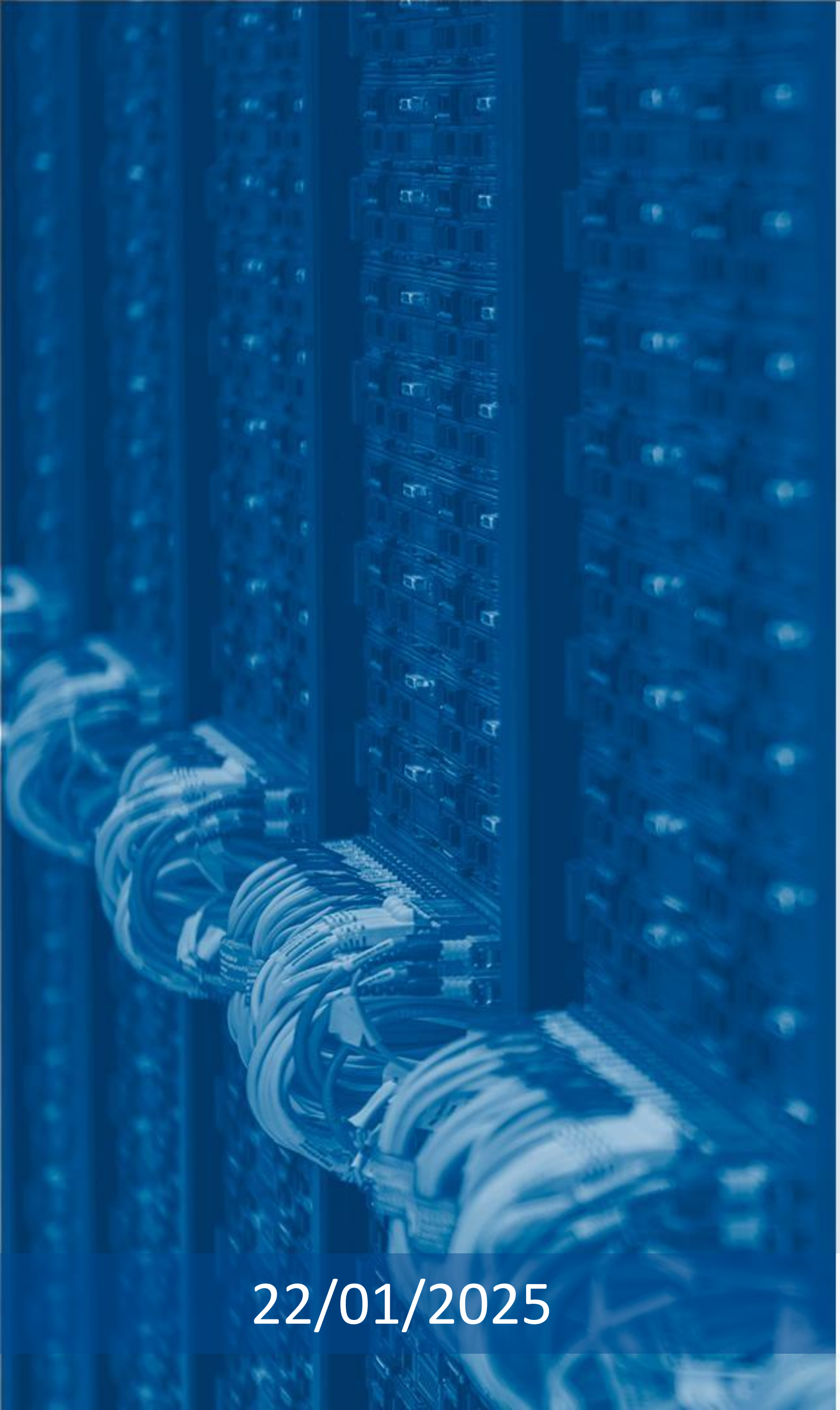

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AI4S
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Climate attribution of the Western Mediterranean warm-dry compound extreme during 2021-2023

The role of natural variability and anthropogenic climate change

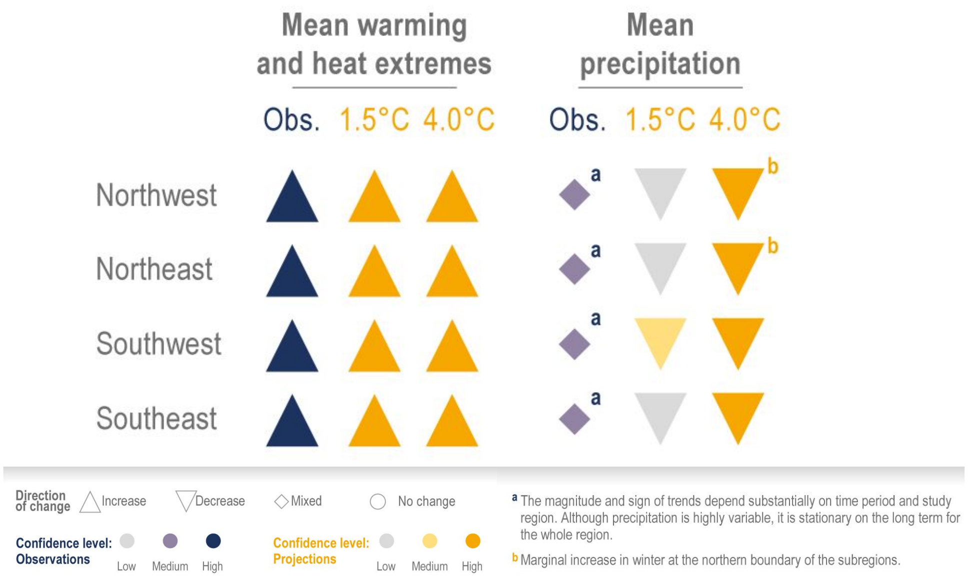
Diego Campos, Matías Olmo, Muñoz A., Doblas-Reyes F., Cos J.

XIII Congreso Internacional – Asociación Española de Climatología

Motivation

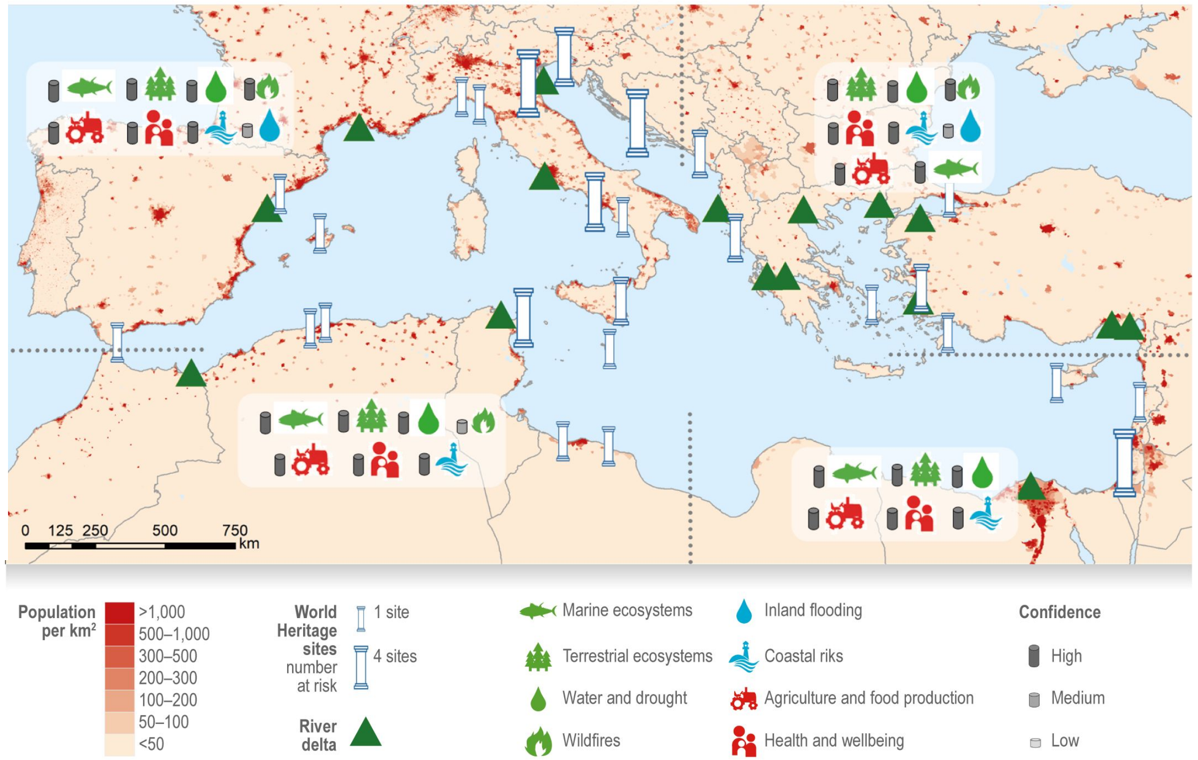
The projected increase in climate hazards, in combination with high regional vulnerability and exposure make the Mediterranean region a prominent ‘climate change hotspot’ (IPCC 2023).

