

Exploring atmospheric drivers during MHW events in the Mediterranean region

Rubèn Martí-Burillo, Cristina González-Haro,
Justino Martínez, Emili García-Ladona,
Joaquim Ballabrera

rubenbm@icm.csic.es



Cofinancat per
la Unió Europea



Generalitat
de Catalunya



CSIC
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS



Institut
de Ciències
del Mar

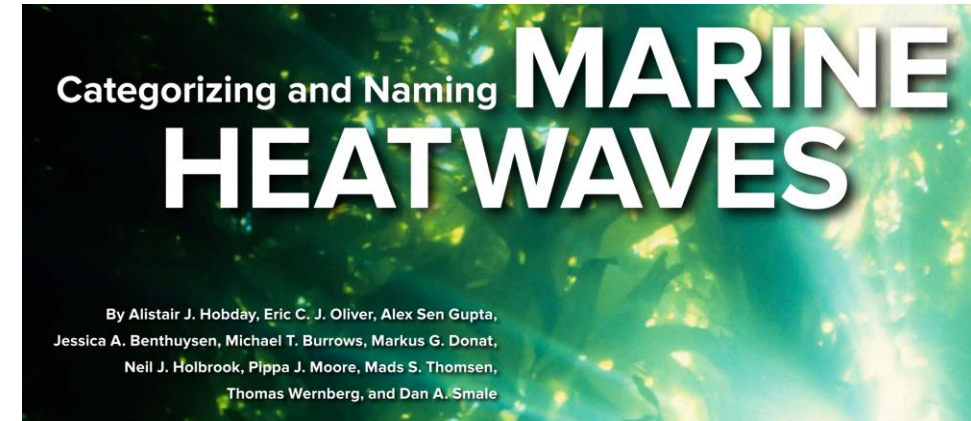
What is a Marine Heatwave?



A hierarchical approach to defining marine heatwaves

Alistair J. Hobday^{a,*}, Lisa V. Alexander^{b,c}, Sarah E. Perkins^{b,c}, Dan A. Smale^{d,e}, Sandra C. Straub^e, Eric C.J. Oliver^{b,f}, Jessica A. Benthuyzen^g, Michael T. Burrows^h, Markus G. Donat^{b,c}, Ming Fengⁱ, Neil J. Holbrook^{b,f}, Pippa J. Moore^j, Hillary A. Scannell^{k,l}, Alex Sen Gupta^{b,c}, Thomas Wernberg^e

Hobday et. al. 2016



Hobday et. al. 2018

“Discrete prolonged anomalously warm SST event in a particular location.”

- ✓ **Discrete:** Well-defined start and end times.
- ✓ **Prolonged:** lasting at least 5 consecutive days.
- ✓ **Anomalously warm:** Relative to a seasonal climatology (~30-year baseline) using the 90th percentile as a threshold.

What is a Marine Heatwave?

Progress in Oceanography 141 (2016) 227–238



Contents lists available at ScienceDirect

Progress in Oceanography

journal homepage: www.elsevier.com/locate/pocean

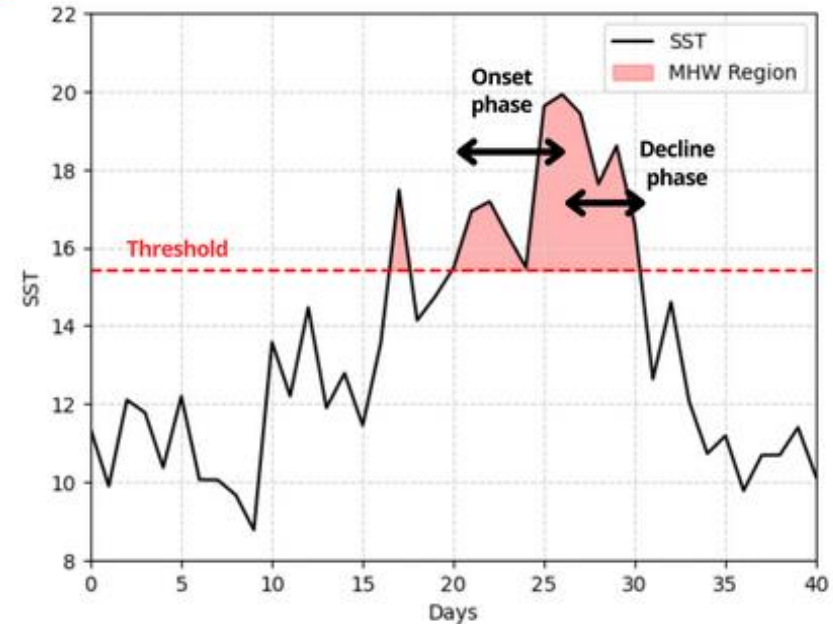


A hierarchical approach to defining marine heatwaves

Alistair J. Hobday^{a,*}, Lisa V. Alexander^{b,c}, Sarah E. Perkins^{b,c}, Dan A. Smale^{d,e}, Sandra C. Straub^e, Eric C.J. Oliver^{b,f}, Jessica A. Benthuyzen^g, Michael T. Burrows^h, Markus G. Donat^{b,c}, Ming Fengⁱ, Neil J. Holbrook^{b,f}, Pippa J. Moore^j, Hillary A. Scannell^{k,l}, Alex Sen Gupta^{b,c}, Thomas Wernberg^e



