Model biases in simulating extreme Arctic sea ice loss

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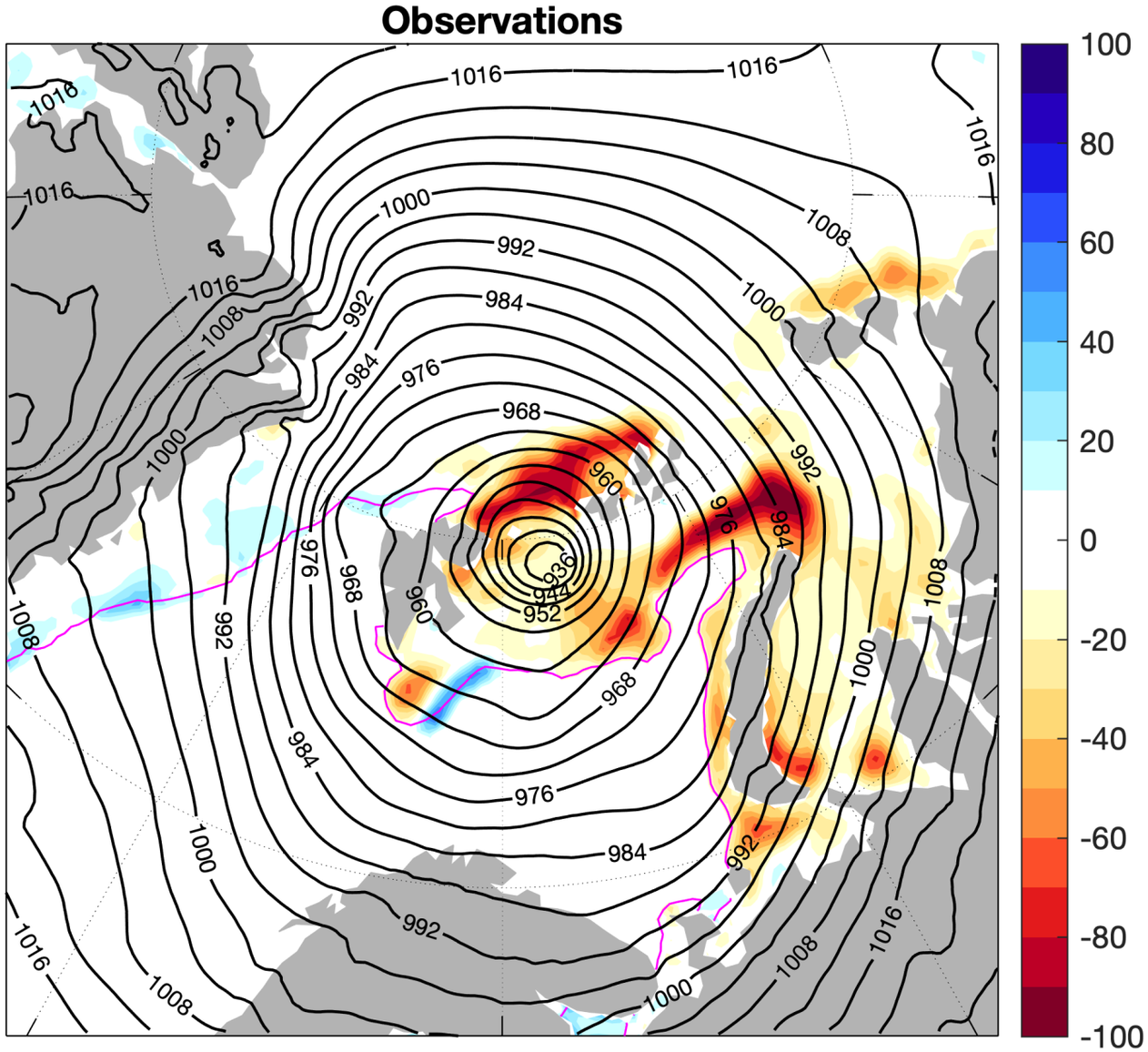
