ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

ArctiC Amplification:
Climate Relevant Atmospheric and SurfaCe Processes and Feedback Mechanisms (AC)³

UNIVERSITÄT LEIPZIG

Supplementary material:
Fram Strait Marine Cold Air Outbreaks and associated surface heat fluxes in the ERA5 & CARRA reanalyses

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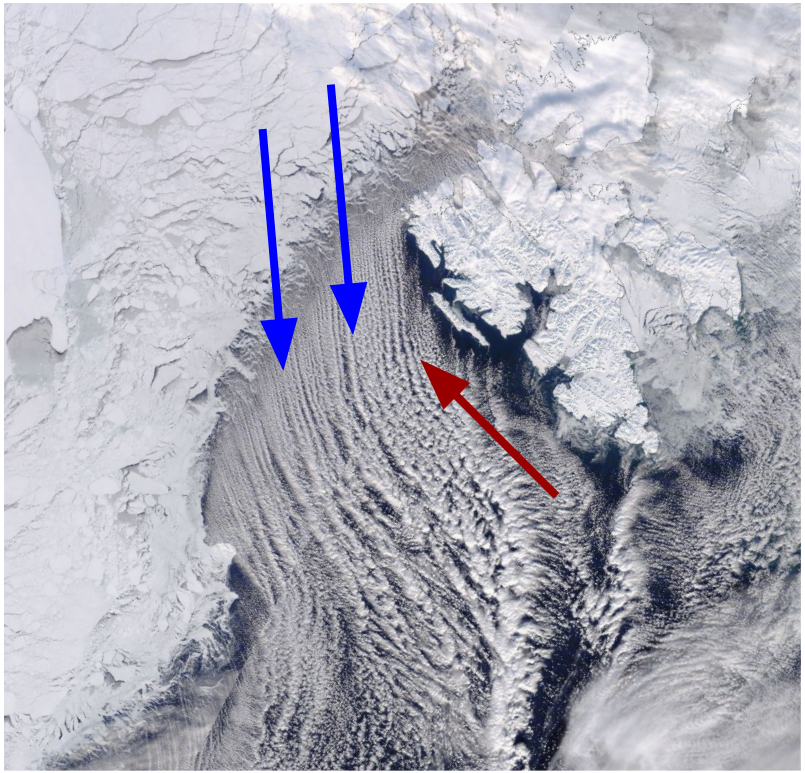
← Abstract

Fram Strait Marine Cold Air Outbreaks (MCAOs)

- Cold air masses advected over ice edge
- Results in large turbulent heat fluxes from the ocean to the atmosphere in winter



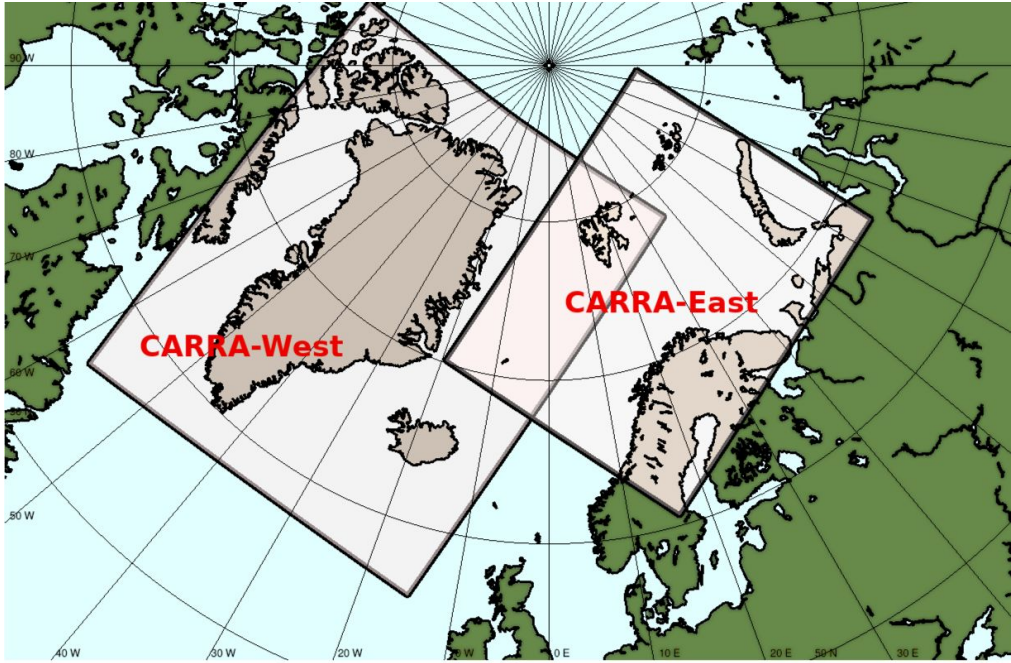
MCAO on 25th March 2022. Image from the NASA Worldview application (https://worldview.earthdata.nasa.gov), part of the NASA Earth Observing System Data and Information System (EOSDIS).

