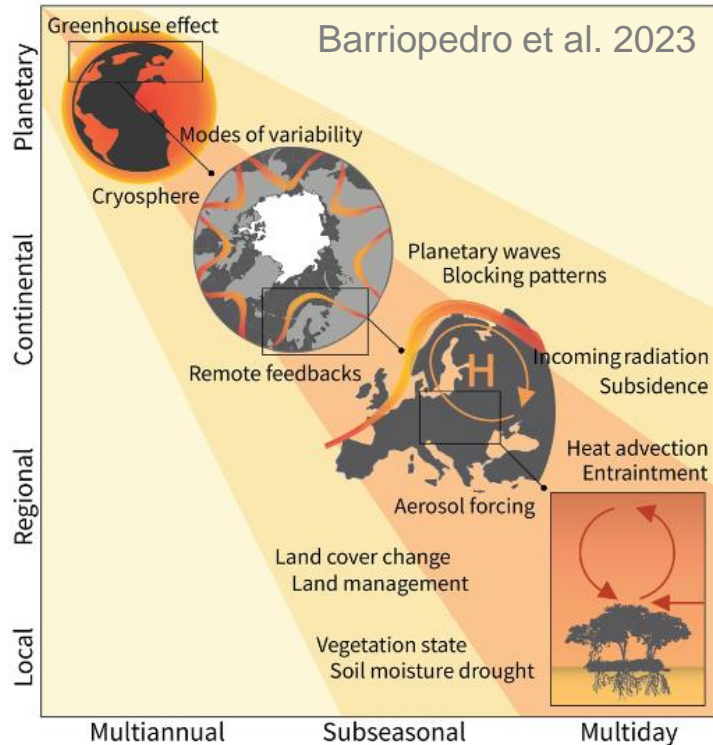


HELMHOLTZ



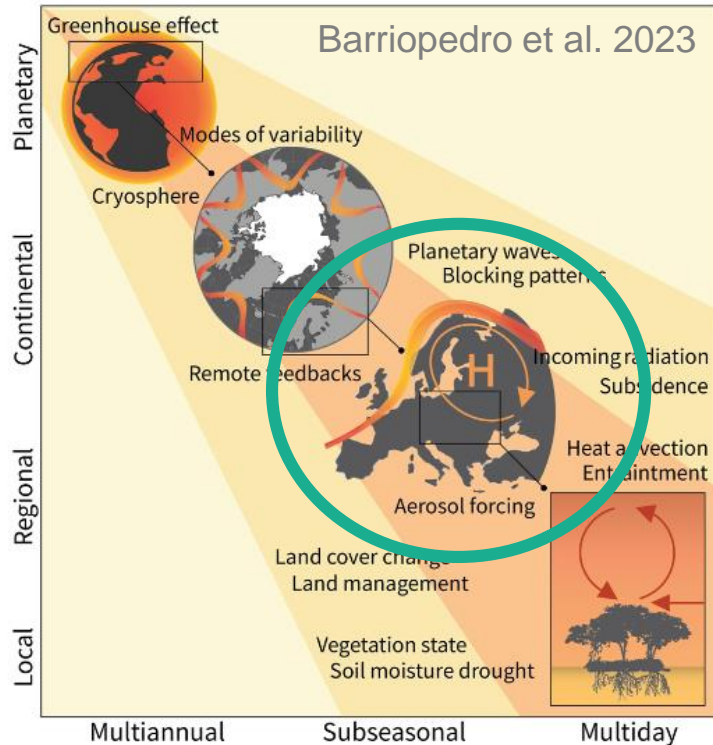
The Role of the North Atlantic for Heat Wave Characteristics in Europe

Sabine Bischof, Robin Pilch Kedzierski, Martje Hänsch, Sebastian Wahl, and
Katja Matthes



What influences the development and persistence of heat waves?

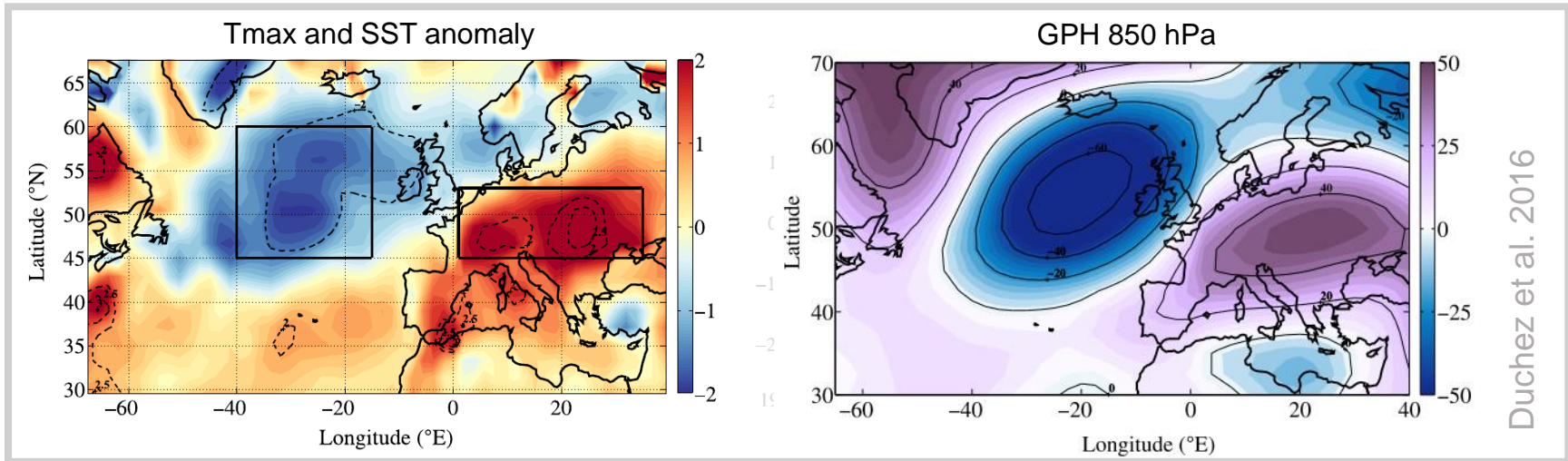
- Stronger and more frequent heat waves due to **climate change**
- Influence from different **modes of variability**, such as ENSO, AMV, PDO, etc.
- Persistent **anticyclones** as a prerequisite for heat waves on a regional scale
- **Local feedbacks** that can enhance heat wave strength or duration (e.g., soil moisture feedback)



What influences the development and persistence of heat waves?

