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Atlantic multi-decadal variability contributing to Arctic warming

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Bjerknes Centre for Climate Research

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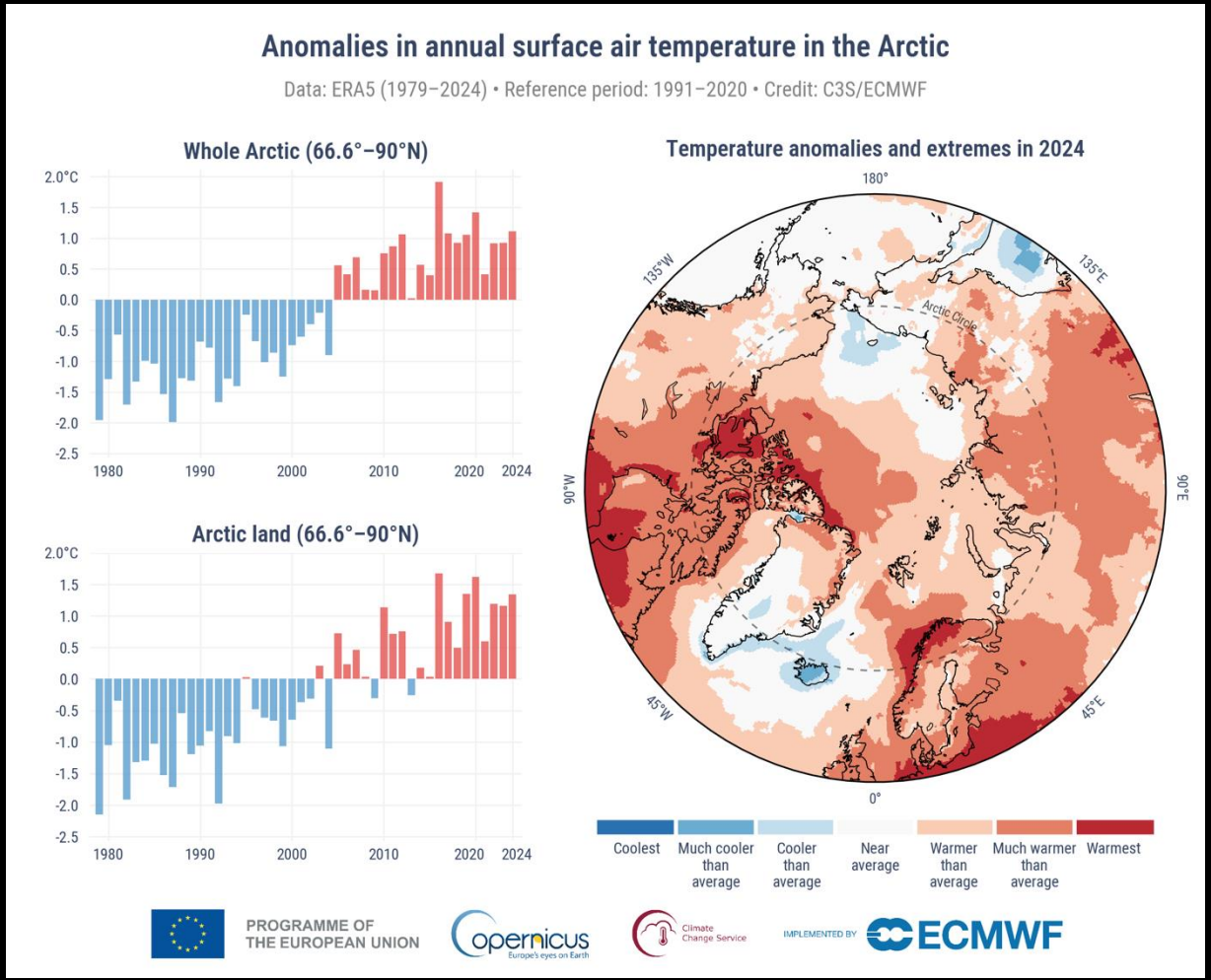
Bjerknes Climate Prediction Unit

Icons of global warming

Arctic & Greenland warming appear to have slowed

What is the contribution of internal climate variability to warming in these two regions?



https://climate.copernicus.eu/esotc/2024/arctic-temperature

Internal Atlantic multi-decadal variability a key driver of Arctic and Greenland warming

Using a novel sea ice reconstruction and atmospheric model experiments, we show Atlantic oceanic heat transport drove

1. ~60% of the early 20th century warming of the Arctic (Li et al. to be submitted)

