Swiss Hydrological Commission CHy
of the Swiss Academy of Sciences
3000 Bern

Report on

Conference on “Operational Hydrological Forecasting”

Improvement at all levels

Many aspects of flood forecasting have improved in recent years: more accurate weather forecasting, differentiated hydrological models, and better communication among the parties involved will be of help in coping better with future crisis situations. However, there is still a need for action in many areas, ranging from the scientific bases of forecasting to prevention. This became clear at an international conference recently held at the University of Bern.

The pictures are always similar. And so it was again this spring when many parts of Poland and southern France were afflicted by major floods. There is no disputing the need for reliable and timely recognition of extreme events of this sort. Although flood forecasting models have been continually improved in recent years, great operational uncertainties are regularly apparent with respect to forecasting exactly when which areas will be flooded. About 100 experts gathered at an international conference on “Operational Hydrological Forecasting” held at the University of Bern on 14 and 15 June 2010 engaged in discussions about practical daily experience with modeling and about the scientific efforts that need to be made to close existing operational gaps. The conference was organized by the Swiss Society for Hydrology and Limnology and the Swiss Hydrological Commission, in cooperation with the Institute of Geography at the University of Bern and the Federal Office for the Environment.

Highly satisfactory medium-term prognoses

Flood forecasting is based on two cornerstones: measurements of runoff and precipitation data. In particular, forecasts of where, when and how much rain- or snowfall will occur is of central importance in assessing flood situations. The weather forecasting model known as COSMO, developed by an international consortium of the same name, has been successfully applied in recent years in Switzerland. This model provides short-term deterministic forecasts as well as ensemble predictions that facilitate medium-term forecasts. MeteoSwiss today uses the COSMO-2 model, which is based on a grid spacing of 2.2 km above the mountains, for short-term forecasts. This small grid size makes it possible to represent large Alpine valleys in the model and to calculate convection over the mountains explicitly. While COSMO-2 makes a deterministic forecast every three hours covering the next 24 hours, a second model – COSMO-LEPS – calculates an ensemble of 16 total possible developments over the next five days using a grid spacing of 7 km.

In operational terms, it is clear that an approach consisting of thoroughly calculating and statistically evaluating several ensembles allows highly satisfactory prognoses for a period of several days. Both meteorological knowledge and knowledge of how numerical models function are required in order to interpret the calculated data reliably. Every model has its strengths and weaknesses and accordingly reacts in different ways to different weather situations. Ongoing critical evaluation of models is important, particularly in the case of extreme events; models frequently have difficulty predicting actual developments with reliability in extreme situations.

International exchange of data

Different examples from Switzerland and abroad were used at the conference in Bern to demonstrate how meteorological prognoses are integrated concretely into hydrological forecasts. In many cases it is necessary for the responsible bodies to cooperate across national borders. The central flood forecasting office (Hochwasservorhersagezentrale, HVZ) in the state of Baden-Württemberg, for example, is involved in close exchanges of information with the Swiss Federal Office for the Environment and the Amt der Vorarlberger Landesregierung (Austria) when the situation on the Lake of Constance or along the Rhine River becomes critical. Private partners are also involved in exchanges of information: the energy company Electricité de France, for instance, relies on the accuracy of the hydrological data it keeps on the catchment area of the Rhine in order to operate its power plants along the river at optimal capacity. The company uses data such as those posted on the Internet by the Federal Office for the Environment. Conversely, the energy company makes its own prognoses on runoff available to other partners such as the HVZ in the interest of contributing to better flood management.

The cantons of Valais and Waadt have undertaken an ambitious project: they are using a new flood management system known as MINERVE for comprehensive monitoring of the situation from the source of the Rhone River to its mouth at the Lake of Geneva. This system is based on a numerical hydrological simulation model constructed with inputs consisting of meteorological forecasts and runoff measurements. The model serves on the one hand to recognise critical situations and trigger alarms; on the other hand, it also provides the necessary bases for reducing the impact of critical flood situations through targeted control of reservoirs and power plants. The developers of MINERVE – a model elaborated by scientists from the EPFL and the University of Lausanne – had a particularly critical task to manage in this respect, as the Canton of Valais has very great differences in elevation that result in a very complex precipitation and runoff situation. Thus on surfaces covered by glaciers or snow, runoff varies depending on the season; this in turn has an influence on the water level in rivers in the valley.

