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Coupling atmospheric, hydrological and hydraulic models to develop a catalogue of worst-case scenarios for extreme flooding in Switzerland

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Extreme flooding are a natural threat that leads to great economical cost, especially in densely populated areas such as Switzerland. However, the study of such extremes is difficult due to the fact they are, by definition, very rare, whereas the instrumental period is relatively short. This hampers the study of events with large return periods, which are precisely those more relevant from the impact point of view. Thus, new methodologies have to be developed that provide a deeper understanding of such disastrous situations and their driving mechanisms. This study employs a chain of models that allow the study of the frequency and severity of such situations and to analyse their driving physical mechanisms. First, a long climate simulation (a control simulation spanning more than 500 years) with the comprehensive Global Circulation Model (GCM) CESM1 is used as test-bed for producing a dataset of several centuries of physically consistent climate. This data is then used to filter out a number of case studies corresponding to extreme situations, which are selected as candidates for further analysis. However, although the physical consistency of this simulation ensures that the synoptic circulation leading to the selected events is plausible, the global model employs a coarse spatial resolution (1 degree) that precludes the accurate simulation of the precipitation in areas of complex topography such as Switzerland. Hence, once the dates of the candidate cases are selected within the GCM run, this dataset is downscaled with the Regional Climate Model (RCM) WRF. The RCM implements a spatial resolution of 2 km over the entire alpine area, which allows it to reproduce more accurately the precipitation induced by interactions between the large-scale forcing and the orography. The results show that WRF is able to improve the simulation of precipitation compared to the GCM alone. Although the large-scale flow and the location of the precipitation maxima is very similar in the high-resolution simulation (as it is driven by the boundary conditions provided by the GCM), the spatial structure of the precipitation is refined, producing stronger precipitation gradients that allow to identify the main orographic barriers. Further on, much higher precipitation rates occur in some river catchments, which are indicative of potential disastrous situations at very localised regions. In a next step, the results of the atmospheric-alone RCM simulations will be used to drive the hydrological model PREVAH. This model produces event hydrographs, that represent plausible catchment reactions on the simulated precipitation produced by the RCM. The event hydrographs will be then routed with the 1D/2D hydraulic model BASEMENT-ETH, that accounts for the retention effects of lakes and inundated areas. Hence, the described model chain will eventually simulate a number of physically plausible peak discharges in Switzerland that are determined by the most extreme situations occurring in the GCM simulation. This will enable the analysis and characterisation of worst-case floodings in Switzerland whose return period exceeds several centuries.