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A glimpse into the future: The 2023 temperature extremes in the North Atlantic in the context of longer-term climate change

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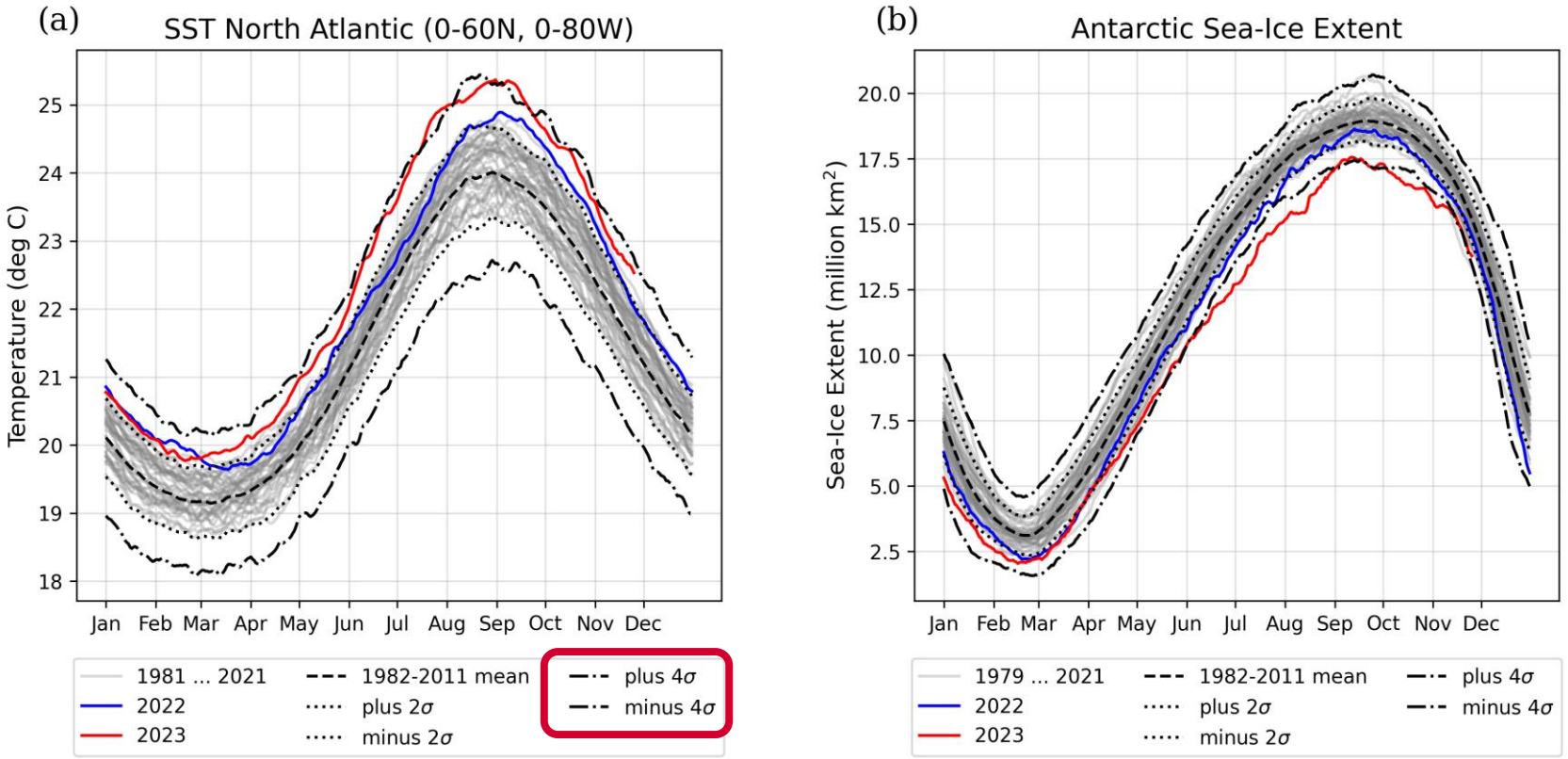
Introduction