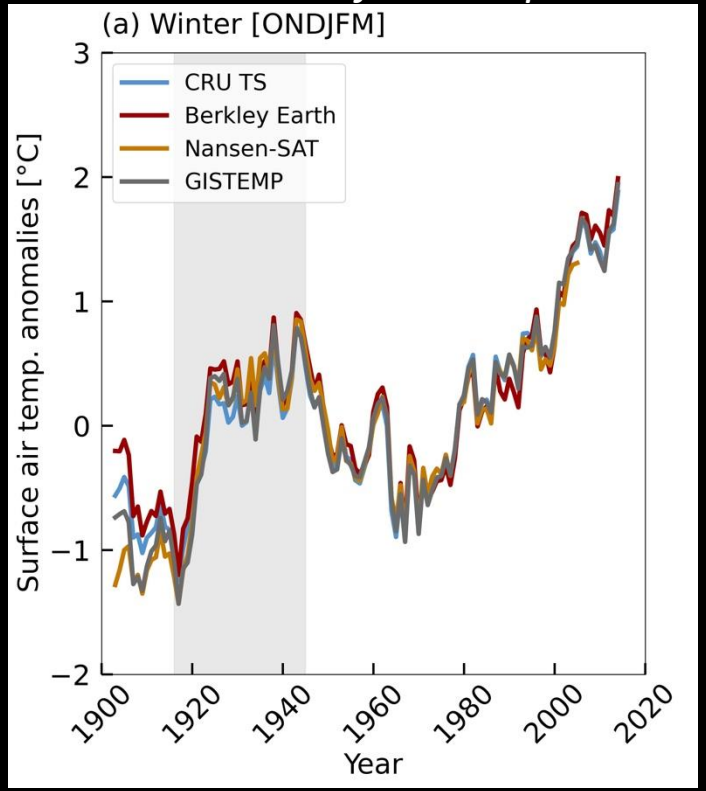
2. ~60% recent decadal surface warming trend over northeastern Canada and Greenland (Ogawa et al. to be submitted)

Two major Arctic warmings, similar strength, different mechanisms

Magnitude similar to the present warming

Early 20th century warming is a baseline for natural variability, as anthropogenic forcing weak

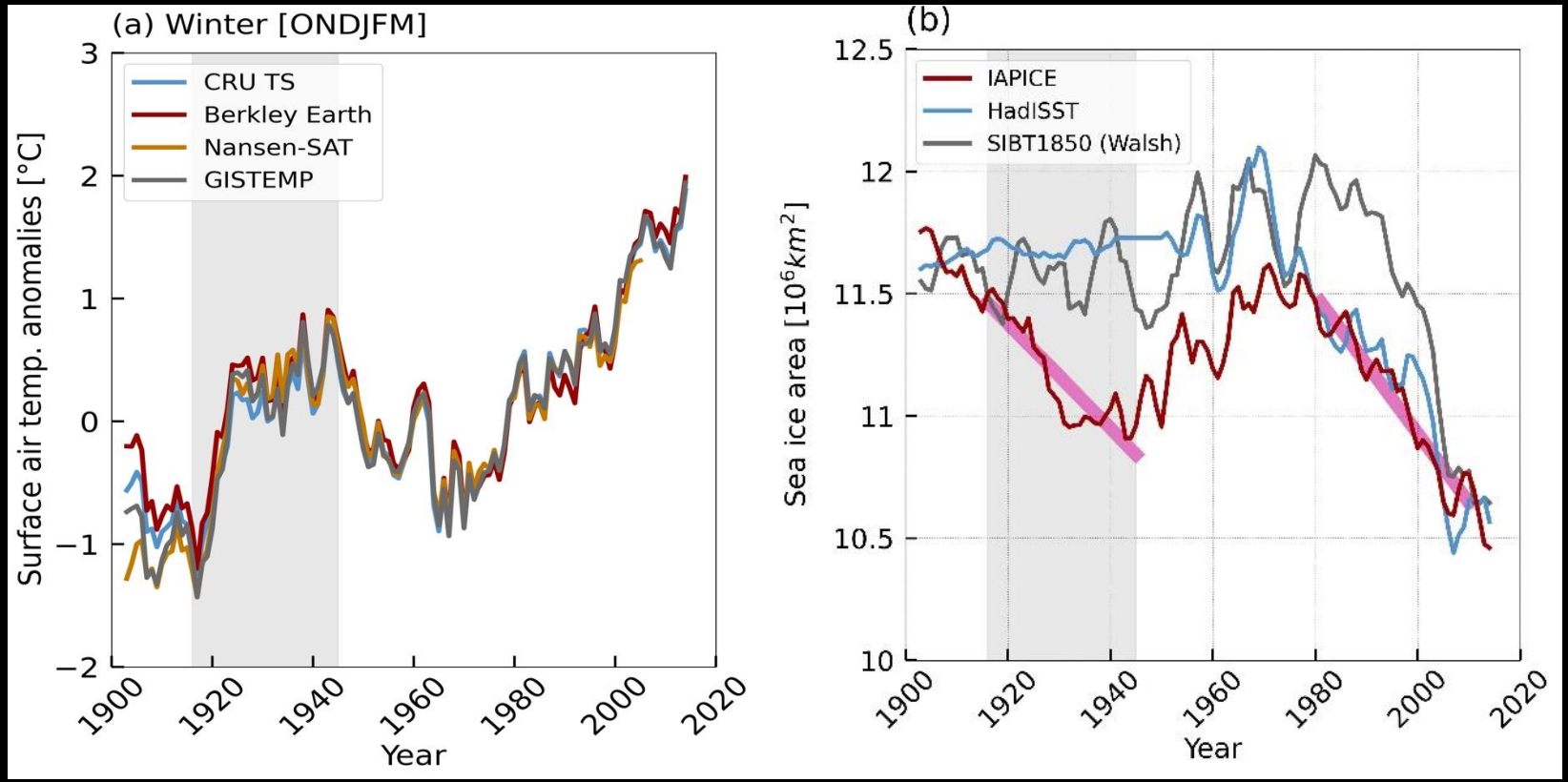
Winter Arctic surface temperature



Sea ice conditions uncertain during the early 20C warming

Arctic surface temp. (winter)

