, however, STDs vary in the range 0.4–0.6 mm/day. In general, STDs of JJA precipitation over eastern Europe – European Russia are slightly higher compared to those over western Europe. Over western Europe the summer precipitation climatology and its interannual variability (expressed by STDs) are lower than those of the winter precipitation (Figures 1e,f). Major seasonal differences are found over central-eastern Europe. In this region, the summer precipitation climatology and magnitudes of its interannual variability exceed respective winter characteristics by a factor of 2–3.5. Similar relationships are found for the summer and winter magnitudes of intraseasonal fluctuations of precipitation. It should be noted that comparisons in the magnitude of winter precipitation are affected by the procedures used to correct the measurements of solid precipitation in both CMAP and CRU products.

Figure 2 shows spatial patterns and respective principal components of the first Empirical Orthogonal Function (EOF) modes of winter and summer seasonal mean precipitation. The first EOF modes of both summer and winter seasonal mean precipitation over Europe are associated with the North Atlantic Oscillation (NAO). However, they explain very different fractions (42% for winter, and 25% for summer) of total precipitation variability, and form different spatial patterns (Figures 2a,b). Temporal behavior of their principal components (Figures 2c,d) is also essentially different (correlation between respective time series is 0.07). It is worth noting that the first EOF mode of summer precipitation shows stronger links to the NAO index correlation of 0.81 with summer (Barnston and Livezey, 1987) compared to that for the winter season (correlation is 0.63). The first EOF mode of the winter magnitudes of intraseasonal precipitation fluctuations (not shown) is also associated with the NAO. The second EOF mode of the seasonal mean winter precipitation (not shown) is linked to the East Atlantic teleconnection pattern.

These results, based on the analysis of the relatively short-time series of the CMAP precipitation, were confirmed and complemented by an analysis of the longer time series of the winter and summer seasonal mean precipitation from the CRU data set for the period 1958–1998.

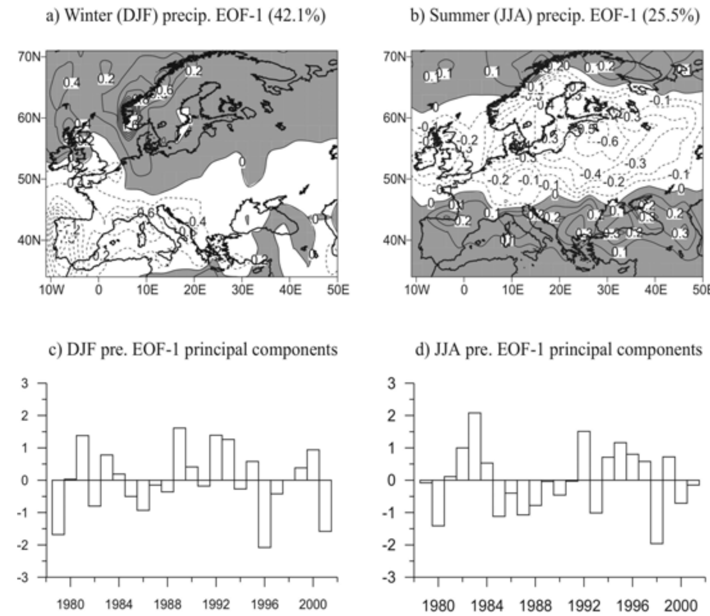

Figure 2. Spatial patterns (a, b) and the respective principal components (c, d) of the first EOF modes of the winter (DJF) and summer (JJA) CMAP precipitation (1979–2001). Principal components are normalized by their standard deviations. In a) and b) shading indicates positive values.

They imply that more attention should be paid to further analysis of summertime precipitation variability in the region. A complete description of these results can be found in *Zveryaev* (2004).

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NEW OROGRAPHIC ADJUSTMENTS IMPROVE PRECIPITATION ANALYSES FOR GAPP

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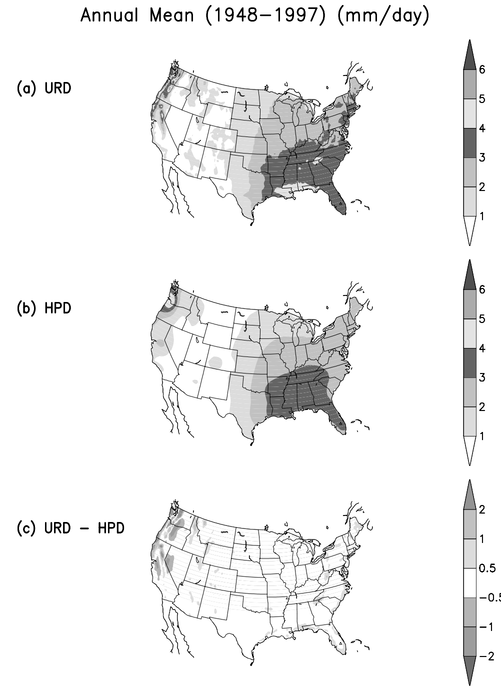
Accurate and complete estimates of precipitation are critical to a wide variety of problems ranging from understanding the water budget to improved monitoring and prediction of climate. Most areas of the globe are not adequately sampled, either by *in situ* or remote sensing data. The conterminous U.S.A., however, is covered by a relatively dense array of *in situ* (hourly and daily) rain gauge data. This resource allows us to focus on improving the quality of the analysis of precipitation in the United States on a range of temporal and spatial scales. These analyses have become an increasingly important contribution to the GEWEX Americas Prediction Project (GAPP) activities aimed at improving monthly-to-seasonal prediction of precipitation and regional water resources.

