software system

Delft-FEWS:
Flood Early Warning System

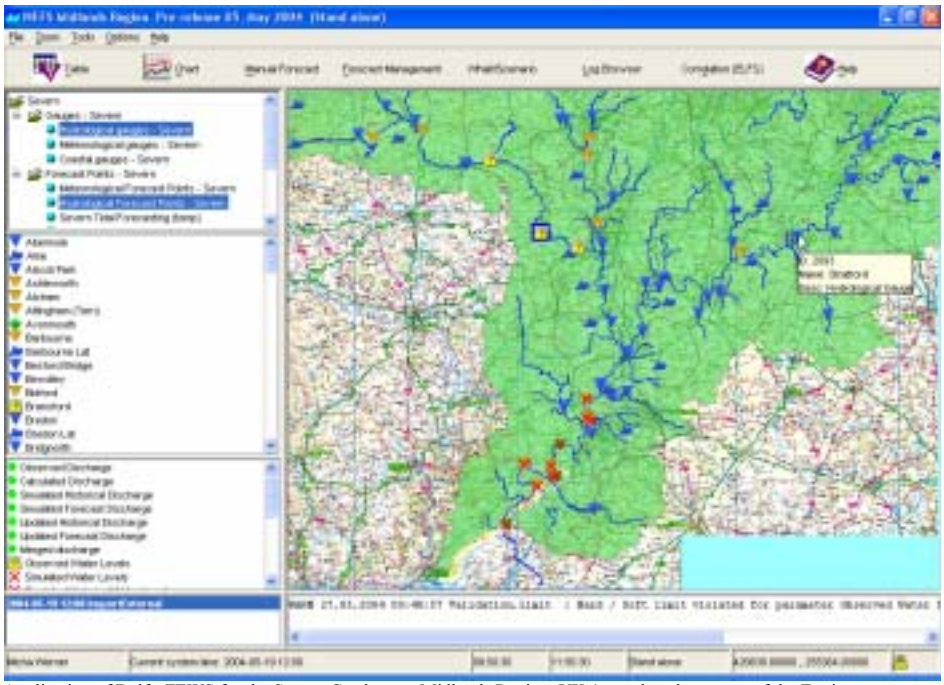
The development of flood forecasting and warning systems is an essential element in regional and national flood alert strategies in many countries. Recent developments in numerical weather prediction, radar data and on-line meteorological and hydrological data collection have resulted in an increasing focus on data import and data processing. The challenges for developing a modern flood forecasting and warning system are found in the integration of large data sets, specialised modules to process the data, and open interfaces to allow easy integration of existing modelling capacities.

openers

In response to these challenges, WL | Delft Hydraulics' Flood Early Warning System (Delft-FEWS) provides a state of the art flood forecasting and warning system. The system is a sophisticated collection of modules designed for building a flood forecasting system. The philosophy of the system is to provide an open shell system for managing the forecasting process. This shell incorporates a comprehensive library of general data handling utilities, allowing a wide range of forecasting models to be integrated in the system through a published open interface. The modular and highly configurable nature of the system allows it to be customised to the specific requirements of an individual flood forecasting agency. Delft -FEWS can be used effectively both in simple forecasting systems, and in highly complex systems utilising the full range of hydrological and hydraulic modelling.

scalability

Delft -FEWS is a fully scalable system. It can be run as a self-contained manually driven forecasting system operating on a normal desktop computer, but can also be deployed as a fully automated distributed client-server application. The client server application allows further scaling through running time consuming tasks in parallel. The system applies the latest software standards. It has been developed in using JavaTM technology, and is fully configurable through open XML formatted configuration files. In the J2EE compliant Client-Server application, JMS is used to provide resilient communication between distributed system components.



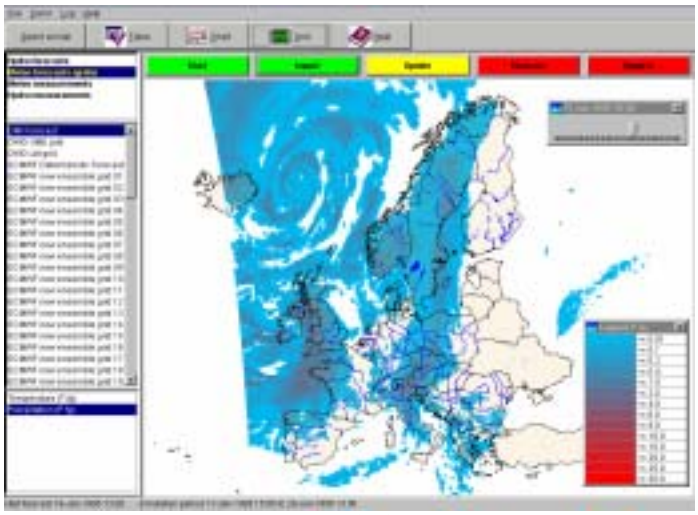
Application of Delft -FEWS for the Severn Catchment, Midlands Region, UK (reproduced courtesy of the Environment Agency, UK

