TABLE OF CONTENTS

REPORT OF THE MAIN ISSUES, ACTIONS AND RECOMMENDATIONS FROM THE SIXTH SESSION OF THE GEWEX HYDROMETEOROGY PANEL (11-15 SEPTEMBER 2000, ANGRA DOS REIS, BRAZIL)

1.0 INTRODUCTION

The GHP was formed to improve the collective contribution to the global requirements of GEWEX, of the five most comprehensive GEWEX Continental-Scale Experiments (CSEs) namely, GCIP (Mississippi River Basin), BALTEX (Baltic Sea region), MAGS (Canadian Mackenzie River Basin), LBA (Amazon region) and GAME (Asian monsoon region). The goals for the sixth meeting of the Panel 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. Specifically, breakout sessions were established to determine the steps necessary for GHP to achieve, by 2005, significant improvement in the simulation of water and energy fluxes and reservoirs over land on diurnal to annual temporal scales as well as the prediction of these on temporal scales up to seasonal and better understand their physical transport mechanisms and their possible physical connections and to document the seasonal advance of the monsoon system.

A series of technical presentations was made on topics which covered research of relevance to the global hydrological issues being promoted by the World Climate Research Programme (WCRP), Global Energy and Water Cycle Experiment (GEWEX). A focused workshop on the status of the GHP, Water and Energy Budget Study (WEBS), was held on the first day of the meeting. Additional time was given to the status of the GHP Water Resources Application Project (WRAP). Each CSE updated their implementation status and the GHP working group set up to plan the GHP/GEWEX Co-ordinated Enhanced Observing Period (CEOP) reported on its progress. Discussions were also undertaken to refine further actions required to ensure a successful CEOP process.

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 Satellite Land-Surface Climatology Project (ISLSCP); the International Association of Hydrological Sciences (IAHS); the National Climate Research Program of Korea; the limited international regional study, designated CATCH in West Africa; the Global Precipitation Climatology Project (GPCP); the Global Precipitation Climatology Center (GPCC); the GEWEX Global Land-Surface/Atmosphere System Study (GLASS); and others. The work of the GHP Working Group on Data Management was also reviewed.

Dr S. Sorooshian, Chairman of the GEWEX-Scientific Steering Group (SSG) characterized the main science and implementation questions for GHP in terms of the key uncertainties facing GEWEX and the broader WCRP climate research community. These questions include whether the global hydrological cycle is accelerating, the extent to which models can reproduce extreme events such as floods and droughts, the ability of models to describe the diurnal cycle (e.g. of precipitation), the process for evaluations that go from the global scale down to the regional scale, especially how downscaling to smaller grid scales can be adapted to with current parameterization formulations and how these factors impact the process and need for GHP to close the water and energy budgets over the CSE regions.

Milestones, which Dr Sorooshian concurred should be set for GHP, that should be attainable in the context of the next phase of GEWEX, included sufficient point measurements necessary for model validations at local scales within each CSE, establishment of basin budgets from large scale diagnostics (monthly/annual) that would lead to a characterization of diagnostic water and energy budgets for each CSE, assessment of model capabilities to simulate water and energy budget variables at all relevant space and time scales for each CSE and the application of GEWEX deliverables to evaluate reanalysis products, confirm the Water Energy Budget Study (WEBS) results including, with the support of the GEWEX Radiation Panel (GRP), the quantification of fluxes to within 10 W/m^2. The action was also accepted to document these plans in an article suitable for publication in the Bulletin of American Meteorology (BAMS) or similar journal in 2001.

Dr Sorooshian also confirmed that the central challenge for the second phase of GEWEX is the exploitation of the new and more diverse measurements of the new Earth Observing System platforms and the application of our improved understanding of regional processes derived from the GEWEX Continental-scale Experiments (CSEs) to the global applications needed to improve climate prediction capabilities. Dr Sorooshian also noted that to accomplish this work, GHP must take the lead in promoting the participation of the hydrological modeling community and supporting operational environmental services in their efforts to develop improved and more accurate hydrometeorological predictions.

In addition to the outcome of the WEBS workshop and the specific results of focused discussions associated with the CEOP that are summarized in Items 4.0 and 5.0 respectively, the following actions/recommendations were addressed at the meeting:

GHP agreed to undertake a joint activity with GPCP to validate new high space/time resolution, regional scale, GPCP precipitation estimation products prepared for each CSE. This effort should be defined in sufficient detail to be presented to the GEWEX SSG for their endorsement, by the GHP Chair.

A presentation on a new regional scale project in the La Plata river basin in south eastern Amazonia was made to the GHP. This effort may be undertaken as a joint GEWEX/CLIVAR experiment but this decision can not 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. The GHP Chair will make the appropriate presentation to the GEWEX SSG.

The GHP was informed that due to special national considerations the availability of Geostationary satellite data from the USA GOES-8 has been restricted below 20 degrees south. These restrictions are limiting the use of this data for the LBA and other climate research initiatives in the region. These limitations are restricting the ability of researchers to achieve their goals and are, thereby, impacting the potential advancement of knowledge important to the global objectives of WCRP/GEWEX. The GHP agreed to raise this issue with the GEWEX SSG and to seek a recommendation for a letter to be signed by the Director of the WCRP asking that consideration be given to reducing the restrictions to the extent possible to accommodate the on-going research at least during the CEOP time period.

The GHP agreed to form a working group to consider issues related to the role of the Carbon Cycle in GEWEX relevant research. Dr Carlos Nobre agreed to assist in the organization of this working group until a permanent Chair can be found. Each CSE agreed to nominate a representative to support the work of the group. Dr Lawford will present the terms of reference of the working group to the GEWEX SSG and seek their endorsement to go forward with the proposed work.

The GHP was informed that funding for the BALTEX Meteorological Data Center will be phased out by the end of 2001. The GHP Chair agreed to coordinate, with the support of the WCRP Joint Planning Staff, the drafting of a letter endorsing the continuation of the Center beyond the end of 2001 and up to at least the end of the CEOP time period. It was recommended that the GHP Chair present the letter to the GEWEX SSG with the intent of obtaining their endorsement and having the SSG Chair sign the letter on behalf of WCRP/GEWEX.

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

2.0 STATUS REVIEW

Dr R. Stewart, GHP Senior Scientist, 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.

2.1 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 2000. 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"

2.2 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 Senior Scientist of any updates to the matrix in the time leading up to the next GHP meeting.

3.0 INDIVIDUAL STATUS SUMMARIES

3.1 MAGS Status Summary

OBJECTIVES/STRATEGY: The goals and objectives of 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.

A major development in the MAGS program strategic plan over the past year has been has been a confirmation to extend the research program into a second, five-year phase. The University research component of this program has secured financial support through the Natural Science and Engineering Research Council of Canada and Environment Canada has committed to support the government research component into its second stage. A number of other industrial and stakeholder partners have also committed to support MAGS-2 program in various ways.

Underlined means checked by CSE

TECHNICAL/LOGISTICAL CRITERIA	GCIP	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.	I-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.	P	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.	Pr	Pr	Pr	B	Pr	N/A
3.) Determine and understand climate system variability and critical feedbacks.	Pr	Pr	Pr	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.	B-Pr	B-Pr	B	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 2000)

STATUS STATEMENT: At each annual MAGS workshop, a brief summary statement is prepared on the status of MAGS. In November 1999 it was noted that All components of the overall strategy continue to progress. In particular, special measurements were made of many critical atmospheric, surface and hydrological parameters during CAGES. Basin scale coupled hydrological-surface models have been run and deficiencies in our overall modelling capability are being identified. The first collective study of a full water year is nearing completion. As well, data products are being produced and are being utilized, and a collective CAGES analysis strategy is being developed. A plan is also being prepared to bring the first phase of MAGS to a successful conclusion.

SCIENTIFIC ISSUES/RESULTS: A synthesis of MAGS-1 was developed for the MAGS November 1999 Workshop by Drs Wrona and Spence. Their report contained the following points related to the issues and results coming from work undertaken as part of the MAGS effort. The objectives of the first phase of MAGS were to quantify the major processes affecting the water and energy cycles of the Mackenzie River Basin (MRB), to assess the relative importance of various high latitude processes, to develop datasets for model parameterization, and develop a framework for coupling the models required to reproduce the observed transport of moisture and energy into and through the basin on monthly and longer time scales.

Cold climate processes have been a key focus. A variety of studies have characterized the MRB moisture properties, identified major moisture sources including strong moisture transport by synoptic systems and summertime evapotranspiration, examined orographic influences, and documented its interannual variability. Some uncertainties, including the diurnal variability and storage effects, remain to be understood and modelled. MRB is very cloudy, associated with cyclonic storms and important orographic effects. Clouds affect the climate via radiation and precipitation, and modelling deficiencies remain to be resolved in both of these areas. Since the available direct observations are not adequate to characterize the surface radiation, MAGS researchers are relying on satellite measurements and special surface measurements to help deduce the solar radiation budget. Model evaluations using these fields are revealing inadequacies to be further examined. Blowing snow is one high latitude process that has been extensively studied by MAGS researchers. Models have been developed and algorithms are available to be incorporated into land surface schemes. For examining heterogeneous land surfaces, boundary layer data sets have been compiled using ground based and aircraft measurements. Better representations of boundary layer processes have been developed for incorporation into large-scale models. Studies have also examined the variability of evapotranspiration and the role of surface wetness in controlling energy partitioning. This has resulted in improved representation in models. Another high latitude hydrology topic is the delivery of water to streams in permafrost and shield regions. Diagnoses have included meltwater infiltration, the influence of the MRB organic layer, and impacts of discontinuities in permafrost zones. Innovative techniques have been used to examine river discharge and lakes' impacts. Storage issues remain to be resolved. MRB energy and water system studies have included internal basin circulation and improving knowledge of linkages with regions outside the MRB. Anomalies in the MRB are amplified in winter and reduced in summer. There are budget imbalances to be explained.

A significant effort has also been dedicated to database development and access. This has included the compilation of available data from operational observation networks, satellites, radar and research basins, augmentation of long-term observations, surface observation enhancements, special aircraft measurements during the Canadian GEWEX Enhanced Study (CAGES), and the establishment of a data management system to maintain, describe, and provide data access.

A coupled modelling framework has also been developed for MAGS. A variety of atmospheric, land surface and hydrologic models (e.g., CRCM, GEM, MC2, SEF, CLASS, ISBA, WATFLOOD, SLURP) have been used for various process, diagnosis and observation support studies. Proof-of-concept demonstrations and prototype tests have been completed with the CRCM driven by CMC analyses over the MRB. This leaves MAGS researchers poised and ready for targeted synthesis and comprehensive studies with next generation models.

MAGS has also developed interdisciplinary linkages, with meteorologists and hydrologists working together in productive partnerships. Despite severe resource reductions in program reviews during the period of MAGS-1, these university-government partnerships have enabled significant progress towards achieving the MAGS goals. Hydrology and land-surface processes are now recognized as high priority areas in environmental prediction and related applications.

TIMELINE OF ACTIVITIES: MAGS-1 will be completed and MAGS-2 will begin on January 1, 2001. This development will allow further adjustment to the MAGS strategic science plan. During the first phase of MAGS the focus had been on enhancing data collection, management and assimilation; improving knowledge of atmospheric and hydrologic cycles and developing modelling capabilities. For MAGS phase 2 the emphasis will shift to integrating knowledge of atmospheric and hydrological cycles into a unified system; developing hierarchy of models for a range of spatial and temporal scales and applying improved predictive ability to environmental and social issues. MAGS-2 will organize its work around five themes that relate to process studies and integration; scaling of data and processes; model development and evaluation; prediction and analyses; and applications and model transfer. Under these themes work will be organized to make progress on a number of specific objectives.

3.2 BALTEX Status Summary

OBJECTIVES/STRATEGY: The aim of 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/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 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*) will be a central element in the BALTEX program in the future. It has been established as the central observational and modelling phase of the program. BRIDGE began as a six month pilot study in April 1999 and is continuing to be carried forward as a specialized observational activity. (see the BALTEX Web Page: http://www.gewex.com/baltex.html)

STATUS STATEMENT: The BALTEX program has generated an active research framework covering the whole field of advanced modelling and data studies in meteorology, hydrology and oceanography for the Baltic Sea catchment region. Of particular importance has been the progress towards the development of accurate high resolution coupled models. Preparations for BALTEX started in 1991. The BALTEX Science Plan was published in 1993 followed by the Initial Implementation Plan in 1995. The BALTEX studies have identified a number of limitations both in the observational system and in the way observations are exploited in the forecasting process. Examples of such limitations are the lack of upper-air observations over the Baltic Sea such as radiosonde and sufficient radar observations, insufficient use of available satellite data as well as insufficient integration of many observations in real-time data processing. New types of very promising observations, such as GPS-based water vapour measurements are not yet incorporated in data-assimilation and forecasting systems. The methodologies developed during BALTEX are expected to be transferred to other continental areas with similar characteristics in order to both improve global climate modelling and enhance regional-scale modelling within these areas. The two outstanding goals of the BALTEX program are to obtain better and more comprehensive observations from the entire Baltic Sea catchment area, and to develop more realistic coupled models for the atmosphere, the land surface including rivers and lakes and the Baltic Sea and sea-ice.

