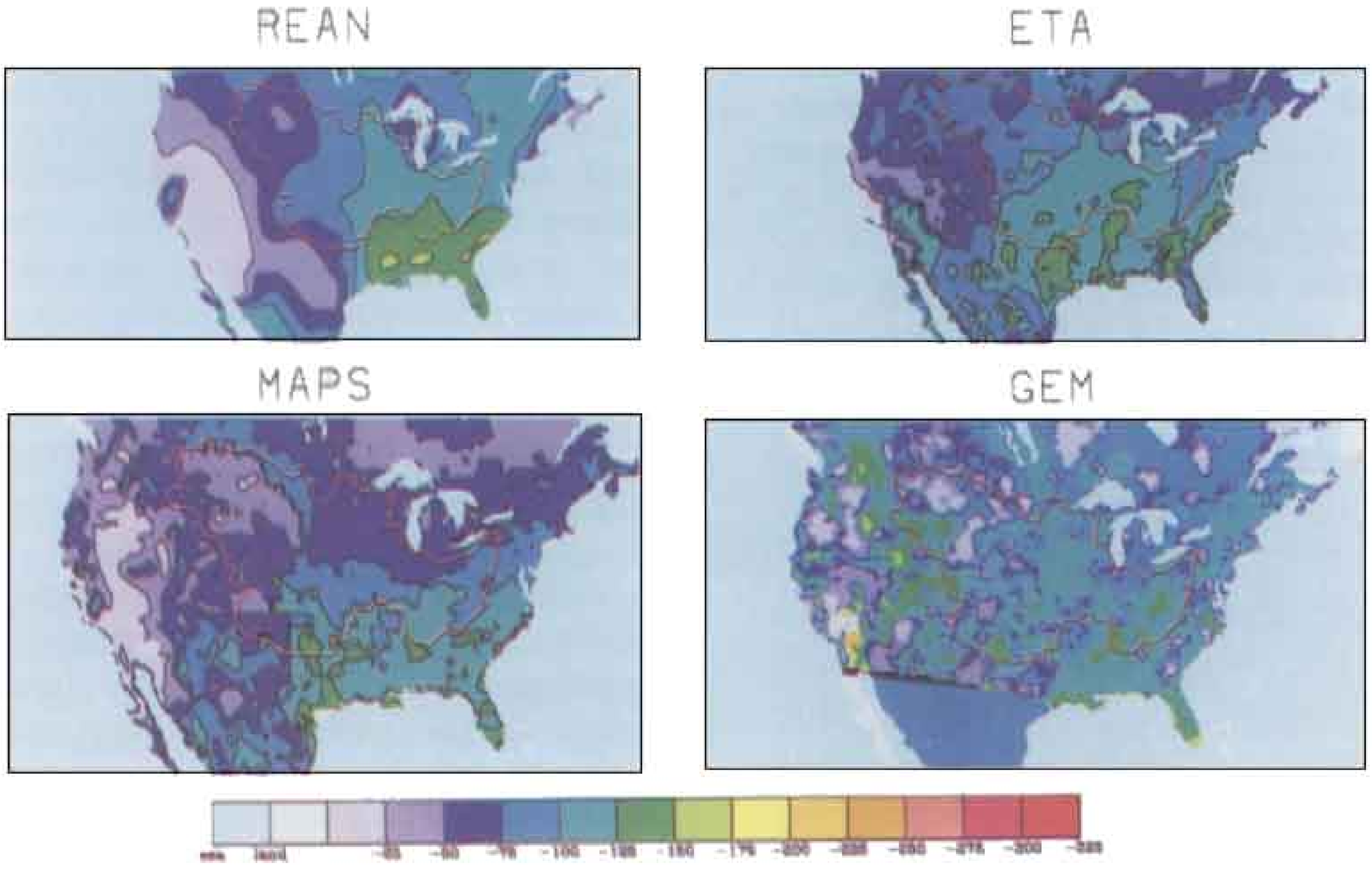
GEWEX WCRP
Global Energy and Water Cycle Experiment
NEWS
Vol. 8, No. 3 August 1998
World Climate Research Programme–WCRP

REGIONAL MODELS NOW PRODUCING REASONABLE HEAT FLUXES



Regional patterns differ, but when heat fluxes are area averaged they tend to agree within ±20 W/m² in data rich areas. The figure shows an assessment of latent heat flux in August 1997 produced by three regional numerical models and a corresponding reanalysis (see article on page 3). Red contour is the boundary of the Mississippi River Basin.

ATMOSPHERIC MOISTURE CYCLING RATE TRENDS FROM MODEL RUNS

John Roads and Shyh-Chin Chen
Scripps Institution of Oceanography

Susan Marshall
University of North Carolina

Robert Oglesby
Purdue University

Because of the potential intensification of the hydrologic cycle as the earth warms from increasing anthropogenic greenhouse gases (Roads et al., 1996; Stephens, 1997), global cycling rates have attracted recent interest. A cycling rate was defined previously by Chahine et al. (1997) and Trenberth (1997) as the ratio of the precipitation to precipitable water, P/QT. Chahine et al. (1997) further suggested that this cycling rate may be

 (Continued on page 7)

THIRD INTERNATIONAL GEWEX SCIENTIFIC CONFERENCE
Beijing, China
16–19 June 1999
(see back for details)

WHAT'S NEW IN GEWEX

- ***Assessment Shows Forecast Benefits for Reservoir Managers!***
- ***New Evaporative Flux Data Collection Begins***
- ***GPCP Now Producing 1°x1° Data Sets***
- ***Large Turnout for GCIP and BALTEX Science Conferences***

COMMENTARY

THE GEWEX RADIATION PANEL FOCUSING ON FEEDBACKS

Moustafa T. Chahine
GEWEX Scientific Steering Group

The GEWEX Radiation Panel (GRP) was organized to bring together theoretical and experimental insights into the radiative interactions and feedbacks of clouds and water vapor within the atmosphere and at the Earth's surface. The most fundamental scientific question the GRP must answer is: How sensitive is the steady state climate of Earth to changes in radiative forcings? Answering this question will enable improved prediction of transient climate variations such as El Niño and provide better understanding of natural and human-induced climate forcings and trends.

Changes in atmospheric water vapor, clouds and aerosols affect the energy balance of the Earth and since these processes are intertwined, complex and simultaneous, considerable uncertainty and controversy remain concerning the quantitative impact of these adjustments and feedback processes. As a result, the treatment of this problem is intricate and requires coordinated observations, modeling and process studies.

Because of the nonlinear interactions between clouds and their ambient environment, the GRP research plans call for new observations to characterize the full atmospheric column in the presence of clouds. Several observational techniques are being studied and proposed by the world space agencies, including the European Space Agency, the United States National Aeronautics and Space Administration and the National Space Development Agency of Japan, to obtain the vertical structure and composition of clouds using active radar and lidar systems. Additional passive infrared and microwave information will complement these active instruments to characterize the temperature, water vapor, precipitation, evaporation, fluxes, clouds and aerosols in the atmospheric column from the surface to the top of the atmosphere.

Confidence in the success of GRP in meeting its future challenges is rooted in a history and record of outstanding achievements. These achievements include the planning and implementation of major process studies and the publication and application of research findings by its various GEWEX projects: The International Satellite Cloud Climatology Project (ISCCP), the Surface Radiation Budget (SRB) Project, the Baseline Surface Radiation Network (BSRN), the Global Water Vapor Project (GVaP), the Global Precipitation Climatology Project (GPCP) and the new Global Aerosol Climatology Project (GACP). During the past decade, these projects have integrated diverse surface measurements with meteorological data and satellite observations producing, in many cases, the first coherent climatological records of important parameters such as rainfall, cloud characteristics, surface radiation and atmospheric humidity. All these projects are now entering a new phase of research using more accurate observations from the new generation of Earth observing systems.

The GEWEX Radiation Panel must continue to accelerate the dual strategy of pursuing the studies of the cloud-energy feedbacks plus improving the global data sets and simultaneously distributing these highly accurate results to be incorporated in global and regional models. The results are important for model development and validation, and for improved weather forecasting and expanded climate prediction.

Contents

ASSESSMENT OF SURFACE HEAT FLUXES FROM REGIONAL MODELS

Ernesto Hugo Berbery
University of Maryland

Kenneth Mitchell
National Oceanic and Atmospheric Administration (NOAA)

Stanley Benjamin and Tatiana Smirnova
NOAA

Harold Ritchie, Richard Hogue, and Ekaterina Radeva
Atmospheric Environmental Service, Canada

The GEWEX Continental-scale International Project (GCIP) has as one of its goals to evaluate the land surface and atmospheric parameterizations from regional numerical weather prediction models and their associated 4-dimensional data assimilation systems. **In recent years there has been an important improvement in the way basic variables are being represented in models, and a host of new parameters that result from physical parameterizations has become available as well.** Soil moisture, evaporation and surface energy balance terms are some examples. Although it would be desirable to have reliable observations to evaluate the quality of those parameters, unfortunately this is not always the case. As an alternative, we have undertaken an assessment of the products of three operational regional models to ascertain their current status in terms of surface energy budget terms. Partial results for August 1997 are reported in this note. **The assessment has the objective of helping detect potential inaccuracies in the parameterizations and provide an estimate of the reliability of surface energy budgets specifically for the Mississippi River Basin.** The models in this study are (a) the National Oceanic and Atmospheric Administration (NOAA) Eta model from the National Centers for Environmental Prediction (NCEP); (b) the Global Environmental Multiscale (GEM) model from the Canadian Meteorological Centre; and (c) the Mesoscale Analysis and Prediction System (MAPS) from NOAA's Forecast Systems Laboratory. As a matter of interest, the corresponding NCEP/NCAR reanalysis fields (Kalnay et al., 1996) are also presented.

