Datamanagement at Flanders Hydraulics Research

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Flanders Hydraulics Research is a research centre of the Flemish Government. The centre provides consultancy services dealing with hydraulics, hydrology and nautical aspects to national and international public or private organisations. Within Flanders Hydraulics Research the Hydrological Information Centre (HIC) is a research group which provides scientific support for water level management on navigable waterways in Flanders. To achieve this, the HIC cooperates actively with the actual managers of these waterways and with other institutions involved in ground water, surface water and sediments.

An efficient functioning of the HIC requires powerful tools to load, store and validate data and to make them accessible for all users. For these purposes an application named HYDRA was developed. This article focuses on the setup, the use and the planned evolution of the application.

Services of the HIC

The services provided by the HIC are the following:

Measurements of hydrological parameters

The HIC measures water levels and discharges along navigable waterways in Flanders. Furthermore, it provides the operational management of gauging networks of other Flemish public authorities. Moreover, precipitation, groundwater and sediment data are measured in several locations. Of all these data, digital historical time series up to 30 years and longer are stored.

Validation and processing of measured hydrological data

The measured data undergo a first, automatic validation process which removes obvious errors, such as spikes and gaps, before publishing on line.

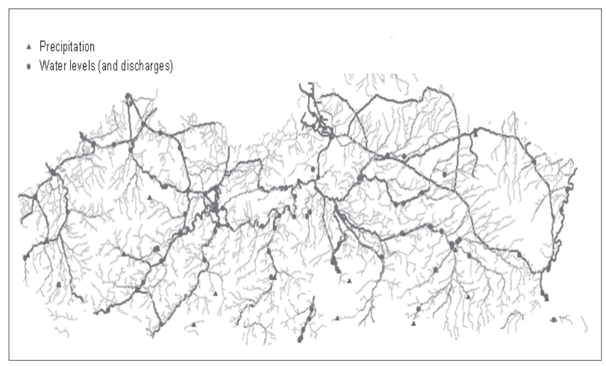

Figure 1: Network of hydrological measurements in Flanders (HIC).

Consequently, a second, more thorough validation is performed by a hydrologist, who examines the measurements over a longer period and corrects errors, shortages in data, etc. All information available, such as data of neighbouring measurement stations, is used in this second-stage validation.

Development of instruments for hydraulic and hydrological studies

Water level management today no longer chooses to prevent floods at all costs, but instead seeks to limit the damage. Also for

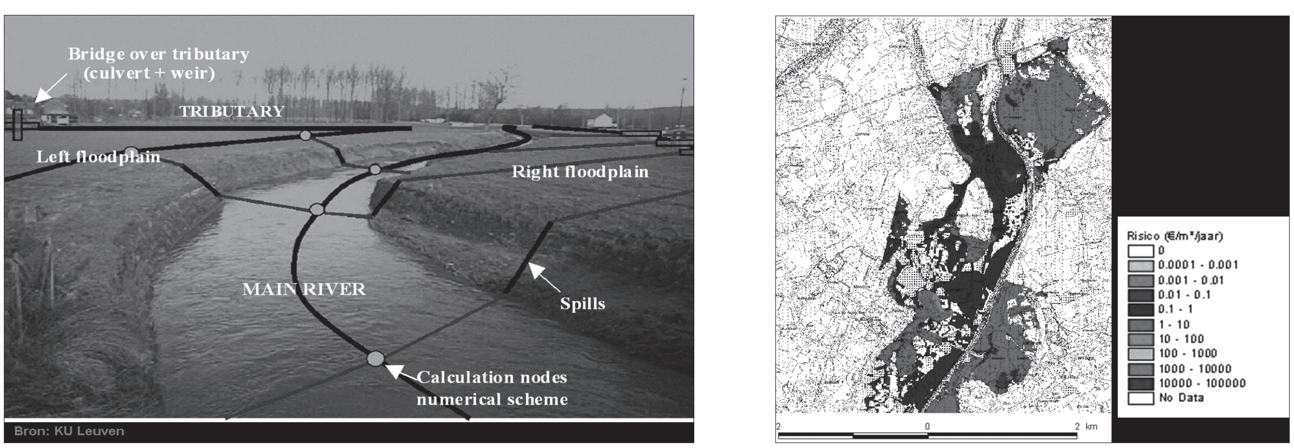

Figure 2: Schematisation principle of a numerical model and flood risk assessment along the river Dender.

low-flow periods, water managers want to minimise the amount of damage. The HIC has developed instruments to implement this risk approach for floods and for periods of water shortage. These instruments are numerical models that simulate the flow behaviour of the navigable waterways. They can be used to estimate the consequences of an intervention on the river's flow behaviour.