First analysis looking into longer-term, large-scale drivers

- Role of the Earth Energy Imbalance
- Trends in the sub-surface ocean
- Current extremes in the context of specific, future global warming levels

Kuhlbrodt et al. (2024), A Glimpse into the Future: The 2023 Ocean Temperature and Sea Ice Extremes in the Context of Longer-Term Climate Change, BAMS 105, 3, **https://doi.org/10.1175/BAMS-D-23-0209.1**



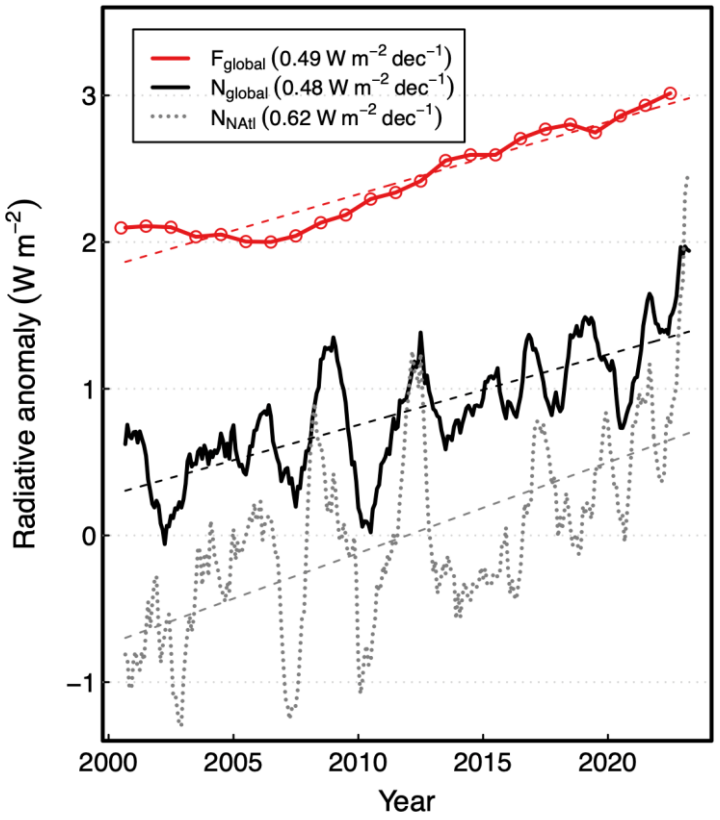
Daily timeseries data of (a) North Atlantic sea surface temperature and (b) Antarctic (Southern Ocean) sea-ice extent. Source: NOAA OI SST V2 and EUMETSAT OSI SAF

Sea surface temperature and sea-ice extent

As of August 2023, the North Atlantic was about 1.4°C warmer than the 1982-2021 average.

Antarctic sea-ice extent was about 2.4 million km^2 smaller than the 1981-2021 average.

The onset in the North Atlantic precedes the ENSO maximum.



CERES-EBAF net radiative imbalance (positive down, 12-month running means), 2001 to September 2023, for the whole Earth (N_global; black, solid) and the North Atlantic (N_NAtl; black, dotted); and annual-mean effective radiative forcing (F_global)

