IFKIS-HYDRO - A FLOOD HAZARD INFORMATION AND WARNING SYSTEM FOR SMALLER CATCHMENTS

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1. INTRODUCTION

To avoid damage due to natural hazards, human settlements and infrastructure should be separated from areas that are in the reach of processes like floods, landslides or debris flows. As first measure to achieve this goal, land use planning is used to avoid hazard prone areas. For historical reasons (settlements were built in hazardous regions) as well as for the shortage of secure land, many settlements and infrastructures are not separated from areas potentially threatened by hazardous processes.

Therefore in a second step technical measures are a widely implemented to reduce the area threatened by hazardous processes. However, even technical measures do not allow for a complete separation of these two areas. One reason for this is that technical protection is not feasible against all processes in all dimensions. But more important is that not all possible technical measures are economically, ecologically and socially reasonable. And even with technical measures implemented a residual risk remains. Every protection measure has its design event up to which protection against hazardous processes is guaranteed. Magnitudes of events normally don't have upper limits; high magnitude events just have a smaller probability.

Therefore not only permanent measures but also emergency measures like temporary deflection dikes are implemented to limit the damage caused e.g. by floods or debris flows. Such emergency measures have one important limitation: To be fully effective, they normally have to be installed before an event really happens. In order to minimise missed events and false alarms, emergency managers need best possible information. The crucial point in this respect is time. The bigger a catchment, the longer its reaction time and therefore the more lead time is available for the installation of emergency measures. In small catchments with short reaction times, however, this poses a particular challenge.

This challenge may considerably be facilitated by a site-specific early warning system. In 2004 the development of an information and early warning system for hydrological hazards in smaller catchments (in the range of 1 to 1000 km^2) started. The system referred back to the good experience with avalanche warning (system IFKIS, Bründl et al., 2004) in Switzerland and was therefore named IFKIS-Hydro. This system is shortly explained below.

2. THE BASIC IDEA OF IFKIS HYDRO

During flood events in mountain areas many different processes interfere, e.g. rainfall, wind, discharge, bed load transport, debris flows, landslides and driftwood transport. To allow decisions about emergency measures in small mountainous catchments therefore many different kinds of information have to be collected and combined. Some of the processes can be measured with technical devices (mainly rainfall and runoff); with others sometimes just the impact can be observed (e.g. driftwood clogging a bridge). Only for few of these processes forecast models exist (whether forecast and in some catchments runoff forecast) but for most of them no such models are available.

A basic set of information always concerns current weather and weather forecasts. Both sets of information are of similar importance. With floods past and present weather information explain the current situation in a catchment and the immediate future, forecasts are used to assess possible trends in the longer run.

The next set of information concerns runoff. If a gauging station is installed, runoff measurements are available. However by far not in every river or creek potentially threatening with floods, such stations can be installed. Therefore observations by trained persons are a very important method to collect information about water levels and discharge (see figure 1). This fully makes sense as at many sites not only runoff information is needed but also information about related processes like bed load transport or driftwood. Since there are no technical measuring or observation devices available for these processes, observers have to be on site anyhow and they can collect information about water levels too.

Figure 1: IFKIS Hydro observation site in the area of the Simplon Pass (Valais, Switzerland). During intensive rainfall periods, local observers pass at this site in regular intervals collecting information about water levels, bed load depositions and other important information.

If a time series of reliable runoff measurements of several years exists, it can be envisaged to implement a hydrological forecast model. As part of IFKIS-Hydro up to now the model PREVAH has been used. This model widely used in Switzerland is explained below.