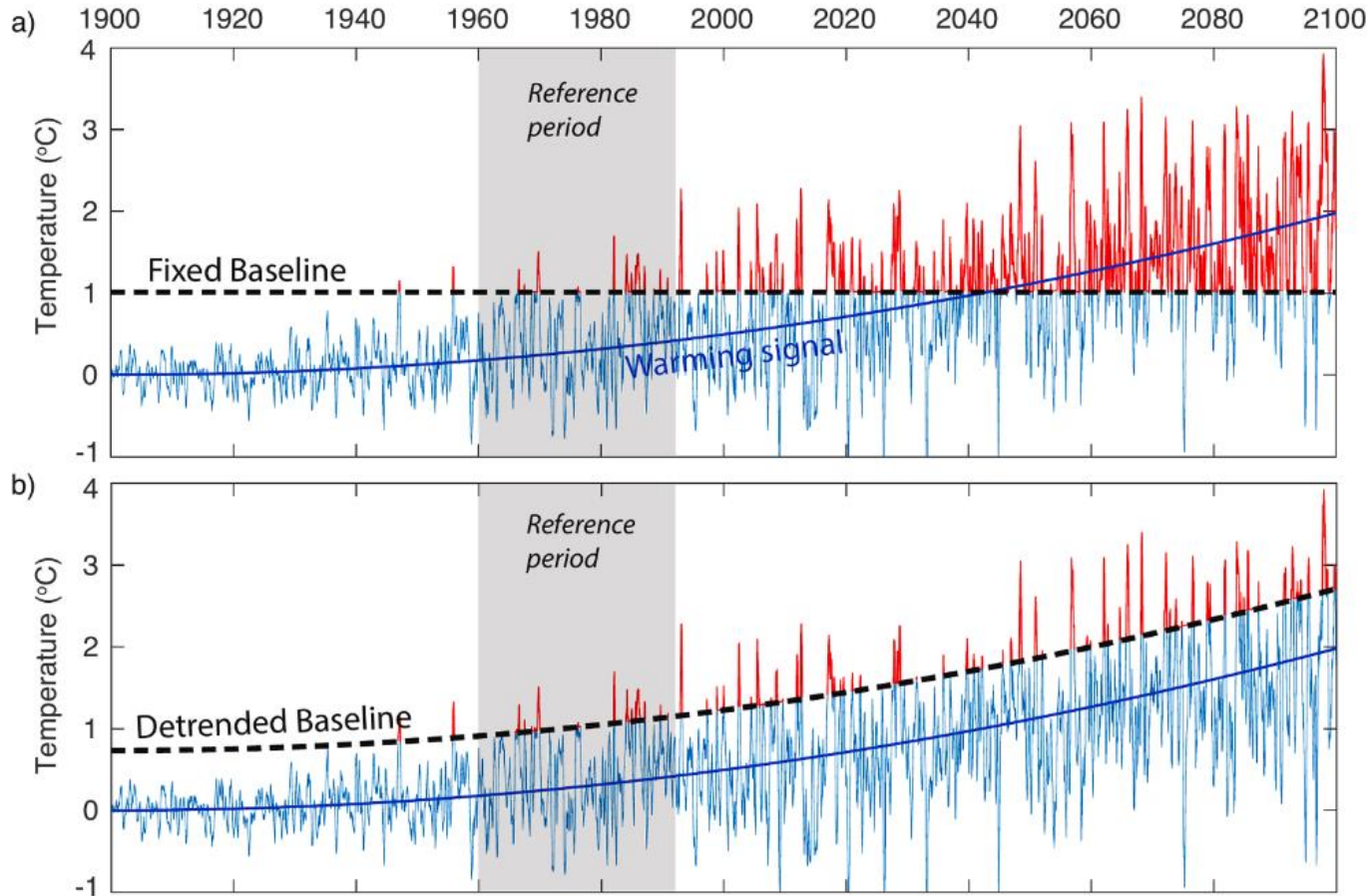
Hobday et. al. 2016



“Discrete prolonged anomalously warm SST event in a particular location.”

- ✓ **Discrete:** Well-defined start and end times.
- ✓ **Prolonged:** lasting at least 5 consecutive days.
- ✓ **Anomalously warm:** Relative to a seasonal climatology (~30-year baseline) using the 90th percentile as a threshold.

Baseline Matters



Extracted from K.E. Smith et. al. 2025

Useful for: Physiological studies on marine species that are affected by absolute temperature extremes (ej. Coral reef monitoring).

Useful for: Understanding the internal mechanisms that trigger MHWs and are responsible for their development and decline.



Detrending separates short-term extremes from climate trends.

K.E. Smith et. al. 2025 survey of the first 100
'most relevant' results in a Google Scholar
search on "marine heatwaves":

"Most studies exploring changes in MHW
characteristics over time and examining
event attribution have used a fixed
baseline"

