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The state of the art of flood forecasting – Hydrological Ensemble Prediction Systems

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Flood forecasting systems form a key part of 'preparedness' strategies for disastrous floods and provide hydrological services, civil protection authorities and the public with information of upcoming events. Provided the warning leadtime is sufficiently long, adequate preparatory actions can be taken to efficiently reduce the impacts of the flooding. Because of the specific characteristics of each catchment, varying data availability and end-user demands, the design of the best flood forecasting system may differ from catchment to catchment. However, despite the differences in concept and data needs, there is one underlying issue that spans across all systems. There has been an growing awareness and acceptance that uncertainty is a fundamental issue of flood forecasting and needs to be dealt with at the different spatial and temporal scales as well as the different stages of the flood generating processes.

Today, operational flood forecasting centres change increasingly from single deterministic forecasts to probabilistic forecasts with various representations of the different contributions of uncertainty. The move towards these so-called Hydrological Ensemble Prediction Systems (HEPS) in flood forecasting represents the state of the art in forecasting science, following on the success of the use of ensembles for weather forecasting (Buizza et al., 2005) and paralleling the move towards ensemble forecasting in other related disciplines such as climate change predictions.

The use of HEPS has been internationally fostered by initiatives such as "The Hydrologic Ensemble Prediction Experiment" (HEPEX), created with the aim to investigate how best to produce, communicate and use hydrologic ensemble forecasts in hydrological short-, medium- und long term prediction of hydrological processes. The advantages of quantifying the different contributions of uncertainty as well as the overall uncertainty to obtain reliable and useful flood forecasts also for extreme events, has become evident. However, despite the demonstrated advantages, worldwide the incorporation of HEPS in operational flood forecasting is still limited. The applicability of HEPS for smaller river basins was tested in MAP D-Phase, an acronym for "Demonstration of Probabilistic Hydrological and Atmospheric Simulation of flood Events in the Alpine region" which was launched in 2005 as a Forecast Demonstration Project of World Weather Research Programme of WMO, and entered a pre-operational and still active testing phase in 2007. In Europe, a comparatively high number of EPS driven systems for medium-large rivers exist. National flood forecasting centres of Sweden, Finland and the Netherlands, have already implemented HEPS in their operational forecasting chain, while in other countries including France, Germany, Czech Republic and Hungary, hybrids or experimental chains have been installed.

As an example of HEPS, the European Flood Alert System (EFAS) is being presented. EFAS provides medium-range probabilistic flood forecasting information for large trans-national river basins. It incorporates multiple sets of weather forecast including different types of EPS and deterministic forecasts from different providers. EFAS products are evaluated and visualised as exceedance of critical levels only – both in forms of maps and time series. Different sources of uncertainty and its impact on the flood forecasting performance for every grid cell has been tested offline but not yet incorporated operationally into the forecasting chain for computational reasons. However, at stations where real-time discharges are available, a hydrological uncertainty processor is being applied to estimate the total predictive uncertainty from the hydrological and input uncertainties. Research on long-term EFAS results has shown the need for complementing statistical analysis with case studies for which examples will be shown.