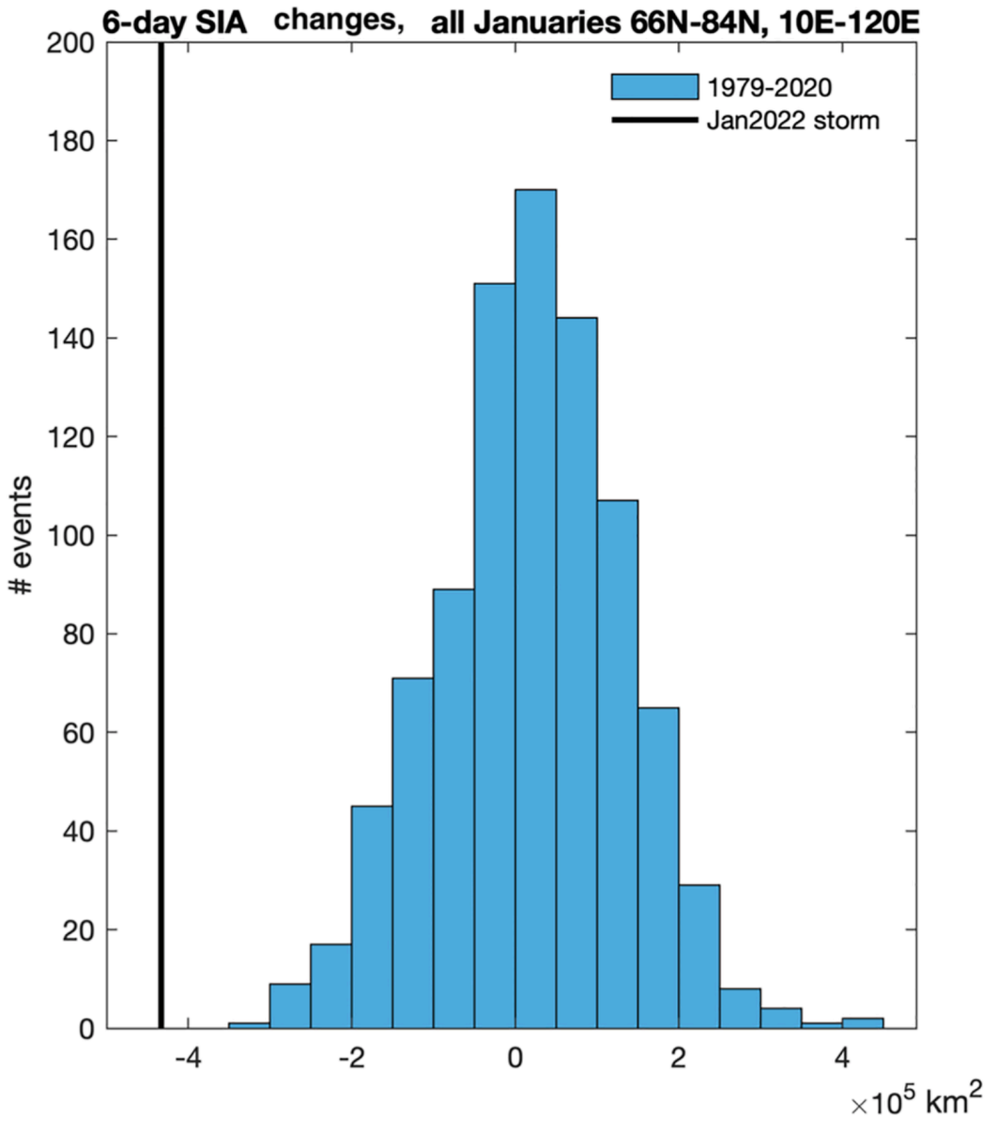
Record January 2022 Arctic cyclone led to record weekly sea ice loss