Synthesis of observed and projected (1.5°C and 4.0°C global warming levels) changes in climate drivers affecting the Mediterranean region



IPCC, 2023

Key risks in the Mediterranean and their location for SSP5-RCP8.5 by 2100



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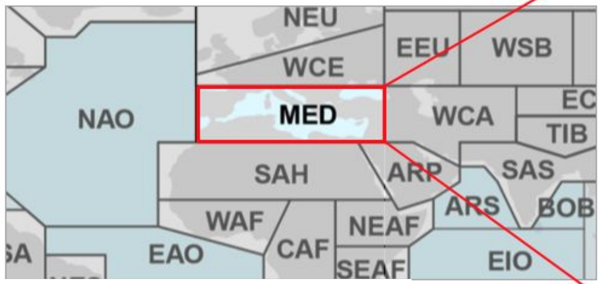
Objectives and Data

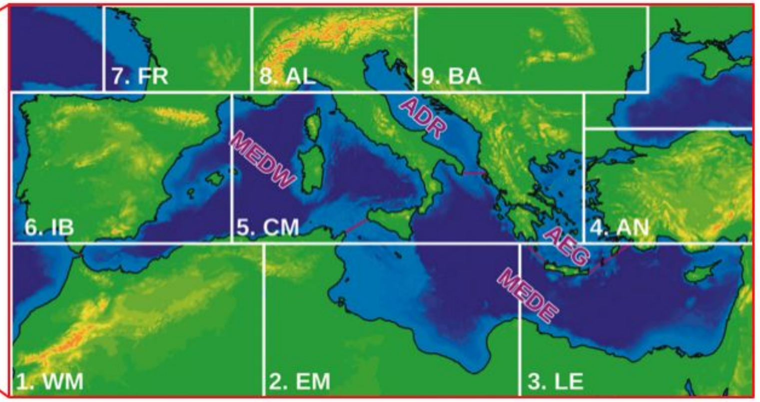
Main goal:

-To analyse recent temperature and precipitation trends in the WMed region, considering the region's climatic diversity and temporal variability.

Updated IPCC WGI reference regions (v4)



Adapted from Iturbide et al., 2020



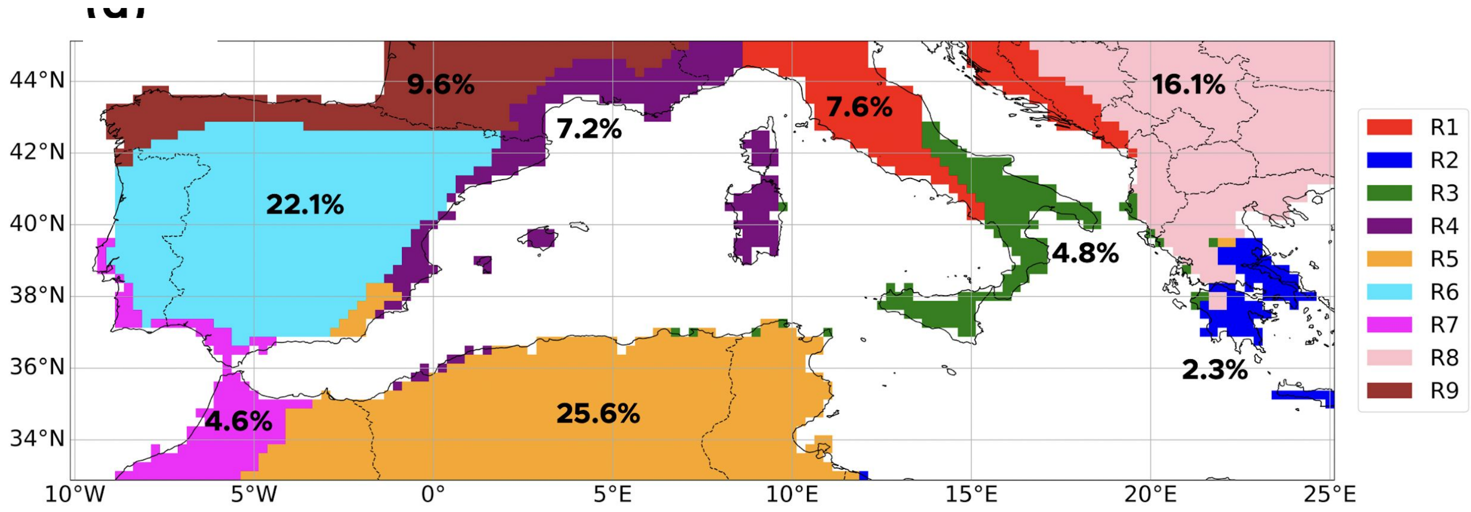
Cherif et al., 2020

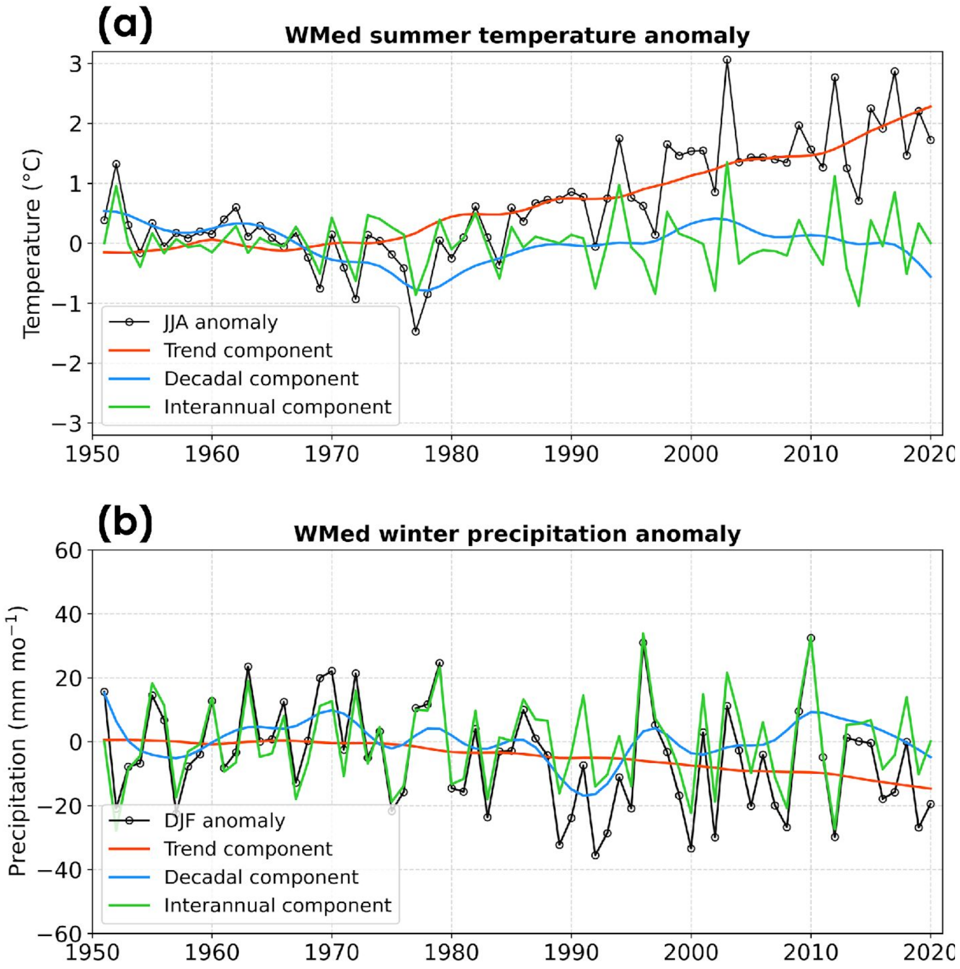
	Data used: monthly pr and tas
Observations	ERA5 – CRU – GPCC / ERA5 – CRU – Berkeley Earth (1950-2020)
Simulations	CMIP6 data (1950-2020, historical + ssp245) (11 models, 63 runs) DAMIP data (1950-2020, 11 models, 99 runs) - Experiments: GHG, Aerosols, Natural Pre-industrial runs (200 years, 11 models)
Modes of variability indices	NAO – Climate Prediction Center (CPC) WeMO – Climatic Research Unit, University of East Anglia AMO – CSU Tropical Weather & Climate Research AO – CPC

Clustering and timescale decomposition

- K-Means was performed on pre-filtering on the temperature-precipitation monthly means.

- Timescale decomposition was performed on the seasonal anomalies.





Long-term trend, decadal, interannual.

Campos et al. 2024 (under review)

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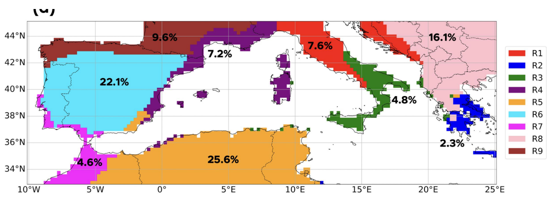


Explained variances

How much of the series variance is explained by each time-scale component?