Table 1 presents basic features of the models. They have approximately a similar resolution over the GCIP area, although they have different advanced parameterizations for radiation, land surface processes, cloud physics and convection. Relevant information on the parameterizations can be found in Chen et al. (1996) and Rogers et al. (1996) for the Eta model; in Smirnova et al. (1996) for MAPS; and in Cote et al. (1997) for the GEM model. Each has its own advantages; for example, the Eta model has many products; MAPS analyses and forecasts are available at hourly frequency; and the GEM model, while being global, has regional capability. It should be noted that the land surface and radiation physics packages are similar between the Eta and reanalysis models, so this may be responsible for some of the similarity in results from these two models. Since all the models have different grids, and to facilitate the comparison, output fields were interpolated to a common grid known as AWIPS 212. Further details about the regional model products can be found at: http://www.scd.ucar.edu/dss/pub/gcip/index.html.

The figures on pages 1 and 16 display the August 1997 monthly average of the latent and sensible heat fluxes at the surface. Mean fields

TABLE 1. Models Features

	Eta	MAPS	GEM	Rean
Horizontal Resolution	48 km	40 km	35 km	T62 (about 210 km)
Vertical levels	38	40	28	28
Convective scheme	Modified Betts-Miller	Modified Grell	Kuo	Pan-Grell
Land Surface scheme	Extended Pan-Mahrt	6-level soil/veg model - Smirnova	Force-restore scheme	Pan-Mahrt
Radiation	GFDL Package	MM5	CMC/RPN package	GFDL Package

were computed as the 31-day average of the 0- to-12-hour forecasts of the 0 and 12 UTC cycles. The figure on page 1 depicts the loss of energy at the surface by latent heat flux (LHF). The general pattern from all models shows the smallest values on the west and increasing toward the southeast. It can be noted that while GEM fields are noisier, the values are of the same order of magnitude of those of the other models. **It would appear that models tend to show better agreement inside the Mississippi River Basin, a fact that may be explained because of the region's abundance of data that are ingested by the assimilating systems and also because in many instances they serve to tune the parameterization schemes**. Interestingly, LHF differences are largest over Canada and the Labrador Peninsula (not shown) in particular, that is, areas where data tend to be sparse. Within the Mississippi River Basin, largest differences (of the order of 25–50 W/m^2) are observed in the central and upper western regions. Still, they do not appear to affect significantly the area averages (Tables 2 and 3).

TABLE 2. Mississippi River Basin

Units: W m^{-2}	Eta	MAPS	GEM	Rean
Latent Heat Flux	98	79	91	91
Sensible Heat Flux	40	91	32	43

TABLE 3. Arkansas/Red River Basin

Units: W m^{-2}	Eta	MAPS	GEM	Rean
Latent Heat Flux	108	105	104	121
Sensible Heat Flux	36	100	28	57

The loss of energy by sensible heat flux (SHF), (see figure on back page) is largest toward the west in all models (as expected; see, e.g., Roads et al., 1997). The reanalysis has larger values than the Eta model estimates on the west coast, while the inverse is true on the east coast. GEM has somewhat smaller values than Eta, and again depicts a noisier field. MAPS has larger values than the other models primarily due to inadequate negative sensible heat flux at night (fix made to MAPS in February 1998) and also due to the rooting depth error (also since corrected). The area averages for the two basins under consideration indicate that SHF differences are proportionally large when compared to the other terms. They become significant in the Arkansas/Red River Basin, where the reanalysis estimate doubles that of the GEM model, and is about 80% higher than that from the Eta model. In turn, the Eta and GEM models estimates differ by about 30%.

In summary, a first look at the main components of the energy budgets from regional models was presented; in spite of the different parameterizations, there is, in general, a good degree of agreement over the central United States and the differences may be taken as a measure of the uncertainty of the estimates. Differences are larger in regions of sparse data or where parameterizations may not be well tuned. **Regional patterns also tend to differ, but when the heat fluxes are area averaged, they tend to agree within 20 W/m^2 (although it should be noted that this value is significant for the SHF estimates)**. Additional intercomparisons will be performed for future periods that include model updates and fixes as well as examination of additional variables.

Acknowledgments: We thank T. Marchok and R. Jenne for their assistance in providing the Eta and MAPS data respectively. This work was supported by NOAA under GCIP grant NA 76GP0291.

References

Chen, F., K. Mitchell, J. Schaake, Y. Xue, H. Pan, V. Koren, Q. Duan and A. Betts, 1996. Modeling of land-surface evaporation by four schemes and comparison with FIFE observations. *J. Geoph. Res.* 101, 7521-7268

Cote, J., J.-G. Desmarais, S. Gravel, A. Methot, A. Patoine, M. Roch and A. Staniford, 1998. The operational CMC/MRB Global Environmental Multiscale (GEM) Model. Part I and II. *Mon. Wea. Rev.*, 126, 1373-1418.

Kalnay E. and co-authors, 1996. The NCEP/NCAR 40-year reanalysis project. *Bull. Amer. Meteor. Soc.*, 77, 437-471.

Roads, J., S. Chen, M. Kanamitsu and H. Juang, 1997. GDAS's GCIP Energy Budgets. *J. Atmos. Sci.*, 54, 1776-1794.

Rogers, E., T. L. Black, D. G. Deaven and G. J. DiMego, 1996. Changes to the operational "Early" Eta analysis/forecast system at the National Centers for Environmental Prediction. *Wea. Forecasting*, 11, 391-413.

Smirnova, T. G., J. M. Brown and S. G. Benjamin, 1997. Performance of different soil model configurations in simulating ground surface temperature and surface fluxes. *Mon. Wea. Rev.* 125, 1870-1884.

ASSESSMENT OF BENEFITS OF CLIMATE FORECASTS FOR RESERVOIR MANAGEMENT IN THE GCIP REGION

Konstantine P. Georgakakos
Scripps Institution of Oceanography (SIO)
and
Aris P. Georgakakos
Georgia Institute of Technology
and
Nicholas E. Graham
SIO and International Research Institute for Climate Prediction

This GCIP research program, initiated in September 1997, aims at providing a quantitative answer to the question: **What is the economic and environmental benefit that Global Climate Model (GCM) forecasts offer to the operational management of reservoirs controlling regional water resources?** Past studies of the authors, aimed at the development of prototype systems for integrated forecast-control of large multi-purpose reservoirs, form the foundation of the research program (see Georgakakos et al., 1995, 1998). These studies were conducted in collaboration with Staff of the U.S. Army Corps of Engineers, Rock Island District, and the Office of Hydrology of the National Weather Service.

The present study focuses on the Saylorville Reservoir located on the Des Moines River in Iowa. The upstream drainage area is 14,120 km^2 (part in Minnesota and part in Iowa) and there are 40 rain gauge stations, six stream gauge stations, one first-order meteorological station, and two pan evaporation stations within and near the reservoir catchment. The hydroclimatology of the region is characterized by a strong annual cycle with annual mean areal values for precipitation and potential evapotranspiration of 0.77 m/y and 0.84 m/y, respectively. The annual flow at Stratford (considered to be the inflow point to the Saylorville Reservoir) is 0.15 m/y. The study reservoir managed by the Corps of Engineers, has a capacity of 834 million m^3 with objectives of flood control, water supply and low flow augmentation. The Corps of Engineers, Rock Island District, manages it.

The methodology applies integrated forecast-control methods with and without GCM information, and compares the results in terms of

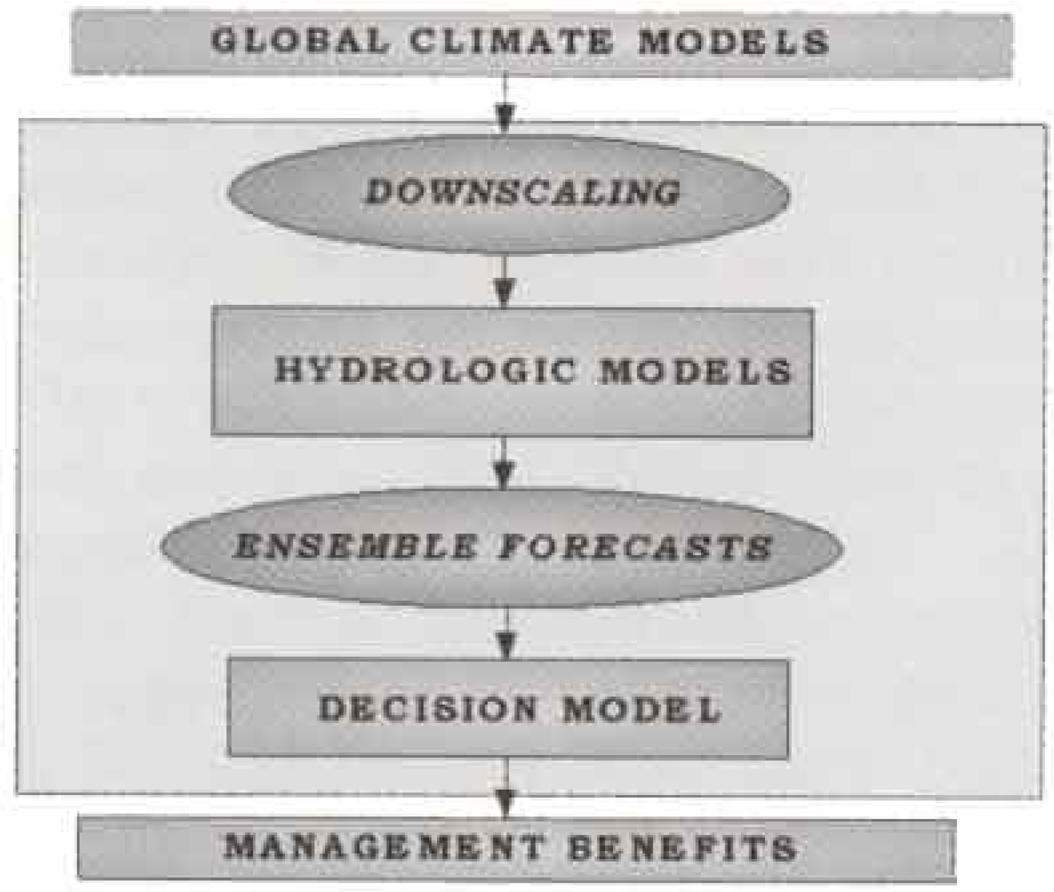


Figure 1. Schematic diagram of the integrated forecast-control decision system implemented and assessed by the research work.

