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# Quantifying the Impact of Future Sea Level Rise, Climate Change, and Climate Variability on Tropical Storm Flood Level Statistics

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Reliable extreme-value hurricane flooding estimates are essential for effective risk assessment, management, and engineering in the coastal environment. However, limited historical flood observations and uncertainty in future climate conditions present a challenge for assessing future hurricane flooding probability. Historical water level observations indicate that sea level is rising in most tropical-cyclone-prone regions throughout the world, while historical observations of tropical cyclone meteorology indicate decadal variation in tropical cyclone patterns, to include landfall location and rate of occurrence. Recent studies, including those by the Intergovernmental Panel on Climate Change, also suggest that in the future sea level rise (SLR) may accelerate and major tropical cyclones may intensify.

In this paper, methods will be presented for incorporating both SLR and time-varying tropical cyclone conditions into extreme-value flood statistics. Surge response functions (SRF), which are dimensionless scaling laws developed from a limited set of hydrodynamic simulations, are used with a joint-probability approach to define time-varying continuous probability mass functions for tropical cyclone flood elevation. Specifically, the SRFs and probability are specified based on tropical cyclone parameters near landfall and local and regional characteristics: central pressure deficit, storm radius, storm forward speed, storm approach angle, continental shelf width, and bay or estuary dimensions. A main advantage to this approach is in the optimization of the complex hydrodynamic simulation set required for probability assessment; the computational burden can be reduced by as much as 75%, without loss in accuracy, when using this approach.

Here, it will be demonstrated that dimensionless SRFs can account for the dynamic coupling between surge generation and changes in mean depth in shallow coastal regions, e.g., bays and estuaries, with SLR without loss in surge-prediction accuracy. It will also be shown that by using a joint-probability approach and SRFs, a time-varying natural upper bound to the cumulative probability distribution can be established, based on projected future hurricane meteorological statistics and sea level rise. Finally, methods for accounting for uncertainty in future climate projections within the joint-probability framework will be discussed.