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The spatial dependence of flood hazard and risk at continental scales

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Due to recent advances in computational capabilities and environmental data acquisition, modelling frameworks have been developed that enable us to conduct flood risk analysis at large (e.g. continental) scales. However, most flood risk assessments still do not attempt to account for spatial dependence in flood events, instead they assume that flow probability (the chance that a given river discharge is exceeded) does not vary spatially within an event. Over a few 10s of kilometres of river this assumption is perfectly fine, but over larger areas it begins to break down. In fact, when applied at national scales traditional risk analyses can only estimate the average annual loss that we might expect. To capture the full probability of loss distribution, it is vital that the spatial dependence of flooding is characterised.

This research describes a modelling framework, developed and validated on freely available data sets, that couples a continental-scale hydrodynamic model at 30m resolution with a conditional multivariate statistical model which is conditioned upon a 40-year data set of ∼2,400 USGS gauge series records. The model is used to simulate 10,000 years of US flooding and associated economic loss, represented by more than 600,000 individual events, with realistic spatial dependence. Intersecting an infrastructure data set comprised of ∼100 million individual assets across the US with depth damage functions and our synthetic flood events we can compute the probability that different values of US annual total economic loss due to flooding are exceeded (i.e. a loss-exceedance curve). This work describes the methodological steps taken to create the flood loss catalogues over a national scale, the validation against reported loss information available, and discusses improvements in data acquisition and modelling approaches that are required to improve risk estimates in the future.