THE POTENTIAL OF THE DELFT-FEWS FLOOD FORECASTING PLATFORM FOR APPLICATION IN THE MEKONG BASIN

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ABSTRACT

The paper provides an overview of the further development of Delft-FEWS and its potential for application in the Mekong Basin. This system has been designed as a generic flood forecasting platform with, among others, applications to the Rhine and Po river catchments and to the European scale flood pre-warning system installed at the Joint Research Centre, Italy to alert national and regional flood forecasting authorities with a lead time of up to 10 days. Contrary to the most common approach of building a flood forecasting system around a specific model, Delft-FEWS provides a platform for data handling and is open to connect a wide range of monitored and forecasted weather inputs on the one side and of hydrological and hydraulic flood routing models on the other side. It has been equipped with generic tools providing a variety of data handling tasks, such as data validation, interpolation, aggregation and error correction in forecasts, including a variety of visualisation and forecast dissemination options. The paper concludes with a description of a number of specific advantages that the use Delft-FEWS as a platform for flood forecasting would provide to MRCS, in particular its open architecture.

I. INTRODUCTION

Recent large floods in Europe, such as those that occurred in the Meuse and Rhine basins in 1993 and 1995, over large areas of the UK in 1998 and 2000, in the Elbe Basin in summer 2002 and in Switzerland, Austria and Romania in August 2005, have increased investments in research, development and upgrading of flood forecasting systems at the scale of medium and large river basins.

One of the initiatives in Europe has been the development of the European Flood Forecasting System (EFFS), based upon WL | Delft Hydraulics' Delft-FEWS flood forecasting platform. Its development took place over the period 2000–2003 with the objective of providing a flood forecasting platform that could be applied at European scale. The system was developed by a consortium of 19 European research institutes, universities and state agencies, with WL | Delft Hydraulics as a leading partner (Gouweleeuw et al., 2004).

In the past, most flood forecasting systems have been built around the application of hydrological and/or hydraulic routing models. Contrary to this, EFFS has been developed as a data management platform. On the one side, this platform is open to various data sources supplying measured or forecasted weather state variables, such as precipitation and temperature. On the other side the platform enables the generic coupling of a variety of hydrological/hydraulic flood routing models (Fig. 1). The data management platform of the EFFS has been equipped with generic tools providing a variety of data handling tasks, such as data validation, interpolation, aggregation and error correction in forecasts, including a variety of visualisation and forecast dissemination options.

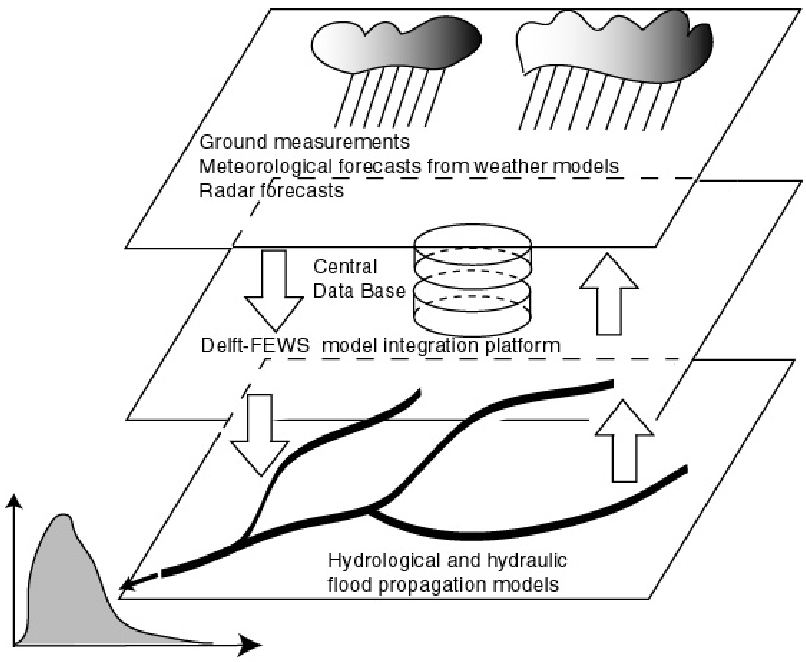

Figure 1 The Delft-FEWS open flood forecasting platform

Within the EU project a number of pilot applications were developed, such as the river Rhine and Po forecasting systems and the European system for medium-term flood forecasting. The EFFS, as delivered in 2003, is driven by German Weather Service (Deutscher Wetterdienst-DWD), Danish Meteorological Institute (DMI) and the European Centre for Medium-Range Weather Forecasts (ECMWF) deterministic and ensemble predictions (Buizza and Hollingsworth, 2002).

For the River Rhine, EFFS provided a flood forecasting pilot, made operational at the forecasting centre of the Ministry of Transport, Public Works and Water Management in The Netherlands at Lelystad. It made use of the DWD and ECMWF weather model data and provided flood routing through the HBV (Bergström, 1995) precipitation-runoff model and the SOBEK hydrodynamic river routing model. The EFFS River Po flood forecasting research pilot also made use of the DWD and ECMWF weather model data. Precipitation-runoff modelling is provided through the Topkapi model (Liu and Todini, 2002) while river routing was simulated by a model based upon Mike11.