For summer temperature:

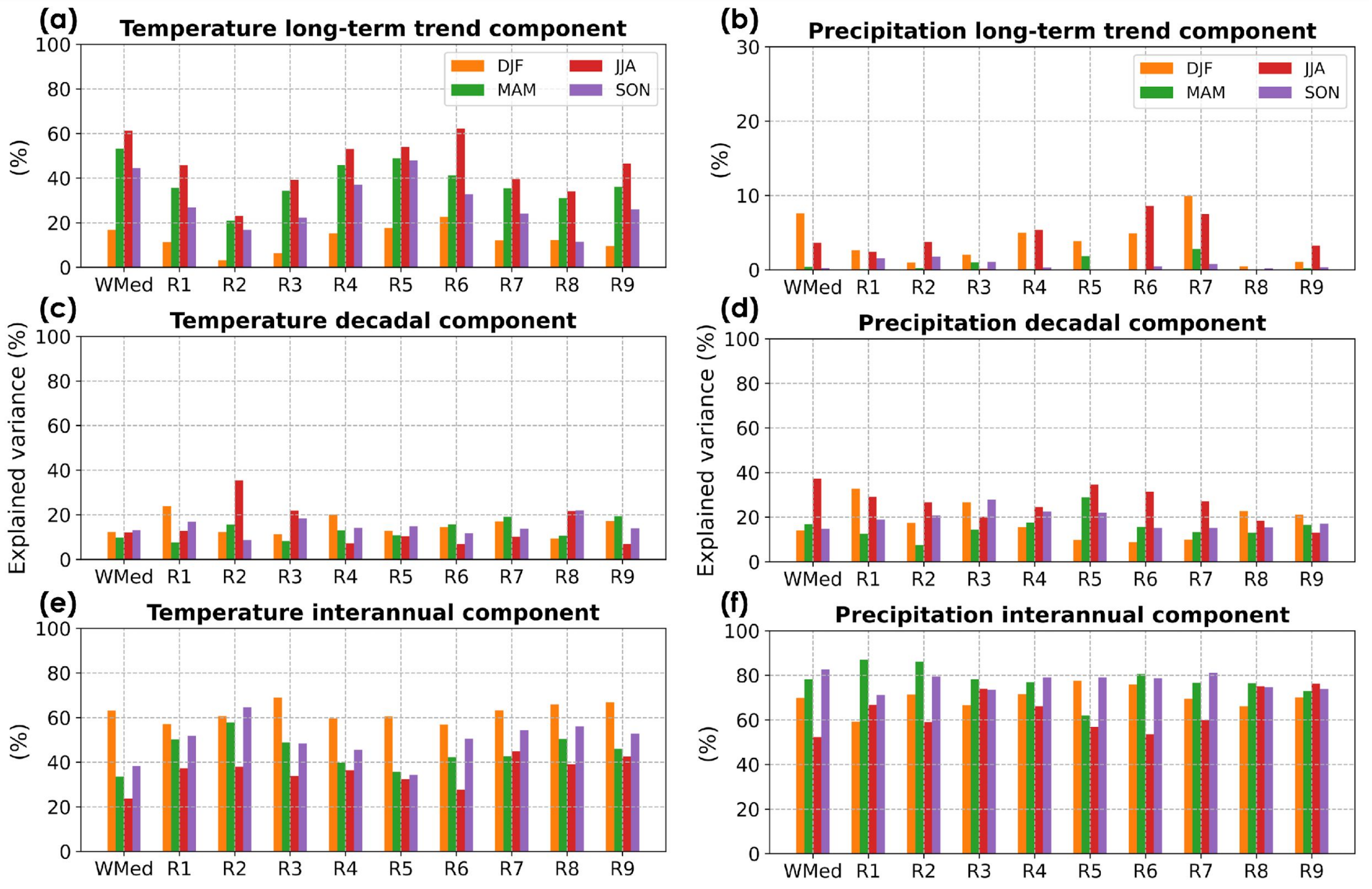
Long-term trends explain most of the variance. (e.g., 60% in R6)

Interannual variability explains ~30%

For winter precipitation:

Long-term trends explain only a small fraction of the overall variance. (máx. in R7 ~ 10%)

Most of the variance is exained by interannual variability (> 60%)



Explained variances are season and region-dependent.

Campos et al. 2024 (under review)

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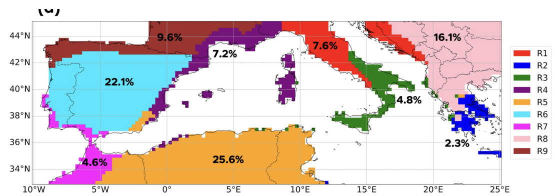
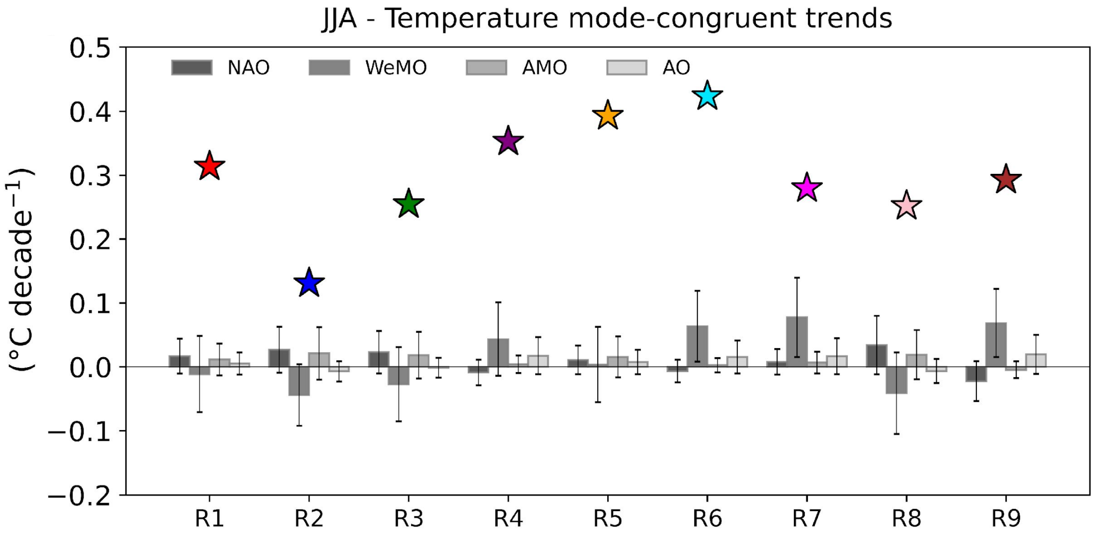
The role of decadal + interannual variability

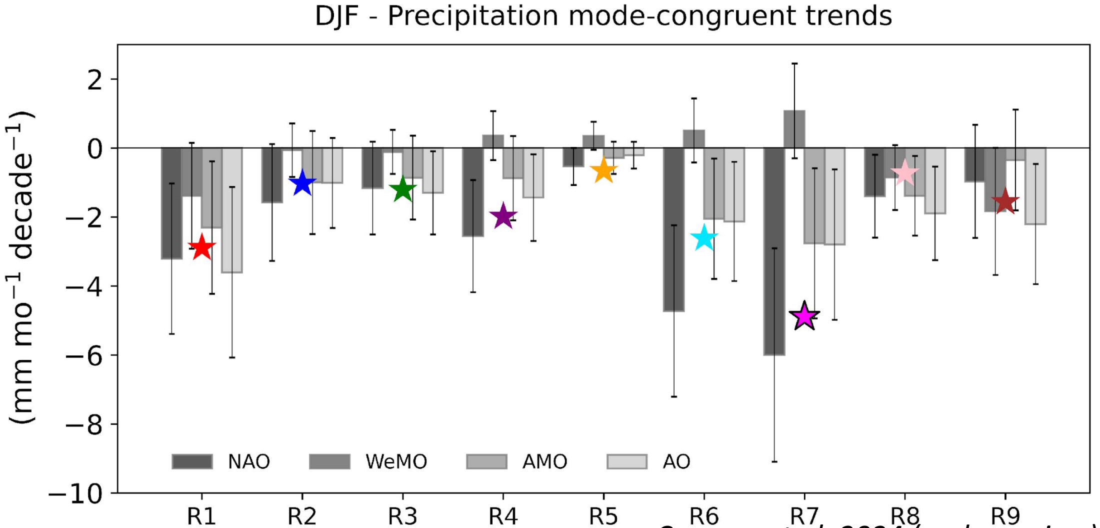
Mode-congruent trends = estimates changes due to the trends in modes of variability that modulate the climate in the WMed (e.g., Boisier et al., 2018).





For summer temperature:

Mode-congruent trends could not explain the observed trends



Campos et al. 2024 (under review)

For winter precipitation:

Mode-congruent trends have the same sign of the observed trends.