SCIENTIFIC ISSUES/RESULTS: Within BALTEX Modelling results from the Max-Planck Institute for Meteorology (MPI) and the Swedish Meteorological and Hydrological Institute (SMHI) have shown that parts of the water cycle and energy budgets over the region can now be modelled reasonably well. Other components need improvement. Studies using ECHAM4, T106, 0.5° resolution 10 year runs, and ECHAM4, T106, 1° resolution (AMIP) 10 year runs, driven by reanalyses from the ECMWF, when compared to observations of total

precipitation, found that although peak values did not agree well, very good agreement was found with the observed average values. The most pressing issues in modelling have been expressed to be the land surface parameterization formulations and the handling of snow (in general the model snow melts too fast, yielding "artificially" large precipitation in the spring period). The snowbelts, which are a result of convective bands over the Baltic Sea in winter time are, however, represented reasonably well, as well is the simulation of sea ice. A key BALTEX objective The development of coupled models, a key BALTEX objective, is considered to be well on its way, but will remain as a high priority goal in the future. The continuing effort will focus on a few remaining issues such as the land surface characterization and calculations of salinity intrusions into the Baltic Sea.

TIMELINE OF ACTIVITIES: 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. There are five two month EOPs between August 2000 and February 2002, which are represent the following periods/seasons: August/September for midsummer conditions, January/February for winter conditions and April/Mai representing typical conditions of the transitional phase, when snow melt takes place in the northern part of the Baltic Sea region. The Coordinated Enhanced Observation period (CEOP), has been included in the BRIDGE timeline to show the potential BALTEX contributions to this effort. Other milestones include the Third Study Conference on BALTEX, (2-6 July 2001 Aland, Finland; EGS XXVI General Assembly, (26 - 30 March 2001, Nice, France).

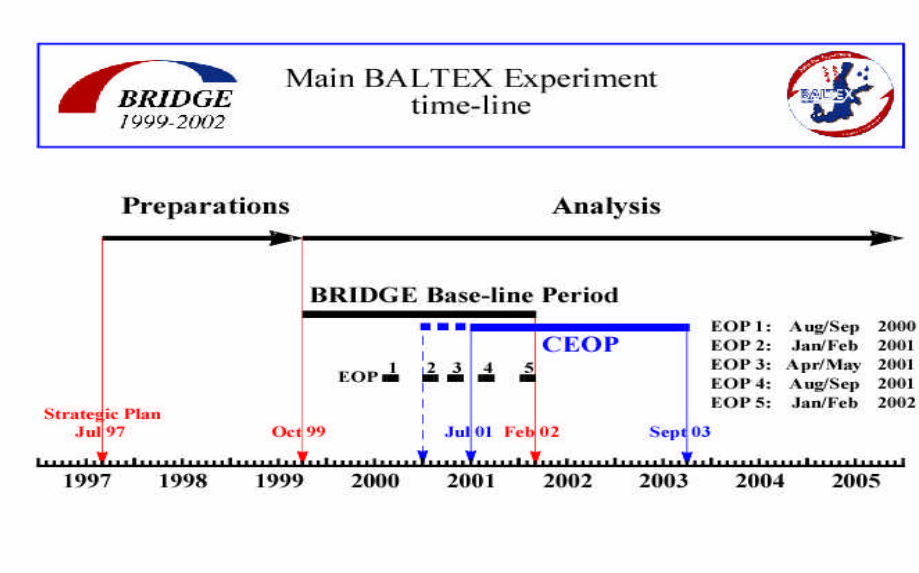

Figure 2: Timeline for the Main BALTEX Experiment (BRIDGE)

3.3 GCIP Status Summary

OBJECTIVES/STRATEGY: GCIP was initiated as a full scale five-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 STATEMENT: Most recently the focus in GCIP has shifted to an area where the modulation of the large scale atmospheric circulation by land surface processes over the entire annual cycle is being addressed. In addition, studies directed at promoting the transition from GCIP to GAPP have also been initiated, particularly as they relate to warm season rain through collaboration with the CLIVAR/PACS program. The participation of NASA in GCIP during the past 4 years has strengthened the remote sensing side of GCIP and it is hoped that NASA participation will continue through the GAPP period. GAPP is part of the US Water Cycle Initiative that is being developed under the USA Subcommittee on Global Change Research. Participation in this initiative creates opportunities to link the project to a larger scientific community and should broaden its influence and visibility. For this reason GAPP has begun to develop plans for project enhancements in the event that increased funding becomes available through the Water Cycle Initiative. For these reasons the transition from GCIP to GAPP is expected to be made without disrupting the continuity of the work now underway

SCIENTIFIC ISSUES/RESULTS: GCIP research covers a broad range of issues of importance to the objectives of GHP and WCRP/GEWEX. Reports of progress on work in many areas were given at the meeting including studies of: Large scale Circulation Controls; Local Surface Controls including Biospheric Processes, Soil Moisture, Boundary Layer Processes, Cold Season Processes, Orographic Processes, and Land Surface heteorogeneities; Clouds and Radiation; Precipitation, including Characterizing rainfall, Snow and Heterogeneity in precipitation; Data Assimilation, including Land Data Assimilation, Atmospheric Data Assimilation and Reanalysis; Model Development, including Hydrologic Models, Coupled models, Transferability studies, Understanding the Climate-Weather link, and Predictability Studies; Remote Sensing Applications; Water Resource Applications; Water and Energy Budget Studies; and Data Management. Some examples of work in these various areas include that GCIP has carried out some diagnostic studies to determine the extent to which precipitation over the Mississippi River Basin is correlated with large scale forcing. Kunkel and his colleagues have shown that the northern part of the basin has below average snowfall during intense El Nino winters. This relationship is statistically significant and applies to the Ohio and middle Mississippi Basins as well as the upper Mississippi. However, intense La Ninas do not produce as strong a signal and would be of less use in a statistical prediction approach of snowfall amounts in the upper Mississippi. The importance of transpiration processes are being documented in different vegetation regimes. Direct measurements of tree water use are being scaled up to derive the contribution of closed canopy forests to local and regional water balances. A comparison of these sapflow estimates of transpiration and eddy correlation measurements of transpiration indicate that 1) the sapflow measurements and transpiration estimates are highly correlated indicating that they are being forced by the same synoptic factors, and 2) the sapflow transpiration estimates are half as large as the actual estimates. Drought conditions were found to have reduced canopy conductance and were positively correlated with increases in the Lifting Condensation Level (LCL). Transpiration rates vary between conifers, early successional hardwoods and upland hardwoods. As an example of how researchers are using data from the various CSEs, analyses of boundary layer conditions over various areas (GCIP, BOREAS/ MAGS, and LBA) has led to the development of a generalized conceptual model of boundary layer development over land surfaces. According to these analyses, for a given vegetative resistance, mixing layer cooling increases as the sensible heat flux increases and latent heat flux increases as the surface moisture forcing (determined by soil moisture and vegetation) increases. In addition surface and mixing layer forcing determine the depth of the boundary layer, although they do not affect significantly the potential temperature of the boundary layer and its specific humidity. GCIP/GAPP continues to place an emphasis on the modeling of snow and frozen ground processes. As a result of the cold seasons work in the upper Mississippi River Basin, data sets have been developed that allow modelers to incorporate snow more effectively in these models. These improvements are benefiting both climate and numerical weather prediction modeling. A plethora of snow models exist, each with their individual strengths and weaknesses. A model known as VISA (Versatile Integrator of Snow Atmosphere processes) has been developed by Yang and his colleagues for use with the CCM3. This model, which includes snowfall, rainfall, frost formation, sublimation on the snow surface, and snowmelt through the bottom of the pack,

is able to simulate a range of snow parameters (e.g., snow density, snow water equivalent). The VISA model appears to provide better results during the snow accumulation period, particularly at high latitudes, but poorer results during the snowmelt period. More information about studies being undertaken as part of GCIP/GAPP can be found at the GCIP home page at http://www.ogp.noaa.gov/mpe/gapp/index.htm.

TIMELINE OF ACTIVITIES: The GAPP Science Plan and Implementation Strategy is currently being finalized. Work will begin on the GAPP Implementation Plan in the near future. Details of this plan will be discussed at the next GCIP/ GAPP PIs meeting in the spring of 2001. A data management committee is being established for GAPP and a scientific steering committee will be established in the near future. In the meantime, a call for proposals has been issued and GAPP related research projects will begin in 2001. A preliminary time table for the implementation of different components of GAPP is outlined below.

	2001 /	2002 /	2003 /	2004 /	2005 /	2006 /	2007 /
Land Memory Processes	XXXXXXXXXXXXXXXXXXX						
NAME Field Experiment			XXXXXXXXXX				
NAME Modeling	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX						
NAME Diagnostics	XXXXXXXXX				XXXXXXXXXXX		
Orographic Diagnostics		XXXXXXXXXXXXXXXXXXXX					
Orographic Field Studies					XXXXXXXXXXX		
CEOP Reference Site	XXXXXXXXXXXXX						
Transferability Studies			XXXXXXXXXXXXXXXXXXX				
Prediction System (Reg)	XXXXXXXXXXXXXXXXXXX						
Prediction System (Global)				XXXXXXXXXXXXXXXX			
Hydrology/ Water Resources	XXXXXXXXXXXXXXXXXXXXXXXXXXXXX						

3.4 GAME Status Summary

OBJECTIVES/STRATEGY: Understanding of the role of the Asian monsoon in the global energy and water cycle remains the main thrust of 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-T), 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 monsoonal region.

STATUS STATEMENT: The main issue associated with further development of GAME is the recommendation from the GAME International Science Panel that endorsed the pending decision for Japan to end the first phase of GAME in 2002 and begin a GAME phase II. This process would shift the emphasis of GAME from enhancement of data collection, management and assimilation; improvement of the characterizations of atmospheric and hydrologic cycles and advancement of modelling capabilities. For GAME phase II (2002-2003/4) the focus will be on applying improved analysis methodologies that rely on advanced information technology (IT) techniques to enhance the integration of knowledge of the unique atmospheric and hydrological characteristics of the monsoon into a unified system; development of model schemes for a range of spatial and temporal scales and applying improved predictive ability to meet the primary goal of GAME. At the same time, a GAME follow-on activity is being proposed that would build on the heritage of the GHP CSEs, including GAME, and will contribute directly to the CEOP. This new initiative is being designated the Coordinated Asian Monsoon Experiment (CAMP). CAMP is expected to be the Asian/Australian region component of CEOP. CEOP/CAMP will at least cover the 2001-2003 time period.

SCIENTIFIC ISSUES/RESULTS: 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 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 in 2001. The GAIN-Hub http://gain-hub.mri-jma.go.jp provides accesses to these products. New results from the GAME Radiation Group have shown that variability of cirrus distribution in East Asia has a significant impact on the radiative forcing in the region which is not well understood. The average distribution was discerned and mapped. Variational patterns in cirrus in the region, which may correlate with the on-set of ENSO phenomenon are being studied. The downward solar flux in the region was also found to have a large year to year variation. Ground based results were also compared with satellite derived values of radiative flux at the surface. The satellite derived values compared well with the ground observations on clear days but not on cloudy days. These differences were found to be mainly due to the assumed optical thickness and cloud amount used in the calculations. These studies will be carried forward into CAMP and GAME-II.

A decision has also been made to continue studies in the GAME-Tropics (GAME-T) region. The second phase of this work has been designated GAME-T2. The GAME-Tropics (GAME-T), which will end in 2001, has improved the quantitative monitoring of vapor flux, precipitation, evapotranspiration, radiative flux, and their seasonal, intra-seasonal, and interannual variation in the south-east Asia region. The data monitoring network set in place for this effort will be retained as a contribution to CEOP/CAMP and GAME-II. In addition a greater focus will be place on water resources and agricultural issues, including flood forecasting, monsoon prediction and impacts of land use changes on regional climate. Utilization of satellite data will also be emphasized to enhance contributions to understanding global climate issues. The next GAME-T workshop is planned for March 2001 in Thailand.

In the GAME-HUBEX study, heat and moisture budgets were calculated using NCAR/NCEP reanalysis data and precipitation data provided by Chinese researchers in the region. The HUBEX Regional Data Assimilation System (RDAS) was also developed by the Chinese investigators. Observational data from the GTS, the HUBEX IOP and the Chinese National Satellite Center were assimilated and the RDAS was tested for a heavy rainfall event observed during the June I998 IOP.

Observations in the GAME-Tibet region of the central Tibetan plateau are continuing to be taken and analyzed by six teams of Japanese and Chinese researchers. The Installation of Automated Weather Stations (AWSs) has continued along with a boundary layer tower, soil moisture and temperature sensors, and a three dimensional Doppler Radar. Intensive observational periods were also conducted as a contribution to GAME-I objectives.

The GAME-Siberia sub-project team is concentrating on the observation of the land - atmosphere interaction in three regions of Siberia marked by tundra, plain taiga, and mountain taiga. The Lena River, which has its source in the mountain taiga area and subsequently flows through the tundra and plain taiga areas, is also under investigation in the GAME Siberian study region. A GAME-Siberia 2000 IOP was carried out from April to June 2000, along the River, in an 80x40km area north of Yakutsk. Three forest towers and a few grass land masts were involved on the ground and mean meteorological, flux, isotopic and carbon measurements were made from aircraft over a 9 day period. Enhanced radio-sonde soundings were also taken at four sites. The data are being analyzed and prepared for use in model studies of the area and the results are to be presented at the Third International Workshop on Water and Energy in Siberia and GAME (15-16 March 2001, near Tokyo, Japan).

TIMELINE OF ACTIVITIES: The first phase of GAME will end and a GAME phase II will begin in 2002. GAME phase II is expected to extend for the period 2002-2003/4. A release of data from the GAME reanalysis project is due in 2001. The first phase of the GAME Tropics study will end in 2001 but a second phase of monitoring and analysis will be continued in the context of GAME II. The next GAME-Tropics workshop is planned for March 2001 in Thailand. The Third International Workshop on Water and Energy in Siberia and GAME has been schedule for the period 15-16 March 2001, near Tokyo, Japan.