Over the past several years the Climate Prediction Center (CPC) has developed a U.S. precipitation quality control (QC) system and analysis that includes state-of-the-art quality control of rain gauge data (including radar and satellite QC of rain gauge data). The system has been used to produce an enormous number of precipitation products and applications in support of climate monitoring, climate prediction, and applied research.

A major thrust of this effort has been the production of near-real-time products in support of real-time GAPP modeling initiatives. Equally important has been the development of a historical (1948–present) Unified Rain Gauge Database (URD) with orographic adjustments for the U.S.A. that has permitted a daily precipitation reanalysis for the period of record.

The major sources of rain gauge data in the URD include CPC's Cooperative Database (~7,000 active daily reports from River Forecast Centers and surface mesonets), The National Climatic Data Center's (NCDC) Cooperative Data set (~8,000 active daily reports) and NCDC's Hourly Precipitation Database (HPD) (~2,500 active hourly sites; see Higgins, et al., 1966). Documentation, including a description of QC procedures, is found in an Atlas by Higgins et al. (2000). For many applications a gridded daily precipitation analysis is produced at a horizontal resolution of (latitude, longitude) = (0.25° x 0.25°) over the domain 140°W–60°W, 20°N–60°N using a Cressman scheme with modifications. An intercomparison of precipitation analyses produced by various schemes (i.e., Cressman, etc.) revealed only minor differences in the analyses, presumably due to sufficient data density over the United States.



Mean (1948–1997) annual precipitation (units: mm day^{-1}) in (a) URD with orographic adjustments, (b) HPD, and (c) the precipitation difference (URD-HPD).

Since the Autumn of 1999 we have been collaborating with the National Weather Service (NWS)/ Office of Hydrology (OH), National Centers for Environmental Prediction (NCEP)/Environmental Modeling Center and members of the Land Data Assimilation System (LDAS) Project on orographic precipitation adjustment in the western U.S.A. We have tested an "OH scheme" [inverse distance weighting plus a monthly climatology from the Parameter-elevation Regressions on Independent Slopes Model (PRISM)] against the Cressman scheme.

CPC's daily precipitation analyses are used to support several major GAPP initiatives, including the NCEP Regional Reanalysis (RR) (Mesinger et al., 2004) and the North American Land Data Assimilation System (NLDAS) (Mitchell et al., 2004). For both NLDAS and RR it was necessary to produce historical (1948–present) daily precipitation reanalyses at higher resolution [e.g. (latitude, longitude) = (0.125° x 0.125°)] using the "OH scheme" with PRISM adjustments. In addition, we produce near-real-time daily analyses to support real-time NLDAS runs and the forthcoming high-resolution North American climate analysis system at NCEP.

As one measure of the improvement of CPC's precipitation analyses over the past few years, we compare those based on the URD and on HPD for the period 1948–1997. The figure on page 8 shows that the URD is resolving the much finer structure of the precipitation patterns in the western United States.

The success of NLDAS and RR hinges, at least in part, on the quality of the URD precipitation analyses. In that sense, it is very important to sustain GAPP's efforts to produce high quality precipitation analyses. This is nontrivial, because it requires daily vigilance not only to address the quality of the analyses, but also to data flow upstream. At CPC, the major emphasis is on data mining to ensure that all good data are incorporated into the URD. In this way we can continue to improve our analyses (both historical and real-time) in support of GAPP and GEWEX objectives.

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NEW GCSS CHAIR

Dr. Christian Jakob (pictured at left) is the new chair of the GEWEX Cloud System Study (GCSS). Christian's research interests are the design and evaluation of cloud and convection parameterizations in GCMs. He has worked on those subjects at the European Centre for Medium-Range Weather Forecasts from 1993–2001 before taking his current position at the Australian Bureau of Meteorology, where he works for the U.S. Department of Energy's Atmospheric Radiation Measurement Program. He replaces Dr. Steven Krueger, University of Utah.

NCEP COMPLETES 25-YEAR NORTH AMERICAN REANALYSIS: *PRECIPITATION ASSIMILIATION AND LAND SURFACE ARE TWO HALLMARKS*

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[2]NCEP Climate Prediction Center
[3]NWS Office of Hydrological Development

Improving the depiction of precipitation in both the assimilation mode and prediction mode of models can be achieved through: 1) improving physical parameterizations, 2) increasing spatial resolution (including topography), and 3) advancing assimilation methods and data, including that for precipitation. The benefit of improving the depiction of precipitation in the assimilation mode is demonstrated here by the results of the North American Regional Reanalysis (NARR).

