Report of the Second Annual Meeting for the Coordinated Energy and water-cycle Observations Project (CEOP), 15-17 September 2008 in the Headquarters of the World Meteorological Organization (WMO), Geneva, Switzerland
(see: http://www.ceop.net)

1. BACKGROUND

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, which was an element of WCRP initiated by GEWEX. This formal merger into the new CEOP was meant to enhance the efforts of both GHP and the Coordinated Enhanced Observing Period. The merger was accomplished without losing sight of any of the GHP and Coordinated Enhanced Observing Period strategic goals or any of their ongoing science work since the same scientists and more are already working on closely related projects and goals. It did mean, however, a refocusing of some activities toward the new CEOP goal and objectives. With this in mind, a new Strategic Implementation Plan (SIP) was developed as a way of documenting the guiding principals of CEOP. The latest version of the SIP, on the Internet at: **http://www.ceop.net**, incorporates comments provided through a thorough review of the first draft of the document undertaken by the GEWEX Scientific Steering Group (SSG) following their February 2008 meeting at Buenos Aires, Argentina.

The **Second Annual Meeting for the Coordinated Energy and water-cycle Observations Project (CEOP)** was planned and undertaken to move ahead with the implementation of CEOP in accordance with the strategy outlined in the SIP. The discussion at the meeting, which was chaired by the CEOP Co-Chairs, covered a number of important issues. The outcome of those discussions is summarized in this report. All of the presentation material provided by the participants at the meeting, including abstracts of talks and posters is available on the Internet through the CEOP Home Page at: **http://www.ceop.net**.

An important decision was made to hold the **Third CEOP Annual Meeting** at Melbourne, Australia from 19-21 August 2009, just ahead of the joint GEWEX/iLEAPS Science Conference, which is being held the following week.

2. MAIN THEMES, OPENING TALKS, SUMMARIZED OUTCOMES

During the planning phase of the meeting the Co-Chairs noted that CEOP needed to focus on its overall strategic approach for discussion at the meeting to include:

(i) taking a comprehensive over view of the status and near future plans of each aspect of CEOP;

(ii) developing and agreeing on a small set of successes up to now including data, scientific achievements and deliverables; and

(iii) kicking-off the full data archiving scheme for getting each element of CEOP (Modeling; RHP/crosscuts/regional studies; and Reference sites and including satellite data) up and running in a mode that is responsive to the needs of both the CEOP and the broader GEWEX/WCRP research communities.

The Director of WCRP provided insight into the strengths of CEOP by noting that since January 2007, CEOP has accepted a new role in promoting research on the use of model prediction ensembles and associated statistics and comparing them with observations, and making these results available to other researchers for further analysis and use. CEOP promotes the use of coupled climate models to study region-specific climate, weather and water resources problems, especially in climatically sensitive regions of the Earth (e.g., high latitudes and

elevations). CEOP has also devoted considerable efforts and resources to assemble and make available sustained regional reference observations of key meteorological and radiation parameters together with analysis tools and methods, standards for archiving, distributing, analysis and visualization of these observations for scientists around the world.

In the future, CEOP must continue to focus on contributions to GEWEX that support the WCRP mission objectives, to "support climate-related decision making and planning adaptation to climate change by developing science required to improve:

(1) climate predictions;

(2) understanding of human influence on climate; and

(3) use this scientific knowledge in an increasing range of practical applications of direct relevance, benefit and value to society" (WCRP Strategic Framework 2005-2015).

In this way, CEOP can maintain its role in the process that WCRP-sponsored scientists and programs/projects have undertaken to make seminal contributions to international environmental assessments such as the Intergovernmental Panel on Climate Change (IPCC).

The Chairman of the GEWEX SSG called the group's attention to the major efforts that are underway to reduce uncertainties associated with the climatically sensitive and key hydrological processes in regions where CEOP is active, and their proper representation in the climate system models.

2.1 Other talking points associated with the focus of the meeting

(i) Special notice of the unprecedented international effort that has resulted in the specialized data integration function developed by CEOP, which has in turn begun to add value to work in both the meteorology and climatology science and operational communities especially the numerical weather prediction centers involved in CEOP.

(ii) The improvement of models based on insights achieved through validation studies and intercomparisons as well as the provision of new capabilities and tools for integrating the model products with satellite and in-situ data.

(iii) The worldwide data sets of the CEOP Reference Sites, the satellite products and Model Output Location Time Series (MOLTS) that have shown strengths and weaknesses of each participating modeling Center's model.

(iv) The well-described meta-data and the distributed- and centralized data integration systems CEOP has developed that are useful for both operational and research needs.

An even broader theme for the meeting was associated with the fact that as described in the GEOSS Ten Year Implementation Plan Reference Document, CEOP can and should be considered a prototype of GEOSS. The presentations were planned and the meeting organized around this theme so as to verify this situation and to show again the enthusiastic nature of the collaboration between CEOP, the numerical weather prediction centers and the broader climate research community represented by WMO, WCRP and GEWEX.

In this context, the Senior Scientific Expert for GEO Water activities pointed out at the meeting that CEOP could contribute directly to both Water Task WA-06-02 (Droughts, Floods and Water Resource Management) and Water Task WA-08-01 (Integrated Products for Water Resource Management and Research) in the near term i.e. 2009-2011. By maintaining its continued efforts to improve models and enhance the quality and integration of important hydroclimate datasets CEOP will meet its commitments to GEO. Additionally, CEOP can make

an immediate contribution to the GEO Portal, which is ready for registration of data and services at: http://www.earthobservations.org.

2.2 Executive Summary of Main Issues/Conclusions and Actions

The presentations and breakout periods organized at the meeting emphasized the expansion of the scope of CEOP science activities. In addition to the Regional Hydroclimate Projects (RHPs), CEOP includes groups focused on studies in high elevations, monsoon, extremes, cold regions, and semi-arid regions. Some of the items discussed during the review of these topics included:

- A special session associated with CEOP Monsoons Study showed how it is synergistic with the overall WCRP Monsoon crosscut initiative.
- A special session on the CEOP High Elevation study identified the possibility of organizing a global high elevation watch period.
- The review of CEOP Extremes studies showed that CEOP would continue to focus on drought, heavy precipitation, floods and low flows including, in some instances, the intermeshing of these extremes.
- The links between the CEOP Cold Regions Study and several RHPs were clearly identified. This work will also be coordinated with the WCRP CliC Project.
- A review of Semi-arid regions studies showed progress on meeting the goals established for this element of CEOP.

The talks also showed that:

- CEOP science continues to provide a traditional focus on Water and Energy budgets, which will extend the efforts to understand average conditions to conditions during the entire CEOP period.

The other CEOP science efforts reviewed at the meeting included a study of the influence of aerosols and the study of water isotopes.

- A review of CEOP modeling efforts was also undertaken at the meeting including explicit global, regional, land surface, and Hydrologic Applications Project (HAP) reports. All of these modeling groups are looking at an ensemble of international models in many different regions focused on the CEOP reference sites that were described at the meeting along with the CEOP satellite dataset during a review of the CEOP Data Management component.

It was agreed at the meeting that CEOP has fulfilled its most ambitious goals to address a number of key scientific issues through a comprehensive improvement in access to integrated observational (in-situ and satellite) and model data. Data Management, which was a focal point of the Coordinated Enhanced Observing Period, 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). Satellite data has come on line at the University of Tokyo (UT) and then along with the other data has been moved to a central data archive where it can be accessed and distributed to interested users.

The CEOP Data Management web page was revised (August 2008) and is available directly at: http://www.eol.ucar.edu/projects/ceop/dm/ with improved links to all CEOP RHP (and related data provider) data archives.

Completed in-situ data are now available from 28 of 32 Reference Sites (including data from 12 sites which contain full annual cycles for both EOP 3 and 4).

The CEOP Model Output Center (located at the World Climate Data Center, Max Planck Institute for Meteorology, Germany) has continued to maintain the archives and Model Output Gateway at http://www.mad.zmaw.de/projects-at-md/ceop/. To date, 5.6 TB of data have been submitted and are available via Internet. Metadata from the 11 Numerical Weather Prediction (NWP) Centers participating in CEOP continues to be updated at: http://www.eol.ucar.edu/projects/ceop/dm/model/model_table.html. Periodic conference calls are conducted between these various NWP Centers to coordinate data submission and data formatting issues.

The CEOP Satellite Data Center (located at the University of Tokyo, Japan) continues to add EOP3/4 satellite data to its archives. A new Satellite Data Gateway web page was developed and is available at: http://monsoon.t.u-tokyo.ac.jp/ceop2/satellite/. This web page provides current data policy, format, inventory, and access information. Data access is also available through the CEOP Centralized Data Integration System at: http://monsoon.t.u-tokyo.ac.jp/ceop-dc/ceop-dc_top.htm.

An unprecedented international effort has resulted in the specialized data integration function developed by CEOP, which has in turn begun to add value to work in both the meteorological and climate science and operational communities especially the numerical weather prediction centers involved in CEOP.

An improvement of models has been achieved based on insights developed through CEOP validation studies and intercomparisons as well as the provision of new capabilities and tools for integrating the model products with satellite and in-situ data.

2.3 Coordination Matrix

In addition to the summary of key issues that was developed following the presentations, discussions and breakout sessions, an effort was made to show how CEOP is dependent on interactions within its own components as well as with other groups in the accomplishment of the goals and objectives associated with its three main scientific foci (Extremes/Monsoons/High Elevations).

To illustrate this interdependence a matrix/table was developed as an example of how such interactions could be identified and exhibited visually in a form that could be easily updated and maintained as such cooperative aspects of the Project evolved. The matrix in its initial form is shown in the Table below.

Table 1. Interaction/Coordination Matrix

		Extremes	Monsoon	HE	
AMMA	→	Event identification. Local data/analysis	Integrated land-atmosphere data sets		
	←	Integrated analysis	Integrated analysis		
BALTEX	→	Event identification. Local data/analysis			
	←	Integrated analysis			
CPPA	→	Event identification. Local data/analysis	Integrated land-atmosphere data sets	Operational Rocky data sets	
	←	Integrated analysis	Integrated analysis	HE climate characteristics	
LBA	→	Event identification. Local data/analysis	Integrated land-atmosphere data sets	?	
	←	Integrated analysis	Integrated analysis	?	
LPB	→	Event identification. Local data/analysis	Integrated land-atmosphere data sets	Operational Andes data sets	

	←	Integrated analysis	Integrated analysis	HE climate characteristics	
MAHASRI	→	Event info. Local data	Integrated land-atmosphere data sets	Operational Tibet/Himalaya data sets	
	←	Integrated analysis	Integrated analysis	HE climate characteristics Glacier melt/ GLOF	
MDB	→	Event identification. Local data/analysis			
	←	Integrated analysis			
NEESPI	→	Event identification. Local data/analysis		Altai data sets?	
	←	Integrated analysis		HE climate characteristics Glacier melt	
AEROSOL	→	Aerosol-Water Cycle anomaly	Impact of aerosol-water cycle interaction	Modification of HE climate	
	←	Anomalous hydro-climate	Basic monsoonal circulation	Aerosol tracing	
EXTREMES	→		Impact propagation	Integrated analysis	
	←		Monsoon anomaly	Event identification. Local data/analysis	
ISOTOPES	→	Trajectory analysis	Precip. Recycling Trajectory analysis	Trajectory analysis	
	←	Anomalous hydro-climate	Basic monsoonal circulation	Isotope tracing	
WEBS	→	Regional anomaly	Atmospheric heating analysis Land surface fluxes	Atmospheric heating analysis Land surface fluxes	
	←	Anomalous hydro-climate	Advection	HE climate characteristics	
COLD	→	Event identification. Local data/analysis	Atmospheric cooling analysis Land surface fluxes	Seasonal /interannual Snow/Glacier variation	
	←	Integrated analysis	Global cold climate variability	HE climate characteristics	
HE	→	Event identification. Local data/analysis	Atmospheric heating, diurnal cycle, orographic effect		
	←	Integrated analysis	seasonal/interannual variation		
MONSOON	→	Monsoon anomaly		seasonal/interannual variation	
	←	Impact propagation		atmospheric heating, diurnal cycle, orographic effect	
SEMI-Arid	→	Event identification. Local data/analysis	Aerosol transport	Impact of regional circulation Snow/glacier melt	
	←	Integrated analysis	Water vapor transport	Impact of regional circulation Snow/glacier melt	
CEOP-AEGIS	→				
	←				

3. CEOP ORGANIZATION AND COMPONENTS OVERVIEW

The reporting at the meeting was associated with the five main components of CEOP as defined in the latest version of the CEOP Strategic Implementation Plan (SIP), namely:

REGIONAL HYDROCLIMATE PROJECTS (RHPS)
- **BALTEX**
- **LBA**
- **MAHASRI**
- **NEESPI**
- **LPB**
- **CPPA**
- **MDB**
- **AMMA**

REGIONAL SCIENCE STUDIES
- **Cold Region Studies**
- **High Elevation Studies**
- **Semi-Arid Studies**
- **Monsoons**

CROSS CUTTING STUDIES
- **Water and Energy Budget Studies (WEBS)**
- **Extremes**
- **Aerosols**
- **Isotopes**

DATA MANAGEMENT
- **In-situ**
- **Satellites**
- **Model output**
- **Data integration**
- **Global Data Centers**

MODELS
- **Hydrological applications**
- **Global Models**
- **Regional Models**
- **Land Surface Models**

Additionally, the organizational structure associated with these scientific and technical topics has been clearly defined as per Table 2, below.

