A new data management infrastructure for improved analysis and real-time publication of flood events in the Canton of Aargau

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ABSTRACT

In order to take appropriate countermeasures before and during flood events, decision makers, crisis committees, and the public need fast, secure and easy access to real-time hydrological data. In order to meet the increased needs and expectations of internal and external parties, new Desktop and Web-tools for real-time data analysis, data collation, interoperability, and interactive visualization have been introduced, and further developed by the Swiss Canton of Aargau. Customizable tools for hydrological data analysis and cartographic publication are now available, tailored to early warning and flood management. Various features of the newly launched data infrastructure, and the real-time map HydroWeb, are highlighted.

KEYWORDS

early warning; flood management; hydrology; real-time cartography; data interoperability

INTRODUCTION

In the Swiss Canton of Aargau, flood hydrology, emergency management and early warning is a high priority as four of the five largest rivers of Switzerland join on its territory. Superficial waters of about two thirds of Switzerland's area, plus some parts of Germany and Austria, flow through the Canton and are discharged by the Rhine. Floods of different severity have occurred in the past, and will occur in the future. Timely and precise information about the state of the waters, as well as forecasts and runoff predictions provided by Swiss Federal agencies, and coordination with upstream Cantons are vital to prepare for, counteract and coping with floods.

In 2012, the Swiss Canton of Aargau has launched the two-years project "Introduction WISKI", during which a commercial water information system software was evaluated, tested, purchased, and implemented. The goal was to replace the previous software for better management of large archive and real-time hydrological datasets, for enhanced hydrological and GIS-based analysis, and for better interface management with Web-based visualization and publication products. The project contained the introduction of a WISKI-Desktop component and a WISKI-Web component (called HydroWeb). The overall project consisted of the following working packages and deliverables:

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- Securing current, parallel data management operations
- Development of a comprehensive, extendable data model to grant role-based access.
- Conversion of telephone-based and FTP-based data retrieval.
- Processing and migration of legacy data, stage-discharge relationships, authoring of new quality concepts and time series models.
- Realization of new manual and automated publications routines, particularly the generation of approved and provisional hydrological yearbook sheets and special reports
- Linking to desktop and Web-based geo-information systems (GIS) for spatio-temporal analysis and cartographic visualization.
- Adjustable interface management for cloud-based data exchange by means of standardized data interoperability tools.
- Complete re-design and implementation of the Web-based hydrological map publication (browser and mobile enabled) within the existing Cantonal IT-environment.
- Internal training of staff after rollout.
- Provision of a location-independent Intranet-based access to real-time data and analysis tools for cantonal flood management staff (flood on-call service).

The decision of the Canton of Aargau fell on the software WISKI which is marketed by the German company Kisters Inc., Aachen, Germany. One of the world's market leaders in the domain of information systems for water resources management, the company now also specializes in Web-based services and application programmable interfaces (API), reflected by the entrance of the product Kisters Web Interoperability Solution (KiWIS) in the company's portfolio. The company also actively participates in the development of Open Geospatial Consortium's WaterML and TimeSeriesML standard, ensuring that hydrological data comply with international standards (Horsburgh et al. 2009, Yu et al. 2015).

KiWIS allows the Canton of Aargau to tap the full potential of their newly set-up large, hydrological database WISKI. It offers tailored data in real-time to either end-users (e.g., flood committees, public users), or third party applications (e.g., HydroWeb). WISKI acts as a comprehensive (thick) internal Desktop application for complex hydrological data analysis. Products based on KiWIS are Web-based (thin) and therefore rather trimmed to the relevant information, ideal for public users or experts who need to monitor hydrological situations at a glance, before initiating more detailed analysis.

METHODS

Linking real-time measurement data with GIS-data

WISKI-Desktop is equipped with GIS interfaces and an additional extension ensures that WISKI may be used in GIS or GIS may be used in WISKI. The goal of the project component HydroWeb, however, was to leverage KiWIS for (carto)graphic visualization of hydrological real-time data on the Web. The main question was how to handle, and combine huge amounts of real-time data with the cantonal spatial data infrastructure and its Web-based publication utility AGISviewer (Lienert & Meier 2014, Vitolo et al. 2015), since this was one of the main requirements of HydroWeb. The AGISviewer framework had, for the first time, to meet the requirement of handling real-time data. So far, predominantly static, pre-processed Cantonal geo-information products are published in this framework. The choice to realize HydroWeb in the AGISviewer framework, as opposed to an entirely external framework, was based on the arguments that measurement data stay in-house and many existing functionalities and services are reusable.