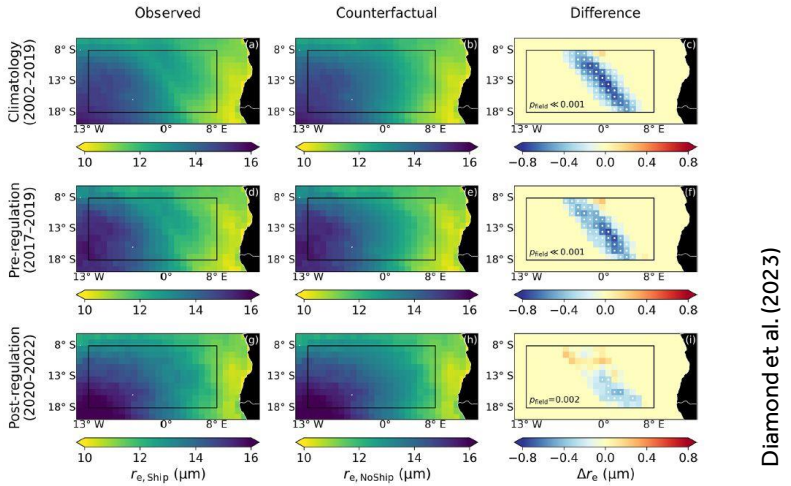


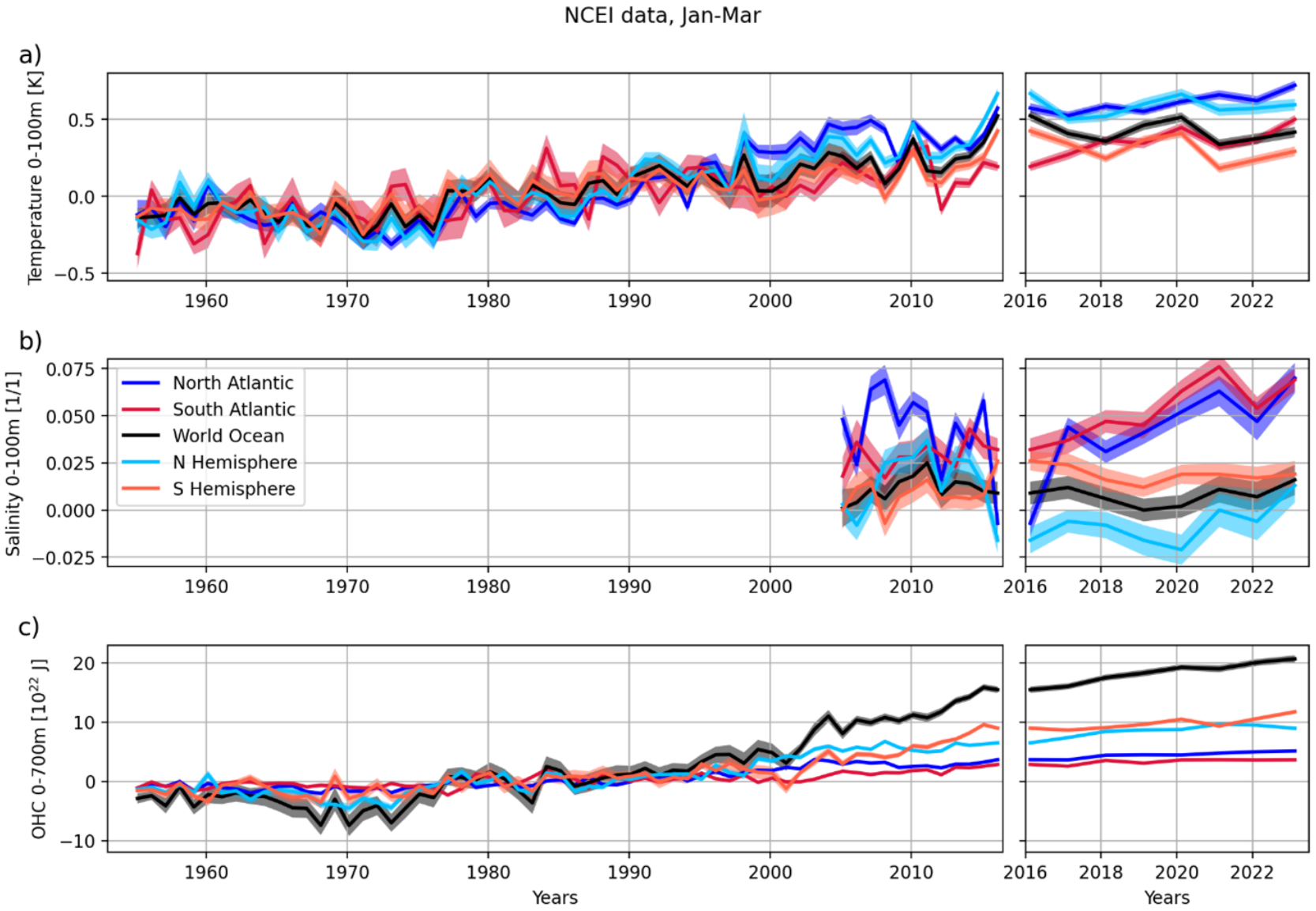
Figure 1. Maps of factual (observed) and counterfactual values and their difference for austral spring cloud-top effective radius for the