Table 2. CEOP Organization Matrix

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-	Amadou Gaye	atgaye@ucad.sn

	international.org/rubrique.php3?id_rubrique=1		
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 Global Data	http://www.ngdc.noaa.gov/wdc/		

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

4.0 BREAKOUT SESSION SUMMARY OF CONNECTIONS BETWEEN KEY COMPONENTS OF CEOP IN CONTEXT OF DATA INTEGRATION OF SATELLITE, MODEL, IN-SITU DATA FOR SCIENCE FOCI TOPIC – MONSOON, HIGH ELEVATION, EXTREMES

From the series of breakout sessions that took place on the last day of the meeting a number of issues and actions were addressed that related to the technical and scientific goals and objectives set out in the CEOP SIP.

The breakout session leaders were asked to consider the following questions during their deliberations:

- Are the goals set for this foci clearly noted and accepted by the community?
- What is the status of this effort in CEOP?
- What model and data products are needed by this scientific thrust?
- How can work in this scientific arena be advanced and coordinated with the CEOP/GEWEX RHPs?
- What are the specific plans going forward in the next 1-3 year period and out to 2013 and beyond
- What mechanisms will be incorporated to allow this work to proceed?

4.1 Monsoon Studies

The Monsoon Studies in CEOP include the MAHASRI RHP and a connected effort within the CEOP Foci designated as the CEOP Monsoon Studies Initiative sub-project. Recent achievements in each area were reported at the meeting and future activities were discussed during the breakout sessions. These were accepted as **actions** for the leaders of these efforts in CEOP.

4.1.1 MAHASRI Recent Achievements

(1) Under the JEPP (Japan EOS Promotion Program) projects, radar-profiler network has been established in the Indonesian Maritime Continent. High density rain-gauge network has also been constructed in Southeast Asia, for example, in central Thailand, central Vietnam, northeast Bangladesh and India including world heaviest rainfall region, Meghalaya Hill.

(2) Combined rainfall maps from radar-rain gauges were developed for analysis of the detailed rainfall distribution under complicated topography. These data are being utilized for the input to a hydrological model and tested for the use in flood forecasting.

(3) Surface and upper-air observations including land surface conditions over Tibet have been conducted in conjunction with the JICA/CMA project. Improvement of rainfall forecasts have been achieved using a new land-surface data integration scheme that uses satellite products which have been calibrated by CEOP in-situ observations.

(4) In semi-arid Mongolia, land-surface and surface energy and moisture flux observations have been conducted. Analyses of these new observations are now under way and some new findings have been already published.

(5) A new project designated AMY for Asian Monsoon Years 2007-2012 has been planned and implemented jointly with CLIVAR/AMMP, CLIVAR/IOP and a number of projects in Japan, China, India and Malaysia through a series of coordination meetings. The Science Plan and

Implementation Plan has been drafted. The coordinated intensive observations in the years 2008-2009 are underway. The observation results will be used for validating and improving models.

Key results include:

- Multi-scale interactions in the heavy rainfall event in Jakarta.
- Coexistence of cold surge-tropical disturbance causing heavy rainfall in central Vietnam.
- Relationship between intra-seasonal rainfall variations and topography in the Indochina Peninsular.
- Water cycle and its relation to soil moisture in Mongolia.
- Heating process over the Tibetan Plateau and its impact on the Indian summer monsoon onset.
- Application of high resolution rainfall data/model output for flood prediction.

4.1.2 MAHASRI: Future Achievements/**Actions**

(1) Research related with WCRP Pan-Monsoon activity will be performed by utilizing AMY IOP data and coordinated modelling activities, for example, multiple-scale interactions between diurnal cycle and intra-seasonal variations, role of Asian monsoon on global climate variations.

(2) Datasets will be developed and the AMY IOP data adequately managed.

(3) Coordination will be undertaken with the WCRP Pan-Monsoon Activity, IGBP/iLEAPS, ESSP/MAIRS, and societal aid and benefit groups such as JICA.

4.1.3 CEOP Monsoons Study Overview and Recent Accomplishments

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.

It was recently proposed that this coordination be accomplished within the context of a formal coordination Group that gives GEWEX/CEOP and GMPP specific roles to play. CEOP has been working to coordinate its Monsoon Studies within such a framework. The form of the proposed group is given in the figure below.

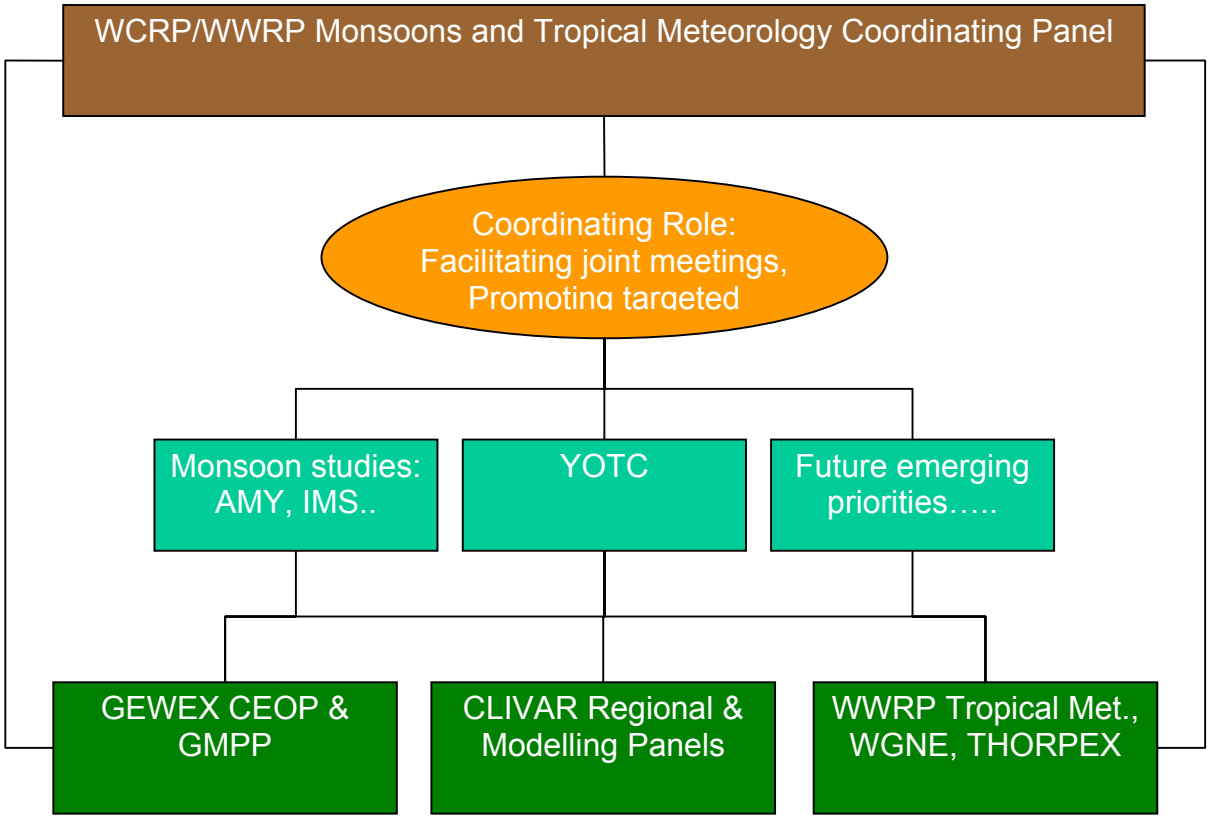


Figure 1: JSC-29 Proposal on Monsoon Issues—April 2, 2008

4.1.4 CEOP Monsoons Study Future Plans/**Actions**

To help understanding, modeling and prediction of the interdependence among heating, circulation and rain components of the monsoon system, CEOP will:

(1) Deal with the data concerning continental forcing including trends, and inter-decadal and inter-annual variability.

(2) Identify Large-scale Orographic forcing particularly over the Tibetan Plateau on time scales including inter-decadal, inter-annual and LFV variability.

(3) Detect the land/sea breeze-- inter-decadal, inter-annual, LFV and diurnal variability.

(4) Contribute to a synthesis paper (s) providing input to next IPCC assessment.

(5) Specify how applying these data and techniques affect predictions of monsoon onset, strength and breaks, including how cloud resolving models improve representation of phenomena such as intraseasonal oscillations and the diurnal cycle.

(6) Specify the important and urgent cross-cutting issues on regional as well as global monsoon systems in the world. Particularly, understanding the role of the monsoons in the changing global climate system, in relation to phenomena such as energy and water cycles and floods and desertification, using various data and coupled ocean-atmosphere GCMs and RCMs.

(7) Improve predictions of seasonal march, intraseasonal variations and extreme events in the monsoon systems, using cloud-resolving models (CRMs).

4.2 CEOP High Elevations Initiative

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.

4.2.1 CEOP High Elevations Initiative Recent Accomplishments

Work has begun to:

(1) collect information on key high elevation monitoring sites where physical and dynamic processes are being studied and to invite site managers to become part of the CEOP-HE network,

(2) create a database of HE stations worldwide;

(3) develop CEOP-approved installation procedures and long-term maintenance guidelines for HE sites and QA/QC policies for data acquisition;

(4) produce high-quality datasets in line with the CEOP data policy.

4.2.2 High Elevations Initiative Future Plans/**Actions**

(1) Provide a mechanism for sharing and harmonizing data from high elevation monitoring stations and for facilitating dialogue amongst researchers concerned with these stations.

(2) Promote long-term (10-20 year) monitoring of meteo-climatic parameters in high elevation areas and analyze environmental responses to global changes.

(3) Improve understanding of the influence of aerosols on the water cycle in high elevation areas.

(4) Improve hydro-climate forecasting capabilities at high elevations to optimize benefits to society, particularly in water resources management.

4.3 Extremes Cross-cutting Science Foci

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.

4.3.1 Extremes Cross-cutting Science Foci Recent Accomplishments

Since this effort officially began in 2007 significant steps have been taken. These include:

(1) Maintaining a listing of extremes-related activities within CEOP.

(2) Arranging a workshop to address common and unique issues.

(3) Organizing special sessions at annual CEOP meetings to address these issues.

(4) Development of specific activities to move the effort ahead.

4.3.2 Extremes Cross-cutting Science Foci Future Plans/**Actions**

Through the activities described above, a number of specific steps are currently underway. These include:

- Assess current definitions of extremes and determine if further ones are needed.
- Assess existing extreme event catalogues (heat waves, floods, droughts on a global basis from 1948 to present) and as appropriate incorporate this into the Extremes information base.
- Produce a high resolution dataset on global precipitation.
- Pull together at least one comprehensive, continental-scale dataset on multi-year drought.
- Assess whether re-analyses are capable of detecting and determining the trend of extremes events over the last 30 years.
- Provide a recipe book for others to follow in terms of conducting comprehensive drought studies.
- Assess whether a review article on extremes is warranted.