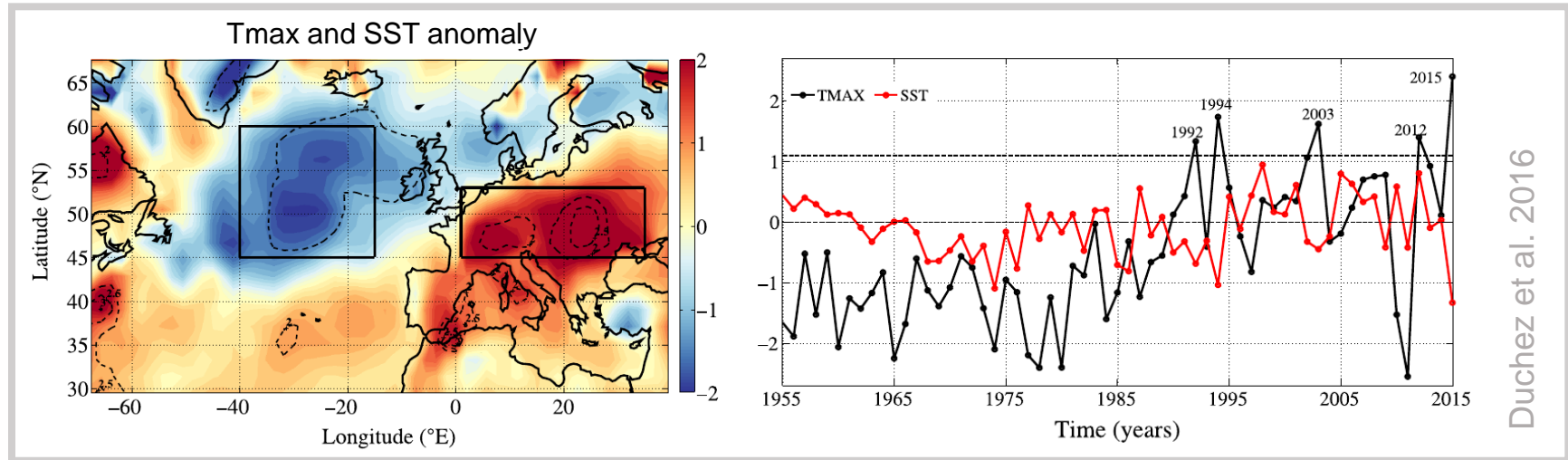
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What influences the development and persistence of heat waves?



The heat wave in 2015 was influenced by SST anomalies in the North Atlantic

What influences the development and persistence of heat waves?