3.5 LBA Status Summary

OBJECTIVES/STRATEGY: LBA wants to determine how Amazonia currently functions as a regional entity and how will changes in land use and climate 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. The objectives of LBA are to:

(i) quantify, understand and model the physical, chemical and biological processes controlling the energy, water, carbon, trace gas, and nutrient cycles found within Amazonia and to determine how these link to the global atmosphere;
(ii) quantify, understand and model how the energy, water, carbon, trace gas and nutrient cycles respond to deforestation, agricultural practices and other land use changes, and how these responses are influenced by climate;
(iii) predict the impacts of these responses both within and beyond Amazonia under future scenarios of changes in land use and climate;
(iv) determine the exchanges between Amazonia and the atmosphere of key greenhouse gases and species regulating the oxidizing potential of the atmosphere and to understand the processes regulating these exchanges; and
(v) provide quantitative and qualitative information to support sustainable development and ecosystem protection policies in Amazonia, in the context of both its regional and global functioning. More information about these points and other information about LBA can be found at the LBA home page http://www.cptec.inpe.br/lba/.

STATUS STATEMENT: 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 through during 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 also sponsoring a number of specialized training activities related to global change research as part of its outreach efforts. Short courses have been held on carbon dynamics, LBA operations and isotopic research techniques.

SCIENTIFIC ISSUES/RESULTS: 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. Recent results from the study of data collected over the basin has indicated that Amazonian forests may taking up carbon at a low but significantly important rate in terms of its impact on the global carbon budget. Some results, but given the size of Amazonia even small rates of uptake will be significant in terms of the global carbon budget. The research indicates, however, that the rate of uptake may be highly sensitive to temperature so that the region may change from being a sink to being a source of carbon with only an average temperature rise of a degree or less. Quantifying the carbon balance of Amazonia and finding out how it may respond to future climate and ambient carbon dioxide concentrations is a high priority for LBA. Moreover, all countries under the terms of the Climate Convention require information on carbon stocks and fluxes. LBA will contribute, through measurements and improved models, to make these assessments and to explore scenarios of future change. A major ground validation program, known as TRMM-LBA, is focused on the dynamical, microphysical, electrical and diabatic heating characteristics of tropical convection in the region.

Data collected in the program partly for validating products from the TRMM-LBA and WET-AMC satellite as it repeatedly overflies Amazonia. This field program is addressing several scientific objectives in the study of

tropical convection including efforts to compare the characteristics of convection in the Amazon Basin to other regions in the tropics and mid-latitudes. A special issue of Journal of Geophysical Research is to be implemented in 2001 with the first results of the TRMM-LBA and WET-AMC. Previously, initial results of those two experiments were presented in a special session of the 15th Conference of Hydrology that took place in Long Beach, California in January 2000. The first LBA Scientific Conference took place in Belen, Brazil, in June 2000, and more than 300 oral presentations and posters were discussed and special issue of a scientific journal in 2001.

TIMELINE OF ACTIVITIES: 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 (the first large Earth Observing System platform), 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. The time line for the LBA experiments coincides better with the CEOP Principal Research Phase from 2003 to 2005, than with the CEOP data collection period of 2001-2002. Finalizing the database is planned for the years 2000 and 2001. Diagnostic and predictive modeling has begun and will extend well beyond the LBA-overall time frame. See Figure 3 below for specific details about the timing of various LBA activities and their connection to CEOP and other major milestones.

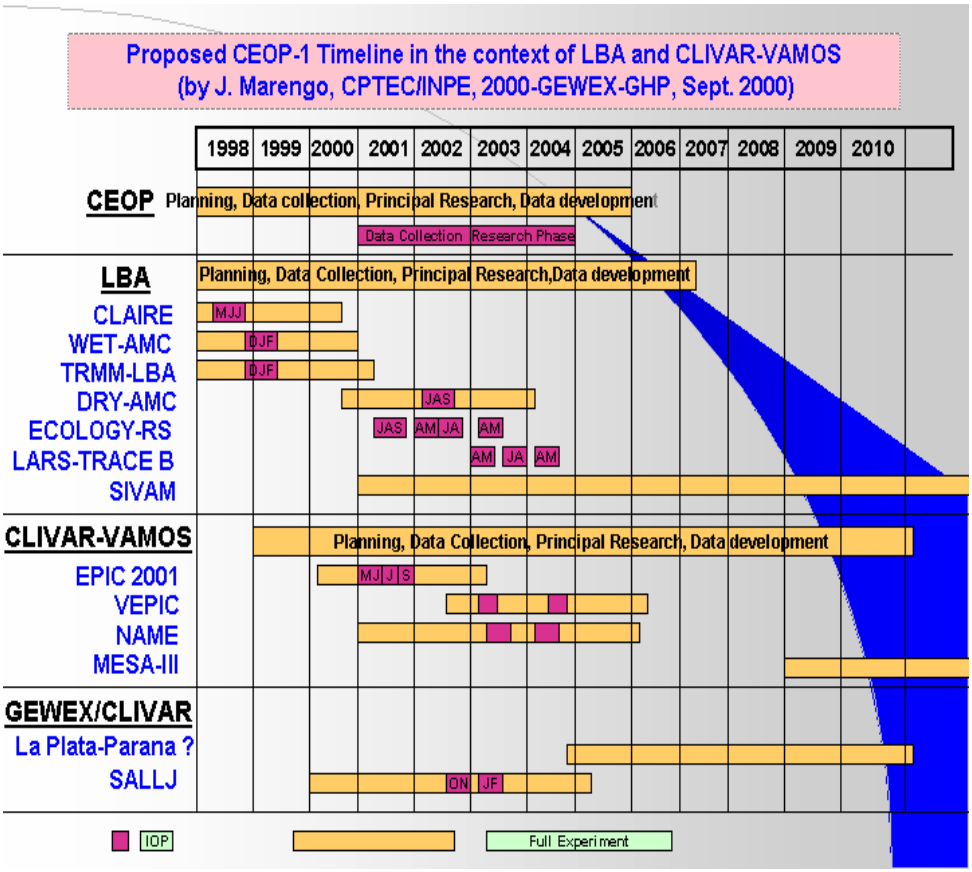

Figure 3: LBA activities and their connection to CEOP and other major milestones

As part of a special Session on LBA at the meeting other talks were given that provide more indepth information on specific study topics including the Status of Research within the Physical Climate Component of LBA by Maria Assunção Faus da Silva Dias of the Instituto Astronômico e Geofísico (IAG/USP); Aerosol Direct and Indirect Radiative Effects, and Cloud Formation Mechanisms in the LBA Experiment by Paulo Artaxo and the

LBA research team of the Instituto de Física (IF/SUP); the Status of Hydrological Studies in LBA, by Javier Tomasella of the Centro de Previsão de Tempo e Estudos Climáticos (CPTEC/INPE); and the Status of the LBA Data and Information System by Maria Victória Ramos Ballester of the Centro de Energia Nuclear na Agricultura (CENA/USP). These reports also include the LBA proposed contributions to CEOP and an overview of the status of other activities within LBA as they relate to the goals and objectives of GHP and WCRP/GEWEX. All of the reports are provided in Appendix B.

3.6 CATCH Status Summary

A special Continental-Scale Affiliate (CSA) experiment status was established for the Couplage de l'Atmosphère Tropicale et du Cycle Hydrologique (CATCH) initiative. 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. More details on the role of CATCH in GHP are given below. Other initiatives, similar to CATCH, may qualify for CSA status, such as one being proposed for the Murray Darling River basin in Australia."

The main action issues associated with GAME were for the GEWEX SSG to discuss recommending that the Director of WCRP send a letter of endorsement for the CATCH proposal, which has been made for funding from the Global Environmental Fund (GEF). The proposal for support to CATCH from GEF was made in early 2000 and no response has been given to its disposition within the GEF funding process. The GHP felt strongly that the SSG should ask WCRP to take the lead in determining the status of the proposal and working to ensure any open issues that could be blocking support for CATCH in GEF are asserted and appropriately addressed.

CATCH should take appropriate steps to gain access to satellite data sets, which could enhance its existing regional observing system. A specific contact that should be made is at the Jet Propulsion Laboratory where data over the CATCH region may be available in association with soil moisture validation sites that have been established as part of the NASA Earth Observing System (EOS) validation studies. Dr E. Enjocu at JPL was determined to be the appropriate contact person to begin with in an effort to set up the required protocol for obtaining the most useful data sets. Action is on Dr T. Label to initiate this interface on behalf of CATCH and to report the results of this effort at the next GHP meeting.

OBJECTIVES AND STRATEGY: 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 inorder 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. CATCH began by aiming to:

- Improve hydrometeorological observations over a period and a reference area sufficiently large to document properly the various interactions between the atmosphere and the continental West Africa;
- better characterise the variability modes of rainfall over the region and their impact onto the water resources variability;
- assess what are the respective roles of the ocean and of the continental surfaces in shaping the rainfall variability patterns from intraseasonal-to-decadal timescales;
- develop prediction schemes, especially those dealing with seasonal forecasting.

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 contine.

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 studing 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 regemes 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 Soudanese 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 STATEMENT: CATCH was granted CSA status (Continental Scale Associate) Project status at the 5th session of the GHP (Hamburg, 1999). This designation reflects the difficulty of organising an experiment that meets all the operational and scientific criteria defining a CSE. 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 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. A workshop was organised in Cotonou (March 2000) in order to co-ordinate the studies carried out by CATCH, IMPETUS and the national agencies on the upper Ouémé. A joint project, named H2O (Hydrometeorological Ouémé Observatory), was created. This will enhance the monitoring capacity on the catchment, regarding the atmosphere (radio sounding site in Parakou), the hydrologic cycle (rainfall and aquifer survey) and the vegetation (field measurements and remote sensing studies).

Another important milestone in 2000, was the meeting of the CLIVAR Africa Task Team (CATT), held in Southampton in February 2000. One recommendation of the CATT was to promote co-operation between GEWEX and CLIVAR, stating that "an urgent issue that the CLIVAR-Africa Panel will deal with is the need to coordinate the Coordinated Enhanced Observing Period (CEOP) activity with GEWEX". CATCH was identified as a possible site for this. The recommendations of the CATT were endorsed by the International CLIVAR Project Office (ICPO) and a CLIVAR Africa Panel was formed. The **CATCH STATUS MATRIX** shown in Appendix E summarises the status of the various components of the CATCH field program up to September 2000.

SCIENTIFIC ISSUES/RESULTS:

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 will be the first with full operation of the nominal hydrometeorological network currently in place. One aspect of the CATCH field program is to contribute to the validation of TRMM data. The set up of a TRMM validation site over West Africa could be part of the a joint European initiative that could be get underway in the near term (See the item on the *TIMELINE OF ACTIVITIES* below). The current CATCH modeling activities are associated primarily with the atmosphere and the continental hydrologic cycle. In broader terms the large atmospheric effort that was organised in conjunction with WAMP led to an improved understanding of some key elements of the West African monsoon. This baseline set of work will benefit CATCH modelling studies in the future. A validation study comparing the LMD GCM to observations taken over the CATCH region showed the difficulty such models can have in properly characterizing the rainfall regime associated with the West African Monsoon (Lebel et al., 2000). This result supports the necessity for reinforcing hydro-climate studies in West Africa. The **CATCH TABLE OF DATABASES** and the **CATCH TABLE OF MODELS AND STUDIES** shown in Appendix E provide a listing of datasets and models that can form the basis for further model studies and shows the need for additional data collection activities to augment existing records and model development and analyses.

TIMELINE OF ACTIVITIES: 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 atpmospheric 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 report on this effort will be available in 2001. Support of IMPETUS, which was funded in 2000, should also be considered a major milestone for CATCH.

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 provided in 2001.

A regional atmospheric sounding campaign (in the context of the GEF proposal) is still considered as a possibility as a contribution to CEOP in the 2001 to 2003 time period. Various international teams have expressed an interest in participating, including one from Brazil that has participated in LBA. Local meteorological services have also shown an interest to contribute, provided their personnel were instructed in the experimental protocol. Within the CATCH region both the Niamey and the upper Ouémé catchment sites will be active during CEOP the application to the GEF proposal is important to how well these sites are prepared to contribute to CEOP.

The field program on the Niamey site and on the upper Ouémé catchment are continuing to add to records that will improve the understanding of the hydrological processes and of the variability of the water balance of these two areas, which are representative of the two major components of the West-African climate (Sahelian and Soudanian respectively). The funding of IMPETUS will enable an enlargement of the experimental regeme over the Ouémé catchment in 2001. A fully integrated study of the atmosphere/land surface interactions in this area, however, will not be realized without additional measurements (fluxes/soundings). This situation will reduce any possibility of CATCH being able to document the links between the large scale atmospheric circulation and the convective scale. Even if the necessary mesurement campaign is not funded in time to support CEOP, none-the-less, there is an enhanced awareness in the region itself and in Europe that it is timely

to begin to promote hydro-climate studies in Africa. Through the WAMP European project and the CLIVAR Africa Task Team/CLIVAR Africa Panel, the coordination of these initiatives made significant progress in 2000 and the prospect for organising a large land-surface/atmospheric experiment in 3 to 4 years time has improved. None of the existing initiatives, however, have yet reached the critical size needed to contribute significantly to the CEOP or to the GHP global objectives.

