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Towards a GEWEX Phase II Strategy
(August 23, 2007)

Background:
The energy and water cycle is the core of the climate system. It is impossible to understand the processes of change that are expected in the climate system without understanding the interconnections between the energy cycle and the water cycle. Within the framework of the World Climate Research Programme (WCRP), the Global Energy and Water Cycle Experiment (GEWEX) plays a key role in contributing to answer the two overarching objectives of WCRP, namely: 1) determining the predictability of climate and 2) determining the effects of human activities on the climate. GEWEX focuses on understanding and predicting the energy and water component of the Earth system by concentrating on key observations, processes studies and model physics improvements related to the energy and water cycle. Furthermore, it focuses on the atmospheric and land surface processes that control the climate at time scales down to the weather time scale.

The GEWEX community, along with recent water cycle study teams, have posed challenging questions that form the basis for the scientific goals of GEWEX Phase II (2003–2012). The goal of GEWEX is to reproduce and predict, by means of suitable models, the variations of the global hydrological regime, its impact on atmospheric and surface dynamics, and variations in regional hydrological processes and water resources, as well as their response to changes in the environment such as the increase in greenhouse gases. It does this through the development and application of planetary earth science, observations and models to the problems of climate and water resources. Within this framework climate system questions such as: “Is the water cycle accelerating?”; “If so, what are the primary processes responsible for these changes?”, and “What are the regional manifestations of these changes and their consequences for water resources?” need to be addressed. To address these questions, GEWEX Phase II will rely on the information and heritage of the first phase of GEWEX. GEWEX Phase I developed data products and tools that could take advantage of the data sets being provided by the Earth Observation Satellites. During Phase II (which will continue until 2012), GEWEX will use these insights, techniques, models, and data sets to develop heritage products and analyses that will help to answer the above questions.

The original GEWEX Phase II objectives were adopted by the Joint Scientific Committee (JSC) at its March 2002 meeting and modified in 2005 to provide additional clarity and focus. The changes reflected the further development of the WCRP Strategic Plan and its emphasis on climate change science, and also addressed the need to clarify the cooperative nature of interactions between global environmental programs, the need to set realistic goals in view of available resources, and the need to ensure that GEWEX produces heritage products and makes significant discoveries by its conclusion in 2012. This roadmap adds further clarification to these objectives and outlines the path that GEWEX will follow in order to achieve its objectives. In particular, this roadmap will identify both interim and final deliverables and milestones to be achieved as we move towards the realization of the GEWEX heritage through scientific insights, analysis tools, models, and data products for the benefit of WCRP, the agencies that sponsor GEWEX, the global environmental community, and other GEWEX stakeholders.

GEWEX is organized into three domains of research: analysis of global variations in the energy and water cycle, modeling and prediction studies with a focus on land and cloud systems, and hydrometeorology research from local to global land scales and global data collection to support studies of regional water and energy balances. The priorities within each of these domains are briefly outlined here and are described in Sorooshian et al. (2005) in more detail. The analysis of global variations relies heavily of global data sets derived from satellite data and are under the guidance of the GEWEX Radiation Panel (GRP). The analyses, simulations and prediction experiments leading to the better parameterization of land and cloud processes are led by the GEWEX Modeling and Prediction Panel (GMPP). This panel uses both *in situ* and satellite measurements to develop and test new parameterizations for land and cloud processes and model evaluation. Work on the Regional energy and water budgets is led by the Coordinated Energy and water cycle Observations Project (CEOP) which was newly formed in January 2007.

The GEWEX Regional Hydroclimate Projects (formerly Continental Scale Experiments (CSEs)), coordinated by the GEWEX Hydrometeorology Panel (GHP), have supported the development of regional meteorology and hydrology (see Lawford et al., 2004). The Coordinated Enhanced Observing Period (CEOP) is an extensive integrated data system development effort that is now developing a stronger scientific agenda by incorporating the former GHP activities that have recently been proposed to be merged with CEOP. The Scientific Steering Group (SSG) and the International GEWEX Project Office (IGPO) both play a critical role in ensuring these scientific efforts are effectively coordinated and that the final GEWEX products and outputs are integrated.

GEWEX also address the cross-cuts within the WCRP Strategic Plan. As a result of decisions made at the 28th Joint Scientific Committee in March 2007, GEWEX works with CLIVAR to lead the Monsoons and Extremes cross-cuts. The following paragraphs identify deliverables representing progress toward the GEWEX objectives listed above. GEWEX scientists are expected to direct their energies and talents towards the realization of these deliverables. This document is intended to be used as a basis for focusing the intellectual and financial resources available to GEWEX and to provide a basis for communicating the coherent nature of GEWEX plans towards funding agencies and the science community at large. GEWEX plans to achieve these objectives in the context of specific science questions that are critical to WCRP. The resulting research agenda is expected to compel the GEWEX scientific community to follow a plan that will maximize contributions directed towards each of the four GEWEX objectives and the appropriate cross-cuts. As noted in the following text, these deliverables build on the heritage scientific results that GEWEX achieved in Phase I. A more detailed description of the contributions of each panel to these milestones is provided in Appendix A.

Objectives:

GEWEX Objective 1:

Produce consistent research quality data sets complete with error descriptions of the Earth's energy budget and water cycle and their variability and trends on interannual to decadal time scales for use in climate system analysis and model development and evaluation.