measurable economic and environmental benefits. The integrated forecast-control method used is based on explicit models for the generation of estimates of forecast uncertainty and for the utilization of such estimates by the reservoir controller (Figure 1). The Max Planck Institute for Meteorology Atmospheric (ECHAM3) GCM is used to provide a five-member ensemble of climate forecasts for January–March and June–May 1970–1988, using the persisted global sea surface temperature anomalies from December and May respectively. The GCM has a spatial resolution of approximately 2.8°, and monthly average dates were used. An adaptation of the operational National Weather Service stream flow forecast model with 1,000–3,000 km^2 resolution provides channel inflow predictions to a Muskingum-Cunge channel routing model, which generates stream flow predictions at a number of locations along the Des Moines River and at the inflow point of the Saylorville Reservoir. The models are used in an ensemble forecasting methodology to generate reservoir inflow forecasts for 4-months into the future, with forecast preparation time on the first day of each month of record and with daily resolution. The generation of ensemble forecasts is based on historical input, with preservation of the seasonal cycle of precipitation and potential evapotranspiration. Two series of runs were performed. For the first series of runs, the flow-forecast ensembles were generated without any conditioning on GCM forecasts. For the second series of runs, the flow forecast ensembles were generated based on input precipitation and evapotranspiration which were drawn from three sample sets of traces defined by the upper, middle and lower thirds of the seasonal precipitation distribution. The choice of which third to use was based on whether or not the GCM forecast January–March (for the December GCM forecasts) and June–August (for the May GCM forecasts) seasonal precipitation was in the corresponding third of the GCM-predicted precipitation, for all nearby GCM grid boxes and all GCM prediction ensembled members. Figure 2 shows that the differences in the cumulative distributions of daily catchment precipitation corresponding to the upper and the lower third of the GCM-forecast seasonal precipitation distribution are for daily rainfall less than 10 mm/d and for extreme rainfall. The simulation of the operational reservoir management using historical data determined whether or not these differences add skill to the forecasts and benefits to management. A decision support system links decisions with system operation on various time horizons (seasonal to hourly), generates trade-offs among various system objectives within a risk-based framework, and, given a certain set of objective priorities, determined in collaboration with the Corps of Engineers Staff, operates the reservoir and assesses the impacts of regulatory policies.

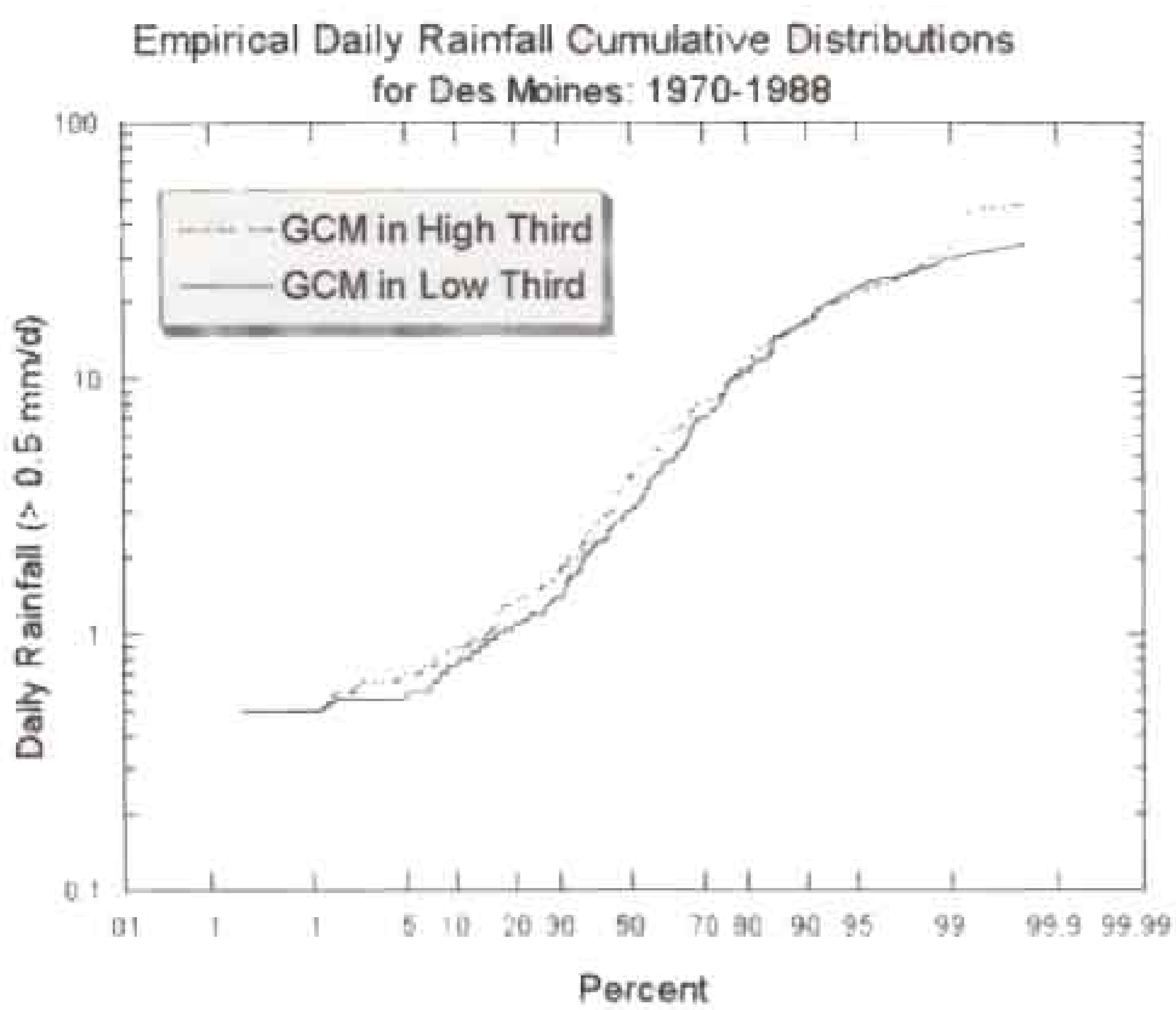


Figure 2. Empirical cumulative distributions of daily rainfall for the upper Des Moines River catchment for 1970-1988. The dashed line is for GCM seasonal rainfall forecasts in the upper third of their distribution and the solid line is for such forecasts in the lower third of their distribution.

Unique aspects of the methodology are: (a) that it makes possible a quantitative answer to the questions posed for reservoir systems, allowing for the best operational performances of the management system (for given decision maker preferences) both with and without the benefit of GCM forecasts; and (b) couples an end-to-end forecast system with a reservoir control system in real time, with explicit account for forecast uncertainty.

Results to-date show that the particular GCM information used can enhance the skill of the ensemble forecasts for the study region, especially during extreme wet periods. For example, results for the high flow year 1984 show a zero likelihood of producing ensemble mean flows for the unconditional ensemble flow forecast methodology that are closer to the observed flows than the GCM-conditioned ensemble mean flows near the observed peak flows. **As a result, Figure 3 shows (Case 3a and 3b) that the reservoir control component manages to reduce the maximum daily flood damage by about 2 million dollars.** Case 3c presents the maximum daily flood damage that would result if neither GCM information nor forecast uncertainty is taken into account. (Namely, the flow forecast of this case corresponds to the mean flow sequence of Case 3b.) This result shows that flood damage increases by another 2 million dollars relative to Case 3b or 4 million