Arctic sea ice area (winter)



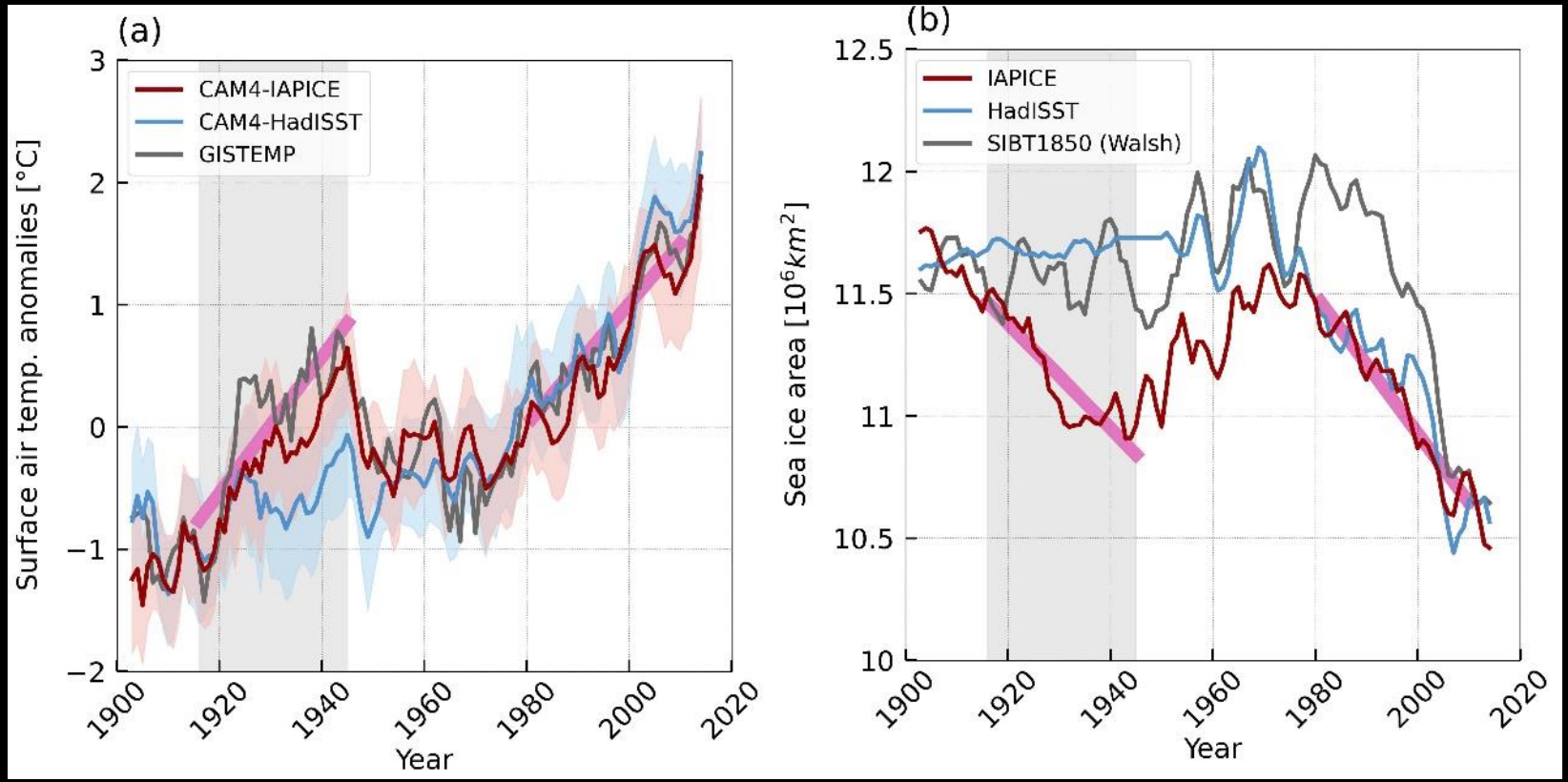
Atmospheric model experiments with new sea ice reconstruction

- CAM4 (0.9 x 1.25 deg., 26 vertical levels extending to 3 hPa)
- Two sets of AMIP-type experiments from 1901 to 2017 with Arctic Sea Ice Concentration
  1. **HadISST v1.1**
  2. **New physically consistent sea ice reconstruction (Semenov et al. 2024)**
- SST in both experiments is from ERSST v5
- For each set, an ensemble of 20 simulations

