

Marine Heat Waves vs Marine Cold Spells: when seasonal upwelling dictates the hotter topic

IDEAS
TO IMPACT



Beatriz Biguino

bibiguino@fc.ul.pt

Supervisors: Ana C. Brito¹, João Miguel Dias², Ivan D. Haigh³

- MARE - Marine and Environmental Sciences Centre / ARNET - Aquatic Research Network, Faculdade de Ciências, Universidade de Lisboa, 1749-016 Lisboa, Portugal
- Centre for Environmental and Marine Studies (CESAM), Departamento de Física, Universidade de Aveiro, 3810-193 Aveiro, Portugal
- School of Ocean and Earth Science, National Oceanography Centre, University of Southampton, Waterfront Campus, European Way, Southampton SO14 3ZH, UK

MIT Portugal
2024 Annual Conference

1. Introduction

What are Marine Heat Waves (MHW) and Marine Cold Spells (MCS)?

A period of at least five consecutive days with water temperatures

above the 90th percentile threshold of the long-term mean seasonal climatology¹

MHW

bellow the 10th percentile threshold of the long-term mean seasonal climatology²

MCS

Why do they matter?

Both can affect ocean health, change ecosystem services and disrupt economic activities. MCSs however may benefit marine ecosystem recovery when damaged by MHWs and buffer the impacts of heat stress. Thus, understanding MHWs and MCSs events and their effects in ecosystems is crucial.

A lot is left to know

- Current knowledge about past occurrences and the future progression of this type of events is limited³
- The changes reported for MHWs and MCSs are not regionally uniform⁴
- It is still unclear if coastal areas, including estuarine systems, follow open-ocean trends⁴

Satellite-derived Sea Surface Temperatures (SST) were used. The SST product analyzed was produced by the ESA Climate Change Initiative (CCI) and the SST CCI project^{5,6}. It has daily estimates of global SSTs with a spatial resolution of 0.05 ° (≈ 5 km).

The SST data was previously validated for the coastal ocean through the comparison with concomitant *in situ* observations.

2. Aims of the work

Be able to answer the following questions:

- How many MHWs/MCSs occurred?
- How intense were they?
- How long did they last on average?
- How have they changed over the years?

Where:

Western Iberian Coast (WIC), which was never studied in this regard

When:

1st JAN 1982
–
31st DEC 2022

Assessed parameters:

- Number of events
- Average, maximum and cumulative intensity
- Duration
- Timing of occurrence

3. Methods

A python module called marineHeatWaves (version 0.28) created and provided by Eric C. J. Oliver was used as a basis for the **identification of events and their characteristics**⁷. MHWs/MCSs statistics were calculated using the blockAverage function from the marineHeatWaves python module, where the event's physical attributes were averaged over annual blocks. From this, information was retrieved to produce **average and trend maps**.

4. Main Results

I. How many MHWs/MCSs occurred?

- In opposition to MHWs, there was a clear higher incidence of MCSs near the coast than offshore, namely between Minho and Douro Estuaries and near Cape São Vicente.
- Summer was the most prominent season for the occurrence of both MHWs and MCSs.

