INTERNATIONAL GEOSPHERE-BIOSPHERE PROGRAMME (IGBP)
WORLD CLIMATE RESEARCH PROGRAMME (WCRP)

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BIOSPHERIC ASPECTS OF THE HYDROLOGICAL CYCLE

GLOBAL ENERGY AND WATER CYCLE EXPERIMENT

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GEWEX and BAHC Improve the Modelling of Water and Carbon Cycle Linkages

New coupled land-atmosphere models with improved land surface schemes, new global land data assimilation systems and GCM inclusion of long-term carbon cycle interactions are providing improved water-carbon cycle linkages.

See the articles in this issue

Bringing Life to the GCM Land Surface

GCMs begin to include carbon cycle feedback into long-term projections, but with widely varying land source and sink characteristics.

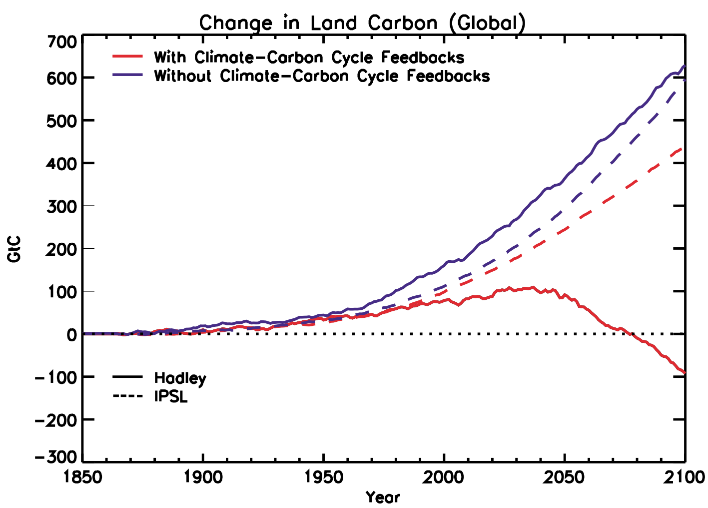

Figure 1. Changes in global land carbon (vegetation plus soils) as simulated by 2 coupled climate-carbon cycle GCMs. Positive represents an increase in land carbon storage. The Hadley Centre results are shown by the continuous lines and the IPSL results by the dashed lines. Blue lines represent runs without climate change, and the red lines are from the fully coupled runs including climate-carbon cycle feedback.

See article by Peter Cox, page 10

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Editorial

Pavel Kabat, Wageningen University and Research Center, The Netherlands, Chairman of the BAHC Scientific Steering Committee and GEWEX-ISLSCP SP; and Soroosh Sorooshian, University of Arizona, USA, Chairman of the GEWEX Scientific Steering Group

The Global Energy and Water Cycle Experiment (GEWEX) was initiated in 1988 by the World Climate Research Programme (WCRP) to observe and model the hydrologic cycle and energy fluxes in the atmosphere, and at the land and ocean surface. GEWEX is an integrated programme of research, observations, and science activities ultimately leading to the prediction of global and regional climate change.

Biospheric Aspects of the Hydrological Cycle (BAHC) was established as one of the core projects of the International Geosphere Biosphere Programme (IGBP) in 1992. BAHC mainly studies the role of the terrestrial biosphere in the hydrological cycle. BAHC combines and integrates expertise from several disciplines, including ecophysiology, biogeochemistry, hydrology and meteorology.

The Earth's climate and its hydrological cycle encompass both the abiotic and the living world, the terrestrial and marine biosphere. The physical climate system and biosphere interact via energy and momentum fluxes, as well as through the biogeochemical cycles. Hence, living vegetation, along with other characteristics of the land surface, plays a key role in modulating the Earth water cycle and climate.

GEWEX and BAHC early recognized the need for thematic synergies and collaboration between their respective programmes, in order to better understand the complex and interactive nature of the Earth climate and hydrological cycle. Both programmes have been successfully collaborating through a large number of joint research, observational and modelling activities. The objective of this joint issue of BAHC and GEWEX News is to report about the success of some of these activities.

The Coordinated Enhanced Observing Period (CEOP) (see page 3) and the FLUXNET project of integrating worldwide CO_2 flux measurements (page 15) are typical examples of experimental activities initiated by GEWEX and BAHC that are positioned at the frontier of the Earth system measurement and monitoring approaches. By putting focus on several main field sites of the continents (CEOP), on "transect studies" (FLUXNET) and on simultaneous use of satellite and ground observation, these experiments will provide data sets of unprecedented completeness and quality.

The Global Land-Atmosphere System Study (GLASS, see page 5), the Project for Intercomparison of Land Surface Parameterization Schemes (PILPS, page 6), the Global Soil Wetness Project (GSWP, page 8) and the article on page 10 are typical examples of successful programmes supported by GEWEX and BAHC in the area of modelling of land surface-atmosphere processes and interactions with climate. Through these projects, a new generation of land surface schemes for climate and hydrological models has emerged, incorporating more biogeochemical and ecological information. Both BAHC and GEWEX encourage these developments in Earth System studies and their applications to scientific queries of broad interest.

The International Satellite Land Surface Climatology Project (ISLSCP), a part of GEWEX, is perhaps one the best examples of an excellent collaboration between the two programmes. BAHC and ISLSCP have operated "back to back" since a Tucson workshop in 1994. ISLSCP is a leading programme in producing and consolidating global data sets for global change studies (see page 13). BAHC and ISLSCP jointly initiated and coordinated an array of land surface-atmosphere experiments, known as HAPEX and FIFE-type of experiments ("Hydrological and Atmospheric Pilot Experiment in the Sahel" and "First ISLSCP Field Experiment"). Both programmes took jointly the first steps to initiate the largest and most integrated experiment so far: the Large-scale Biosphere-Atmosphere Experiment in Amazonia (LBA).

Finally, both GEWEX and BAHC place much of their emphasis on water. Climate change is expected to lead to an intensification of the global hydrological cycle and can have major impacts on regional water resources, affecting both ground and surface water supplies for domestic and industrial uses, irrigation, hydropower generation, navigation, ecosystems and water-based recreation. Changes in the amount of precipitation and in its frequency and intensity directly affect the magnitude and timing of run-off and the intensity of floods and droughts; however, specific regional effects are still uncertain. This remaining uncertainty is one of the factors that has thus far hindered the effective application of GEWEX and BAHC research results to operational hydrology and water management strategies. Better links to applications in water resources is therefore one of the main priorities for phase II of GEWEX and BAHC in the near future.

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CEOP Implementation Beginning

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The Experiment

The Global Energy and Water Cycle Experiment's (GEWEX) Hydrometeorology Panel (GHP) is organizing a Coordinated Enhanced Observing Period (CEOP) to address critical aspects of land processes in the climate system. CEOP will focus on water and energy fluxes and reservoirs over land areas and monsoon systems. It will include observations from a number of reference sites around the world, subsets of extensive GEWEX continental-scale experiments, field and ongoing satellite-derived measurements of critical parameters as well as exploitation and evaluation studies for data from the new series of environmental satellite systems. These observations will be examined in concert with output from the global and regional models, ongoing data assimilation developments, and a substantial data management effort.

CEOP will run from July 2001 to September 2003. It was originally envisioned as a major step towards bringing together the research activities in the GHP and its continental-scale experiments with related projects within the World Climate Research Programme (WCRP), i. e. GEWEX, Climate Variability and Predictability Programme (CLIVAR), Climate and Cryosphere (CLIC). CEOP has evolved into a WCRP project in cooperation with the World Meteorological Organization (WMO), the Integrated Global Observing Strategy (IGOS) and the Committee on Earth Observation Satellites (CEOS). Some of the goals of these groups are related to more accurate determination of the water cycle in association with climate variability and change as well as baseline data on the impacts of this variability on water resources. CEOP will enable us to address such crucial issues through a "hands-on" focused examination of the water cycle over a particular time period.

Specifically, CEOP builds upon a number of opportunities and developments:

- A new generation of remote sensing satellites (including TERRA, AQUA, ENVISAT and ADEOS-II) - in addition to TRMM, Landsat-7, NOAA-K series and the other operational satellites - will be available. These satellites will provide an unprecedented enhancement of observing capabilities to infer critical atmospheric, surface, hydrological and oceanographic parameters (Fig. 1).
- A great deal of experience has been gained in the utilization of data from operational satellites; this experience provides a long - term perspective and allows the efficient exploitation of information from new satellites.
- Global modelling centres have made impressive gains in data assimilation techniques and are continually devising means for assimilating new data sets.
- Monsoonal system efforts under CLIVAR are now ready to interact with GHP to address land-ocean-atmosphere interactions.
- CLIC cold - region hydrologic efforts will work jointly with GHP to address higher-latitude land-based climate processes.

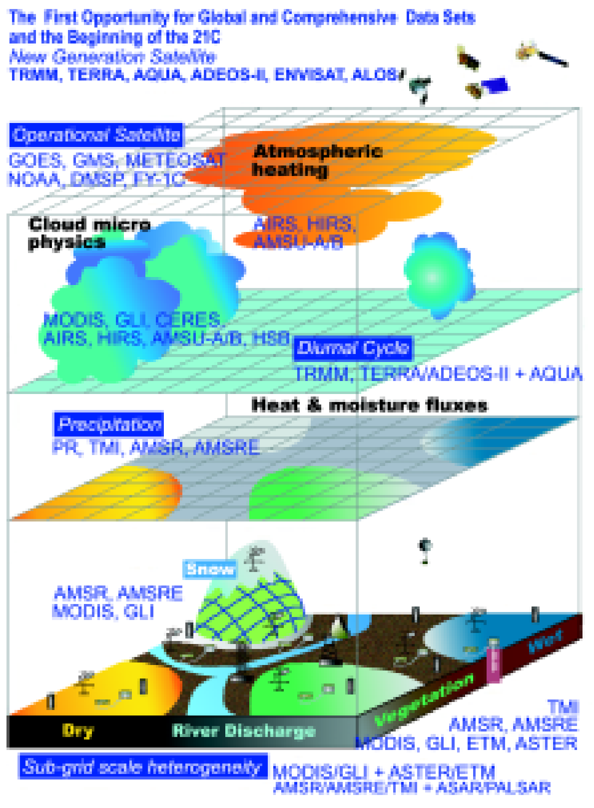

Figure 1. Schematic diagram indicating some of the satellites and their derived products that are available during CEOP.

Objectives

The objectives of CEOP are:

Water and Energy: To use enhanced observations to better document and simulate water and energy fluxes and reservoirs over land on diurnal to annual scales and to better predict these on temporal up to seasonal scales for water resource applications.

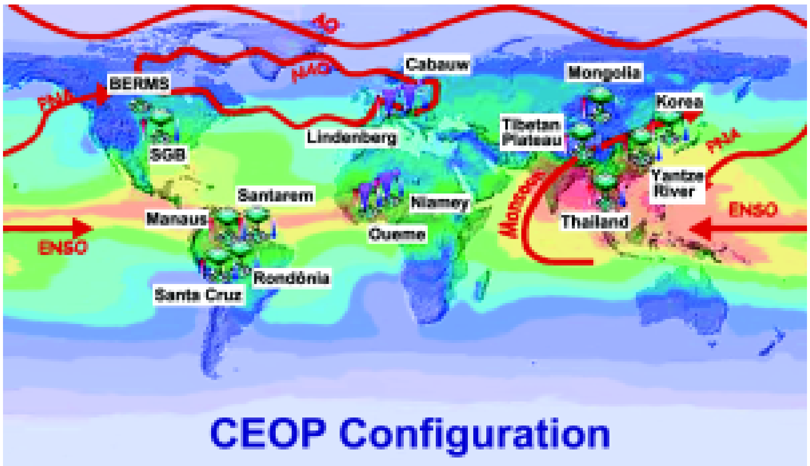

Figure 2. Schematic diagram indicating the ground-based reference sites participating in CEOP.