3.7 Korean Enhanced Observing Period (KEOP) Status Summary

OBJECTIVES AND STRATEGY: The KEOP is an intensive field-based experiment that will follow-on from the Korean Monsoon Experiment (KORMEX). KEOP will be implemented for a three year period beginning in 2001 and ending in 2003 with a monitoring and analysis period that will over lap and extend beyond the field phase. KEOP is an experiment that will consist of intensive observational systems including upper-air, radar, satellite and drifting buoy measurements as well as long-term monitoring of radiation and related flux measurements. The data archive and application studies will start in 2002, and will continue to 2005 or longer. The objective of KEOP is to improve the prediction skill of severe weather events including typhoons, and heavy rainfall activity that are characterized by the "Changma" front monsoonal flow pattern over Korea in summer. Observations of the three dimensional atmospheric and ocean interactions will be combined with mesoscale model studies, including simulations of sea surface temperatures and winds, to better understand the dynamical and physical mechanism of the effects of the monsoon in Korea as associated with the Changma phenomena and to improve its prediction. The experiment will also be advanced through the development of a KEOP data center that will act as a link between the observing network and the scientific research community as well enhancing collaboration with other international programmes such as the Coordinated Asian Monsoon Project (CAMP) and others. The main goals of KEOP are to establish a temporary intensive field-based observational network to gather information on the typhoons and other severe weather events during the summer season, to produce high-resolution observational data sets suitable for initialization of typhoon track prediction models and to establish a long term 3-D observational network based on remote meteorological monitoring stations. Integration of satellite data into the analysis schemes is being set as a major part of experiment.

STATUS STATEMENT: Based on work already carried out in the context of KORMEX an initial short term Intensive Observing Period (IOP) is being established using aerosonde, autosonde, and radiosonde observing techniques with collection of radar and drifting buoy observations. Connections with GAME and CAMP have been established and cooperation with the China has been initiated to ensure coverage over the east China Sea. Better quality atmosphere and land-surface data assimilation schemes are being investigated in collaboration with CEOP as a way to maximize the application of satellite data. Improved oceanic data are also being sought through collaboration with the ARGO network. Plans are in place for the establishment of a long term monitoring network that will provide automated collection of radiation and land and sea surface heat and moisture flux measurements.

SCIENTIFIC TECHNICAL RESULTS: KEOP has already deployed the necessary instrumentation to carry out the initial IOP and results from this effort are expected to improve prediction of typhoons including both the track and intensity of these events. An second IOP will focus on collection of high resolution SST data that can be provided in real time to assist with longer range predictions of severe events. The IOPs will be augmented by the existing operational observation networks of the Korea Meteorological Administration (KMA) and together they will provide the bulk of the meteorological and hydrological data needed for physical initialization and validation of models and for diagnostic studies. Korea is an unique region in which a dense network of meteorological stations exists including 400 AWS stations, 4 radiosonde stations, five C-band weather radars including the dual-Doppler Radar observation to produce a high resolution (100 - 101 minute, 1 km horizontal resolution) consecutive radar data. The surface radiation and flux sites are in long-term monitoring mode now. The KEOP data center will become operational and will have links with other centers in Japan and China that have developed as part of GAME, SCSMEX, TIPEX, and HUAMEX for the mutual exchange of the meteorological data. A data assimilation system also has been developed by several groups based on high resolution models.

TIMELINE OF ACTIVITIES: The Planning and Preparatory Phase of KEOP has been underway throughout 2000, with a Pre-Observation Phase schedule for the last quarter of 2000. Deployment of enhanced aerosonde and autosonde instruments was started in 2000 and will continue to be deployed throughout 2001. An initial IOP is planned for mid-2001 and a second IOP will begin in 2002 and carry over into 2003. Data collection has begun and will be carried on throughout the IOP phase which extends through 2002 and up to early 2003. Application studies will begin in 2002 and will intensify beginning in 2003 at the start of the Major

Study Phase of KEOP. This work will continue up to the end of 2005 and perhaps beyond. The first KEOP workshop is anticipated in 2001.

4.0 WATER AND ENERGY BALANCE STUDY (WEBS) WORKSHOP RESULTS

A workshop was held for WEBS on September 11, 2000 in conjunction with the GHP meeting. WEBS is a critical effort within GHP in that it drives the process whereby assessments can be made of the collective ability of the components of GHP to develop observations of basic climate variables, to simulate those observations with atmospheric and hydrologic models, to develop budgets from observations and models, and to clarify levels of uncertainty in those budgets at annual, seasonal, diurnal, interannual and longer time scales over the various continental-scale experiments of GEWEX as well as other areas. WEBS was initiated at the 1999 GHP meeting.

The workshop's specific objectives were to summarize WEBS activities within the various CSEs and other activities of GHP; to clarify the extent of to which it is possible to characterize, model and understand water and energy parameters over such regions; and to move towards syntheses of the individual and GHP-wide efforts.

4.1 LBA Progress on WEBS

There are a number of WEBS activities underway within LBA. These are associated with specific field campaigns to better observe water and energy fluxes and reservoirs and with the analysis of operational and re-analysis model information. For example, Marengo (2000) is using the NCEP re-analysis as well as observational information to characterize the annual cycle of critical water budget parameters and their variations. In general, there is presently considerable difficulty in the balancing of atmospheric motions with stream flow information, due to a considerable degree with uncertainties in the measurement of basic parameters. Plans for improved measurements over the basin should help to alleviate such uncertainties in the future.

4.2 GCIP Progress on WEBS

Many WEBS related activities are taking place within GCIP. This ranges from the development of many basin-scale observational products of critical parameters to the analysis of model products to account for these. Particular emphasis is being placed on the systematic evaluation of both high resolution regional models as well as lower resolution global models. The many individual studies that have been carried out under this general framework are currently being brought together for a comprehensive synthesis article. This effort will result in a state-of-the-art assessment of GCIP's capability to characterize, model and understand the water and energy balance over the central United States.

4.3 MAGS Progress on WEBS

WEBS related activities in MAGS span a wide range of studies from small-catchment areas of a few kilometers in horizontal scale all the way up to basin scale of the order of 106 km^2 and using a range of observational and modelling approaches. There is considerable capability to close budgets at the small scales, despite wide variations in surface conditions and the effects of variable slopes. As well, an observationally-based atmospheric balance study has been carried out in conjunction with a large scale hydrological modelling study to reduce errors. In particular for the 1994/95 water year, budget studies over the basin have been carried out using numerical weather prediction as well as regional climate models; such studies show general agreement with available measurements for some parameters but problems with others (such as orographic precipitation).

4.4 BALTEX Progress on WEBS

A number of WEBS-related studies have already been carried out within BALTEX. Examples include Heise (1996) for the atmosphere and surface and Omstedt and Rutgersson (2000) for the Baltic Sea. The first study relied upon short-range forecast information and it documented the annual cycle of the atmospheric water budget, the surface energy budget over the sea, and the atmospheric energy budget and compared these against available observation. In general, model and observational results were comparable. Omsted and Rutgersson used observations to demonstrate the close balance between the gain of the Baltic Sea by precipitation and the inflow of rivers. At the Max-Planck-Institute a water budget study over the BALTEX area was

performed where the results of 10 year runs from the global climate model and the regional model, REMO, were compared. Results show an enhancement of evaporation and precipitation by the regional model over land and the opposite over the Baltic Sea. As well, a regional model intercomparison was performed with 8 models running in various modes (assimilation, forecast and climate) and the results are presently in the process of being published.

4.5 GAME Progress on WEBS

A considerable amount of the WEBS-related activity within GAME is focused on the analysis of its major field project in 1998. This includes producing a comprehensive dataset through a special re-analysis effort by JMA and the bringing together of many observational measurements taken over many regions of Asia. Ground-based and remote sensing information has been and in general continues to be acquired to characterize water and energy balance components. Model studies are using a hierarchy from high resolution regional ones through to operational and re-analysis products.

4.6 Other WEBS Considerations in GHP

By holding a focused workshop on WEBS in conjunction with the regular GHP meeting various elements within GHP were able to illustrate their current efforts in regards to WEBS. Substantial progress is being made within the regional GHP activities to characterize individual components of the regional water and energy fluxes and reservoirs and to examine the overall budgets. An effort will be made to better collectively summarize the observational and modelling activities that are taking place within the various regions on this issue. In addition, some of the CSEs have already embarked on the production of collective scientific articles to summarize their overall capabilities to observe and model water and energy fluxes and reservoirs. It is also critical to improve the global perspective. This needs to make better use of the GEWEX and other global data products and it will also rely upon the examination of re-analysis products. Such global products will be compared against regional ones. As well, more attention will be paid towards the development and application of physically-based indices for characterization and interpretation purposes. All of these efforts will eventually be summarized within a GHP-wide article that will highlight the collective capabilities of GHP to address water and energy balances regionally and globally.

Specific actions resulting from the workshop were first to organize a follow-up Workshop in 2001 most likely in conjunction with the GHP 2001 meeting. The basis for the next workshop is to continue to evaluate the progress by the CSE's to close the water and energy budgets over their regions and to extend that work to a more generalized collective conclusion about the larger scale issues related to the global system.

The CSE points of contact agreed to carry the WEBS analyses forward in their own regions and contributing to the collective effort by providing an improved listing of the point measurements and local area models being applied to these studies, by promoting further work on the basin scale budgets obtainable from large-scale diagnostics on both monthly and annual temporal dimensions and by characterizing diagnostic water and energy budgets for each of their regions. In concert with this work an ad hoc working group made up of Drs Roads, Stewart, Yasunari and Schaake, agreed to undertake an evaluation of what options exist for climate indices, beyond existing standard cases, that could be applied in unique ways to characterize these budgets.

The CSE points of contact will also undertake to asses the capabilities of models to simulate on suitable spatial and temporal scales appropriate water budget variables and energy budget variables. This action is related to the responsibility of the CSE's to contribute to the completion of the table of models and variables presented at the meeting by Dr B. Rockel. Completion of this table will improve the understanding of the variation in approaches to WEBS being undertaken within the various CSE's. Dr Rockel agreed to coordinate the individual inputs and maintain a master matrix of the variables/models being utilized by the various CSE's in their WEBS efforts.

Other actions accepted by individuals for continuing progress on WEBS for GHP, beyond the specific requests for inputs from the CSE points of contacts, were also part of the conclusions of the Workshop. In this context Dr R. Stewart agreed to lead the effort to connect the WEBS work in GHP with the satellite data collection, integration and evaluation activities being advanced in the GEWEX Radiation Panel (GRP). This action is to ensure adequate consideration is given to the application of satellite data in the WEBS analyses. Dr Stewart also agreed to undertake the coordination of a journal article on the collective GHP WEBS initiative to be published in an appropriate scientific/technical publication. Dr J. Roads agreed to coordinate an assessment

of existing and newer re-analysis products that are being applied in WEBS by the CSE's. Reanalyses are known to be poor in reproducing some of the variables that are necessary to the WEBS effort (e.g. precipitation). An evaluation of the reanalysis products as part of the WEBS exercise is needed with each CSE being involved.

5.0 COORDINATED ENHANCED OBSERVING PERIOD (CEOP) CONSIDERATIONS

The planning for the CEOP by the GHP has been an ongoing activity by a small working group on a part-time basis. This planning has focused on a central CEOP goal 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 results of this planning are available on the Internet at URL: http://www.msc.ec.gc.ca/GEWEX/GHP/ceop.html.

The GHP agreed to focus the CEOP scientific effort within two major activities:

(i) Simulation and Prediction and
(ii) Monsoon systems.

5.1 CEOP Issues in Simulation and Prediction

The objective of the CEOP focus in this area is to use enhanced observations to document and improve the simulation and prediction of water and energy fluxes and reservoirs over land on diurnal to annual temporal time scales as well as the prediction of these on temporal scales up to seasonal (for water resource applications). The session dedicated to this theme resulted in agreement that there were a number of items of importance to the scientific community, which could be accomplished in the CEOP framework that would have an impact on simulation and prediction issues. These included that: documentation of simulation results and models at both regional and global scales could be improved; biases in modeled statistics (mean and higher modes) could be better determined; process representation (by exposing local models to different data) could be improved; initiation of both regional and global models (through LDAS and G-LDAS) could be improved; improvements and failures in prediction could be demonstrated and quantified; model transferability studies could be facilitated; a contribution to improved water resource prediction (ULA, LDAS, G-LDAS) could be made; and new participation, products and funding could be found in support of these activities.

With agreement that this list of accomplishments was achievable the discussion centered on what the implementation strategy for their attainment. The main steps included efforts to build greater involvement of both the meteorological and the hydrological modeling community in CEOP. It was felt this could be done, in the short term by first working with the GEWEX Modeling and Prediction Panel (GMPP) and the Working Group on Numerical Experimentation (WGNE) on issues of mutual interest in the CEOP framework and secondly by holding a CEOP Workshop that brings the broader community of observationists, process study implementors and modelers together. In the process of carrying through with these actions it was noted that it would be necessary to specify what CEOP will provide to other entities (GEWEX, Panels, CLIVAR, etc.) and the data needed by CEOP from these groups. These requirements were formulated to be that all relevant GEWEX global data sets must be updated to include the CEOP period (including the ISLSCP Initiative II data sets). The update process would require that CEOP specify the data products needed, that high resolution sub-sets of the data would be necessary and that the products would have to incorporate validated global model outputs. The specifications to meet these CEOP needs were stated to be:

(i) High resolution regional model datasets based around monsoon regions as well as other energy sources and sinks to the atmosphere;
(ii) Model Location Time Series (Molts) around basins and areas relevant to CEOP questions; and
(iii) Validate the low-resolution datasets used in global models against the "high quality", high-resolution data used in CSE regional models.

The feasibility of meeting these needs would be carefully addressed in the interactions with GMPP/WGNE, which meet jointly each year and at the CEOP Workshop. The SSG will be briefed on these actions.

5.2 CEOP Issues in the Context of Monsoon Systems

The objective of the CEOP focus in this area is to document the seasonal march of the monsoon systems and better understand their physical driving mechanisms and their possible physical connections. The session dedicated to this theme resulted in agreement that there were a number of items of importance to the scientific community, which could be accomplished in the CEOP framework that would have an impact on the study of monsoon systems. These included that: the seasonal march of the monsoon systems could be documented; the driving mechanisms of the monsoon systems could be better understood; the links between monsoon systems and remote phenomena could be more closely examined; and model performance in predicting and simulating monsoon systems could be better assessed.