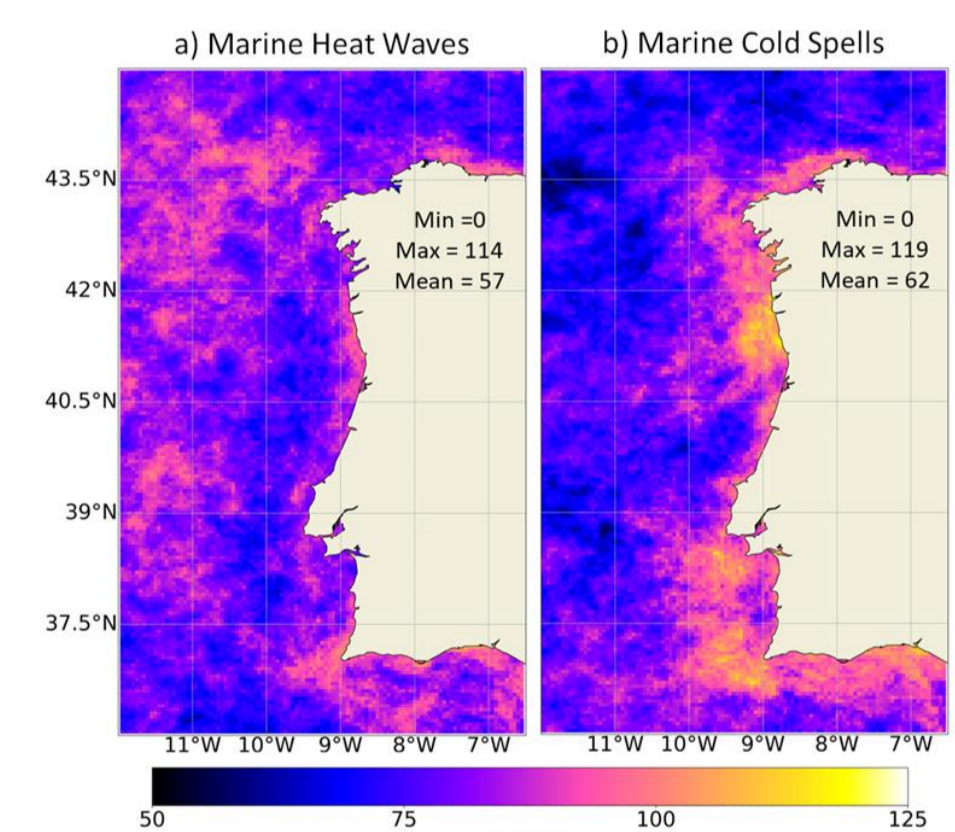


Figure 1. Total number of events that occurred throughout the region between 1982 and 2022.

II. How intense were they?

- The highest average intensity events were recorded near the coast.
- For both MHWs and MCSs, the coastline between Minho and Aveiro and the south coast of Portugal were detected as regions of higher intensity events.

