The outstanding European and Mediterranean heatwave activity during summer 2022

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Motivation

- Intensification of the **continental drought** (e.g. Faranda et al., 2023; Garrido-Pérez et al., 2024)

- The **exceptional fire season** over southwest Europe (e.g. Rodrigues et al., 2023)

- The **glacier melt events** in Switzerland (e.g. Cremona et al., 2023)

- Large **heat-related mortality** in Europe (~60,000 excess deaths) (e.g. Ballester et al., 2023)

- **Extreme climatic conditions** on regional scales (e.g. Yule et al, 2023; Guinaldo et al., 2023)

Role played by **atmospheric circulation** (e.g. Ibebuchi et al., 2023; Herrera-Lormendez et al., 2023)

Role played by the **high SST values in the Western Mediterranean** (e.g. Guinaldo et al., 2023)

Role played by **low soil moisture** values (e.g. Tripathy et al., 2023)

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The impact of summer 2003 and 2010 mega-heatwaves in Europe

European summer temperature
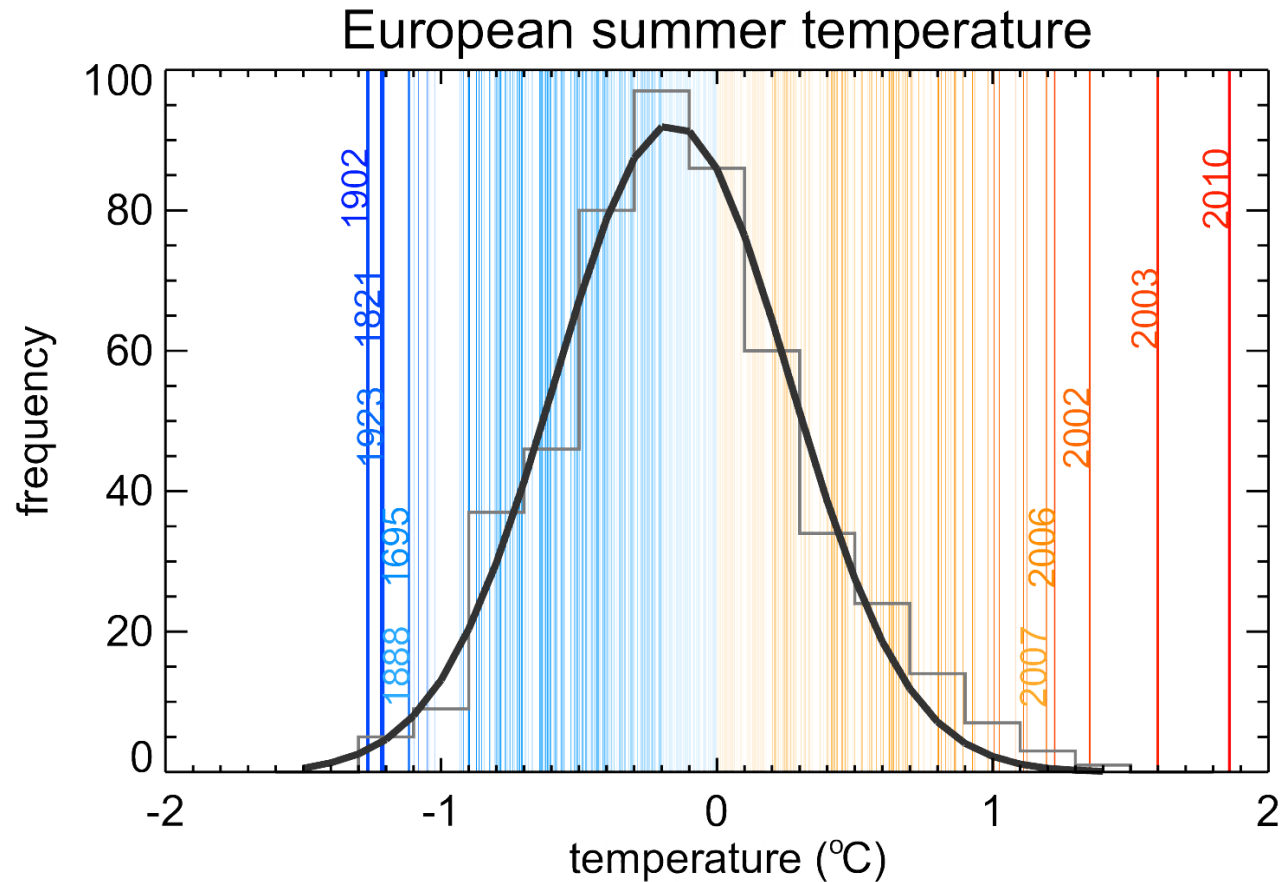
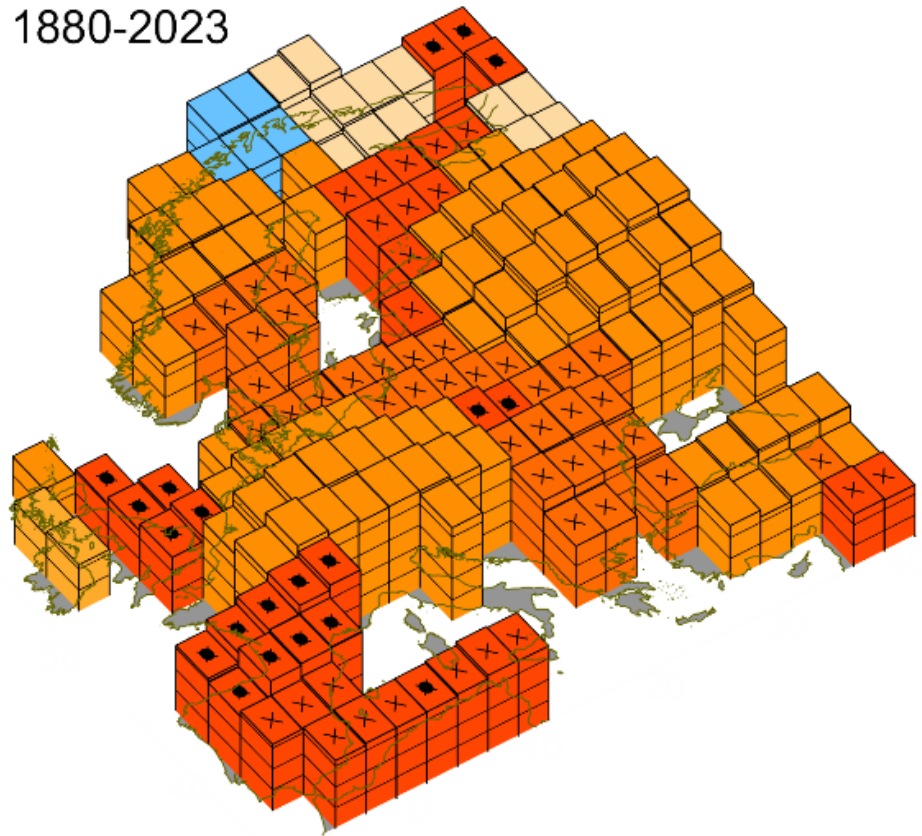
European summer land temperature anomalies (1951-1980) for **1500–2010** and their frequency distribution (percentage, grey bars).