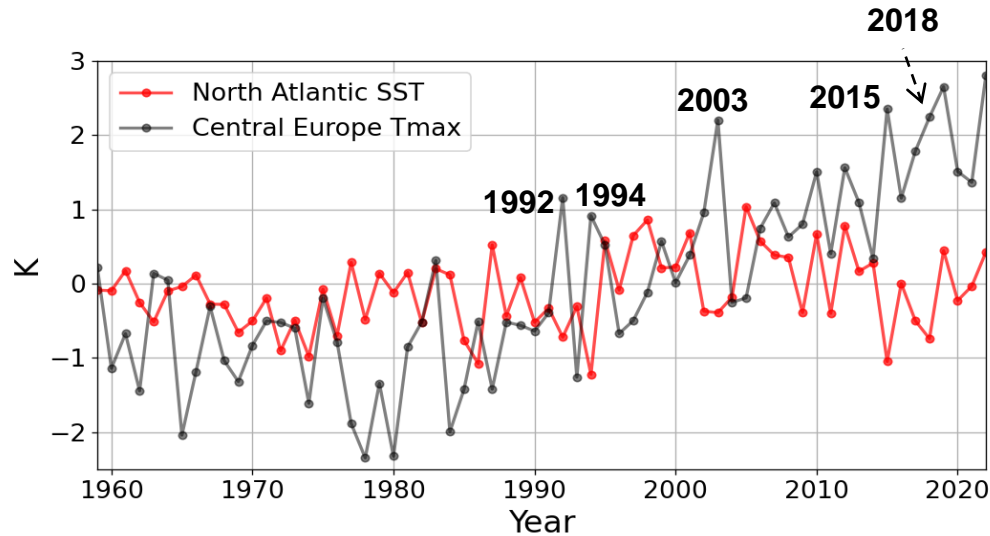


The heat wave in 2015 was influenced by SST anomalies in the North Atlantic

Also in other years, cold NA SSTs coincide with heat waves in Europe

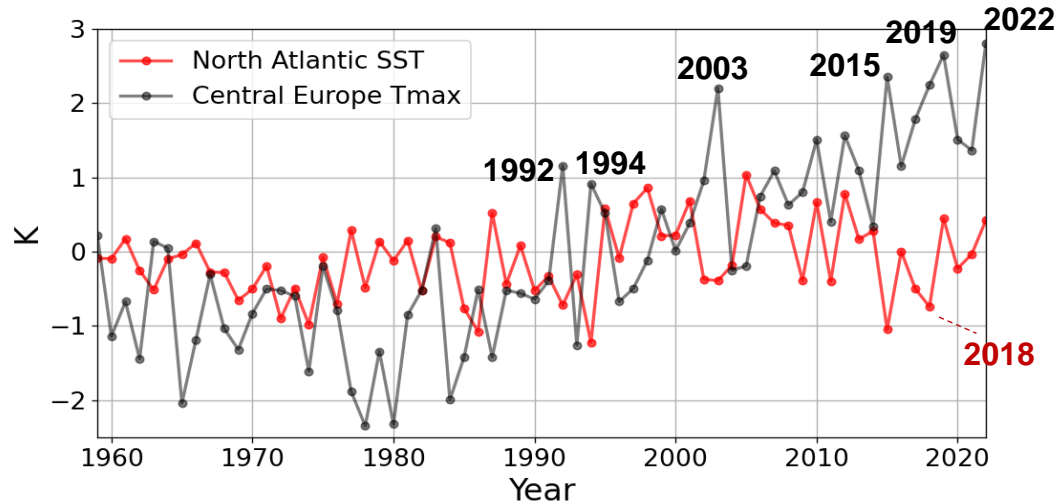
Extending the time series

- 2018 showed similar conditions as 2015
- global warming impact superimposed

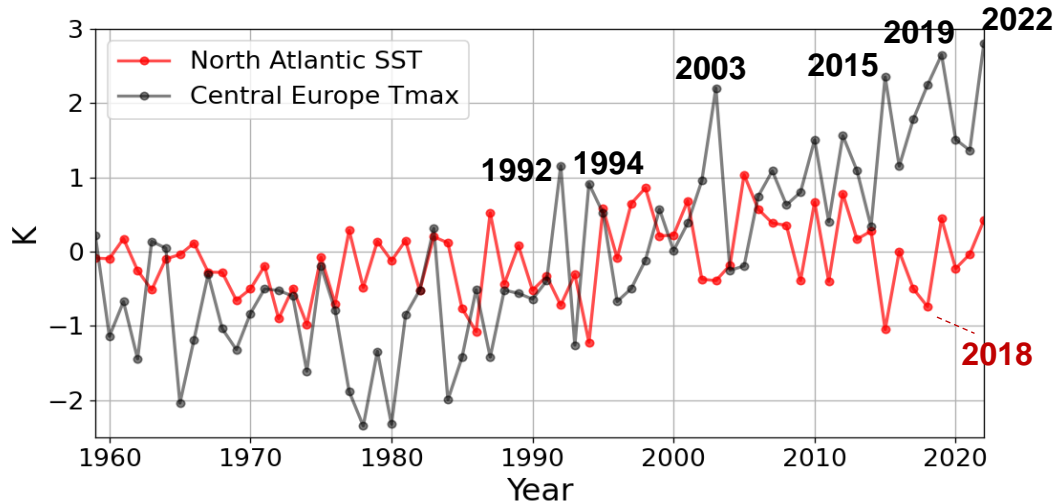


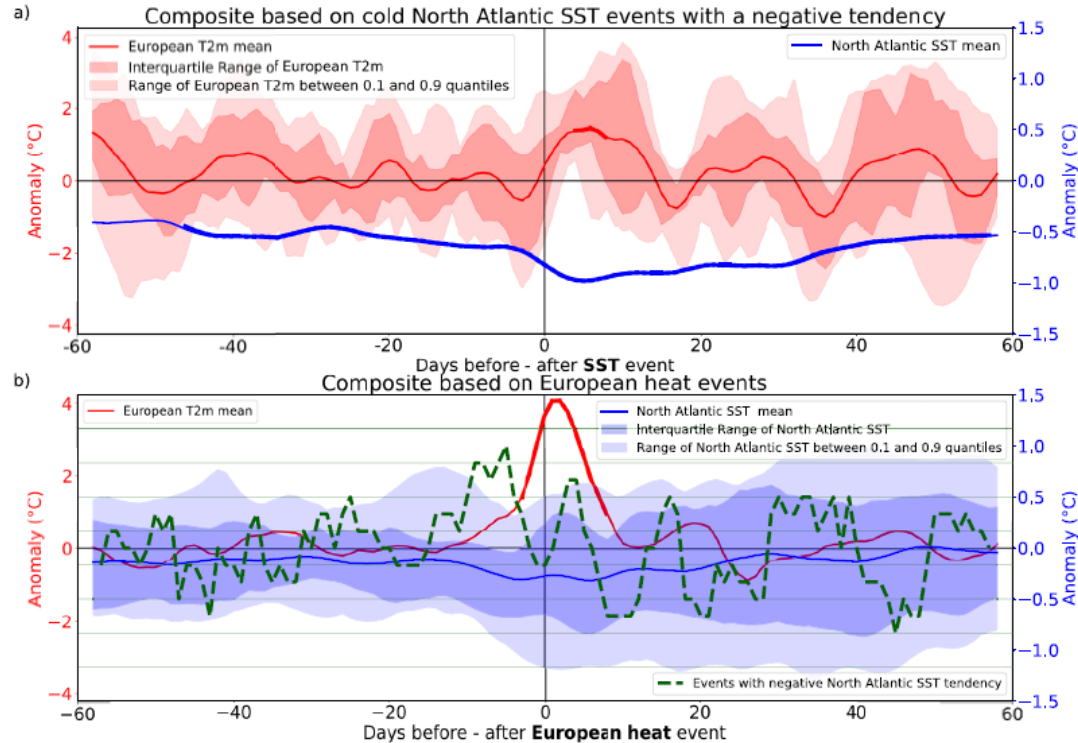
Extending the time series

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- global warming impact superimposed



Do North Atlantic SST anomalies influence European heat waves?





Krüger et al. 2023 (Tellus A)

ERA5 1979 -2019

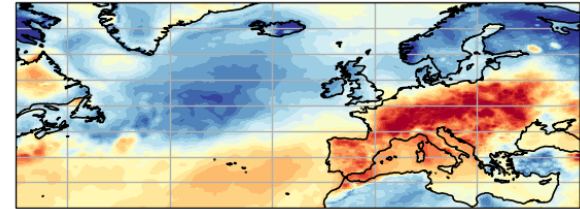
Events with a negative NA SST tendency are often followed by positive European air temperature anomalies during summers when the North Atlantic SSTs are persistently low for several months.

ECHAM6 (incl. JSBACH) time slice experiments forced with **daily 2018 SST and sea ice**

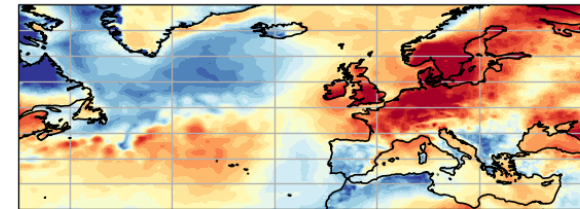
ECHAM6 settings:

- T63L95
- AMIP-like setup
- perpetual 2018 conditions (daily SSTs, sea ice, GHGs, aerosols, land use)
- 100 model years per experiment

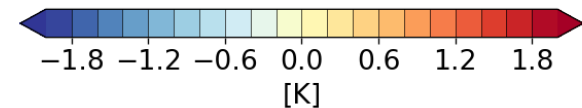
2015



2018



COLD → With cold SST anomaly

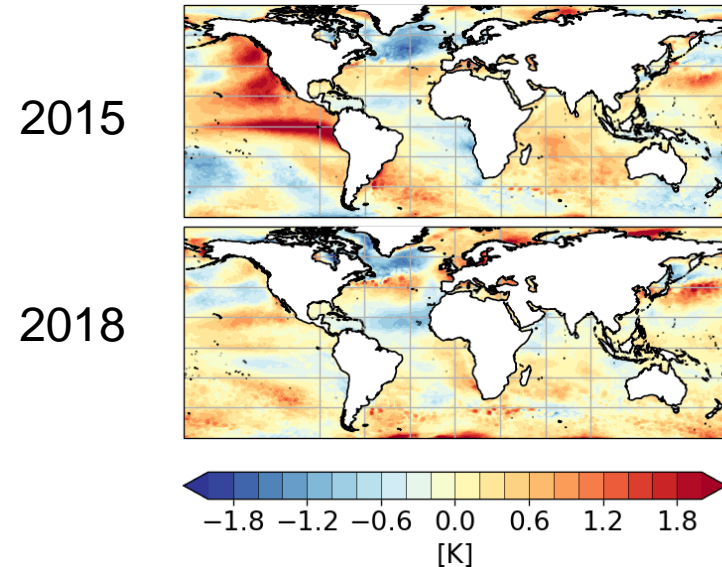


ECHAM6 (incl. JSBACH) time slice experiments forced with **daily 2018 SST and sea ice**