The HIC created a workable methodology to map the flood risk for all navigable waterways in Flanders. It offers a means to calculate the flood risk objectively providing policymakers with enough information to carry out a social cost-benefit analysis.

Moreover, a methodology to deal with acute low-flow problems is based on numerical models of the rivers and channels. It guarantees an appropriate evaluation of the proposed solutions and the best implementation strategy.

Both methodologies strongly rely on accurate time series of hydrologic parameters.

Daily hydrological forecasts

The HIC has been given the task of forecasting the water levels and discharges of navigable waterways in Flanders. Forecasts are made systematically: the models calculate the expected water levels for a period of 48 hours.
The river models are linked to the hydrological measurements. Based on these data and on weather forecasts, the HIC predicts water levels and discharges up to five times per day.

Publication of the measured data on web pages

Besides internal use by the researchers of the HIC, the measurements are also published online. The public can consult the measurements of the last 10 days by means of the following web link: http://hydra.lin.vlaanderen.be/. Registered users can obtain even more data such as historical time series, metadata and the rating curves of certain gauging stations.

Data exchange with other partners

Rivers do not stop at municipal or even national borders. The HIC collects all the hydrological data which are relevant to navigable waterways in Flanders. The data come from diverse measuring networks including other related Flemish organisations (RMI, Water, EM, Kust,…) and foreign parties (RWS, SETHY, DIREN,…). The Flemish data are also exported to some of our partners in neighbouring countries.

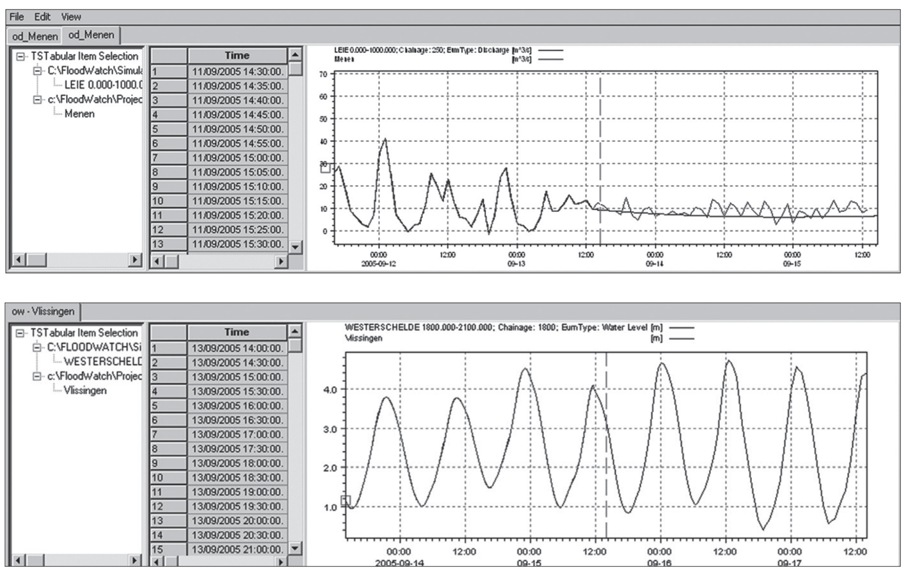

Figure 3: Forecasts for the rivers Lys and Scheldt.

Information centre

The HIC is the central knowledge and information centre for navigable waterways in Flanders. Questions about the surface water system in Flanders and about hydrological data are to be sent to hic@vlaanderen.be.

The HIC mainly works for water managers, policy makers and research organisations, but it also has also other customers.