Intensity Duration Numbers

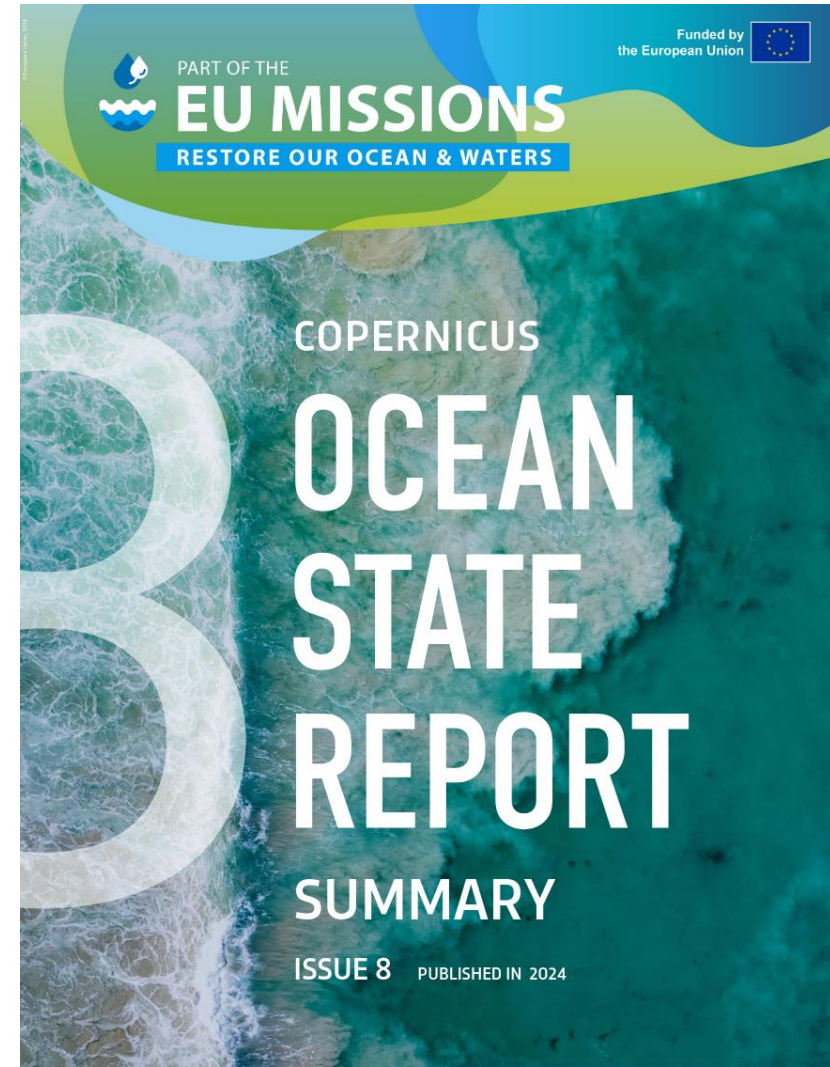
K.E. Smith et. al. 2025 survey of the first 100 'most relevant' results in a Google Scholar search on "marine heatwaves":

"Most studies exploring changes in MHW characteristics over time and examining event attribution have used a fixed baseline"

Intensity

Duration

Numbers



K.E. Smith et. al. 2025 survey of the first 100 'most relevant' results in a Google Scholar search on "marine heatwaves":

"Most studies exploring changes in MHW characteristics over time and examining event attribution have used a fixed baseline"

↑
Intensity

↑
Duration

↑
Numbers



The image shows the cover of a report titled "A Deeper Look Into Europe's Marine Heatwaves in 2022". At the top, it says "PART OF THE EU MISSIONS RESTORE OUR OCEAN & WATERS" and "Funded by the European Union" with the EU flag. Below the title, there is a paragraph: "Over the past few decades, marine heatwaves in the northeast Atlantic and adjacent seas grew in strength, occurred more often, stretched further and lasted longer." The next section is "2. NORTHWEST EUROPEAN SHELF" with a sub-header "OSR 8". Below this, it says "More frequent and longer-lasting marine heatwaves are striking the Northwest European Shelf, including during winter." At the bottom, it says "ISSUE 8 PUBLISHED IN 2024".

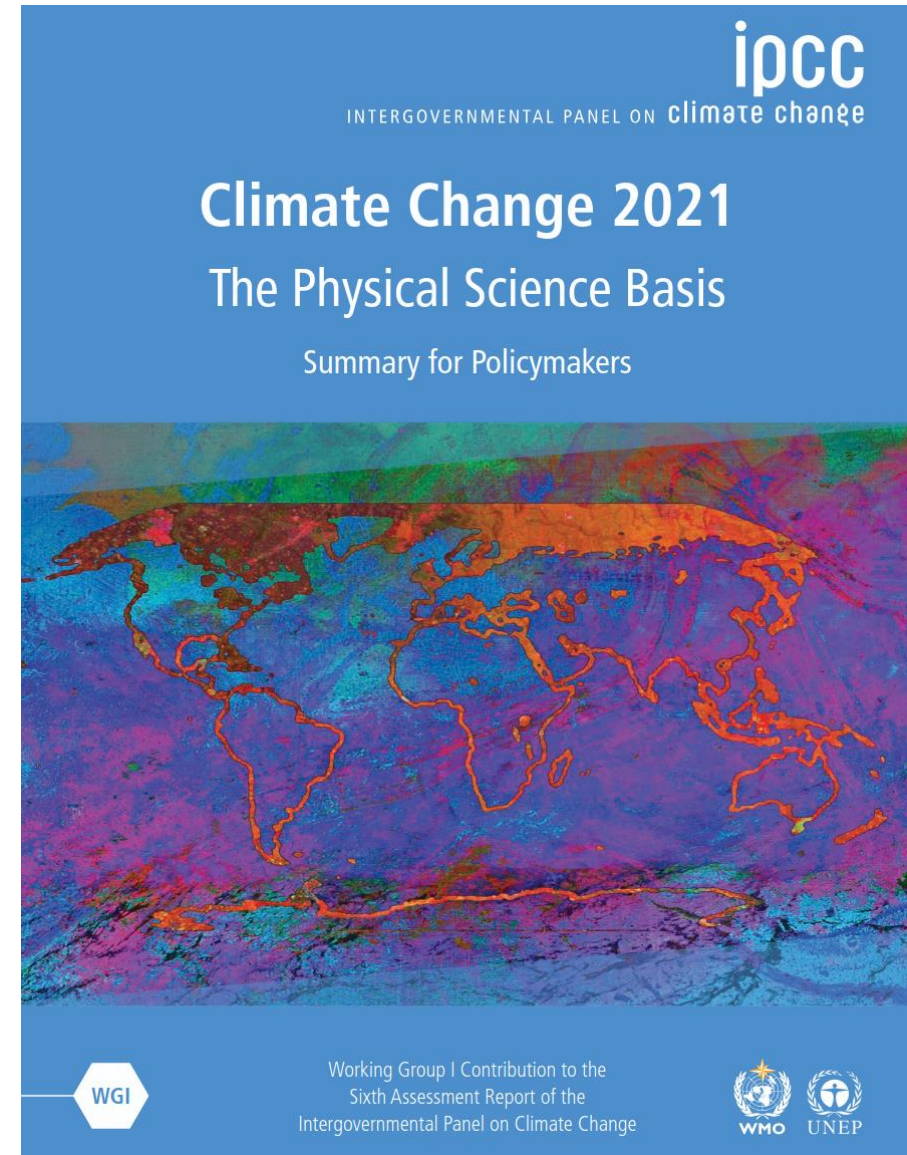
K.E. Smith et. al. 2025 survey of the first 100 ‘most relevant’ results in a Google Scholar search on “marine heatwaves”:

