A Global Flood and drought Forecasting system, FEWS-World

Applicants:
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Discipline: Hydrology – Global forecasting
Kerndomein: 12.1
Business units: Deltares-Zoetwater systemen; Deltares- Ondergrondse systemen

Summary
The research aims to develop a global flood and drought forecasting system based on existing hydrological models; to evaluate the predictive quality of the system in different parts of the world and to assess the value of the system for mitigation of water-related disasters risks. The value of the system is expected to be significantly high for populations in low-income countries of the world.
To carry out the work we propose a PhD at the Utrecht University, to be supported by Deltares Staff. Preferably the PhD has a position at Deltares. For 2007 the request is 75 K-EURO. The complete project will run until 2011 where the total costs will be approximately 300 K-EURO.

State of the Art

The hydrological model
At the moment there exist a number of hydrological models that act on a global scale. These include the WaterGAP model, developed for the purpose of impact assessment of global climate change (Alcamo et al., 2000); the Water Balance Model (WBM) (Vorosmarty, 1989) and the LaDWorld model (Milly et al., 2002). The model PCR-GLBWB, that has recently been developed at Utrecht University Faculty of Geosciences is a global hydrological model with a daily time-step, and a 0.5 x 0.5 degrees resolution (approximately 50 km at the equator) (Van Beek and Bierkens, 2005). It is based on the computer language PC-Raster, which has also been developed at Utrecht University for the construction of spatio-temporal environmental models. PCR-GLBWB is an extension of the HBV model (Bergstrom, 1992), which is originally a lumped model, but recoded into PC-Raster script language and applied on a pixel by pixel basis.

System Engineering: Delft-FEWS
There has been a remarkable increase in the availability of on-line meteorological, hydrological and earth observation data. This has resulted in a focus on data assimilation within flood and drought forecasting. The challenge for developing an effective forecasting system is found in the integration of large data sets and existing model capacities. The modeling environment Delft-FEWS (Flood Early Warning System) by WL-Delft Hydraulics is specially developed for handling various modeling codes, several data sources and different data formats in a real-time mode.

Prototype FEWS-World
Previous R&D has resulted in a running global hydrological modeling system. The current system uses gridded global weather data, on a daily time step. The model parameter values are based on information on land use type, soil type, topography, etc. Many of the required data sets are already available at the Utrecht University, due to the development of the global hydrological model PCR-GLBWB.

System Assessment: Quality and Value
Modern assessment of forecasting systems address both the *quality* and the *value* of the system. In terms of the proposed research the quality of the system is its ability in predicting discharge on a global scale. The value of the system is its usefulness for the purpose of mitigation of flood and drought damage.

Research question(s)

1. How good is the existing model capability in generating accurate flood and drought early warning? Are there regions where model performance is better than others; and if yes, what are the reasons for this?
2. What is the required level of accuracy of discharge predictions for flood and drought forecasting? What is the required lead-time for early warning? How do these differ from one river basin to another; and why?
3. How useful is the hydrological modeling system for the purpose of mitigation of water-related disasters in various regions of the world?
4. Which sources of earth observation data besides the regular meteorological data sources can substantially improve results of the hydrological simulations? How can this additional data be incorporated in the forecasting system?

Method/Approach

The research plan follows a stepwise approach:

1. Validating the model results:

   The model will be run for a longer historical period using ERA40 weather data. This weill need slight adaptations to the FEWS environment. The results will be compared with observed data that is collected for several large river basins of the world. Usually hydrological modeling skill is judged on the basis of comparison of simulated discharges with those measured at gauging stations along a river. During the proposed research, additional types of objective functions other than those normally used in hydrology will be developed and applied.

   The second step answers the first research question and leads to a measure of the predictive quality of the system.

2. Evaluating the modeling system:

   The value of a modeling system can vary according to the purpose for which the model results are to be used. Since the purpose of the proposed system is mitigation of flood and drought risks, the system should be able to produce a measure of the magnitude of a wet or dry event, rather than an exact discharge. The timing and and order of magnitude of the predicted floods and droughts should be sufficient to determine a response. A limited number of drainage basins with different climatological, cultural and economic circumstances will be studied in detail. The actual choice will be made during the project, but possible basins are those of the Nile, the Mississipi, the Congo, the Ganges-Bramaputra and one of the larger Siberian rivers (OB, Yenesay, Lena).

   The third step answers the second and third research questions and leads to a measure of the value of the system for the mitigation of flood and drought risks in various regions of the world.

3. Exploring the possibilities to improve the system by integrating additional information:

   Additional sources of data, other than regular meteorological data will be explored. Promising sources, which may substantially improve the results of hydrological simulations, typically provide space born near real-time information. These include the remotely sensed soil moisture information derived from the AMSR-E sensor (de Jeu, 2003), which can be used to improve the rainfall distribution. A second source is the TOPEX/Poseidon satellite, which provides water level data for large lakes. A third source is the MODIS satellite which provides frequent information on snow cover. MODIS data can also be used to estimate evaporation using the Surface Energy Balance System (SEBS) algorithm (Su, 2002). Other data sources will be searched during the project as the accessibility of data is growing rapidly. These additional data will be used to update the model state in order to evaluate their potential to improve model value and quality.

   The fourth step answers the fourth research question; and leads to an evaluation of the improvement brought to the system by using additional data sources.

4. Transferring the simulation system into a forecasting system:

   A first version of the Global model has been developed in 2007. This global hydrological modeling system that has been described so far is currently evaluated in a simulation (off-line) mode. It is the purpose to transfer the current model to the internet, to be accessible for selected users. During the research the model will be regularly updated based on the findings.

   The forth step leads to a prototype global hydrological forecasting system that provides flood and drought early warning for large river basins of the world.

Relevance for science, technology or society
The research is directly relevant for populations threatened by hydrological extreme events. Floods and droughts claim more and more lives and cause increasingly higher economic damage all over the world. Low-income countries suffer most from the adverse effects of floods and droughts, due to lack of early warning systems. The proposed global hydrological forecasting system will provide information that can be used for the mitigation of water-related disaster risk in the data and model-poor parts of the world. Distribution of the results of the forecasts on the internet will be of great value for governments in these areas.

Relevance for Deltares
Since Deltares is aiming to become a leading institute in the world water science it is also of national importance to contribute to global efforts in the mitigation of water-related disasters. Running such a system on the Deltares servers will draw much attention to the institute by many parties outside the Netherlands. Although it is already possible to run a prototype the system's value will significantly increase when validated and described in the scientific literature.

Organisation
In proposal we assume a PhD at the University Utrecht to be supported by Deltares Staff

Finances

	2008	2009	2010	2011	Totals
PhD	40	42	44	46	172
Rens van Beek (UU)	0	0	0	0	0
Marc Bierkens (TNO-B&O)	10	10	10	10	40
Jaap Kwadijk (WL-ZWS)	10	10	10	10	40
Support FEWS-Team	15	20	15	5	55
	75	82	79	71	307