GEWEX WCRP

Global Energy and Water Cycle Experiment

NEWS

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4TH INTERNATIONAL SCIENTIFIC CONFERENCE ON THE GLOBAL ENERGY AND WATER CYCLE

Paris, France
10–14 September 2001

ABSTRACTS DUE MARCH 30TH

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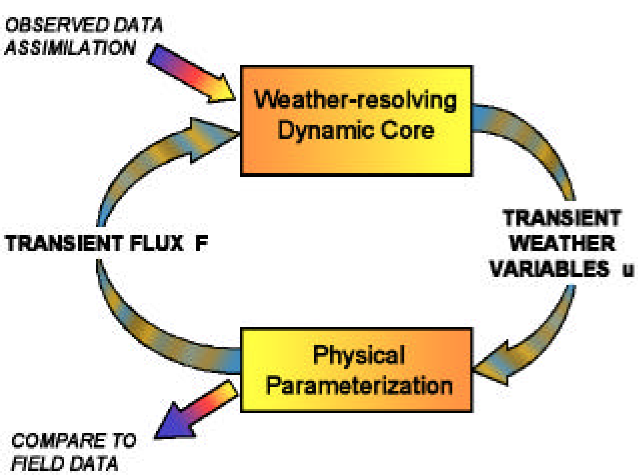
WHAT'S NEW

- New boundary layer project started
- New Chairs for GRP and GHP
- GRP to focus on integrated/joint data set analysis and diagnostics
- CEOP Draft Implementation Plan issued
- Pre-CEOP CD ROMs Planned
- New cloud, precipitation, and water vapor profiling group to be formed



Conceptual representation of "weather-process resolving" climate models advocated by GEWEX. Such models, derived from operational Numerical Weather Prediction systems, have the capability to assimilate observations and mimic the observed evolution of the atmospheric general circulation. State variables and flux products computed in the course of this process are directly comparable to observations at a particular location and time. See adjacent article.

WHY GEWEX? THE AGENDA FOR A GLOBAL ENERGY AND WATER CYCLE RESEARCH PROGRAM

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"Wet Processes" in Climate Models?

The most successful climate models, judged by their explanatory power in regard of their complexity, are radiative-convective equilibrium models (Manabe and Wetherald, 1967; Manabe, 1997) based on a precise treatment of the transfer of radiant energy in a vertical column (using the plane-parallel approximation) and the condition that the lapse rate should not exceed a preset limit (for example, 6.5°K per kilometer). Early estimates of global warming, and the very notion of radiative forcing, proceed from this approximation. In fact, it can be argued that many existing "three-dimensional" climate models are essentially the juxtaposition of a number of single column radiative-convective models weakly coupled by horizontal advection.

Continued on page 7

COMMENTARY

GEWEX MOVING AHEAD SCIENTIFICALLY AND REACHING OUT ACROSS DISCIPLINES / ORGANIZATIONS

Soroosh Sorooshian, Chairman
GEWEX Scientific Steering Group

The result of the January 2001 meeting of the GEWEX Scientific Steering Group (SSG) in Barcelona, Spain, was a lively and extremely productive discussion of the role of GEWEX's Phase II in the broader context of a number of global water cycle initiatives. Because the Phase I activities have built a solid foundation for the global water cycle initiatives, the Group identified a good number of action items which need to be addressed as we move towards the implementation of Phase II. I am pleased to report that there will be greater outreach across disciplinary and organizational lines. Much of these new activities will continue to be coordinated and implemented through our panels.

The GEWEX Radiation Panel (GRP) is moving towards an increased focus on joint and integrated data analyses and diagnostics and will be working closely with the Atmospheric Radiation Measurement (ARM) Program and other international groups in establishing cloud, precipitation, and water vapor profiling measurement/analyses activities. The GEWEX Precipitation Climatology Project (GPCP) is broadening its consideration of methods for precipitation estimation and establishing a relationship with the new World Meteorological Organization (WMO) Coordination on the Geostationary Meteorological Satellites International Precipitation Working Group. Along the same lines, GEWEX has been strengthening its ties with the World Weather Research Program (WWRP) to identify collaborative activities.

The GEWEX Hydrometeorology Panel (GHP) is further expanding its emphasis to address the role of GEWEX to the broader WCRP activities on the Global Carbon Cycle Study. A new working group on carbon is being developed to assist in this endeavor. Clearly, GEWEX's major initiative, the Coordinated Enhanced Observing Period (CEOP), continues to look for ways to increase participation across the entire climate community. Our special interactions with the South China Sea Monsoon Experiment II (which is moving up to coincide better with CEOP) is just one example. The 3-year appointment of a new permanent GHP Chair and the integrated activities of the Water Resources Application Project, CEOP, and the new Water and Energy Budget Study group illustrate that the hydrometeorology side of GEWEX is also moving rapidly ahead into Phase II.

The GEWEX Modeling and Prediction Panel (GMPP) has been redefining its scope by consolidating similar activities to continue the scientific advances, while keeping the focus on significant model improvements (at all scales) through better parameterizations. The new GEWEX Atmospheric Boundary Layer Study has been formed to address major issues of process representation in order to improve our connections with the large-scale modeling community. In the *February 2000 GEWEX Newsletter*, I already discussed GEWEX's Global Land Atmosphere System Study (GLASS) under the sponsorship of GMPP. GLASS is well on the way towards providing improved methods for the modeling community.

This issue's lead article is by our dear colleague, Pierre Morel, who challenges us to continually improve our scientific questions and our implementation plans for GEWEX. The GEWEX SSG and its various panels place important value on such opinions as we move towards our Phase II implementation activities, which include more integrated joint data acquisition/analyses and diagnostics, regional process measurements and model representation, and improved large-scale model cloud, land-surface, and boundary layer parameterizations—all with a wet process focus.

CONTENTS

Participants at the 13TH GEWEX Scientific Steering Group Meeting, 29 January – 3 February 2001, Barcelona, Spain.

SIMULATION OF NORTH AMERICAN SUMMERTIME CLIMATE WITH THE NCEP ETA MODEL NESTED IN THE COLA GCM

K. Mitchell[1], M. J. Fennessy[2], E. Rogers[1], J. Shukla[2], T. Black[1], J. Kinter[2], F. Mesinger[1], Z. Janjic[1], and E. Altshuler[2]

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Ensembles of summer seasonal hindcasts have been carried out with the National Centers for Environmental Prediction (NCEP), Environmental Modeling Center (EMC) Eta model nested in the Center for Ocean-Land-Atmosphere (COLA) atmospheric general circulation model (GCM) over the North American region. The COLA GCM used here is a global spectral model with rhomboidal truncation at zonal wave number 40 (R40) and 18 sigma levels in the vertical, based on a modified version (Kinter et al., 1997) of the NCEP global spectral model (MRF) used for medium range weather forecasting. The Eta model used is a slightly modified version of the March 1997 operational NCEP Eta model (Mesinger et al., 1988; Black, 1994). For computational efficiency, we reduced the horizontal resolution from 48 km to 80 km (92 x 141 grid), while retaining the 38 Eta vertical levels used then in operations and a large spatial domain (close to the then-operational Eta domain) covering all of North and Central America.

For each of 15 June-July-August-September (JJAS) COLA GCM 4-month integrations, a one-way nested 4-month integration with the Eta model was done, starting from the same initial data (NCEP/NCAR global Reanalysis, Kalnay et al., 1996) as the GCM and using as lateral boundary conditions the 12-hourly GCM forecast data linearly interpolated in time. To obtain the 15 JJAS integrations, 3 integrations were initialized 12 hours apart in late May for each of the 5 years of 1986, 1987, 1988, 1993, and 1994. Observed weekly SST analyses (Reynolds and Smith, 1994) were linearly interpolated in time and used in all the integrations. The soil wetness and snow were predicted after initialization in both the GCM and the nested Eta model by their respective coupled land-surface parameterizations. The COLA GCM executions utilized the COLA SSiB land scheme (Xue et al., 1991), while the nested Eta runs utilized the NCEP Eta land scheme, i.e., the NOAH scheme (Mitchell et al., 2000). Because the land surface treatments in these two models are quite different, the initialization of the snow and soil wetness are not identical, but follow the same principles. All the integrations were initialized with soil wetness derived from continuously cycled global data assimilation systems (coupled atmosphere/land). The soil wetness used for initialization of the GCM (*Eta*) integrations was derived from the soil moisture of the ECMWF operational global data assimilation system (*NCEP/NCAR global Reanalysis*). Further information on the soil moisture initialization, and analysis of all the integrations, including the winter simulations, are given by Fennessy and Shukla (2000).

