Nonstationary analysis of extreme storm surges in the Mediterranean under climate change using multiple covariates

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Global climate change is closely associated with extreme marine events of higher intensity and frequency, and is generally considered as one of the main causes of nonstationarity in marine signals. In the present work the Generalized Extreme Value (GEV) distribution function is used within a nonstationarity framework to assess extreme storm surges for selected coastal regions in the Mediterranean Sea, both for the present and the future climate. The storm surge-induced sea level data in coastal regions result from high-resolution simulations with MeCSS, a 2-DH barotropic model of hydrodynamic ocean circulation (Androulidakis et al., 2015; Makris et al. 2016), and cover the reference (1971-2005), the short-term (2021-2055) and the long-term (2061-2095) future climate. The atmospheric forcing of the model consists of wind (velocity and direction) and atmospheric pressure fields by three high-resolution Regional Climate Models (RCMs), namely CMCC, CNRM and GUF, implemented in the framework of the MED-CORDEX initiative (https://www.medcordex.eu/; Ruti et al., 2016). Historical climate data by all the RCMs for the reference period are validated against ECMWF reanalyses, based on assimilation system fields produced under CERA-20C. Future estimations of RCMs are based on RCP 4.5 and RCP 8.5 climate scenarios (IPCC, 2014). For each study period, the parameters of the nonstationary GEV distribution are specified as functions of time-varying covariates and estimated using Vector Generalized Linear and Additive models (VGLM and VGAM; Yee, 2015), which are semi-parametric regression type models. The nonstationary models use multiple covariates, namely time, teleconnection indices such as the North Atlantic Oscillation (NAO) index, deep depressions, and wind fields. Bayesian model averaging is then used to generate a statistical model accounting for multiple possible storm surge covariates. Time-dependent return levels for reference and future timespans are produced for several return periods of interest and conclusions are extracted regarding the effects of climate change on storm surge extremes.

References

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