“Most studies exploring changes in MHW characteristics over time and examining event attribution have used a fixed baseline”

Intensity

Duration

Numbers



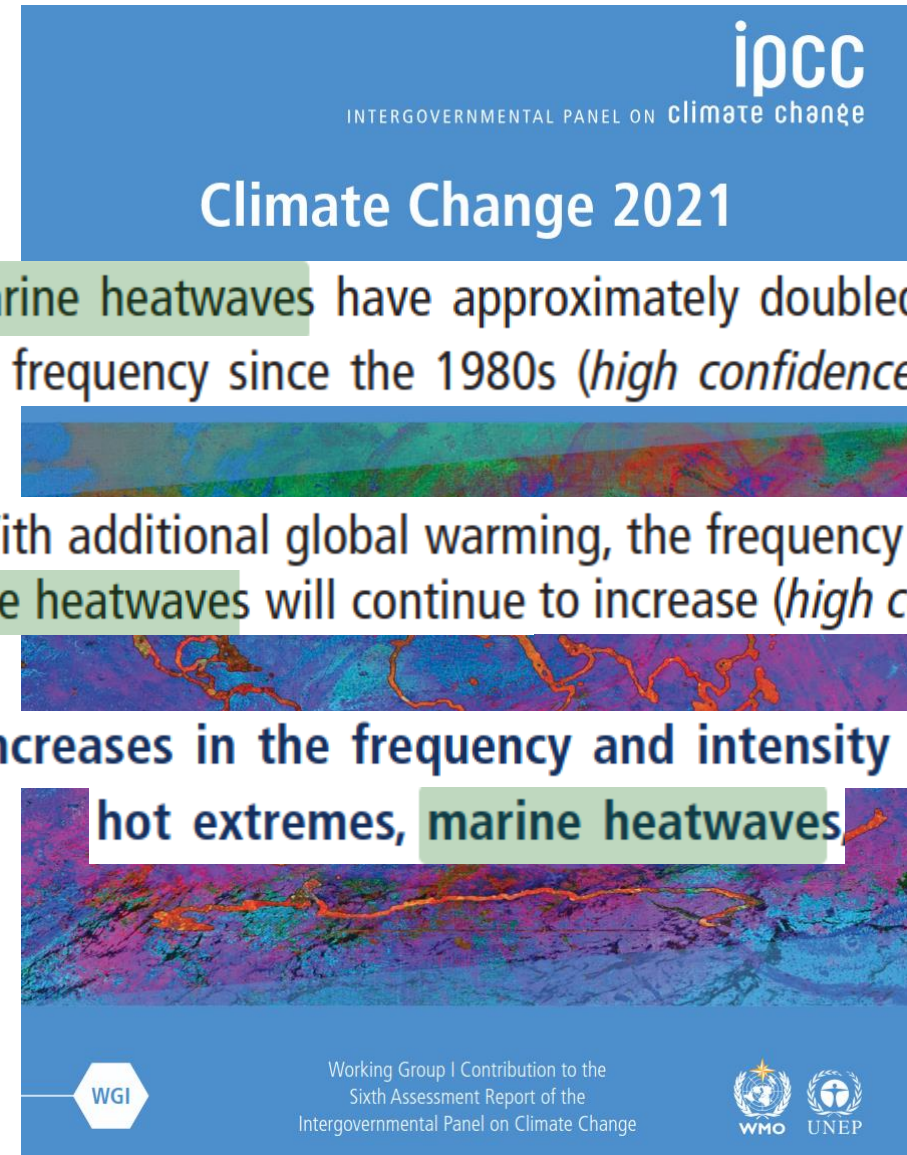
K.E. Smith et. al. 2025 survey of the first 100 'most relevant' results in a Google Scholar search on "marine heatwaves":

"Most studies exploring changes in MHW characteristics over time and examining event attribution have used a fixed baseline"

