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Development of a data-driven distributed hydrological model for regional scale catchments prone to Mediterranean flash floods

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Flash floods represent one of the most destructive natural hazards in the Mediterranean region. These floods results from very intense and spatially heterogeneous rainfall events. Distributed hydrological models are valuable tools to study these phenomena and increase our knowledge on the main processes governing the generation and propagation of floods over large spatial scales. Distributed hydrological models are generally built using a bottom-up approach, that generalizes small-physics representations of processes. However, top-down or data-driven approach, is increasingly shown to provide also valuable knowledge.

A simplified semi-distributed continuous hydrological model, named SIMPLEFLOOD, was developed, based on the simple dynamical system approach proposed by Kirchner (WRR, 2009, 45, W02429), and applied to the Ardèche catchment in France (2355 km^2). This data-driven method assumes that discharge at the outlet of a given catchment is only a function of catchment storage and determines a 3 parameter nonlinear model according to rainfall and runoff and recordings. This model was distributed over subcatchments and coupled with a kinematic wave based flow propagation module. The parameters were estimated by discharge recession analyses at several gauged stations (Adamovic et al., HESSD, 2014, 11, 10725–10786), and were regionalized over the whole catchment according to the dominant geology, which was found to be the main predictor of hydrological response variability. The SIMPLEFLOOD model was applied for a 12-year continuous simulation over the Ardèche catchment, that included several flood events. The simulated hydrographs were compared with the observations at 10 hydrometric stations. The results show a good performance of the model, both for the continuous and event simulations.

Starting from simple functioning hypotheses and discharge recession curves analyses, it was possible to build a simple distributed hydrological model assuming that a catchment is behaving as a simple dynamical system. Although based on recession analysis, the model proved to be able to simulate properly flood events in a Mediterranean context. The regionalization based on geology proved to be efficient. The approach must be evaluated on other catchments before being used by practitioners, but these results open perspectives for the building of a new generation of flood forecasting models in the Mediterranean context, provided that reliable data sets are available for model parameter estimation.