With agreement that this list of accomplishments was achievable the discussion centered on what the implementation strategy for their attainment. The main steps included the need to articulate a few key science issues relevant to the objective, to make use of ensemble predictions with "enhanced" IC/BC, to carry out a series of ensemble seasonal simulations with "enhanced" IC/BC and to conduct appropriate empirical (diagnostic) studies.

The GHP also agreed that the implementation of CEOP will begin with a short build-up period of about three months starting on 1 July 2001 to produce an initial seasonal data set. The Enhanced Observing Period will cover two annual cycles from 1 October 2001 through 30 September 2003. The CEOP Research Phase will begin in a formal sense with the availability of the initial seasonal data set about the end of September 2002 and continue for three years.

There was agreement that the planning for CEOP needs to be extended beyond the part-time efforts of the three person CEOP Working Group. This will be accomplished through an International CEOP Workshop, which has been scheduled to take place at the Goddard Space Flight Center, in Greenbelt, Maryland, USA from 27 February to 1 March 2001. In preparation for this CEOP Workshop, the CEOP Working Group accepted responsibility to prepare a final draft of the CEOP Science Plan by 15 November 2000 and distribute it to a large group including those participants in the planned CEOP International Workshop. The Working Group also agreed to prepare a draft of a CEOP Implementation Plan by 15 December for circulation among GHP Participants with an updated Working Draft Implementation Plan completed by 15 January 2001 for distribution to the CEOP International Workshop Participants.

The CEOP Working Group appealed for some expert help in completing the CEOP Science Plan and the Working Draft of the CEOP Implementation Plan by the scheduled dates given above. The GHP in response to this request identified a number of action items designed to contribute to the preparation of the CEOP Science Plan and the working Draft of the CEOP Implementation Plan.

Dr R. Stewart agreed to make a CEOP presentation to the GMPP/WGNE session on 23 October 2000 and to lead the efforts to prepare a Final Draft of the CEOP Science Plan by 15 November 2000. **Drs R. Stewart and B. Rockel** agreed to draft a write-up on what CEOP needs to do to facilitate transferability studies. **Dr J. Leese** agreed to give a CEOP presentation including CEOP data requirements to the ISLSCP Science Advisory Team Initiative II planning meeting from 15 to 17 November 2000. **Dr Leese** also agreed to lead the efforts to prepare a Draft of the CEOP Implementation Plan for distribution by 15 December 2000 and a revised Working Draft by 15 January 2001. **Dr R. Lawford** agreed to make arrangements for a CEOP Implementation Workshop in Washington, D.C. area early in 2001 (See note above) and to provide a draft write-up on what CEOP needs to do to aid water resource prediction via LDAS and GLDAS in conjunction with the GHP Water Resources Application Project (WRAP). **Dr T. Koike** agreed to complete the compilation of Remote Sensing Data Products for CEOP and give and appropriate CEOP presentation to the International Global Observing Strategy Partners meeting with the Committee on Earth Observing Systems in November 2000. **Dr J. Schaake** agreed to draft a write-up pertaining to a CEOP objective to determine biases in modeled statistics (means, higher modes) in both meteorological and hydrological models. **Drs D. Randall, H. Gupta and J. Polcher** were contacted to draft a write-up pertaining to the capability of CEOP to improve process representation (by exposing regional models to different data from other regions)**. Drs P. Houser and K. Mitchell** were contacted to draft a write-up for a CEOP capability to improve initiation of both regional and global models (through LDAS and GLDAS). **Drs J. Roads, D. Randall and R. Mechoso** agreed to draft a write-up for a CEOP capability to demonstrate/quantify both meteorological and hydrological model failures versus improvements in prediction.

Other actions specifically associated with the CEOP strategy for monsoon system studies were developed at the meeting. **Drs T. Yasunari, T. Lebel and H. Berbery** accepted responsibility to draft a paper,

which would articulate the science issues relevant to the Monsoon systems Studies in CEOP. **Dr J. Morengo** agreed to draft a write-up on Ensemble predictions with enhanced IC/BC and **Dr R. Mechoso** agreed to draft a write-up on Ensemble seasonal simulations with enhanced IC/BC. In addition **T. Yasunari and Hugo Berbery** agreed to draft a write-up on Empirical (diagnostic) studies.

The GHP agreed to provide the GEWEX SSG with an update of the status of the implementation of CEOP and the specific actions underway in the continuing effort to develop this activity as a major WCRP/GEWEX global initiative. The main points will be presented at the next SSG meeting to be held at Barcelona, Spain, from 29 January to 2 February 2001. The GHP will want to have the SSG's input on the current CEOP plans.

6.0 WATER RESOURCES APPLICATION PROJECT (WRAP) STATUS

6.1 Background

Recognizing that the GHP, specifically, and GEWEX, in general, need to develop stronger links with the water resource community, the GEWEX Hydrometeorology Panel, 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.

6.2 Recent Progress

A working group was established with representation from each of the CSEs and from major international water resource agencies including UNESCO, HELP, WWDR, WMO, and IAHS. The working group held its first meeting on August 29 and 30, 2000 at the International Research Institute in New York. The major recommendations from the meeting are as follows:

(i) CSEs and GHP/ WRAP will participate in regional WWDR workshops and case studies, as appropriate.

(ii) Hydrology, for Environment, Life and Policy (HELP) Project will develop mechanisms for working more closely with GEWEX.

(iii) Plans will be developed for two meetings:

- 2001 or 2002: "Applications of GEWEX products for water resource management." (Planning committee: GRDC/ GPCP rep, W. Grabs, GCIP rep, LBA rep, A. Hall, HELP rep, R. Lawford, TBD);
- 2003: Special joint WRAP workshop with IUGG/ IAHS/IAMAS on "the role of GEWEX hydrological and hydrometeorological sciences in improved water resource management." (Planning committee: Lawrence Martz (GEWEX lead), Thada Sukhapunnaphn., Bob Varady, Alan Hall (IAHS lead), Dennis Lettenmaier, Phil Graham).

(iv) WRAP will help facilitate regional workshops on water resources that are coordinated with or organized by CSEs. Where possible and appropriate, these workshops should involve other regional hydrologic expertise such as FRIEND-Asian Pacific.

(v) Each CSE is expected to undertake a "scoping diagnostic" workshop or study to define the information that is needed by water resource managers in their area.

A detailed report of the meeting is attached for further information in Appendix D. Additional progress made since the August 2000 meeting was also reported. These items included:

(i) The identification of HELP "regional shepherds" has enabled HELP to interface more effectively with some CSEs (e.g., GAPP). In addition, most CSEs have nominated HELP basins.

(ii) At least one CSE is moving forward with a scoping diagnostic study for a watershed within their boundaries.

(iii) A preliminary WRAP contribution was provided for the CEOP implementation plan.

(iv) Plans for two meetings to bring the GEWEX community together with other scientific groups and water resource managers have been developed and will be presented at the GEWEX SSG meeting.

The characteristics of these meetings were decided to be:

- First, a workshop is to be organized by GHP-WRAP in the Spring of 2002 in Europe, likely in association with another major water resource meeting. The purpose of the workshop will be to demonstrate the value of GEWEX products and to obtain feedback from the water resource community on their utility.

- A second workshop is being planned to be held in conjunction with the IUGG 2003 meeting in July 2003. 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. Lawrence Martz and Alan Hall are leading the preparations for these workshops.

6.3 Future Plans for WRAP

In addition to preparing for and hosting two major workshops, plans for the coming year in relation to progress on WRAP include, identifying a central water resource applications project in which two or more CSEs will participate, identifying permanent chair or co-chairs for the WRAP working group (at its next meeting), facilitating CSE participation in HELP and WWDR, and contributing to CEOP as required.

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APPENDIX B

LBA Reports presented during a Special LBA Session at the 6th GHP meeting

11-15 September 2000, Angra dos Reis, Brazil

1. Introduction

Among the GEWEX CSE's, LBA was the last one to start its data collection activities. They started with an IOP in January-March 1999 over SW Amazonia (Rondonia), the combined Wet Season Atmospheric Mesoscale Campaign (LBA WET-AMC) and LBA Tropical Rainfall Measuring Mission (TRMM) Validation Experiment. From September through November, a smaller campaign took place also in Rondonia to study atmospheric processes during the wet-up transition period from dry to wet season and the role of aerosols from biomass burning.

Over the last one and half years, 10 continuous monitoring sites, including flux towers for water/energy/carbon fluxes, have been established covering a range of climatic conditions and vegetations types in Amazonia. These continuous measurements will run through 2004. There are about 75 studies being carried out in LBA in all its thematic areas: physical climate, atmospheric chemistry and composition, carbon storage and exchange, biogeochemical cycles, land susrface hydrology and water chemistry, land use and land cover changes, and human dimensions.

LBA held its first scientific conference 26-29 June 2000, in Belem, Brazil. Over 260 papers were pesented and 7 thematic workshops were conducted. The conference was regarded as a success by all measures. It highlighted initial results of ongoing investigations within LBA and provided a forum to place LBA in the context of broader Amazonian and tropical ecosystems science. A second scientific conference will take place in mid-2002 in Manaus.

This report summarizes the status of some research within LBA which is more directly linked to GEWEX goals and objectives, that is, those related to water and energy cycles (section 2), aerosols and clouds (section 3), and land surface hydrology (section 4). It also reviews the status of the LBA Data and Information System (LBA DIS) in section 5. Section 6 concludes the report with the planned contributions of LBA to CEOP.

2. Status of research within the Physical Climate Component of LBA

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The activities of this component started in January 1999 with the Wet Season Atmospheric Mesoscale Campaign - WETAMC. The WETAMC was collocated with the TRMM/LBA validation campaign and was carried out in SW Amazon Basin in the state of Rondonia for just about 2 months.

Other campaigns are planned for the next few years. In July 2001 a campaign is planned for the Santarém region in E Amazon, focusing on the dry season local circulations and their impact of cloud formation. Another boundary layer experiment is planned in 2001 for the region of Manaus. Both experiments focus on the problem of upscaling the turbulent fluxes from site to regional. In September and October, 2002, a DRYAMC is planned for the Rondonia region focusing the end of the dry season and the onset of the rainy season. The possibility to have simultaneously a major chemistry field campaign (LBA Airborne Regional Source Experiment - LARS) is being explored.

The first scientific results of the first 2 years of research have already shown very distinct features of the atmospheric evolution in general of the Amazon Region and, in particular, of the cloud and precipitation regime.

The character of precipitation has been shown to vary from a very continental behavior in the beginning of the rainy season to a more maritime regime during the rainy season. But more important, during the rainy season, there is an alternation between a more maritime and more continental regime associated to large scale controls such as the presence, or absence, of large scale low level convergence provided by approaching mid-latitude frontal boundaries or even the establishment of the South Atlantic Convergence Zone. Rainfall is more continuous throughout the day and occurs also at night when a large scale forcing is present. Radar profiles indicate low reflectivities in the upper half of the troposphere and minima of lightning is detected. In the absence of large scale forcing, convective systems form in the afternoon, are more isolated, have large reflectivities above the 0°C isotherm, and lightning is observed. Large scale forcing is seen locally in the southern half of the Amazon Basin as a low level westerlies regime; while during the break periods the low level flow is dominated by easterlies. Measurements of CCN concentration during westerlies are significantly lower than during easterlies in the wet season, both being much smaller than during the dry season. Rainfall during the westerlies may contribute significantly to lower the CCN concentration. The question is then how is the CCN concentration increased during the break period? What are the sources? Advection of rich CCN air mass seems to be the less likely mechanism since in the remote regions of the Amazon Basin the air parcels have a long path trough clean air and, being the rainy season, CCN are being scavenged out. The possible role of biogenic compounds is being explored in this sense. However, from the point of view of modeling, the main question that arises is how to parameterize convection in large scale models in the two different regimes. Latent heat release peaks above the 0°C isotherm in the easterlies and below the 0°C isotherm in the westerlies. This means a different pattern of energy transfer to the atmosphere from a tropical heat source, i.e., the case of maxima of latent heat release in upper levels favors a remote influence while the release of latent heat in lower levels favors a local influence.

The effect of land cover change on cloudiness and precipitation is one of the focus of LBA. Previous studies of the Amazon had shown that during the dry season, shallow cumulus clouds form preferably over deforested areas due to enhanced sensible heat flux and low level convergence forced by local circulation between forested and deforested areas. Mixed layer heights over pasture are several hundred meters deeper than over forest. In the rainy season, preliminary results indicate that the first cumulus clouds form over the forest due to the lower albedo favoring a higher sensible heat flux early in the morning also influenced by a higher roughness length. With that, the mixed layer height is about the same in forest and pasture during the rainy season, actually as an average it is about 100 m deeper over forest. The effect of this early start of convection over forest on the rainfall regime is not known.

The upscaling of local measurements to regional estimates, especially in the case of fluxes has to rely on the mixed layer properties. In the Amazon Basin, several local measurements are made close to rivers with significant associated river breeze. The evolving mixed layer features and the associated local circulation are the tools provided by nature to upscale, during daytime. Modeling the upscaling is a focus of present research especially at night and in forested areas where the decoupling of the below canopy processes from the atmosphere above is intermittent and poorly understood. It is expected that an improvement in this area will lead to more realistic numerically simulated diurnal cycles of surface values with an impact on the evolution of the boundary layer and ultimately to the precipitation triggering mechanism.