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COLD → With cold SST anomaly



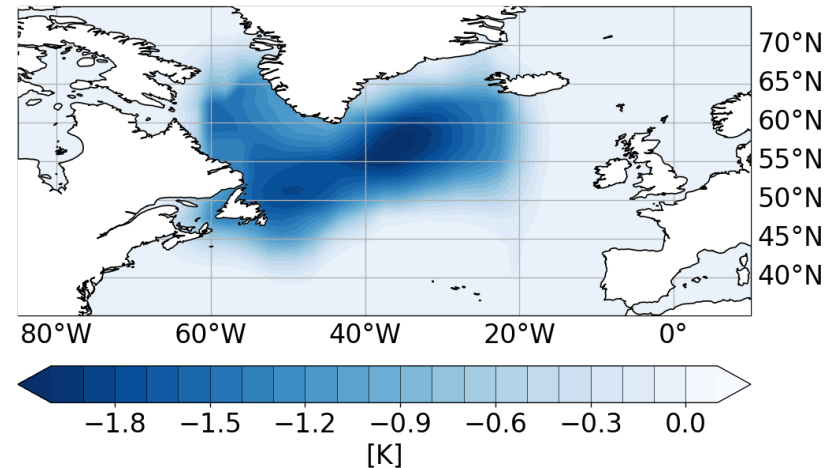
ECHAM6 (incl. JSBACH) time slice experiments forced with **daily 2018 SST and sea ice** + complementary simulation in which **the negative SST anomaly was removed**.

ECHAM6 settings:

- T63L95
- AMIP-like setup
- perpetual 2018 conditions (daily SSTs, sea ice, GHGs, aerosols, land use)
- 100 model years per experiment

COLD → With cold SST anomaly
NEUTRAL → Without cold SST anomaly

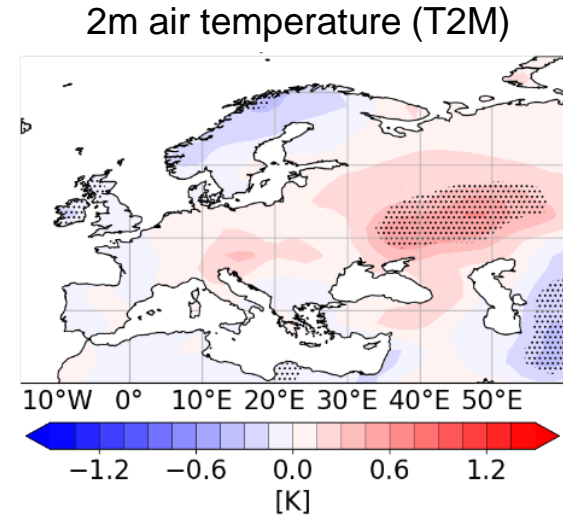
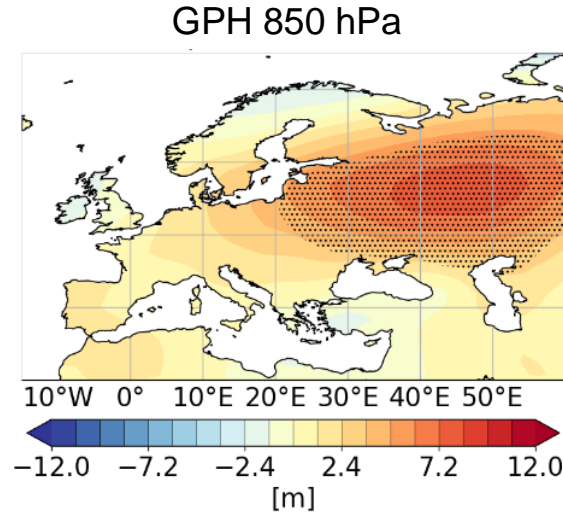
SST forcing difference (JJA) COLD-NEUTRAL



Cold NA SSTs lead to ...

- high pressure anomaly over easternmost Europe
- higher mean summer temperatures

JJA difference: COLD minus NEUTRAL

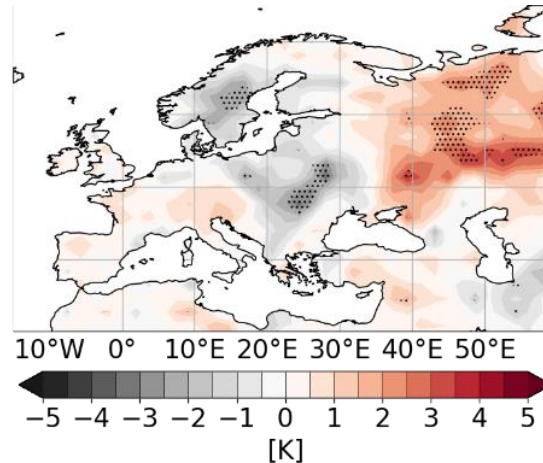


Cold NA SSTs lead to ...

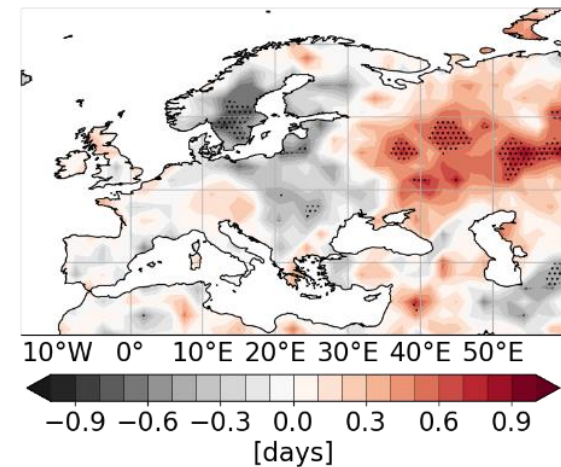
- high pressure anomaly over easternmost Europe
- higher mean summer temperatures
- **longer lasting and stronger heat waves in that region**

