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Modelling the interannual variability of extreme wave climate combining a time-dependent GEV model and Self-Organizing Maps

Cristina Izaguirre, Fernando J. Mendez, Paula Camus, Roberto Minguez, Melisa Menendez, and Iñigo J. Losada
Enviromental Hydraulics Institute "IH Cantabria", Universidad de Cantabria, Spain

It is well known that the seasonal-to-interannual variability of extreme wave climate is linked to the anomalies of the atmosphere circulation. In this work, we analyze the relationships between extreme significant wave height at a particular site and the synoptic-scale weather type. We combine a time-dependent Generalized Extreme Value (GEV) model for monthly maxima and self-organizing maps (SOM) applied to monthly mean sea level pressure field (SLP) anomalies.

These time-varying SLP anomalies are encoded using principal component analysis, obtaining the corresponding spatial patterns (Empirical Orthogonal Functions, EOFs) and the temporal modes (PC, principal components). The location, scale and shape parameters of the GEV distribution are parameterized in terms of harmonic functions (seasonality) and linear covariates for the PCs (interannual variability) and the model is fitted using standard likelihood theory and an automatic parameter selection procedure, which avoids overparameterization. Thus, the resulting anomalies of the location and scale parameters with respect to the seasonality are projected to the SOM lattice obtaining the influence of every weather type on the extreme wave height probability distribution (and subsequently, return-level quantiles). The use of Self-organizing maps allows an easy visualization of the results.

The application of the method to different areas in the North Atlantic Ocean helps us to quantify the importance of the North Atlantic Oscillation and the East Atlantic pattern in the location and scale parameters of the GEV probability distribution. Additionally, this work opens new forecasting possibilities for the probabilities of extreme events based on synoptic-scale patterns.