INTERNATIONAL COUNCIL FOR SCIENCE

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION

WORLD METEOROLOGICAL ORGANIZATION

WORLD CLIMATE RESEARCH PROGRAMME

REPORT OF THE SEVENTH SESSION OF THE

GEWEX HYDROMETEOROLOGY PANEL

(Paris, France, 6-7 September 2001)

JULY 2002

WCRP Informal Report No. 10/2002

TABLE OF CONTENTS

1. INTRODUCTION

A crucial aspect of the overall strategy for GHP has been to carry out a number of regional research activities as a first step towards global application. In this regard, five continental-scale experiments (GAPP, formerly GCIP (Mississippi River Basin), BALTEX (Baltic Sea region), MAGS (Canadian Mackenzie River Basin), LBA (Amazon region) and GAME (Asian monsoon region), as well as one affiliate experiment (CATCH) have been initiated. A strong proposal for a new CSE in the Murray-Darling Basin (Australia) was given at this meeting and will be presented to the GEWEX SSG at their next meeting in January 2002. Two efforts with strong ties to CLIVAR are also in the planning stages including the Rio de la Plata Basin Study and the North American Monsoon Experiment (NAME). This collectively brings together an international group of over 500 researchers to address water and energy fluxes and reservoirs over various land areas. In each regional experiment, efforts have been mounted to acquire the necessary observations to characterize water and energy fluxes and reservoirs and to simulate these with appropriate atmospheric, land surface and hydrological models.

Dr. S. Sorooshian, Chairman, GEWEX Scientific Steering Committee, noted that it is important for GHP to define and provide specific predictions using GEWEX studies that are useful to water management agencies. (e.g., future predictions might be as follows: the monsoon season will begin 2 weeks late; precipitation will be infrequent but intense, and will occur mainly at night). The Water Resources Applications Project (WRAP) Working Group has the charge to facilitate a dialogue with the water resource community to inform them of GEWEX technologies and to obtain guidance on how these technologies can be modified to be of greater societal relevance. A white paper is being prepared to identify case studies related to water resource application issues and will include a list of hydrological products useful to the water resource management community.

At the 2001 meeting, the SSG noted that for continuity on important issues that relate to the commitment by GHP to meet certain goals, associated with the Coordinated Enhanced Observing Period (CEOP), the Water and Energy Budget Studies (WEBS), and WRAP, as well as others, as contributions to WCRP/GEWEX global objectives, a GHP Chair should be appointed for a minimum of a 3-year term. Dr. Ron Stewart, who had been acting as GHP Senior Scientist, was appointed to undertake the first, non-rotating, GHP Chair position, for an initial 3-year term. The position of GHP Senior Scientist was dissolved. The SSG also appointed Dr. Toshio Koike as Lead Scientist and Director of Implementation of CEOP.

The goals for the Seventh Meeting of the GHP included taking specific action to advance progress on the GHP scientific focus, which relates to assisting GEWEX to demonstrate skill in predicting variabilities in water resources and soil moisture on time scales up to seasonal and annual as an element of WCRP's prediction goals for the climate system. A series of technical presentations was made on topics which covered research of relevance to the global hydrological issues being promoted by WCRP/GEWEX. A focused workshop on the status of WRAP was held the day before the GHP meeting, where the WRAP mandate and progress was reviewed and CSEs reported on water resource issues and scoping activity. Immediately following the GHP meeting, a CEOP meeting was held to report on progress and planning.

The transferability of regional models between regions and/or the validation of global models over continental-scale experimental regions and other regions was addressed. A list of models being used in different regions continues to be updated each year and made available through the GHP web site and plans for a transferability test over BALTEX are being developed. Under the Coordinated Enhanced Observing Period (CEOP), further tests of transferability and validation will be developed.

A review of contributions to GHP/GEWEX by various national and international projects and organizations including those within and outside the GEWEX framework was given by representatives of such activities as the International Hydrological Programme (IHP); the International Association of Hydrological Sciences (IAHS); the International Satellite Land-Surface Climatology Project (ISLSCP); the limited international regional study, designated CATCH in West Africa; the Murray-Darling Basin Water Balance project in Australia, the La Plata Basin study in South America, the North American Monsoon Experiment (NAME), the Global Precipitation Climatology Center (GPCC); and others. The work of the GHP Working Group on Data Management was also reviewed.

This report summarizes the meeting of GHP-7 and the main issues, actions (Appendix A) and recommendations taken under advisement by the Panel. The list of participants at the meeting can be found in Appendix B.

2. IHP

Dr. A. Szöllösi-Nagy, Secretary, International Hydrological Programme, and Director, Division of Water Sciences, UNESCO, talked about some of the IHP programs where GEWEX involvement would be welcome. Currently, 160 countries are involved in IHP, UNESCO's intergovernmental scientific cooperative programme in water resources, which is open to all scientists in the world dealing with water. IHP aims at the improvement of the scientific and technological basis for the development of methods for the rational management of water resources, including the protection of the environment.

Since IHP's inception in 1975, much progress has been achieved regarding methodologies for hydrological studies and training and education in the water sciences. Although the general objectives remain valid, greater emphasis is being put on the role of water resources management for sustainable development and the adaptation of the hydrological sciences to cope with the expected changing climate and environmental conditions. Another important objective is to integrate the developing countries into the worldwide ventures of research and training.

The principal modes of execution of IHP, which is a long-term programme executed in phases of 6-year duration, have been working groups, symposia, workshops, publications and extra-budgetary projects, the latter especially through the UNESCO Regional Offices where Regional Hydrologists are located. The present cycle, IHP-V (1996-2001), is devoted to the theme: Hydrology and Water Resources Development in a Vulnerable Environment

In the development of its various phases, IHP has gone through a transformation from a single discipline to a multi-disciplinary program. Recently, with the increased presence of the social sciences component, IHP has become a truly interdisciplinary programme, capitalizing on the recognition that the solution of the world water problems is not just a technical issue. The next phase of IHP, IHP-VI, covering the period 2002-2007, will be devoted to "Water Interactions : Systems at Risk and Social Challenges" and will have the following themes:

- Global Changes and Water Resources
- Integrated Watershed and Aquifer Dynamics
- Land Habitat Hydrology
- Water and Society
- Water Education and Training

One of the IHP's successes is a program called Flow Regimes from International Experimental and Network Data (FRIEND) which aims to develop a better understanding of hydrological variability and similarity across different regions through the mutual exchange of data, knowledge and techniques. Such knowledge is vital to improve practical water resource and flood design methods. FRIEND involves research institutes, universities and operational agencies from over 90 countries around the world and has developed an extensive hydrological database containing long-term series of gauged daily river flows, catchment boundaries and maps of climate, geology and soil type.

A new UNESCO program, the World Water Assessment Program (WWAP) is being organized to assess the state of the world's freshwater. More detailed information on WWAP and IHP programs can be found at http://www.unesco.org/water/ihp/index.shtml.

3. STATUS REVIEW

Dr R. Stewart, GHP Chair, continues to consider the qualitative status of GHP, which is reviewed by the CSE Points of Contact (POCs) and utilized as a means of gauging progress on the overall elements of GHP and the specific components that make up the GHP Global Applications and Transferability Strategy (GATS). This effort acknowledges that GHP is moving towards the realization of its goals through several overall efforts and a number of specific ones. Periodically, the status of each of these elements will be briefly assessed. The designations of status will be the descriptors **P**, **F**, **I** and **B**, **Pr** and **C.** These are applied to illuminate the status of the on-going work without any other assessment.

P = In Planning = Activity is underway with definite movement toward implementation
I = Implemented = Plans or projects are in the implementation phase, but may take several years to be fully functioning (e.g., due to funding restrictions or other complications)
F = Functioning = An activity has been implemented and is fully functioning. Schedules are set and delivery of products is assured.

The transition designation such as **I-F**, can mean that implemented studies are producing experimental results and later when this activity is deemed fully functioning the work would be in an operational mode.

B = Beginning = Plans have been implemented and preliminary data has been collected
Pr = Progressing = Data exists to accomplish the task and work is underway to organize it for analysis
C = Concluding = Data is organized into appropriate data bases and analyses are being finalized

A dual designation i.e. **B-Pr** indicates that most of the work required to collect the appropriate data has been accomplished and structuring of data bases has begun.

3.1 Consolidated Status Review

A consolidated overall assessment of the status of GHP in the context of the qualitative measurement scheme the participants recommended at the 1999 GHP session has been updated to reflect the status as of September 2001. The current consensus of the status of the key components of GHP is as follows:

- Water/Energy Budget Closure "Pr"
- Hydrological Modelling (full Coupling) "Pr"
- CEOP "Pr"
- Transferability "B"
- Predictability "B"
- Water-Resource Community Interactions "B-Pr"

3.2 CSE Contributions Matrix

The GHP CSE Matrix of Contributions to GEWEX has been set up to gauge CSE contributions to specific technical/logistical and scientific needs of GHP/GEWEX. The criteria that have been set are associated with work that is necessary for GHP/GEWEX to accomplish its global objectives including the successful accomplishment of CEOP especially that aspect associated with the transferability of results across regions of differing climatic regimes. The matrix is given in Figure 1. Action is on the CSE POCs to review and advise the GHP Chair of any updates to the matrix in the time leading up to the next GHP meeting.

4. STATUS SUMMARIES

4.1 BALTEX

OBJECTIVES/STRATEGY: The aim of the Baltic Sea Experiment (BALTEX) is to enhance the scientific understanding of the mechanisms responsible for energy and, in particular, water transports within the atmosphere, the land surface including rivers and lakes and the Baltic Sea with the objective of improving weather forecasts and climate models. BALTEX also is studying the effects of the Baltic Sea on the weather and climatological conditions in the region. The influence of these effects on the environmental and economical conditions in the Baltic Sea region are also being studied. The area around the Baltic Sea represents an ocean/continental transition zone with specialized meteorological, hydrological and oceanographic conditions. A further particular aspect of BALTEX is the development of better modelling support for flood forecasting and the design of integrated meteorological/hydrological forecasting systems for the area. The Baltic Sea also requires special analysis techniques related to issues associated with specific types of water pollution. The predicted climatic changes have a relatively large uncertainty in the Baltic Sea region due to the strong natural variability of weather and climate over Northern Europe. The main scientific objectives include the determination of the energy and water cycle in the Baltic Sea region by a combined

TECHNICAL/LOGISTICAL CRITERIA	GAPP	MAGS	LBA	GAME	BALTEX	CATCH
1.) NWP centre atmospheric and surface data assimilation and estimates of hydro-meteorological properties.	F	F	F	F	F	P
2.) Suitable atmospheric-hydrological models and numerical experimentation and climate change studies.	F	F	I-F	F	F	P
3.) Mechanism for collecting and managing adequate hydrometeorological data sets.	F	F	F	I-F	F	I
4.) Participate in the open international exchange of scientific information and data.	F	I-F	F	I-F	F	I
5.) Interactions with water resource agencies and related groups to address the assessment of impacts on regional water resources.	F	I-F	F	I-F	I-F	F
6.) Evaluation of GEWEX global data products.	I	I	I-F	I	I	N/A-Not applied
7.)Contributions to CEOP and transferability data bases.	I	P	P	P	P	P
SCIENTIFIC CRITERIA						
1.) Simulate the diurnal, seasonal, annual and interannual cycles.	Pr	Pr	Pr	Pr	Pr	Pr
2.) Close water and energy budgets.	C	Pr	Pr	B	Pr	N/A
3.) Determine and understand climate system variability and critical feedbacks.	Pr	Pr	C	Pr	Pr	Pr
4.) Demonstrate improvements in predictions of water-related climate parameters.	B	Pr	Pr	B	Pr	N/A
5.) Demonstrate the applicability of techniques and models to other regions.	Pr	B-Pr	Pr	B	B-Pr	Pr

P Planning	Activity is underway with definite movement toward implementation
I Implemented	Plans or projects are in the implementation phase, but may take several years to be fully functioning
F Functioning	An activity has been implemented and is fully functioning. Schedules are set and delivery of products is assured.
B Beginning	Plans have been implemented and preliminary data have been collected
Pr Progressing	Data exist to accomplish the task and work is underway to organize it for analysis
C Concluding	Databases have been organized and analyses are being finalized

FIGURE 1: STATUS OF CONTINENTAL-SCALE EXPERIMENTS (September 2001)

data and modelling exercise, and the development of an advanced coupled, high-resolution forecasting system for a better handling of the complex weather and climate processes. An additional objective is the provision of a physical/dynamical framework for future development of integrated environmental assessment and prediction systems. The experiment is timely in its efforts to take advantage of improved observational techniques, data assimilation and forecasting methods utilizing integrated atmospheric, oceanographic and hydrological phenomena. Scientific results of the BALTEX research program strongly suggest that the exploitation of these developments will be highly important for the prediction of extreme weather, river flooding, and severe ice, as well as other related conditions. The Main BALTEX Experiment (*BRIDGE*) is a central element in the BALTEX program. It has been established as the central observational and modelling phase of the program. BRIDGE began as a 6-month pilot study in April 1999 and was carried forward as a specialized observational activity through February 2002 and may be extended to September 2003 for CEOP.

