Coordinated Energy and water –cycle Observations Project

Strategic Implementation Plan

December 1, 2008

Coordinated Energy and Water-cycle Observations Project (CEOP)
Strategic Implementation Plan (SIP)
FINAL DRAFT
(01/12/08ROADS/et al)

0. Executive Summary

The Coordinated Energy and water cycle Observations Project (CEOP) is a merger of the previous World Climate Research Project (WCRP) Global Energy and Water-cycle Experiment (GEWEX) Hydrometeorology Panel (GHP) and the 'Coordinated Enhanced Observing Period' ('CEOP'), which was an element of WCRP initiated by GEWEX. This natural merger between GHP and 'CEOP' now better coordinates similar activities being undertaken by both groups, which were largely comprised of similar scientists doing similar projects.

Many of the former GEWEX Continental Experiments (CSEs) have evolved to more complete Regional Hydroclimate Projects and even beyond in that more than GEWEX efforts are now needed to solve regional problems involving a climate prediction focus (CLImate VARiations; CLIVAR) and a biological focus (International Geosphere Biosphere Program, IGBP). Many now have an anthropogenic climate focus.

This development has prompted CEOP to begin investigating how to efficiently cooperate with other elements of WCRP including the Climate and Cryosphere (CliC) project, which has as part of its supporting objectives to enhance model evaluation and change detection and to promote improvements in the management of data and information relating to the cryosphere and climate. These needs to improve models and to make data more readily available for use by the broad scientific community lend themselves to collaboration with CEOP's cold regions study focus, which has some parallel and complimentary objectives with CliC in terms of science in cold regions, improvement of models and with one of CEOP's other major tasks to enhance integration of data from in-situ, satellite and model sources. In the same way, but on the broader international scale CEOP is committed to investigating outreach initiatives with other Earth System Science Partnership elements such as DIVERSITAS and IGBP.

In addition to the Regional Hydroclimate Projects (RHPs), the new CEOP includes groups focused on regional studies in cold regions, high elevations, monsoon, and semi-arid regions. These groups are an outgrowth of the previous 'CEOP' Monsoon project, which attempted to bring together scientists within both the CSEs and CLIVAR. The new CEOP Monsoons Regional Study will also reach out to CLIVAR and the WCRP Monsoon crosscuts to make sure its activities are synergistically connected with these other groups. At the same time the new CEOP Regional Studies Cold Regions Study (CRS) will begin to reach out to the RHP and WCRP scientists involved in similar activities in the WCRP CliC Project and will be a part of the International Polar Year (IPY).

The science of CEOP continues to provide a traditional focus on Water and Energy budgets, which will extend the efforts to understand average conditions to conditions during the 'CEOP' time period of 2003-2004 to present and a GHP effort to understand average conditions during an earlier period. This extension will have a special focus on extremes during the 'CEOP' period, which will be another connection to WCRP crosscut activities. New crosscutting CEOP science efforts include a study of the influence of aerosols and the studies of water isotopes, which is also connected to IGBP efforts.

CEOP now adds explicit global, regional, land surface, and Hydrologic Applications Project (HAP) as part of its group activities. All of these modeling groups are looking at an ensemble of

international models in many different regions focused on the new CEOP reference sites described in the Data Management section. Some of these modeling projects expect to show not only their capability to simulate the present climate but also to predict at seasonal (HAP) and also be useful for global change assessments in some of the RHPs.

CEOP Data Management, which was perhaps a focal point of the 'CEOP', has now successfully implemented a data policy allowing the sharing of in situ reference site data, model output data, and satellite data and set up archival centers of this data at the National Center for Atmospheric Research (NCAR) and the Max Planck Institute (MPI). During CEOP, satellite data will come on line at the University of Tokyo (UT) and then along with the other data be moved to a central data archive where it can be accessed and distributed to interested users. By the end of CEOP in 2012, we expect to have developed a functioning CEOP data center that will have been used by all of the CEOP science groups. It should be noted that this CEOP data is already open to outside groups. CEOP data management is also in the process of developing links to a number of associated groups, such as the Global Runoff Data Centre and Global Precipitation Climatology Centre.

In short, CEOP is now the international focal point for WCRP/GEWEX Global Hydrometeorological Research and we welcome all interested researchers to participate and contribute to the development of current and future hydrometeorological observations, simulations, and predictions.

1. General Background

1.1. GHP

When the GEWEX commenced in 1988 with a focus on global products, its lead scientists recognized that the global data sets needed to be evaluated at regional scales (Sorooshian et. al., 2005). At the same time significant improvements were being made to land surface models as a result of intensive regional experiments being carried out by the International Satellite Land Surface Climatology Project (ISLSCP) and the Biospheric Aspects of the Hydrologic Cycle (BAHC) initiative under the IGBP. In particular, the ISLSCP carried out intensive field campaigns focused on relatively homogeneous areas of 10,000 km2 (approximately the size of a climate model grid square) and involved intensive observational periods for (generally) two to four weeks several times a year. This concept continued to be developed by the US Dept. of Energy Atmospheric Radiation Measurement (ARM) program, who initially proposed world wide coverage with a number of sites, but ultimately, due to cost constraints, focused first on one site in Oklahoma, US and then later additional sites in Alaska and the western Pacific - sites which are still operating today.

As a result of the convergence of GEWEX interests for a regional test bed, the need to scale up the ISLSCP land surface studies to larger geographical areas, and the desire of the International Association of Hydrological Sciences (IAHS) to involve hydrology more actively in climate research, the concept of a continental scale hydrologic experiment was developed in 1990. The proposed regional experiment was based on the hypothesis that water and energy budgets over a large basin would not be as sensitive to random errors as they are at a point or for a small watershed, but they could still be examined in a meaningful way because there was an increasing likelihood of closing continental-scale water and energy budgets to acceptable limits using the newly available data sets and models.

In 1990, a group of international experts recommended the Mississippi River Basin as a focus area and then worked with others to draw up a science plan for the GEWEX Continental-scale International Project (GCIP). As planning progressed, however, a consensus emerged that areas with other important processes such as permafrost and tropical forests should also be studied. In addition, a number of countries could make stronger national contributions to GEWEX if they studied a basin that included their national territories. As a result several experiments were developed to cover large land areas. The GEWEX CSEs have included: MAGS (MAckenzie GEWEX Study), GCIP/GAPP/CPPA (GEWEX Continental-scale International Project/ GEWEX Americas Prediction Project / Climate Prediction Program for the Americas), LBA (Large-scale Biosphere Atmosphere Experiment in Amazonia), LPB (La Plata Basin), BALTEX (BALTic sea EXperiment), GAME/MAHASRI (GEWEX Asian Monsoon Experiment / Monsoon Asian Hydro-Atmosphere Scientific Research and prediction Initiative), MDB (Murray Darling Basin), AMMA (African Monsoon Multidiscplinary Analysis). These CSEs have had different start and end dates. For example, AMMA was approved as a CSE beginning in 2005 and MAGS, which began in 1994, ended in 2005. The Northern Eurasia Earth Science Partnership Initiative (NEESPI) was accepted by the GEWEX Scientific Steering Group (SSG) in 2007.

GEWEX established the GHP beginning in 1994 (Lawford et. al., 2004) to coordinate the wide range of regional interests and activities involved in these CSEs. GHP also took responsibility

for coordinating relevant activities of the ISLSCP, the Global Runoff Data Center (GRDC), and the Global Precipitation Climatology Center (GPCC). The overall GHP mission was to "demonstrate the capability to predict changes in water resources and soil moisture at time scales up to seasonal and interannual as a component of the World Climate Research Program's prediction goals for the climate system." To this end GHP influenced the priorities of each CSE and global project. The GHP further promoted and coordinated interactions with the GEWEX Radiation Panel (GRP) and the GEWEX Modeling and Prediction Panel (GMPP). The GHP also initiated, synthesized, reviewed and recommended joint activities that promoted a common research agenda for each of the CSEs. CSE representatives agreed to a set of technical and scientific requirements, which have now been modified below.

GHP set up several international working groups composed of CSE representatives, which would attempt to globally coordinate diverse regional activities happening within each of the CSEs. These working groups included: WEBS (Water and Energy Budget Studies), WISE (Worldwide Integrated Study of Extremes), SWING (Stable Water Isotope Working Group), TWG (Transferability Working Group), WRAP (Water Resources Applications Project) / HAP, DM (Data Management), 'CEOP' (Coordinated Enhanced Observing Period)

'CEOP' (Bosilovich and Lawford, 2002) and (Lawford et. al., 2006) was part of the initial GHP strategy to help coordinate the diverse GEWEX CSE activities to understand and model the influence of continental hydroclimate processes on the predictability of global atmospheric circulation and changes in water resources. As a contribution to 'CEOP', the CSEs identified high-quality in situ measurements (many of these are tower sites) at several global locations that would be able to provide coordinated global measurements during the period 2001-2004.

1.2. 'CEOP'

'CEOP', began as a discussion item at the 2nd GHP meeting in 1995 and subsequently, the 'CEOP' Working Group was formed, which was then moved from GHP in 2001 and the World Climate Research Programme Joint Steering Committee designated it as "an element of WCRP initiated by GEWEX". 'CEOP' was strongly supported by GHP and many GHP science activities soon became actively entrained within 'CEOP', in part through the 'CEOP' data management and modeling activities, and in part through cross linkages of many of the CSEs and GHP science working groups within the 'CEOP' Intercomparison Monsoon Study CIMS and the Water and Energy Simulation and Prediction (WESP) project, 'CEOP' also took advantage of the coincident new generation of remote sensing satellites (including TERRA, AQUA, ENVISAT, ADEOS-II) in addition to TRMM, Landsat-7, NOAA-K series and the other operational satellites, which are providing enhancement of observing capabilities to quantify critical atmospheric, surface, hydrologic and oceanographic data during this time period. 200 km snapshots of the highest resolution raw radiances (with geographic location, i.e. level I) remote sensing data at the 35 in situ reference sites are now being archived. Geophysical products are being developed for these sites by international research teams as part of individual satellite science teams. In conjunction with the in situ and remote sensing observations, international operational numerical weather prediction centers are also archiving both analysis/assimilation and short-term forecast/analysis model products from both global and regional Numerical Weather Prediction (NWP) suites. Several model output variables (pertinent to atmospheric and surface water and energy processes) have been archived and the two types of requested model

output, globally GRIdded Binary (GRIB) and site-specific Model Output Location Time Series (MOLTS) at each of the 'CEOP' International Reference Sites are being developed.

1.3. Rationale for the GHP/'CEOP' merger

Now, initially 'CEOP' was a pilot experiment, designed to intensively study a limited time period, 7/1/2001-12/31/2004, a period when many CSEs would likely have corresponding intensive observation periods to complement 'CEOP' and a time when many of the new Earth Observing Satellites would be providing a wealth of new information about the earth. This pilot experiment was formulated and guided by formal Science and Implementation Plans (Stewart et. al., 2001a), (Stewart et. al., 2001b), and (Leese et. al., 2001c) and involved a number of technical and science driven working groups that were reviewed and received direction and oversight from a Science Steering Committee and an Advisory and Oversight Committee. With the demonstrated uniqueness of 'CEOP' and advent of CEOP, which will extend the time period of enhanced observations and enhance the science agenda, it is clear that 'CEOP' will contribute to the scientific objectives of GEWEX and integrated data management activities of WCRP on a much longer term.

As a result, GEWEX, in full agreement with the GHP, and with 'CEOP', decided at the GEWEX SSG meeting in January 2007, to merge GHP and 'CEOP' to form a new entity, now designated the Coordinated Energy and water cycle Observations Project (CEOP). This formal merger into the new CEOP is meant to enhance the efforts of both GHP and 'CEOP' and will not lose sight of any of the GHP and 'CEOP' strategic goals or any of the ongoing GHP and 'CEOP' science work since the same scientists and more are already working on closely related projects and goals. It does mean, however, a refocusing of the former GHP and 'CEOP' activities toward the new CEOP goal and objectives.

2. CEOP Goals, Objectives, and Strategy

The goal of CEOP is: **To understand and predict continental to local-scale hydroclimates for hydrologic applications**

To achieve the above goal, CEOP's strategic objectives, which are similar to the GEWEX objectives include:

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 2: Enhance the understanding of and quantification of how energy and water cycle processes contribute to climate feedbacks.

Objective 3: Improve the predictive capability for 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 4: Undertake joint activities with operational hydrometeorological services, related Earth System Science Partnership Program (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

The above defined objectives will help us answer some of the following science questions including: What are the average hydroclimate conditions over various regions and seasons? How does water and energy flow into and through individual regions as well as being redistributed within these regions by local mechanisms? How do extremes occur and what is their role in the hydroclimate? How do aerosols affect the hydroclimate? Does knowledge of water isotopes help us to understand the water cycle? Can we simulate and predict the hydroclimate at least at the seasonal timescale with prospects of achieving some success up to inter-annual time periods? What is the benefit of this increased knowledge about the hydroclimate for society?

Specific technical issues that are being addressed as part of the objectives mentioned above include:

1. Developing an integrated hydroclimate data set that can be used to answer the main scientific questions noted above.
2. Developing the capability to handle and disseminate a large amount of amount of data from diverse sources
3. Analyzing and comparing with model simulations this diverse data to understand the underlying mechanisms and model deficiencies.
4. Assimilating and integrating the data with newly developed models.

5. Transferring CEOP methodologies to other regions, sectors, and applications

A CEOP observation and modeling strategic implementation plan has now been developed that is organized around 5 main CEOP Elements with various subprojects

1. Regional Hydroclimate Projects (RHPs)
    1.1. AMMA
    1.2. BALTEX
    1.3. CPPA
    1.4. LBA
    1.5. LPB
    1.6. MAHASRI
    1.7. MDB
    1.8. NEESPI
2. Regional Cross Cutting Studies
    2.1. Cold Region Studies
    2.2. High Elevation Studies
    2.3. Monsoons
    2.4. Semi-Arid Studies
3. Topical Cross Cutting Studies
    3.1. Water and Energy Budget Studies (WEBS)
    3.2. Extremes
    3.3. Aerosols
    3.4. Isotopes
4. Models
    4.1. Global Models
    4.2. Regional Models
    4.3. Land Surface Models
    4.4. Hydrological applications
5. Data Management
    5.1. In-situ
    5.2. Satellites
    5.3. Model output
    5.4. Data integration
    5.5. Global Data Centers

As part of this CEOP implementation plan, we first provide some brief background for each CEOP element (Sec. 3), followed by a summary discussion of the planned implementation efforts (Sec. 4). Contributions to CEOP and GEWEX objectives are then provided in Sec. 5. Contributions to WCRP crosscut activities, Group on Earth Observations (GEO) activities, and society in general are also described in later chapters. It should be noted that individual CEOP elements report directly to GEWEX and have more extensive reports and documentation in these reports and on their developing web sites than is provided in this implementation plan. In that regard, we have tried to make reference to all relevant web sites where further information may be obtained. We should also note that we plan to make this a living document and plan to update it on a routine basis.

3. CEOP Elements

3.1. Regional Hydroclimate Projects

There are a number of regional studies associated with GEWEX and now CEOP. The major regional studies include the RHPs that have already been tasked by the GEWEX SSG with satisfying a number of scientific and technical criteria that can only be established by large projects involving a multitude of investigators. These criteria now include:

TECHNICAL CRITERIA

- Cooperation of an NWP center for provision of atmospheric and land surface data assimilation.
- Atmospheric-hydrologic models for studying transferability and climate variability.
- Mechanism for collecting and managing adequate hydrometeorological data sets.
- Participation in the open international exchange of scientific information and data.
- Interactions with hydrologic services and related groups
- Commitment of adequate resources and personnel.
- Evaluation of GEWEX global data products
- Contributions to CEOP in situ, remote sensing, and model output databases.

SCIENTIFIC CRITERIA

- Observe, simulate, and predict diurnal, seasonal, annual and interannual variability.
- Determine climate system variability and critical feedbacks.
- Demonstrate improvements in predictions of water-related climate parameters.
- Demonstrate the applicability of techniques and models for other regions.
- Assess the human impact on hydroclimate variations, including vulnerability to climate change

The RHPs are organized and funded by national organizations and are or have the potential of satisfying the GEWEX technical and scientific criteria: As part of their annual reports each RHP provides an assessment on their progress in satisfying these GEWEX criteria in their region. This assessment is done by filling out, as a minimum, a reporting template, in a timely manner, before the yearly held GEWEX SSG meeting (usually January of each year). The template, which is consistent with the one used by GEWEX itself, is available upon request at the International GEWEX Project Office. It should be noted that the current group of 8 GEWEX RHPs include some of the original or ancestors of the original GEWEX CSEs established in 1994 (BALTEX, GCIP/GAPP/CPPA, LBA, GAME/MAHASRI) as well as some newer ones (MDB, LPB, AMMA, NEESPI). We note here that although one of the original RHPs, the MAGS has now concluded a highly successful 10-year project, many of the MAGS scientists and researchers are still quite active in GEWEX and CEOP activities. In particular, R. Stewart, a former GHP chair, chairs the Extremes effort.

Where as MAGS, for example, has been completed within the framework of the initial criteria established by GEWEX, other established experiments have entered new phases and still others have been newly established. In each case, the GEWEX SSG has approved these developments and tasked the managers of these efforts to evolve or begin their work in compliance with the criteria noted above. Recently, it has been seen and reported by CEOP to the GEWEX SSG that a few of these experiments have evolved or begun work along courses of development, which

have found them to be unable or at least limited by other external factors, including constraints placed on them by their funding agencies, to continue to meet the criteria they had initially committed to abide by. The GEWEX SSG has taken the position that if CEOP is unable to confirm compliance by a specific RHP with the established criteria, that RHP may be reclassified as only an affiliate effort not to be formally operating as a GEWEX RHP under the definition established within the context of the GEWEX/WCRP international framework. This caveat is underscored here, because if and when such action is undertaken in the future it could lead to a reassessment of CEOP objectives in specific study areas dependent on provision of actual results from the RHPs associated with each criteria.

3.1.1 AMMA http://www.amma-international.org/rubrique.php3?id_rubrique=1
Input to be received

3.1.2 BALTEX http://www.baltex-research.eu/
The Baltic Sea Experiment (BALTEX) was established as a regional research programme and a contribution to GEWEX in 1993 and 1994 (Raschke et al., 2001). BALTEX Phase I was concluded in 2002 followed by Phase II of the programme with revised and extended science objectives. The related science and implementation documents were published in 2004 and 2006 (BALTEX, 2006), respectively. The present status of BALTEX may best be described as an international, interdisciplinary partner network across more than 10 countries. The individual project or initiative geometry and size are highly variable. BALTEX has no major central funding. At present, the individual project funding relies heavily on institutions' resources, while major funding at the national or international levels is minor. BALTEX has a functioning management structure in place with an SSG, several working groups, data centres and an international secretariat, both the latter of which enjoy permanent funding by individual European Institutions such as SMHI, DKRZ-MPI and GKSS. The BALTEX SSG has representatives of almost all major national hydro-meteorological services in the Baltic Sea region as members, thus indicating the importance of a major group of stakeholders for the steering process of the programme. BALTEX organises international conferences in 3-year intervals, the 5th Conference in this series with 140 registered participants was conducted in June 2007 in Estonia. So far more than 50 research institutions and organisations in all countries of the catchment of the Baltic Sea and beyond have contributed to BALTEX. Results of BALTEX are published in more than 270 peer-review journal articles, six dedicated special journal issues and numerous reports (http://www.baltex-research.eu/publications).

The science plan for BALTEX Phase II (2003-2012) has the following major goals and objectives for the programme:

1. Better understanding of the energy and water cycles over the Baltic Sea basin;
2. Analysis of climate variability and change since 1800, and provision of regional climate projections over the Baltic Sea basin for the 21st century;
3. Provision of improved tools for water management, with an emphasis on more accurate forecasts of extreme events and long-term changes;
4. Gradual extension of BALTEX methodologies to air and water quality studies;
5. Strengthened interaction with decision-makers, with emphasis on global change impact assessments;
6. Education and outreach at the international level.

3.1.3. CPPA http://www.climate.noaa.gov/cpo_pa/cppa/

The Climate Prediction Program for the Americas (CPPA) program is an integrated program that combines the former GEWEX/GAPP and CLIVAR Pan American Climate Studies (PACS). CPPA has a CPPA Science Panel that was formed in Feb. 2006. CPPA is solely sponsored by the National Oceanic and Atmospheric Administration (NOAA) Climate Program Office. CPPA funding has been steady, but varies from year to year.

CPPA has four main scientific objectives:

1. to quantify the sources and limits of predictability of climate variations on intra-seasonal to interannual time scale;
2. to improve predictive understanding and model simulations of ocean, atmosphere and land-surface processes, including the ability to quantify uncertainty;
3. to advance NOAA's operational climate forecasts, monitoring, and analysis systems by transferring research to operation;
4. to develop climate-based hydrologic forecasting capabilities for decision support and water resource applications.

3.1.4. LBA http://lba.cptec.inpe.br/lba/site/

The Large-Scale Biosphere - Atmosphere Experiment in Amazonia (LBA) is primarily funded by the Brazilian Government (Science and Technology Ministry) and is centered on two key questions:

1) How does Amazonia currently function as a regional entity?
2) How will changes in land use and climate affect the biological, chemical, and physical functions of Amazonia, including the sustainability of development in the region and the influence of Amazonia on global climate?