Objective 1 Strategy:

Throughout Phase I, GEWEX scientists developed, produced, and tested global products related to radiation [GEWEX Radiation Panel (GRP)], water vapor (GRP), clouds (GRP), precipitation (GRP), aerosols (GRP), and modelled soil wetness and land surface states [GEWEX Modelling and Prediction Panel (GMPP)]. These products are of research quality and are reliable when used for their intended use. A related data set project involved the development of land surface data sets from both observations and models and their compilation in co-registered data sets [former GEWEX Hydrometeorology Panel (GHP)/International Satellite Land-Surface Climatology Project (ISLSCP)]. These data sets are useful for research and for specifying boundary conditions for modelling studies. Experience has shown that the value of these data sets for the climate community increases as the length of the data set increases. Consequently, the continuation of these data sets must be recognized as a priority for GEWEX Phase II.

During Phase I, regional water budgets were described within the former GHP for a number of continental-scale river basins using a mix of observations and model outputs. On a global basis, GEWEX did not have access to all the fields needed to close the water and energy budgets. For example, surface fluxes over the ocean are available for limited intervals through the SeaFlux project. To address these needs, the second phase of GEWEX will rely on data from new satellites and make more extensive use of data assimilation systems. The planned Phase II LandFlux activity and the ongoing Global Land Data Assimilation System outputs will form a major part of the GEWEX effort to address the data gaps over land. Phase II will require a more coordinated approach to the testing and use of new satellite products and in deriving relationships between the ongoing products and data products from new satellites so that the benefits can be fully realized in supporting long-term data records.

Some global GEWEX products are now in wide use. For example, with 25 years of data collected, quality-controlled, and processed into useful global data products for a number of variables, the GEWEX results are contributing to ongoing discussions about the climate processes and their variability in space and time. In addition, these GEWEX products provide a direct representation of the variables derived

from the radiances observed by satellite and are therefore very useful to experts involved in comparing various algorithms. Many of these data sets will contribute to the process understanding and model validation required for the WCRP cross-cuts related to Anthropogenic Climate Change and decadal prediction and support future IPCC assessments. However, these data sets could be used by an even broader set of users if they were optimized for global climate analysis by homogenizing the records through the removal of the effects caused by orbit drift and sensor degradation. Consequently, GEWEX and WCRP will place a higher priority on producing reprocessed data sets that are appropriate for global climate analysis as part of this objective. As described in Koike (2004), CEOP is developing integrated data sets that bring together *in situ* measurements from reference sites distributed over the land areas of the globe, global and regional satellite data sets, and global model output data sets. The strength of this activity lies in the development of quality control procedures, the acquisition of countries with restrictive data policies, and the integration of data sets accompanied by analysis and visualization tools.

In order to address this objective, global water and energy budgets have been identified as a priority research focus. It is recognized that GRP activities make a unique contribution to this objective in characterizing the global energy and water cycle and its variations while the other panels (e.g., GMPP, CEOP) contribute to terrestrial aspects of the challenge. Comprehensive coordinated contributions are required from each of the GEWEX panels and appropriate support is needed from other components of WCRP. To effectively address global and regional energy and water cycles, it is necessary to address the full cycle over land and ocean. At the same time, advances can be made in estimating various land components as a preliminary step in developing the tools to prepare accurate global water cycle estimates. To this end, GMPP, GHP, and CEOP will coordinate their efforts with GRP as they try to integrate their land-based activities with the global energy and water budget efforts in GRP. This will be followed by an intercomparison and a highly coordinated project aimed at producing the most accurate water and energy budget possible over the entire globe.

Objective 1 Timeline:

2007(a): Release current GRP Data Product Package – publish announcement (GRP)

2007(b): Complete review of radiance calibrations of the primary satellite radiances used to produce the global data products (GRP)

2007(c): Complete first global analysis of the energy and water cycle with existing products (all panels will contribute to this analysis) (GRP, CEOP, GMPP)

2007(d): Complete the quality control, production, and distribution of the CEOP Phase I data sets (CEOP)

2008(a): Complete assessments of global data products and issue formal reports describing their estimated uncertainties (GRP)

2008(b): Complete observations and diagnosis of causes of global energy and water cycle variations from weather to decadal scales (GRP, CEOP)

Work with CLIVAR and other efforts to utilize and/or develop consistent definitions of extreme hydrometeorological events?

2009(a): Complete reprocessing of global precipitation, cloud, aerosol, and radiation data products (GRP)

2009(b): Develop a synthesis of the climatology and diurnal-to-interannual variations based on observations and models of water and energy budgets with improved observations and models (GRP/CEOP)

2009(c): Through continued involvement in WOAP (the WCRP Observation and Assimilation Panel), GCOS (the Global Climate Observing System), IGOS-P (Integrated Global Observing Strategy – Partners), and GEO (Group on Earth Observations), GEWEX will help to assess and, where appropriate, promote observations for the global energy and water cycle (ongoing) (GRP, CEOP, IGPO)

2009(d): Within the scope of their mandates, all GEWEX panels will work to complete the set of products needed to describe the global energy and water cycle (GRP, GMPP, CEOP)

2009(e): Improve models to better simulate the climatology and diurnal-to-interannual variations in water and energy budgets (GMPP)

