GEWEX WCRP

Global Energy and Water Cycle Experiment

NEWS

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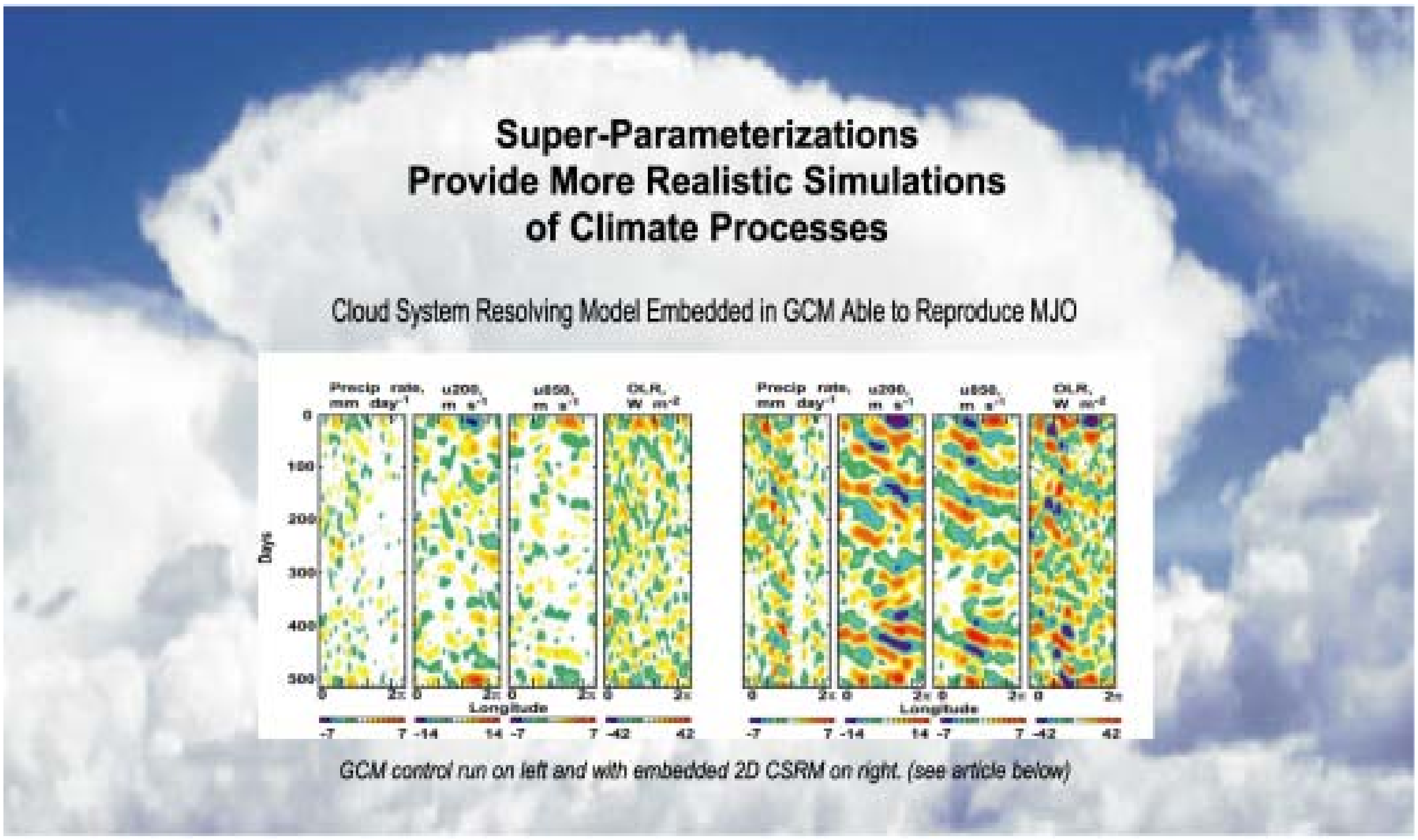
World Climate Research Programme–WCRP

LAND-SURFACE DATA ASSIMILATION SYSTEM CONCEPTS ARE EXPANDING

(See Articles on Pages 2 and 9)



SUPER-PARAMETERIZATIONS: FAST FORWARD TO THE FUTURE

David Randall and Marat Khairoutdinov
Colorado State University

Editor's Note: This is a summary of a talk given at the GCSS-ARM workshop in Kananaskis, Canada.

Deficiencies in the representation of cloud-dynamical processes in climate models drive much of the uncertainty surrounding predictions of climate change. This was true 30 years ago and it is still true now. To take conventional parameterizations much beyond where we are now, it seems likely that we will have to make them very complicated—in some ways much more complicated than Cloud-Sys-

(Continued on Page 5)

NEW GEWEX
E-mail and Website
E-mail: gewex@gewex.org
Web: www.gewex.org

What's New

- SSG Members and Panel Chairs Highlighted
- CEOP to benefit from GLDAS
- GSWP-2 to Begin this Year
- GCSS and GLASS Set Strategies for the Future

COMMENTARY

NEW GEWEX SSG MEMBERS ENHANCE INTERDISCIPLINARY AND INTERNATIONAL GUIDANCE

Soroosh Sorooshian, Chair
GEWEX Scientific Steering Group

The GEWEX Scientific Steering Group (SSG) has added more new members than usual this cycle after many years of excellent service from our previous members. The diversity of this SSG provides an opportunity to enhance our interdisciplinary and international participation and guidance of our ongoing projects, as well as helping to expand the guidance needed for several of our new developing projects. As usual we strive for a balance of expertise within the hydrology, atmospheric physics and radiation, modeling and assimilation, and observational communities while covering the breadth of international aspects. The broad responsibilities we place on the SSG are indicated in The Terms of Reference:

- To formulate the programme for GEWEX, consisting of both observation and theory, for understanding and eventually modeling the global energy and water cycle;
- To provide scientific guidance for the conduct of GEWEX using advice from individual experts or expert groups, as necessary;
- To formulate the concept of an observing system which would fulfill the data requirements for GEWEX taking into consideration possible national contributions to the programme;
- To use existing or, where necessary, propose new mechanisms for assuring the exchange and analysis of GEWEX data and the dissemination of scientific results; and
- To establish scientific liaison with relevant organizations and existing programmes, as appropriate.

I think you will find that our latest membership covers the broad spectrum necessary to provide this guidance for GEWEX. Not explicitly included within these, but implied within the last bullet, is the responsibility to assist in the spread of information about the objectives and plans for our projects among the diverse spectrum of national and international organizations our SSG members are involved with. This will also provide a mechanism for the feedback we need to improve our implementation process.

Please note closely on the following pages the names, affiliations and interests of our SSG members and feel free to communicate directly with them, as well as directly with myself or the IGPO, on ideas, concepts, criticisms, or suggestions for improving any of the many aspects of our overall GEWEX Project.

GLDAS: AN IMPORTANT CONTRIBUTION TO CEOP

Paul R. Houser and Matthew Rodell

Hydrological Sciences Branch
NASA Goddard Space Flight Center

Scientists at NASA's Goddard Space Flight Center (GSFC) have developed a high-resolution Global Land Data Assimilation System (GLDAS) in cooperation with researchers at NOAA's National Centers for Environmental Prediction (NCEP). The goal of GLDAS is to produce optimal output fields of land surface states and fluxes by making use of data from advanced observing systems (See figure on back page). Errors in land surface forcing and parameterization tend to accumulate in modeled land stores of water and energy, leading to incorrect surface water and energy partitioning. GLDAS aims to minimize this effect by constraining the models in two ways. First, by forcing the land surface primarily by observations (such as precipitation and radiation), the biases in atmospheric model-derived forcing are avoided. Second, by employing land surface data assimilation techniques, observations of land surface storages (soil temperature, soil moisture, and snow depth/cover) can be used to steer unrealistic simulated storages towards reality. These techniques also enable identification and mitigation of observational errors and minimization of the impact of

(Continued on page 7)

Contents

GEWEX SCIENTIFIC STEERING GROUP (SSG) MEMBERS

The SSG provides scientific guidance in formulating the program for GEWEX and advises the Joint Scientific Committee of the World Climate Research Programme of progress achieved in the implementation of GEWEX and scientific advances in the understanding of the global energy and water cycle. The following are the current members of the SSG, chaired by Soroosh Sorooshian.