Early 20C warming is simulated with new reconstruction

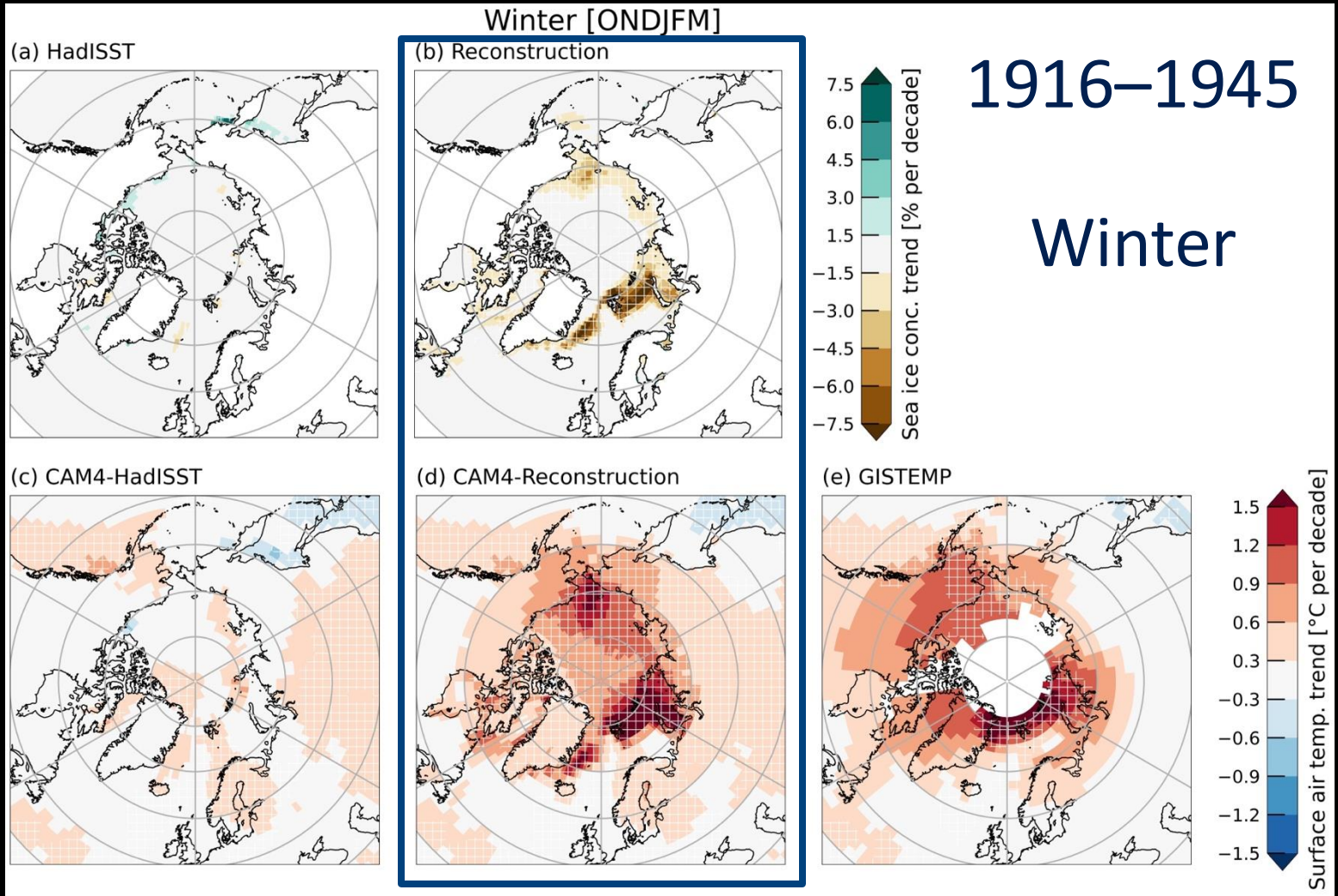
Arctic surface temp. (winter)

Arctic sea ice area (winter)