↑
Intensity

↑
Duration

↑
Numbers



K.E. Smith et. al. 2025 survey of the first 100 'most relevant' results in a Google Scholar search on "marine heatwaves":

"Most studies exploring changes in MHW characteristics over time and examining event attribution have used a fixed baseline"

Intensity

Duration

Numbers



ARTICLE

DOI: 10.1038/s41467-018-03732-9

OPEN

Longer and more frequent marine heatwaves over the past century

Eric C.J. Oliver^{1,2,3}, Markus G. Donat^{4,5}, Michael T. Burrows⁶, Pippa J. Moore⁷, Dan A. Smale^{8,9}, Lisa V. Alexander^{4,5}, Jessica A. Benthuisen¹⁰, Ming Feng¹¹, Alex Sen Gupta^{4,5}, Alistair J. Hobday¹², Neil J. Holbrook^{2,13}, Sarah E. Perkins-Kirkpatrick^{4,5}, Hillary A. Scannell^{14,15}, Sandra C. Straub⁹ & Thomas Wernberg⁹

PNAS

RESEARCH ARTICLE

ENVIRONMENTAL SCIENCES



Global warming drives a threefold increase in persistence and 1 °C rise in intensity of marine heatwaves

Marta Marcos^{a,b,c,1}, Angel Amores^{a,b}, Miguel Aguilles^a, Jon Robson^d, and Xiangbo Feng^d

occurred in the last 15 y. Our approach goes a step beyond and permits quantifying that, without global warming, the 47% of the observed number of MHW during the period 2000–2020 would have not been identified as extreme events.

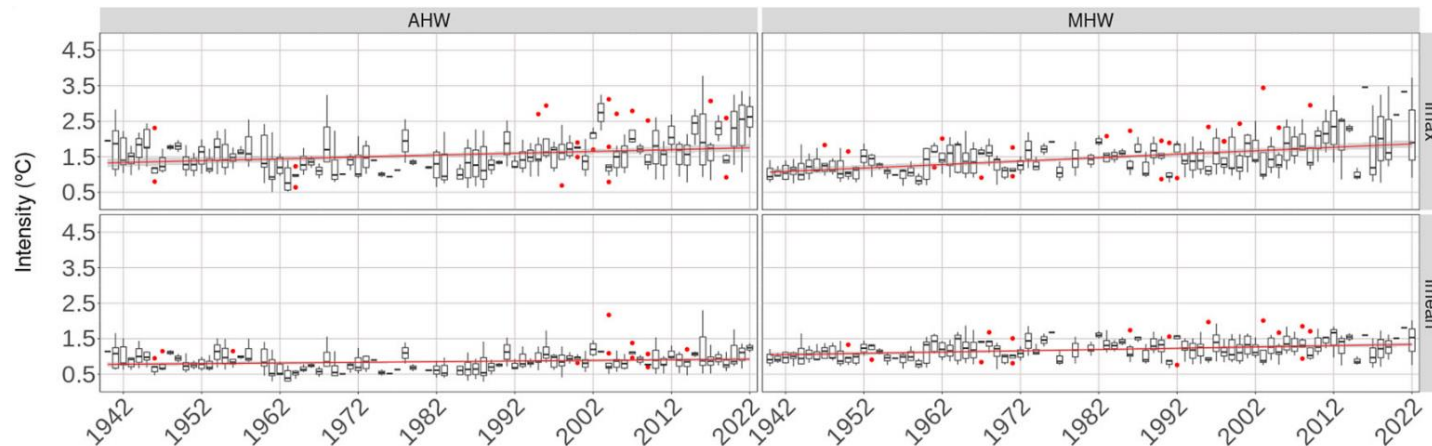


<https://doi.org/10.1038/s43247-024-01982-8>

Mediterranean marine heatwaves intensify in the presence of concurrent atmospheric heatwaves

Check for updates

Francisco Pastor , Laura Paredes-Fortuny & Samira Khodayar



- New methodology to track the spatiotemporal evolution of both MHWs and AHWs:

MHW requires $\geq 5\%$ regional coverage to be considered.

- Concurrent MHW-AHW events significantly intensify MHWs, but AHWs remain mostly unchanged.
- MHWs in the Mediterranean have become more frequent, intense, and long-lasting.