Monsoonal Systems: Document the seasonal march of the monsoonal systems, assess their physical driving mechanisms and investigate their possible physical connections.

These objectives will be addressed through a comprehensive modelling, observational and data management strategy. The modelling strategy will advance our capabilities to:

- balance water and energy budgets over land areas and, as appropriate, over associated ocean areas;
- transfer modelling techniques for water and energy fluxes and budgets between various land areas on temporal up to annual scales; and
- predict water and energy fluxes and budgets over land areas on temporal up to seasonal scales.

To accomplish these objectives, extensive use must be made of global and regional models, including data assimilation activities. These models and techniques need to be evaluated over diverse climatic regions in order to understand their limitations and to exploit their capabilities. CEOP with its wide base of observational information should achieve this requirement.

The objectives of the observational strategy are to:

- utilize information from the available suite of experimental and operational satellites;
- obtain critical-point measurement information at a number of reference sites (currently 15 as schematically shown in Fig. 2) within the continental-scale experiment regions of GEWEX as well as at other locations;
- carry out intensive observing experiments as appropriate in support of specific studies of critical water and energy cycle features; and
- encourage the extension of various GEWEX and other global data set projects to cover the CEOP period.

The data management strategy is based on the reality that the research community will need to have efficient access to the wide mix of data sets being obtained from many sources. The data management strategy will lead to both the production of specific new products as well as the utilization of existing data archiving centres. Specific data products and related outputs from CEOP will be:

- consistent reference site information from numerous locations around the world;
- specially-archived global and regional model information over reference sites as well as other locations;
- special field campaign information for satellite and model evaluation as well as comprehensive information on phenomena in different regions; and
- ready access to a wide range of satellite products.

CEOP represents a major step in carrying out GHP's long-range objective to work with other WCRP initiatives in order to better predict changes in water resources and soil moisture on time scales of seasonal to annual as an integral part of the climate system. By assuming the responsibility to directly tackle this major challenge, CEOP will facilitate numerous activities beyond the development of individual data sets, including:

- unification of huge and disparate data sets into manageable composite ones with common protocols for general scientific use and for research on the water and energy cycle;
- implementation of regional model transferability;
- evaluation, development and intercomparison of models and observations in the context of many climatic regimes (the essence of transferability) by providing a focused period of intensive observations as well as consistent forcing and validation data sets;
- provision for GEWEX continental-scale experiments to interact with global programmes outside of the WCRP (e.g. IGOS and CEOS); and
- provision for a consistent legacy data set that will be useful well into the future for global water and energy cycle studies.

Additional information on CEOP and the Implementation Plan are available at: http://www.msc.ec.gc.ca/GEWEX/GHP/ceop.html

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Building on PILPS and GSWP, GLASS Accelerates Integration of Remote Sensing and Carbon Cycle Elements into Land Surface Schemes

The Global Land-Atmosphere System Study (GLASS)

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A new generation of Land Surface Schemes (LSSs) is emerging. The schemes are evolving from General Circulation Model (GCM) parameterizations that just provide fluxes to the atmosphere, into independent models which are increasingly being compared to models of hydrology, biogeochemistry and ecology. This expanding scope is driven by the growth of interdisciplinary studies of the Earth system. GLASS aims to encourage these developments by coordinating the evaluation and intercomparison of this new generation of LSSs and to apply them to scientific questions of broad interest.

Workshops organized by the Global Energy and Water Cycle Experiment (GEWEX), the International Geosphere-Biosphere Programme (IGBP), the European Centre for Medium-range Weather Forecasts (ECMWF) and the French National Institute for Sciences of the Universe (*Institut National des Sciences de l'Univers* - INSU) during the last few years have pointed out a number of directions through which the next generation of LSSs will be developed. The first direction identified was the inclusion of biophysical processes. There is a need to include the carbon cycle to provide the atmospheric models with CO_2 fluxes and to simulate the evolution of the vegetation and thus the feedback between climatic variations and the biosphere. The second feature, which will set this new generation of LSSs apart, will be the importance given to the horizontal complexity of the surface. Previous LSSs were characterized by a very sophisticated description of the vertical processes while retaining simple as-sumptions on the horizontal variance of surface conditions. The final innovation, that will be includ-ed in the next generation, will be data assimilation methods for either the analysis of the state of the surface, or the evaluation of LSSs at the global scale. The remotely sensed variables, which will become available over the next few years, will demand from the LSSs new methods for taking advantage of the new information. With this increase in complexity, new feedbacks between the atmosphere and the surface will be simulated and a more systematic analysis of the sensitivity of the climate to surface processes will be possible.

As LSSs are applied from the plot scale to the regional scale and in a forced or coupled mode, the experiments proposed under GLASS will specifically address the issues of sub-grid scale variability of the surface and the feedback between surface processes and the atmosphere. The complementarities of the various applications of LSSs provide a richness of research and can be illustrated, for instance, with the case of simulated soil moisture. In the PILPS experiments (see page 6) the soil moisture simulated with the atmospheric forcing observed at a site could be compared to the measured values (Shao and Henderson-Sellers 1996). In the Global Soil Wetness Project (GSWP, see page 8) only the soil moisture anomalies at 1 by 1 degree could be evaluated as the models use different water-holding capacities that were all different from the one which can be deduced from observed values (Entin et al. 1999). When using a LSS coupled to an atmospheric column model, the relationship between the soil moisture and the atmospheric conditions can be explored at the local scale. This set-up was used to determine how the assimilation of near-surface temperature and humidity could help improve the simulated soil moisture by Douville et al. (2000). Finally, with coordinated GCM-sensitivity experiments the impact of the different approaches to soil moisture modelling on climate change could be evaluated (Crossley et al. 2000). Unfortunately, we are not presently able to say how the results obtained, e.g. in PILPS, can be related to the uncertainty in soil moisture changes found for a climate with increased greenhouse gas concentrations. Thus a coordination of projects is needed to take full advantage of the diversity of strategies currently underway in understanding and improving LSSs. The aim of GLASS is to foster evaluations of the next generation of LSSs and to coordinate the evaluation of LSSs in their different applications. GLASS will also serve as an interface between the land surface community and other GEWEX projects. The proposed structure of GLASS highlights the spatial scales at which the schemes are applied and the degree of interaction allowed with the atmosphere. This defines four actions that will coordinate intercomparisons within a particular LSS application. GLASS will also include one overarching action, the Assistance for Land Surface Modelling Activities (ALMA), which will provide an infrastructure and technical support for these intercomparisons (see Fig. 1).

Within the next few months a number of specific projects begin to fill out the structure laid out for GLASS. PILPS will be the first experiment to validate the new processes linked to the carbon cycle and its interaction with the water and energy cycles (see article below). The off-line local scale is ideally suited for this exercise as all the data needed is available. In preparation for GSWP-2, the Rhône Aggregation Experiment has been launched (see page 8). Over this basin, where high-resolution and high-quality atmospheric forcing are available, the dependence of simulated soil moisture on model resolution will be explored. GSWP will also set the stage for data assimilation (see box, page 8). It will encourage LSS-developers to think about their use of the wealth of information provided by satellites. On a longer term it is planned to propose an intercomparison on the coupling between the surface and the atmosphere over the Atmospheric Radiation Measurement Programme - Cloud and Radiation Test-bed (ARM-CART) site. This will help us understand the role of surface heterogeneity play on atmospheric processes. The acceleration of the development of LSSs will allow the community to embark on studies of the climate-carbon cycle feedback in the 21st century in the global surface-atmosphere coupled system (see page 10). This will constitute one of the major applications of this new generation of LSSs.

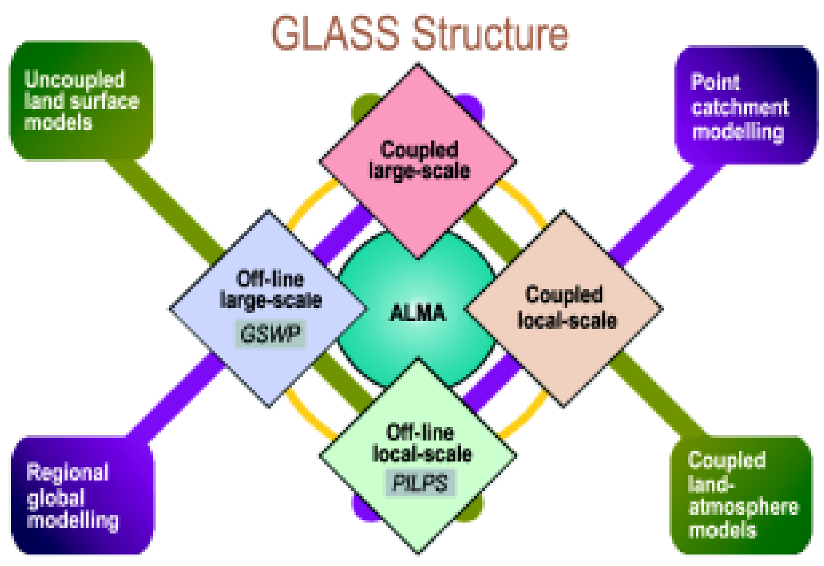

Figure 1. The proposed structure of GLASS.

References

Crossley J, Polcher J, Cox P, Gedney N and Planton S (2000) Uncertainties linked to land surface processes in climate change simulations. Climate Dyn, in press

Douville H, Viterbo P, Mahfouf J-F and Beljaars ACM (2000) Evaluation of the optimum interpolation and nudging techniques for soil moisture analysis using FIFE data. Mon Weather Rev 128, in press

Entin JK, Robock A, Vinnikov K Y, Zabelin V, Liu S, Namkhai A and Adyasuren T (1999) Evaluation of global soil wetness project soil moisture simulations. J Meteor Soc Japan 77:17-32

Shao Y and Henderson-Sellers A (1996) Modelling soil moisture: A project for intercomparison of land surface parameterization schemes phase 2(b). J Geophys Res 101(D3):7227-7250

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More information at http://hydro.iis.u-tokyo.ac.jp/GLASS/

PILPS Continues, Building on Success

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A useful step in any attempts to improve numerical models is to compare the formulations used by the models and the performance of the models in controlled conditions. To begin the process of comparing the land surface models used in GCM and Numerical Weather Prediction (NWP) models, the Working Group on Numerical Experimentation (WGNE) and the Science Panel of the GEWEX Continental-scale International Project (GCIP) launched PILPS in 1992. The main objective of PILPS is to enhance our understanding of the capabilities of land surface schemes in atmospheric models (Henderson-Sellers et al. 1995). In an attempt to realize this objective, phase 1 of PILPS was initiated where a series of land surface models were forced “off-line” with a single year of data generated from a GCM. Results from the final year of a multi-year equilibrium simulation were reported (Pitman et al. 1999). Within these highly controlled conditions, there were large differences in how the models partitioned available energy between sensible and latent heat. Annually averaged, simulations for the tropical forest ranged by 79 W m^{-2} for the sensible heat flux and 80 W m^{-2} for the latent heat flux. For the grassland, simulations ranged by 34 W m^{-2} for the sensible heat flux and 27 W m^{-2} for the latent heat flux. Similarly large differences were found for simulated run-off and soil moisture and at the monthly timescale.