The Hydrology component will consider issues related to both the quantity and the chemistry of water in the Amazon Basin. The stores and fluxes of water, and the controls on movement of water in soils and in streams, and the associated transport of constituents, will be determined for a nested suite of catchments representing a range of land use intensities. Forested and deforested catchments of several square kilometers will be instrumented to make measurements with high temporal resolution of discharge, rainfall, evaporation, interception, soil water storage, ground water leakage and export of sediment and nutrients. The data will be used to improve the capability of hydrometeorological models to assess the response of flows of the Amazon and its tributaries to changes in climate and changes in land use. Controls on the movement of materials from the upland through the riparian zone and into streams will be studied in small catchments drained by low order streams. Models of nutrient budgets in larger catchments will integrate results from fieldwork in the small catchments with extant models of higher order river biogeochemistry and extant and new models of hydrologic routing.

3.1.5 LPB http://www.eol.ucar.edu/projects/lpb/

The La Plata Basin (LPB) is an International Project that that has been endorsed by GEWEX and CLIVAR. It aims to improve the predictive skill of the hydroclimate system of that South American basin. It also seeks to establish the possible impacts of regional and global climate change on the water resources of the region. The La Plata basin is highly vulnerable to floods, a fact that has been gradually worsened due to the notable positive trends in precipitation and

streamflow. LPB is working with several organizations and agencies to promote its agenda and bring awareness of activities of high impact to the regional community.

LPB is currently planning the development of the Monitoring Activities and a Field Experiment, as presented in the LPB Implementation Plan. The LPB Implementation Plan foresees complementary observational and modeling activities. The monitoring of hydroclimate variables and a field experiment will develop a set of unique data that will, first, help understand the land surface-atmosphere processes that may lead to persistent events, and second, help calibrate and improve parameterizations in regional and global models employed for forecasting and prediction up to seasons. Modeling activities include the development of coupled atmospheric and hydrologic models to better understand the behavior of rainfall-runoff relationships and improving the long-term weather forecast and climate prediction of all components of the hydroclimate system.

The fundamental issues to be addressed in LPB can be summarized in three main questions:

- What climatological and hydrological factors determine the frequency of occurrence and spatial extent of floods and droughts?
- How predictable is the regional weather and climate variability and how predictable are their impacts on the hydrological, agricultural and social systems of the basin?
- What are the impacts of global climate change and land use change on regional weather, climate, hydrology and agriculture?

3.1.6. MAHASRI http://mahasri.cr.chiba-u.ac.jp/index_e.html

The Monsoon Atmospheric-Hydrologic Analysis Sustainability Research and prediction Initiative (MAHASRI) is the successor of the former GAME, but also includes several new aspects like ocean-atmosphere interaction, aerosols, winter monsoon, application to the society, and capacity building. MAHASRI was approved by the GEWEX SSG in January 2006. The International MAHASRI Science Steering Committee was formed already, although some members are still tentatively determined. Pilot projects are just launched, and the data management structure is under discussion. It is almost impossible to count the number of participating organizations because many governmental agencies, universities and institutes are participating from various countries of Asia. Among them, the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) will be a key institute. The MAHASRI is a coordinated project of projects that are funded by many funding sources not only in Japan but also in China, India, Thailand, and other Asian countries.

The objective of the MAHASRI is “to develop a hydro-meteorological prediction system, particularly with the time scale up to a season, through the better scientific understanding of Asian monsoon variability” with the following activities:

- determine the predictability and key components of Asian monsoon variability with a time scale up to a season for the development of a hydro-meteorological prediction system;
- develop a real-time monitoring capability for hydro-meteorological observation;
- develop an integrated hydro-meteorological database including data-rescue;
- examine and improve hydro-meteorological models in some specific river basins.

Key scientific issues are focused on:

- atmosphere-ocean-land interactions;
- effect of various-scale orography on monsoon;
- temporal interactions among diurnal, synoptic, intraseasonal and seasonal variability of Asian monsoon;
- spatial interactions among hydro-meteorological phenomena;
- transferability of hydrological models and parameters.

One particular plan worth mentioning is coordination of Asian monsoon observations under the WCRP Pan-monsoon activity as Asian Monsoon Year 2008 (AMY08) starting from March/April 2008 to April 2009, which will also contribute to the overall GEWEX and CEOP objectives.

3.1.7. MDB http://www.gewex.org/mdb.html

The Murray Darling Basin Water Budget Project (MDB) was approved as a GEWEX CSE in January 2002, and was initially aimed at enhancing the capability of numerical weather prediction models to provide a real-time surface water budget over the Murray-Darling for application by water authorities. The 2005 implementation plan incorporated new involvement from stakeholders and the wider University community, and identified the importance of ACCESS (Australian Community Climate Earth System Simulator), a comprehensive ensemble prediction modeling system for weather and climate system, to the objectives of the MDB.

The MDB is now an active program of activities is continuing in various Australian Agencies (ANSTO, BMRC, CSIRO and Melbourne University). The research activities are also supported by the eWater Cooperative Research Centre, which has over 30 participating research and operational water agencies. Along with the influence of ACCESS, especially the land surface scheme that will focus efforts on water –carbon – energy interactions, we envisage considerable enhancement of the research activities, and perhaps funding, as a result of the new role that the national weather agency, the Bureau of Meteorology, has in water resources. The intersection between the objectives and research within the Bureau's new water division, and the MDB, will become clearer.

Relevant objectives of the MDB project are to:

1. Observe, understand and model the dynamics of the coupled water, energy and carbon cycles of the Murray Darling Basin, a developed, semi-arid zone Basin
2. Improve predictive tools for water management, including real-time forecasting products for use by water agencies in the Basin
3. Strengthen interaction between the climate research community and decision-makers, to maintain a practical focus on water and climate issues that impact both the region and the Australian continent
4. Promote education and international exchange to improve global change science capability and innovation in Australia and worldwide.

3.1.8. NEESPI http://neespi.org/

The Northern Eurasia Earth Science Partnership Initiative (NEESPI) mission is to identify the critical science questions and establish an international program of coordinated research on the state and dynamics of terrestrial ecosystems in northern Eurasia and their interactions with the

Earth's climate system to enhance scientific knowledge and develop predictive capabilities to support informed decision-making and practical applications. . It focuses on issues in Northern Eurasia that are relevant to both regional and global scientific and decision-making. The Initiative has partial central funding (e.g., special calls/programs by the National Aeronautics and Space Administration (NASA) and the Russian Academy of Sciences and investments into the Initiative infrastructure from national and international agencies). However, more than half of the NEESPI projects are individually funded to address specific science question/problem that corroborates with the NEESPI Science Plan.

Currently, about 400 scientists from about 200 institutions of 30 countries are involved in the NEESPI scientific projects (the latest count is 116 projects). A large group of proposed projects is still under review and/or in the process of recognition by NEESPI. Expected NEESPI future funding situation depends upon the overall quality of the scientific results delivered by the Science Team and the strength of the proposals that the Team researchers will put forward. During the past two years, the NEESPI program has been endorsed by several ESSP Projects (IGBP through the Integrated Land Ecosystem-Atmosphere Processes Study (ILEAPS), WCRP through GEWEX and CliC, and ESSP through GCP and GWSP). Thereafter, the NEESPI program has requested from ESSP the status of an ESSP Integrated Regional Study in the northern part of Eurasia.

NEESPI's goal is to develop a comprehensive understanding of the Northern Eurasian terrestrial ecosystem dynamics, biogeochemical cycles, surface energy and water cycles, and human activities and how they interact with and alter the biosphere, atmosphere, and hydrosphere of the Earth. The anticipated outcome from this program is the ability to measure, monitor, and model the processes that will provide accurate future projections of climatic and environmental changes in this region, which is essential because these changes and potential changes are believed to have a substantial potential to impact the global Earth system and the human society. On the regional (and to some extent on the global) scales this goal corroborates well with the GEWEX mission "Development and application of planetary Earth science, observations and models to the problems of climate and water resources".

3.2. Regional Cross-Cutting Studies

An additional number of CEOP Regional Studies (RCCS) have been established that involve fewer numbers of investigators but which have the potential capability to bring together interested researchers in many RHPs and other parts of GEWEX interested in common regional problems associated with Cold Regions, High Elevations, Monsoons, and Semi-Arid Regions.

3.2.1 Cold Region Studies

CEOP previously recognized through its WESP science and implementation review process (and endorsed by the AOC/Scientific Steering Committee (SSC)) that there is a need to advance knowledge of processes in cold regions in cooperation with the CliC Core Project (http://clic.npolar.no/). The CEOP science and oversight groups along with the broader scientific community have stressed the importance to ensure that a complete record of observations in cold regions (especially snowfall precipitation) be continued and further developed as part of CEOP through the CRS.

The central theme of CliC is to establish the present state of the cryosphere as the baseline for assessing the changes now going on and that might occur in the future system. CliC believes that by working together with CEOP there is an unprecedented opportunity to document current conditions utilizing shared data archives (in-situ and satellite) and access capabilities of both projects. In addition, the assimilation and modeling capabilities of CEOP might be used as a major contribution to the assessment of the cryosphere as part of CliC objectives. Conversely, the on-going observation and monitoring of the cryosphere in CliC will support CEOP process studies, model evaluation, and change detection. It will also improve understanding of the physical processes in cold regions so that they can be represented more precisely in models to reduce uncertainties in simulations of climate and predictions of climate change. Tools and techniques already established will use these enhanced observations to diagnose, simulate and predict water and energy fluxes and reservoirs in cold regions on diurnal to annual temporal scales as well as apply these predictions for water resource applications.

Further, it was recommended that CEOP undertake a joint initiative with the CliC project as part of the IPY initiative (2007-2008) as part of its multi-disciplinary framework. The purpose of this effort is for CEOP to assist CliC and possibly the IPY effort as well with a primary objective: *to assess and quantify the impacts of climatic variability and change on components of the cryosphere and their consequences for the climate system, and determine the stability of the global cryosphere; and* related secondary objectives. This coordination is especially synergistic with the IPY, which is envisioned to be "…*an intense, internationally coordinated campaign of research that will initiate a new era in polar science. IPY 2007-2008 will involve a wide range of research disciplines, including the social sciences, but the emphasis will be interdisciplinary in its approach and truly international in participation*…" These objectives include assessing and quantifying the impacts of climatic variability and change on components of the cryosphere and their consequences for the overall climate system.

During 'CEOP' the development of a template for homogenization of the "snow" data from CEOP cryospheric sites was undertaken. An on-line questionnaire was developed and distributed to these sites by the CEOP Data Management Working Group. The questionnaire results include basic background information for the CEOP Reference Site metadata file and will identify which sites can be used for development, validation and analysis of cold region observations, processes and modeling. Responses to the questionnaire are found at:
http://www.eol.ucar.edu/projects/ceop/dm/webresponse/snow/

To accomplish its goals this cross-cutting study will establish means of cooperating with elements of GEWEX, WCRP and ESSP initiatives including: CEOP-HE, CEOP-WEBS, GRP-(for cloud datasets), GMPP-GLASS, NEESPI and BALTEX; CliC, IPY; and GWSP respectively. In most cases the cooperation will take the form of establishment of direct contact with a specific individual(s) in each activity nominated by the leaders of the effort to open lines of communication about developments, which impact both. The identification of such individuals will allow for attendance at relevant meetings and communication through direct e-mail and international conference call mechanisms. This means is preferable to the option of creating any new groups to manage these interactions and will be implemented in every case where collaborative interaction will eliminate redundancy and lead to positive results.

3.2.2. High Elevations http://www.ceop-he.org

The High Elevations (HE) Project will be a concerted, international and interdisciplinary effort to further knowledge of the physical and dynamical processes in high altitude areas. High elevation areas provide interesting locations for the early detection and study of the signals of climate change and the assessment of climate related impacts on hydrogeological, ecological and societal systems at a global level.

The main purpose of this working group is to:

- establish a coordinated activity between the high altitude climatic stations with aims at building a network within CEOP reference stations;
- contribute to the understanding of water and energy cycles in high elevation regions and study their role within the climate system by means of globally integrated analysis of CEOP reference sites data, remote sensing observations and models analysis and application;
- build synergies between meteorological-climate and hydrological studies in order to improve the management of water resources;
- provide QA/QC protocols for high altitude sites installation and for data representativeness;
- create an electronic archive of high altitude monitoring stations;
- improve the forecast capabilities of extreme weather events in high altitudes that influence not only mountain regions but also a much wider environment and an elevated number of people, with important social consequences depending on the interaction between the three major components: environment, economics and society.

To accomplish its goals this cross-cutting study will establish means of cooperating with elements of GEWEX, WCRP and ESSP initiatives including: CEOP-CRS, CEOP-WEBS, CEOP-Extremes, CEOP-Model, MAHASRI, NEESPI and GMPP-GLASS; CliC; and GWSP, respectively. In most cases the cooperation will take the form of establishment of direct contact with a specific individual(s) in each activity nominated by the leaders of the effort to open lines of communication about developments, which impact both. The identification of such individuals will allow for attendance at relevant meetings and communication through direct e-mail and international conference call mechanisms. As noted above, this means is preferable to the option of creating any new groups to manage these interactions.

3.2.3 Monsoons

Monsoon climates are characterized by a distinct alternation of wet summer and dry winter seasons accompanied by large-scale circulation changes in response to seasonal differential heating between the continents and ocean. At present, more than 70% of the world population lives under monsoon climate influences. Vegetation, economy, and society in the monsoon regions are strongly influenced by the variability of the monsoon. Further, many of the countries in monsoon regions are under developing conditions whose economies are growing yet considerately affected by anomalous climate and disastrous weather. Future change in the monsoon climate under global warming is also of greatest concern to the world economy and sustainable development. Accurate seasonal forecasting of monsoon rainfall and its relation to regional hydroclimate has been strongly requested by society.

Monsoon science has advanced enormously in the last two decades due to a wealth of new data

from satellite observations, objective analyses, and field experiments, as well as advances in computing power and mathematical representations of coupled climate systems by numerical models, but the forecasting skill for monsoon prediction is still not satisfactory for many social needs. Consequently, further development of monsoon science is still needed.

The CEOP Monsoon Study (MONS) effort includes multiple observation and science activities within the fields of hydrometeorology and hydroclimatology. CEOP has evolved components to integrate observations based on coordination among field science groups, space agencies, and NWP centers in the local, regional and global scales. Other synergistic elements of CEOP that are also multidisciplinary include: components required to exchange and disseminate observational data and information including data management that encompasses functions such as Quality Assessment/Quality Control, access to data, and archiving of data, data integration and visualization, and information fusion.

To accomplish its goals this cross-cutting study will establish means of cooperating with elements of GEWEX, WCRP and ESSP initiatives including: CEOP-Aerosols, CEOP-WEBS, CEOP-Extremes, CEOP-Model, MAHASRI, LBA, LPB, AMMA, GMPP, and GRP; CLIVAR; and GWSP and MAIRS, respectively. In most cases the cooperation will take the form of establishment of direct contact with a specific individual(s) in each activity nominated by the leaders of the effort to open lines of communication about developments, which impact both. The identification of such individuals will allow for attendance at relevant meetings and communication through direct e-mail and international conference call mechanisms.

3.2.4 Semi-Arid Studies

CEOP Semi-Arid Studies (SAS) focus on semi-arid continental areas, which are the transition zone between arid climates and humid monsoon climates. These areas can be very sensitive to climate and human perturbations. The potential evaporation there exceeds the precipitation and dry climate, low vegetation cover, low nutrition content and low capacity of water conservation of the soil characterize the landscapes. These areas are vulnerable in global environmental change. These areas are also known as the major source of dust aerosols, which not only directly cause serious damage to human health, agriculture and economics in regions, but also to other regions through long distance transport of huge amount of dust particles across the Pacific ocean to North America. The dust aerosols also have significant influence on the regional and global climate through their radiative forcing. When this dust is deposited in the ocean, the Aeolian mineral dust becomes important to many biogeochemical cycles, including the growth of phytoplankton, which will influence the carbon cycle in the ocean. Researchers have also proposed an interaction process between dust aerosols and the hydrological cycle. Both observation and numerical modeling have shown that an aridity trend is occurring and will occur most significantly in the semi-arid regions under the global warming.

On the other hand, the semi-arid region is also the one with most significant change of land cover under the development by humans. The human-induced land cover changes in this region have brought about further land degradation, the expansion of land under desertification, loss of groundwater reservoirs and the increase of dust storm frequency and so on. The large-scale destruction of natural vegetation by human activities would also influence the intensity of the summer monsoon and reduce the moisture transfer into the continent, which would enhance the

aridity even more over the semi-arid regions.

It should also be pointed out that current climate models have shown the highest bias error of simulated precipitation in summer over the arid and semi-arid Asia. This could be due in part to lack of knowledge of land surface process, especially about the hydrological process over arid and semi-arid regions in current land surface models. Currently most hydrological modules in land surface model are developed and calibrated for use in humid areas.

SAS goals are:

- Make contributions to understanding the water and energy cycles of semi-arid regions and their role in climate system by globally integrated analysis of CEOP reference sites data, satellite observations and model output
- Assist in better prediction of climate and water resources and their management in semi-arid regions where the shortage of water supply is critical.

To accomplish its goals this cross-cutting study will establish means of cooperating with elements of GEWEX, WCRP and ESSP initiatives including: CEOP-Aerosols, CEOP-WEBS, CEOP-Extremes, CEOP-Model, MAHASRI, AMMA, and GMPP; CLIVAR; and GWSP and MAIRS , respectively. In most cases the cooperation will take the form of establishment of direct contact with a specific individual(s) in each activity nominated by the leaders of the effort to open lines of communication about developments, which impact both. The identification of such individuals will allow for attendance at relevant meetings and communication through direct e-mail and international conference call mechanisms.

3.3. Topical Cross Cutting Studies

CEOP has a number of Topical Cross-Cutting Studies (TCCS) that is being pursued in collaboration with the RS, RHPs and Modeling Studies (MS). These regional include Water and Energy Budget Study, Extremes, Aerosols, and Isotopes projects.

3.3.1 Water and Energy Budget Study

Water and energy budgets on the surface and in the atmosphere are key processes of the climate system, which in turn drive/affect other processes in the system. The water and energy budgets are not only dependent on a variety of time scales (from diurnal and seasonal variations to inter-annual and decadal variability), but also characterized by regional differences and inter-connections. A WEBS was first initiated by GEWEX/GHP to develop the “best available water and energy budgets”, for the global land regions associated with the GEWEX CSEs. GEWEX Phase I Results have now addressed regional variability of water and energy components, the importance of land surface parameterization for precipitation forecast, and the importance of Continental-Scale Experiments in closure of the regional water and energy budgets (Roads et. al., 2008).

The CEOP WEBS element will merge research activities of GHP WEBS with activities of the ‘CEOP’ WESP (such as multi-model inter-comparisons). The CEOP/WEBS is now helping CEOP to develop situ data, model output, satellite in a form that can be exchanged and disseminated Based on this CEOP integrated data of observations, satellite products, and model

output, CEOP/WEBS will address the following key issues related to data quality, model deficiencies and science:

- Quantify data accuracy, uncertainties, and discrepancies of energy and water components, particularly for RHP regions?
- Since there are many data sources for each hydrological/energy component, can we find which is superior to others, if any?
- How can we integrate in situ, model and satellite to develop the "best available water and energy budgets", for the global land regions associated with RHP?
- With current available data, how can we identify deficiencies of model parameterizations and satellite algorithms?
- How can we characterize differences and inter-connections of regional water and energy budgets, and their temporal variability, particularly for hydroclimate "hotspots", extreme events as well as low-frequency climate events?
- What is the role of land-atmosphere interactions for hydroclimate "hotspots", extreme events as well as low-frequency climate events?

Water and energy budgets are a broad topic in the GEWEX research community. The WEBS is trying to define its scope to be an analysis and assessment project (though it also covers modeling and data assimilation) and to address regional water and energy budget more than global one. It is a data-based project, and needs strong collaboration from RHPs, NWP centers, space agencies, data integration centers. The WEBS group will work jointly with other groups (CEOP subprojects, GRP-SRB and GMPP-follow-on) on some topics for improving quantitative knowledge on water and energy budgets from local short-term to global long-term (multi-decadal) scales.

WEBS Objectives

- Determine and understand average values and temporal variability for components of the water and energy cycles
- Identify systematic errors and uncertainty of various types of water and energy data (in situ, model, satellite, etc.)
- Characterize the temporal variability of water and energy budget of regional hydroclimate phenomena with particular attention to hydroclimate "hotspots", extreme events, and low-frequency climate events

3.3.2. Extremes http://www.drinetwork.ca/extremes/

A fundamental aspect of the water and energy cycle is the occurrence of extremes. Extremes develop and evolve on a continual basis within the current climate system, and they lead to enormous impacts when and where they occur. How can we improve our understanding and prediction of extremes? To what extent will the types, distributions, and impacts of extremes change in a world with an altered climate? Extremes will systematically address these issues within the present climate system and this solid foundation will then allow us to contribute significantly to understanding to what extent they may change in the future.

