PAST AND FUTURE SEASONAL VARIABILITY OF THE SPECTRAL WAVE CLIMATE IN THE MEDITERRANEAN SEA

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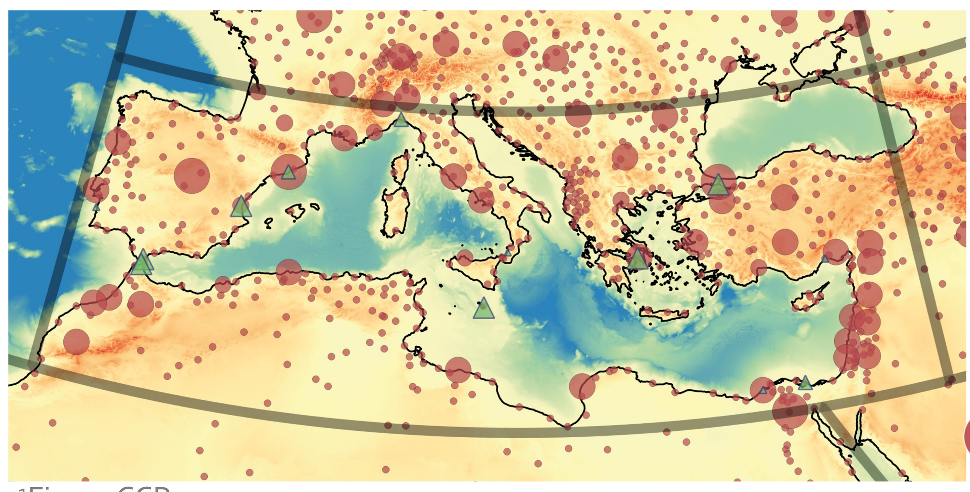
CONTEXT

1 CLIMATE CHANGE IN THE MEDITERRANEAN SEA

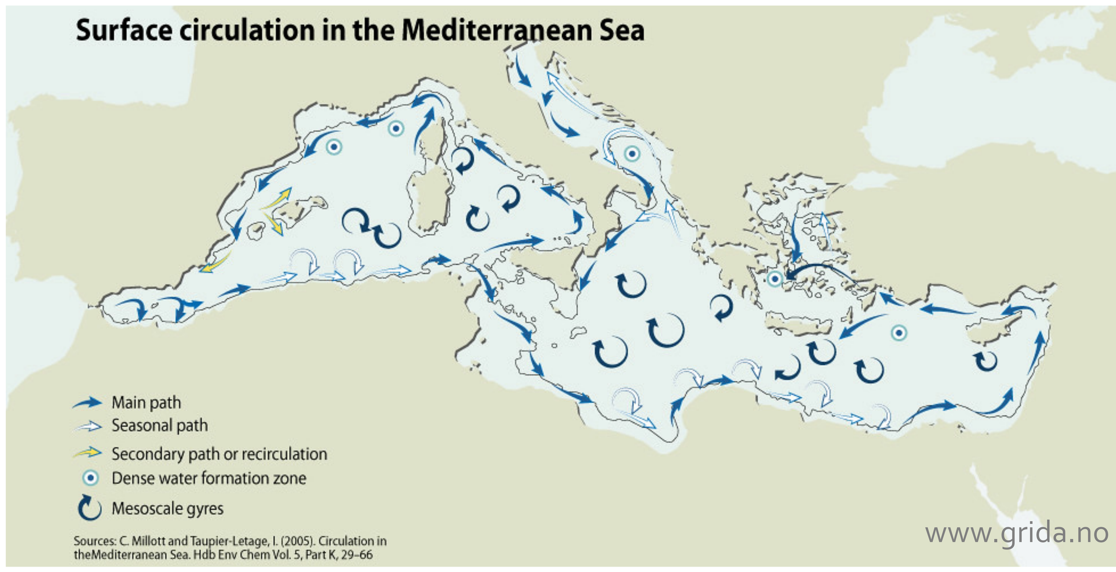
Climate change impacts in the Mediterranean basin are pronounced, marked by higher increasing rates of sea surface and air temperatures than global averages and high exposure and vulnerability of about 20 million people living in low-lying coastal areas (<5 m.a.s.l)[1,2].



[1]Figure CCP4.1

2 REGIONAL DYNAMICS AND WAVE SPECTRA

Wave models driven by RCMs surface winds allow an enhanced regional characterization of waves climate including a multimodal characterization given by the directional wave spectrum.