To explore these differences further, phase 2 of PILPS was initiated where observed forcing was used. A series of locations have been used to investigate a range of land surface conditions. In phase 2a Chen et al. (1997) used data from Cabauw (The Netherlands); phase 2b used the data from the Hydrological Atmospheric Pilot Experiment-*Modélisation du Bilan Hydrique* (HAPEX-MOBILHY) (e.g. Shao and Henderson-Sellers 1996); phase 2c used the Red River-Arkansas Basin data from the USA (e.g. Wood et al. 1998), phase 2d used data from Valdai in the former Soviet Union (Schlosser et al. 2000); and finally, phase 2e used data from the Torne/Kalix River system in northern Scandinavia. Phase 2e of PILPS is currently ongoing, led by Dennis Lettenmaier, University of Washington, USA. Further details are available at http://www.hydro.washington.edu/Lettenmaier/CurrentResearch/PILPS-2e/in-dex.htm. Phases 2a through 2d all found large differences in the partitioning of energy and water despite attempts to control parameters between schemes. Both phases 2d and 2e have placed significant focus on snow processes and also found major differences in the way that these schemes represent these processes (Slater et al. 2001).

The latest initiative linked with GLASS and PILPS is dealing with the ability of LSSs to simulate the carbon cycle and will be labelled PILPS-C1. This is a new feature that is staring to be included in LSSs and the local off-line intercomparison method is the most suitable framework to evaluate and intercompare these developments. The first PILPS intercomparison on this topic will be performed over a well instrumented site in the Netherlands with a two- year data set. The carbon cycle has a longer time constant than the water cycle, bringing new challenges to the methodology used in PILPS and new methods will need to be developed. Recent simulations of climate change that include a representation of the full carbon cycle have shown the need to have a thorough validation of LSSs on this aspect (see page 10). It is thus very important to address quickly within PILPS the representation of the carbon cycle so that the global simulations using LSSs stand on a stronger foundation.

PILPS is also investigating the impact of the land surface coupled with atmospheric models (phase 3) as part of the Atmospheric Model Intercomparison Project (AMIP). Finally, in phase 4, several LSSs were coupled to the same atmospheric models. Two sub-phases were conducted using the Limited Area Prediction System (LAPS) developed by the Bureau of Meteorology Research Centre (BMRC), Melbourne (Zhang et al. 2001) and the Community Climate Model (CCM 3) developed at the U.S. National Center for Atmospheric Research (NCAR). Initial experiments to evaluate the coupling have been performed (Timbal and Henderson-Sellers 1998). This coupling has been performed physically as a first step since, via this process, we were able to learn about which components would be required in a generic coupling. Following a PILPS workshop in 1997, the first steps towards a generic coupling methodology were formally proposed (Polcher et al. 1998).

A series of new initiatives are planned linked to PILPS as part of the GLASS framework, which will try to concentrate more on the validation of surface schemes in tropical and arid regions.

References

Chen TH, Henderson-Sellers A, Milly PCD, Pitman AJ and 38 authors (1997) Cabauw experimental results from the Project for Intercomparison of Land Surface Parameterization Schemes. J Climate 10:1194-1215

Henderson-Sellers A, Pitman AJ, Love PK, Irannejad P and Chen T (1995) The project for intercomparison of land surface parameterizaton schemes (PILPS) Phases 2 and 3, Bull Amer Meteorol Soc 76:489-503

Pitman AJ, Henderson-Sellers A, Yang Z-L, Abramopoulos F and 22 authors (1999) Key results and implications from phase 1(c) of the project for intercomparison of land-surface parameterization schemes. Climate Dynamics 15: 673-684

Polcher J, McAvaney B, Viterbo P, Gaertner M-A, Hahmann A, Mahfouf J-F, Noilhan J, Phillips T, Pitman AJ, Schlosser CA, Schulz J-P, Timbal B, Verseghy D and Xue Y (1998) A proposal for a general interface between land surface schemes and general circulation models. Global and Planetary Change 19:261-276

Schlosser CA, Slater AG, Robock A, Pitman AJ and 30 authors (2000) Simulations of a boreal grassland hydrology at Valdai, Russia: PILPS phase 2(d), Monthly Weather Review 128:301-321

Shao Y and Henderson-Sellers A (1996) Validation of soil moisture simulation in land surface parameterisation schemes with HAPEX data. Special Issue of Global and Planetary Change 13(1-4):11-46

Slater AG, Schlosser CA, Desborough CE, Pitman AJ and 30 authors (2001) The representation of snow in land-surface schemes. Results from PILPS 2(d). J Hydrometeorology 2:7-25.

Timbal B and Henderson-Sellers A (1998) Intercomparisons of land-surface parameterisations coupled to a limited area forecast model. Global and Planetary Change 19(1-4):247-260

Wood EF, Lettenmaier DP, Liang X, Lohmann D and 23 authors (1998) The project for intercomparison of land surface parameterisation schemes (PILPS) phase 2(c) Red Arkansas River Basin experiment. 1. Experiment description and summary intercomparison. Global and Planetary Change 19(1-4):115-135

Zhang H, Henderson-Sellers A, Pitman AJ, McGregor JL, Desborough CE and Katzfey K (2001) Limited-area model sensitivity to the complexity of representation of the land-surface energy balance. J Climate 14:3965-3986

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GSWP Implements Phase 1.5 and Prepares for Phase 2.0

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The Global Soil Wetness Project (GSWP) is an ongoing modelling activity of the International Satellite Land-Surface Climatology Project (ISLSCP) and the Global Land-Atmosphere System Study (GLASS), both contributing projects of the Global Energy and Water Cycle Experiment (GEWEX). GSWP is charged with producing large-scale data sets of soil moisture, temperature, run-off, and surface fluxes by integrating one-way uncoupled LSSs using externally specified surface forcings and standardized soil and vegetation distributions.

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 wetness is essential for climate predictability on seasonal to annual time scales. However, soil wetness is difficult to measure in situ, remote sensing techniques are only partially effective, and few long-term data sets 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.

The goals of GSWP are to:

- produce state-of-the-art global data sets of soil moisture, surface fluxes and related hydrologic quantities;
- develop and test large-scale validation techniques over land;
- provide large-scale validation and quality check of the ISLSCP data sets; and
- compare LSSs, and conduct sensitivity studies of specific parameterizations which should aid future model development.

The Pilot Phase

For the pilot phase, the ISLSCP Initiative I data for 1987-1988 were used. Approximately one dozen participating LSS groups on four continents took the common ISLSCP forcing data to execute their state-of-the-art models to generate global data sets at 1°-resolution. An overview article describes results of the pilot phase (Dirmeyer et al. 1999) and a special issue of the

New Efforts to Exploit Remote Sensing and Land Surface Schemes

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The best hope for validation of land surface schemes at the global scale is in using remotely sensed data. To encourage the community to move in this direction, GSWP will pursue means to diagnose from LSSs variables which could be compared to remotely sensed data. Initial work in GSWP-1.5 will focus on thermal emission (skin temperature, infrared brightness temperature or surface long-wave flux). Eventually, application of other forms of remotely sensed information, such as microwave information in bands sensitive to surface or canopy moisture, will be pursued. Information on the state of vegetation, e.g. via the Normalized Difference Vegetation Index (NDVI), is already being incorporated as a parameter specification in LSSs and could also be assimilated into dynamic vegetation models where vegetation is a predicted quantity.

A major problem to large-scale validation by remote sensing is that the typical state variables of a LSS are so different from what is observed by satellite. As a consequence, the development of algorithms that will provide satellite-observable quantities, namely brightness temperatures, as prognostic variables in LSSs needs to be encouraged. In some sense, the retrieval algorithm should be built into the land model. Such algorithms to estimate satellite observable variables for use in LSSs will be developed in collaboration with the satellite research community as part of future efforts in GSWP.

Another major problem is the discontinuity between what is represented by a LSS grid box versus what is observed in a satellite pixel. Satellites perform “automatic” aggregation as a consequence of instrument resolution. Is a LSS which includes sub-grid surface heterogeneity really representing the same kind of varied surface that is viewed by the satellite? It is very difficult to define or measure physical temperature, e. g. over complex land surfaces which are a mix of vegetation and bare soil. A satellite is measur-ing an averaged irradiance over a footprint containing surfaces with different radiative properties, orienta-tions, and emissivities. Today's LSSs typically report a radiative flux based on an average temperature.

Overcoming such obstacles is a goal of GLASS and GSWP. In addition to aiding validation, such developments will advance us toward direct assimilation of remotely sensed data in LSSs. Thus, a wide range of LSSs may finally be “confronted” with remotely sensed observations.

Journal of the Meteorological Society of Japan, (Vol. 77, No. 1B) details the work. Results suggest that the GSWP framework is very useful and valuable for assessing and developing land surface models on a global scale with relatively little computational expense, and to investigate questions of land surface hydrology and land-atmosphere interaction. Requirements for observational networks were defined, sensitivities of LSSs were investigated, and the importance of inter-annual variations of the land surface on climate were verified in the modelling framework.

Current Plans

A new phase of the project will take advantage of the 10-year ISLSCP Initiative II data set (see page 13), the ALMA data standards developed in GLASS (see above, page 5), and the infrastructure developed in the pilot phase of GSWP. In preparation for GSWP-2, further studies will be undertaken over the ISLSCP I period. In this interim phase, called GSWP-1.5, several questions will be addressed that have arisen as a result of the original experiment:

- Can LSSs produce a run-off within observational range when driven by the range of "observed" precipitation data sets?
- Can remotely sensed variables be used to validate and inter-compare the various LSSs (see box)?
- What is the spatial and inter-model variability of potential evaporation and soil dry-down in LSSs?
- How far (in time) is the control integration operating from its field capacity or "wilting point"?
- Can we define the transfer functions to map soil moisture from one LSS to another?

Regional Aggregation Studies

The Rhône Aggregation (Rhône-AGG) project in GSWP is a multi-model regional study of the impact of spatial aggregation on estimates of surface fluxes. It makes use of the Rhône modelling system, developed by the French research community. The system combines an analysis system to determine the near-surface atmospheric forcing, a distributed hydrological model, and a LSS interface. It utilizes high resolution European soil and vegetation databases, but it has been designed such that it is transferable to other regions.

The Rhône Basin size is on the order of a few grid boxes of a global Climate Model, but the atmospheric forcing, the soil and vegetation parameters, and the observed river discharges are avail-able at a significantly higher spatial resolution, on the order of 8 km. It is of interest to examine how the simulations from a wide range of LSSs, which are used in GCMs, Numerical Weather Prediction (NWP) models, meso-scale atmospheric models or hydrological models, are impacted by changing the spatial resolution over the domain. The main goals of the Rhône-AGG are to examine how various LSSs simulate the river discharge over several annual cycles when inserted into the Rhône modelling system, and to explore the impact of the various aggregation methods on the simulation of components of the hydrological cycle (such as snow cover and surface run-off). A limited number of multi-year experiments have been developed in an attempt to adequately address these science questions. This experiment will be conducted during the course of the next several months.

