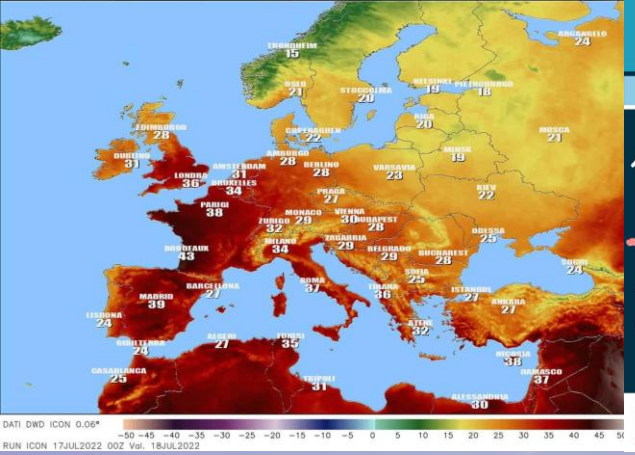
EMS Annual Meeting
Utrecht & online | 6-11 September 2026

aemet

Emerging evidence of Greenland Ice Sheet melt influence on recent Euro-Mediterranean record-breaking heat and convective storms

Juan Jesús González Alemán
Head of Climate Prediction & MedCOF Coordinator
Department of Applied Science and Climate
Spanish State Meteorological Agency (AEMET)

Colaborators: Marilena Oltmanns, Sergi González-Herrero, Markus Donat, Francisco Doblas-Reyes, Jacopo Riboldi, Frederic Vitard, David Barriopedro, Pep Cos, Carlos Calvo-Sancho, Bernat Jiménez Esteve, Michael F. Wehner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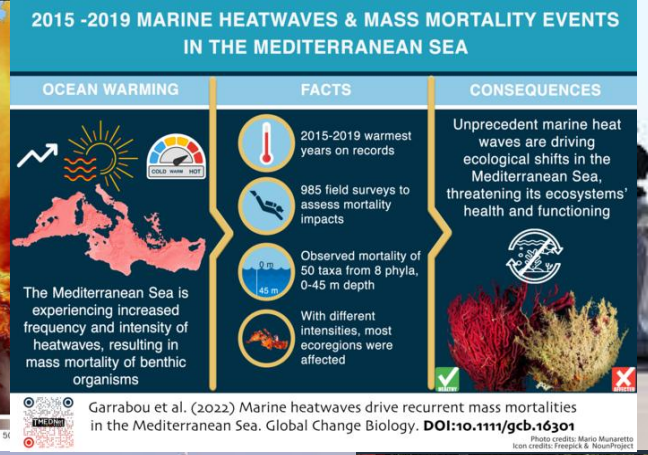
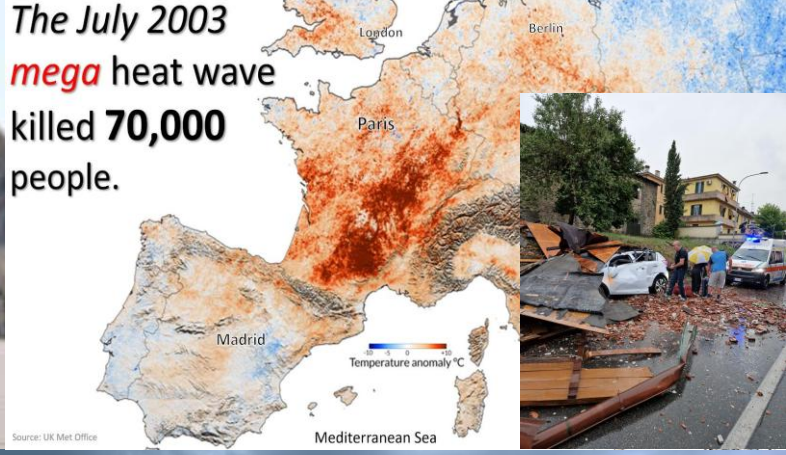
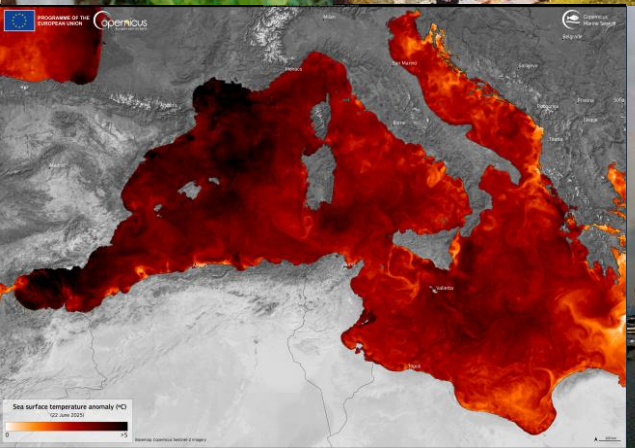
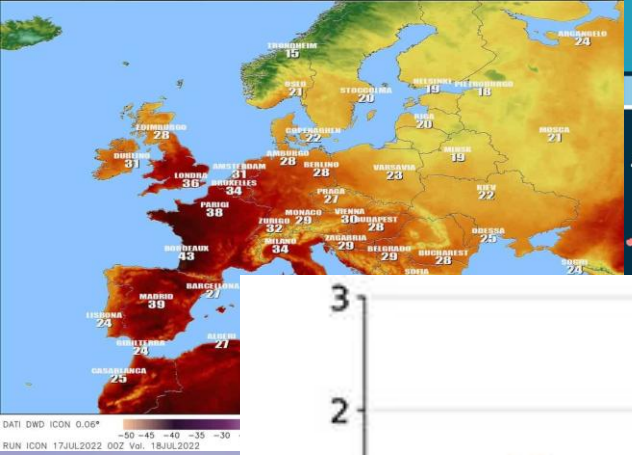

2015 -2019 MARINE HEATWAVES & MASS MORTALITY EVENTS IN THE MEDITERRANEAN SEA
OCEAN WARMING
FACTS
CONSEQUENCES
The Mediterranean Sea is experiencing increased frequency and intensity of heatwaves, resulting in mass mortality of benthic organisms
2015-2019 warmest years on records
985 field surveys to assess mortality impacts
Observed mortality of 50 taxa from 8 phyla, 0-45 m depth
With different intensities, most ecoregions were affected
Unprecedent marine heat waves are driving ecological shifts in the Mediterranean Sea, threatening its ecosystems' health and functioning
Garrabou et al. (2022) Marine heatwaves drive recurrent mass mortalities in the Mediterranean Sea. Global Change Biology. DOI:10.1111/gcb.16301
Photo credits: Mario Munaretto
Icon credits: Freepick & NounProject

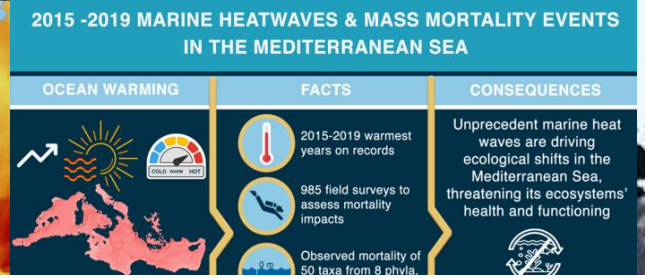

The July 2003 mega heat wave killed 70,000 people.
London
Berlin
Paris
Madrid
Temperature anomaly °C
Source: UK Met Office
Mediterranean Sea

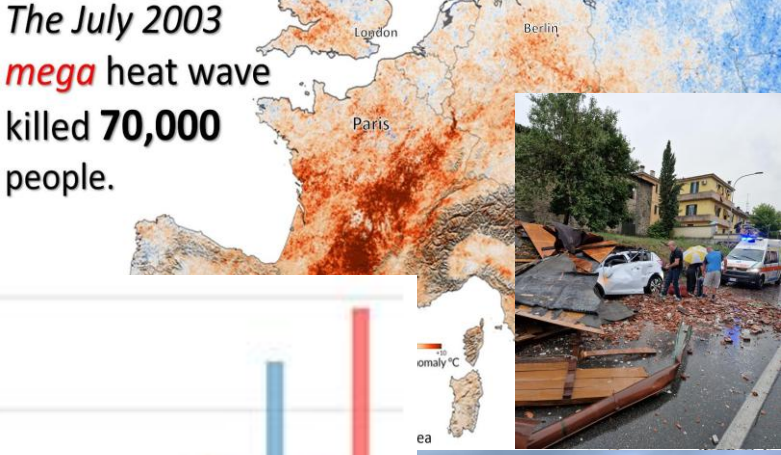

THE SUMMER
THAT KILLED 70,000

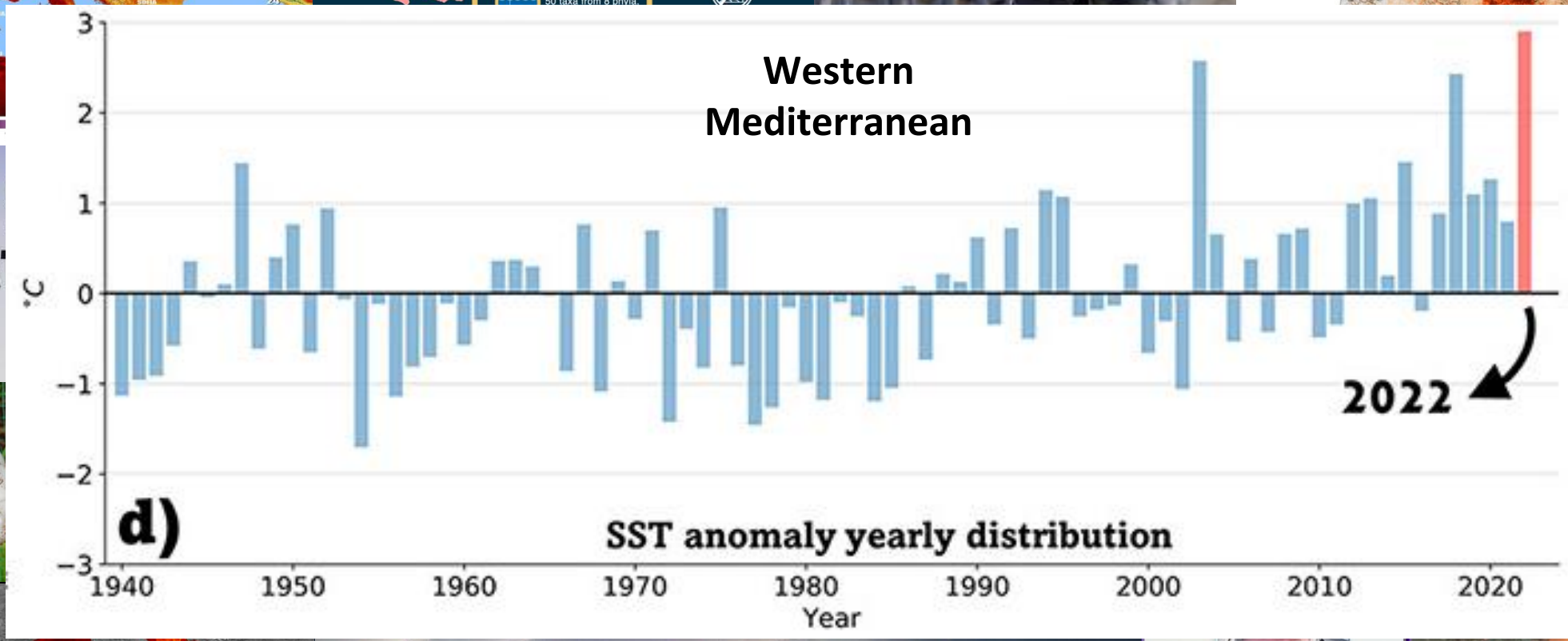

Sea surface temperature anomaly (°C)

