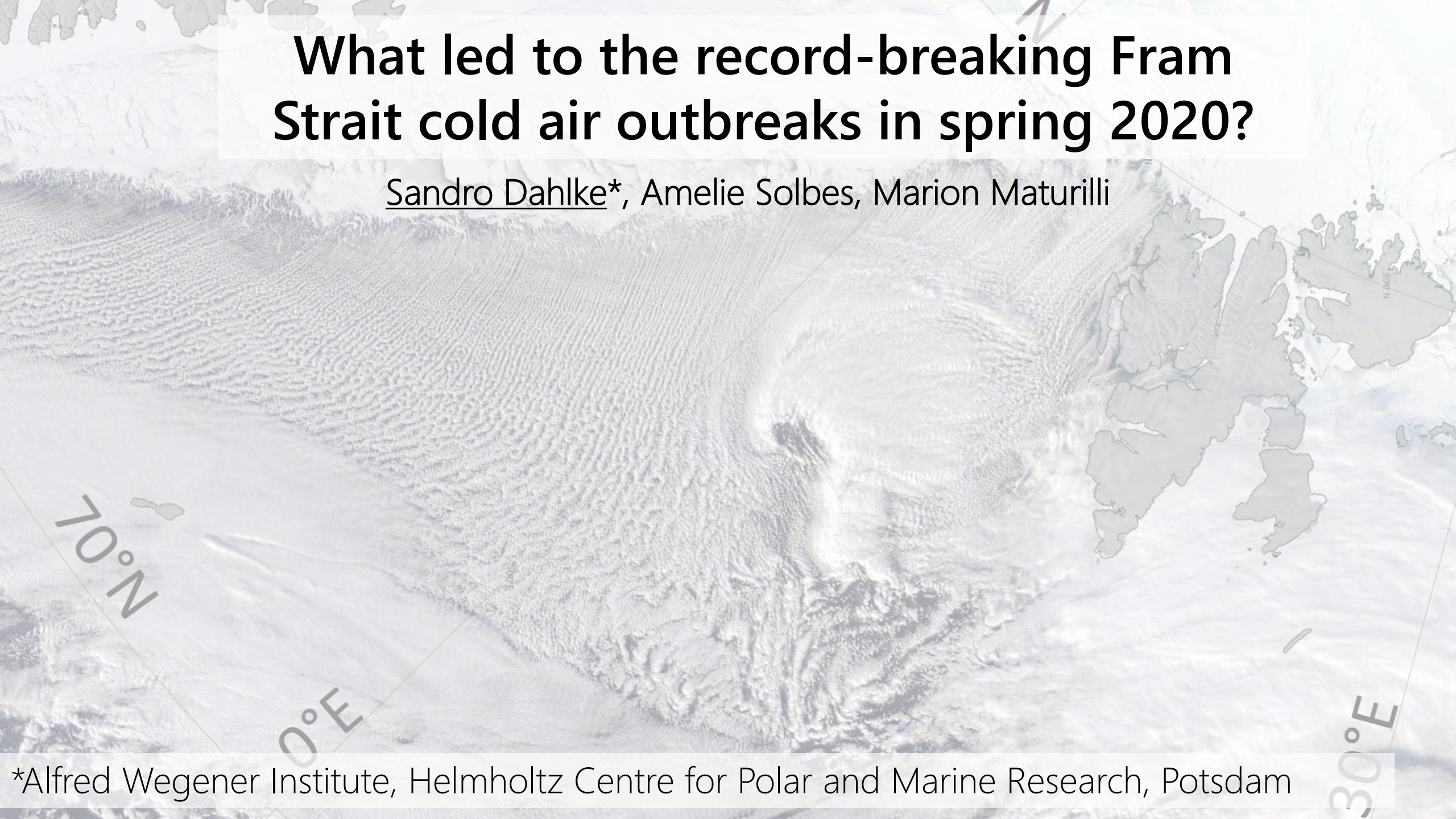
What led to the record-breaking Fram Strait cold air outbreaks in spring 2020?

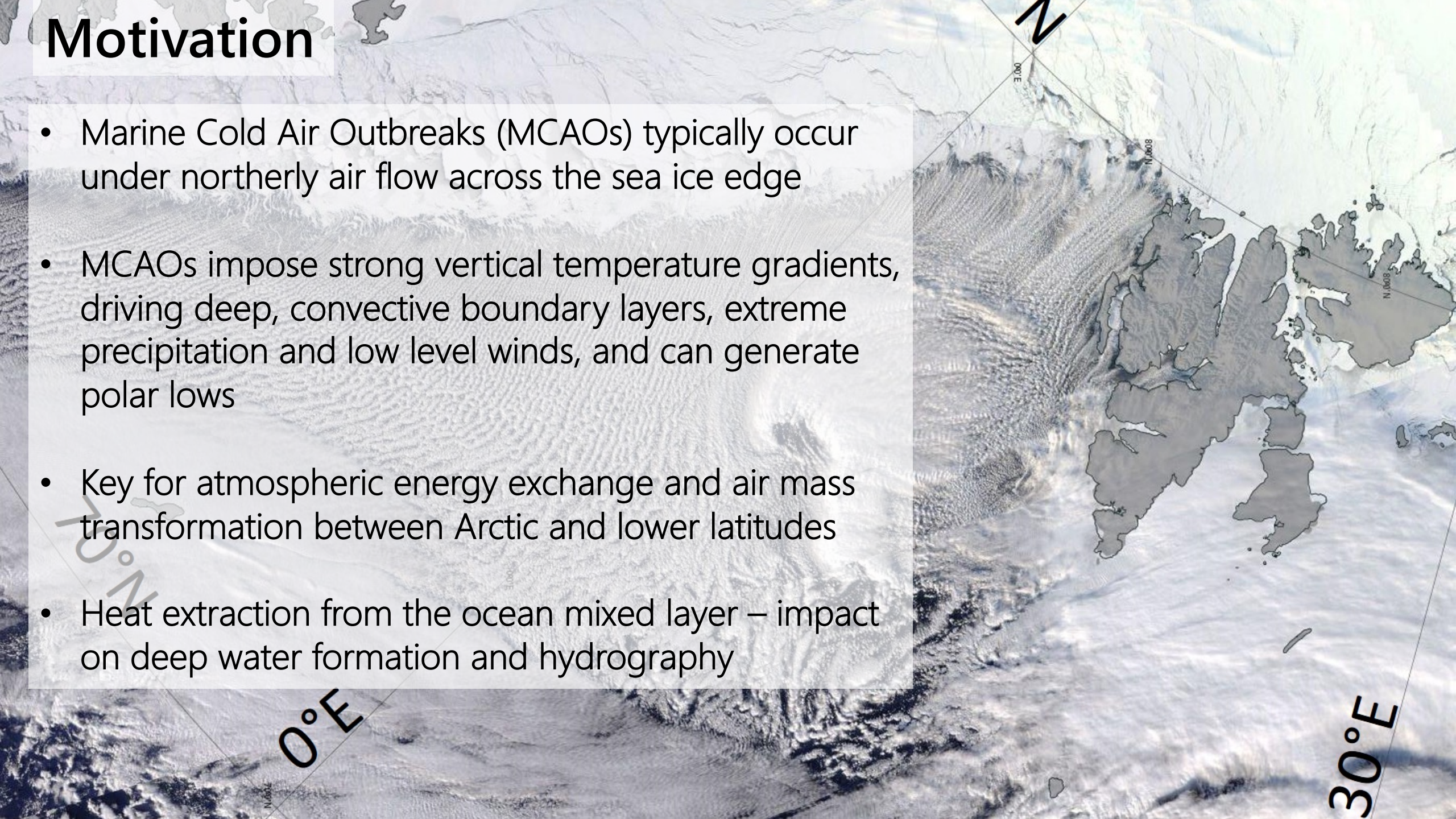
Sandro Dahlke*, Amelie Solbes, Marion Maturilli



*Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Potsdam

Motivation

- Marine Cold Air Outbreaks (MCAOs) typically occur under northerly air flow across the sea ice edge
- MCAOs impose strong vertical temperature gradients, driving deep, convective boundary layers, extreme precipitation and low level winds, and can generate polar lows
- Key for atmospheric energy exchange and air mass transformation between Arctic and lower latitudes
- Heat extraction from the ocean mixed layer – impact on deep water formation and hydrography

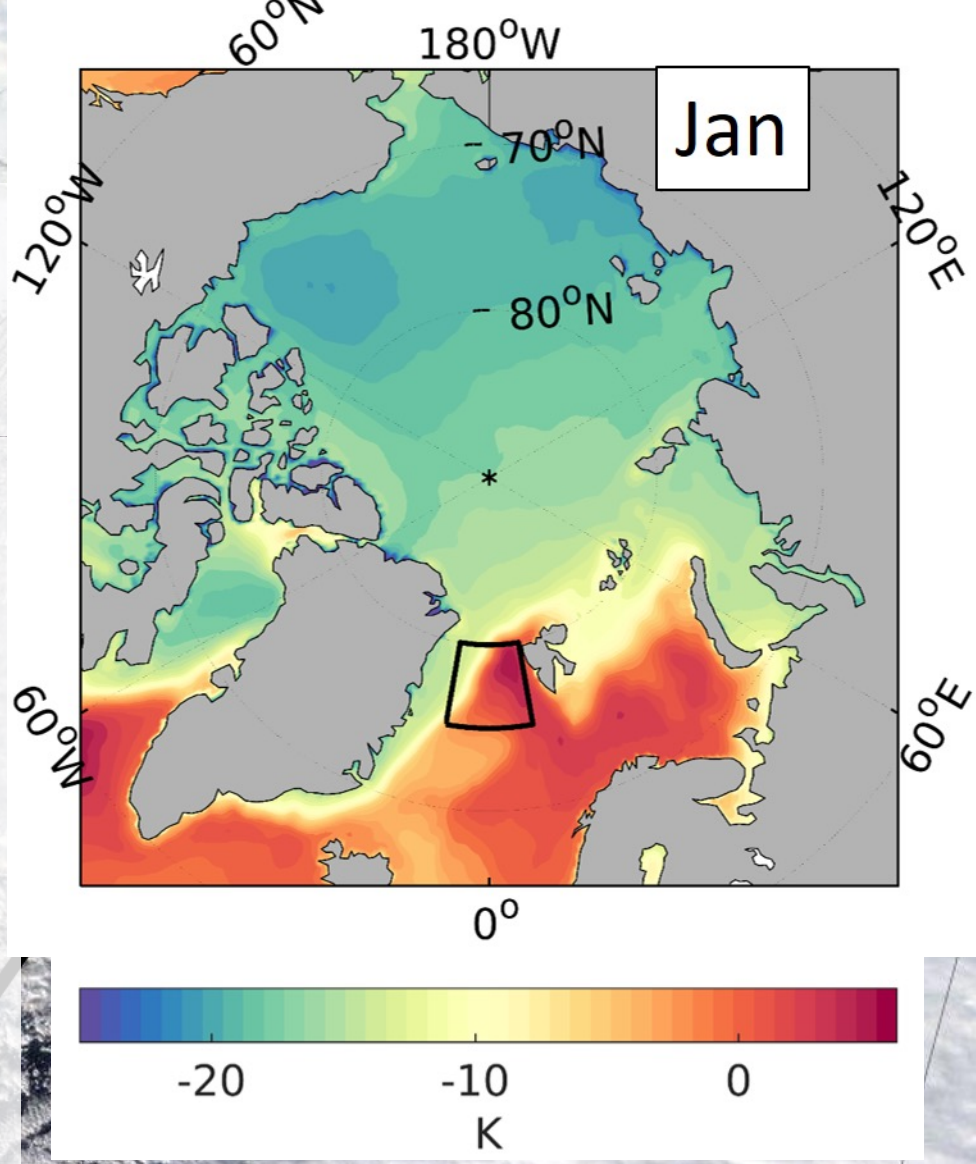


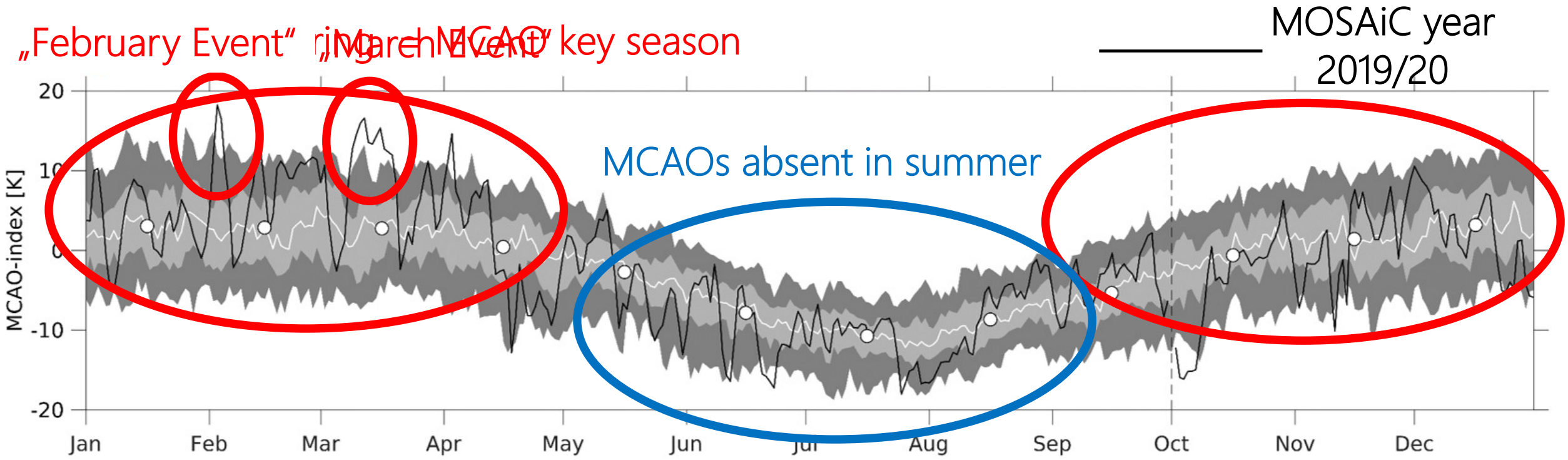
Method

- MCAO index *M* = daily difference $\theta_{SKT} - \theta_{850hPa}$ area averaged over ice free portion of Fram Strait Box, ERA5, 1979-2020

- MCAO events = starts, as soon as *M* turnes positive and ends when *M* turnes negative afterwards, but event needs to last for at least 2 days

- Occurrence frequencies of MCAOs of different strengths are considered:
  M < 4 K … „weak“
  4 K < *M* < 8 K … „moderate“
  8 K < *M* < 12 K … „strong“
  12 K < *M* … „very strong“