Glossary

MCAO	marine cold air outbreak
SIC	sea ice concentration
SLHF	surface latent heat flux
SSHF	surface sensible heat flux
(Turbulent) heat fluxes	SSHF and SLHF
WS10	wind speed at 10 m height

CARRA

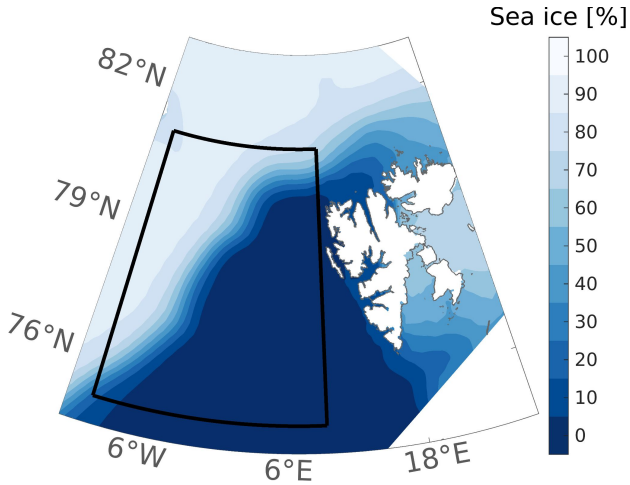
- Copernicus Arctic Regional Reanalysis
- Boundary conditions from ERA5
- Based on the HARMONIE-AROME weather prediction system
- 2.5 km horizontal resolution

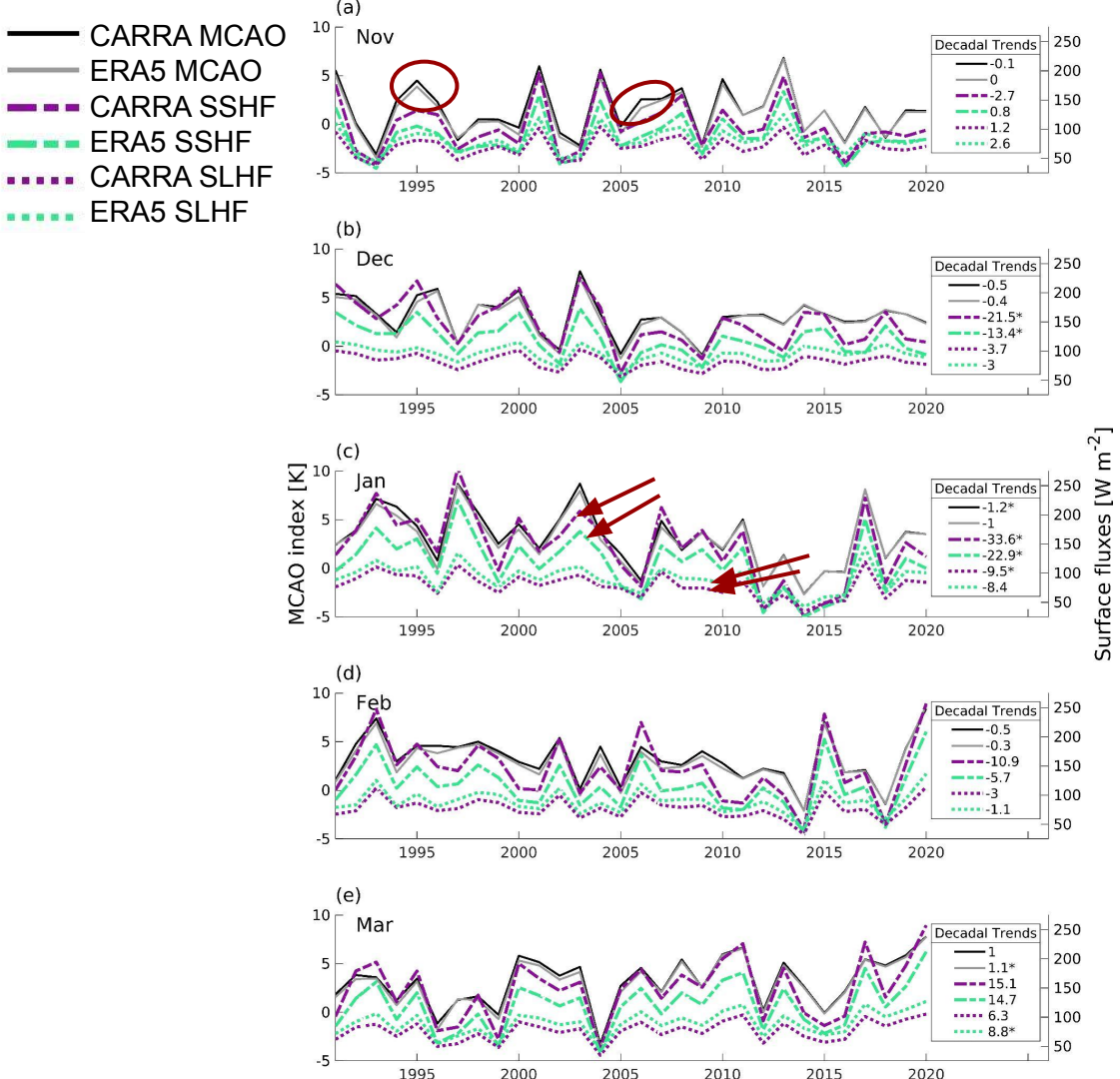


PROGRAMME OF THE EUROPEAN UNION
Copernicus Europe's eyes on Earth
IMPLEMENTED BY ECMWF
Climate Change Service climate.copernicus.eu