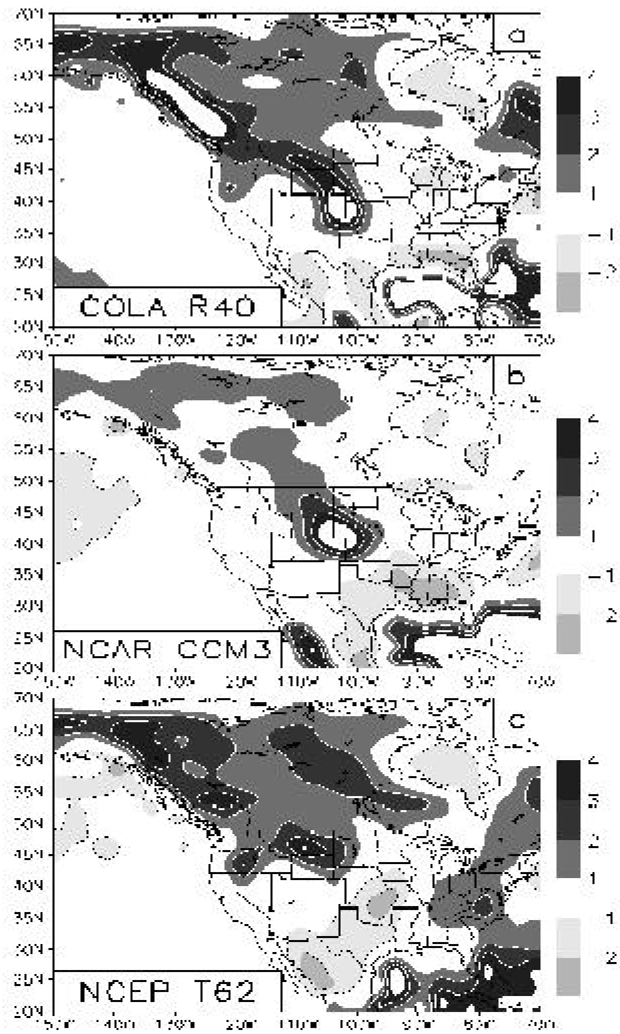
The observed 5-year mean JJAS precipitation from a combination of station and satellite data (monthly GPCP, Version 2x79, Huffman et al., 1997) is shown in top left panel (a), on the back page.

This GPCP mean is very similar to that obtained from the data set of Xie and Arkin (1996) shown by Fennessy and Shukla (2000). The corresponding15-member ensemble-mean GCM and nested Eta model precipitation is shown on the back page in the left middle panel (b) and left lower panel (c), respectively. **The superiority of the nested Eta model in predicting warm season total precipitation is immediately evident. The GCM prediction grossly overestimates the summer precipitation over much of the continent. The Eta model correctly predicts the precipitation maxima over the northwest and eastern coastal areas, as well as the gradient across the central United States and the minima over the western United States.** The main weakness in the nested model hindcasts is the low bias in precipitation over the far southeast United States, the Gulf of Mexico, and the Atlantic.

Poor skill in simulating continental summer precipitation is a problem common to many GCMs. For the same 5 years cited above, the figure in the next column shows the corresponding mean JJAS precipitation errors, relative to GPCP, from fifteen (5 x 3) 4-month integrations by COLA for each of three GCMs: (a) COLA R40, (b) NCAR CCM3, and (c) NCEP T62 (as used in Kalnay et al., 1996). Large positive biases over the central and northern continent occur in all three GCMs, accompanied by negative (positive) biases over the southern continent (Gulf of Mexico and nearby Atlantic Ocean).

Two often-studied anomalous North American summers were purposely included in the ensemble set. During April, May, and June of 1988, low rainfall caused a severe drought in the corn belt of the central United States. During June and July of 1993, persistent heavy rainfall caused severe flooding along the Mississippi river basin. The precipitation difference between these two summers presents a strong climatic signal that must be predicted by models that are to be used for seasonal prediction research. The 1993 versus 1988 lower boundary-forcing differences for the COLA GCM and the nested Eta model used here were very similar. The models had identical observed SST forcing (Reynolds and Smith, 1994), and similar positive 1993 minus 1988 initial soil wetness differences in the central U.S. (not shown).

The GPCP observed June-July mean 1993 minus 1988 precipitation difference is shown in the top right panel (a), on the back page. The corresponding three-member ensemble-mean precipitation

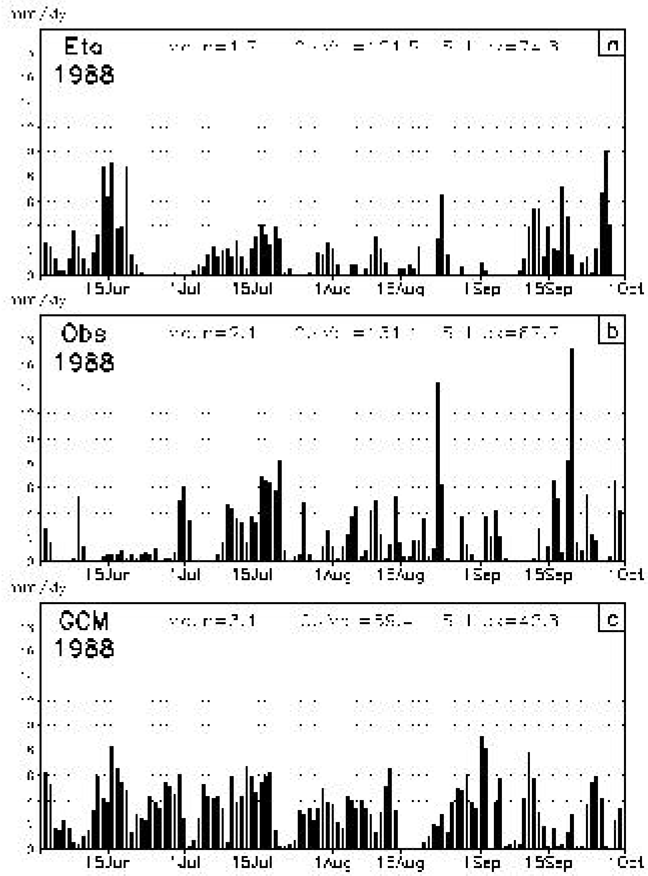


JJAS 5-year ensemble mean precipitation errors relative to GPCP for (a) COLA GCM, (b) NCAR CCM3 GCM, and (c) NCEP Reanalysis GCM. Contours are –2, –1, 1, 2, 3, 4 mm day^{-1}.

differences for the COLA GCM and the nested Eta model are shown in the middle right panel (b) and lower right panel (c), respectively. Prominent in the observations is a broad 1 mm day^{1} positive precipitation difference that spans much of the central United States and reaches over 4 mm day^{-1} over the upper Mississippi basin. The GCM does not predict this signal at all, but rather has weaker positive differences both eastward and southward of the observed positive difference. Incidentally, an identical experiment was also done with the NCAR CCM3 GCM and the NCEP Reanalysis GCM, and none of the GCMs could simulate the observed signal. The nested Eta model does a far better job of predicting the broad 1 mm day^{-1} difference, though it extends it a bit too far southward and eastward. The nested model also properly places the center of the large difference over the corn belt with a maximum of over 3 mm day^{1}, albeit somewhat less than observed.