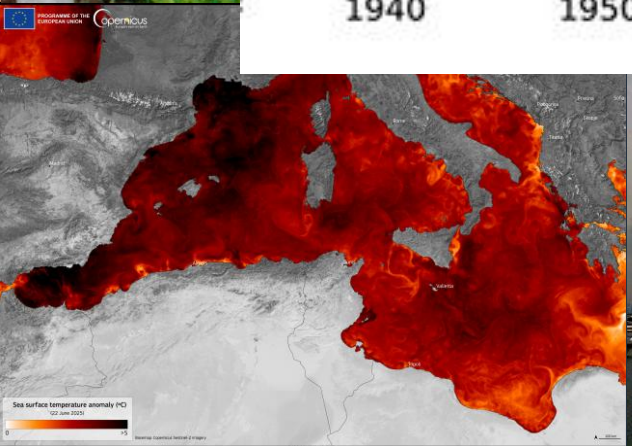

Barcelona, Spain
5:43 PM
EXTREME WEATHER
CONNECT THE WORLD
REPORT: 2022 EUROPEAN HEAT WAVES KILLED MORE THAN 61,000
Joan Ballester | Professor, Barcelona Institute of Global Public Health
CNN











EXTREME WEATHER CONNECT THE WORLD

REPORT: 2022 EUROPEAN HEAT WAVES KILLED MORE THAN 61,000

Joan Ballester | Professor, Barcelona Institute of Global Public Health

CNN

Background

- Europe and the Mediterranean have recently experienced record-breaking land and marine heatwaves.
- The same period saw intense convective storms across the region, producing severe and localized hazards.
- They have been studied separately.
- 2022 has been a recent key example year of this kind.
- It’s not all about the phenomena itself but the impacts:
  - Increased heat stress and elevated heat-related health risks.
  - Heightened wildfire danger and ecosystem stress.
  - Reduced water availability and impacts on agriculture and energy demand.
  - Storm-related flooding/wind, fatalities, infrastructure damage, and disruptions to transport and services.
  - Even economic impact on inflation.

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AMS American Meteorological Society
Bulletin of the American Meteorological Society

BAMS Our New Century

Anthropogenic Warming Had a Crucial Role in Triggering the Historic and Destructive Mediterranean Derecho in Summer 2022

Juan Jesús González-Alemán, Damián Insua-Costa, Eric Bazile, Sergi González-Herrero, Mario Marcello Miglietta, Pieter Groenemeijer, and Markus G. Donat

A record-breaking marine heatwave and anthropogenic climate change have substantially contributed to the development of an extremely anomalous and vigorous convective windstorm in August 2022 over the Mediterranean Sea.

AFFILIATIONS: González-Alemán*—Department of Development and Applications, Spanish State Meteorological Agency, Madrid, Spain; Insua-Costa*—Hydro-Climate Extremes Lab (H-CEL), Ghent University, Ghent, Belgium, and CRETUS, Non-linear Physics Group, Universidade de Santiago de Compostela, Galicia, Spain; Bazile—CNRM, Université de Toulouse, Météo-France, CNRS, Toulouse, France; González-Herrero—WSL Institute for Snow and Avalanche Research SLF, Davos, Switzerland; Miglietta—CNR-ISAC, Padua, Italy; Groenemeijer—European Severe Storms Laboratory, Wessling, Germany; Donat—Barcelona Supercomputing Center, and Institució Catalana de Recerca i Estudis Avançats, Barcelona, Spain

* Co-first authors.

DOI: https://doi.org/10.1175/BAMS-D-23-0119.1

CORRESPONDING AUTHOR: Juan Jesús González-Alemán, jgonzaleza@aemet.es

Supplemental material: https://doi.org/10.1175/BAMS-D-23-0119.2

In final form 4 August 2023

On 17 August 2022, very high atmospheric instability and strong wind shear developed over the western Mediterranean. Ahead of an eastward moving shortwave trough, convective cells organized into a bow-shaped system, producing a long swath of severe winds from the Balearic Islands to southern Czech Republic on August 18 (Fig. 1a), with maximum wind gust of 62.2 m s^{-1}, measured by Météo France at Marignana, Corsica. In total, 12 people died and 106 people were injured. This system can easily be classified as a derecho (ESSL 2022), a particularly long-lived and severe convective windstorm (Johns and Hirt, 1987; Corfidi et al, 2016). Concurrent with the derecho, a record-breaking marine heatwave (MHW) was present over the Mediterranean Sea during summer 2022, peaking in July. The sea surface temperature (SST) anomalies exceeded 3°C (see Fig. 1b) over the region where the storm developed.

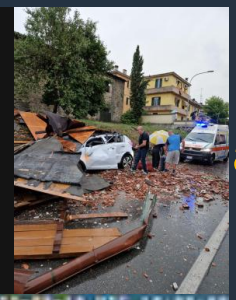
Derechos have been reported in different parts of Europe (e.g., Gatzen 2004; Punkka et al. 2006; Gatzen

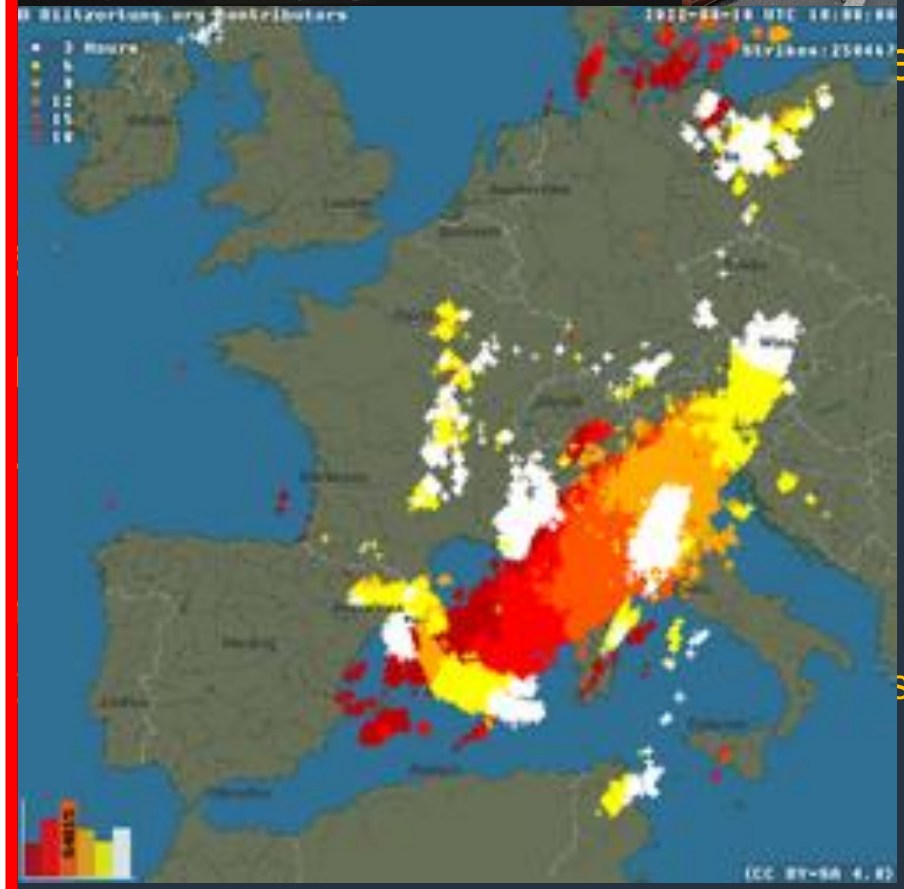
Capital Weather Gang

Rare 1,000-mile derecho event crosses Europe, killing at least a dozen

Gusts traveled from Corsica to southern Czech Republic, hitting speeds of up to 140 mph at times

Updated August 19, 2022 More than 3 years ago





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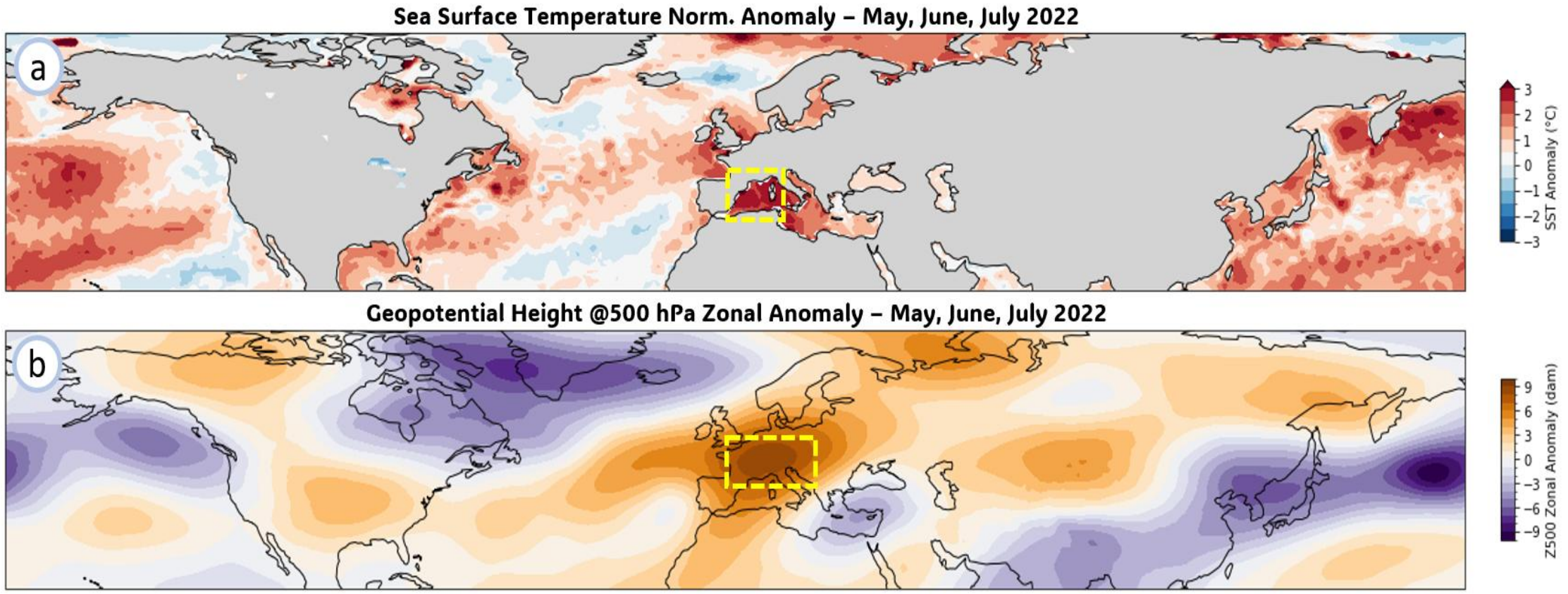
2022 extreme atmospheric & oceanic event