Soroosh Sorooshian

Chair, GEWEX SSG
Regents Professor/Director, SAHRA
Hydrology and Water Resources
University of Arizona
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Areas of Interest: Semi-arid hydrology, precipitation and rainfall-runoff modeling, remote sensing applications in hydrology, optimization and system analysis.

Thomas Ackerman

Chief Scientist
Atmospheric Radiation
Measurement Program
United States Department of Energy
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Areas of Interest: Atmospheric radiative transfer and remote sensing.

Robert Atlas

Head, Data Assimilation Office
NASA/Goddard Space Flight Center
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Areas of Interest: Synoptic and dynamic meterorology, data assimilation, applications of space-based data to numerical weather prediction, observing system simulation experiments.

Maria Assunção F. Silva Dias

Professor, Department of
Atmospheric Sciences
Vice-Director, Institute of Astronomy,
Geophysics, and Atmospheric Sciences
University of São Paulo, Brazil
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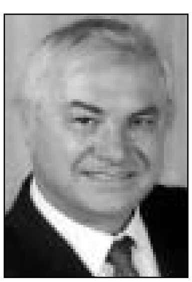
Areas of Interest: Mesoscale meteorology with focus on convective systems, local circulation, biosphere-atmosphere interactions, and scale interactions.

Lars Gottschalk

Professor, Tekn., Dr.
Department of Geophysics
Univerity of Oslo
E-mail: gottschalk@lyon.cemagref.fr

Areas of Interest: Mapping of large-scale variations in hydrologic characteristics, process-based distributed models, stochastic interpolation methods, extreme value analysis and risk assessment, effect of environmental and climate change on water resources.



Anthony Hollingsworth

Head of Research and Deputy Director
European Centre for Medium-Range
Weather Forecasts
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Areas of Interest: Numerical weather prediction, both deterministic and stochastic; data assimilation; use of satellite data.

Yann Kerr

Head, Global Monitoring Unit and Lead
Investigator for the
SMOS Mission (ESA)
Centre d'Etudes Spatiales de la
BIOsphère (CESBIO)
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Areas of Interest: Theory and techniques for microwave and thermal infrared remote sensing of the Earth, with emphasis on hydrology and energy budgets.

GEWEX SCIENTIFIC STEERING GROUP (SSG) MEMBERS *(Continued)*

Zurab Kopaliani

Deputy Director
The State Hydrological Institute
St. Petersburg, Russia
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Areas of Interest: Human impact on river systems and water resources, water balance, hydrological and hydraulic modeling, computations and forecasting river channel changes and sedimentation, river responses to water projects.

David Randall

Professor
Department of Atmospheric Science
Colorado State University
E-mail: randall@redfish.atmos.colostate.edu

Areas of Interest: Clouds and climate modeling.

Ulrich Schumann

Professor, Deutsches Zentrum für Luft- und Raumfahrt (DLR),
Institute of Atmospheric Physics,
Oberpfaffenhofen
E-mail: Ulrich.Schumann@dlr.de

Areas of Interest: Atmospheric physics, cloud physics, aircraft emissions, turbulence, lidar, radar, mesoscale and global atmospheric dynamics and climate.

Kenji Nakamura

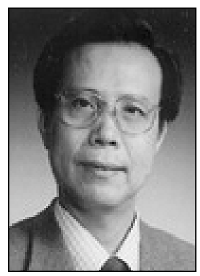
Professor
Hydrospheric Atmospheric
Research Center
Nagoya University
E-mail: knakamura@pat.hi-ho.ne.jp

Areas of Interest: Satellite remote sensing of the atmosphere and precipitation systems.

Kuniyoshi Takeuchi

Professor, Department of Civil and
Environmental Engineering,
Yamanashi University
E-mail: takeuchi@mail.yamanashi.ac.jp

Areas of Interest: Water resource systems.

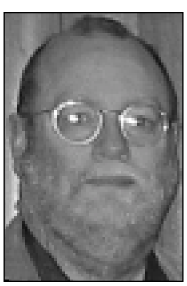


Guoxiong Wu

Professor, Institute of
Atmospheric Physics
Chair, Academic Committee,
National Key Laboratory of
Atmospheric Sciences and
Geophysical Fluid Dynamics
Chinese Academy of Sciences
E-mail: gxwu@lasg.iap.ac.cn

Areas of Interest: Climate and weather dynamics.

GEWEX PANEL LEADERS



GEWEX RADIATION PANEL

William Rossow, Chair

NASA Goddard Institute
for Space Studies
E-mail: wrossow@giss.nasa.gov

Areas of Interest: Climate, atmospheric general circulations, clouds, radiation, satellite data analysis.

GEWEX MODELING AND PREDICTION PROJECTS

Jan Polcher, Chair

Laboratoire de Météorologie
Dynamique du CNRS
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Areas of Interest: Land-surface modelling and the land-surface atmosphere interactions.

GEWEX HYDROMETEOROLOGY PANEL

Ronald Stewart, Chair

Climate Processes and
Earth Observation Division
Meteorological Service of Canada
E-mail: Ron.Stewart@ec.gc.ca

Areas of Interest: Water cycle, clouds and precipitation, and extreme events.

COMPONENTS OF GEWEX PANELS

Hydrometeorology Projects

- **GEWEX Hydrometeterology Panel (GHP)**
  Chair: R. Stewart, Meteorological Service of Canada,
- GHP Data Management Working Group
  S. Williams, UCAR
- Baltic Sea Experiment (BALTEX)*
  H.-J. Isemer, GKSS
- Coordinated Enhanced Observation Period (CEOP)
  T. Koike, University of Tokyo
- Couplage Atmosphère Tropicale et Cycle Hydrologique (CATCH)#
  T. Lebel, ORSTOM
- GEWEX Americas Prediction Project (GAPP)*
  R. Lawford, NOAA/OGP
- GEWEX Asian Monsoon Experiment (GAME)*
  K. Nakamura, Nagoya University
- Global Runoff Data Centre (GRDC)
  T. Maurer, Federal Institute of Hydrology
- International Satellite Land-Surface Climatology Project (ISLSCP)
  P. Kabat, Wageningen University
- Large-Scale Biosphere-Atmosphere Experiment in Amazonia (LBA)*
  J. Marengo, INPE
- Mackenzie GEWEX Study (MAGS)
  K. Szeto, Environment Canada
- Murray-Darling Basin (MDB) Water Budget Project*
  M. Manton, BMRC

Modeling and Prediction Projects

- **GEWEX Modeling and Prediction Panel (GMPP)**
  Chair: J. Polcher, Laboratoire de Météorologie Dynamique du CNRS
- GEWEX Atmospheric Boundary Layer Study (GABLS)
  B. Holtslag, Wageningen University
- GEWEX Cloud System Study (GCSS)
  S. Krueger, University of Utah
- Global Land/Atmosphere System Study (GLASS)
  J. Polcher, Laboratoire de Météorologie Dynamique du CNRS

Radiation Projects

- **GEWEX Radiation Panel (GRP)**
  Chair: W. Rossow, NASA/Goddard Institute for Space Studies
- Baseline Surface Radiation Network (BSRN)
  E. Dutton, NOAA/CMDL
- Global Aerosol Climatology Project (GACP)
  M. Mishchenko, NASA/GISS
- Global Precipitation Climatology Project (GPCP)
  A. Gruber, NOAA/NESDIS
- Global Water Vapor Project (GVaP)
  B.Soden, NOAA/GFDL
- International Satellite Cloud Climatology Project (ISCCP)
  W. Rossow, NASA/GISS
- Surface Radiation Budget (SRB) Project
  P. Stackhouse, NASA/LaRC

* Continental-Scale Experiment
\# Continental-Scale Affiliate

SUPER-PARAMETERIZATIONS: FAST FORWARD TO THE FUTURE

(Continued from Page 1)

tem-Resolving Models (CSRM). A CSRM can be used as a super-parameterization inside a GCM. Results to date suggest that super-parameterizations can give significantly more realistic climate simulations than conventional parameterizations do.

