

**Towards a new Coordinated Energy and Water-Cycle Observations Project (CEOP):  
Integration of the Coordinated Enhanced Observing Period (formerly known as ‘CEOP’\*)  
and the GEWEX Hydrometeorology Panel (GHP)**

A rationale and proposed initial actions

John Roads, Sam Benedict, Toshio Koike, Rick Lawford, and Soroosh Sorooshian  
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**I. Introduction**

When the Global Energy and Water-Cycle Experiment (GEWEX) commenced in 1988 with a focus on global products, its lead scientists recognized that the global data sets needed to be evaluated on 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 carried out by the International Satellite Land Surface Climatology Project (ISLSCP) and the Biospheric Aspects of the Hydrologic Cycle (BAHC) initiative under the International Geosphere-Biosphere Programme (IGBP). In particular, ISLSCP carried out intensive field campaigns focused on relatively homogeneous areas of 10,000 km<sup>2</sup> (approximately the size of a climate model grid square) that involved intensive observational periods for (generally) 2 to 4 weeks several times a year. This concept continued to be developed by the US Department of Energy Atmospheric Radiation Model (ARM) program, which initially proposed worldwide coverage with a number of sites but ultimately, due to cost constraints, focused first on one site in Oklahoma, US and then later on additional sites in Alaska, US 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 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 could still be examined in a meaningful way. This is 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.

**II. Development of GEWEX CSEs and Inception/Organization of GHP**

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. GEWEX Continental Scale Experiments (CSEs) have included:

\* Note: in this document, the former Coordinated Enhanced Observing Period is designated by the acronym ‘CEOP’ in italics.

- MAGS (MAcKenzie GEWEX Study)
- GCIP/GAPP/CPA (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 Multidisciplinary 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) will be proposed to 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 International Satellite Land Surface Climatology Project (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 (WCRP) 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) and 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 as shown below.

GHP set up several international working groups composed of CSE representatives who would attempt to globally coordinate diverse regional activities occurring within each of the CSEs. These working groups have included:

- WEBS (Water and Energy Budget Studies)
- WISE (World-wide Integrated Study of Extremes)
- SWING (Stable Water Isotope Working Group)
- TWG (Transferability Working Group)
- WRAP (Water Resources Applications Program)/HAP (Hydrologic Applications Project)
- DM (Data Management)
- ‘CEOP’ (Coordinated Enhanced Observing Period)

The Coordinated Enhanced Observing Period (‘CEOP’) (Bosilovich and Lawford, 2002; 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.

### III. Growth of ‘CEOP’

‘CEOP’, began as a discussion item at the 2<sup>nd</sup> GHP meeting in 1995. Subsequently, the CEOP Working Group was formed. It was moved from GHP in 2001 and the Joint Scientific Committee (JSC) 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 some of the CSEs and GHP science working groups within the ‘CEOP’ Monsoon Panel (MP) and the Water and Energy Simulation and Prediction panel (WESP). Examples of current highly parallel ‘CEOP’ and GHP activities include:

<b>GHP</b>	<b>‘CEOP’</b>
Transferability Working Group	Inter-Continental-Scale Experiment (CSE) Transferability Study (ICTS)
Worldwide Integrated Study of Extremes Data Management	Extremes Reference Sites/Basins Data Management

‘CEOP’ also took advantage of the coincident new generation of remote sensing satellites (including Terra, Aqua, the ENVironment SATellite (ENVISAT), the ADvanced Earth Observation Satellite (ADEOS)-II) in addition to the Tropical Rainfall Measuring Mission (TRMM), the Land (Remote Sensing) Satellite (LANDSAT)-7, the National Oceanic and Atmospheric Administration (NOAA)-K series and 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 will be 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. Finally, there are two major science working groups under ‘CEOP’: (1) Water and Energy Simulation and Prediction (WESP), and (2) Monsoon studies. Again, these focused science activities are designed to take advantage of the unique international cooperation developed by ‘CEOP.’

Initially ‘CEOP’ was a pilot experiment, designed to intensively study a limited time period (7/1/2001–12/31/2004) 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,b; Leese et al., 2001) 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*’ Phase I and advent of ‘*CEOP*’ Phase II, 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*’, has decided to merge GHP and ‘*CEOP*’ to form a new entity, tentatively designated the Coordinated Energy and water cycle Observations Project (CEOP). This formal merger is meant to enhance the efforts of both GHP and ‘*CEOP*’ and will not lose sight of any of the GHP strategic goals or the ongoing GHP science work, due to the fact that the same scientists and more are already working on closely related projects and goals in ‘*CEOP*.’ It does mean, however, a refocusing of the former GEWEX CSE and GHP agendas toward the new CEOP.