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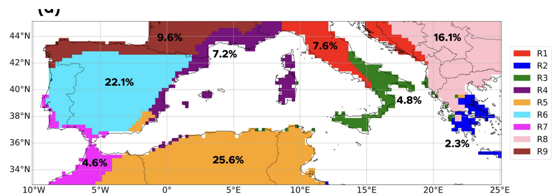
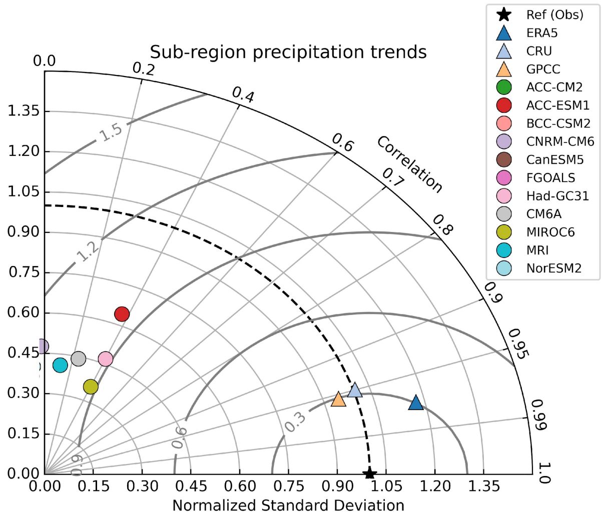
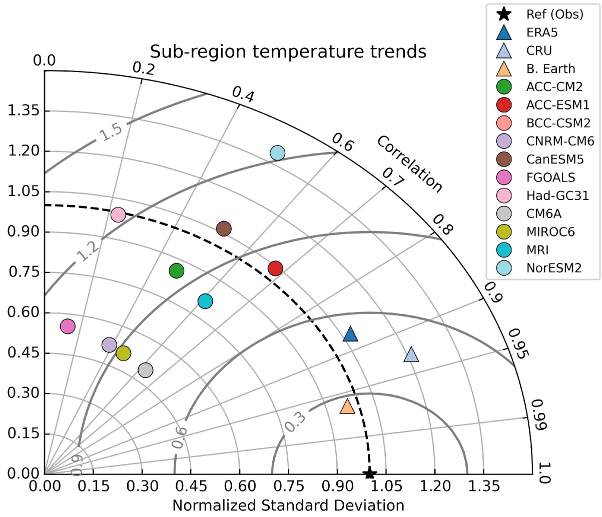
Model evaluation and selection

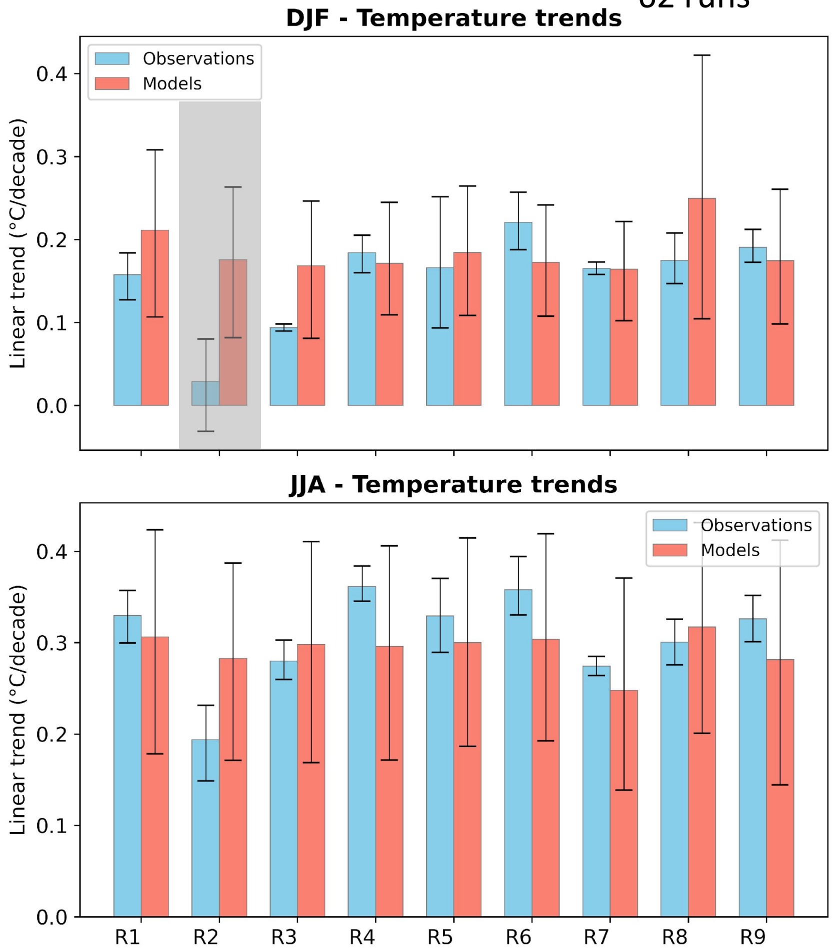




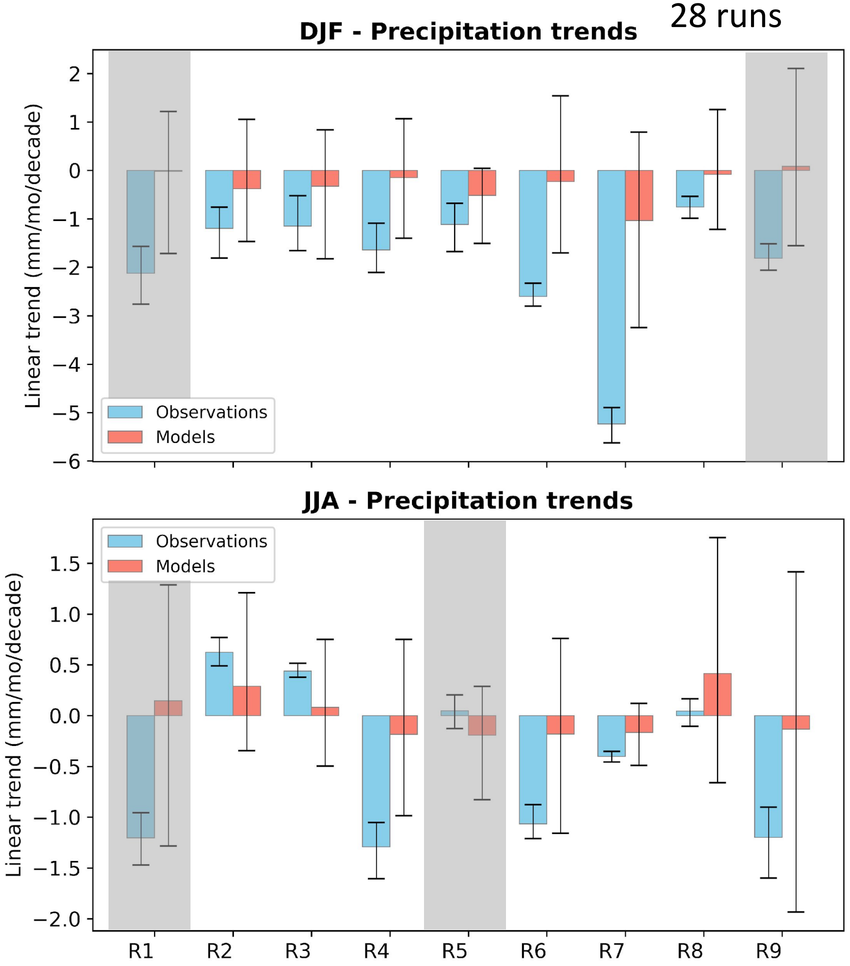


11 models
63 runs

10 models
62 runs



5 models
28 runs



Even after the model selection the trend some regions is not well represented (in grey)

Campos et al. 2025 (in prep.)

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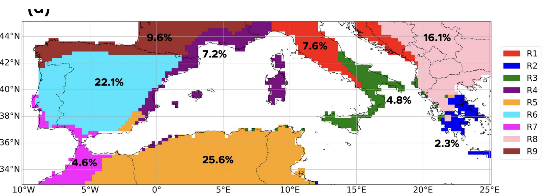
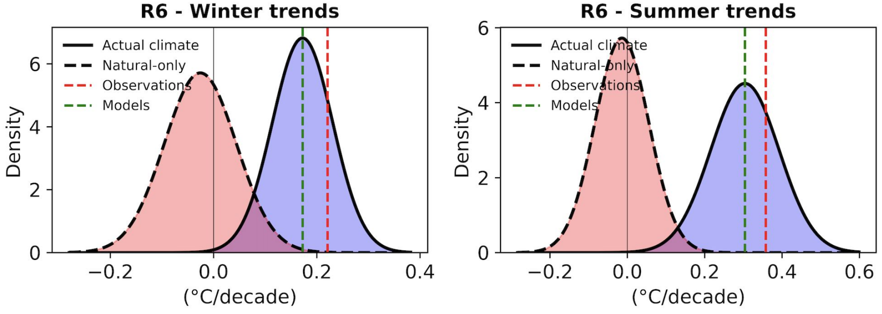
Fraction of Attributable Risk