The following are examples of the complicated cloud processes.

- Convective updrafts and downdrafts, and their "environment"
- Interactions of convection with the boundary layer
- Mesoscale anvils and mesoscale dynamical systems
- Tightly coupled radiative and turbulent processes
- Interactions of convection with gravity waves
- Interactions of clouds with topography
- Strong dependence of radiation on microphysical parameters
- Cloud overlap in the radiative and microphysical senses
- Aerosol effects, linked to atmospheric chemistry

There are two kinds of complexity in devising realistic cloud parameterizations.

- Numerical complexity: A next-generation conventional parameterization can easily include as many prognostic degrees of freedom as a high-resolution cloud model.
- Conceptual complexity: A conventional cloud parameterization is conceptually more complicated than a high-resolution cloud model, because in a

(Continued next page)

conventional parameterization we substitute a statistical theory (closure assumptions, etc.) for the relatively straightforward governing equations of the cloud model.

CSRMs have resolutions fine enough to represent individual cloud elements, and space/time domains large enough to encompass many clouds over many cloud lifetimes. CSRMs can be driven by observations of large-scale weather systems. A CSRM explicitly represents cloud-dynamical processes, such as formation and dissipation, on their "native" space and time scales (kilometers and minutes). CSRMs have been a central focus of GCSS from the beginning.

Single-Column Models (SCM) are the column-physics components of GCMs, surgically extracted from their host GCMs and driven by observations of large-scale weather systems. **GCSS has actually demonstrated that CSRMs give better results than SCMs, through a number of case studies.**

Current climate-simulation models typically have on the order of 10^4 grid columns, averaging about 200 km wide. A future global model with grid cells 2 km wide will have about 10^8 grid columns. The time step will have to be roughly 10^2 times shorter than in current climate models. The CPU requirements will thus be $10^4 \times 10^2 = 10^6$ times larger than with today's lower-resolution models. In a few more decades such global CSRMs will become possible.

There is another approach, Super-Parameterizations. We can run a CSRM as a "super-parameterization" inside a GCM. Wojciech Grabowski of NCAR, Chair of GCSS WG 4, implemented a 2D CSRM inside a simplified global model with globally uniform SSTs (no mountains, etc.) (Grabowski and Smolarkiewicz, 1999; Grabowski, 2001). Each copy of the CSRM represents a "sample" of the volume inside a GCM grid column. Statistics computed using the CSRM are based on this "sample" in much the same way that statistics from an opinion poll are based on interviews with a sample of the population. Grabowski's approach was to use a 2D CRM, and cyclic lateral boundary conditions

Inspired by Grabowski's idea, Marat Khairoutdinov of CSU embedded his 2D CSRM as a super-parameterization in the atmosphere sub-model of the Community Climate System Model (CAM) (Khairoutdinov and Randall, 2001). This global model has realistic topography, SSTs, etc. The CSRM takes the place of the stratiform and convective cloud parameterizations, and in the future will also replace the PBL parameterization. Because he was already familiar with both the CAM and the CSRM, Marat was able to get the super-parameterization working in the CAM in about a month.

Results to date suggest that super-parameterizations can enable more realistic simulations of important climate processes, such as the Madden-Julian Oscillation (MJO) and we have demonstrated that super-parameterizations can be incorporated into GCMs with a modest effort. The figure on the cover shows Hovmuller diagrams for the precipitation rate, 200 mb zonal wind, 850 mb zonal wind, and outgoing longwave radiation (OLR) in a control run with the T21 CAM, and in an experiment with the same model modified to use the super-parameterization. The results have been filtered to show variability with periods in the range 20 to 100 days.

There are many *a priori* reasons to believe that super-parameterizations have the potential to provide more realistic and more reliable simulations of climate.

Super-Parameterizations: What do we get from using them?

- Explicit deep convection, including mesoscale organization (e.g., squall lines), downdrafts, anvils, etc.
- Explicit fractional cloudiness
- Explicit cloud overlap in the radiative sense
- Explicit cloud overlap in the microphysical sense
- Convective enhancement of the surface fluxes
- Possible explicit 3D cloud-radiation effects
- Convectively generated gravity waves
- The ability to compare global model results on the statistics of mesoscale and microscale cloud organization with observations from new platforms, such as CloudSat
- The ability to assimilate cloud statistics based on high resolution observations
- The ability to compare results obtained with the super-parameterization to results obtained with conventional parameterizations

Super-Parameterizations: What problems don't go away?

- Microphysics, aerosol effects, etc. must still be parameterized. But these problems are much more tractable with explicit cloud elements.
- Radiative transfer must still be parameterized. But some aspects of the problem are drastically simplified as already noted.
- Turbulence and small-scale convection must still be parameterized. But high resolution facilitates this too.
- The usual issues related to the numerical simulation of large-scale dynamics still remain.

Super-Parameterizations: What does it cost?

In our tests to date with the CAM, the embedded CSRM slows the model down by about a factor of 180. A one-day simulation with CSRM embedded in a T42 GCM takes about one hour on 64 processors of an IBM SP and a simulated century would take about 4 years of wall-clock time on 64 processors. However, we are rescued by massive parallelism since super-parameterizations provide a way to utilize more processors for a given GCM resolution, and with 1024 processors, a simulated century would take just a few real months to run.

The CSRM can be driven off-line using field data. Super-parameterizations thus provide a radically new way to make connections between field data and GCMs, providing a new pathway for GCSS to explore.

In conclusion, super-parameterizations represent a distinctly new approach to climate simulation. They are not "more of the same, only better." Super-parameterizations give us a way to "fast-forward" to the future of climate modeling. *(For a more complete discussion of this work, see Randall et. al., 2002)*

References

Grabowski, W. W., and P. K. Smolarkiewicz (1999). CRCP: A cloud resolving convection parameterization for modeling the tropical convective atmosphere. *Physica D,* 133, 171-178.

Grabowski, W. W., (2001). Coupling cloud processes with the large-scale dynamics using the cloud-resolving convection parameterization (CRCP). *J. Atmos. Sci.*, 58, 978-997.

Khairoutdinov, M. F., and D. A. Randall (2001). A cloud-resolving model as a cloud parameterization in the NCAR Community Climate System Model: Preliminary results. *Geophys. Res. Lett.*, 28, 3617-3620.

Randall, D., M. F. Khairoutdinov, A. Arakawa, and W.W. Grabowski (2002). Breaking the Cloud-Parameterization Deadlock. Submitted to *Bul. of the Am. Met. Soc.*

GLDAS: AN IMPORTANT CONTRIBUTION TO CEOP

(Continued from Page 2)

simplified land parameterizations. **The value-added data produced by GLDAS will improve land surface, weather, and climate predictions by providing global fields of land surface energy and moisture stores for initialization.**

Drivers have been installed in GLDAS for three land surface models (LSM): Mosaic; the Community Land Model (CLM); and the NCEP, Oregon State University, United States Air Force, and Office of Hydrology model (NOAH). GLDAS runs globally with a 15-minute time step at 0.25° (soon to be 0.125°) and coarser resolutions. A vegetation-based "tiling" approach is used to simulate sub-grid scale variability, with the University of Maryland's 1 km global vegetation data set as its basis. Soil parameters are derived from 5-minute global soils information produced by the USDA Agricultural Research Service. GLDAS uses the GTOPO30 global digital elevation model as its standard and corrects input fields accordingly. In addition to an operational, near-real-time simulation using the standard parameterization and forcing data, several parallel simulations run with varying combinations of models, forcing data, and advanced options. Forcing options include the global atmospheric forecast model output (from GSFC's Data Assimilation Office, NCEP, and the European Centre for Medium-Range Weather Forecasts) and observation-based precipitation and radiation fields. Advanced options, which are in various stages of planning, implementation, and testing, include a routine for satellite-based updates of leaf area index, canopy greenness and albedo, soil moisture and temperature data assimilation, observation-based snow corrections, simulation of the atmospheric boundary layer, and runoff routing.