Earth's Energy Imbalance Trend

Most recent EEI is +1.9 Wm^{-2}

2006 – 2020 average EEI was +0.76±0.2 Wm^{-2} (von Schuckmann et al., 2023)

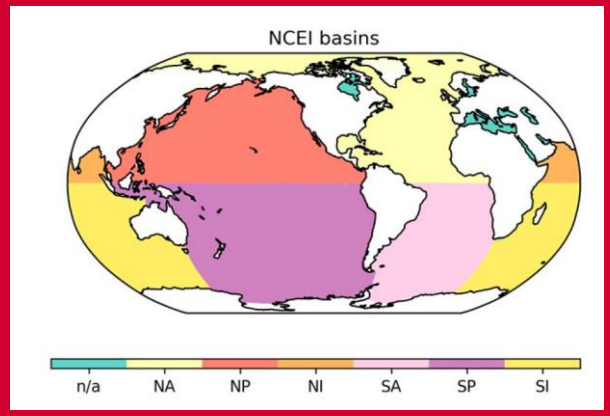
Given the interannual variability of N_Natl, a role for reduced aerosol emissions from ships is unlikely

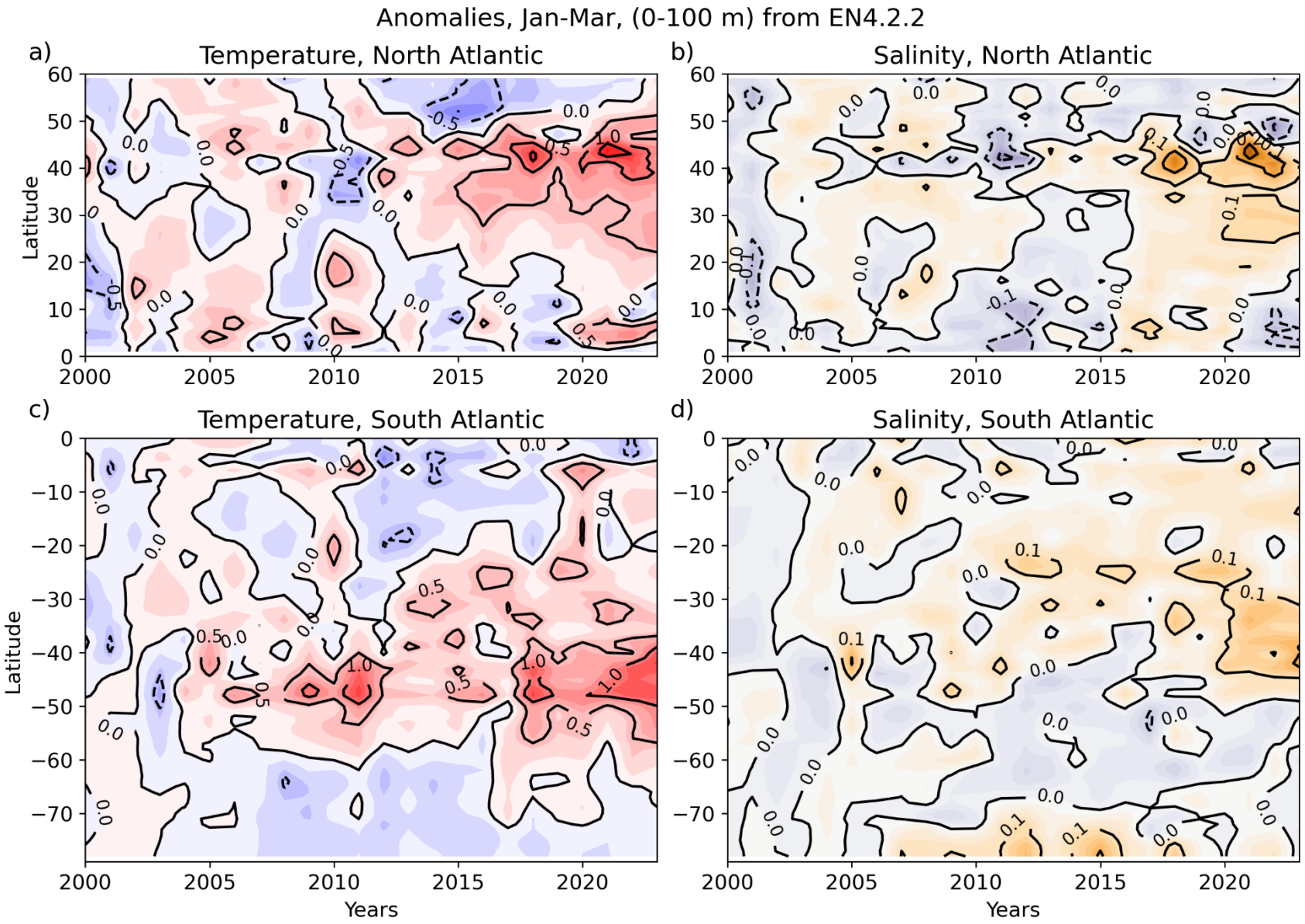


January-March averages. Reference period is 1955-2006.
Shading indicates the observational uncertainty

NCEI data: 0 – 100m

- Since 2016, stronger upward trends in the Atlantic basins
- OHC in 0 – 700 m does not show the specific Atlantic signal