#### **IV. Benefits of the GHP/‘*CEOP*’ Merger**

It is anticipated that both GEWEX and WCRP will derive benefits from this merger. Some of the major advantages are noted in this section and are as follows.

**1.** GEWEX in its Phase II and in developing its roadmap through 2013 is attempting to achieve maximum efficiency in utilizing the resources necessary to reach its objectives. This merger will be an important step towards this goal and will be streamlining overlapping activities between CEOP and GHP.

**2.** ‘*CEOP*’ has already established the interoperability arrangement capability in cooperation with the following key institutes in three countries: (i) the World Data Center for Climate, Max-Planck Institute for Meteorology of Germany for numerical model output; (ii) the National Center for Atmospheric Research (NCAR) Earth Observation Laboratory (EOL) of the USA for *in situ* data; (iii) the University of Tokyo and the Japan Aerospace Exploration Agency (JAXA) for satellite data. ‘*CEOP*’ has also developed a distributed and centralized data integration function in cooperation with CEOS. These elements could eventually form the basis for internationally coordinated data management for WCRP. This scheme has already shown significant benefits to the data providers by allowing for a quality control check of their data, which adds value to the final products developed from the data. The research communities of ‘*CEOP*’ and, more broadly, of GEWEX and WCRP also derive benefit from having the data quality checked, standardized in format and easily accessible. In addition, tools for manipulating the data to ease specific research efforts and intercomparison projects are also made available through the ‘*CEOP*’ data system. With the CSEs more directly involved in these activities, these advantages should become even more significant to the research being undertaken within their regions both at the smaller and larger scales up to global.

**3.** In accordance with GEWEX Phase II objectives, the ‘*CEOP*’/GHP merger will realize a wide-ranging and important coordination framework for observation convergence and data interoperability arrangements among the CSEs, as well as the reference site data integration that was established during CEOP Phase I in collaboration with GHP. Applying the specialized qualities of the CSEs, the ‘*CEOP*’ data infrastructure will contribute to improvement of availability of satellite data sets, NWP model output and data assimilation products. ‘*CEOP*’ crosscutting activities, including extremes analysis, model intercomparisons and hydrology

applications, in full cooperation with the CSEs will invigorate continental hydro-climate sciences.

4. It is understood that WCRP and GEWEX goals, like those of other research initiatives, cannot be achieved without a full and open exchange of data. Effective data integration and information fusion with minimum time delay and at minimum cost is also central to achieving climate research goals. It is expected that there will be a large increase in the volume diversity of climate data in the future. This merger action should be helpful for WCRP to establish data management functions for a diverse and large-volume climate data flow from inhomogeneous information sources in cooperation with existing data centers of the WCRP project. The 'CEOP'/GHP merger should provide a positive milestone toward a climate observation system of systems in WCRP and GEWEX.

## **V. Administrative/Technical Recommendations/Actions of the GHP/'CEOP' Merger**

1. This new arrangement has, therefore, led to the decision that it would be both appropriate and necessary to better characterize the activities under the new CEOP by finding a structure and corresponding designation that would reflect the expanding scope and capabilities which the merger would provide. Consensus is being sought for various formulations of an appropriate structure and designation that would preserve the acronym as much as possible. As noted above, the current name under consideration is the Coordinated Energy and water-cycle Observations Project (CEOP), which reflects the greater emphasis that will be placed on the type of research that has been carried out within GHP through the CSEs since its inception. This new structure will have two co-chairs, one for data issues and one for science issues.

2. The former GHP working groups will become an integral part of the CEOP structure. For example, like GHP, 'CEOP' already has WEBS, the Inter-CSE Transferability Study (ICTS) and other model intercomparison working groups. Other GHP working groups, such as SWING, could provide a focus for new isotope activities. The former GHP DM will become part of the CEOP DM, while the HAP project will merge with the former CEOP crosscutting Downscaling and Water Resources Studies.

3. The former GEWEX CSEs will form a new GEWEX CSE organization within CEOP. Terms of reference will be revised to better reflect changing priorities of the new and changing CEOP (from GHP and 'CEOP' Phase II to CEOP) as well as the changing nature of the original CSEs. The terms of reference will include updating the technical and scientific criteria to be met by GEWEX CSEs to better reflect WCRP and GEWEX objectives. The GEWEX CSEs will report to GEWEX through CEOP. In view of the changing nature of the original CSEs, it is also recommended that the GEWEX SSG approve changing the name 'GEWEX CSE' to 'GEWEX Regional Hydroclimate Project (RHP)'.