BRIDGE is the main modelling and observational period in BALTEX. BRIDGE consists of ongoing activities like continuous observations at different sites and five Enhanced Observation Periods (EOPs) with special process studies and field activities. The time-line for *BRIDGE* is given in Figure 2. The Coordinated Enhanced Observation period (CEOP), has been included in the BRIDGE timeline to show the potential BALTEX contributions to this effort.

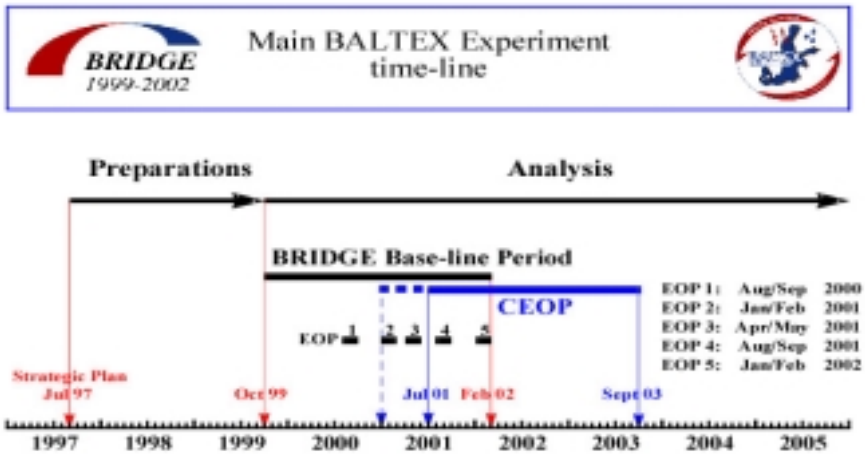

FIGURE 2: TIMELINE FOR THE MAIN BALTEX EXPERIMENT (BRIDGE)

STATUS: BALTEX studies have shown that precipitation in Sweden increased 20 percent in the 20th Century. This corresponds with models of increases in greenhouse gases. Phase I of BALTEX (1993-2002) brought an improved understanding of the energy and water cycle in the Baltic Sea Basin. Phase II will build upon the results of Phase I and enlarge the network of observations. New satellite observations for pre-operational applications will be integrated. Transferability studies will use coupled BALTEX models in several CSEs. A key element of BALTEX Phase II, (2003 -), is a new thematic network proposal to the European Commission called BALTNET, the Baltic Research Area: Global Change, Natural Variability and Anthropogenic influences in the Baltic Sea Catchment, which would add studies of pollution and carbon nutrients studies to the BALTEX objectives. BALTNET foci will include:

- Evaluation of regional climate variability for 1800 to 2100
- Transport of nutrients, pollutants and tracers in tested coupled BALTEX models
- Impact of environmental policies in the Baltic Sea Basin (SO_2, lead, mercury) using observations and models.
- Stable isotopes in precipitation, river water, clouds, etc.
- Short-term impacts (e.g., floods, droughts, severe weather, eutrophication)
- Long-term impacts (e.g., water quality and availability, land use changes, power supply)
- Mitigation and adaptation

BALTEX has applied to the World Data Centre for Climate (WDC) to perform long-term weather and seasonal prediction studies with coupled BALTEX models; to replace the REMO model with the German Meteorological Service (DWD) model; and use coupled ocean/atmosphere/land regional models. BALTEX, as a multi-national group, has also applied for European Union funding.

4.2 GAME

OBJECTIVES/STRATEGY: Understanding of the role of the Asian monsoon in the global energy and water cycle remains the main thrust of the GEWEX Asian Monsoon Experiment (GAME). The purpose of GAME is to improve the simulation and seasonal prediction of the monsoon and its impact on water resources in the Asian region. The strategy is to undertake a series of processes studies in different climatic zones including a tropical monsoon region (GAME-Tropics), the Tibetan Plateau area (GAME Tibet), a large catchment basin [Huai-He River-(GAME HUBEX)] and a cold regions location (GAME Siberia). A monitoring and observations network has been developed in each area and linked to allow measurements to be utilized in various analysis and modelling schemes. The monitoring and analysis methodologies utilize global-scale satellite measurements, data from an Asian Automatic Weather Station network and information from operational meteorological and hydrological stations. These products are coupled with 4DDA assimilation data and GCM-based model studies to understand the multi-scale interactions between the energy and hydrological cycles in the monsoon region.

STATUS: Phase I of GAME started in 1996 and the Inhanced Operating Period (IOP) was implemented in 1998. In Phase II (2001-2003), the emphasis of GAME will shift from data collection, management and assimilation to improvement of the characterizations of atmospheric and hydrologic cycles and advancement of modelling capabilities. Observations and process studies from Phase I will be succeeded by the Coordinated Asian Monsoon Experiment (CAMP), which has been established as part of GAME in cooperation with the CLIVAR monsoon panel (see Figure 3). The principal objective of CAMP is to understand and model seasonal to interannual variation of the A/A-monsoon and its influence on changes in water resources, with a particular focus on the heat source and sink regions among the land, atmosphere and ocean. The A/A monsoon is characterized by its strong interactions with land and ocean processes associated with high temporal and spatial variations.

Predicting seasonal to interannual variations of the A/A monsoon requires an improved understanding of interactions among the Eurasian continent, the Indian Ocean, the Western Pacific Ocean and the atmosphere over the region. Within this region-scale perspective, a number of relevant research projects, which are ongoing and planned under the framework of GAME and CLIVAR, are coordinated to implement a common enhanced observing period while keeping the identity of each research plan. CEOP/CAMP will at least cover the 2001-2003 time period. Further details on CAMP are available at <http://monsoon.t.u-tokyo.ac.jp/ceop/overview/>

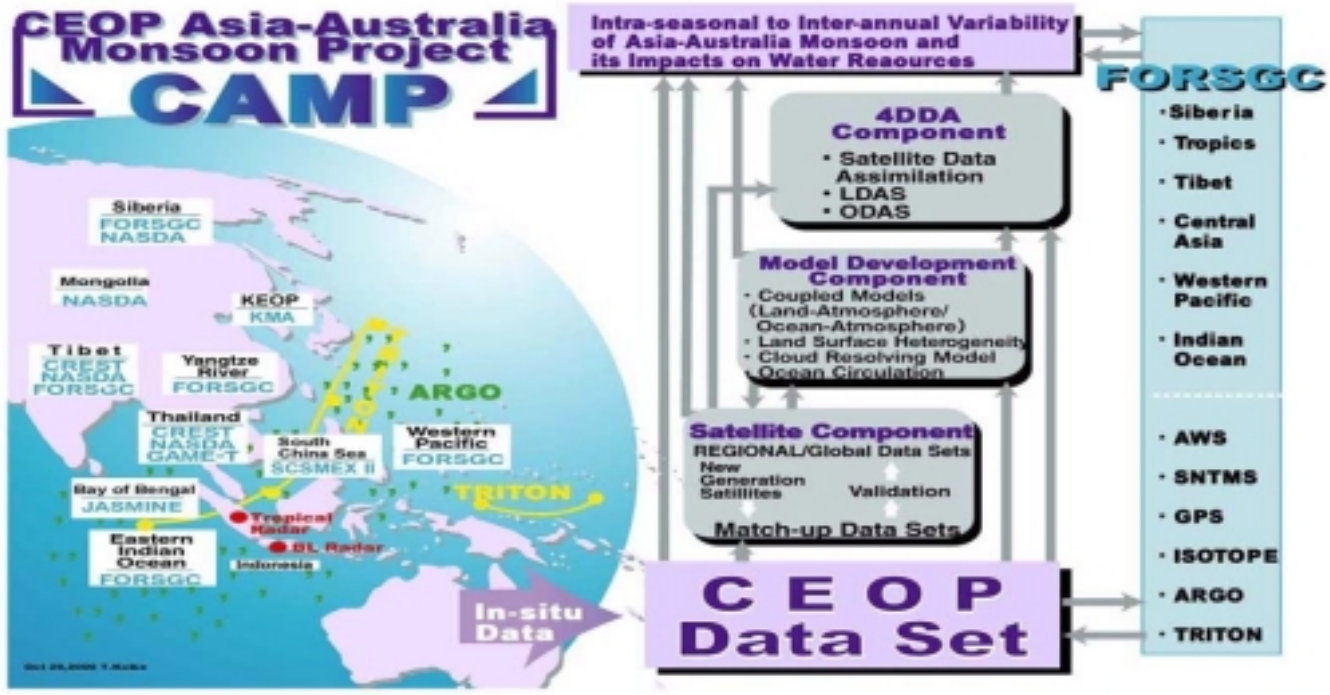

FIGURE 3. CONFIGURATION FOR THE CEOP ASIAN/AUSTRALIAN MONSOON PROJECT

A main element of GAME includes the support of the Japan Meteorology Agency (JMA) to perform 4DDA using advanced global forecasting models (e.g. T213L30) with horizontal grid-scales of about 50km or less. Where possible high quality data has been collected during special GAME Inhanced Observing

Periods (IOPs) at the GAME regional sites to be assimilated for estimating energy and water cycle processes of the monsoon system. Enhanced radiosonde observations have been activated over the whole Asian monsoon region and have contributed to an improved understanding of the multi-scale interactions of energy and water between the land surface, PBL, and the troposphere.

Progress in the use of, regional modeling and regionally-nested 4DDA will be essential to the success of GAME Phase II. In addition regional atmospheric models combined with macro-scale hydrological models are being developed and utilized. Products from the initial work undertaken during the GAME IOPs and reanalyzed products using the most updated assimilation system with the highest quality data gathered during the IOP have been entered into nodes under the control of the GAME Archive Information Network (GAIN). The initial version of the results from the GAME reanalysis project was released in September 2000 and another release is due at the end of 2001. The GAIN-Hub http://gain-hub.mri-jma.go.jp provides accesses to these products.

Surface radiation sites have been established in Sri-Samrong, Thailand and Hefei, China. The surface radiation budget derived from measurements and simulations agree, with some deviation from satellite derived values depending on the aerosol concentration. Satellite retrieved aerosol numbers and low optical properties correlate with each other. Results from GAME-Tropics show that variations in local rainfall are closely related to the large-scale Monsoon regimes. Observations from GAME-Siberia of Larch (deciduous) and Pine (evergreen) forests show a very clear interannual variation in the energy balance, with latent heat being much higher in the Pine forest than the Larch forest in early Spring. The depth of the thawing layer was much deeper in the pine forest at the end of April.