Sea ice conc. trend

Surface temp. trend



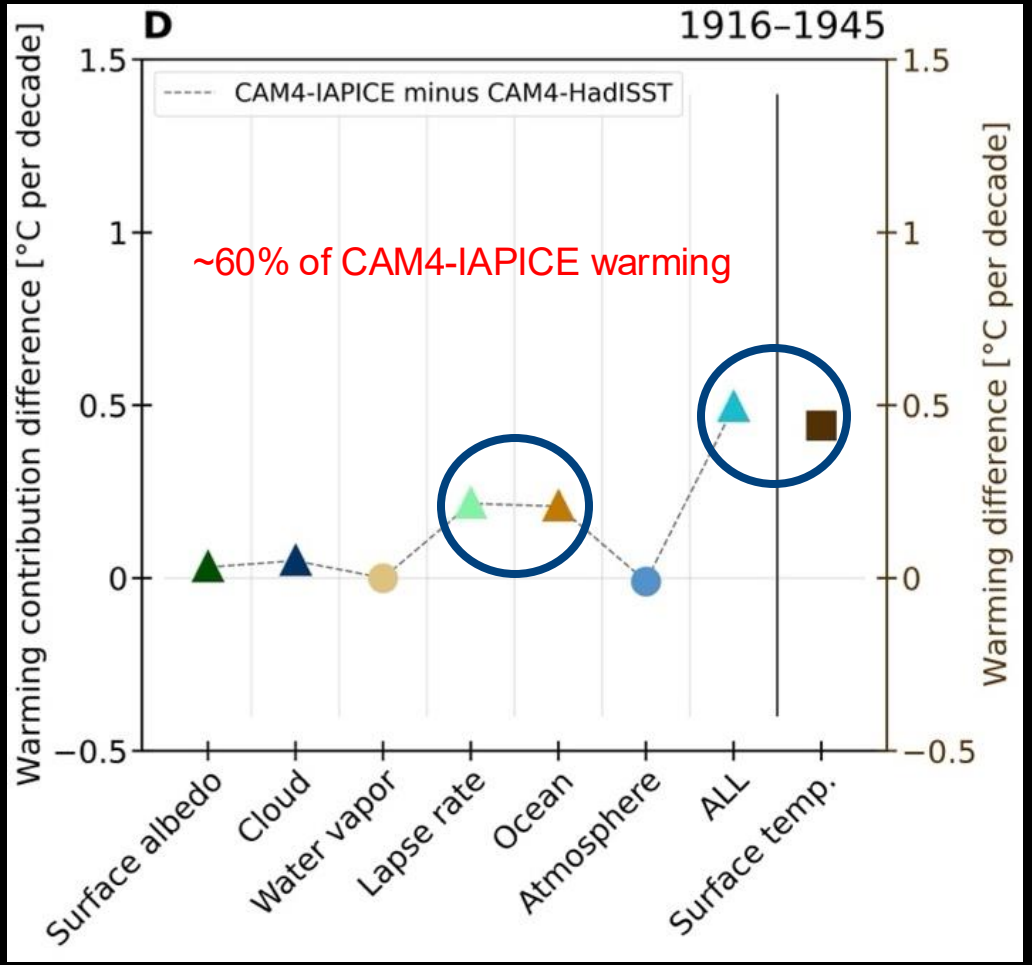
1916–1945

Winter

Sea ice driven warming caused by ocean heat transport convergence and lapse rate feedback

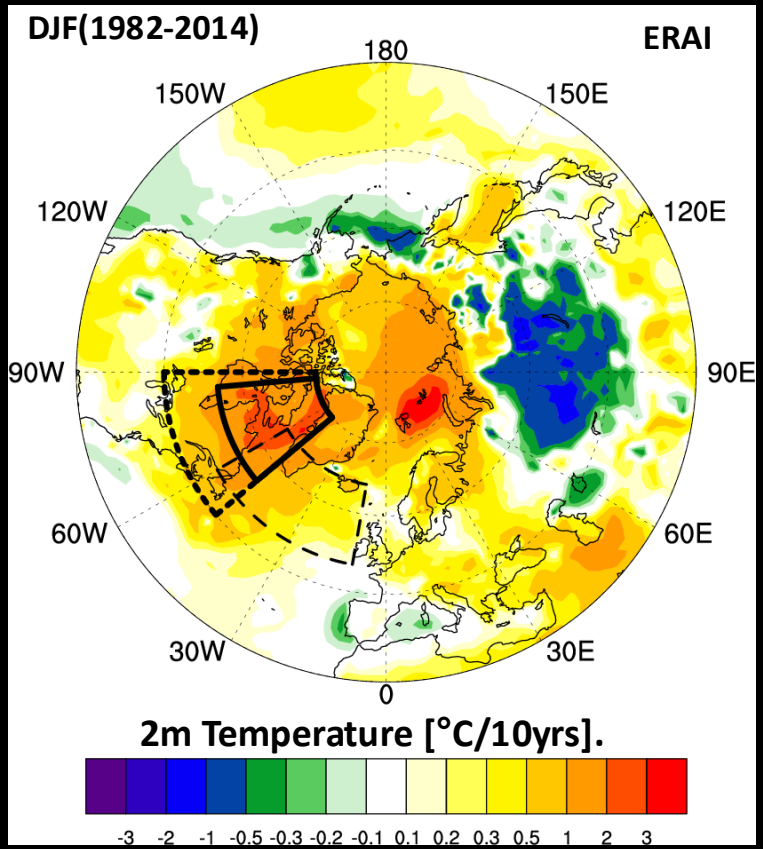
Ensemble mean difference between the two simulations Winter 1916-1945 trends

Ocean = ocean-to-atmosphere heat release.
Atmosphere = atmospheric energy convergence.
ALL = all feedbacks.



And for Greenland warming ....

Greenland has warmed much faster than the rest of the Arctic in winter



We will consider

Labrador SST , SIC (solid box), and

North Canada/Western Greenland (NCWG) land T2m (dashed box)

Our focus is on 1982-2014, when AMV warmed greatly

Assess local impacts through coordinated AGCM experiments

Lower boundary condition: NOAA OI-SST daily data (1982-2014)

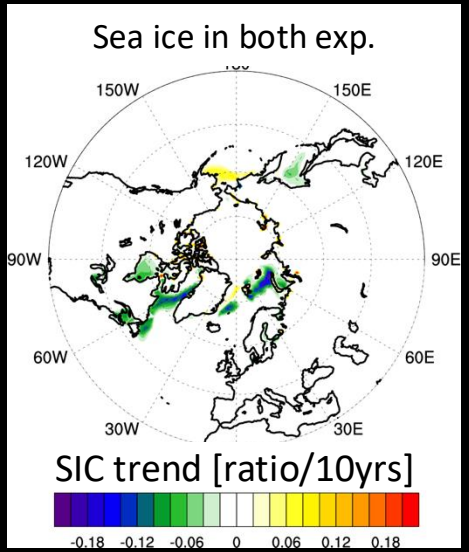
① CTRL-EXP: AMIP-type experiment.
(observed daily SST & SIC)