4. RHP representatives have begun to review the original set of CSE technical and scientific requirements and will propose a number of changes for GEWEX SSG consideration. The GEWEX SSG is asked to, in turn, review and make recommendations for the new RHP criteria. These recommended changes are intended to fit new WCRP, GEWEX, and CEOP foci. The current draft criteria under consideration are:

**Draft RHP TECHNICAL CRITERIA** (To be proposed for 2007)

- 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

**Draft RHP SCIENTIFIC CRITERIA** (To be proposed for 2007)

- Observe, simulate, and predict the diurnal, seasonal, annual and interannual cycles
- 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

Additional information about each criteria will need to be developed by the RHP representatives, CEOP and the GEWEX SSG.

5. The former GHP global projects will come under the auspices of the other GEWEX panels or CEOP. ISLSCP has now finished two highly successful phases and will begin to focus on land flux issues under the GRP. GPCC, GRDC, IAHS, and International Atomic Energy Agency water resources are potentially capable of making contributions to other GEWEX panels and will be invited to make appropriate contributions to these other panels as well as the new CEOP.

6. CEOP will instigate a new organizational structure that brings GEWEX and CSE knowledge and experience to the center of both its science and review and oversight aspects. The new structure, which will be open for review and comment to the entire GEWEX organizational elements, will start with the disbanding of the current 'CEOP' Advisory and Oversight and Science Steering Committee. It is proposed that the new structure instead have a single oversight group, the CEOP Science Advisory Group (SAG), composed of the co-chairs of CEOP and outside organizations, which are helping to nurture CEOP. CEOP working groups will also have chairs and co-chairs.

**RHPs and CEOP Working Groups: TBD and Acronyms defined**

- GEWEX RHPs (CPPA, LBA, LPB, BALTEX, AMMA, MAHASRI, MDB, NEESPI\*)

**- CEOP Hydroclimate Science**

- Monsoon studies (CMIPS (the Coupled Model Intercomparison Project), MSIC, AMWCI)
- WESP (WEBS, Regional Climate Models, the Global Land Data Assimilation System, SWING, Simplified Arakawa Schubert Scheme, CRS)
- Cross-Cutting Studies (CAIP, EEIAP, HAP)

\* NEESPI will be proposed at the 2007 GEWEX SSG meeting

## **- CEOP Data Infrastructure for Hydroclimate Science**

Data Management (Reference Sites/Basins, Satellite Data, Model Output)

CEOP Data Integration and Dissemination (University of Tokyo, WTF-CEOP (the WGISS (Working Group on Information Systems and Services) Test Facility for CEOP)

## **SAG Membership: TBD and Acronyms Defined**

CEOS, NWP, IGWCO (International Global Water Observations), CliC (Climate and Cryosphere)/IPY (International Polar Year), CLIVAR (Climate Variability and Predictability), iLEAPS (International Land Ecosystem-Atmospheric Processes Study), CEOP co-chairs (*ex officio*)