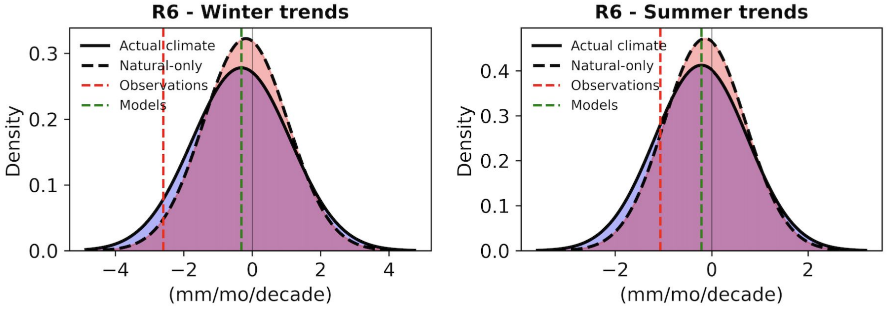


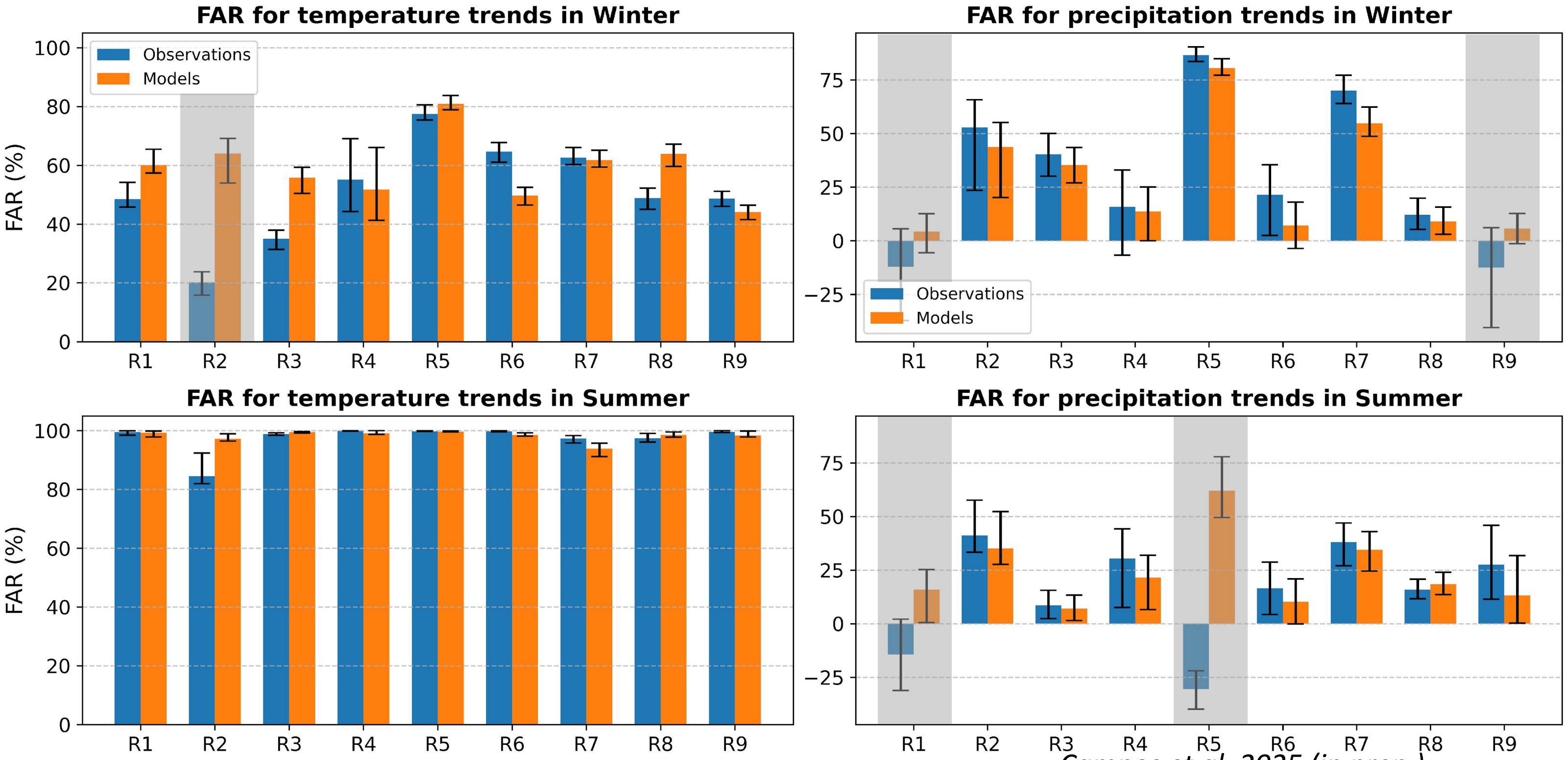
$$FAR = 1 - \frac{P_{NATURAL}}{P_{ACTUAL}}$$

Temperature



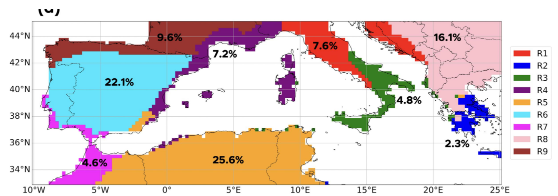
Precipitation





Campos et al. 2025 (in prep.)