The Coordinated Enhanced Observation Period (CEOP) was initiated by the international efforts of GEWEX and is focused on the measurement, understanding and modeling of water and energy cycles within the climate system. It is motivated by the synchronism of the new generation of Earth observing satellites and GEWEX Continental Scale Experiments (CSE). Its primary goal is to develop a consistent data set for 2003-2004 to support research objectives in climate prediction and monsoon system studies. The requirements of the international climate research community at large have been taken fully into account in planning the assembly of the data set. CEOP also will assist studies of global atmospheric circulation and water resources availability. CEOP has gained the interest of a broad range of international organizations, as evidenced by the proposal for an Integrated Global Water Cycle Observations (IGWCO) theme within the framework of the International Global Observing Strategy Partnership (IGOS-P), which has reaffirmed CEOP as "the first element of the IGWCO." The CEOP implementation plan can be viewed at: http://www.gewex.org/ceop/ceop_ip.pdf.

CEOP aims to integrate the many streams of data coming from new space-based observation systems into a coherent database relevant to CEOP science issues, which will facilitate analytical investigations.

GLDAS is a valuable tool for CEOP because it assimilates the information from multiple models and observation platforms to provide the best available assessment of the current state of the land surface. The international GEWEX and CEOP communities have recognized that GLDAS can be leveraged and further developed to address the needs of CEOP. CEOP is specifically interested in the generation and application of GLDAS results in regional climate analysis, model initialization, and comparison with results from field campaigns and modeling experiments. The use of GLDAS model location time series (MOLTS), which are time series of land surface model output for points of interest, will be one of the primary tools to enable this globally consistent intercomparison. Each GLDAS MOLTS will be particularly relevant because it will be generated based on a GLDAS subgrid "tile" with a vegetation class that matches that of the observation. Furthermore, GLDAS MOLTS can be produced using each of the land surface models that GLDAS drives (currently three; five planned). These comparison exercises and the data produced by the continental scale experiments also will provide much-needed validation for the GLDAS project. NASA has been requested to further develop GLDAS as a central "CEOP data integration center," including the following aspects:

- A test bed for evaluating multiple land surface models
- Long term land model baseline experiments and intercomparisons
- Linking and inclusion of reference site observations with globally consistent observation and modeling to enable GEWEX-CSE land transferability studies
- Land initialization for seasonal-to-interannual coupled predictions
- Evaluation of numerical weather and climate predictions for land
- Integration of remotely sensed land observations in land/atmospheric modeling for use in CEOP and higher level understanding
- A quality control check on observations
- 4DDA "value-added" GLDAS-CEOP data sets
- The production of GLDAS MOLTS
- The expansion of GLDAS to include selected atmosphere and ocean observations
- The development of a long-term archive function

The GLDAS contribution to CEOP is expected to have the following timeline:

- Data Integration Period (2002–2005): Compile the forcing data (observations and analyses) and assimilation data including radiance observations (level 1), high-level satellite data products, *in situ* observations, and NWP land analyses into a long term archive. Produce MLDAS (MOLTS LDAS) by reconfiguring GLDAS to run only MOLTS points for explicit linkages to CEOP reference sites.
- Reanalysis Period (2006–2007 work activity): Reprocess CEOP data in a globally consistent 1/8 degree resolution; global land reanalysis including multiple land model products (NOAH, CLM, VIC, etc.) and data assimilated value-added analysis.

For more information on GLDAS, please visit http://ldas.gsfc.nasa.gov.

GCIP RELEASES WEBS CD-ROM

This CD-ROM contains a Water and Energy Budget Synthesis (WEBS) for the GEWEX Continental Scale International Project (GCIP). The synthesis includes a brief description of the Mississippi River Basin climate, physiographic characteristics, a brief description of available observations, representative types of models used for GCIP investigations, and a comparison of water and energy variables and budgets from models and observations from the recent period.

Since GCIP was a climatological experiment, the focus was on developing a seasonal climatology during the period 1996–1999. Because the interannual variations during this period were minimal, this synthesis has been extended to the 1988–1999 time period.

The WEBS CD-ROM may be ordered from the UCAR/JOSS CODIAC Data Management System at http://www.joss.ucar.edu/cgi-bin/codiac/dss?21.113. The CD-ROM can also be ordered from the International GEWEX Project Office (gewex@gewex.org).

EUROPEAN LDAS ESTABLISHED

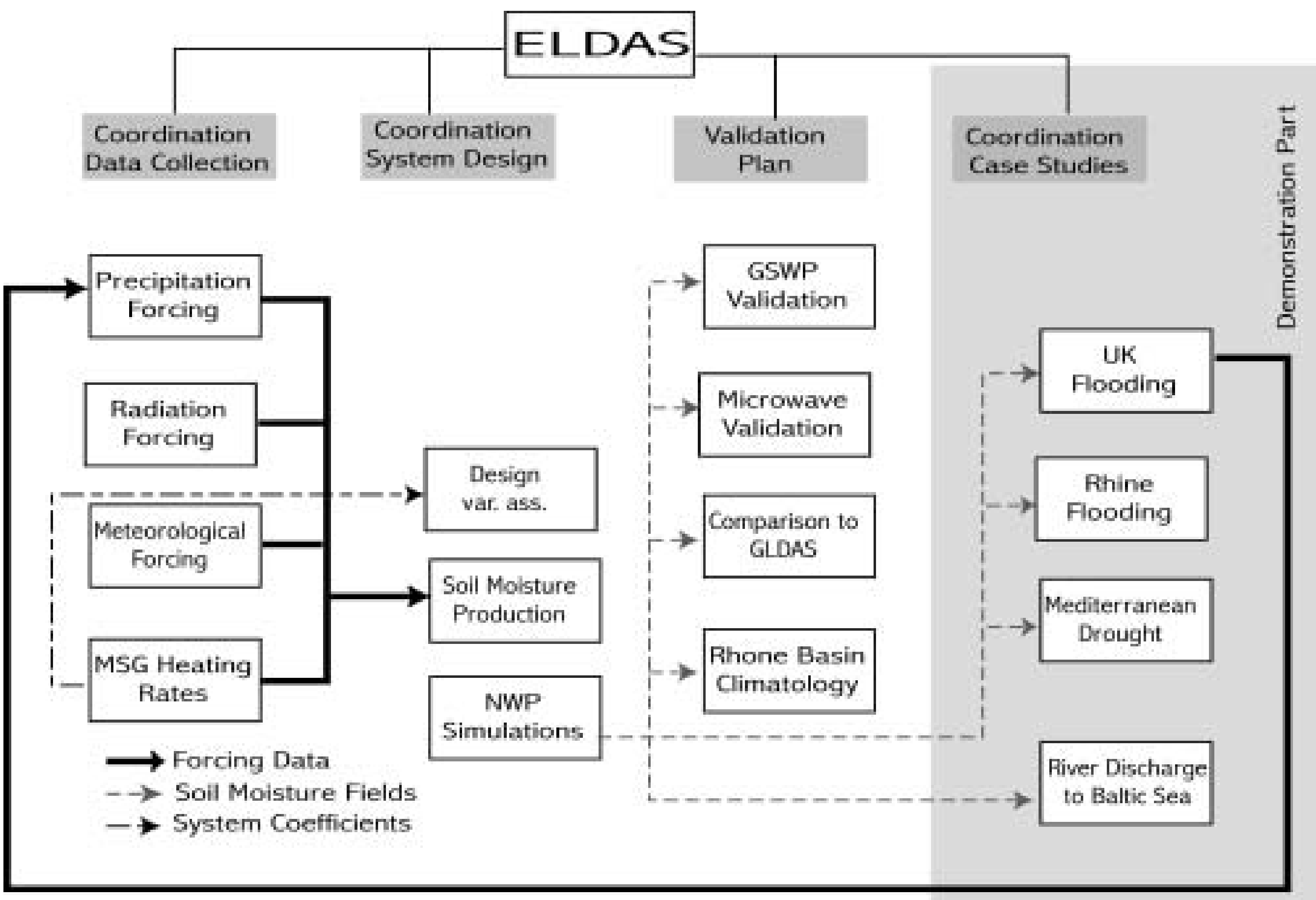
Bart van den Hurk
Netherlands Royal Meteorological Institute