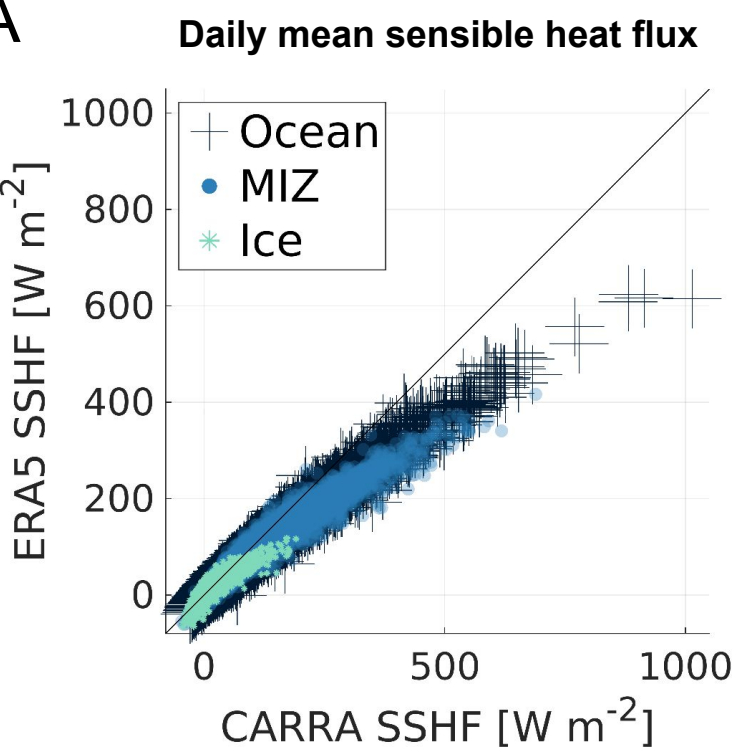
The two CARRA domains. Image from Copernicus (https://climate.copernicus.eu/copernicus-arctic-regional-reanalysis-service)

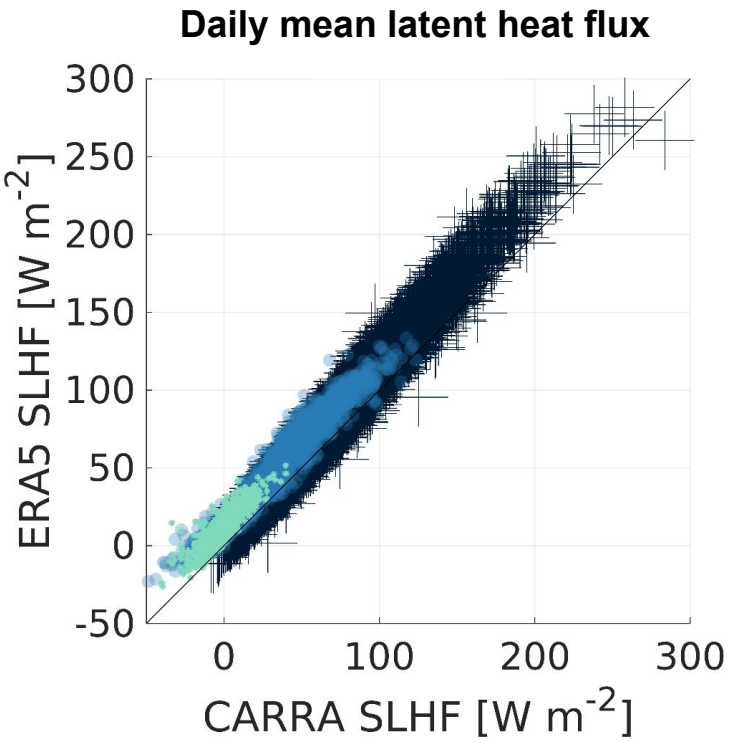
- **MCAO index** based on difference between potential temperature at surface and at 850 hPa (MCAO index = $\theta_{skin} - \theta_{850}$) and averaged across the ice-free fraction of Fram Strait (black box below)
- Period: Nov-Mar 1991-2020
- Fluxes: Positive upwards, i.e. positive numbers denote a flux from the surface to the atmosphere