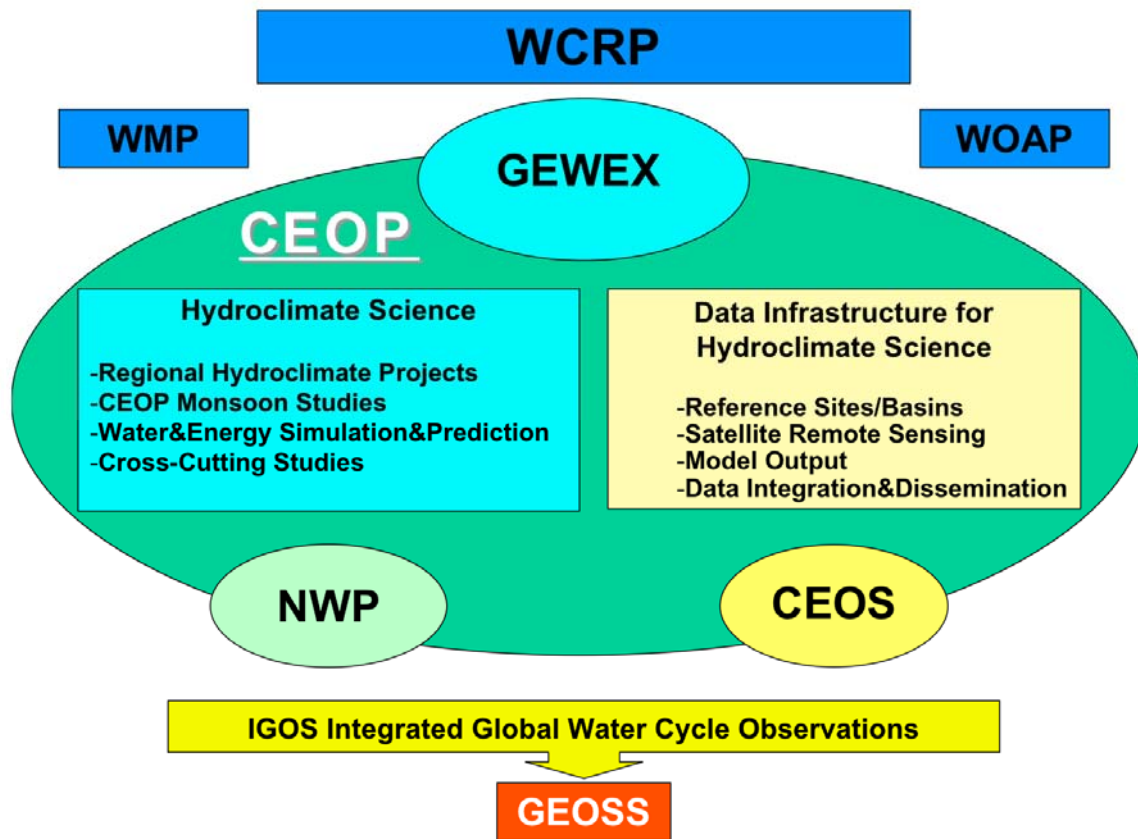
This new structure will connect CEOP directly to GEWEX for reporting and review through the GEWEX SSG and will strongly align CEOP research and data development initiatives with those being undertaken in the other panels of GEWEX.

**7.** Appointments of CEOP co-chairs and working group leads will be made by GEWEX SSG in consultation with CEOP SAG, which will also be appointed by GEWEX SSG. Terms of appointment will be for 3 years with possibility for extension and renewal.

**8.** Working Group co-chairs, SAG members, and a CEOP chair and vice-chair(s) and members of the CEOP SAG will be recommended to the GEWEX SSG for their review and advice. Following discussion and final endorsement of the candidates by the SSG, they would then be formally installed at the next CEOP International Implementation Planning Meeting (12–17 March 2007, Washington, DC). Further modifications to the ‘*CEOP*’ implementation plan must now begin, given this new merging of GHP and CEOP and the transitioning from a Coordinated Enhanced Observing Period (‘*CEOP*’) to a Coordinated Energy and water-cycle Observations Project (CEOP).

**9.** As directed by the JSC for WCRP, CEOP will seek advice and review of its Hydroclimate Processes Science Goals from the GEWEX SSG. On matters related to Hydroclimate Processes Data Infrastructure Goals, depending on the nature of the issue, CEOP will seek review and advice from the GEWEX SSG and/or the WCRP Observation and Assimilation Panel (WOAP).

**10.** CEOP will thus conduct its routine day-to-day activities and implementation development in an independent manner, similar to the manner in which panels of GEWEX and other WCRP core projects carry on their work. These interactions will be carried out by CEOP as a collaborative body with WOAP, GEWEX and the other WCRP core projects. CEOP may, therefore, have a formal representative at the WCRP JSC meeting to report on CEOP progress/status as required. At the same time, CEOP will remain responsive to both GEWEX and WOAP requests and advice and will look to the infrastructure associated with those groups, such as the International GEWEX Project Office (IGPO) for support in the same way that other elements of the organization do. A graphical representation of these concepts is given in Fig1. below.



**Figure 1: Management structure for the new Coordinated Energy and Water-Cycle Observations Project**

In addition to reporting to the World Climate Research Programme (WCRP) and the WCRP Modeling Panel (WMP) through GEWEX, CEOP will report to the WCRP Observation and Analysis Panel (WOAP). Many members of Numerical Weather Prediction (NWP) centers and Committee on Earth Observations (CEOS) space agencies contribute to CEOP. A scientific advisory group comprised of CEOP working group chairs and representatives of Numerical Weather Prediction (NWP) centers and the Committee on Earth Observations (CEOS) space agencies that contribute to CEOP will further help guide CEOP activities. CEOP is also a project of the Integrated Global Observing System (IGOS) Integrated Global Water Cycle Observations (IGWCO) project, which is helping to formulate the Global Earth Observation System of Systems (GEOSS).

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