The Fifth International Study Conference on GEWEX in Asia and GAME will be held 3-5 October 2001 in Nagoya, Japan.

4.3 GCIP/GAPP

OBJECTIVES: GCIP was initiated as a full scale 5-year program in October 1995. The program was centered around focused efforts in different parts of the Mississippi River Basin. GCIP has focused considerable effort on characterizing the regional water and energy budget in the Mississippi River Basin as a first step in achieving its overall mission and contributing to the central mission of GHP namely to " predict changes in water resources and soil moisture on time scales of seasonal to annual as an integral part of the climate system". Initially the focus was on the role of soil moisture in regional precipitation patterns and the development of the low level jet. Efforts then shifted to an area where studies addressed land-atmosphere interactions during the winter and the winter to spring transition. Subsequently, effort was directed to understanding hydrometeorological processes in a humid region of the basin. Although GCIP has accomplished most or all of its objectives it has not fully delivered on the central mission of the GHP. In order to address this need GCIP has been extended and reformulated to provide a clearer focus on prediction issues. The extended program will be known as the GEWEX Americas Prediction Project (GAPP). It will consider processes and factors influencing the predictability of precipitation in the USA and will accelerate the use of this knowledge in global prediction systems and regional applications. In order to give GAPP a sharper focus on predictability and prediction system issues, its first objective has been defined as: "to develop and demonstrate a capability to make reliable monthly and seasonal predictions of precipitation and land surface hydrologic variables through improved understanding and representation of land surface and related hydrometeorological and boundary layer processes in climate prediction models." This objective will be addressed through a series of modeling, process, and observational studies in the areas of land memory, orographic, and monsoonal processes. GAPP will also work towards this objective through its involvement in GHP CEOP and transferability studies. GAPP will build upon the data sets, reanalysis products, process understanding and models that have been developed through GCIP. In addition, it will address land-atmosphere interactions in areas not considered in GCIP (e.g., mountains, arid regions) and build a better understanding of the role of land in the monsoonal processes of North America. Work related to the application of this research to water resource management will also be advanced during GAPP.

STATUS: GCIP research covers a broad range of issues of importance to the objectives of GHP and WCRP/GEWEX. A number of new projects have been initiated through joint NOAA and NASA funding, including studies in the area of multi-model ensembles, the use of satellite data in model development, the calibration of soil moisture sensors across the USA, and the simulation of the boundary layer over mountain snow pack. A number of the contributions of GCIP have culminated in a major upgrade to the Eta model at NCEP. GAPP has completed its analysis of the climatology of the Mississippi River basin and is completing its contributions to the GHP Water and Energy Budget Study (WEBS). GAPP has contributed a number of demonstration studies to the WRAP activities and has undertaken hydrologic and land surface model development. Several predictability studies are underway and the land surface memory effects at monthly to

seasonal time scales are now being evaluated. GAPP is actively supporting CEOP and has been contributing data from the CART/ ARM site to the Phase 1 CEOP data archive. There is good reason to believe that the USGCRP water cycle initiative will provide GAPP with new opportunities for coordination with other US GEWEX initiatives, as well as being a possible avenue for some new resources.

4.4 LBA

OBJECTIVES: The Large-Scale Biospheric Experiment in Amazonia (LBA) plans to determine how Amazonia currently functions as a regional entity and how changes in land use and climate will affect the biological, chemical and physical functions of the region, including the sustainability of development in the region and the influence of Amazonia on global climate. More about LBA can be found at the LBA home page http://www.cptec.inpe.br/lba/.

STATUS: The actual field phase of LBA started at the end of 1998. The first IOP occurred during January/February 1999 in the form of two closely coupled experiments, a wet season atmospheric mesoscale campaign (LBA WET/AMC) and a ground validation experiment for the Tropical Rainfall Measuring Mission (Referred as TRMM-LBA). A 100 km grid box over the Southwest Amazonia region (Rondonia) was heavily instrumented for atmospheric and land surface monitoring. These data were complemented by specialized measurements from two research aircraft, one looking at lower level cloud microphysical properties and the other at high altitude for remote sensing of clouds and precipitation. Eleven long term, continuously monitoring flux/climate/ecological sites have been established over the LBA region. An IOP campaign designed to study the transition from dry to wet seasons is to take place from October 2001 through the second half of 2002 in Southwest Amazonia. A number of atmospheric measurements will be made and the effort will be coupled with an atmospheric chemistry measurement campaign. Seventy different research projects are now in various stages of implementation covering all LBA thematic foci (e.g. physical climate; carbon cycle dynamics; biogeochemistry; atmospheric chemistry; land surface hydrology and water chemistry; land use and land cover changes; remote sensing studies; and human dimensions).

LBA is looking to quantify and understand the exchanges of energy, water, carbon, trace gases and nutrients through the atmospheric, terrestrial and river systems of Amazonia at all scales. Since conversion of tropical forest will alter those exchanges the primary issue is being able to predict what impact deforestation will have on the ecological, climatological and hydrological functioning of Amazonia and how it may affect the region's long-term sustainability. The work LBA will do to improve predictions of the impact of these changes outside the region connects LBA to the global objectives of GEWEX and WCRP.

Scientific results from the first 2 years of LBA research have shown very distinct features of atmospheric evolution in the Amazon Region, in particular, the cloud and precipitation regimes. The daily cycle of the energy budget at the pasture and forest shows differences between morning and afternoon behavior. Rn is larger at the forest in the morning and larger in the pasture in the afternoon. This would imply cloudier skies over forest in the afternoon. It would also mean lower cloud base in the morning over forest since LE is always larger at the forest while H is similar during the morning and larger over pasture in the afternoon. In a day which starts sunny and clear, the temperature evolution favors a faster evolution of the mixed layer over forest. After rains start at different times over forest and pasture this particular day, the continuous evolution is broken. This can be explained based on two modes of convection. During the easterly regime, convective systems are more continental, with vigorous convective cells, more isolated, with a well-defined mixed ice water region and frequent lightning. During the westerly phase, the systems are larger and more stratiform, no mixed ice water phase region and almost no lightning. To incorporate the role of CCN into this picture involves looking also into the dynamic/thermodynamic forcing provided by different regimes. The evolving picture may be seen as an interrelation of processes in different scales. Starting from a large scale forcing in the form of a low level westerly regime which is associated with low level convergence and absence of convective inhibition in the form of a thermal inversion, rain starts to pick up, from a more convective type to gradually more stratiform. As the CCN become less available, warm rain processes dominate, lightning is basically absent and systems occur at all times during the day or night with a moderate maximum in the afternoon. As the large scale forcing changes to an easterly regime, clouds start to respond to daytime heating and to surface heterogeneities becoming more localized. CCN counts become more abundant since there is less chance to be caught in a cloud updraft, and the increased amount of CCN help inhibit the warm rain process and the ice water mixed phase region becomes more prominent and lightning is observed (Silva Dias et al. 2001).

The overall time frame for LBA has been set as 1996 – 2005. Between 1996 and 1998, several preliminary activities took place, including installation of the measurement and monitoring components. The ecological monitoring started during 1997, including a number of flux measuring sites across the Amazonian

basin, and it will extend over a period of at least 4 years. The main phase of LBA has just begun corresponding to the period around the launching of the TRMM (Tropical Rainfall Monitoring Satellite) in November 1997, EOS-AM1, ENVISAT, CBERS (Chinese-Brazilian Earth Resources Satellite) and Landsat 7. During this period, most of the intensive measurements will be simultaneously deployed in the field. The atmospheric chemistry component of LBA is to be partly accomplished in 2003, with possibly more field campaigns in 2004. It is expected that special issues of scientific journals related to LBA research results (ecology, climate, hydrology, human dimensions, etc) be published in 2001-2002. See Figure 4 below for specific details about the timing of various LBA activities and their connection to CEOP and other major milestones.

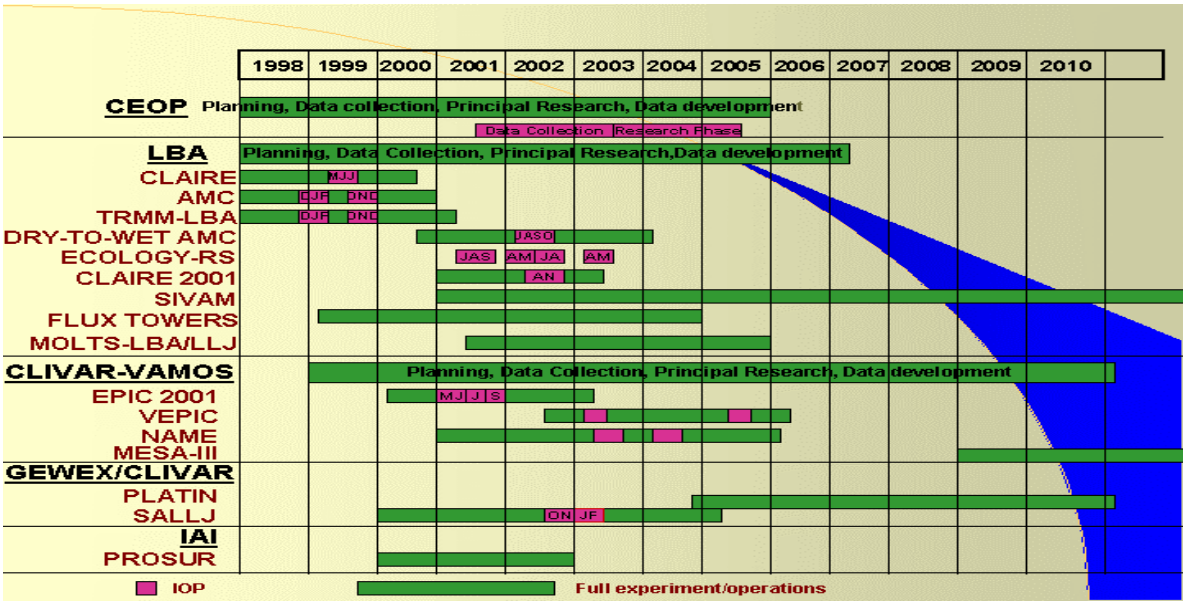

FIGURE 4: Timeline of LBA and LBA-related planned activities. Other efforts relevant to LBA, such as those developed as part of CLIVAR, IAI and GEWEX are also included. Green boxes represent the time period from planning to data development, while purple boxes indicate the approximate timing of field experiments and campaigns.

4.5 MAGS

OBJECTIVES: The goals and objectives of the Mackenzie GEWEX Study (MAGS) have been fully articulated in earlier documents that are available for review from the MAGS Secretariat and by way of the MAGS web page at http://www.msc-smc.ec.gc.ca/GEWEX/MAGS.html. The goals stated in brief are:

(i) To better understand and model the high latitude water and energy cycles that play a major role in the global climate system

(ii) To improve our ability to assess the changes in Canada's water resources that arise from climate variability and human-induced climate change.

The first phase of the Mackenzie GEWEX Study (MAGS-1) has been brought to a successful conclusion. Achievements during MAGS-1 include:

1. Better understanding of water and energy sources and partitioning within the Mackenzie Basin.
2. Importance of spatial variability of land cover, precipitation and snow accumulation to the water and energy cycles.
3. Demonstrated capability to model linked land-atmosphere system.
4. Preliminary closure of surface-atmosphere water budget at the regional/annual scale.
5. Compilation of major database for future modelling and analytical activities.