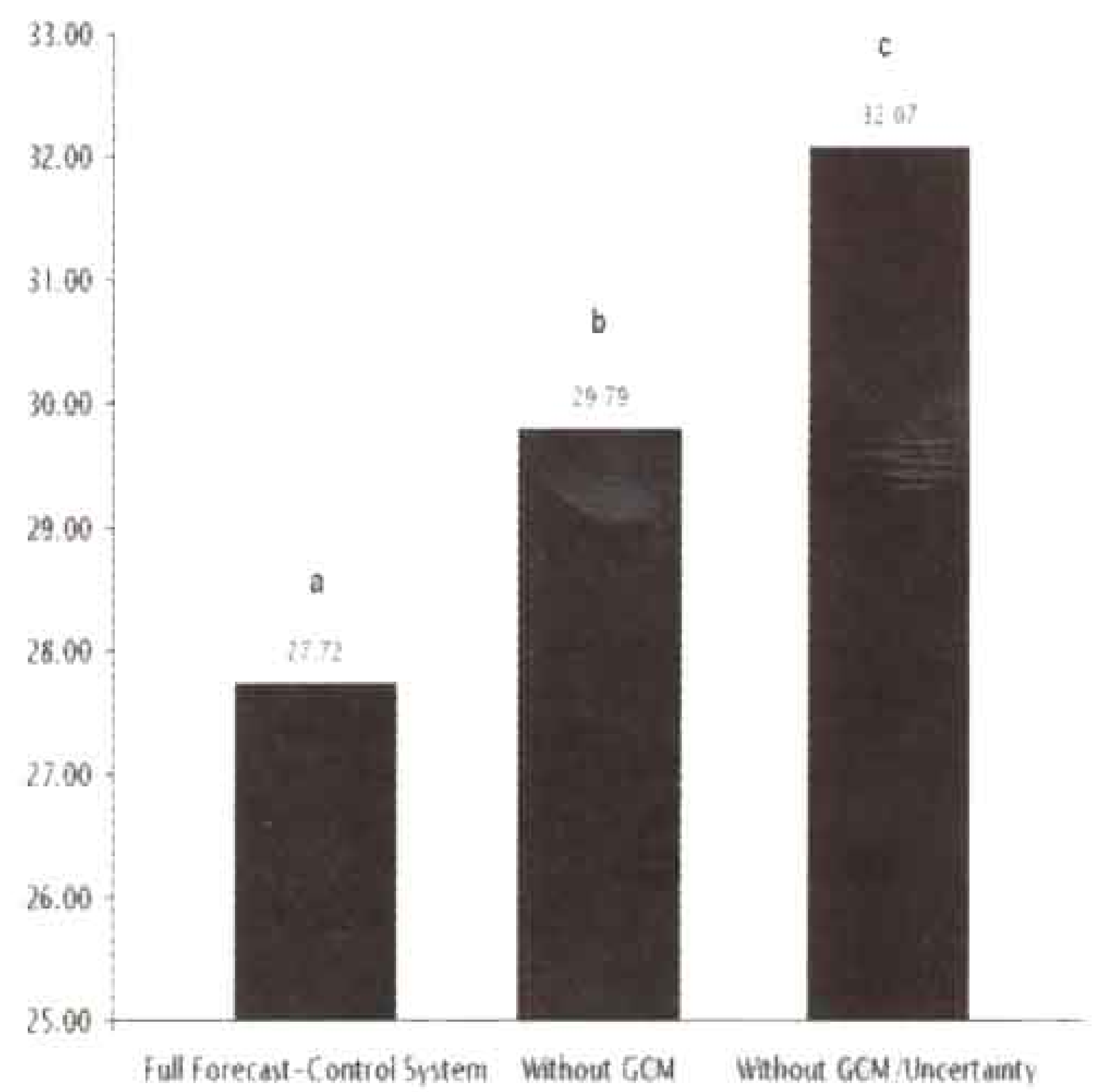


Figure 3. Reduction of maximum daily flood damage (millions of dollars) when full forecast control system is used.

dollars relative to Case 3a. Lastly, a fourth experiment (not shown), where GCM information is used but without uncertainty characterization, yields results similar to Case 3c. Furthermore, computational experiments over a 19-year period indicate that (1) the same observations can be made relative to average annual flood damage and spillage, and (2) that explicitly stochastic reservoir control approaches outperform heuristic, rule-based operational procedures.

Based on these and other investigations, we conclude that the following components have the potential to enhance the operational management of river basins: GCM information, forecast uncertainty characterization, reservoir control procedures accounting for forecast uncertainty, and integrated forecast-control systems. However, we also showed that a significant part or all of these enhancements could be reversed if some of the other components are missing.

Relative to value, we note that such performance is typical in many parts of the globe. While we showed that such information does entail modest benefits during extreme events, it may also have value relative to other water uses pertaining to longer time scales (e.g., energy generation). **On the basis of these studies, it is recommended that further research implement such integrated forecast-control systems in an operational environment at suitably selected prototype sites, and the benefits of climate forecast information be evaluated in the context of integrated forecast-control methodologies in collaboration with reservoir management agencies.**

Acknowledgments: The research is sponsored by NOAA's Office of Global Programs through a GCIP Grant, through the SIO Experimental Climate Prediction Center and the International Research Institute for Climate Prediction.

References:

Georgakakos, A. P., Mullusky, M. G., Yao, H., and K. P. Georgakakos, 1998. Impacts of climate variability on the operational forecast and management of the upper Des Moines River basin. *Water Resource Research*, 34(4), 799-821.

Georgakakos, K. P., Bae, D. H., Mullusky, M. G., and A. P. Georgakakos, 1995. Hydrologic variability in Midwestern drainage basins: Diagnosis, prediction, and control. In *Preparing for Global Change: A Midwestern Perspective*. E. Folk, G. L. Schnoor, G. Carmichael (eds.), SPB Acad. Publ., Amsterdam, The Netherlands, 61-90.

ATMOSPHERIC MOISTURE CYCLING RATES

(Continued from page 1)

increasing, at least during the limited sample period. **We suggest here, however, that the cycling rate could ultimately decrease in the future, because water vapor storage may increase relative to the precipitation rate**.

Cycling rates and their inverse, residence times need to be calculated from temporally and spatially averaged values of precipitation and precipitable water. Local instantaneous cycling rates have extreme values, especially in the highest latitudes where precipitable water can be close to zero but precipitation can still be relatively large. In any event, the cycling rate should refer to a multitude of events for large spatial and temporal regions. In Table 1 we show globally and seasonally averaged values of precipitation and precipitable water, and these averages are used to define the cycling rate. Because of extreme values, using zonal and monthly means to define the rates and then globally averaging the zonal rates yielded higher cycling rates. Even larger rates occurred when instantaneous values at individual gridpoints were averaged.

A number of different gridded sources can be used to calculate the cycling rate. Monthly averaged precipitation and precipitable water from the last 10 years of 21-year simulations with the latest community climate model (CCM3; see Kiehl et al., 1996; Marshall et al., 1996) from the National Center for Atmospheric Research (NCAR) are available. In addition to a control run forced by observed sea surface temperatures for the period 1950–1994, there is another 20-year control run with a mixed layer model using current estimates of CO_2 (355 ppm), as well as 20 years from a doubled CO_2 run (710 ppm) and a reduced CO_2 run (230 ppm). The range of CO_2 chosen for these experiments represents possible ranges for CO_2 for the past, present, and future of this planet. For simplicity, we only examined the second decade of all the mixed layer runs. The first decade is needed for the enhanced and reduced CO_2 experiments to reach an approximate equilibrium. NCEP/NCAR reanalysis (see Kalnay et al., 1996) provided another estimate for the precipitation and precipitable water and was discussed previously by Trenberth (1997). Although the reanalysis is likely to better represent nature than CCM3, there can still be some significant deviations from observations. Finally, as part of GEWEX sponsored activities, there are now observations for precipitation and precipitable water. In particular, the NASA Water Vapor Project (NVAP) (see Randel et al., 1996) precipitable water is available for the period 1988–1992. Monthly mean global precipitation climatology (GPCP) products including Xie and Arkin (1996, 1997; hereafter referred to as XA) monthly mean precipitation values for the period 1979–1996 are also available. It should be noted that both the NVAP precipitable water and XA precipitation were developed independently from the reanalysis. Chahine et al. (1997) discuss some additional satellite data sources.

All available months and all available gridpoints were used for each computation of the areally weighted global means shown in Table 1 and Figure 1. In this regard, it should be noted here that there were a number of missing observations (especially for the NVAP precipitable water). However, several tests (reanalysis calculated at the same gridpoints as observations) showed that because most of the missing observations occurred in high latitudes, averaging over only the gridpoints with data was likely to be minimally different from using true global averages. The time period over which the observations are being compared can also provide some differences. For example, as shown in Figure 1e the reanalysis indicates much larger precipitation occurred prior to 1965 as well as after 1992. Although there could be a problem with the analysis since the increase after 1992 is in disagreement with the XA observations and the large amounts prior to 1965 are in disagreement with the CCM3 control run, this also suggests that long period records may sometimes show significantly different climatologies.

Taking into account some of the potential differences, there are still some distinct climatological differences in the precipitable water and precipitation. The precipitable water (Figures 1a and 1d) from NVAP is quite a bit higher than the precipitable water in the reanalysis, which is slightly higher than the precipitable water from the control runs (mixed layer and forced SST) of CCM3. An opposite order occurs for precipitation (Figures 1b and 1e), where the observed precipitation is smaller than reanalysis precipitation and quite a bit smaller than the precipitation from the control run of CCM3. It should also be noted here that reanalysis and observed annual variations show little correspondence. That is not the case, however, for local variations where there is likely to be more of a correspondence. It should also be noted that the correct seasonal cycle occurs in all sources with the dominant increase in precipitable water and precipitation occurring during the boreal summer when the Asian monsoon kicks in.

The smallest cycling rate (Figures 1c and 1f), occurs for the observations. The cycling rate is a bit higher for the reanalysis and quite a bit higher for each of the CCM3 simulations. (As shown in Table 1, the cycling rate is even higher if monthly mean zonal values are calculated and then globally and annually averaged.) Note the seasonal similarities among the observations, reanalysis, and CCM3 simulations in that the cycling rate is largest during the boreal winter and smallest during the boreal summer. This seasonal variation is similar to what occurs in the changed CO_2 experiments in that the cycling rate decreases with increasing CO_2. This decrease is due to the large increase in atmospheric moisture relative to smaller increases in precipitation. Interestingly, supporting marginal trends do appear in the CCM3 forced SST experiment. Unfortunately, there appear to be no significant trends in the reanalysis

Table 1. Globally and seasonally averaged precipitation {P}, precipitable water {QT}, and cycling rate {P}/{QT} from observations, NCEP reanalysis, the CCM3 forced SST experiment and the three CO_2 simulations (230, 355, 710). The column labeled {P/QT} provides values for cycling rates first calculated from zonal and monthly averages and then globally and annually averaged.