3. Aerosol direct and indirect radiative effects, and cloud formation mechanisms in the LBA Experiment

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Large seasonal variability in the Amazon Basin are observed for the concentrations of aerosol particles, cloud condensation nuclei and trace gases. This seasonal variability is mostly caused by biomass burning emissions in the dry season (July-October). In terms of aerosol concentrations, typical wet season values are 10-15 micrograms per cubic meters ($\mu g/m^3$) for particles less than 10 micrometers, while in the dry season very high concentrations in the range of 250-400 $\mu g/m^3$ are observed over large areas in Amazonia. In terms of aerosol optical depth measure using a network of sun-photometers, background aerosol column amounts to 0.10-0.15 at 550 nanometers in the wet season. In the dry season, values of 2.5-3 are observed over large areas. Taking into account that SCAR-B (Smoke Clouds Aerosol and Radiation – Brazil Experiment) measurements shows a direct radiative forcing of -80 watts/m^2 per unit of optical depth, this high aerosol loading accounts for -200-250 w/m^2 of radiation deficit at 500 nm (Yoram Kaufman, NASA Goddard). This large aerosol direct radiative forcing has certainly an impact on the Amazonia ecosystem that still have to be addressed. Also the large atmospheric aerosol loading can be altering the precipitation regime in areas heavily impacted by biomass burning emissions. In measurements in Southeast Asia, it was observed a significant reduction in precipitation due to enhanced CCN amounts. Similar mechanisms are possibly also occurring in Rondonia and South of Para state, regions heavily impacted by biomass burning (Daniel Rosenfeld, Hebrew University, Israel). There is a possibility that the large amounts of aerosols in the end of the dry season are delaying the beginning of the wet season in Amazonia, by a few weeks. Further experiments are necessary to assess this important issue in Amazonia.

Aerosol particles act as cloud condensation nuclei (CCN), being an essential ingredient in the cloud formation mechanisms. In the wet season, very low concentrations of CCN in Amazonia, in the range of 100-150 particles per cc, possibly helps to obtain large cloud droplet sizes. In the dry season, CCN concentrations increases to 5,000-10,000 particles per cc, making these seeds easily available for the available water vapor, decreasing the cloud droplet size significantly (Andi Andreae and Greg Roberts, MPIC). Using remote sending with the NOAA-14 sensors, droplet size for the wet season was estimated at about 13 μm and in the dry season at 9 μm (Teriyaki Nakajima, University of Tokyo). Cloud reflectance is enhanced significantly as a result of this cloud droplet change. Composition of aerosol particles influences strongly their capability to nucleate cloud droplets. New founded organic compounds that are highly soluble, helping to explain the relatively high aerosol to CCN ratio. Also the predominance of biogenic coarse mode particles with large diameters (4-8 μm) makes them more efficient as cloud condensation nuclei in the wet season. There are also ideas on how the low aerosol concentrations in the wet season are responsible for the low flashing rate observed by TRMM sensors over Amazonia (Earle Williams, MIT). Natural biogenic trace gases emissions such as terpenes and other volatile organic compounds also are contributing to a fraction of CCN population.

A network of continuous ground based aerosol measurements is being operated as part of LBA. These ground based sites are in operation at Santarem (Pará state), Balbina (near the city of Manaus, Amazonas state), Alta Floresta (State of Mato Grosso) and Ji Paraná, State of Rondonia). Also a network of automatic tracking sun-photometers is in operation as collaboration with NASA Goddard as part of the AERONET network. CIMEL sun-photometers are being operated in Santarem, Balbina, Alta Floresta, Ji Parana, and Rio Branco, in the state of Acre. These sun-photometers are carefully calibrated within the AERONET quality assurance protocol, and measure every 15 minutes the aerosol optical thickness for 5 wavelengths. Also almucantar measurements are taken to derive the aerosol size distribution, and also single scattering albedo can be retrieved from the data. In parallel to the aerosol optical thickness measurements, PAR and total radiation are measured every minute with well-calibrated sensors (Brent Holben, NASA Goddard).

Remote sensing is also an important part of the aerosol-cloud studies in LBA. The use of the MODIS sensor on the Terra satellite allows a detailed cloud-screening procedure, and allows obtaining much improved aerosol products over land (Vanderlei Martins, NASA Goddard). Currently a validation program between the MODIS aerosol products and the LBA sun photometer network is under way. The MODIS simulator has flown over Brazil in 1995 and its characteristics are very well known for Amazon Basin biomass burning aerosols. Single scattering albedo, aerosol size distribution and column optical thickness are the most relevant aerosol products from MODIS to LBA. These products allow obtaining the geographical distribution and key microphysical properties of aerosol particles over the Amazon on a continuous and long-term basis.

Several intensive campaigns are being planned for LBA over the next few years, aiming to study the complex relationship between aerosol particles, clouds and radiation over the Amazon. These studies are integrated in mesoscale experiments to couple atmospheric chemical measurements such as trace gases and aerosol elemental composition with convective and mesoscale transport. Coupling with aircraft experiments is also key to cover large geographical areas, and to obtain vertical profile of key atmospheric properties. In May-June 20001, an aircraft and ground based experiment will be done in the Manaus area, aimed to measure fluxes of key trace species such as O_3 NO_2, CO_2, aerosols and CCN. In September-November 2002 a large Mesoscale experiment will study the large scale circulation and the changes on cloud properties at the transition between dry to wet season. Other large experiments such as the LBA/LARS experiment will measure the large-scale flux of greenhouse gases, aerosols and oxidants basin wide in two large airborne campaigns in 2003. The direct and indirect radiative effects of aerosols are an integral part of all these experiments.

4. Status of hydrological studies in LBA

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4.1 Macroscale Hydrological studies

Under Nasa-LBA hydromet funding, Charles Vörösmarty intends to establish a water budget closure system (WBC-LBA) for computing high-resolution water balance elements in support of the LBA campaign. The system will integrate several existing scientific tools including algorithms that produce high-resolution climatology fields, water balance and river transport models, and a recently-established GIS-based WWW-site that serves as a data repository for participating hydrometeorological agencies in South America, Central America, and the Caribbean (R-HydroNET v1.0).

The aim in developing the WBC-LBA is to produce high resolution gridded fields for precipitation, temperature and other climatic variables, evapotranspiration, soil water, drainage basin storage, runoff, and river discharge that are consistent with the observational record of data collected at hydrometeorological monitoring stations. We plan also to test runoff and convergence field predictions made by an atmospheric model (ie. the CPTEC/COLA GCM with coupled 4DDA ETA model) applied over the experimental domain. Both retrospective (1960-present) and LBA-contemporary time frames will be analyzed and the results made available to the LBA research community through the LBA-Data Information System (DIS).

Coe and Costa (NASA – hydromet) are developing a new version of HYDRA - the HYDrological Routing Algorithm, (Coe, 2000) for the Amazon. The model simulates time-varying flow and storage of water in hydrological systems including rivers, floodplains, wetlands, lakes, and human-made reservoirs. Rivers, lakes, wetlands, and floodplains are treated as a continuous hydrological network, where locally derived runoff is accumulated and then transported across terrestrial water bodies, and eventually to the ocean. The model requires the knowledge of the river or channel length, the riverbank geometric characteristics, the aquifer transmissivity, river sinuosity and cross section geometry.

Under Brazilian Funding (FAPESP) Javier Tomasella is building a hydrological model for Brazilian macro basins. The model will integrate existing meteorological, topographic, vegetation and pedological data, together with remote sensing derived products. To upscale point information into the grid scale required by the model, statistical approach will be used. Parameterization of basic hydrological processes will be based on pedological information.

The model will be use primary as a real-time monitoring tool capable to provide update information about soil moisture and river discharges, to support several economic activities related to water management. In addition, model's results will be used in off-line mode to initialize weather forecast models. To provide guidance to policy makers in planning mitigation actions, seasonal forecasts will be used in the hydrological model to try to assess the impact of extreme climatic events.

4.2 Mesoscale Hydrological study

Thomas Dunne (NASA-hydromet) is working in Rondonia trying to understand the influence of land-cover change on the streamflow of Amazonian river basins with areas of approximately 10,000 km^2. To achieve that goal, the research will try to quantify the influence of both climate and land-cover change on river flow in mesoscale Amazonian; to understand processes governing those influences; and to define the range of basin size over which land use affects the hydrology of rivers.

The results will be expressed in the form of a mathematical model, checked against the response of river flow, driven by measurements of rainfall, energy sources, and terrain characteristics, derived initially from ground-based measurements and eventually from satellites. The model will be applicable to meso-scale basins in other physiographic regions of the Amazon Basin.

4.3 Microscale hydrological funding

Under EC (Carbosink Project) and G7 funding for tropical forests conservation – PPG7 (Ecocarbon Project) funding, a microscale basins will be set up close to Manaus at the end of 2000. The main goal of the project will be to understand the carbon exchanges between soil vegetation and atmosphere on a pristine forest. The hydrological component will try to understand the main mechanisms of runoff generation on tropical basins (still poorly understood), the functioning of deep root in the dry season, and the role of interception in the partitioning of energy. The research will be crucial to conceptualize macroscale hydrological models.

5. LBA Data and Information System

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All data gathered under contributing initiatives to LBA will be made available to all other contributors to LBA as soon as possible but at least within no more than two years of the date of their original collection. By the end of the project all data will be in the public domain. LBA will produce a large and complex data set. Therefore, a data management system was created: LBA Data and Information System provides the tools for documenting, storing, searching and distributing LBA data. LBA-DIS is a simple, efficient, flexible and distributed system designed and developed to support data exchange by electronic webs. The LBA-DIS acts as a repository for all the LBA data, including satellite data, ADDA data and data from the individual science teams. The data is quality checked, rendered to a common format, and made available to the LBA community as rapidly as possible and eventually transferred to a permanent archive. To facilitate use, each data set is carefully documented and linked in the orderly framework, so that it remains useful after the project has been completed. The development and implementation of this system is the result of a collaborative effort between Brazil, EU and EC. The main feature is the Web Crawler Beija-flor, which creates the Metadata to be harvests to produce a searchable database.

The web crawler Beija-flor: An Internet-based Approach for Sharing Scientific Data in LBA

Beija-flor is the search and data sharing system that supports a truly distributed environment via the Internet. All of the data and documentation can reside with the individual data providers' servers. Basically, a researcher documents data using the LBA Metadata Editor and places the documentation file on the web to be searched by Beija-flor. Inside the documentation are links to the data files themselves, and when the user finds the data in question, getting it downloaded is a simple process of a few clicks. Beija-flor uses the Internet to form a "virtual system" interconnecting those servers. The metadata are saved in sections inside documentation files that are in HTML format. The documentation containing the metadata is automatically extracted, or "harvested", and sent to the central system at the frequency specified by the project. Using Beija-flor's Metadata Editor, the researcher can easily create the files to be harvested without knowing any HTML. When the documentation and metadata for a data set are complete, the researcher adds an entry for the new file to the locator file. During its harvest, Beija-flor will collect metadata from only the files listed in the locator file at that time. Beija-flor allows researchers to select which data sets and metadata/documentation files are visible to the world. At any time, the researcher can share a metadata/documentation files with Beija-flor, can update the file, or can stop sharing the file with Beija-flor. The researcher provides the metadata/documentation files that are shared with Beija-flor by maintaining a simple list of URLs in a text file, known as a "locator file". The locator file, metadata, documentation and data files must reside on a machine (MAC, PC, UNIX box) that is running a web server and is connected to the Internet. Beija-flor provides a low maintenance, highly distributed, user-friendly data search and retrieval system to facilitate data sharing among LBA researchers and eventually to the public.

References:
Beija-flor Search Page: http://lba.cptec.inpe.br/beija-flor
LBA Metadata Editor: http://lba.cptec.inpe.br/cgi-bin/LME/access.pl;
LBA Home Page: http://www.cptec.inpe.br/welcomei.html
(you will find the LBA project link down on the sidebar)

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6. LBA Proposed contribution to CEOP, activities and plans as of September 2000

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Background:

From the Geesthacht 1999 report, there was an agreement on the scheduling of a workshop that took place during 27 to 29 January 2000 at Honolulu, Hawaii, USA. 10. The most significant results associated with the further development of CEOP during this workshop session were the following:

1. Matching of the proposed activities given in the Working Draft with the expected contributions from the CEOP participants with particular emphasis on those from the GHP members, being LBA as one of the CSE.
2. Identifying the major activities to be planned for the CEOP Data Collection Phase in 2001-2002 along with the research activities planned during the CEOP Principal Research Phase from 2003 to 2005. More information can be found on the CEOP web site:

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

Based on this information, the following report shows the contribution of several field campaigns planned and to be implemented since 2001 as part of the science development of the LBA experiment, as well as from other field campaigns from which LBA is an integral part. For more detail on these activities it is necessary to refer to the proposed CEOP time line in the context of LBA and CLIVAR-VAMOS (Expanded/Updated September 2000) as shown in Item 3.5 above.

LBA Proposed contribution to CEOP:

An Intensive Observing Period (IOP) will be accomplished during the July to October 2002 period as part of a dry season atmospheric mesoscale field campaign in Southwest (Rondonia) DRY-AMC (reference Figure 3 in Item 3.5 above). This effort will be consistent with a wet season campaign, which has already been carried out in the same region during January-February 1999. The goal is to investigate dry and moist convective processes over differing vegetation covers (e.g. forest and pasture). Resources are being planned and phased to ensure all long-term measurements in the region will be extended throughout CEOP. At least 13 flux towers distributed across the basin will remain operational with complementary meteorological, radiative and specific soil moisture measurements collected at each site. Several of these sites are candidates to become CEOP reference sites including validation sites for satellite based remote sensing systems. By mid-2001, most of the new meteorological observational networks being deployed by the Amazon Surveillance Project (SIVAM) will be operational including 13 upper air stations (two soundings a day at 00Z and 12Z), 10 Doppler weather radars and approximately 100 automatic meteorological stations and 200 automated hydrometeorological stations (stream level and rainfall). This is a project for surveillance of the Brazilian Amazon basin, coordinated by the Brazilian Government in collaboration with the Raytheon Corporation from USA. This SIVAM project consist of a network of meteorological radars and an upgrade/implementation of radiosonde stations all across the Amazon basin.