Extremes initially to be studied are those with a 'climatologically significant duration and/or spatial extent' as opposed to individual, short-term events such as thunderstorms or flash floods. This perspective includes:

- extended wet period (producing a substantial period of precipitation for one to several days that affects areas on scales of at least 10,000 km^2);
- drought (with its standard definitions) and this may include heat waves (lasting for days to weeks);

Associated research will include, for example:
- examination of storm track variations;
- long periods of dry conditions interspersed with heavy rain.

Specific scientific issues to be addressed include:
- How we define extremes;
- What extremes have occurred;
- How do extremes develop, evolve and end within the climate system;
- Have extremes changed in occurrence and character and why or why not;
- Given our progress, how can we contribute to assessing whether extremes may change in the future?

3.3.3. Aerosols

As a result of the work in CIMS to understand and document the seasonal, diurnal and intraseasonal variation of the monsoon systems, and to carry out inter-monsoon comparison studies to identify possible physical connections, and common features, we have identified aerosol-monsoon water cycle interaction as an important common problem in all monsoon regions that has not received enough attention under the existing panel structure of CLIVAR and GEWEX. Under the new aerosol-cross cut initiative of CEOP, we will examine the impact of aerosol radiative forcing in affecting diurnal to seasonal cycles, as well as evaluating impacts on climate variability and change.

Recent studies have shown that regional and global water cycles may be profoundly affected by the increased loading of aerosols in the atmosphere. Aerosols attenuate shortwave radiation by scattering and/or absorption causing cooling at the earth's surface. Some aerosol species such as dust and black carbon can heat the atmosphere by absorbing solar radiation. Further, aerosols may affect the water cycle by interfering with the microphysical processes of clouds and precipitation formation, suppressing or enhancing rainfall depending on the ambient large-scale moisture and circulation conditions.

Collectively, the diverse sources of aerosols, both natural and man-made, provide significant perturbations on the energy balance in the climate system, altering the horizontal and vertical heating contrast in the atmosphere and at the earth's surface. The heating contrast drives anomalous atmospheric circulation, resulting in changes in cloud formation, convective stability, and rainfall in the atmosphere. Recent studies have shown that, aerosols effects may be instrumental in producing droughts and floods in Asian monsoon regions. Dust and black carbon may increase heating of the atmosphere and enhance monsoon rainfall, and induces hydroclimate feedback including snowmelt and retreat of glacier over high-mountain domains. There is also the possibility that the solar attenuation effect may spin-down the monsoon water cycle on longer-time scales. Studies have also shown that Saharan dust may affect the climate and water cycle of West Africa and Atlantic, including the suppression of tropical cyclo-genesis, and

hurricanes.

To summarize, the objectives of CEOP Aerosol activities are to:

- unravel the effects of natural and anthropogenic aerosols on the monsoon water cycle and their interaction with the atmosphere-land-ocean system, from diurnal, intraseasonal to interannual time scales;
- provide better understanding of the mechanisms of extreme events that affect water availability in monsoon regions, and their relationships to oceanic, land, atmospheric (including aerosols) forcings.

CEOP's aerosol effort has evolved with the knowledge and participation of its key persons about other aerosol initiatives. First among these is the Aerosols, Clouds, Precipitation and Climate (ACPC) initiative recently jointly proposed by the IGBP core projects iLEAPS and IGAC, and the WCRP/GEWEX. At a kickoff workshop attended by CEOP aerosol experts ACPC was noted to address the question: How do aerosol-precipitation interactions manifest themselves at the full range of temporal and spatial scales in the climate system? The objectives of the CEOP aerosol activities as specified above can be seen to be synergistic with this matter, especially issues that are central to understanding of the mechanisms of extreme events that affect water availability in monsoon regions, and their relationships to oceanic, land, atmospheric (including aerosols) forcings. CEOP will not lose sight of developments in ACPC and will initiate a collaborative arrangement with support of the GEWEX SSG to ensure direct contact with a specific individual(s) nominated by the leaders of ACPC to open lines of communication about developments, which impact both activities. The identification of such individuals will allow for establishment of mechanisms for collaborative interaction including attendance at relevant meetings and communication through direct e-mail and international conference calls.

3.3.4. Isotopes

The Isotope Cross Cut Study (ICCS) contributes to CEOP by facilitating isotope studies, which augment and enhance the predominant non-isotope studies within GEWEX/CEOP. The ICCS includes modeling (both validation and assessment), process studies from in situ and remote sensed data, and integration of these studies with other CEOP studies.

The ICCS includes a modeling research group called Stable Water Isotope Working Group (SWING; http://atoc.colorado.edu/~dcn/SWING). The SWING aims to use water isotope information to understand water cycle processes and to quantify their role in climate and climate feedbacks. The SWING incorporates an intercomparison of current state-of-the-art water isotope general circulation models and related observational isotope data. It brings together scientists with a common wide range of interest in both modeling and measuring stable water isotopes ($H_2{}^{18}O$, HDO) and its application to earth system problems with a special focus on atmospheric hydrologic balance and water movement in the land surface. Recent developments in satellite observational capability have allowed water isotope measurements and have become an integral part of SWING. Since the isotope information provided through ICCS/SWING is of great utility for diagnosing cloud processes and surface exchange in models and in nature, there are many opportunities to work with other groups, which are not presently being exploited. An example of success was the IPILPS project, which used land models from the SWING models and other models to assess surface energy and water balance with isotopes.

Specific opportunities for partnership with existing GEWEX activities include an isotope counterpart to, for instance, GCSS. Similar isotope partnerships would assist activities such as WEBS. An example of success from such an interaction was the extension of the PILPs program to include an isotope element (IPILPS) that lead to further insight into the ability (or otherwise) of land surface parameterization schemes to not only simulate local surface water and energy balance, but to do so in the right way. The same approach could be adopted for cloud parameterizations; river and ground water flow models and large (continental) scale energy and water budgets. While these new opportunities have not been realized, planning for the isotope crosscut under CEOP is such that these can be developed.

3.4. Model Studies

CEOP has initiated a number of Modeling Studies organized around global, regional, and land as well as a particular hydrologic applications component. Personal communication between the newly appointed Chair of the GEWEX Modeling and Prediction Panel (GMPP) and the Leader of the CEOP Model Studies sub-project has now led to the direct interchange of technical and scientific information and knowledge. As a result a new collaborative arrangement has been instituted between CEOP and GMPP, with support of the GEWEX Executive Committee, to ensure direct contact with a specific individual(s) nominated by both leaders to open lines of communication about developments, which impact both activities. The identification of such individuals is allowing for establishment of mechanisms for collaborative interaction including attendance at relevant meetings and communication through electronic means and international conference calls. A specific example of this new scheme is the assurance that the leader of the CEOP Modeling Studies will be invited to participate at the initial and subsequent meetings of a newly formed GEWEX model studies group jointly established between GMPP and WGNE.

Such a one-on-one collaborative process between each CEOP model initiative and GMPP will be undertaken by CEOP as preferred to the option of creating any new groups to manage these interactions. It is felt that such an approach can be utilized not just in the modeling arena but can be generally implemented in every case where collaborative interaction will eliminate redundancy and lead to positive results.

3.4.1. Global Models

Evaluating CEOP global analyses has primarily been through the single point MOLTS co-located with CEOP reference sites (Yang et. al., 2007), (Bosilovich et. al., 2007), and (Roads et. al., 2007). To get at the intercomparison of global grids, CEOP is developing an ensemble global Model Analysis Comparison (MAC). This project serves several purposes. First, the variance of the analyses can provide a measure of uncertainty in analyses. It also provides a range of the state-of-the-art analyses. Second, this ensemble may make a better benchmark for comparing individual analyses than simply differencing one against another. We can also test the veracity of the ensemble against global independent observations (e.g. the Global Precipitation Climatology Project (GPCP), the International Satellite Cloud Climatology Project (ISCCP), Surface Radiation Budget (SRB), etc). Lastly we would like to demonstrate the benefit of such a Multi-Model analysis for global atmospheric data assimilation systems for future longer-term studies.

3.4.2. Regional Models

CEOP has a special focus on regional climate models, not only for particular regions, but also as part of an ongoing transferability intercomparison begun as a part of the previous 'CEOP'. There are now two recognized regional model projects, Inter-Continental scale Transferability Study (ICTS) and Scale Interaction EValuation Experiment (SIEVE).

ICTS http://icts.gkss.de

Controlled numerical simulations of regional climates are currently being conducted over areas having fundamentally different climate regimes (e.g., tropical, midlatitude, polar) focused on particular climate characteristics (e.g., monsoons, low-level jets, mesoscale convective systems). In particular, the ICTS, which is an outgrowth of the former 'CEOP'/WESP/ contribution, is making continuous multiple regional simulations to the CEOP model archive and in turn uses the CEOP global analyses, in-situ, and satellite data to evaluate these regional simulations. The goal of ICTS is to understand the physical processes underpinning the global water and energy cycles through systematic intercomparison of regional simulations of diverse climates to CEOP observations and global model analyses. . This way the best parameterizations will be localized to simulate certain regional scale meteorological conditions, which we believe will also help to improve future global climate models. For the ICTS seven computation areas over the different RHPs were defined. Several aspects were considered in this process (e.g. orography at the boundaries of the simulation areas; inclusion of main typical synoptic features). One area is over the MAGS region. The second covers GAPP and was defined by the Project for Intercomparison of Regional Climate Simulations (PIRCS). Another area covering both the LBA and the La Plata Basin region was used for a previous South America intercomparison. Over Europe we chose an area that includes the BALTEX catchment, taken from the definition of the CLM area used for the European Union Prediction of Regional scenarios and Uncertainties for Defining European Climate change risks and Effects (PRUDENCE) project. The area over Africa covers the AMMA region. The area over Asia covers the GEWEX GAME region, expanded to cover the Himalayan CEOP reference site. The selection for the MDB (Murray-Darling-Basin Water Budget Project) area was based on a previous case study from the GEWEX Cloud System Study. The horizontal resolution of the regional models was initially chosen to be approximately 50 km. The initial simulation period was from January 2000 to December 2004.Currently the National Center for Environmental Prediction (NCEP) Department of Energy (DOE) Reanalysis II is being used for the lateral boundary condition for these regional simulations.

To summarize, the main objectives of the ICTS are to:

- Study the transferability of regional climate models to areas of different continental scale experiments (i.e. to different climate regimes)
- Apply CEOP (satellite, reference sites, global analysis and model data) and other available observational data sets to evaluate the energy and water cycles in regional models
- Assess the influence of different driving global re-analyses

SIEVE

The unifying scientific question for the companion Scale Interaction EValuation Experiment (SIEVE) is to clarify the mechanisms by which large-scale disturbances ultimately produce these

extremes at regional scales. SIEVE will use nested regional climate models as tools to investigate these mechanisms. Large-scale aspects of seasonal extremes may have their origin as sea surface temperature anomalies (e.g., ENSO) or as planetary-scale circulation anomalies (e.g., the blocking pattern associated with the 2003 European heat wave). Regional-scale extremes then result or are intensified by interaction of these large-scale disturbances with regional processes such as orographic flows or land surface feedbacks. The latter can be diagnosed in detail from regional model results, or manipulated in controlled numerical experiments. This diagnosis also will help to uncover deficiencies in physical parameterizations when applied to such extremes, and will point to specific needs for model improvement.

The objective of SIEVE is to study the mechanisms by which large-scale climate anomalies are manifested as seasonal extremes on regional scales. These seasonal extremes occur on larger spatial and temporal scales than individual extreme events such as tropical storms or localized floods. Examples of such seasonal extremes are the summer 1993 regional flood over the central U.S. and the summer 2003 European heat wave.

3.4.3. Land Surface Models

Land Surface Models (LSMs) simulate the stocks and fluxes of water and energy at and beneath the land surface, towards the goal of improving understanding and prediction of these phenomena and their interactions with the atmosphere. LSMs have been developed and run by dozens of groups. There have been a few efforts to coordinate their activities, beginning with the local-scale Project for Intercomparison of Land Surface Parameterizations (PILPS) experiments. The first coordinated global scale land surface modeling activities were the Global Soil Wetness Project (GSWP) phases 1 and 2, which aimed to:

- Produce state-of-the-art global data sets of land surface fluxes, state variables, and related hydrologic quantities;
- Develop and test large-scale validation, calibration, and assimilation techniques over land;
- Provide a large-scale validation and quality check of the ISLSCP data sets;
- Compare Land Surface Schemes, and conduct sensitivity studies of specific parameterizations and forcings, which should aid future model and data set development.

With the completion of GSWP-2, several researchers present at the CEOP Implementation Planning Meeting in Washington DC expressed interest in forming a new working group "to coordinate global land modeling activities and share data, towards the goal of improved understanding and prediction of the land surface water and energy cycles at the global scale", which would contribute to CEOP research objective 1. Land surface models can also contribute to objective 4 by assessing the anthropogenic impacts on the water and energy cycles at regional to continental scales. New CEOP land surface modeling activities need to include groups traditionally active in CEOP LSM such as the University of Tokyo, the NASA/Goddard Space Flight Center (GSFC) Global Land Data Assimilation System (GLDAS) project, amongst others. Additionally, the RHPs must have modeling groups to run regionally developed LSMs and to help analyze model output for their region, since they are most familiar with their hydroclimate.

The CEOP LSM activity will identify, gather and analyze gridded global forcing data sets that are available for regional to global off-line LSM simulations. Current contributions by exiting groups (like the University of Tokyo and the GLDAS project) include contributions of both

MOLTS and global, gridded model output datasets. GLDAS maintains a large archive of surface meteorological forcing data, land parameters, and output datasets, much of which is made publicly available. These data sets will be augmented by additional global forcing data sets (e.g. from Princeton University Land Hydrology Group, NCAR from A. Dai, and various re-analysis land surface meteorological data sets), and regional forcing data sets from the RHPs. In the later case it is expected that the RHP data sets will be of a higher quality than the available global sets.

The CEOP LSM activity will analyze the consistency among the data sets to help assess the uncertainty in the global terrestrial surface meteorology and radiation fields. The goal of the LSM activities under CEOP, then, is to generate physically coherent fields of land surface states and fluxes by optimally merging disparate data products, and by using a suite of advanced land surface models, to estimate the terrestrial component of the Earth's energy budget and water cycle, including an estimate of the error. One approach is to utilize NASA's Land Information System (LIS) software package, which is able to drive multiple LSMs at high resolutions with various user-defined configurations and forcing options, but alternative approaches for running multi-model systems need to be developed since many RHP regional models are not in the LIS software package.

Passive microwave remote sensing provides the most feasible technique to monitoring spatially distributed soil moisture and snow over land and water vapor, cloud and precipitation over ocean in a large scale. The sensitivity to soil moisture of brightness temperature at low frequencies is a well-known phenomenon. Methods to estimate regional to global snow depth or Snow Water Equivalent (SWE) have been developed based on snow particle scattering in microwave region. Radiation emission from water vapor and liquid droplet and scattering extinction for solid particle in atmosphere are used basically for monitoring atmospheric hydrological condition over ocean at higher frequencies.

The current techniques or algorithms need to be further improved or developed in order to obtain the required accuracy for atmospheric and hydrologic modeling. The key elements of the Radiative Transfer Models (RTMs), for example, vertical profiles of soil moisture, snow grain size and water vapor and air temperature, cannot be obtained only by passive microwave remote sensing. It is also difficult to use satellite products in numerical weather prediction models directly. To solve these issues, it is effective to assimilate passive microwave remote sensing data with numerical simulation schemes, Land Surface Schemes, Snow Physical Models, and Cloud Microphysics Models, which are embedded in Global Climate Models (GCMs) or regional models.

3.4.4. Hydrologic Applications Project

The Hydrologic Applications Project (HAP) addresses CEOP's research objective 4 as it relates to demonstrating the value of GEWEX research, data sets and tools for assessing the consequences of climate predictions and global change for water resources. HAP is a CEOP activity that crosses ESSP projects, particularly with the GWSP.

The HAP was formulated with the goals being:

- Developing procedures for assessing current hydrologic conditions (nowcasting) through application of GEWEX supported data products, including remotely sensing;

- Developing and testing of reliable, skillful hydrologic ensemble forecast procedures based on seasonal climate model forecasts;
- Demonstrating that the procedures can be applied at scales useful for water resources through test-bed sites and demonstration projects;

Thus, one important research focus of HAP is to assist GEWEX in "demonstrating skill in predicting variability in water resources and soil moisture on seasonal to annual as an element of WCRP's prediction goals for the climate system." Thus HAP will help foster and develop the science behind skillful ensemble hydrologic seasonal forecasts, and demonstrating their usefulness.

In addition, HAP will work with the IAHS Project on Ungauged Basins (PUB) to demonstrate how remote sensing data, land data assimilation products and hydrological prediction can improve the decisions made by water resource managers. This activity offers GEWEX science and data products to the applications community. GEWEX will also promote strategies to work more closely with the WMO Hydrology and Water Resources Department, operational hydro-meteorological services and the United Nations Educational Scientific and Cultural Organization (UNESCO)'s International Hydrology Programme. These lead to HAP's fourth goal; namely,

- Working with related projects, like Extremes, Hydrologic Ensemble Prediction EXperiment (HEPEX), the PUB, and other GEWEX panels, particularly the GMPP.

HAP's goals will result in a set of activities that cross a number of GEWEX panels (in particular the GMPP and projects within the Coordinated Energy and water-cycle Observations Project (CEOP). For example these range from data products from remote sensing to transferability modeling studies and the WISE activities on extremes. Additionally there are related activities in the WCRP that HAP should contribute to including GEWEX's contribute to the Global Water System project within the ESSP framework; WCRP's new strategy, commonly known as the Coordinated Observation and Prediction of the Earth System (COPES); and the WCRP Task Force on Seasonal Prediction.

3.5. Data Management http://www.eol.ucar.edu/projects/ceop/dm/

Data Management (DM), a former key component of both GHP and then 'CEOP' is a key component of CEOP, which has successfully managed to get diverse international groups to agree to a general data policy and other groups to then help maintain an internationally distributed database of extensive hydrometeorological data.

The data collection done within the RHP's (and formerly CSE's) is of crucial importance to advance the science about a region and at a regional level. However, by combining of, centralizing of, quality control etc. of, and providing open access to all the data from these regional experiments global assessments and advancement of science becomes feasible, Furthermore, accessibility of these data is essential for the cross-cutting studies (both topical and regional) to become successful.

In this section we describe first the data policy and then the distributed data archive that was set up under 'CEOP, mainly the in situ data archive and the model data archive. The remaining data archive centers, the satellite data archive, the central data archive center are described under section 4, which also describes some new interoperability, metadata and data integration efforts

in support of CEOP.

3.5.1 Data Policy

Improvement of understanding and predictability of the energy and water cycle cannot be achieved without data and information sharing including data management and integration that encompasses functions such as Quality Assessment/Quality Control, access to data, and archiving of data, data integration and visualization, and information fusion. CEOP data and documentation may be accessed from the CEOP web page or directly through the CEOP Data Management web page (http://www.eol.ucar.edu/projects/ceop/dm/)

The WMO Resolutions 40 and 25 (adopted by the XII Congress on 26 October 1995) comprises the basis for the CEOP data policy and protocol to be adopted and practiced by each of the CEOP Data Archive Centers:

"As a fundamental principle of the World Meteorological Organization (WMO), and in consonance with the expanding requirements for its scientific and technical expertise, the WMO commits itself to broadening and enhancing the free and unrestricted international exchange of meteorological and related data and products".

In general, the scientific community will have free and open access to all CEOP data, subject to procedures in place at the various Data Archive Centers involved. The following six "golden rules" have been established as part of the CEOP Data Policy to ensure a smooth and successful use of CEOP Data by the scientific community:

- No financial implications are involved for the CEOP reference site data exchange.
- Commercial use and exploitation of CEOP reference site data is prohibited.
- Any re-export or transfer of the original data received from the CEOP archive to a third party is prohibited.
- The origin of CEOP data being used for publication of scientific results must be acknowledged and referenced in the publication.
- CEOP data users are strongly encouraged to establish direct contact with data providers for complete interpretation and analysis of data for publication purposes.
- Co-authorship of data users and CEOP data sources. Principle Investigators on publications making extensive use of CEOP data is justifiable and highly recommended.

Further details regarding the CEOP Data Policy may be found at:
http://www.eol.ucar.edu/projects/ceop/dm/documents/ceop_policy.html

3.5.2 CEOP Data Centers

One success of CEOP data management has been in linking to the various RHPs and contributing national agencies to develop in-situ, model output and satellite remote sensing archives and providing the data to the science community. The three CEOP Archive Centers are: (1) the NCAR/Earth Observing Laboratory (EOL) Central Data Archive for CEOP Reference Site Data; (2) the International Council for Science (ICSU) WDC for Climate which is supported by the Max Planck Institute for Meteorology (MPIM) and the German Climate Computing Center (DKRZ) in Hamburg for NWP Model Output; and (3) the Satellite and Data Integration Center at UT, which is jointly administered by the Japan Aerospace Exploration Agency

(JAXA), the Japan Meteorological Agency (JMA), and UT. These Centers abide by the CEOP Data Policy Criteria described above, established with the data providers and this data is then freely available to any and all users free of any costs, with the exception of possible modest expenses for mailing costs of any data that is requested other than through the electronic schemes set up by the administers of each of these centers. The data users are required to comply with the use and citing of the material in accordance with the CEOP data policies as noted for the in-situ data, the model data and the satellite data. In this section we describe the already functioning in situ and model data archives here.