	{P} mm day^{-1}	{QT} mm	{P}/{QT} day^{-1}	{P/QT} day^{-1}
Obs.	2.68	25.45	0.106	0.129
NCEP	2.76	23.87	0.116	0.165
CCM3	3.08	23.17	0.133	0.172
CCM3 230	3.01	21.35	0.141	0.187
CCM3 355	3.09	23.45	0.132	0.173
CCM3 710	3.21	26.75	0.120	0.155

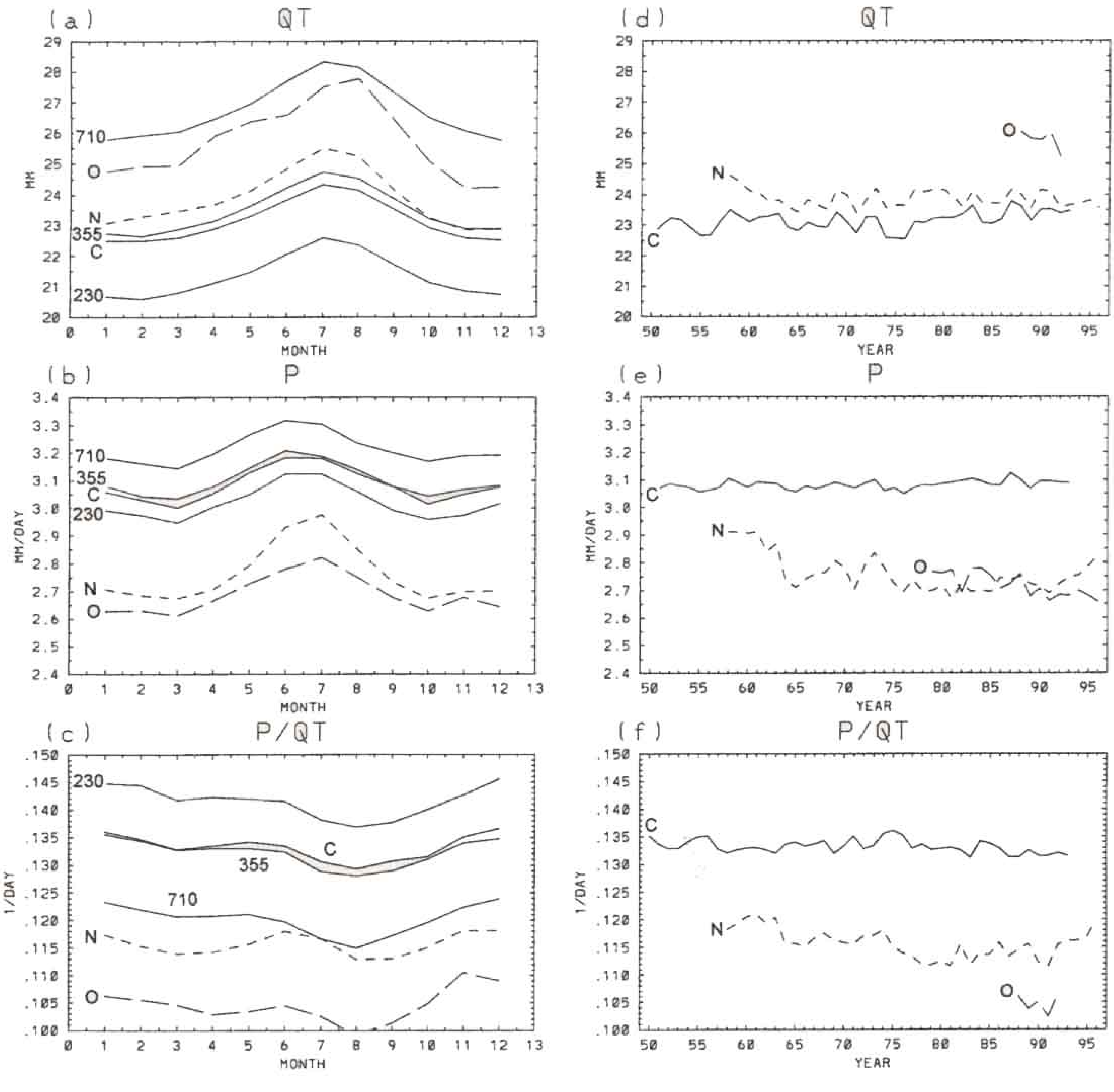


Figure 1. Globally averaged precipitable water QT, precipitation P, and cycling rate P/QT, from: NVAP and/or XA observations (O, long dash lines); NCEP/NCAR reanalysis (N, short dash lines); the CCM3 forced SST experiment and the three CO_2 simulations (C, 230, 355, 710, solid lines). (a) Mean precipitable water, mm. (b) Mean precipitation, mm/day. (c) Mean recycling rate day^{-1}. (d) Monthly precipitable water, mm. (e) Monthly precipitation, mm/day. (f) Monthly recycling rate, day^{-1}.

and the available observations have too short a time series to confirm this hypothetical future decrease in the cycling rate. Also, note the fairly large discrepancies among the observations, re-analysis, and CCM3 simulations, which suggests that much more work is still needed to resolve model, analysis, and observational differences.

Acknowledgments: This study was supported by NOAA grants A37GP0372 and NA36GP0377 and NASA grant NAG5-4775. NCEP/NCAR Re-analysis data were provided through the NOAA Climate Diagnostics Center.

References

Chahine, M. T., R. Haskins, and E. Fetzer, 1997. Observation of the recycling rate of moisture in the atmosphere: 1988:1994. *GEWEX NEWS*, August, 1997.

Kalnay, E. M. Kanamitsu, R. Kistler, W. Collins, D. Deaven, J. Derber, L. Gandin, S. Saha, G. White, J. Woolen, Y. Zhu, M. Chelliah, W. Ebisuzaki, W. Higgins, J. Janowiak, K. C. Mo, C. Ropelewski, J. Wang, A. Leetmaa, R. Reynolds, and R. Jenne, 1996. The NMC/NCAR Reanalysis project. *Bull. Amer. Meteor. Soc.*, 77, 437-471.

Kiehl, J. T., J. J. Hack, G. B. Bonan, B. A. Boville, B. P. Briegleb, D. L. Williamson and P. J. Rasch, 1996. Description of the NCAR Community Climate Model (CCM3), NCAR Technical Note, NCAR/TN-420+STR, Boulder, Colorado, 152 pp.

Marshall, Susan, J. O. Roads, and R. J. Oglesby, 1997. Effects of Resolution and Physics on Precipitation in NCAR's CCM. *J. Geophys. Res. - Atmos.*, 102, D16, 19528-19541.

Randel D. L., T. H. Vonder Haar, M. A. Ringerud, D. L. Reinke, G. L. Stephens, T. J. Greenwald and C. L. Combs, 1996. A new global water vapor dataset. *Bull. Amer. Meteor. Soc.*, 77, 1233-1246.

Roads, J. O., S. Marshall, R. Oglesby, S-C. Chen, 1996. Sensitivity of CCM1's Hydrologic Cycle to CO_2. *J. Geophys. Res.*, 101, 7321-7339.

Stephens, G., 1997. Intensifying the hydrologic cycle. *GEWEX NEWS*, August 1997.

Trenberth, K., 1997: Atmospheric moisture residence times and cycling: Implications for how precipitation may change as climate changes. *GEWEX NEWS*, August 1997.

Xie, P. and P. A. Arkin, 1996. Analysis of global monthly precipitation using gauge observations, satellite estimates, and numerical model predictions. *J. Clim.*, 9, 840-858.

Xie, P. and P. A. Arkin, 1997. Global precipitation: A 17-year monthly analysis based on gauge observations, satellite estimates and numerical model outputs. *Bull. Amer. Meteor. Soc.* (submitted)

ASSESSING THE EVAPORATION IN CLIMATE MODELS USING DIRECT OBSERVATIONS

Martin Wild, Hans Gilgen, Raelene Sheppard and Atsumu Ohmura
Swiss Federal Institute of Technology, Switzerland

Over the past years, substantial efforts have been put into the inclusion of comprehensive land surface schemes in climate models to improve the simulation of exchange processes between the surface and the atmosphere. The assessment of the performance of the models with respect to the energy fluxes at the surface has, however, been hampered by the lack of adequate observational data sets and difficult access to observations for the validation. **At the Swiss Federal Institute of Technology (ETH), a major effort has been undertaken to compile observational data on surface energy fluxes systematically in a database for the worldwide measured surface energy fluxes, the Global Energy Balance Archive (GEBA), (see Gilgen et al., 1997).** A number of studies have used this data set of direct measurements to assess the radiative fluxes at the surface in General Circulation Models (GCM) (e.g., Garratt et al., 1994; Wild et al., 1995). A previous GEBA data set was compared to and distributed with a WCRP/GEWEX shortwave radiation data set (Whitlock et al., 1995). Wild et al. (1996) demonstrated that direct observations can also effectively be used for the assessment of the nonradiative or latent heat flux (the energy equivalent of evaporation), which is crucial for the link between the surface energy and water balance. **It was shown that long-term measurements of evaporation, as available for example from lysimeter stations, are useful to detect deficiencies in the simulation of these quantities in GCMs, particularly on a seasonal time scale. An example is given in Figure 1.** Rietholzbach is a hydrological research station equipped with a lysimeter, with more than 10 years of evaporation measurements (Menzel, 1997). The comparison allows the identification of a significantly too high evaporation in winter and an excessive dryness during summer calculated in the GCM, a problem common to many current models and contributed to the improvement of the surface processes of the new ECHAM4 version. So far, however, the number of sites available from GEBA with these types of measurements is rather limited and mainly restricted to the European area.