2010(a): Implement the CEOP data system as a prototype GEOSS (Global Earth Observation System of Systems) data handling system (CEOP)

2010(b): Conduct second assessment of the Global Data Products, including surface turbulent fluxes over oceans and land (GRP)

2010(c): Produce water and energy budgets over oceans and polar regions for comparison with CLIVAR (Climate Variability and Predictability) and CliC (Climate and Cryosphere) products.(GRP)

2011(a): Complete second global analysis of energy and water cycle variations. This product will provide the best estimate of the water cycle variables and their uncertainties for the period 1980 to 2010. (GRP)

2012(a): Complete a comparison of feedback processes involving stable boundary layer components of SCMs (single column models) (GMPP)

GEWEX Objective 2:

Enhance the understanding of and quantify how energy and water cycle processes contribute to climate feedbacks.

Objective 2 Strategy:

Observations play a central role in the GEWEX contributions to WCRP climate prediction goals. Not only do GEWEX activities result in data that are essential for evaluating the performance of climate models and the ability to simulate energy and water cycles over a range of scales, but they also lead to the improved understanding that is fundamental for improving the physics in the models.

Climate feedbacks include processes that involve clouds and land-atmosphere coupling that interact in a non-linear fashion on many time and space scales and result in complex interactions. One of the greatest sources of uncertainty in current climate scenarios arises from the inability of coarse resolution climate models to simulate clouds and their feedback. GEWEX has already organized itself to study these interactions as part of its effort to improve climate prediction. While some processes that are important for understanding the full complexity of the system—such as mesoscale air-sea interactions—lie outside the domain of GEWEX, GEWEX will focus on arguably the most challenging problem: *understanding the contributions of water and energy cycles and their highly coupled non-linear interactions in regulating feedbacks to the climate system.* In addition to the analysis associated with GEWEX Objective 1, GEWEX studies will be directed at understanding and quantifying the diabatic heating of the atmosphere and the Earth's surface by radiative, sensible, and latent energy exchanges with accuracy sufficient to determine how these processes influence climate and surface conditions on weather to decadal climate time scales.

As part of this approach, GEWEX will assess the factors that contribute to different climate phenomena and processes; included in this list will be the diurnal cycle, precipitation processes, and floods and droughts. In addition, the processes that combine within monsoons will also be present under a modified climate and there will be a need to understand and explain the changes that may occur in the future. The primary process specifically being studied under the purview of GRP is radiative transfer; however, the SeaFlux and LandFlux activities also foster studies of the turbulent flux processes over oceans and land. Cloud and precipitation studies will be advanced by the production of new merged satellite data products.

Another very significant uncertainty in feedback and forcing effects arises from atmospheric aerosols and their effects on clouds, precipitation, and the radiation budget. In many cases, these aerosols have their

origin in anthropogenic activities such as industrial activity or land use change. While some studies infer that aerosols affect the cloud condensation nuclei and the rate of precipitation production, the processes responsible for these effects are neither fully known nor adequately represented in models. Results from GEWEX research are needed to examine some of the critical questions related to the role of tropical convection and monsoons in the global climate system. GEWEX is also contributing to issues such as the net effect of aerosols on climate by studying the aeorosol-cloud interaction and the Atmospheric Chemistry and Climate Cross-cut.

Objective 2 Timeline:

2007(a): Develop new cloud feedback analysis approaches from the International Satellite Cloud Climatology Project (ISCCP)-the Global Precipitation Climatology Project (GPCP)-the Surface Radiation Budget (SRB) results (GRP)

2007(b): Provide an online Radiation Code Test Kit [Continuous Intercomparison of Radiation Codes (CIRC)] (GRP)

2007(c): Conduct field experiments to understand regional hydrometeorological processes (CEOP)

2007(d): Advance cloud-precipitation studies with a merger of ISCCP-Tropical Rainfall Measuring Mission (TRMM)-CloudSat data (GRP)

2007(e): Conduct coupled land cover change experiment, phase I: Land-Use and Climate IDentification of Robust Impacts (LUCID) (GMPP)

2008(a): Develop an inventory of floods and droughts and the role of land-atmosphere feedbacks in causing those events (CEOP, GRP)

2008(b): Advance the understanding of surface turbulent fluxes over oceans (SeaFlux) (GRP)

2008(c): Advance the understanding of surface turbulent fluxes over land (LandFlux/the Global Soil Wetness Project (GSWP 2–3) (GMPP, GRP)

2008(d): Through a joint workshop with the Earth System Science Partnership (ESSP), clarify the contributions that WCRP and GEWEX will make in addressing aerosol issues (GMPP, GRP, IGPO)

2008(e): Complete the first intercomparison of water cycle feedback processes in single column models (SCMs) involving the atmosphere only (GMPP)

2009(a): Advance cloud-aerosol studies with a merger of ISCCP-the Global Aerosol Climatology Project (GACP)-CloudSat- Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) data (GRP)

2009(b): Conduct coupled land-cover change experiment, phase II: C20C-type land-cover change experiment (GMPP)

2009(c): Advance the understanding of surface turbulent fluxes over land (LandFlux/GSWP 2–3) (GMPP, GRP)

2009(d): Provide a land surface coupling framework for modeling applications (GMPP)

2010(a): Develop advanced analysis techniques to investigate causes of variability, to separate forced and unforced responses, and to estimate feedbacks and predictability (GRP, CEOP)