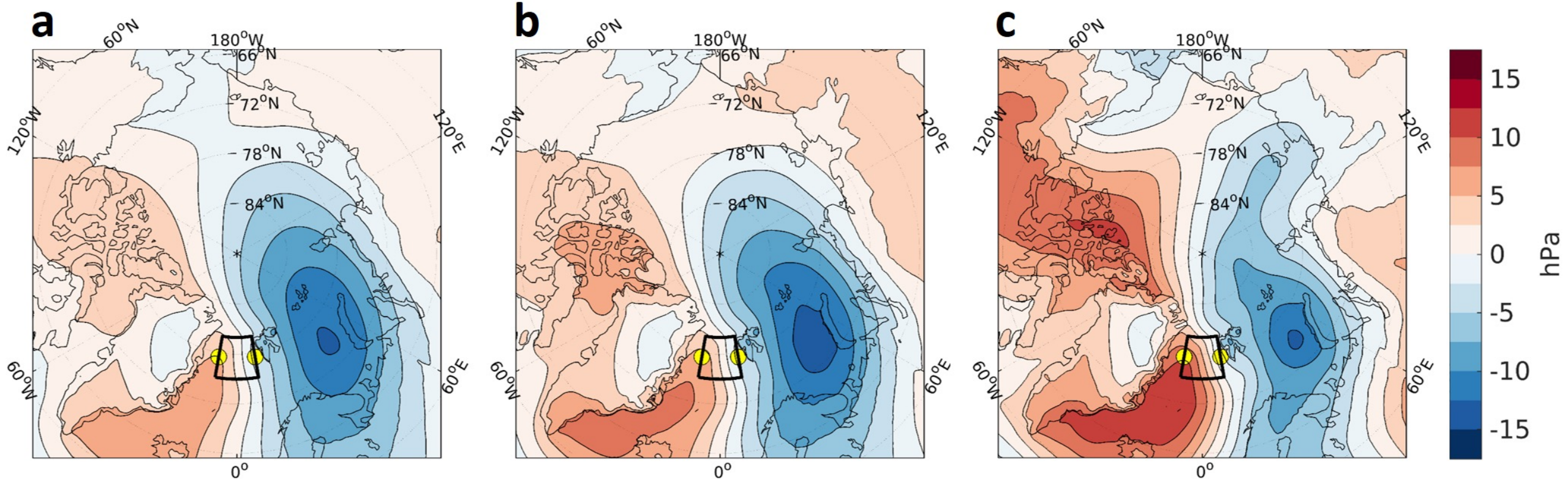


„Strong“ MCAOs	Mean occurence	95th percentile	2020
February	14.5%	26.5%	48.3%

„Very Strong“ MCAOs	Mean occurence	95th percentile	2020
March	3.6%	15.5%	32.2%

Dahlke et al., 2022, JGRA

MSLP composite anomaly for the strongest MCAOs



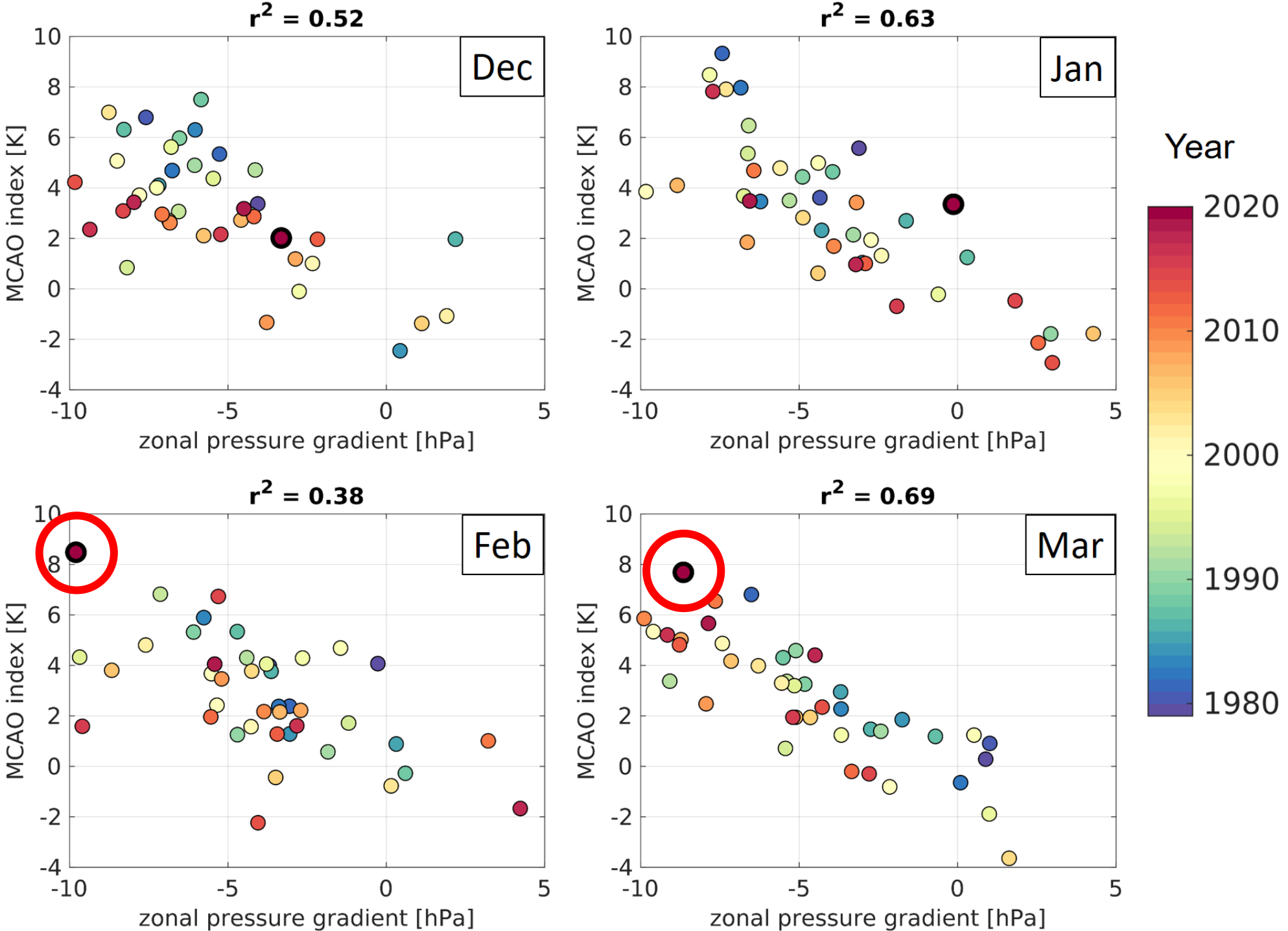
90th percentile

95th percentile

99th percentile

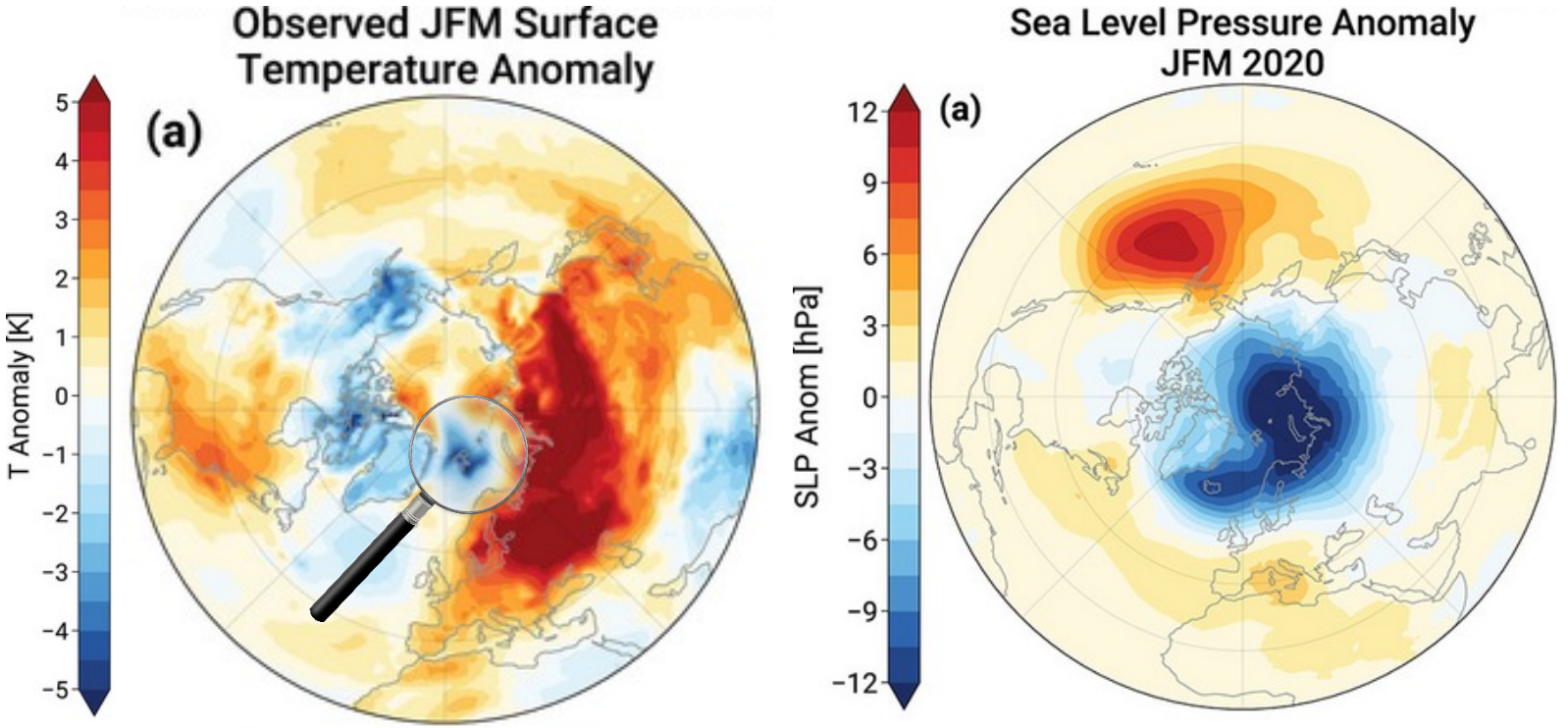
MCAOs scale to first order with cross-Fram Strait pressure gradient,