A project called the Development of a European Land Data Assimilation System to predict Floods and Droughts (ELDAS) has been established after a successful kick-off meeting held on January 7–8, 2002. **ELDAS, which is sponsored by the European Commission, is designed to develop a general data assimilation infrastructure for estimating soil moisture fields on the regional (continental) scale, and to assess the added value of these fields for the prediction of the land surface hydrology in models used for numerical weather prediction (NWP) and climate studies.**

Briefly, ELDAS has the following goals:

- Combine current (European) expertise in soil moisture data assimilation, and design and implement a common flexible and practical data assimilation infrastructure at a number of European NWP centres.
- Validate the assimilated soil moisture fields using independent observation material.
- Assess the added value of soil moisture data assimilation for prediction of the seasonal hydrological cycle over land (associated with drought prediction) and for the risk of floodings.
- Build a demonstration database covering at least one seasonal cycle and the European continent.
- Anticipate the use of data expected from new satellite platforms, in particular, METEOSAT Second Generation (MSG) and the ESA Soil Moisture/Ocean Salinity Mission (SMOS).
- **Provide a European contribution to the Global Land Data Assimilation System (GLDAS), a US initiative for generating near-real-time information on land surface characteristics on a global scale.**

ELDAS consists of a number of work packages (see figure below), each dealing with a specific task in the project. Four clusters of work packages can be defined: For more information: http://www.knmi.nl/samenw/eldas.

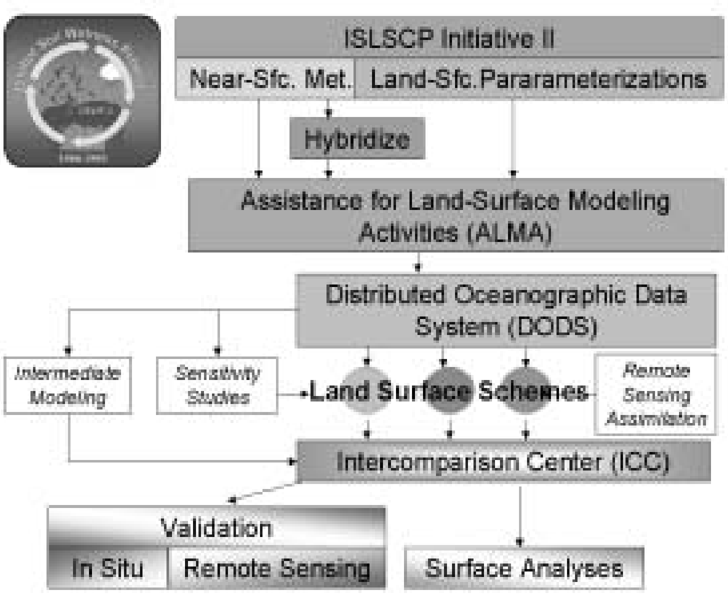


GLOBAL SOIL WETNESS PROJECT-2 BEGINS THIS YEAR

Paul Dirmeyer[1] and Taikan Oki[2]

[1]Center for Ocean-Land-Atmosphere Studies
[2] University of Tokyo

The Global Soil Wetness Project (GSWP) is an ongoing modeling activity of the International Satellite Land-Surface Climatology Project (ISLSCP) and the Global Land-Atmosphere System Study (GLASS), both contributing projects of GEWEX. **The GSWP is charged with producing large-scale data sets of soil moisture, temperature, runoff, and surface fluxes by integrating one-way uncoupled land surface schemes (LSS) using externally specified surface forcings and standardized soil and vegetation distributions. GSWP-2 is the follow-on project to GSWP-1, a 2-year pilot phase based on the ISLSCP Initiative I data set for 1987–1988.** The motivation for GSWP stems from the paradox that soil wetness is an important component of the global energy and water balance, but it is unknown over most of the globe. Soil wetness is the reservoir for the land surface hydrologic cycle, it is a boundary condition for the atmosphere, it controls the partitioning of land surface heat fluxes, affects the status of overlying vegetation, and modulates the thermal properties of the soil. Knowledge of the state of soil moisture is essential for climate predictability on seasonal-annual time scales. However, soil moisture is difficult to measure *in situ*, remote sensing techniques are only partially effective, and few long-term climatologies of any kind exist. The same problems exist for snow mass, soil heat content, and all of the vertical fluxes of water and heat between land and atmosphere.



Schematic of the implementation plan for GSWP-2.

GSWP-1 revealed that the quality of simulated land surface quantities, particularly, in the hydrologic cycle, is a strong function of the availability of *in situ* observations feeding into the analysis stream of meteorological forcing data. Where forcing and parameter data are of good quality, the participating LSSs performed well. LSSs were found to have some variation in the partitioning of precipitation between runoff and evaporation, but much larger differences were found among the soil moisture simulated by the LSSs. GSWP-1 results have also been used in a number of coupled land-atmosphere climate modeling studies, which have shown the impact of high-quality soil moisture data, and land surface variability on climate simulations. Participation in GSWP gave land surface modelers a global testbed for improving their LSSs, and many of the participants have used it for that purpose. A special issue of the *Journal of the Meteorological Society of Japan* (Vol. 77, No. 1B; 1999) was published containing the preliminary results of GSWP, and an overview article was also published. Subsequently, other papers have been published—a complete bibliography is maintained on the GSWP website, http://www.iges.org/gswp (see on-line bibliography for references in above text.)

The first phase of GSWP-2, a global 10-year multi-model simulation and comparison using the ISLSCP Initiative II data set (1986–1995), begins later this year with a kickoff meeting 30 September – 2 October 2002 in Calverton, Maryland.

In addition to providing a large-scale test-bed for comparison of LSSs, several sub-projects are proposed. Estimates of continental and global-scale surface energy and water budgets will be calculated, and inter-model uncertainties will be established. The ability of multiple LSSs to simulate large-scale interannual variations will be investigated.

GSWP-2 will serve as a global platform for the application of remote sensing to LSS calibration, validation and assimilation. Sensitivity of simulated fluxes and state variables to uncertainties in atmospheric forcings, and model parameters will be examined. The ability of simple and intermediate models to replicate the behavior of complex LSSs will be explored as a tool for better understanding of surface processes. *In situ* validation of LSSs with data from numerous field campaigns conducted during the 10-year period will also be possible. GSWP-2 will also explore promising new data management technologies, including the capability to perform model integration and analysis with distributed data sets, reducing the data management burden on participants. A subsequent continental phase will focus on North America, and will focus on issues of aggregation (from 1/8 degree to 1 degree).