The surprising difference in the ability of the GCM and Eta model to predict this large signal merits further analysis. The upper level circulation associated with this precipitation difference appears to be quite similar in the two models. Both models simulated similar large negative June-July 1993 minus 1988 differences in the 300 hPa geopotential height over the United States (90 meters) that were weaker than the very large observed difference (150 meters, not shown). **An examination of the surface and low-level flux fields in the two models reveals that the difference in the two models' hindcasts is related to their differences in both local surface evaporation and meridional flow (not shown). It appears likely that improvements in the nested Eta model (relative to the GCM) in the simulation of (a) the mean summer precipitation (primarily convective) and (b) the summer low-level jet (LLJ) are responsible for its more realistic simulation of the 1993 minus 1988 differences.** This agrees with Mo et al. (1995), who concluded that an anomalously strong LLJ was an essential ingredient in the summer floods of 1993.

The models also differ in their ability to simulate the observed daily variability of the precipitation. The figure in the next column shows the JJAS 1988 time series of daily precipitation averaged over the drought/flood region (85°W–100°W, 37°N–45°N) for (a) the nested Eta model, (b) the Higgins et al. (1996) daily analysis of gauge observations, and (c) the COLA GCM. Frames (a) and (c) are from the same randomly chosen single integration rather than an ensemble. The JJAS mean, coefficient of variability (CV) (ratio of mean to standard deviation expressed in percent), and "storminess index" (SI) are also given in this figure. The SI is a measure of the day-to-day variability and is calculated as the scaled (by 1000) seasonal mean of the square of the daily ratio of the present-day minus previous-day difference to the present-day and previous-day mean. The sporadic nature of the observed day-to-day variability is much better simulated by the nested Eta model, as evident from either inspection of the figure or comparison of the CV and SI values. The observed JJAS mean precipitation over the region (2.1 mm day^{1}) is also better simulated by the Eta model (1.7 mm day^{1}) than by the GCM (3.1 mm day^{1}).



JJAS 1988 daily precipitation averaged over the drought/flood area (85°W–100°W, 37°N–45°N) for (a) nested Eta model, (b) Higgins et al. (1996) analysis, and (c) COLA GCM. (The labels "Co.Var" and "St.Indx" denote the quantities CV and SI, respectively, as defined in the text.)

It is not apparent whether the cause for the cited improvement in the nested model was the different physics, the enhanced resolution or the better representation of orography in the nested model, or some combination of the three. Nevertheless, in closing, we offer two implications suggested by (1) the differences in the summer convectively dominated precipitation between the GCM and Eta model and (2) the similarity in their upper-level circulation anomalies over the large nested domain. First, the convection scheme in a GCM (especially a GCM intended for climate prediction) is generally formulated, assessed, and tuned with respect to tropical deep convection globally, dominated by oceans, whereas the convection scheme in a nested continental model is likely formulated, assessed, and tuned for continental deep convection (including high orography). In this regard, we noted earlier that the GCM (*Eta model*) mean warm-season precipitation patterns over the United States continental domain (*tropical seas*) were poor. Second, the different surface heat fluxes of the respective land schemes in the two models may have yielded (1) different seasonal-mean convective instabilities over the continent and/or (2) a different response in the low level moisture convergence. In the end then, a nested continental model whose complex physics package has evolved over 1–2 decades with an emphasis on performance over land may indeed have some advantage over its parent GCM for seasonal-range predictions (1–6 months lead) of continental anomalies during the weak circulation regime of summer.

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NEW BOUNDARY LAYER STUDY

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GEWEX is initiating a new study focusing on the representation of the atmospheric boundary layer in regional and global models. The project referred to as the GEWEX Atmospheric Boundary Layer Study (GABLS), was accepted by the GEWEX Scientific Steering Group at its last meeting in Barcelona, Spain and will be presented to the WCRP Joint Scientific Committee in March. The main goal of GABLS is to improve the representation of the atmospheric boundary layer in models on the basis of a proper understanding of the relevant processes. Such activity is important in itself and also very relevant for other activities in GEWEX and for activities within the World Climate Research Programme (WCRP) and the International Geosphere-Biosphere Programme (IGBP).

The atmospheric boundary layer is an important aspect of the physics in regional and global models, which has become crucially important in this new age of coupled atmosphere-land surface-ocean modeling. The intention is to organize an international activity as part of the GEWEX Modeling and Prediction Panel (GMPP) aimed at stimulating and coordinating research on planetary boundary layer physics, and taking advantage of opportunities to interact with existing activities inside and outside of the GEWEX arena, such as CLIVAR (Climate Variability) and the Working Group on Numerical Experimentation (WGNE). The new GMPP activity complements the GEWEX Cloud System Study (GCSS) and the Global Land-Atmosphere System Study (GLASS).

A kick-off meeting for GABLS will be held at the "Climate Conference 2001," as planned for 20–24 August 2001 in Utrecht, the Netherlands (convened by Han van Dop, Utrecht University); with related workshops (convened by Peter Duynkerke, Utrecht University and Bert Holtslag, Wageningen University). Invited contributions at the conference will include those by Anton Beljaars, European Centre for Medium-Range Weather Forecasts, David Randall, Colorado State University, and Bjorn Stevens, University of California at Los Angeles. For more information on the climate conference and also to sign up, please consult **www.phys.uu.nl/~wwwimau/cc2001.html.** Deadline for poster submission is 30 March 2001.

INTENSIVE OBSERVATION PERIOD OF GAME – SIBERIA 2000

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The objective of the Siberian Regional Study of GEWEX Asian Monsoon Experiment (GAME) is to understand the water and energy flow in the atmosphere and land surface system stressing the cryosphere components and vegetation which characterized this area. The study up to now has been advanced through the detailed measurements at local observation sites in the tundra area, the taiga area, and the mountainous taiga area within the Lena River drainage. Preliminary results can be seen in the Activity Reports (Japan National Committee for GAME, 1998, 1999, 2000, 2001). In the year 2000, we concentrated on the taiga area near Yakutsk for the purpose of clarifying the seasonal variation and spatial inhomogeneity of water and energy flow. The surface measurement network was extended to different surfaces such as pine forests, young larch forests and grasslands. Aircraft was introduced for measuring spatial distribution of various fluxes and related surface parameters from snow covered season to vegetated season.

Three forest towers, 3 grassland masts, and nearly 15 sites for measuring specific meteorological elements were set in the area of 100 x 50 km and measurements lasted for more than half a year. Aircraft measurements were made for 9 days from 24 April to 20 June 2000 from 100 m to 4000 m above surface for clear weather days, in cooperation with Central Aerological Observatory (Moscow). **Results revealed the large variability of flux at various sites and an indication of local circulation modifying the water/heat transfer in this region.** For example, aircraft data show the vertical profiles of vertical latent heat fluxes on a snow covered day (24 April), to be negligible in comparison to the aircraft profiles after the blooming of forest (20 June). On a good weather day, along the same flight course from the east bank to the west bank of the Lena River indicate, at 1200 m height levels, a region of up to 300 Wm^{-2}. The patterns of sensible heat fluxes over the river valley were similar for the April and June days with a minimum over the valley. However, the sensible heat fluxes over the adjacent field and forest region were greater at all altitudes in June.

WHY GEWEX?

(Continued from Page 1)

Such models are suited for estimating first-order changes in atmospheric temperature profiles (and thus, surface temperature) in response to changes in radiant energy transfer or radiative forcing caused by various factors, such as changes in the concentration of greenhouse gases, anthropogenic aerosols, surface albedo, or the solar constant. Consistent with this state of affairs, assessments of climate change, notably those conducted by the Intergovernmental Panel on Climate Change, focus almost exclusively on surface and air temperature variations and trends. **On the other hand, existing climate models are notoriously challenged wth regards to reproducing and predicting changes in atmospheric wet processes.** For example, the projected soil moisture trends estimated by the two climate models used in the U.S. National Assessment of the Potential Consequences of Climate Variability and Change **(http://www.gcrio.org/NationalAssessment/)** were in opposite directions over most of the central and eastern half of the country (see back page, lower panels). For this reason, observed or projected changes in precipitation, river flow, and water resources are largely ignored in global warming scenarios and climate change assessments.

