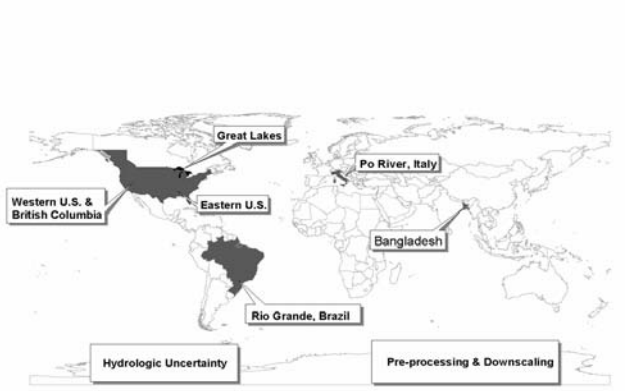
Hydrologic Ensemble Prediction Experiment (HEPEX)

Reporting Period: October, 2005 – September, 2006
Project Starting Date: March 2004
URL: http://hydis8.eng.uci.edu/hepex/
Chair(s) John Schaake and Roberto Buizza

Overview:
Objectives:
Develop and test procedures to produce reliable hydrological ensemble forecasts, and to demonstrate their utility in decision making related to the water, environmental and emergency management sectors.

Status:
Operated eight test-bed projects. Annual reports are on the HEPEX web site. A HEPEX Test-Bed is a setting for HEPEX-community experiments. A test-bed could be a single basin (and its sub-basins), a region containing multiple basins, or possibly a global collection of basins that facilitate experiments addressing questions over a range of scales and climates. Regardless of geographical domain, test-beds focus on one or more clearly defined HEPEX scientific topic, have the potential to develop data resources needed for community experiments to address the questions, and are expected to include active user participation.



Locations of HEPEX test bed projects. The test-beds "Hydrological Uncertainty" and "Preprocessing and Downscaling" have a global scope and scientifically cross-cut the other test beds.

Proposals for eight test bed projects were presented at the 2nd HEPEX workshop, July 2005. Six of them represent a variety of basins or sub-basins with different terrain, different climatologies, different hydrological issues, different data densities, and differences in the amount of regulation of stream flows in the basin. The remaining two test beds are focused on development and intercomparison of procedures that cross-cut the other six test beds. The figure above shows the global distribution of the test beds.

These test beds and the outstanding research objectives for each test beds are as follows:

- **T1 Great Lakes, Canada/US** - To demonstrate the importance of detailed atmospheric and hydrologic modelling for medium-range atmospheric and hydrologic forecasting on large basins.
- **T2 Bangladesh** - To provide operational real-time forecasts of river discharge into Bangladesh at daily, weekly, monthly, and seasonal time-scales.
- **T3 Rio Grande** - To explore the use of ensembles produced by the CPTEC model of global climate, the use of forecasts produced by RAMS for lead times extending up to a month and longer, and the use of short-term rainfall forecast from the operational ETA model of CPTEC.
- **T4 Po Basin, Italy** - To test simplistic routines for bias removal in an area, such as Northern Italy that is dominated by important orography (Alps), and to test methods for flood forecasting based on threshold exceedances.

- **T5 Western Basins, US/B.C. Canada** - To develop hydrologic ensemble forecasting techniques that are particular to the orographically complex, snowmelt-driven basins of the Western US and British Columbia with a focus on monthly to seasonal lead-times.
- **T6 Southeast Basins (US)** - To address the following HEPEX science questions: How do we generate skillful and reliable meteorological forcing for seasonal hydrologic forecasting? How do we generate the hydrologic ensembles that reflect the total uncertainties? How can climate information, such as climate model forecasts or teleconnections, be used reliably in seasonal hydrologic forecasting? How do we validate hydrologic ensembles for extreme events?
- **T7 Statistical downscaling** - To identify the space-time scales for which forecast skill is present for different variables and develop methods to extract and combine information at different space-time scales; to identify the GFS output variables that can be used to provide sub-grid information for use in a statistical model to replicate precipitation processes; to identify the sample size required to reliably forecast precipitation, temperature, and streamflow for different thresholds.
- **T8 Hydrological uncertainties** - To investigate the relative merit of the different sources of prediction uncertainties including: model inputs, model parameters, and model structure; leading to uncertainties in model states and fluxes. To address questions such as: what are the advantages and limitations of different methods for characterizing and reducing uncertainty in hydrologic model simulations?

The HEPEX Strategic Implementation Plan has been completed. (See HEPEX web site). HEPEX Supported shared data sets that were developed by some of the test-bed projects (See test-bed annual reports on HEPEX web site). Several articles about HEPEX were submitted or published (see below). A special issue of the HESSD on ensemble prediction is being published. HEPEX has been accepted as an activity of GEOSS (WA-06-02)

New directions (longer term vision):

- Several of the test-bed projects will place increased emphasis on long range ensemble prediction and multi-model applications.
- Increasing user participation as capability to produce reliable hydrological ensemble forecasts is demonstrated.
- Close collaboration with HAP
- Assessment of possible regional improvements in forecast skill resulting from including improved representation of land surface forcing in weather and climate models.