GSWP-2

GSWP-2 will be a multi-model investigation into variability and predictability of the global surface water and energy cycles, expanding upon the pilot phase. In addition to the ten-year global phase, GSWP-2 will also include a continental-scale component based on the Land Data Assimilation System (LDAS) products to examine issues of aggregation and spatial scaling between satellite and numerical model grid-scale resolutions.

GSWP-2 represents an evolution in multi-model large-scale land-surface modelling with the following features:

- The ten-year length of the ISLSCP Initiative II allows for a better investigation of inter-annual land surface climate variability.
- The ISLSCP Initiative II data set will contain more than one rendition of many global fields, produced by different methods and scientists. This gives us a straightforward means to investigate LSS sensitivity to the choice of forcing data sets.
- Application and further development of the methods of calibration and validation of LSSs with satellite data (begun in GSWP 1.5).
- Broader investigation of aggregation at scales between global (GSWP-1) and river basin (Rhône-AGG) scales.

Future goals of GSWP include investigation of the carbon cycle and the water and energy cycles in LSSs as well as expansion in the areas of data assimilation and use of remote sensing. For details about GSWP including contacts for scientists interested in participation, a complete bibliography and links to related programmes, please visit the web site http://www.iges.org/gswp/.

Reference

Dirmeyer PA, Dolman AJ and Sato N (1999) The Global Soil Wetness Project: A pilot project for global land surface modeling and validation. Bull Amer Meteor Soc 80:851-878

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Bringing Life and Carbon to the GCM Land Surface Processes

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A major priority for the Global Land-Atmosphere System Study (GLASS) will be to accelerate the process of introducing biological realism into Global Circulation Model (GCM) land surface schemes (LSSs). Most LSSs now include quite detailed representations of short-timescale interactions between the land surface and the atmosphere. For example, many schemes incorporate coupled models of stomatal conductance and photosynthesis, which simulate how plants control water loss and CO_2 gain in response to environmental factors such as solar radiation, temperature, humidity deficit and soil moisture availability. Generally though, GCM land surface schemes do not yet include longer-timescale changes in vegetation structure, distribution or carbon content.

The first attempts to include the carbon cycle as an interactive element of climate models suggest that these longer-timescale interactions could produce significant feedback on climate change over the next century. Carbon budget studies show that only about a half of the current human emissions of CO_2 remain in the Earth's atmosphere. The remainder is being absorbed by the oceans and by vegetation and soil on the land, but in both cases the processes involved are known to be sensitive to climate. GCM climate change simulations typically use prescribed scenarios of increases in atmospheric CO_2, which are derived "off-line" neglecting the potential impacts of climate change on the carbon cycle. These simulations therefore exclude the effects of feedback between climate and the carbon cycle.

Two recent GCM experiments have instead treated atmospheric CO_2 as an internal variable, calculating its evolution based on emissions and modelling uptake by land and ocean as a function of the climate. Both experiments show accelerated climate change as a result of suppression of the land carbon sink, but the magnitude of the effect differs markedly. The Hadley Centre coupled climate-carbon cycle model produces about 250 ppmv higher CO_2 concentrations by 2100, compared to an experiment with the same GCM in which climate and carbon cycle are decoupled (see Fig. 1 on page 1) (Cox et al. 2000). As a result the climate warming predicted for the 21st century is much more rapid than previously modelled. This positive feedback is associated with the conversion of the global net land carbon sink to a source by the middle of the 21st century. A similar set of numerical experiments carried out at the Pierre Simon Laplace Institute (IPSL), France (Friedlingstein et al. 2001) shows a smaller increase of 75 ppmv in the atmospheric CO_2 projected for 2100.

The reasons for these different responses are under investigation, but are probably due to both different climate model sensitivities to CO_2 as well as different terrestrial model responses to climate. For example, the Hadley Centre model produces a large warming and drying in Amazonia under enhanced CO_2, and this leads to dieback of the tropical forest which releases carbon to the atmosphere. A smaller tropical drying is seen in the IPSL model which does not include a dynamic vegetation component. Both models produce reduced soil carbon (relative to experiments without climate-carbon cycle feedback) but this effect is dependent on uncertain factors such as the assumed sensitivity of soil respiration to temperature, and the fraction of the total soil carbon which can be readily decomposed by micro-organisms.

The experiments to date suggest that the response of the land biosphere to climate change represents a zeroth-order uncertainty in climate predictions. It is therefore vital that we identify the key uncertainties, and then work with our colleagues from ecological and climate disciplines to reduce these. The coupling of physical climate models with models of the biosphere is clearly a cross-disciplinary activity which requires expertise encompassed by both the Global Energy and Water Cycle Experiment (GEWEX) and the International Geosphere-Biosphere Programme (IGBP). The most fruitful way to bring life to the GCM land surface will be to make use of the findings gained in both communities, to produce models which consistently treat the cycling of energy, water, carbon and nutrients within the Earth system. For the land surface this will entail combining the short-timescale components included in GCM land surface schemes with the longer-timescale components modelled by Dynamic Global Vegetation Models (DGVMs).

A first stage will be to produce a better sample of possible climate-carbon cycle feedback by encouraging other groups to include interactive carbon cycles within their GCMs. The Coupled Climate Carbon Cycle Model Intercomparison Project (C4MIP) is an important component of the future IGBP-Global Analysis Integration and Modelling (GAIM) programme which will provide a vital link to the land surface modelling in GLASS and the coupled GCM modelling of the Working Group on Coupled Models (WGCM) of the World Climate Research Programme (WCRP). C4MIP will provide a framework for the inter-comparison of coupled climate-carbon cycle models and ultimately an assessment of the dominant sources of uncertainty (for further details see contact information below).

These are exciting times; the biosphere is finally taking its rightful place in our models of the greenhouse world by giving the carbon cycle the same level of attention as the hydrological cycle. GLASS is contributing to it by evaluating in parallel the processes in our models by the local off-line approach in PILPS-C1 and their global performance in the coupled GCM environment with the C4MIP project. This approach has proven successful in the past for improving the representation of the hydrological cycle in our models and will certainly also help to improve representation of the carbon cycle.

References

Cox PM, Betts RA, Jones CD, Spall SA, Totterdell IJ (2000) Acceleration of global warming due to carbon cycle feedbacks in a coupled climate model. Nature 408:184-197

Friedlingstein P, Bopp L, Ciais P, Dufrene J-L, Fairhead L, LeTreut H, Monfray P, Orr J (2001) Positive feedback of the carbon cycle on future climate change. Geophys Res Let, in press

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The Global Land Data Assimilation Scheme (GLDAS)

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Accurate initialization of land surface moisture and energy stores is critical in weather and climate prediction because of their regulation of surface water and energy fluxes between the surface and atmosphere over a variety of timescales. Since these are integrated states, errors in land surface forcing and parameterization accumulate in land stores, leading to incorrect surface water and energy partitioning. However, many new land surface observations are becoming available that may provide additional information necessary to constrain the initialization of land surface states critical for weather and climate prediction. These constraints can be imposed in two ways. Firstly, by forcing the land surface primarily by observations (such as precipitation and radiation), the often severe atmospheric numerical weather prediction land surface forcing biases can be avoided. Secondly, by employing land surface data assimilation techniques, observations of land surface storage (soil temperature, soil moisture, and snow depth/cover) can be used to constrain unrealistic simulated storage (see Fig. 1).

Therefore, a high-resolution, near-real-time Global Land Data Assimilation Scheme (GLDAS) that uses relevant remotely-sensed and in situ observations within a land data assimilation framework is being developed at the NASA Goddard Space Flight Center and NOAA's National Center for Environmental Prediction (NCEP). This development will greatly increase our skill in land surface, weather and climate prediction as well as provide high-quality global land surface assimilated data fields that are useful for subsequent research and applications. Analysis of the constant confrontation of model predictions with observations at various time and space scales provides an opportunity to improve our understanding and assessment of the space-time structure of land-atmosphere interaction, the relationship between model estimates and observations of land surface conditions, and the role of the land surface in regulating hydrologic and climatic variability.

GLDAS includes four components:

1. Land modelling: The GLDAS driver is being developed in a modular fashion to facilitate the inclusion of multiple land surface models (LSMs), including Mosaic, the Common Land Model (CLM), and the National Oceanic and Atmospheric Administration's NOAH Model. A run-off routing scheme will be implemented in the driver to permit run-off validation and the possible assimilation of lake / wetland /large river heights.
2. Land surface observation: NCEP operational global meteorological predictions will be the backbone of GLDAS forcing; however, to avoid known biases, these fields will be replaced (or corrected) by observations as available. Satellite remote sensing missions that will be used include Landsat TM, AVHRR, MODIS, ASTER, SSM/I, TRMM-TMI, AMSR, GRACE, and TOPEX/Poseidon.
3. Land surface data assimilation: Data assimilation techniques merge a range of diverse data fields with a model prediction, to provide the model with the best estimate of the state of the natural environment, so that it can then produce more accurate

