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Modelling the spatial dependence of floods in a medium-size catchment in Switzerland

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Traditionally, flood hazard assessments have been focusing on single site flood frequency analyses, which neglect the dependence of events at different sites within a region. The regional assessment of flood hazards, however, should consider this dependence. The joint estimation of floods at multiple locations requires the choice of an appropriate model which allows for the simulation of stochastic event sets capturing the dependence between event sets at multiple locations and for the analysis of regional design quantiles. If ungauged locations are of interest, the model should allow for the simulation of events at ungauged locations jointly with events at gauged locations. The dependence of events may vary with the stations' distance along the river network and the degree of dependence might change as floods get more extreme. Several potential models have been proposed to model the spatial dependence of extreme events. These include, among others, conditional exceedance models, max-stable models, and copula models. Conditional exceedance models can handle different strengths of dependence but a number of models has to be fitted by conditioning on each gauging station separately. Max-stable models extend the generalized extreme value distribution to the spatial setting and allow for predictions at ungauged locations but they assume asymptotic dependence, i.e. it is possible that the largest events occur at the same time even at very distant sites. Copula models devise the marginal distributions and the dependence structure separately, which makes them very flexible. However, classical copulas such as the Normal or Student copulas do not allow for varying degrees of dependence.

In this work, we assessed the suitability of several max-stable and copula models to mimic the spatial dependence of floods within the nested Thur catchment in northeastern Switzerland. These included the Gaussian and Brown-Resnick max-stable processes and the Gaussian, Student-t, Gumbel, Fisher, and R-vine copulas. We found that the two copula based methods R-vines and the recently developed Fisher copula, which contrary to classical copula models allow for varying degrees of dependence, are most suited to model the spatial dependence of floods within the Thur catchment. In contrast to the other models, they retained the dependence structures between the different locations and captured the decreasing dependence of flood events with increasing distance along the river network. The use of such models allows for the simulation of multivariate event sets for the region under consideration and therefore for the extension of short time series. We are currently extending the model to a spatial interpolation framework since both the Fisher and the R-vine copulas can relate the level of dependence of a given pair to the distance between their locations.