The role of external factors

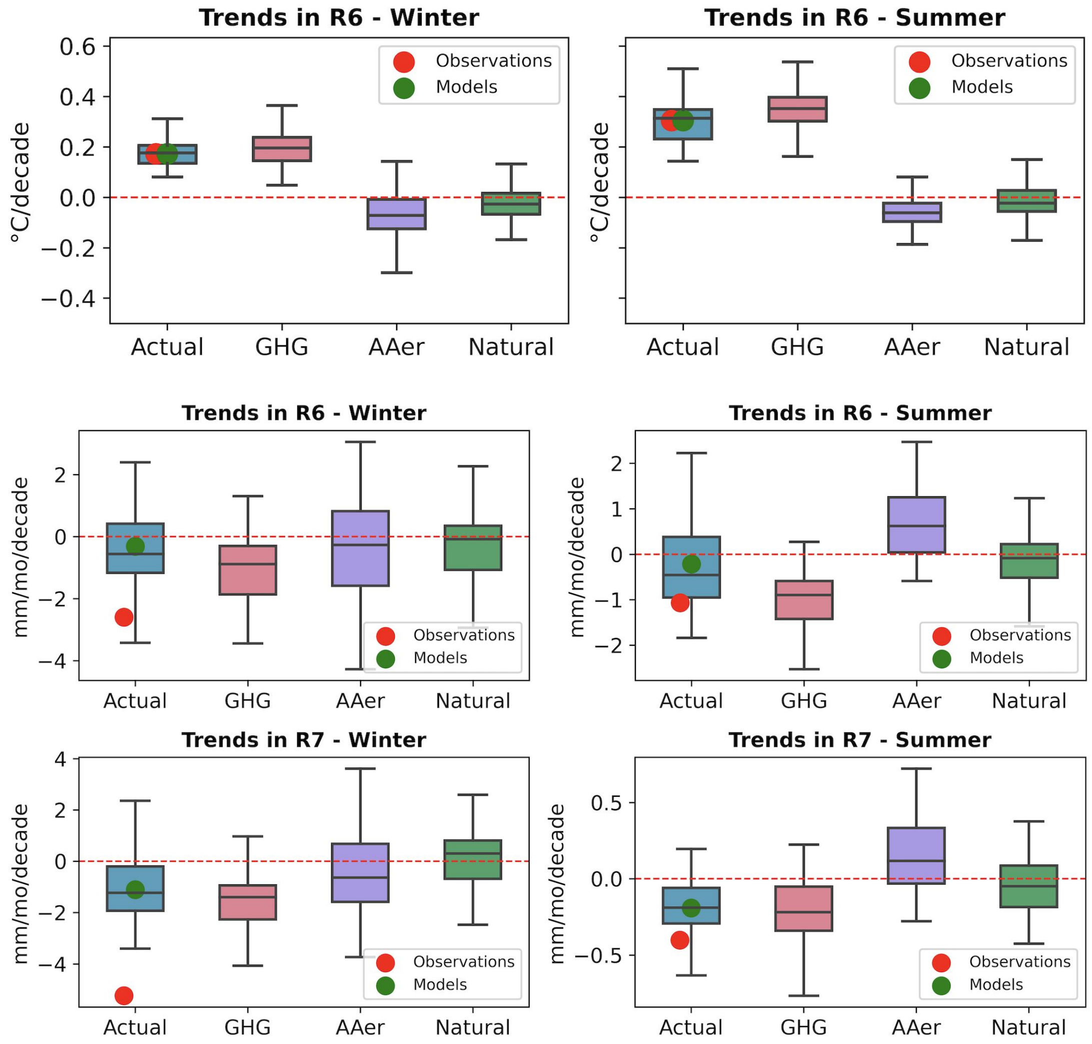


1951-2020

1981-2020

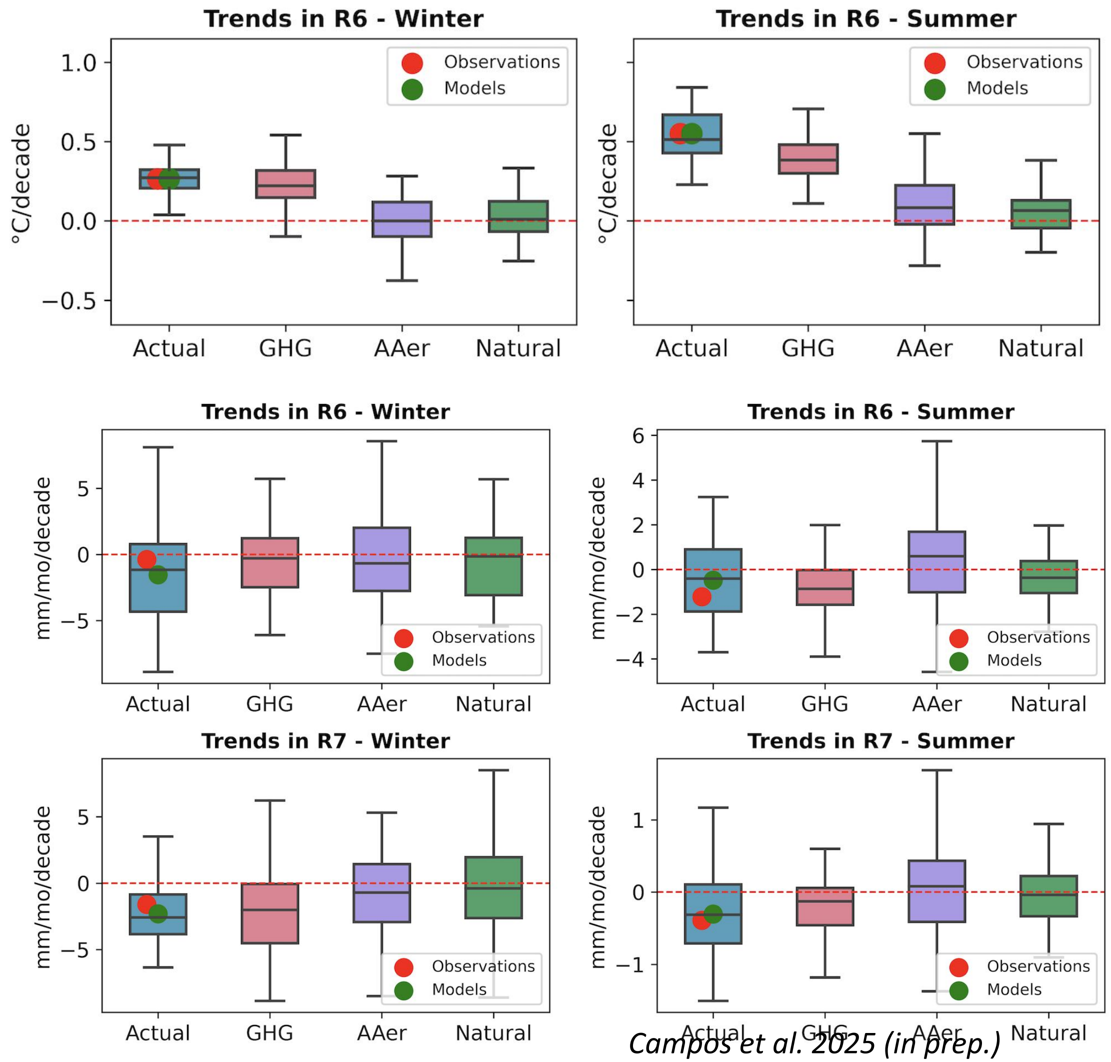
Temperature

Precipitation



Temperature

Precipitation



Campos et al. 2025 (in prep.)

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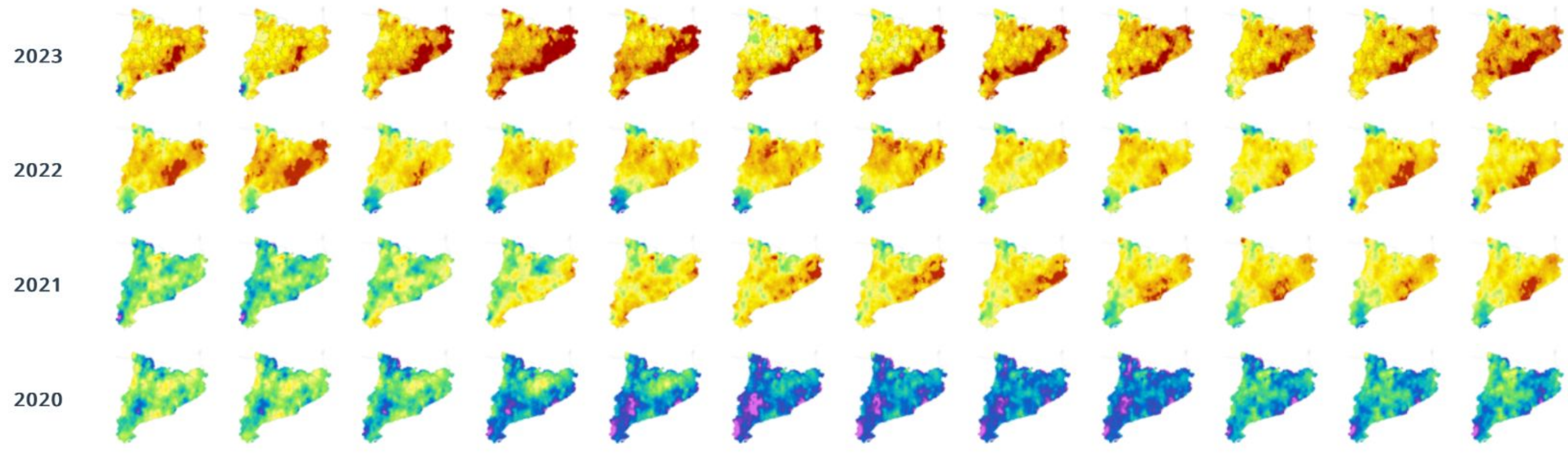
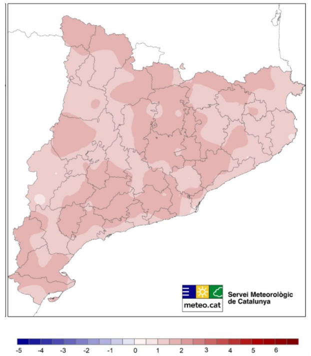
The 2021-2023 warm-dry compound extreme

In the drying-warming context of the Western Mediterranean, the 2021-2023 period was extraordinary in some places, such as Catalonia.





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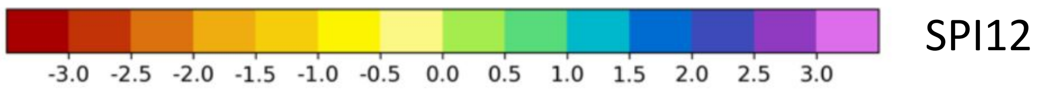
meteo.cat



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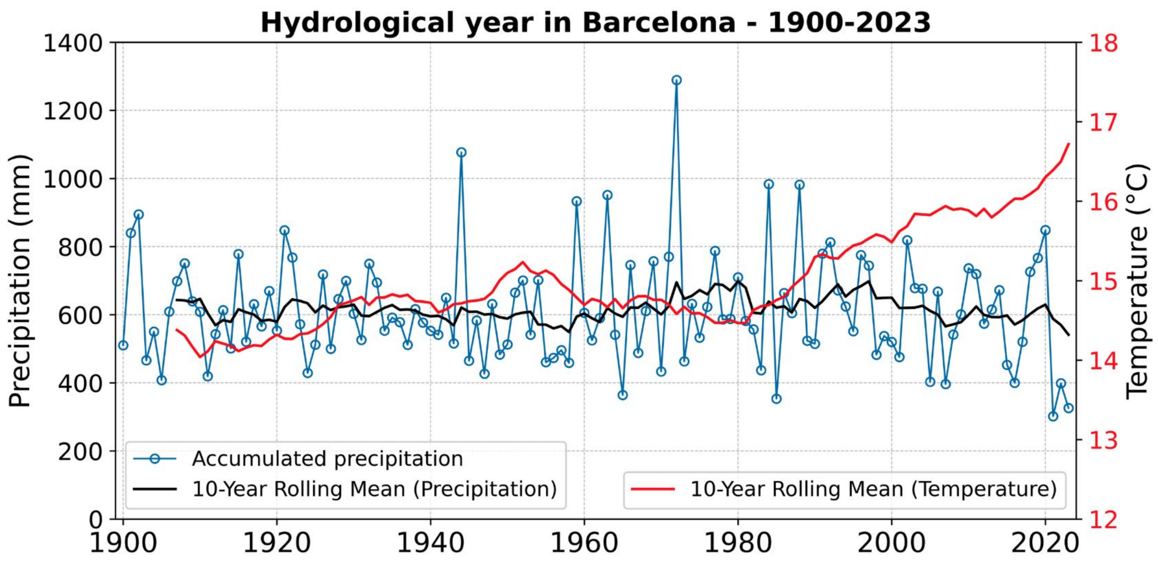
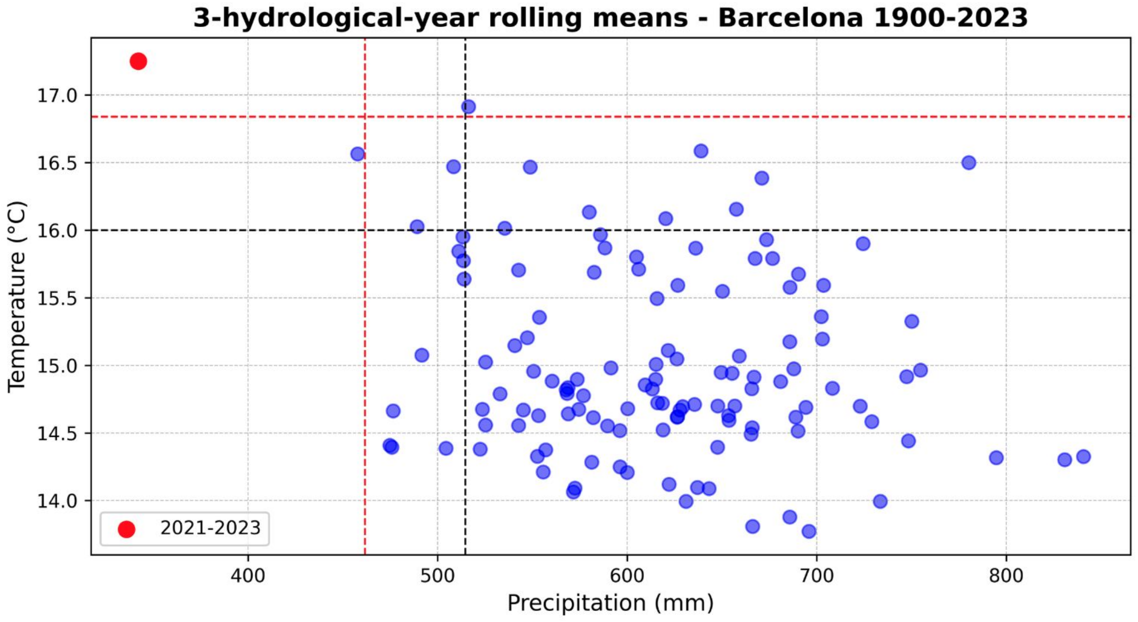