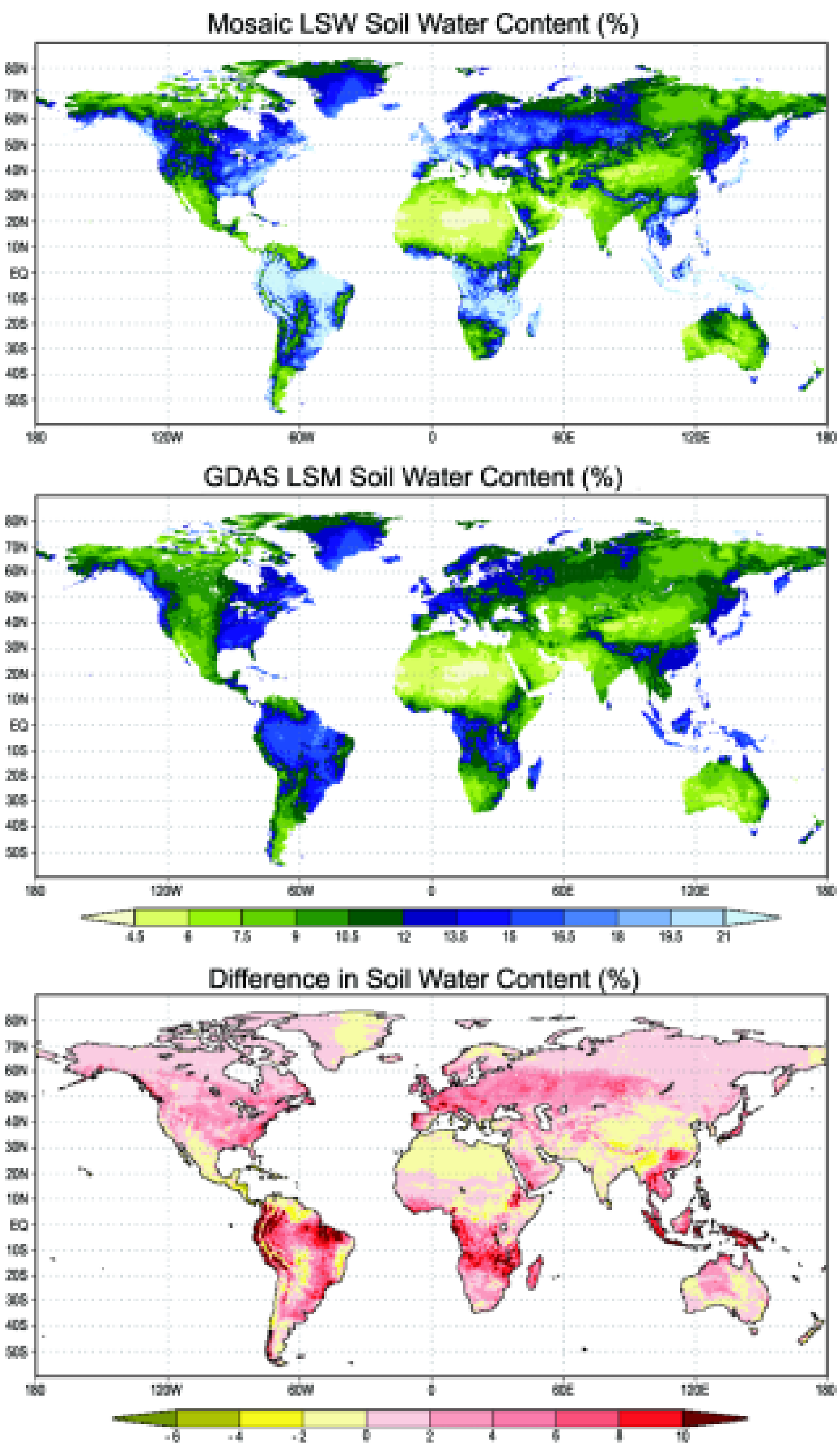

Figure 1. The panels compare volumetric water content (%) in the top meter of soil predicted by GLDAS, running Mosaic and forced with GDAS meteorology (top), to that predicted by the land model coupled to GDAS (middle), at 00Z on 31 March 2001. GLDAS was initialized with GDAS states, including soil moisture, on 1 March 2001. The predictions of soil moisture from the two systems display similar patterns, but the GLDAS field is more extreme, being wetter in locations such as Amazonia, south-central Africa, and western Europe, and dryer in regions such as south-central Asia and central America. The bottom panel shows the difference between the two predictions. The global average soil water content is 11.22% in the GLDAS field and 11.31% in the GDAS field, and so are very close, but clearly GLDAS allows for more variability.

predictions. A Kalman filter-based land assimilation strategy is being implemented for GLDAS.

4. Calibration and validation: Because a number of land model states will be assimilated from observational data sets, the structure of the initialization scheme ensures their accurate reproduction. However, output will also be compared to independently derived observations. Through the validation process, the quality of the land initialization will be evaluated and, if necessary, appropriate changes to the model structure, forcing, or parameters will be instituted to increase the reliability of the initialization.

Currently, GLDAS is able to run at 1/4-degree resolution globally using atmospheric forcing fields from either of two general circulation models (GCMs): NASA's GEOS 3.24 GCM and NOAA's GDAS GCM. Drivers for two LSMs (Mosaic and CLM) have been developed, and at least three others are planned. Subgrid spatial variability is simulated using a tiling approach based on the quantitative distribution of vegetation types within each 1/4-degree land surface pixel. Users can designate the maximum number of tiles within a pixel and/or the minimum vegetative coverage required to define a tile. Globally varying soil properties are also being implemented.

Several potential sources of observation-derived forcing fields, such as precipitation based on remotely sensed infrared and microwave emissions and solar radiation based on cloud cover and/or visible and infrared satellite imagery, have been identified. We will replace modelled input fields with these observations, as available, in the near future.

After the development phase is complete, several studies will be performed, including an assessment of the impact of GLDAS re-initialization on the predictive capabilities of coupled land-atmosphere models, a comparison of off-line versus coupled predictions, scaling and sensitivity investigations, and calibration/validation studies.GLDAS products will be made available in near-real time over the internet.

GLDAS is relevant to many international research programmes. The land surface data produced by GLDAS will be valuable to Global Energy and Water Cycle Experiment (GEWEX) projects, including the GEWEX Americas Prediction Project (GAPP), Climate Variability and Predictability (CLIVAR) projects such as the Global Ocean-Atmosphere-Land System (GOALS) as well as projects associated with the Coordinated Enhanced Observing Period (CEOP). GLDAS data will be used for regional climate analysis, model initialization, and comparison with results from field campaigns and modelling experiments.

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ISLSCP II: New 10+ Year Multi-Parameter Near-Surface Global Data Set - Including Greater Carbon and Vegetation Data - Nears Completion

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Introduction

Global change studies require regional and global, multi-year, interdisciplinary data collections. The International Satellite Land Surface Climatology Project (ISLSCP) of the Global Energy and Water Cycle Experiment (GEWEX) initially addressed some of these requirements through the publication of such a data collection, ISLSCP Initiative I (Sellers et al. 1996). This collection consisted of a 5-volume set of CD-ROMs containing high-priority global data sets gridded to a common 1-degree Earth grid and covering the years 1987 and 1988. This initial data collection proved very successful, with over 4 000 sets of CD-ROMs ordered, over 53 000 files downloaded through the Internet, and over 120 citations in referred journals. The collection supported a wide variety of users and applications, including weather forecast improvements, macroscale basin modelling, global carbon flux model intercomparisons as well as educational aids.

The International GEWEX Project Office (IGPO) recognized the importance and unique contributions of data collections such as ISLSCP I but also the need to expand this collection both in space and time (IGPO 1996). The requirements articulated by the IGPO specified that new data collections should span a period of at least 10 years to enable studies of interannual variability, and that the common spatial resolution of the data sets should be at least 0.5 degrees to accommodate recent advances in General Circulation Models (GCMs). Based upon the proven need for an expanded collection, we began the process of developing, acquiring, publishing and distributing such an interdisciplinary science-driven data collection, ISLSCP Initiative II.

Data Set Category	Number of Parameters
1. Carbon	15
2. Vegetation	29
3. Oceans	1
4. Hydrology, soils and topography	39
5. Radiation and clouds	45
6. Near-surface meteorology	95
Fixed	(11)
Monthly	(12)
Monthly 3-hourly	(44)
3-hourly	(28)
7. Snow and sea ice	4
8. Other	2
Total	230

Table 1. Number of parameters included in the ISLSCP II data collection organized by broad categories. Numbers in parentheses are those included in the near-surface meteorology category. Full data lists can be viewed at http://islscp2.gsfc.nasa.gov.

Methods

The global modelling community and algorithm developers were engaged to review the

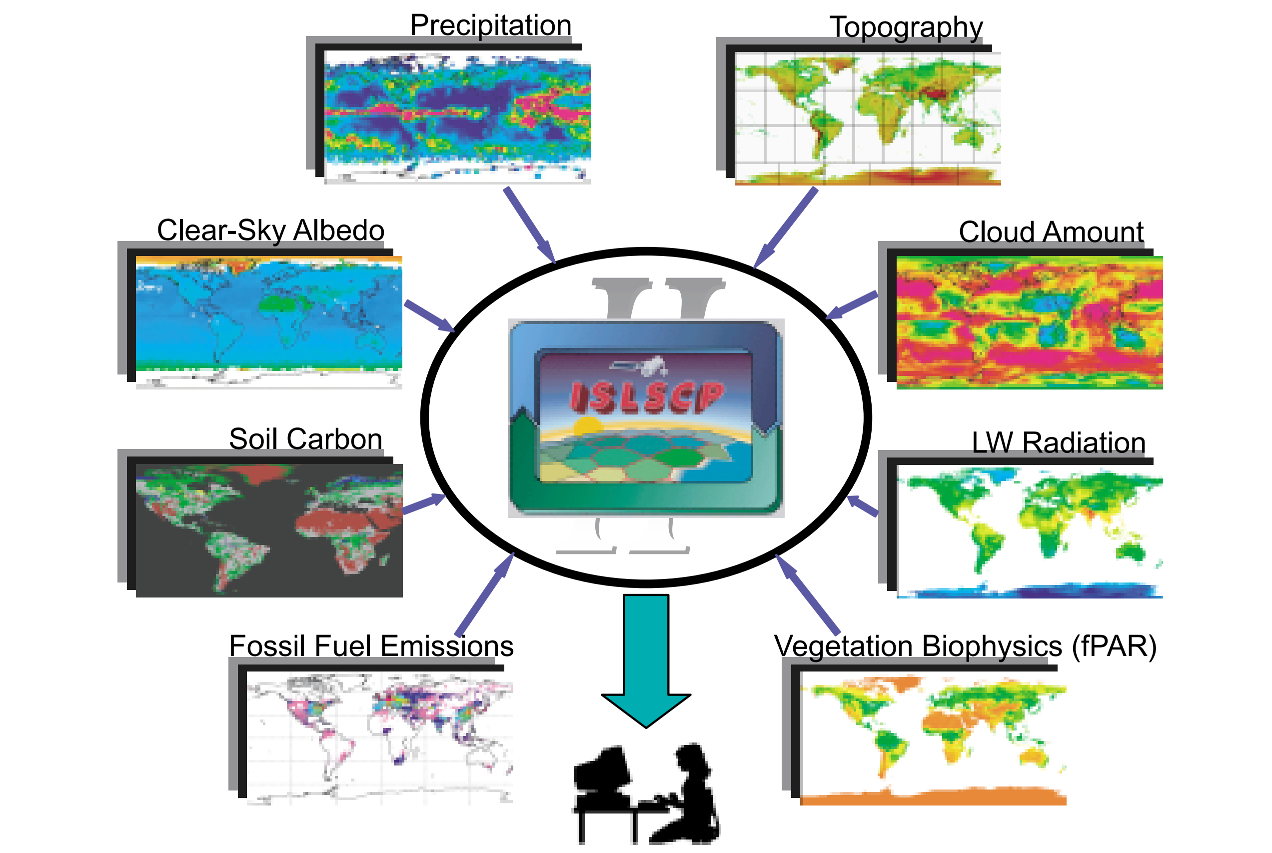

Figure 1. Integration of ISLSCP data sets.

current global data requirements for energy, water and carbon investigations, and the algorithms for producing the data sets. Over the past two years we have initiated and led a series of ISLSCP-sponsored workshops focusing on developing community consensus on ISLSCP Initiative II products, algorithms and spatial and temporal scales. Based on these recommendations, the ISLSCP II collection consists to date of 230 different parameters organized in several broad categories (Table 1). Figs. 1 and 2 show the ISLSCP data sets included in Initiative II.

Since the project inception, we have been acquiring many non-land surface data sets from the originating organizations, formatting, documenting and registering them to a common grid, and making them rapidly and easily accessible to the general science community via the web (http://islscp2.gsfc.nasa.gov). The primary purpose for doing so is to provide the ISLSCP user community access to data sets as quickly as possible and to obtain feedback from that community. The data and associated documentation will be subjected to a formal peer review and revised in response to the reviews. A final, validated, and revised version of the ISLSCP II data collection will be completed and distributed on CD-ROM or DVD at the end of the project in May 2002.