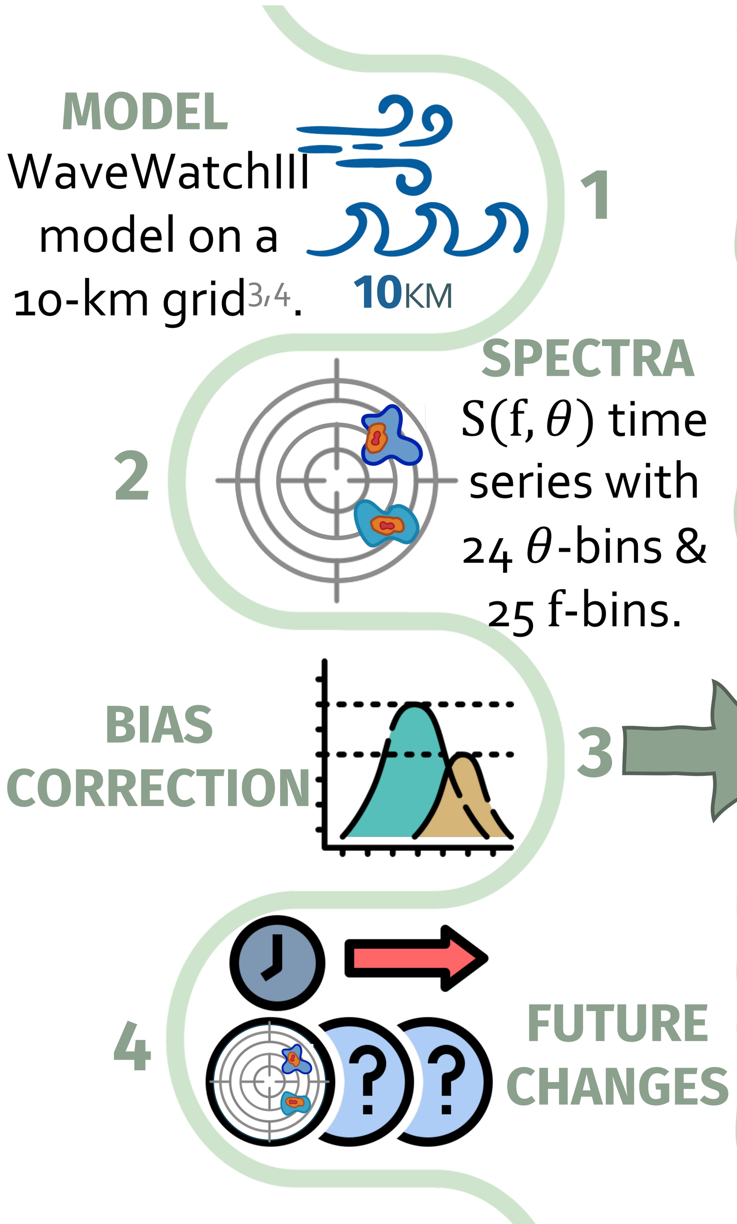
3 BIAS CORRECTION OF WAVE CLIMATE

Systematic biases are present in GCM and RCMs atmospheric simulations due to factors such as spatial resolution, simplified physics and parameterizations, internal variability, and downscaling processes, which are addressed through the use of bias adjustment methods.

Traditional bias-adjustment techniques, designed for univariate scalar variables, can be applied to H_s, T_p, and ϑ_m scalar fields independently but fail to account for the complex interaction between them as well as their joint spatial and temporal variability.

This work addresses the correction of systematic errors in 2D wave spectra for the assessment of future changes.

METHOD



ENERGY CONSERVATION

i. Directional Wave spectra to **Wave Energy**

$$E = \int_0^{2\pi}\int_0^{\infty} S(f,\theta)\, df\, d\theta$$

ii. Energy distribution bias-correction :
Monthly Gumbel Distribution Mapping per month[5]