JJA GPH difference: COLD minus NEUTRAL

heat wave magnitude



heat wave duration

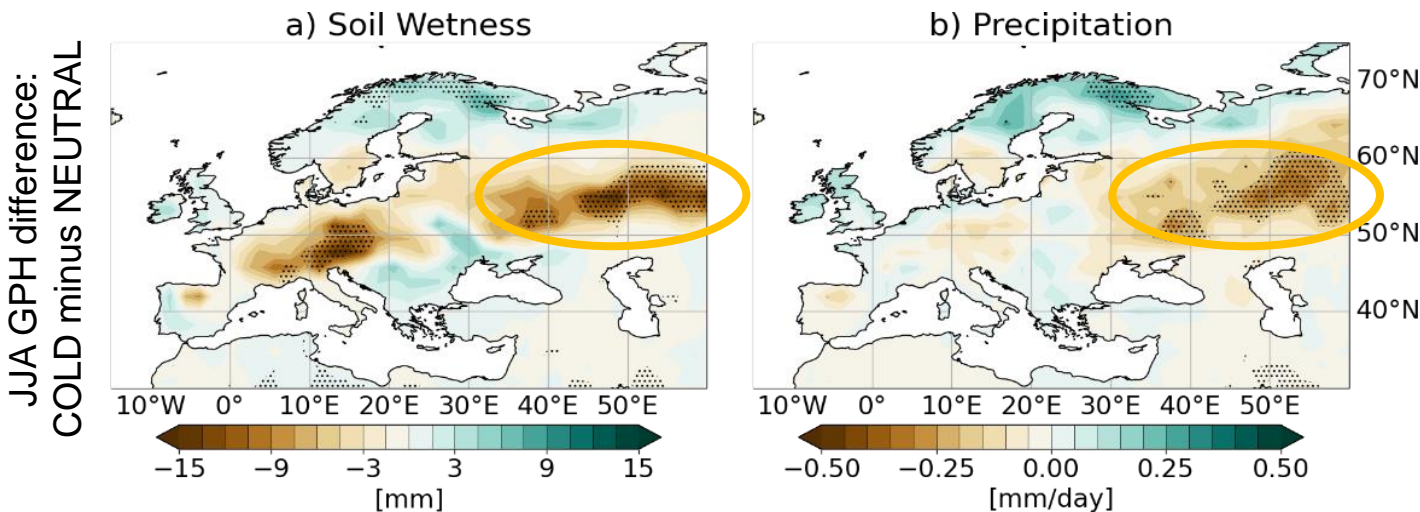


Local feedbacks enhance surface heat

Soil moisture and precipitation deficits in region with positive GPH anomalies

➔ Lower evaporative cooling in that region

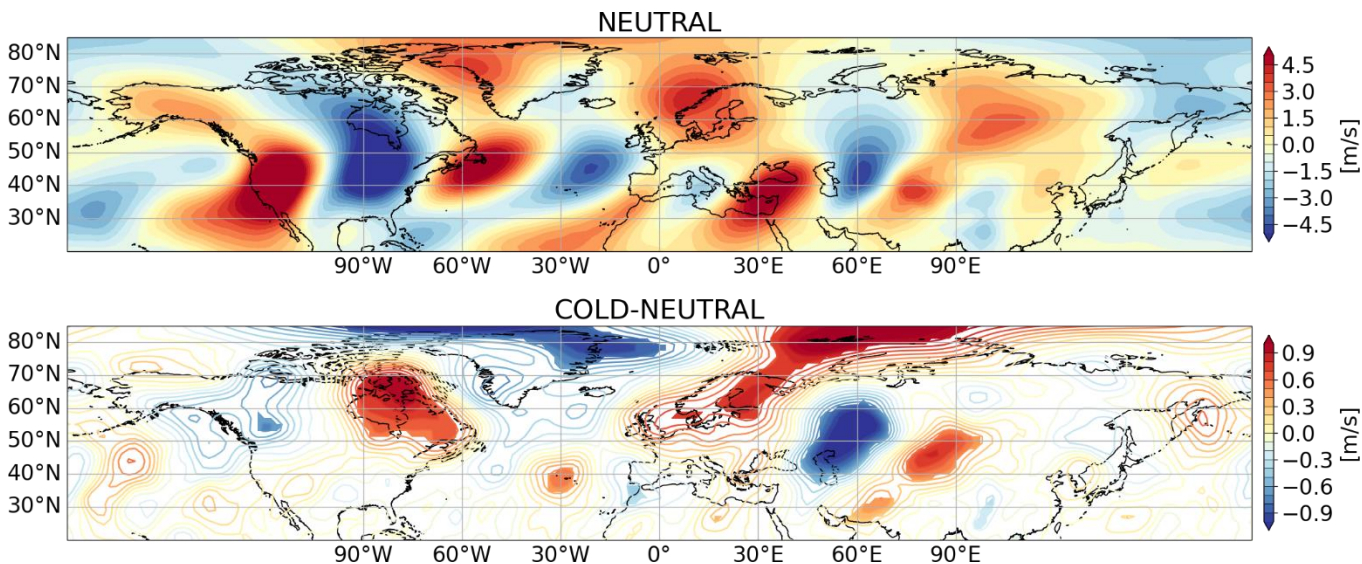
➔ Higher temperatures



Positive soil moisture feedback increases T2M response

Enhancement of the mid-tropospheric wave

Meridional wind component at 300 hPa (v300) in JJA

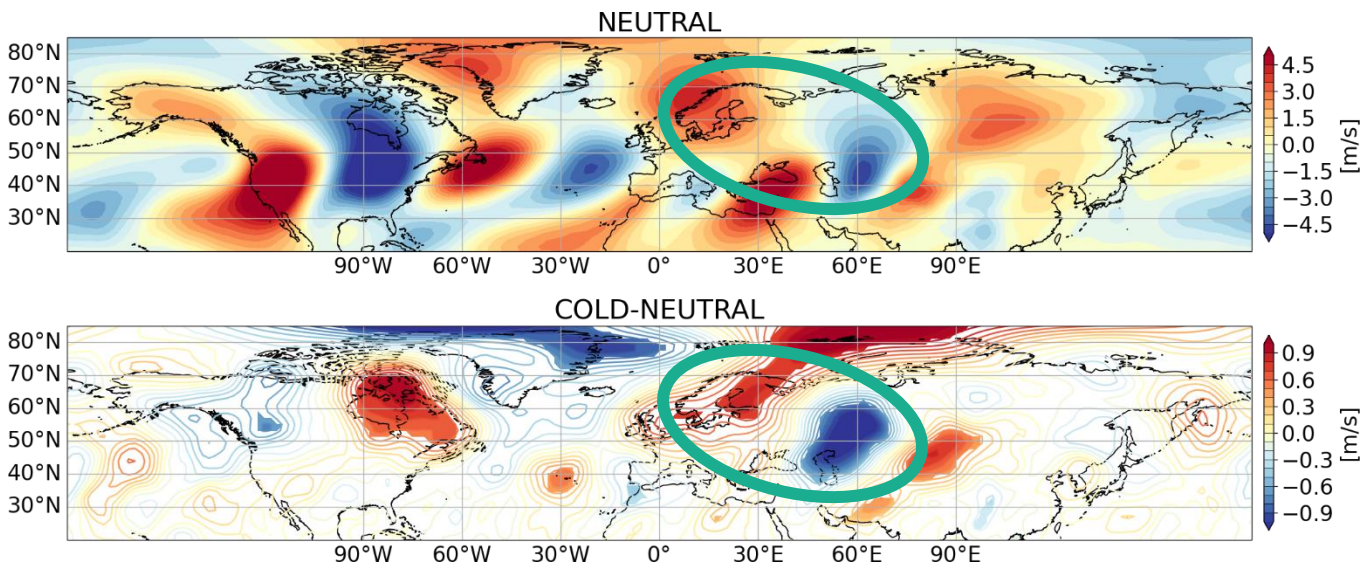


► enhanced wave pattern over eastern Europe and western Russia