Improved atmospheric models will be available during CEOP including those to be developed and run on a new more powerful computer system being installed at CPTEC/INPE in 2001 (NEC SX-5). The suite of models that will be available during CEOP will include the CPTEC Global model at resolution T319L40, the Eta regional model over South America with resolution of 15 km and 40 vertical levels, the Florida State University (FSU) spectral regional model over South America using a physical assimilation scheme. Additionally, the University of Sao Paulo will run RAMS with a 40 km grid over South America with a nested grid of 10 km over the SW Amazonia region. Analysis of the NCEP and ECMWF operational models will also be collected. Special efforts to collect satellite data over the LBA area will be underway during CEOP including from the existing suite of operational meteorological satellites, new research satellites (i.e., TRMM, TERRA, EOS PM1, etc.) and special earth resources satellites such as LANDSAT 7, and the Brazilian-Chinese satellite and possibly others.

From the NASA-LBA Ecology and Hydrometeorology programs, several studies involving modeling at different levels (global, regional, hydrological) and remote sensing techniques, together with observational networks in the entire Amazonia are being implemented in order to develop regional efforts to be used in the implementation of studies of aerological water balance, regional moisture and rainfall recycling, interannual variability of moisture transport with emphasis on El Niño and La Nina cases. One example is the project on **Water Budget Closure System to Support LBA Hydrometeorology and Ecology Studies,** led by C. Vorosmarty from University of New Hampshire, and J. Marengo from CPTEC. An expected product is the LBA-HydroNET system, a combination of river routing and water balances schemes, of great utility in water balances studies in both hydrological-atmospheric, and should be considering when analyzing the problem of closure of the water balance in the region.

As pointed out on the report of the **GEWEX HYDROMETEOROLOGY PANEL (GHP) WORKSHOP ON SYNTHESIS OF WATER AND ENERGY BUDGETS (13-14 SEPTEMBER 1999, GEESTHACHT, GERMANY) AND THE GHP FIFTH BUSINESS SESSION, (15-17 SEPTEMBER 1999, GEESTHACHT, GERMANY) [WMO 1999],** the main scientific focus within GHP and the underlying basis for CEOP relates to assisting GEWEX to demonstrate skill in predicting variability 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. The CEOP contribution to this effort is to better understand and model the influence of continental hydroclimatic 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.

It has been agreed that the CEOP activities planned for the 2001-2002 period should be viewed as an initial pilot activity toward achieving these goals with a more modest and focused set of objectives. A major science theme for the CEOP is the impact of land and hydrological processes on predictability and prediction on weather and climate time scales. Availability of suitable data sets for land surface process and modeling studies is an important requirement to be fulfilled to enhance the progress in this area.

One of the major objectives as discussed on Geesthacht in 1999 was the matching of the proposed activities given in the Working Draft with the expected contributions from the CEOP participants with particular emphasis on those from the GHP members. There is a need in identifying the major activities to be planned for the CEOP Data Collection Phase in 2001-2002 along with the research activities planned during the CEOP Principal Research Phase from 2003 to 2005. Figure 3 in item 3.5 above, shows the main fields activities proposed for the LBA CSE as part of the LBA research plan, and from other research efforts from which LBA is a significant component, such as the CLIVAR-VAMOS, and GEWEX/CLIVAR proposed activities. The figure in item 3.5 shows some of the previous field experiments that took place as part of LBA research: CLAIRE (1998), the WET-AMC as integral part of TRMM-LBA (1999), and the proposed field experiments of a DRY-AMC, and the ECOLOGY-RS, LARS-TRACE B for the 2001-2004 time frame. The SIVAM (Amazon Surveillance System) is scheduled to start in 2001. The time frame of this project together with the timing of the field experiments falls into the time line of CEOP.

The field components of CLIVAR-VAMOS, from which LBA is component, are listed in Figure 3 above. EPIC 2001 and VEPIC are more related to the Pacific Ocean and stratus clouds. As part of the American monsoon system, current efforts are devoted to the implementation of the field campaigns of 2002-2003 of the South American Low Level Jet (LLJ) east of the Andes, a joint effort between universities and research centers of Brazil, Argentina, USA, and hopefully Bolivia and Paraguay. This experiment is being planned under the same model of the LBA WET-AMC of 1999 is it designed to match partly the DRY-AMC in 2002 so there is a continuity in field observations to study the onset of the rainy season in Amazonia and the meridional moisture transport from the Amazon basin to southern Brazil- La Plata River basin. This LLJ feature and the field experiment themselves are extremely important since its represents the possible connections between the links of the Amazon and the La Plata river regions. For more information on the South American Low Level Jets component of VAMOS, the reader should refer to the science plan of the LLJ http://www.met.utah.edu/jnpaegle/research/sallj_imp_sman.html, and for the implementation plan of the South American LLJ field experiment, the reader is referred to he same web site. The priority activities during the CEOP Data collection Phase will coincide with the proposed LLJ field campaign dates, and it definitely will cover some of the activities and plan proposed for CEOP, and things like the following are to be discussed together with CEOP for possible matching and coordination efforts and science planning activities.

The South American LLJ and the proposed field experiment for the La Plata-Parana basin (Spanish name, in Portuguese would be Bacia do Prata) are a combination of GEWEX/CLIVAR effort, as shown in Figure 3 above, and they are designed in such a way that would take advantage of the experience and infrastructure of LBA. The LLJ would represent a conjugation of LBA (Amazonia) and La Plata-Parana, the scientific committees and panel members are being chosen at this time. A name for the La Plata-Parana basin experiment is to be chosen. All the field experiments from GEWEX (LBA among them and one of the CSEs) and the GEWEX/CLIVAR share the same main issues:

(i) Reference Site Data Sets for applications to Land/Hydrology/Atmosphere Coupling Issues.
(ii) Coupled Hydrologic/Atmospheric Model Transferability Experiments

GHP LBA Matrix of Contributions to GEWEX

As indicated in the Geesthacht 1999 [WMO 1999] report, action has been given to a special Team of Experts for CEOP Modeling to advance planning on a transferability/intercomparison experiment, which may be led by GCIP/GAPP in the Americas region. This American Transferability Experiment (AMTEX) would be developed as a contribution to CEOP. The membership of the team was confirmed at the meeting to include Drs Roads for GCIP, Rockel for BALTEX, and Oki for GAME, and MacKay for MAGS, and Nobre for LBA, and Afouda/Lebel for CATCH.

Most of the LBA proposed field activities are planed for the mid 2001-2004 time frame, while the CEOP Data Collection phase is scheduled for 2001 and 2002, which will cover the proposed DRY-AMC, the LBA Ecology campaigns, and the SALLJ, and also fall in to the SIVAM lifetime.

The GHP CSE Matrix of Contributions to GEWEX for LBA be expanded to include two additional technical/logistical criteria one related to the contribution by the CSEs to the process of (a) evaluation of GEWEX global data products and the other to their contribution to the (b) development of databases necessary to successfully accomplish CEOP and specifically the aspect associated with the transferability of results across regions of differing climatic regimes. The matrix has also been expanded to gauge CSE contributions to five specific scientific needs of GHP/GEWEX. These scientific criteria are connected to the work that is necessary for GHP/GEWEX to accomplish its global objectives. The measurement of success in meeting these criteria are given in the matrix as **B**, **Pr** and **C** depending on whether the CSE is **B**eginning this work, is **Pr**ogressing toward a solution or is actually **C**oncluding a specific milestone in the noted scientific endeavor. The result of these changes is shown in Figure B-1, and what was produced for the Geesthacht 199 report has been updated to September 2000. The letter code in the table is explained as: **P = In Planning**, **I = Implemented, F = Functioning**. D 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 databases has begun.

TECHNICAL/LOGISTICAL CRITERIA	LBA
1.) NWP center atmospheric and surface data assimilation and estimates of hydro-meteorological properties.	F
2.) Suitable atmospheric-hydrological models and numerical experimentation and climate change studies.	I-F
3.) Mechanism for collecting and managing adequate hydrometeorological data sets.	F
4.) Participate in the open international exchange of scientific information and data.	F
5.) Interactions with water resource agencies and related groups to address the assessment of impacts on regional water resources.	F
6.) Evaluation of GEWEX global data products.	I-F
7.)Contributions to CEOP and transferability databases.	P
SCIENTIFIC CRITERIA	
1.) Simulate the diurnal, seasonal, annual and interannual cycles.	Pr
2.) Close water and energy budgets.	Pr
3.) Determine and understand climate system variability and critical feedbacks.	Pr
4.) Demonstrate improvements in predictions of water-related climate parameters.	Pr
5.) Demonstrate the applicability of techniques and models to other regions.	P

Figure B-1: Status of LBA Compliance with Criteria Established for GEWEX Continental Scale Energy and Water Budget Studies (Expanded/Updated September 2000).

It is important to mention that observational and modeling efforts on the energy and radiation balances are taking place at this time. There is a lot of experience on radiation budgets from the ABRACOS observations from 1990 to 1994, as well as from another field experiments previous to LBA. Information and data from these experiments can be found in the CD collection of pre-LBA information, available from CPTEC.

As noted the matrix in Figure B-1 has been updated to reflect the current status of LBA in meeting both the technical/logistical and scientific criteria.

APPENDIX C

GRDC - condensed input to the GHP/CEOP-Meeting presented by Dr Wolfgang Fröhlich

The main task of GRDC is to collect and archive the global discharge data sets on a global scale and make this data pool accessible for different purposes. Therefore GRDC is trying to use all different ways and sources to expand the stock of data in spatial and temporal scale.

Data acquisition

One important task is to get ***historic data*** sets as long as possible but possibly close to the present. GRDC has committed to make different hydrological investigations during CEOP-I in all CSEs on the basis of the available discharge data.

To do this research work, GRDC is collecting data from all CSE-areas to add that what is already in the GRDC databank. Aim is the installation of a regular data updating cycle.

Till now it is already working for the US-data, which includes the Mississippi basin stations.

For the other CSEs similar regulations are under construction. We hope to implement that soon. Until now updates for that areas happen spontaneously on request.

Especially under consideration that the 5th GAME International Science Panel Meeting (Tokyo, 26-27 June 2000) reconfirmed the data opening policy and that the data will be opened to communities nearly on schedule, GRDC will intensify the contact to the GAME-offices to get that data. Regarding the GAME-TIBET river stations we got already the data from the 1998 observing period. We hope to get also the GAME-HUBEX discharge data in this way. From its ACSYS-work GRDC got a huge set of Russian data. So GRDC could double the number of stations from the Lena-river-basin (CSE GAME-Siberia). Now we have data from nearly 200 stations of the Lena-basin. Unfortunately nearly all data sets end before 1991.

Aside from this acquisition of historic data GRDC is also involved in different programs and projects linked with problems of ***near real-time discharge data*** acquisition and exchange. Main projects are the preparations to the establishment of a "Global Hydrological Observing Network for Climate" and the development of a prototype of a "European Flood Forecasting System".

Global Hydrological Observing Network for Climate

In June 2000 an expert meeting (GCOS/GTOS) on the establishment of a Global Hydrological Network for Climate took place in Geisenheim, Germany. The goal of the meeting was to lay the groundwork for an Initial Operational System for a Global Hydrological Observing Network for Climate or Global Terrestrial Network - Hydrology (GTN-H) that would produce near real-time data sets for climate users and others in hydrology and water resources management.

The **objectives** of the meeting were to:

- Establish user needs for a Global Hydrological Network for Climate
- Identify deliverables of such a network
- Develop a vision and a strategy for establishing an initial, end-to-end global hydrology observing system
- Identify existing networks, centres and mechanisms that could contribute to this strategy. This should include an assessment of functions and services of existing observing networks and sites, data assembly and quality assessment 'sites', and data archiving and distribution 'sites'.

GRDC will investigate the possibilities of a near-real-time access of discharge data and will contribute to design and to implement such near real-time hydrological data and information system.

European Flood Forecasting System

The EFFS project (sponsored by EU) aims at developing a prototype of an European flood forecasting system for 4-10 days in advance. This system provides daily information on potential floods for large rivers such as the rivers Rhine and Oder as well as flash floods in small basins. This flood forecasting system can be used as a pre-warning system to water-authorities that already have a 0-3 day forecasting system. The system can also provide flood warnings for basins that at present do not have a forecasting system (Eastern-European countries). The framework of the system will allow incorporation of both detailed models for specific basins as well as a broad scale model for entire Europe. Once designed, the prototype will be tested and evaluated for several months. Together with end-users, channels to disseminate the forecasts and their uncertainties will be developed.

Main Objectives

- To take advantage of currently available Medium-Range Weather Forecasts (4 - 10 days) to produce reliable flood warnings beyond the current flood warning period of approximately 3 days.
- To design a Medium-Range Flood Forecasting System for Europe that will produce flood warnings on the basis of the Medium Range Weather Forecasts.
- To produce flood forecasts in regions where at present no flood forecasts are made on the basis of the newly developed system.

Main Part of GRDC

- To deliver hydrological discharge datasets for calibration and validation of the hydrological models
- In cooperation with Swedish Meteorological and Hydrological Institute work out recommendations for exchange of information within the EFFS.

Therefore GRDC has to get an representative overview over the:

- existing operating Flood forecast- and warning systems in Europe
- online accessible hydrological data in Europe.