→ dynamics play an important role in driving MCAO variability



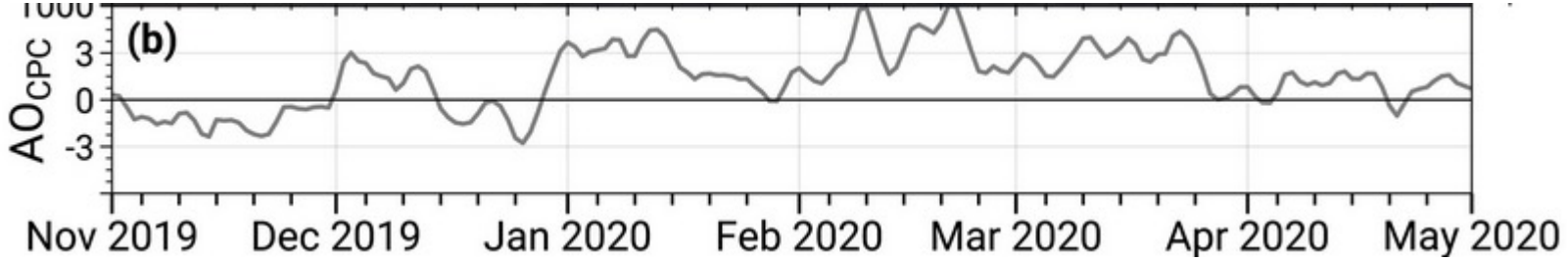
2020:

A year
of
new records

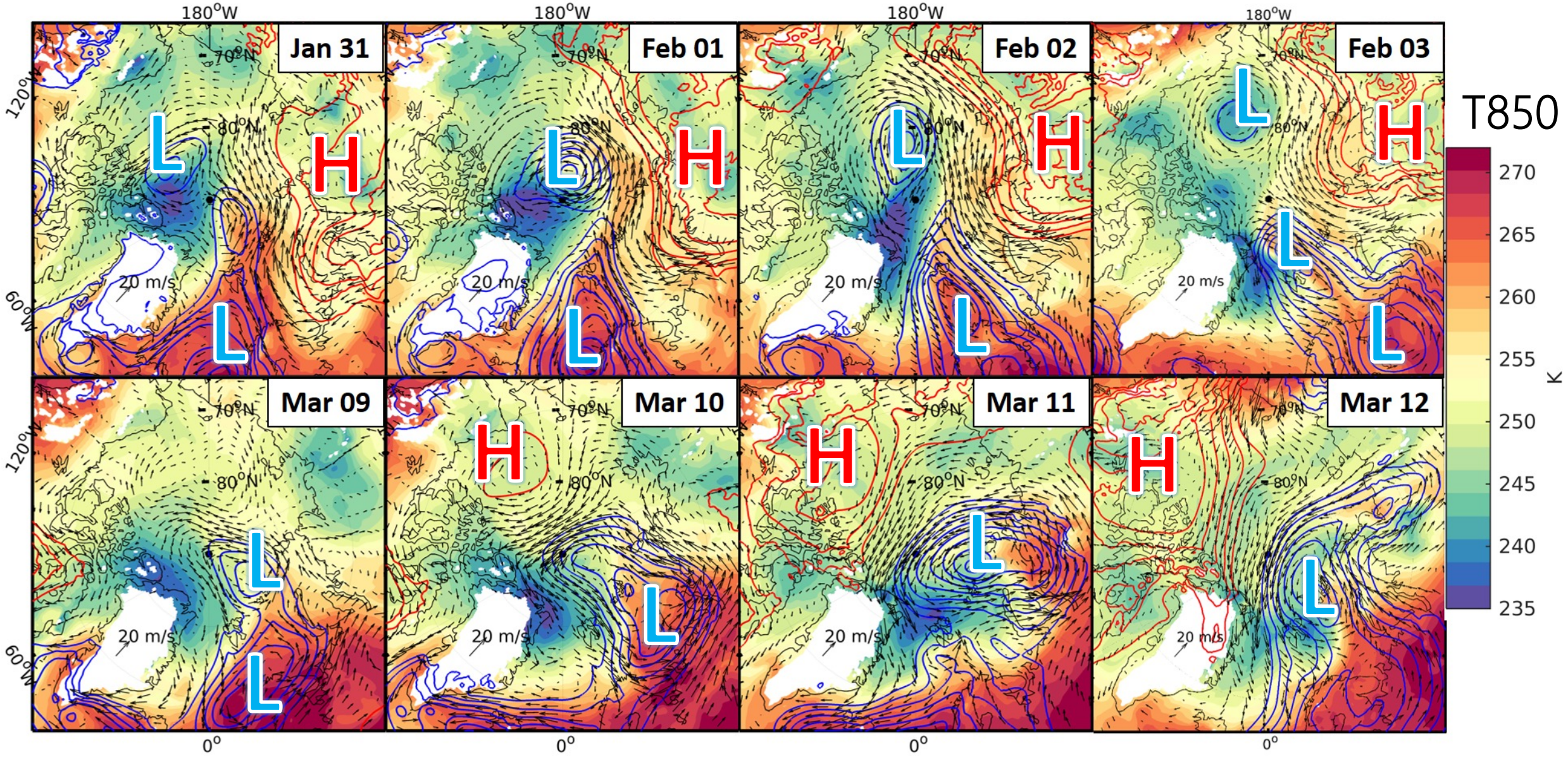


Lawrence et al., 2021, JGRA

AO index

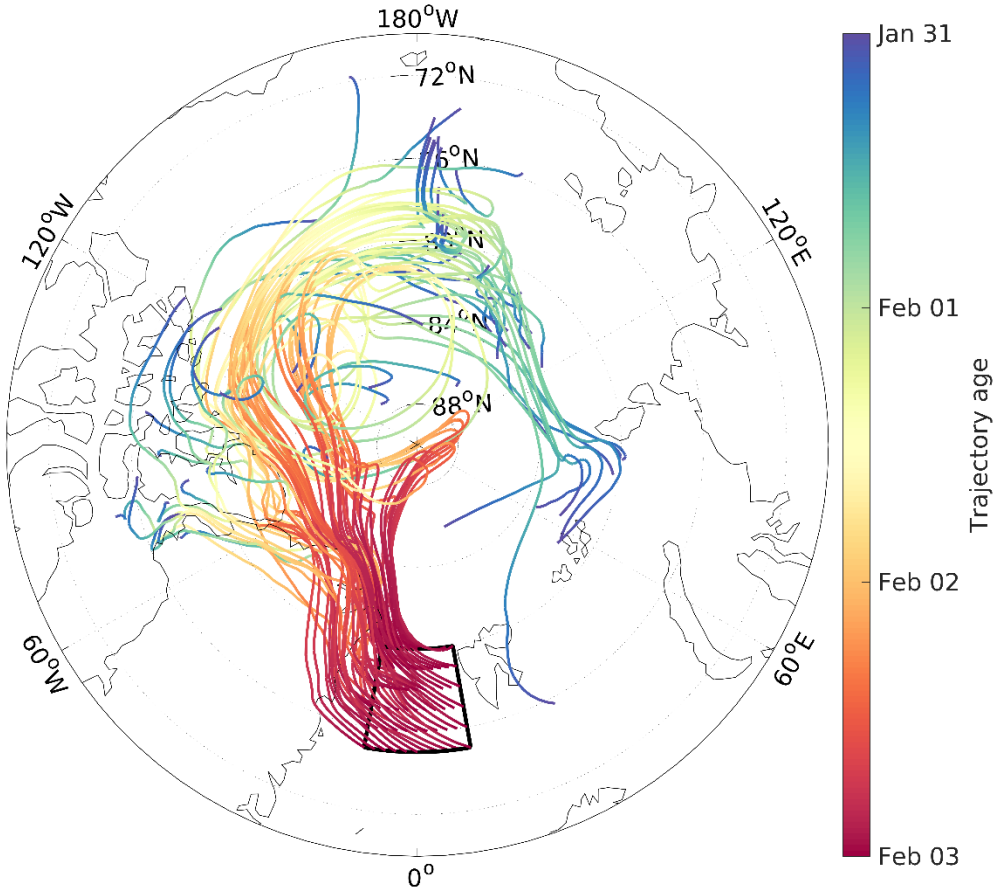


4-day Synoptic evolution of extreme MCAOs