The second phase concentrates on the modeling, prediction and application aspects of our long-term goal. By the end of MAGS-2 (2001-2005), we will (a) have an improved understanding of, and ability to model, the response of energy and water cycles in the Mackenzie Basin to climate variability and change, (b) be able to characterize the impacts of its atmospheric and hydrological processes and feedbacks on the regional and global climatic systems, and (c) have the ability to apply our predictive capabilities to climatic, water resource and environmental issues in the Mackenzie Basin and other high latitude regions.

Upcoming MAGS Activities

- 2nd MAGS-GAME Workshop (8-9 October 2001)
- 7th Annual MAGS Meeting (November 2001)
- Continuing collaboration with BALTEX and GAPP on transferability studies
- Joint workshop with GAPP on cold region processes being considered
- New MAGS model transferability study (SAGE) in planning stages
- Special workshop on CAGES and issues of data management and distribution in planning stages
- MAGS Scientific Planning Meeting (March 2002)
- Finalize 1994-95 Water Year Special Issue
- Initiate CAGES special issue

4.6 CATCH

The Couplage de l'Atmosphère Tropicale et du Cycle Hydrologique (CATCH) initiative was granted CSA status (Continental Scale Associate) Project status at the 5th Session of the GHP (Hamburg, 1999). This designation acknowledges that CATCH will make an important contribution to GHP/GEWEX global objectives, but recognizes the difficulty CATCH will have in fully meeting all of the CSE criteria.

OBJECTIVES: The CATCH initiative has developed from work accomplished during the HAPEX-Sahel experiment that was carried out under GEWEX auspices in Niger from 1991 to 1993. HAPEX-Sahel was a mesoscale experiment aimed at studying atmosphere/ land surface interactions in the Sahelian region of West Africa (Goutorbe et al., 1997). It has been agreed that in order to understand the mechanisms controlling the hydrological variability of the West Africa region it is necessary to study its unique features as a climatic ensemble. Therefore, in 1997, CATCH as a regional experiment that could be undertaken on a time scale that could account for the interannual and decadal variabilities of the water cycle of the region, was promoted.

Even though the above objectives are fully consistent with those promoted by the GHP through the setting up of Continental Scale Experiments (CSE's), it has been impossible to-date to mount a CSE in West-Africa nor in Africa as a whole. The strategy to bring CATCH up to the CSE level has been focused on finding local agencies that could provide the framework for such an international project and also on securing funding to sustain such a large research project in the region. Limitations on finding a continental scale catchment, other than the Niger, which is limited in terms of availability of required data to study its water balance along its entire the watershed, has also narrowed the scope of such research to regional scales as opposed to a continental scale experiment.

Since no watershed of sufficient size could be identified to set up a CSE, a multiscale approach was chosen. West Africa as a whole was considered to provide the basis for studying the structure and the variability of large atmospheric entities, such as the prevailing jets, the easterly waves and the convective complexes that propagate over several hundred to a few thousands of kilometers. A 5° (0°- 5°E) by 9° (6°N-15°N) window (the CATCH window, covering roughly 660,000 km²) has been defined to study in more detail the atmospheric and hydrologic variabilities over a region spanning all of the climatic regimes of West Africa. This window is being used as a reference area to compare the outputs of various atmospheric models (global to mesoscale) with observations. At a lower scale, two focus areas have been selected for carrying out fine resolution measurements and process studies. One, the Niamey square (2°E – 3°E; 13°N – 14°N) is located in the Sahel, with an average annual rainfall of about 500 mm. The other is the upper Ouémé catchment (11,700 km²) extending over one degree in latitude (9°N – 10°N), characterized by a Sudanese climate, with an average annual rainfall of about 1000 mm. In each of the two focus areas, it is envisioned that super sites covering in the order of a hundred km² could allow for targeted studies, especially regarding fluxes at the soil-atmosphere interface.

The main thrust of the CATCH field program is to build up an array of measurements allowing for quantifying the water balance of the two mesoscale areas (the Niamey square and the upper Ouémé catchment). However, appropriate atmospheric measurements are also needed at the regional scale in order to link the mesoscale to the large circulation and to study the respective influence of the oceans and of the continental surface on the rainfall variability.

STATUS: CATCH activities are organised around three scientific and technical foci. One is the field work carried out on two observing system networks, one in the Sahel and the other, the upper Ouémé Catchment. In concert with the field activity a major data collection effort is underway over a regional window covering 5° in longitude (0°- 5°E) and 9° in latitude (6°N- 15°N). These data are provided by the operational

networks of the national agencies involved and by specific networks set up in the framework of various national/international research initiatives. These initiatives are being coordinated along the Ouémé catchment. A joint international project designated Hydrometeorological Ouémé Observatory (H20), is being undertaken by several Benin, French and German institutions. The main project has been set up to study the water balance of the Ouémé catchment, its interannual variability and the impact of this variability on the water resources, food security and socio-economics of the region. CATCH is also involved in modeling activities, through the European West African Monsoon Project (WAMP). Validation of large-scale climate models, regional atmospheric modeling and hydrological modeling are currently part of the on-going activities in the WAMP regional study. CATCH is also involved in the coordination of a related international effort on the study of the West African monsoon and its hydrological impact. A workshop funded by the European Union and various French national programs was held during the period from 18 to 20 September 2000 to define a scientific and funding strategy for future studies on the atmospheric, hydrologic and biospheric issues related to the West African monsoon. CATCH has been selected by the Institut de Recherche pour le Développement (IRD), to become part of its program on the "*Variabilité climatique tropicale et impacts régionaux*" (Tropical climate variability and regional impacts). This initiative is a co-operative effort with national agencies in Niger and Benin. In 2000, the German program Integratives Management-Projekt für einen Effizienten und Tragfähigen Umgang mit Süßwasser in Westafrika (IMPETUS) chose the upper Ouémé catchment as its anchor site for its wet savannah component.

At the mesoscale, a series of 10 years of high resolution measurements are now available on the Sahelian site of Niamey. Given the return to wetter conditions since 1998, this data set will allow the study of the water balance of the region over a range of annual rain amounts. On the Ouémé site, the year 2000 was the first year of full operation of the nominal hydrometeorological network currently in place.

The issue of coupling between atmospheric and hydrologic models is being addressed at the regional scale. The aspects of a weak coupling are under study, and the work to improve the understanding of this circumstance should be started in 2001. Vegetation models and SVAT schemes that are applied in GCM's and in regional atmospheric models are also under consideration as part of future CATCH modeling studies. In particular a comparison of the regional model performances depending on the surface scheme applied is planned in 2001 and beyond. At the end of 1999, ACMAD (the African Center for Meteorology Applied to Development) had decided to support the CATCH regional atmospheric sounding program. A research proposal was transmitted for funding by the GEF (the Global Environmental Facilities program sponsored by UNDP, UNEP and the World Bank). WCRP with support from the WMO Voluntary Cooperation Programme (VCP) assisted in the initiation of the request on behalf of CATCH. The campaign associated with this proposal is important to meeting the objectives of CATCH. In particular, there may be some basis for the belief that improving soundings over Africa may help to reduce uncertainties in NWP and GCM results not only in Africa but over other parts of the globe, as well. The Director of WCRP has agreed to undertake to determine the status of this proposal with the understanding that it would be an important contribution to CATCH if the performances of dynamical models could be tested with additional atmospheric data being available over West Africa in the 2001 to 2003 time period.

A joint workshop organized by CATCH and WAMP, with funding from the European Union and from various French national programs, was held at *Ecole de Physique* in Les Houches, France from 18 to 20 September 2000. Entitled "The West African monsoon and its hydrological impact: observing and modeling issues", the workshop aimed to define an international program on the West African Monsoon, especially related to issues of tropical convection and their interactions with the hydrological cycle. Results of the Workshop will be published in November 2001 as a white book entitled "Hydrological Impacts of the West African Monsoon". This proposal will be sent to various partners in the north and south and discussed a workshop in is planned for February 2002 in Niger.

4.7 ISLSCP Initiative II Global Data Sets

OBJECTIVES: In 1994, a 5-volume CD-ROM collection of global data sets to support energy, water and biogeochemical cycling was published by the International Satellite Land Surface Climatology Project (ISLSCP). This ISLSCP Initiative I data collection contained 159 parameters of global data for the base years of 1987-1988. Most of the data sets were provided at a monthly temporal resolution and at a common 1-degree spatial resolution. In 1999, NASA's Hydrology Program provided funding to initiate the production and publication of the ISLSCP Initiative II data collection. Following recommendations from ISLSCP members and the general scientific community, a set of 382 key data parameters was compiled. The data sets that are being produced for Initiative II are based on the need to develop a comprehensive data set that covers the 10-year period from 1985 to 1995. The intent is to produce a consistent collection of high priority global data sets using existing data sources and algorithms, and designed to satisfy the needs of modelers. The data will be produced at a spatial resolution of 1-degree for the meteorological data and 0.5 and 0.25

degrees for topography, soils, and vegetation parameters. The temporal resolution for most data sets is monthly, however, a few are at a finer resolution (e.g., 3-hourly or daily). As the data sets become available from the providing institutions, they will be checked for consistency and any erroneous values, and ultimately placed on line at the ISLSCP II web site at http://islscp2.gsfc.nasa.gov for distribution

STATUS: To date, a total of 11 data sets have been processed and are available through the Initiative II web site at <islscp2.gsfc.nasa.gov/>. An additional 15 data sets have been received and are currently being processed. It is expected that a preliminary version of the complete Initiative II collection will be available by December 2002 and will contain many test data sets for parameters, which have a later availability date. A final version, which will include documentation is slated to be produced by the end of the project in May 2002. A peer review process will be organized to ensure the quality of the data and documentation.

4.8 GRDC

OBJECTIVES: The Global Runoff Data Centre (GRDC) was established at the Federal Institute of Hydrology in Koblenz, Germany in 1988, to collect and disseminate hydrological data. GRDC provides a mechanism for international exchange of data pertaining to river flows on a continuous, long-term basis. The scope of data collection is global, regional and river basin scale. Thus far, 147 countries have contributed to the development of the database, which now consists of data from over 3,800 stations monitoring about 2,900 rivers world-wide. More information about GRDC is available at www.bafg.de/grdc.htm.

STATUS: Progress was reported on the formation of a Global Terrestrial Network-Hydrology (GTN-H), which will meet the needs for global hydrological observations for climate. Several meetings have taken place to develop an implementation strategy, the latest on 21-22 June 2001 in Koblenz. At these meetings it was recognized that there is a critical need for improved availability and access to global hydrological data, information and products for climate and hydrological research and applications in order to quantify key environmental change processes, identify significant trends, assess variability and develop response strategies. The GTN-H would consist of existing networks, global databases and global data product centres, capturing the ten key hydrological variables. The main objective for the network is to:

- Respond to urgent information requirements with regard to climate prediction, impacts and adaptation, including the characterization of hydrological variability to detect climate change.
- Assess water sustainability as a function of water use versus water availability,
- Improve understanding of hydrological processes.

4.9 GPCC

OBJECTIVES: The Global Precipitation Climatology Centre (GPCC) is operated by the Deutscher Wetterdienst (DWD, National Meteorological Service of Germany) located in Offenbach, Germany. GPCC was established in 1989 on invitation of WMO as a German contribution to WCRP. The Centre supports the Global Precipitation Climatology Project (GPCP), the Global Climate Observing System (GCOS), and the Arctic Climate System Study (ACSYS). GPCC is active in the GHP and contributes to regional projects (e.g. BALTEX). GPCC is one of the major components of GPCP. GPCC evaluates raingauge data and provides GPCP with gridded land-surface precipitation analyses for the purposes of validation and correction of remotely sensed data. The combined gauge-satellite precipitation products of GPCP are designed for the global research community, especially for the verification and initialization of global climate models and for large-scale budget studies.

