SAND2025-03344A

Characterization of Extreme Wave Heights and Relative Risk Ratios for US Coastal Regions

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International recommended best practices and standards outline the estimation of n-year return period extreme wave height values for the design of marine energy converters (MECs) to ensure their integrity and safe operation. International Electrotechnical Commission (IEC) design technical specification (IEC TS 62600-2) provides guidance for defining design load cases and for determining design loads based on 1-, 5-, and 50-year return periods. Furthermore, IEC TS 62600-2 recommends the usage of historical measurement data where available for the estimation of extreme wave height values; however, available historical buoy data is sparse in the nearshore regions of the US coast, both spatially and temporally. To supplement the limited available historical buoy data, herein extreme wave height values are estimated using significant wave height data from validated 42-year spectral wave model hindcasts—developed following IEC TS 62600-101—covering nearshore regions of the US Exclusive Economic Zone (EEZ), and with a spatial resolution of 200-300 m (over 14 million unique locations) and temporal resolution of 3 hours. The extreme wave height values are estimated using the annual maxima (AM) method for the 5-, 50-, and 100-year (as available) return periods and an automated peak-over-threshold (POT) method for the 1-year return period, as recommended by international best practices guideline DNV-RP-C205. The presented extreme wave height values estimated using the AM method are based on the mean values estimated from twelve different annual windows, while the threshold utilized for the POT method is site specific and specified as the value that results in the minimum error between the sampled and modeled data. Historical data from NDBC buoys located along the US coast are used to correct the systematically underbiased model-derived estimates of the extreme wave height. Depth-induced wave breaking is accounted for by replacing the model-derived estimates of extreme wave height values at shallow nearshore sites with an empirical model based on breaking depth limits. The ratio of the 50-year return period extreme wave height to the mean significant wave height (relative risk ratio)—which been proposed as a metric to access project risk—is computed using the model-derived, buoy corrected 50-year return period extreme wave height values. The model-derived, buoy corrected extreme wave height estimates and computed relative risk ratios provide the marine energy—and larger maritime—community important metrics for device design as well as for site analysis, characterization, and classification at a resolution far exceeding that available through historical buoy data alone.