keywords:
floodforecasting
hydrology
modelling

wl | delft hydraulics

connecting Delft -FEWS to external data sources

Of paramount importance in an operational flood forecasting system is an efficient connection to external data sources. Delft FEWS provides an import module that allows importing of on-line meteorological and hydrological data from external databases. These data include for example time series obtained from telemetry systems like observed water levels, observed precipitation, but also meteorological forecast data, radar data and numerical weather predictions. Data are imported using standard interchange formats, such as XML, GRIB and ASCII. The import of external data also supports ensemble weather predictions, such as those provided by the European Centre for Medium Range Weather Forecasts (ECMWF).

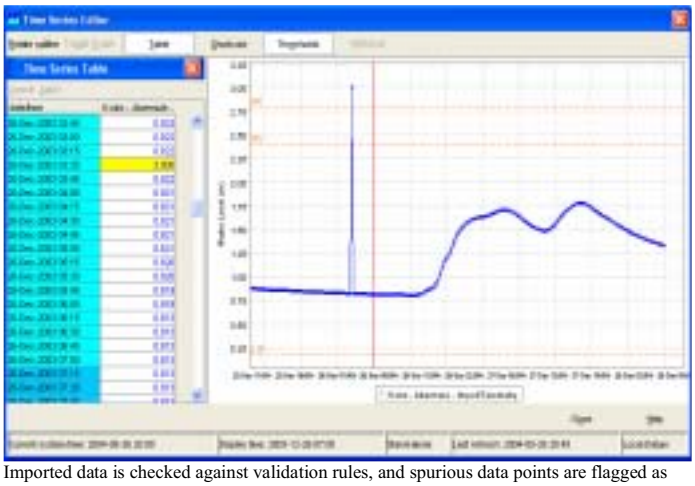


Application of Delft -FEWS for an European Flood Forecasting System (EFFS), showing forecast precipitation field over Europe in January 1995 imported from the Danish Meteorological Institute

validating, interpolating and transforming data

Particular emphasis is placed in Delft FEWS on quality checking of data obtained from external sources, using extensive data validation options. Serial interpolation (gap-filling) is available to complete data series where required. Data hierarchy options allow alternative data sources to be used as a fallback, ensuring continuity of the forecasting process, even if available data is incomplete or inconsistent. Validation and interpolation will normally be automated, but user intervention can also be configured.

Another set of utilities is available for transforming data with disparate spatial and temporal scales. This includes spatial interpolation to derive for example areal weighted precipitation from spatially

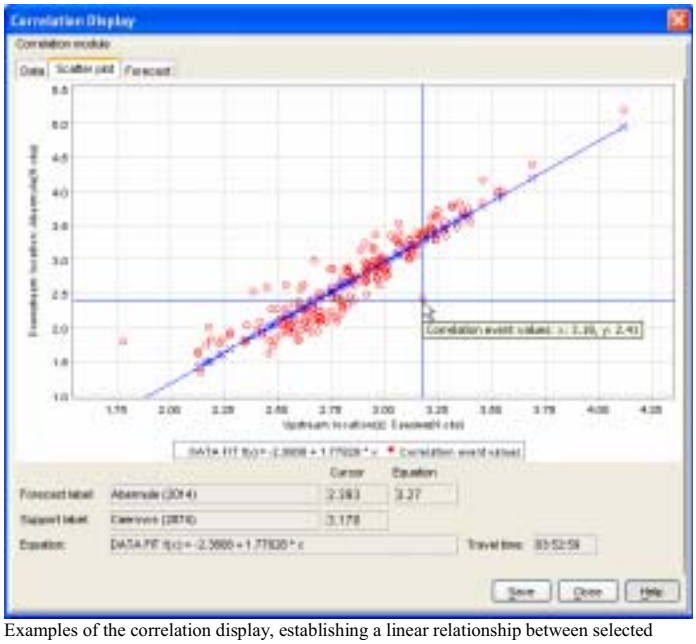


Imported data is checked against validation rules, and spurious data points are flagged as invalid. These will not be used in forecasting