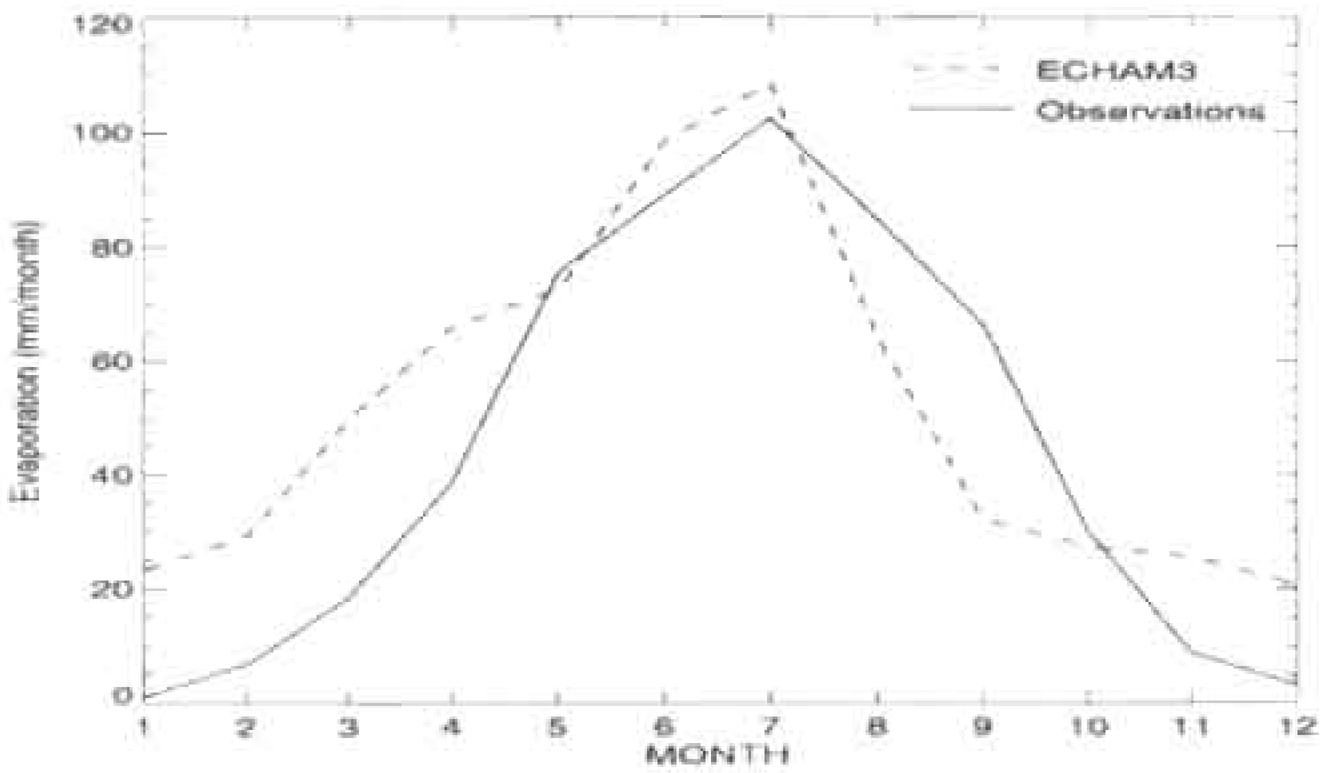


Figure 1. Annual cycles of evaporation at the Swiss station Rietholzbach, calculated with the ECHAM3 GCM and observed with lysimeter.

The ETH group has, therefore, started a new effort with special emphasis on the complementation and enhancement of the GEBA with respect to the nonradiative flux measurements (particularly evaporation). A central storage of the numerous disperse measurements should greatly facilitate the validation of fluxes in GCMs and for GEWEX data sets (e.g., the Surface Radiation Budget Project data sets) in the future, thereby contributing to the improvement of the associated model parameterizations. **To efficiently reach this aim, institutions involved in long-term measurements of nonradiative fluxes (e.g., institutions equipped with lysimeters) are strongly encouraged to provide their data to the Global Energy Balance Archive (GEBA).** The stored quantities in GEBA are monthly means and the focus is on the seasonal and long-term behaviour of these fluxes. Institutions willing to cooperate in this project and offer their data may contact us, either by e-mail at: gilgen@geo.umnw.ethz.ch or sheppard@geo.umnw.ethz.ch, or by normal mail to: Dr. H. Gilgen, Swiss Federal Institute of Technology, Geography Department, Winterthurerstr. 190, CH 8057 Zuerich, Switzerland.

References

Garratt, J. R., 1994. Incoming shortwave fluxes at the surface—a comparison of GCM results with observations. *J. Clim.*, 7, 72-80.

Gilgen, H., M. Wild, and A. Ohmura, 1997. Global Energy Balance Archive GEBA, World Climate Program—Water Project A7, Report 3: The GEBA version 1997 database. Nr. 74, Verlag der Fachvereine, Zurich, 105.

Menzel, L., 1997. Modelling the Evapotranspiration in the system soil-plants atmosphere. Zuericher Geografische Schriften Nr. 67, Verlag der Fachvereine, Zuerich, 62pp.

Whitlock, C. H., T. P. Charlock, W. F. Staylor, R. T. Pinker, I. Laszlo, A. Ohmura, H. Gilgen, T. Konzelman, R. C. Dipasquale, C. D. Moats, S. R. LeCroy and N. A. Ritchey. First Global WCRP Shortwave Surface Radiation Budget Dataset, *Bull. Amer. Meteor. Soc.*, 76, 905-922.

Wild, M., A. Ohmura, H. Gilgen and E. Roeckner, 1995. Validation of GCM simulated radiative fluxes using surface observations. *J. Clim.*, 8, 1309-1324.

Wild, M., L. Dumenil and J. P. Schulz, 1996. Regional climate simulation with a high resolution GCM: surface hydrology. *Clim. Dyn.*, 12, 755-774.

MEETING SUMMARIES

GPCP WORKING GROUP ON DATA MANAGEMENT

San Diego, California
14–17 April 1998

The following is a compilation of the conclusions, recommendations and related action items that came out of the deliberations of the Global Precipitation Climatology Project (GPCP) Working Group on Data Management (WGDM) and Science Advisory Team (SAT) at its twelfth meeting.

All elements of the project involved in the data processing and merging scheme agreed to modify their current procedures to enable more frequent transfer and delivery of data consistent with moving from the current quarterly update schedule of the suite of GPCP Version 1 rainfall estimation products to a monthly or less update and release cycle. Results of analyses were presented which supported the decision to replace the pentad, 2.5° x 2.5° histogram populations and GPCP Precipitation Index (GPI) estimates with 1° x 1°, 3-hourly IR data as the primary IR archive. **As a result of the need to move toward a higher spatial and temporal scale GPCP primary product, an implementation strategy was devised at the meeting for a pilot processing effort to have a daily 1° x 1° global precipitation climatology for 1 or 2 years (1997-1998) by April 1999.** The Global Precipitation Climatology Center (GPCC) announced plans for further advancing the quality of its extended data base of monthly gauge precipitation reports by way of improved visual and automated techniques. The process is proceeding in a stepwise manner leading toward a full visual quality-controlled product. A review of the tasks being carried out by the Surface Reference Data Center (SRDC), now with the Environmental Verification and Analysis Center (EVAC) at the University of Oklahoma, resulted in agreement that beginning immediately SRDC will utilize state-of-the-art technology to produce accurate gridded rainfall estimates, with accompanying error estimates. Also, that by 1 October 1998, SRDC will begin to produce regular quarterly verification (statistics/maps/time series) reports for GPCP products. In addition, SRDC accepted the responsibility to begin collecting reference data and to take the lead in recommending a framework for the organization of an anticipated rainfall estimation algorithm intercomparison exercise which could focus on 1° x 1° daily rainfall estimates.

Other relevant decisions included production and distribution of a GPCP CD-ROM in 1998 and the need to couple the 1999 session of the Group with a GPCP data users workshop with emphasis on error assessments and analyses.

New research topics and national initiatives that are complementary to GPCP activities were addressed at the meeting and included: development of a "split-window" algorithm which utilizes data from both of the IR channels on the GMS-5 satellite; retrieval of new types of precipitation products from the SSM/I, namely, rain type (convective/stratiform/warm/solid), rain frequency, and rain area; production of an experimental 1° x 1° daily, observation-only combined precipitation data product for August 1997 using SSM/I, GPI, and (optionally) TOVS data; and the investigation of monthly mean precipitation estimates using neural network analysis procedures on ISCCP monthly mean data.

ISLSCP SCIENCE PANEL MEETING

UNESCO Headquarters
Paris, France
27–28 April 1998

To foster cooperation between the International Satellite Land-Surface Climatology Project (ISLSCP) and International Geosphere Biosphere Program (IGBP)-Biospheric Aspects of the Hydrological Cycle (BAHC), back-to-back meetings of the ISLSCP Science Panel (ISP) and the BAHC Science Steering Committee (SSC) were held. In addition, a jointly sponsored workshop on land surface data in climate and weather models was held in conjunction with the two project science meetings. ISLSCP and BAHC agreed to develop linkages between the two programs on the biophysical components of the climate system through joint experiments, data products, modeling efforts, and common workshops.