2022 extreme atmospheric & oceanic event

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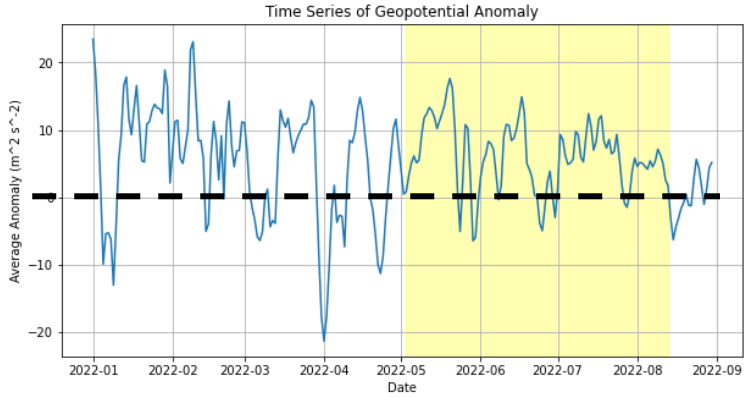
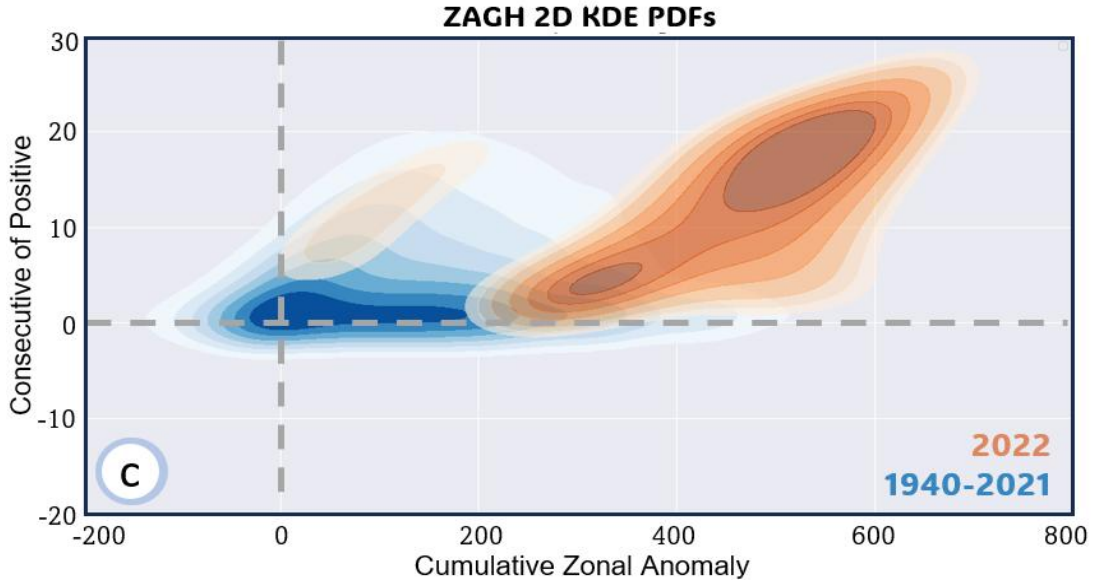
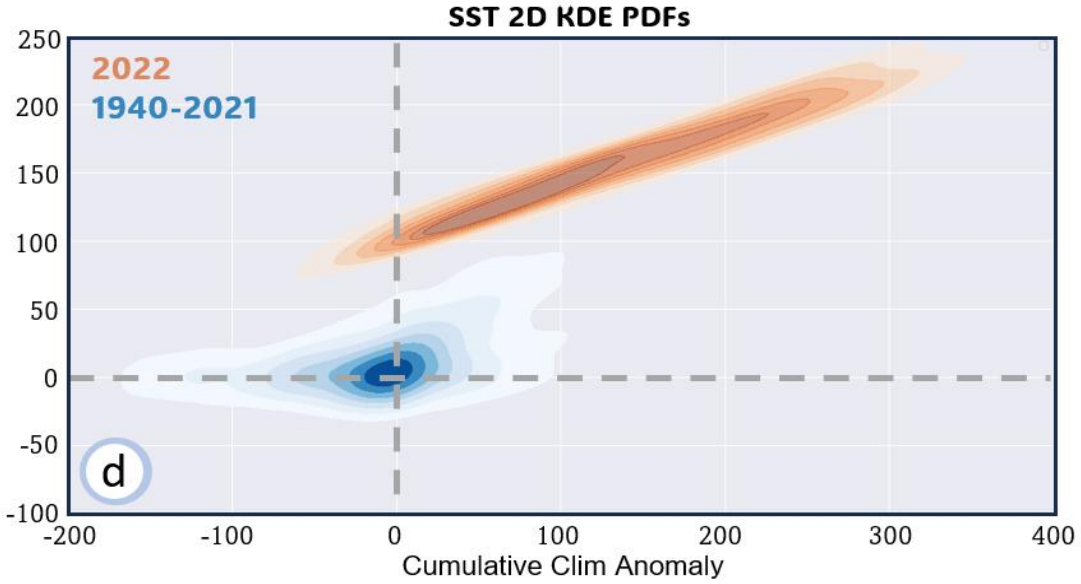


Geopotential Height @500 hPa Zonal Anomaly – W-C Europe

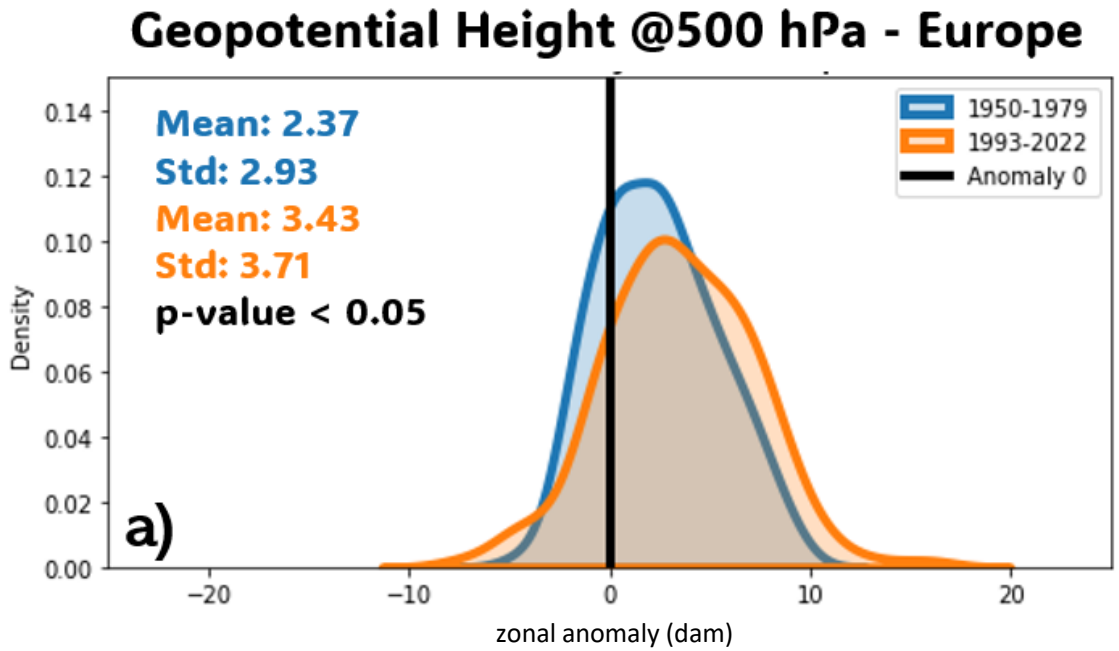


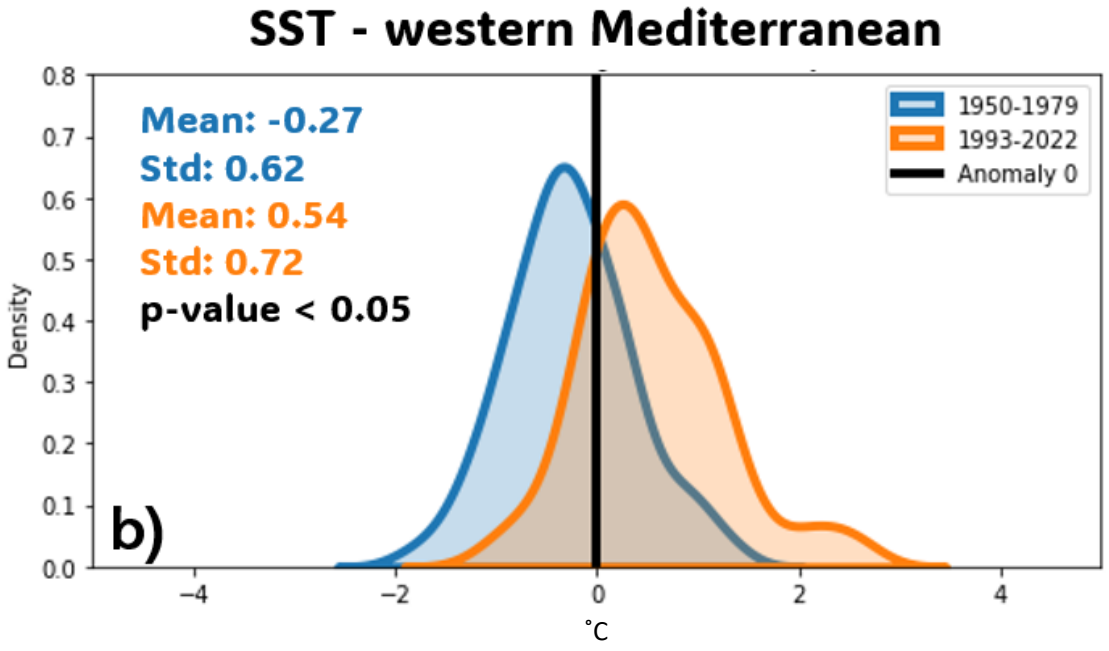
Sea Surface Temperature Anomaly – W. Mediterranean



