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Development of an adaptive flood forecasting model for the White Elster catchment – concepts and methods

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Extreme floods are the result of extreme rainfall events. Magnitude and frequency of such events has increased during the last 30 years in low mountainous areas. Consequently, a continuation of this trend will increase the frequency of extreme flood events. The forecast of discharge and water levels during extreme events is still afflicted with considerable uncertainty, as could be seen during the flood event in the Elbe basin 2002.

The objective of this work is i) the development of a real-time flood forecasting model implementing a run-time calibration algorithm and ii) to update flood probabilities by the aid of precipitation-runoff modelling, using actualized distributions of extreme rainfall events. This contribution focuses on the conceptual approach and the methods to be used.

For rainfall-runoff modelling the hydrologic model WASIM-ETH (Shulla 1999) will be used in combination with the hydraulic river model FEQ (Franz & Melching 1997). The models are set up for batch and real-time simulations. In the batch mode, the simulations transform a given rainfall distribution into a discharge distribution. In the real-time mode, the simulation period is incrementally moved in time and new observations and new forecasts of weather information are incorporated into the model. In this application, the forecasts are taken from historical data series.

In our opinion, advancing the simulation of extreme hydrologic events, needs to consider the following issues. 1) In real-time flood forecasting, model results are generally corrected by a gain factor based on the deviation to observed discharge values. This method fails, however, if gauging stations or signal transmission collapse, as it is not based on an appropriate representation of the physical processes involved. 2) Model parameters are assumed to be time-invariant, which does not necessessarily be the case. However, little is known about time-variant parameter behaviour in hydrologic models. 3) The uncertainty associated to model predictions is a key information to increase credibility of the models.

The key idea of our modelling approach is to perform parameter optimisation, sensitivity analysis and uncertainty analysis in a moving window context, i.e. an "observation" period beeing incrementally moved along the time axis. For each move, a new optimization run and uncertainty and sensitivity analyses are started. The combination of these moving-window simulations shall reveal changes of parameters, sensitivities and uncertainties during the total simulation period. A complementary analysis of model behaviour in "batch" mode will provide a reference for comparison purposes. The moving window scheme will also provide the framework for real-time simulations with a continuous update of weather forecasts and discharge observations. Depending on the results of the preceding analysis, the results can be incorporated into a real-time forecast model in two possible ways: If parameter variance can be related to state variables in a functional form, this relations can be incorporated into the model as a rule for parameter update during run-time of the model. If this is not the case, the model has to be corrected according to observed data by changing parameters or parameter groups according to their sensitivity.

For optimization, sensitivity analysis and uncertainty analysis we use various methods and software packages being developd during the last years, e.g. UNCSIM (Reichert 2003) and Parasol-Sunglasses (Van Griensven & Meixner 2003).

The calculation of flood probabilities is based on the continuous precipitation-runoff simulation using stochastically generated rainfall data. This approach allows to create an arbitrary number of realistic precipitation scenarios. The continous simulation leads to a large amount of hydrologic events determined by precipitation on the one hand and the associated catchment response on the other. Frequency distributions will be adapted to multiple scenarios allowing a statistical analysis of peak discharges for given return periods.

The simulation studies are carried out for the White Elster basin (5300 km^2), a tributary to the Saale/Elbe river system covering parts of Saxony-Anhalt, Saxony and Thuringia and Czech republik.

The methods applied introduce the concept of parameter uncertainty in discharge prediction and the concept of non-static parameter values. We expect that the results of this approach enable hydrologists to generate consistent model predictions and information on the uncertainties of these predictions.

Literature

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