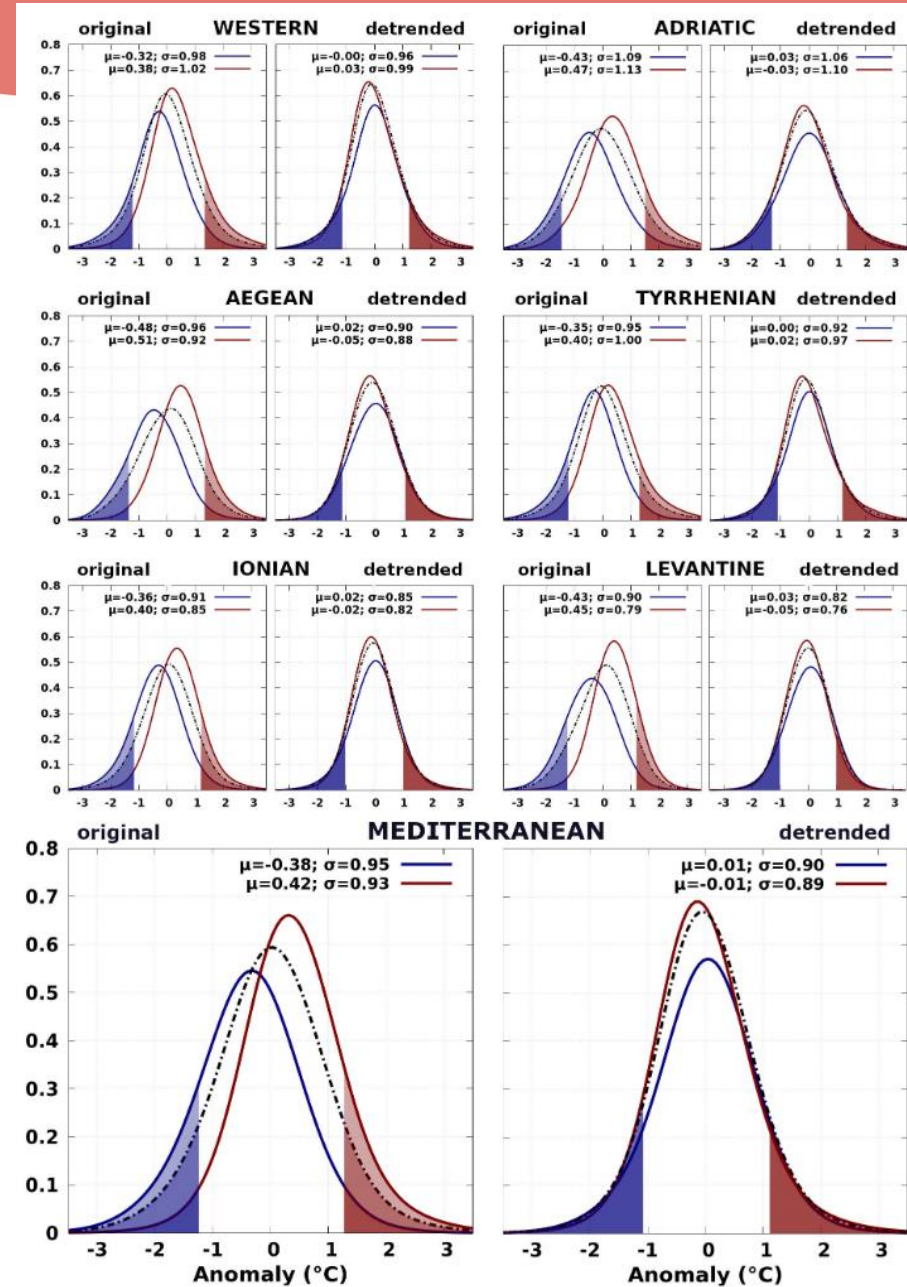
Evolution of marine heatwaves in warming seas: the Mediterranean Sea case study

Justino Martínez^{1*}, Francesca Elisa Leonelli^{2†},
Emilio García-Ladona¹, Joaquim Garrabou¹, Diego K. Kersting³,
Nathaniel Bensoussan⁴ and Andrea Pisano²

Figure 2 extracted from Martínez et. al. 2023:

Probability density functions (PDFs) of daily SST anomalies per sub-basin and for the Mediterranean Sea

- Blue lines: 1982–2001
- Red lines: 2002–2022
- Black dashed lines: Whole period



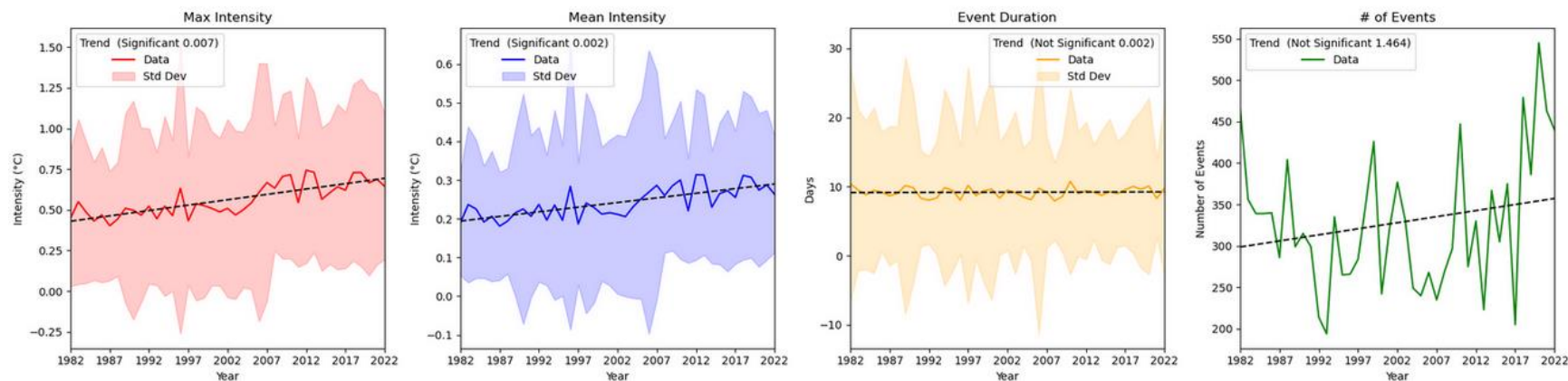
Objectives

- **Compute MHWs and AHWs metrics with a detrended baseline using ERA5.**
- **Compute new metrics considering only events with $\geq 5\%$ regional coverage (F. Pastor methodology).**
- **Compare ERA5 results using ESA CCI SST from satellite observations.**