Background

After several years of development sponsored by the Office of Global Programs (OGP) of the National Oceanic and Atmospheric Administration (NOAA) through its GEWEX Americas Prediction Project (GAPP), the Environmental Modeling Center (EMC) of the National Centers for Environmental Prediction (NCEP) recently completed 25 years of the NARR for October 1978 through December 2003. The NARR is a long-term, consistent, data assimilation-based, climate data suite for the North American domain, executed at high spatial and temporal resolution (32-km, 45-layer, 3-hourly). In addition, EMC has developed a realtime daily NARR update, called the Regional Climate Data Assimilation System (R-CDAS). By this summer, R-CDAS will be executed daily by NCEP's Climate Prediction Center (CPC) as a climate-monitoring tool, thus extending the NARR to future years. Together, the retrospective and realtime NARR will span the enhanced observing periods (July 2001 to December 2004) of the Coordinated Enhanced Observing Period (CEOP).

The NARR is based on NCEP's mesoscale Eta forecast model and its Eta Data Assimilation System (EDAS), as configured in NCEP operations in April 2003, when the NARR system was frozen. The NARR applies 3-hour cycling in which a 3-D variational objective analysis updates the background fields of the Eta model. The system was developed as a major improvement in both resolution and accuracy upon the earlier NCEP/NCAR Global Reanalysis 1 (GR1) (Kalnay et al., 1996; Kistler et al., 2000) and the NCEP/Department of Energy Global Reanalysis 2 (GR2) (Kanamitsu et al., 2002).

In this article we highlight two key advancements in the NARR over the GRs, namely, the assimilation of observed precipitation fields and a decade of improvements to the Noah land surface model (Noah LSM), which is the land component of NARR. Both advancements were achieved through EMC's participation in the GEWEX Continental Scale International Project (GCIP), GAPP and other GEWEX initiatives. Noah LSM improvements and impacts in both uncoupled and Eta model coupled settings are described in several papers in the recent GCIP special issue of the *Journal of Geophysical Research-Atmospheres* (Mitchell et al., 2004; Ek et al., 2003; Berbery et al., 2003). Additionally, the NARR improves over the GRs through increased resolution, other new sources of observations (e.g., direct assimilation of satellite radiances), and improved physics (e.g., inclusion of explicit cloud microphysics).

The NARR is summarized in three papers available at the NARR web site: (http://wwwt.emc.ncep.noaa.gov/mmb/rreanl/index.html). They provide 1) a NARR overview (Mesinger et al., 2004); 2) description of NARR input observations and data (Shafran et al., 2004); and 3) summary of the content of and access routes to NARR output (Ebisuzaki et al., 2004). The NARR web site also provides updates on the status of access to the NARR database. The database includes 3-hourly analysis/assimilation fields and fields from companion 72-hour forecasts (initialized every 2.5 days), plus hourly time series at 1300 plus sites. NCEP and NOAA's Climate Data Center (NCDC) are populating GrADS DODS (GDS) public servers to allow: 1) cost-free distribution of NARR output by ftp (including user-defined sub-setting utilities); 2) interactive user-initiated calculations and plots; and 3) clients such as GrADS running on external servers to access NARR data. Other institutions are arranging to distribute different subsets of the NARR.

As one subset, NCEP/EMC has derived a "land surface" subset consisting of land-surface forcing fields, land-surface states (e.g., soil moisture, snowpack) and land-surface water/energy fluxes. NCEP/CPC has produced a second subset consisting of 24-year means (1979–2002) of many NARR fields, including monthly means and monthly-mean diurnal cycles for a large number of variables along with, for selected variables, daily means (for each of 365 days) and 3-hourly means (mean annual cycle of 365 days x 8 daily analysis times).

Precipitation Assimilation

The GR systems do not include atmospheric precipitation assimilation. **Poor GR precipitation patterns have substantially reduced the reliability of GR-derived water and energy budgets, particularly land-surface water budgets.** It was anticipated that the assimilation of precipitation could reduce such uncertainties and errors in the reanalysis fields. The U.S. hydrological community, which advocated the NARR project from its inception, found particular appeal in the precipitation assimilation and upgraded land-surface components of the NARR.

The following paragraphs summarize the precipitation assimilation methodology in NARR. All the precipitation analyses ingested in NARR are ultimately dissaggregated into hourly analyses on the NARR's Eta model computational grid. Over the Continental United States (CONUS), Mexico, and Canada, the precipitation disaggregation begins with a daily precipitation analysis (of 24-hour totals) derived solely from gauge observations (see Shafran et al., 2004, and the article by Higgins et al. on page 8). Over the oceans and the remaining land portions of the NARR domain, satellite-dominated precipitation analyses from CPC are used, though only south of 42.5°N, and their sources and temporal/spatial resolution are different for the retrospective (1979–2002) and realtime NARR (2003–present). For all ocean and remaining land areas north of 42.5°N, no precipitation data is assimilated. For brevity, we describe the precipitation analysis and its disaggregation only over the CONUS. See Mesinger et al. (2004) and Shafran et al. (2004) for the details in other regions.