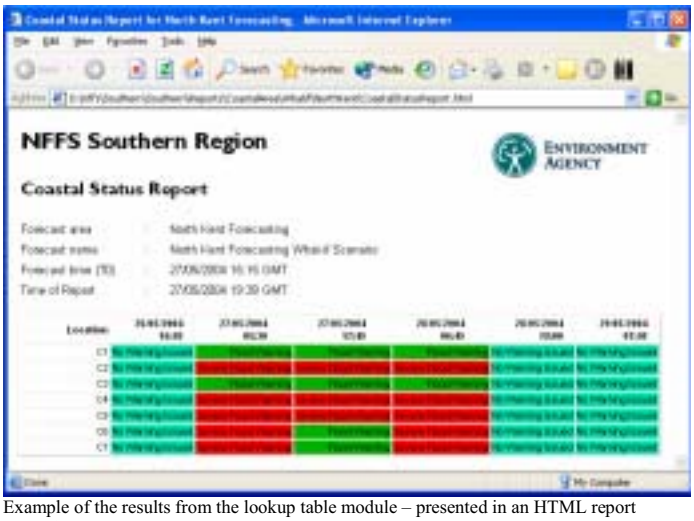
distributed point sources, or from spatial data such as radar data and numerical weather prediction models. Data transformation utilities also include methods for temporal aggregation and dis-aggregation, evaluation of simple equations, and typical hydrological functions such as stage-discharge relationships and evaporation calculations.

starting with simple forecasting models

Delft -FEWS provides a number of modules to rapidly establish a simple forecasting system where hydrological and/or hydraulic models are not available, or are under development. This includes a correlation module that generates forecasts for a downstream location based on the correlation of events at that location and a suitable upstream location. A lookup table module can be used to derive warning levels on the basis of a heuristic combinations of critical conditions in the imported data.



Examples of the correlation display, establishing a linear relationship between selected events at two sites

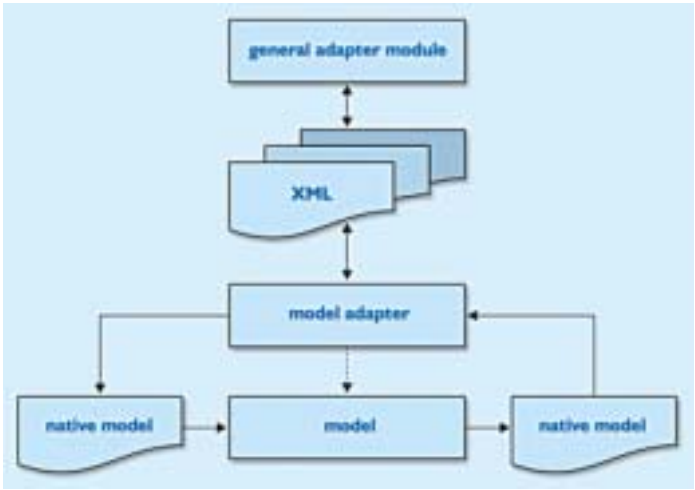


Example of the results from the lookup table module – presented in an HTML report (reproduced by kind courtesy of the Environment Agency, UK)

Once more advanced models become available these simple modules may be replaced. Alternatively these can be retained for comparison purposes, or as a backup should these models fail.

expanding to more advanced modelling

The philosophy of Delft -FEWS is to provide an open system that allows a wide range of existing forecasting models to be used. This concept is supported by the general adapter module, which communicates to external modules through an open XML based published interface, effectively allowing "plugging-in" of practically any forecasting model.



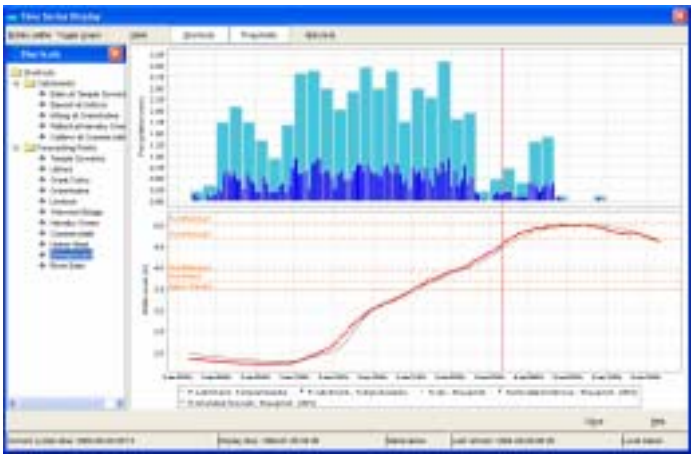
Schematic overview of the open concept of the general adapter

An adapter between the native module data formats and the open XML interface is typically required, and such adapters are already available to support a wide range of hydraulic and hydrological models.

The great advantage of this open interface is that existing hydrological and hydraulic models and modelling capabilities can easily be integrated in the forecasting system, without the need for expensive re-modelling using a specific model.

using some of the advanced forecasting tools

Delft -FEWS provides a number of advanced forecasting tools that can be used in improving and assessing the quality of forecasts. This includes generic data assimilation methods such as an ARMA based error correction module; a what-if scenario tool to quickly establish the effects of different input scenarios; a performance module to assess the accuracy of forecasting models used; and a calibration tool to help optimally tune models within the forecasting environment. A flood mapping module can be used to project forecast levels as flood extent maps.