2010(b): Through CEOP, GEWEX Cloud System Study (GCSS) field studies, and GRP analysis projects, provide new insight on the role of aerosols in cloud and precipitation production (GRP, GMPP, CEOP)

2010(c): Provide an assessment of the role of land-atmosphere interactions during extremely wet and extremely dry (drought) periods (CEOP)

2010(d): In collaboration with the Cloud Feedback Model Intercomparison Project (CFMIP), complete an investigation into the impact on climate sensitivity of improved representations of cloud-related processes in global climate models (GCMs) (GMPP)

2010(e): Complete a comparison of hydrological components in SCMs involving atmosphere-land hydrology interactions (GMPP)

2011(a): Use the Soil Moisture and Ocean Salinity (SMOS) Mission and other satellite data to study the role of soil moisture in land-atmosphere interactions (GMPP, CEOP, GRP)

2012(a): Complete a comparison of feedback processes involving stable boundary layer components of SCMs (GMPP)

GEWEX Objective 3:

Improve the predictive capability of key water and energy cycle variables and feedbacks through improved parameterizations to better represent hydrometeorological processes, and determine the geographical and seasonal characteristics of their predictability over land areas

Objective 3 Strategy:

GEWEX has worked towards achieving a goal related to the improvement of better seasonal predictions from its inception. For example, the goal of GMPP research is "to demonstrate the capability to predict water storage and runoff over continental regions, as an element of seasonal-to-interannual climate predictability, and to demonstrate the capability to predict the radiation budget and fluxes, as an element of decadal-to-centennial climate variability and response to changes in external forcing factors" (Chahine, 1997). GMPP has developed improved parameterizations of processes that have been incorporated into simulation and prediction models. Intercomparisons have been carried out to show the way towards improving parameterizations, and similar steps have been taken within some of the CSEs. This was facilitated by both the CSEs, which were required to develop links with regional numerical weather prediction (NWP) centers, and with CEOP, which has entrained at least 11 NWP and data assimilation centers into producing routine global outputs. For instance, in the GEWEX Americas Prediction Project (GAPP)/GEWEX Continental-scale International Project (GCIP), a number of techniques and parameterizations have been transferred to the National Centers for Environmental Prediction (NCEP) operational prediction system. These innovations, which have led to better forecasts, also will help in the identification of models with the greatest chance of success. Similar methods for moving results from GEWEX research to operations are needed in other meteorological centers.

In order to efficiently address the opportunities to build better prediction systems, there is a need to understand which factors can contribute to the prediction of different phenomena. Clearly the sea surface temperature distributions (e.g., the El Niño Southern Oscillation (ENSO)) have a major role during all seasons, although the magnitude of their effect varies according to location and climate variables. As a first step in this process, GEWEX will undertake a suite of studies to assess the influence of anomalies on the seasonal predictability of precipitation and monsoon intensity. The results from these studies will be used to set priorities for studies directed at improving prediction systems. In addition, GEWEX will collaborate with CLIVAR to ensure that its newest and most promising parameterizations are incorporated into global climate models (GCM) and tested along with other model upgrades in both coupled and uncoupled prediction systems. Results from model studies such as the Global Land Atmospheric Coupling Experiment (GLACE) have suggested that there are critical land areas ("hot spots") in the world where surface wetness has a very significant influence on the predictability of seasonal precipitation at lead times of one to three months (Koster et al, 2004). This influence is strongest during the summer months. Furthermore, it is not known whether vegetation or soil moisture is the major contributor to this predictability.

Within GHP, regional models have been used extensively. While there are some areas where regional models produce better results than global models, there are other regions where regional models are

unable to outperform global models in spite of their higher resolution. It has been suggested that the benefits of downscaling and the more precise representation of surface features are less in some areas than the benefits of more accurately representing the regionally dominant forcings from the oceans. In some cases, the evaluation of regional models may require enhanced data collection activities either through CEOP or enhanced field campaigns within the continental scale experiments (CSEs). In addition, the activities of the Model Transferability Working Group can contribute to these assessments.

GEWEX recognizes the responsibility to contribute to improving the prediction system and will assist in improving forecasts through contributions to prediction systems, the development and testing of experimental products, and the transfer of new parameterizations to operations. GEWEX expertise is needed to address the contributions of land processes and clouds in all climate phenomena where they play a significant role. These processes are of particular importance with the monsoon systems where land-ocean temperature contrasts and their feedback to the local and regional atmospheric circulations play a major role and in the intensification of climate systems to produce extremes over inhabited land areas. The results of this research will also benefit WCRP efforts related to longer time scales including decal prediction and ACC.