Future: Next year foreseen activities:

- Continued operation of existing test-bed projects
- Possible development of new test-bed projects – with assistance of HAP (to be discussed at 3rd HEPEX workshop)
- Plans to apply THORPEX/TIGGEE ensemble products should begin to emerge in the next year.
- The statistical downscaling test-bed will begin working with other test-bed projects to try to develop an integrated Community Ensemble PreProcessor (CEPP).

Key results:

- Atmospheric forecasts of hydrologic forcing variables (e.g. precipitation, temperature, etc.) are highly scale dependent in space and time. Because hydrologic systems integrate and process these scale dependent inputs over a wide range of space and time scales, it is essential that this space-time scale dependency be represented in ensemble predictions of hydrologic forcing variables. This means that application of long-range (intra seasonal to inter annual) ensemble forecasts must also represent uncertainty beginning at the computational space and time scales at which the models operate and at all intermediate space-time scales over the forecast space-time domain.
- Ensemble re-forecasts are required for a period of many years (i.e. 25+) to: (i) establish the credibility of hydrologic ensemble forecasts for water resource users, (ii) estimate parameters of Ensemble PreProccesing (EPP) algorithms and (iii) estimate parameters of hydrologic ensemble postprocessing algorithms that will be required to remove hydrologic biases.

- Representation of hydrologic uncertainty is at an embryonic stage. Hydrologists are just beginning to think about how new ways to represent the effects of imperfect hydrologic models on ensemble prediction.

Issues and Recommendations:

- Relationships between HEPEX and HAP are vital to both GEWEX and HEPEX. These need to be articulated and a shared understanding of them developed among participants in both GEWEX and HEPEX.
- Potential relationships between HEPEX and other parts of GEWEX (e.g. CEOP and GLASS) should be considered.

Contributions to WCRP strategic framework (including overall strategy on observation, assimilation and modelling, and WCRP cross-cutting task teams):

HEPEX is demonstrating how to use results being produced by WCRP for hydrological forecasting and for water resource applications. It also is in a position to provide diagnostic feed back that should have some influence on future WCRP activities.

Contributions to society and to WCRP/GEWEX visibility:

- Ensemble forecasts are beginning to be made by operational hydrological services using procedures being developed by participants in HEPEX test-bed projects.
- Ensemble forecasts are beginning to be used by water resource agencies that are participating in HEPEX test-bed projects.
- A GOOGLE search on "hydrologic ensemble prediction" will produce many pages of focused references to research and applications, including references to HEPEX and GEWEX.

List of key publications:

Schaake, J., K. Franz, A.Bradley and R. Buizza, 2006: The Hydrologic Enemble Prediction Experiment (HEPEX). *Hydrology and Earth System Science, hessd-2006-0095.*

Schaake, J. C., T. M. Hamill, R. Buizza and M. Clark, 2006: HEPEX, the Hydrological Enemble Prediction Experiment. Submitted for publication in *Bul. Amer. Meteo. Soc.*

Franz, K., N. Ajami, J. Schaake, and R. Buizza, 2005: Hydrologic Ensemble Prediction Experiment Focuses on Reliable Forecasts, Eos, Vol. 86, No. 25

Schaake, J., K. Franz, A. Bradley, and R. Buizza, 2005: Hydrologic Ensemble Prediction Experiment, GEWEX Newsletter, Vol 15, No. 4, p10.

List of meetings, workshops:

- ACTIV workshop, 2005, Tromso, Norway, Keynote presentation on ensemble prediction
- Fall AGU, 2005, session on ensemble prediction
- AMS Annual Meeting, 2006, session on ensemble prediction
- Hydrology Commission for the Rhine River workshop, 2006- Keynote presentation on ensemble prediction
- EGU meeting, 2006, session on ensemble prediction
- COST731 workshop, 2006-Keynote presentation on ensemble prediction

Planned meetings, workshops:

- 3rd HEPEX Workshop, Stresa Italy, June, 2007.
- IAHS meeting, 2007, Symposium on Uncertainty
- Proposed AGU Chapman Conference on ensemble prediction, 2007, Brazil
- Waterpower Conference, 2007, Chattanooga, Tennessee. Sessions on long range ensemble prediction and water resource applications
- Ensemble forecast papers and sessions to be included in AGU Fall 2006, AMS 2007 and EGU 2007 meetings

List of members

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3. Collaborating Organizations

GEWEX
WMO-HWR
IAHS
WWRP-THORPEX/TIGGEE
GEOSS