Over the CONUS, about 12,000 (7,000) gauge observations of daily precipitation are available to the retrospective (realtime) NARR and analyzed to a one-eighth-degree CONUS grid using the least-squares distance-weighting scheme of Schaake (2002, personal communication). The latter scheme also applies the Parameter-elevation Regressions on Independent Slopes Model (PRISM) (Daly et al., 1994) climatology of CONUS precipitation to account for orographic influences on precipitation. For a given grid point, any gauge observation within the influence radius for that grid point is multiplied by the ratio of the value of the PRISM precipitation climatology at the location of the grid point divided by that of the location of the observation. The resulting daily precipitation analysis then is disaggregated to hourly by using hourly temporal weights computed in: 1) the retrospective NARR from a 2.5-degree analysis of the lower-density hourly gauge observations of precipitation (many received after realtime); and 2) the realtime NARR from the hourly 4-km WSR-88D radar-dominated precipitation analyses, known as Stage-II/Stage-III. Lastly, these hourly analyses are interpolated to the Eta model's computational grid.

The precipitation assimilation technique in NARR is similar to one developed (Lin et al., 1999) and implemented operationally in EDAS at NCEP. **The essential component is a procedure wherein the observed hourly precipitation at any given model grid point is used to adjust the model's vertical profiles of latent heating, water vapor and cloud water during an hourly assimilation interval.** To that end, for each time step and each grid point where precipitation observations are available, we compare the model precipitation (P_{mod}) against the observations (P_{obs}) and make adjustments depending on the following three mutually exclusive precipitation conditions: 1) if $P_{mod} > 0$ but $P_{obs} = 0$, we zero the P_{mod} and take back the corresponding amount of latent heating (cool the temperature) at any model layer where latent heating had been applied and adjust the model's water vapor and cloud condensate mixing ratios to be consistent with zero precipitation; 2) if $P_{mod} > P_{obs} > 0$, we reduce the latent heat release in each precipitating layer by the factor of P_{obs}/P_{mod} and adjust the model's water vapor and cloud condensate mixing ratios to be consistent with reduced precipitation; or 3) if $P_{mod} < P_{obs}$, (including zero model precipitation) we make serial adjustments to, first, conditions in the model's deep convection scheme and, second, to conditions in the grid-scale precipitation physics. More details on this third adjustment condition (which is the most difficult, especially if P_{mod} is zero) or the previous two adjustment conditions are online at http://wwwt.emc.ncep.noaa.gov/mmb/papers/lin/pcpasm/paper.html.

The assimilation of observed precipitation is a critically important addition to the NARR and yields NARR precipitation patterns that are strikingly similar to the ingested precipitation analyses, especially during the warmer seasons. **Unlike GR1 and GR2, the NARR effectively reproduces diurnal precipitation signatures (not shown) over the CONUS, including reasonable nocturnal maxima in summer. Over the southeast CONUS, for example, the daily frequency of summer convective precipitation in the NARR is vastly improved over the high bias of that in GR1 and GR2.**

Land Surface Model Improvements

The good precipitation patterns produced in the NARR by the assimilation of observed precipitation provide notably improved precipitation forcing for the Noah LSM component compared to the GRs. The Noah LSM used in NARR closely follows that described and evaluated in both the coupled Eta/Noah study of Ek et al. (2003) and the uncoupled North American Land Data Assimilation System (NLDAS) study of Mitchell et al. (2004). The Noah LSM simulates soil temperature and soil moisture (including frozen) in four soil layers of 10, 30, 60, and 100 cm thickness. The surface infiltration scheme accounts for subgrid variability in soil moisture and precipitation. The surface evaporation includes evaporation from the soil, transpiration from the vegetation canopy, evaporation of dew/frost or canopy-intercepted precipitation, and snow sublimation. The Noah LSM simulates snowpack states of water content, density and fractional coverage via the processes of sublimation, snowfall, and snowmelt and the snowpack surface energy fluxes of radiation, sensible/latent heat flux, subsurface heat flux, and phase-change heat sources/sinks. In the NARR, the snowpack depth is updated daily from the daily global snow depth analysis (47-km) of the U.S. Air Force, known as SNODEP. This daily update increment is the minimum needed to achieve a NARR snow depth within a factor of two of the Air Force snow depth.

As an illustration, we present here a warm season example of the difference in NARR land-surface and PBL response between a summer drought episode (1988) and a summer flood episode (1993) over CONUS. On the front cover (bottom), the three precipitation panels show the 1993 minus 1988 difference in June-plus-July total precipitation (mm). The left panel shows that of the observed precipitation analyses assimilated in NARR. The middle panel shows that from the output of NARR. The close agreement between the observation-based and the NARR-based results is clear. In contrast, the results from GR1 (right panel) shows a positive precipitation anomaly over the north central CONUS that is spatially too broad and bland, and it extends much too far to the northwest and southeast. Meanwhile the GR1 negative anomaly is too dry in the southern Great Plains and northern Mexico.