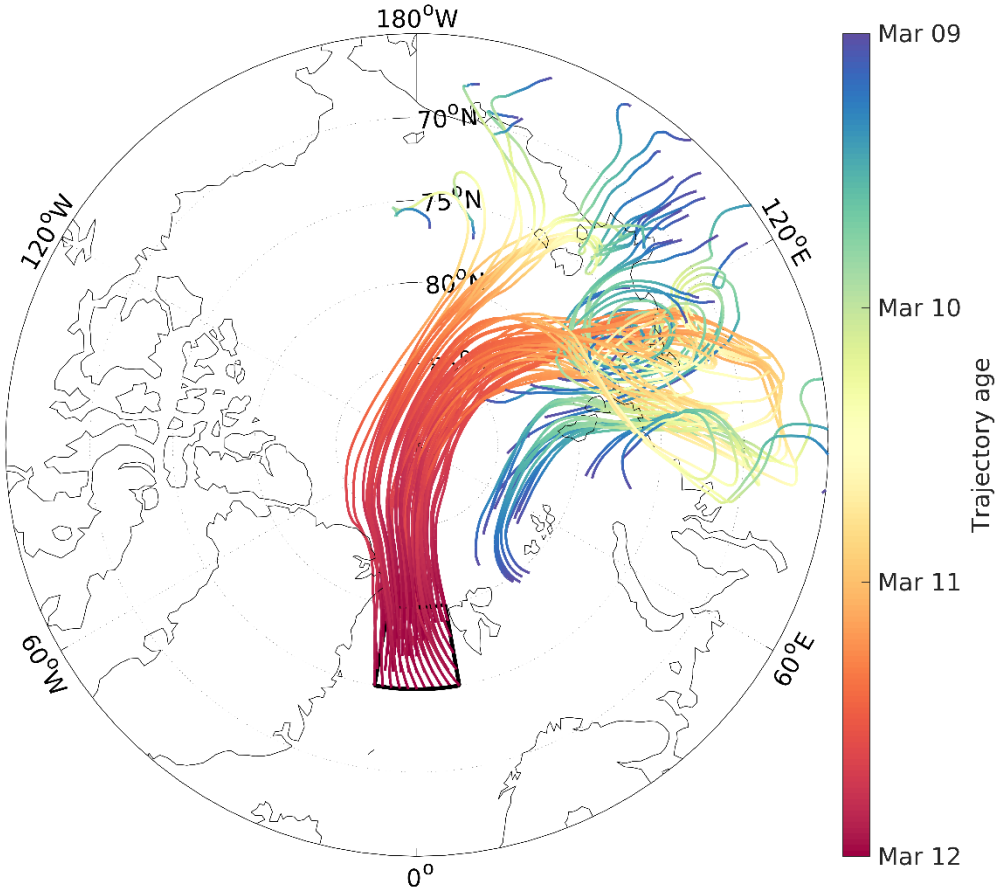


6 day Air-back trajectories from Fram Strait Box

February event

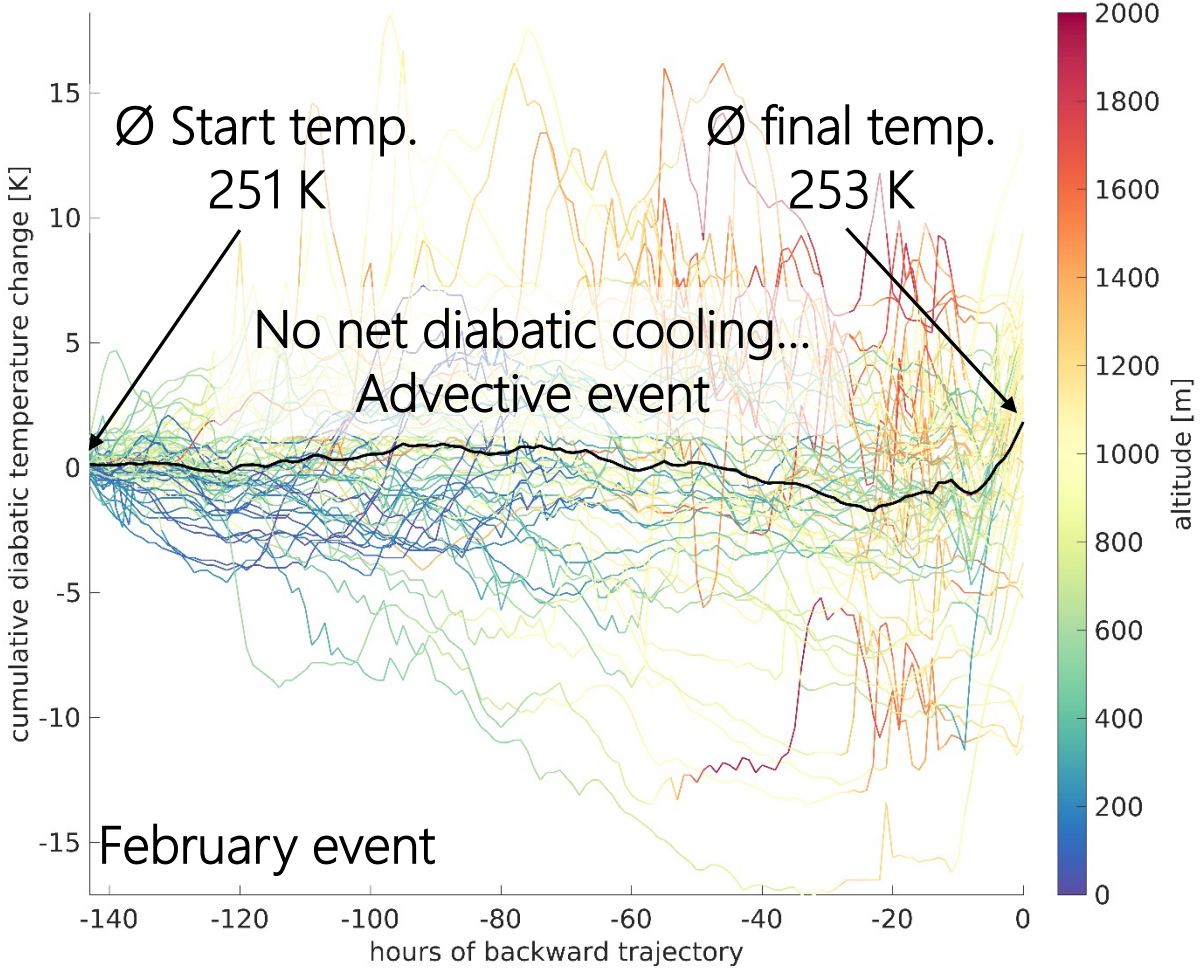


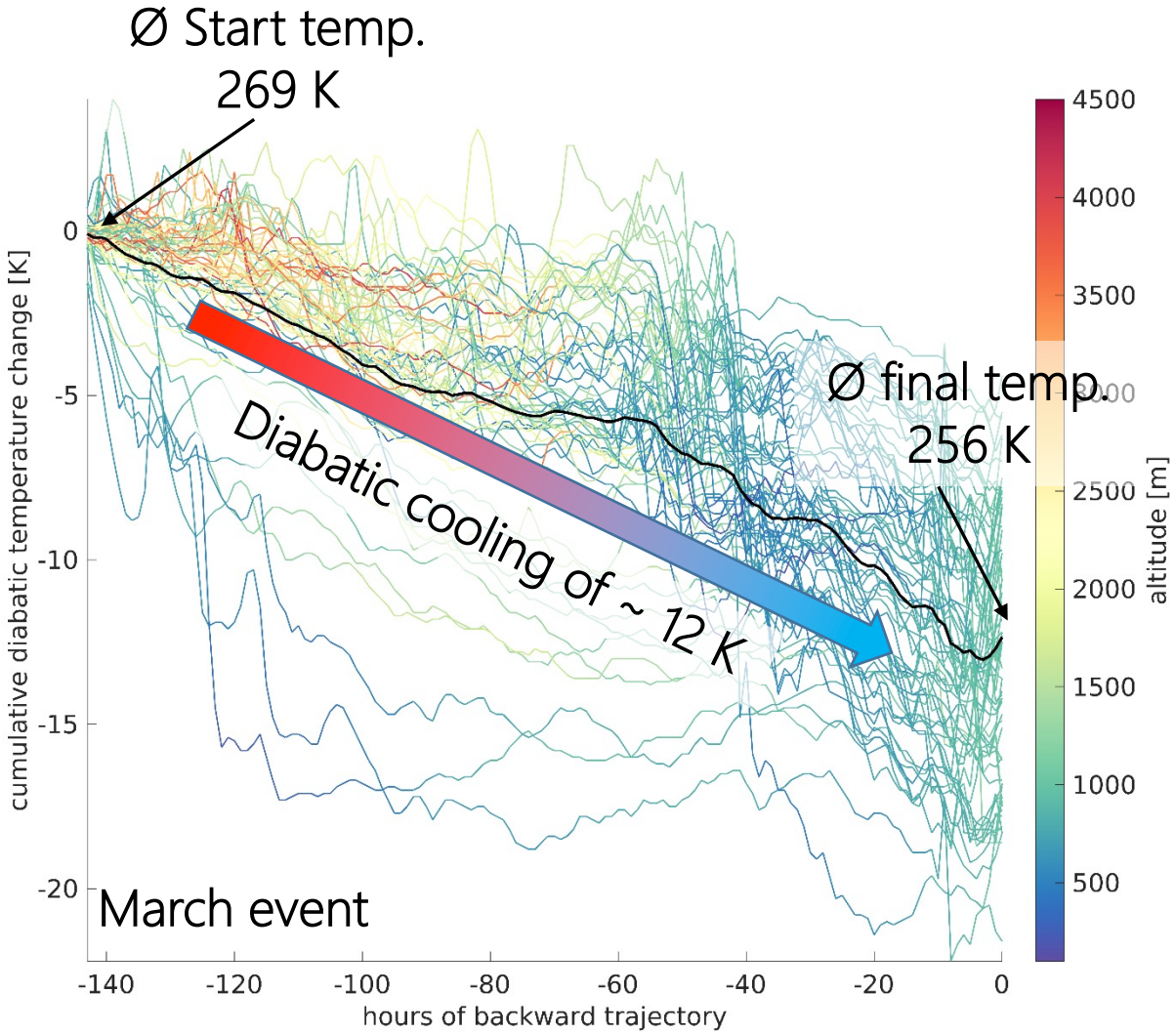
March event



(initiated at 1000m agl)