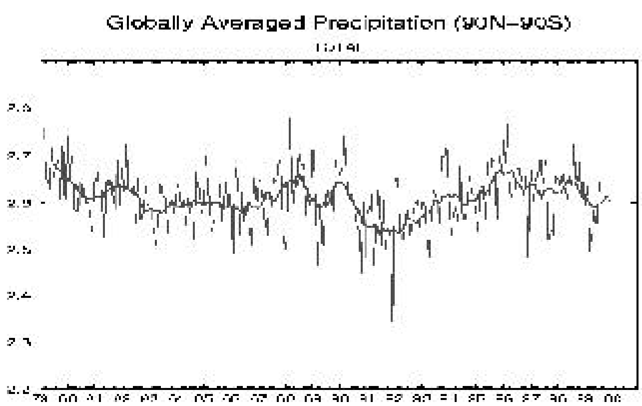
However, what makes sense for assessments based on published science is not what should guide the climate research agenda for the future. The overall objective of the GEWEX program is to bring ***wet processes***, including the dynamics of weather disturbances, precipitation and evaporation, and land surface hydrology and water resources, to the rightful place they should have in climate research.

The Global Water Cycle: Variability and Trends

The U.S. National Research Council report *Research Pathways for the Next Decade* recognized that: “Water is at the heart of both the causes and the effects of climate change. It is essential to establish current rates of, and possible changes in precipitation, evapotranspiration, and cloud water content… Better time series measurements are needed for water runoff, river flow and… the quantities of water involved in various human uses” (NRC, 1999). **Ascertaining the rate of cycling of water in the Earth system, and detecting possible changes, is a first-order problem as regards the renewal of water resources.**

Substantial efforts have been devoted by established and well supported teams, to the production and analysis of global surface and air temperature data sets (e.g., UK Meteorological Office; Russian Hydrometeorological

Service; Climate Research Unit, University of East Anglia; NASA Goddard Institute for Space Studies). By contrast, only minimal agency support has been given so far to GEWEX-initiated global water vapor, precipitation, cloud, and surface radiation climatology projects. Climate models generally project an acceleration in the rate of global water cycling and an increase in global precipitation; for example, the global precipitation increase projected by the NCAR Community Climate Model over the next century for two likely greenhouse gas increase scenarios, is about 0.1 mm day^{-1} (**http://www.cgd.ucar.edu/~tls/CSM/tables.html**). The latest IPCC assessment can only state that: "In contrast to the Northern Hemisphere, no comparable systematic changes have been detected in broad latitudinal averages over the Southern Hemisphere… There are insufficient data to establish trends in precipitation over the oceans." Actually, the best estimates of global precipitation, based on a combination of rain gauge and satellite data (GEWEX Global Precipitation Climatology Project), does not show a significant trend over a period of 22 years (as shown by the figure below).



GEWEX Global Precipitation Climatology Project: 22-year global-mean precipitation record, based on a combination of raingauge data over continents, and global infrared and microwave remote sensing estimates. The observational record provide no significant evidence of a global precipitation trend in the last two decades.

This state of affairs is unfortunate, as the most significant manifestation of climate change for humans and the environment would be an intensification of the global water cycle, leading to increased global precipitation, faster evaporation and a general exacerbation of extreme hydrologic anomalies, floods, and droughts. A more active water cycle might also generate more frequent and/or more severe weather disturbances, although this climate-weather connection is far from being obvious. GEWEX is the only existing program which develops, through international cooperation, the means to estimate the components of the water and energy cycles globally, and which assembles global climatological data sets, based on *in situ* and/or satellite measurements, to describe the wet atmospheric processes: clouds (ISCCP) and surface radiation (SRB). This international data sets stewardship role of GEWEX is all the more essential that this type of information is, for the main part, ignored by the climatological establishment.

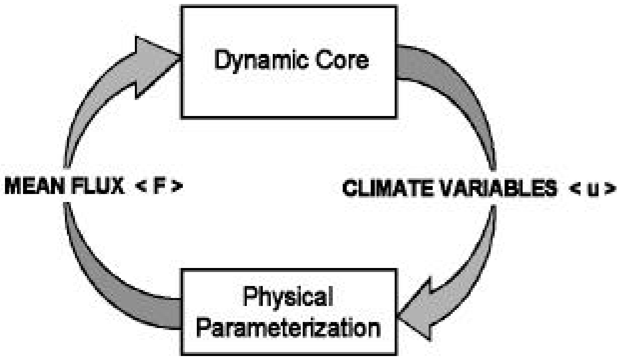
The first scientific objective of the GEWEX program should, therefore, be assembling the required observational information to answer the highly relevant question: **Are global precipitation, evaporation, and the cycling of water intensifying as a result of climate change?** To this effect, GEWEX has taken responsibility to serve the world climate research community by maintaining and improving key global wet-process data sets, through enhanced collection of existing data, improved retrieval algorithms and reprocessing, and the utilization of new observing systems that are coming online. In this respect, the current period of rapid deployment of NASA's Earth Observing System missions, emulated in Europe and Japan by a number of imminent major Earth Observation satellite launches, calls for a renewed (and increased) interest of the international GEWEX science community in new global observing systems and the production of internationally tested data sets for characterizing the Earth's wet atmospheric processes.

The foremost problem facing GEWEX is that of engineering a smooth transition from "discovery-driven" climatological data projects to a more institutional mode of operation, while ensuring that adequate attention continues to be paid to validation and intercomparison of data originating from different instruments, and to record consistency over successive generations of sensors and observing systems.

The Climate: Weather Connection

Another unique and essential role of GEWEX is investigating and quantifying the connections between changes in area- and time-averaged climate properties, and the statistics of weather disturbances. **This central component of the GEWEX program aims to determine: "The extent to which variations in global climate induce predictable changes in the frequency, intensity, and geographic distribution of weather systems?"** Why is this important? The first and most obvious reason is that people are not particularly sensitive to "climate" (i.e., area- and time-averaged properties) but rather transient weather and hydrologic events, especially extreme ones: blizzards, severe storms, floods, and droughts. Weather systems generate winds and rain, control the recharge of water reservoirs and, in general, make life pleasant or miserable. A second, more fundamental reason for paying attention to the role of weather dynamics in the climate system is that the

fluxes of water and energy, which determine the Earth's climate, are governed by weather variables, not mean climate properties. This is a source of considerable complication and, for this reason, generally played down in the climate research community.



Conceptual representation of current climate model computations. Note that "mean fluxes" computed by parametric formulas involving only area-averaged state variables have no directly comparable equivalent in nature.

It has been standard operating procedure in climate models, and low Reynolds number simulations in general, to account for the effects of physical processes in the atmosphere and at the Earth's surface through parametric formulas which express mean fluxes of momentum, energy, water, or any other relevant quantity, as functions of area-averaged climate variables (see figure above). While such formulas can be tuned to produce climate quantities that match climate observations, they are a long way from representing the real physics of the turbulent atmosphere. The relation between mean fluxes and mean (area and/or time-averaged) state variables is expected to be different from the space- and time-average of the local relationship between instantaneous fluxes and their governing parameters. This is a problem because only the latter (instantaneous/local) relationships can be **verified** against high-precision local observations.