Another version of EFFS was installed as a pre-operational version for medium-term flood forecasting at the Joint Research Centre (JRC) of the European Commission in Ispra, Italy. It provided flood pre-warnings to national and regional flood forecasting authorities with a lead time of up to 10 days. It made use primarily of the ECMWF weather model results, while the hydrological and channel routing components were provided by the distributed continental-scale modelling system LISFLOOD (De Roo et al., 2000). Computations were performed for the entire area of Europe at a spatial resolution of 5 x 5 km, at hourly time-steps.

II. THE FURTHER DEVELOPMENT OF EFFS INTO AN IMPROVED DELFT-FEWS

Following the completion of the EFFS in 2003, further developments were taken up in the Delft-FEWS flood forecasting platform as part of assignments given by various forecasting agencies in Europe. The first and so far most important contract was awarded in 2003 by the UK Environment Agency (EA) to the consortium of WL | Delft Hydraulics and Tessella Plc. (UK). Objective of this contract was the development of the UK National Flood Forecasting System (NFFS) as a generic open platform for England and Wales. In addition, the EU Joint Research Centre (JRC) was provided with an upgrade of Delft-FEWS to improve the European pre-warning system, currently run under the name European Flood Alert System (EFAS: http://efas.jrc.it). Additional contracts were also given by operational forecasting agencies in The Netherlands (RIZA, various Water Boards), Scotland, Switzerland (FOGW), Austria (State of Lower Austria), Germany (BfG), Pakistan etc. Currently, applications are found in other areas, such as water temperature forecasting along the River Rhine, drought forecasting in Taiwan and in the Red River Basin in Vietnam and salinity intrusion forecasting for the Songkhla Lagoon in Thailand. These contracts have led to a substantial revision of the original EFFS platform in order to comply with the various operational demands of the agencies. Examples of typical requirements of such operational forecasting environment are given by Werner et al. (2004, 2005).

The most important of these is the need felt for a standardized approach to flood forecasting over large areas, aimed at integrating new or existing simulation models, hydro-meteorological data and meteorological forecasting products. An important selection criterion for a forecasting tool is the open-architecture design of the system to allow for the reuse of existing hydrological and hydraulic flood routing models that form the core of already pre-existing forecasting systems (Verwey, 2006). In the past, extensive investments may have been made by the agencies to develop such models. The construction and calibration of entirely new models, jointly with the development of a new forecasting platform, would increase significantly the investment costs and waste past efforts. The openness of Delft-FEWS has provided a solution to this problem, whereby only minor adaptations were required to plug existing sets of models into the novel framework.

Additional requirements put forward by the UK Environment Agency were the flexibility needed to realise scalable platform-independent client-server installations that would guarantee sufficient resilience of the forecasting system to potential failure of individual components. Another important requirement has been the creation of a web-based dissemination of forecasting results through configurable reports.

These recent developments have strengthened the Delft-FEWS platform (http://www.wldelft.nl/soft/fews/int/index.html) as follows:

- Further opening up of the system to process precipitation data, including weather modelling, weather radar and satellites products;
- Further opening up of the system to include a variety of existing and calibrated hydrological and hydraulic modelling systems. Currently, generic coupling has been provided to the modelling systems Sacramento, NAM, LISFLOOD, HBV, SOBEK, Mike11, ISIS, Hec-RAS and a variety of other modelling systems;
- Reprogramming parts of the system using Java™ technology to facilitate platform independent installations for a variety of operating systems;
- Facilitation of system configuration to meet the specific requirements of river basin authorities using XML formatted configuration files;

- Further development of tool kits that give access to look-up tables, correlation tools, performance indicators, generic model calibration tools, flood mapping applications and "what-if" scenario simulators;

- Facilitation of distributed and scalable client-server configurations.

The most recent version of the flood forecasting platform efficiently manages the following tasks:

- Import of external data sources, such as meteorological forecasts, including numerical weather model outputs (GRIB format), radar images, rainfall, discharge and water level time series from telemetric systems and data from external data sources. Processing also includes imports of ensemble weather predictions, such as those provided by the ECMWF-EPS;

- Data validation and serial and spatial interpolation of incoming data, using extensive data validation rules, including user-defined validation rules. Readily available interpolation methods are regression functions, Kriging, Thiessen polygons and the inverse distance method;

- Options with gap-filling and hierarchy rules allow alternative data sources to be used as a fall-back to ensure continuity in the forecasting process;

- Data transformation to prepare the required inputs for reporting and for the forecasting models, such as aggregation of precipitation from distributed point sources, from radar and from numerical weather models, as input to precipitation-runoff modelling and discharge-stage transformations;

- Execution of the hydrological and hydraulic forecasting models. These models may be provided by third parties, such as regression analysis models, lumped hydrological models, spatially distributed hydrological models and hydraulic models;

- Updating the state of the models through a feedback mechanism aimed at minimizing the gap between observed and forecasted data. Delft-FEWS provides some of the possible data assimilation models, such as the ARMA error correction method and ensemble Kalman filtering. The forecasting platform also supports the implementation of other updating techniques;

- Visualisation of results on maps that can be imported from various sources, such as GIS, areal photo's and others, including geographic navigation, warning options and flood extent mapping;

- Dissemination of forecasts through maps and HTML-formatted reports that allow broadcasting forecasting results to relevant authorities and the public through channels such as intranet and internet.