Cumulative Diabatic cooling along trajectories

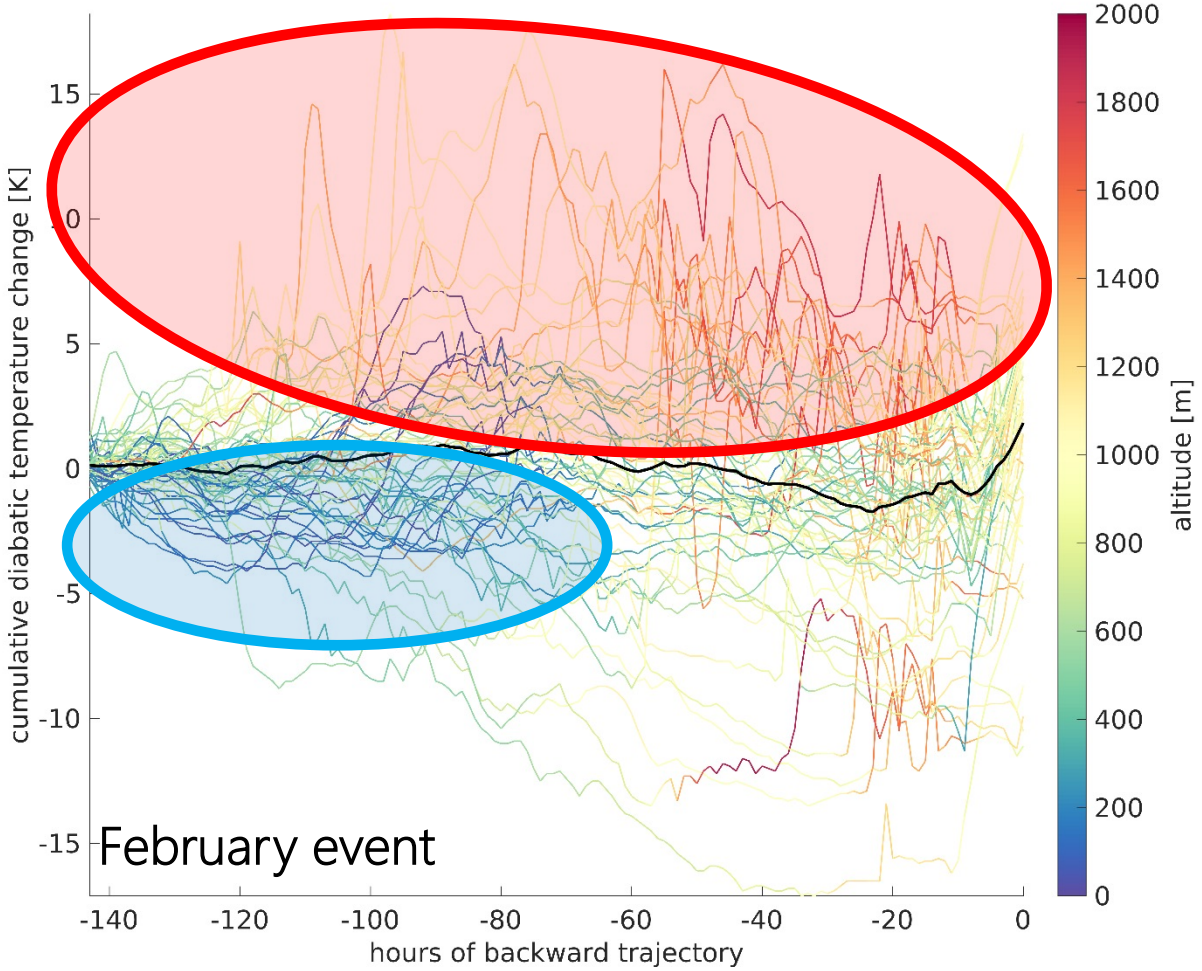


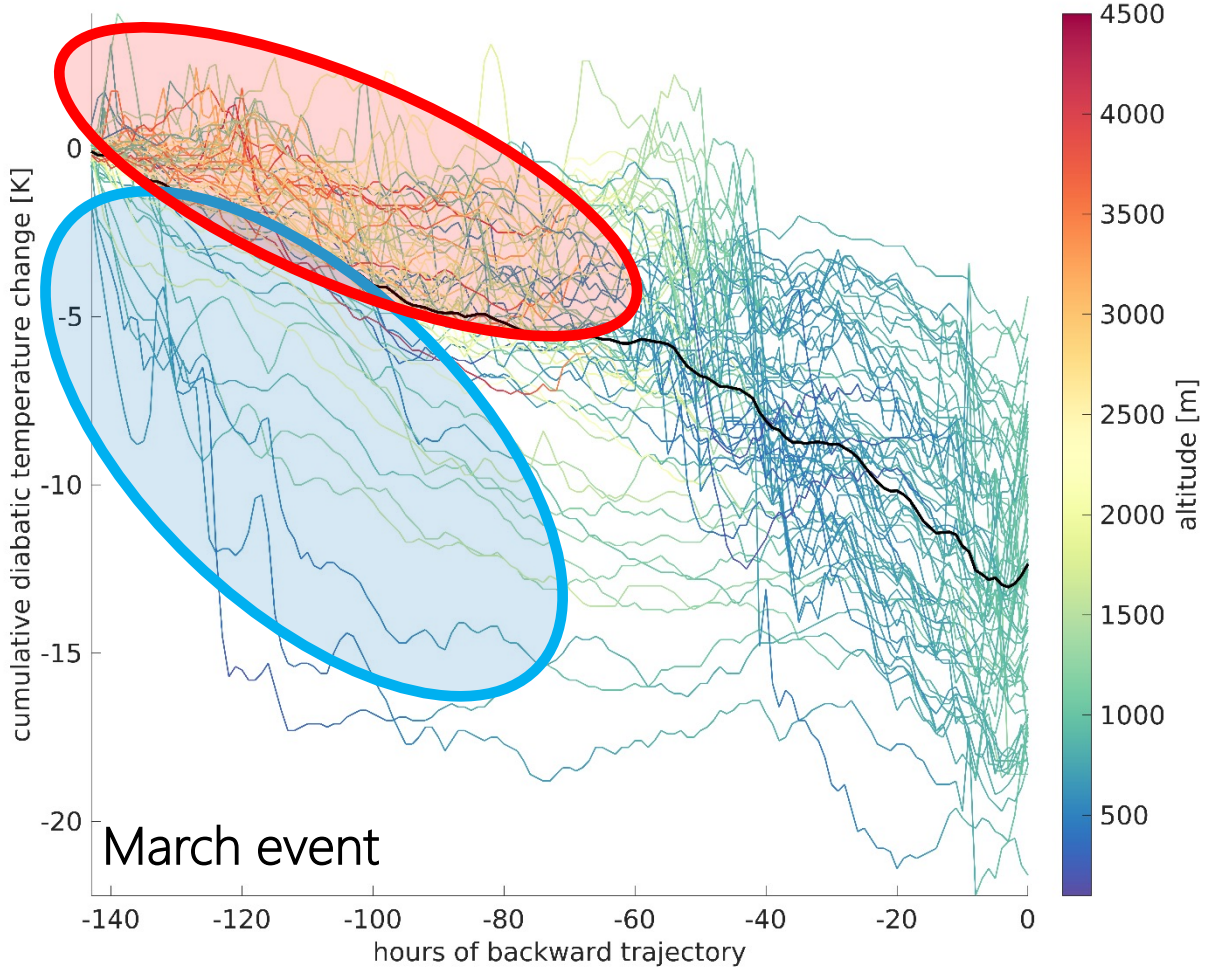


Source region ⟶ Fram Strait arrival

Diabatic cooling along trajectories

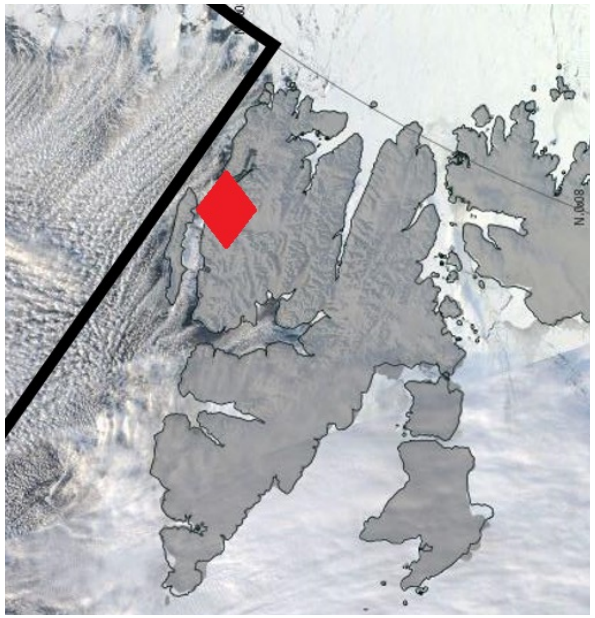
… is most effective at lower altitudes

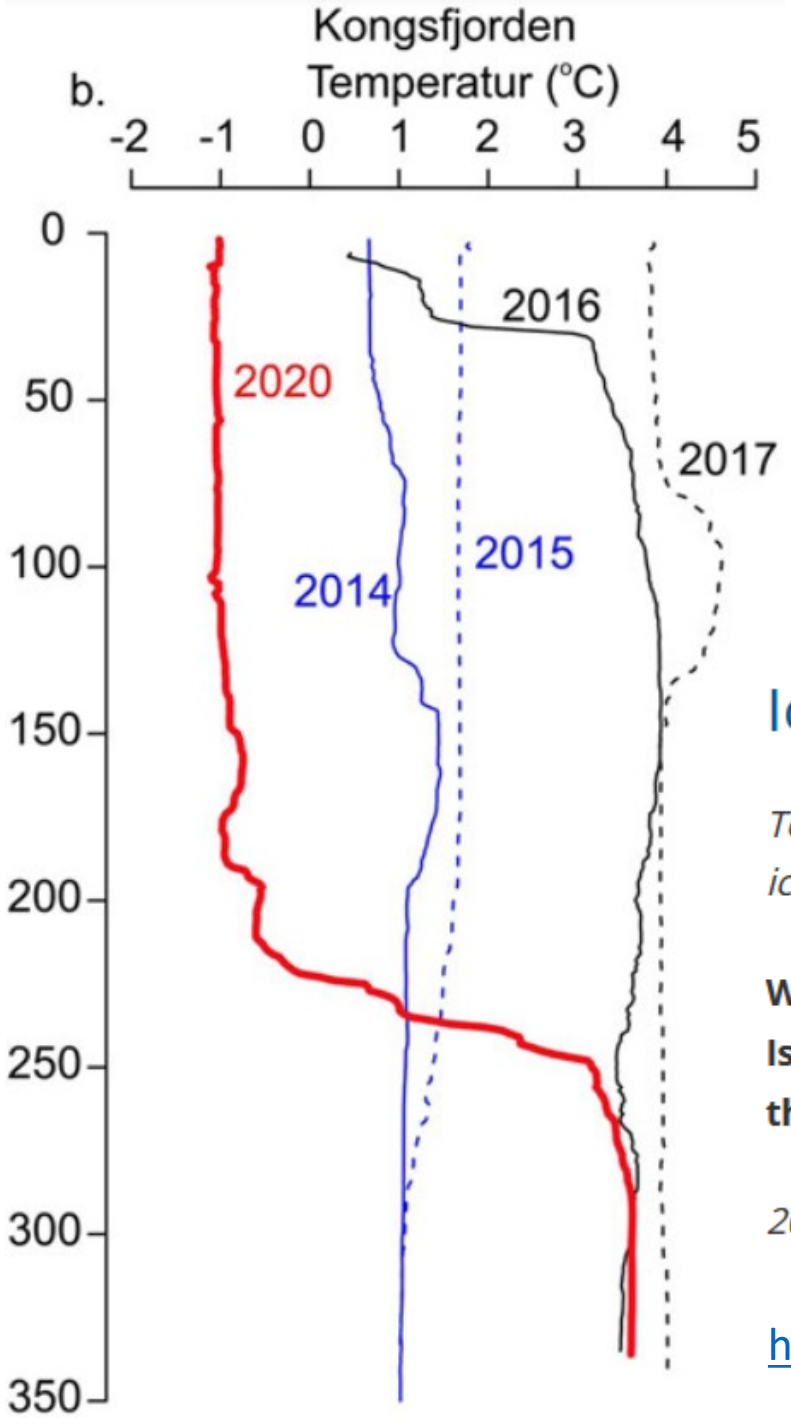


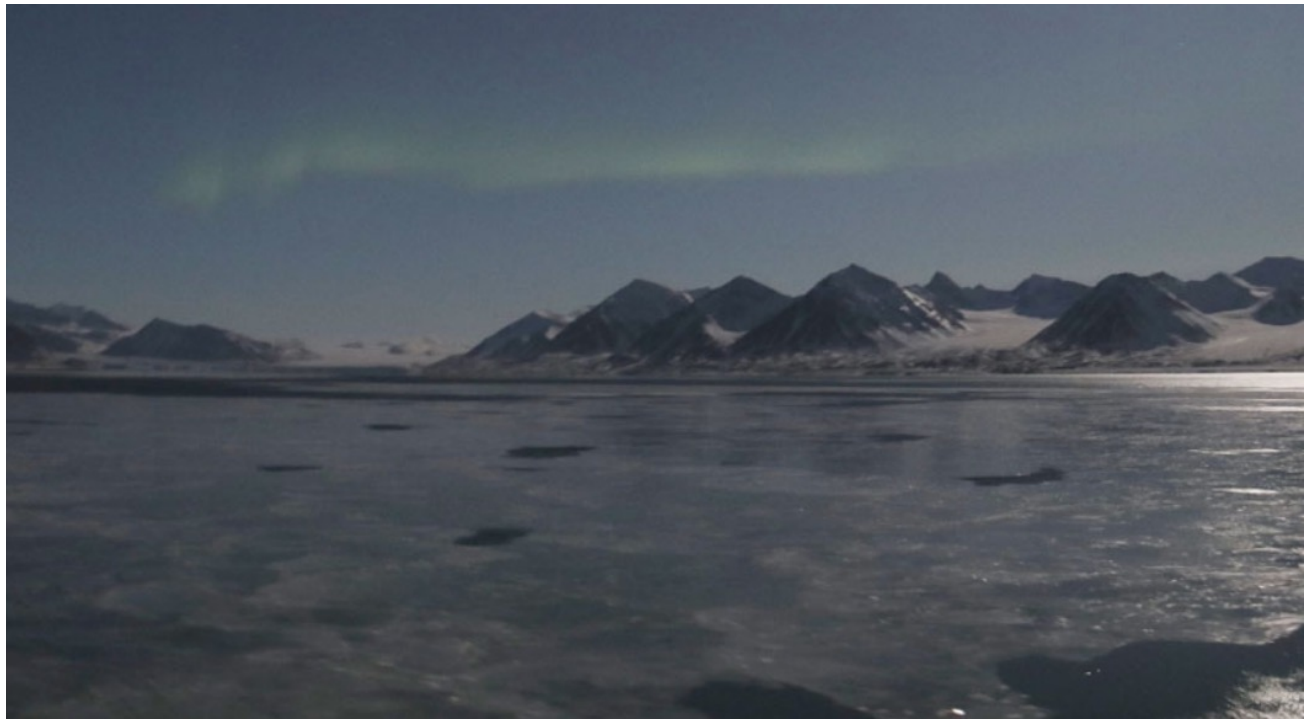


Source region ⟶ Fram Strait arrival

Ice on Kongsfjorden during 2020 MCAOs







Ice in sight!

Top image: Kongsfjorden in clear weather, moonlight, northern lights and newly frozen sea ice. Photo: Malin Daase.

We are on a polar night cruise and measurements we have taken show that both Isfjorden and Kongsfjorden are almost five degrees colder now in 2020 than it was at the same time in 2017, and the fjords are simply freezing around us!

