Delft-FEWS

A platform for real time forecasting and water resources management

Expert data handling and model integration software for flood forecasting, drought and seasonal forecasting, and real-time water resources management

Flood forecasters, reservoir operators and operational managers in the water sector often need to make responsible, time critical decisions informed by recent observations and predictions of water related events. Such decisions are becoming increasingly important due not only to the increasing occurrence of weather related extremes such as floods and droughts and the increasing pressure on already stressed water resources, but also due to the increasing impacts that these events have. Through taking well-informed decisions, adverse consequences such as loss of life and damage to environmental and ecological assets can be minimised, or the adverse effects of the sub-optimal distribution of water in the face of shortage can be avoided.

Unfortunately the data that is used to support these decisions is often fragmented and the forecast process manual and cumbersome. The challenges for developing a good water information or forecast

system are found in the efficient integration of large data sets, specialised modules to process data, and open-interfaces to allow easy integration of new and existing modelling capabilities.

For over 15 years Deltares' answer to the question on how to best manage the forecast process for decision making in case of flood risk or other water related conditions is to equip your experts with the Delft Flood Early Warning System (Delft-FEWS). Delft-FEWS is freely available expert software that handles large amounts of forecast data efficiently, integrates the latest observations with the most recent meteorological forecasts and provides for consistent data quality, standardised work processes, visualisation and reporting. Delft-FEWS can orchestrate massive computations on dedicated hardware, in the cloud, or both, and allows for remote collaboration between multiple experts working and interacting with the same data.

Delft-FEWS consists of a sophisticated set of configurable modules for building a hydrological forecasting system customised to the specific requirements of an individual organisation. Delft-FEWS was designed to support the flood forecasting process, but due to its flexible and modular structure, it is also very well suited to support day-to-day operational management, real-time control and forecasting and warning in other disciplines, like water quality, reservoir management, hydropower, navigation, groundwater, drought and dike strength monitoring.

Streamline your forecast data and process Create a dedicated Delft-FEWS configuration for your area of interest to integrate your historical observations, external forecast data and model simulations. Import all your relevant data efficiently, deploy the Delft-FEWS modules you need, define workflows for managing your data centrally, run tasks in the background and view the results in a single and rich graphical user interface. Set up a client-server system for distributed or cloud computing and for multi-user access.
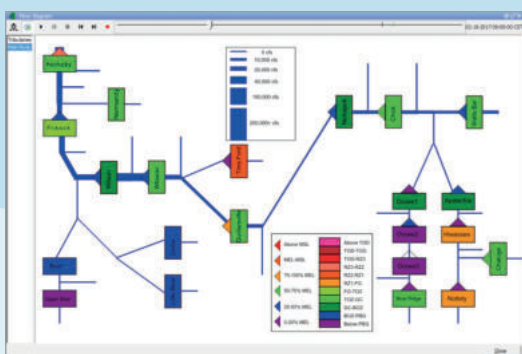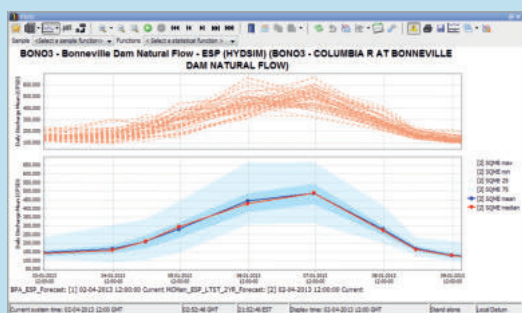
Handle large heterogeneous datasets

Delft-FEWS provides import modules that allow data to be imported from a variety of external sources such as web services, external databases and many different file formats. These data include for example time series obtained from telemetry systems such as water levels and precipitation, but also water quality sample data, meteorological forecast data, radar data and numerical weather predictions. Data are imported using standard interchange formats, such as CSV, XML, GRIB, Hdf5, NetCDF as well as some 150+ propriety data formats. The import of external data also supports ensemble weather predictions now routinely made available by meteorological forecasting agencies. The efficient data storage in the Delft-FEWS database offers extensive performance optimisations to handle all of these heterogeneous datasets fast and effectively.