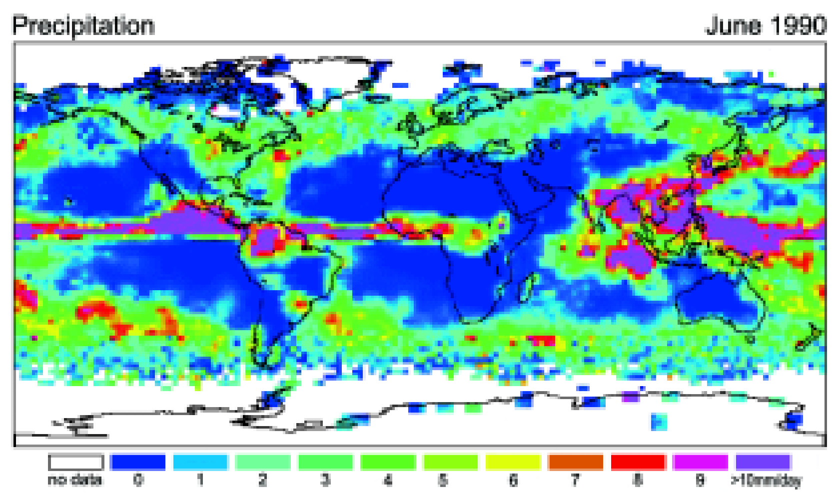

Figure 2. An example of a data set included in the ISLSCP II data collection for June 1990: Global precipitation from the Global Precipitation Climatology Project (GPCP).

We are also producing a 17-year satellite-derived vegetation data set that is based on data from the Advanced Very High Resolution Radiometer (AVHRR). The extension of this standardized land surface data set to 17 years will allow studies of interannual variability to be performed for much longer periods of record (e.g., Bounoua et al. 2000; Los et al. 2001) and will address many of the needs of the global modelling community. The data set contains monthly Normalized Difference Vegetation Index (NDVI), FASIR NDVI (FASIR is an acronym that refers to corrections for outliers, solar zenith angle effects, missing data and cloud-contaminated data) and a suite of derived vegetation biophysical parameters (Los et al. 2000). A pre-release data set is currently available through the ISLSCP II web site. The final land surface data set is currently being developed and will be released at 0.25, 0.5 and 1 degree resolution around October 2001.

Finally, we are developing the methodology to validate the ISLSCP II data sets from the joint perspectives of data quality, data utility and data usability. The evaluation will address content and quality of the data collection before it is published. We will employ a five-step peer review process that enables oversight by the ISLSCP community on issues of data set quality, data types and production procedures. A second phase will address post-publication quality and utility issues by assessing the usefulness of the data collection to the scientific community and the scope of the research and education activities that it enabled.

Summary

The ISLSCP II data collection is unique both in scope and breadth. It provides global modellers in a variety of disciplines with the tools with which to address important global change questions. Further, the interdisciplinary nature of the data sets can foster more global change research with cross-cutting themes. The collection is easily accessible via the web, offering a centralized distribution point. The need for data syntheses and collections such as ISLSCP II remains strong today and well into the future with the advent of new satellite platforms, new global data sets and improved algorithms. The current and continued success of such activities is possible principally because of the in-kind contributions of data sets by many institutions and organizations.

References

Bounoua L, Collatz GJ, Los SO, Sellers PJ, Dazlich DA, Tucker CJ and Randall DA (2000) Sensitivity of climate to changes in NDVI. Journal of Climate 13:2277-2292

International GEWEX Project Office, (1996) International Satellite Land-Surface Climatology Project (ISLSCP) Initiative II: Global data sets 1986-1995. IGPO Publication Series No 17, 68pp

Los SO, Collatz GJ, Bounoua L, Sellers PJ and Tucker CJ (2001) Global interannual variations in sea surface temperature and land surface vegetation, air temperature and precipitation. Journal of Climate 14:1535-1549

Los SO, Collatz GJ, Sellers PJ, Malmström CM, Pollack NH, DeFries RS, Bounoua L, Parris MT, Tucker CJ and Dazlich DA (2000) A global 9-year biophysical land-surface data set from NOAA AVHRR data. Journal of Hydrometeorology 1:183-199

Sellers, PJ, Meeson BW, Closs J, Collatz J, Corprew F. Dazlich D and Hall FG (1996) The ISLSCP Initiative I global data sets: Surface boundary conditions and atmospheric forcings for land-atmosphere studies. Bull Am Met Soc 77:1987-2005

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FLUXNET Advances Integrated Studies of Terrestrial Biosphere - Atmosphere Exchanges of Carbon Dioxide, Water and Energy

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Never before have scientists been able to study the biophysical functions of the world's major terrestrial ecosystems in parallel and with temporal scales ranging continuously from minutes to years. Through the auspices of the FLUXNET project, it is possible. FLUXNET is a global network of micrometeorological tower sites, which measure the exchanges of carbon dioxide, water vapour and energy between terrestrial ecosystems and the atmosphere. Its goals are to understand the mechanisms controlling the flows of CO_2, water and energy to and from the terrestrial biosphere across the spectrum of time and space scales and to provide ground information for validating estimates of net primary productivity, evaporation and energy absorption that are being generated by sensors mounted on the NASA-TERRA satellite.

FLUXNET emphasizes the importance of jointly studying the exchanges of CO_2, water and energy at multiple temporal and spatial scales because photosynthesis and transpiration are intimately related processes driven by solar energy. Reflecting this emphasis, FLUXNET conducts studies to examine magnitude and dynamics of annual ecosystem carbon and water balances, to quantify the response of CO_2 and water vapour flux densities to controlling biotic and abiotic factors, and to validate a hierarchy of soil-plant-atmosphere transfer models. The generated process and mechanism-based informa-

Fluxes	Meteorology	Vegetation	Soil	Landscape
CO_2 Water vapour Sensible heat Soil heat Global solar radiation Photosynthetically active radiation Net radiation Soil respiration rate	Air temperature Air pressure Vapour pressure deficit Relative humidity CO_2 concentration Wind speed Wind direction Friction velocity Precipitation	Vegetation type Leaf area index (LAI) Specific leaf area Leaf nitrogen content Leaf carbon content Leaf longevity Species composition Canopy height Stand age Stem density Basal area Diameter at Breast Height (DBH) Leaf water potential A-Ci curves	Soil type Soil temperature Soil water content Soil water-holding capacity Soil carbon content Soil nitrogen content Litter carbon content Litter nitrogen content	Site history Fetch size Species and density variation around the tower Slope Any anthropogenic carbon sources nearby

Table 1. Typical variables measured at FLUXNET tower sites.

tion can be essential for other more specialized international programmes such as Biospheric Aspects of the Hydrological Cycle (BAHC) and the Global Energy and Water Cycle Experiment (GEWEX). FLUXNET also collaborates with atmospheric inversion modellers to interpret terrestrial carbon fluxes inverted from atmospheric CO_2 concentrations.

The initiation of FLUXNET reflects an increasing understanding of the vital roles of terrestrial biosphere in global environmental changes. Studies have shown that terrestrial biosphere has critical impacts on climate and weather. Human activities such as fossil fuel burning and changes in land use and land cover have been introducing great uncertainties to the future climate. To get a clear picture of it, it is imperative to understand the terrestrial biosphere-atmosphere interactions, which are physically characterized by the exchanges of CO_2, water vapour and energy. To this end, constant monitoring of diverse terrestrial ecosystems, rapid sharing of quality-controlled data among the global science community and multidisciplinary synthesizing of scientific findings are extremely important. This is the guiding principle for FLUXNET.

FLUXNET builds upon the scientific initiatives of regional networks of tower flux sites in South and North America (AmeriFlux), Europe (CarboEurope), Asia (AsiaFlux), Australia and New Zealand (OzFlux) as well as independent sites in southern Africa. These sites measure, non-destructively, net carbon and water fluxes between vegetated canopies and the atmosphere using a micrometeorological technique known as the eddy covariance method. The measurements cover the spatial scale of tens of hectares at the time resolution of 30 minutes. To interpret the flux measurements, researchers also collect data on site vegetation, soil, hydrologic, and meteorological characteristics (Table 1). At present, over 140 sites are operating on a long-term and continuous basis. Many sites have produced over 4 years of data, and the Harvard Forest site has accumulated ten years of data. Vegetation under study includes temperate conifer and broad-leaved (deciduous and evergreen) forests, tropical and boreal forests, crops, grasslands, chaparral, wetlands and tundra. The latitudinal distribution of these sites ranges from 70 degrees north to 30 degrees south (Fig. 1). The broad coverage in climate conditions and vegetation functional types enables FLUXNET to collect information essential for spatial scaling.

FLUXNET activities are designed to facilitate the use of data collected at individual tower sites by the global science community and to generate value-added products from the “sum” of

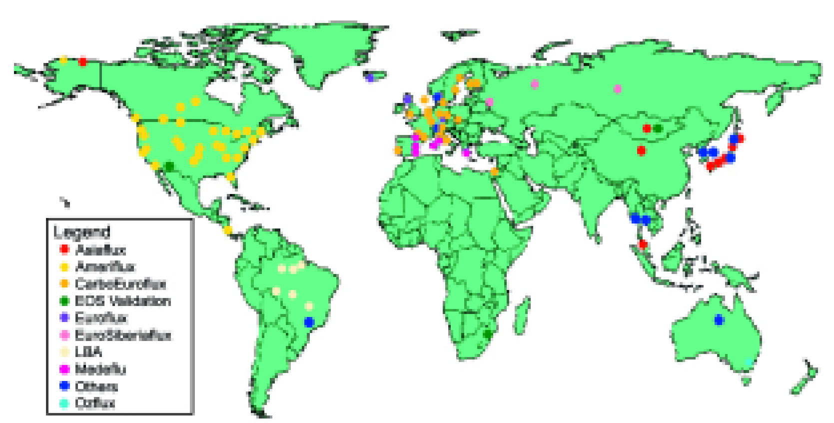

Figure 1. Global view of tower flux sites.

these sites. They fall in the following four aspects: First, FLUXNET provides infrastructure for compiling, archiving and distributing carbon, water and energy flux measurement, meteorological, plant and soil data. Standard algorithms are used to fill gaps of missing observations to provide continuous data that can be aggregated to daily, weekly, monthly, and annual flux estimates. Data and site information are available from the FLUXNET web site (see contact information below) Second, the project supports calibration and flux intercomparison activities. This activity ensures that data from the regional networks are intercomparable. Third, FLUXNET promotes the synthesis, discussion and communication of ideas and data by supporting project scientists, workshops and visiting scientists. And fourth, as NASA Earth Observing System (EOS) validation project, FLUXNET provides processed ground data and algorithm validation to aid the spatial extrapolation of remote sensing data to the region, continent and globe.

FLUXNET is also supporting continental-scale estimates of carbon balance. The tower FLUXNET consortium in Europe (CarboEuroflux) is fully integrated in a multi-scale exercise from ecosystem level process understanding to atmospheric inversion models to infer the European continent carbon balance. The measurements encompass soil carbon and biomass studies, continuous measurements of carbon, nitrogen, energy and water fluxes at forest stand scale as well as an aircraft monitoring programme of CO_2 and atmospheric tracers on regional and European scale. Joint efforts are taken to develop techniques for upscaling ecosystem models from stand and ecosystem level to landscape (bottom-up approach) and for downscaling results of inverse atmospheric modelling from the continental and regional level to ecosystems (top-down approach) in order to verify the various approaches and to constrain the CO_2 budget at the local, regional, national and continental level. Furthermore, atmospheric mesoscale models are coupled to terrestrial ecosystem models to bridge the existing gap at regional level.

By combining continental-scale regional networks, FLUXNET expands our ability to examine such distinct features as temperature adaptation of stand scale respiration and photosynthesis. For instance, heat transferred to Europe by the Gulf Stream allows temperate forest ecosystems to exist at much northerly latitudes than in North America. It also leads to distinctively different geographic patterns in carbon assimilation in the two regions: Europe consistently shows higher uptake than North America for a given latitude. Nevertheless, European ecosystems experience cooler growing seasons, on average. And their optimal temperature for photosynthesis occurs at lower temperatures than do those in North America, for similar functional types.