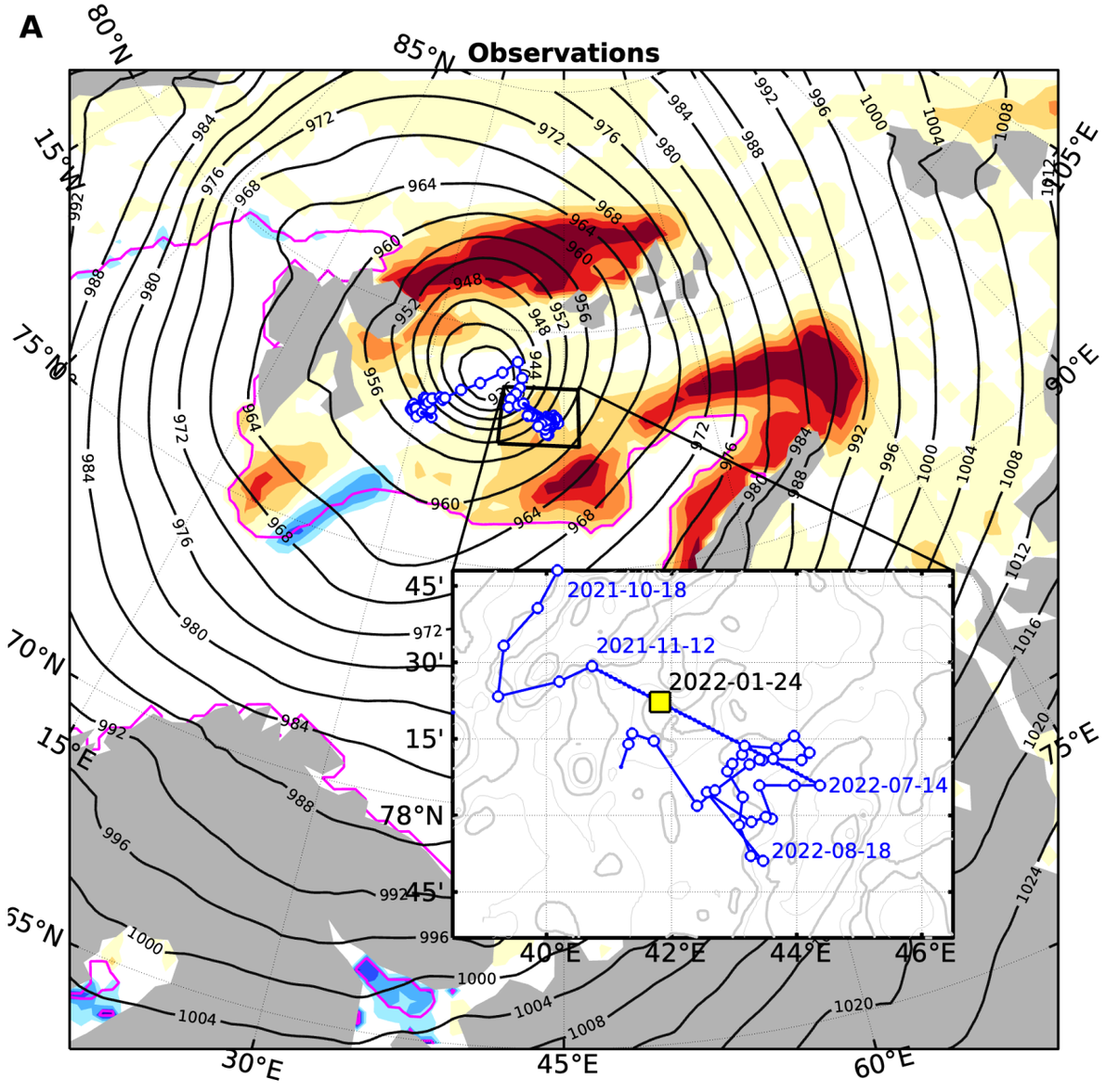


Contours: 24 January 2022 SLP

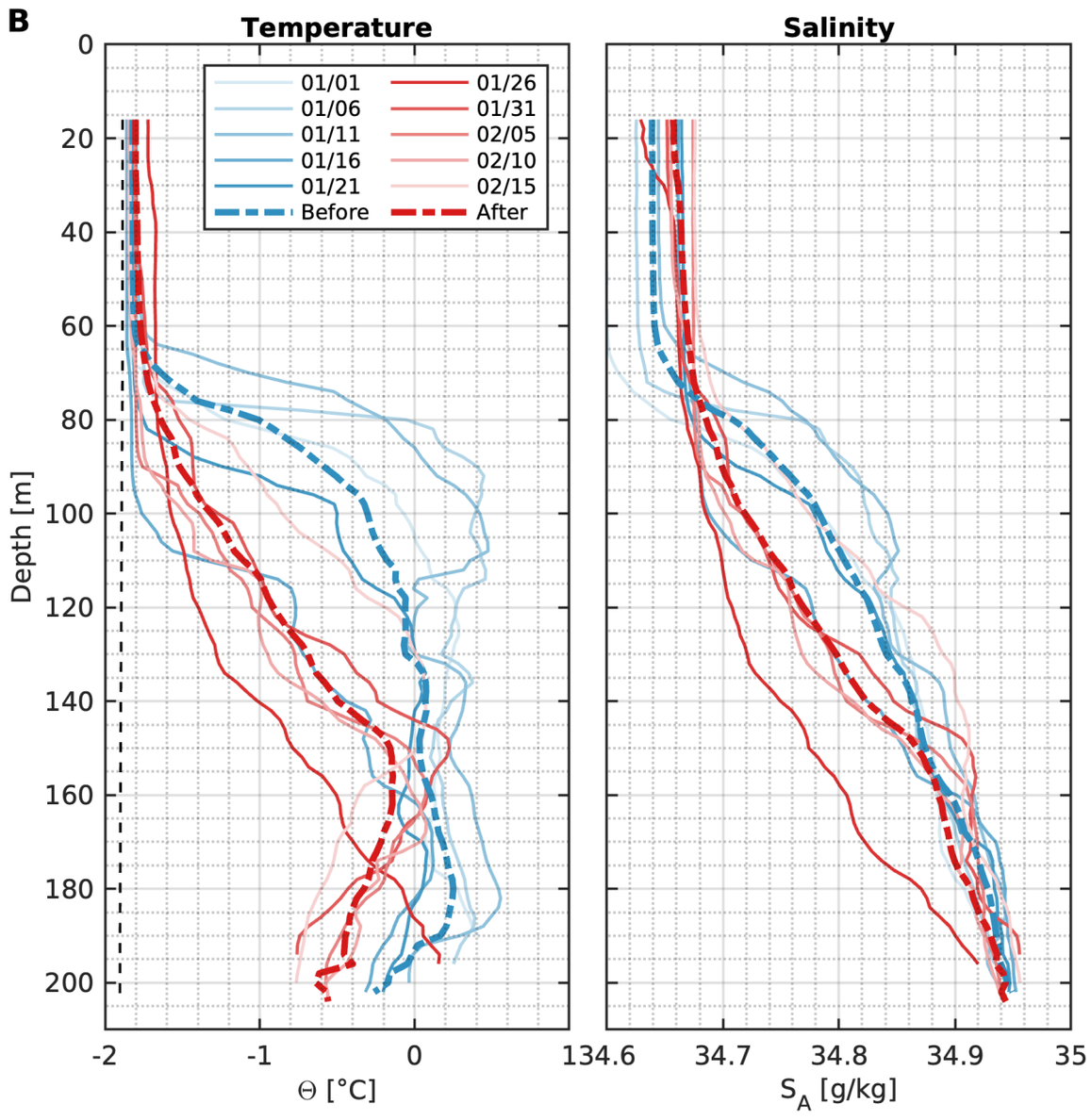
Shading: sea ice concentration difference, 21-27 January 2022

Cyclone results in huge sea ice loss, but atmospheric heat fluxes to sea ice cannot account for loss (BW et al, 2022)

Record January 2022 Arctic cyclone led to record weekly sea ice loss