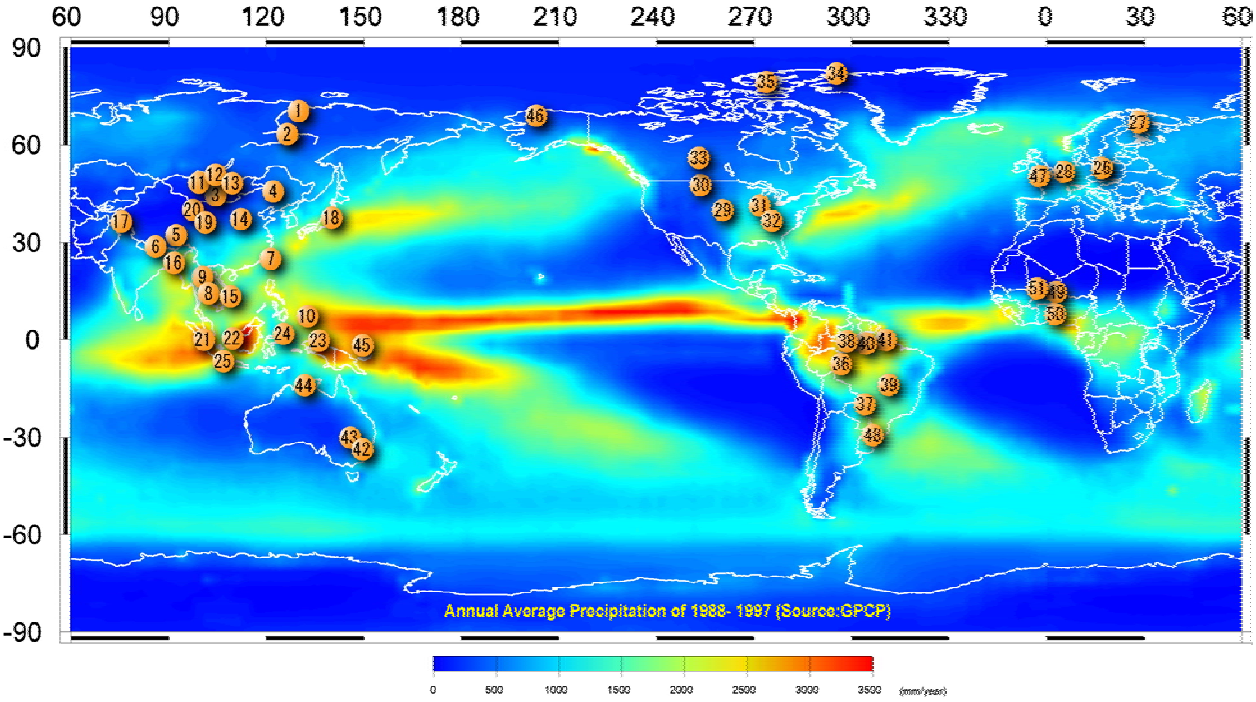
In Situ Archive

Key agreements were initiated to obtain in-situ data from 35 selected globally distributed "reference" stations, as shown in **Figure 1**, involved with the various CEOP RHPs. These Reference Sites provide enhanced observations of sub-surface (soil profiles), surface (standard meteorological and radiation), near surface (flux tower), atmospheric profiles (rawinsonde and profiler), and ancillary data sets (radar, special observations) in a common format. All Reference Site data are archived and disseminated by the NCAR/EOL, in Boulder Colorado. Further details are available at: http://www.eol.ucar.edu/projects/ceop/dm/.

Collection of the data from the CEOP Reference sites for the initial CEOP period has shown that adherence by the sites to a consistent format is especially important to ensure an efficient continuation of the CEOP dataset development and delivery process. The reference site characteristics and metadata have been cataloged along with all of the information about the entire CEOP in-situ database. The data collection has been an on-going process and it is the role of the CEOP Data Management Working Group to maintain the status of the contributions from the CEOP reference sites at the RHPs.

Besides being posted at the CEOP Data Management web page, the In-situ Data Archive ensures that each request for data from the CEOP Reference Site Archive is accompanied, automatically/electronically, by a copy of the CEOP Data Policy. Whereas, the data policy has stood the test of time and application in CEOP, the ability for the reference sites to meet their agreed to data contribution deadlines has proven harder, but workable. Experience in collection, quality checking, delivery and posting of the data has shown that while data collection and delivery are often completed as requested the final quality checks that enable the data to be certified for posting on the database must be undertaken on an iterative basis by the In-situ Data Archive with each site spokesperson/manager. This process seems to become more efficient with each data delivery milestone but up to now it remains a time consuming effort that is rarely completed on the agreed to dates. This points toward the need to be more reflective and realistic in the future with setting the dates for the data to reach the research quality level set by CEOP and thereby be posted on the database for user access. This issue has now been factored into the CEOP in-situ dataset development process.

CEOP Reference Site Map



CSE/ RHP	Ref #	Ref. Site Name	Latitude		Longitude	
MAHASRI/(CAMP)	1	Eastern Siberian Tundra	71.617	N	128.750	E
	2	Eastern Siberian Taiga	62.255	N	129.618	E
	3	Mongolia	45.743	N	106.264	E
	4	Tongyu	44.416	N	122.867	E
	5	Tibet	31.370	N	91.900	E
	6	Himalayas	27.959	N	86.813	E
	7	Northern South China Sea - Southern Japan	24.967	N	121.181	E
	8	Chao-Phraya River	18.400	N	99.470	E
	9	North-East Thailand	14.466	N	102.379	E
	10	Western Pacific Ocean	7.452	N	134.476	E
	11	Mongol Arvayheer	46.246	N	102.798	E
	12	Mongol Nalaikh	47.766	N	107.336	E
	13	Northern Mongolia	47.213	N	108.742	E
	14	Downstream of the Yellow River	36.649	N	116.054	E
	15	Central Vietnam	16.033	N	109.185	E
	16	Northeast Bangladesh	24.900	N	91.893	E
	17	Pakistan Karakorum Network	35.728	N	76.286	E
	18	Tsukuba	36.110	N	140.100	E
	19	Lanzhou	35.946	N	104.137	E
	20	Heihe River Basin	39.500	N	100.000	E
	21	Western Maritime Continent	0.200	S	100.300	E
	22	Central Maritime Continent	0.000	S	109.400	E
	23	Eastern Maritime Continent	1.200	S	136.100	E
	24	Northern Maritime Continent	1.500	N	124.900	E
	25	Southern Maritime Continent	6.400	S	106.700	E

CSE/ RHP	Ref #	Ref. Site Name	Latitude		Longitude	
BALTEX	26	Lindenberg	52.170	N	14.120	E
	27	Sodankyla	67.370	N	26.633	E
	28	Cabauw	51.970	N	4.930	E
CPPA /GAPP	29	ARM/Southern Great Plains	36.610	N	97.490	W
	30	Fort Peck	48.310	N	105.100	W
	31	Bondville	40.010	N	88.290	W
	32	Oak Ridge	35.960	N	84.290	W
CliC	33	BERMS (MAGS)	53.990	N	105.120	W
	34	Alert, Nunavut	82.467	N	62.500	W
	35	Eureka, Nunavut	79.995	N	85.813	W
LBA	36	Rondonia	10.080	S	61.930	W
	37	Pantanal	19.560	S	57.010	W
	38	Manaus	2.610	S	60.210	W
	39	Brasilia	15.930	S	47.920	W
	40	Santarem	3.020	S	54.970	W
	41	Caxiuana	1.710	S	51.510	W
MDB	42	Tumbarumba (tower)	35.660	S	148.150	E
	43	Murrumbidgee (soil moisture, tempera	35.116	S	146.375	E
Others	44	ARM/Tropical West Pacific (Manus)	2.060	S	147.430	E
	45	ARM/Tropical West Pacific (Darwin)	12.430	S	130.890	E
	46	ARM/Northern Slope of Alaska	71.320	N	156.620	W
	47	Chilbolton, UK	51.150	N	1.433	W
LPB	48	Cruz Alta	28.600	S	53.400	W
AMMA	49	Niamey	13.530	N	2.660	E
	50	Ouémé	9.692	N	1.662	E
	51	Gourma	15.300	N	1.500	W

Figure 1 CEOP Reference Sites

Satellite Data Archive

It will be essential to integrate the data from satellites observing both land and ocean in generating new CEOP data sets for the overall water cycle. The work associated with satellite data set archive is being undertaken by the University of Tokyo in collaboration with JAXA, NASA and ESA. Dataset documentation and background information are available at: http://monsoon.t.u-tokyo.ac.jp/camp-i/doc/sat_info/index.htm. A contribution by JAXA in coordination with the University of Tokyo has been established that applies to an on-going effort to provide CEOP satellite datasets for integration with the CEOP in-situ and model output data. The data set consists of the main water cycle parameters necessary to accomplish CEOP scientific goals; these data are geo-coded (i.e. re-sampled to a regular LAT/LON Grid). They are generated at three scales, 250km rectangular, monsoon regional and global scales, associated with product levels 1b, 2 and 3. The processing levels have also been defined to ensure a clear understanding of the nomenclature and reduce ambiguity in the statement of requirements. The Levels of processing have been established to be:

[Level-1b] - Radiance product with full resolution at reference sites.
[Level-2] - Geophysical product at the same resolution at reference sites and monsoon regions.
[Level-3] - Statistical geophysical product in space and/or time at reference sites, monsoon regions and global. (example: Monthly mean rain rate at reference sites, etc.)

These components consist of an image element and a metadata part element that is compliant with the ISO-19115 metadata standard.

The Committee on Earth Observation Satellites (CEOS) membership encompasses the world's government agencies responsible for civil Earth observation satellite programs. Within CEOS, the Working Group on Information Systems and Services (WGISS) aims to coordinate and monitor the development of the systems and services, which manage and supply the data and information from participating organizations' missions. Under this coordination framework, NASA and ESA are providing their satellite data sets to the UT archiving system. JAXA works as a coordinator of the CEOP satellite data archive in CEOS/WGISS.

NWP Output Archive

The basis of the NWP model output component of CEOP was a letter, which was sent in September 2001 from the Director of WCRP to NWP and data assimilation centers worldwide requesting analysis/assimilation and forecast model products from global and regional NWP suites, including both operational and reanalysis systems. Nine operational NWP and two data assimilation centers are currently contributing to this component of CEOP. To assist with the organization of this activity, a CEOP Model Output Management Document was drafted as a guide for the participating centers to use in setting up their processes for meeting their commitments to CEOP. The Guidance Document addressed the two issues of (1) the model output variables requested by CEOP and (2) the two types of requested model output, namely gridded (in GRIB format) and site-specific time series MOLTS at each of the CEOP Reference Sites. Further information can be found at the CEOP Model Output web page at: http://www.eol.ucar.edu/projects/ceop/dm/model/

The MPIM in coordination with the ICSU World Data Center for Climate (WDCC) in Hamburg, Germany was designated as the CEOP model output archive center. The WDCC is administered by the Model and Data Group (M&D) at MPIM and the DKRZ. The Model Output web site is

located directly at: http://ceop.wdc-climate.de/. A new version of the Guidance Document will be compiled that clarifies what model output data will be generated by the NWP Centers and Groups contributing to the model output component of CEOP and how they will interface/transfer the data that will be handled and retained at the WDCC. The issues covered in the document will include: (1) global versus regional products; (2) desired assimilation output; Interval and length of free-running forecasts; (3) Operational versus reanalysis data; (4) the CEOP schedule/archive periods; (5) the number and locations of MOLTS sites; and (6) the homogenizing of the model output and metadata formats (i.e. standard parameters). All of the contributing centers have been discussing these issues on periodic conference calls and have agreed to meet these requirements as closely as possible.

Results up to this point in the CEOP model output generation effort make it clear that the transfer aspect of the data handling effort has been progressing well. Data from all Eleven Centers (NCEP, UKMO, NASA-GMAO, NASA-GLDAS, JMA, BMRC, ECMWF, NCMRWF, ECPC, CPTEC-INPE, and MSC) participating in CEOP have been received at the data archive center and has either been placed into the database at the Hamburg facility, or is in the process of being entered into the database. The current data in this archive is shown in **Figure 2**.

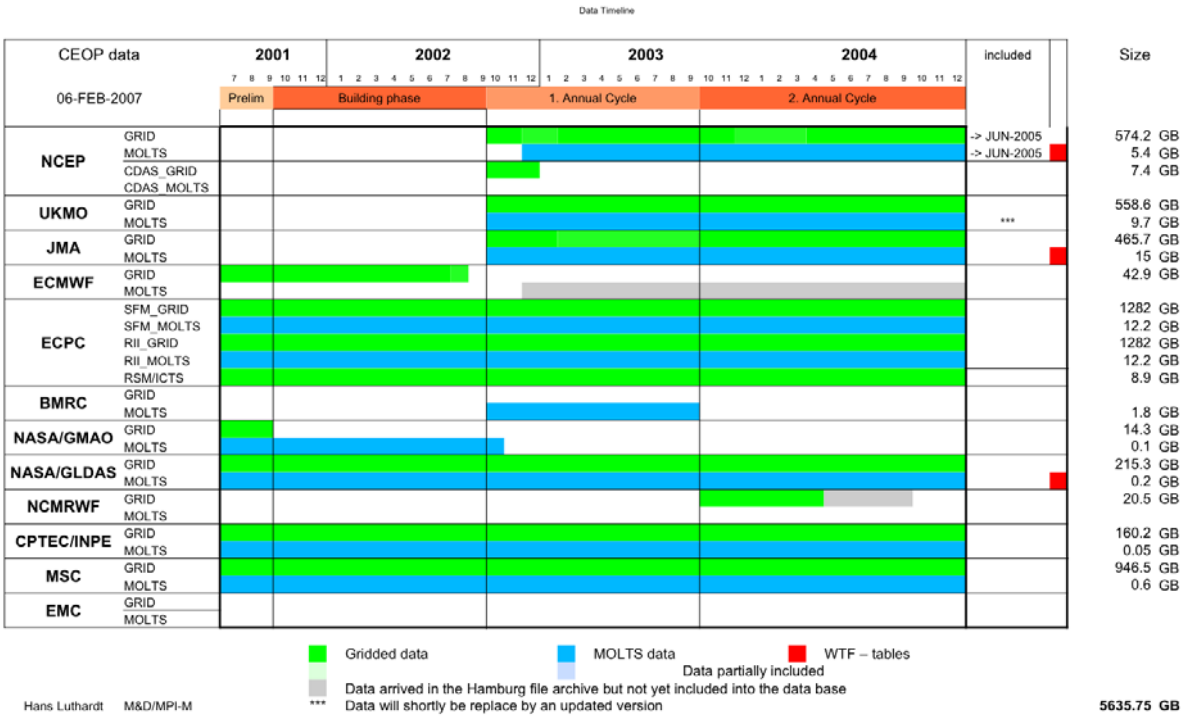


Figure 2 CEOP Model Archive at MPI

3.6 Global Data Centers

There are a number of additional data sources that will be contributing to CEOP including a number of Global Data Centers. The GRDC and the GPCC have had long-term affiliation with GEWEX and GHP and will continue this collaboration under the new CEOP.

In essence, Collaboration with these data Centers does no harm to CEOP and by strengthening connections with them opportunities exist for improving CEOP datasets associated with river

discharge and precipitation respectively. Since the affiliation with these centers up to now has been loosely maintained the leader of the CEOP Data Management sub-project has undertaken to work directly with the leaders of each of these Centers to strengthen the oversight and formalize the interaction between the Centers and CEOP. While GRDC has been recognized as a GEWEX Hydrometeorology Project, CEOP seeks to focus on what this designation implies, especially as it relates to meeting specific technical and scientific criteria as enumerated in section 3.1 above.

At the core of the collaboration between CEOP and these Centers is their potential contribution to CEOP studies through provision of quality controlled datasets that the CEOP database would not otherwise have available. The assessment of the added value that these datasets might provide to CEOP as weighed against the amount of effort that would be required to make them usable in the context of the current CEOP Data Management framework is still underway. Action is on CEOP to continue to scrutinize its relationship with these Centers and rather than to rush to formally embrace them to instead maintain an active dialog with them on all aspects of potential mutual benefit that might be accrued from closer formal collaboration. CEOP is obligated to report progress on this on-going assessment process and to not taking further action on this interface without approval of the GEWEX SSG.

At a minimum the objective of the cooperation with these Centers is to provide quality assured data to the research community. This requires the historical data to be put through plausibility checks and quality assurance procedures before entry into any CEOP/GEWEX database. Background that must be taken into account to achieve successful mutual interaction includes the fact that at least in the case of the GRDC it is mandated by WMO resolutions to collect data on a global scale, harmonize the data and provide the data to predominantly water and climate related programs and projects of the United Nations (UN), their specialized agencies and the scientific research community. A complication with this situation is that the data from National Hydrometeorology Services (NHS's) to the GRDC is not institutionalized and is based on WMO Resolutions on the free and unrestricted exchange of Hydrometeorological data. The scale of issue must also be considered in that currently the GRDC is holding quality assured historical mean daily and/or monthly discharge data for more than 7300 stations from 156 countries, as noted below, and even though the data are available free of charge to the scientific community more efforts are needed to add value to the data by obtaining near real-time river discharge data from a global baseline river gauging network for improved studies on global climate variability and change and the verification of hydro-climatological models.

These are some of the matters that CEOP is facing as it endeavors to interact more formally on behalf of GEWEX/WCRP with these specialized data centers.

3.6.1 Global Runoff Data Centre http://grdc.bafg.de/

The Global Runoff Data Centre (GRDC) was established in 1988 at the Federal Institute of Hydrology (BfG) under the auspices of the WMO. It is a contribution of the Federal Republic of Germany to the World Climate Programme Water (WCP-Water) of WMO. WMO mandates and directly supports GRDC by its Resolutions 21 (Cg XII, 1995: Request to the member states to provide GRDC with river discharge data) and 25 (Cg XIII, 1999: Free and unrestricted exchange of hydrological data). An international Steering Committee is guiding and overseeing the activities of the GRDC. The steering committee consists of representatives from WMO,

UNESCO, UNEP, ICSU, IAHS and partner data centres GPCC and the International Groundwater Resources Assessment Centre (IGRAC).

The main objective of the GRDC is the worldwide acquisition, storage and dissemination of historical and near-real-time river-discharge data in support of the predominantly water and climate related programmes and projects of the United Nations (UN), their specialized agencies and the scientific research community. Additionally the GRDC has the following objectives:

- Operation and further development of the GRDC database, improvement of integration with external databases, contribution to the development as well as application and propagation of international standards for metadata, discharge data and data structures
- Preparation and maintenance of applied global data products and discharge-related geo-information, partly in collaboration with specialized external institutions
- Application of mathematical models on various scales for estimation of water balances, water availability and coupling with climate models
- Collaboration with and consulting of international organizations, other world data centres as well as foreign institutions in the fields of hydrology, water resources as well as data management and data acquisition. This includes active participation in a number of national and international working groups, steering committees and panels.

There are various GRDC activities in the framework of the GEWEX. GRDC is recognized as one of the hydrometeorological projects in GEWEX. As such the GRDC seeks to provide inputs to the GEWEX/GHP RHP and modeling efforts by providing improved data sets. These points, however, require close consideration before CEOP can clearly delineate the exact extent of its association with GRDC and the potential mutual value to be added through such collaboration, as noted above under Item 3.6.

As of end-2007 the GRDC database holds world-wide discharge data of 7,332 stations in 156 countries featuring around 276,000 station-years of monthly and daily values with an average time-series length of 37.7 years. Over the past 12 months data of 2133 stations from 10 countries have been updated. Additionally the GRDC maintains the following four specialized databases:

- Arctic Runoff Database (ARDB) containing data from over 2400 stations specifically for the arctic research community associated with the WCRP ACSYS (Arctic Climate System Study) and the CLiC Project
- Global Terrestrial Network for River Discharge (GTN-R) database for near-real time data, a contribution towards the Implementation Plan for the Global Observing System for Climate and to GTN-H
- European Terrestrial Network for River Discharge (ETN-R) database for near-real time data, a GRDC contribution towards the European Flood Alert System (EFAS) under development by the European Union (EU) Joint Research Centre
- European Water Archive (EWA) in support of the Northern European Flow Regimes from International Experimental and Network Data (NE-FRIEND) research community

3.6.2 Global Precipitation Climatology Centre http://gpcc.dwd.de

The Global Precipitation Climatology Centre (GPCC) was established in 1988 at the request of

the WMO. The Deutscher Wetterdienst (DWD, National Meteorological Service of Germany) operates it as a German contribution to the WCRP. The mandate of GPCC is the global analysis of monthly precipitation on earth's land-surface based on in situ rain gauge data. Since its start, the centre is the in situ component of the GPCP. In 1994, the long-term operation of the GPCC has been requested by WMO in order to contribute to the climate monitoring activities of the Global Climate Observing System (GCOS). Since 1999, GPCC has been a global GCOS Surface Network Monitoring Center (GSNMC), which has a special emphasis on precipitation. Mid December 2006, GPCC started its newest function as the WMO Commission for Basic Systems (CBS) Lead Center for GCOS data for Europe. The German Meteorological Service (DWD) continuously funds GPCC operation.