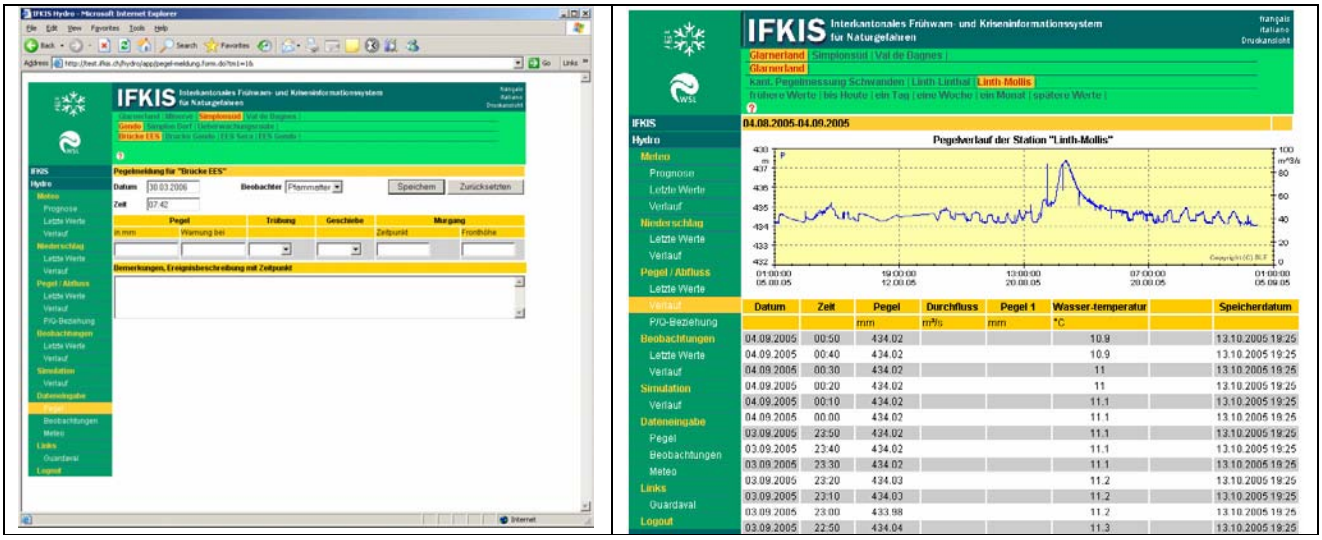

Figure 2: Screen shots of the IFKIS-Hydro web platform. The left image shows the screen where observations at a site as shown in figure 1 can be entered. The left image shows a measured hydrograph

All this information is then collected in a database and presented on a web based platform (figure 2). The platform also allows looking at information from earlier events for comparison. Information about earlier events does not necessarily include measurements or observations as described above. For events that took place before such a system was installed a simpler form of information, mainly qualitative descriptions of processes and damage, can be used too.

To allow for comparison between different catchments and to detect trends in initial conditions in any basin, a geomorphic survey of all catchments incorporated in IFKIS-Hydro has to be carried out from time to time. In such geomorphic surveys traces of past processes are assessed together with information on the actual state of a catchment (soil, geology, etc.) to develop scenarios, what combinations and magnitudes of processes have to be expected in future events. Such surveys should also be carried out after every major event, to detect changes in the catchment in areas that are not covered with observations during events for security reasons or for the limited availability of trained staff. The results of such surveys will also be made available in the web platform.

The system IFKIS-Hydro is based on the three pillars described above:

- On geomorphic surveys to assess the so called disposition of a catchment for hazardous processes,
- On information about past events and,
- In the case of an emergency on information (measurements, observations) and forecasts describing the past and probable future development of this event.

Emergency managers can then assess this information and make their decisions and their planning based on best available information. Decisions in emergency situations are in many cases mainly choices between different plans that have been established beforehand. Even with the best forecasts time will be too limited to carry out a full scale planning process (including staffing plans, organisation of necessary material etc.) in the case of an emergency. Therefore a system like IFKIS-Hydro does not replace careful planning for different scenarios (possible emergency situations), but the combination of emergency plans (e.g. Romang et al. 2006)and of an emergency information system like IFKIS-Hydro increase each others value drastically.

3. THE HYDROLOGIC FORECAST MODEL PREVAH

The spatially distributed hydrological model PREVAH (Precipitation-Runoff- EVApotranspiration-HRU related model) has been selected for runoff predictions (Gurtz et al. 1999). PREVAH has been originally developed with the intent of improving the understanding of the spatial and temporal variability of hydrological processes in catchments with complex topography. For full information on the model physics, structure and parameterizations we refer to previous work with PREVAH (Zappa 2002, Verbunt et al. 2006, Wöhling et al. 2006). PREVAH is forced by interpolated values of observed climatic variables. Six meteorological variables are required: precipitation, air temperature, global radiation, relative sunshine duration, wind speed and relative humidity.