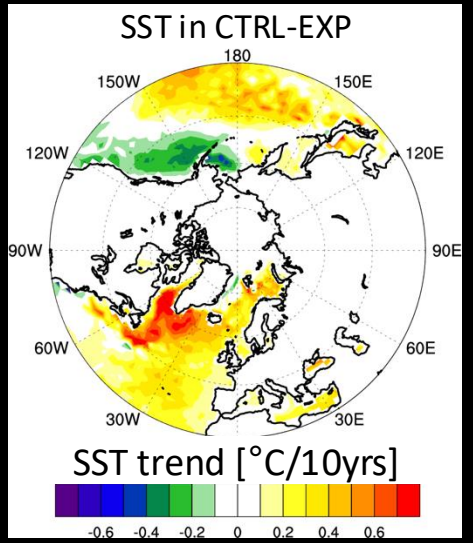
② Clim SST-EXP: SIC is the same as ①.
SST is replaced to climatology
when daily sea-ice anomaly is small (<15%).

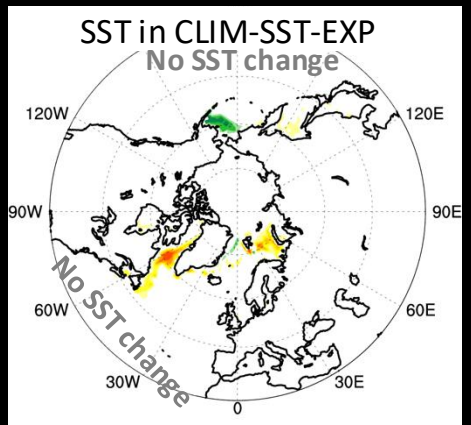
- SST is climatology everywhere, but
- High-latitude SST varies.

3. Large ensemble using 6 AGCMs from the GREENICE project (Ogawa et al. 2018)

DJF(1982-2014)

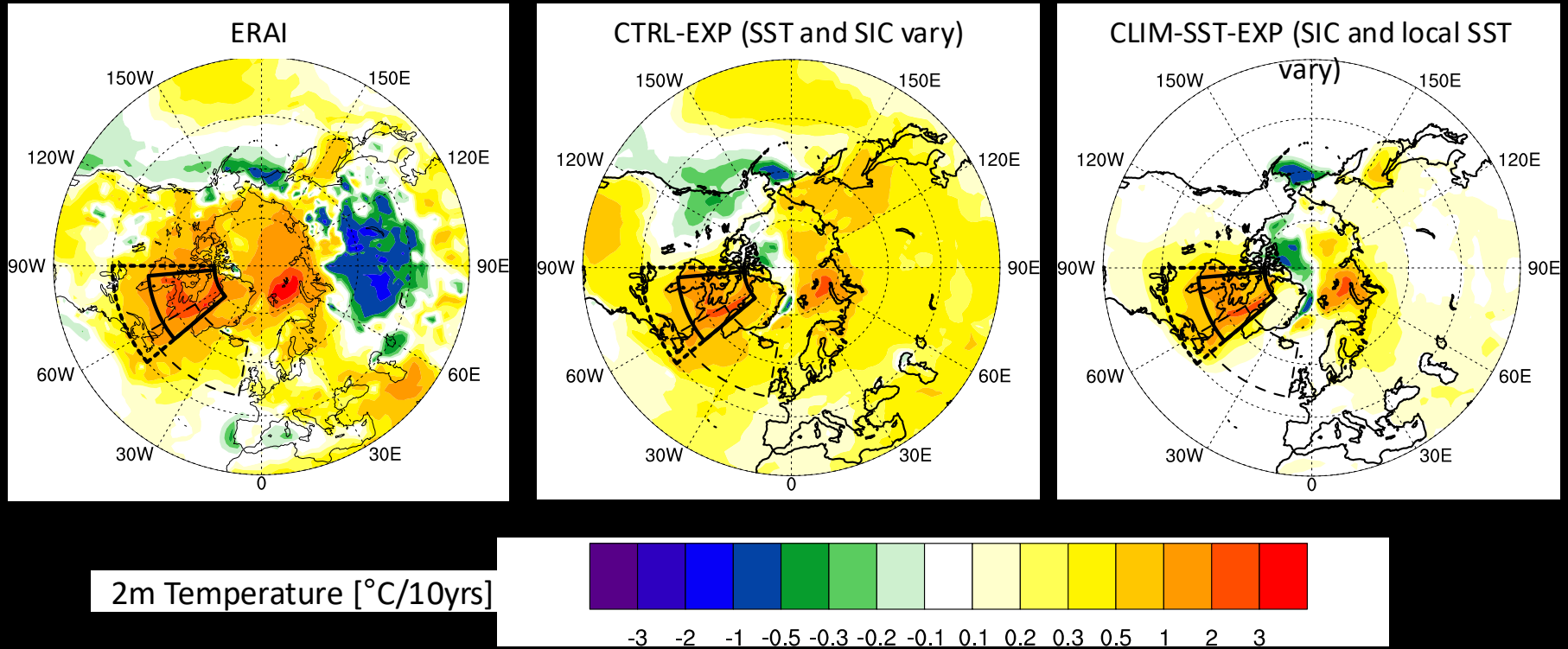






North Canada/Western Greenland Warming reproduced by sea ice and local SST

Reanalysis and Simulated changes of 2m temperature in winter (DJF, 1982-2014)