Although not definitive, other activities/**actions** out to 2013 will probably include:

- Assess the capabilities of remote sensing techniques for monitoring extremes.
- Assess to what extent the same mechanisms are responsible for 'ordinary' precipitation as opposed to 'extreme' precipitation.
- Agree on the complete data needed to characterize extremes.
- Include data set developers (for GPCC and GPCP, for example) in trend and related studies since they are familiar with the data issues such as inhomogeneity.
- Assess the need for data rescue efforts for vulnerable data records in many countries.
- Assess weaknesses in predictive models for extremes.
- Undertake comparative analyses of extremes in reanalysis data and long-term forecasts and actual extremes inferred from data as a way to find areas where large differences exist.
- Assess the feasibility of using high-resolution models for downscaling during extremes.

The Extremes effort is one that needs to continue long past 2013. Some of the expected issues and **actions** to be addressed will include:

- Fully documenting extremes on a global basis to the needed accuracy and resolution
- Achieving a comprehensive understanding of the means through extremes develop and evolve with a particular focus on land-area processes
- Contributing to reliable seasonal to inter-annual prediction of extremes such as drought
- Contributing to assessments of the future occurrence of extremes
- Working with other organizations to reduce impacts from extremes

4.4 CEOP Integrated Datasets Breakout Group Conclusions/**Actions**

The need to develop a systematic effort to match the expanded science framework of CEOP with new and better specialized data sets and data integration tools was an over arching conclusion. This concept was thoroughly discussed during the Meeting's General Sessions and especially during the Breakout group process. The breakout session leaders were asked to consider the following questions during their deliberations:

- What are the CEOP Requirements for this data type?
- What is our status in addressing the CEOP Requirements for this data type?
- What key issues need to be addressed that may prevent achieving success in provision/handling of this data type
- How can we best coordinate RHP efforts in provision/integration of this data type?
- What coordination is need within CEOP, GEWEX Panels, other groups to ensure this data type is provided?
- What are the plans over the next 1-3 year period for handling/providing/integrating this data type?

The Breakout Group's conclusions/actions included:

(i) Issue: What are the CEOP data requirements going forward to accomplish its main Science goals and objectives?

Conclusion: better datasets are needed with greater sampling at multiple scales and with other related characteristics that are necessary for improved and timely application to CEOP Science research.

Action: CEOP (Co-Chairs) must focus on defining and generating new multi-sensor, multi-scale, integrated datasets.

(ii) Issue: What is the current status in addressing the CEOP need for improved datasets?

Conclusion: CEOP has made significant advances with the management of satellite, and ground-based remote sensing and in-situ observations and with coordination with the climate modeling community for model output products leading up to the establishment of an excellent opportunity for the development of the datasets required in the future.

Action: CEOP (Co-Chairs) must aggressively pursue the fulfillment of commitments made by the International participants in CEOP to provide, validate, archive and stage the complete baseline dataset prescribed in the initial CEOP requirements.

(iii) Issue: What key issues need to be addressed that may prevent achieving success in provision/handling of the new data type.

Conclusion: In the context of its data collection process the newly constituted CEOP must ensure that data continue to be collected, it must also continue its relationship with data archive Centers at UCAR, MPI and JAXA/UT. CEOP must also work to ensure that Funding for these efforts will be maintained and that the data providers and data management centers will work together to ensure the synergy of the three data types is maintained for production and application of new data sets in the future.

Action: the CEOP Co-Chairs on behalf of the entire CEOP community was to consider the material presented by Space Agencies at the general business meeting and to take steps necessary to ensure that these agencies, through CEOS, and other important funding groups are encouraged to actively support the CEOP implementation process. Each CEOP community member has responsibility to suggest and move forward with actions that will lead to more involvement and support being given to their activities by funding agencies.

(iv) Issue: How can CEOP best coordinate RHP efforts in provision/integration of the new data type necessary to achieve CEOP Science Objectives?

Conclusion: GEWEX and now CEOP has up to now not encouraged enough capacity building within the context of the RHPs. This situation may now lead to one or more RHPs being reclassified as only affiliate activities by the CEOP, with approval and endorsement of the GEWEX SSG.

Action: CEOP, led by its Co-Chairs, must begin to take steps to support and promote capacity building within the Regional Hydroclimate Project (RHP) regions. At least by the time of the 2009 GEWEX SSG meeting, CEOP must evaluate the possibility of recommending that a re-designation of one or more of the RHPs is necessary. Such a recommendation will require a quantitative assessment of the impact on CEOP scientific objectives in specific study areas dependent on provision of actual results, from the specified RHPs nominated for re-designation, associated with each criteria under which the RHPs were established.

(v) Issue: What coordination is need within CEOP, GEWEX, and other groups to ensure the required data types are provided.

Conclusion: CEOP cannot and should not attempt to produce all the data types necessary to meet the new dataset requirements, since to do so would mean replicating work already underway by other groups.

Action: CEOP, led by its Co-Chairs and supported by its International Coordination Function, must eliminate any redundancy of effort and waste of scarce intellectual and monetary resources by increasing its cooperation and coordination with other groups, especially within GEWEX/WCRP, who have already developed specialized data products that are important components of the datasets now being defined. These include but are not limited to the radiation, cloud, aerosol and precipitation data products, which are the responsibility of the GEWEX Radiation Panel (GRP) and the land data assimilation (LDAS) products developed under the auspices of the GEWEX Modeling and Prediction Panel.

5.0 GENERAL SESSION SUMMARY: ACCOMPLISHMENTS AND FUTURE PLANS FOR CEOP BY MAIN STUDY AREAS: WHAT WE HAVE DONE (2007-2009) AND WHAT WE WILL DO (2009-2013)

During this part of the meeting the CEOP elements having representatives at the meeting reported on the following items:

Background and Objectives
Recent Scientific Achievements contributing to GEWEX and WCRP Plans

Data Contributions/Requirements
Issues and Plans (1–3 Years) including Coordination

Some elements of CEOP that did not participate directly in the meeting provided written inputs covering the same items as noted above. As defined in the organization section 3 above the following topics will be covered in the remainder of this report.

5.1 Regional Hydroclimate Projects
- BALTEX
- MDB
- CPPA
- NEESPI
- LPB
- LBA
- (MAHASARI covered in section 4.1 above)

5.2 Regional Studies
- Cold Region Studies
- Semi-Arid Studies
- (High Elevations and Monsoons covered in section 4.1 above)

5.3 Cross-Cutting Studies
- Water and Energy Budget Study
- Aerosols
- Isotopes
- (Extremes was covered in Part 2)

5.4 Model Studies
- Global Models
- Regional Models (ICTS, SIEVE)
- Land Surface Models
- Hydrologic Applications Project

5.5 Data Management

5.1. Regional Hydroclimate Projects (RHPs)

The RHPs are organized and funded by national organizations and are or have the potential of satisfying the GEWEX technical and scientific criteria. 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). It was noted 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.

5.1.1. Criteria for Functioning of RHPs in CEOP/GEWEX

The RHPs in CEOP have already been tasked by the GEWEX SSG with satisfying a number of scientific and technical criteria that are meant to govern their conduct and contributions to the global objectives of CEOP in GEWEX. The discussion at the meeting included issues with adherence to the criteria, which can only be established by large projects involving a multitude of investigators. The criteria under which the RHP's were assumed to be operating at the time of the meeting 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

5.1.2. Summary of Recommendations/Actions for RHPs

Presentations were made by key persons or their designates from LPB, MAHASRI, LBA, BALTEX, CPPA and NEESPI. The presentations themselves are on the Internet through the CEOP Home Page at: **http://www.ceop.net.**

A number of points were raised and resolved during the meeting related to the tasks being undertaken within each RHP as represented by the presentations provided.

A few specific actions resulting from these discussions included:

(i) that the LBA representatives and the CEOP in-situ data manager would take an **action** to workout a plan for improved data quality checking and more regular interaction leading to fulfillment of LBA data contribution commitments to CEOP. Subsequently, side meetings were held with the principles and arrangements were made to enable progress to be made on accomplishment of this action.

(ii) that the CEOP International Coordination function would take an **action** to contact the key persons associated with AMMA and MDB to attempt to bring them into alignment with the other RHPs in terms of meeting their commitments associated with the criteria that have been established for their acceptance into the WCRP/GEWEX/CEOP international framework. Subsequently, MDB has acknowledged their continued effort to meet their commitment to CEOP and has provided a new representative to be the point-of-contact for actions associated with MDB's contributions to CEOP.

No further progress has been made in connections with AMMA and its adherence to the specified criteria noted above. This situation and other concerns about the role of the large scale experiments in GEWEX, their transition into RHPs and their overall integration into CEOP was cause for discussion at the meeting.

(iii) That one or more RHPs may have to be reclassified as only affiliate activities by the CEOP Co-Chairs, with approval and endorsement of such action by the GEWEX SSG.

This over arching matter, was characterized by the point that where as MAGS, for example, has been completed within the framework of the initial criteria established by GEWEX for the large scale experiments, 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 was underscored at the meeting, because it was anticipated that such an **action** would be undertaken in the future by the CEOP Co-Chairs. The consequence of such a re-designation of one or more of the RHPs will then require CEOP to take an **action** to reassess CEOP objectives in specific study areas dependent on provision of actual results associated with each criteria from the specified RHPs.

(iv) That CEOP RHP Community Conference Calls be established in an attempt to ensure that the RHP contributions to the broader CEOP science objectives are made in a timely and coordinated manner. The CEOP Coordination Function agreed to investigate the interest in renewing these calls within the broader CEOP RHP Community and to instigate their initiation, in due course. Subsequently the form and content of the calls was addressed and an initial call took place.

5.1.3 Baltic Sea Experiment (BALTEX): Recent Accomplishments

(1) **Special journal issue on 5th Study Conference on BALTEX** in *Boreal Environment Research, BER*). In October 2007, 26 papers, which were presented at the 5th BALTEX Study Conference on Saaremaa, 4-8 June 2007, were submitted to the editors of BER. The papers reflect the whole range of BALTEX research objectives with an emphasis on water and energy budgets and climate variability and change. 24 papers were accepted for publication and will be published as a special issue on the 5th Study Conference on BALTEX in the beginning of 2009.

(2) **The BACC book *(BALTEX Assessment of Climate Change for the Baltic Sea basin)* was published** at Springer, Heidelberg, on 16 January 2009. There was a tremendous press resonance in the weeks following the press release. Alone in Germany, over 100 newspapers, online services, TV and radio stations made a reference to the book and cited the main findings of the report. The BALTEX Secretariat provided articles on BACC for various scientific publications (EOS, various Newsletters). The BACC book summarizes climate change observations and projections as well as potential impacts on the terrestrial and marine environments of the Baltic Sea basin in a comprehensive way and thus helps to make current knowledge in regional climate change easily available to local decision makers, stakeholders and the interested public. Similar regional assessment reports are currently being compiled in different regions of the world.

Findings of the BALTEX Assessment of Climate Change for the Baltic Sea basin (BACC), including for example:

- A marked increase of mean surface air temperature of more than 0.7^{o}C in the region during the recent century.
- Consistent changes in other variables such as extreme temperatures, increase of winter runoff, shorter ice seasons and reduced ice thickness on rivers and lakes in many areas.
- Assessment of indications that at least part of the recent warming in the Baltic Sea basin is related to the steadily increasing atmospheric concentrations of greenhouse gases.
- A spatially non-uniform pattern of upward and downward trends in precipitation.
- For the future, projections indicate that increased winter precipitation may emerge later in this century over the entire area, while summers may become drier in the southern part –

but this expectation is uncertain for the time being; for the Baltic Sea, a tendency towards lower salinity could be expected; no clear signals, whether for the past or for future scenarios, are available with regard to wind conditions.

- Observed changes in past temperature have been associated with consistent changes in terrestrial ecosystems, such as earlier spring phenological phases, northward species shifts and increased growth and vigour of vegetation, these changes are expected to continue in the future.
- An assessment for the marine ecosystem of the Baltic Sea is particularly difficult because of the presence of strong non-climatic stressors such as eutrophication, fishing, release of pollutants, related to human activities.
- Studies using both *in-situ* and remotely sensed data show improvements in understanding and quantifying a variety of water and energy cycle relevant variables such as atmospheric precipitable water and water vapour, surface wind speed, solid precipitation and extreme marine snowfall.
- Pathways and ages of inflowing salt- and freshwater to the Baltic Sea have been determined by a 3-dimensional model study.

