Assessing the benefits of coupling hydrological and hydrodynamic model approaches for an improved simulation of flash floods

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Heavy rainfall and resulting flash flood events have been in the focus of research and the public in recent years. The relevance of the topic will become more prominent with increasing temperatures due to climate change. Extreme rainfall events in Germany like 2014 in Münster (North Rhine-Westphalia) or 2016 in Simbach am Inn (Bavaria) and Braunsbach (Baden-Wurttemberg) have also raised public awareness.

Hydrodynamic models for the simulation of fluvial events have been developed for a long time and are often used. However, the question arises to what extent these methods can be used for pluvial events. Hydrodynamic models allowing precipitation input are therefore well suited for the simulation of pluvial events, as they can display flow paths, depths, and velocities in high resolution. Nevertheless, defining precipitation without infiltration leads to an overestimation of the surface runoff. For this problem, an improved event simulation can be achieved by nesting hydrological processes into the hydrodynamic simulation procedure. In this study, we are using TELEMAC-2D as a hydrodynamic model because it uses precipitation in a spatially and temporally distributed manner and can be used very well by high-performance computing. LARSIM (Large Area Runoff Simulation Model) and WaSiM (Water Flow and Balance Simulation Model) are used as hydrological models.

The methodology for simulating flash floods can be divided into two important processes: runoff generation and runoff concentration. These are divided according to the strength of the respective model types:

- Runoff generation: SCS-CN value method (TELEMAC-2D), Green Ampt method (LARSIM), layer-resolving Richards method (WaSiM)
- Runoff concentration: Strickler roughness approach (TELEMAC-2D), Kalinin-Miljukov method (LARSIM), flow time index method (WaSiM)

In this study, we examine three different types of couplings:

1. The runoff concentration is calculated using the hydrodynamic model, the runoff generation...
is carried out using the CN value method.

- (2) The runoff generation in the entire catchment is calculated using the hydrological processes (LARSIM/WaSiM). The runoff concentration is still generated by the hydrodynamic model.
- (3) The runoff concentration in the upper catchment area is also calculated using hydrological methods, only the urban area is calculated hydrodynamically.

We compare the different coupling types with each other using some real flash flood events. The results are presented with the aim to identify which approach is necessary for a good representation of the flash flood event. This depends mainly on the local conditions in the catchment area (e.g. culverts, land use) and the rainfall event (e.g. rainfall intensity and duration).

The findings from this study will be transferred to unobserved catchments in the further course.