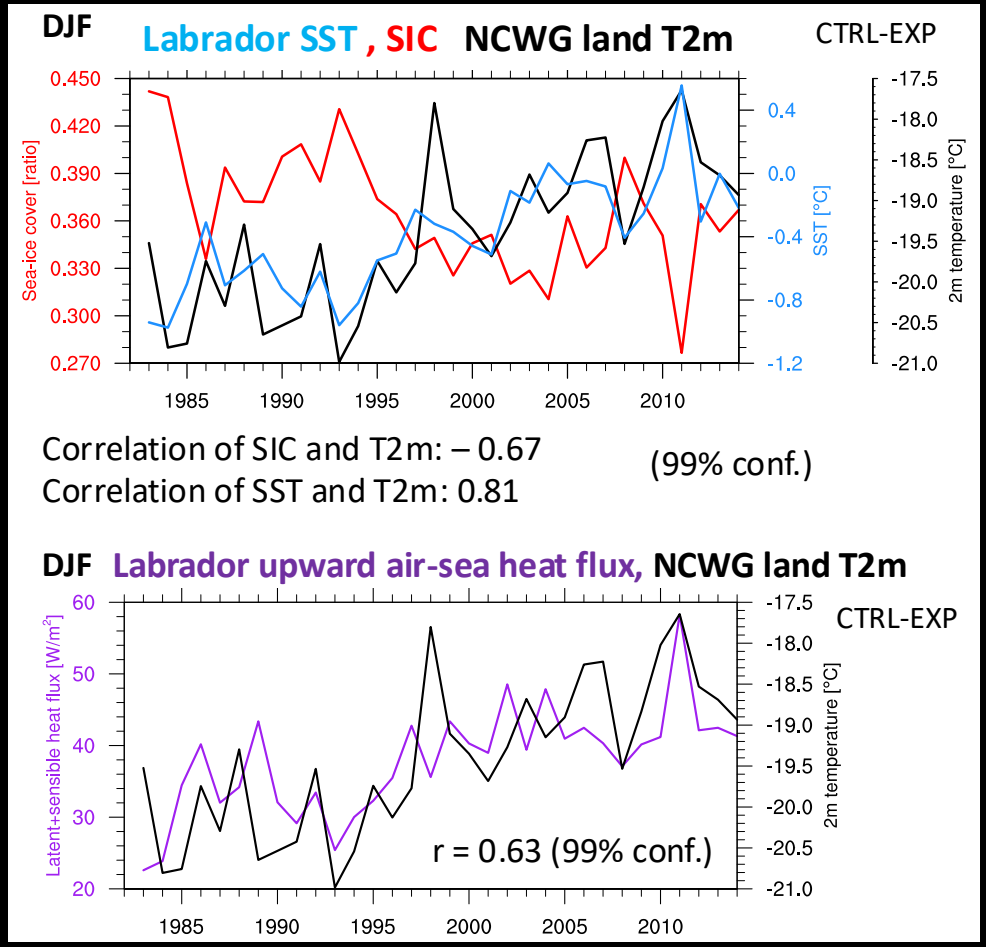
Active role of local SST/SIC on the NCWG temperature change

Correlations are similar in both experiments

Upward surface heat flux shows positive correlation with T2m.

↓

Local SST/SIC changes are forcing the NCWG temperature (& its trend) in winter.



Atlantic SST and external forcing explain approx. 60% of North Canada/Western Greenland Warming

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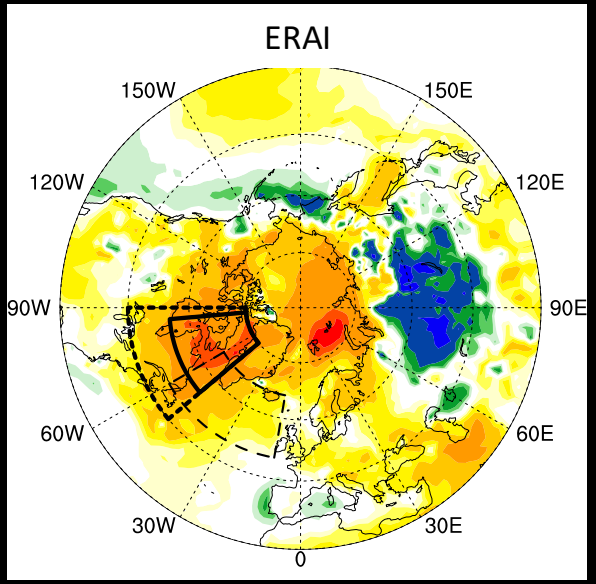

