Conditional stochastic model chains in reduced space: Towards efficient simulation of non-stationary typhoon precipitation patterns

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Stochastic simulation of realistic and statistically robust patterns of Tropical Cyclone (TC) induced precipitation is a challenging task. It is even more challenging in a catastrophe modeling context, where tens of thousands of typhoon seasons need to be simulated in order to provide a complete view of flood risk. Ultimately, one could run a coupled global climate model and regional Numerical Weather Prediction (NWP) model, but this approach is not feasible in the catastrophe modeling context and, most importantly, may not provide TC track patterns consistent with observations. Rather, we propose to leverage NWP output for the observed TC precipitation patterns (in terms of downscaled reanalysis 1979-2015) collected on a Lagrangian frame along the historical TC tracks and reduced to the leading spatial principal components of the data. The reduced data from all TCs is then grouped according to timing, storm evolution stage (developing, mature, dissipating, ETC transitioning) and central pressure and used to build a dictionary of stationary (within a group) and non-stationary (for transitions between groups) covariance models. Provided that the stochastic storm tracks with all the parameters describing the TC evolution are already simulated, a sequence of conditional samples from the covariance models chosen according to the TC characteristics at a given moment in time are concatenated, producing a continuous non-stationary precipitation pattern in a Lagrangian framework. The simulated precipitation for each event is finally distributed along the stochastic TC track and blended with a non-TC background precipitation. The proposed framework provides means of efficient simulation (10000 seasons simulated in a couple of days) and robust typhoon precipitation patterns consistent with observed regional climate and visually undistinguishable from high resolution NWP output. The framework is used to simulate a catalog of 10000 typhoon seasons implemented in a flood risk model for Japan.

Keywords: Reduced models, Stochastic simulation, Typhoon precipitation

