How likely are widespread floods in US river basins? Seeking answers using a stochastic, wavelet-based approach

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Flooding can affect large regions leading to high economic and societal costs. Estimating regional flood risk is crucial for developing adaptation strategies, public awareness policies, and protection structures. Yet, estimating regional flood hazard is not trivial because of the few large flood events observed. Here, we derive regional flood hazard estimates for large river basins in the United States by using a stochastic streamflow generator. This allows us to increase the number of flood events available for the analysis and to investigate the simultaneous occurrence of flooding in different parts of a river basin.

We propose the continuous, stochastic simulation approach (PRSim.wave), which combines a non-parametric spatio-temporal model based on the wavelet transform with the parametric kappa distribution. The model reproduces the temporal and distributional characteristics of streamflow at individual sites and retains the spatial dependencies between sites even for spatial extremes. We use PRSim.wave to generate long and spatially consistent time series of daily discharge for a large set of catchments in the conterminous United States. For each catchment, we extract flood events from the simulated series using a peak-over-threshold approach to derive a spatial dataset of flood occurrences. Using this dataset, we estimate how probable it is that a certain percentage of stations within a specific river basin is jointly flooded. We show that: (1) there are strong regional differences in the likelihood of joint and potentially widespread flooding and (2) there are spatial differences in regional flood hazard estimates which could not be derived from observed data only. We deem our approach a valuable tool for water managers and policy makers to make informed decisions on the risk of widespread flooding.