State-of-the-art parametric representations of subgrid-scale atmospheric processes have now progressed to the point where they refer to physical variables, such as cloud water or ice content, and account implicitly or explicitly for subgrid-scale variability. The parameterization of water vapor fluxes at low synoptic wind speed over the tropical oceans illustrates this point. Conventional "bulk aerodynamic" formulas, generally used to represent eddy-fluxes, are founded on wind tunnel turbulence observation and theory; all include a dynamic factor proportional to wind speed at a specified anemometer level. As applied in climate models, the formulas involve the mean wind averaged over a grid box several hundred kilometers in size. It is known, however, that the "gustiness" of local wind does not die out when the large-scale mean wind velocity is near zero and that evaporation does not vanish at very low synoptic wind velocity. Miller, Beljaars, and Palmer (1992) introduced an *ad hoc* correction to account for this effect in the (then) current ECMWF general circulation model, with remarkable improvement in the computed global distribution of monthly rainfall accumulation, compared to GPCP data and general meteorological knowledge. This story brings home two lessons: (1) comparison between global model outputs and corresponding global observations can provide ***sensitive diagnostics*** of model errors related to the parameterization of physical processes, although attributing discrepancies to a particular process may be tricky, and (2) it is important for GEWEX to develop and nurture such ***global climatological data sets***, particularly those which relate most directly to wet atmospheric processes.

Likewise, distributed land surface parameterization schemes explicitly include a first-order representation of subgrid-scale variability in land hydrologic properties and landscape. Based on such representations, most climate models agree in predicting that wholesale replacement of the Amazonian rain forest by short-stem grasslands and shrubs would lead to a significant *reduction* in precipitation. On the other hand, high-resolution (mesoscale) model experiments showed that deforestation of discrete land patches or corridors actually induced *increased* precipitation, through the generation of secondary mesoscale (10 km-scale) circulation systems, i.e., a phenomenon similar to the convective cells generated by the juxtaposition of cloudy and clear areas in nearly unstable air (P. Kabat, personal communication; see also Weaver and Avissar, 2001). The phenomenon escapes even advanced parametric representations simply because it is a response to **non-linear dynamics** of the atmospheric flow that are not resolved by climate models.

Introducing variables that represent subgrid-scale variability certainly is an important and welcome first step. Nevertheless, parametric formulas which operate within a single grid-size column cannot account for weather phenomena not resolved by the model, such as frontal passages that travel from one grid-box to the next. A central goal for GEWEX is to promote and facilitate the representation of weather variability as an integral part of the climate system, i.e., replacing the simple feedback loop shown in figure on previous page, by the more cumbersome scheme of the figure on the first page, which includes a "weather generator" adding unpredictable but realistic weather variability in the climate system. Obviously, climate models cannot (yet) embrace directly the mesoscale details of weather dynamics; instead, alternative strategies must be invented for climate model development and validation, possibly involving a hierarchy of models that resolve successively smaller-scale processes, down to the scale of Large-Eddy Simulation (LES) models. An example of this approach is the GEWEX Cloud System Study, which makes extensive use of Cloud Ensemble Models (LEM) that could, in principle, resolve cloud dynamical processes and explicitly account for cloud physical variables.

Because of the chaotic nature of climate dynamics, there is no reason why any particular model-generated climate scenario or "trajectory" should be more or less valid than any other trajectory within an ensemble of similar climate prediction runs with the same model. For this reason, process-level validation against values observed in nature at a particular location and time can only be pursued in a **data assimilation mode**, where the model "trajectory" is constantly being forced to fit the observed evolution of the real atmosphere (as illustrated by the figure on the first page). There are formidable obstacles arising from the sheer size and complexity of the data assimilation machinery. Nonetheless, GEWEX has a major task to promote the necessary adjuncts to climate model development strategies that will accommodate the need for detailed validation of subgrid-scale process parameterizations in "weather-forecasting mode," under the actual synoptic conditions observed in nature.

Hydrologic Consequences of Climate Variations and Long-term Trends

Fresh water is an essential ingredient of life, indispensable to all terrestrial species and essential for agriculture. Water also plays a unique role in a broad range of domestic applications and industrial processes. For these reasons, fresh water is an immensely valuable resource on which our existence depends. As civilizations progress, the human population, agriculture, and industry place ever-increasing demands on water resources and, by now, significant change in the global water cycle would entail serious consequences in many regions where water resources are already strained. Thus, a compelling goal of GEWEX is to develop the scientific foundation for predicting future changes in the distribution of precipitation and the availability of fresh water to terrestrial ecosystems and human societies.

The long-range transport of water vapor by winds, condensation and precipitation, the partitioning of rainfall between ground water storage and river runoff, and evaporation (evapotranspiration) from ground and vegetation all contribute to determining the fresh water budget of land areas. Unfortunately these processes have yet to be quantified with sufficient accuracy to allow assessing the extent to which projected trends in water use can be sustained in the future, or delivering water cycle predictions that can be usefully exploited for improved water resource management. The source of the difficulty is the high level of unpredictable weather variability that cause large uncertainties in precipitation and hydrologic forecasts on spatial scales of interest to water system managers (usually a particular river catchment).

Given such uncertainty, it is a safer bet for most practical water resource applications to rely on past statistics rather than state-of-the-art deterministic weather forecasts or climate predictions. Indeed, an executive decision based on the authority of past observational records is far more secure, at least regarding possible after-the-fact litigation, than one based on scientific judgment of complex dynamical and physical processes. Yet, it is obviously "unsafe" to assume that past climatic conditions constitute a reliable guide for operations indefinitely in the future, as we have unquestionable historical examples and strong model-based evidence of climate variability and long-term changes. Here lies a major challenge for the GEWEX community: that of finding a common language with water system operators and water resource managers, based on agreement about the optimal spatial scales and time averages that would allow a faithful translation of the findings of predictive climate science in terms that carry significance for the industry. The problem obviously revolves around the issue of irreducible uncertainty in weather and climate anomaly forecasts, i.e., the role of weather variability in the climate system, as well as the type of information hydrologic engineers can take usefully into account.

To pursue this matter, GEWEX must add to its "discovery" objectives the practical "application-driven" goal of assessing: ***"How will large-scale changes in global climate affect the amount and distribution of rainfall, the availability and quality of fresh water, and the likelihood of extreme hydrologic events?"*** Addressing these questions will require identifying classes of potentially useful information products for water system and natural resource managers, as well as fundamental understanding of the processes that govern the response of water systems to expected changes in land use and climate conditions.

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VALIDATION DATA SET FOR CERES SURFACE AND ATMOSPHERIC RADIATION BUDGET (SARB)

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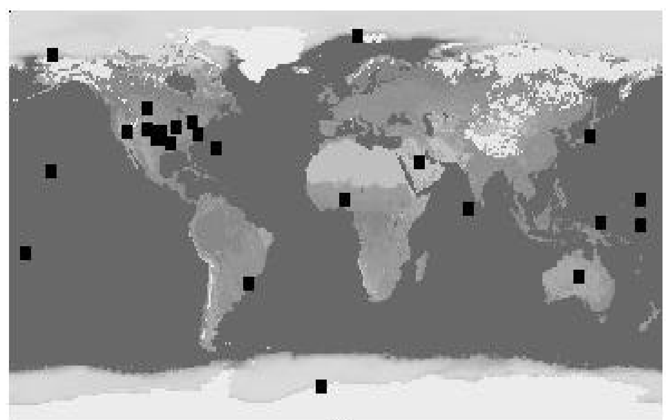
The Clouds and the Earth's Radiant Energy System (CERES) project (Wielicki et al., 1996) is a series of scanning radiometers measuring broadband Top Of Atmosphere (TOA) radiation. The instruments are on board the Tropical Rainfall Measurement Mission (TRMM) and Earth Observing System (EOS) Terra and Aqua satellites. Among the many goals of CERES, one is to compute the Surface and Atmospheric Radiation Budget (SARB) of the vertical column for each footprint. Inputs for these calculations include cloud optical properties (determined by higher resolution imagers on the respective satellites), meteorological profiles (supplied by ECMWF), ozone (from NCEP using SBUV/2 and TOVS), a characterization of the column loading of aerosols (currently monthly climatologies over land and imager derived optical depths over oceans.) With these inputs and global maps for spectral variation of surface albedo and emissivity (see: **http://tanalo.larc.nasa.gov:8080/surf_htmls/SARB_surf.html**), a modified 1-D radiative transfer code (Fu and Liou, 1993, can be run online at **http://srbsun.larc.nasa.gov/flp0300/**) computes the broadband flux profiles. Given the large number of input variables, the global scope of the problem, and the natural variability of the atmosphere there is an obvious need for validation of the model fluxes.