The main GPCC objective is the analysis of the spatial and temporal distribution of land-surface precipitation on a monthly time-scale based on in situ rain gauge data compiled from stations located worldwide. The aim of the GPCC is to serve user requirements esp. regarding accuracy of the gridded precipitation analyses and timeliness of the product availability. All four different GPCC analysis products result from the same data management and analysis system. However, depending on the user requirements, esp. regarding timeliness and quality, they differ with regard to the number of the stations included and the level of data quality control being performed. Recent research activities supported the preparation of homogenized 50-year precipitation climatology, used for assessment of precipitation variability and trends in the 2007 report of the Intergovernmental Panel on Climate Change (IPCC).

As of end-2007 the GPCC database holds world-wide precipitation data of more than 78,000 stations in more than 170 countries featuring more than 19,000,000 station-years of monthly values. Over the past 12 months 40 countries have provided new or updated monthly precipitation time series to GPCC. The GPCC products are adjusted to contribute to WCRP core projects:

- The GPCC Full data product is adjusted to support Global and regional hydrometeorological research activities in the context of CEOP hydroclimate projects and studies;
- The GPCC VASClimO product is adjusted to support climate variability and change studies in context of CLIVAR and contributes also to the IPCC Assessment Reports:
- The GPCC Monitoring product and the supplementary products related to solid/liquid precipitation and systematic error correction are useful to support studies in context of CLIC. In addition GPCC implemented the Arctic Precipitation Data Archive (APDA).

As noted under Item 3.6 above. The connection between CEOP and GPCC still requires close consideration before CEOP can clearly delineate the exact extent of its association with GPCC in terms of the potential mutual value to be added through such collaboration.

4. CEOP Implementation

CEOP is organized around coordinated activities in the RHPs, RS, CCS, MS and DM, with major contributions to these activities coming from the RHP funded activities. A summary CEOP implementation plans is described below for each of the CEOP elements.

4.1. Regional Hydroclimate Projects

Besides focusing on their own regional GEWEX hydroclimate goals, the RHPs are making a significant contribution to CEOP through their contribution of reference site, model and satellite data. Particular mention should be made of the BALTEX project for its support of the Model Data Archive at the World Data Center housed at MPI and for its support of the ICTS project at the GKSS, the support CPPA for archiving the in situ data at NCAR and for their support of HAP activities over the US and other global regions, and the GAME/MAHASRI project for supporting the satellite data archive at JAXA, the Integrated Data Management at the Univ. of Tokyo, as well as the CEOP Project office at the Univ. of Tokyo.

4.1.1 AMMA http://amma.mediasfrance.org/about/index

African Monsoon Multidisciplinary Analysis (AMMA) is an international project to improve our knowledge and understanding of the West African monsoon (WAM) and its variability with an emphasis on daily-to-interannual timescales. AMMA is motivated by an interest in fundamental scientific issues and by the societal need for improved prediction of the WAM and its impacts on West African nations.

Vulnerability of West African societies to climate variability is likely to increase in the next decades as demands on resources increase in association with one of the World's most rapidly growing populations. Vulnerability may be further increased in association with the effects of climate change and other factors linked to the fast growing population such as land degradation and water pollution.

Recognising the societal need to develop strategies that reduce the socioeconomic impacts of the variability of the WAM, AMMA will facilitate the multidisciplinary research required to provide improved predictions of the WAM and its impacts.
We are currently hindered in providing skillful predictions of WAM variability and its impacts. There are still fundamental gaps in our knowledge of the coupled atmosphere-land-ocean system at least partly arising from lack of appropriate observational datasets but also because of the complex scale interactions between the atmosphere, biosphere and hydrosphere that ultimately determine the nature of the WAM. The monitoring system for the WAM and its variability is inadequate with many gaps in the standard routine network and lack of routine monitoring of some key variables. While the next generation of satellites will undoubtedly help with routine monitoring and prediction efforts, more research is required to validate and exploit these data streams. Dynamical models used for prediction suffer from large systematic errors in the West African and tropical Atlantic regions; current models have problems simulating fundamental characteristics of rainfall such as the diurnal, seasonal and annual cycles. Finally, there is a lack of integrative science linking the work on WAM variability with work on food, water and health impacts. More effort needs to be made to integrate scientists working in these different areas.

Further motivation for a research project concerned with WAM variability and predictability

comes from recognizing the role of Africa on the rest of the world. Latent heat release in deep cumulonimbus clouds in the ITCZ over Africa represents one of the major heat sources on the planet. Its meridional migration and associated regional circulations impact other tropical and midlatitude regions, as is exemplified in the known correlation between West African rainfall and Atlantic hurricane frequency. In addition to the large-scale interactions, we know that a majority of hurricanes that form in the Atlantic originate from weather systems over West Africa; however we know little about the processes that influence this and why only a small fraction of these "seedlings" actually become hurricanes.

The WAM system provides an ideal framework for considering scale interactions in a monsoon system: it possesses pronounced zonal symmetry with characteristic jets and associated well-defined weather systems. Research on such scale interactions and in particular those linking dynamics and convection with the land surface will be relevant to other monsoon systems and is needed in order to improve coupled atmosphere-ocean-land models used for weather and climate prediction. In order to carry out this research extra observations are needed.

West Africa is also an important source region for natural and anthropogenic emissions of precursors to key greenhouse forcing agents (e.g. ozone, aerosols). For example, Africa contributes around 20% of the global biomass burning fires. These emissions are modulated by the activity of the WAM but in contrast to other surface impacts they feedback directly on the climate. Long-range transport of trace gases out of West Africa has important implications for the global oxidizing capacity of the atmosphere (which controls the level of many greenhouse gases), global climate change and the transport of key constituents (e.g. water vapour, ozone depleting substances) into the stratosphere. The fires also produce huge quantities of particles, complex mixtures of organic materials and black carbon.

Tropical Africa is the world's largest source of atmospheric dust. Both the fire aerosols and dust play a major role in radiative forcing and in cloud microphysics, and thus are an important part of WAM system. A key priority is to determine the transport of trace gases and aerosols from the surface to the upper atmospheric layers and the subsequent transport by the WAM. It is thus necessary to study the dynamics and the chemistry of the atmosphere in the same framework.

4.1.2 BALTEX http://www.baltex-research.eu/

BALTEX now has the goal of understanding past and future climate variability in the Baltic river and sea basin. During the next several years BALTEX plans include the immediate (2007) assessment and development of future projected climate change and variability in the Baltic Sea Basin for major water and energy-cycle related parameters, as well as their potential impact on marine and terrestrial ecosystems (the BALTEX Anthropogenic Climate Change (BACC) Project). Based on the BACC assessment, research priorities and gaps related to identification and attribution of regional climate change as well as to projections of future climate variability and change will be identified. Climate projections for the 21st century using the coupled regional models for the Baltic Sea basin will then be established and discussed.

BALTEX will subsequently establish and discuss assessments of the availability of water resources based on ensemble climate projections for the 21st century in cooperation with water

management authorities in selected river basins and for the entire Baltic Sea basin. It will also provide an assessment of the role of land-atmosphere interactions during major wet and dry (drought) periods, specifically for the 1995 to 2004 period, as a contribution to pan-GEWEX activities.

A research quality long term energy and water budget data set (complete with error bars) including both observational and model outputs will be produced, and discussed, for use in climate trend and variability analysis, model initialization and validation studies. This will be used to provide assessments of water resources including ground water based on ensemble climate projections for the 21st century for the entire Baltic Sea basin. Establish long-lasting cooperation or joint ventures with river basin management authorities for selected river basins with the view to continuously update water resources assessments.

The second assessment of climate change and variability for the Baltic Sea basin will be established as one final document originating from BALTEX by the end of 2012.

4.1.3 CPPA http://www.climate.noaa.gov/cpo_pa/cppa/

As a contribution to CEOP activities, CPPA will assess land -surface process simulations in NCEP Global Model using CEOP reference site observations. These will be complemented by an observation and modeling study of diurnal cycles in monsoon region (NAME). The role of land surface in drought and extremes will also be assessed. The GLDAS Participated in the GMP and initiated modelling activities, such as, the 2nd Global Land-Atmosphere Coupling Experiment (GLACE-2) and various other model inter-comparison projects.

As part of CPPA's contribution to HAP and HEPEX efforts, a pilot project to demonstrate multi-model ensemble hydrological prediction (streamflow, snow pack, soil moisture) on medium range (1-2 weeks) and seasonal time scales will be launched. Uncertainties in hydrologic forecasts (from climate forecasts, initial boundary condition, model, and predictability studies) will be quantified (HAP). The Experimental Western and Eastern Seasonal Hydrologic Prediction System will be transferred to the NCEP Operation Platform.

Regional field experiments to understand Mountain and Cold Season processes, especially in complex terrain will be conducted. Dynamical downscaling and hydrologic applications of seasonal hindcasts of the NCEP GFS model will complement these studies.

4.1.4 LBA http://lba.cptec.inpe.br/lba/site/

Input to be received

4.1.5 LPB http://www.eol.ucar.edu/projects/lpb/

Input to be received.

4.1.6 MAHASRI http://mahasri.cr.chiba-u.ac.jp/index_e.html

Several river basins in Asia will be selected and used for demonstration of practical flood and drought prediction. Water managers will be involved. Impact of short-term and seasonal weather

predictions will be surveyed. The JMA Asia Pacific Climate Center will be involved. Support for PUB activities in Asia will be initiated as part of this effort.

Impact of land surface conditions on Asian monsoon will be surveyed particularly through modelling studies. Land surface models will be validated and improved via the use of specially observed data in particular during the AMY08 period in Asia. Also comparisons of hind-cast seasonal predictions will be conducted by utilizing AMY08 data.

Regional climate model comparisons may be carried out with the collaboration with other projects and programs such as the CEOP/ICTS. Land atmosphere interactions in special regions like Tibet, Mongolia, Northwest China, Indochina and the like will be investigated with special observations in AMY08. Aerosol observation over Asia will be carried out. Temporal characteristics of diurnal and intra-seasonal cycles, and their interactions will be surveyed with in-situ, special, radar and satellite observations.

Beginning in 2009, MAHASRI will cooperate with other RHPs (CPPA) and the High Elevations Regional study to study the impact of orography on hydroclimate in Asia will be examined.

Output of anthropogenic climate models will eventually be used for various applications. For example, the impact of global warming on water resources will be shown over several selected river basins of Asia. Land-surface change impacts and aerosol-impacts that may be associated with these changes will also be examined.

4.1.7 MDB http://www.gewex.org/mdb.html

This RHP has contributed data to CEOP Phase 1. The soil moisture data provided has in fact assisted with the development/assessment of a soil moisture algorithm for application to regional analyses relevant to the processing of AIRS data over the Tibetan Plateau. The CEOP Co-Chair and Senior Scientist has published results of this algorithm validation exercise and reported the outcome to the GEWEX SSG. A summary of these results can be provided through the CEOP International Coordination Office (petra@hydra.t.u-tokyo.ac.jp).

The MDB will expand on work investigating the interaction between surface hydrology and groundwater, particularly in terms of managed agricultural systems, and in collaboration with the operational centre and water authority. Efforts to improve relevant data collection and dissemination are increasing through the Bureau of Meteorology water division. This is enabling a wider community of researchers to focus on understanding and modeling the dynamic coupled systems involved.

The coupling between the land-surface and atmosphere will be a renewed focus of future MDB work with expanded use of regional climate models. One aim being the quantification of the relative influence of local feedbacks and distant teleconnections on drought processes within the basin. Contributions will also be made to the ICTS GEWEX program.

Contributions to ICCS will improve with an expanded isotopic observational network within the MDB. Isotopic data collection during future field campaigns and closer interaction with modelers of the isotopic hydrologic cycle will also enhance the contributions to this program.

Much of the MDB is semi-arid and future interaction with SAS could prove beneficial to both programs and will be sought.

4.1.8 NEESPI http://neespi.org/

CEOP recognizes that NEESPI has its own data center, but this alone does not preclude data from that center to be provided to or linked with the CEOP data center. The NEESPI data policy could, however, be problematic if it is not synergistic with the CEOP data policy. Coordination between the CEOP Data Center at NCAR and the NESSPI data center to resolve these matters is paramount to the prospects of a mutually beneficial collaboration between CEOP and NEESPI. CEOP will report its conclusions on this and other related matters such as the specific contributions NEESPI will make to CEOP's enhanced observation periods in the future. As NEESPI develops as a GEWEX RHP it is expected that it will abide by the criteria under which it was designated to be an RHP as specified in Section 3.1 above. If NEESPI provides the results and outcomes implied in the context of those criteria it can be expected that the collaboration between NEESPI and CEOP will meet its expectations. Otherwise, CEOP is required to note any non-compliance to the GEWEX SSG for its consideration.

The Russian Hydrometeorological Centre (Moscow, Russia) in the NEESPI activities with experiments to improve regional weather forecast with the help of the NEESPI data (e.g., operational remote sensing products) and modeling products (e.g., land surface schemes). Milestone: 2010.

Opposite to North America, Europe, and several other parts of the Globe, the NEESPI domain is still lacking many essential tools (e.g., well developed Regional Climate Models (RCMs), hydrological models, and regional reanalyses) that are a prerequisite for answering the major NEESPI science questions. This justifies an urgent need for modern models' development within the Initiative that will include critical physical, biogeochemical, and even social processes (some of which are unique for the region and/or have a potential for global feedbacks). Processes of permafrost thawing and linked to it biogeophysical and biogeochemical feedbacks (land cover changes and methane and CO2 release into the atmosphere), energy and water cycles change associated with land cover and land use change and other human activities in the region are closely intertwined. With the NEESPI launch, these processes are being assessed within modern LSMs and RCMs. It is expected that these models will provide their estimates of regional "global" feedbacks outside the NEESPI domain serving as an input (e.g., in the form of better parameterizations of terrestrial biosphere processes) to GCMs. More than 10 integrative NEESPI projects are currently clustered to address this problem. Throughout the entire life of the Initiative, efforts will continue to build (a) a suite of process-oriented models for each major terrestrial process in all its interactions (including those with the society) and (b) a suite of regional models that seamlessly incorporate all regionally specific feedbacks associated with terrestrial processes in Northern Eurasia. The latter are expected to contribute to Global Earth modeling (as component of global models).

NEESPI expects that during the next 2-3 years:

- Hydrological and biogeochemical models that are suited for diagnosis and prognosis of

changes in lake and wetland extent on the regional carbon balance of northern Eurasia will have been established.
- Enhanced models of permafrost dynamics will have been established.
- An integrative environment of modeling of the dust storm dynamics in the southern half of the NEESPI domain that includes RCM embedded into the global reanalysis product, LSM, dust producing module, dust transportation model, and aerosol remote sensing monitoring system to control the dangerous dust events as well as to control the modeling performance will have been established.

4.2. Regional Studies

The RS are currently focused on specific regional areas but all have the goal to eventually entrain other RHPs, CCS, and MS to focus on global regional problems associated with the CRS, HE, Monsoons, SAS regional studies.

4.2.1 Cold Region Study

CEOP currently has sites contributing data from Siberia, Mongolia, Tibet, Himalayas, Canadian boreal forest region, northern Germany, Finland, Netherlands and North Slope of Alaska. During the next two years efforts would take place to expand the range of sites to include others in the arctic and Antarctic. There are a number of special issues that are required to ensure the sites can provide the data as required. Contact points will have to be identified at each site. Meetings and workshops will have to be planned and held. Data and metadata standards will have to be established and adhered to. An initial joint workshop to address these issues was held at the 2006 CEOP International Science meeting (Paris, France).

The CEOP data archive and integration facilities offer a unique opportunity to help assemble archive and distribute datasets that would be part of the cryospheric studies in CliC. During 2005-2006 CliC and CEOP would collaborate in the design and assembly of a diverse and unique dataset that would be used to help define the snapshot of the cryosphere during the IPY period and beyond. Datasets would include such key components as:

- The CEOP reference sites that are located in cryospheric regions of the planet;
- Special satellite data and products generated from platforms such as ICESat, CRYOSAT, ERS, … and others;
- Datasets that would be the result of CliC and CEOP facilitated field studies during the IPY;
- Other IPY data collection efforts (e.g. AON, Arctic and Antarctic Buoy Programs, GTS reported surface stations).

The Data and Information Service (DISC) for CliC offers users the ability to peruse and access a variety of information related to the cryosphere including reports, reference materials and information on and access to cryospheric and related datasets. DISC utilizes the ISO19115 metadata standard thus making it interoperable with the CEOP archive structure. As a first step we would propose to link the CEOP archive to DISC. Next metadata associated with CEOP datasets relevant to the cryosphere could be provided to the CliC International Project Office for inclusion in DISC. This will allow the cryospheric community to learn much more about the rich CEOP datasets and permit access to these data via the CEOP archive.

Commitments from funding sources specifically interested in contributing to a CEOP cold regions initiative will be sought beginning immediately with the approval for moving forward with this proposed activity.

4.2.2 High Elevations http://www.ceop-he.org

HE is developing similar mechanisms to work with RHPs, CCS, and MS, particularly those projects where high altitude regions are present. HE is also interested in collaborating with the aerosol group in the study of natural and anthropogenic aerosol impacts on climate and the hydro-geological cycle.

Main peculiarity of HE research is related to the extremes characteristics of these sites, whose conditions of low pressure and temperature as well as the landscape roughness of the high altitude areas could affect data quality and representativeness.

It is furthermore important taking into account that high elevations are often located in developing countries where the carrying out of capacity buildings activities is very important for local populations.

The HE research agenda includes:

- studies of climatic characteristics at high altitude;
- links to climatic change with energy and water budgets and their effects on glacial areas, hydrological regime, etc;
- development of high resolution modelling of atmosphere physics and dynamics in complex topography;
- global and regional climate modelling;
- evaluations of the influence of aerosol on the hydro-geological cycle and climate

As part of the implementation strategy, HE will also:

- collect information on data availability in existing high altitude sites;
- conduct analyses of available CEOP reference sites' data in high elevation regions;
- initiate inter-comparison studies by analyzing at the same time different climate areas, to better understand any interaction among global, continental-regional and meso-local scales;
- develop physical/chemical models specifically for high altitude environments.

The starting point of this study will be the Himalayas area where data availability and quality and modelling infrastructures are established, and due to its importance for global dynamics and climate.

4.2.3 Monsoons

Under the CEOP RHPs, MAHASRI in the Asian monsoon region, AMMA in the West African monsoon region, CPPA in the North American monsoon region, LBA and LPB in the South American monsoon region are examining, to different degrees, the hydrometeorological conditions under the monsoon system. Large-scale dynamics plays a major role in the monsoon system, but the effect of surface conditions is also recognized. For example, studies have shown that the timing of the onset of the wet season in a given region seems to respond, at least in part, to the surface conditions. Changes in surface conditions even affect the boundary layer structure,

feeding back to dynamic elements like the low-level jet structure and ability to transport moisture into the monsoon region (e.g., Betts and Viterbo 2005) and (Collini et al. 2008).

In addition, numerical experiments have shown that a better representation of the surface conditions can lead to improved forecasts and simulations and more realistic evolution of the monsoons through modifications to the Bowen ratio due to the explicit representation of the vegetation processes.

The ultimate goal of MONS is to improve forecasts of monsoon variability, in particular from intra-seasonal to inter-annual time-scales. To tackle this goal, it is needed to share common recognition of the need to advance knowledge of energy and water cycle processes in various monsoon regions over the major continents in the world.
CEOP MONS will address the following questions by examining the land surface-atmosphere feedbacks that may affect the different stages of the monsoon precipitation:

- What are the characteristics of land-atmosphere interactions in the evolution and variation of monsoon system?
- How do the diurnal, intraseasonal, seasonal and inter-annual variations of monsoon interact with land surface?
- What is the impact of nearby high elevated heating onto the monsoon system?
- What is the role of the monsoons on floods and droughts of large river basins?
- What is the role of human activity on changing the activity and/or characteristics of monsoons?

4.2.4 Semi-Arid Studies

SAS is developing a mechanism to work with RHPs, Cross-cutting groups by entraining key representatives from each of the CEOP working groups to develop arid/semi-arid region land surface model simulations and applications. SAS will study of frequency of extreme droughts in semi-arid regions as well as possible increases in aridity trends and collaborate with the aerosols group on the study of dust aerosol and impacting climate and hydrological cycles. It will also cooperate with the Monsoon Asia Integrated Regional Study (MAIRS) of ESSP on the coupled human-natural system in semi-arid Asia. The SAS research agenda includes:

- Studies of atmospheric boundary layer physics and dynamics of semi-arid regions;
- Analysis of water and energy cycles of air-soil-vegetation system in semi-arid regions;
- Improvements in parameterization of land surface process for semi-arid regions in coupled climate models;
- Assessments of impacts of dust aerosols on the hydrological cycle and climate at regional and global scales.