Quality control and pre-process your data the way you want

Delft-FEWS supports quality checking and pre-processing of the imported data using extensive data validation and transformation libraries. Data validation includes checks on extreme values, rate of change, spatial homogeneity and trend detection. Serial interpolation (gap filling) for example is available to complete data series where required. Data hierarchy options allow alternative data sources to be used as a fall-back, ensuring continuity of the forecasting process, even if available data is incomplete or inconsistent. Another set of utilities is available for transforming data with disparate spatial and temporal scales. This includes for example spatial interpolation to derive areal-weighted precipitation from spatially-distributed point sources, or from gridded spatial data such as radar data and numerical weather prediction models. Data transformation utilities include typical hydrological functions such as stage-discharge relationships and evaporation calculations, but also allow the user to define their own mathematical equations or even write small data transformation scripts that include an extensive library of GIS operations. Data validation and transformation modules can be automated, but can also be operated interactively while reviewing data in dedicated displays.

Integrate your numerical models and scripts

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 a module called the General Adapter, which communicates to external models through an open XML or NetCDF based interface, effectively allowing "plugging-in" of practically any forecasting model, algorithm or script. An adapter between the native module data formats and the open interface is typically required, and

Jan Gooijer | Waterboard Noorderzijlvest, NL.

"With Delft-FEWS being operational and based on a research project, an array of possible improvements in managing the water system and in early response to calamities were identified"
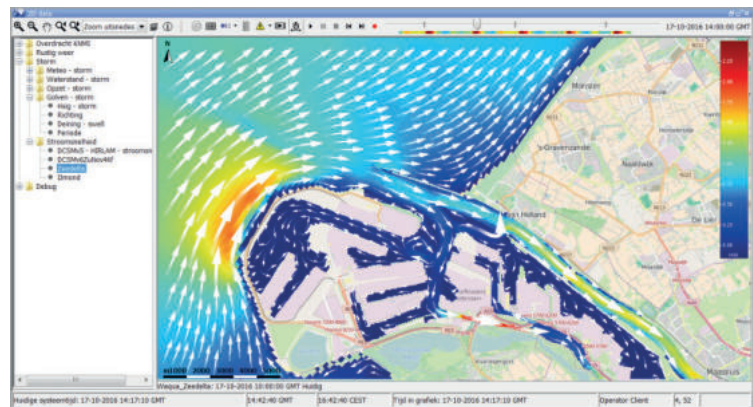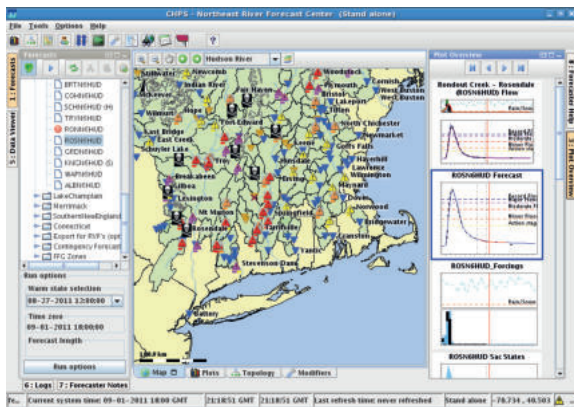
numerous specialized adapters are already freely available to support a wide range of hydraulic and hydrological models, including HEC-RAS, HEC-HMS, ISIS, Mike11, OpenDA, OpenStreams, RTC Tools, SOBEK, DELFT-3D, Flood Modeller Pro and HBV. Once integrated, Delft-FEWS feeds the model with processed input data and then various scenarios and forecast simulations can be executed. The great advantage of the open interface is that existing models and modelling capabilities can easily be integrated in the forecasting system, without the need for expensive re-modelling using a specific model.

Apply advanced data assimilation techniques
Delft-FEWS provides a number of advanced forecasting tools that can be used in assessing and improving the quality of forecasts. This includes generic data assimilation methods such as an ARMA (Auto Regressive Moving Average) based error correction module and the openDA data assimilation toolbox which includes a variety of algorithms for state updating and parameter calibration such as Ensemble Kalman Filtering and Particle Filtering. Manual data assimilation and general user interaction with model parameters, states and time series is offered through the Delft-FEWS displays. A performance module is also provided to assess the accuracy of forecasting models used and provides a powerful set of analysis tools to assist post event analysis.