$$E^* = F_{hind}^{-1}\left(F_{RCM}^{baseline}(E)\right)$$

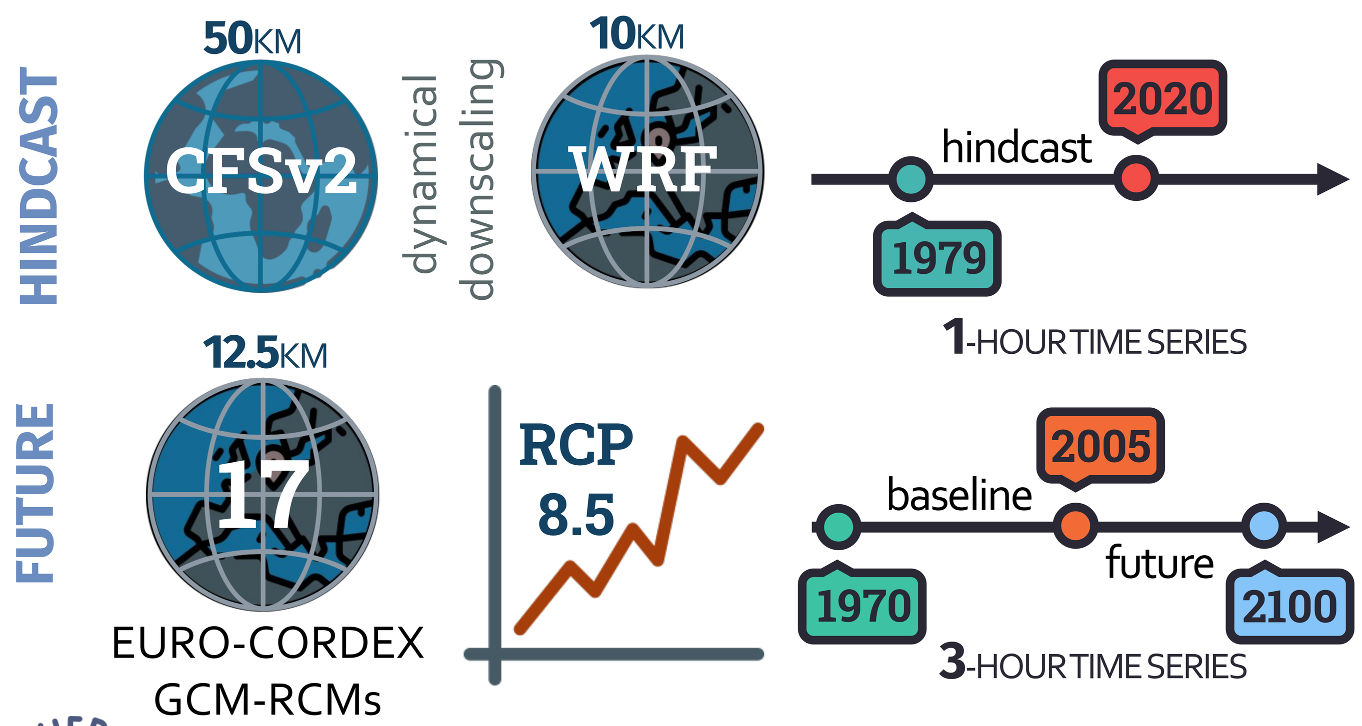
iii. Reconstruction of 2D wave spectra

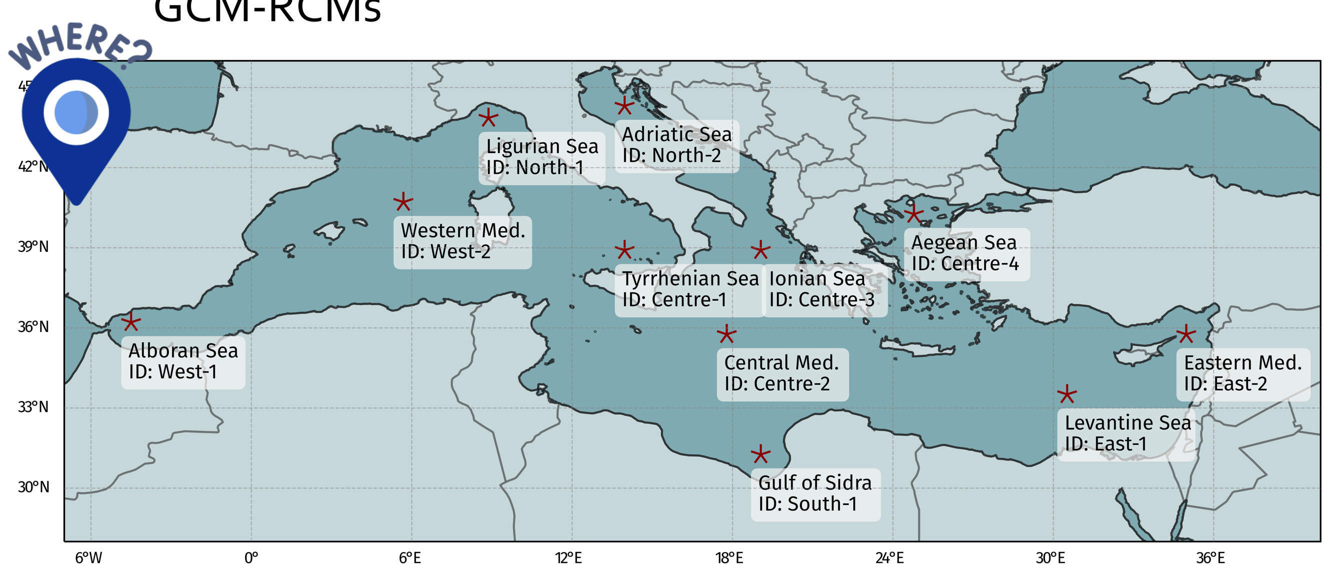
$$\widehat{S(f,\theta)} = \frac{S(f,\theta)\Delta f \Delta\theta}{E}$$