2022 extreme atmospheric & oceanic event

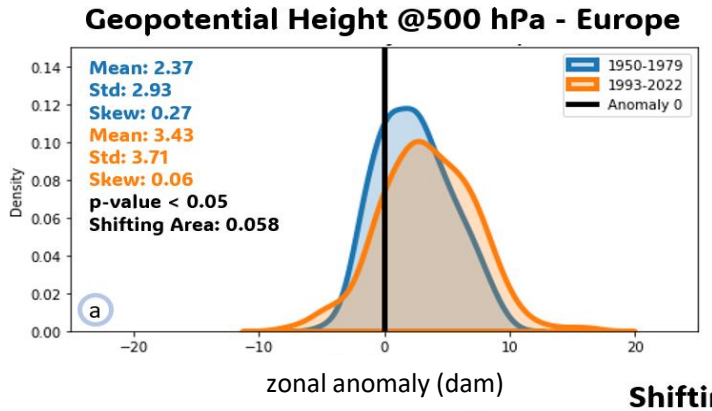
May-Aug

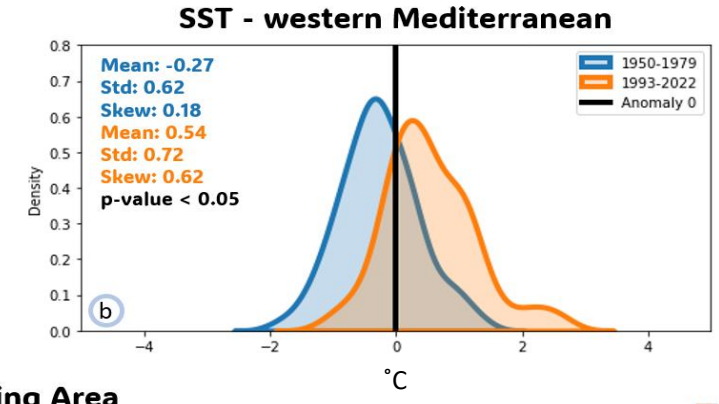


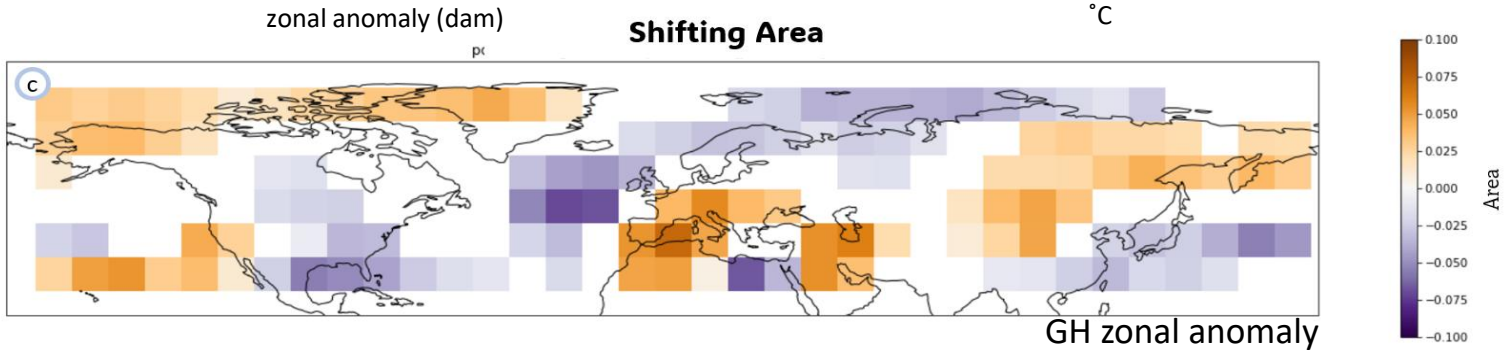


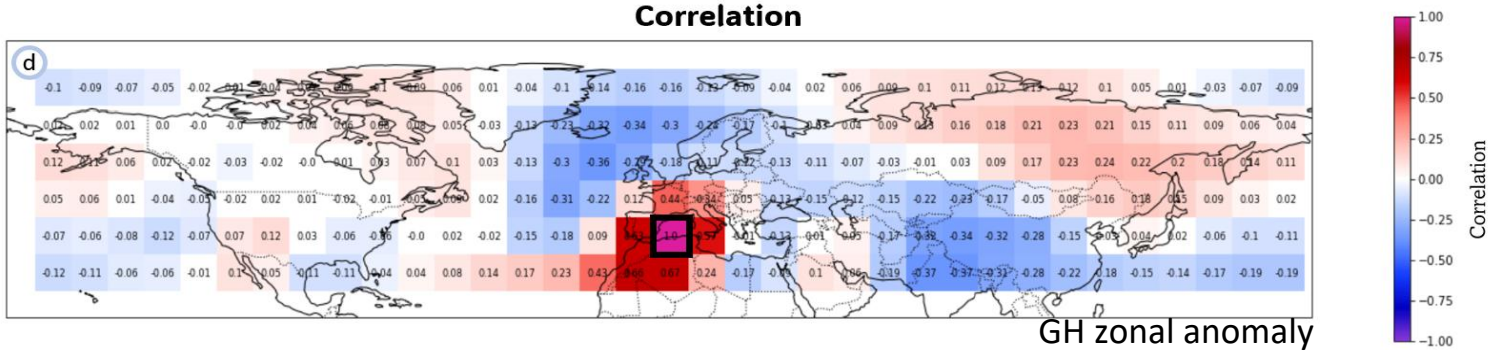
Recent changes in the atmospheric circulation