Fluxes: CARRA vs ERA5

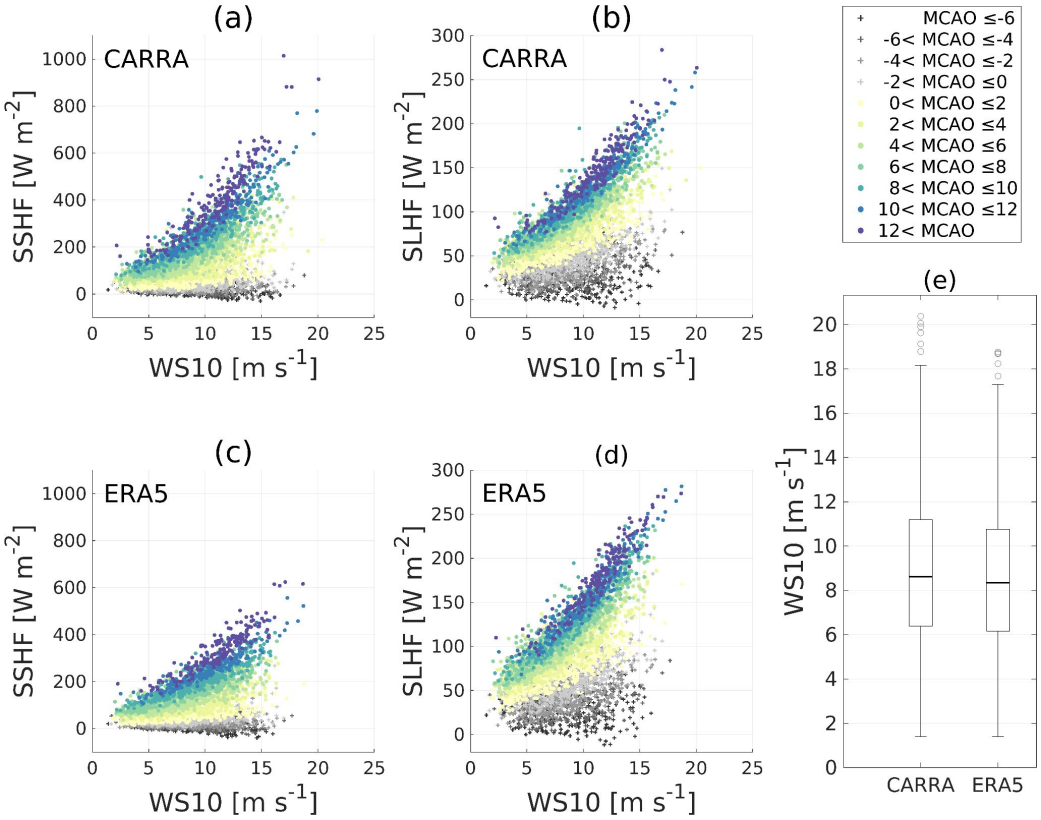




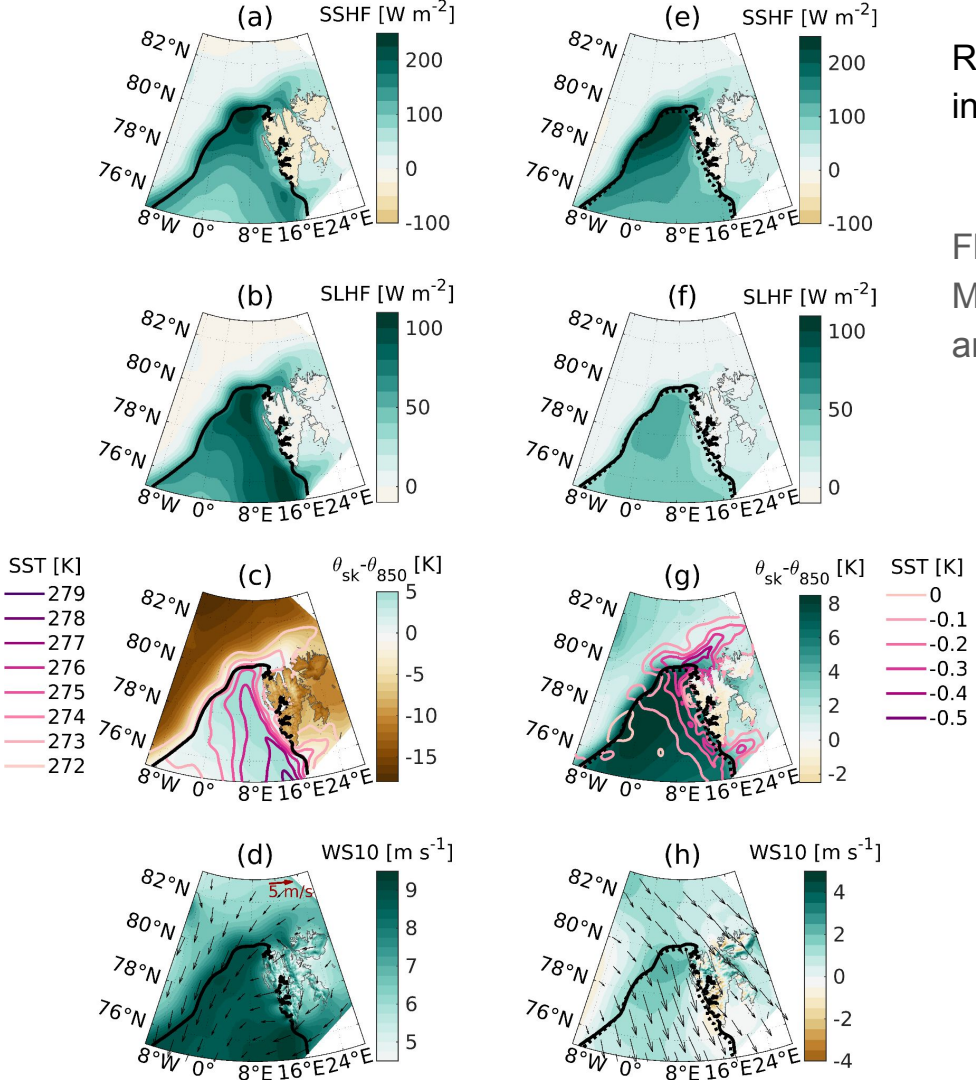
- SSHF differences scale with SSHF magnitude: largest difference over ocean
- Normalized differences largest over ice, and larger for SLHF than SSHF
- Renfrew et al. 2021 (https://doi.org/10.1002/qj.3941): ERA5 overestimates SLHF