The NARR precipitation anomaly is well manifested in NARR mid-July soil moisture states (see figure at the top of page 16) for 1988 (left) and 1993 (right). Over the central CONUS, the much wetter soil (and more cloud cover, not shown) in NARR in mid-July 1993 (right) vs.1988 (left) yields (not shown) much lower mid-day surface sensible heat flux and skin temperature. In turn, this lower sensible heat flux in 1993 vs. 1988 produces a notably lower boundary-layer height (see figures in the middle of page 16) in that same region. The 2-week mean fields (16–31 July, not shown) corresponding to the four 15 July figures on the back cover show analogous features.

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GEWEX RELEVANT PUBLICATIONS OF INTEREST

This is a new GEWEX News section to alert readers to papers of possible interest.

Predictability of Precipitation in a Cloud-Resolving Model

Reference: Walser, André, Daniel Lüthi, and Christoph Schär, 2004. Predictability of Precipitation in a Cloud-Resolving Model. *Monthly Weather Review*, Vol. 132, No. 2, pp. 560-577.

Summary: An ensemble methodology is developed and tested to objectively isolate and quantify meso-beta-scale predictability limitations in numerical weather prediction (NWP). The methodology involves conducting an ensemble of limited-area simulations with slightly modified initial conditions (representing small-scale observational uncertainties) and identical lateral-boundary conditions (representing perfect synoptic-scale predictability). The methodology is applied using a nonhydrostatic NWP model with a convection-resolving mesh size of 3 km over the entire European Alps. The initial perturbations of the ensemble members have a small-scale structure with predominant scales between 10 and 100 km.

Case studies of ensembles for different weather conditions are analyzed for 24-hour forecasting periods, with particular attention to quantitative precipitation forecasting. The simulations show that the predictability of precipitation amounts differs strongly depending upon the weather type and the spatio-temporal scales considered. It is demonstrated that, during episodes of convective activity, small-scale predictability limitations may be critical even at scales exceeding 100 km. For smaller spatial scales, the uncertainties in precipitation forecasts increase rapidly with decreasing scale in the precipitation event as individual convective cells are rendered unpredictable by chaotic aspects of the moist dynamics. However, the results suggest also that the presence of convective activity alone may not necessarily limit predictability. Additional consideration is given to the role of underlying orography, nonlinear processes and perturbation growth.

Improving Fine Resolution Precipitation Estimates

References: Hong, Y., K. Hsu, X. Gao, and S. Sorooshian, 2004. Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks—Cloud Classification System, *Journal of Applied Meteorology*, In Review.

Hsu, K., Y. Hong, and S. Sorooshian, 2004. Rainfall estimation using a cloud patch classification map. In the Book: *Measuring Precipitation from Space: EURAINSAT and the Future*, Edited by V. Levizzani, P. Bauer, and J. Turk. Kluwer Academic Publishers, In Review.

Summary: A patch-based image classification and rainfall estimation system is under development at the University of California, Irvine. This system, known as the PERSIANN-Cloud Classification System (PERSIANN-CCS), enables classification of satellite infrared imagery based on cloud patch temperature, size, and texture variability. Precipitation intensity and distribution of cloud patch are adjusted based on ground radar and space-based microwave rainfall measurements. PERSIANN-CCS is applied over the southwest U.S. region where limited ground-based observations are available (Hong et al., 2004; Hsu et al., 2004). PERSIANN-CCS fills the gaps of WSR-88D radar network and demonstrates the capability in capturing high variability of rain rates at small temporal and spatial scales (3-hour at 0.12° x 0.12°).

Comparison of Precipitation Differences over Europe from Four Reanalyses

Reference: Zolina, O., A. Kapala, C. Simmer, and S. Gulev, 2004: Analysis of Extreme Precipitation over Europe from Different Reanalyses: A Comparative Assessment**,** accepted for *Global and Planetary Change*, April 2004.

Summary: Statistical characteristics of daily precipitation in the reanalyses of the National Centers of Environmental Prediction (NCEP1 and NCEP2) and the European Centre for Medium-Range Weather Forecasts (ERA15 and ERA40) are intercompared with each other and with the *in situ* data assembled from different collections of station observations. Intercomparison is performed over the European continent. The precipitation parameters analyzed included precipitation intensity, parameters of the gamma distribution and the 99% percentiles of daily precipitation. NCEP1 and NCEP2 reanalyses show a higher occurrence of heavy precipitation than ECMWF products. In comparison to the reanalyses, station data show significantly higher estimates of heavy and extreme precipitation. Among the four reanalyses, NCEP2 estimates are closest to station data estimates of extreme precipitation. The analysis of linear trends of statistical characteristics of heavy precpitation in ERA40 and NCEP1 for a 43-year period shows similarity of the trend patterns in winter and identifies strong local differences, resulting in trends of opposite signs dur-

(Continued on Page 15)

WORKSHOP/MEETING SUMMARIES

25th JSC MEETING

1–5 March 2004
Moscow, Russia

Rick Lawford, IGPO

The 25th annual meeting of the Joint Scientific Committee (JSC) featured overviews of WCRP projects, discussions about new initiatives, and a 1-day combined meeting with the International Geosphere-Biosphere Programme (IGBP) to discuss Earth System Science Partnership (ESSP) projects and other activities of mutual interest.