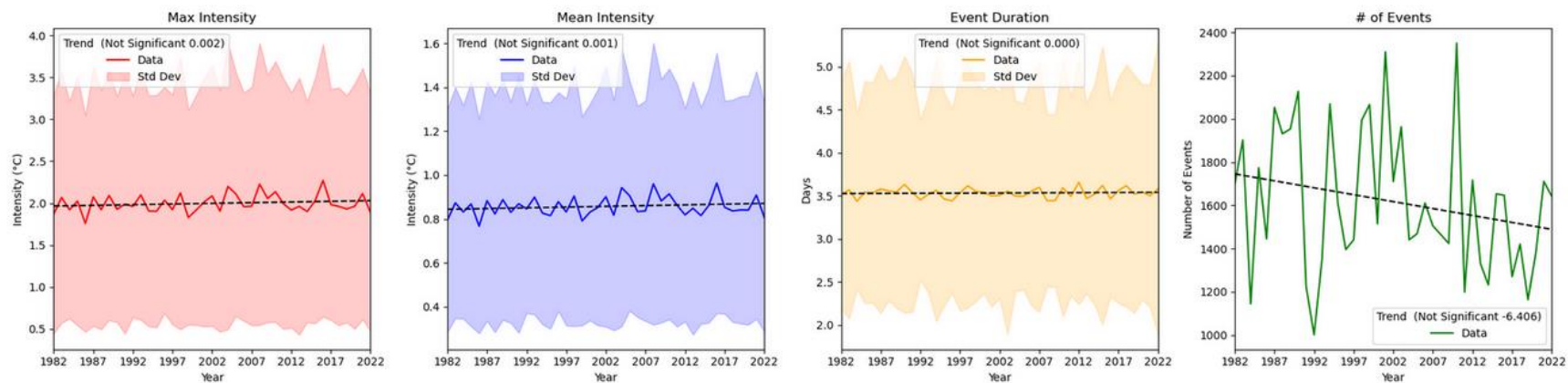
Results

ERA5 MHW and AHW metrics

MHW



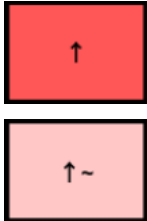
AHW



	AHW	MHW
Imax	~	↑
Imean	~	↑
Duration	~	~
# Events	↓~	↑~

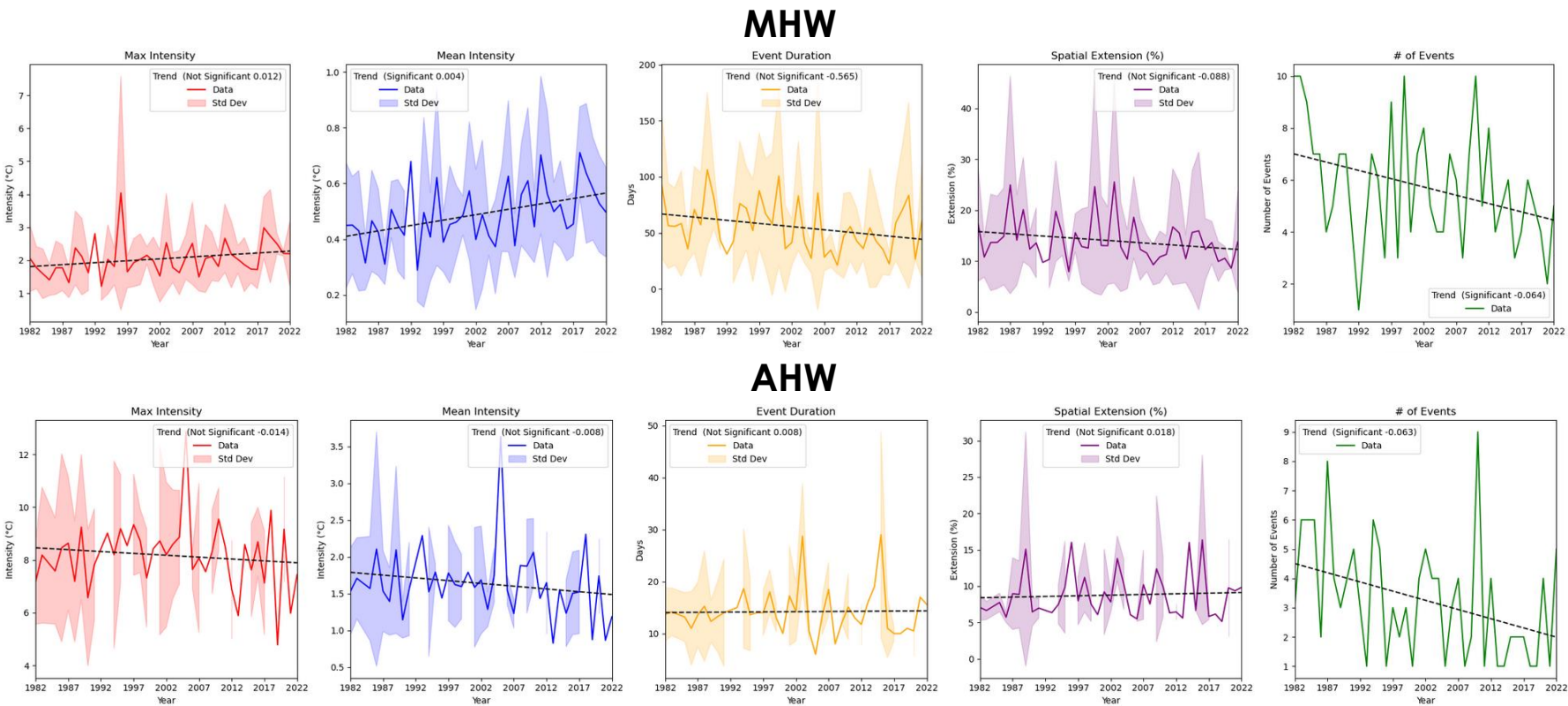
Bold color:
Significant trend

Faded color:
Not significant trend



Results

ERA5 MHW and AHW metrics (F. Pastor methodology)