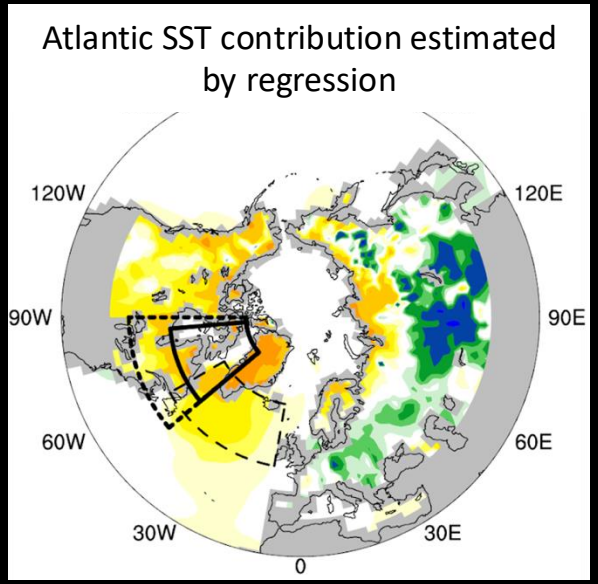

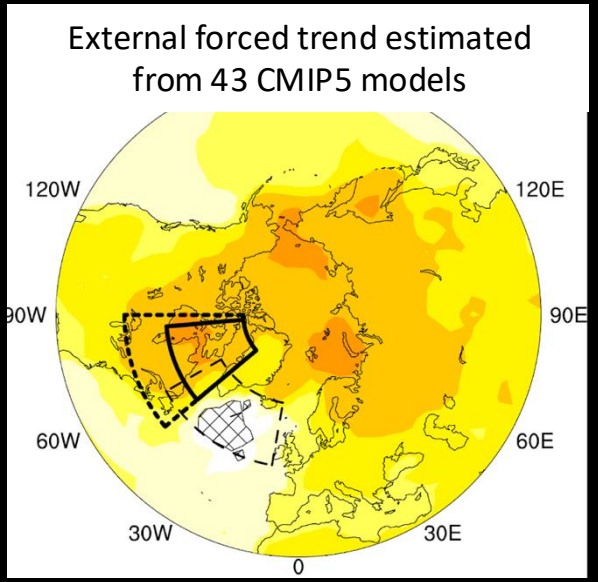

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Thank you for your attention

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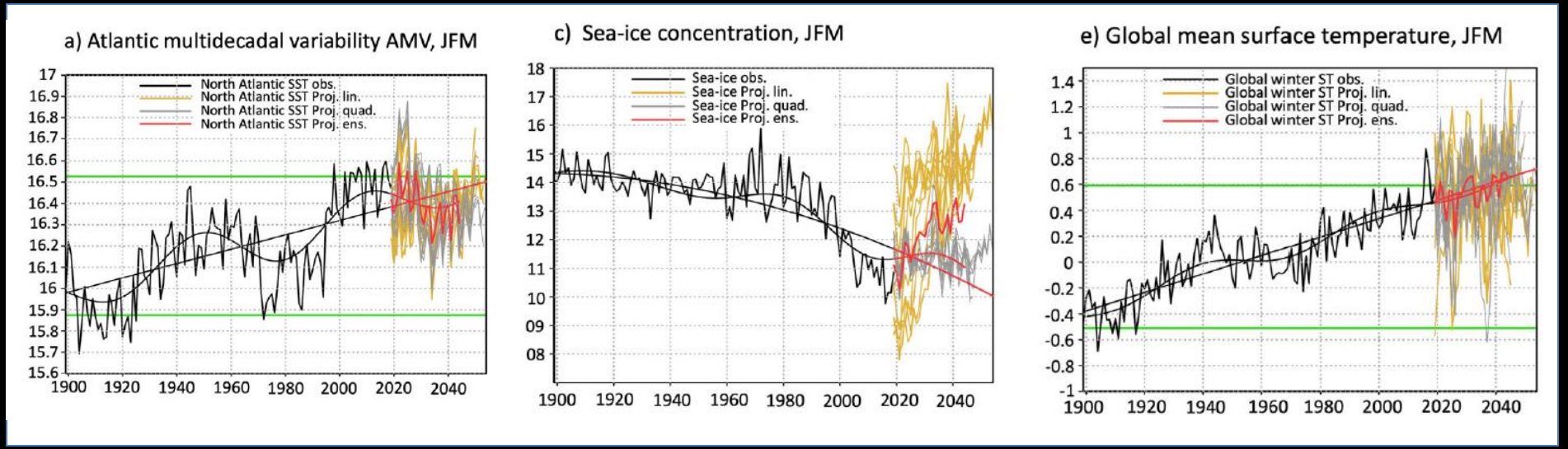
What could all this mean for the next 10-20 years?

Simple linear regression models are used to estimate potential future changes in the AMV and its impacts



The present and near future wintertime decadal conditions resemble those of 1950s-1970s showing:
North Atlantic cooling, weakening of the NAO, hiatus in Arctic sea-ice European and global temperature

Omrani et al. 2022