STATUS: The products of GPCC include monthly precipitation, precipitation anomalies, the number of stations used and correction factors regarding systematic gauge measuring errors on gridboxes of both 2.5^{o} by 2.5^{o} and 1^{o} by 1^{o} for all months since January 1986. Seasonal and annual products are also published. GPCC's near real-time "Monitoring Product" is based on GTS data from about 7,000 stations. It is freely available via internet (http://gpcc.dwd.de) on a routine basis within a delay of 2 months after observation. GPCC's "Full Data Product" is based on all real-time data and delayed non-real-time data from 27,000 – 38,000 stations provided by more than 160 countries of the world. Results from a reanalysis for the time period 1986-1995 will be published with the ISLSCP Initiative II data set.

A new project beginning in October 2001 and jointly performed by GPCC and the University of Frankfurt/Main, is the compilation of a comprehensive climatological data base of precipitation, snow cover, surface air temperature (average and extremes) and mean sea level air pressure time series, as well as indices describing atmospheric circulations such as the North Atlantic Oscillation, Arctic Oscillation and Southern Oscillation (correlated with El Nino-ENSO). The time-series will cover the period from 1890 to

2000 on a monthly data basis. Later on in the project, daily data will also be collected and evaluated. The collection of past climate data will be founded on a number of already existing collections (GHCN, CRU, FAO, UNESCO, etc.) which will be merged.

Starting in January 2001, GPCC analyses daily precipitation totals on a 1^{o} x 1^{o} grid for Europe (31^{o} – 72^{o} N, 11^{o} W – 44^{o} E) on a routine basis. The analysis is done non-real-time in combination with the monthly GPCC routine about 1-2 months after the end of an observation month.

4.10 IAHS/WMO WORKING GROUP ON GEWEX

OBJECTIVES: The International Association of Hydrological Sciences (IAHS) is an international nongovernmental organization that deals with hydrology and water resources. It was established in 1922, incorporating the International Commission of Glaciers, which had been set up in 1894, with the aim of bringing together hydrologists from all countries to promote the hydrological sciences.

STATUS: During the last quarter of 2000 a "Prospectus" for the revised Working Group on GEWEX was prepared with the assistance of the past members of the Group. This defined the aims and rationale for the Group and the Phase II initiatives of GEWEX. This was sent to the past members who indicated their wish to continue as active member, the presidents of six international commissions inviting them to nominate a member of the Group and the heads of the CSEs. The Working Group now consists of six of the original members, representatives of ICSW, ICSI, ICWRS, ICASVAR and ICRS (2) and a representative of UNESCO (HELP). A detailed account of the Working Group and its preliminary programmes was published in the IAHS Newsletter, No. 71, January 2001.

The Working Group held its 10th meeting on the 26 July 2001 during the IAHS Assembly in Maastricht. From the WRAP meeting in September 2000, proposals have been pursued from the Working Group's Birmingham meeting of two workshops on the use of GEWEX products in water resources management. The first will be held during ICWRER in Dresden in July 2002 and the second is proposed for IUGG Sapporo in July 2003 in conjunction with IAMAS with which discussions have already been held. Four members of the Working Group are assisting with the organization of the Workshops, including two Commission Presidents.

A Workshop on Precipitation Fields is planned in St Moritz in April 2003. This has its origins in a call for more accurate precipitation fields in predominantly mountainous areas for the verification of atmospheric models. A MOPEX Workshop on Model Parameter Estimation will be held at the SAHRA Center of University of Arizona in April 2002 and will be co-hosted by the NWS Hydrology Laboratory. This will be restricted to an estimated ten active groups working on this problem. The Workshop will also act as a lead up to a proposed broader based Workshop to be held at IUGG in Sapporo. These last three workshops will address key ungauged catchment issues which is to be a focus of IAHS over the next ten years under the guidance of a Working Group on the Prediction of Ungauged Basins (PUBS).

The MOPEX workshops were discussed at the MOPEX Coordination Group meeting held at the conclusion of the related Symposium 5, Soil-Vegetation-Atmosphere Transfer Schemes and Large Scale Hydrological Models, on Wednesday 25 July 2001. The MOPEX meeting reported on the status of the MOPEX database, emphasising the additional data since the last meeting in Birmingham in 1999. These mainly comprised the hourly rainfall data for 438 basins in the US for which there is now daily streamflow, hourly rainfall, daily climatological potential evaporation, together with topographic, soils and vegetation data. Meteorological forcing data are being developed for the 438 basins. Additional discussions held with European hydrologists earlier in the year on the provision of MOPEX data were reported. Resulting from these, data from about 70 basins outside the US will be obtained and added to the database during the next twelve months. These developments were seen as a major task but well worthwhile and a significant development for international hydrological research.

A second focus of IAHS is to be taken up by a Working Group on Global Change Assessment. At the IAHS/WMO Working Group on GEWEX meeting it was recognised that GEWEX as a global programme is currently based around the CSEs and specific to their own region, and a broader body of hydrologists had little contact with this work within IAHS and the WMO Hydrology and Water Resources Programme. Furthermore, the 3rd IPCC Assessment Report had little new on the potential impact of climate change on extreme events, even though this is of enormous interest to decision makers and the general public and is of major socio-economic importance. Hence the CSEs should be asked to study longer records in their area to seek signals of change and impact of climate variability on the hydrological cycle.

4.11 NAME

OBJECTIVES: The North American Monsoon Experiment (NAME) is an internationally coordinated, joint CLIVAR-GEWEX process study aimed at determining the sources and limits of predictability of warm season precipitation over North America, with emphasis on time scales ranging from seasonal-to-interannual. It focuses on observing and understanding the key components of the North American monsoon system and their variability within the context of the evolving land surface-atmosphere-ocean annual cycle. It seeks improved understanding of the key physical processes that must be parameterized for improved simulation with dynamical models. NAME employs a multi-scale (tiered) approach with focused monitoring, diagnostic and modeling activities in the core monsoon region, on the regional-scale and on the continental- scale. NAME will be part of the CLIVAR/VAMOS program, US CLIVAR Pan American research, and the GEWEX Americas Prediction Project (GAPP).

The scientific objectives of NAME are to promote a better understanding and more realistic simulation of:

- The evolution of the North American monsoon system and its variability;
- The response of the warm season atmospheric circulation and precipitation patterns over North America to slowly varying, potentially predictable surface boundary conditions (e.g. SST, soil moisture and vegetation);
- The effects of land surface processes and orography on the variability of the seasonal rainfall patterns;
- The diurnal heating cycle and its relationship to the seasonally varying mean climate;
- Intraseasonal aspects of the monsoon.

To accomplish these objectives, planning has proceeded with the intent of developing:

- Empirical and modeling studies plus data set development and enhanced monitoring activities that carry on some elements of the existing PACS program and the US CLIVAR/GEWEX Warm Season Precipitation Initiative (2000 onward), initiate new elements, and provide the spatial and temporal context for NAME;
- Field activities in the core region of the North American monsoon during the summers of 2003-2004, including build-up, field, analysis and modeling phases (2003-2008);
- Strong links between the VAMOS element of CLIVAR, US CLIVAR Pan American research, and the GEWEX Americas Prediction Project (GAPP).

In addition to significant improvements in short-term climate prediction, NAME will lead to joint international experience with Mexican and Central American scientists in the exploitation of in situ and satellite data, advancements in high-resolution climate models, advancements in the development of the climate observing system, and the production of consistent data sets over the Americas. An online version of the NAME Science and Implementation Plan is available at
<http://www.cpc.ncep.noaa.gov/products/precip/monsoon/NAME.html>.

STATUS: Proposals are being prepared for support of enhanced NAME observations (wind profilers, radars, research vessels). An important component of the NAME raingauge component has been funded by PACS/GAPP Warm Season Precipitation Initiative. A NAME Model Intercomparison (NAMIP) initiative is being organized. The Fifth Annual Meeting (March 2002) of the CLIVAR/VAMOS Panel will feature NAME.

4.12 Rio de la Plata Basin Study

OBJECTIVES: The Rio de la Plata basin in southeastern South America covers an area of approximately $3.6*10^6$ km^2, which is slightly larger than the Mississippi River basin ($3.2*10^6$ km^2), and is the water resource for one of the most densely populated regions of South America. Several hydroelectric power plants regulate the river flow and, in turn, can affect the navigability of these natural waterways. Harvests and livestock are also an important asset to the region. All these elements are greatly affected by precipitation variability and more generally by changes in the hydrological cycle.

There is an effort to develop a CSE to study the hydroclimatology of the Rio de la Plata basin. This initiative would link the GEWEX interests on hydrological issues with CLIVAR/VAMOS concerns in monsoon circulations. In addition, because the Rio de la Plata and Mississippi River basins have similarities and

differences worth investigating, it has been considered that a transferability study between GAPP and the Rio de la Plata could serve as a precursor for the future CSE.

STATUS: This effort may be undertaken as a joint GEWEX/CLIVAR experiment but this decision cannot be made until a more specific framework for the initiative is defined in terms of the role GEWEX is expected to play and until these details are discussed and a recommendation made by the GEWEX SSG to the Director of WCRP for final disposition. A formal proposal will be brought forward for final review and action at the 2002 meeting of the SSG.

4.13 Murray-Darling Basin Water Budget Project (MDBWBP)

OBJECTIVES: The Murray-Darling Basin (MDB) covers a catchment area of $1x10^6$ km^2 or about 14% of Australia (Figure 1). Both the Murray and Darling Rivers have lengths greater than 2500 km, and so the MDB is one of the world's major river systems. A key feature of the MDB is that it represents a semi-arid zone, and so its ratio of discharge to precipitation is extremely low (less than 0.05) due to the potential evaporation rate being more than twice the precipitation rate. The significance of this ratio is highlighted in Table 1, which compares the characteristic features of the MDB with those of other basins in the GEWEX Continental Scale Experiment (CSE) program. MDB is complicated not only by the high evaporation rate, but also by the large interannual variability of the rainfall, mainly due to the impact of the El Nino - Southern Oscillation (ENSO) on the climate of southeastern Australia. This variability in rainfall is amplified in the annual runoff figures, which are more variable than runoff elsewhere in the world (except for parts of Southern Africa that experience a similar climate). The MDB includes the three longest rivers in Australia. The Darling is 2740 km long from its source in the north to its confluence with the Murray at Wentworth, the Murray is 2530 km long from its source in the Australian Alps to its mouth on Encounter Bay in South Australia, and the Murrumbidgee is 1690 km long. The Basin also includes many rivers and creeks, but many of these are dry most of the time and they carry water only during flood times.

Feature	**MDB**	**GCIP**	**MAGS**	**BALTEX**
Drainage Area (10^6 km^2)	1.0	3.2	1.8	2.0
Annual Discharge (km^3/yr)	12.6	570	300	470
Mean Precipitation (mm/yr)	200-1000	300-1200	400	720
Discharge/Precipitation	0.01-0.06	0.2-0.6	0.4	0.3

Table 1. Comparison of features of some basins in the CSE program with those of the MDB.