Today there is widespread consensus among experts that such hydrological forecasting systems are an important contribution to prevention or mitigation of flood damage. The report entitled “Optimierung von Warnung und Alarmierung bei Naturgefahren”

(OWARNA; “Optimising Warning and Alarm during Natural Disasters”) showed that damage from floods in 2005 would have been an estimated CHF 600 million less with better warning and alarm systems. Switzerland’s Federal Council accordingly decided on 26 May 2010 to expand Switzerland’s alarm system and to ramp up the responsible departments within the Federal Office for the Environment. At the same time cooperation between federal authorities and managerial staffs in the cantons and communes is to be improved.

Taking account of different demands

Making hydrological prognoses is one thing; applying them in practice is quite another thing. In the final analysis, decisions must be made in specific cases that can have far-reaching and costly consequences. This is particularly the case wherever the hydrological budget in a catchment area can be influenced by regulation of lakes. In the Canton of Bern, for instance, the levels of the Lake of Thun and the Lake of Biel are regulated by locks so that runoff from the Aare River can be precisely controlled. Flooding in the years 1999, 2005 and 2007 showed that targeted regulation of lakes can be decisive in mitigating the situation.

From the perspective of flood protection it also makes sense to reduce the water level in lakes prior to periods of heavy precipitation as a preventive measure in order to create additional intake capacity. Other aspects must also be taken into account when doing this, however. Reducing lake water levels too greatly can produce damage in ecologically sensitive shallow water areas and also have a negative impact on boat traffic important to the tourist industry. Different interests must always be balanced against each other in critical situations. New, forward-looking regulatory instruments were developed for the lakes of Thun and Biel so that the responsible offices know how to act in the event of a crisis. These instruments provide clear bases for decision-making regarding the conditions under which water levels in both lakes can be greatly reduced.

The Office for Waste, Water, Energy and Air in the Canton of Zurich, on the other hand, is confronted with a very different challenge. If the heavy precipitation of August 2005 had not occurred above Central Switzerland or the Bernese Highlands but above the catchment area of the Sihl River, large portions of the city of Zurich – including the main railway station – would have been inundated. Yet many official governmental offices are still not aware that the city of Zurich is exposed to a serious risk of flooding. In view of the construction of the new cross-over railway line from Altstetten to Oerlikon, the core of which is a new railway station to be constructed under the Sihl River, the Canton of Zurich installed a costly flood warning system. A second step in this process will involve clarification of how construction measures can better protect the city of Zurich from floods.

Ongoing evaluation

Although hydrological forecasting instruments have been considerably improved in recent years, there is still a need for research and development. Runoff forecasts made with different hydrological and meteorological models were verified in the context of a study carried out by the Federal Office for the Environment and the Federal Office for Forest, Snow and Landscape Research (WSL). This study showed that it cannot be stated a priori which hydrological model is basically more reliable. Even the application of high-resolution weather models does not lead to better prognoses in every case. For practical application, it is important to know in which areas the models do not work reliably today so that these forecasting instruments can be specifically improved.

The WSL is currently engaged in different projects to improve hydrological models with a view to operational use. The PREVAH hydrological model that underwent continual development at the ETH Zurich, the Institute of Geography at the University of Bern, and the WSL plays a particularly important role in this regard. Forecasts have been made with PREVAH in over 25 catchment areas since 2007, and PREVAH will also be integrated as an additional forecasting model in the Federal Office for the Environment's "Flood Early Warning System" (FEWS) beginning in summer 2010. In addition, the WaSiM hydrological model (water budget simulation model), the basis for which was elaborated at the ETH Zurich in the 1990s, is also to be developed further. In recent years it has been possible to include in the model different important factors that also influence river runoff regimes such as permafrost, groundwater and land use. WaSiM is used in the context of FEWS for operational forecasts and also in many other countries.

