Characterizing multi-hazard extreme distributions of coastal flooding induced by tropical cyclones

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Coastal areas, which are among the most populated regions on Earth, are the interface between continental land and the ocean. As a consequence of their location, they are subject to complex flooding dynamics, arising from the interaction between coastal and continental dynamics. This complexity is translated to the characterization of extreme distributions and the effects induced by climate change in the distribution of extreme events. In this work, we develop a methodology that serves to characterize the extreme distribution of flooding in a coastal environment. We focus in the dynamics induced by tropical cyclones that are both marine (storm surge and wave run-up) and continental (precipitation and runoff).

Our approach makes uses of historical cyclones that have affected the study area in the past. This ensemble is augmented by synthetically generated cyclones in order to better cover the range of possible tracks. A maximum dissimilarity algorithm is used on the augmented database to select a reduced subset of tracks best representing the variability on the data (Camus et al. 2014). This subset is used to carry out a dynamical downscaling.

Numerical simulations are carried out for these subset of tropical cyclones to derive the spatial fields of wind (by means of the Hydromet-Rankine Vortex model) and rainfall (using R-Clipper model) induced by the cyclone. SWAN model is used to derive the wave fields (Díaz et al. 2014), H2D to derive the storm surge fields and a CUENCAS-like model (IH-Mole) to derive runoff fields. All the flood-inducing dynamics are the input to the RFSM-EDA model that computes flood depths for the study area.

A Monte Carlo simulation is used to generate synthetic time series of tropical cyclones. Tropical cyclone climate is related to the spatial patterns of sea surface temperature (SST) fields using a non-linear clustering technique, which are used in turn as the main driver of a Monte Carlo simulation. Flood time series are derived from cyclone time series using the dynamical downscaling database and interpolation, for those cyclones that have not been simulated.

Our hybrid approach (mixing statistical and dynamical downscaling) allows us to compute any statistic of the complete flooding distribution at every location of the study site. Moreover, making use of SST data from simulations of future climate, obtained from general circulation models (AOGCM), we can study the effects of climate change in these distributions of extremes.

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