WORKSHOP/MEETING SUMMARIES

GLASS WORKSHOP SETS NEW EXPERIMENTAL STRATEGY ON TESTING LAND–ATMOSPHERE INTERACTIONS

De Bilt, The Netherlands
19–20 April 2002

Bart van den Hurk[1], Paul Houser[2], and Jan Polcher[3]

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The goal of this Global Land–Atmosphere Systems Study (GLASS) workshop (co-sponsored by GEWEX/WCRP and KNMI) was **to identify an experimental strategy to address the importance of land–atmosphere interaction in surface model calibration and data assimilation**. The following questions were addressed at the workshop:

- Are the results of the offline surface model evaluations in the context of the Project for Intercomparison of Land Surface Parameterisation Schemes (PILPS) or the Global Soil Wetness Project (GSWP) affected by the lack of land surface-atmosphere feedback?
- Is the use of offline land surface models in Land Data Assimilation Systems (LDAS) making optimal use of the assimilated data?

The workshop was attended by 30 participants with backgrounds ranging from numerical weather prediction (NWP) to climate modelling, and from parameterization design to data assimilation. The first day was devoted to 13 scientific presentations, giving examples of land-atmosphere interaction in global climate modelling experiments and comparing calibration results of single-point experiments with either an offline land-surface model or one coupled to a model for the overlying atmosphere. Another set of presentations was devoted to sharing experience with land data assimilation systems operated in the US and in Europe. A third set of presentations addressed the technical interface between a (tiled) land model and a single column model (SCM) for the atmosphere. These highlighted that the degree to which land–atmosphere feedback affects the results of the model simulations varies widely between the existing modelling systems, and it is not at all clear whether this is a property of the land model, the boundary layer parameterization, or even more complex 3-dimensional interactions in the energy and water cycles simulated by the models. On the data assimilation aspect, the use of atmospheric screen level observations or surface temperature observations requires degrees of freedom by an atmospheric component in the model system. This makes the resulting control variables sensitive to the coupling between the land surface and the atmosphere in the model used for the data assimilation.

There is clearly a need for a new set of experiments designed to quantify the role of land–atmosphere feedback in land surface modelling and data assimilation. These experiments are supposed to take a next step in the complexity chain from offline land surface models to fully coupled GCMs. They should do so by focussing on the land–atmosphere coupling by means of turbulent exchange, but discarding the processes related to radiation and formation of precipitation. The main scientific questions that have to be addressed in these experiments are:

1. Under what conditions does land–atmosphere interaction play a significant role in the evolution of land-atmosphere fluxes and state variables? This question is related to both short-time scales (that determine the evolution of the atmospheric boundary layer, diurnal cycles of fluxes and profiles) and long climate time scales, where equilibrium partitioning of precipitation and energy at the land–atmosphere interface may be dependent on the coupling.
2. Does the absence of this coupling in PILPS-like calibration/evaluation experiments put a strong constraint on the general applicability of the results of these experiments? In other words, would calibration in a coupled model yield a different result owing to a reformulation of the sensitivities of the surface model to atmospheric forcings and vice versa?
3. Is the solution of a land data assimilation experiment using an offline land surface model configuration different from a system that includes land–atmosphere feedback? Or, similarly, does the degree of coupling between the land and the atmosphere change under influence of data assimilation? A number of clear situations can be identified in which the answer can be immediately provided. For instance, the assimilation of snow cover requires the atmospheric forcing of an offline

surface model to be compatible with the existence of a snow cover (air temperature below freezing level).

However, it is not clear how critical the land–atmosphere coupling is for other situations, and what is the optimal solution to account for these feedbacks.

In a series of discussion rounds taking place on the second workshop day, the contours of an experimental strategy addressing these questions have been formulated. As in PILPS, a number of experimental stages were defined, roughly following the three main questions posed above.

In *Phase 1*, the central aim will be to make an inventory of conditions (climate, land cover and heterogeneity, synoptic situation) where modelled fluxes and state variables are sensitive to the land-atmosphere coupling. For a number of locations and time periods, the behavior of land surface models in an offline and a coupled mode will be compared. The coupling will involve the use of a Simplified Atmosphere Model (SAM) that is able to calculate the vertical exchange processes due to turbulence, thermodynamics and radiation, but does not necessarily compute the precipitation and radiation forcing to the land surface. The land-surface behavior will mainly be explored by analyzing the sensitivity of modelled quantities to perturbations in the forcings (precipitation, radiation, atmospheric quantities) and surface conditions. Greater discrepancies between these responses to perturbations from an offline and a coupled land-surface model imply a greater role of land–atmosphere coupling. For experiments covering the seasonal or even interannual time scale, a consistent data set containing the relevant atmospheric and land surface forcings is nonexistent. Use could be made of atmospheric profiles or multi-level tendencies extracted from a simulation of a high resolution limited area model, nested in a time series of analyzed atmospheric fields. As such, the limited area model acts as a physical interpolator of the analysed fields. SAM and offline surface model calculations should both use radiation and precipitation time series simulated by this limited area model, as these variables are considered to be dominated by large-scale processes that cannot be represented adequately in this simplified local coupling. Locations for which these experiments are carried out should at least cover a wide range of climatic and land cover conditions, and preferably be collocated with local field experiment sites. The participating models should be able to be operated both in an offline and coupled mode. The atmospheric component of the SAM should be able to pick up lateral driving forces affecting the local vertical profiles, while the surface model receives precipitation and radiation forcings from an external database. A number of technical issues remain to be resolved. An important one is that the atmospheric profiles should be consistent with the precipitation and radiation that is provided. Relaxation to the profiles from the host model is probably ensuring optimal compatibility.

These experiments may be helpful in identifying the conditions under which land–atmosphere feedback may be significant in the given combination of the land surface scheme and the overlying boundary layer model, it will not be easy to attribute the nature of this coupling to either of the SAM components. As an example, it is well known that land–atmosphere coupling plays a major role in the development in stable boundary layers, but the degree to which either the surface temperature dependencies in the land model, the flux-profile relationships in the PBL-model or the turbulent or radiative coupling itself is responsible for the strength of the stratification remains yet unclear. For this, it should be possible to exchange land models and boundary layer schemes using a general coupling interface.

Phase 2 of our proposed experiment aims at identifying the nature of the land–atmosphere coupling by varying the combinations land model – boundary layer model in a systematic way. It will necessarily use a common land–atmosphere coupler (which is being established within the Assistance Land Surface Modelling Activities action of GLASS), and start with providing a single boundary layer model, to which a range of land surface models can be connected. If responses to perturbations in the forcings (as applied in Phase 1) behave differently for different land surface schemes, they should be considered to be (at least partially) responsible for the strength of the coupling for the conditions concerned. If all land schemes behave similarly, additional investigations in the boundary layer scheme sensitivities have to be promoted, for instance in the context of the GEWEX Atmospheric Layers Study (GABLS) initiative.

The relation between data assimilation and land–atmosphere feedback will be addressed in *Phase 3* of the proposed experiment plan. In this phase, a combination of an offline model and SAM should be allowed to assimilate additional data that are not present in the forcings already provided. If the forcings from the nested limited area model are used, these additional data could consist of surface state variables (soil moisture, snow), atmospheric quantities (screen level parameters, surface heating rates), surface fluxes or combinations of these obtained from collocated field experiments or remote sensing. There are four combinations of model coupling (offline or coupled) and data assimilation (do or do not assimilate additional data), and comparisons between subsets of these four experiments may reveal the significant properties of the system. For both experiments where data assimilation is applied, the comparison between the offline and coupled simulations may be used to detect whether the land–atmosphere coupling can result in a different optimal solution of the model's control variable(s). For a perfect model, the additional data should not lead to a correction of the control variables. The increments that are calculated, however, may be different for the offline and coupled simulations. When, for instance, the increments in the offline model configuration are greater than the coupled system, this may point at internal adjustment of the model state under influence of the overlying atmosphere, for instant by a negative feedback cycle between the land and the PBL. Alternatively, for both experiments with a coupled system, the data assimilation may actually alter the significance of the land–atmosphere coupling, for instance, by bringing the surface model into a more robust state in which propagation of perturbations becomes less significant.