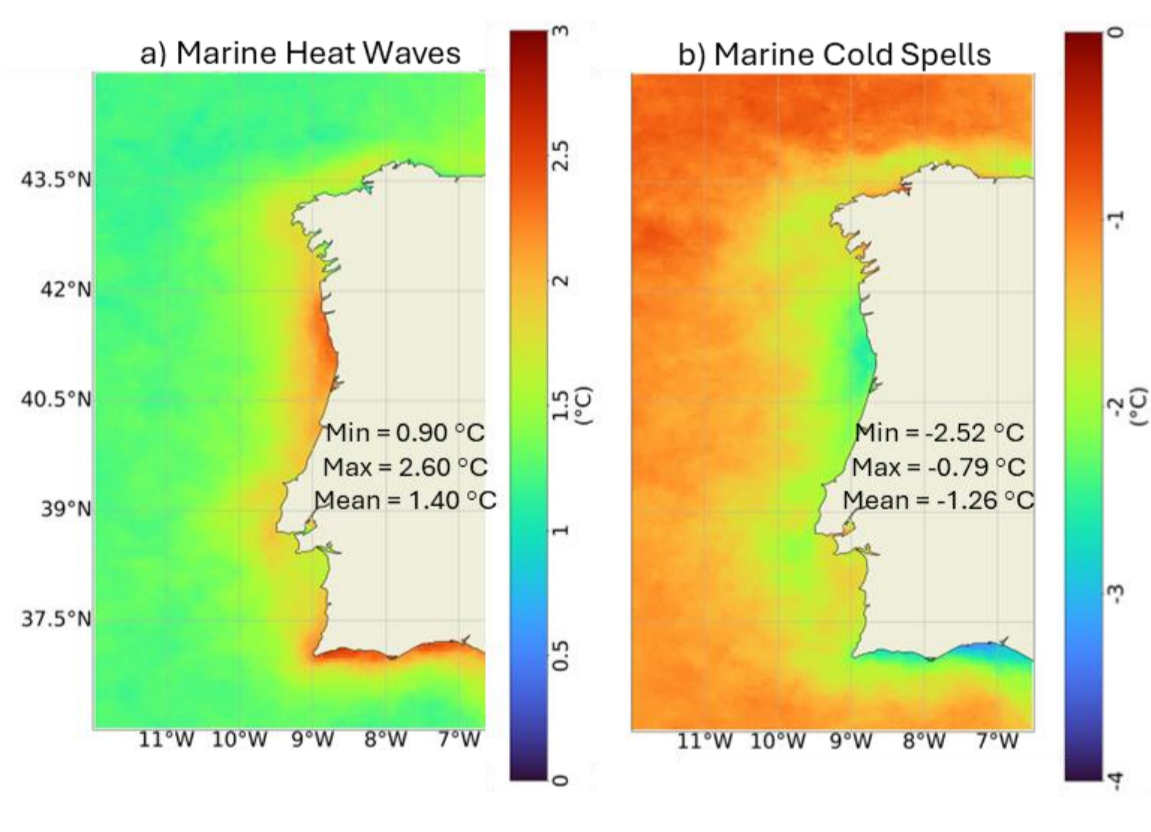


Figure 2. 41-year average mean intensity of MHWs and MCSs throughout the WIC. For MCSs, higher intensities correspond to lower values (negative values).

III. How long did they last on average?

- MCSs lasted longer than MHWs.
- The 41-year average points to longer MHWs of ≈17 days along the coastal area of Southwest Portugal.
- The longest-lasting MCSs were located offshore. The shortest MCSs (≈10 days) were identified where on average the longest MHWs were recorded.

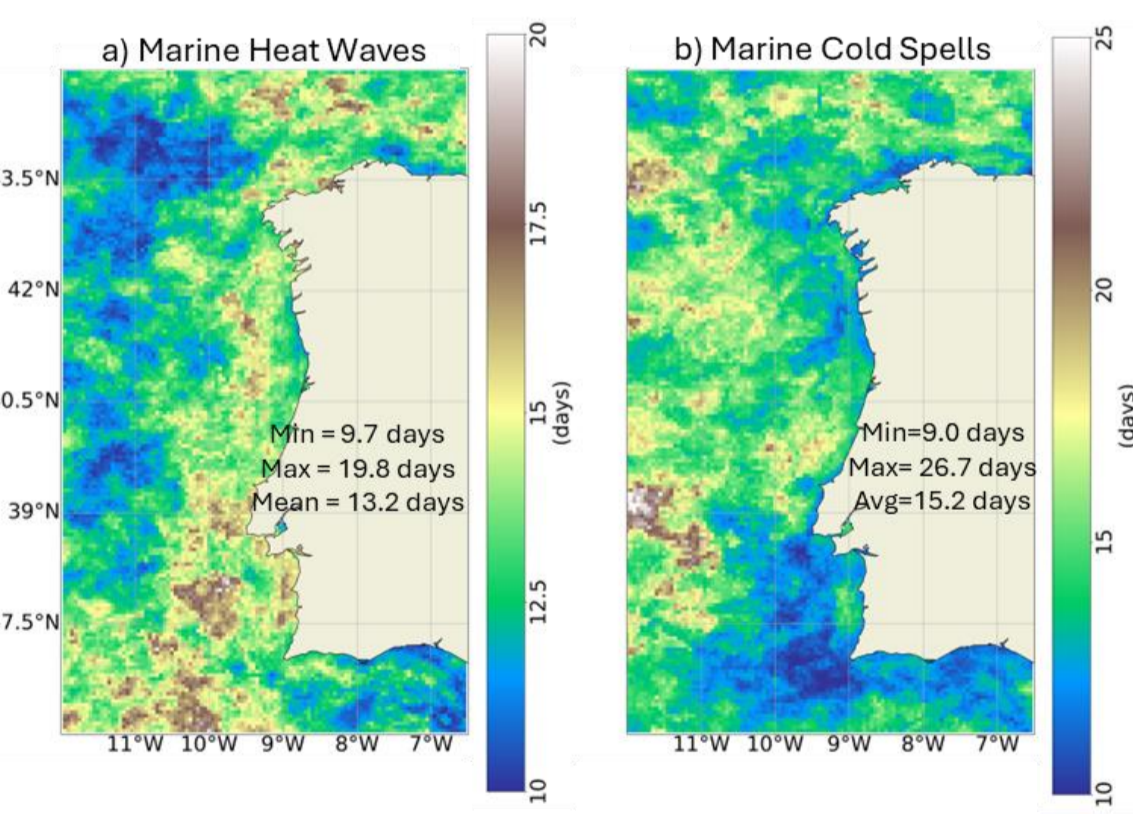


Figure 3. 41-year average duration of MHWs and MCSs throughout the WIC.