MCAO & wind speed vs fluxes

- Wind speed strongly related to fluxes when MCAO index is high
- Higher CARRA SSHF
  - MCAO index higher
  - Max wind speed higher
  - Normalized regression coefficients stronger for CARRA SSHF
- Higher ERA5 SLHF
  - Normalized regression coefficients stronger for ERA5 SLHF



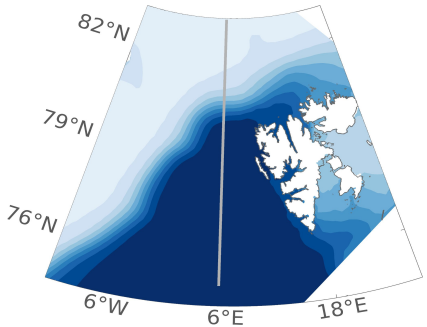
Left: Extended winter mean conditions



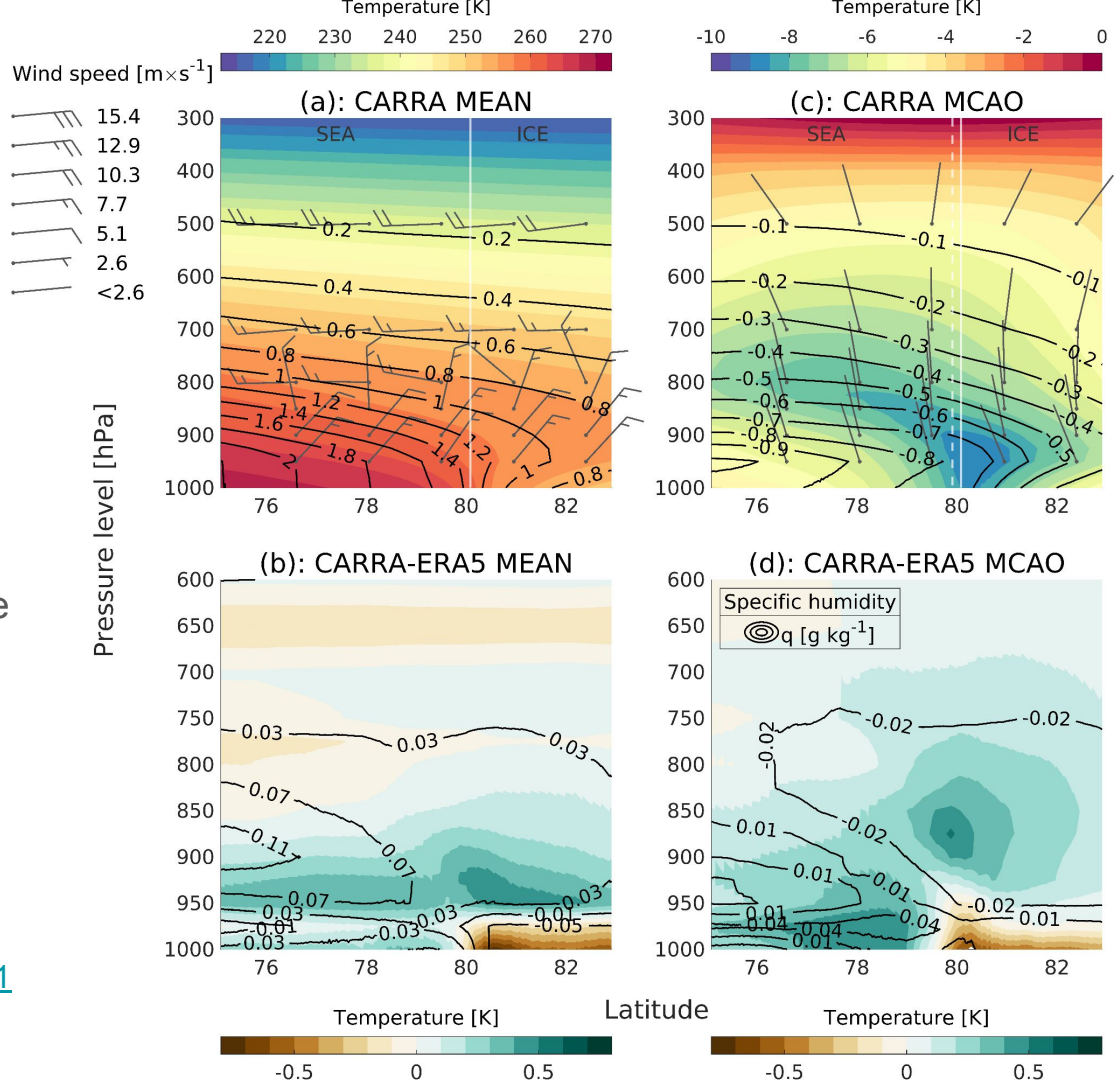
Right: Anomalies (MCAO index>8K - mean)