Most of the Basin consists of extensive plains and low undulating areas, with an elevation less than 200 m above sea level. The Basin is limited to the south and east by the Great Dividing Range, which includes Mt Kosciuszko at an elevation of 2228 m. The nature of the Basin means that its rivers tend to meander slowly over plains, so that for example the course of the Darling River is about three times the direct distance between its ends. There is a range of climatic conditions across the Basin, with cool humid conditions on the eastern uplands supporting areas of rainforest, and sub-tropical conditions in the north-east. The climate to the southeast is temperate, while the large western plains are semi-arid and arid areas. The Murray-Darling Basin is the food bowl of Australia with rich irrigation, farming and grazing land. The Basin accounts for 40% of Australia's agricultural production, utilizing about 70% of all water used for agriculture across the nation. The 1,500,000 hectares under irrigation for crops and pastures represents 70% of the total area under irrigation in Australia. More than 80% of the divertible surface water resource is consumed in the Basin. The Basin holds a population of 2 million people, which is about 10% of the national population. In addition to agriculture, there are manufacturing industries that have an annual turnover of more than $10 billion. There are more than 30,000 wetlands in the Basin, and at the time of European settlement the species in the Basin included 85 mammals, 367 birds, 151 reptiles, 24 frogs and 20 freshwater fish. At present there are at least 35 endangered birds and 16 endangered mammals.

The objectives of the Murray-Darling Basin Water Budget Project are:

- Enhance the capability of the operational systems of the Bureau of Meteorology to provide accurate and reliable estimates of the real-time surface water budget across the MDB
- Measure the spatial and temporal variability of soil moisture and temperature across the Murrumbidgee River basin
- Identify and reduce key limitations in the representation of soil moisture and temperature in BMRC atmospheric model using data from the Murrumbidgee River basin
- Develop products for water authorities in the MDB based on the output of the Bureau's operational systems

These objectives are being achieved through a program of combined observation and modeling studies, based on the hydrology and spatial modeling expertise at The University of Melbourne and the meteorological modeling expertise in BMRC. Detailed observations of soil moisture and temperature are being collected at 18 sites across the Murrumbidgee River basin, and they will be compared with the results of the BMRC numerical models. These observations will provide a unique data set for the evaluation and development of numerical models.

STATUS: The GHP acknowledged that the MDBWBP could make an important contribution to GHP/GEWEX global objectives and that the project meets all the established criteria for a CSE. A recommendation will be made at the next GEWEX SSG meeting that MDBWBP be accepted as a CSE.

5. WATER AND ENERGY BALANCE STUDY (WEBS)

OBJECTIVES: WEBS was initiated at the 1999 GHP meeting and is a critical effort within GHP in that it strives to collectively assess our ability to develop observations of basic climate variables, assess our ability to simulate those observations with atmospheric and hydrologic models, assess our ability to develop budgets from observations and models, and clarify levels of uncertainty in these budgets at annual, seasonal, diurnal, interannual and longer time scales over the various continental-scale experiments of GEWEX, as well as other areas.

STATUS: Many WEBS-related activities are taking place within GCIP/GAPP to understand the water and energy balance for the Mississippi River basin. Initially, it was thought that just use observations could be used to describe and close the CSE budgets. However, global and regional models and analyses, as well as hydrologic models provide a framework for integrating sparse observations into a coherent description of water and energy budgets. Global models are typically only constrained by observed SSTs, but can be further constrained by global atmospheric observations into a global atmospheric analysis. Regional models are also constrained by global atmospheric analyses and can be even further constrained through additional regional atmospheric observations into a regional analysis. Hydrologic models are constrained by tuning the model runoff to observed runoff using observed precipitation. Eventually they will be constrained by additional land observations in land data assimilations. All of these models can be compared to each other and to available observations within the CSEs, in order to assess current and future capabilities for diagnosing and eventually predicting water and energy budgets.

An atlas now exists of geographical, seasonal and temporal characteristics of all the major components in the GCIP WEBS and we have learned which processes are easier to simulate, observe, and even acquire data. In general, the global analysis and especially the GSM, do not always capture some of the regional characteristics of the Mississippi River basin that are better provided by regional and hydrologic models. The VIC model appears to provide the best simulation of the surface water budget, suggesting, for example, that its evaporation might be a benchmark for the other models. However, the VIC surface energy output is noticeably different from other models and also observations of at least the net solar radiation. The Eta model also has a noticeable bias in the net solar radiation, which may have influenced its relatively large sensible heating. Presumably the Eta analysis provides the best precipitation and overall simulation, although the RSM also has many realistic features. The Eta analysis does not provide the best depiction of interannual variations, presumably because model changes are larger than naturally occurring variations. In that regard, an Eta reanalysis is underway.

Vertically integrated global and regional water and energy budgets from the NCEP reanalysis II (NCEPRII) can be used to provide a global background for the CSE regional WEBS studies. Important mechanisms can be discerned in the reanalysis, such as water and energy cycles that can be characterized by surface temperature. Water vapor, precipitation, evaporation, surface and atmosphere radiative heating (less atmosphere cooling) and atmospheric heat divergence increase with increasing surface temperature.

Surface water decreases with surface temperature in middle latitudes but increases in tropical monsoon regions. This surface water variation has a strong impact upon the sensible heating, which increases over the drying mid-latitude land surface and decreases over the moist monsoon land regions. Surface runoff is also bimodal with surface temperature, in part because much runoff occurs near melting temperatures as well as during the rainy monsoon seasons. Moisture convergence also has two preferred modes. During winter, the atmosphere is more efficient in transporting moisture to high latitude regions. During summer, increase in moisture convergence is a large contributor to the monsoon rainfall, whereas summertime moisture divergence is common over the mid-latitude continents. Future work must not only begin to examine regional characteristics in greater detail, and how they might have changed under different conditions, but must also begin to understand regional characteristics that may be influenced by remote influences.

6. GHP DATA MANAGEMENT WORKING GROUP (DMWG)

OBJECTIVES: The DMWG was formed in 1999 to assist in the coordination and facilitation of observational data sets from the Continental-Scale Experiments (CSEs) and ISLSCP. The broader modeling community will use coordinated ground, atmospheric and satellite measurements of the type taken during these experiments to test such formulations as prognostic cloud schemes and the representativeness of related interactions being implemented in their global models. This process can be made much more efficient if these data sets are gathered into a uniform database easily accessible by the various modeling centers represented across the CSEs. The functions of the DMWG are to:

- Advise on GHP data management activities
- Develop a MOU on data policy and exchange
- Develop data plans for CEOP and other enhanced observing periods
- Assist the scientific community and respond to data questions/requests
- Develop plans for "composite" or coordinated GHP data sets
- Develop and maintain a GHP DMWG World Wide Web page (http://www.joss.ucar.edu/ghp/)

STATUS: Current activities of the DMWG are

- Reviewing the CEOP-I Science and Implementation Plan
- Identifying CSE "reference" sites and compiling data sets
- Planning the GHP "composite" data set for distribution
- Developing a MOU for data exchange between the CSEs

7. WATER RESOURCES APPLICATION PROJECT (WRAP) STATUS

OBJECTIVES: Recognizing that the GHP, specifically, and GEWEX, in general, need to develop stronger links with the water resource community, the GHP, with the approval of the GEWEX SSG, formed a WRAP (Water Resources Applications Project) Working Group in the Spring of 2000. This group was charged with facilitating a dialogue with the water resource community to inform them of GEWEX technologies and to obtain guidance on how these technologies can be modified to be of greater societal relevance.

STATUS: A white paper on WRAP is being prepared for distribution at GHP-8. The focus of the paper is on identifying case studies related to water resource application issues and will include a list of hydrological products that would be useful to the water resource management community. A powerpoint presentation is being developed in parallel with the white paper.

Plans for two meetings to bring the GEWEX community together with other scientific groups and water resource managers are being developed. A workshop is being planned in conjunction with the 3rd International Conference on Water Resources and Environmental Resources (ICWRER), July 22-26, 2002 in Dresden, Germany. The purpose of this WRAP workshop will be to demonstrate the value of GEWEX products and to obtain feedback from the water resource community on their utility. Expected outcomes of the workshop include: determining the kinds of forecast and modeling products that would be most useful to water managers, how these products would be used in water management decisions, and best way to make them available to water managers.

A second workshop is being planned "on the role of GEWEX hydrological and hydrometeorological sciences in improved water resource management" to be held in conjunction with the IUGG 2003 meeting. This 2-day workshop would be cosponsored by IAHS and IAMAS. It would consist of invited and submitted presentations and include a significant discussion period to identify and address key research issues. The proposal for this workshop is under review by the IUGG program committee. Formal approval is expected in December 2001.

8. LAND-SURFACE HYDROLOGICAL MODELING

An overview was given of the work that has been completed related to developing macroscale hydrologic models in the CSEs. Progress was reviewed on integrating hydrologic models with SVATS models and the recent results from the PILPS 2e intercomparison. The contributions that the CSEs and PILPS have made in bringing together the hydrologic modelers and land surface modelers were noted. An overall assessment of this area of research was that it is in good shape relative to a number of others, such as precipitation, and did not need to be a high priority for a GHP special effort.

9. TRANSFERABILITY

The transferability of regional models between regions and/or the validation of global models over continental-scale experimental regions and other regions is being addressed on a case-by-case basis. A list of models being used in different regions continues to be updated each year and made available through the GHP web site. Under CEOP, specific tests of transferability and validation are being planned.

There are four possible types of model transferability studies that could be used by GHP:

1. "Home-based" global model using CEOP validation data
2. "Home-based" global model and embedded regional model -- comparative evaluation with "home-based" regional model output (e.g. other models with Eta over GCIP region) plus CEOP validation data
3. Model transferability intercomparison using a "neutral global model" (e.g. ECMWF or NCEP/NCAR reanalyses)
4. Regional model embedded in different global models to evaluate the effects of initial and boundary conditions from different global models

Research priorities for transferability studies:

- Evaluate and improve the representations of the effects of seasonally varying land-use, soil moisture, vegetation cover, and other soil characteristics forcing and their spatial heterogeneity in regional coupled models.
- Determine and model the multi-scale responses of complex terrain on the regional hydroclimate at seasonal and diurnal time scales.
- Examine the model's surface energy budgets to evaluate the performance of the parameterizations in physical terms.
- Characterize and model the temporal and spatial distribution of different land surface conditions, such as snow cover including its accumulation/melt and the impact of frozen ground, on atmosphere/hydrology interactions.

Characteristics of possible coupled hydrometeorological model case studies:

- A relative simple geographic region without major topographic complexities, which has sufficient observations for data assimilation as well as model evaluation studies, such as the Mississippi River basin being studied by the GCIP CSE.
- A complex geographic region, such as the Baltic Sea and surrounding land areas now being studied by the BALTEX CSE.
- A neutral geographic region, which has not been studied by any of the CEOP participants, such as the region of the Niger river basin of west Africa, CATCH.

It was agreed at the meeting that a first transferability study should be over the BALTEX region for the PIDCAP period (August-October 1995). The Max Planck Institute for Meteorology in Hamburg and the GKSS Research Centre in Geesthacht will host this study and will distribute detailed information.

10. PREDICTION AND PREDICTABILITY

A proposal was presented for a study that would assess the seasonal to interannual predictability for each CSE region and provide linkages to global (monsoon) circulation. Hydrologic modeling and in situ characteristics, river routing, etc., would provide "hydrologic predictability." CSE data sets could be used for verification of skill and validation. CPTEC volunteered a post-doc to carry out some studies in liaison with the CSEs using seasonal predictability experiments from ECMWF, CPTEC, etc.

It is feasible to do seasonal to interannual climate variability studies, including simulations and model validation, predictability assessments and studies in Brazil at CPTECD/INPE, using the CPTEC AGCM. Examples are given below.

- Climate predictability in the Amazon and South American Monsoon regions
- Validation of rainfall anomalies during extreme situations of SST anomalies: El Nino 1997-98 and La Nina 1998-99.
- Simulation of rainfall annual cycle (1982-91)
- Example of regions with high predictability: NE Brazil
- Anomaly correlation for rainfall (observed vs. model)

A white paper that synthesizes/summarizes the current experience of CSEs and outlines a plan for GHP predictability studies will be drafted for review and discussion at the next SSG meeting.