The SAS implementation strategy includes plans to:

- Initiate the study in the semi-arid Asia;
- Add a particular site over Loess Plateau in Northwest China;
- Initiate an Asia and North America inter-comparison study;
- Analyze available reference sites of CEOP in semi-arid regions;
- Upscale site data using satellite observations;
- Develop land surface model and aerosol-chemical model specifically for semi-arid regions

4.3 Cross-Cutting Studies

4.3.1 Water and Energy Budget Study

Based on CEOP integrated data of observations, satellite products, and model output, WEBS will evaluate and analyze regional water and energy budget. According to discussions during the 6th and 7th CEOP implementation planning meetings, CEOP WEBS will:

- Collection of in situ data, model output, and satellite data and products.
- Data inter-comparison study to identify model deficiencies in simulating water and energy budget and to evaluate satellite products needed for water and energy budget study.
- Application of land data assimilation to produce multi-years soil moisture and land flux for regions with large component interactions (so-called high-impact regions, such as Tibet and semi-arid regions).
- Evaluation of exchange and variability among surface, atmospheric, and full-column water and energy budget profiles in high-impact regions.
- Analyze relationships between water and energy budget anomalies in high-impact regions and relevant extreme events.
- Evaluate global water cycle using regional model inter-comparison and parameterization sensitivity experiments to improve parameterization schemes and understanding diurnal ~ inter-annual variability.
- Identify and focus on regions where water cycle simulation has trouble.

4.3.2 Extremes http://www.drinetwork.ca/extremes/

Extremes research will be carried out through several activities. This includes the potential development of new measures of extremes for droughts and extended wet periods, updating datasets on extremes, the analysis of several 'case studies' of extremes, and the examination of trends of extremes. It may also include 'case studies' of extremes within climate scenarios.

A table summarizing activities within Extremes and their individual timelines is shown below:

Year	2007	2008	2009	2010	2011	2012	
Definitions	_____						update definitions of extremes
Datasets	_____						ongoing additions of datasets
Case studies	_____						mainly through RHPs
Trend analyses	_____						ongoing
Workshops	_	_ _	_	_	_	_	annual meetings with CEOP

An Extremes workshop will be held in spring 2008 to initiate this effort.

Section 4.3.3 Aerosol-Water Cycle Interaction

The CEOP Aerosol-Water Cycle Cross-Cut (CAWC) is aimed at multi-disciplinary studies of aerosol effects on the regional and water cycle, including forcing and responses of the climate system. It addresses scientific issues associated with aerosol-clouds-precipitation-climate interaction, from the perspective of the continental scale water cycle. The scientific objective of CAWC is to *unravel the physical mechanisms and multi-scale interactions associated with aerosol-continental scale water cycle interaction, with emphases on, but not limited to, monsoon regions and*

adjacent deserts and semi-arid regions. Major science issues to be addresses are:

- Determination of regional and global aerosol forcing functions over different biomes, including monsoon regions, deserts, semi-deserts, vegetated land and forests.
- Forcing and responses of regional and global water cycle to aerosol forcing
- Aerosol physical, chemical and radiative properties.
- Aerosol transport processes linking dry regions (deserts and semi-deserts), high-mountains, e.g., Himalayas and Tibetan Plateau, to wet regions, e.g., monsoon and adjacent oceans.
- Solar attenuation effect vs. elevated heating effect in affecting continental scale water cycle dynamics.
- Possible aerosol microphysics effects on clouds and precipitation.
- Coupled aerosol-land hydroclimate processes, e.g., impact of soil moisture, snow cover, glacier processes.
- Coupled aerosol-ocean-atmosphere processes e.g., SST, El Nino

CAWC will draw on the diverse expertise in the current CEOP new organization, with strong interactions among the following elements: AMMA, RHPs (particularly, AMMA, MAHASRI, CPPA, LBA), and synergy with the CEOP elements of Semi-Arid, High-Elevation, WEBS, Extremes. CAWC plans to implement the following initiatives in conjunction with the Asian Monsoon Year and International Monsoon Year (2008-2012):

a) The Joint Aerosol-Monsoon Experiment (JAMEX), using integrated field measurements and satellite observations and modeling to study aerosol-water cycle interaction over the Asian continent and adjacent oceanic regions, in conjunction with large number of national field campaigns in East Asia, South Asia, and Southeast Asia.
b) West Africa Monsoon Modeling and Evaluation (WAMME) project, with the objective to better understanding the influence of aerosol forcing, atmosphere-land coupled processes on the West Africa Monsoon and Sahel drought.

Both initiatives are now underway, with strong community support. CEOP reference data, satellite data and field campaign observations will be used to validate numerical experiments using high-resolution RCMs, *e.g.* WRF, coupled to LSM over high mountain regions, e.g., Himalayas, semi-deserts or desert regions, with and without interactive aerosol, and/or land surface forcing to determine their relative roles in maintenance of the continental scale water cycle, and causes of droughts and floods.

4.3.4. Isotopes

With the SWING Phase 1 experiments almost complete, initial planning for a Phase 2 experiment set is underway. Due to availability of new high quality satellite data, the scope of the experiment can extend naturally to more detailed analysis of cloud processes. The Phase 1 experiments focused on mean quantities as basic validation of isotopic modeling and capturing primary aspects of the hydrologic cycle. The Phase 2 experiments aim to target understanding the isotopic hydrology under perturbed conditions and in associated with variability in cloud and surface exchange processes.

Along with the original three global models participating in the intercomparison, additional

groups are beginning to contribute simulations using the original Phase 1 protocol, although this has been slow to begin due to ongoing in-house validation of new models. A related effort to constrain existing isotope models with observed meteorology (Reanalysis, for instance) has been underway by a small number of groups and is potentially useful new direction within the SWING.

In response to requests from users of the existing archive data, the SWING will strive to make simulations available for both warming scenarios (double CO2) and for glacial periods. These simulations will satisfy the need to use model isotope output as constraints on global and regional water budget calculations for these epochs.

A key function of the isotope crosscut is facilitation access to isotopic datastreams (both observations, model simulation results and remote sensing data) that are otherwise difficult to obtain for integrative studies. This requires the establishment of data storage capabilities. For the implementation under CEOP it is recommended that:

- Each RHP to contribute (existing and new) isotope data to a common archive. This includes precipitation, vapor, rivers, as we well as biosphere specific data (i.e., leaf, stem xylem, soil water)
- A collection of appropriate satellite data (TES, also IMG, possibly upper trop/stratosphere via MIPAS and ACE) is available in a processed form useful to investigators.
- Continued support of existing SWING modeling activities and support of new extensions to the SWING model standard output, and global observations, aimed to aid in isotope analysis of RHP studies. Includes addition of new modeling groups (potentially 7+ groups, plus possible model variants/improvements from existing groups)
- CEOP provision of data center facilities for coordinated isotope measurements access RHPs

In this context the ICCS will:

- Continue to host and maintain model output database for the SWING and community members
- Analyze results in a summary paper
- Compile observational datasets for comparison
- Develop satellite climatology of isotopes in atmospheric vapor
- Establish group Phase 2 experiment based on SWING member interest, and wider community interest

Finally, since the isotope information provided through the ICCS may be of great utility for diagnosing cloud processes and surface exchange in models and in nature, there are many opportunities to work with other groups, which are not presently being exploited. An example of success was the IPILPS project, which used the land models from the SWING and other models to assess isotope surface energy and water balances

New research items that require forward thinking for CEOP integration in the ICCS include:

- On going development of “isotope reanalysis” for the 20-th century, especially 1958 onward.
- Developing framework for new regional scale isotope models likely to be available in next few years.

Isotope management under CEOP would also provide a needed framework for non-GEWEX

activities, including WRCP BASIN/SAIBE and FLUXNET, and allow coordination with various IAEA networks (GNIP, GNIR, MIBA, and subsidiary national efforts).

Within the IGBP, the BASIN project (now BASIN2) bring together groups mostly working at field sites working with water and carbon isotopes. The SWING has close contact with this group and continues to interact with them though provision of data and modeling. Many of the BASIN sites and individual investigators are involved in RHPs. There is an opportunity to compile a "GEWEX" isotope database that brings together these measurements. Actually, the largest user of SWING results continues to be the biogeochemical community (associated with BASIN 2). This is likely to continue though provision of data and modeling capabilities being developed in the ICCS. Isotope modeling will be featured at an upcoming BASIN2 workshop on global scale mapping of isotopes.

4.4 Model Studies

4.4.1 Global Models

Each of the global models contributing to CEOP has its own grid, frequency and variable list. MAC will provide a way for CEOP science activities to better accessibility of the data. In order to absolutely understand the results of an ensemble of analyses and the variance in the ensemble and outliers, the contributing NWP centers will be entrained into the MAC analysis. The centers themselves are best positioned to take the results, and review their model code and physical parameterizations to understand and improve their own analysis systems. Regardless, even external evaluations of the data have already contributed to some center's attention to specific biases and deficiencies. In addition the resulting MAC data set should be useful to other CEOP science activities, such as WEBS, Semi-Arid Regions and Extremes. The MAC data will be a simplified set of physical parameters and their range across the contributing models. The MAC scientific objective is to contribute to understanding the level of uncertainty to model analyses for these projects.

4.4.2 Regional Models

The Regional Model studies in CEOP are no different than other aspects of CEOP model development or other CEOP implementation processes in general in that every effort is being made to improve outcomes of all studies through enhanced interaction between CEOP groups and other synergistic groups especially within GEWEX. As has already been highlighted The Chair of the GEWEX Modeling and Prediction Panel (GMPP) and the Leader of the CEOP Model Studies sub-project have made personal contact leading to direct interchange of technical and scientific information and knowledge. As a result a new collaborative arrangement has been instituted between CEOP and GMPP, with support of the GEWEX Executive Committee, to ensure direct contact with a specific individual(s) nominated by both leaders to open lines of communication about developments, which impact both activities.

In the case of each of the CEOP regional model studies this one-on-one collaborative process is being especially enhanced. For example, the CEOP Inter-Continental scale Transferability Study (ICTS) highlighted below will benefit from the CEOP Model Analysis Comparison (MAC) described in Section 3.4.1. At the same time MAC, which is being led by the CEOP Model Studies Leader, is also being presented to the GMPP and through GMPP to WGNE. Because of the connection between MAC and GMPP that is already in place aspects of ICTS

such as high resolution simulations will also be exposed to and discussed at GMPP and the joint GMPP/WGNE committee meetings.

In a similar way, through the direct connection now established between the leader of the CEOP Model Studies and the Chair of GMPP and through the technical and scientific aspects underlying MAC as presented to GMPP, other aspects of the CEOP regional model studies such as Scale Interaction Evaluation Experiment (SIEVE) and Cloud Microphysics Data Assimilation System (CMDAS), outlined below, are also linked to GMPP. MAC and SIEVE will draw on GMPP experience in data assimilation especially at regional or smaller scales. GMPP's Global Land Atmosphere Systems Study (GLASS) will be the specific link to MAC and, thereby, to SIEVE for this work. In the case of CMDAS there will be links to GMPP's GEWEX Cloud System Study (GCSS) through more than just common datasets (International Satellite Cloud Climatology Project data are being formatted for use by CEOP). CMDAS will draw on knowledge and experience in physically-based cloud parameterizations based on cloud resolving models of different cloud systems that is at the heart of GCSS studies.

Again these interactions, as they have already begun to form, are being based on a one-on-one collaborative process between each CEOP regional model initiative and GMPP without the creation of any new groups to manage these interactions.

Inter-Continental scale Transferability Study

In order to understand ensemble means, the variance in the ensemble and outliers, the contributing NWP centers will be entrained into the MAC analysis. They are best positioned to take the results, and review their model code and physical parameterizations to understand and improve their own analysis systems. In addition the resulting MAC data set should be useful to other CEOP science activities, such as WEBS, Semi-Arid Regions and Extremes. The MAC data will be a simplified set of physical parameters and their range across the contributing models. This should contribute to understanding the level of uncertainty to model analyses for these projects.

The results from ICTS simulations in 'CEOP' will be further analyzed. Presently available data sets from RHPs are in use for these analyses. Upcoming new data sets in CEOP will also be taken into account. From several options for additional simulations in CEOP the following are the most likely ones:

- Simulations with higher resolution
- Different analysis forcing for areas where differences between global analyses are significant
- Extend time period of simulation into CEOP
- Add new domain according to NEESPI

Scale Interaction EValuation Experiment

SIEVE will interact with several CEOP projects. Interaction with MAC will be necessary to ascertain the uncertainty of analyses and data assimilation systems in representing both extreme large-scale anomalies and their regional manifestations. Such analyses are needed both as initial/boundary conditions and verification data for regional extremes in SIEVE. In addition, the potential exists for strong complementary between the primarily observation-oriented studies in

Extremes and the primarily model-oriented studies of SIEVE.

Cloud Microphysics Data Assimilation System

A Cloud Microphysics Data Assimilation System (CMDAS) for meso-scale modeling has been developed for use over the ocean. The sea surface can be considered as a homogeneous and cold background in passive microwave remote sensing. The information of the atmosphere over ocean can be readily retrieved from the passive microwave remote sensing. The cloud liquid water, cloud ice and water vapor can be assimilated by coupling a RTM for atmosphere over ocean, cloud microphysics schemes embedded in a non-hydrostatic model (NHM), and the AMSR-E, TMI and SSM/I.

4.4.3 Land Surface Models

Land Data Assimilation System

A Land Data Assimilation System (LDAS) for soil moisture, land surface fluxes, and snow water equivalent has been developed by combining the SiB2 as a model operator and a RTM for soil layer as observation operator. The validations of the LDAS can be carried for different land surface classification with several types of vegetations and several land surface roughness conditions by using CEOP reference site data sets, the AMSR-E, TMI and SSM/I data, and the numerical weather prediction model outputs.

Land-Atmosphere Coupled Data Assimilation

Two data assimilation systems, the LDAS and the CMDAS, are employed for effecting coupled assimilation of both land surface and atmosphere over land. Both systems use the same RTM (LA-RTM) and NHM for simulating evolution of surface and atmospheric conditions with time. This system can be run as follows:

Step 1:

The LDAS with the LA-RTM as the observation operator assimilates lower frequency (6.9, 10.7 and 18.7 GHz) TB satellite observations. Cloud water, ice and light precipitation can be assumed transparent to lower microwave frequencies, and thus the retrieved land surface conditions is representative of prevailing surface conditions.

Step 2:

Output from the LDAS, which now includes some improvements to atmospheric variables, through the refinement of the land surface condition is used to provide initial and boundary condition for the LA-RTM embedded in CMDAS, the observation operator to assimilate high frequency (23.8 and 89.0 GHz) TB observations, with an ice microphysics scheme being used to retrieve water vapor, cloud water, cloud ice, rain and snow columns describing atmospheric state.

Step 3:

This retrieved atmospheric condition is then fed back to the LDAS step to refine surface condition.

The output from this scheme can be validated by the CEOP reference site data sets and RHPs and will be used for addressing water and energy cycle needs.

4.4.4 Hydrologic Applications Project

HAP activities will have a number of regional foci and test-bed activities. A very important activity is the development of an Asian Water Cycle Initiative being lead by the University of Tokyo. The regional water management concerns include water extremes (floods and droughts, characterized by the large fluctuations of the Asian-Australian monsoon rainfall system and subsequent large human and socio-economic impacts); water scarcity, pollution and environmental degradation in a region with the largest population increment in the world; and concerns about adverse impacts of global climate change. Equally important will be the development of RHP-based and lead HAP test-beds, which will assess similar issues as well as the usefulness of seasonal forecasts in managing water resources.

HAP activities will be implemented in cooperation with integrated regional activities, like the Global Earth Observation System of Systems (GEOSS) Asian Water Cycle Initiative (AWCI), and RHP test beds. The latter RHP activity requires the participation of RHP-based scientists, and an important contribution of the RHP coordinators is the identification of the relevant RHP test bed participants. In short, HAP would like to encourage the RHP to self-organize water management test bed projects in a similar manner to the GEOSS/AWCI.

As one of the GEOSS regional activities, the GEOSS/AWCI will serve as an important implementation activity and can serve as a model for other large regional water cycle initiatives. To structure the GEOSS/AWCI activities, an International Coordination Group (ICG) has been established consisting of representatives of participating countries and scientific projects. The GEOSS/AWCI data policy is identical with the CEOP data policy. Subsequently, they developed implementation activities that include demonstration projects in Asia that would demonstrate effectiveness of downscaling from global to local scale and show the value of the global integrated data sets to decision makers through the actual use of the data by the projects. There has been a meeting on capacity building where information on best practices in the application of earth observations for water resource management was exchanged. These activities will utilize CEOP models and data products, and tie directly into the water elements under the Global Earth Observation System of Systems (GEOSS). Over the next year or so, HAP expects to augment these activities with HAP-generated seasonal climate forecasts that the GEOSS/AWCI participants can test within a water resources management framework.

It is anticipated that HAP will contribute to CEOP through a variety of activities that include the following during the next 2-3 years:

- Launch at least two pilot projects in GEWEX RHP basins that will utilize hydrological ensemble prediction techniques. This would be done in conjunction with HEPEX initiative, and should get underway in 2007.
- Downscale and evaluate seasonal climate re-forecasts over the RHP regions using NOAA and DEMETER seasonal models output archive. These re-forecasts need to be assessed by RHP scientists, and is an important contribution to HAP by the RHPs.
- Evaluate seasonal hydrological forecasts from re-forecasting studies for the initial two pilot studies; and launch additional pilot studies in conjunction with RHP scientists.
- Using GLDAS and the IAHS/PUB, launch several studies to demonstrate the value of using remote sensing data in un-gauged (or under-gauged) basins.

- Contribute to the Global Land/Atmosphere System Study (GLASS) goal to evaluate the predictive capability from land initialization conditions to the prediction of terrestrial hydrological variables at different time scales.
- In collaboration with GLDAS and IAHS/PUB, determine the contribution of remote sensing to hydrologic modeling, with particular focus on un-gauged and poorly gauged basins.
- In collaboration with HEPEX, evaluate newly developed procedures for hydrologic ensemble generation and their impact on seasonal hydrologic prediction for the RHP pilot test beds.

4.5 Data Management http://www.eol.ucar.edu/projects/ceop/dm/

As described in the background section above, CEOP DM has already successfully set up the CEOP data policy and distributed data archives, with the greatest functionality at the in situ and model data archives. These efforts will continue to evolve. In addition, during the next 5 years of CEOP, there will be increased emphasis on satellite observations and the central data archive, which will lead to increased interoperability and Metadata standards for hydroclimate data and then ultimately to full data integration. These new CEOP efforts that will be launched during the next few years are described below. Full functionality is expected by the end of 2012.

4.5.1 Distributed Integrated Archive http://jaxa.ceos.org/wtf_ceop/

Multiple agencies within CEOS WGISS, in partnership with the CEOP science community, are tailoring and developing tools to access over the Internet the various data collections with the data services needed to support data integration. To meet various CEOP science objectives, the CEOP science community requires data integration services that allow it to access and inter-compare diverse data types from multiple sources. The WGISS agencies' prototypes offer a variety of capabilities towards this goal.

The JAXA is developing a prototype distributed data integration system to provide user-friendly services for discovery, analysis and visualization of CEOP (in-situ, satellite and model output) data to water cycle research scientists globally. The prototype system provides users with menus for selection of data and services through a standard web browser, and for access to the CEOP data from the 3 CEOP data archive centers. The system is distributed in the sense that while the main server is located in Tokyo, the data is located in archive centers, which are globally distributed. Further, a global distribution of users is supported. The system is integrated in multiple ways. First, while the data may be created and archived in a variety of formats the system masks the data formats and presents the data in a uniform style. Second, the system knows the geolocation and time of all the data sets, and coordinates the selection, retrieval and display of the various types of data both temporally and geospatially. Thirdly, the system supports selection of the data through a uniform set of menus, by data type, data providing agency, reference site and station, and supports sub-setting according to time, area and height/depth. The system provides user-friendly services to view plots and graphs of the data, to view data values on the screen, to provide information (metadata) about the CEOP data, or to download data from an archive directly to the user's (local) computer. **Figure 3** shows an overall system diagram of the JAXA prototype system.

The NASA team prototype is focusing on the enhancement of access to its satellite data resources by implementing access to satellite data through the OGC Web Coverage Service

(WCS) and tailoring the OPeNDAP and WCS software to enable access to the WCS served satellite data by OPeNDAP enabled analysis clients. These OPeNDAP enabled analysis clients are used by many CEOP scientists. Enabling this access will enable CEOP scientists to more easily access and use satellite data with model and reference site data in a variety of analysis clients such as GrADS, Matlab, IDL, Ferret, LAS, Giovanni, etc. The NASA team plans to make their software available to other interested CEOS WGISS agencies that are interested in offering their agency satellite data through this mechanism. In the future, additional data services in support of data integration may be selected to be offered through the NASA software.

Other CEOS WGISS agencies may choose to enable easier access to their satellite data with the additional data services needed to support data integration.