Dataset: Luerbacher et al. (2004, SCIENCE)

Barriopedro et al. (2011, SCIENCE)

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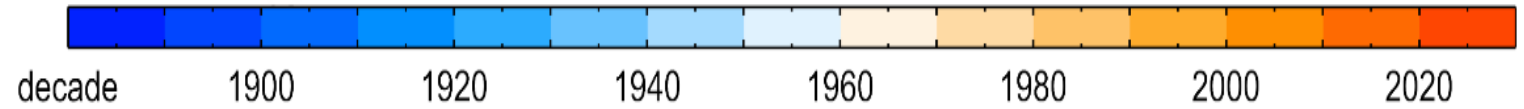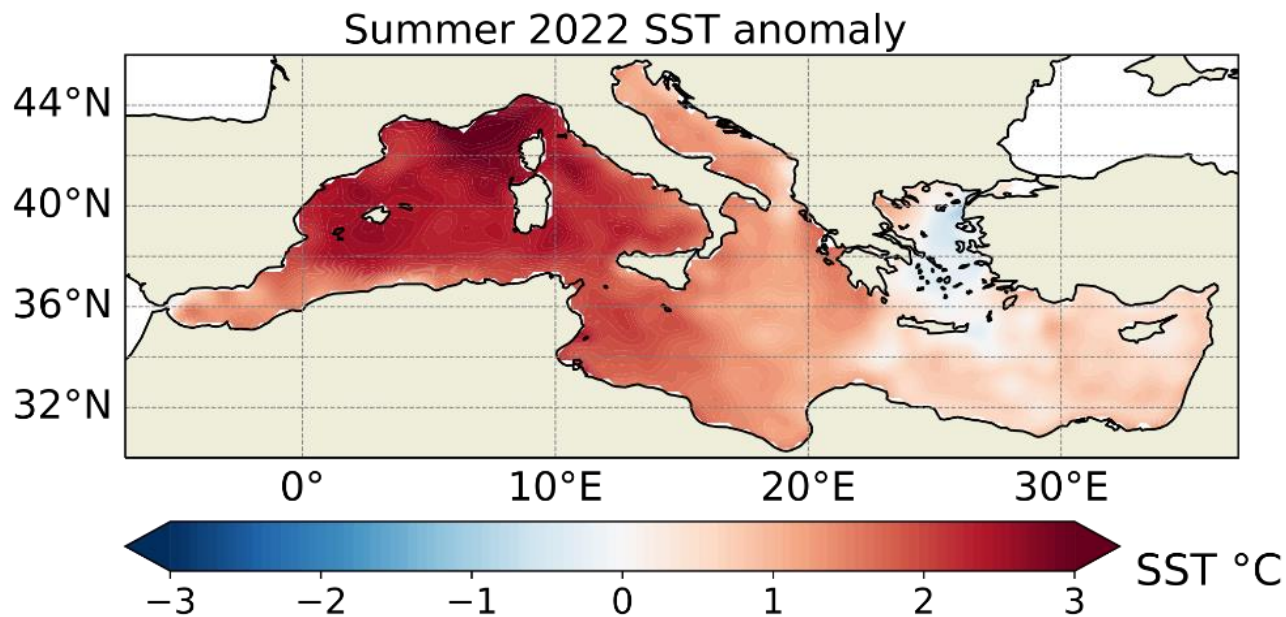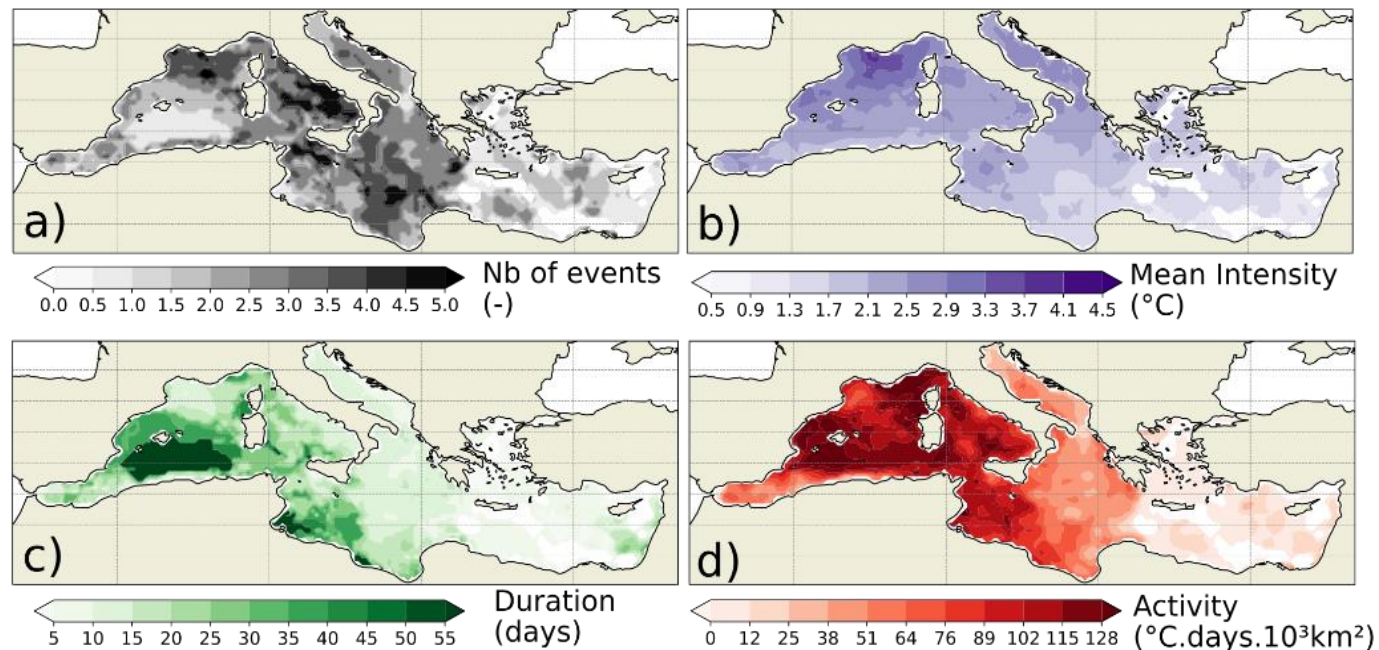a) European summers (1500-2023)
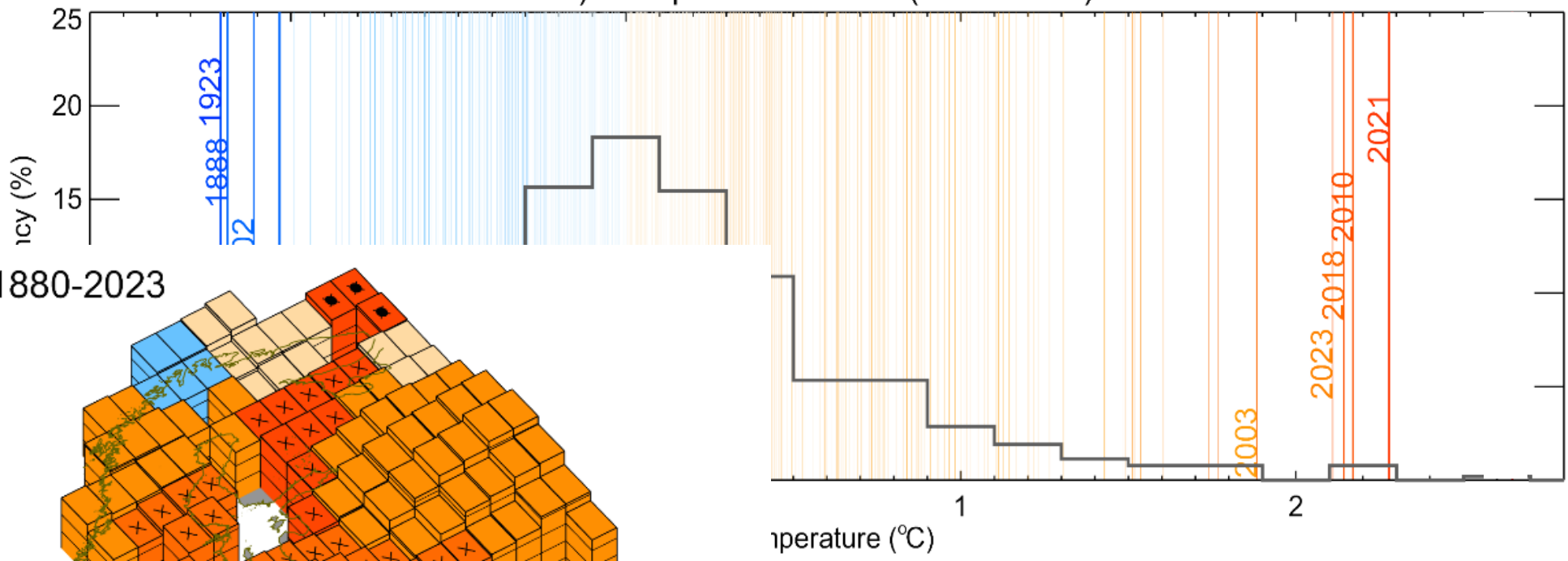
c) 1880-2023