IV. How have they changed over the years?

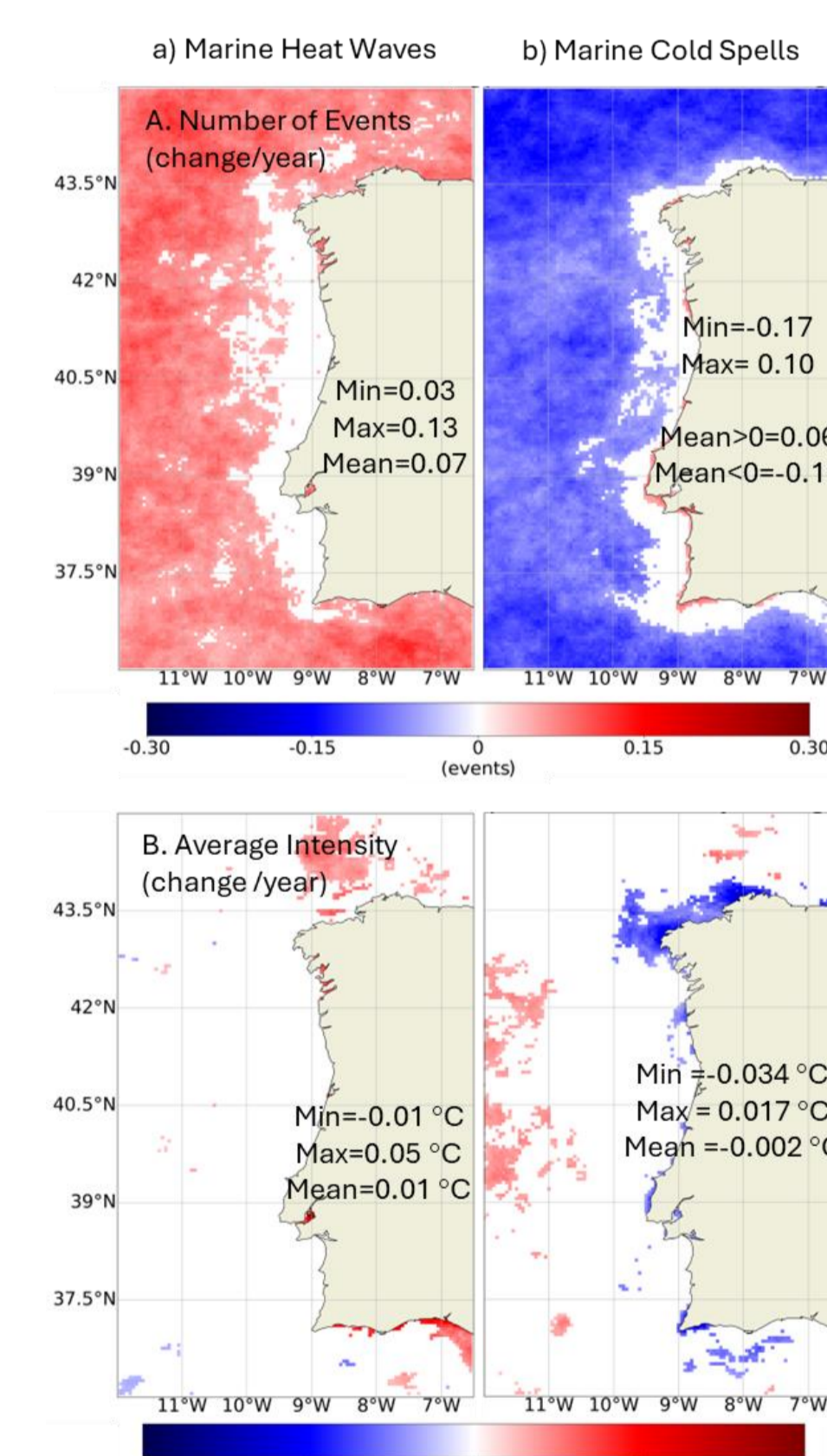


Figure 4. Trends (change/year) of MHWs and MCSs number of events per year (A) and average intensity (B) considering the period between 1982 and 2022. Only significant changes are colored (p-value=0.05). For MCSs, higher intensities correspond to lower values (negative values).

- The number of MHWs has increased along the North and Southern margins of the WIC and offshore (≈0.07 events/year).
- A significant decrease in the number of MCSs was observed offshore (≈-0.1 events/year). Near the coastline (first few km), positive trends were observed (increase of 2.5 events in 41 years).
- MHWs average intensity tended to increase very locally, namely along the southern margin of the WIC.
- An increase in the average intensity of MCSs was observed close the coast, with greater spatial relevance near Galicia (≈0.03-0.04 °C/year).

5. Take home messages

The WIC was not exceptionally favorable for the occurrence of MHWs. More MCSs than MHWs were observed. Yet, MCSs tended to be less intense.

The coast between Minho and Douro Estuaries and Cape São Vicente were identified as most prone for the occurrence of both MHWs and MCSs.

No relevant significant changes regarding the duration, first day of the event and average, maximum and cumulative intensity were observed for both MHWs and MCSs.

MHWs (MCSs) were found to have been increasing (decreasing) offshore. The near coastal area works as a buffer for long-term changes.

Increased seasonal upwelling could be contributing to mask the development of MHWs and enhance MCSs in the region.

References

