Proposal for an international Hydrological Ensemble Prediction Experiment (HEPEX)

Ensemble forecast techniques are beginning to be used for hydrological prediction by operational hydrological services throughout the world. These techniques are attractive because they allow effects of a wide range of sources of uncertainty on hydrological forecasts to be accounted for. Forecasting should not only offer an estimate of the most probable future state of a system, but also provide an estimate of the range of possible outcomes. Indeed, users are often more concerned with having a quantitative estimate of the probability that catastrophic effects may occur, than with knowing the most probable future state. Not only does ensemble prediction in hydrology offer a general approach to probabilistic prediction; it offers an approach to improve hydrological forecast accuracy as well.

The main objective of HEPEX is to bring the international hydrological community together with the meteorological community to demonstrate how to produce reliable "engineering quality" hydrological ensemble forecasts that can be used with confidence to assist the water resources sector to make decisions that have important consequences for the economy and for public health and safety. Representatives of operational hydrological services and operational water resources agencies are expected to participate in helping to define and execute the project. This objective can be achieved if the meteorological, hydrological and water resources communities understand the key challenges they face and work together both to couple currently available forecasts tools and to improve the current quality of available systems.

Many scientific questions need to be addressed for operational hydrological services to use these techniques to their full potential. Examples of these questions include: What are the properties of weather and climate forecasts? How can weather and climate information, including ensemble forecasts, be used reliably? How can the space and time scale properties of weather and climate forcing together with space and time scale properties of hydrological systems be best integrated in a hydrological ensemble prediction system? How does the uncertainty in weather forecasts translate into hydrological uncertainty? How can uncertainties in hydrological models, model parameters and hydrological initial conditions be represented in hydrological ensemble prediction? How do long-range Ocean-Atmosphere phenomena (i.e. El Niño) affect short- medium- and long-range hydrological forecasting? What is the relative role of weather and climate forecasts vs initial hydrological conditions in affecting the skill of hydrological forecasts? How can hydrological ensemble forecasts be verified, and what can be done to gain confidence that a given forecast system is reliable? What is the role of a human forecaster? What interface is needed for forecasters to control the operation of a hydrological ensemble forecast system? What is the experience of different groups throughout the world with ensemble hydrological prediction? What are the key science questions that need to be addressed by the HEPEX science plan? These questions need to be expanded and, in some cases, clarified. To address these, we need to collect data in lots of areas and work together.

To address these, we need to collect data in lots of areas and work together. Therefore, it is proposed to address these kinds of questions through an international Hydrological Ensemble Prediction Experiment (HEPEX) that would organize a set of cooperative activities that could include inter-comparison experiments as well as scientific workshops and meetings. A goal of the project will be to develop a pilot capability for hydrological ensemble prediction that could be used by hydrological services throughout the world. The results would be demonstrated by application by operational hydrological services and water resources agencies, including the U.S. National Weather Service Advanced Hydrologic Prediction Services (AHPS).

To initiate the project a workshop will be held at the European Centre for Medium Range Weather Forecasting (ECMWF) to define the objectives and outline the science agenda. Although this project will be concerned with all aspects of ensemble prediction, it will be particularly concerned with approaches to prescribe future ensemble forcing (weather and climate) for hydrological models. It will be concerned with hydrological ensemble prediction for all lead time ranging from flash-flood to annual. The workshop will address the following four key questions:

- why? why is an ensemble approach to hydrological prediction important to provide services to users?
- what? what needs to be done to produce accurate and reliable hydrological ensemble forecasts?
- how? how can meteo- and hydro-logical ensemble systems be developed and coupled?
- who? who is going to do what?

The workshop will also provide an opportunity for meteorologists to get a better understanding of what hydrologists need and for hydrologists to understand what meteorologists are doing to provide better information to hydrologists.

The agenda for the workshop will include a number of invited presentations to provide the basis for discussion as well as structured discussion sessions to address the key questions (see paragraph above). Limited space for contributed poster presentations will be available.

Different international scientific activities and organizations have a strong interest in the subject of hydrological ensemble prediction. These include the GEWEX (Global Energy and Water Cycle Experiment) that would participate in the project through its GHP's (GEWEX Hydrometeorology Panel) WRAP (Water Resources Application Project). The goal of WRAP is to help GEWEX to meet a goal of demonstrating a capability to apply the results of its research in support of the water resources sector. The IAHS (International Association of Hydrological Sciences) has begun a new activity called (PUB) Prediction for Ungaged Basins with a goal to account for and reduce uncertainty in hydrological predictions for ungaged basins. Several of the PUB working groups could contribute to HEPEX. And HEPEX could provide a framework for some of the PUB activities. Linkages between HEPEX and operational hydrological and water resources organizations could be facilitated by the WMO Hydrology and Water Resources (WMO/HWR) program. WMO/HWR, representing operational hydrological

services internationally, could help to define the hydrological requirements (from a user perspective) for what HEPEX might produce, participate in the execution of the project and assist in evaluating the results. The workshop will consider opportunities for HEPEX to benefit these organisations/groups/projects. This would include helping them to focus onto some very specific questions about the uncertainty in hydrological forecasting, and help them realize and to support a valuable product (a HEPEX) that does not exist and that is needed.

HEPEX does not have a dedicated source of funding. HEPEX activities will be planned and carried out by scientists that already have appropriate funding or who might seek funding for their efforts. The HEPEX science plan (that will be developed) will define the scientific agenda for HEPEX, give legitimacy to the need for general areas of research, stimulate scientists to undertake the research, avoid duplication of efforts, stimulate international research cooperation and stimulate research funding agencies to support the work needed for HEPEX to succeed. It also is expected that scientists participating in HEPEX will organize special sessions at scientific meetings and publish their results in peer-reviewed scientific journals including occasional special issues.

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