$$\boldsymbol{S^*(f,\theta) = E^* \cdot \widehat{S(f,\theta)}}$$

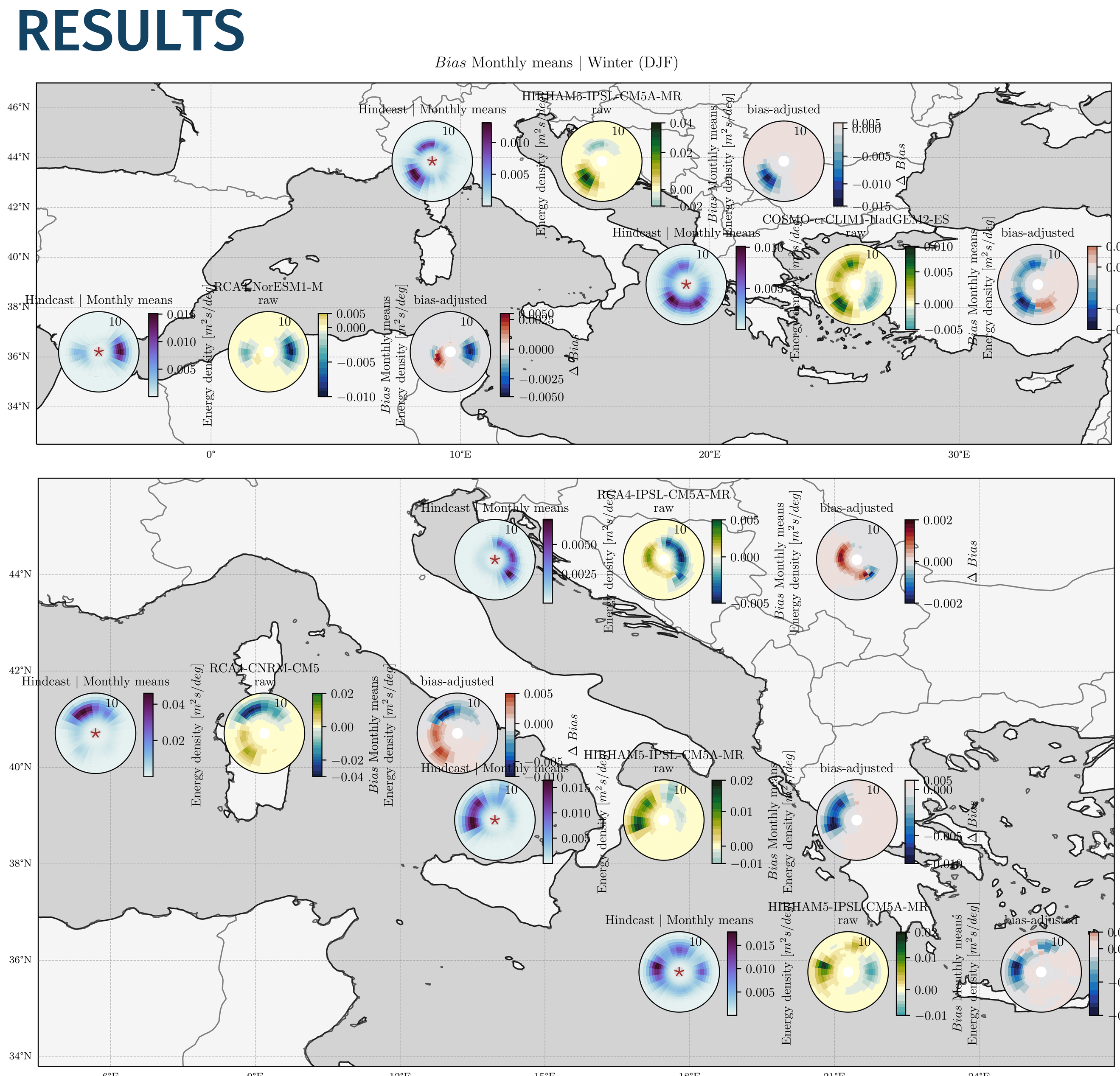
SEGDM-month
Spectral Energy Gumbel Distribution Mapping per month