- Hobday, A. J., Alexander, L. V., Perkins, S. E., Smale, D. A., Straub, S. C., Oliver, E. C. J., Benthuyzen, J. A., Burrows, M. T., Donat, M. G., Feng, M., Holbrook, N. J., Moore, P. J., Scannell, H. A., Sen Gupta, A., and Wernberg, T. (2016). A hierarchical approach to defining marine heatwaves. *Progress in Oceanography*, 141, 227–238. <https://doi.org/10.1016/j.pocean.2015.12.014>
- Schlegel, R. W., Darmaraki, S., Benthuyzen, J. A., Filbee-Dexter, K., and Oliver, E. C. J. (2021). Marine cold-spells. *Progress in Oceanography*, 198, 102684. <https://doi.org/https://doi.org/10.1016/j.pocean.2021.102684>
- Frölicher, T. L., Fischer, E. M., and Gruber, N. (2018). Marine heatwaves under global warming. *Nature*, 560(7718), 360–364. <https://doi.org/10.1038/s41586-018-0383-9>
- Simon, A., Poppechi, C., Plecha, S., Charria, C., and Russo, A. (2023). Coastal and regional marine heatwaves and cold spells in the northeastern Atlantic. *Ocean Science*, 19(5), 1339–1355. <https://doi.org/10.5194/os-19-1339-2023>
- Good, S. A., Embury, O., Bulgin, C. E., and Mittaz, J. (2019). ESA Sea Surface Temperature Climate Change Initiative (SST_CCI): Level 4 Analysis Climate Data Record, version 2.0. Centre for Environmental Data Analysis.
- Merchant, C. J., Embury, O., Bulgin, C. E., Block, T., Corlett, G. K., Fiedler, E., Good, S. A., Mittaz, J., Rayner, N. A., Berry, D., Eastwood, S., Taylor, M., Tsumihima, Y., Waterfall, A., Wilson, R., and Donlon, C. (2019). Satellite-based time-series of sea-surface temperature since 1981 for climate applications. *Scientific Data*, 6(223).
- Oliver, E. C. J. (2018). Marine Heatwaves detection code. Python code, version 0.28. <https://github.com/ericjolver/marineHeatWaves>

Funded by:



MIT Portugal



under the Doctoral Grant PRT/BD/152829/2021 | Climate Science & Climate Change