CLIMCAT project report, 2024.

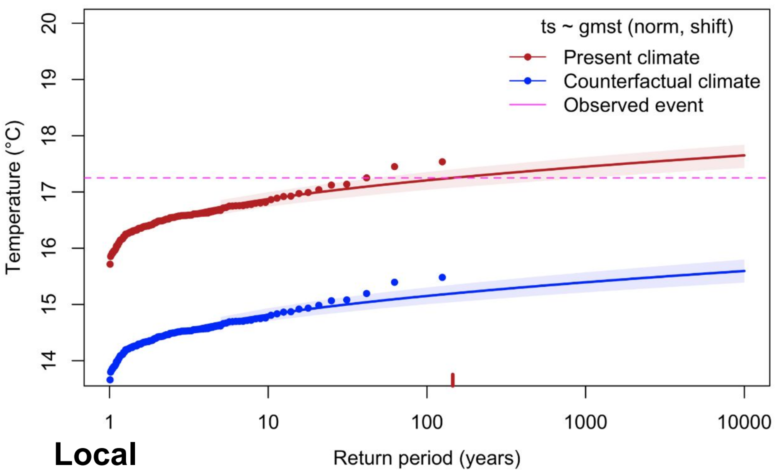
Return period comparison

Current climate

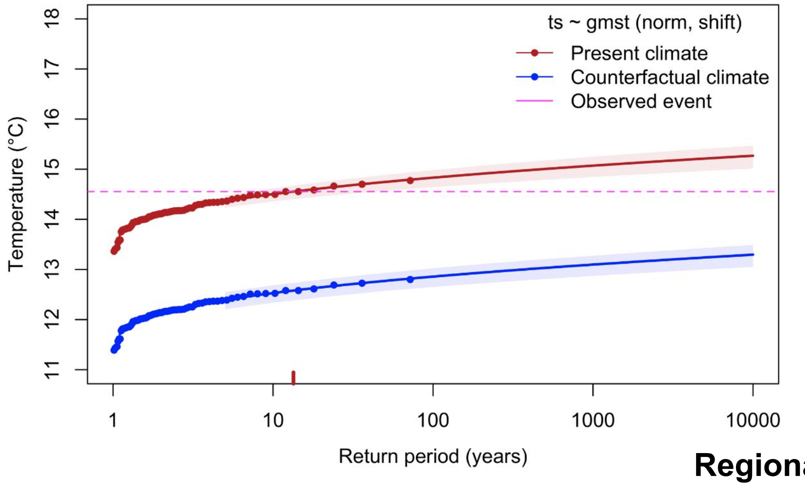
Preindustrial climate (a climate 1.2°C colder), obtained with a linear regression against smoothed GMST.

Temperature

Current climate vs preindustrial
Barcelona weather station



Current climate vs preindustrial
ERA5 Land

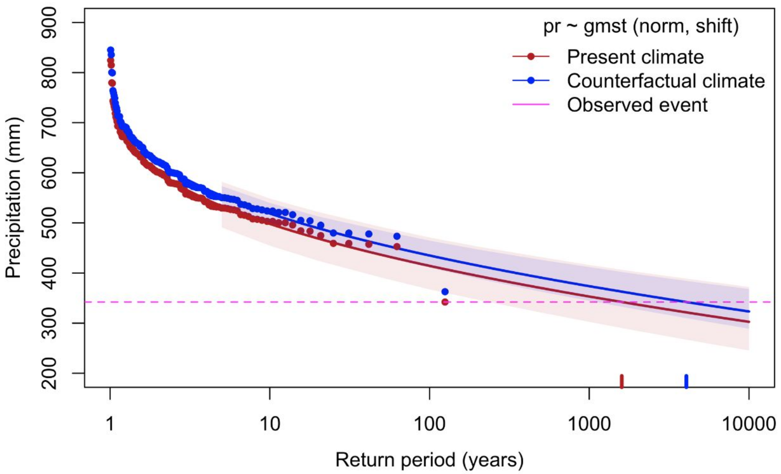


Local anomalies

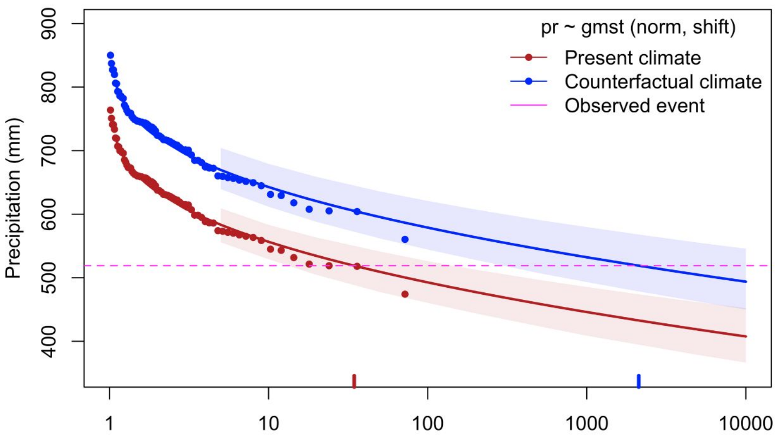
Regional anomalies

Precipitation

Current climate vs preindustrial
Barcelona weather station



Current climate vs preindustrial
ERA5Land



CLIMCAT project report, 2024.