The first part of the meeting involved a review of JSC activities, and the new Coordinated Observation and Prediction of the Earth System (COPES) initiative. Each of the four main WCRP projects [(Climate Variability and Predictability (CLIVAR), GEWEX, Climate and Cryosphere (CliC) and Stratospheric Processes and their Role in Climate (SPARC)] presented overviews. The GEWEX presentations were led by Soroosh Sorooshian, Chair of the GEWEX Scientific Steering Group. In general, GEWEX and the Coordinated Enhanced Observing Period (CEOP) received positive feedback from the JSC. The presentations highlighted the La Plata Basin, the newest GEWEX Continenal Scale Experiment (CSE); progress in global data set development; advances in land surface and hydrologic modeling; CEOP progress, and contributions of GEWEX to priority WCRP issues. The JSC approved the GEWEX proposal to have the Baseline Surface Radiation Network serve as the reference radiation network for the Global Climate Observing System (GCOS) and to seek support for the continuation of the global data set projects. The JSC asked CEOP to prepare a Phase 2 implementation plan.

Other WCRP reports of interest to GEWEX were received from the Working Groups on numerical experimentation and coupled modelling, and from observational programs, such as GCOS, the WCRP Satellite Working Group and the Integrated Global Observing Strategy-Partnership (IGOS-P) Global Water Cycle theme. Other presentations with implications for GEWEX included a status report on preparations for the next Intergovernmental Panel on Climate Change (IPCC) assessment by Dr. Susan Solomon and an overview by Dr. Joe Alcamo on the Global Water System Project (GWSP). Significant progress has been made in recent months on the GWSP and GEWEX has the potential to make a number of contributions to its implementation. The next JSC meeting is planned for Ecuador in March 2005.

FIRST CEOP MODEL OUTPUT WORKSHOP AND THIRD IMPLEMENTATION PLANNING MEETING

8–12 March 2004
University of Irvine

Sam Benedict
CEOP International Coordinator

A large group from the international climate and water cycle modeling and research community attended the Coordinated Enhanced Observing Period (CEOP) Model Output Development and Analysis Workshop (8–9 March) and Third Implementation Planning Meeting (10–12 March), both of which were hosted by the the Department of Earth System Science and the Department of Civil and Environmental Engineering at the University of California, Irvine.

All of the participants at the Workshop agreed that the priority activities for the Model Output Component of CEOP are related to production and handling of data (i.e., production, transfer, archiving, accessing) and utilization of data in analyses. These two main topics are related to three action items that were acknowledged and accepted by the contributing centers to act upon by the end of 2004:

(i) Achieve routine transfer of CEOP model output data by electronic means for placement in the CEOP Database;

(ii) Access CEOP Model Output Database through the web page at: http://www.mad.zmaw.de/CEOP or through the CEOP Data Management Internet Page, Model Output and Information section;

(iii) Access CEOP data sets, including *in situ*, model and satellite and use them in model inter-comparison/validation exercises to improve model parameterizations and predictability.

By being selected as the first element of the Integrated Global Water Cycle Observations (IGWCO) theme within the framework of the International Global Observing Strategy-Partnership (IGOS-P), CEOP has been recognized as an important scientific effort by the broad association of international organizations, which make up the Committee on Earth Observation Satellites (CEOS). The implications of this commitment were identified by the CEOP Science Steering Committee (SSC) as including the following actions:

(i) Identify representatives from within the CEOP organization/community to serve as a subcommittee to the IGWCO science committee;

(ii) Arrange for a written report to be prepared on its activities that can be presented at a future IGOS meeting in 2005;

(iii) Coordinate the development of a plan that defines CEOP activities beyond the completion of its initial observational phase at the end of 2004 to be integrated with the IGWCO implementation plan. A preliminary version of the CEOP extended activites plan will be available in June 2004.

Representatives from the Japan Aeronautics Exploration Agency (JAXA), U.S. National Aeronautics and Space Administration (NASA) and the U.S. National Oceanic and Atmospheric Administration (NOAA) were at the meeting and reported on the issues and concerns they have with respect to the CEOP implementation process and their commitments to the CEOP infrastructure. Earlier meetings with European Space Agency (ESA) representatives have also resulted in important commitments to assist CEOP in its quest for specialized satellite data sets. These agreements are an important initial step in the development of a formal framework within which CEOP Satellite Data Requirements will be recognized and responded to by the international community.

Dr. J. Kaye, Director of the Research Division, NASA, and Co-Chair of the CEOP Advisory and Oversight Committee (AOC), noted the importance of CEOP's role in increasing the focus on the important topic of water resources applications. Many aspects of the existing U.S. priorities parallel those within the international community related to building new global descriptions of the Earth's environment and upgrading model representations on which to base predictions and improve descriptions of key local and regional processes. The global products and data sets derived through the exploitation of new satellite sensors will be critical to these developments and will extend our current knowledge.