Flux anomalies co-located with MCAO and wind speed anomalies

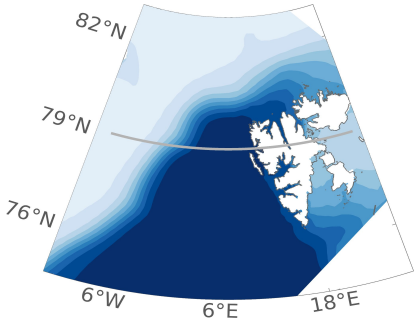
Temperature, winds & humidity at 6°E



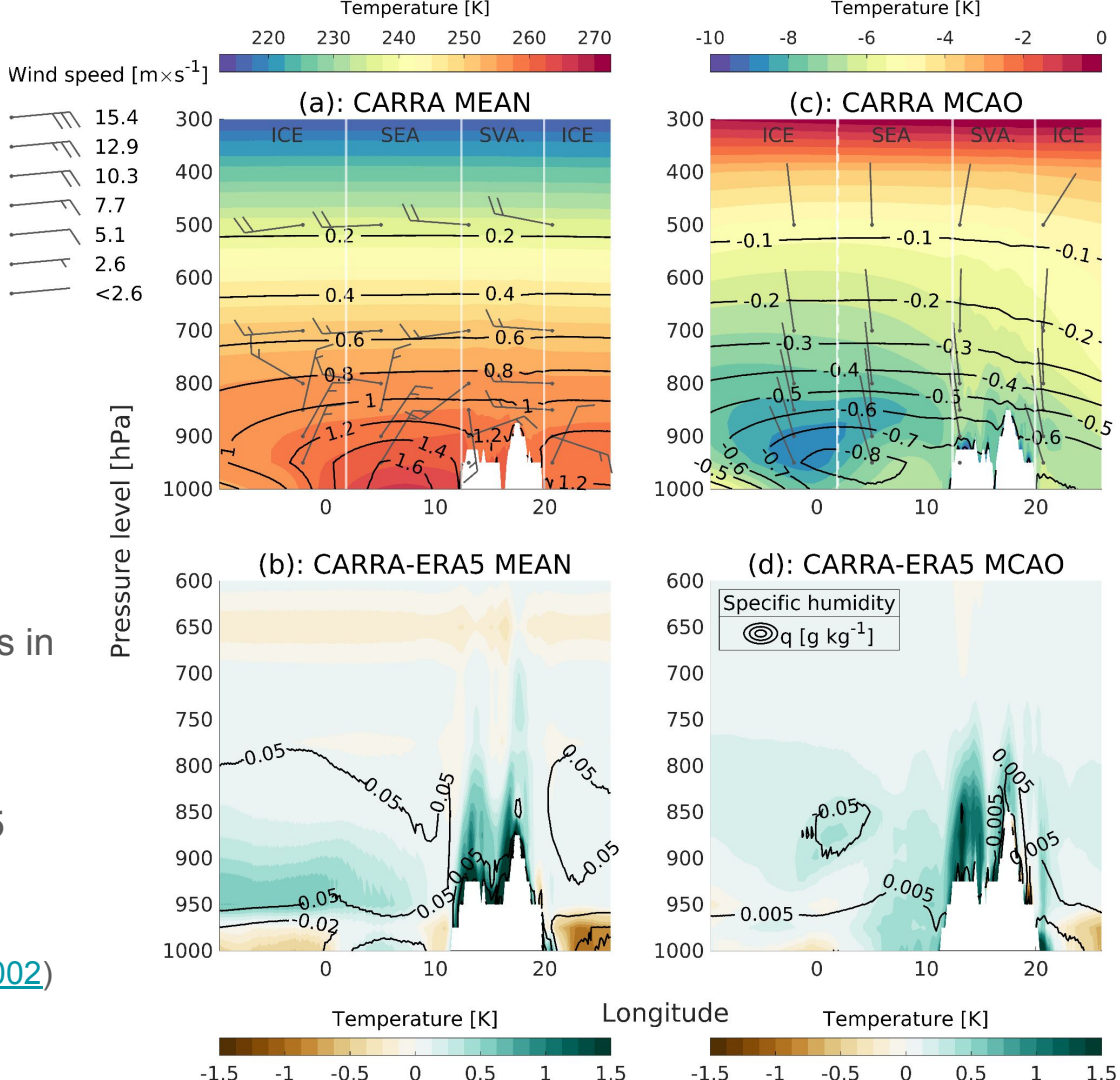
- Cold + dry MCAO anomalies from surface to tropopause
- Humidity anomaly largest in the south, temperature anomaly largest in MIZ
- ERA5: Higher temperature and humidity than CARRA over sea ice
  - ERA5 overestimates sea ice temperature (Batrak & Müller, 2019, https://doi.org/10.1038%2Fs41467-019-11975-3)