20 January 2020

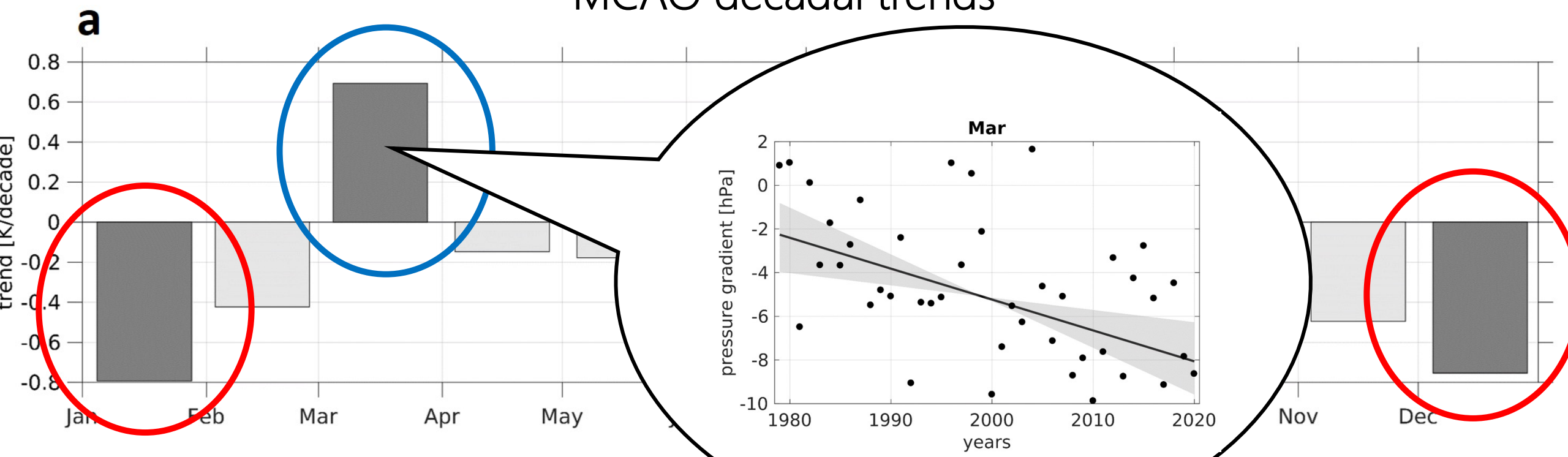
Jørgen Berge et al.

https://www.unis.no/ice-in-sight/ accessed May 18,2022

Summary

- Late winter/spring 2020 featured a recordbreaking MCAO season in Fram Strait, that is inline with long-term increase
- MCAOs largely driven by dynamics and persistent weather patterns
- Extreme MCAO events can occur with- or without major air mass transformations
- Not only MCAOs, but many regional climate parameters were observed as being unusual in winter/spring 2020

MCAO decadal trends



MCAO Decrease in mid-winter exp tically differing pace of warming

MCAO Increase in March is dynamically driven

The extreme MCAO spring season of 2020 is consistent with the trend