**Comparison of statistical and integrated statistical/physical modeling approaches for extreme storm surge estimation**

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**Abstract**

Estimating storm surge magnitude and annual exceedance probability (AEP) are key elements in the siting and design of coastal nuclear power plants (NPPs) in both the U.S. and France. However, different storm climatology between U.S. and French coastal areas, such as relative importance of tropical cyclones versus extratropical storms, have led to application of different modeling approaches (i.e., statistical vs. combined statistical and physics-based models) as well as differences in statistical estimation method development. This work compares extreme storm surge modeling approaches developed by the French Institute for Radiological Protection and Nuclear Safety (IRSN) and the U.S. Army Corps of Engineers (USACE) applied to the U.S. North Atlantic coast, which is subject to both tropical and extratropical influences. Hazard variables of interest include skew storm surge, maximum instantaneous storm surge, non-tidal residual, and maximum seal level. IRSN has adopted a statistical modeling approach that applies classical extreme value theory to local observations and developed an extremogram-based method that leverages regional information to improve local estimates. The extremogram method forms a homogeneous region centered on a target site. Regional information is then transferred to the target site using an optimized multiple linear regression model. Data used in the IRSN analysis include observed water levels and water levels predicted from tidal harmonic constituents. USACE has adopted both statistical and expanded Joint Probability Method (JPM)-based approaches in a series U.S. North Atlantic coast studies. The Stochastic Simulation Technique (SST) is an extreme value analysis method applied here to local observed water levels. The JPM-based probabilistic framework used here integrates statistical analysis of surge forcing (i.e., storm parameters) with mechanistic models for surge response. Machine learning is used to expand the initial suite of high-fidelity storm simulations.

IRSN and USACE approaches are compared using the storm surge variables of interest at two locations near New York City affected by multiple storm types (tropical cyclones, extratropical cyclones, mixed populations). Overall, it can be concluded that the IRSN and USACE statistical methods give comparable results in terms of estimated water levels and uncertainties. It is important to note that all statistical methods have more difficulty fitting the right tails of the distributions for the cases evaluated in this study. In particular, the data point associated with Hurricane Sandy was difficult to fit. The JPM-based approach has the lowest uncertainty for most cases considered.