Improved bases for snow

Those areas where there are still gaps in the basis for modeling are naturally of interest for research. One aspect that plays a major role, particularly in spring, is accurate incorporation of snow in the models. Switzerland has a dense measuring network; snow depth in winter is measured at about 300 sites. Snow water equivalent, the relevant parameter for flood forecasting, is only sporadically determined however, i.e. every 14 days at 40 sites. The Institute for Snow and Avalanche Research (SLF) has now developed a model for determining corresponding snow water equivalent from snow depth. Based on calculations with this model, the SLF regularly produces maps that can be used for operational assessment of conditions in flood situations.

Researchers in the Group for Hydrology at the Institute of Geography, University of Bern, are confronted with a very different problem: they are developing methods for making robust flood warnings also in smaller catchment areas. Reaction times in such catchment areas are as a rule very short; at the same time, inaccuracies in precipitation data lead to serious errors in flood forecasting. Both these factors make it difficult to assess the situation in specific cases. Researchers in Bern are pursuing two approaches to deal with this problem. The first involves real-time calculation of the hydrological situation, first in a medium-size catchment area; information about smaller areas of a catchment can be derived from this. The second approach involves increasing the forecasted precipitation intensity in the model step by step. This allows for determination of the point at which the amount of precipitation could lead to a critical development.

In terms of practical response, it is crucial for responsible governmental offices to be able to get a rapid, thorough overview of a situation. The Institute for Cartography at the ETH Zurich and the Institute of Geography at the University of Bern have therefore developed a cartographic model that decision-makers can use in an emergency to access both current and historical measurement data in order to get an overview. Presentation on an interactive map provides those responsible with a continual and comprehensive overview and thus helps them to assess a situation correctly. In the final analysis, even the best prognoses are of little use if local crisis management teams and emergency responders lose their overview and are therefore no longer in a position to take the right measures to cope with critical events.

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Note: Detailed documents on the conference can be found on the website of the Hydrological Commission at:
http://chy.scnatweb.ch/d/Aktuell/Veranstaltungen/vergangene_Veranstaltungen.php

Figures:

Figure 1: Hydropower plants use runoff forecasts to plan their operations, particularly during flooding. The Winznau retaining dam regulates inflow from the Aare River to the bypass channel of the Gösgen run-of-river plant. (Photo by Bruno Schädler)

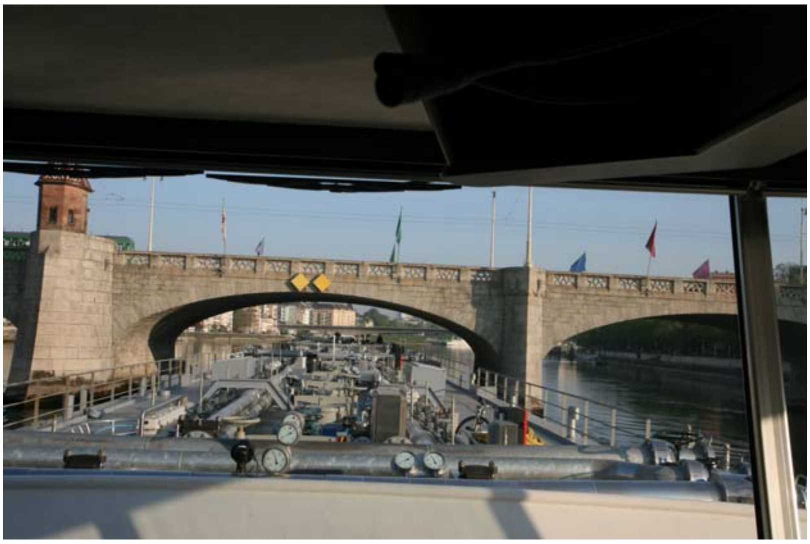

Figure 2: Forecasts of low and high water levels are important to ship traffic on the Rhine. Will there still be enough space under the middle bridge over the Rhine in Basel for the downstream journey of the TMS OASE (125 m long and 11.45 m wide) the day after tomorrow? (Photo by Peter Sauter).

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