The formal product for the SARB computed by CERES consists of radiative fluxes at the surface, 500 hPa, 200 hPa, 70 hPa and TOA. Computations for TOA are compared directly with CERES observations. Given the lack of *in situ* flux measurements within the atmosphere, we turn to validation at the surface. The sites selected for the CERES "Atmospheric Radiation Measurement (ARM)" Validation Experiment (CAVE) are indicated in the map below. All CAVE sites subscribe to traceable calibration protocols. Consistent with the CERES goal of relating radiation to climate change, the CAVE sites observe and record several radiation fields almost continuously for the long term. **The goal of CAVE is to make available via the World Wide Web an informal, continuous record of radiation and meteorological data for these sites having:** (1) TOA broadband observations from the CERES instruments collocated in space and time with, (2) surface broadband flux measurements.

Where available other important variables such as surface meteorology, aerosols, and atmospheric profiles are included. The CAVE record begins 1 January 1998 shortly after TRMM launch. Depending upon the surface site, the data sets will be continuous and kept nearly up to date.



Locations of validation sites.

To keep the data files relatively small and easy to handle, a standard time unit of 1/2 hour was chosen as the basic time step for CAVE data. Surface data is averaged into 1/2 hour intervals, while the intermittent "snapshot" CERES observations are placed into the nearest 1/2 hour interval in a similar format allowing for ease of comparison with surface observations. Ancillary data sets are similarly averaged (placed) into the same format to facilitate use with the surface and TOA files.

Participating groups from which we receive the surface observations of radiometric fluxes are: The Atmospheric Radiation Measurement Program (ARM), The Baseline Surface Radiation Network (BSRN), Climate Monitoring & Diagnostics Laboratory (CMDL), NOAA Surface Radiation Research Branch, SURFRAD data, NASA Langley Research Center's Chesapeake lighthouse CERES Ocean Validation Experiment (COVE), the Indian Ocean Experiment (INDOEX), and the National Renewable Energy Resources Laboratory's (NREL) Saudi Solar Village. Most aerosol data come from NASA Goddard Spaceflight Center's Aerosol Network (AERONET) and SUNY Albany Atmospheric Sciences Research Center (ASRC). A number of other researchers have contributed their time and talent in supplying ancillary data and their contributions are noted at the web site.

Along with observations several calculated fields are added to CAVE data files. Where possible diffuse SW radiation measured by pyranometers is corrected for a "nighttime offset." Many CAVE files include supplementary estimates of cloud cover based on temporally intensive surface radiometric data. See the web site for references for these calculations.

The CAVE data is made available via ftp over the world-wide-web. The homepage describing the data, its sources, and programs to read the data is: **http://www-cave.larc.nasa.gov/cave/**.

Surface and TOA data for the first 8 months of 1998, the CERES/TRMM time period, are available. Surface observations from a number of sites through 2000 are also available and soon CERES TOA footprint data from the Terra satellite will be made available in the CAVE format.

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FOR UPDATES ON CEOP

http://www.msc-smc.ec.gc.ca/GEWEX/GHP/ceop.html

GEWEX POSITION CHANGES

(accepted by the GEWEX SSG in February 2001)

Dr. Ronald Stewart, Meteorological Service of Canada, named to a 3-year term as Chairman of the GEWEX Hydrometeorology Panel (GHP).

Dr. Toshio Koike, University of Tokyo, Leader of the Science and Implementation Office/Panel for the Coordinated Enhanced Observing Period (CEOP).

Dr. William Rossow, Goddard Institute for Space Studies, Chairman of the GEWEX Radiation Panel (GRP).

Dr. Steven Krueger, University of Utah, Chairman of the GEWEX Cloud System Study (GCSS).

Prof. Bert Holtslag, Wageningen University, Chairman of a new GEWEX Atmospheric Boundary Layer Study (GABLS) project under the GEWEX Modeling and Prediction Panel (GMPP).

WORKSHOP/MEETING SUMMARIES

FLOOD FORECASTING WORKSHOP

6–8 November 2000
Beijing, China

[1]DingYihui and [2]Ehrhard Raschke

[1]China Meteorological Administration
National Climate Center, China
[2]GKSS Research Center, Germany

Each year heavy floods cause dramatic losses in life and economy in Southeast and East Asia. This situation is not expected to change if no preventive measures are applied. Therefore, the National Climate Center of China, with the support of the World Climate Research Program and the National Natural Science Foundation of China, invited national and international experts to review the state of art of flood forecasting in Eastern Asia and to identify areas requiring further intensive research at the Workshop on Flood Forecasting. This workshop had the additional and important purpose to establish a closer than before link between atmospheric scientists, hydrologists, and flood and water managers, and to build a bridge between the advances made recently in climate research and numerical weather forecasts, and in flood research. Participants in the conference came from different institutions and organizations in China (including Hong Kong and Macao), neighboring countries (Japan, Korea and Malaysia), Canada and Europe (Germany, France and Italy) working in this field.

Presentations and discussions addressed the following problem areas.

Large-scale influences on flood occurrence: monsoons, typhoons, teleconnections and their modeling. The monsoon flow and its interaction with the cold air mass from mid-latitude are the primary cause of floods in East Asia. The variability of monsoons is linked closely with air-sea interaction and the snow cover over Tibet and the Eurasian continent. As a powerful tool for studying the influences of large-scale circulation on floods the GCM must be improved. Seasonal forecasts, as now routinely published by the European Centre for Medium-Range Forecasts and some East-Asian countries, should be the basis of experimental precipitation forecasts over Southeast Asia.

Convective processes in the atmosphere. Extended rain field and associated convective systems provide in most cases the water amounts necessary for flood formation. Cumulus parameterizations are still not developed well enough to simulate and forecast mesoscale convective systems. More experimental case studies and fields experiments are required to validate and check these schemes. More use of multi-Doppler radar and of bi-static radar systems in conjunction with geostational satellite measurements is recommended. Further, the impact of soil moisture on the development of convective systems needs more studies.

Mesoscale modeling. One major problem for mesoscale flood forecasting model systems consists of determining the appropriate initialization of the soil moisture and atmospheric forcing fields. Some studies demonstrated the dependence of precipitation forecasts on parameterization schemes for convection and land-surface processes. Particular attention should be paid to future research of the representation of subgrid-scale surface properties in models, such as the orography, vegetation cover, and soil moisture.

Hydrological modeling. In order to close the water and energy budgets on the seasonal and long terms it is necessary to develop and implement hydrological distributed models at regional scales. These models will finally be coupled with the meteorological models by sharing common interfaces for the representation of surface processes and exchanges. A number of models of this type are already available in Europe and China. The interface must be represented by a physically meaningful representation of land surface schemes, including the various terms of energy and water budget such as vegetation, snow, soil hydrology, and runoff production. The coupling scale is generally beyond the micro-scale at which the processes have been parameterized. The need exists of upscaling the processes and their relevant parameters while preserving their physical interpretation. Such an approach is already available for surface runoff as, for instance, the Xinanjiang model which can be used as a sub-grid scale parameterization of runoff production at a macroscale. Further studies are required to tie this type of parameterization to physically meaningful quantities, and thereby allow the spatial extension of the models to a large variety of basins under different climatic conditions. For flood representation, horizontal transfers such as overland and channel flow, unsaturated and saturated flow must also be represented by models where processes and their relevant parameters are upscaled while preserving their physical interpretation. For water resources management and climatic impact studies, special care should be placed on groundwater storage and flow representation.

