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Predicting the ocurrence probability of freak waves baed on buoy data and non-stationary extreme value models

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In the last decades, freak or rogue waves have become an important topic in engineering and science. Forecasting the occurrence probability of freak waves is a challenge for oceanographers, engineers, physicists and statisticians. There are several mechanisms responsible for the formation of freak waves, and different theoretical formulations (primarily based on numerical models with simplifying assumption) have been proposed to predict the occurrence probability of freak wave in a sea state as a function of N (number of individual waves) and kurtosis (k). On the other hand, different attempts to parameterize k as a function of spectral parameters such as the Benjamin-Feir Index (BFI) and the directional spreading (Mori et al., 2011) have been proposed. The objective of this work is twofold: (1) develop a statistical model to describe the uncertainty of maxima individual wave height, Hmax, considering N and k as covariates; (2) obtain a predictive formulation to estimate k as a function of aggregated sea state spectral parameters. For both purposes, we use free surface measurements (more than 300,000 20-minutes sea states) from the Spanish deep water buoy network (Puertos del Estado, Spanish Ministry of Public Works).
Non-stationary extreme value models are nowadays widely used to analyze the time-dependent or directional-dependent behavior of extreme values of geophysical variables such as significant wave height (Izaguirre et al., 2010). In this work, a Generalized Extreme Value (GEV) statistical model for the dimensionless maximum wave height (x=Hmax/Hs) in every sea state is used to assess the probability of freak waves. We allow the location, scale and shape parameters of the GEV distribution to vary as a function of k and N. The kurtosis-dependency is parameterized using third-order polynomials and the model is fitted using standard log-likelihood theory, obtaining a very good behavior to predict the occurrence probability of freak waves (x>2).
Regarding the second objective of this work, we apply different algorithms using three spectral parameters (wave steepness, directional dispersion, frequential dispersion) as predictors, to estimate the probability density function of the kurtosis for a given sea state.

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