Hottest European summers since 1880. The height and the color of the bars indicate the summer temperature anomaly (1951–1980) and the decade of the corresponding summer.

GISTEMP (NASA) **1880-2023**

(Trigo et al. 2024, submitted)
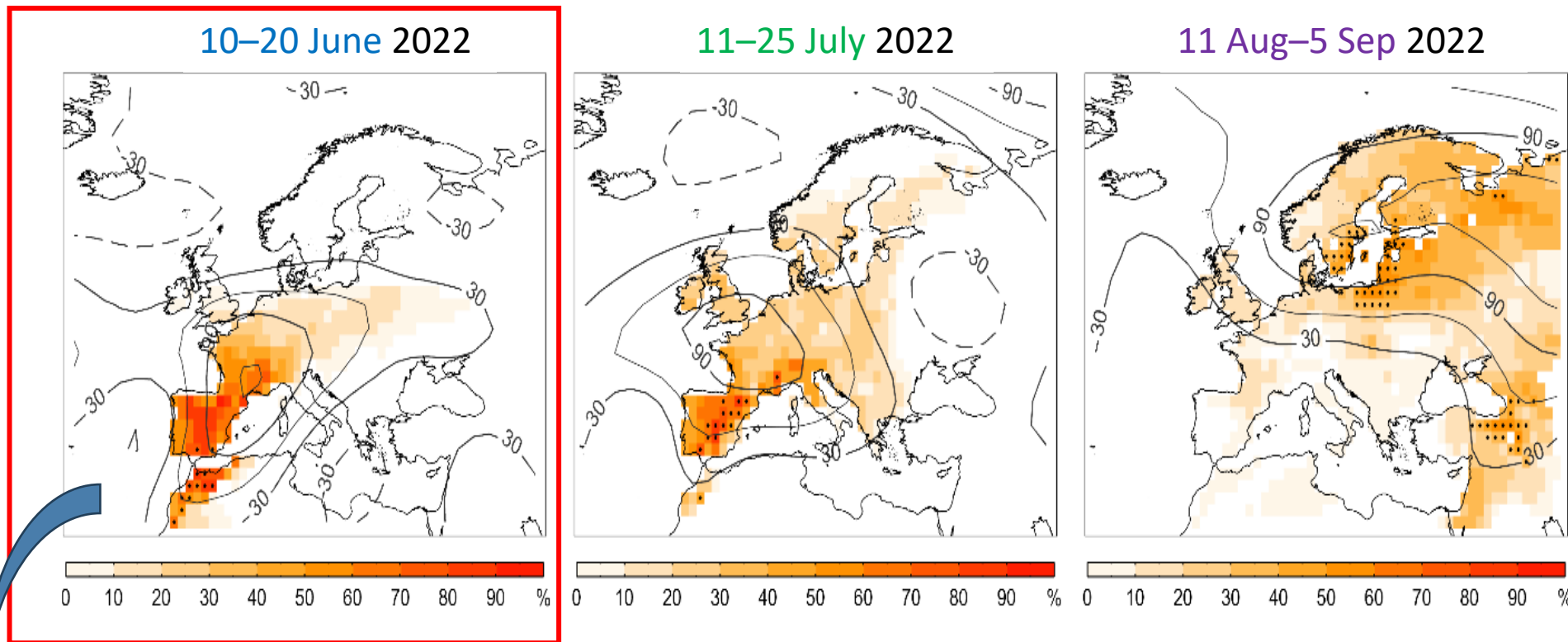
Summer 2022 SST anomaly

NOAA OISSTV2
(1982-2023)

Marine HW Index

Hobbay et al. (2016)

Simon et al. (2022)

Marine heatwaves in summer 2022

a) Nb of events (-)
0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0

b) Mean Intensity (°C)
0.5 0.9 1.3 1.7 2.1 2.5 2.9 3.3 3.7 4.1 4.5

c) Duration (days)
5 10 15 20 25 30 35 40 45 50 55

d) Activity (°C.days.10³km²)
0 12 25 38 51 64 76 89 102 115 128

Three persistent HW events (> 10 days)