5.1.4 Baltic Sea Experiment (BALTEX): Future Achievements

Two major international project proposals were retained for funding through the BONUS programme (www.bonusportal.org) which are expected to start by the end of 2008, as follows:

(1) **ECOSUPPORT**: Advanced modelling tool for scenarios of the Baltic Sea ecosystem to support decision making.

The response of the marine ecosystem during the 21st century depends on several, partly competing drivers, like expected reduced phosphorus and nitrogen loads, increased water temperatures, and reduced salinities. Thus, presently discussed targets for nutrient load reductions that may be sufficient to improve the ecological status in present climate might fail under future climate conditions. The proposed project ECOSUPPORT combines the assessments of various drivers to promote an ecosystem approach to the management of human activities. The main aim is to provide a multi-model system tool to support decision makers. The tool is based upon scenarios from an existing state-of-the-art coupled atmosphere-ice-ocean-land surface model for the Baltic Sea catchment area, physical-biogeochemical models of differing complexity, a food web model, statistical fish population models, economic calculations, and new data detailing climate effects on marine biota. The expected outcome is an advanced modelling tool for scenario simulations of the whole marine ecosystem that can underpin and inform design strategies to ensure water quality standards, biodiversity and fish stocks. For the aims of ECOSUPPORT, 12 institutes from 7 Baltic Sea countries plan to form an excellent consortium consisting of University institutes, national governmental agencies and research institutes (including EU-recognized Centers of Excellence) with a wide range of expertise.

(2) **BALTIC-C**: Building predictive capability regarding the Baltic Sea organic/inorganic carbon and oxygen systems.

Baltic-C will for the first time constrain the organic and inorganic carbon budgets of the Baltic Sea, addressing C-fluxes from land, the exchange fluxes with the atmosphere and the sediments, as well as addressing internal C-fluxes in the water bodies of the major basins. Only such holistic description of all C-fluxes will allow scenario analyses on possible impacts of eutrophication, climate change and acidification. Baltic-C objectives are to develop and apply a new integrated ecosystem model framework based on the cycling of organic carbon (C_{org}) and carbon dioxide (CO_2) in the Baltic Sea water, drainage basin, atmosphere, and sediments.

The outcome of the project will be a model framework in support of water management of the Baltic Sea and its ecosystem, addressing the consequences of climate change,

eutrophication, increasing atmospheric CO_2 and acid precipitation, and demonstration applications of the framework of direct value for management.

Four major events are planned and organized or co-organized by BALTEX that will focus on issues for future study they are:

- 2nd International Workshop on "21st Century Challenges in Regional Climate Modelling", in Lund, Sweden, 4-8 May 2009
- International conference on "Climate Change - The environmental and socio-economic response in the Southern Baltic Region" in Szezecin, Poland, 25-29 May 2009
- BALTEX Summer School on "Ecosystems of the Baltic Sea basin under climate change" on Bornholm, 24 August-4 September 2009 (tentative title, venue and time window)
- 6th Study Conference on BALTEX, Miedzyzdroie, Wolin, Poland, 2010 (dates still to be defined)

5.1.5 Murray Darling Basin (MDB) Study: Recent Achievements

(1) Various projects within this initiative have documented the relative importance of the El Nino – Southern Oscillation (ENSO), the Indian Ocean Dipole (IOD) and the Southern Angular Mode (SAM) on the precipitation of the MDB region. These factors when combined with the effects of the sub-tropical ridge can explain a considerable amount of the variability in precipitation in the MDB region. This information has been used in the development of the seasonal climate forecasting model POAMA which is showing promise in providing economically useful seasonal forecasts. These precipitation changes generally produce much larger streamflow responses; this has been attributed in part to the change in seasonality of precipitation. It has also been found that an increase in temperature of 1K has resulted in a 15% decrease in streamflow which may be a significant problem in a globally warmed world.

(2) The GCMs contributing to AR4 CSIRO, IPSL, and MIROC-m capture the observed probability density functions of maximum and minimum temperature and precipitation relatively well. It is these four models that are, therefore, recommended to users of model results for the MDB.

(3) The availability of moisture substantially affects the impact of increases in the leaf-level CO2, where the physiological feedback can indirectly lead to more rainfall which decreases the warming effect of reduced transpiration. The influence of moisture availability suggests that the potential of the physiological feedback to affect the future climate may be affected by uncertainties in rainfall projections, particularly for water-stressed regions.

5.1.6 Murray Darling Basin (MDB) Study: Future Achievements

Main study topics for future work under MDB, include:

(1) While significant work has already produced relevant land surface hydrology and climate datasets these are stored in various locations and are made available through varying processes. A priority will be to make these various data resources available at a single location using a consistent process. This will foster wider collaborations with researchers outside the directly involved organizations. Similarly, a bibliography of relevant research publications will also be maintained and made available.

(2) The government's decision in 2007 to invest in a national plan for water security lead directly to the large expansion of the Bureau of Meteorology's water division. This division is providing a new government organizational focus for hydrology and water cycle studies. Once the division is fully established it will provide a point of reference for most water related datasets and a distribution centre for water related, government backed research.

(3) The WIRADA initiative is a major 5-year collaborative research agreement between the Bureau of Meteorology and CSIRO focused on the research and development of water information services. The program will address a number of objectives of relevance to the MDB RHP

- Development of an evolvable architecture for water information systems. This includes a framework of open standards for information exchange, data and computational services, and tools for visualization, quality assurance and analysis of historical data and real-time data from monitoring infrastructure.
- Developing methodologies, data models and techniques for creating and maintaining core hydrological information products to support water information management, reporting, forecasting, assessment and accounting.
- Developing spatial and temporal information about the past and present generation, distribution and use of water resources. Using this information to develop water balances, water resource assessments, national water accounts and interactions between components of the water cycle at many scales.
- Extending the Bureau's hydrological forecasting services from short-term flood forecasting to continuous forecasting of flows, water inundation and water demand several days out as well as water resources availability forecasts to one or more seasons.

(4) Research aimed at improving the understanding of land-atmosphere interactions and drought processes through the use of coupled models (e.g. regional climate models) is also planned. The use of multi-model ensemble approach will be used to provide quantitative estimates of the strength of this coupling and the uncertainty associated with it.

(5) A new direction of the MDB RHP will be to assess, and improve on, current land-surface modeling capabilities by providing a unique set of isotopic observations from new *in-situ* and satellite based techniques. *In-situ* data will come from the field placement of Cavity Ring Down Spectrometry (CRDS) based water vapor and liquid water instruments, while the satellite data to be used is isotopic composition derived from the Tropospheric Emission Spectrometer (TES) on-board the AURA satellite.

5.1.6 Climate Prediction Program for the Americas (CPPA): Recent Accomplishments

(1) Support research quality climate observing system in North Mexico.

(2) Provide data from 2004 NAME field experiments to research community for process studies, validation for models and satellite estimates.

(3) Support data management for Global CEOP in-situ reference site data.

(4) Provide data in the CPPA region (in-situ, remote sensing, and global and regional land and coupled assimilation products) to CEOP.

(5) Determining seasonal shifts in the energy and water balance at the point and basin scales (and vegetation controls).

(6) Providing forcing and verification data sets for land surface models in the NAM region (Noah and tRIBS models).

(7) Developing soil and vegetation parameterizations that can be used in the broader NAM region.

(8) Improving seasonal hydrological forecasting and assessing changes in runoff mechanisms through distributed models.

(9) Instrumentation augmentation for Regional Studies: 10 additional rainfall and soil moisture stations (35 total in network), High elevation eddy covariance tower (evapotranspiration), 3 scintillometer transects (sensible heat flux).

(10) CPPA Extremes Study Initiated showing Impact of intraseasonal variability on the formation of tropical Atlantic Storms and Impact of wind shear on U.S. landfalling hurricanes.

(11) CPPA Drought Predictability Study initiated showing Tropical influences on drought in North America and providing simulations of future droughts in Southwest USA.

(12) CPPA Monsoon Process Studies initiated providing diagnoses of observed NAM diurnal variability; Formulation a conceptual model of diurnal convection; Role of SST on the diurnal cycle of the NAM and development of ad-hoc datasets; Model representation of the diurnal cycle of convection: role of the “convection trigger mechanism”.

(13) CPPA High Elevations Study initiated providing CPPA co-sponsored North American Mountain Hydroclimate Workshop (Oct 07); A. Mariotti (Associate Program Manager) attended CEOP-HE Workshop; Land surface-climate interaction in cold season and high-elevation is one of CPPA FY09 priorities.

5.1.7 Climate Prediction Program for the Americas (CPPA): Future Accomplishments

(1) Representations of physical processes in climate models.

(2) Hydrologic and water resource applications.

(3) Climate predictability studies.

(4) Accomplishment of the Multi-RCM Ensemble Downscaling of multi-GCM Seasonal Forecasts (MRED) Project to “Demonstrate the usefulness of multi-model downscaling of global seasonal forecasts for hydrologic applications”.

5.1.8 Northern Eurasia Earth Science Partnership (NEESPI): Recent Accomplishments

(1) March 17-19, 2008, Jena, Germany. Workshop of the NEESPI Focus Research Center for Biogeochemical Cycles. Max-Planck Institute for Biogeochemistry (52 presentations, 28 oral and 24 posters).

(2) April 13-18, 2008, Vienna, Austria. NEESPI Session at the European Geosciences Union General Assembly 2008. Session BG2.8: "Land-atmosphere interactions in Northern Eurasia" (61 presentations, 24 oral and 37 posters).

(3) June 2-6, 2008, Helsinki, Finland. Regional NEESPI Science Team Workshop “Environmental and Climate Change in High Latitudes of Northern Eurasia (51 presentations, 39 oral and 12 posters).

(4) August 23-28, 2008, Odessa, Ukraine. Regional NEESPI Science Team Workshop “Regional aspects of climate-terrestrial-hydrologic interactions in non-boreal Eastern Europe” (49 presentations, 39 oral and 10 posters).

5.1.9 Northern Eurasia Earth Science Partnership (NEESPI): Future Accomplishments

(1) December 15-19, 2008, San-Francisco, USA. NEESPI Session at the Annual American Geophysical Union Fall Meeting. Session GC2: "Land-atmosphere-cryosphere interactions in Northern Eurasia" (47 abstracts submitted).

(2) In 2009, 2 Regional Workshops (High Elevation and Siberia).

(3) New course towards strengthening of the NEESPI research focus on projections regional modeling will play a key role within this focus.

5.1.10 La Plata Basin (LPB) Project: Recent Accomplishments

(1) Extreme events study focused on Floods and Droughts

(2) Monitoring and Prediction initiatives

(3) Climate change studies: ACC, land use change, biomass burning

(4) An agreement with the Itaipu Hydropower Plant Authority in 2008 has led to a plan for a field campaign initiative that will focus on Data collection and data recovery; Radar, satellite and lightning measurements; Radiation, aerosols, and trace gases; and Flux Towers and soil moisture measurements.

5.1.11 La Plata Basin (LPB) Project: Future Accomplishments

(1) A capacity building course aimed at graduate students and young scientists will take place during 2009 with emphasis on:

- Assimilation of surface data (specifically related to surface processes),
- The regional climatic controls that impact the hydroclimate of the La Plata Basin.
- Land surface interactions with the atmosphere,

5.1.12 Large Scale Biosphere-Atmosphere Experiment in Amazonia (LBA): Recent Accomplishments

(1) Recent LBA Data Accomplishments:

- Vegetation Fire Data: contains Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Level-1B satellite imagery over controlled burns in the State of Roraima in Northern Brazil, plus simultaneously collected soil and near-surface air temperature profiles.
- AVHRR Derived Fire Occurrence: contains an ArcGIS ArcInfo grid provides the number of hot spots detected across the legal Amazon Basin at 5 km resolution by the Advanced Very High Resolution Radiometer (AVHRR) sensor on NOAA 12, 14, 15, 16, 17, and 18 satellites
- Flux tower measurements:
  - CO_2 profiles at km 67 tower site, tapajos national forest.
  - Temperature profiles at km 67 tower site, tapajos national forest.
  - CO_2 concentrations at km 67 tower site, tapajos national forest.
  - CO_2 and H_2O eddy fluxes at km 67 tower site, tapajos national forest.
  - H_2O profiles at km 67 tower site, tapajos national forest.
- Vegetation characterization results:
  - Forest litter data for km 67 tower site, tapajos national forest ground-based biometry data at km 67 tower site, tapajos national forest.
  - Coarse woody debris data at km 67 tower site, tapajos national forest.
  - Tree dbh measurements at the km 67 tower site, tapajos national forest.