Dr. M. Colton, Director of Research and Applications, NOAA, National Environmental Satellite, Data, and Information Service (NESDIS), and member of the CEOP AOC, reported that an agreement has been reached for NESDIS to provide CEOP with data from NOAA operational satellites. The agreement is expected to be fulfilled through the NESDIS archive system known as the Comprehensive Large Array-data Stewardship System.

A joint working session of the CEOP SSC and AOC addressed several important issues including methods and metrics for how to: (a) maximize the science and technology benefits from CEOP; (b) improve the framework for oversight of CEOP implementation/science plans and results; (c) make and implement specific recommendations for efficient organization/management of CEOP; (d) achieve the main CEOP science objectives; (e) initiate a successful CEOP Science Workshop in 2005; (f) highlight items relevant to CEOP implementation and planning that require further development; (g) focus CEOP implementation plans and schedules in the context of the priorities being set by the broader International Climate Research Community and recommend changes in scope and areas where gaps exist; and (h) develop a strategy to continue the work being carried out within the International framework built up in CEOP beyond the currently defined CEOP observation and research phase.

The Fourth CEOP International Implementation Planning meeting is planned for 28 Feburary to 4 March 2005 at the University of Tokyo (UT), Tokyo, Japan, possibly in conjunction with an IGOS-P meeting.

GEWEX RELEVANT PUBLICATIONS

(continued from Page 13)

ing summer. Interannual variability of the statistical characteristics in different reanalyses are more consistent over Northern and Eastern Europe than in the mountain regions of Southern Europe. Correlations between statistical characteristics of precipitation in different reanalyses and between the reanalyses and station data are 20% to 30% higher during the winter season.

The diagnosed differences in the characteristics of gamma-distribution (shape and scale) parameters and extreme precipitation values between different NWP products may vary within 30% to 40% on average. This is larger than the differences in these characteristics simulated by climate models with doubled greenhouse gasses, which report normally the largest changes between model projections and the present climate to be within 10% to 20%. Thus, one has to be careful when choosing reanalysis data sets for the description of what we term the present climate.

GEWEX/WCRP MEETINGS CALENDAR

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

24–28 May 2004—FOURTH STUDY CONFERENCE ON BALTEX, Island of Bornholm, Denmark.

21–25 June 2004—1ST INTERNATIONAL CLIVAR SCIENCE CONFERENCE, Baltimore, Maryland, USA.

20–22 July 2004—GEWEX EXECUTIVE MEETING, Baltimore, Maryland.

26–28 July 2004—3RD LBA SCIENCE CONFERENCE, Brasilia, Brazil.

26–30 July 2004—8TH BSRN WORKSHOP AND SCIENTIFIC REVIEW, Exeter, UK.

30–31 August 2004—GAPP PRINCIPAL INVESTIGATORS MEETING, Boulder, Colorado, USA.

13–16 September 2004—10TH MEETING OF THE GEWEX HYDROMETEOROLOGY PANEL, Montevideo, Uruguay.

21–23 September 2004—GCSS SCIENCE PANEL MEETING, NASA GISS, New York, NY, USA.

11–15 October 2004—20TH SESSION OF THE CAS/JSC WGNE/8TH SESSION OF THE GMPP, Exeter, UK.

18–19 October 2004—GRP WORKING GROUP ON DATA MANAGEMENT AND ANALYSIS (WGDMA), Kyoto, Japan.

20–22 October 2004—15TH SESSION OF THE GEWEX RADIATION PANEL, Kyoto, Japan.

1–5 December 2004—GAME INTERNATIONAL SCIENCE PANEL MEETING AND 6TH INTERNATIONAL STUDY CONFERENCE ON GEWEX IN ASIA AND GAME, Kyoto, Japan.

20–24 June 2005—5TH INTERNATIONAL SCIENTIFIC CONFERENCE ON THE GLOBAL ENERGY AND WATER CYCLE, Orange County, California, USA.