10–20 June 2022 | 11–25 July 2022 | 11 Aug–5 Sep 2022
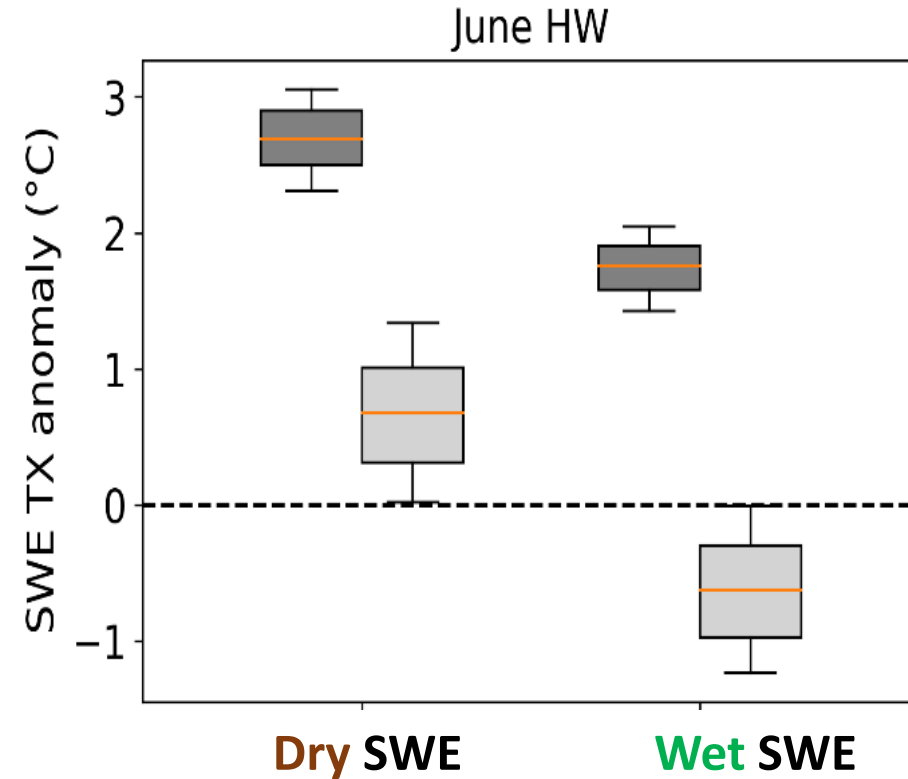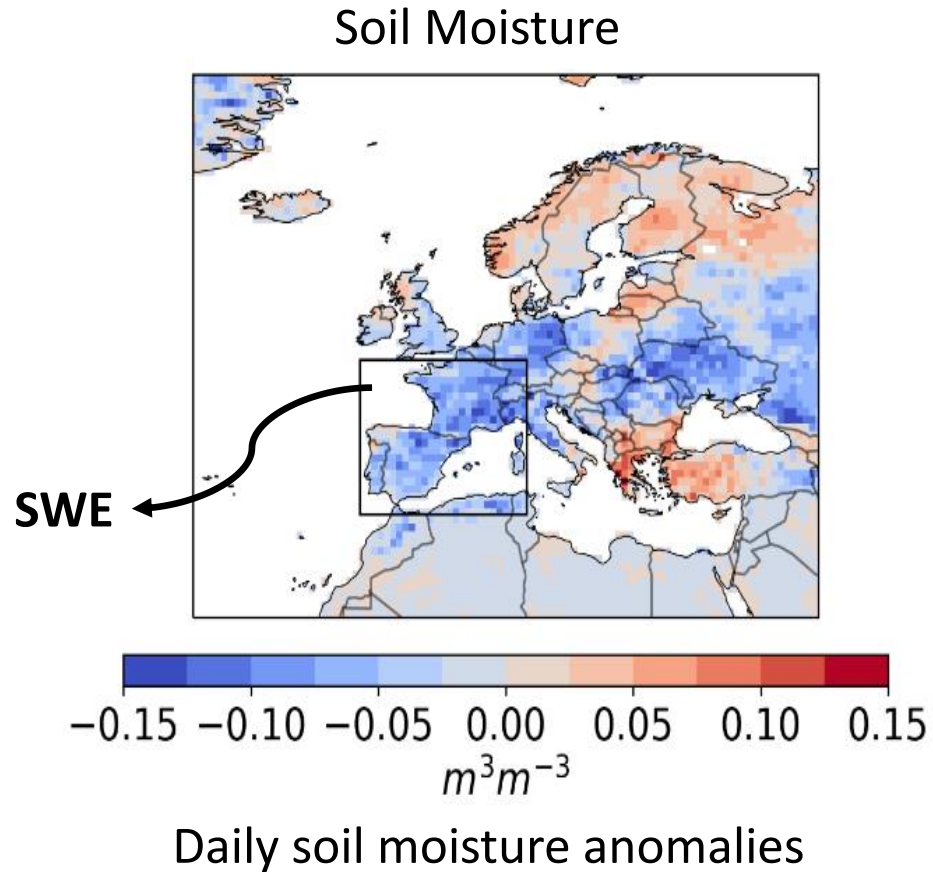
HW tracking

Sanchez-Benitez et al. (2020)

ERA5 (1940-2021)

Local frequency of HW days (% of days wrt the total duration of the HW event) and mean Z500 anomaly (m) during the three main HW events of summer 2022.

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Flow analogue method (Cattiaux et al., 2010)

(Trigo et al. 2024, submitted)

(June HW)   Analogue **Model 1**   (Soil moisture SWE)

Soil Moisture

SWE

Daily soil moisture anomalies

(Trigo et al. 2024, submitted)

Distributions of the daily SWE Tmax for the June HW event, as reconstructed by **flow-conditioned analogues** and **random days** preceded by **dry** and **wet** conditions over the same region.