(2) Recent Scientific Achievements:

- LBA has provided the first comprehensive picture of the spatial and temporal variability of CO_2 fluxes between the biosphere and atmosphere in the Amazon.

- There are parts of the Amazon rainforest mosaic that behave as either a carbon sink or a carbon source or are carbon neutral.
- This variability is largely related to soil fertility and precipitation gradients and to climate driven effects, such as ENSO.
- The soils are more fertile to the Southwest of the Amazon rainforest, and there is more precipitation to the Northwest.
- The basal area and dry season length are negative correlated (Malhi et al., 2006).
- In addition, the above ground live biomass is larger to the north than to the south (Malhi et al., 2006, Saatchi et al., 2007).
- Flux towers measurements confirm that forests have lower albedo compared with pasture, greater net radiation, and greater evapotranspiration (ET), particularly during the dry season (Bonan, 2008).
- Observations show that forest ET is sustained during the dry season (da Rocha et al., 2004; von Randow et al., 2004; Hutyra et al., 2007; Fisher et al., 2008).
- This is seen also in carbon fluxes (von Randow et al., 2004; Hutyra et al., 2007) and satellite monitoring of vegetation (Huete et al., 2006; Saleska et al, 2003), to a greater extent than represented in many models (Dickson & Henderson-Sellers, 1998; Werth & Avissar, 2004; Lee et al., 2005).
- In Eastern Amazonia the zone of active water withdrawal extended to a depth of at least 10 m (Bruno et al., 2006).
- Drought of South-western Amazonia in 2005 was associated with anomalously warm tropical North Atlantic sea surface temperatures (SST) (Marengo et al., 2008; Cox et al., 2008).

(3) Contributions to GEWEX and WCRP goals:

- Global Climate Models (GCMs) and Regional Climate Models (RCMs) generally predict decreases in Amazonian ET during the dry season, in phase with precipitation.
- Hasler & Avissar (2006) showed strong seasonality in ET for stations near the equator (2°–3°S), with ET increasing during the dry season (June–September) and decreasing during the wet season (December–March), both correlated and in phase with the net radiation annual cycle.
- In stations located farther south (9°–11°S) no clear seasonality could be identified in either net radiation or ET. For these more southerly stations, net radiation and ET are still correlated in the wet season, but correlations decrease in the dry season, which is likely associated with water stress.
- GCMs and RCMs indeed tend to overestimate dry season water stress in the Amazon basin and, therefore, should be revised to better simulate this region, which has a key role in the global hydrometeorology (Hasler & Avissar, 2006).
- In central Amazonia observations revealed a strong memory effect in the groundwater system, which can carry over seasonal climate anomalies from one year to the next (Tomasella et al., 2007).
- This effect is crucial for sustaining stream flow and evaporation in years with rainfall deficiency, and raises serious concerns for attempting to close the water balance in atmospheric models for the Amazon basin, specifically when groundwater system is usually not taken into account explicitly.

5.1.13 Large Scale Biosphere-Atmosphere Experiment in Amazonia (LBA): Future Accomplishments

(1) Development of enhanced data CEOP validation routines.

(2) New flux-tower was installed in a forest fragment in June 2008 (about 80 km N-NE off Manaus).

(3) Establish concurrent measurements of biometry, air quality, ecophysiology and hydrology.

(4) The new flux-towers sites, as well as to extend them to the previous sites.

(5) Establish new sites to the West of Amazonia and also in the wetlands.

(6) Recovering of degraded/abandoned areas (either via agroforestry systems or afforestation or reforestation).

5.2 Regional Studies Recent Accomplishments and Future Plans

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

5.2.1 Cold Regions Study Recent Accomplishments

The process of integrating data from CEOP cold region sites (see Figure 2 below) has begun. The characteristics of the cold regions data archive and data-set have been defined to include snow cover/frozen ground from Asian regions that can be compared with EOP sites.

5.2.2 Cold Regions Study Future Accomplishments

(1) Application of a land hydrological model will be undertaken for all Siberian rivers based on long-term data available for understanding the hydrological intensification (run-off increase) that is occurring.

(2) Information, data and analysis results within the activities of the glacier group of Asia-CliC and CliC will be gathered and formatted for application toward meeting the goals of the CEOP Cold regions study.

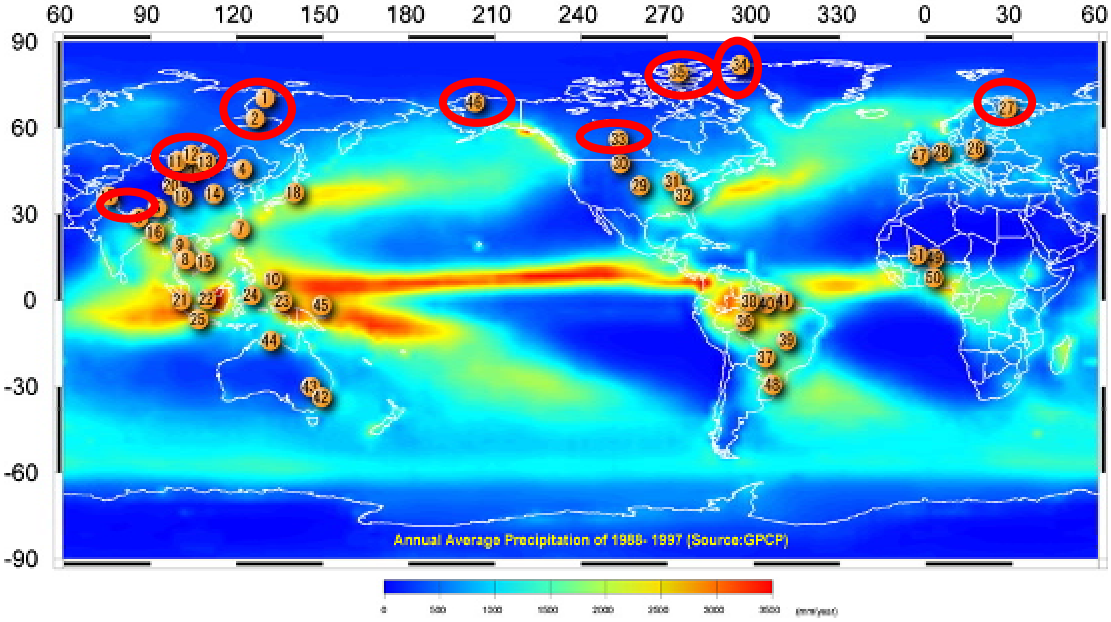


Figure 2: CEOP Reference Site Locations

5.2.3 Semi-Arid Studies (SRS) Recent Accomplishments

(1) An International Workshop on Semi-arid Land Surface-Atmosphere Interaction, was held in Lanzhou, China, 9-11 September, 2007. The workshop was co-organized by CEOP/SRS and MAIRS (Monsoon Asia Integrated Regional Study). Over 80 scientists from Asia, US, and EU attended the workshop. To discuss (a) climate and environmental change in semi-arid regions, (b) land surface-atmosphere interactions, (c) monitoring, observation and data system, (d) modeling, (e) aerosols, cloud and hydrological cycle, and (f) impact of aridity trend in arid and semi-arid region.

(2) Four task groups have been formed and are working on the following issues in the context of the CEOP SRS study framework:

- Observation standards and data quality control;
- Application of remote sensing information;
- Intercomparison of land surface models;
- Feedback mechanism between aerosol-cloud-precipitation.

(3) An international joint research project "A Comparative Study on the Interactions of Atmosphere-Land-Water in the Semi-arid Regions of Asia and North America" was approved by National Natural Science Foundation of China. This project is the major component of CEOP/SRS. By choosing the most representative semi-arid regions in Asia and North America, where aridity trends have occurred most dramatically, the research project is making the best use of data collected in eight CEOP reference observation stations in the semi-arid regions of the two continents.

(4) On May 17, 2008, the "Kick-off meeting of a pilot experiment of coordinated observations in arid/semi-arid China" was held in Beijing with participation of PIs from 14 observation stations. The period of the pilot observations experiment was from July 1st to September 30th, 2008. Results are currently being analyzed.

(5) Validation of several land surface models has been accomplished by using data from Tongyu stations in China along with parameter sensitivity identification and optimization of Land Surface Model in semi-arid area;

(6) Observations of dust storm and mechanism study on the feedback between dust storm, cloud, and precipitation.

5.2.4 Semi-Arid Studies (SRS) Future Plans

Based on the data analyses from all available reference sites of CEOP in semi-arid regions, up scaling of site data from satellite observation, and numerical model simulation, plans now exist to carry out studies in the following areas:

(1) Study of structure and dynamic characteristic of boundary layer in semiarid areas with different land use and land cover pattern;

(2) Study of diurnal, seasonal and annual variations of exchange of energy and water between land and atmosphere in semiarid areas;

(3) Validation of land surface processes model for application in semiarid areas and improvement of land surface parameterization;

(4) The analysis and simulation of land use and land cover on surface energy and water budget in semi-arid area and its affection to regional climate;

(5) The research of satellite remote sensing information applied in the semi-arid area; and

(6) Development of land surface model and aerosol-chemical model specifically for semi-arid region.

5.3 Cross-cutting Science Foci Studies

CEOP has a number of Cross-Cutting Science Studies that are being pursued in collaboration with the regional Studies, the RHPs, and the CEOP Modeling Studies. These topical studies include Water and Energy Budget Study, Extremes, Aerosols, and Isotopes projects.

5.3.1 Water and Energy Budget Studies (WEBS) Foci Recent Accomplishments

Recent key results in the CEOP WEBS cross-cutting Science foci include the following:

(1) University of Maryland developed a high-resolution shortwave radiation product. This product is proved superior to GEWEX-SRB and ISCCP-FD for Tibet region;

(2) Satellite-derived estimates reached the best performance when convective rains prevailed, while its accuracy was degraded for estimating light, stratiform and solid precipitation. The models showed a very different ability in predicting precipitation over Europe, with WRF greatly outperforming RSM through all the seasons.

(3) The microwave land data assimilation system developed by University of Tokyo was evaluated with Mongolian soil moisture network. Soil moisture and soil porosity estimated by this system were comparable with observations.

(4) A satellite algorithm was developed to utilize high-resolution Landsat-7 ETM and ASTER to estimate surface energy budget on Tibet for clear-sky conditions. The estimates agree with in-situ observations, and all their absolute percent difference is less than 10 %.

(5) The diurnal cycle of water and energy (both surface and integrated column) was compared over the continental United States from three analyses, showing consistent phases despite varying amplitude.

(6) Two evaluations are conducted, respectively, for (1) dominant balances and exchanges of the atmospheric water cycle in the NCEP/DOE Reanalysis-2, (2) the temporal variability of the water cycle's sensitivity to pairings of land-surface schemes and convective parameterizations.

5.3.2 Water and Energy Budget Studies (WEBS) Foci Future Plans

(1) Evaluation of MOLTS and satellite products against ground observations. The evaluation should target both the mean value and the long-term trend, in order to investigate both processes and climate change impacts on water and energy budget studies. Data evaluation should consider the representativeness of in situ data. It is probably better to evaluate a coarse-resolution product by comparisons with a validated high-resolution product instead of direct comparisons with limited observations.

(2) Satellite data assimilation. An assimilation system, which combines a model and satellite signals, may provide a promising means to estimate surface or atmospheric parameters. Microwave signal has high potential for land process studies, as microwave can penetrate cloud layers and directly "see" land surfaces. We need to complete products of multi-years soil moisture and land fluxes for regions with large component interactions (such as Tibet and semi-arid regions) using a validated land data assimilation system.

(3) Complete evaluation of exchange and variability among surface, atmospheric, and full-column water and energy budget profiles in high-impact regions. They are crucial to understand the processes in water and energy cycles, as well as their impact on extreme events in surrounding areas, such as droughts and floods.