► favoring high pressure systems with cold NA SSTs

Enhancement of the mid-tropospheric wave

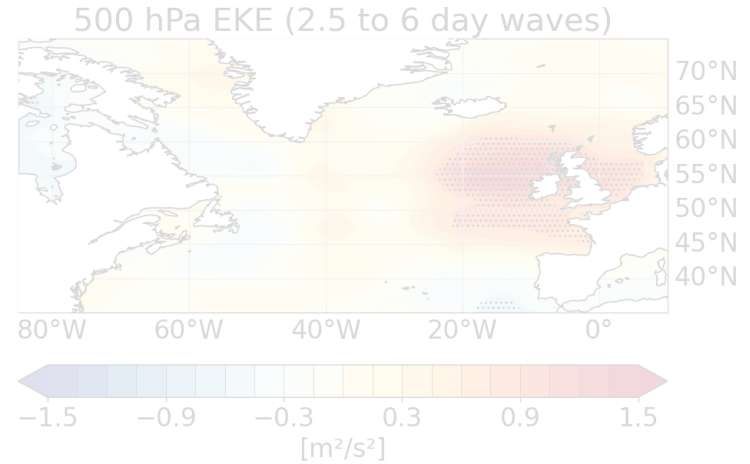
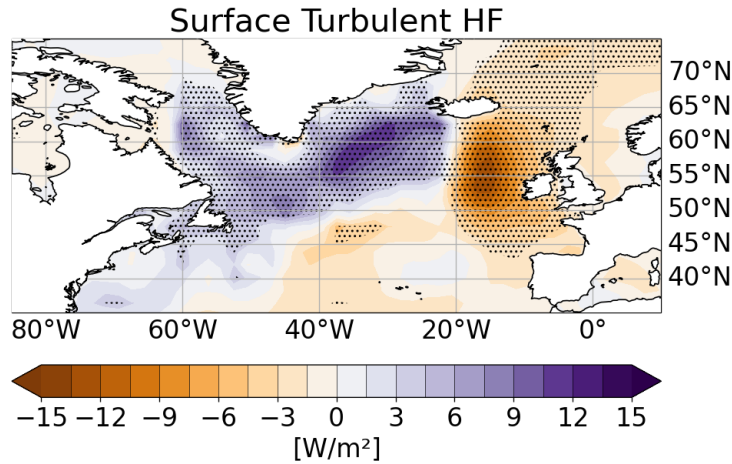
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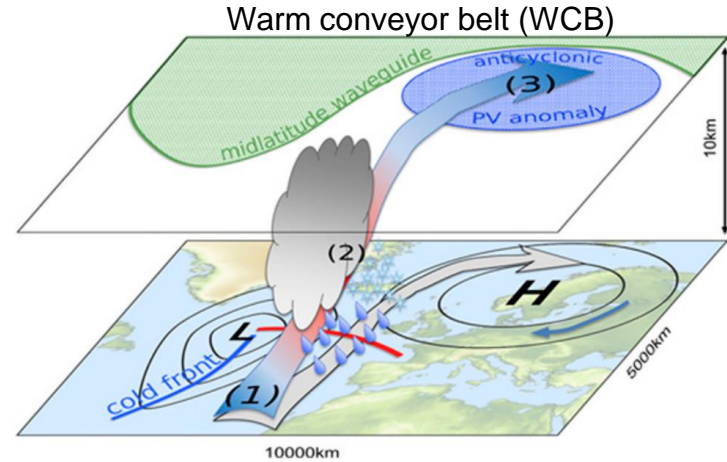
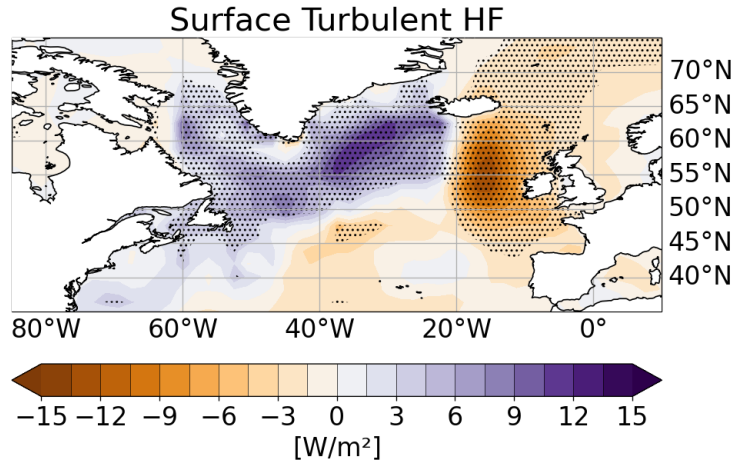
Ocean forcing differences and atmospheric response

JJA GPH difference:
COLD minus NEUTRAL



- Stronger turbulent heat release in eastern NA

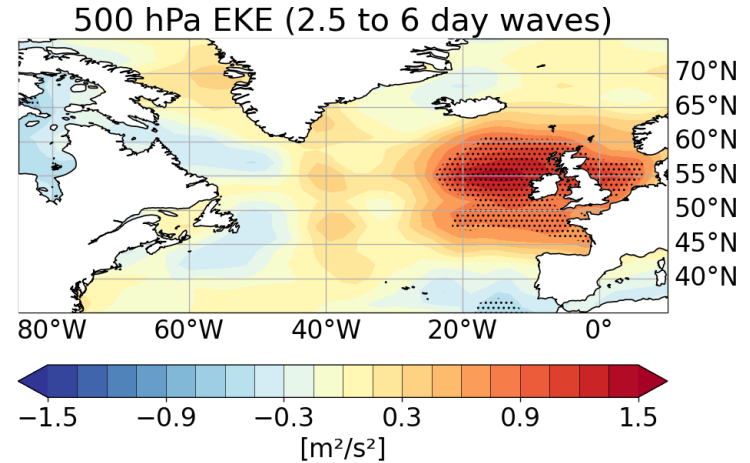
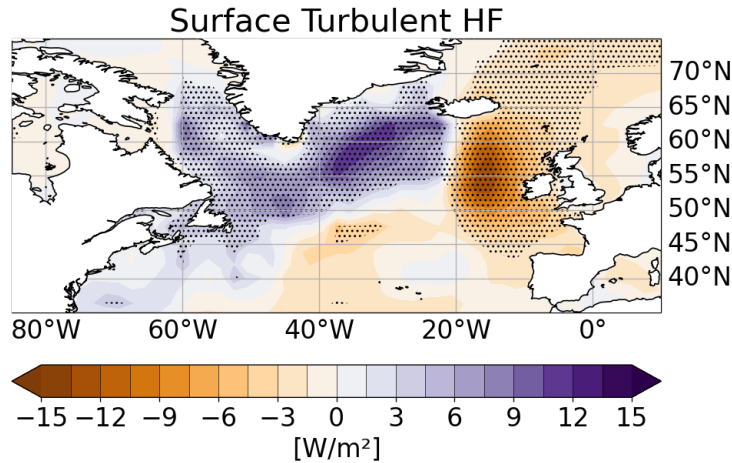
JJA GPH difference:
COLD minus NEUTRAL