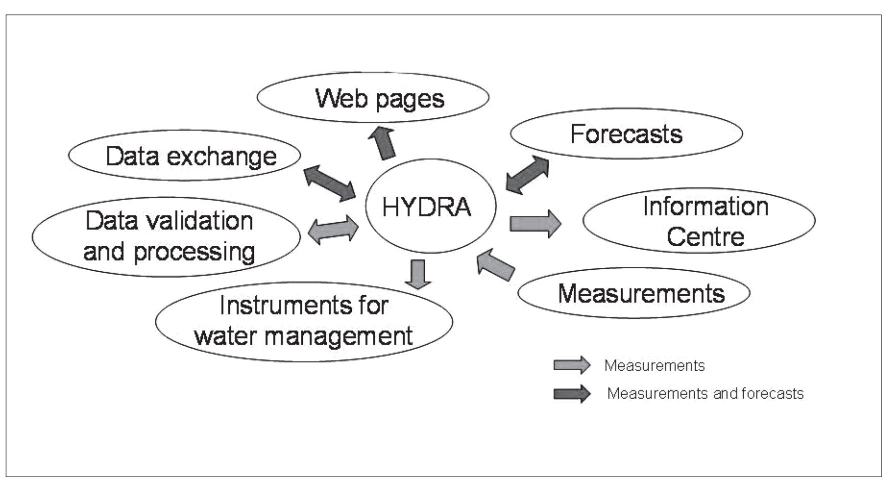

Figure 4: Use of the HYDRA application for different services of the HIC.

Specific requirements

To support all these activities, a hydrological database (HYDRA) was developed. In addition to the general properties of a database for time series, HYDRA needs to fulfil the following requirements:

- Two kinds of data must be stored: *calculated and measured data*. The calculated data include discharges based on rating curves on the one hand and forecasts on the other.
- Huge amounts of measured and calculated hydrographical, hydrological, sedimentological and meteorological data enter Flanders Hydraulics Research. The main variables that are stored are values for: water level, discharge, precipitation, water velocity, sediment load, bathymetry, wind velocity, temperatures and evapotranspiration. *Daily more than 20,000 files* are processed, containing about 500,000 measurements and 30,000 forecasts. As new measurement stations are added easily and frequently, and the number of forecasting models increases, the amount of data and the stress on the database increase constantly.
- *Several time steps* (1', 5', 10', 15', 30', 1h, 3h, 24h) need to be handled
- A *data versioning system* is needed. The goal of this data versioning is to store all changes made to a measurement, allowing retrieval of the different historical versions of a certain time series. Among others, this is important for the use of off-line computer models of the rivers. These off-line models are composed and calibrated with specific time series. If later on, changes to the model are needed, one has to be able to perform the calibration with the same version of time series.
- *Special environments* must be available for specific users: Data owners can work in their own environment with a personal configuration. Some data can only be viewed by a restricted public.
- An *overview of the status* of the measurement stations (normal, alert and alarm defined by thresholds) and the defects of the stations must be available on-line. A system to monitor the *quality of the stations* must be available.
- By means of *export routines*, measured and forecasted data are sent to external organisations (RWS, SETHY, RMI,…). Import of measurements and forecasts from these organisations must be possible.

The development of HYDRA is a continuing evolution. In the next paragraphs, the main steps in the setup of this database are described.

AREV, the first generation database

A first version of the hydrological database was built in 1990. This version was developed in Advanced REVelation. The database contained an internal system to query historical data and an application to validate data and to modify configurations such as rating curves.
Most of the measurements were only available on paper. These data were digitized and imported in the database. Some measurement stations were linked in a telemetry system: a central module called the stations regularly to load data and to realise an on-line availability. A preliminary internet application existed.
The system had restrictions for the planned evolution of the HIC. External time series could not be collected and stored. Other than hourly values could not be saved.

HYDRA, an important evolution

In 2000, the restrictions of the AREV system gave birth to a new database (HYDRA). Special attention was given on the following topics:
- Data exchange with *several data sources* had to be possible
- The different data sources created a need for different storing frequencies
- *A new telemetry system* was needed, resulting in a better availability of data during crisis situations
- It must be possible to query recent and historical data by means of *a web application*
- *Sufficient extension capacity was needed* to fulfil the expected growth of the database

At present the HYDRA application runs in parallel with the AREV application. The AREV system is used to validate the data. HYDRA contains the remaining functionalities.

HYDRA is based on an Informix database using the `time series' module. This module is very economical in comparison with a relational model. In a relational model, a timestamp and a value is saved for each individual measurement. In a 'time series' module, a timestamp and a value indicating the interval between two timestamps are stored only once. These are followed by all measured values. Thus more data can be stored and the expected growth of the database can be fulfilled.

Relational model	Time stamp 1	Value 1	Time stamp 2	Value 2	Time stamp 3	Value 3	…
Time series module	Time stamp	Δ t	Value 1	Value 2	Value 3	Value 4	…

Figure 5: Storage principle of a relational model and the time series module.