(4) Promotion of the application of remotely-sensed data. The improved estimates of soil moisture through microwave land data assimilation enable us to further study its role in land-atmosphere interactions, especially during extremely wet and dry periods, and contribute to the hydrologic modeling, with a particular focus on ungauged or poorly gauged basins.

(5) Evaluate water cycle using regional model inter-comparison and sensitivity experiments, in order to improve modeling of diurnal ~ inter-annual variability by customizing/improving land-surface, convection, and boundary layer schemes.

(6) Identify regions where water cycle simulation has trouble by collaborating with other cross-cut elements, such as semi-arid, high-elevations, and cold region projects.

5.3.3 Aerosol Cross-cutting Science Foci Recent Accomplishment

Major recent activities for the CEOP Aerosol Study include two pilot field observations in 2008, one in China and one in India, in conjunction with the Asian Monsoon Year (AMY) /Joint Aerosol Monsoon Experiment (JAMEX).

(1) Aerosol Field Observations in northern and central China: The U.S. Department of Energy Atmospheric Radiation Measurements (ARM) Mobile Facility (DOE/AMF) and ARM Ancillary Facility (AAF) were deployed for the first time simultaneously in China during the Asian Monsoon Year (AMY), February through December, 2008 to acquire comprehensive ground-based observations for aerosol-cloud-water cycle studies with the objectives to better understand the aerosol direct and indirect effects; optical and chemical characteristics; transport processes and possible feedback mechanisms on the large-scale monsoon rainfall and circulation. The mobile unit was set at three different sites during the experiment thus allowing; analyses of simultaneous measurements from these three sites that will provide a better understanding of dust properties near different source regions, as well as properties downwind from a large metropolitan area (Lanzhou).

(2) AERONET Field Campaign in India – TIGERZ: A field campaign focused on improving the understanding of atmospheric aerosol columnar optical properties, vertical distributions, and aerosol-cloud interaction, led by NASA's AERONET project called TIGERZ (Team Lead; B. Holben), commenced in April through the end of July 2008. The field observations primarily emphasized the pre-monsoon period (April through June) to test, among others objectives, the aerosol "elevated heat pump" mechanism (Lau et al 2008). A core monitoring capacity will remain in the field to continue data collection during the monsoon months of July through September, and into the dry winter season. The TIGERZ campaigns are intended to augment the Continental Tropical Convergence Zone (CTCZ) programme, which is being implemented under the Indian Climate Research Programme (ICRP).

Further understanding of the optical properties of dust/pollution mixtures is a goal of the combined CTCZ and TIGERZ campaigns. Combined observations of in situ aerosol properties taken in profiles above the Cimel sun-sky radiometer locations especially in combination with ground-based, airborne, and spaceborne lidar will provide new insights into these mixtures of aerosol types.

(3) Data set development and access: The data from each of the AMF/AAF field campaign shall be formatted and delivered within six months after the completion of the respective field campaign phase and provided to the ARM Data Archive through the External Data Center. Finally, quality assured data sets will be retained in the Archive and will be accessible from there. Once

submitted in final form, data sets will be freely accessible to CEOP as well as to the general scientific community. The TIGERZ aerosol data are available from the AERONET website.

5.3.4 Aerosol Cross-cutting Science Foci Future Plans

(1) The CEOP Aerosol Studies team expects the AAF and TIGERZ field campaigns will continue in 2009 and beyond, in coordination with other AMY observations in China and in India. These campaigns will also serve as calibration experiments for the A-train series of satellites, providing unprecedented datasets for study of aerosol and water cycle interaction. Measurements of AOD and sky radiance distributions (in the solar principal plane) simultaneous with CALIPSO satellite overpasses over India and China will be utilized to make joint retrievals of aerosol optical properties.

(2) Through AMY/JAMEX, the CEOP Aerosol Element will provide an opportunity to attract other resources to conduct joint aerosol-monsoon research. The data collected will be a part of the AMY and CEOP data archive. We anticipate collaborations to develop with groups that will allow assessment of the direct, and indirect radiative forcing and water cycle feedback processes. In particular TRMM and CLOUDSAT may augment precipitation monitoring in the I-G.

5.3.5 Isotope Cross-cutting Science Foci Recent Accomplishments

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. In summary there has a public data archive of the simulation data has been developed, 20-year control experiments (fixed SST) have been undertaken, as well as common 20thc experiments (variable SST) and (Common LGM experiments), two papers and many presentations have also been accomplished.

In specific this effort has:

(1) Continued to host and maintain model output database for SWING and community members.

(2) Analyzed results in a summary paper Yoshimura et al., 2008; Buenning and Noone, 2008

(3) Compiled observational datasets for comparison monthly/sub-monthly data: Bowen, 2008.

(4) Develop satellite climatology of isotopes in atmospheric vapor TES data: Worden et al., 2007; Brown et al., 2008

(5) Establish group Phase 2 experiment based on SWING member interest, and wider community interest.

There has been agreement within the community that the work done by this group has shown that stable water isotopes are a useful additional tracer for water cycle studies and that hydrological cycles of GCMs can be improved by their incorporation. Additionally, SWING experiments have been shown to be a good common standard to evaluate isotope GCMs. The SWING model might also help to improve the understanding of observed isotope values in precipitation (and other water pools).

5.3.6 Isotope Cross-cutting Science Foci Future Plans

A Kick-off meeting for SWING 2 was held in November 2008. This continuation of SWING into the future plans to accomplish the following tasks:

(1) Evaluate the capability of climate models to represent the spatial and temporal variability of water isotope composition in precipitation.

(2) Spatially and temporally interpolate the GNIP (Global Network of Isotope in Precipitation, IEAE/WMO since 1960's) dataset by applying the nudging technique or something else.

(3) Deliver an optimal reconstruction of monthly gridded maps of water isotopes in precipitation, by merging simulations and observations.

(4) Assess the uncertainties and confidence intervals of the above gridded data-set (for all approved methods).

5.4 CEOP Model Studies

CEOP has initiated a number of Modeling Studies organized around four main types/scales, namely: (i) Global; (ii) Regional; (iii) Land Surface; and (iv) Hydrologic Applications.

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.

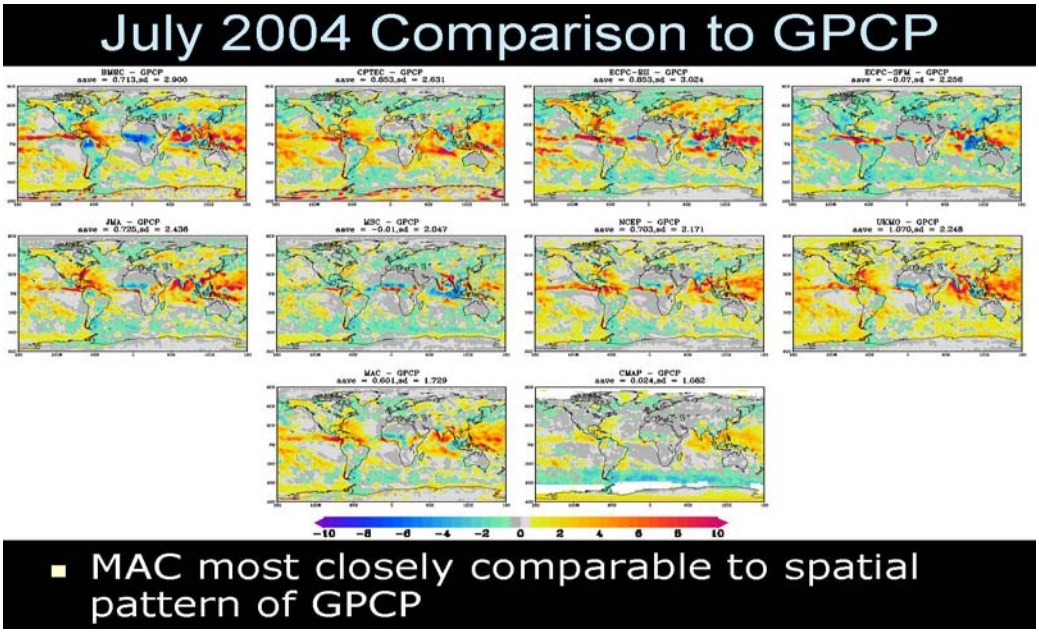
5.4.1 Global Models Recent Accomplishments

The global modeling effort within CEOP has been providing global analyses and forecasts supporting CEOP science goals including MOLTS for local process studies. It has also been evaluating the uncertainty of models and analyses with the intent of having the science activities provide feedback into understanding the global NWP systems.

Most recently this effort has achieved a number of accomplishments including:

- Adding cloud data and process studies in the global model frameworks.
- Defining new global MOLTS and Converting them to standard NetCDF.
- 8 global analyses archived at MPI.
- Begun quantifying uncertainty in analyses through the initiation of the Multi-model Analysis for CEOP (MAC).
- Adding value to toward meeting GEWEX Objectives (i.e. 1 and 2) by providing a data set that can be used to better understand Water and Energy cycles and that contributes to the RHPs regional and CEOP focused studies.
- A NASA initiated reprocessing of the Coordinated Enhanced Observing Period EOP 3-4 period as a contribution.
- NCEP use of the data in their system evaluations.
- Application of the results in the NASA Energy and Water Cycle Studies (NEWS).

More specifically a number of important results have been achieved through the MAC initiative including the finding that MAC Ensemble data compare well to Global P (GPCP), Global OLR and Basin scale precipitation as shown respectively in the Figure 3 (a,b,c) below:



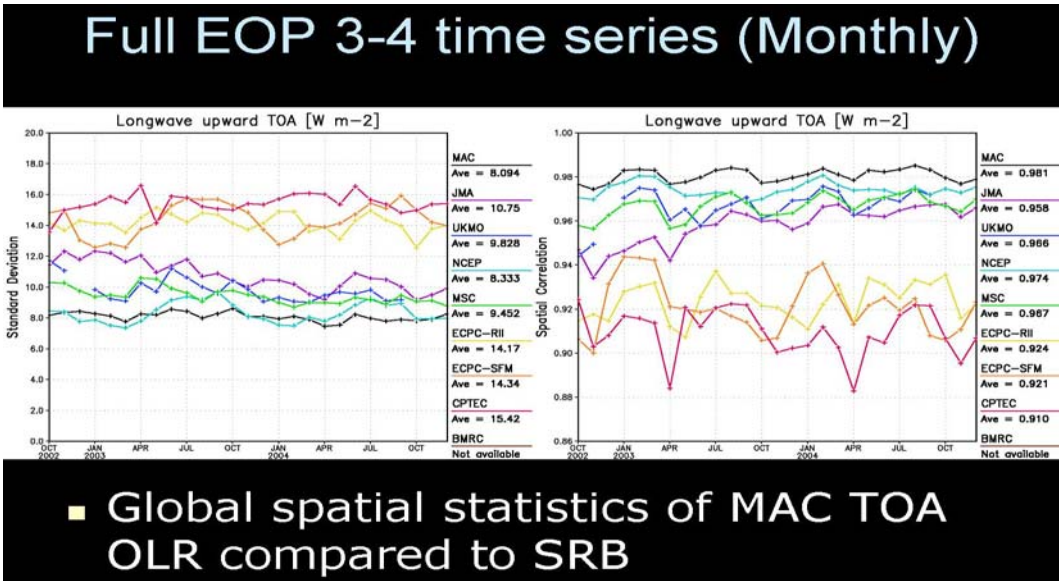


Figure 3 a, b results from MAC study

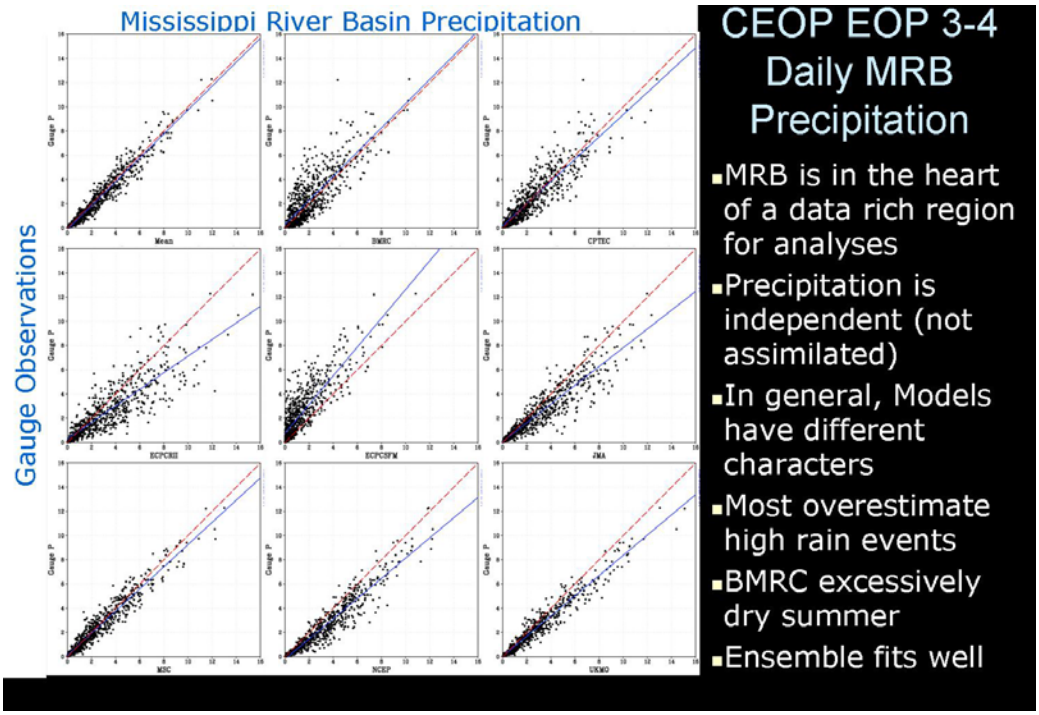


Figure 3c – Results from MAC Study

5.4.2 Global Models Future Accomplishments

Plans are for development of a MAC Version 2, that will include GMAO and ECMWF (Interim) contributions to be added in early 2009. CEOP through MAC-2, therefore, plans to continue:

(1) Providing the impetus to continue or expand the efforts tested in the CEOP Global modeling group

(2) Furthering scientific testing, not just from CEOP but also GMPP (plus CLIVAR and the broader community)

(3) Showing the value of the CEOP global datasets

(4) Achieving more and longer term commitments from NWP centers, not just data, but formatting, and documentation

(5) Enhancing the archive site to handle the reformatting of the model analyses and forecasts with input from the contributing centers.

5.4.3 Regional Models: Inter-Continental Transferability Study (ICTS) Recent Accomplishments

ICTS was set up to study the transferability of regional climate models to areas of different continental scale experiments (i.e. to different climate regimes) and to apply CEOP (satellite, reference sites, global analysis and model) and other available observational data sets to validate the energy and water cycle in regional models. The main objective of this work is to assess the influence of different driving global re-analysis.

The corrected results from the first analysis of the ICTS experiment that are stored at the CEOP model data archive at the WDCC (World Data Centre for Climate) Hamburg, Germany have been made available to the scientific community.

The ICTS participants have performed different analyses on the results of the first ICTS experiment including:

(1) Z. Kodhavala (University of Quebec) compared MOLTS data of ICTS regional model results with CEOP reference sites observations a publication is in work. The figure below shows one of the types of comparisons made with the data from the CEOP Bondville site.

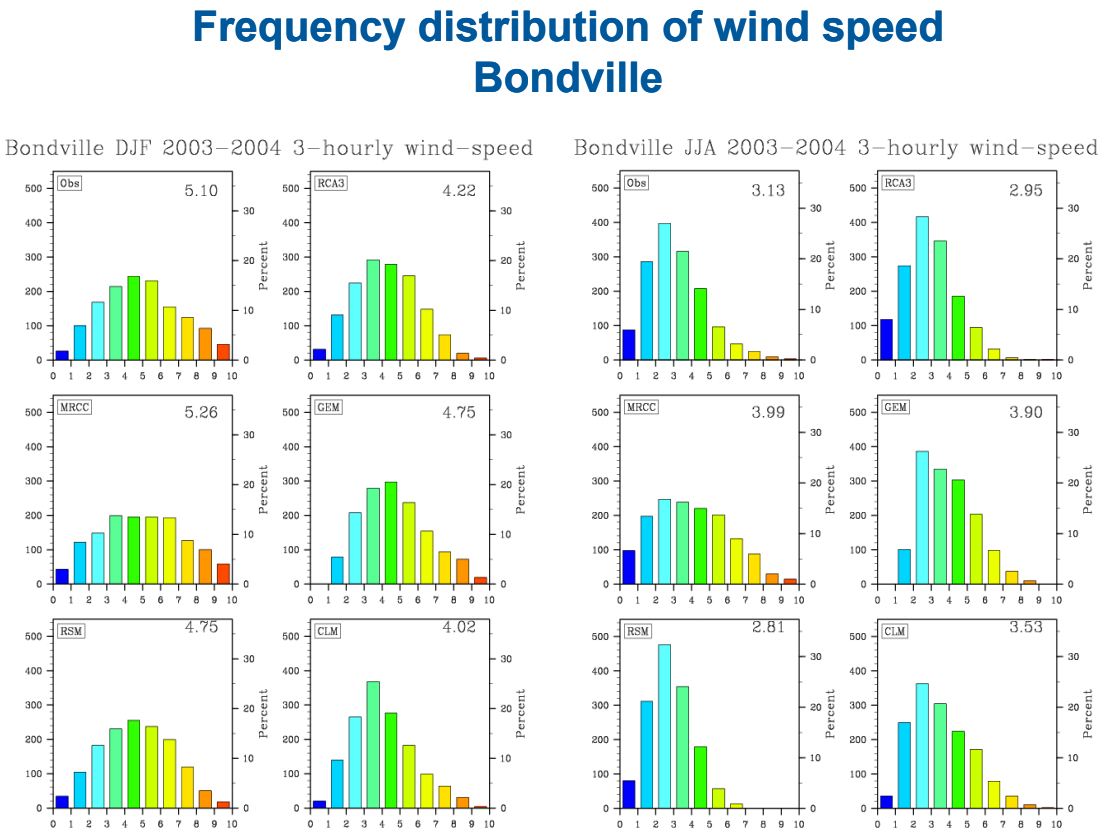


Figure 4: Comparison of ICTS results with CEOP Reference Site Data

(2) D. Paquin (Ouranos) has looked at a mini-ensemble of ICTS runs for the large Asia/Himalaya domain. In addition to the requested simulations over 7 domains, supplementary simulations with the CRCM over the GAME domain (Asia) were generated with the aim of estimating the internal variability of the model. This estimation is needed to assess how much of the inter-model variance observed in this domain can be explained simply by model internal variability (sensitivity to initial conditions), rather than model configuration differences.

(3) I. Meinke, J. Roads, and M. Kanamitsu (ECPC) compared gridded observations of the Global Precipitation Climatology Project (GPCP) and the Global Precipitation Climatology Center (GPCC), as well as CEOP reference site precipitation observations with the RSM simulated precipitation for the first half of the CEOP Enhanced Observation Period (EOP) III (October 2002 to March 2003). After estimating the uncertainty ranges of both the model and the observations, model deficiencies were obtained for almost all model domains in terms of the amount of simulated precipitation.

(4) B. Rockel and B. Geyer (GKSS) performed similar comparison as I. Meinke et al. but with the regional climate model CLM. As expected, the quality of the simulations for temperate and continental climates is similar to those over Europe. Tropical climates, however, display systematic differences with a land-sea contrast. Here, precipitation is overestimated over warm oceans and underestimated over land. Another similarity in all regions is the positive bias in precipitation occurring over high and narrow mountain ranges, which stand perpendicular to the main wind direction. In these cases, the CLM produces higher precipitation values than those given in the Global Precipitation Climatology Project (GPCP) data set. The work highlights the major role of the convection scheme in tropical regions. The study confirms the assumption that in order to gain optimal results, one standard model setup is not appropriate for all climate zones.

(5) The experiences gained during the first CEOP model simulation experiment will be a benefit to other groups that CEOP will coordinate with who are beginning to perform related types of experiments.

5.4.4 Regional Models Future Plans

The following options are being considered as possible additional simulations to be undertaken in the ICTS frameworks:

- Different boundary conditions (LBCs)
- Variable set up
- Higher resolution
- Enhanced simulation period (beyond 2004 i.e. for CEOP2, 10 years)
- Revision of output parameter list
- Additional regions
- Update with new model versions
- Additional MOLTS

In addition, further analysis of ICTS results will be undertaken. Different groups are going to concentrate on different aspects. These are e.g. investigation on the diurnal and seasonal cycle, simulation of high-time frequency (initially daily timescale) precipitation across seasons and varied climatic regime (as encompassed by the ICTS domains and CEOP data availability).

5.4.5 Land Surface Models Recent Accomplishments

(1) The CEOP LSM activity has identified, gathered and analyzed gridded global forcing data sets that are available for regional to global off-line LSM simulations. Current contributions by existing groups include contributing both MOLTS and global, gridded model output datasets.

(2) The NASA Global Land Data Assimilation System (GLDAS) project maintains a large archive of surface meteorological forcing data, land parameters, and output datasets, much of which is made publicly available. These data sets have been augmented by additional global forcing data sets (e.g. from Princeton University Land Hydrology Group, NCAR from A. Dai, the University of Tokyo, and various re-analysis land surface meteorological data sets), and regional forcing data sets from the RHPs.

(3) The CEOP land modeling activity has analyzed the consistency among the data sets to help assess the uncertainty in the global terrestrial surface meteorology and radiation fields. The goal of the land modeling activities under CEOP, then, has been 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.

(4) One approach has been 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 are also being developed since many RHP regional models are not in the LIS software package.

(5) The NASA GLDAS group has made significant progress in the areas of data assimilation, irrigation modeling, and runoff routing:

- In particular, a new forward looking approach for snow covered area data assimilation has been developed, as described by Zaitchik and Rodell (2008).
- An algorithm has been developed for incorporating MODIS derived maps of irrigation intensity into the GLDAS models in order to simulate irrigation and its effects on land surface states and fluxes. A manuscript on the subject is in preparation.
- A source-to-sink runoff routing scheme has been implemented in order to improve the ability of GLDAS to generate realistic runoff hydrographs for major river basins.

(6) The University of Tokyo LSM group has focused on improving data assimilation capabilities. They have:

- Demonstrated improved flux estimation in their LDAS-UT models over Tibet using MOLTS and AMSR-E,
- Shown improvement in heavy rainfall prediction using NCEP-GFS and AMSR-E data in their CMDAS, and
- Continued to develop data assimilation methods in a coupled land-atmosphere modeling system.

5.4.6 Land Surface Models Future Plans

During the next several years the CEOP Land Model Working Group will:

(1) Continue to implement and test new modeling and assimilation techniques.

(2) Provide the newest assimilated output datasets to the community.

(3) Perform several hydrometeorological analyses.

(4) Have a new focus on practical applications including drought monitoring and water resources planning in data-scarce regions of the world.

Secondary objectives for the future involve:

(1) Describing the individual and combined impacts of the new capabilities, including data assimilation algorithms, and new datasets in particular.

(2) Results of this research will set the course for future investigations of energy and water cycle functioning and change.

(3) Impacts will be judged using sensitivity analyses and error assessments, with an eye toward improving our understanding of the value of each data product, dataset compatibility, and the uncertainty in the assimilated fields that result.

The mechanisms for data integration in the future will be:

- Parameterization, forcing, constraint (via data assimilation), and evaluation of multiple, sophisticated LSMs, including Noah, the Community Land Model, and the Variable Infiltration Capacity model, and several versions of SiB.

- The assimilated output fields, impact assessments, and error analyses that result will support CEOP related studies and hence provide the basis for improving understanding and skill at predicting energy and water cycle phenomena.

5.4.7 Hydrologic Applications Project (HAP) Recent Accomplishments

The main activities of HAP have been to:

(1) Develop procedures for assessing current hydrologic conditions, like water availability and drought assessment, through application of GEWEX supported data products, including remotely sensed observations.

(2) Develop and test reliable, skillful hydrologic ensemble forecast procedures based on seasonal climate model forecasts.

