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Capabilities and limitations of a process-based hydrological model for flash flood simulation

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Flash floods can cause severe damage to affected inhabited areas and are therefore a major concern to municipalities at risk. The unpredictable occurrence of flash floods in space and time, mostly induced by short and extreme convective rainfall events, still impose large challenges on any mitigation and adaptation measure. The means to simulate the triggers and dynamics of flash floods with hydrological and hydrodynamic models remains a critical current research task.
In this study, we assess the capability of the process-based, spatially distributed hydrological model WaSiM (www.wasim.ch) to simulate flash floods in Bavaria (Germany). The model is supposed to provide two services: a) ability to reproduce the initial conditions before the extreme rain event, since these are considered to have a major impact on the timing and severity of the flash flood and b) simulation of the flash flood event in a satisfactory manner (timing, runoff volume). Some aspects of flash flood dynamics impose difficulties for a water balance model like WaSiM, as some of the relevant processes are not sufficiently described (e.g. overland flow, hydraulic flow simulation, log/debris jams) and require event-specific parameterization to better capture peak time and flow of runoff extremes. Nevertheless, the results of the hydrological model are needed to describe the hydrological behavior of the upstream catchment, often providing significant amounts of the destructive discharge in the affected urban areas. Therefore, a nesting approach is proposed within a one-way-coupling scheme, where the hydrological model provides the streamflow input to a fully-hydraulic 2D model, which utilizes the streamflow data from the upstream catchment to provide more detailed information for the urbanized areas below.
This study thus comprises three parts: 1) Set up and calibrate a hydrological model towards water balance terms to accurately implement the basic hydrological behavior of the catchment in the model for retrieving initial conditions at any time. 2) Change parameterization and spatio-temporal resolution of the model to aim for a sufficient representation of the flash floods (event calibration). This includes the research question if the model is able to properly simulate flash floods, and which approximations in process parameterizations are necessary. 3) Use the acquired knowledge from several study sites, to generalize a setup procedure for flash flood modelling. This procedure to simulate artificial flash flood events is then transferred to a large number of municipal catchments in Bavaria.

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