May-Aug



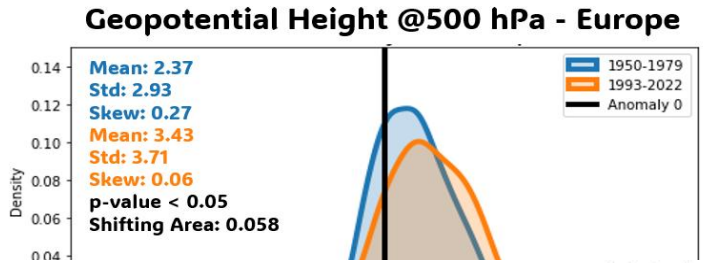


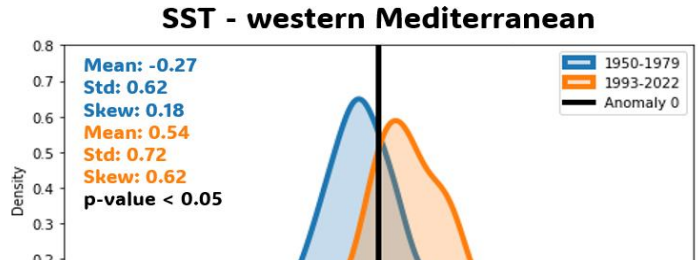


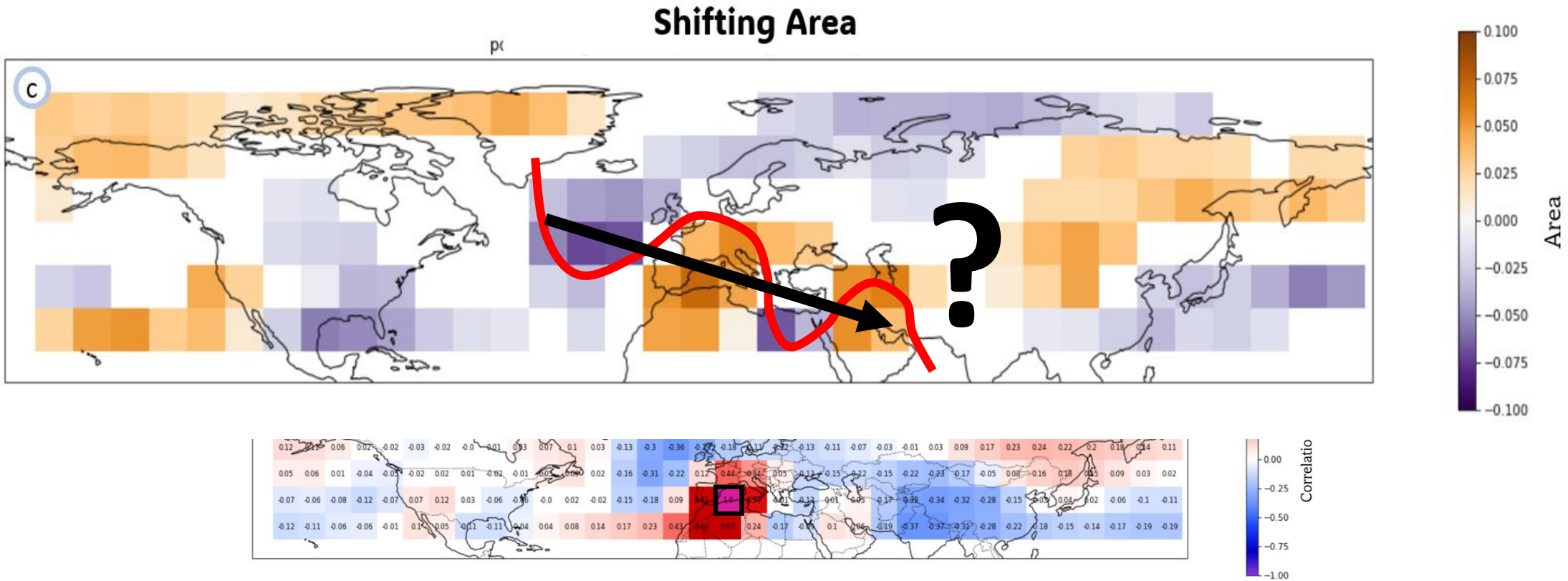


Recent changes in the atmospheric circulation

May-Aug

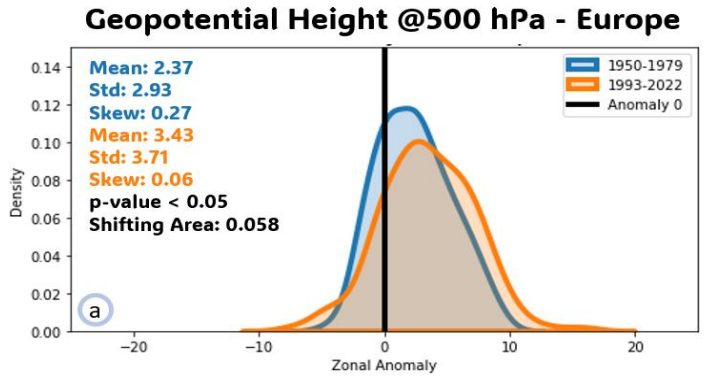


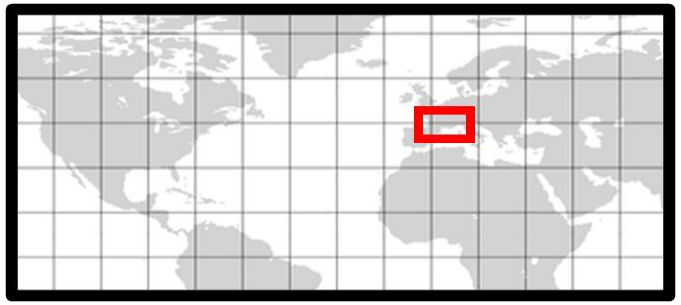


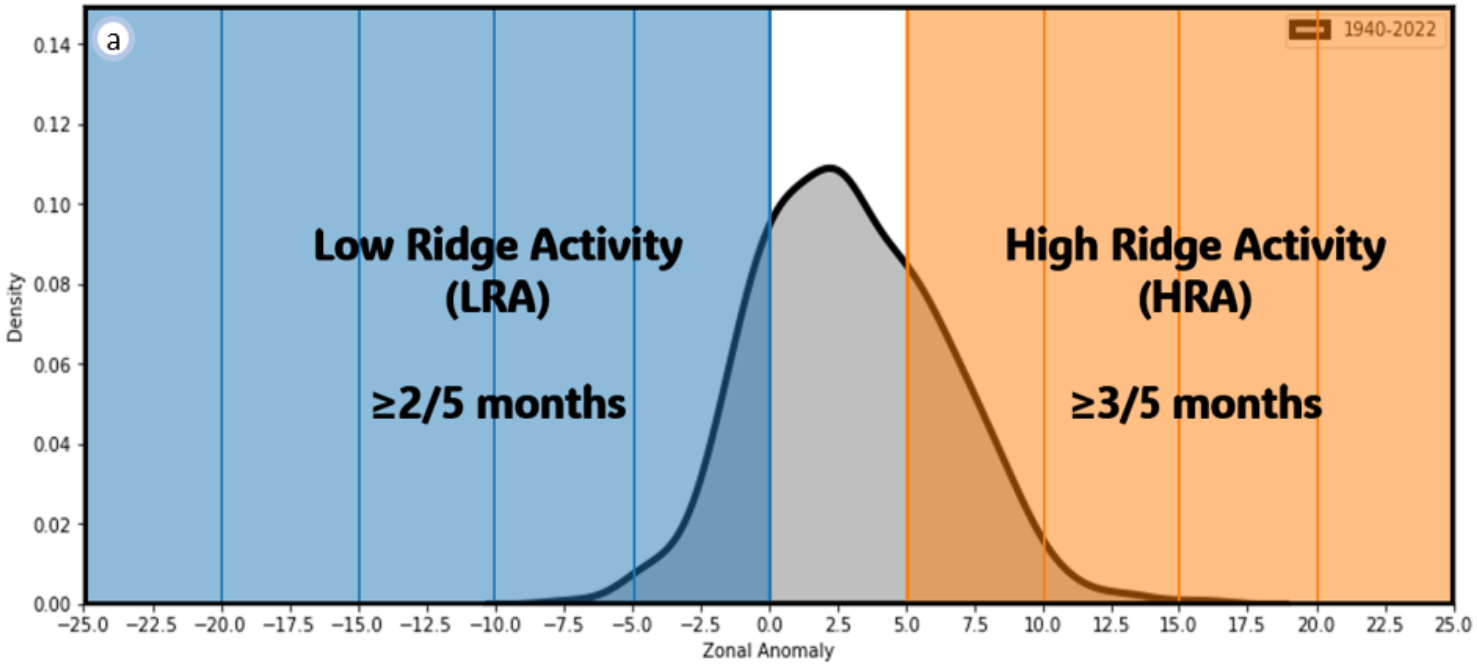


Recent changes in the atmospheric circulation

May-Aug

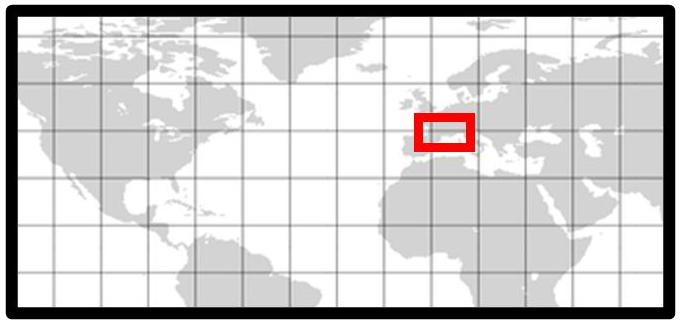


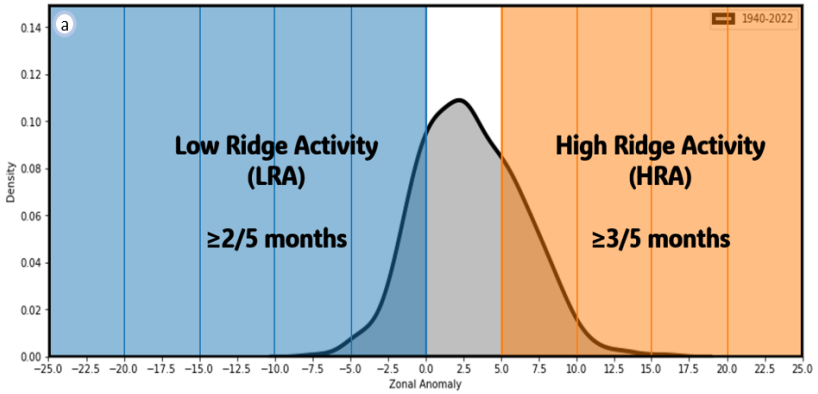




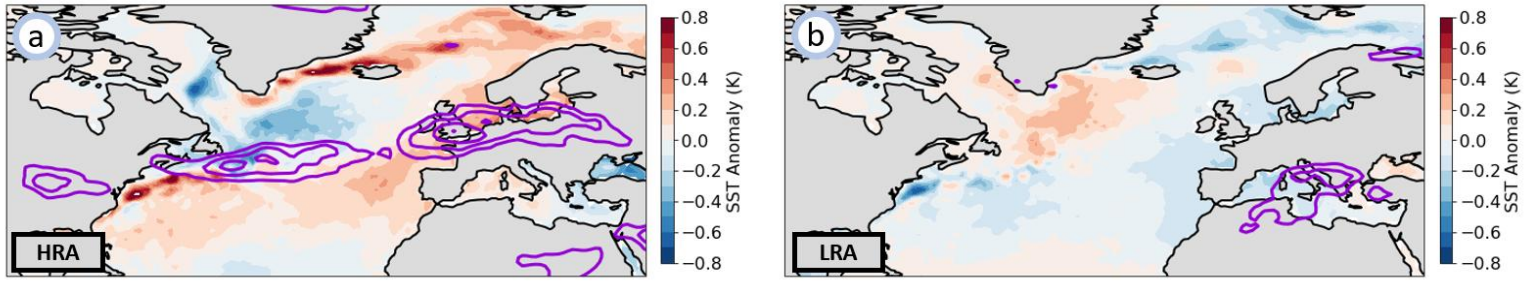
These recent changes can be explained though a dynamical pathway

MJJ

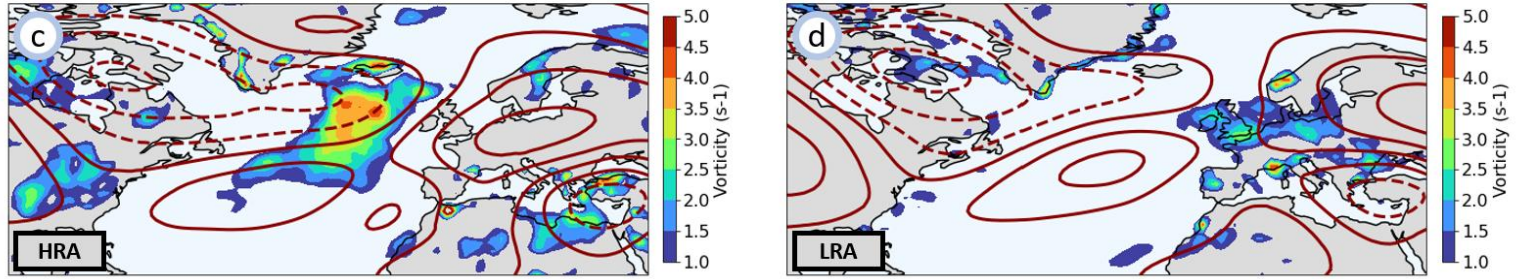




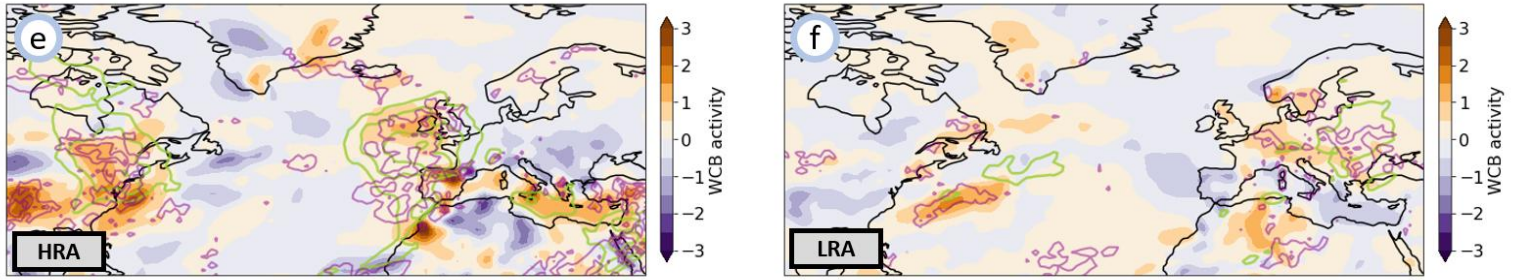
Sea Surface Temperature + EBG @700 hPa



Vorticity @850 hPa + ZAGH @500 hPa

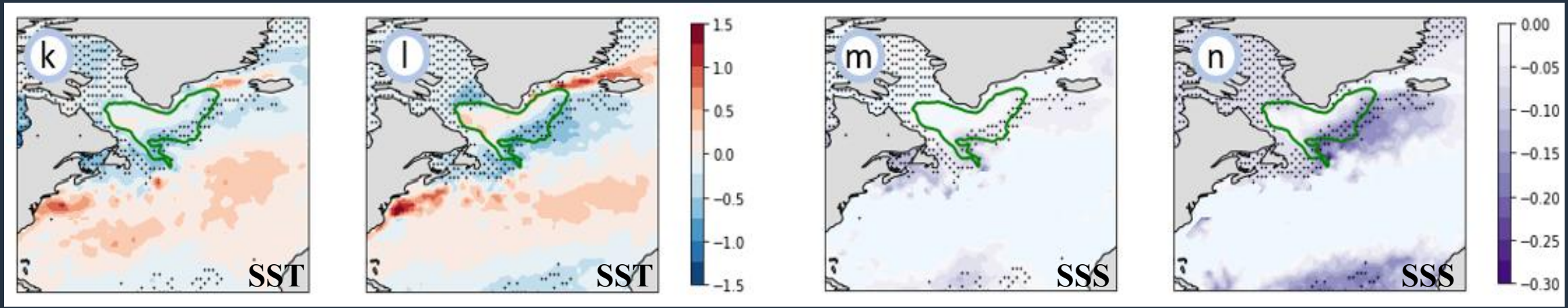


WCB activity + WHAA + upper-level divergence



The SST pattern in HRA/LRA appears to be linked to Greenland melting

HRA – LRA (march) **HRA – LRA (seasonal change)**



- (k,m) Composite March differences of (k) sea surface temperature (SST) and (m) sea surface salinity (SSS) between HRA and LRA years.
- (l,n) Composite differences of the seasonal surface cooling (l) and surface freshening (n) between the HRA and LRA years, with negative SSS anomalies indicating enhanced freshening.
- The seasonal cooling and freshening refers to the SST and SSS differences from autumn (averaged over September to November) to March.