(3) Demonstrate that the procedures can be applied at scales useful for water resources through test-bed sites and demonstration projects, especially in close collaboration with test-bed projects of the Hydrologic Ensemble Prediction Experiment (HEPEX) and the Global Water System Project (GWSP).

Also HAP has a primary role in:

(4) Fostering links between GEWEX and HEPEX, and GEWEX and GWSP, and to provide leadership to help HEPEX and GWSP contribute to the GEWEX goals.

(5) Working with related CEOP projects, like CEOP Extremes, and GEWEX-affiliated groups like the International Association of Hydrological Sciences (IAHS), including the IAHS Project for Ungauged Basins (PUB) to share demonstration project sites, supporting data sets and approaches and results to further the project goals.

(6) *Test-bed projects.*

HAP though its collaboration with HEPEX is participating in a number of test-bed projects. Two new projects were developed in 2008:

- One is in the Uruguay River basin (Brazil) where seasonal forecasts for agriculture and water management are being evaluated.
- The second new test-bed is in the United Kingdom, where downscaling procedures for seasonal forecasts will be evaluated. HAP provided Bayesian multi-model statistical downscaling software that will be evaluated in the UK study.

(7) *Hydrologic nowcasting and drought monitoring*

Based on the procedures developed for hydrologic nowcasting/forecasting, the HAP forecasting working group has developed an integrated Drought Monitoring and Prediction System (DMAPS). HAP interacted with UNESCO's International Hydrology Programme (IHP) to apply the system to develop a "Africa Drought Monitoring" (ADM) system. The ADM builds on NASA-supported science and satellite data products that are also central to GEWEX and to HAP's goal of providing GEWEX data and science products to water resources managers and related users.

(8) *Interaction with water management sector*

One HAP/HEPEX test-bed project is led by a private sector consulting firm (HYDROCOMP) that is applying hydrologic ensemble forecasts at all time scales for major water resources clients in the western US.

(9) *Collaboration with the Hydrologic Ensemble Prediction Experiment (HEPEX)*

GEWEX, through HAP, was instrumental in organizing the Hydrologic Ensemble Prediction Experiment (HEPEX) and in helping HEPEX to develop activities in support of the

GEWEX hydrologic applications objective. Accordingly, HAP and HEPEX are collaborating on the execution of a wide range of test-bed projects and related workshops.

(10) *Collaboration with GEO/GEOSS*.
HAP with HEPEX is collaborating to contribute to GEO/GEOSS through GEO water activity WA-06-02.

5.4.8 Hydrologic Applications Project (HAP) Future Plans

(1) (2008): HAP and HEPEX will co-sponsor (with several other organizations) a workshop on Post-Processing and Downscaling of Atmospheric Ensemble Forecasts for Hydrologic Applications. This will be hosted by Meteo-France in Toulouse, June 15-19, 2009.

(2) (2008-2009): HAP and HEPEX will develop a test-bed project on Ensemble Representations of Rainfall Observation and Analysis Uncertainty, with a related workshop in the 2009 timeframe.

(3) (2010 and beyond):

- HAP and HEPEX expect to sponsor a Hydrologic Ensemble Forecast User's workshop in 2010 where example hydrologic ensemble forecast applications and potential applications can be discussed with the user community.
- Complete plans to collaborate with WGHP on applying GEWEX science and data sets to the international Prediction of Ungauged Basins (PUB) and hydrologic model calibration under MOPEX.
- HAP seasonal forecasting working group members will continue to participate in the GMPP GLACE-2 experiment whose goal is to assess the role of using soil moisture initial conditions to improve seasonal forecasting.
- HAP will continue to try and establish test-beds in the RHP regions, but needs the RHP coordinators to help identify collaborators. CEOP management needs top help encourage the RHP coordinators to identify these testbeds so the goals of GEWEX can be met.
- HAP will continue its activity to generate a global (land) hydrologic re-forecasts (hindcasts) based on NOAA and DEMETER/EuroSIP seasonal forecasts. RHPs should identify testbed activities, and groups to evaluate the hydrologic ensemble forecasts. HAP will expand its collaboration with HEPEX.
- HAP will try to work with other GEWEX activities and weather centers to obtain real-time data that will allow for such estimation.
- Will contribute to GEWEX objectives through "…Improving the predictive capability for key water and energy cycle variables and determine the geographical and seasonal characteristics over land areas" and "…demonstrating the value of GEWEX research" to operational hydrometeorological services.

5.5 CEOP Data Management

The CEOP Data Management Group has acted on behalf of CEOP to successfully manage a diverse set of data types and products and to organize and stage them for use by the CEOP community and the broader GEWEX and WCRP climate research communities as well. An important milestone was achieved by this group at the time of start of the Coordinated Enhanced Observing Period, which was 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. This effort has carried over to through the transition to the current CEOP structure.

5.5.1 CEOP Data Management Recent Accomplishments

Most recently the CEOP Data Management Group has accomplished a few key results that include:
(1) Provided access to CEOP data through individual data archive centers (in-situ, model output, and satellite) as well as through distributed and centralized data interfaces.

(2) Coordinated CEOP data management activities with other GEWEX Panels, WCRP Programmes, and other related projects.

(3) Developed and maintained the CEOP Data and Metadata archives.

(4) Refined plans for long-term CEOP/RHP data archival.

More specifically progress has been made in the overall management of CEOP data and in handling of each of the main CEOP data types, in-situ, model and satellite.

Overview and In-situ

(1) The CEOP Data Management web page was revised (August 2008) and is available directly at: http://www.eol.ucar.edu/projects/ceop/dm/ with improved links to all CEOP RHP (and related data provider) data archives, Reference Site data/metadata, data policies, information regarding NWP Models, Satellite data access and other pertinent data links. This new web page is linked to the CEOP home page.

(2) A dynamic matrix table of the inventory and metadata of 'CEOP' Reference Sites has been provided directly at: http://www.eol.ucar.edu/projects/ceop/dm/documents/rsite/. It summarizes specific information and metadata about the individual Reference Sites.

(3) The DMWG continued to work on the 'CEOP' EOP-3 and 4 "composite" Reference Site dataset. As data/ metadata were submitted, NCAR/EOL performed consistency checks and applied a final quality assurance review to the final data. Any resulting problems or issues were subsequently solved with the respective data providers. Completed datasets were then posted to the on-line CEOP archive for distribution to the scientific community located at; http://data.eol.ucar.edu/master_list/?project=CEOP/EOP-3/4 Completed on-line data are available from 28 of these Reference Sites (including data from 12 sites which contain full annual cycles for both EOP 3 and 4). Data from 4 of these Reference Sites were received for the period 2005-2006 during the transition to the Coordinated Energy and water-cycle Project. These data are being processed and will be added to the archive.

(4) NCAR/EOL has been coordinating with the CEOP Distributed Data Integration System http://jaxa.ceos.org/wtf_ceop/ and has established and maintains a DODS (OpenDAP) in-situ server for the interactive distribution of Reference Site data.

(5) A Soils and Land cover questionnaire (http://www.eol.ucar.edu/cgi-bin/ceop/ceop_veg) for the CEOP Reference Sites was developed and maintained to facilitate the metadata needed to perform model/satellite data intercomparisons and improved site data analysis.

(6) The CEOP DMWG has been represented on the International Group on Earth Observations (GEO) Data and Architecture Committee.

(7) The CEOP Data Management Group has coordinated the addition of CEOP Hydrology Reference Basins to the CEOP database. Data from 3 of these Reference Site Basins are available from the CEOP archive in "native" formats. The CEOP DM Group has also continued to coordinate with the Asian Water Cycle Initiative (AWCI).

(8) Discussions continued with the CLIVAR and CLIC programs to keep data activities better coordinated. A frozen precipitation questionnaire was developed to obtain needed metadata for the CEOP existing and planned Reference Sites located in the cryosphere. Responses are located at: http://www.eol.ucar.edu/projects/ceop/dm/questionnaires/webresponse/snow/

Model Data

(9) The CEOP Model Output Center (located at the World Climate Data Center, Max Planck Institute for Meteorology, Germany) has maintained the 'CEOP' (Phase 1) archives and Model Output Gateway at http://www.mad.zmaw.de/projects-at-md/ceop/ . To date, 5.6 TB of 'CEOP' data have been submitted and are available via internet. Metadata from these 11 Numerical Weather Prediction (NWP) Centers continues to be updated and is available at: http://www.eol.ucar.edu/projects/ceop/dm/model/model_table.html.

Satellite Data

(10) The CEOP Satellite Data Center (located at the University of Tokyo, Japan) has added EOP3/4 satellite data to its archives. A new Satellite Data Gateway web page was developed and is available at: http://monsoon.t.u-tokyo.ac.jp/ceop2/satellite/ . This web page provides current data policy, format, inventory, and access information. Data access is also available through the CEOP Centralized Data Integration System at: http://monsoon.t.u-tokyo.ac.jp/ceop-dc/ceop-dc_top.htm.

5.5.2 CEOP Data Management Future Plans

In the future, a number of efforts will continue to be undertaken by the CEOP Data Management Working Group (DMWG) that relate to activities already underway as well as starting new work particularly as related to the handling of data from and to the CEOP RHP's which were merged into the Coordinated Enhanced Observing Period.

(1) The DMWG will continue the compilation of CEOP Reference Site data/metadata and begin data collection for Reference Sites (including new ones identified in the CEOP SIP). This information will be maintained on the CEOP data management web page(s).

(2) More interaction and coordination between the RHPs and the Reference Site Managers will take place in order to expedite data and metadata submission.

(3) The DMWG work to ensure that updated RHP information on data policy, data inventory, data access, and data contacts, is maintained.

(4) The RHPs will be contacted to provide information on what additional regional data sets and products might be useful as "CEOP datasets" as well as continuing long-term archival.

(5) Both the Model Output and Satellite Data Centers will maintain and add new data to their archives.

(6) NCAR/EOL was funded by the NOAA Climate Projects Office (CPO) to continue work on compilation of the CEOP "composite" Reference Site data set through FY 2009. This work includes incorporating common parameters, format, and temporal resolution. Also as a component of this grant, NCAR/EOL will continue to reformat existing CEOP Reference Site data to improve the efficiency of its existing DODS Server. The DMWG will continue to work with the RHPs and individual reference sites to coordinate the data submission, quality assurance, and posting of data to the scientific community.

In this context, each member of the DMWG was requested to provide a summary of the plans for final archive of the RHP data. See the CEOP Data Management web page

http://www.eol.ucar.edu/projects/ceop/dm/ for direct links to the respective RHP (and associated data provider) web pages. The following is a brief updated summary by RHP:

AMMA/CATCH - Plans and issues with the data policy with CEOP are being formulated with the International AMMA Project Office, Paris. The full archive will be maintained through the AMMA Data User System.
BALTEX – The operational data are already archived and available in long-term European Data Centres and will be available through these respective Data Centers through BALTEX policies. The individual BALTEX PI data/products are not included but arrangements are being coordinated with the BALTEX Secretariat and are currently available from the respective investigators.
GAME/MAHASRI – Distributed data will be archived and available at respective institutions for 10 years (an additional 10 year extension is being discussed). Most data are also available on CD/DVD with on-line "image" versions. The MAHASARI Data are now becoming available on-line and long-term data archival plans are underway.
GCIP/GAPP/CPPA – The GCIP data are archived at NCDC and NCAR (with subsets at DOE/ARM). GAPP data are archived at NCAR and ARM. Both project datasets will be available from NCAR/EOL project archives and are also linked through the NCAR Community Data Portal (CDP).
LBA – The Brazil Ministry of Science and Technology has agreed to archive the data for 20 years (probably at CPTEC). Data will be available through the LBA Data Information System (DIS).
LPB – Data archive and access plans are being formulated. It is envisioned that a shared or mirrored archives will be established between CPTEC and NCAR/EOL.
MAGS – The final data archive is located at the University of Saskatchewan and selected datasets will be available on CD/DVD.
MDB – Data archive and access plans are being formulated.
NESSPI – Data plans are being formulated. A distributed archive between long-term World Data Centers is expected.
GPCC – The gridded/point data are all archived at GPCC. GPCP data are archived and will be available at long-term archives at NASA/GSFC and NOAA/NCDC.
GRDC – All data are archived and will be available at GRDC.