Quinting and Grams 2021

- Stronger turbulent heat release in eastern NA
- WCB theory implies anticyclonic growth in the mid-troposphere by latent heat forcing

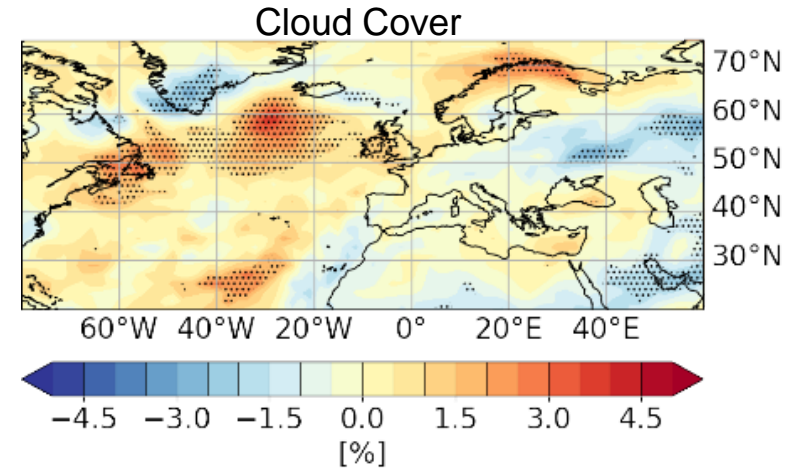
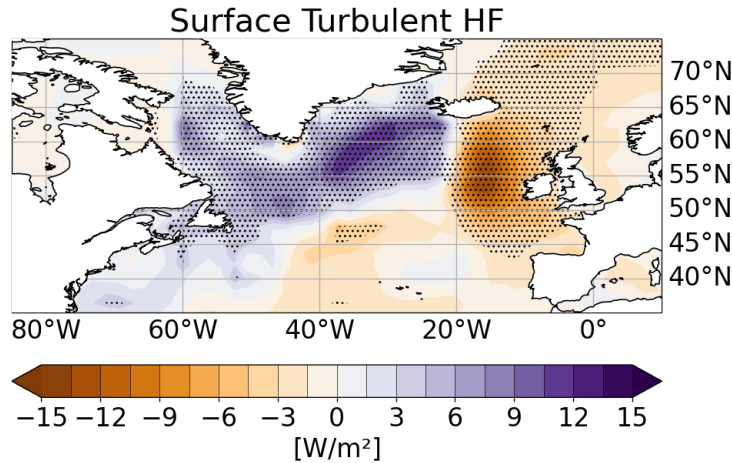
JJA GPH difference:
COLD minus NEUTRAL



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- Mid-troposphere effect is also found in our experiments:
 - synoptic scale EKE at 500 hPa increased directly downstream of the HF anomaly