III. POTENTIAL OF DELFT-FEWS FOR THE EKONG BASIN

MRCS and the individual member countries are making use of a number of different modelling systems to simulate hydrological and hydraulic processes. A significant investment has been made to support planning in the basin through the development of the Decision Support Framework (DSF) covering the complete area of the Mekong catchments in Thailand, Laos, Cambodia and Vietnam. This model is based upon the hydrological models SWAT and IQQM and the hydrodynamic model ISIS. In the development of a new flood forecasting system, the current DSF could provide a good starting point for the modelling of flood wave propagation along the Mekong River and its branches.

The openness of the Delft-FEWS platform allows for the coupling of these existing models. No additional investments are required on the short term for the development of new models. Also, when the existing models are recalibrated, they can immediately replace the previous calibrated versions. Connections between ISIS and Delft-FEWS have already been developed in the framework of the UK Environment Agency contract. A connection to the modelling systems SWAT and IQQM would only require a minor effort. Moreover, the structure of Delft-FEWS would allow for the replacement of part of these models by other models available, such as the earlier developed VRSAP for the Mekong Delta and existing models based upon Mike11. A longer term advantage of Delft-FEWS is that gradually the hydrological and hydraulic models can be replaced by state of the art products, without being bound to one single manufacturer.

A flood forecasting system is heavily relying on meteorological inputs. One problem in the Mekong Basin is the scarcity of rainfall stations and the difficulties in maintaining these. In general, however, there is a trend in data collection that the importance of point measurements is reducing, while the importance of spatial information is increasing. Spatial information is provided by satellite observations, processed to feed numerical weather models. With the developments in computing power and associated data storage capacity, these weather models become more refined and more accurate. This certainly also applies to the Mekong Basin.

Delft-FEWS can be made operational in various ways. For the Mekong Basin it could be configured as a client-server application with one central server at the Regional Flood Management and Mitigation Centre in Phnom Penh and web-based client applications at the local MRC offices in Vietnam, Thailand, Cambodia and Laos. These clients can also be authorized to select and run their own scenarios and other clients (read: countries) will have access to these alternative forecasts. Moreover, various authorities in the member countries can be given access to the forecast reports and to associated messaging services. This will be of great help in case of calamities by facilitating the coordination of emergency operations. The system can also be set up to provide improved resilience by duplicating the central server in one or more of the other countries.

With the overall platform in place, MRCS can gradually increase the detail with which forecasting is provided. In such detailing, the role of meteorological information based upon weather models and radar would become more dominant. With Delft-FEWS, extensive experience has been built up with connections to radar and to a large variety of weather models.

An example of such detailing would be the forecasting of inflows into the Nam Ngum reservoir in Laos in order to minimize the flood risks at the Vientiane Plain. In 1995, severe floods in the Vientiane Plain caused substantial damages, which could have been reduced with a good forecasting system in place. The floods had a number of possible causes, such as high discharges into the Nam Ngum reservoir, added flood hydrographs from the Nam Lik River, high precipitation on the Vientiane Plain and increased Mekong River levels, impeding drainage from the Nam Ngum catchments (Verwey, 1999). A forecasting system would enable the consistent evaluation of all these effects including the effects of measures to minimize flood risks.

IV. CONCLUDING REMARKS

The present article gives a brief outline of the potential of Delft-FEWS for serving the flood forecasting needs of the Mekong River Commission. The platform facilitates the integration of meteorological forecasting systems with hydrological as well as hydraulic models within an open forecasting environment.

The principal advantage of this approach is that it enables a shift from a model-centred forecasting approach towards a data-centred system. In this approach, already existing software modules and models such as hydrological, hydraulic and inundation models can be mutually combined, re-used and encapsulated into (new) forecasting environments, whereby the data organisation remains unchanged. Examples are the SWAT, IQQM and ISIS models already in place in the Mekong Basin.

Adopting such a system enables a flood forecasting organisation to replace software modules freely without the need to change the entire structure of the forecasting system, as it would be necessary in case of a model-centred approach. In the latter case a change of a relevant software module would require significant retraining of the organisation in the use of the system once changes of the models take place. These concepts have been reinforced in newer versions of Delft-FEWS, which have been developed to serve new applications, such as that of the National Flood Forecasting System for England and Wales. Currently, Delft-FEWS also finds new applications, such as drought forecasting in the Red River catchments of Vietnam and salt intrusion forecasting for the Songkhla Lagoon in Thailand.

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