Disseminate and archive your forecast information
Forecast products can be disseminated through configurable file formats and web services, allowing easy communication to relevant authorities and public through intranet and internet. When desired, web services can be built on top of our webservice API for accessing time series or starting new tasks. Storing and accessing historical data, simulations, forecast products and other products is offered in external storage in the fully supported Deltares Open Archive. This archive can be used for post-event analysis, model calibration, reviews, and performance analysis. The system also includes an integrated training mode, the Delft-FEWS Water Coach, which can be used to familiarise users with the system operation, as well as for setting up exercises where the real-time environment is emulated. This provides essential support in training users not only in the use of the software, but also for training the end-to-end forecast process.

Work with numerous specialised displays
Delft-FEWS provides structured, concise, and highly configurable displays to help the user carry out the required tasks for operational forecasting in a structured way. Enjoy the comprehensive navigation and visualisation on the various customised windows that can be spread over available desktops. The interactive map display allows geographic navigation and situational awareness, while icons give the user rapid insight in warning levels being reached. Data can be displayed using bars, points or lines, as longitudinal profiles, grids and polygons, or even with user defined graphics using Scalable Vector Graphics. In terms of capabilities, the interface can be configured to support additional functionality, such as on-the-fly statistics of time series, or manual editing. Displays can be pre-configured based on templates relevant to a particular work process, so the users have easy and structured access to the data of interest.

Ray Canterford | Deputy of Hazards, Warnings & Forecasts, The Bureau of Meteorology, Australia.

"Delft-FEWS enables the Bureau to become more involved with the international hydrological forecasting community, especially fostering greater co-operation with key international players, such as the US Weather Service and UK Environment Agency"

Scale, configure and deploy your Delft-FEWS application

Delft-FEWS is a fully scalable system. It can be run as a standalone manually driven forecasting system operating on a laptop, but can also be deployed as a fully automated distributed Client-Server application, that can be extended to the cloud. The Client-Server platform supports operational forecasting with job scheduling, remote administration, email/text message alerts, automated failover, multiple remote clients, and continuous data ingest and product export. It has been developed using JavaTM technology, and is fully configurable by the user through open XML and CSV formatted configuration files. By configuring and automating your imports, data handling routines, model runs and displays, optimal structure and control over forecast processes can be obtained.

Jon Roe | Chief Hydrologic Software Engineering Branch, National Weather Service, USA

"Deltares has successfully conducted and completed the implementation of the Flood Early Warning System for the USA National Weather Service Community Hydrologic Prediction System (CHPS)"

Sharing developments within the community

The Delft-FEWS business model has become a success through shared investments by the Delft-FEWS community.

One of the key principles on which Delft-FEWS is based, is the idea of shared development. This means that development efforts are not duplicated between agencies and all members of the Delft-FEWS community can benefit from the embedded knowledge and methods available. Deltares acts on the community's behalf to implement new features while maintaining the highest standards of software integrity through rigorous design, development, testing and release procedures. This allows our users to actively contribute to the knowledge base of Delft-FEWS, which currently bundles decades of hydrological knowledge and software development, but also to stay up to date with the international best practices in operational (flood) forecasting. The Delft-FEWS community is extremely important in the exchange of knowledge and ideas and the sustainable development of hydrological forecasting science. Each year the users

of Delft-FEWS come together during the Delft-FEWS user days to present and exchange ideas. Visit our web-portal (*www.delft-fews.com*) to find out more.

Deltares has a very flexible license model and supports clients by being closely involved in setting up Delft-FEWS as an operational forecasting system in combination with a comprehensive training programme on the operation and maintenance of the system. Once the system is set up Deltares offers many services as part of our support and maintenance contracts, to support clients in further expanding and maintaining the system. In-depth training courses are available, teaching users not only how to use the system, but also how to independently add new displays, models or data products to the system and customise Delft-FEWS to the changing requirements of an operational system.

Deltares

Deltares is an independent institute for applied research in the field of water, subsurface and infrastructure. Throughout the world, we work on smart solutions, innovations and applications for people, environment and society. Deltares is based in Delft and Utrecht.