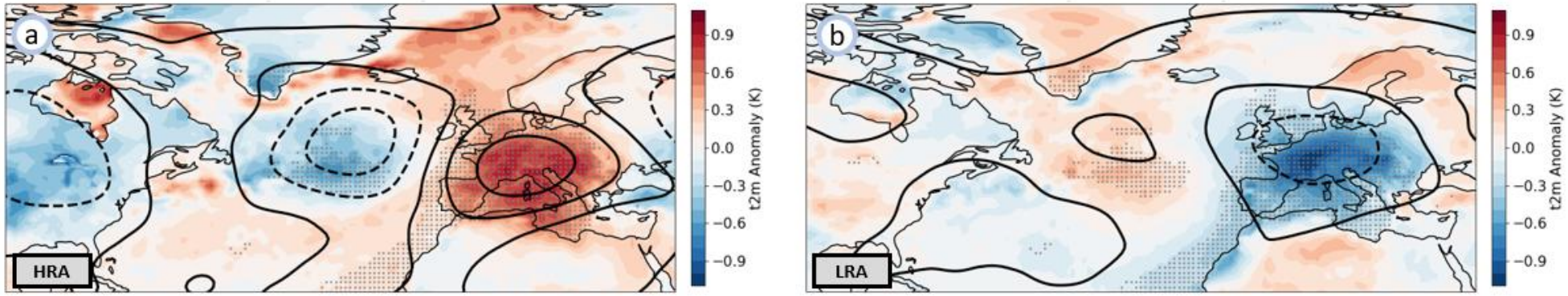
The SSS has been estimated using a surface mass balance.
The green contour line represents the mean location of the subpolar gyre, represented by the -0.5 m isoline of the mean absolute dynamic topography.
Dots indicate significant statistical difference ($p \leq 0.05$; rank-sum test).

The cascading mechanism impacts on surface

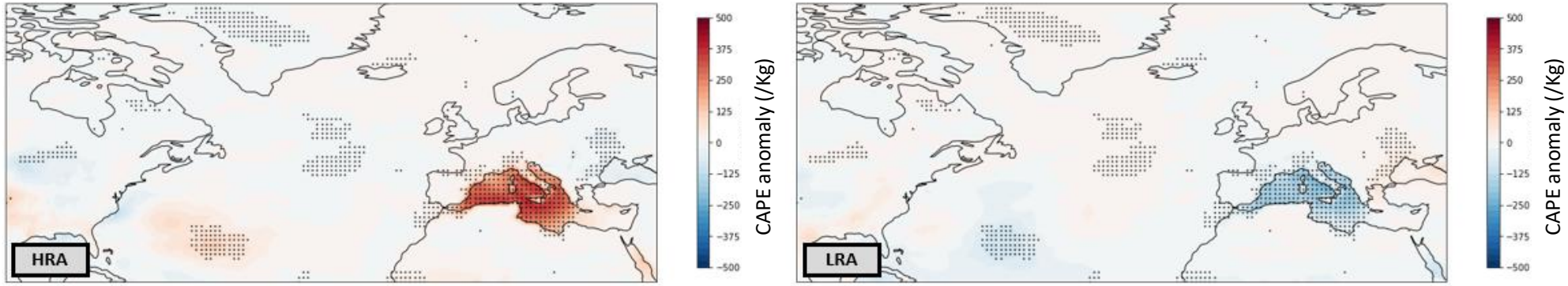
Jun-Jul

Temperature & Convective Impacts

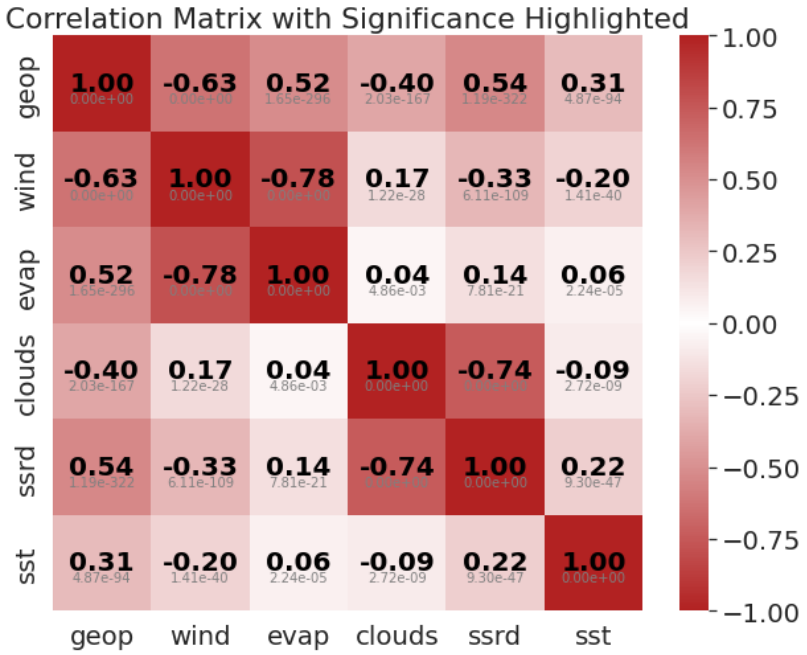
Geopotential Height @500 hPa + Temperature @2 m. + Sea Surface Temperature



Geopotential Height @500 hPa + CAPE

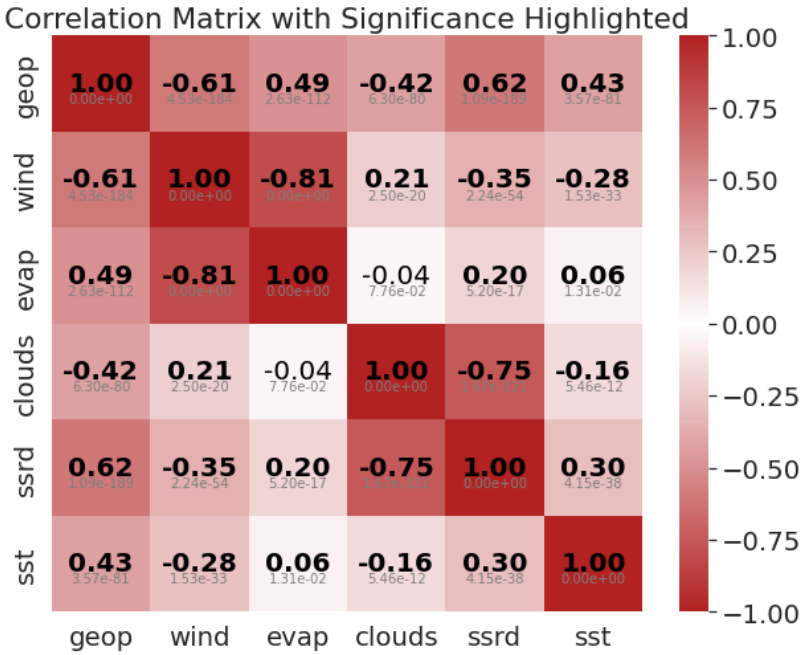


The atmosphere influences on the sea over the W Med region



Weekly detrended

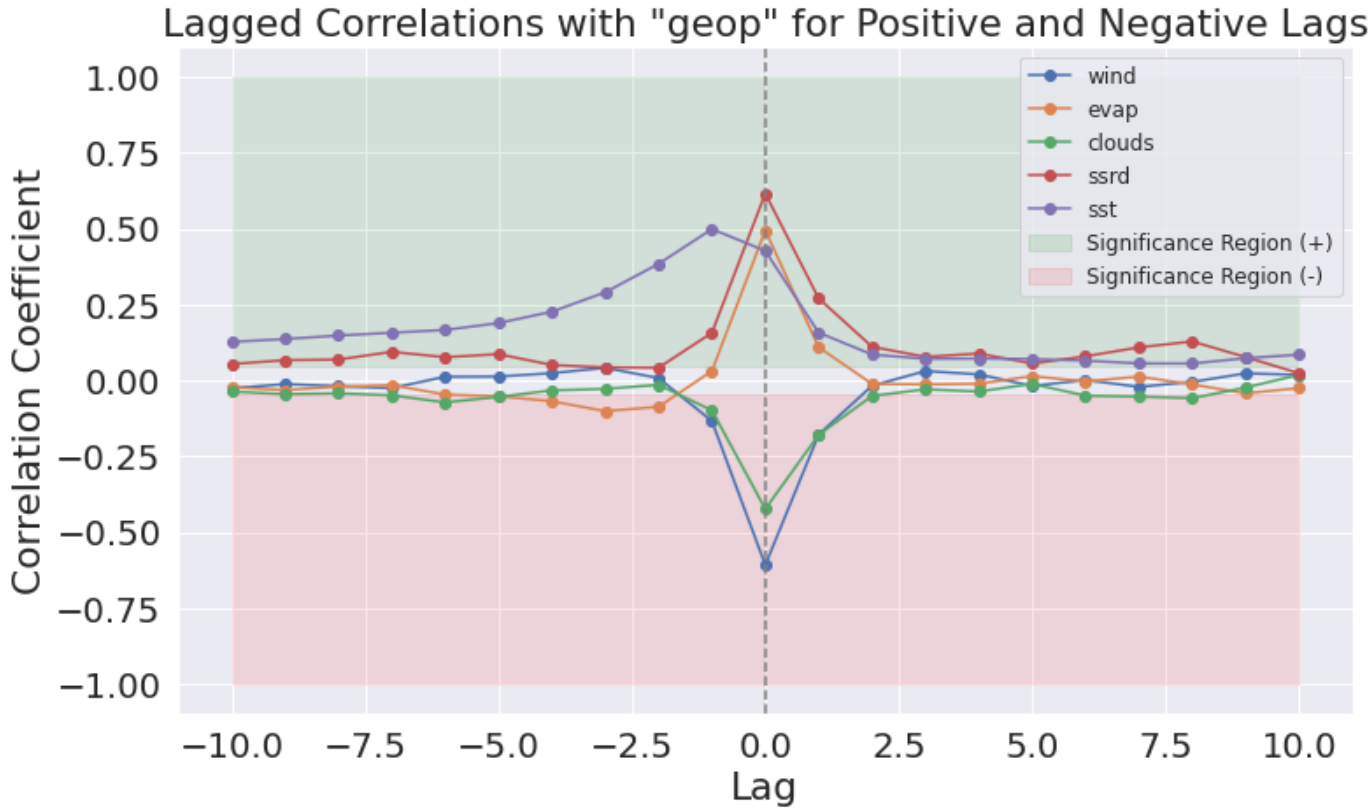
wind: mistral
evap: evaporation
clouds: cloud cover
ssrd: downward solar IR radiation at surface
sst: sea surface temperature



Weekly detrended Apr to Aug

*p-value in grey

The atmosphere influences on the sea over the W Med region



Weekly detrended Apr to Aug 2022 (lagged)

(left is after; right is before)

wind: mistral
evap: evaporation
clouds: cloud cover
ssrd: downward solar IR radiation at surface
sst: sea surface temperature

Z500 ↑

wind ↓ ---> evaporation ↓? ---> SST ↑

cloud cover ↓ ---> sfc solar radiation ↑ ---> SST ↑

IFS seasonal ensemble modelling experiments with prescribed SSTs support the physical pathway