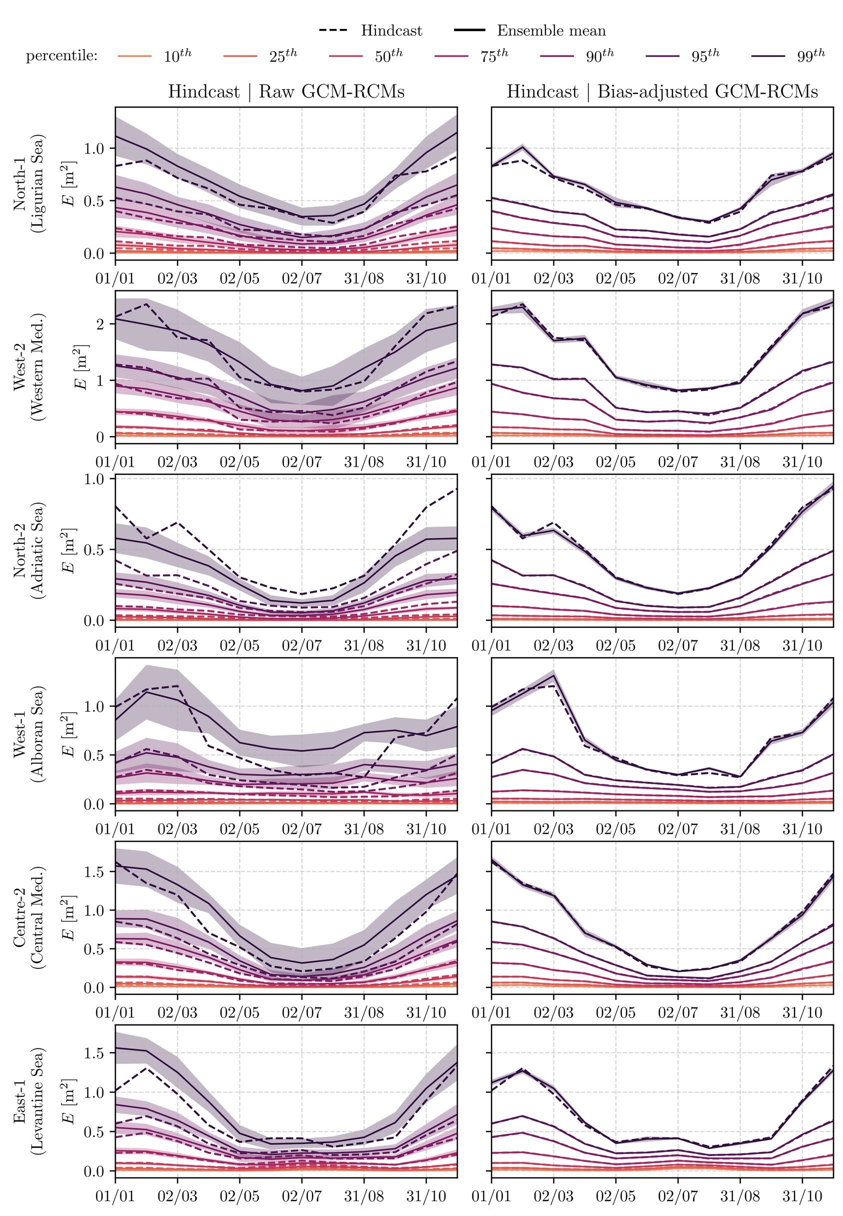
DATA

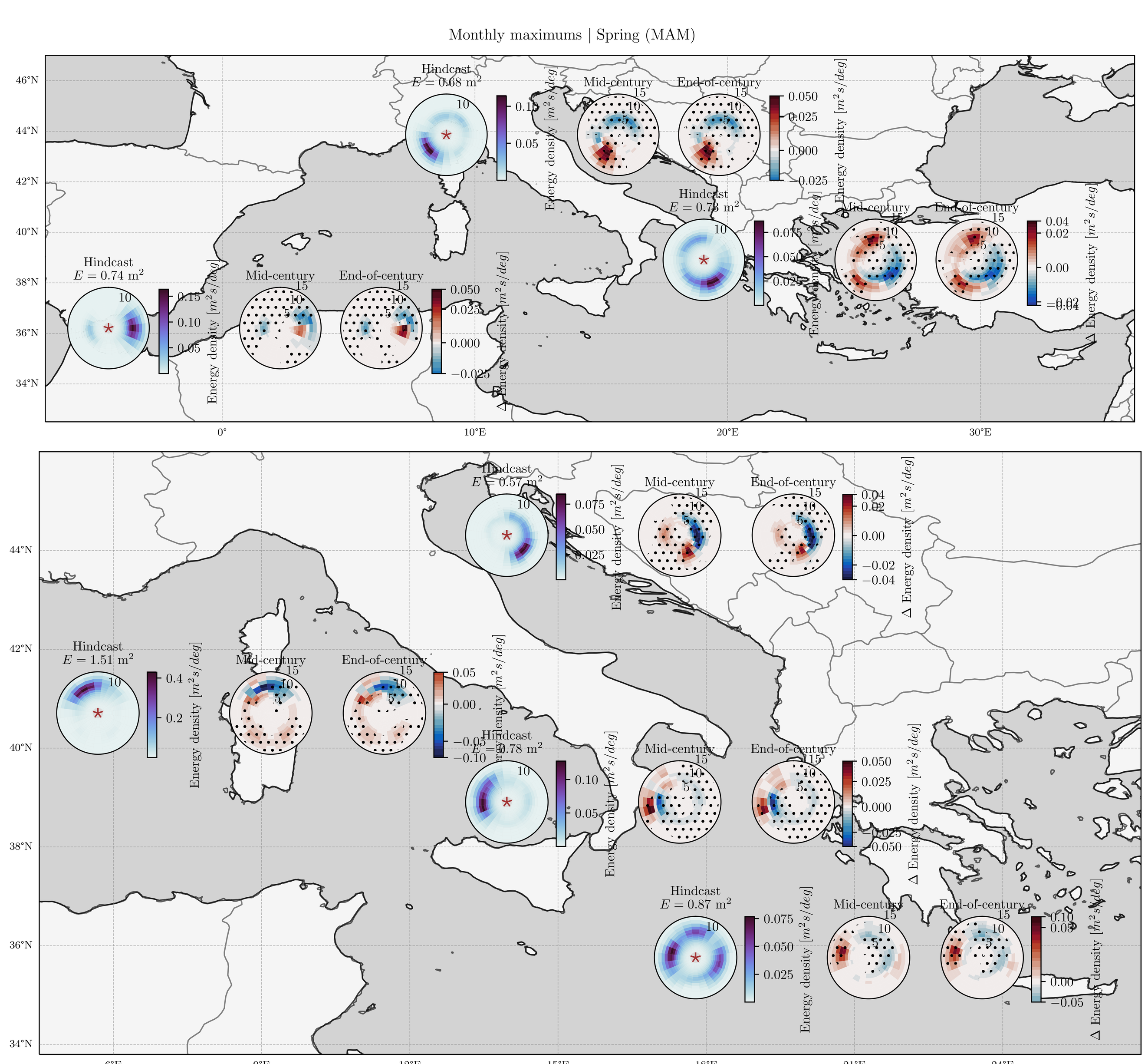


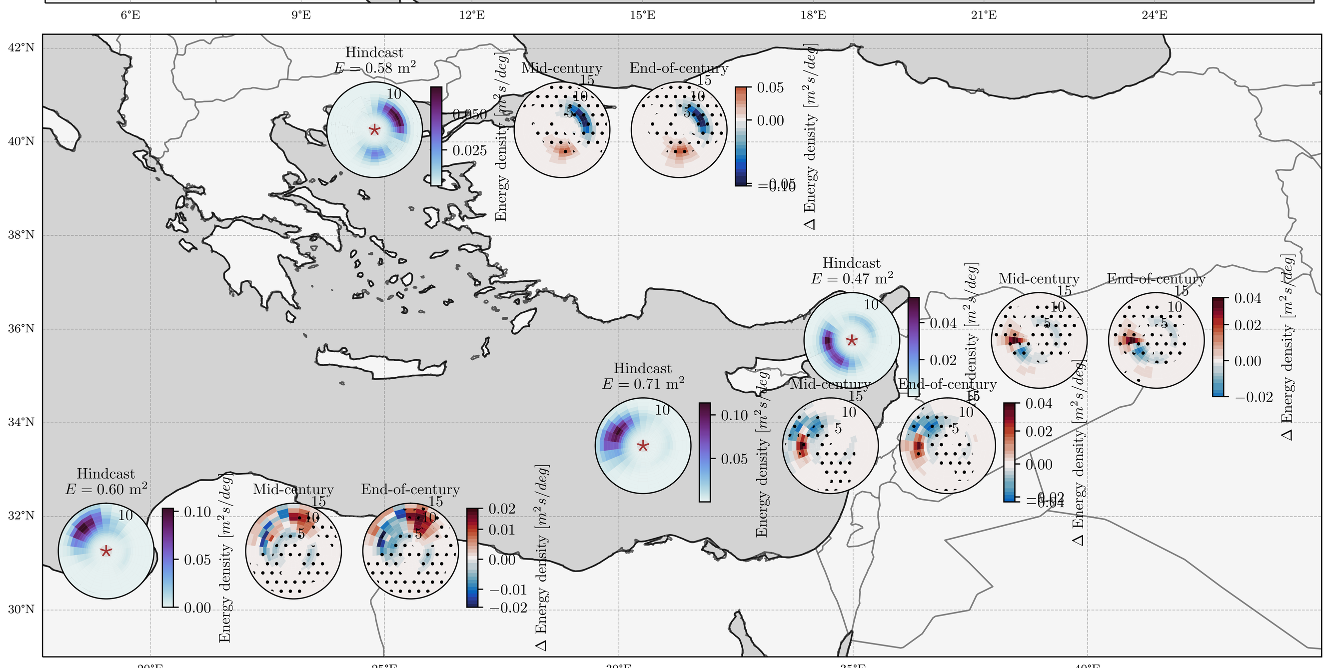


RESULTS









There is a systematic underestimation of the most energetic bins for the raw GCM-RCM spectra in the Alboran Sea, Western Mediterranean, Adriatic and Aegean Sea while the rest present an overestimation. Negative ΔBias indicate an improvement in the performance of the GCM-RCM wave spectra due to the bias-correction. The bias in the most energetic systems is reduced, except for the Adriatic and Aegean Seas, with no noticeable changes.

The raw GCM-RCMs present an overestimation of the upper-quantiles for the winter months for the Western Mediterranean, Ligurian and Levantine Sea and an