Ocean forcing differences and atmospheric response

JJA GPH difference:
COLD minus NEUTRAL

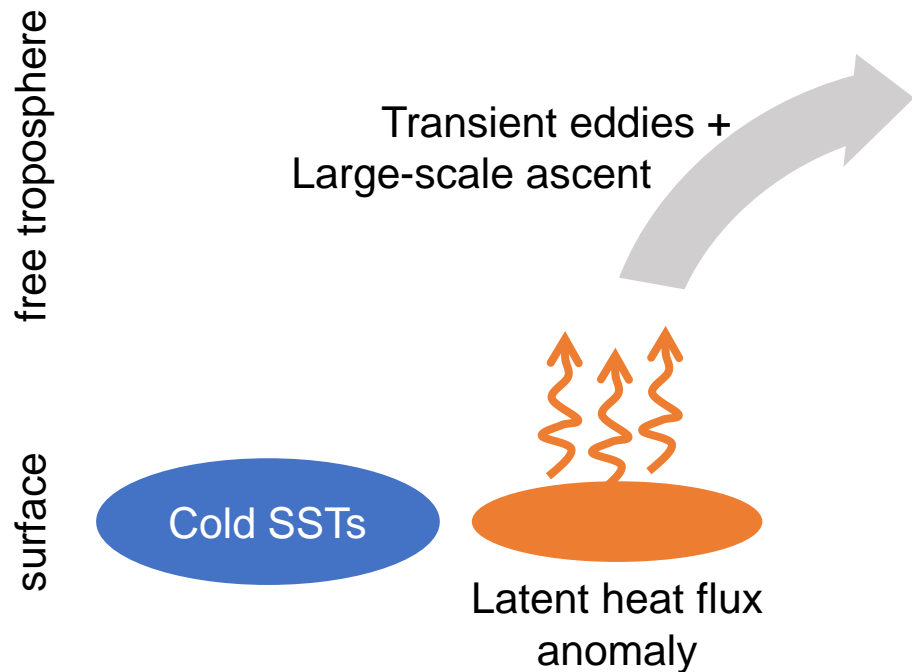


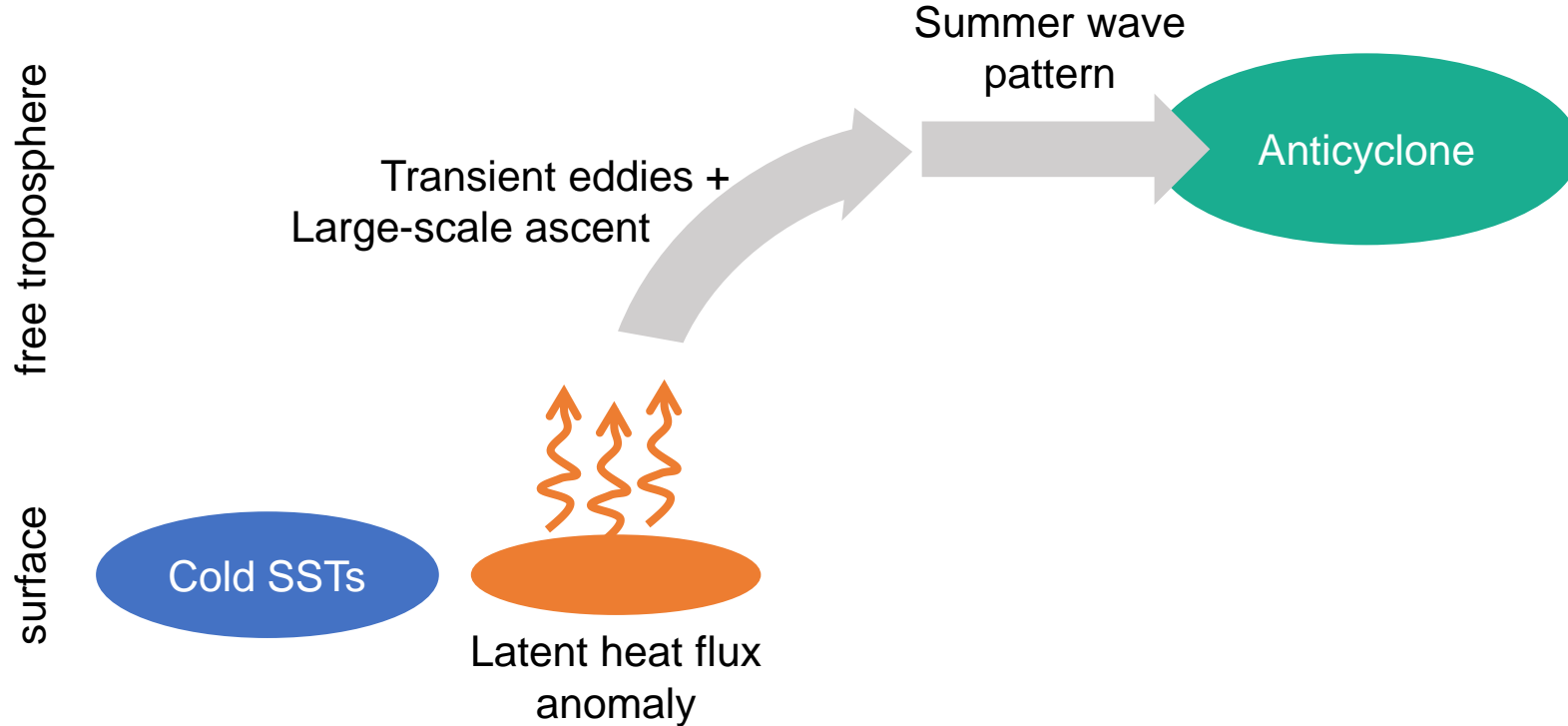
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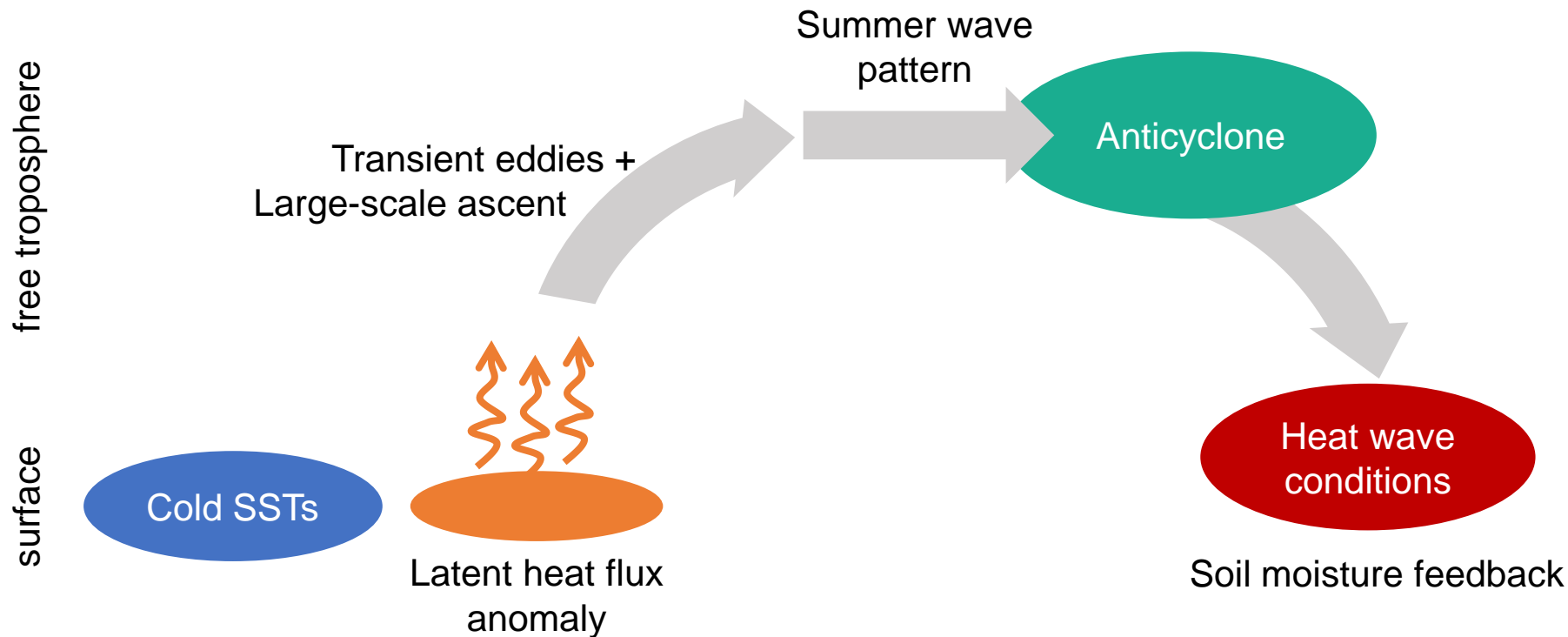
free troposphere

surface

Cold SSTs







Cold NA SST anomalies, such as in 2018, are associated with

- SST anomaly affects mid-tropospheric circulation further downstream (WCB theory)
- High pressure anomaly over the continent
- Higher temperatures in the mean and stronger and longer lasting heat waves (amplified by positive soil moisture feedback)
- **Potential to improve predictability**

What are the implications for coupled climate simulations?

NA SST bias

Warming hole

HELMHOLTZ



Thank you for your attention!

sbischof@geomar.de

Bischof, S., Pilch Kedzierski, R., Hänsch, M., Wahl, S., & Matthes, K. (2023). The role of the North Atlantic for heat wave characteristics in Europe, an ECHAM6 study. *Geophysical Research Letters*, 50, e2023GL105280. <https://doi.org/10.1029/2023GL105280>