Investigation of already available near-real-Time Discharge Data

As one of the start activities GRDC in the framework of the mentioned projects is seeking for already available online sources of hydrological data. For some CSEs (GCIP, LBA) there are discharge data free accessible via the internet. Additionally there are also such data available from Australia, Japan and South Africa. Also a number of further countries publish there near real time water level data on the web, especially in Europe.
For GRDC this activities also includes to get the historical data related to all that stations where near-real-time data available via the internet to update its data bank and also to use that for the research work in the framework of CEOP/GHP.

Collaborate in gridded runoff-fields calculations

In cooperation with University of New Hampshire (UNH), University of Tokyo and University of Kassel (Germany) GRDC takes part in the development of different gridded runoff products in a global scale. For the ISLSCP-II-initiative UNH is using GRDC-datasets to calculate the 0.5° - runoff-fields. Therefore UNH, GRDC and GPCC met in June 2000 in Germany. Similar calculations will be made by the University of Tokyo. University of Kassel is also calculating the gridded runoff but is focussing its interests on water-use and availability in global scale.

During the GTN-H-Workshop (see above) also the idea of UNH to develop a gridded runoff product for operational use (monthly) was discussed. By using of online-accessible discharge data and a suitable water-balance model, similar to that of the above mentioned universities have developed, a gridded runoff-field output could produced monthly by GRDC.

Summary of GRDC-contributions to the GHP/CEOP

GRDC will continue to:

- update the GRDC database with special focus to the CSEs,
- undertake research activities as follows:
  - comparative analysis of hydrological regimes in CSE regions
  - interannual variations of streamflow in the CSE regions
  - contributions to analyses of teleconnections based on relevant GRDC data sets
  - regional and global gridded composite runoff fields (in cooperation with different universities)
- investigate the possibilities of near-real-time data access in connection with other activities,
- improve the easily access of the GRDC data to the research community.

APPENDIX D

REPORT ON THE FIRST MEETING OF THE WATER RESOURCES APPLICATION PROJECT (WRAP) WORKING GROUP MEETING

BACKGROUND:

On August 29 and 30, 2000, the inaugural meeting of the GEWEX Water Resources Applications Project (WRAP) working group took place at the International Research Institute (IRI) at Columbia University. The working group was established by the GEWEX Hydrometeorology Panel (GHP) to promote dialogue between the GEWEX/ GHP scientists and the water resources community regarding existing and potential contributions of GEWEX to water management. The primary purposes of the meeting were to:

1) determine the scope of WRAP and develop a strategy/ plan for its activities.
2) plan a large meeting to bring together GEWEX expertise and water resource managers from national and international communities.

PRESENTATIONS AND DISCUSSIONS:

The meeting began with a number of presentations aimed at bringing participants to a common level of understanding of the activities of GEWEX/ GHP and related programs. Chet Ropelewski welcomed the group to IRI and indicated that the major efforts at the Institute involve producing one to two season predictions and relating these predictions to the needs of users. Rick Lawford briefly described a number of national and international activities with implications for water resource applications. In particular, he reviewed the GEWEX objectives and activities including some of the GHP initiatives that relate to water resource applications.

These introductions were followed by descriptions of the relevant CSE activities. Phil Graham described the hydrologic research in BALTEX noting the value for water resources of combining SVATS models with high vertical resolution and distributed hydrologic models that provide a capability to represent horizontal variability. BALTEX has ongoing hydrologic modeling activities in basins in Poland, Latvia, Finland, Russia, Germany and Sweden. High resolution precipitation products for some basins are being provided from radar.

The GAME Tropics joint presentation by Utai Pisone and Thada Sukhapunnaphan emphasized the importance of GEWEX research for water management in Thailand. Local applications using GAME observations from GAME-T are being made in Thailand. Areas of particular interest are information on flood warnings on the Nan River, periods of low flow when rainmaking is undertaken, and better information for reservoir management. Plans for GAME-T Phase II address social and economic problems of water resources, long term monsoon predictions, flood and drought forecasting, and the impact of population, land use and industrial growth on environment on the water cycle.

GCIP activities and GAPP plans in the area of hydrology and water resources were described by Dennis Lettenmaier and Rick Lawford. The Mississippi River Basin is characterized by large variability and heavy usage. Studies exploring the use of ensemble and probability forecasts, and climate predictions are being carried out in the eastern and north-central parts of the Mississippi River Basin. Dennis Lettenmaier gave some examples of the complexity of decision systems that use hydrologic forecasts, methods for compensating for differences between modeled precipitation estimates and measured precipitation amounts, and the economic benefits of using hydrologic predictions. The GAPP initiative will provide an opportunity to contribute to a prediction system that could provide more benefits and insights into the needs of water resource users both nationally and internationally.

Lawrence Martz described the MAGS-II plans to further integrate knowledge of atmospheric and hydrologic cycles into a unified system. Models will play a central role in developing tools to predict systematic responses to climate variations and changes for a variety of needs. Tasks have been defined and a number of potential applications of the results have been identified. These applications include providing a scientific basis for planning and policy development, interbasin transfers, water licensing for northern development, reductions to natural hazards, etc. Wolfgang Grabs outlined the plans for GRDC to address the needs of the water resource community. These plans include more readily accessible data through the internet, gridded runoff fields, a European flood forecasting system, and modeling tools to identify, on a basin scale, water resource availability and use.

The discussion regarding GEWEX activities indicated that GEWEX was approaching problems from the perspective of science. However, it was noted that other approaches could also be of value to GEWEX. The first example discussed was the new HELP (Hydrology for Environment, Life and Policy) initiative. In his presentation, Bob Varady emphasized that HELP uses a multidisciplinary, “bottom-up” process to define its activities. It builds upon existing networks and is complementary to other international water related projects. HELP needs hydrologic research that is directly responsive to water related policy and that goes beyond traditional approaches.

The ambitious WWDR (World Water Development Report) initiative was described by Gordon Young. WWDR is a UN initiative hosted by UNESCO and funded primarily by Japan that will assess the state of the world’s freshwater resources, both on a global basis and through case studies of individual basins. WWDR emphasizes a balanced approach between the assessment of need and availability. Coping with water-related stress through adaptability of natural ecosystems and human societies is an important component of this strategy. If the first report is successful and the project becomes financially self sufficient, these reports will be completed every two years.

Kuni Takeuchi presented IHP-Friend project emphasizing the success FRIEND has had in implementing its program in Asia. FRIEND activities are directed at understanding and simulating variations in water resources through time and space. FRIEND has wide coverage in Europe, Africa, Asia and the Pacific and is working on the demand side of problems as well as the supply side.

The WMO-Hydrology and Water Resources Programme was outlined by W. Grabs. He described the WHYCOS programme and noted that most of the data from this initiative are freely available over the internet. More WHYCOS data are expected to be freely available in the future. He indicated a number of new initiatives that are occurring within WMO-Hydrology including IGRAC (Global Data Base for Lakes and Reservoirs, GTN-H). In addition, the World Climate Programme-Water (WCP-Water) is being reconstituted and could become a stronger partner for GEWEX water resource activities.

Alan Hall outlined plans for future IAHS meetings related to hydrology and water resources. IAHS has a long standing association with GEWEX and the CSEs and can provide direct links to the water resource communities in different countries. He noted that the joint IAHS/ IAMAS meeting in 2003 in Sapporo offered a good venue for a special GEWEX session related to water resource applications. The IAHS/ WMO Working Group on GEWEX could serve as a facilitating mechanism between GEWEX, IAHS activities and WMO. He noted that proposals for a GEWEX water resources meeting had been made by the IAHS/ WMO Working Group in Birmingham.

Shourong Wang described recent developments in China where a number of rivers are likely to experience water shortages due to increased population and climate change effects. New initiatives include studies to support the economic development of western China, a mechanical engineering project to reduce dust storms, and increased emphasis on snow storms, floods and droughts and ecological research. He indicated that their most immediate need is for a macro scale hydrologic model.

Antonio Moura and Chet Ropelewski described the activities of the IRI. It was clear that a number of the goals and strategies employed by the IRI have potential application in WRAP. Areas of research include Water Resources Monitoring and Diagnostics (floods, droughts, areas of vulnerability, observed predictability), Water Resources Forecasting (statistical and dynamic) and Water Resource Management.

There was extensive discussion on a number of items during the various plenary and small group sessions. Issues that came out of these discussions were:

1) GEWEX needs to find a way to interact more effectively with the user community so their views can influence the research agenda.
2) HELP is a new and evolving initiative and its relationship with GEWEX is just now being defined. Developing connections between the well-defined and operational GEWEX program and the emerging HELP initiative is an opportunity challenge for WRAP. Insofar as possible, HELP basins and CSEs should overlap. While having HELP basins outside the CSEs could provide increased coverage it is recognized that synergy will be lost if no HELP basins are designated within the CSEs or CSAs.

SUMMARY:

Based on the discussions and agreements reached at the WRAP meeting:

1. GEWEX/ WRAP in collaboration with CSEs will participate in regional WWDR workshops and case studies. (Basins of high interest to WWDR include Rio de la Plata and basins in the GAME area. The Mississippi River Basin is also of interest but ranks lower).

2. HELP will be encouraged to develop mechanisms for working more closely with GEWEX. Furthermore, GEWEX will be a principal source of hydrologic and hydrometeorological expertise for HELP, within the limits of geography, expertise and resources.

3. GEWEX/ WRAP will organize the following meetings:

   - 2001 or 2002: “Applications of GEWEX products for water resource management” (Planning committee: GRDC/ GPCP rep, W. Grabs, GCIP rep, LBA rep, A. Hall, HELP rep, R. Lawford, TBD)
   - 2003: Special IUUG/ IAHS/ IAMAS Workshop on “The role of GEWEX hydrologic and hydrometeorological science in improved water resources management” (Planning committee: Lawrence Martz (GEWEX lead), Thada Sukhapunnaphn., Bob Varady, Alan Hall (IAHS lead), Dennis Lettenmaier, Phil Graham)

4. WRAP will facilitate regional workshops on water resources that are coordinated or organized by the CSEs. Where possible and appropriate, these workshops should involve other regional hydrologic expertise such as FRIEND-Asian Pacific.

5. WRAP will develop an overview of the water resource needs through work with the CSEs. Each CSE is asked to hold one or more “scoping diagnostic” workshops or studies in which they would:

   - based on input from regional water resource managers and other regional stakeholders, define the important water resource issues and opportunities for their basin.
   - define the research needed to address these particular problems.

(In cases where the basin is both a CSE and a HELP basin these scoping exercises should involve HELP and also address social and institutional issues of interest to HELP). It is recommended that GHP add these scoping workshops/ studies to its criteria for CSEs.

Prepared by Rick Lawford

APPENDIX E

CATCH STATUS TABLES

CATCH STATUS MATRIX:

Scale / Objective	Measurement	Status	Teams
Linking the large scale atmosp. circulation with the CATCH Window variability	Radiosoundings on 3-5 sites around the CATCH Window Preliminary aircraft measurements	Funding application to the GEF* through ACMAD Completed	DMNs Bénin, Niger, Nigeria with support of European teams UK Met. Office and Reading (JET 2000)
Atmosphere and Boundary layer monitoring within the CATCH Window	Radiosoundings Radiative Budget Fluxes (LE) LIDAR	Funded, waiting for implementation. Considered (no teams) Considered	Universities of Cologne and Bonn (IMPETUS*) LMD
Surface conditions	Mapping Remote sensing Field studies	Implemented Funded	IRD, CENATEL IMPETUS, CESBIO
Hydrometeorological observatory Ouémé Hydrometeorological observatory Niamey	Rain, streamflow, aquifer gauges Weather radar (X band; others) Rain, ponds, aquifer	Implemented (1997 - ..) Expected 2003 Implemented (1990-2000)	LTHE-IRD, DH Bénin LTHE, Mc Gill, CETP IRD, DMN Niger
Local Process studies	Soil water dynamics Hillslope Hydrology Eco-physiology	Measurements to start in Dec. 2000	LTHE-IRD, IMPETUS Univ. Bonn
Water Resources studies	Ground water recharge Reservoirs	Implemented Considered	IRD, DH Bénin

CATCH TABLE OF DATABASES:

Scale	Type of data	Period and Status	Teams
Regional data bases	**Rainfall, daily, point.** **Rainfall gridded** (Sahel, .5° to 2.5°resolution)	..*- 1990 1968 - 1998	**AGRHYMET, LTHE**
CATCH Window	**Rainfall, daily, point.** **Vegetation map** **DTM**	..*- 1998 and updated	**LTHE, DMN Bénin and Niger**
Niamey Square **Mesoscale sites**	**Rainfall, 5 minutes** **Ponds, aquifers**	1990 - 2000	**LTHE, HSM**
Upper Ouémé	**Rainfall, 5 minutes** **River flows**	1997- .. 1998- ..	**LTHE, DH Bénin** **LTHE, DH Bénin**
Local			

*since beginning of operation of the stations

CATCH TABLE OF MODELS AND STUDIES:

Scale	Model	Status	Teams
GCM	**LMD-6 / LMD Zoom**	**6 runs 1960 1994** (forced mode)	**LMD**
Regional Atmospheric Modeling	**MAR**	**Rainy Season 1992** (ECMWF nested)	**Louvain-La-Neuve / LTHE**
Mesoscale Atmospheric Modeling	**Meso-NH**	**Squall line 1992** (HAPEX-Sahel)	**CNRM**
Hydrological Modeling **Ouémé** **Sahel**	**Conceptual / Explicit** **ABC**	**In development** **1991-1996**	**LTHE, DH** **Bénin** **HSM**
Coupling studies	**MAR / ABC**	**In study**	**LTHE / HSM**
Links between the synoptic and the Convective scales	**Diagnostic studies using NCEP/ ECMWF reanalysis**	**1991-1994** (METEOSAT and ground data)	**LMD, LTHE**