Integrating various data sources

In HydroWeb, two main distinctions are made as to data sources and measurement network: 1) data sources owned by Canton of Aargau 2) third-party data from other public authorities, such as several Federal Offices, other neighboring Cantons, German State Baden-Wuertemberg (neighboring the Canton of Aargau across the river Rhine), research institutes, and private measurement network operators. Further distinctions are made between a) real-time versus archive, b) enduring versus temporary time series, c) original (non-editable) versus productive (editable) time series, d) persistent versus on-the-fly calculated time series.
The following measuring parameters are stored in the Cantonal WISKI database: precipitation, soil moisture, soil temperature, water temperature, air temperature, groundwater height, pumping volumes, river discharge, various drinking water quality parameters, and various bathwater quality parameters. Further environmental parameters will be integrated in the near future (Lienert & Meier, 2014).

Basic data model

On top of the vendor data model, a cascade of several steps describes and determines the basics of the overall WISKI data model operated by the Canton of Aargau:

– data owner (e.g., Canton of Aargau = AG)
– organization (e.g. Division Landscape and Waters = ALG)
– gauging site (e.g., City of Rheinfelden, and gauge number 0374)
– gauge type (e.g. flowing waters = FG, or meteorology = METEO, etc.)
– measuring parameter (e.g., water discharge = Q)
– time series (e.g., original series with raw data = Cmd.O)
– agents (e.g., agents to import raw, unverified data from some source)

Each of the above mentioned steps has up to a dozen further attributes attached to them, and further interrelations. For example, on each gauging site level, information is stored regarding identification, location (geo-coordinates), and flood statistics.

The Web-Service interface KiWIS

Technically speaking, KiWIS is Web-based application programming interface (API) of WISKI, based on the Representational State Transfer (REST). Using KiWIS, the Canton of Aargau has established a basis to considerably facilitate online collation and publication of hydrological data in real time, to support flood management and other activities. In summary, KiWIS:

- allows for the publication of large amounts of time series data
- supports authorities to perform their legal data publication tasks
- helps foster cooperation with third-parties
- distributes specific data and information to assigned user groups
- enables customers build customized Web-applications and data-hubs, in order to use data across applications

Data requests from external customers may now be conveniently answered by URLs contain all desired information. Other data services were deployed to deliver real-time data to other program components. One component is the real-time list; another component is the real-time map (HydroWeb). Both components are discussed in the next chapter.

RESULTS

Data analysis and publication using real-time lists

The most current data are accessible through either maps or list. The list shown in Fig. 1 is optimized for mobile devices and complies with cantonal corporate design guidelines. As maps are not yet accessible via mobile devices, mobile users are automatically redirected to the list.

KANTON AARGAU Hydrometrie

1 2 3 4 5
aktuelle Gefahrenstufen für Hochwasser

gewählte Liste: ABFLUSS

Aabach	Hitzkirch	01.05.2015	**21:10**	**2**	**m³/s**	pdf
Aabach	Seengen	01.05.2015	**22:00**	**7.4**	**m³/s**	pdf
Aabach	Lenzburg	01.05.2015	**22:00**	**11.7**	**m³/s**	pdf
Aare	Untersiggenthal	01.05.2015	**21:10**	**1291.3**	**m³/s**	pdf
Aare	Murgenthal	01.05.2015	**22:00**	**792.8**	**m³/s**	pdf
Aare	Brugg	01.05.2015	**22:00**	**840.7**	**m³/s**	pdf
Altachen	Reiden	01.05.2015	**22:00**	**0.1**	**m³/s**	pdf
Bruggbach	Gipf-Oberfrick	01.05.2015	**22:00**	**9.6**	**m³/s**	pdf
Bünz	Wohlen	01.05.2015	**22:00**	**18**	**m³/s**	pdf
Bünz	Muri	01.05.2015	**22:00**	**20.8**	**m³/s**	pdf
Bünz	Othmarsingen	01.05.2015	**22:00**	**21**	**m³/s**	pdf

Figure 1: Real-time data list optimized for mobile devices. River discharge, water levels, water temperatures or precipitation are available. Colored data rows indicate the exceedance of pre-defined warning levels.

The list is derived from a tailored KiWIS service and is further processed on the server for better readability. The user may choose one of the measured parameters (river discharge, water level, water temperatures, precipitation) using drop down functionality. The list is immediately reloaded when the parameter is changed, or when the browser is refreshed. For river discharge, the current values are related to different warning levels. Depending on whether and what warning levels are reached, data rows are automatically colored. Warning levels and its coloring comply with Swiss national flood management standards and ensure quick looks. The real-time data list is accessible at www.ag.ch/hydrometrie/liste.