Measurements and forecast results are both processed. The forecasted data are used in flood warning and low-flow bulletins which are published on web pages.

Forecasted data	Time of forecast	Time stamp	Δ t	Value 1	Value 2	Value3	…

Figure 6: Storage principle of forecasted data.

The new telemetry system – which contains nearly all measurement stations – ensures that all data are available and thus published online with a delay of maximum 30 minutes during crisis situations.

By means of Export Transfer Load procedures (ETL) data are exchanged with 11 different data sources within and outside of Flanders. All data are stored in the HYDRA database, where they can be accessed by several applications such as the forecasting models.

The HIC researchers query the database thoroughly by means of a VB-application named 'Hydradownload'. For users within the Flemish community, an intranet application is available to download historical data. Due to development problems however, this application is not yet available on the internet. Until now external users must request the data by mail.

HYDRA contains a number of other applications being used by the HIC. An overview of the malfunctioning stations and of the exceeded alert and alarm levels is given on a web page. When an agreed alarm or alert level is reached, the HIC staff is informed by means of SMS and the first flood warning bulletins are published. Flood warning bulletins are published manually as it requires interpretation of skilled hydrologists, but large parts of the bulletin are compiled directly from Hydra.

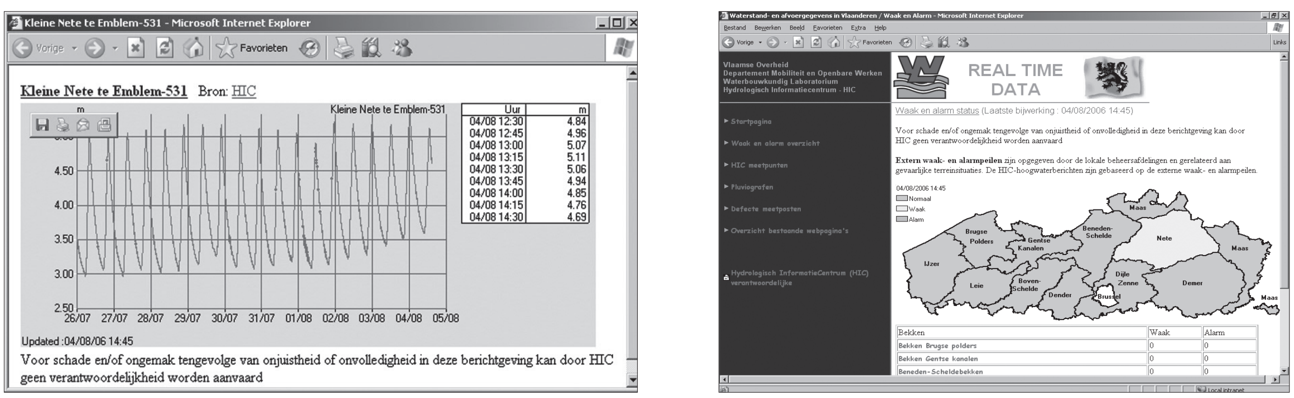

Figure 7: Web pages with recent measurements and an overview of the situation (normal, alert, alarm).

HYDRA+: optimization of the existing database

The principal shortcoming of the current system is the validation process, which still occurs in the AREV database. Moreover, the web application for downloading historical data should be more user-friendly. For these reasons a third phase has been started, which at present is in full development. Final results are expected by the end of 2006.

In the new set-up two databases, HYDRA and WIS (Water Information System), are active in parallel. The two databases functionally complement each other. The combination of both offers a set of functionalities which can't be offered by one of them. The incoming files are converted as quickly as possible and loaded into both the HYDRA and the WIS databases after an automatic validation. Once the data are stored in the database, they are immediately available for different applications and retrievable for scientific validation.

The WIS database is based on the software of KISTERS AG and offers a wide range of possibilities to visualise and validate data. It replaces all previous applications having the same objectives.

By means of a web application based on the WIS database, data can be retrieved in different layouts (charts, Excel, download CSV). Every user receives a login name, for which access rules define the retrievable data and the layout. For example, not everyone is allowed to consult the long-term minute values because this could overload the server.

Derived values are defined and also published on the internet. For minute values for instance, derived mean hourly values or maximum monthly values are made available. For tidal rivers high- and low-water values are derived.

Using access rules as described above, a special environment can be created for privileged users. Thus a specific water manager will be able to access and manipulate data for its region of interest.