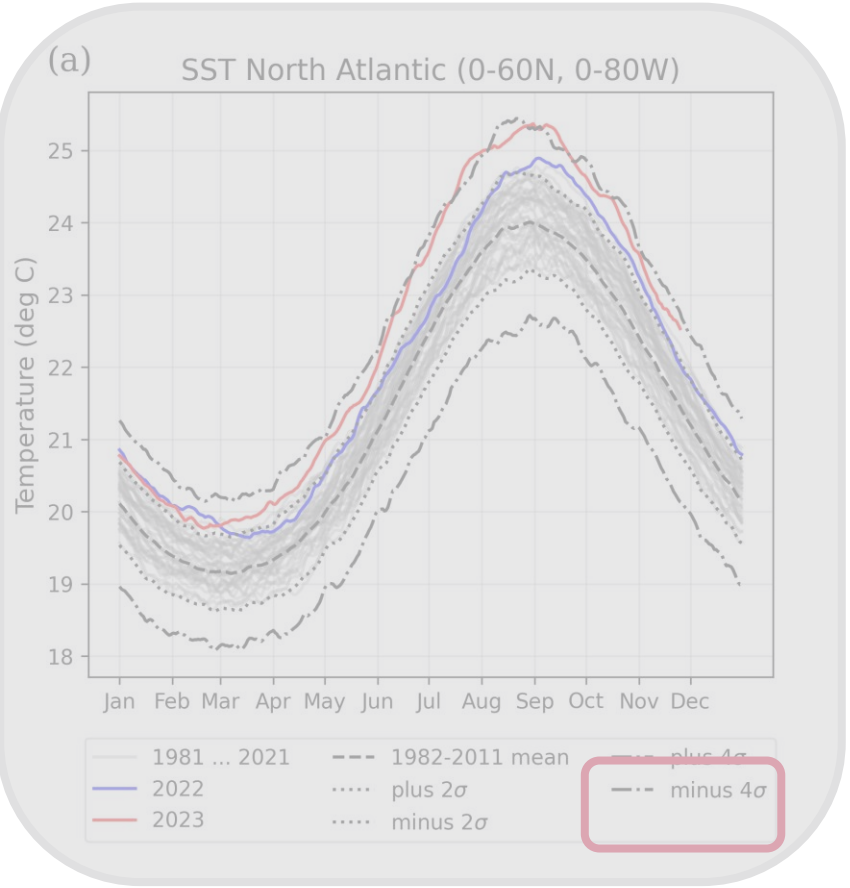


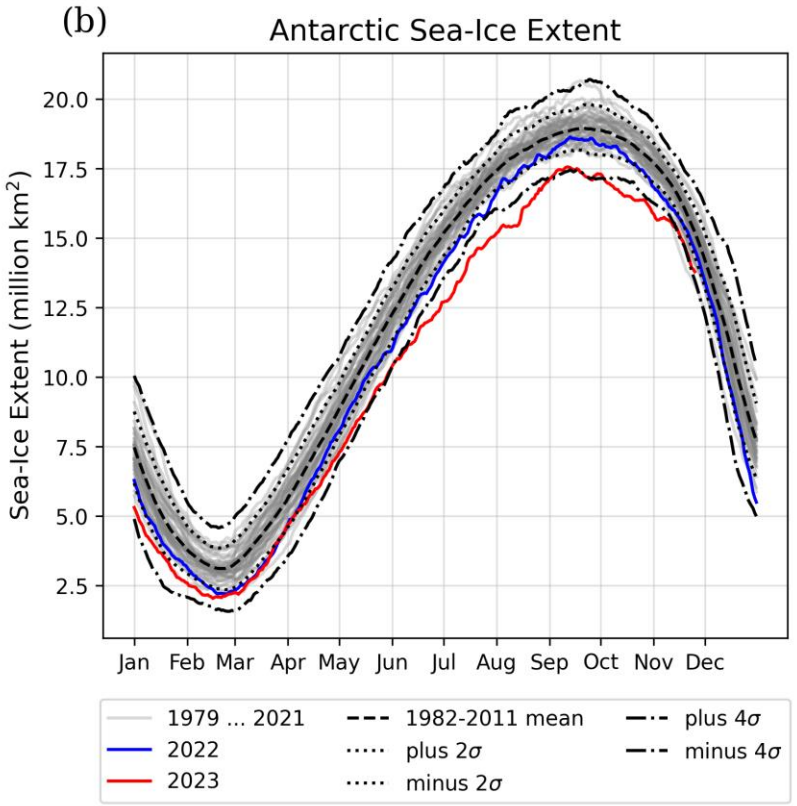


Hovmöller plot of temperature (°C) and salinity (dimensionless) anomalies in the two Atlantic basins, from EN4.2.2

Atlantic Basin, 0-100 m, Jan-Mar

- Warm extremes are centered in the mid-latitudes
- Warm anomalies in the North Atlantic appear to be density compensated
- Not so in the South Atlantic: different processes