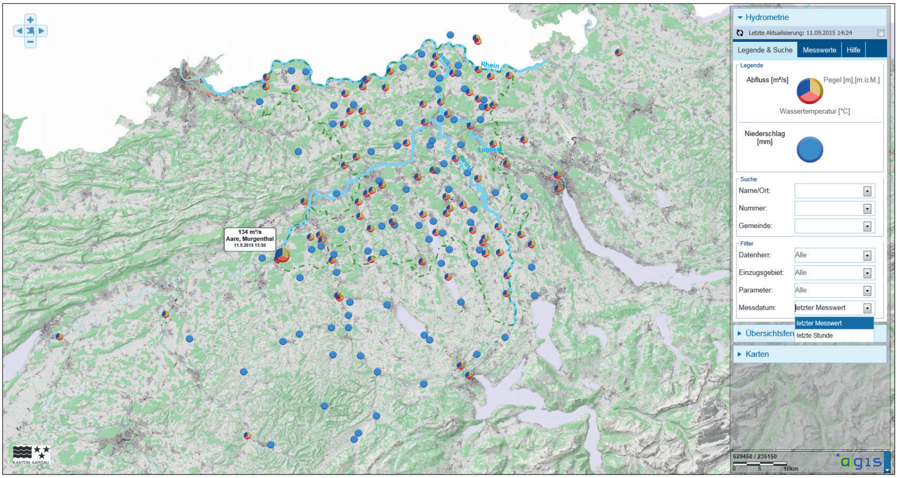

Figure 2: Real-time map HydroWeb on the national scale. Real-time data from neighboring areas and upstream Cantons are also integrated. Base map: Topographic landscape model TLM by Swiss Federal Office of Topography, swisstopo (provided as Webmap-service).

Data analysis and publication using real-time maps

In Fig. 2, the real-time hydrological map with the territory of the Canton of Aargau (dashed border) is shown. Tripartite circle map symbols depict the measured parameters river discharge (dark blue), water levels (green), water temperature (red), and full blue circle symbols represent precipitation gauges.

Depending on the chosen map scale, specific interactivity and responses are provided on HydroWeb. Clicking on the map symbols in the legend window on the right either activates or deactivates onMouseOver-functionality. Depending on the scale, gauge information is either provided when the mouse is moved over the symbol, or attached to the symbol and therefore visible as a flag.

As shown in the map in Fig. 2, several other gauges are visualized outside the cantonal territory. Joint measuring networks (e.g., the precipitation network operations between

Cantons Aargau and Lucerne), as well as real-time data exchange agreements with partner networks allow to publish more than just cantonal data. Key gauges of upstream Cantons are therefore visualized jointly on HydroWeb, helping to get the bigger picture when assessing and analyzing floods.

Space conflicts and cluttering of map symbols on larger overview map scales have been addressed by a scale-dependent filter, giving one gauge location priority over the other. The priority of a gauge was determined expert-based, depending on its overall significance for flood management, measuring network affiliation, measuring quality, and representativity. The prioritization is controllable using a configuration file.

Data widgets, as well as interactive search, and filter functionality are an integral part of HydroWeb. The functionalities are shown in Fig. 3 on the right side. Users may search for gauge locations or numbers, and names of municipalities. Likewise, there are filter options that automatically remove gauges on the map. The following filter criteria are available:
– data ownership
– catchment area
– measuring parameter
– date of measurement

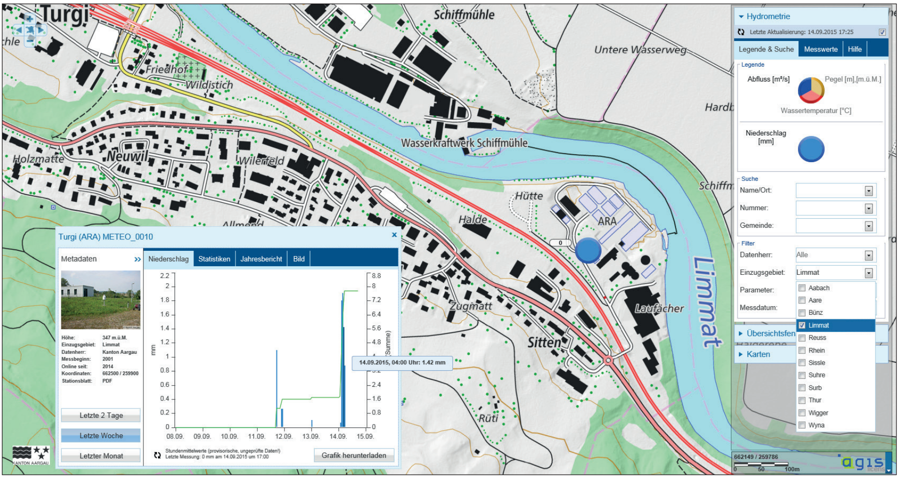

Figure 3: Real-time map HydroWeb on the catchment scale. The data widget contains hourly precipitation data. Time series may be viewed on different temporal aggregation levels (10min, 1h, 1d), and different retrospect (2d, 7d, and 31d).

