A statistical model derived from process-based modelling to assist flood risk minimising reservoir operation in a pre-alpine flash flood prone catchment

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Construction activities at the central railway station of the Swiss metropolis Zurich temporarily enhance the risk for flooding due to reduced cross-section of River Sihl, which drains a flash flood prone catchment with an area of 336 km^2. Floods triggered in the headwater area (155 km^2) can be retained by a large reservoir (Lake Sihlsee) constructed for hydroelectric power production. An anticipatory operation of this reservoir based on an early flood-warning system can simultaneously reduce the flood risk downstream of the dam and minimise the economic losses due to excessive release of water, which cannot be used for hydropower production, prior to heavy rainfall. Ideally, such a flood warning system includes a complex, deterministic watershed model driven by meteorological weather forecasts. However, more straightforward approaches for flood risk oriented reservoir control can sometimes be required owing to a tight time schedule or limited funding available for development of appropriate rules.

Our study discusses the development and application of a statistical model which can be used for peak flow forecasting as well as for planning of precautionary reservoir operation to minimise the likelihood of flooding. The statistical model is presented as a matrix of scatter-plots relating areal precipitation of different duration to peak flow at the catchment outlet, also considering initial water levels in the reservoir. A combined deterministic hydrologic-hydraulic modelling system was set up to provide the data needed for the statistical model. This system was employed to simulate runoff response from observed rainfall events, taking into account the different initial reservoir water levels. Furthermore, the modelling system was used for extrapolating the range of observed rainfall-runoff events with help of rainfall scenarios. The statistical model has proven its utility in practical application. It supports a team of specialists in their decision on reservoir operation in case of flood warnings.