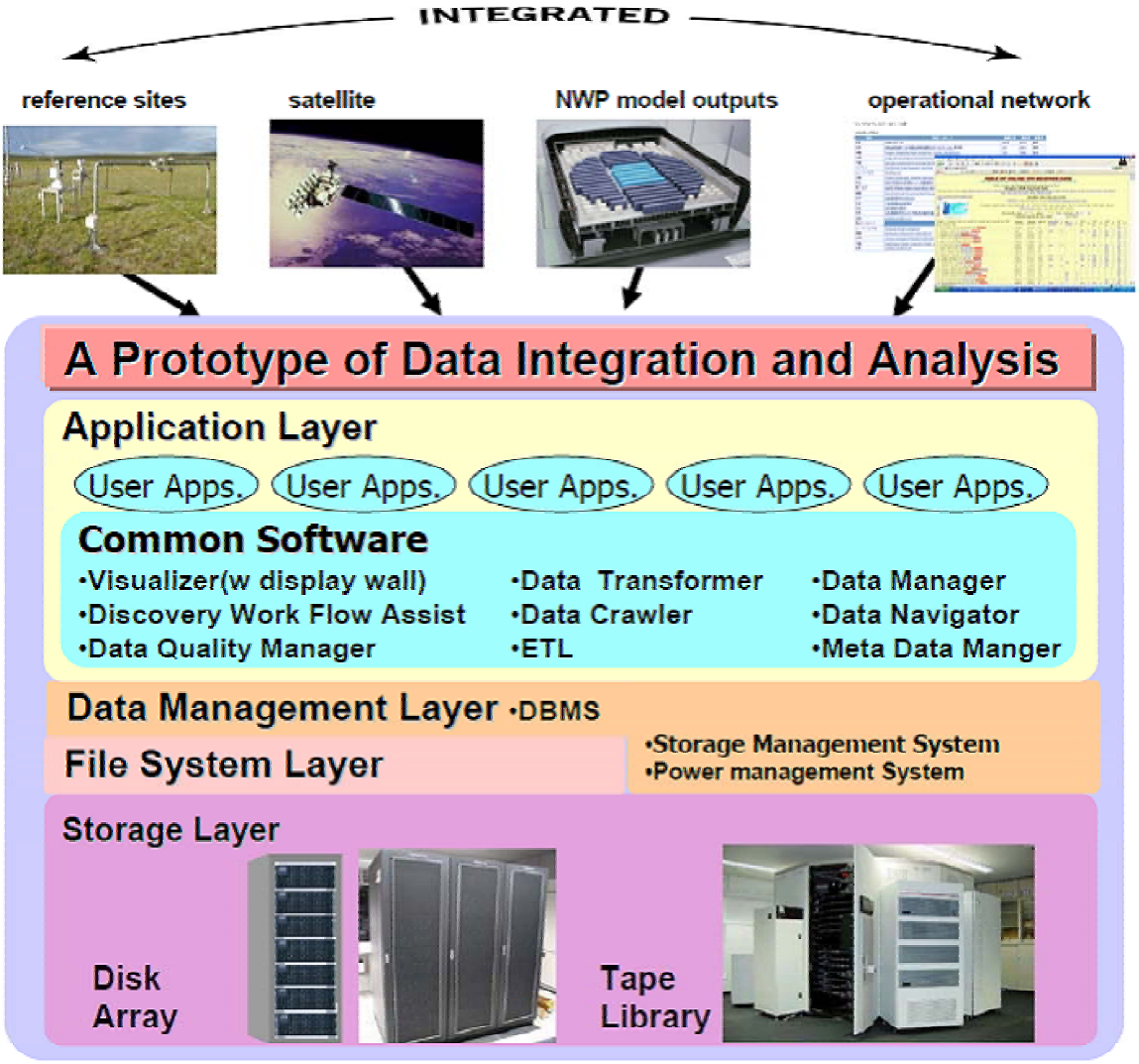


Figure 3 CEOP's data integration and analysis system

4.5.2 Centralized Integrated Archive http://monsoon.t.u-tokyo.ac.jp/ceop-dc/ceop-dc_top.htm
The architecture of the centralized data archiving and integration system is shown in **Figure 4.** Diverse and large-volume Earth Observation data from i2nhomogeneous information sources is

archived by 1 Peta-Byte hard disk array and complementary tape library. Some analysis operations such as average, difference, correlation and visualization can be applied to single or multiple data types through the interface. The browse and analysis interface is performed by dedicated clients, which provide the users with menus, integrated access to the data, and analysis tools. The connection between the clients and the server is based on HTTP. Users can access all types of data through a single interface and can view the retrieved data as graphic charts or bitmap images, depending on their dimensionality. User can integrate various observed data and numerical model outputs easily and effectively. Identifying targeted data, date, and region, the user can obtain analyzed outputs and then visualize the results on a display wall. 3D visual analysis tools are also available.

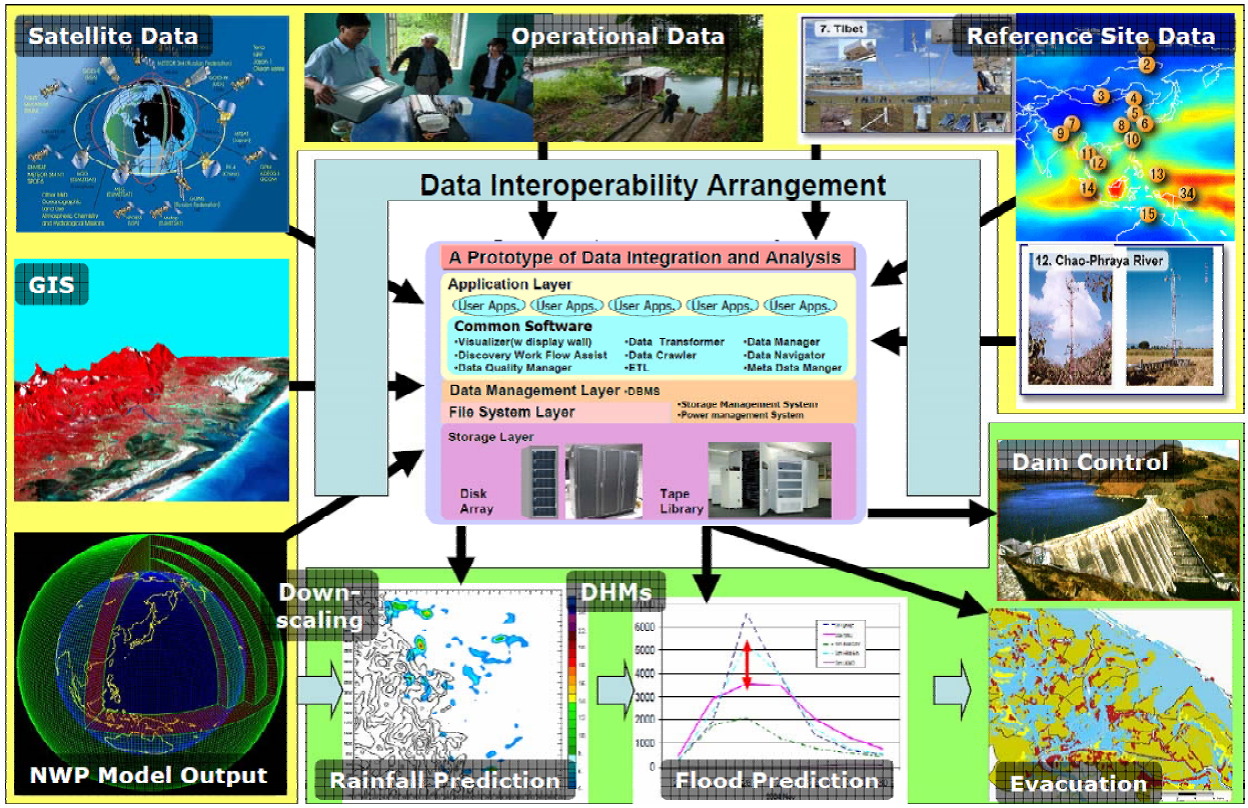


Figure 4 The architecture of the centralized data archiving and integration system

4.5.3 Interoperability and Metadata

Nowadays, metadata applications are increasingly required for data description, data indexing, and data services such as data mining. Metadata is commonly defined as "data about data", which may provide information about the content, quality, condition, and characteristics of data. Major applications of metadata require CEOP to: (1) Organize and maintain data in which significant resources may have been invested. (2) Provide information to data catalogs and data clearinghouses. (3) Provide information to aid data transfer.

Standardized metadata can provide data producers with the format and content needed to properly describe their data, and to effectively and efficiently manage and maintain data. Also, it can support data users in finding and obtaining useful data more effectively and efficiently. The ISO TC/211 19115 metadata standard defines the schema required for describing geographic

information and services and provides information about identification, extent, quality, spatial and temporal schema, spatial reference and distribution of digital geographic data. CEOP metadata was developed in conformity to this ISO metadata standard.

An implementation approach has been introduced for metadata application to CEOP data services over networks.

- Clients perform service discovery operations on the registry service to find the service providers it needs and then accesses service providers for provision of the desired service.
- Registry services help service providers and clients to find each other by acting as a registry or clearinghouse of services.
- Service providers publish services to a registry and deliver services to clients.

To improve data inter-operability, an ontology system development is now on going for supporting target data and information from diverse data sources with high complexity. Data integration needs to find meaning similarity and difference among different disciplines. To find data with similar meanings, it is often necessary to confirm the definition of the terminology. The ontology system teaches the definition. Furthermore, when the name of data is not clear, the system can provide several candidate data name by inputting keywords into the system. Standardized metadata should be prepared for data exploring, confirmation of data meaning and quality, and open data sharing.

4.5.4 Data Integration

As originally produced by the various sources, the data is in a wide variety of formats and structures. In response to this situation there was recognition of need for data management systems for the collection, sharing and provision of data from which users can obtain precisely the data they need, whenever they want it and in formats familiar to the science community. It is essential to transform observation data into scientifically and socially relevant information through the systematic collection and integration of data, merging of essential related information, and building of systems for sharing this knowledge on an international basis.

In cases in which large amounts of heterogeneous observation data are handled, this data along with socioeconomic and other related data must be dealt with systematically in order to produce useful scientific knowledge and translate it into information pertinent to users. Communicating comparatively lighter amounts of heterogeneous data requires the standardization of data formats and protocols, and the development of a network-linked distributed data system.

By looking at the earth observation satellite, reference site and related operational observation systems in an integrated manner, and integrating these observed data, with numerical weather prediction model outputs, geographical information, and socio-economic data, CEOP can disseminate usable information for sound water resources management decision making.

4.6 Global Data Centers

4.6.1 Global Runoff Data Centre http://grdc.bafg.de/

The GRDC contributes to the development of international standards, such as the so-called WMO Core Metadata Profiles of ISO 19115. Furthermore, GRDC stresses the importance of "technical data integration" in its contributions to the framework plans of a number of respective

international initiatives.

The GRDC has the following Plans (next 2-3 years) as part of supporting CEOP:

- Renewed data acquisition strategy and initiatives on a regional basis to update and expand the excising historical database, at the same time trying to institutionalize the provision of data and automate data downloads from National Hydrological Services that provide their discharge data on the Internet.
- Complete the ETN-R project for the EU Joint Research Centre and implement near-real time data acquisition tools and strategies
- Transfer ETN-R experience to the GTN-R initiative for near-real time data acquisition
- Continue to develop, support and implement metadata standards for improved data exchange
- Support actively international programmes and initiatives for improved exchange and sharing of hydro-meteorological data
- Support the research community with relevant river discharge datasets and spatial products

4.6.2 Global Precipitation Climatology Centre http://gpcc.dwd.de

The GPCC has the following Plans (next 2-3 years) as part of supporting CEOP:

- Production of a new mean monthly global precipitation climatology (period mainly 1961-1990) based on the updated GPCC normals database (more than 50,000 stations), which has been doubled with regard to the number of useful stations compared to the previous normals version. The climatology will be ready during February 2008;
- this new data will provide a better representation of orographic rainfall effects due to the use of a higher number of stations (which are expected to lead to a better station distribution in different altitudes);
- Production of a new version of the GPCC Full Data Reanalysis (Version 4) based on the significantly enlarged GPCC database. GPCC Full Data Reanalysis (Version 4) will be calculated for every month of the time period 1901-2006 in grid resolutions of 2.5°, 1.0° and 0.5° lat x lon. The new product version will be ready in Spring 2008;
- Production of a new version of the GPCC VASClimO 50-year Climatology (Version 2) based on the significantly enlarged GPCC database. GPCC VASClimO 50-year Climatology (new Version 2) will be calculated for every month of the time period 1951-2005 in grid resolutions of 2.5° and 1.0° lat x lon. The new product version will become available during 2008;
- Contribution to a Re-Analysis of the monthly gauge-satellite combined products of the GPCP in year 2008/2009;
- merging of ground-based precipitation radar products with real time available in situ precipitation data (automatic measurements) into hourly high-resolution (1 km x 1 km) precipitation products will be tested on a Central European scale in year 2008/2009;
- testing of a new method developed by an Austrian university in context of an EU project to merge daily near-real time observed in situ (SYNOP) based analyses of GPCC for the earth's land surface with satellite-based products (e.g. GPCP-1DD). The procedure might be operationally implemented at GPCC during year 2009/2010.

The GPCC has close links to various research activities worldwide: Its products are used by researchers in context of activities concerning the global water and energy cycle as well as with research into climate variability and changes. The GPCC also has close links with the GRDC,

esp. in context of the development of the Global Terrestrial Observing System (GTOS) Network on Hydrology (GTN-H) and as a member of the GRDC Steering Committee. Closer links would be desirable between the RHPs, Regional, Crosscutting, and Modeling studies. The links to CEOP data management and the interaction with it need to be enhanced, especially in relation to the CEOP DM activities.

5. CEOP Deliverables

CEOP remains open to and in fact encourages a continued review of its objectives and deliverables and will embrace every opportunity to discuss them and their timelines to ensure that they are synergistic with other milestones with the GEWEX/WCRP international framework. CEOP especially wants to be compatible with the form and substance of the GEWEX Roadmap including specific requirements for deliverables at specified points in time.

5.1 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.

CEOP DM and associated global data centers are producing multi-year integrated prototype hydroclimate data seta that will allow a user to get model output data, satellite data, and in situ measurements of various hydrometeorological data, including its isotopes, for a particular in situ location. It will eventually be possible to scale up the CEOP data to cover continental-scale to global regions. This data will come from in situ measurements, remote sensing, and model analyses and simulations and will have a focus on the water cycle. CEOP expects that it will be able to provide observations of many of the fundamental variables of the water and energy cycle that are now only available as model output. For example, CEOP data will include evaporation, precipitation, atmospheric moisture and transport, streamflow, soil moisture, snow water, radiation fluxes at the bottom and top of the atmosphere, turbulent and horizontal transport of sensible heat, atmospheric and subsurface temperature. Water isotopes in precipitation, groundwater, streamflow, water vapor will add another dimension to the developing CEOP database. By the end of 2012, we expect that the CEOP data will become a recognized part of a GEWEX/WCRP and perhaps eventually GEOSS distributed data center.

5.2 Objective 2

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

This objective is the main focus of all of the CEOP Elements. CEOP data will be used to:

- describe the connection between high altitude reference stations and regional monsoons (Africa, South America, North America, Asian/Australian);
- evaluate satellite products of precipitation, aerosols, clouds and surface radiation and energy budget with reference data;
- improve our understanding of hydrologic processes in the atmosphere and on land, and their interactions as well as possible influence by aerosol radiative forcing.
- provide an estimate of uncertainty in various global analyses and regional simulations of water and energy processes and variables.

CEOP modeling studies, will further focus on understanding how large-scale circulation anomalies interact with the regional energy and water cycle (e.g., land surface processes) to focus and amplify the regional response to large-scale climate anomalies. These modeling studies will be complemented by WEBS intercomparison and parameterization sensitivity experiments, with emphasis on improving the diurnal to interannual variability as well as simulation and prediction of extreme events.

5.3 Objective 3

Improve the predictive capability for 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.

All of the RHPs are connected to an NWP center as well as research with hydro-meteorological models capable of simulating and predicting the hydroclimate variable. These models will be confronted with CEOP data in order to better understand where current physical parameterizations may be failing. Prior research and model inter-comparisons have shown that physical parameterizations (especially for land surface processes and atmospheric moist physics) are important in determining regional responses to large-scale circulation anomalies. CEOP will have a special focus on the land surface, including soil moisture, snow cover, and complex terrain. Besides coarse seasonal averages, an additional focus will be on predictability of high temporal resolution features associated with diurnal to annual cycles. The interaction of aerosol and the continental scale water cycle and their influence on water and energy cycles, droughts and floods in monsoon and semi-arid and arid regions will be investigated through the CEOP cross-cut studies (see Sections 3.3 and 4.3).

5.4. GEWEX Objective 4 Applications

Undertake joint activities with operational hydrometeorological services, related ESSP projects like the 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

The RHPs are fully committed to developing applications as part of their Technical requirements, which requires Interactions with hydrologic services and related groups. These individual RHP efforts will be internationally organized within CEOP by HAP in collaboration with other international groups such as HEPEX and the IAHS. An initial focus will be on seasonal forecasts in gauged basins with later efforts focused on predictions in un-gauged basins (PUB), especially for predictions of extreme events. Some regions such as BALTEX are also focused on providing assessments of water resources later in this century. Besides HAP, these efforts will also be done in concert with LSM and regional modeling groups contributing to CEOP and the GMPP efforts. Finally, it should be mentioned that CEOP is committed to assessing the contribution of remote sensing measurements for hydrologic applications and predictions.

6. CEOP Contributions and Synergy with International Activities

Questions and dialog about CEOP's unique nature has led to a clearer understanding that it is

science driven as well as science enabling. It is important for scientists to be involved in data related activities to ensure the value of the resultant products to the broader community. CEOP does not, therefore, necessarily have to be shy about establishing an integrated data system, even though that might be an outcome of the implementation of the unique coordinated data management scheme it has fostered.

CEOP in its new framework will work to further clarify it function/status in WCRP. Connections with other core projects such as CliC and CLIVAR and oversight by groups such as the WCRP Joint Scientific Committee (JSC)/WCRP Observation and Assimilation Panel (WOAP) will result in conclusions about its unique structure and range of interactions among and between multi-disciplinary scientists/groups and various technical and data management experts/centers. Such a new unifying configuration should result in CEOP continuing to be a collaborating Project within WCRP.

It is valid and appropriate for CEOP in its new configuration to expand its science scope and from material incorporated into its Implementation/Science Plan the new work on extremes / tele-connections; aerosols and water cycle; watershed hydrology as science issues and the extension/enhancement of data collection and analyses into cold and semi-arid regions is to be part of CEOP's future vision.

In the context of a clarification of its unique contribution to climate research CEOP will want to revisit its role and position in WCRP to the point of it being established as a special coordinating Project in WCRP. These concepts/recommendations for future action and direction of the new CEOP lead to further efforts to clarify CEOP within the context of GEWEX, WCRP and the broader Integrated Global Observing System (IGOS) and GEO communities.

6.1. CEOP Contributions to WCRP crosscuts

6.1.1 RHP Contributions

Besides GEWEX, many of the RHPs are endorsed by other international groups because of the many crosscutting themes inherent in a regional study. For example, LBA and NEESPI are RHPs endorsed by both GEWEX and the IGBP programmes because of their interest in understanding the biological as well as physical controls on the regional climate. In a similar vein, LPB and MAHASRI have a marked interest in hydrological variability and prediction, but at the same time focus on the atmospheric controls of precipitation and evaporation and are thus endorsed by CLIVAR as well as GEWEX. It should also be mentioned that the main areas of research within the RHPs cover the following other crosscutting themes within WCRP: extreme events (floods and droughts) and monsoon systems (the South American monsoon, coordinated also with the Monsoon Experiment for South America –MESA).

Due to its interdisciplinary nature, NEESPI RHP has been recognized as an External IGBP Project that contributes to several Interdisciplinary ESSP Projects such as GLP, GWSP, and GCP. The closest coordination has been established between NEESPI and the iLEAPS Project of IGBP. The research objectives and science plans of NEESPI and iLEAPS notably overlap (however, the NEESPI scope is regional, while the iLEAPS scope is global). The projects share facilities for Science Team meetings, officers' work, and jointly sponsor sessions at International Meetings and Assemblies (e.g., the BG2.8 Session at the EGU Assembly in Vienna, April 2008).

Furthermore, iLEAPS International Office is hosting one of the NEESPI Regional Focus Research Centers. This collaboration is mutually beneficial and is projected to continue.

6.1.2 Monsoons

CEOP-MONS will provide the GEWEX perspective to the WCRP crosscut activities of "Integrated Monsoon Studies (IMS)". Under the IMS, collaborations among GEWEX, CLIVAR, THORPEX (YOTC), WWRP and MAIRS are expected. *The contributions of the CEOP-MONS to the IMS, in particular, will be in the fields related with land surface conditions and/or processes in monsoon regions over the major continents of the world, role of high elevated land heating onto the monsoon system and floods and drought in large river basins.* In addition, the role of human activity on changing the activity and/or characteristics of monsoons, in particular, land-use change effect should also be targeted.