The map in Fig. 4 contains small flags next to the gauge, some of which with a yellow color, as these have reached a specific warning level. When clicking on such a gauge, the widget shows the time series graph, plus the yellow warning level. The widgets are movable and resizable, and each displays uniform metadata on their left side, and time series information on the right side. On the right side, information is organized by tabs and contains the following items:

– discharge with time series graphs
– water level with time series graph
– water temperature with time series graph
– precipitation with bar graphs, cumulative curves
– statistics with extreme values (river discharge)
– statistics with intensity, sum and event analysis (for precipitation)
– annuals with verified, authorized data of the past year(s)
– gauge images

As shown in Fig. 1, the entire list of available gauges may also be retrieved in HydroWeb, displayed in Fig. 4 on the right side. The list may be sorted as to station name, parameter name, measuring value, or time of last measurement. Clicking on a list item releases an automatic zoom to the chosen gauge. HydroWeb is accessible at www.ag.ch/hydrometrie/karte.

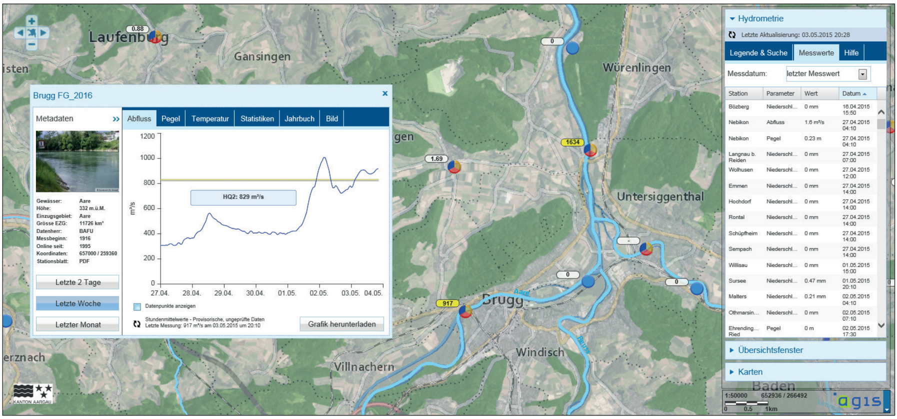

Figure 4: Real-time map HydroWeb on a regional scale. Yellow value flags next gauge symbols indicate moderate danger. In the widget, the graph is visualized jointly with the warning threshold.

FURTHER DELIVERABLES

HydroWeb is supposed to be an "anytime-anywhere" tool for flood management and early warning. It is available in all major browsers and does not require any plug-ins. comprehensive load tests were carried out before rollout and findings showed that the system is capable of handling 5000+ concurrent visitors without noticeable compromises. In order to calculate and analyze visitor statistics, especially during flood events, the well-known Google Analytics tool has been integrated.

Each system component (servers, services, databases, middleware) of the entire WISKI-Architecture is regularly checked by another server for its availability and functionality. A dashboard specifically built for this purpose allows for quick views and performance checks. In case some component is (repeatedly) underperforming, emails are dispatched to cantonal IT-staff.

CONCLUSION AND OUTLOOK

Due to extended technical and organizational requirements, the Swiss Canton of Aargau has introduced new measurement data software, in order to meet the increased needs and expectations of internal and external parties during floods. In order to take appropriate countermeasures before and during flood events, decision makers, crisis committees, and specialists need rapid, secure and easy access to real-time discharge and precipitation data. In September 2014, the Canton of Aargau has introduced the new Desktop-Software WISKI and its Web-based module KiWIS, facilitating data exchange in standardized format, and timely processing and publication of hydrological data, relevant to flood management and early warning. The discussed hydrological real-time map HydroWeb constitutes a "front-end" of these real-time data workflows. It allows for cartographic access to multi-source, multi-parameter, and multi-format data in a harmonized, interactive, and attractive way.

It may be assumed that WISKI will be established at several Cantons and Federal agencies in Switzerland as a tool for hydrological (and other environmental) data management. With this present contribution, experiences and deliverables of the successful introductory project WISKI are shared. Further developments comprise the integration of real-time raster data sets. Presently, a project is carried out that deals with the integration and visualization of raster-based precipitation distribution data in WISKI, and its interface through KiWIS for interactive visualization in HydroWeb.

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