11. CARBON

At GHP-6 it was agreed to form a working group to consider issues related to the role of the Carbon Cycle in GEWEX relevant research. Each CSE agreed to nominate a representative to support the work of the group. Terms of reference for this working group are in work and a recommendation for further development of this action in concert with GRP and GMPP is being formed. The issue of the WCRP contributions to improved understanding of the role of the Carbon Cycle in the global climate system extends beyond GHP and requires close coordination within WCRP and among other international frameworks, such as the International Geosphere/Biosphere Programme (IGBP).

Studies show that CO_2 has been increasing rapidly over the past 100 years. Data from Cape Grim, Mauna Loa and the south pole show that CO_2 has a high seasonality. There is a cyclical behavior to CO_2 variability corresponding with El Nino and dryer conditions. A simple analysis of this is that the dry condition droughts caused by El Nino correspond with low growth rate whereas La Nina corresponds to wetness and biomass growth.

Examples of research being undertaken in carbon are the IGBP/WCRP/IHDP "Carbon Project", the CEOS/TCO Carbon team (terrestrial and ocean) (Terrestrial Carbon Observing program = TCO), and many highly visible regional/continental "carbon initiatives" (CarboEurope, US and NASA Carbon, Australia, LBA, etc.) Possible activities for a GHP contribution to carbon research is to contribute to a scientific basis for determining if, when and where land areas are a sink for CO_2. GHP could also provide enhanced observations and predictions for geophysical variables. As a first step, the GHP agreed to review the GEWEX carbon science plan drafted by Dr. M. Chahine.

Carbon Issues/ Questions that GHP could address include:

- How can we most effectively coordinate energy flux and CO_2 flux measurements?
- How can we effectively link interactive vegetation models and ecosystem carbon models?
- How can we use column measurements of CO_2 to understand lower atmosphere and land surf processes?
- What can we contribute to the debate on whether land areas are a sink or source for atmospheric CO_2?

12. ACSYS/CLIC and GHP

ACSYS has a planned end date of 31 December 2003 and will continue as a separate visible program (jointly with CliC) until then. Since CliC is focussed on the interactions of the cryosphere with the other components of the physical climate system, most, if not all, ACSYS activities will be continued in CliC in one form or another. Certain ACSYS activities, such as the assembly of Arctic runoff and precipitation data sets are relevant to GEWEX and the approach is to maintain and develop joint activities in such areas.

A memorandum of understanding (MOU) for interaction between GHP and ACSYS/CLiC was developed and approved at the 1997 GEWEX SSG meeting. For details, see http://www.msc-smc.ec.gc.ca/GEWEX/GHP/ghp_acsys.html. Instead of amending the MOU to reflect the evolution of the two programs, ACSYS/CliC and GHP have agreed to cancel the MOU and continue their collaboration informally. For example, a Joint CliC/GEWEX Workshop on Solid Precipitation is planned for June 10-15, 2002 at the Institute for Arctic Research in Fairbanks, Alaska. Other specific joint activities will be developed as needed.

13. ISOTOPES AND GHP STUDIES

BACKGROUND: Isotopic tracers provide a mechanism for assessing our ability to understand the dynamics of the water cycle by allowing us to account for the flux of water between natural reservoirs (clouds, humidity, surface storage in lakes, surface channels, soil, plants, ground water, etc.), and by assessing the processes through which the water molecules proceed in the water cycle (surface-groundwater exchange; evaporation, transpiration, snowmelt). Stable isotopes of oxygen (Oxygen-18) and hydrogen (Deuterium) have long been known to vary in precipitation and atmospheric moisture in response to meteorological conditions and moisture sources. Isotopic methods using tracers such as Tritium can be used to study catchment-scale dynamics, both the partitioning of water between surface and groundwater components and the residence time of water within a watershed. While an isotope network exists [Global Network for Isotopes in Precipitation (GNIP)], few global or continental scale data sets of isotopes in runoff have been obtained thus far. The International Atomic Energy Agency (IAEA) has a 3-5 year pilot project for isotope tracing of hydrological processes in large river basins. Related isotope studies in the CSEs would complement IAEA studies and include the following.

GAPP activities:

- DOE-supported water cycle isotope pilot study incorporating isotopes into mesoscale atmospheric model MM5 and land surface models.
- Research in a new cloud microphysics model incorporating isotope mixing ratios and tied to the land surface scheme.

MAGS related activities:

- Regional water balance assessment based on sampling of 285 lakes and analysis of station-based precipitation data in shield areas of NW Mackenzie Basin and adjacent areas of continental Arctic.
- Isotope hydrograph separation analysis at the small catchment scale in five wetland-dominated basins for improved hydrological modelling (4-years study in progress).

GAME related activities:

- Isotopes are incorporated in the Japanese Water Isotope GCM
- Supported by a stable isotope network, the Asian Network for Stable Isotopes in Natural Water (ANSIN).
    - Isotope precipitation sampling in Siberia, Tibet, Nepal, Thailand, Indonesia
    - Additional river, lake, groundwater (wells, springs) and snow pack isotope sampling in above areas' progress.

CATCH related activities:

- Isotope precipitation sampling over meridional transect in West Africa has been implemented.

14. CEOP

OBJECTIVES: The overall goal of the Coordinated Enhanced Observing Period (CEOP) is to pull together the observations being taken and results being achieved by the CSEs to understand and model the influence of continental hydroclimate processes on the predictability of global atmospheric circulation and changes in water resources, with a particular focus on the heat source and sink regions that drive and modify the climate system and anomalies. The primary objectives of CEOP are to:

- document, better understand and improve the simulation and prediction of water and energy fluxes and reservoirs over land for water resource applications; and
- document the seasonal march of the monsoon systems and better understand their physical driving mechanisms and their possible connections.

The implementation of CEOP requires close cooperation across other projects and related activities within WCRP projects, such as the Climate Variability and Predictability (CLIVAR) study, the emerging Climate and Cryosphere (CliC) project, and the joint WMO Commission for Atmospheric Sciences/Joint Scientific Committee WCRP Working Group on Numerical Experimentation (WGNE). CEOP has also been endorsed by the Integrated Global Observing Strategy Partnership (IGOS-P) as an initial step of a prospective IGOS Water Cycle Theme.

STATUS: CEOP will create a database of common measurements from both *in situ* and remote sensing observing platforms and a number of carefully selected reference stations will be linked closely with the existing network of observing sites involved in the CSEs. The initial purpose of CEOP is to develop a pilot global hydro-climatological data set that can be used to help evaluate, develop and eventually predict water and energy cycle processes in global and regional models. *In situ* and satellite observations, model output, and four-dimensional data analyses (4DDA; including global and regional reanalyses) will be developed and coordinated during this period. Enhanced observations will begin in October 2001 and end on 30 September 2003 (possibly extended to September 2004), at which point enhanced research efforts by the international community will begin. More details about CEOP are available at <www.gewex.com/ceop.htm>

Three spatial scales (local, regional, global) are of interest to the CEOP community. At local scales, *in situ* data from several international tower sites, along with level II and level III satellite data plus numerical model and 4DDA output for these same sites, will be consolidated into useful data sets for studying water

and energy budgets. At regional and global scales, regional and global networks of more standard observations, as well as model and 4DDA output, are also needed for closing regional and global water and energy budgets and understanding monsoon interactions over land and ocean.

CEOP will provide a wealth of data to enable extensive testing of atmospheric model parametrizations and will help with determining what experimentation/research/validation should be carried out, and help to assess whether model systematic errors might be affected in any way. It is planned that the data collected in CEOP will be made available in real-time so that rapid feedback can be provided from operational Numerical Weather Prediction (NWP) Centers**.** The Director of WCRP has sent letters to the NWP centers, requesting their support for CEOP by providing to the international research community some of their global and regional analyses and model predictions of water and energy cycle processes over the proposed CEOP period. In particular, CEOP would like to obtain high temporal resolution time-series output at specified individual sites and gridded output in both three- and two-dimensional forms. In the GEWEX community, the first type of output is referred to as Model Output Location Time Series or MOLTS. MOLTS refers to model output at individual sites in vertical model columns (including the earth surface and subsurface) at hourly or more frequent intervals. MOLTS represents the model-output analogue of "observing station" time series and such output is needed by researchers to validate data sets. NWP centers have also been requested to provide 3D and 2D gridded output processed as synoptic snapshots at a minimum of six-hourly intervals. MOLTS output is being requested for at least 18 international reference sites, which will have corresponding *in situ* tower and surface station measurements. For each of these sites, MOLTS output at some model grid points that surround each site in order to reduce sampling error and to assess uncertainty has been requested. The University of Tokyo will provide a central archive for CEOP data. The archive has a capacity of 500 Terabits.

To facilitate communication between the parties involved in CEOP, monthly teleconferences will be conducted. The Asian coordination body of CEOP is finalizing the design of the CEOP logo and developing a CEOP web site at the University of Tokyo. They are also finalizing a CEOP that will provide information on CEOP to the broader scientific community. In addition, an update on CEOP activities will be distributed quarterly with the GEWEX newsletter.

15. GHP-8

The next meeting of GHP will take place the second week of September 2002. A location for this meeting has not yet been decided. One possibility might be to hold the GHP meet jointly with WRAP and the Global Water Partnership Dialogue Workshop.

APPENDIX A

ACTION ITEMS

Provide feedback to the following projects: - Ron Stewart

- Rio de La Plata Basin
- Murray-Darling Basin Water Budget Project (GHP to present proposal to SSG)
- NAME

WEBS – John Roads

Address following issues:

- Do we need better coordination of the WEBS efforts to better synthesize the CSE efforts? Do we want to try to transfer CSE data sets into a specific spot? Use GAPP template for all CSEs?
- Should WEBS try to come up with a list of data that we want from each of the CSEs?
- Develop a grand synthesis over the next year.

WRAP – Lawrence Martz

- Prepare white paper for distribution at GHP-8
- Organize WRAP workshops in 2002 and 2003

DMWG – Steve Williams

- CSEs to investigate representative GHP data sets (i.e., gridded data sets) and provide links or submit these data sets
- CSEs to continue providing and updating Reference Site info and sample data sets
- GHP to define what data sets are required for transferability studies – DMWG can work out details of formats and accessibility.
- CSEs to make their data available and widely accessible (despite cultural, political, socio-economic hurdles)

Land-Surface Hydrologic Modeling – Dennis Lettenmaier

- Provide electronic version of action items on overall goals and specific efforts
- Coordinate joint working group and workshop for involvement in modeling centers

Transferability Issues –Burkhardt Rockel

- Identify CSE representatives (by September 31)

Predictability Studies – Carlos Nobre

- Prepare white paper for next GEWEX SSG

Carbon – Pavel Kabat

- Update GHP carbon plan

GEWEX/CLiC (Ron Stewart)

- Review and update GEWEX/CliC Memorandum of Understanding with specific joint activities.

Isotopes – Soroosh Sorooshian, Harmut Grassl and Al Pietroniro, Environment Canada, will serve as contacts for the International Atomic Energy Agency (IAEA) Pilot Project

GHP Linkages to other elements of GEWEX (Ron Stewart and John Schaake)

- How would GHP like to see these linkages evolve in the future?