Water and flood management. Water and flood management is the process of assessing and mitigating risks associated with extremes of hydrological variability. Improved forecast lead times reduce social and economic costs, but forecast uncertainty increases with increased lead time. Specific knowledge of the uncertainty associated with any given forecast is essential for wise decision-making based on that forecast. Forecast uncertainty can be a consequence of any imperfection in the process of transforming data into decisions.

Projections into the future. In order to anticipate the risks of flooding in future climate several aspects need to be addressed. Methods, which allow assessment of the accuracy of GCMs in present CO_2 (1x) through downscaling over a broad time domain, are needed to assess current flood regimes. This will provide a probabilistic basis for climate-based floods (snowmelts) as opposed to floods (e.g., monsoons) originating primarily from atmospheric processes that can be used to evaluate the predicted 2 x CO_2 scenarios. Similarly, land use and water use will not remain constant into the future as population grows. Methods to evaluate the hydrologic (and climatic) significance of the growth of mega-cities and megalopolises in large watersheds will be needed. Finally also such methods will be required that allow a critical assessment of forecasts and scenarios of non-linear and non-stationary processes.

GCSS SCIENCE PANEL MEETING

29 November – 1 December 2000
Tokyo, Japan

Steven Krueger
University of Utah, USA

At the GEWEX Cloud System Study (GCSS) Science Panel meeting in Tokyo, some changes were announced; including: Dr. Steven Krueger follows Dr. David Randall as Chair of the GCSS and two of the working groups have new chairmen. GCSS has a unique Working Group (WG) organizational structure that has facilitated the collection and application of test cases for focused research and analysis exercises. The five WGs are: [WG 1] Boundary-layer cloud systems (Chair: Dr. Peter Duynkerke), [WG 2] Cirrus cloud systems (Chair: Dr. David Starr), [WG 3] Extratropical layer cloud systems (Chair: formerly Dr. Brian Ryan, now **Dr. George Tselioudis**), [WG 4] Precipitating convective cloud systems (Chair: formerly Dr. Steven Krueger, now **Dr. Wojciech Grabowski**), [WG 5] Polar cloud systems (Chair: Dr. Judith Curry).

During calendar year 2000, all WGs held meetings and made scientific progress towards the objectives of GCSS. For more information on the activities of the individual WGs, follow the links to their web sites from the GCSS home page (**http://www.gewex.com/gcss.html**).

In response to a recommendation from the Joint ECMWF and WCRP/GCSS Workshop (9–13 November 1998), the GCSS Chair, David Randall, with the support of a drafting team, produced the Second Science and Implementation Plan for the GEWEX Cloud System Study (GCSS). The plan was published in the International GEWEX Project Office (IGPO) Report series. A copy can be obtained from **http://www.gewex.com/gcss_sciplan.pdf**, or by contacting IGPO by email at **gewex@cais.com**. In the original GCSS strategy, as articulated in the first GCSS science plan, data is collected in various field programs and provided to the Cloud Simulation Modeling (CSM) Community, which uses the data to certify the CSMs as reliable tools for the simulation of particular cloud regimes, and then uses the CSMs to develop parameterizations, which are provided to the GCM Community. **The revised plan presents the results of a re-thinking of the scientific strategy of GCSS. The main elements of the proposed new strategy are a more active role for the large-scale modeling community, and an explicit recognition of the importance of data integration. In addition, the new plan describes ways in which GCSS can approach the key climate issue of cloud feedback.** Finally, the document summarizes the many accomplishments of the Working Groups.

OPPORTUNITIES FOR 21ST CENTURY METEOROLOGY

14–19 January 2001
Albuquerque, New Mexico USA

The 81st American Meteorological Society (AMS) Annual Meeting offered to the 2600 attendees a dozen symposia and conferences. There were joint sessions built around two interdisciplinary symposia addressing climate and precipitation issues.

Most of the GEWEX presentations were in the two interdisciplinary symposia. Examples included a report on the GPCP 1º x 1º global data sets and their application in studies of rainfall and precipitation related variables in the hydrological cycle. Another GEWEX interdisciplinary paper was on the development of a browser for high spatiotemporal resolution precipitation data in the GCIP domain.


Dr. Anthes

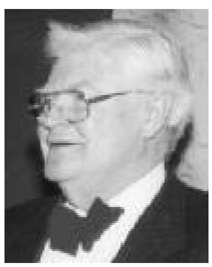
There were, throughout the week, presentations addressing planned satellite observational capabilities. This forward looking theme was evident from the first of technical sessions when Dr. Richard Anthes, University Corporation of Atmospheric Research, presented his thoughts on the opportunities of 21st century global observational systems using operationally derived data from satellites for numerical prediction models that have the capability to produce accurate predictions out to ten or more days, useful seasonal forecasts and realistic climate change outlooks. Dr. Anthes used Dr. Anthony Hollingsworth's (ECMWF) overheads to make his point on ensemble models success, chemical constituent forecasts, and 4D variational technique to assimilate satellite scatterometer data for surface winds.

The highlight of the AMS Meeting was a plenary session addressing the opportunities for the 21st century with presenters from industry, government, and academia. The invited speakers to the plenary session were asked to give their perspective on climate, water, and weather events. The president of a major power company described the electric generation system and how it is adjusted based on tailored weather forecasts. The seasonal projections are also important for scheduling maintenance and managing fuel storage in the electric power industry.

The railroad industry is more interested in long-term (seasonal) forecasts. The transportation and storage of fuel is based on climate and weather predictions. Interestingly, in the United States the profits of railroads rely heavily on the shipping of coal and grain. Both of these commodities are weather related.

Dean Dutton

Also at the unique plenary session, Dean John A. Dutton, Pennsylvania State University, presented his thoughts on new opportunities in the 21st century for meteorologists. Dr. Dutton cited several factors driving deviation from traditional meteorology. They include: (1) applying of satellite derived data for both the operational numerical models and models tailored for a specific purpose such as water resource management; (2) exploiting the information to move data to forecast centers and effectively distribute timely predictions directly to the public or for private sector value added use; (3) transitioning efficiently scientific results into new models; (4) planning ahead for emerging technology progress in sensors, communication and super computers; and (5) developing global climatology science efforts that include space, atmosphere, land, and ocean observations for realistic climate models. GEWEX researchers are, for the most part, already applying these five factors.



Prof. Bromley

Prof. D. Allan Bromley, Yale University, added in his presentation the demand from the private sector economic reasons for new opportunities. Prof. Bromley discussed differences in how U.S., Europe, and Japan approach the government and private sector relationships in the productions and dissemination of predictions. Prof. Bromley illustrated his point by using Japan's Weather Service Incorporated experience in the world market for private weather and climate forecasting.

Many of the presentations during the week followed a forward looking theme toward opportunities for scientists in the 21st century; opportunities which require interdisciplinary knowledge, as is the case in GEWEX. This concept, according to the speakers, requires a change in the traditional training of scientists.

Photographs courtesy of American Meteorological Society.

GEWEX/WCRP MEETINGS CALENDAR

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

5–7 March 2001—GAME TROPICS WORKSHOP, Phuket, Thailand.

7–9 March 2001—INTERNATIONAL WORKSHOP ON GAME-ASIAN AUTOMATIC WEATHER STATION (AWS) NETWORK (AAN)/RADIATION. For more information: http://erc2.suiri.tsukuba.ac.jp/Project/aan/aan.html.

15–16 March 2001—THIRD INTERNATIONAL WORKSHOP ON WATER AND ENERGY CYCLES IN SIBERIA AND GAME, Tokyo, Japan.

19–24 March 2001—WCRP JOINT SCIENTIFIC COMMITTEE MEETING, Boulder, Colorado, USA.

30 April–4 May 2001—GAPP PRINCIPAL INVESTIGATORS MEETING AND GAPP IMPLEMENTATION PLAN WORKSHOP, Potomac, Maryland, USA.

14–17 May 2001—15TH SESSION OF GPCP, GEWEX DATA MANAGEMENT GROUP AND SCIENCE ADVISORY TEAM MEETING, Bologna, Italy.

