ADVANCES AND ISSUES IN UNCERTAINTY QUANTIFICATION FOR COASTAL FLOOD HAZARDS

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INTRODUCTION
Probabilistic flood hazard assessments have advanced substantially, with modern methods for dealing with the risk from tropical cyclones utilizing either a variation of the joint probability method with optimal sampling (JPM-OS)[2,3] or the statistical deterministic track method (SDTM)[1,4]. In the JPM-OS, tropical cyclones are reduced to a set of 5 to 9 parameters, whose characteristics are analyzed statistically to develop a joint probability distribution for tropical cyclones of given characteristics. In the SDTM, cyclogenesis of a large number of storms is seeded via a statistical model from historical data, then storms are propagated using one of several different methods, incorporating varying degrees of the physics of cyclone transformation as the storms propagate. Due to the significant cost of storm surge simulations, some form of optimization or selection is then performed to reduce the number of synthetic storms that must be simulated to determine the flood elevation corresponding to a given recurrence interval (e.g. the so-called 100-year flood). In both methods, substantial uncertainties exist, which have a tendency to increase the estimated flooding risk. Efforts to account for these uncertainties have varied, and there remains significant work to be done. Here, we demonstrate how these uncertainties tend to increase the flood risk and show that additional sources of uncertainty remain to be accounted for.

METHODS AND RESULTS
Review of data from a large number of high-quality hindcasts of major storms has been performed and surge error data were collected in order to carry out a statistical analysis of model error and its natural scaling. Results (Figure 1) indicate that the error, and therefore the hydrodynamic model uncertainty, should scale with the intensity of the event. This runs contrary to current practices. Results also provide definitive information on the skill level of the current set of high-quality hindcast modeling efforts.

An analytic experiment was carried out to provide an illustrative case for why and how uncertainty, even when unbiased, tends to result in higher flooding risks. Results (Figure 2) give a sense for how substantial this effect can be, increasing the flood hazard by 10-20% in common problems.

All flood studies to-date have neglected several potentially noteworthy sources of uncertainty, leading to an unknown level of error in study results. Through quantification of these sources of uncertainty, their effects are shown to be important in the context of probabilistic flood studies.

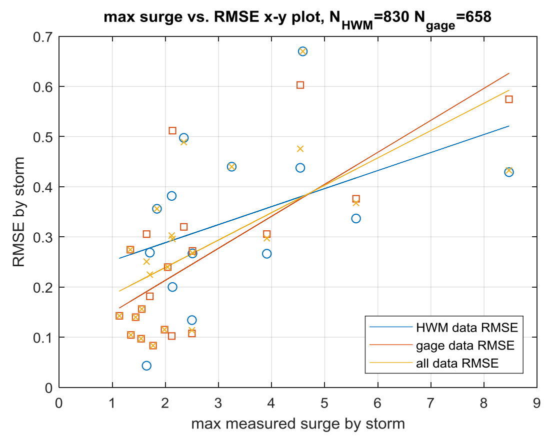

Figure 1 - RMSE correlation with peak storm surge; HWM denotes surveyed high water marks

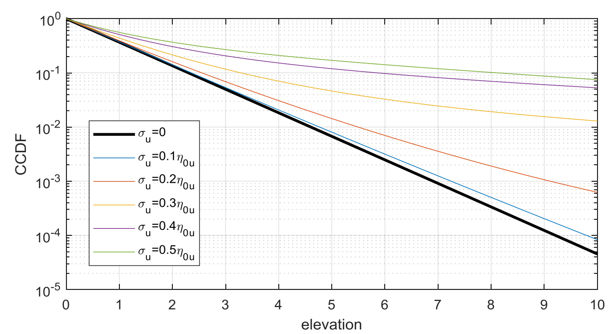

Figure 2 - Shift in mean flood hazard elevation due to uncertainty; σ denotes standard deviation of uncertainty (e.g. model error), lines are (complementary) cumulative distribution functions (i.e. flood hazard curves) with uncertainties proportional to the surge elevation η

REFERENCES
[1]Emanuel, Ravela, Vivant, and Risi. “A Statistical Deterministic Approach to Hurricane Risk Assessment.” Bulletin of the American Meteorological Society 87, no. 3 (March 1, 2006): 299-314.

[2]Resio, Irish, and Cialone. “A Surge Response Function Approach to Coastal Hazard Assessment - Part 1: Basic Concepts.” Natural Hazards 51, no. 1 (October 2009).

[3]Toro, Niedoroda, Reed, and Divoky. “Quadrature-Based Approach for the Efficient Evaluation of Surge Hazard.” Ocean Engineering, A Forensic Analysis of Hurricane Katrina’s Impact: Methods and Findings, 37, no. 1 (January 2010): 114-24.

[4]Vickery, Skerlj, and Twisdale. “Simulation of Hurricane Risk in the U.S. Using Empirical Track Model.” Journal of Structural Engineering 126, no. 10 (October 2000).