underestimation for Adriatic Sea and Alboran Seas which are adequately corrected by the SEGDM-month. The use of the Gumbel distribution for the upper-tail allows for a correct characterization of the energy extremes.

A robust projected increase is observed in the main South-East swell system of the Ligurian Sea and a robust decrease for the remaining NW-E system. For the Ionian Sea, the main South-easterly swell system depicts robust projected decreases for both mid-century and end-of-century conditions and a robust projected increase is depicted for South-westerly and Northern swells leading to a projected multimodal extreme wave spectrum.

[1] Ali, Cramer, Carnicer, Georgopoulou, Hilmi, Le Cozannet, Lionello, 2022. Mediterranean Region. Climate Change 2022: Impacts, Adaptation, and Vulnerability. WGII AR6.
[2] UNEP/MAP & Plan Bleu, 2020. State of the Environment and Development in the Mediterranean.
[3] Mentaschi, L., Besio, G., Cassola, F. and Mazzino, A., 2015. Performance evaluation of Wavewatch III in the Mediterranean Sea. Ocean Modelling, 90, pp.82-94.
[4] Lira-Loarca, A., Ferrari, F., Mazzino, A. and Besio, G., 2021. Future wind and wave energy resources and exploitability in the Mediterranean Sea by 2100. Applied Energy, 302.
[5] Lira-Loarca, A., Berg, P., Baquerizo, A. and Besio, G., 2023. On the role of wave climate temporal variability in bias correction of GCM-RCM wave simulations. Climate Dynamics. 1–28.
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