Static maps serve as an interface for the web application. They are based on the data in the database. When a station in the database is added or deleted, the map is automatically renewed.

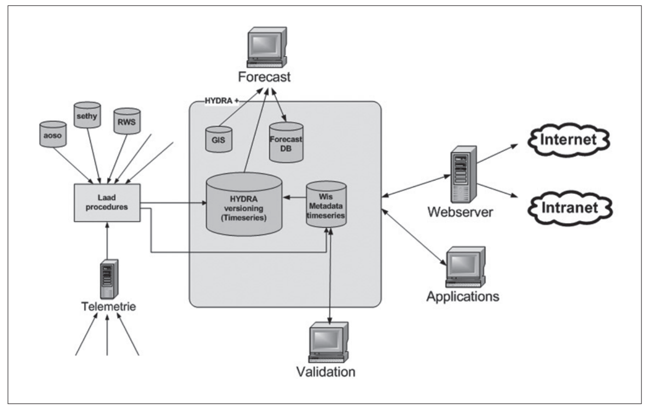

Figure 8: Schematic principle of the HYDRA+ application.

The WIS database only stores raw data and the most recent version of data, called the production time series. Whenever the production time series is changed, the new validated data are sent to the HYDRA database, where they are stored as a new and improved version. Former versions of the same data are also kept. This allows to reconstruct the historic data availability and thus to recalculate simulations that were made in the past identically. The HYDRA database also stores the different versions of forecast data similarly.
The forecasting system also works with data of the HYDRA database and makes use of the data versioning. The original forecasting application worked with several PC's, each running their own forecast model. The new system's forecasting software has its own central database, in which the model configuration is kept for each forecasting model.

In the development of the HYDRA+ system, an important effort was spent on the availability of the database system. For each part of HYDRA+, a back-up system is installed to minimise the probability of failure.

Future evolutions

Possible improvements to the HYDRA+ database include a further improvement of fail-over and security as well as extending the database with all available metadata. Furthermore is the improvement and extension of the internet site with additional information planned as well as modernization of the format of the yearly hydrological reports.

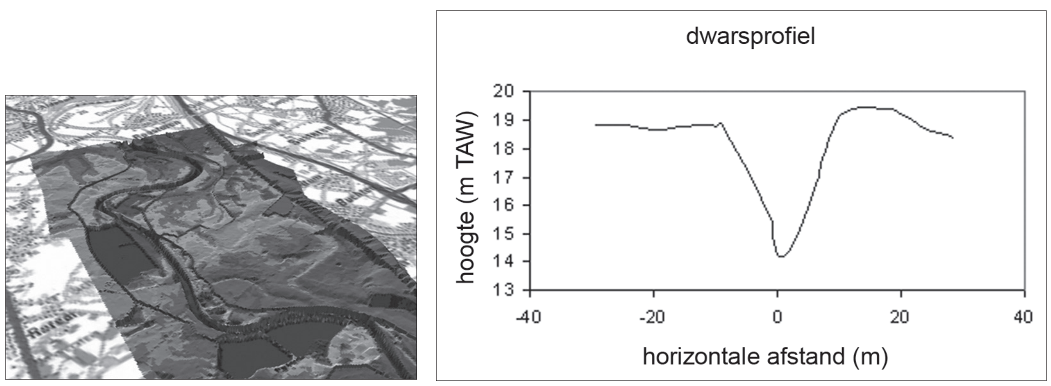

Figure 9: Survey data to be stored in a hydrographical database.

The database will be extended with a server using a versioning system for geographical data. These data will be stored in a Geographical Information System and are used for the website and the forecasting software.

Beside the hydrological database, a hydrographical database will also be created to store survey data of dykes and river banks.

A fileserver with a version management system for the numerical models will be installed. These models are to be fed automatically with versioned time series from the HYDRA+ database and bathymetry data from the new hydrographical database.

Conclusions

The HYDRA+ application is a powerful system for management and retrieval of extensive data sets. The current and future improvements guarantee an even better support. The configuration with two databases combines the best properties of two systems and offers Flanders Hydraulics Research and its clients an innovative, reliable and flexible multipurpose system.
By means of a versioning system, historic data availability can be reconstructed any time, which allows recalculating simulations that were made in the past identically.
Access rules make it possible to create a special environment for privileged users in order to access and manipulate specific data.
Its high availability and required security is an important support for the HIC in providing its main services.

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