GEWEX NEWS

Published by the International GEWEX Project Office

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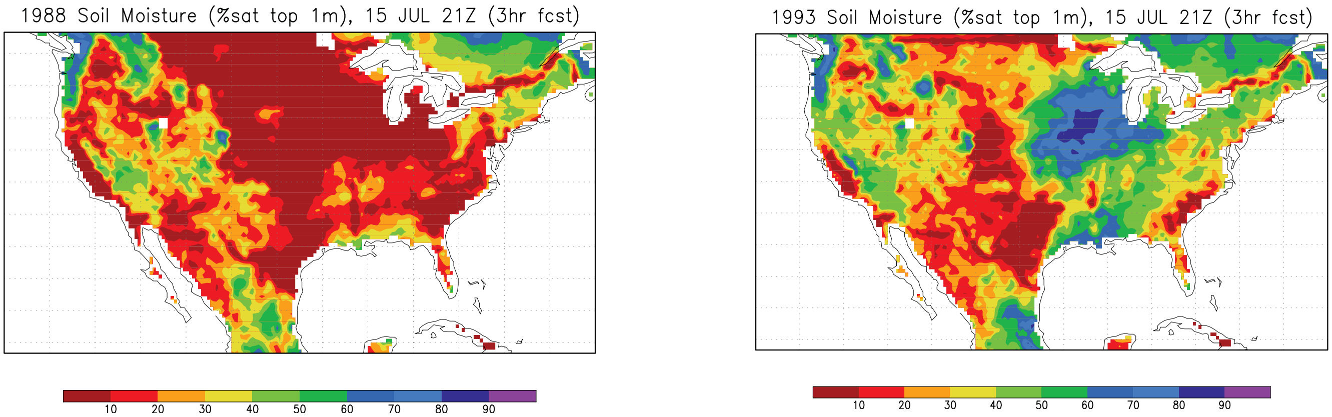
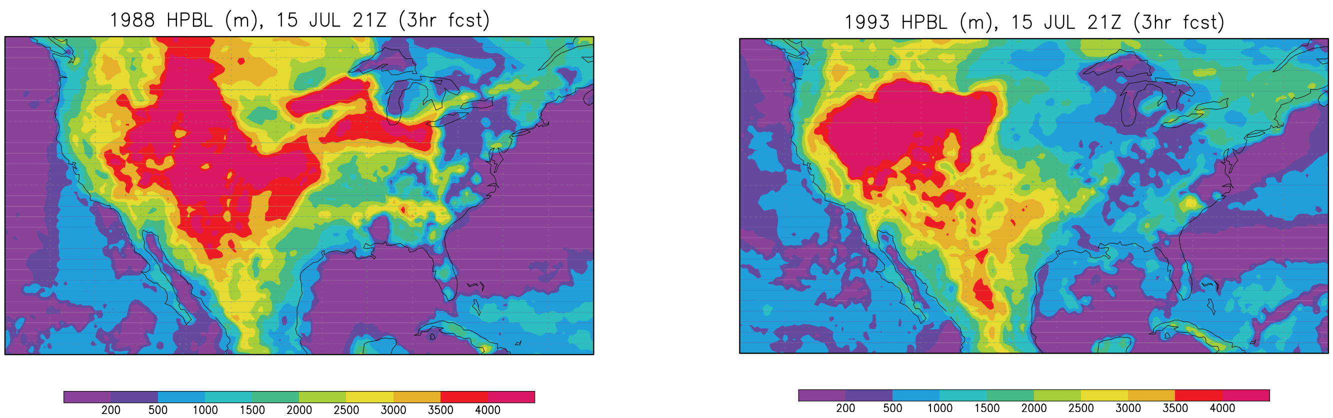
ASSIMILATING PRECIPITATION INTO NARR SHOWS SIGNIFICANT IMPACT ON SOIL MOISTURE AND PLANETARY BOUNDARY LAYER DEPTH

(see article on page 9)



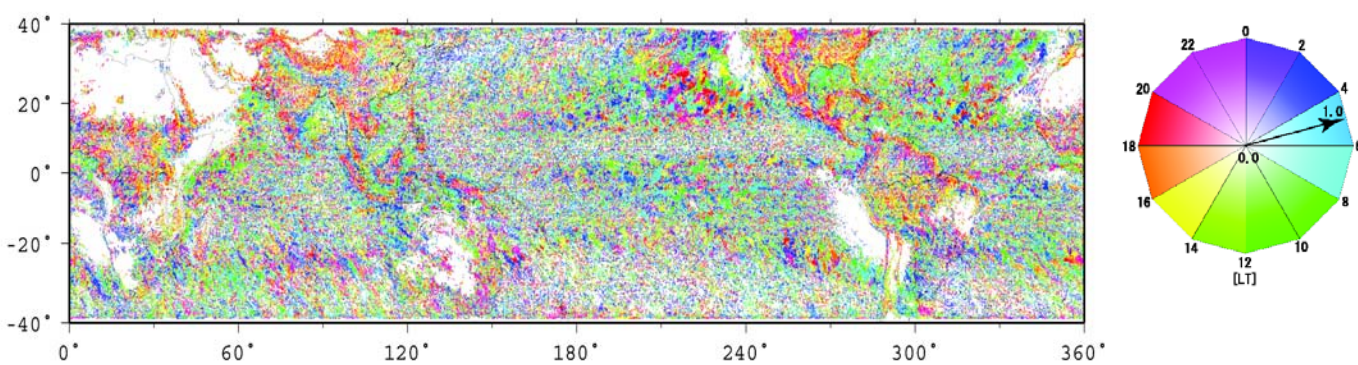
Soil moisture (as percentage of saturation) of North American Regional Reanalysis (NARR) for top 1 meter of soil column valid at 21 UTC for 15 July 1988 (left) and 1993 (right).



Planetary boundary layer depth (m) of NARR valid at 21 UTC for 15 July 1988 (left) and 1993 (right).

TRMM SHOWS STRONG DIURNAL VARIATION OVER MARITIME CONTINENT AND OVER TROPICAL AND SUB-TROPICAL LAND

(see article on page 4)



Map of local time with TMI maximum rainfall rate during JJA on 1998–2002 (color level) with the saturation of 0–1 as an amplitude of diurnal variation, NA = (R_max-R_min)/(R_max+R_min). Saturation of unity shows large NA, and zero shows small NA.