The design of this coupling-experiment clearly addresses the two-way coupling between the land surface and the overlying Atmospheric Boundary Layer (ABL). It could actually serve as a first step for a GLASS-GABLS collaboration. However, many details have yet to be resolved before a "call for participation" can be distributed over the scientific community. A selection of suitable data sets (a first list has been compiled during the workshop) or limited area models has to be made, as well as a clear definition of the way perturbations are applied and model output is diagnosed. To be able to exchange the atmosphere and land models that are mutually coupled, the interface has to be finalised and a set of suitable models must be defined. And, last but not least, an experiment team should be formed that will take the initiative and coordinate the analysis. People that are interested in joining a coordination team are kindly invited to contact members of the GLASS and GABLS panels.

MISSISSIPPI RIVER CLIMATE AND HYDROLOGY CONFERENCE

New Orleans, Louisiana USA
13–17 May 2002

Rick Lawford and Jin Huang
NOAA Office of Global Programs

Approximately 175 meteorologists, hydrologists, water managers, science teachers, and representatives from local organizations attended the Mississippi River Climate and Hydrology Conference sponsored by the GEWEX Continental Scale International Project (GCIP). The purpose of this meeting was to review the research findings resulting from the past 6 years and to provide directions for future research under the follow-on, NOAA/ NASA GEWEX Americas Prediction Project (GAPP). GCIP has had many major scientific achievements since it was fully implemented in 1995, including: (1) closure of water and energy budgets in the Mississippi River Basin, (2) development of land surface and hydrological models, and (3) water resource management applications. The New Orleans meeting marked the successful completion of the GCIP science program.

More than 150 scientific oral and poster presentations were delivered in the science sessions. Topics covered included the fundamental aspects of climate and hydrology in the Mississippi River Basin in the areas of observations, modeling, process studies, and applications. Some highlights of the scientific presentations in the five major GCIP science sessions are briefly described in the following paragraphs.

Many aspects of water and energy budget studies were presented, including comparisons of water and energy processes using observations and data assimilation system outputs, observational studies of individual processes, modeling studies that describe and validate water and energy processes from mesoscale to the continental scale. A presentation was given on the Water and Energy Budget Synthesis (WEBS) during the period of 1996–99 for GCIP in which different model outputs were compared with observations. The results of this research have been summarized in the WEBS CD-ROM (see page 8).

Studies on warm season precipitation presentations included observational analyses, model simulations, and studies of processes that affect the warm season precipitation over North America included an overview of North American Monsoon Experiment (NAME), which has the goal of determining the sources and limits of predictability of warm season precipitation over North America.

There were presentations on predictability studies showing the effects of land-surface processes on the predictability of precipitation using both numerical models and statistical methods, and studies on prediction system with regional and global climate models. Other presentations addressed coupled land-atmosphere models and climate and water resource applications.

Six GAPP working group meetings were held to discuss the future of GAPP implementation priorities:

- Predictability and regional climate modelling
- Land memory and land-atmosphere interactions
- Remote sensing applications
- GAPP data management
- Warm season precipitation
- Hydrology and water resources

The research results presented at the meeting provided clear evidence of the success of GCIP and its contributions to NOAA's operational forecasting system. These results will be documented in a special issue of the Journal of Geophysical Research. The same principles that contributed to GCIP's success will be applied in the GAPP initiative. Although the dialogue will need to continue, the working group meetings helped to clarify the nature of the contributions that GAPP could make to the United States Global Water Cycle Program Climate Change Reseach Initiative.

GCSS–ARM WORKSHOP AND GCSS SCIENCE TEAM MEETING

Kananaskis Village, Alberta, Canada
20–24 May 2002

Steven K. Krueger
University of Utah

The GEWEX Cloud System Study (GCSS)–Atmospheric Radiation Measurement (ARM) Workshop on the Representation of Cloud Systems in Large-Scale Models was a follow-on to the GCSS Workshop on Cloud Processes and Cloud Feedbacks in Large-Scale Models that was held November 1998 at European Centre for Medium-Range Weather Forcasts, Reading, England, U.K. The GCSS Science Team Meeting was held on the last day of the Workshop.

Over 70 scientists from 9 countries attended the Workshop. This group included global modelers with an interest in cloud parameterization, mesoscale and microscale cloud modelers and observationalists, radiative transfer specialists, cloud microphysics/aerosol specialists, and remote sensing specialists. Representatives from many global modeling and numerical weather prediction (NWP) centers were present.

The goal of GCSS is to improve the parameterization of cloud systems in global climate models (GCM) and NWP models through improved physical understanding of cloud system processes. The primary goals of the Workshop were to facilitate communication between large-scale cloud modelers/observationalists and cloud-scale modelers/observationalists, as well as between the various GCSS working groups. In order to meet these goals, the meeting included plenary sessions for 13 invited and 64 contributed talks. In addition, there were four evening break-out sessions in which GCSS-specific issues and plans were addressed.

In addition to plenary sessions devoted to activities of each of the five GCSS Working Groups, there were sessions on the representations of clouds and radiation in GCMs, general observations of clouds and radiation, and on modeling cloud microphysics, chemistry, aerosols, and radiation. In comparison to the 1998 Workshop, the talks reflected a greater interaction of GCSS with the radiation, microphysics, aerosol, and cloud-remote sensing communities, in particular, with the U.S. Department of Energy ARM Program and the International Satellite Cloud Climatology Project (ISCCP). Also, a greater number of new parameterizations were described. Abstracts of the talks are available at http://www.met.utah.edu/skrueger/gcss-2002/abstracts.pdf.

The parameterizations described at the Workshop included a new shallow convection parameterization by C. Bretherton, J. McCaa, and H. Grenier; a fast Monte Carlo implementation of the Independent Column Approximation for radiative transfer by H. Barker and R. Pincus; several for cirrus cloud microphysical properties by G. McFarquhar et al. and by A. Heymsfield; and the super-parameterization approach of D. Randall and M. Khairoutdinov.

Many talks described observations of clouds, either by remote sensing or by *in situ* measurements. A notable development, as indicated by several talks, is the increased availability and use of remotely sensed cloud properties via ISCCP, ARM, the Tropical Rainfall Measuring Mission (TRMM) and others.

A few highlights of the working group activities and plans are noted below. For more information and links to the individual working group web sites, see http://www.gewex.org/gcss.html.

Working Group 1 (WG1), Boundary-Layer Cloud Systems (Chair: C. Bretherton), is currently completing a model intercomparison project (MIP) on the diurnal cycle of shallow cumulus over land and another on the diurnal cycle of marine stratocumulus. WG 1 is planning to join with the Rain In Cumulus over the Ocean (RICO) experiment in order to carry out a trade cumulus experiment. In coordination with the EUROpean Cloud Systems (EUROCS), WG 1 is undertaking a survey of how well large-scale models represent boundary layer clouds over the northeast Pacific in a cross section from California southwest to the Inter-Tropical Convergence Zone (ITCZ) (http://www.knmi.nl/samenw/eurocs).

WG 2, Cirrus Cloud Systems (outgoing Chair: D. Starr; incoming Chair: P. Brown) is completing two idealized MIPs, one for cirrus parcel models and another for cirrus CRMs. The next MIP will be based on cirrus from Hurricane Nora as observed at the ARM Southern Great Plains (SGP) site.

The next MIP for WG3, Extratropical layer cloud systems (Chair: G. Tselioudis), will be based on the March 2000 Intensive Observation Period (IOP) at the ARM SGP. In addition to remote-sensing measurements of clouds, there were many obtained from aircraft. WG 3 is also undertaking a survey of cloud properties in large-scale models for a climatological March using March 2000 surface boundary conditions.

WG 4, Precipitating Convective Cloud Systems (Chair: W. Grabowski), is continuing analyses of Case 3, a MIP based on the summer 1997 IOP at the ARM SGP site. The next MIP will be an idealized case based on the observed diurnal transition from shallow to deep convection over the Amazon.