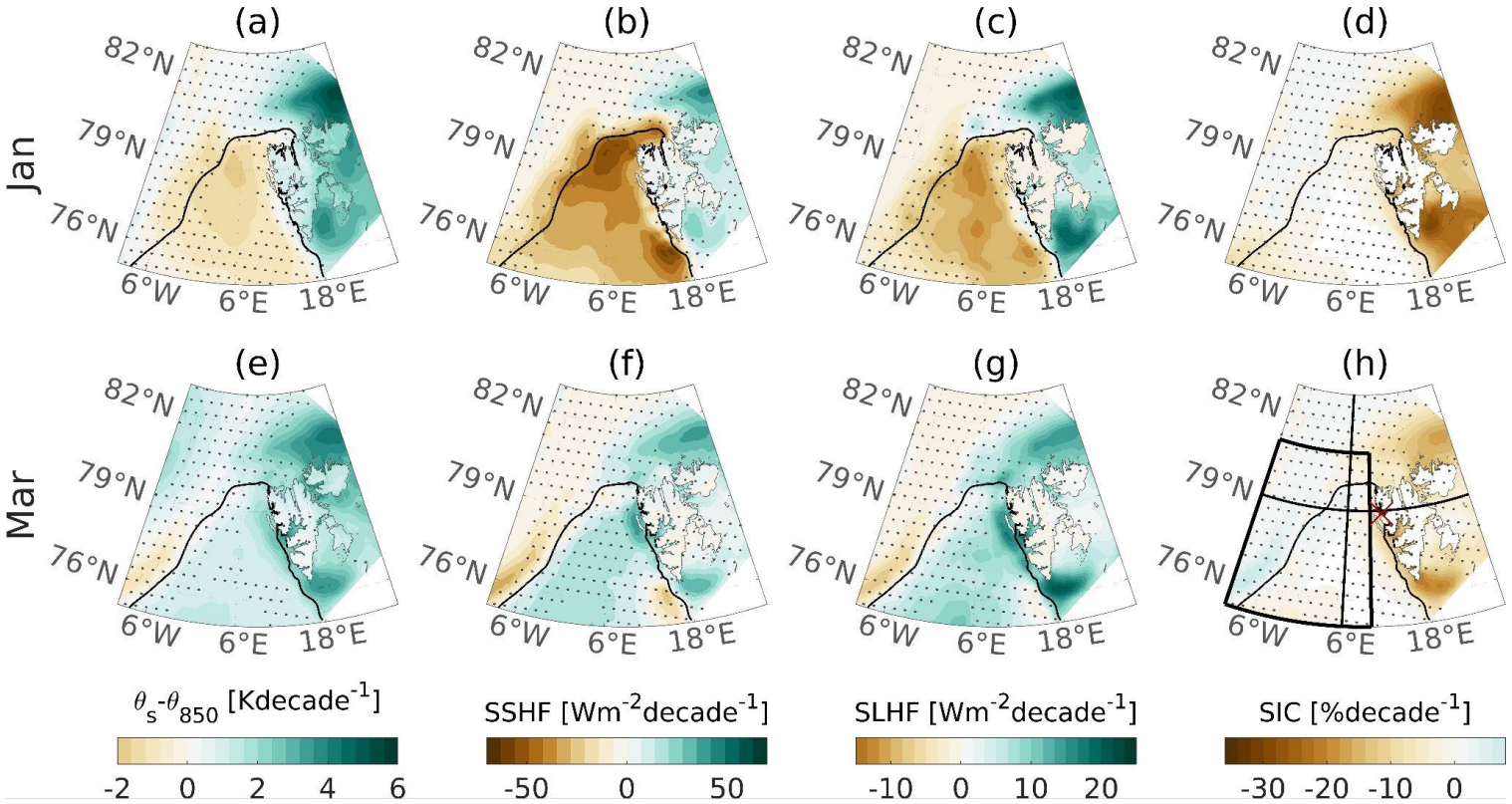
Temperature, winds & humidity at 79 °N



- Svalbard: strongest MCAO anomalies in temperature
- Svalbard: CARRA has higher temperature and humidity than ERA5
  - ERA5 underestimates 2 m temp on Svalbard (Køltzow et al., 2022, https://doi.org/10.33265/polar.v41.8002)



January and March 1991-2020 trends in CARRA

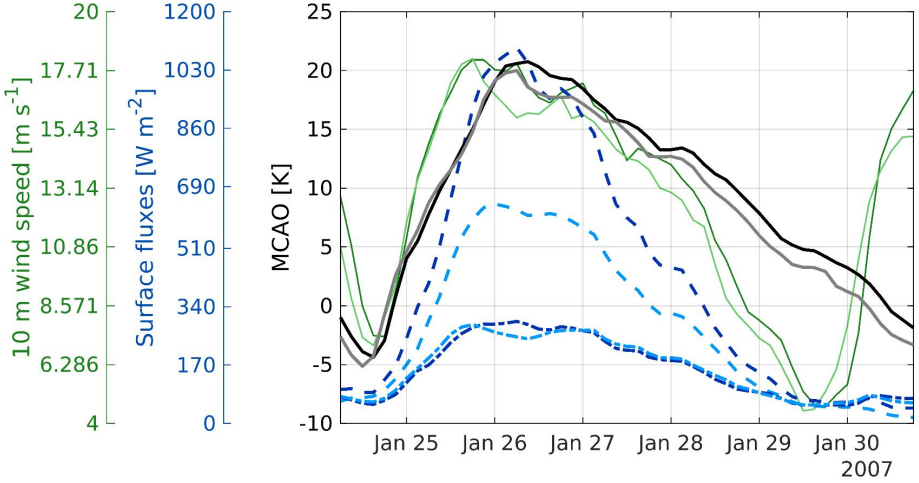


January vs March: Opposing θ-difference and heat flux trends in Fram Strait. See also Dahlke et al., 2022 (https://doi.org/10.1029/2021JD035741)