CEOP

- Ad-hoc group on CEOP reference sites
  - Identify possible reference sites in Alaska and Murray-Darling Basin
  - Responsibility
  - Classification by referring to the CEOP Sciences
  - Date stream: how to package?
  - Membership

- Ad-hoc review panel which consists of users
  - Reference site model, satellite outputs by referring to CEOP sciences
    i. GCM /climate modeling
    ii. Hydrometeorology
    iii. Atmosphere BL/NWP
    iv. 4DDA

LIST OF PARTICIPANTS

Dr. Omar Baddour
African Centre of Met. Apps for Dev.
Climate Division/DMN of Morocco
Rabat
Morocco
Tel: 212-37-75-76-46
Fax: 212-37-75-55-13
E-mail: baddour@mtpnet.gov.ma

Mr. Samuel Benedict
World Climate Research Programme
7 Bis, Avenue de la Paix
Case Postale 2300
CH-1211Geneva
Switzerland
E-mail: seb@www.wmo.ch

Dr. Hugo Berbery
University of Maryland
Dept of Meteorology
3411 Computer & Space Sci Bldg
College Park, MD 20742-2425
USA
Tel: 1-301-405-5351
Fax: 1-301-314-9482
E-mail: berbery@atmos.umd.edu

Dr. Michael Bonell
UNESCO-IHP
Division of Water Sciences
1, rue Miolis
75732 Paris Cedex 15
France
Tel: 33-1-45-68-39-96
Fax: 33-1-45-68-58-11
E-mail: m.bonell@unesco.org

Dr. David Carson
World Meteorological Organization
Director, Joint Planning Staff, WCRP
Case Postale No. 2300
7 bis, Avenue de la Paix
CH-1211Geneva
Switzerland
Tel: 41-22-730-8246
Fax: 41-22-730-8036
E-mail: Carson_D@gateway.wmo.ch

Mr. Christian Depraetere
Institut de Recherche pour le Developpement
01 BP 4414
Recette Principale Cotonou
République du Bénin
Tel: 229-33-66-49
E-mail: ird@bow.intnet.bj

Professor Pedro Leite Silva Dias
University of Sao Paulo-USP
Instituto Astronomico e Geogisico-IAG
Departamento de Ciencias Atmosfericas
Rua do Matao, 1226
Sao Paulo/SP 05508-990
Brazil
Tel: 55-11-818-4713
Fax: 55-11-818-5034
E-mail: pldsdias@model.iag.usp.br

Ms. Dawn Erlich
International GEWEX Project Office
1010 Wayne Avenue
Suite 450
Silver Spring, MD 20910
USA
Tel: 1-301-565-8345
Fax: 1-301-565-8279
E-mail: gewex@cais.com

Professor Reiner A. Feddes
Wageningen Univ. Dept. & Groundwater Mgmt
Sub-dept. Water Res. Nieuwe Kanaal 11
Room 218, Bodenummer 82
6709 PA Wageningen
The Netherlands
Tel: 31-317-48-2875/2293
Fax: 31-317-48-4885
E-mail: reinder.feddes@users.whh.wau.nl

Dr. Tobias Fuchs
Global Precipitation Climatology Centre
Deutscher Wetterdienst (DWD)
Frankfurter Str. 735
CH-63067 Offenbach/Main
Germany
Tel: 49-69-8062-2872
Fax: 49-69-8062-3759
E-mail: tobias.fuchs@dwd.de

Dr. Hartmut Grassl
Max Planck Institute fur Meteorology
Bundesstrasse 55
D-20146 Hamburg
Germany
Tel: 49-40-41173 225
Fax: 49-40-41173-350
E-mail: grassl@dkrz.de

Mr. Alan Hall
IAHS/WMO GEWEX Working Group
17 Crisp Street
Cooma NSW 2630
Australia
Tel: 61-2-6452-1920
E-mail: hallalan@acr.net.au

Dr. Holger Hoff
Potsdam Inst. for Climate Impact Research
International BAHC Project Office
Telegrafenberg
D-14473 Potsdam
Germany
Tel: 49-331-288-2543
E-mail: Holger.Hoff@pik-potsdam.de

Dr. Paul R. Houser
NASA/Goddard Space Flight Center
Hydrogical Sciences Branch, Mail Code 974
Greenbelt, MD 20771
USA
Tel: 1-301-614-5772
Fax: 1-301-614-5808
E-mail: Paul.Houser@gsfc.nasa.gov

Mr. Yasuyuki Ito
NASDA/Earth Observation Research Center
ADEOS-II Science Proj. Mgr.
Triton Square Tower-X, 23rd Floor
1-8-10 Harumi, Chuo-ku
Tokyo 104-6023
Japan
Tel: 81-3-6221-9000
Fax: 81-3-6221-9191
E-mail: yito@eorc.nasda.go.jp

Dr. Pavel Kabat
ALTERRA Green World Research,
Wageningen UR
Climate Change and Biosphere Programme
Droevendaalsesteeg, P.O. Box 47
NL-6700 Wageningen AC
The Netherlands
Tel: 31-317-474314
Fax: 31-317-424812
E-mail: P.Kabat@Alterra.wag-ur.nl

Dr.Toshio Koike
University of Tokyo
Dept. of Civil Engineering
7-3-1, Hongo
Bunkyo-ku
Tokyo 113-8656
Japan
Tel: 81-35841-6106
Fax: 81-35841-6130
E-mail: tkoike@hydra.t.u-tokyo.ac.jp

Mr. Richard Lawford
NOAA/OGP
GAPP Program Manager
1100 Wayne Avenue, Suite 1210
Silver Spring, MD 20910
USA
Tel: 1-301-427-2089, ext. 146
Fax: 1-301-427-2222
E-mail: lawford@ogp.noaa.gov

Dr. Dennis Lettenmaier
University of Washington
Department of Civil Engineering
Box 352700
164 Wilcox Hall
Seattle, WA 98195
USA
Tel: 1-206-543-2532
Fax: 1-206-685-3836
E-mail: dennisl@u.washington.edu

Dr. Michael J. Manton
Bureau of Meterological Research Center
GPO Box 1289K
Melbourne, Victoria 3001
Australia
Tel: 61-3-9669-4444
Fax: 61-3-9669-4660
E-mail: m.manton@bom.gov.au

Dr. Jose A. Marengo
CPTEC/INPE
Rodovia Dutra Km 40
CEP 12630-000 Cachoeira Paulista
Sao Paulo CEP 12630-000
Brazil
Tel: 55-12-560-8464
Fax: 55-12-561-2835
E-mail: marengo@cptec.inpe.br

Dr. Lawrence Martz
University of Saskatchewan
Dept. of Geography
9 Campus Drive
Saskatoon, SK S7N 5A5
Canada
Tel: 1-306-966-5667
Fax: 1-306-966-5680
E-mail: martz@sask.usask.ca

Dr. Thomas Maurer
Global Runoff Data Centre (GRDC)
Federal Institute of Hydrology (BfG)
Am Mainzer Tor 1
D-56068 Koblenz
Germany
Tel: 49-261-1306-5224
Fax: 49-261-1306-5280
E-mail: thomas.maurer@bafg.de

Dr. Carlos R. Mechoso
University of California, Los Angeles
Dept. of Atmospheric Science
7127 Math Sciences Building
405 Hilgard Avenue
Los Angeles, CA 90095-1565
USA
Tel: 1-310-825-3057
Fax: 1-310-206-5219
E-mail: mechoso@atmos.ucla.edu

Dr. Carlos Nobre
CPTEC-INPE
Rod. President Dutra, Km 40
Case Postal 01
C. Paulista, SP 12630-000
Brazil
Tel: 55-12-561-2890
Fax: 55-125-61-2835
E-mail: nobre@cptec.inpe.br

Dr.Taikan Oki
University of Tokyo
Institute of Industrial Science
4-6-1 Komaba, Meguro-ku
Tokyo 153 8505
Japan
Tel: 81-3-5452-6382
Fax: 81-3-5452-6383
E-mail: taikan@iis.u-tokyo.ac.jp

Dr. John Roads
Scripps Institution of Oceanography
Climate Research Division
UCSD, 0224
La Jolla, CA 92093-0224
USA
Tel: 1-858-534-2099
Fax: 1-858-534-8561
E-mail: jroads@ucsd.edu

Dr. Burkhardt Rockel
GKSS Research Centre
Max Planck Strasse
D-21502 Geesthacht
Germany
Tel: 49-4152-87-2008
Fax: 49 4152-87-2020
E-mail: rockel@gkss.de

Dr. John C. Schaake
NOAA/NWS/(W/OH)
1325 East West Highway
Silver Spring, MD 20910
USA
Tel: 1-301-713-1660
Fax: 1-301-713-0963
E-mail: john.schaake@noaa.gov

Dr. Soroosh Sorooshian
University of Arizona
Hydrology and Water Resources
Harshbarger Bldg. 11
Tucson, AZ 85721
USA
Tel: 1-520-621-7122
Fax: 1-520-626-2488
E-mail: soroosh@hwr.arizona.edu

Dr. Ronald E. Stewart
Meteorological Service of Canada
Climate Processes and Earth Observ. Div.
4905 Dufferin Street
Downsview, Ontario M3H 5T4
Canada
Tel: 1-416-739-4122
Fax: 1-416-739-5700
E-mail: Ron.Stewart@ec.gc.ca

Professor Akimasa Sumi
University of Tokyo
Center for Climate System Research
4-6-1, Komaba, Meguro-ku
Tokyo 153
Japan
Tel: 81-3-5453-3951
Fax: 81-3-5453-3964
E-mail: sumi@ccsr.u-tokyo.ac.jp

Dr. Andras Szollosi-Nagy
International Hydrological Programme
Division of Water Sciences
UNESCO
1 rue Miollis
75732 Paris Cedex 15
France
Tel: 33-1-45-68-40-02
Fax: 33-1-45-68-58-11
E-mail: a.szollosi-nagy@unesco.org

Dr. Javier Tomasella
INPE/CPTEC
Rod. Presidente Dutra, Km 40
12630-000 Cachoeira Paulista
Brazil
Tel: 55-12-560-8461
Fax: 55-12-561-2835
E-mail: javier@cptec.inpe.br

Dr. Paul Try
International GEWEX Project Office
1010 Wayne Avenue
Suite 450
Silver Spring, MD 20910
USA
Tel: 1-301-565-8345
Fax: 1-301-565-8279
E-mail: gewex@cais.com

Dr. Shourong Wang
China National Climate Center
Deputy Director
Baishiqiao Road, 46
Beijing 100081
China
Tel: 86-10-62170353
Fax: 86-10-62176804
E-mail: wangsr@rays.cma.gov.cn

Dr. Martha Whitaker
University of Arizona
Dept. of Hydrology and Water Resources
J. W. Harshbarger Bldg.
P.O. Box 210011
Tucson, AZ 85721-0011
USA
Tel: 1-520-626-2972
Fax: 1-520-626-1422
E-mail: mplw@hwr.arizona.edu

Mr. Steve Williams
UCAR/JOSS
P.O. Box 3000
Boulder, CO 80301
USA
Tel: 1-303-497-8164
Fax: 1-303 497-8158
E-mail: sfw@ucar.edu

Dr. Eric Wood
Princeton University
Dept. of Civil Eng. & Operations Research
Princeton, NJ 08540
USA
Tel: 1-609-258-4675
Fax: 1-609-258-1270
E-mail: efwood@princeton.edu

Dr. Dawen Yang
Assistant Professor
University of Tokyo
7-3-1 Hongo, Bunkyo-ku
Tokyo, 113-8656
Japan
Tel: 81-3-5841-6139
Fax: 81-3-5841-6130
E-mail: dyang@hydra.t.u-tokyo.ac.jp

Professor Tetsuzo Yasunari
Institute of Geoscience
University of Tsukuba and FRSGC
Tennodai 1-1-1
Ibaraki, Tsukuba 305-8571
Japan
Tel: 81-298-53-4399
Fax: 81-298-51-9764
E-mail: yasunari@atm.geo.tsukuba.jp