Objective 3 Timeline:

2007(a): Complete preliminary analysis for the Snow Model Intercomparison Project (SnowMIP-2) (GMPP)

2008(a): Assess the current capabilities of land data assimilation systems at regional and global scales and their applicability to regional and global forecast systems (GMPP)

2008(b): Establish a framework for collaborative studies between the GEWEX Cloud System Study (GCSS) and the Stratospheric Processes And their Role in Climate (SPARC) projects (GMPP, GRP)

2008(c): Undertake an assessment of GEWEX and International Land Ecosystem-Atmospheric Processes Study (iLEAPS) activities to explore potential linkages between the two programs in terms of identifying land atmosphere interactions and the relationship between land surface chemical fluxes and energy and water fluxes (IGPO)

2008(d): Complete first offline intercomparison of radiative transfer processes in land surface models (GMPP)

2008(e): Provide an initial review of the success of GMPP in improving parameterization at operational numerical weather prediction (NWP) and climate modeling centers and make recommendations for further improvement of the GMPP process (GMPP)

2009(a): Promote the use of remotely-sensed data and develop related products to study the role of soil moisture in land-atmosphere interactions (GMPP, CEOP, GRP)

2009(b): Complete a multi-site intercomparison of latent and sensible fluxes and net carbon fluxes simulated by land surface models (Project for the Intercomparison of Land-Surface Parameterization Schemes (PILPS) C-2) (GMPP)

2009(c): Complete an uncoupled intercomparison of urban parameterizations available for use in numerical models (PILPS-urban experiment) (GMPP)

2009(d): Carry out an enhanced observing period to obtain data for process understanding and model validation in areas of complex terrain (CEOP)

2009(e): Launch GLACE-2 to better understand the role of realistic land states in seasonal prediction skill (GMPP)

2010(a): Develop the understanding and parameterizations required to reproduce the diurnal cycle for monsoon regions in a GCM (CEOP)

2010(b): Assess the accuracy requirements of Global Land Data Assimilation Systems (GLDAS) as a useful input for global prediction systems (GMPP)

2010(c): A complete study of the effects of aerosols on monsoons will be examined through CEOP using a combination of observational and modeling studies (CEOP)

2011(a): Launch GLACE-2b to assess the effects of vegetation and snow on the prediction skill (GMPP)

2012(a): Provide a final review of the success of GMPP in improving parameterization at operational NWP and climate modeling centers and its impact on the predictive capabilities for key energy and water cycle variables, including hydrological prediction (GMPP, CEOP)

2011 b): Demonstrate the contribution of improved prediction systems for forecasting the onset and intensity of droughts and the recovery from drought (CEOP)

GEWEX Objective 4:

Undertake joint activities with operational hydrometeorological services, related ESSP projects like the Global Water System Project (GWSP), and hydrological research programs to demonstrate the value of GEWEX research, data sets, and tools for assessing the consequences of climate predictions and global change for water resources.

Objective 4 Strategy:

GEWEX has led a number of initiatives that have entrained Numerical Weather Prediction (NWP) Centres and promoted dialogue with the water resources community. During the first phase of GEWEX, the Water Resources Applications Project (WRAP) held a number of workshops with stakeholders. A number of key issues were identified regarding factors that limited the use of hydrometeorological information at these workshops for water resource managers, including the need for better precipitation predictions and better hydrological models. During Phase II, GEWEX will move forward in close cooperation with the hydrological research community to launch projects dealing with hydrological seasonal forecasts. GEWEX will work closely with the Hydrological Ensemble Prediction Experiment (HEPEX) to advance regional pilot projects to show how ensemble forecasts from atmospheric models can be used with hydrologic models to provide improved hydrologic seasonal forecasts. In addition, the Hydrologic Applications Project (HAP) will work with the Project on Ungauged Basins (PUB) of the International Association of Hydrologic Sciences (IAHS) to demonstrate how remote sensing data, land data assimilation products, and hydrological prediction can improve the decisions made by water resource managers. Through HAP and other GEWEX activities such as the Global Land Atmosphere System Study (GLASS), GEWEX will lead WCRP's contributions to the Global Water System Project. GEWEX will also promote strategies to work more closely with the World Meteorological Organization's Hydrology and Water Resources Department, operational hydro-meteorological services, UNESCO's International Hydrology Programme, and IAHS.

In order to achieve these objectives, a new approach to hydrometeorological research in support of the water resources sector is needed. An important element of this approach will be the strategy of focusing GEWEX efforts in collaboration with hydrologic research programs and operational services with the mandate to provide predictive and informational services to users in the water resources sector.

Work in this area is expected to contribute to the implementation of the goals of work in the WCRP Monsoon and Extremes Cross-cuts. Through the deliverables outlined below and the research they represent, GEWEX will contribute ot the delivery of applications dimensions, particularly in the water resources area. GEWEX also will advance hydrologic modeling through HAP, collaboration with HEPEX and the RHPs. These activities have strong linkages outside WCRP, supporting the Group on Earth Observations through the tasks outlined in their 2007-2009 Work Plan.

Objective 4 Timeline:

2007(a): Launch the Hydrologic Applications Project (CEOP)

2007(b): Launch at least two pilot projects in GEWEX CSEs that will utilize hydrological ensemble prediction techniques as a HAP and HEPEX initiative (CEOP)

2007(c): Downscale and evaluate seasonal hindcasts over the CSEs using the National Oceanic and Atmospheric Administration (NOAA) and DEMETER seasonal forecasts that can be assessed by CSE scientists (CEOP)

2008(a): Launch several studies with PUB to demonstrate the value of using remote sensing data in ungauged (or under-gauged) basins (CEOP, GMPP)

2008(b): Evaluate seasonal hydrological forecasts from hindcast studies for the initial two pilot studies; and launch additional HAP and HEPEX pilot studies (CEOP)

2008(c): Develop links with THORPEX (THe Observing System Research and Predictability Experiment) to undertake predictions on daily to monthly time scales in order to look at intra-seasonal prediction capabilities (CEOP)