WG 5, Polar Cloud Systems (Chair: J. Curry) current activities include the Arctic Regional Model Climate Model Intercomparison Project, and a Radiation Model, and Surface Layer Model Intercomparison Projects.

An Ad Hoc activity called the Data Integration for Model Evaluation (DIME) has the goal is to provide "test kits" for model evaluation based on the GCSS MIPs, including detailed results from the participating CRMs. DIME (chair: W. Rossow) has a website at http://gcss-dime.giss.nasa.gov.

The breakout session on "Making Connections Between Data and Climate Models" generated a lively discussion. It was generally agreed that implementation of improved parameterizations is a major bottleneck in GCM development.

Based on the talks presented at this workshop, I expect (1) rapid progress on the representation of subgrid scale cloud overlap and inhomogeniety due to the combination of CRMs, cloud radar observations, and faster methods of calculating radiative fluxes for arbitary cloud configurations; (2) steady progress in the understanding and representation of cloud microphysical, formation, and dissipation processes due to integrated use of CRMs, SCMs, GCMs, and cloud-scale observations, plus insights from recent and upcoming field experiments; and (3) that super-parameterizations (i.e., CRMs used as parameterizations) will be used in some GCMs to provide more physically realistic representations of cloud processes, to increase knowledge and understanding of interactions between cloud processes and large-scale processes (including cloud feebacks), and to help improve conventional parameterizations. It is an exciting time for cloud modeling!

GEWEX/WCRP MEETINGS CALENDAR

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

9–14 June 2002—WCRP WORKSHOP ON DETERMINATION OF SOLID PRECIPITATION IN COLD CLIMATE REGIONS, Fairbanks, Alaska, USA.

17–19 June 2002—BALTEX SCIENCE STEERING GROUP MEETING #13, Tallinn, Estonia.

7–10 July 2002—2ND LBA SCIENCE CONFERENCE, Manaus, Brazil.

9–12 July 2002—WESTERN PACIFIC GEOPHYSICS MEETING, Wellington, New Zealand.

15–19 July 2002—15TH AMS SYMPOSIUM ON BOUNDARY LAYERS AND TURBULENCE, Wageningen University, The Netherlands. **Special Meeting on GABLS Activities on 16 July 2002.**

22–25 July 2002—THIRD INTERNATIONAL CONFERENCE ON WATER RESOURCES AND ENVIRONMENT RESEARCH (ICWRER), Dresden, Germany.

28 July–1 August 2002—SECOND FEDERAL INTERAGENCY HYDROLOGIC MODELING CONFERENCE, Las Vegas, Nevada, USA.

31 July–2 August 2002—13TH SESSION OF THE WCRP/GEWEX RADIATION PANEL, ETH, Zurich, Switzerland.

2–6 September 2002—WMO/WWRP INTERNATIONAL CONFERENCE ON QUANTITATIVE PRECIPITATION FORECASTING, Reading, UK.

4–5 September 2002—MAGS MODELLING TRAINING COURSE, Toronto, Canada.

9–13 September 2002—8TH SESSION OF THE GEWEX HYDROMETEOROLOGY PANEL, IRI, Palisades, New York, USA.

30 September–2 October 2002—GSWP-2 KICKOFF WORKSHOP, COLA, Calverton, Maryland, USA.

1–3 October 2002—GOES USERS' CONFERENCE II, NIST, Boulder, Colorado, USA.

2–4 October 2002—GLASS PANEL MEETING, COLA, Calverton, Maryland, USA.

10–19 October 2002—34TH COSPAR SCIENTIFIC ASSEMBLY (Special Session on Properties of the Earth-Atmosphere-Ocean System as Inferred from the New Generation of Earth Science Satellites), Houston, Texas, USA.

6–10 November 2002—8TH ANNUAL MAGS MEETING AND SCIENCE COMMITTEE MEETING, Jasper, Canada.

12–15 November 2002—2ND INTERNATIONAL ATMOSPHERIC MODEL INTERCOMPARISON PROJECT (AMIP) CONFERENCE, Météo-France, Toulouse, France.

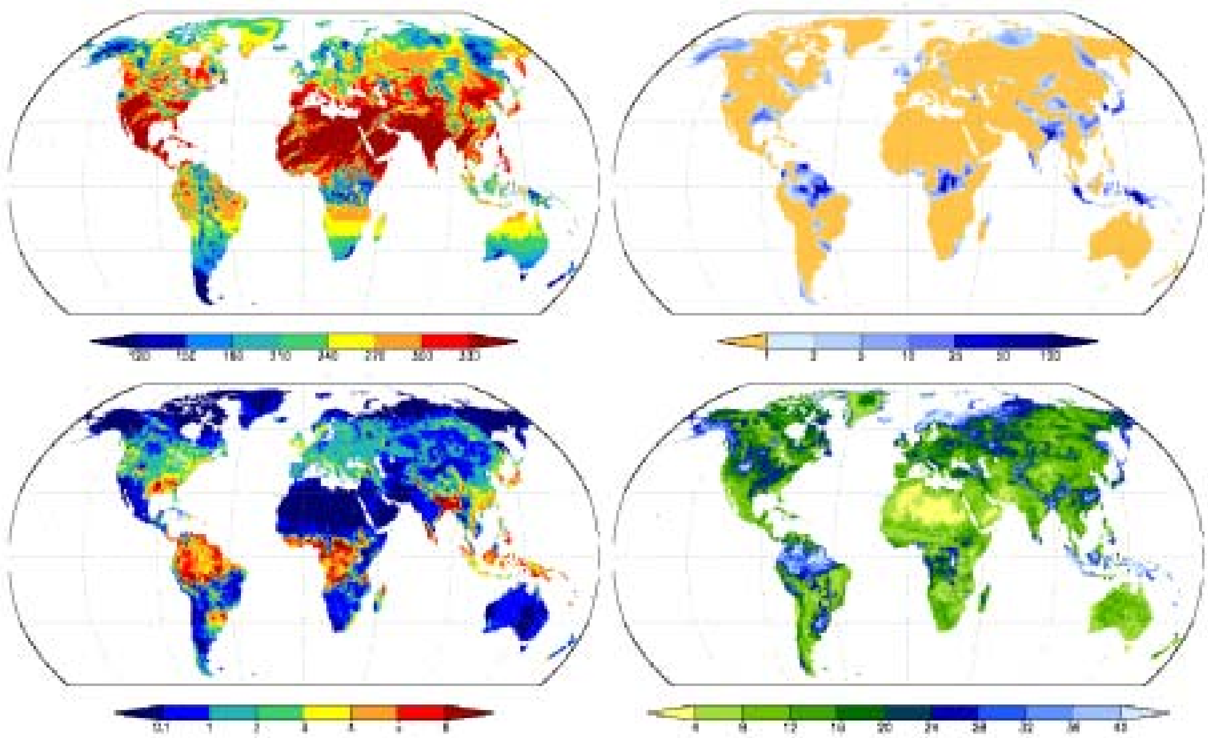
18–22 November 2002—WGNE/GMPP MEETING, Météo-France, Toulouse, France

6–10 December 2002—AGU FALL MEETING, San Francisco, California, USA. Special theme session on research in climate and hydrology in the Southern Hemisphere.

20–25 January 2003—15TH SESSION OF THE GEWEX SSG, Bangkok, Thailand. (tentative)

9–13 Feb 2003—83RD AMERICAN METEOROLOGICAL SOCIETY ANNUAL MEETING, Long Beach, California, USA.

GLDAS: AN IMPORTANT CONTRIBUTION TO CEOP
(See Article on Page 2)



GLDAS forcing and output, 30 April 2002. Mean observation-based downward shortwave radiation [W/m^2] (top left); total precipitation [mm] (top right); total evapotranspiration [mm] (bottom left); mean root zone soil water content [%] (bottom right).

GCSS ARM workshop participants at Kananaskis Village. See workshop report on page 14.

GEWEX NEWS

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