2–6 July 2001—THIRD STUDY CONFERENCE ON BALTEX, Aland, Finland. For information consult website: http://w3.gkss.de/baltex/.

10–13 July 2001—CHALLENGES OF A CHANGING EARTH–A GLOBAL CHANGE OPEN SCIENCE CONFERENCE, RAI Conference Center, Amsterdam, The Netherlands. Abstracts are due 31 March 2001. For information: http://www.sciconf.igbp.kva.se/fr.html.

14–15 July 2001—JOINT ISLSCP/BAHC SCIENCE PANEL MEETING, Amsterdam, The Netherlands.

18–27 July 2001—SIXTH SCIENTIFIC ASSEMBLY OF THE INTERNATIONAL ASSOCIATION OF HYDROLOGICAL SCIENCES (IAHS)-S5 SOIL-VEGETATION-ATMOSPHERE TRANSFER SCHEMES AND LARGE SCALE HYDROLOGICAL MODELS, Maastricht, The Netherlands.

10–14 September 2001—FOURTH INTERNATIONAL SCIENTIFIC CONFERENCE ON THE GLOBAL ENERGY AND WATER CYCLE, Paris, France. Abstract may be submitted through the Conference web site or copy sent to: GEWEX Conference, Institut Pierre Simon Laplace, Université Pierre et Marie Curie, Tour 15, B 102, 4 Place Jussieu, 75252 Paris Cedex 05 France; Fax: 33-1-44276272.

1–2 October 2001—SIXTH GAME INTERNATIONAL SCIENCE PANEL MEETING, Aichi Trade Center, Nagoya, Japan.

GEWEX NEWS

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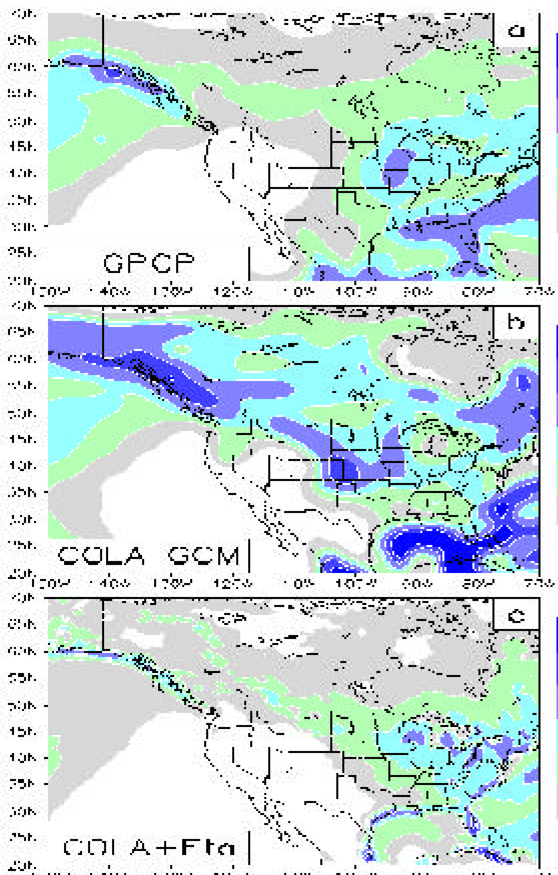
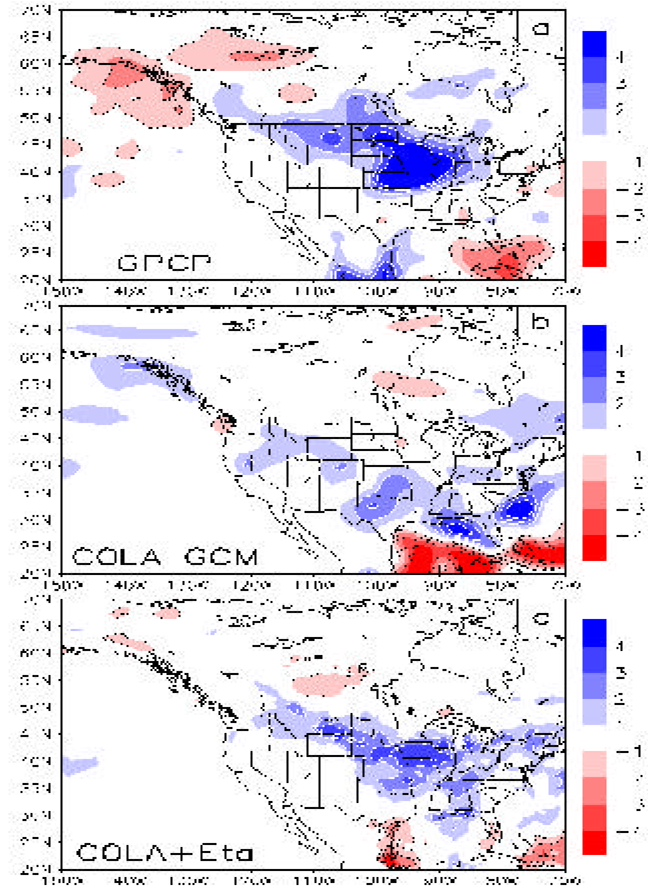
SIMULATION OF NORTH AMERICAN SUMMERTIME CLIMATE

(See article on page 3)



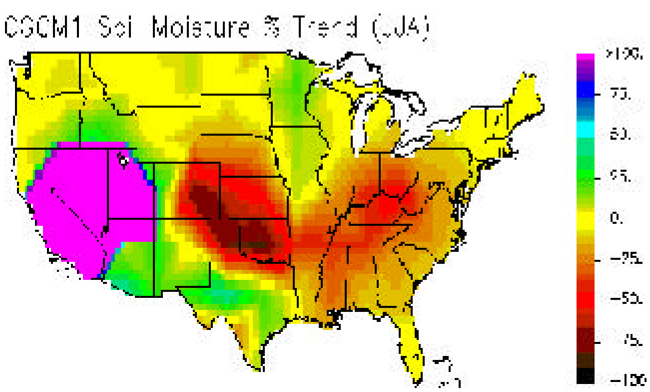
JJAS 5-year ensemble mean precipitation for: (a) GPCP analysis, (b) COLA GCM, and (c) nested Eta model. Contours are 1,2,3,4,6,8 mm day[1].



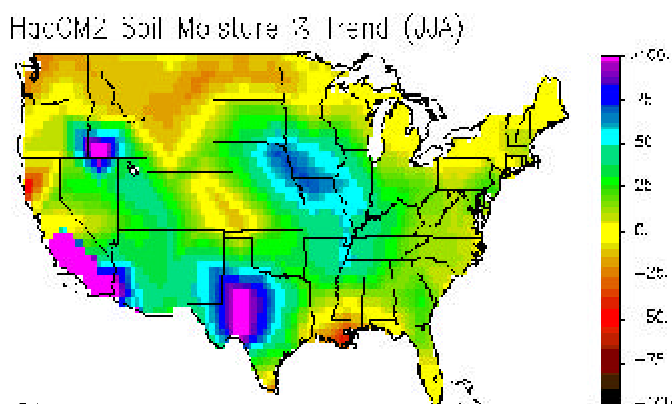
June-July mean 1993 minus 1998 precipitation difference for: (a) GPCP analysis, (b) COLA GCM ensemble, and (c) nested Eta model ensemble. Contours are ± 1,2,3,4 mm day[1].

LARGE CLIMATE MODEL DIFFERENCES IN WET PROCESSES

(See article beginning on page 1)



(a)



(b)

Summer soil moisture changes (percentage of past climatological soil moisture) with respect to the reference period 1961–1990, as predicted by two state-of-the-art climate models in the course of a 100-year integration assuming a "business-as-usual" scenario for future increases in greenhouse gases. Panel (a) Canadian Climate Center. Panel (b) UK Meteorological Office Hadley Center.