FUTURE CHANGES IN EXTREME WAVES AND THEIR SEASONALITY IN THE MEDITERRANEAN SEA

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INTRODUCTION

Climate change impacts threaten coastal areas all over the world, driven by increasing extreme sea levels. With higher sea surface and air temperatures, continued sea-level rise and high exposure and vulnerability of about 20 million people living in low-lying coastal areas, climate change affects the Mediterranean Sea significantly more than the world average and is therefore defined as a vulnerability hotspot (Ali, 2022). Projected changes in waves vary on a regional and local scale and play a crucial role in future extreme coastal water levels and coastal impacts. Several past studies used Global Climate Models (GCM) with coarse spatial resolution to study the future changes of wave climate. However, wave models driven by high-resolution dynamically-downscaled surface winds from Regional Climate Models RCM) allow an enhanced characterization of wave climate at local scale, which is fundamental for coastal impact assessment and adaptation studies.

Here we present the analysis of extreme wave events and their seasonality using a state-of-the-art regional ensemble of wave climate projections developed with the numerical wave model Wavewatch III forced by surface wind field data of 17 EURO CORDEX GCM-RCMs.

DATA AND METHODS

Wave climate projections in the Mediterranean Sea were generated on a 10km grid providing, for each GCM-RCM combination, 3-hourly data for 1970-2005 for the reference period and 2006-2100 for projections under the high-emission scenario RCP8.5 of H_s, T_p and θ_m (De Leo, 2020; Lira-Loarca, 2021). Wave projections were bias-adjusted by means of a monthly-EQM method to remove inherent biases in GCM/RCM simulations. Future changes were evaluated for a weighted ensemble mean against a validated hindcast generated with the same setup for 1979 until 2020 and used as reference for the bias correction (Mentaschi, 2015). The robustness of the results was analyzed following the AR6 methodology to identify areas with robust, conflicting, or no robust change accounting for internal variability.

Extremes wave events were analyzed by means of the ETCCDI extreme indices *rough wave days* (NRh)and *high wave days* (NHh) defined as the yearly number of days when $daily - max\{H_s\}$ exceeds 2.5 m and 6 m, respectively as well as the 50-year and 100-year return periods. Additionally, to analyze the future temporal variability in waves extremes, the indices were analyzed seasonally and the temporal variability of the 99th and 99.5th percentiles was examined.

RESULTS

The projected changes in wave extremes with respect to hindcast were analyzed for mid-century from 2034 to 2060 and for end-of-century conditions from 2074 until 2100. The analysis was done for annual and seasonal means to assess the seasonality of future extreme wave events. Figures 1, 2 and 3 present the NRh, seasonal-NRh and NHh indices, respectively, for hindcast in the Mediterranean Sea and the projected changes in the two mentioned periods. There is a projected decrease in NRh in the entire basin for both periods with expected decreases of 6-30 days in the central Mediterranean.

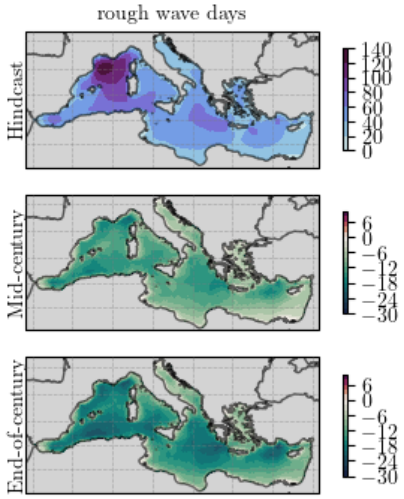

Figure 1 - Number of rough wave days for hindcast (top) and projected changes for mid-century (middle) and end-of-century (bottom).

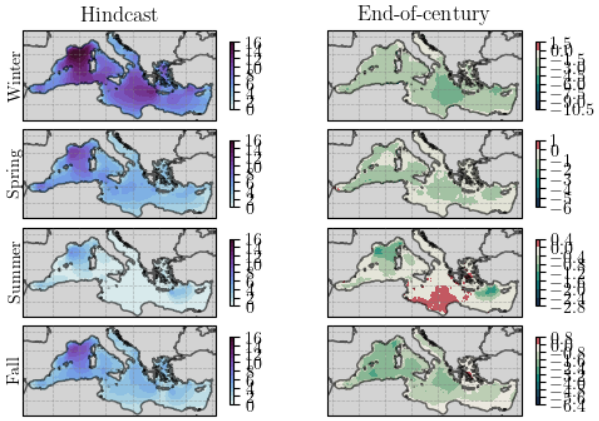

Figure 2 - Number of rough high wave days for hindcast (top) and projected changes for mid-century (middle) and end-of-century (bottom).

Regarding the seasonal behavior of NRh it can be observed that the higher values are presented for winter, as expected where the projected changes at the end of

the century present an overall decrease of up to 6 days in the Mediterranean basin. Spring and Fall present a similar behavior as the winter values. It can be highlighted that, during Summer, where a lower value of NRh is observed for hindcast conditions ($NRh < 8$ days), very slight increases are observed for some parts of the Mediterranean that although very small provide an indication of the seasonal changes that are projected under a climate change scenario.

Regarding NHh, in the hindcast this indicator shows values <1 in a large part of the basin. In the future there is an expected increase in some regions such as the Balearic Sea while the expected decrease observed in NRh is kept in the central part of the basin. Nonetheless, given the lower wave energetic conditions characteristic of the Mediterranean with respect to other open-sea basins, this work defines a *Med. high wave days* ($MNHh$) for $daily - max\{H_s\} > 4$ m whose results will be presented including their seasonality and alongside the expected changes in 50 and 100-year return periods and higher percentiles.

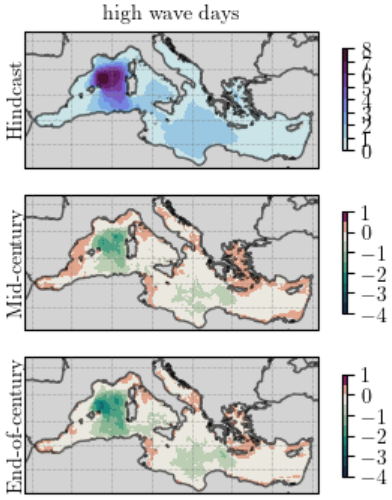

Figure 3 - Number of high wave days for hindcast (top) and projected changes for mid-century (middle) and end-of-century (bottom).

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