(June HW)   Analogue **Model 2**   (SST West Med)
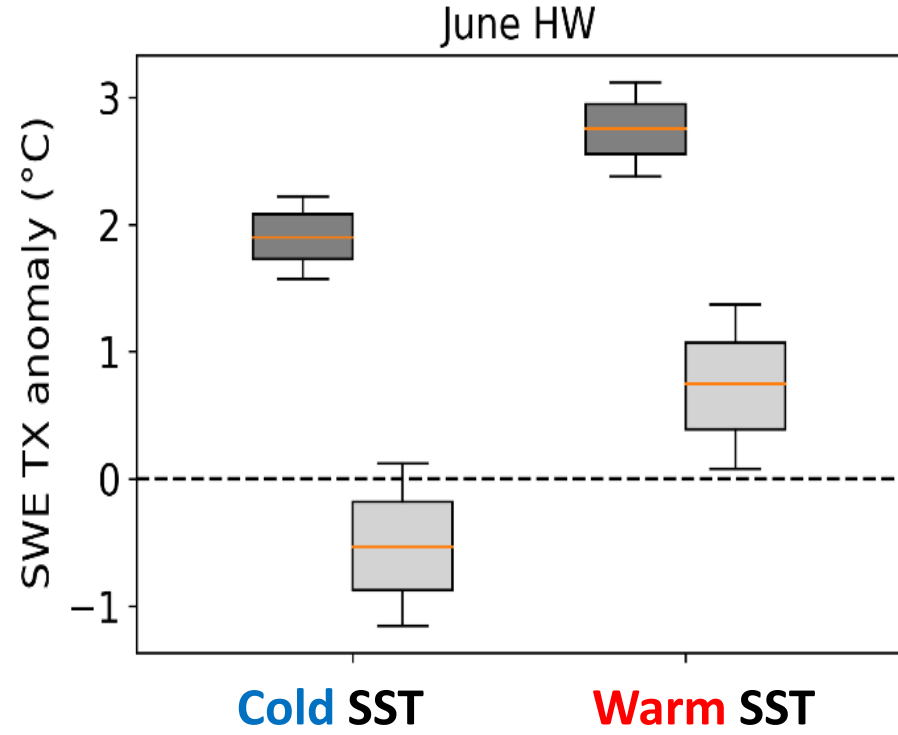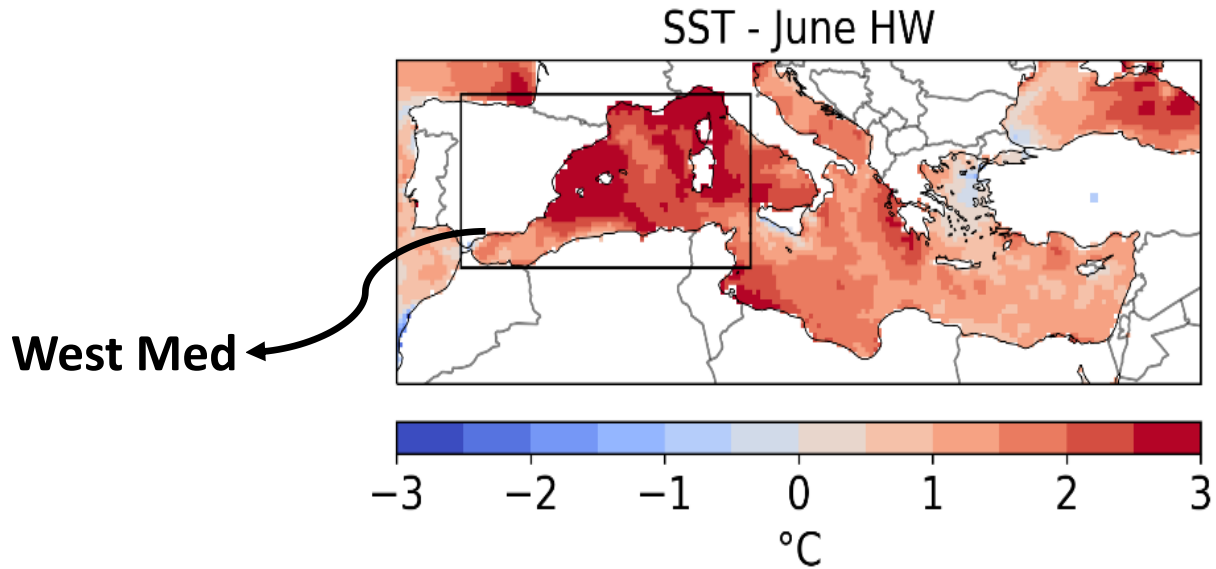
SST - June HW

West Med

June HW

Cold SST   Warm SST

Distributions of the daily SWE Tmax for the June HW event, as reconstructed by **flow-conditioned analogues** and **random days** preceded by **cold** and **warm** SST conditions over the WM region.