2008(d): Assess the ability of models to simulate the impact of heavy rain events and droughts on water resources (CEOP)

2008(e): Evaluate the predictive capability from land initialization conditions to the prediction of terrestrial hydrological variables at different time scales (GMPP, CEOP)

2009(a): Contribute appropriate models and methodologies for completing water balance studies to the Global Water System Project (CEOP)

2009(b): Assist the Integrated Global Water Cycle Observations Theme in its 5-year review of global water cycle systems to determine the actions needed to strengthen water cycle observation systems (IGPO)

2010(a): Determine the contributions of remote sensing to hydrologic modeling, with particular focus on ungauged and poorly gauged basins (CEOP)

2010(b): Evaluate newly developed procedures for hydrologic ensemble generation and the impact on seasonal hydrologic prediction for the pilot test beds (CEOP)

2012(a): Prepare a review article on the hydrological response of basins of different sizes to drought and extreme rainfall events as well as the interactions between these two types of extremes (CEOP)

2012(b): Review the outcome of PUB's contributions to GEWEX science and specify future areas of research required of the hydrological science community (CEOP)

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Appendix A
Expanded Contributions from Panels: Detailed Panel Milestones

GEWEX Radiation Panel

Objective 1

2007: Complete review of radiance calibrations

Calibrations of the primary satellite radiances used to produce the global data products (visible, infrared and microwave wavelengths) will be reviewed and revised in light of new results from newer instruments and consistency checks across products.

2007: Release current GEWEX Radiation Panel (GRP) Data Product Package, publish announcement

A package of monthly mean maps on the same grid will be prepared for precipitation [the Global Precipitation Climatology Project (GPCP)], radiation [the Surface Radiation Budget (SRB) and the International Satellite Cloud Climatology Project (ISCCP-FD)], clouds [ISCCP], and aerosols [the Global Aerosol Climatology Project (GACP)] with other data sets describing ocean surface turbulent fluxes and other land surface and atmospheric properties, and will be released online to advertise this data collection. Soon after, the full resolution versions of these data will be supplied on an active server by the NOAA National Climatic Data Center (NCDC). Small notices will be published in *BAMS*, *GEWEX News* and *Climate Variability and Predictability (CLIVAR) News*.

2007: Complete first global analyses of the energy and water cycle with existing products

Production of the current data products will continue and experimental versions of SeaFlux and LandFlux products will be combined with other surface and atmospheric data sets to conduct the first global analyses of the global energy and water cycle and its variations using the current versions (CEOP could evaluate the accuracy of the global products for a distribution of locations; GMPP could evaluate cloud and land surface processes implied by the budget results).

2008: Complete assessments of global data products

All GRP global data products [GPCP, ISCCP, GACP, the Surface Radiation Budget (SRB)] are being assessed by international working groups soliciting input from the research community (CEOP could contribute to these assessments). This assessment also includes other similar, global, long-term products, some of which are newly available. Formal reports of the estimated uncertainties for these products will be published.

2008: Complete observations and diagnosis of the causes of global energy and water cycle variations from weather to decadal scales (GRP, CEOP)

2009: Complete reprocessing of global data products

The products for precipitation [GPCP], clouds [ISCCP], aerosols [GACP] and radiation [SRB] will be completely reprocessed to make improvements in the analysis methods identified by the assessments and by other research to correct artifacts that have been identified in the long-term records, including improved radiance calibrations, to increase the physical consistency among the products, and to provide some versions of the products with common space-time intervals.

2009: Complete the set of products needed to describe the energy and water cycle

Assuming that a revised global atmospheric water vapor and temperature dataset is obtained from operational groups, the minimum set of products—besides the general circulation of the atmosphere from weather analysis—needed to complete a characterization of the global energy and water cycles is the surface turbulent fluxes of energy and water to be produced by SeaFlux over oceans (including sea ice) and LandFlux over land (including snow).

2009: Through continued involvement in the WCRP Observation and Assimilation Panel (WOAP), the Global Climate Observing System (GCOS), the Integrated Global Observing Strategy – Partners (IGOS-P) and the Group on Earth Observations (GEO), GEWEX will help to assess and, where appropriate, promote observations for the global energy and water cycle (ongoing). (GRP, CEOP, IGPO)

2010: Produce water and energy budgets over oceans and polar regions for comparison with CLIVAR and Climate and Cryosphere (CliC) products. (GRP)

2010: Conduct second assessment of the global data products

The second assessment of the global data products will not only verify the changes made to the precipitation, clouds, radiation, and aerosol products during their reprocessing but will undertake assessments of the newer products, including the SeaFlux and LandFlux products and the atmospheric temperature and humidity products. These assessments will take about two years to complete.

2011: Complete second global analysis of energy and water cycle variations

New analyses of the variations of the global energy and water cycle will begin.