As of March 31, 1998, over 4,426 Initiative I CD-ROMs have been shipped and 69,664 files pulled by anonymous FTP. The ISLSCP Initiative II data set will incorporate a longer time span (minimum of 10 years: 1986–1995); higher spatial resolution (0.5° for land; 1.0° resolution for atmosphere); improved temporal resolution: 3-hourly to monthly; improved data sets and algorithms; and additional data sets (topography, carbon emissions, atmospheric CO_2 concentration). The planned ISLSCP Initiative II data set will be a valuable tool for both ISLSCP and BAHC.

Joint ISLSCP/GEWEX Continental-scale International Project (GCIP) plans for coordinated research include: land surface characterization activities; studies to scale up from tower measurements to basin-wide characterization of fluxes; studies of the time dependence of vegetation-atmosphere-land interactions; and the parameterization of these processes in models and work to improve land components of coupled models.

The following priorities for ISLSCP were discussed:

- Establishing observational sites and undertaking process studies in climate regimes that are currently under-represented in other programs.
- Developing global data sets that can be used in model transferability studies.
- Developing tools for interpreting land surface remote sensing data sets for use in models.
- Providing an understanding of vegetation-atmosphere interactions with particular emphasis on the links between water cycling in the atmosphere and carbon cycling.

A new ISLSCP project is being considered to analyze existing data sets to assess the accuracy of remote sensing algorithms and the propagation of errors in remote sensing through models to their outputs. This would include modifying existing models to incorporate remote sensing data; designing new models to produce outputs which can be tested against remote sensing products; comparing the outputs from models with and without remote sensing inputs against ground-based measurements; and comparing a number of models that use remote-sensing inputs with data from one or two sites.

ISP and BAHC supported the proposal to hold an international workshop to plan the post-EOS era hydrometeorology program. The meeting, which will be hosted by the International Pacific Research Center in April 1999, will better define the linkages between ISLSCP/BAHC global modeling interests and the coupled model transferability studies under the GEWEX GHP and the Coordinated Enhanced Observing Period (CEOP), which is also now actively being planned under GHP.

SECOND STUDY CONFERENCE ON BALTEX

25–29 May 1998
H.-J. Isemer and E. Raschke
GKSS Research Centre, Germany

The Second Study Conference on BALTEX was held on the island of Rügen, Germany, located at the southern coast of the Baltic Sea. The conference was open for contributions related to the water and energy cycles of the entire water catchment area of the Baltic Sea. The major objectives of the conference were to review results in meteorology, hydrology and physical oceanography from the first BALTEX research period 1994 to 1998; and to plan and prepare for the central BALTEX modelling and observational period called BRIDGE in 1999 to 2001.

The conference was organized through the BALTEX Secretariat staff and the conference programme committee, chaired by E. Raschke. The conference received substantial support from the European Union, several German agencies including the National Research Ministry, the national Research Foundation and GKSS Research Centre, as well as from commercial companies. This gratefully acknowledged support made it possible to finance the participation of several scientists, in particular, from Eastern Europe.

The conference opening ceremony summarized the advanced status of BALTEX as a GEWEX CSE and the expectations scientists and the public have with respect to BALTEX and GEWEX research. Speakers at the ceremony included Prof. L. Gates, chairman of the WCRP/Joint Scientific Committee, who illuminated the interdisciplinary character of BALTEX; Dr. P. Twitchell from the International GEWEX Project Office, who pointed out the role of BALTEX within the GEWEX community; Dr. A. Ghazi representing the EU, Dr. U. Katenkamp of BMBF, Dr. V. Sengbusch of the GKSS Research Centre; and politicians from both the regional and local levels who stressed the importance of BALTEX research for the development of the Baltic Sea area. Prof. L. Bengtsson, chairman of the BALTEX Scientific Steering Group (SSG), closed the opening ceremony by giving a summary presentation on the objectives and achievements of the BALTEX programme. He, in particular, outlined plans for a 2-year (1999–2001) modelling and observational period planned for BRIDGE.

In total, 180 participants from 20 countries attended the conference. There were 13 invited overview talks and more than 120 contributed papers. The latter were given both orally and as posters covering the whole range of BALTEX science issues including hydrological, land surface, atmos- pheric and Baltic Sea (including sea-ice) modelling, field experiments, data assimilation and coupled modelling, remote sensing applications, as well as data analysis and climatological studies. The presentations included several highlights a few of which are briefly mentioned here.

The meteorological and hydrological conditions leading to the catastrophic Odra flooding event in the summer 1997 were described and preliminary model runs for this event described the evolution of the flood wave.

Successful steps were reported on the coupling of different models as part of the overall BALTEX aim to develop coupled models of the entire atmosphere/land surface/hydrology/Baltic Sea/sea ice system.

Application of new data and data combinations such as GPS, weather radar, SSM/I and ground-based microwave radiometer for both model validation and data assimilation purposes are highly encouraging. Noteworthy steps are now being undertaken as concerted actions between weather services in the BALTEX area to combine weather radar data from different national networks into composite products covering almost the entire Baltic Sea and parts of the drainage area.

Prof. W. Lawrence Gates, during his welcome address on behalf of WCRP/Joint Scientific Committee.

Prof. Lennart Bengtsson, SSG Chairman, summarizes BALTEX scientific issues.

All four major BALTEX field experiments have been implemented and at least pilot phases were successfully conducted during 1997 or 1998.

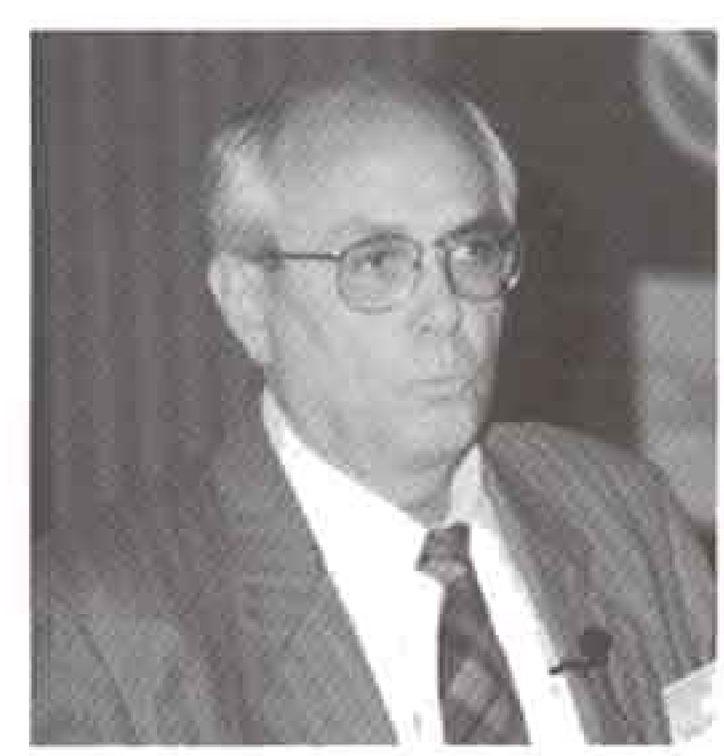
Interested readers may request the conference proceedings containing the extended abstracts of all presentations at the BALTEX Secretariat (e-mail: isemer@gkss.de).

GCIP MISSISSIPPI RIVER CLIMATE CONFERENCE

St. Louis, Missouri 8–12 June 1998

The GEWEX Continental-scale International Project (GCIP) Conference was organized to optimize the transfer of information between scientists and to convey important scientific concepts to the public. A mix of over 300 plenary talks, science papers and posters were presented on climate prediction, hydrology and the variability of water and energy budgets in the Mississippi River Basin over all time scales. The conference also featured an evening public lecture series, a science teachers workshop on climate, a special workshop on the impacts of climate change on the Mississippi River Basin by the Climate Institute, and a round table discussion on decision making in the water resource sector using climate forecasts and scenarios. In addition, a short course at Saint Louis University for graduate students and others to learn how to make more effective use of GCIP data sets in their research was coordinated by Dr. John Leese.

The overall conference, was planned and implemented by Rick Lawford, GCIP, Program Manager, was a part of a summer event known as the Mississippi River Summer, which involves a traveling exhibit that is spending a month at each major science center as it moves down the Mississippi River throughout 1998.



Dr. Michael Hall, Director of the NOAA Office of Global Programs

Dr. Michael Hall, Director of OGP, opened the plenary with a presentation on new directions for climate research. Highlights of the Public Lecture Series included a talk by Prof. James O'Brien, Florida State University, on the effects of 1997/98 El Niño and a presentation by Dr. Soroosh Sorooshian, chair of the National Academy of Sciences GEWEX Panel, on how hydrology can address the issues of water resources.

Dr. Soorosh Sorooshian,Chair U.S. National Academy of Sciences GEWEX Panel

The venue and organization of papers at the conference contributed greatly to the exchange of information between scientists and the general community.

WCRP/GEWEX MEETINGS CALENDAR

For calendar updates, see the GEWEX Web Site: http://www.cais.com/gewex/

24-26 August 1998—GCSS WORKING GROUP I WORKSHOP ON TRANSITIONAL CUMULUS CASE FROM ASTEX, Madrid, Spain. Local organizer Joan Cuxart Rodamilans (j.cuxart@inm.es); Fax: 34 1 544-5823.