(Trigo et al. 2024, submitted)
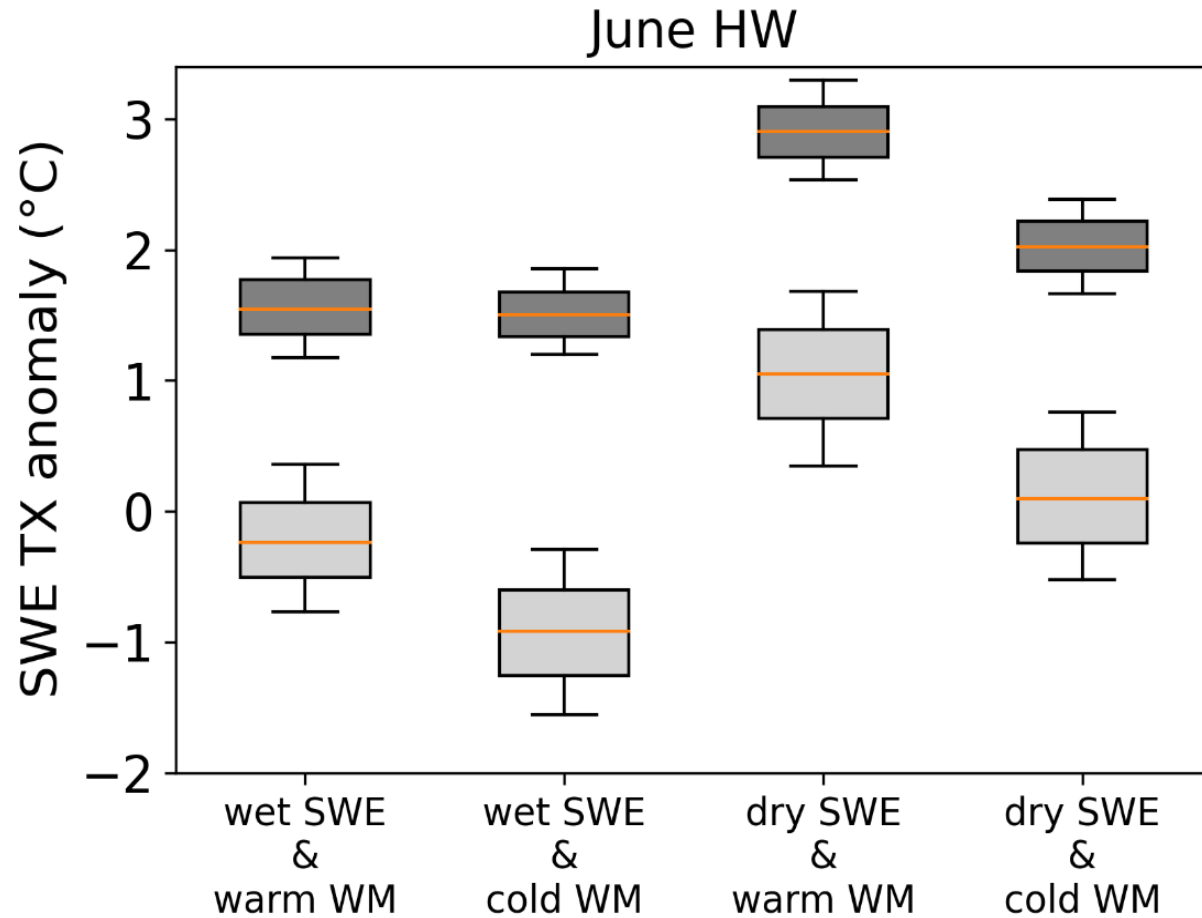
Distributions of the mean daily Tmax over SWE (in °C) as reconstructed from random days and from **historical flow analogues** of the June HW that were preceded by wet SWE and hot WM, wet SWE and cold WM, **dry SWE and hot WM**, and dry SWE and cold WM.

(Trigo et al. 2024, submitted)

Conclusions

➤ The European summer of 2022 **was the warmest since at least 1500**, while the <u>Mediterranean displayed the largest Marine HW activity of the 1982–2022 period</u>, particularly over western Mediterranean.

➤ Unlike previous record-breaking summers of 2003 and 2010, we identified <u>three European mega-HW events in mid-June, mid-July and August/early September 2022</u>, but with noticeable differences in their associated weather systems, which ranged from **subtropical ridges** to **high-latitude blocks**.

➤ Flow analogues of the June 2022 HW were used to reconstruct the expected temperatures under different combinations of soil moisture and Med SST drivers and **assess, for the first time, their separate and combined influences on the intensity of the event**.

Thank you for your attention!   *rmtrigo@fc.ul.pt*

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