Objective 2:

2007: Develop new cloud feedback analysis approaches from ISCCP-GPCP-SRB results

2007: Provide online Radiation Code Test Kit [Continuous Inter-comparison of Radiation Codes (CIRC)]

2007: Advance cloud-precipitation studies with a merger of ISCCP-Tropical Rainfall Measuring Mission (TRMM)-CloudSat data (GRP)

2008: Develop an inventory of floods and droughts and the role of land-atmosphere feedbacks in causing those events (CEOP, GRP)

2008: Advance understanding of surface turbulent fluxes over oceans (SeaFlux) (GRP)

2009: Advance cloud-aerosol studies with a merger of ISCCP-GACP-CloudSat-Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) data (GRP)

2009: Advance the understanding of surface turbulent fluxes over land (LandFlux/GSWP 2-3) (GMPP, GRP)

2010: Develop advanced analysis techniques to investigate causes of variability, to separate forced and unforced responses, and to estimate feedbacks and predictability (GRP, CEOP)

2010: Through CEOP, GEWEX Cloud System Study (GCSS) field studies, and GRP analysis projects, provide new insight on the role of aerosols in cloud and precipitation production (GRP, GMPP, CEOP)

2011: Use Soil Moisture and Ocean Salinity Mission (SMOS) and other satellite data to study the role of soil moisture in land-atmosphere interactions (GMPP, CEOP, GRP).

GEWEX Modeling and Prediction Panel

Objective 1:

2007: Complete first global analysis of the energy and water cycle with existing products *(All panels will contribute to this analysis) (*GRP, CEOP, GMPP)

2007: Conduct coupled land cover change experiment Phase I: LUCID (Land-Use and Climate IDentification of Robust Impacts)(GMPP)

2008: Complete first intercomparison of water cycle feedback processes in single column models (SCMs) involving the atmosphere only (GMPP)

2009: Conduct coupled land cover change experiment Phase II: C20C-type land cover change experiment (GMPP)

2009: Within the scope of their mandates, all GEWEX Panels will work to complete the set of products needed to describe the global energy and water cycle (GRP, GMPP, CEOP)

2009: Improve models so they are capable of better simulating the climatology and diurnal to interannual variations in water and energy budgets (GMPP)

2009: Advance the understanding of surface turbulent fluxes over land (LandFlux/GSWP 2-3) (GMPP, GRP)

2009: Provide a land surface coupling framework for modeling applications (GMPP)

2010: Through CEOP, GCSS field studies, and GRP analysis projects, provide new insights on the role of aerosols in cloud and precipitation production (GRP, GMPP, CEOP)

2010: In collaboration with the Cloud Feedback Model Intercomparison Project (CFMIP), complete an investigation into the impact on climate sensitivity of improved representations of cloud-related processes in GCMs (GMPP)

2010: Complete a comparison of hydrological components of SCMs involving atmosphere-land hydrology interactions (GMPP)

2011: Use SMOS and other satellite data to study the role of soil moisture in land-atmosphere interactions (GMPP, CEOP, GRP).

2012: Complete a comparison of feedback processes involving stable boundary layer components of SCMs (GMPP)

Objective 2:

2007: Conduct coupled land cover change experiment Phase I: LUCID (GMPP)

2008: Advance the understanding of surface turbulent fluxes over land (LandFlux/GSWP 2-3) (GMPP, GRP)

2008: Through a joint workshop with the Earth System Science Partnership (ESSP), clarify the contributions that WCRP and GEWEX will take in addressing aerosol issues (GMPP, GRP, IGPO)

2008: Complete first intercomparison of water cycle feedback processes in SCMs involving the atmosphere only (GMPP)

2009: Conduct coupled land cover change experiment Phase II: C20C-type land cover change experiment (GMPP)

2009: Provide a land surface coupling framework for modeling applications (GMPP)

2010: Through CEOP, GCSS field studies, and GRP analysis projects, provide new insights on the role of aerosols in cloud and precipitation production (GRP, GMPP, CEOP)

2010: In collaboration with CFMIP, complete an investigation into the impact on climate sensitivity of improved representations of cloud-related processes in GCMs (GMPP)

2010: Complete a comparison of hydrological components of SCMs involving atmosphere-land hydrology interactions (GMPP)

2011: Use SMOS and other satellite data to study the role of soil moisture in land-atmosphere interactions (GMPP, CEOP, GRP).

2012: Complete a comparison of feedback processes involving stable boundary layer components of SCMs (GMPP)

Objective 3:

2007: Complete preliminary analysis for the Snow Model Intercomparison Project (SnowMIP)-2 (GMPP)

2008: Assess the current capabilities of land data assimilation systems at regional and global scales, as well as their applicability to regional and global forecast systems (GMPP)

2008: Complete first offline intercomparison of radiative transfer processes in land surface models (GMPP)

2008: Provide an initial review of the success of GMPP in improving parameterization at operational numerical weather prediction (NWP) and climate modeling centers; make recommendations for further improvement of the GMPP-process (GMPP)

2008: Establish a framework for collaborative studies between GCSS and Stratospheric Processes And their Role in Climate (SPARC) (GMPP, GRP)

2009: Promote the use of remotely-sensed data and develop related products to study the role of soil moisture in land atmosphere interactions (GMPP, CEOP)

2009: Complete a multi-site intercomparison of latent and sensible fluxes and net carbon fluxes simulated by land surface models (PILPS C-2) (GMPP)

2009: Complete uncoupled intercomparison of urban parameterizations available for use in numerical models (PILPS-urban experiment) (GMPP)

2009 Launch GLACE-2 to better understand the role of realistic land states in seasonal prediction skill (GMPP)

2010: Assess the accuracy requirements of GLDAS systems as a useful input for global prediction systems (GMPP)

