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Moving towards a new paradigm for global flood risk estimation

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Traditional approaches to flood risk assessment are typically indexed to an instantaneous peak flow event at a specific recording gage on a river, and then extrapolated through hydraulic modeling of that peak flow to the potential area that is likely to be inundated. Recent research shows that property losses tend to be determined as much by the duration of flooding as by the depth and velocity of inundation. The existing notion of a flood return period based on just the instantaneous peak flow rate at a stream gauge consequently needs to be revisited, especially for floods due to persistent rainfall as seen recently in Thailand, Pakistan, the Ohio and the Mississippi Rivers, France, and Germany.

Depending on the flood event type considered, different rainfall inducing mechanisms (tropical storm, local convection, frontal system, recurrent tropical waves) may be involved. Each of these will have a characteristic spatial scale, expression and orientation and temporal characteristics. We develop stochastic models that can reproduce these attributes with appropriate intensity-duration-frequency and spatial expression, and hence provide a basis for conditioning basin hydrologic attributes for flood risk assessment. Past work on Non-homogeneous Hidden Markov Models (NHMM) is used as a basis to develop this capability at regional scales. In addition, a dynamic hierarchical Bayesian network model that is continuous and not based on discretization to states is tested and compared against NHMM. The exogenous variables in these models comes from the analysis of key synoptic circulation patterns which will be used as predictors for the regional spatio-temporal models.

The stochastic simulations of rainfall are then used as input to a flood modeling system, which consists of a series of physically based models. Rainfall-runoff generation is produced by the Variable Infiltration Capacity (VIC) model. When the modeled streamflow crosses a threshold, a full kinematic wave routing model is implemented at a finer resolution (<=1km) in order to more accurately model streamflow under flood conditions and estimate inundation. This approach allows for efficient computational simulation of the hydrology when not under potential for flooding with high-resolution flood wave modeling when there is flooding potential. We demonstrate the results of this flood risk estimation system for the Ohio River basin in the United States, a large river basin that is historically prone to flooding, with the intention of using it to do global flood risk assessment.