Example of the time series display in Delft -FEWS, showing rainfall hyetographs and forecast water levels for the Eden River, Northwest Region, UK

viewing results and disseminating forecasts

Delft -FEWS provides easy to understand, advanced graphical and map-based displays to help the user carry out the required tasks for flood forecasting in a structured way. The interactive map display allows geographic navigation, while icons give the forecaster rapid insight in warning levels being reached. The time series display can be used to explore data further – or edit input data when necessary. Additional insight in the dynamics of a flood event may be gained through the animated longitudinal profile and flood map displays.

Forecast results can be disseminated through configurable HTML formatted reports, allowing easy communication to relevant authorities and public through intranet and internet.

Example of the flood map display in Delft -FEWS, showing floodplain flooding in a 14km reach of the Eden River, Northwest Region, UK (reproduced by kind courtesy of the Environment Agency, UK)

configuring and deploying the Delft -FEWS system

The system may either be used in a stand alone environment, where forecasts are run and analysed manually, or as a J2EE compliant client-server application. Established standards such as Java Messaging Service (JMS) ensure smooth and resilient communication between clients and servers.

In the client-server configuration, the heart of the system is the master controller, which manages the forecasting process and schedules all forecasting runs. Forecasting modules are run on dedicated forecasting shell servers. For most forecasting systems one forecasting shell server may be adequate, but the system is fully scalable, and where required multiple forecasting shell servers may be applied to process forecasting tasks in parallel.

Duty Forecasters access the forecasting system through client software, allowing full control whether in the office, or at home connected through a Modem. Reports generated by the system showing relevant forecasting results may be accessed by relevant authorities, emergency services, or even the general public through the web server connected to Internet/Intranet.

system application and training

WL | Delft Hydraulics will normally be closely involved with the client in setting up Delft -FEWS as an operational flood forecasting system, and configuring the system such that it meets any specific requirements. In-depth training courses are available, teaching users not only how to use the system, but also how to independently add new models to the system and customise Delft-FEWS to the changing requirements of an operational system

applications and ongoing projects

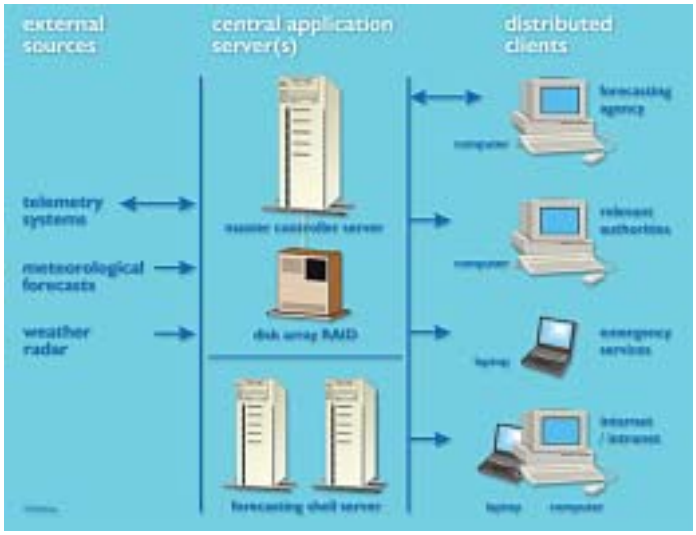
FEWS RHINE: An operational flood forecasting system for the Rhine, delivered to the Dutch Ministry of Public Works and Water Management.

FEWS-Switzerland: An operational flood forecasting system for the Upper Rhine basin in Switzerland, delivered to the Swiss Federal Agency for Hydrology and Geology.

NFFS: Development of Delft -FEWS as the National Flood Forecasting System, commissioned by the Environment Agency for operational forecasting across England & Wales.

FEWS-Tanshui: An operational flood forecasting system for the Tanshui Basin in Taiwan.

An European Flood Forecasting System (EFFS): This EC-funded research project aimed at developing a prototype European flood forecasting system with a four to ten days lead time forecast for entire Europe.



Schematic overview of a possible configuration for a full client server deployment of Delft -FEWS

WL | Delft Hydraulics

Decisive advice: from multidisciplinary policy studies to design and technical assistance on all water-related issues.

Rotterdamseweg 185
p.o. box 177
2600 MH Delft
The Netherlands
telephone +31 15 285 85 85
telefax +31 15 285 85 82
e-mail info@wldelft.nl
internet www.wldelft.nl