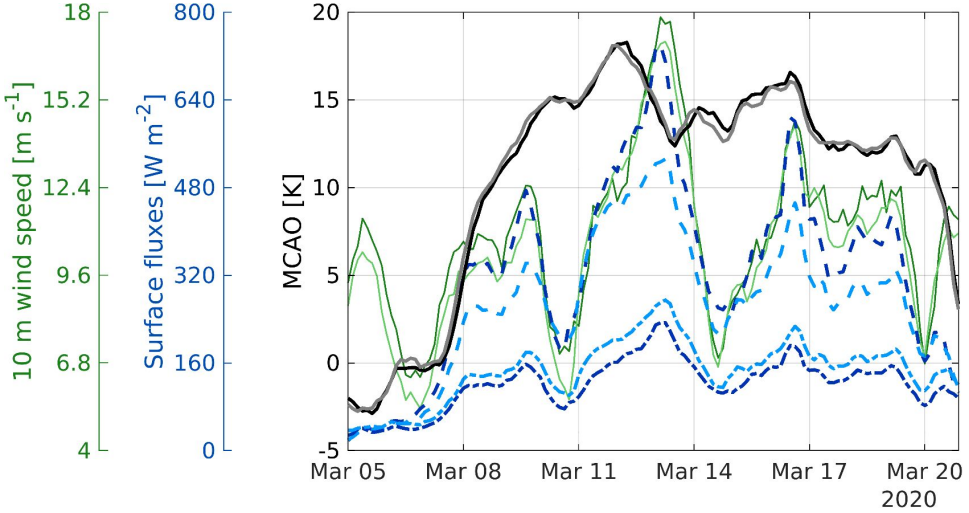
Dotting: Trend NOT significant at the 95% level

Ny-Ålesund marked by ×

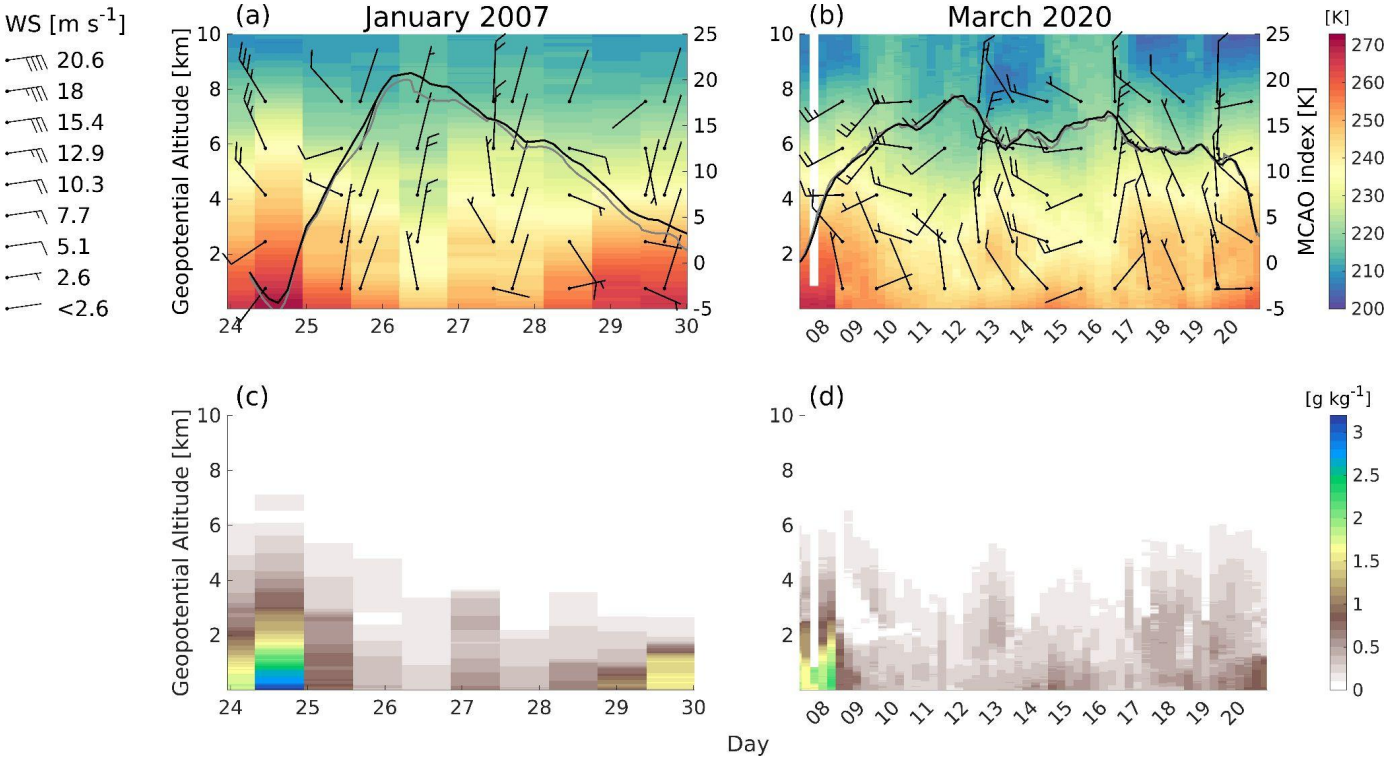
MCAO case studies: January 2007 and March 2020



Data averaged over
ice free Fram Strait



The MCAO cases in Ny-Ålesund, Svalbard (78.92° N, 11.91° E)



>20 K drop in near surface temperatures from onset to peak

Temperature and specific humidity from radiosondes launched at the AWIPEV station in Ny-Ålesund (Maturilli 2008, https://doi.org/10.1594/PANGAEA.695515 and Maturilli 2020, https://doi.org/10.1594/PANGAEA.914973)

Questions?

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