

# Evaluating Synthetic Hurricane Datasets for Extreme Metocean Conditions in Higher-Latitude Regions

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Hurricanes produce extreme wind, wave, and current conditions critical for offshore infrastructure design. In higher latitudes where tropical cyclone activity is infrequent, such as Atlantic Canada, the limited historical record introduces uncertainty in characterizing extreme metocean conditions. Standard extreme value analysis, which fits probability distributions to historical data, often fails to capture the distribution of hurricanes. Synthetic storm datasets provide an alternative by generating large numbers of events based on statistical properties of historical storms combined with parametric wind models. While computationally efficient and reliable in hurricane-active regions like the Caribbean, their robustness decreases in areas with infrequent hurricane activity, as the statistical basis is hindered by limited historical data.

Furthermore, these models only provide wind and pressure, and estimating waves and currents relies on process-based models forced by these wind fields, which is computationally expensive. To reduce the number of storms required for these simulations, a stratified sampling approach is applied, selecting representative subsets and applying weights to match the full population. However, hydrodynamic response depends on multiple factors, so sampling by a single variable (e.g. wind speed) may not capture the correct distribution of extreme waves and currents.

This study evaluates synthetic datasets and stratified sampling approaches for characterizing extreme metocean conditions in regions where hurricanes are infrequent. Using the TCWiSE model, a 30,000-year synthetic storm dataset for the North Atlantic was generated, with over 200,000 storms from ~1,200 historical events. Wind and pressure fields were calculated for the coast of Nova Scotia using the parametric Holland model. The dataset included >7,000 regional storms passing over the region, including Category 4 and 5 storms absent from the record. This approach enables evaluation of the potential impacts of more extreme tropical cyclones in the region.