2011: Launch GLACE-2b to assess the effects of vegetation and snow on the prediction skill (GMPP)

2012: Provide a final review of the success of GMPP in improving parameterization at operational NWP and climate modeling centers and its impact on the predictive capabilities for key energy and water cycle variables, including hydrological prediction (GMPP, CEOP)

Objective 4:

2008: Launch several studies with the Project for Ungauged Basins (PUB) to demonstrate the value of using remote-sensing data in ungauged (or under-gauged) basins (CEOP, GMPP)

2008: Evaluate the predictive capability from land initialization conditions to the prediction of terrestrial hydrological variables at different time scales (GMPP, CEOP)

Coordinated Enhanced Observing Period (CEOP)/GEWEX Hydrometeorology Panel

Objective 1:

2007: Complete first global analyses of the energy and water cycle with existing products *(All panels will contribute to this analysis)* (GRP, CEOP, GMPP)

2007: Complete the quality control, production, and distribution of the CEOP Phase I data sets (CEOP)

2007: Complete first global analysis of the energy and water cycle with existing products (GRP, CEOP, GMPP)

2008: Complete observations and diagnosis of causes of global energy and water cycle variations from weather to decadal scales (GRP, CEOP)

2009: Develop a synthesis of the climatology and diurnal to interannual variations based on observations and models of water and energy budgets with improved observations and models (GRP/CEOP)

2009: Through continued involvement in WOAP, GCOS, IGOS-P and GEO, GEWEX will help to assess and, where appropriate, promote observations for the global energy and water cycle (ongoing) (GRP, CEOP, IGPO)

2009: Within the scope of their mandates, all GEWEX Panels will work to complete the set of products needed to describe the global energy and water cycle (GRP, GMPP, CEOP)

2010: Implement the CEOP data system as a prototype Global Earth Observation System of Systems (GEOSS) data handling system (CEOP)

Objective 2:

2007: Conduct field experiments and carry out analyses over West Africa to understand regional hydrometeorological processes and the dynamics of the African monsoon (CEOP)

2008: Develop an inventory of floods and droughts and the role of land-atmosphere feedback in causing those events (CEOP, GRP)

2010: Develop advanced analysis techniques to investigate causes of variability, to separate forced and unforced responses, and to estimate feedbacks and predictability (GRP, CEOP)

2010: Through CEOP, GCSS field studies, and GRP analysis projects, provide new insight on the role of aerosols in cloud and precipitation production (GRP, GMPP, CEOP)

2010: Provide an assessment of the role of land-atmosphere interactions during extremely wet and extremely dry periods (CEOP)

2011: Use SMOS and other satellite data to study the role of soil moisture in land-atmosphere interactions (GMPP, CEOP, GRP).

Objective 3:

2009: Promote the use of remotely-sensed data and develop related products to study the role of soil moisture in land atmosphere interactions (GMPP, CEOP)

2009: Carry out an enhanced observing period to obtain data for process understanding and model validation in areas of complex terrain (CEOP)

2010: Develop the understanding of and parameterizations required to reproduce the diurnal cycle for monsoon regions in a GCM (CEOP)

2010: Complete a study of the effects of aerosols on monsoons to be examined through CEOP using a combination of observational and modeling studies (CEOP)

2012: Provide a final review of the success of GMPP in improving parameterization at operational NWP and climate modeling centers and its impact on the predictive capabilities for key energy and water cycle variables, including hydrological prediction (GMPP, CEOP)

2012: Demonstrate the contribution of improved prediction systems for forecasting the onset and intensity of droughts and the recovery from drought (CEOP)

Objective 4:

2007: Launch the Hydrologic Applications Project (HAP) (CEOP)

2007: Launch at least two pilot projects in GEWEX CSEs that will utilize hydrological ensemble prediction techniques as a HAP and HEPEX initiative (CEOP)

2007: Downscale and evaluate seasonal hindcasts over the CSEs using NOAA and DEMETER seasonal forecasts that can be assessed by CSE scientists (CEOP)

2008: Launch several studies with (PUB to demonstrate the value of using remote-sensing data in ungauged (or under-gauged) basins (CEOP, GMPP)

2008: Evaluate seasonal hydrological forecasts from hindcast studies for the initial two pilot studies; and launch additional HAP and HEPEX pilot studies (CEOP)

2008: Develop links with THORPEX to undertake predictions on daily to monthly time scales in order to look at intra-seasonal prediction capabilities (CEOP)

2008: Assess the ability of models to simulate the impacts of heavy rain events and droughts on water resources (CEOP)

2008: Evaluate the predictive capability from land initialization conditions to the prediction of terrestrial hydrological variables at different time scales (GMPP, CEOP)

2009: Contribute appropriate models and methodologies for doing water balance studies to the Global Water System Project (GWSP) (CEOP)

2010: Determine the contribution of remote-sensing to hydrologic modeling, with particular focus on ungauged and poorly gauged basins (CEOP)

2010: Evaluate newly developed procedures for hydrologic ensemble generation and the impact on seasonal hydrologic prediction for the pilot test beds (CEOP)

2012: Prepare a review article on the hydrological response of basins of different sizes to drought and extreme rainfall events (CEOP)

2012: Review the outcome of PUB's contributions to GEWEX science and specify future areas of research required of the hydrological science community (CEOP)