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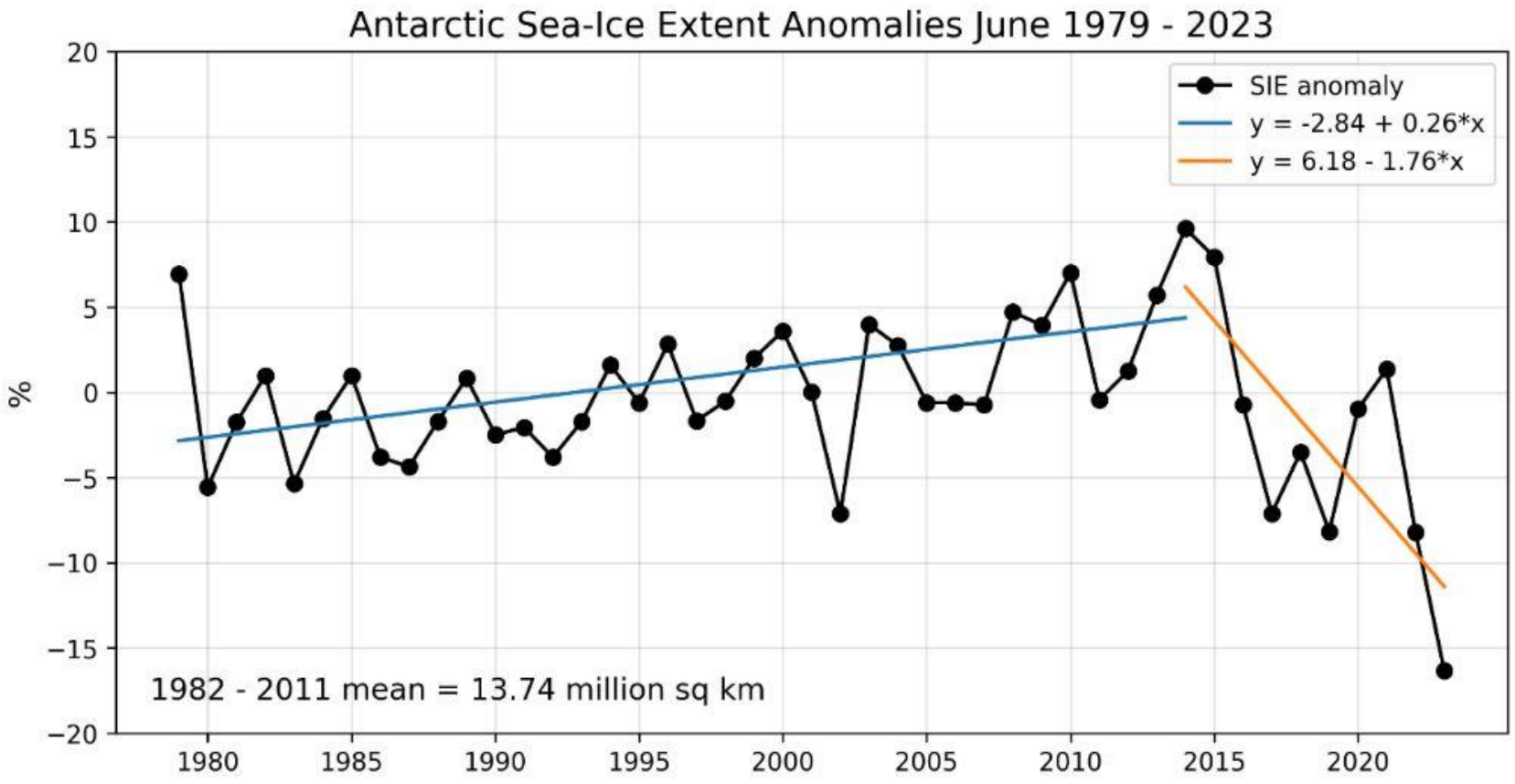
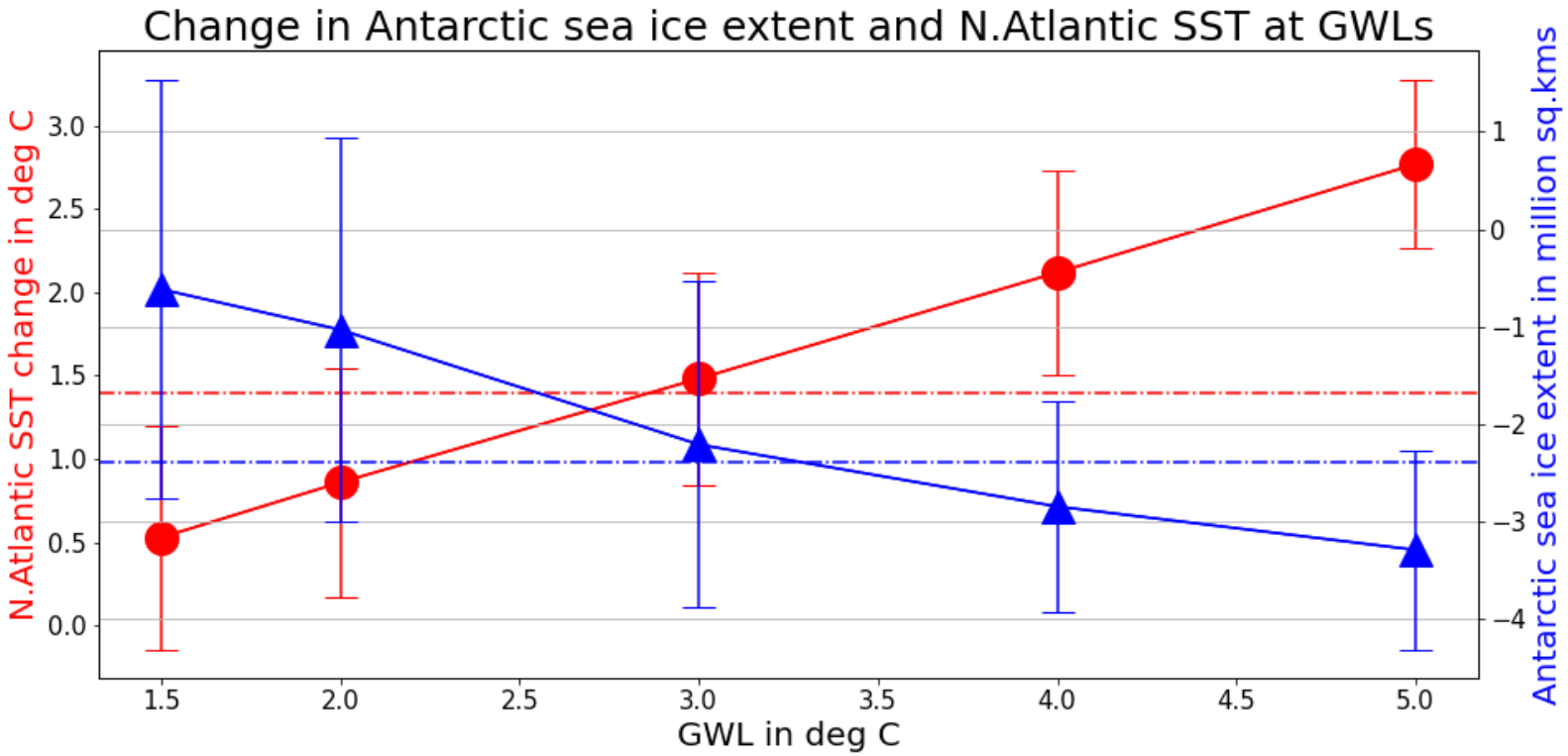


Antarctic sea-ice extent anomalies

in June for the period 1979 – 2023 against a baseline mean 1982 – 2011.

Source: EUMETSAT OSI SAF

Trend change around 2015 (Purich and Doddridge, 2023)



Changes in JJA North Atlantic SST (°C) in red circles (LHS)
Changes in JJA Antarctic sea-ice extent (10^6 km^2) in blue triangles
Vertical bars indicate spread as one standard deviation

Global Warming Levels

The SST and sea-ice extent extremes of JJA 2023 *(one year)* give a glimpse of the projected *average* conditions (CMIP6 models) at a 3°C GWL.

2023 extremes are within the 1.5°C GWL 1σ spread for sea-ice, but not for SST

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Conclusions

The ongoing North Atlantic SST extremes are likely to have multiple drivers:

- Earth's Energy Imbalance
- Regional atmospheric forcing (Azores high)
- AMV/ NAO?
- ENSO?
- […]

Here we highlight:

- The role of the strong decadal trend in EEI
- Multiannual trends in the upper Atlantic contributing to the extremes, and possibly hinting at circulation changes
- The 2023 extremes are an illustration of the average climate at 3°C global warming