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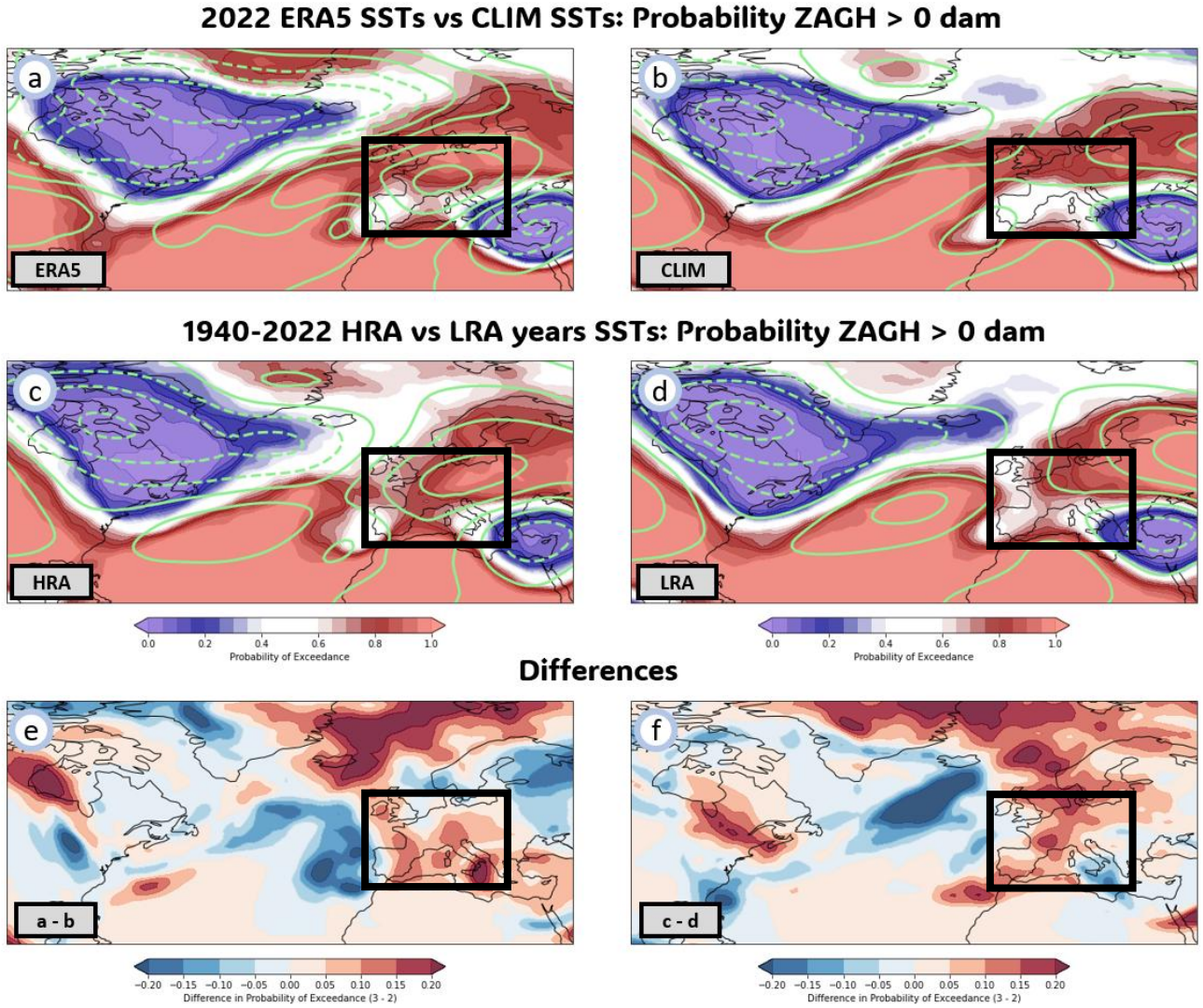
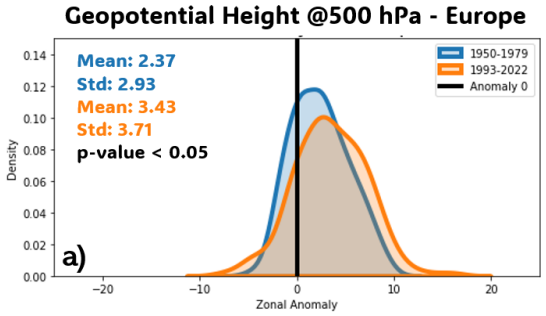
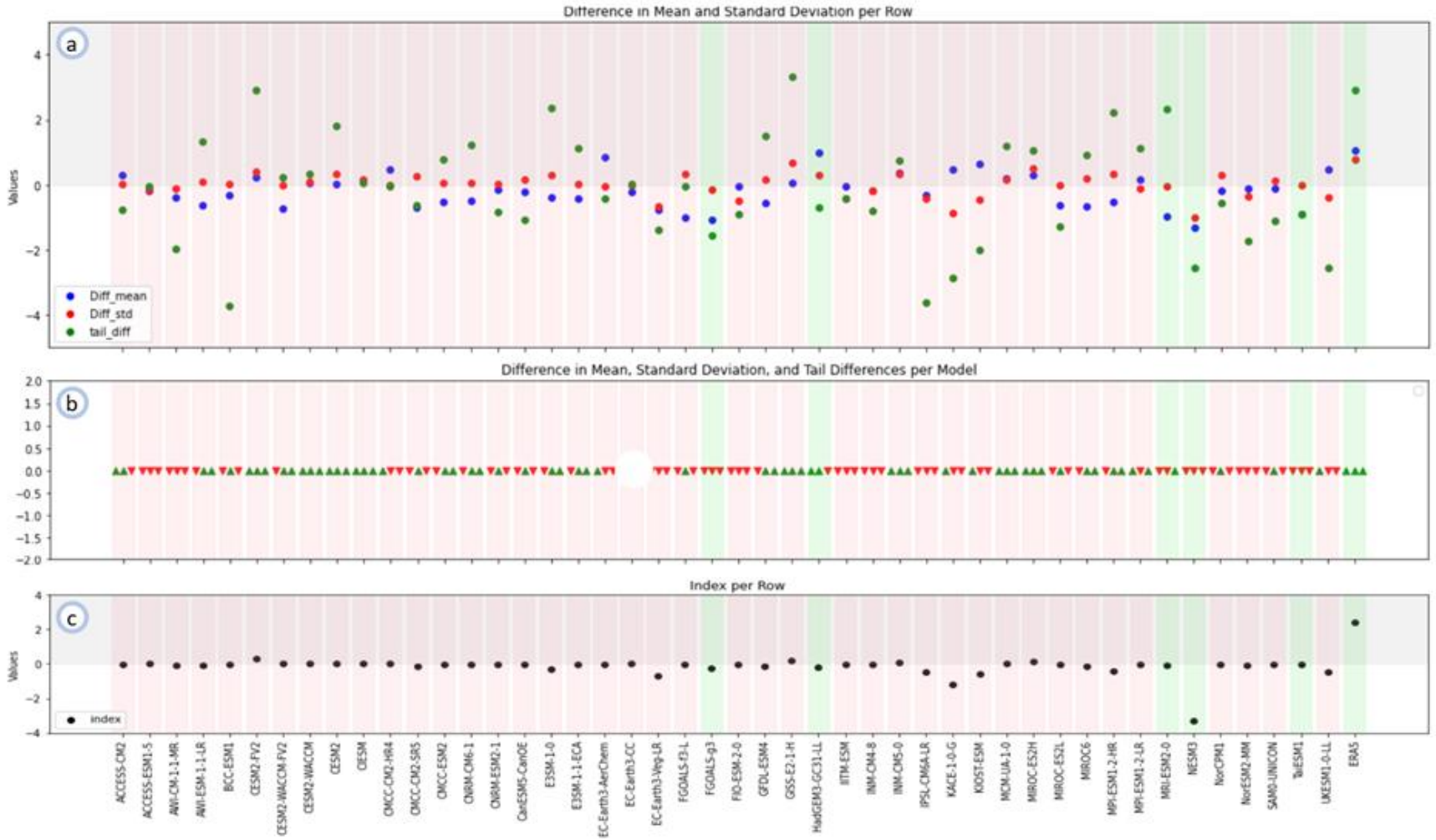
observed