JAMEX (See Section 4.3.3), which began as the previous CEOP Inter-Monsoon Studies (CIMS) subproject, and now under the CEOP Aerosol-Water Cycle Cross-Cut (CAWC) studies, has evolved to be a core component of the WCRP/AMY Initiative (2008-2012). JAMEX will be the first large-scale international organized effort to study aerosol-water cycle interaction over the Asian continent, including the Tibetan Plateau, and adjacent oceans, using an integrated approach combining enhanced ground observations, field observations, satellite observations, and regional and global scale modeling, with major contributions from many countries in Asia.

Another CAWC initiative, WAMME (See Section 4.3.3) is focused on better understanding, and improving representations of atmosphere-land processes including aerosols in the West Africa Monsoon. Thanks to strong grass-root support and support from GEWEX/CEOP, WAMME has assembled a significant number of international modeling groups to carry out model intercomparison and evaluation. WAMME is now emerging as a prototype of an international effort under the WCRP International Monsoon Year (IMY) initiative, involving international, broad-base participation including scientists and stake-holders from African countries. Furthermore, CAWC is actively involved in the new Aerosol-Clouds-Precipitation-Climate (ACPC) Initiative, sponsored jointly by GEWEX, the Integrated Land-Ecosystem-Atmosphere Process Studies (iLEAPS), and the International Group on Atmospheric Chemistry (IGAC), which calls for highly interdisciplinary approach to address scientific and society issues arising from the impending threat of climate change.

6.1.3 Extremes Contributions to WCRP

The extremes effort within GEWEX is working with CLIVAR to contribute to the WCRP Extremes Cross-cut. From a policy perspective, in many of the extremes studies, researchers are working directly with organizations developing policy. One example is in Canada where a national drought adaptation strategy is being developed using, in part, information from a study of drought under GEWEX. With respect to capacity building in WCRP the global and regional aspects of this activity are well-suited to application in all regions of the world.

6.2. CEOP Contributions to GEO

CEOP in its new framework will continue to evolve as a relevant aspect of the initial

configuration of GEO/GEOSS. The new CEOP will relate to GEO in a positive manner but the specific ways this will be accomplished needs to be fully explored and explicitly explained in the future.

7. CEOP Organization

As summarized by **Table I**, two Co-Chairs, Toshio Koike and Ron Stewart, now lead CEOP. A chair or co-chairs also lead each of the individual CEOP elements. They are supported in this role by the international coordinator, Sam Benedict, as well as the International GEWEX Project Office (IGPO).

Although the merger between the Coordinated Enhanced Observing Period and the GEWEX Hydrometeorology Panel (GHP) culminated in GHP being replaced in GEWEX by the Coordinated Energy and water-cycle Observations Project (CEOP) there should be no difference in the manner in which progress reporting is accomplished. CEOP wishes to adhere to all the existing methods and mechanisms embraced by both of the other GEWEX Panels, namely the GEWEX Radiation Panel (GRP) and the GEWEX Modeling and Prediction Panel (GMPP).

Whatever, provisions CEOP is directed to make to be consistent with the current GEWEX reporting scheme especially as it makes cross links, advancements, etc. transparent and includes data management activities will be promptly implemented. If the current reporting template is not sufficient to prescribe the necessary path to make these activities coherent or at least co-productive in the same way the other GEWEX Panels make these clear in their reports CEOP will want to take the examples of the GRP and GMPP Chairs methodologies and institute them in the same clear and consistent manner exhibited by those other Panels.

CEOP is further open to any suggestions on how to bring its reporting process in line with the GRP and GMPP schemes. It would be especially helpful if CEOP could be pointed to the description of these methodologies as well as other important aspects of the implementation processes employed by GRP and GMPP. Most especially, CEOP would be grateful if comparable Strategic Implementation Plans could be provided that may have been generated and maintained by those Panels and which have, therefore, established a baseline for the form and content of such reporting and planning that has withstood the test of time within the GEWEX framework.

Table 1. CEOP Organization

FUNCTION	**WWW sites**	**Representative**	**Email address**
CEOP co-chair	http://monsoon.t.u-tokyo.ac.jp/ceop/	Toshio Koike*	tkoike@hydra.t.u-tokyo.ac.jp
CEOP co-chair	http://www.drinetwork.ca/extremes/	Ron Stewart*	ronald.e.stewart@gmail.com
International Coordinator	http://www.gewex.org/	Sam Benedict*	sam.benedict@gewex.org, gewex@gewex.org
RHPs			
CPPA	http://www.climate.noaa.gov/cpo_pa/cppa/	Jin Huang	jin.huang@noaa.gov
LBA	http://lba.cptec.inpe.br/lba/site/	Jair Maia	jairmaia@inpa.gov.br
LPB	http://www.eol.ucar.edu/projects/lpb/	Hugo Berbery	Berbery@atmos.umd.edu
BALTEX	http://www.baltex-research.eu/	Hans-Joerg Isemer*	Hans-Joerg.Isemer@gkss.de

AMMA	http://www.amma-international.org/rubrique.php3?id_rubrique=1	Amadou Gaye	atgaye@ucad.sn
MAHASRI	http://mahasri.cr.chiba-u.ac.jp/index_e.html	Jun Matsumoto	jun@eps.s.u-tokyo.ac.jp
MDB	http://www.gewex.org/mdb.html	Jason Evans	jason.evans@unsw.edu.au
NEESPI	http://neespi.org/	Pasha Groisman	Pasha.Groisman@noaa.gov
Regional Studies			
CRS		Tetsuo Ohata	ohatat@jamstec.go.jp
High Elevation	http://www.ceop-he.org	Gianni Tartari	tartari@irsa.cnr.it
Monsoon co-chair		Jun Matsumoto	jun@eps.s.u-tokyo.ac.jp
Monsoon co-chair		Hugo Berbery	Berbery@atmos.umd.edu
Monsoon co-chair		William Lau	lau@climate.gsfc.nasa.gov
SAS		Congbin Fu*	fcb@mail.tea.ac.cn
Cross Cutting Studies			
WEBS	http://www.itpcas.ac.cn/users/webs/	Kun Yang	yangk@itpcas.ac.cn
Extremes	http://www.drinetwork.ca/extremes/	Ron Stewart*	ronald.e.stewart@gmail.com
Aerosols		Bill Lau	
Isotope co-chair		David Noone	dcn@Colorado.edu
Isotope co-chair		Kei Yoshimura	k1yoshimura@ucsd.edu
Models			
Global (MAC)		Mike Bosilovich*	Michael.Bosilovich@nasa.gov
Regional			
ICTS	http://icts.gkss.de	Burkhardt Rockel*	Burkhardt.Rockel@gkss.de
SIEVE		Ray Arritt	rwarritt@bruce.agron.iastate.edu
LSM		Matt Rodell	Matthew.Rodell@nasa.gov
HAP		Eric Wood*	efwood@princeton.edu
Data Management	http://www.eol.ucar.edu/projects/ceop/dm/		
Reference Sites/Basins	http://www.eol.ucar.edu/projects/ceop/dm/	Steve Williams*	sfw@ucar.edu
Model Output	http://www.eol.ucar.edu/projects/ceop/dm/model/	Michael Lautenschlager	Michael.Lautenschlager@zmaw.de
Satellite Data	http://monsoon.t.u-tokyo.ac.jp/camp-i/doc/sat_info/index.htm	Toshio Koike	tkoike@hydra.t.u-tokyo.ac.jp
Data Integration & Dissemination	http://jaxa.ceos.org/wtf_ceop/	TBD	
Central Data Integration	http://monsoon.t.u-tokyo.ac.jp/ceop-dc/ceop-dc_top.htm	Kenji Taniguchi	taniguti@hydra.t.u-tokyo.ac.jp
Asoociated	http://www.ngdc.noaa.gov/wdc/		

Global Data Centres			
GRDC	http://grdc.bafg.de/	Ulrich Looser	Looser@bafg.de
GPCC	http://gpcc.dwd.de	Tobias Fuchs*	Tobias.Fuchs@dwd.de

Figure 5 shows the general structure for the new Coordinated Energy and water cycle Observations Project within GEWEX, which has now merged with the old GHP and 'CEOP'. Many members NWP centers and CEOS space agencies contribute to CEOP. A scientific advisory group comprised of the CEOP co chairs and representatives of NWP centers and the CEOS space agencies that contribute to CEOP will further help guide CEOP activities. CEOP is also a project of the IGOS Integrated Global Water Cycle Observations (IGWCO) Project, which is helping to formulate the GEOSS.

Annual CEOP meetings will be held in the fall, supplemented by meetings of opportunity at various national and international meetings to assess progress and chart future efforts. At the first annual meeting to be held in Sept. 2007, progress toward development of this Strategic Implementation Plan will be discussed with the chairs of the CEOP Elements.

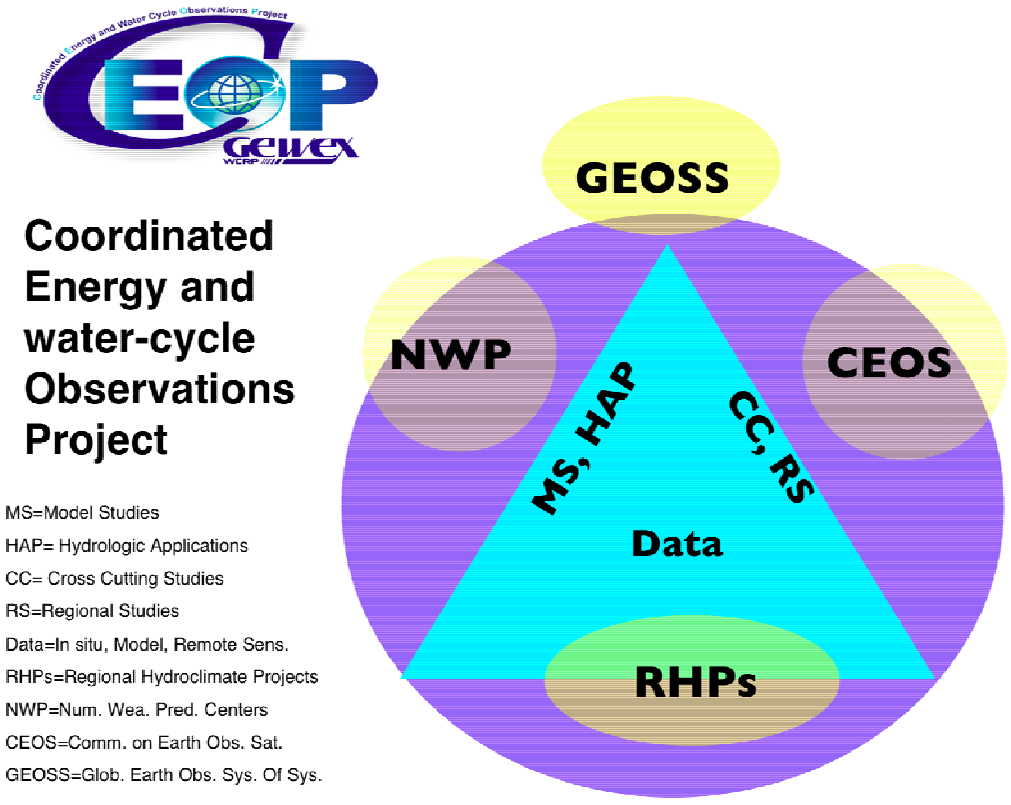


Figure 5 Overall Structure of the new CEOP project of GEWEX, showing the contributions by the RHPs, RS, MS and HAP, anchored by the Data Management. CEOP depends on community participation from the international NWP centers, Committee on Earth Observations (remote sensing) and intends to make a significant contribution to the evolving implementation of GEOSS

8. Timeline

Major events planned and executed during the lifetime of CEOP are shown below. Now that CEOP and GHP have combined it makes sense to follow the schedule of the former GHP and have the CEOP meeting in the fall. In addition to these regular meetings, we also will continue our ongoing international teleconferences with the CEOP community.

2007	
12-14 March	6th International 'CEOP' Implementation Planning Meeting
25 July	Initial input to straw man document
31 July	First straw man document conference call (06 PDT)
21 August	Second inputs to straw man document
22 August	Second straw man conference call (06 PDT)
6-9 September	1st CEOP annual meeting Bali, Indonesia
30 September	Final input for crosscutting section
8 October	Conference call
15 October	First rough draft
15 November	Final inputs to first draft
20 November	Conference call (approximate)
1 December	Second draft available
20 December	Final inputs to second draft
2008	
4-5 January	Executive meeting in San Diego (John, Sam and Toshio)
7 January	Submit draft to SSG
2-4 February	GEWEX SSG Buenos Aires, Argentina
May	CEOP Extremes Workshop (tentative)
Sept.	2nd CEOP annual meeting
2009	
September	3rd CEOP annual meeting
2010	
September	4th CEOP annual meeting
2011	
September	5th CEOP annual meeting
2012	
September	6th CEOP meeting and wrap-up conference

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APPENDIX A -LIST OF ACRONYMS

ACCESS	Australian Community Climate Earth System Simulator
ACCS	Aerosol Cross-Cut Studies (CEOP)
ACSYS	Arctic Climate System Study
AMMA	African Monsoon Multidiscplinary Analysis
AMY08	Asian Monsoon Year 2008
ANSTO	Australian Nuclear Science and Technology Organisation
AON	Arctic Observing Network
APDA	Arctic Precipitation Data Archive
ARDB	Arctic Runoff Database
ARM	Atmospheric Radiation Measurement Program (DOE)
AWCI	Asian Water Cycle Initiative
BACC	BALTEX Anthropogenic Climate Change Project
BAHC	Biospheric Aspects of the Hydrologic Cycle
BALTEX	BALTic sea EXperiment
BfG	Federal Institute of Hydrology (Germany)
BMRC	Bureau of Meteorology Research Centre
CBS	Commission for Basic Systems (WMO)
CCS	Cross-Cutting Studies (CEOP)
CEOP	Coordinated Energy and water cycle Observations Project
'CEOP'	Coordinated Enhanced Observing Period
CEOS	Committee on Earth Observation Satellites
CIMS	'CEOP' Intercomparison Monsoon Study
CLiC	CLImate and Cryosphere Project
CLIVAR	CLImate VARiations Program
CMDAS	Cloud Microphysics Data Assimilation System
COPES	Coordinated Observation and Prediction of the Earth System
CPPA	Climate Prediction Program for the Americas
CPTEC	Centro de Previsão de Tempo e Estudos Climáticos (Brazil)
CRS	Cold Regions Study (CEOP)
CSE	Continental Scale Experiment (GEWEX)
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DISC	Data and Information Service (CLiC)
DKRZ	German Climate Computing Center
DM	Data Management
DOE	Department of Energy (United States)
DWD	Deutscher Wetterdienst (German Meteorological Service)
ECMWF	European Centre for Medium-Range Weather Forecasts
ECPC	Experimental Climate Prediction Center (Scripps)

EFAS	European Flood Alert System
ENSO	El Niño-Southern Oscillation
EOL	Earth Observing Laboratory (NCAR)
ESSP	Earth System Science Partnership Program
ETN-R	European Terrestrial Network for River Discharge
EU	European Union
EWA	European Water Archive
GAME	GEWEX Asian Monsoon Experiment
GAPP	GEWEX Americas Prediction Project
GCIP	GEWEX Continental-scale International Project
GCM	Global Climate Model
GCOS	Global Climate Observing System
GEO	Group on Earth Observations
GEOSS	Global Earth Observation System of Systems
GEWEX	Global Energy and Water-cycle Experiment
GHP	GEWEX Hydrometeorology Panel
GHz	GigaHertz
GLACE	Global Land-Atmosphere Coupling Experiment
GLASS	Global Land/Atmosphere System Study
GLDAS	Global Land Data Assimilation System
GMAO	Global Modeling and Assimilation Office (NASA/GSFC)
GMPP	GEWEX Modeling and Prediction Panel
GNIP	Global Network of Isotopes in Precipitation
GNIR	Global Network of Isotopes in Rivers
GPCC	Global Precipitation Climatology Centre
GPCP	Global Precipitation Climatology Project
GrADS	Grid Analysis and Display System
GRDC	Global Runoff Data Centre
GRIB	GRIdded Binary
GRP	GEWEX Radiation Panel
GSFC	Goddard Space Flight Center (NASA)
GSNMC	GCOS Surface Network Monitoring Centers
GSWP	Global Soil Wetness Project
GTN-R	Global Terrestrial Network for River Discharge
GTOS	Global Terrestrial Observing System
GTS	Global Telecommunication System
GWSP	Global Water System Project
HAP	Hydrologic Applications Project
HE	High Elevations (CEOP) Project
HEPEX	Hydrologic Ensemble Prediction Experiment
HTTP	Hypertext Transfer Protocol
ICCS	Isotope Cross Cut Study (CEOP)
ICSU	International Council for Science

ICTS	Inter-Continental scale Transferability Study
IDL	Interactive Data Language
IGBP	International Geosphere Biosphere Programme
IGOS	Integrated Global Observing Strategy
IGPO	International GEWEX Project Office
IGRAC	International Groundwater Resources Assessment Centre (Netherlands)
IGWCO	Integrated Global Water Cycle Observations
IHAS	International Association of Hydrological Sciences
ILEAPS	Integrated Land Ecosystem-Atmosphere Processes Study
IMS	Integrated Monsoon Studies
INPE	Instituto Nacional de Pesquisas Espaciais (Brazil)
IPCC	Intergovernmental Panel on Climate Change
IPILPS	Isotopes in Project for Intercomparison of Land-surface Parameterization Schemes
IPY	International Polar Year
ISCCP	International Satellite Cloud Climatology Project
ISLSCP	International Satellite Land Surface Climatology Project
ISO	International Standards Organization
ITT	International Task Team (AWCI)
JAMEX	Joint Aerosol-Monsoon Experiment
JAMSTEC	Japan Agency for Marine-Earth Science and Technology
JAXA	Japan Aerospace Exploration Agency
JMA	Japan Meteorological Agency
JSC	Joint Scientific Committee (WCRP)
LBA	Large-scale Biosphere Atmosphere Experiment in Amazonia
LPB	La Plata Basin
LIS	Land Information System
LSM	Land Surface Model
MAC	Model Analysis Comparison
MAGS	MAckenzie GEWEX Study
MAHASRI	Monsoon Asian Hydro-Atmosphere Scientific Research and prediction Initiative
MAIRS	Monsoon Asia Integrated Regional Study
MDB	Murray Darling Basin
MESA	Monsoon Experiment for South America
MIBA	Moisture Isotopes in the Biosphere and Atmosphere
MOLTS	Model Output Location Time Series
MPI	Max Planck Institute
MPIM	Max-Planck Institute for Meteorology
MS	Modeling Studies (CEOP)
MSC	Meteorological Service of Canada
NAME	North American Monsoon Experiment

NAO	North Atlantic Oscillation
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NCEP	National Centers for Environmental Prediction (NOAA)
NCMRWF	National Centre for Medium Range Weather Forecasting (India)
NE-FRIEND	Northern European Flow Regimes from International Experimental and Network Data
NEESPI	Northern Eurasia Earth Science Partnership Initiative
NHM -	Non-Hydrostatic Model
NOAA	National Oceanic and Atmospheric Administration
NWP	Numerical Weather Prediction
OGC	Open Geospatial Consortium
OPeNDAP	Open-source Project for a Network Data Access Protocol
PACS	Pan American Climate Studies (CLIVAR)
PDO	Pacific Decadal Oscillation
PILPS	Project for Intercomparison of Land-surface Parameterization Schemes
PRUDENCE	Prediction of Regional scenarios and Uncertainties for Defining European Climate change risks and Effects
PUB	Project on Ungauged Basins
QA	Quality Assurance
QC	Quality Control
RCM	Regional Climate Model
RHP	Regional Hydroclimate Projects
RTM	Radiative Transfer Model
RS	Regional Studies (CEOP)
SAS	Semi-Arid Studies (CEOP)
SIEVE	Scale Interaction EValuation Experiment
SISG	Science and Implementation Steering Group
SMHI	Swedish Meteorological and Hydrological Institute
SRB	Surface Radiation Budget (GRP) Project
SSC	Scientific Steering Committee
SSG	Scientific Steering Group
SSM/I	Special Sensor Microwave Imager
SWE	Snow Water Equivalent
SWING	Stable Water Isotope Working Group
THORPEX	THe Observing System Research and Predictability Experiment
TRMM	Tropical Rainfall Measuring Mission (NASA)
TWG	Transferability Working Group

UKMO	United Kingdom Meteorological Office
UN	United Nations
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational Scientific and Cultural Organization
US	United States
UT	University of Tokyo
WCRP	World Climate Research Programme
WCS	Web Coverage Service (OGC)
WDC	World Data Center
WDCC	World Data Center for Climate (Hamburg, Germany)
WEBS	Water and Energy Budget Studies
WESP	Water and Energy Simulation and Prediction project
WGISS	Working Group on Information Systems and Services (CEOS)
WISE	Worldwide Integrated Study of Extremes
WOAP	WCRP Observation and Assimilation Panel
WRF	Weather Research and Forecasting model
WMO	World Meteorological Organization
WRAP	Water Resources Applications Project
YOTC	Year Of Tropical Convection