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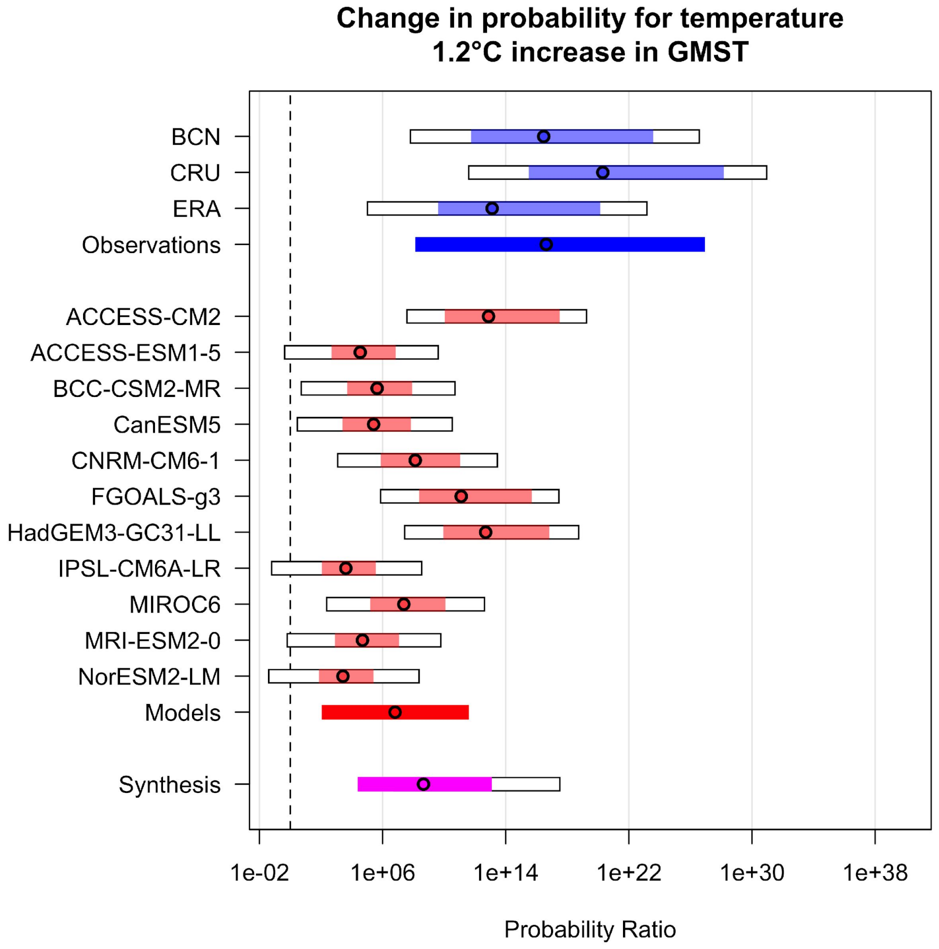
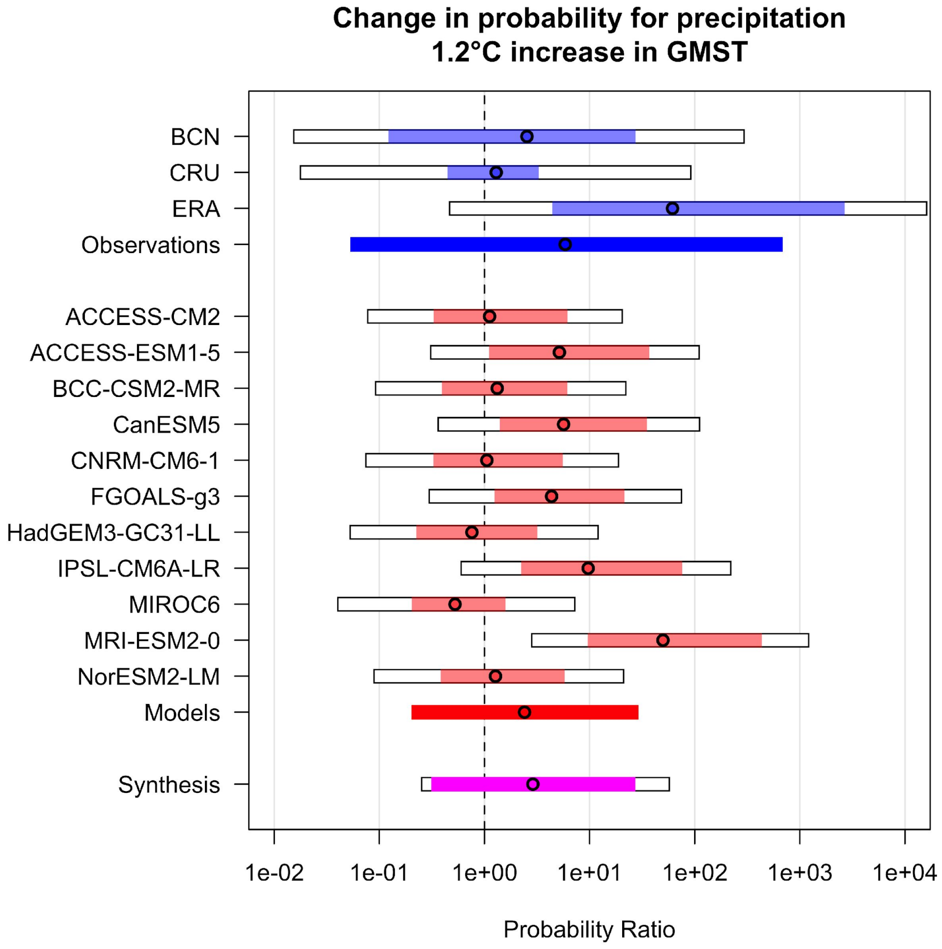
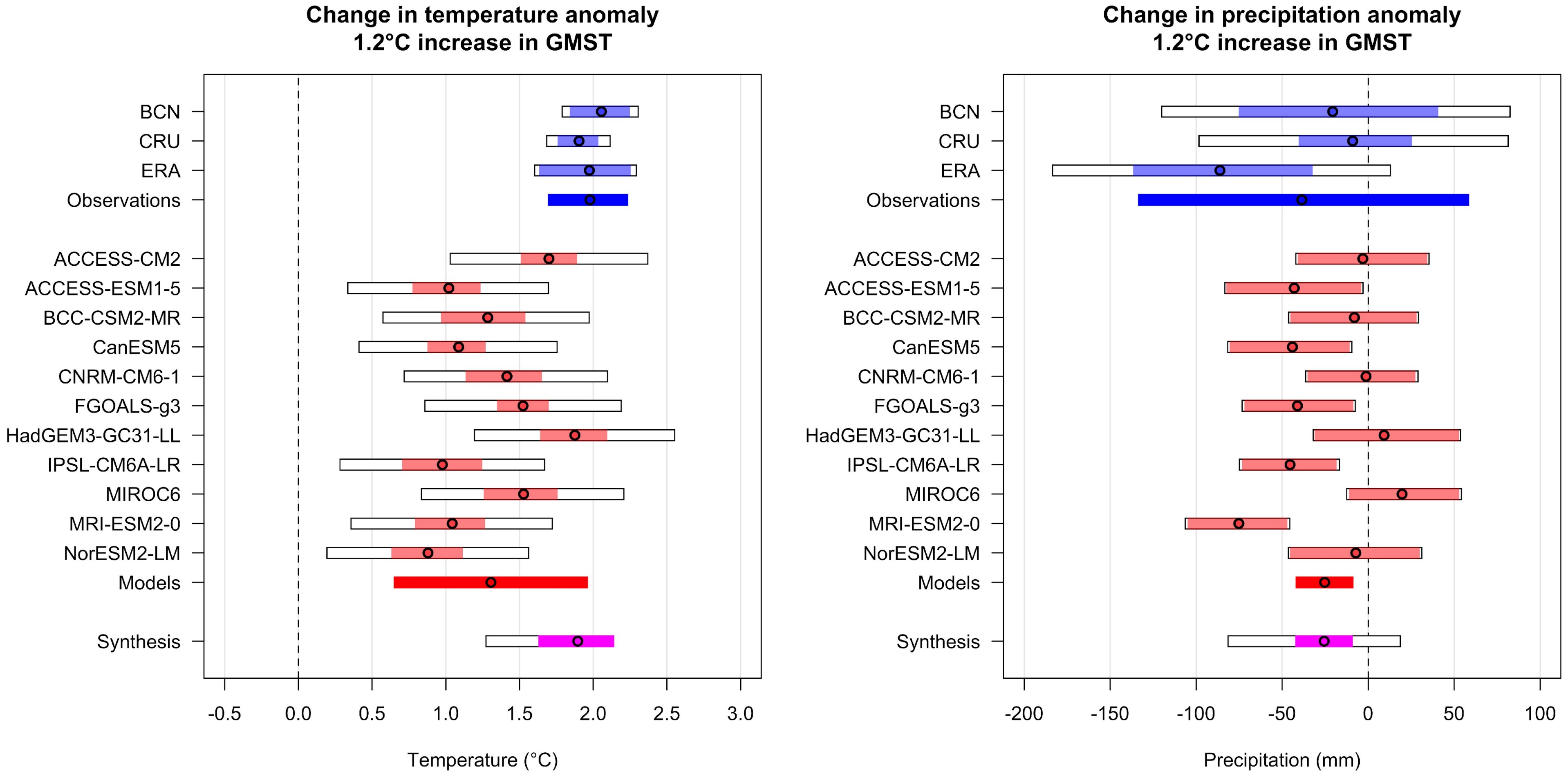
Change in the likelihood of the event





CLIMCAT project report, 2024.

Change in the intensity of the event



CLIMCAT project report, 2024.

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Take aways

- The 2021-2023 period is framed in a context of significant warming and drying trends (for some regions and seasons) in the WMed.

- All regions in the WMed are experiencing significant warming throughout the year. Long-term trends component is explaining most of the variance during summer, which is explained mostly by the action of external forcing, GHG and AAER, especially since ~1980.

- Precipitation trends in the WMed are more complex and less uniform. Significant decreases in winter precipitation are observed only in specific regions, and do not appear to be solely driven by external climate forcing; they are also influenced by natural variability.

-Periods like 2021-2023 are likely to be more frequent and warmer in the future due to climate change (high confidence) and to be drier (low confidence). Also, climate change could have affected other aspects of the drought, like frequency of rainy days.

D. Campos, M. Olmo, P. Cos, F. Doblas-Reyes and A. G. Muñoz, "Regional aspects of the recent observed trends in the Western Mediterranean: Insights from a Timescale Decomposition Analysis". Submitted to the Journal of Geophysical Research: Atmospheres.

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