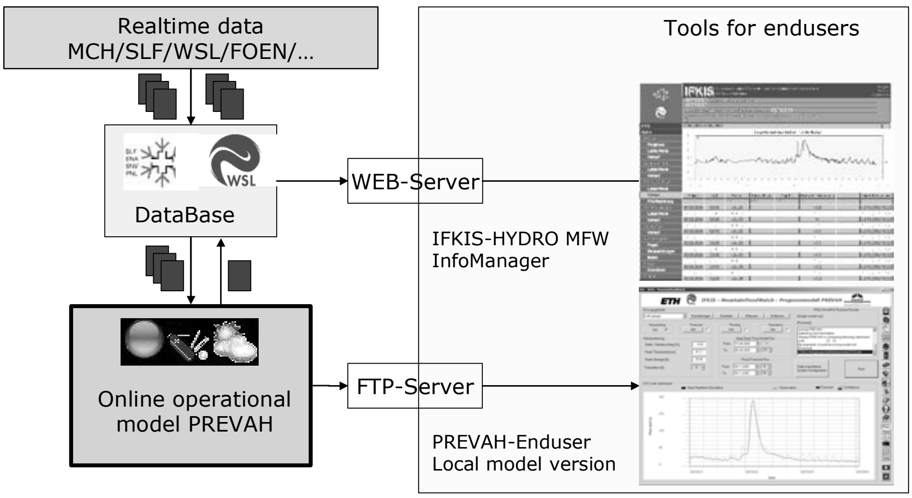

Figure 3: Work flow of the forecast model PREVAH, as implemented in Canton Glarus for real time runoff nowcasting and forecasting. Screen shots of the IFKIS-Hydro web platform.

The newly developed operational version of PREVAH is embedded in a complex system guaranteeing the real time flow of the required meteorological information (Figure 3). PREVAH obtains such data from an operational database operated at SLF. This database collects and integrates information from different observation networks: the Swissmetnet network of MeteoSwiss (MCH), the IMIS network of SLF/WSL, the hydrometric network of the Swiss Federal Office for Environment (FOEN) and other local data sources such as cantonal hydrometric stations and rainfall gauges of hydropower companies.

Once every hour the online PREVAH version running on a LINUX machine downloads the newest information from the database, runs its spatial interpolation procedure and performs a model run over the last 13 days. At the end of the operational model run the results (precipitation, runoff, snow water equivalent, evapotranspiration, and soil wetness) are uploaded into the SLF database. After the upload the latest data can be accessed though the InfoManager Web-Platform (Figures 2 and 3). Furthermore, the metadata for running the 13-days simulation are uploaded to a dedicated FTP-Server. The end-user can access such Server and use this data to make local model runs with a specific Desktop-Version of PREVAH with friendly graphic user interface running on standard Windows computers. With this Desktop-version the end-user can perform forecasts. To achieve this he can interactively feed PREVAH with forecasted rainfall and temperatures for the next days and start a forecast run. After a forecast run it is possible to vary the forecasts in order to explore which conditions have to occur in order to trigger a hazardous flood event within the basin. The local model version also allows the modification of the initial conditions and the update of the model in order to fit the latest observations (Wöhling et al. 2006).

With this system it is possible to provide precious information in order to coordinate mitigation strategies previous and during alarm situations. The nowcasting system is currently implemented for the Linth basin up to the Mollis gauge (600 km²) in the canton of Glarus (central Switzerland).

4. OUTLOOK

The new possibilities e.g. offered by ensemble weather forecast systems and radar now casting, open up challenging and exciting new opportunities for emergency managers dealing with floods and related processes. However as emergency managers normally are not meteorologists or hydrologists, they are probably facing quite some problems in implementing the full potential of these new types of information. Therefore we think that it is necessary to have specialists for natural hazards in every crises staff, which can analyse this information and draw the necessary conclusions for the specific site they are responsible for. The project MAP-D-PHASE will evaluate how this information can be put into value for emergency managers.

To fully make use of the potential of these new meteorological forecasts also hydrological forecast methods have to be improved. Up to now hydrological forecasts work fully deterministic. With this all uncertainties about antecedent moisture etc. are ignored. It has to be expected that this and other simplifications in the hydrological models actually in use will become more important and also visible in the new environment. Therefore an improvement of hydrological models especially for small catchments has to be tackled in the near future. This has to happen if possible together with attempts to develop forecast models for debris flows and landslides.

All these developments will not be able to replace observations at specific sites. This information will remain an essential part of any emergency management system in mountain areas. Together with better forecasts it will even become more valuable because it forms the base to assess trends correctly.

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