Other findings so far include: (1) Net CO_2 exchange of temperate broadleaved forests increases by about 5.7 g C m^{-2} day^{-1} for each additional day that the growing season is extended. (2) The sensitivity of net ecosystem CO_2 exchange to sunlight doubles if the sky is cloudy rather than clear. (3) The spectrum of CO_2 flux density exhibits peaks at time scales of days, weeks and year and a spectral gap at the month time scale. (4) The optimal temperature of net CO_2 exchange varies with mean summer temperature. (5) Stand age affects carbon dioxide and water vapor flux densities. (6) Water availability plays an important role in Mediterranean ecosystem carbon balance, not only in influencing photosynthesis but also in stimulating ecosystem respiration.

A special issue of AGRICULTURAL AND FOREST METEOROLOGY will soon report the scientific findings from the FLUXNET synthesis workshop, held in Marshall, California, 11-14 June 2000. The FLUXNET Project Office is now planning a special session in the American Geophysical Union (AGU) fall meeting in San Francisco, California. This special session is aimed to provide a common forum for ecologists, atmospheric scientists, micrometeorologists and climatologists to report advances in the studies of terrestrial biosphere - atmosphere exchanges of water, CO_2 and energy. In addition, a new FLUXNET investigators workshop is also under consideration for early next year to review scientific findings and to identify remaining challenging issues and future directions. For more details, readers are referred to the web site and the references given below.

References

Baldocchi DD, Falge E, Gu L, Olson RJ, et al (2001) FLUXNET: A new tool to study the temporal and spatial variability of ecosystem scale carbon dioxide, water vapor and energy flux densities. Bulletin of the American Meteorological Society 82, 11:2415–2434

Gu L, Baldocchi DD, Kiang N (2000) FLUXNET evaluates 'breathing' patterns of diverse ecosystems. EOS Transactions of American Geophysical Union 81(47):565, 570

Running SW, Baldocchi DD, Turner D, Gower ST, Bakwin P and Hibbard K (1999) A global terrestrial monitoring network, scaling tower fluxes with ecosystem modeling and EOS satellite data. Remote Sensing of the Environment 70:108-127

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FLUXNET at AGU

The Programme Committee of the American Geophysical Union (AGU) has approved a special session on FLUXNET at the Fall Meeting 2001 (10-14 Dec.) in San Francisco.

Title: Water, Energy and Carbon Cycles in Terrestrial Systems: Local Scale Observations through FLUXNET and Other Micrometeorological Tower Sites.

Abstract: Understanding the flows of CO_2, water and energy to and from the terrestrial ecosystems is the basis for revealing roles of terrestrial biosphere in global environmental change. This requires constant monitoring of diverse ecosystems, rapid sharing of quality-controlled data among the global science community and multidisciplinary synthesizing of scientific findings. This session welcomes reports from the following topics: Multi-year tower flux measurements; measurements from under-represented ecosystems (savannahs, tropical rainforests, wetlands, etc.) and regions (Asia, Africa, Eastern Europe and South America); cross-vegetation type and cross-climate type flux comparisons; partitioning of net ecosystem exchange (NEE) or net ecosystem productivity (NEP) using multiple methods such as stable isotopes, chamber, night time flux extrapolation, light response functions, etc.; impacts of clouds, fronts, extreme weather events, El Niño on flux exchanges; controls of site conditions, stand age, succession stages, canopy structures, species diversity on flux exchanges; Scaling-up of tower flux measurements; validation of SVAT models for multi-temporal and spatial scales; interpretation and validation of results from remote sensing such as MODIS-derived products and atmospheric inversion; development of a global network of flux towers.

Conveners: Lianhong Gu, University of California at Berkeley, Ecosystem Science Division, Department of Environmental Science, Policy and Management, 151 Hilgard Hall, Berkeley, CA 94720 USA, phone: +1-510-642-2421, fax: +1-510-643-5098, e-mail: lianhong@nature.berkeley.edu; Dennis Baldocchi, University of California, Berkeley, Ecosystem Science Division, Department of Environmental Science, Policy and Management, 151 Hilgard Hall, Berkeley, CA 94720 USA, phone: +1-510-642-2874, fax: +1-510-643-5098, e-mail: baldocchi@nature.berkeley.edu; Steven W. Running, University of Montana, School of Forestry, Missoula, Montana 59812 USA, phone: +1-406-243-6311, fax: +1-406-243-4510, email: swr@ntsg.umt.edu.

GABLS: A New GEWEX Activity on Atmospheric Boundary Layers

Bert Holtslag, Wageningen University, The Netherlands; and Dave Randall, Colorado State University, Fort Collins, USA

The Global Energy and Water Cycle Experiment (GEWEX) is initiating a new project focusing on the representation of the Atmospheric Boundary Layer (ABL) in regional and global models. The project referred to as GEWEX Atmospheric Boundary Layers Studies (GABLS), was approved by the GEWEX Science Steering Group at its last meeting in Barcelona, Spain.

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. As such, GABLES will provide a platform in which scientists working on boundary layers at different scales will interact. 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 ABL 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 modelling. The intention is to organize an international activity under the GEWEX Modelling and Prediction Panel (GMPP) aimed at stimulating and coordinating model-oriented research on ABL physics, and taking advantage of opportunities to interact with existing activities inside and outside of the GEWEX arena, such as the Climate Variability and Predictability Research Programme (CLIVAR) and the Working Group on Numerical Experimentation (WGNE). The new GMPP activity comes in addition to the GEWEX Cloud System Study (GCCS) and the Global Land-Atmosphere System Study (GLASS). A kick-off workshop for GABLS was held at the Climate Conference 2001 in Utrecht, The Netherlands. As an outcome of the workshop a Science and Implementation Plan for GABLS is foreseen.

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Water and Global Environmental Change: Towards a New Joint Project of IGBP, IHDP and WCRP

Holger Hoff, BAHC International Project Office, Potsdam, Germany

Increasing water scarcity and water quality degradation are phenomena affecting human livelihoods and environmental integrity in many regions of the world. Humans are suffering from, and are at the same time causing changes in the hydrological cycle and water resources at various scales. This human impact is manifested, e.g. by frequent water quality degradation and temporary drying out of some major rivers.

Recognizing that water-related problems require an integrated or Earth system perspective that combines biophysical and socio-economic understanding, the three global environmental change (GEC) research programmes, the International Geosphere - Biosphere Programme (IGBP), the International Human Dimensions Programme on Global Environmental Change (IHDP) and the World Climate Research Programme (WCRP), have taken the first steps towards a Joint Water Project. This concerted scientific effort is to assess the effects of global change on local and regional water resources and the feedback of changes in the hydrological cycle, water use, and water management for understanding the role of water systems as part of the Earth system. A new level of value-added knowledge could provide a scientific basis to a sustainability transition of water systems.

A Joint Water Project would collaborate with existing water-related activities, such as the GEWEX Hydrometeorological Panel (GHP), IGBP-BAHC assessment of river fluxes, IHDP activities on cities and water, and others. It would build upon water-related activities in the three programmes and place them in an integrated Earth system context. One possible focus of a new Joint Water Project identified at a scoping meeting of the three programmes (Amsterdam, 22-23 May 2001) is on water-related extreme events and the potential for adaptation of natural and managed hydrologic systems to them. Other integrative themes that were identified include:

- cities and water;
- irrigation;
- surface waters being modified by dams and reservoirs.

These and other suggestions, as well as a summary of the discussions at the Amsterdam meeting are currently under consideration by the various GEC programmes.

Given the critical nature of the topic, and a perceived need for the GEC programmes to take a more active role in policy discussions, a two-track implementation strategy is being considered: Consolidated scientific input from a fast track would be produced for the global water discussions, e.g. in time for the 3rd World Water Forum in 2003, while a longer-term activity would focus on new integrated scientific products, such as a Water Atlas.

The participants at the scoping meeting recognized the importance of involving a wide cross-section of the scientific and engineering communities and other groups that are working on water problems. The Open Science Conference "Challenges of a Changing Earth" in Amsterdam in July this year provided one opportunity for such broadly based involvement.

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GLOWA: An Example of Integrative, Interdisciplinary and Application-Oriented Global Change Research

Martin Rieland, Federal Ministry of Education and Research, Germany

Introduction

Research in the area of global change is done with the objective of revealing to politics, industry and society the causes of observed global pattern changes and the interactions involved, the extent to which natural variability of global environmental phenomena is influenced by humankind, the extent to which changes can be forecasted and the implications of these changes for social systems, in particular with regard to the aim of sustainable development. Global environmental changes, such as changes in the chemical composition of the atmosphere, the climate or the biosphere, show regionally varying patterns. They have to be related to very specific social sensitivity patterns in different regions and therefore also entail specific regional adaptation and reduction options. Therefore global environmental changes show highly complex, regionally varying and mainly long-term cause-effect structures which are linked to special demands on research methodology and tools as well as on early-warning and planning tools.

This situation was pointed out in Germany for the first time by the German Advisory Council on Global Change of the Federal Government in its 1996 annual report "World in Transition: The Research Challenge". The issue was discussed and thematically further focused by the National Committee on Global Change Research of the German Research Foundation and by the bodies of the Federal Ministry of Education and Research (BMBF). This process led to the establishment of the BMBF programme GLOWA (Global Change and the Hydrological Cycle) as a major approach in Germany towards the realization of integrative, interdisciplinary and application-oriented global change research.

The BMBF Programme GLOWA

The medium and long-term availability of water is not only called into question by a continuously growing world population and partly excessive use of water a a resource but is also increasingly influenced by global environmental changes. The aim of GLOWA is the development of strategies for sustainable and future-oriented water management on a regional level while taking into account global environmental changes and socio-economic framework conditions. The programmatic orientation of GLOWA focuses on case studies for large river catchment areas (i.e. some 100 000 km²), where simultaneous research is done in a collaborative research programme on interrelations between changes in the hydrological cycle and

- the large-scale climate and precipitation variability,
- changes in the biosphere (in particular caused by changes in land use) as well as
- the effects on water availability and related conflicts of use.

Water use in the Volta Region

First Experiences from the GLOWA Volta Project

Annette van Edig, Centre for Development Research, University of Bonn, Germany

The Volta Basin covers 398 000 km^2 of the sub-humid to semi-arid West African savannah zone. It is an international watershed shared by six riparian countries. 42% of the basin lies in Ghana, 43% in Burkina Faso, and the remaining 15% in Mali, Côte d'Ivoire, Togo, and Benin. The Volta has an average rainfall of 400 km^3/year and a run-off of 35 km^3/year.

Water use and land use choices in Ghana and Burkina Faso and their effects on transboundary river flows are already an issue between these two major stakeholders. The objective of the GLOWA Volta project is to develop a decision support system for the optimal management of the Volta Basin. A central question is whether water should be used for hydropower generation in the urbanized south or for irrigation development in the rural north.

Questions of global change research come into the scene when accounting for the fact that the Volta River flow is highly sensitive with respect to rainfall: relatively small changes in yearly rainfall cause large changes in river flow. Clearly, surface water resources in the basin are very vulnerable to droughts. Through our atmospheric model we simulate the impact of global climate change on water availability. The run-off/rainfall sensitivity also implies sensitivity with respect to the mechanisms that divide rainfall between evapotranspiration and run-off. Within the region, land use change is the major global change phenomenon, the modelling of which is a central activity within the project. Changes in land use and land cover may have a potentially large impact on water resources. This sensitivity of surface water run-off to rainfall has therefore important implications not only for agronomic planning, but also for energy supply, which is one major water use sector in Ghana. It is thus of crucial importance for policy-makers to have a clear estimation of water use in different sectors as well as predicted rainfall in order to plan future water allocation for these sectors.