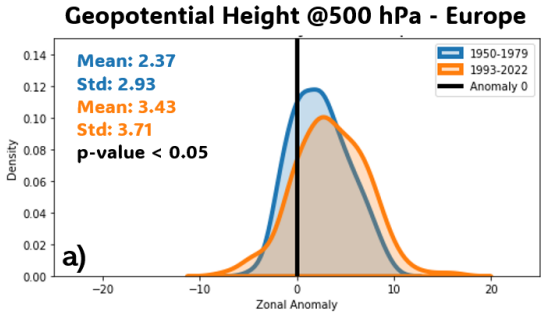


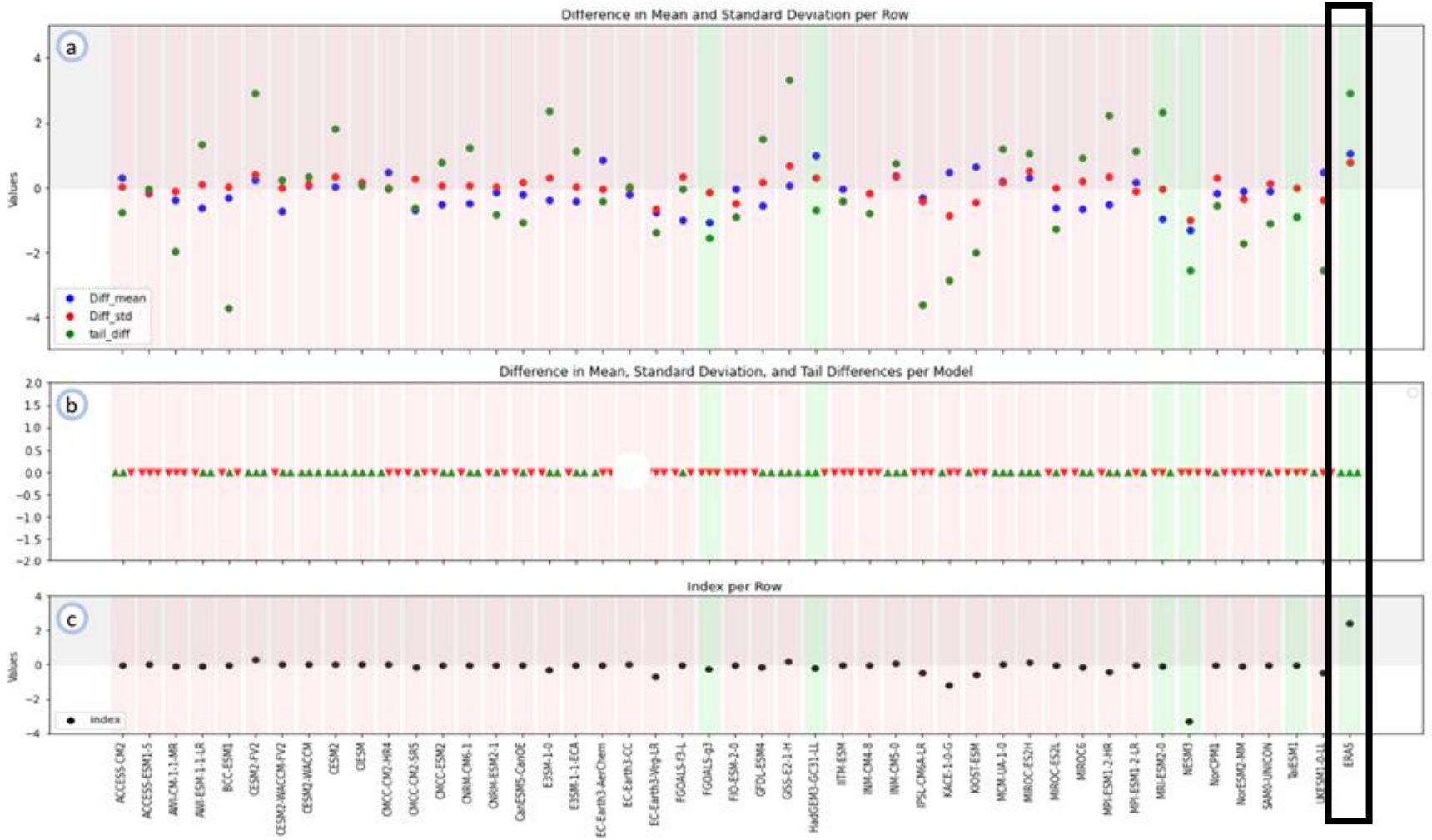
Mechanism not present in CMIP6



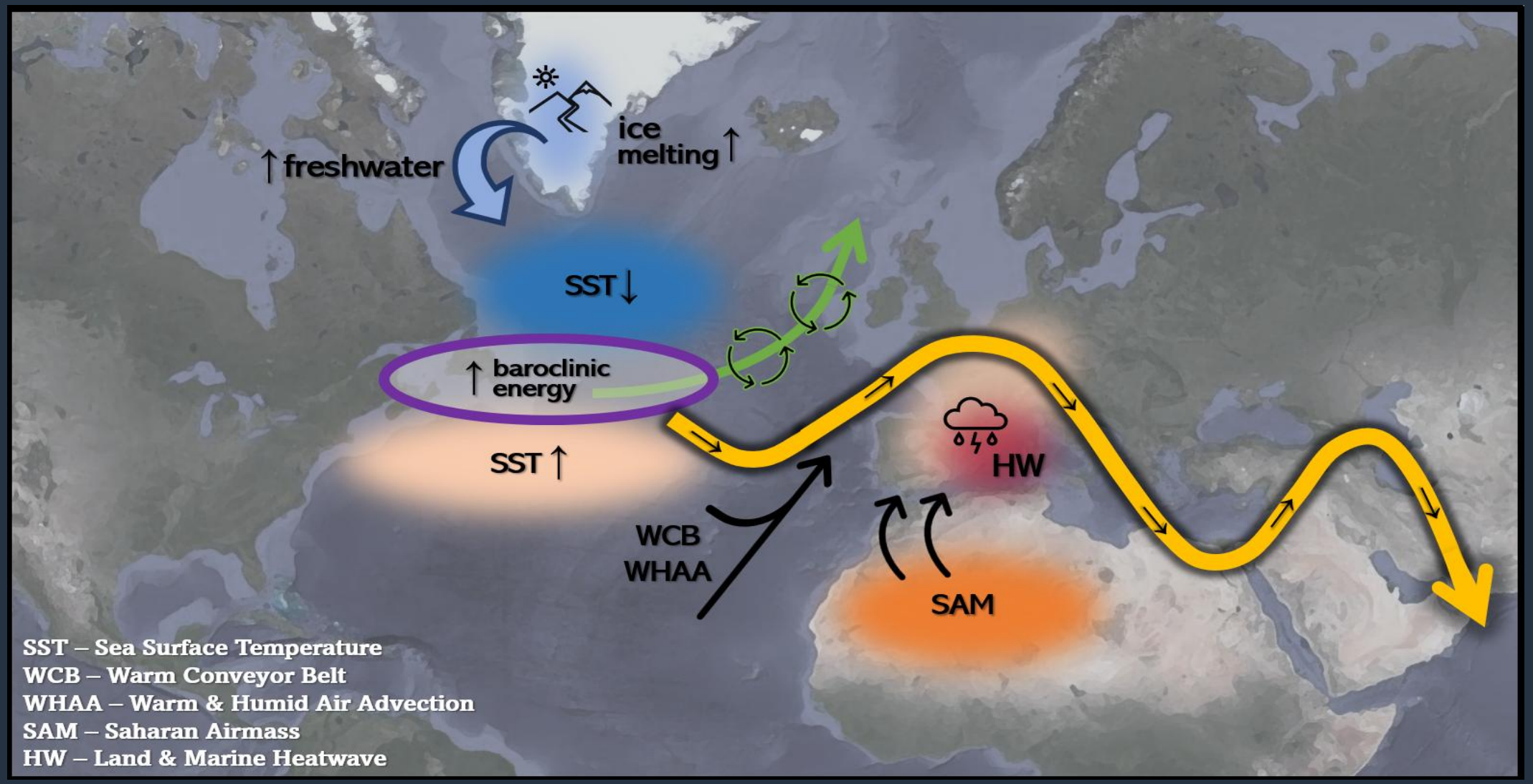


Mechanism not present in CMIP6





Summary Schematic

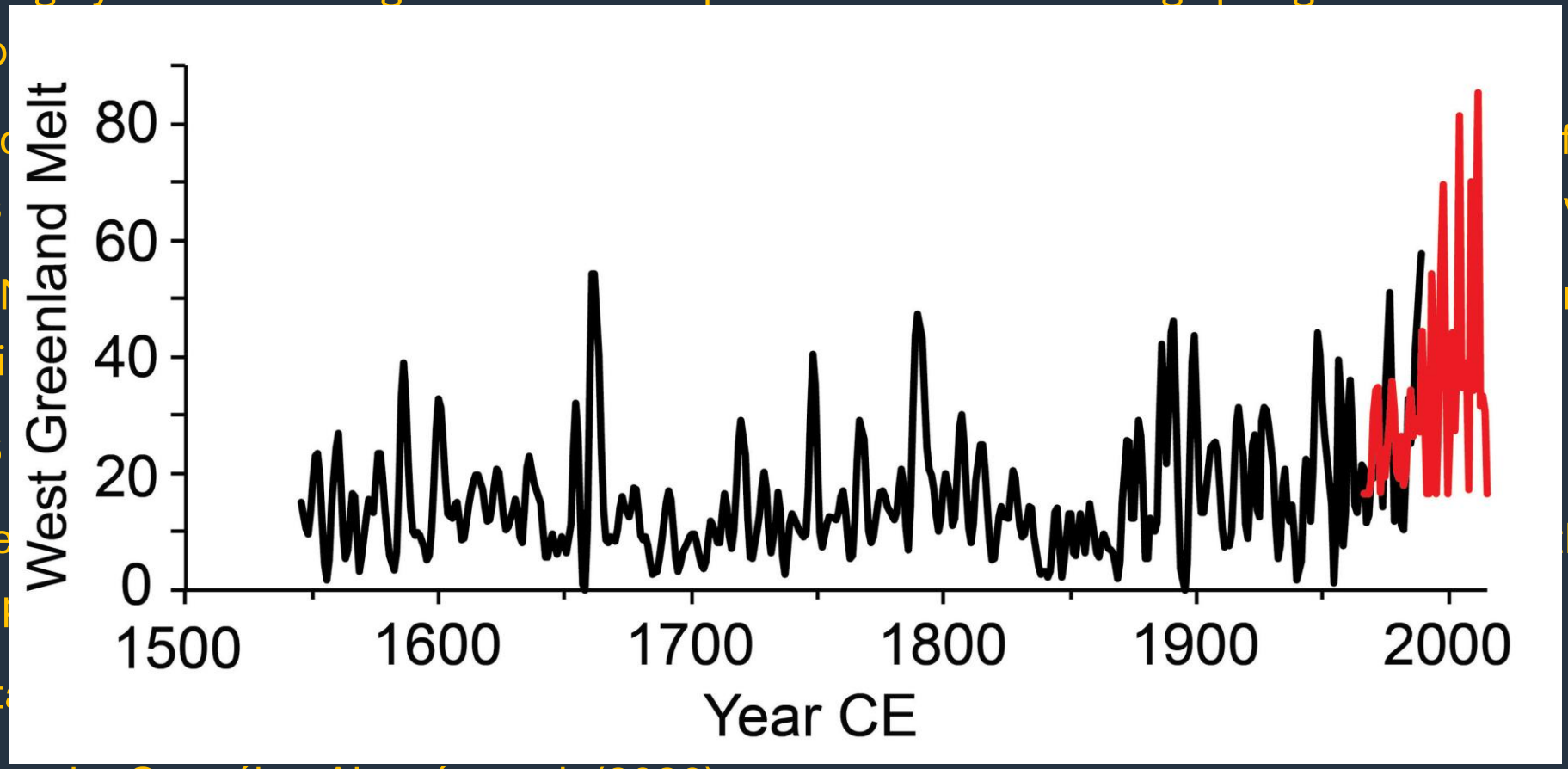


Conclusions

- Emerging dynamical changes in the atmospheric circulation during spring-summer in the NH, which are more robust over the western Euro-Med region.
- These changes are potentially associated with North Atlantic SSTs and are the cause of extreme MHWs over the western Mediterranean, leading to more potential for extreme convective storms.
- These North Atlantic SSTs changes seem to be linked to Greenland Ice Sheet melting and runoff: An emerging impact from the melting.
- CMIP6 models do not reproduce this mechanism, worrying for future projections.
- Another potential mechanism to explain why Europe is warming more than the rest of the Northern Hemisphere? And why the Mediterrranean Sea is warming more rapidly?
- Important source of predictability for seasonal2decadal scale?
- Submitted… González-Alemán et al. (2026).

Conclusions

- Emerging dynamical changes in the atmospheric circulation during spring-summer in the NH, which are mo
- These c f extreme MHWs ve storms.
- These M nd runoff: An emergi
- CMIP6
- Anothe he Northern Hemisp
- Import
- Submitted… González-Alemán et al. (2026).



Conclusions

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- These … eme MHW… orms.
- These … noff: An emer…
- (…
- A… I…
- I…
- Submitted… González-Alemán et al. (2026).

LETTER

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Nonlinear rise in Greenland runoff in response to post-industrial Arctic warming

Luke D. Trusel[1,2*], Sarah B. Das[2], Matthew B. Osman[3], Matthew J. Evans[4], Ben E. Smith[5], Xavier Fettweis[6], Joseph R. McConnell[7], Brice P. Y. Noël[8] & Michiel R. van den Broeke[8]

Rising Extreme Meltwater Trends in Greenland Ice Sheet (1950–2022): Surface Energy Balance and Large-Scale Circulation Changes

Josep Bonsoms, Marc Oliva, Juan I. López-Moreno, and Xavier Fettweis

Muchas gracias por vuestra atención!

Thank you for your attention!

Contact: jgonzaleza@aemet.es / @glezjuanje / glezjuanje.bsky.social