25-27 August 1998—GHP/ACSYS WORKSHOP ON COLD REGIONS MODELING, Quebec City, Canada. For information e-mail contacts are V. Vuglinski: admin@vggi.spb.nu and R. Lawford: lawford@ogp.noaa.gov.

26-28 August 1998—GVAP/SPARC WORKSHOP ON UPPER TROPOSPHERE/LOWER STRATOSPHERE WATER VAPOR, Boulder, Colorado, USA.

31 August-4 September 1998—GEWEX RADIATION PANEL MEETING, St. Andrews, Scotland.

14-18 September 1998—GEWEX HYDROMETEROLOGY PANEL MEETING, Boulder, Colorado, USA.

12-16 October 1998—FIFTH SESSION OF THE WORKING GROUP ON DATA MANAGEMENT FOR WCRP RADIATION PROJECT, Beijing, China.

25-28 October 1998—AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, Fairbanks, Alaska. Topics include ocean-atmosphere-land-ice interaction and international calaboration on global change research. For information visit: http://www.gi.alaska.edu.

2-6 November 1998—JOINT JSC/CAS WGNE AND GEWEX MODELING AND PREDICTION PANEL, Montreal, Canada.

9-13 November 1998—GEWEX CLOUD SYSTEM STUDY AND WORKING GROUP ON NUMERICAL PREDICTION WORKSHOP ON CLOUD PROCESSES AND FEEDBACKS OF LARGE-SCALE MODELS, European Centre for Medium-Range Weather Forecasts, UK.

16-18 November 1998—4TH CANADIAN GEWEX/MAGS WORKSHOP, Montreal, Canada. See web site or contact Secretariat: E-mail: Geoff.Strong@ec.gc.ca.

30 November - 4 December 1998—GEWEX CLOUD SYSTEM STUDY SCIENCE PANEL, Kauai, Hawaii, USA.

10-15 January 1999—AMERICAN METEOROLOGICAL SOCIETY ANNUAL MEETING, Dallas, Texas, USA. The meeting theme is "Climate and Global Change: Focus on the Americas". Call for papers found in Bull. American Meteorological Society. Abstracts due at AMS Headquarters, 45 Beacon Street, Boston, MA 02108-3693, no later than 1 October 1998.

25-29 January 1999—GEWEX SCIENTIFIC STEERING GROUP, Tuscon, Arizona, USA.

15-20 March 1999—WCRP JOINT STEERING COMMITTEE MEETING, Kiehl, Germany.

6-8 April 1999—GLOBAL HYDROECOLOGIC-ATMOSPHERIC INTERACTIONS: A RESEARCH AGENDA FOR THE NEXT DECADE, International Pacific Research Institute, Honolulu, Hawaii.

16-19 June 1999—THE THIRD INTERNATIONAL SCIENTIFIC CONFERENCE ON THE GLOBAL ENERGY AND WATER CYCLE, Beijing, China. See back page for Announcement and Call for Papers.

19-30 July 1999—GHP-RELATED SYMPOSIA AND WORKSHOPS AT THE 22ND GENERAL ASSEMBLY OF THE INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS (IUGG), Birmingham, UK. Further information contact School of Earth Sciences, Univ. of Birmingham, Edgbaston, Birmingham B15 2TT, UK; Fax: 44 121 414 4942; E-mail: IUGG99@bham.ac.uk.

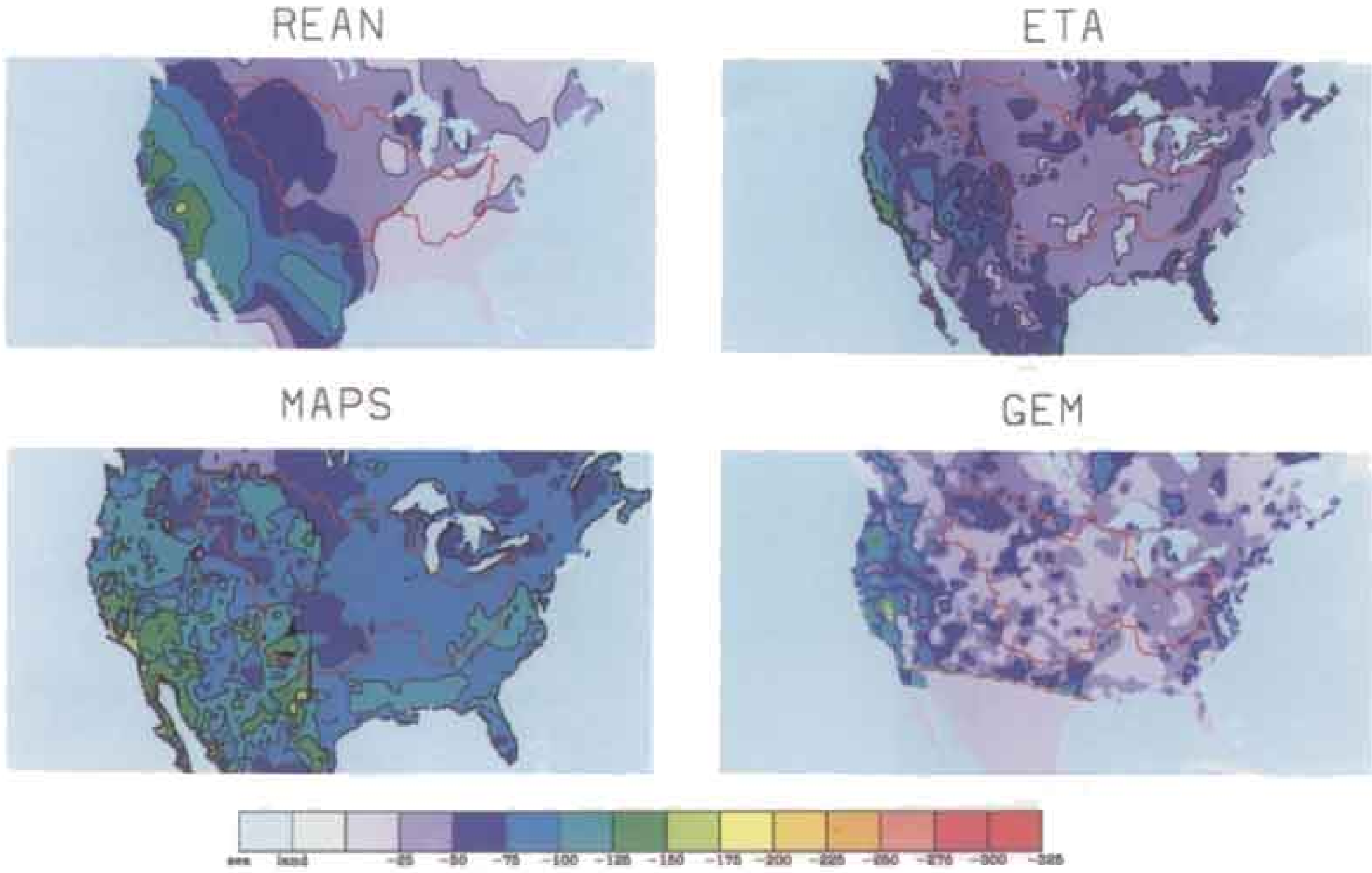
23-27 August 1999—2ND INTERNATIONAL REANALYSIS CONFERENCE, U.K. (date tentative)

GEWEX REPORTS AND DOCUMENTS

(Available from IGPO)

For complete listing of GEWEX reports and documents, consult the GEWEX Web Site:

http://www.cais.com/gewex/



Loss of energy by sensible heat flux (W/m²) for August 1997. Note largest flux is towards the west in all models. (See article on page 3). Red contour is the boundary of the Mississippi River Basin.

CALL FOR PAPERS

THIRD INTERNATIONAL SCIENTIFIC CONFERENCE ON THE GLOBAL ENERGY AND WATER CYCLE

Beijing, China
16–19 June 1999

The Conference will be held in conjunction with the 4th Study Conference on the GEWEX Asian Monsoon Experiment (GAME) and will focus on the Global Energy and Water Cycle Experiment (GEWEX) scientific interests involving the contribution of the coupled land-atmosphere system to climate predictability through soil memory, surface characteristics and radiation processes. Papers are invited on the following topics:

- Variability and predictability of the Asian/Australian and African monsoons
- Heavy precipitation and cloud systems in the topics and subtropics
- Cloud and radiation processes within the atmosphere and at the surface
- The water and carbon cycle connection and its role in global and regional hydrological cycles
- High-latitude and high-altitude hydrology: ocean-atmosphere-ice/snow exchange
- Observations, data analysis and modeling studies related to the GAME Intensive Observing Period
- Satellite remote sensing and TRMM related studies

ABSTRACTS DUE: 15 November 1998. Send abstracts in paper copy (and, if possible, on e-mail to yhding@public.bta.net.cn) to: National Climate Centre, China Meteorological Administration, No. 46 Baishiqiao Road, Western Suburb, Beijing 100061, China, Attn: Prof. Ding Yihui.

For more information: http://www.cais.com/gewex/

GEWEX NEWS
Published by the International GEWEX Project Office (IGPO)
Dr. Paul D. Try, Director

Editor: Dr. Paul F. Twitchell
Mail: International GEWEX Project Office
1100 Wayne Avenue, Suite 1210
Silver Spring, MD 20910, USA

Assistant Editor: Dawn P. Erlich
Tel: (301) 427-2089 ext. 196
Fax: (301) 427-2222
E-mail: gewex@cais.com

WWW Site: http://www.cais.com/gewex/