The GLOWA Volta Project is divided into three different research clusters: atmosphere, land use and water use. Each cluster is subdivided into different subprojects, which answer concrete questions. Permanent communication, not only between the different subprojects but also between the clusters, ensures information exchange between disciplines and in this way contributes to the process of "interdisciplinary learning". Field work is organized in such a way that information gathered by different disciplines can at all times be correlated through consistent georeferencing and the use of a common sampling frame. Different subprojects work together and collect information on the following topics: water usage and its purposes, water management, water availability in the region, water quality, agricultural use, soil quality and precipitation. Socio-economic information is collected in the regions through a household survey. To compose a questionnaire that satisfied socio-economists, anthropologists, soil scientists and hydrologists was a rather complicated task. Researchers are currently in the field collecting the relevant information. Soil quality will be assessed by soil scientists, agro-economists will analyse land use change, hydrologists will measure water availability and anthropologists study water institutions and cultural factors of water use.

When all the relevant information is collected, a detailed picture on the existing and predicted water use in the regions will arise that will be interpolated over the Volta Basin. These facts and predictions will form the basis not only for the water allocation model but the combination of models which will also provide policy-makers with a decision support system. The latter will allow them to allocate the water optimally in economic as well as social and environmental sense and will thereby apply global change research to regional resource management.

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Figure 1. No water in the north of Ghana. *Photo by Annette van Edig, see box.*

The BMBF announced GLOWA on 10 December, 1998. The following 4 GLOWA projects were launched in 2000:

IMPETUS: (Integrated Approach to the Efficient Management of Scarce Water Resources in West Africa); case studies in the catchment areas of the rivers Drâa (Morocco) and Ouémé (Benin)

GLOWA - Volta: Sustainable management of water resources; intensive land use, precipitation variability and water need in the Volta Basin; case study in Ghana and Burkina Faso.

GLOWA - Elbe: Integrated analysis of the impact of global change on environment and society in the Elbe area

GLOWA - Danube: Integrative techniques, scenarios and strategies concerning global change of the hydrological cycle of the catchment area of the upper Danube

The final goal of these GLOWA projects is to develop simulation tools which can be used for preparing and supporting decision-making. A GLOWA project combines up to some 15, natural and socio-economic scientific disciplines to set up such a simulation tool. The methodology for the integration has not been prescribed. Each GLOWA project realizes its own integrated approach which depends on the specific circumstances (e.g. availability of data and models, depths of contribution / cooperation of stakeholders) in the area of investigation.

The BMBF supports these projects over an initial period of three years, which may be extended for up to eight years. The current support budget of the BMBF is some DM 13 million per year. Under these GLOWA projects, integrative competence centres in the area of global change research are being developed at some universities, relevant activities are coordinated and supported by the universities and the German Federal States concerned (20% of total costs).

Outlook

Global change issues should be adequately dealt with only if research, which is currently still mainly discipline-oriented, is extended to include an integrative, interdisciplinary point of view with a sufficient degree of abstraction. Such an approach must be oriented towards the overall system and focused on the complex interactions between natural and social systems. In the context of water and similar to GLOWA there are now new international programmes and initiatives on their way, such as the Joint Water Project by the International Geosphere - Biosphere Programme (IGBP), the World Climate Research Programme (WCRP) and the International Human Dimensions Programme on Global Environmental Change (IHDP), or the new Hydrology for the Environment, Life and Policy (HELP) programme within the oncoming 6th International Hydrological Programme of UNESCO, which aim to achieve this higher degree of cooperation, integration and interfaces between seemingly incompatible disciplinary research approaches.

Thus, Global change research is at the beginning of a learning process in which the plurality of methodological approaches in integrated and interdisciplinary research is decisive. It is obvious, that there is the need to have intensive exchanges of knowledge and experiences between these different initiatives. The learning process will take time. We need to go further step by step while concentrating on concrete questions and applications. The crucial and still open question for this approach is that of the applicability of the results. Global environmental changes alter the future living conditions of people. It must be demonstrated that Global Change research is able to give answers which will allow decision-makers to actively shape global change in a future-oriented and sustainable way.

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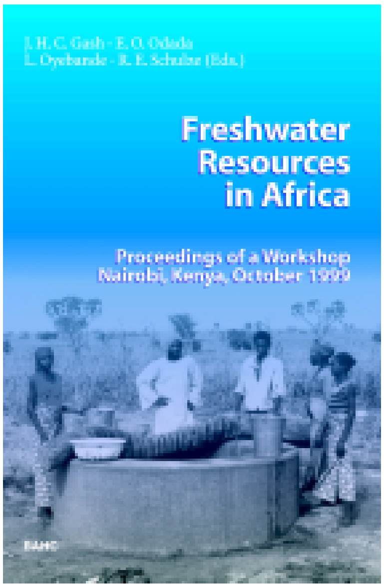
For additional information see
www.glowa.org

New Products



John H.C. Gash, Eric O. Odada, Lekan Oyebande, Roland E. Schulze (Eds.)

Freshwater Resources in Africa

Proceedings of a Workshop, Nairobi, Kenya, October 1999

BAHC International Project Office, Potsdam 2001, 146 pp. with 13 figures and 11 tables

The publication is also available in French.

Alfred Becker, Harald Bugmann (Eds.)

Global Change and Mountain Regions

The Mountain Research Initiative

IGBP Report 49, GTOS Report 28, IHDP Report 13

International Geosphere-Biosphere Programme, Stockholm 2001, 86pp.

Both publications can be obtained free of charge via the BAHC International Project Office (see page 24 for contact details) The IGBP / GTOS / IHDP Report can also be downloaded from the Internet. (http://www.igbp.kva.se//uploads/report_49.pdf)

Forthcoming in the IGBP Book Series *Global Change*

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The aim of the International Geosphere-Biosphere Programme book series is to present major results of IGBP research - at both the core project and the programme-wide level - in a single series. The volumes emphasize the key findings of the programme and each is based on an integration of a large body of work carried out around the world under the auspices of the programme. The IGBP synthesis project, involving most core projects, will produce at regular intervals a set of “state-of-the-science” volumes on the nature of the changing environment of the Earth and prospects for the future.

Meetings Calendar 2001/2002

The following events relate to issues of the IGBP and/or BAHC science agenda. Please notice that not all of them are open meetings.

2001

10th LBA SSC Meeting Palmas/Tocantins, Brazil, 28-30 November
Contact: Flávio Luizão, email: fluizao@inpa.gov.br

International Conference on Freshwater Bonn, Germany, 3-7 December
Contact: Secretariat of the International Conference on Freshwater, Tulpenfeld 7, 53113 Bonn, Germany; phone +49-(0)228-28046-55, fax +49-(0)228-28046-60, email info@water-2001.de
More information at http://www.water-2001.de/contact/
In conjunction: Launching event of the **Dialogue on Water and Climate**; contact: Holger Hoff, BAHC International Project Office, hhoff@pik-potsdam.de

Fall Meeting of the American Geophysical Union San Francisco, USA, 10-14 December
Special Session on **Water, Energy, and Carbon Cycles in Terrestrial Systems: Local-Scale Observations Through Fluxnet and Other Micrometeorological Tower Sites**
Contact: Lianhong Gu and Dennis Baldocchi, University of California at Berkeley, Ecosystem Science Division, Dept. of Environmental Science, Policy and Management, fax: +1-510-643-5098, email: lianhong@nature.berkeley.edu, baldocchi@nature.berkeley.edu; Steven W. Running, University of Montana, School of Forestry, Missoula, fax: +1-406-243-4510, email: swr@ntsg.umt.edu
More information at http://www.agu.org/meetings/fm01top.html

2002

Workshop on Managing Shared Aquifer Resources in Africa Tripoli, Libya 20-22 January
Contact: Alice Aureli, UNESCO International Hydrological Programme, Division of Water Science, 1 rue Miollis, F-75732 Paris Cedex 15, FRANCE; e-mail: a.aureli@unesco.org

14th Session of the GEWEX SSG Reading, United Kingdom, 28 Jan.-1 Feb.
Contact: International GEWEX Project Office, 1010 Wayne Ave., Suite 450, Silver Spring MD 20910, USA, phone: +1-301-5658-345, fax: +1-301-5658-279, e-mail: gewex@cais.com

ISLSCP Initiative II Review Workshop TBD, USA, February
Contact: International GEWEX Project Office, 1010 Wayne Ave., Suite 450, Silver Spring MD 20910, USA, phone: +1-301-5658-345, fax: +1-301-5658-279, e-mail: gewex@cais.com

16th GPCP-WGDM Meeting Tokyo, Japan, 13-17 May
Contact: International GEWEX Project Office, 1010 Wayne Ave., Suite 450, Silver Spring MD 20910, USA, phone: +1-301-5658-345, fax: +1-301-5658-279, e-mail: gewex@cais.com

GCSS-ARM Workshop on the Representation of Cloud Systems in Large-Scale Models
Kananaskis Village, Alberta, Canada, 20-24 May
Contact: International GEWEX Project Office, 1010 Wayne Ave., Suite 450, Silver Spring MD 20910, USA, phone: +1-301-5658-345, fax: +1-301-5658-279, e-mail: gewex@cais.com

2nd LBA Science Conference Manaus, Brazil, 7-10 July
Contact: LBA Central Office, CPTEC/INPE, Rod. Presidente Dutra km 40, 12630-000 Cachoeira Paulista SP, phone +55-(0)12-560-8529, email: yara@cptec.inpe.br

BIOGEOMON - 4th International Symposium on Ecosystem Behaviour Reading, UK, 17-21 August
Contact: University of Reading, Aquatic Environments Research Centre; email: h.prior@reading.ac.uk
More information at http://www.rdg.ac.uk/biogeomon/home.html

United Nations World Summit on Sustainable Development Johannesburg, South Africa, 2-11 September
More Information at http://www.johannesburgsummit.org/

Workshop on Vulnerability of Water Resources to Environmental Change
in conjunction with **BAHC Scientific Steering Committee Meeting and GEWEX/ISLSCP Science Panel Meeting**, Beijing, P.R. China, September Contact: BAHC International Project Office, Potsdam Institute for Climate Impact Research, P.O. Box 60 12 03, D-14412 Potsdam, Germany; phone: +49-331-288-2543, fax: +49-331-288-2547, e-mail: bahc@pik-potsdam.de

Joint meeting of the IGBP-BAHC Scientific Steering Committee and WCRP-GEWEX/ISLSCP Science Panel, during the Global Change Open Science Conference "Challenges of a Changing Earth", Amsterdam, 10-13 July 2001.

Erratum

On page 23 of the BAHC News No. 8, December 2000, in the article "Integrated Water Resources Management at River Basin Level: The Role of the Organization of the American States (OAS), please note that under the listed projects, the two projects *Environmental Protection of the Rio de la Plata and its Maritime Front: Pollution Prevention and Control and Habitat Restoration* and *Conservation of Biodiversity in the Titicaca Basin* are being **executed by UNDP**.

Bernhard Griesinger, OAS

Editorial Information

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