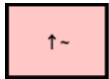


	No Spatial Extension		Spatial Extension	
	AHW	MHW	AHW	MHW
Imax	~	↑	↓~	↑~
Imean	~	↑	↓~	↑
Duration	~	~	~	↓~
S.E %			↑~	↓~
# Events	↓~	↑~	↓	↓

Bold color:
Significant trend

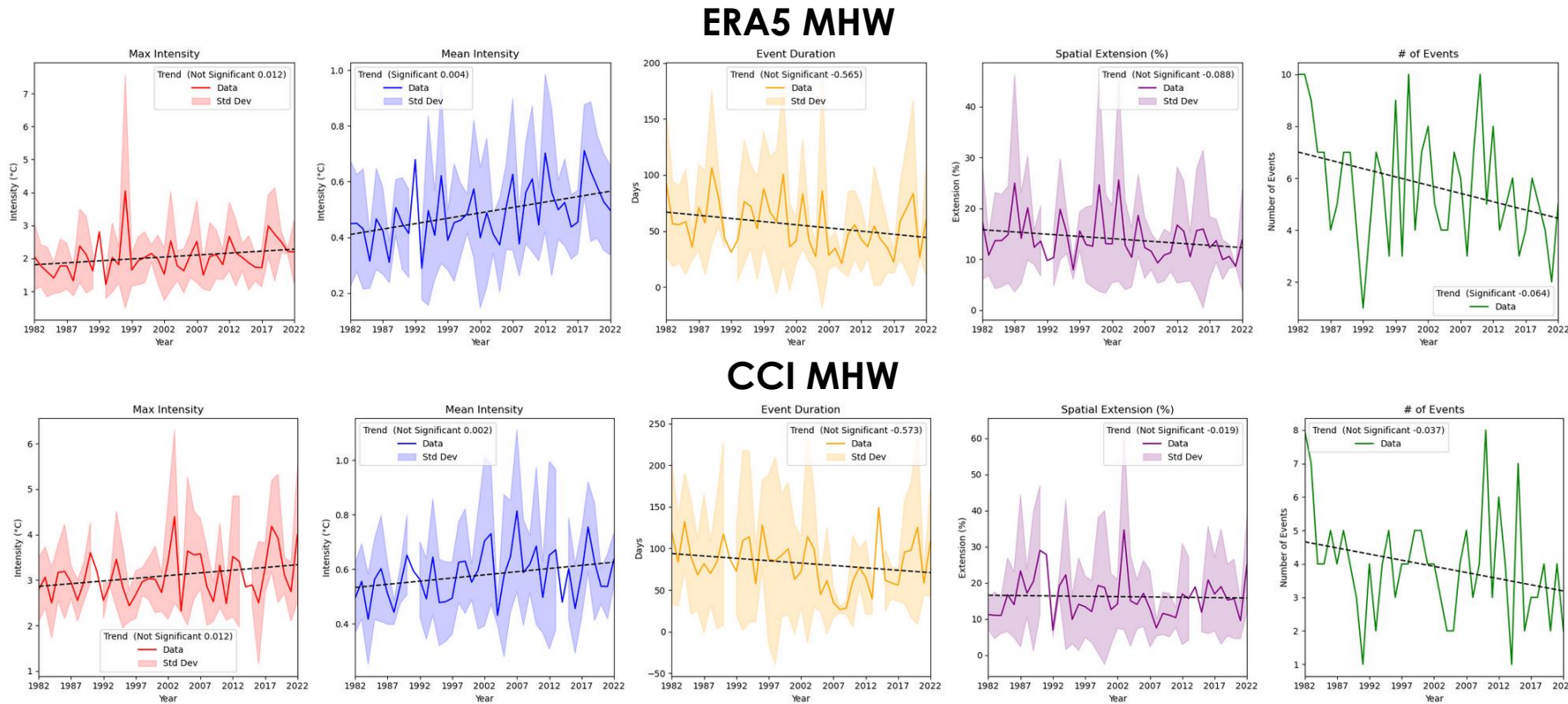


Faded color:
Not significant trend



Results

ERA5 vs CCI MHW metrics (F. Pastor methodology)



	ERA5	CCI
	MHW	MHW
I_{max}	↑~	↑~
I_{mean}	↑	↑~
Duration	↓~	↓~
S.E %	↓~	↓~
# Events	↓	↓~

Bold color:
Significant trend



Faded color:
Not significant trend



Conclusions

- When computing metrics using a detrended baseline results do not show an increase in all MHW and AHW metrics.
- Same trends are obtained using different datasets but significance is lost for CCI observations



A DEEPER LOOK INTO EUROPE'S MARINE HEATWAVES IN 2022

Over the past few decades, marine heatwaves in the northeast Atlantic and adjacent seas grew in strength, occurred more often, stretched further and lasted longer.

Intensity

Duration

Numbers

Thanks for your attention

rubenbm@icm.csic.es



Cofinancat per
la Unió Europea



Generalitat
de Catalunya



CSIC
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS



Institut
de Ciències
del Mar