Change in SIC January 21-27, almost 0.5 million km2 loss of SIA in Barents/Kara/West Laptev.



ARGO float T and S profiles.

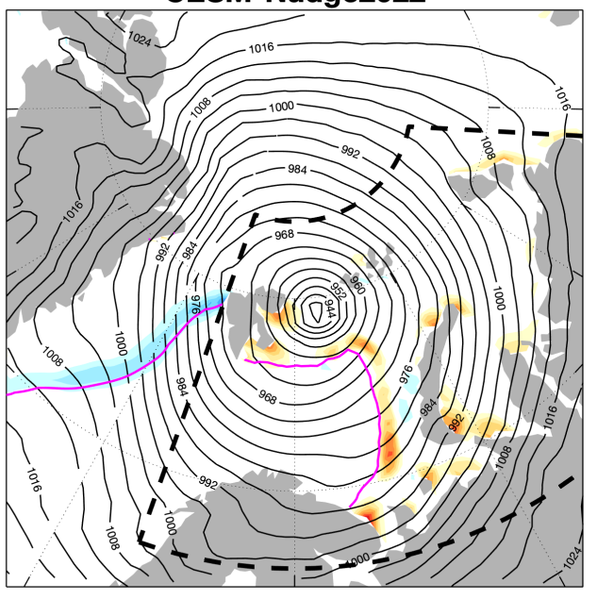
Ocean cooling releases enough heat to melt >0.5m sea ice

Impact of January 2022 cyclone on sea ice in CESM

SLP on 1/24 12UTC & SIC difference 1/21 -> 1/27

replicate observed cyclone in fully coupled CESM1-CAM5 by nudging winds above boundary layer to 2022 ERA5 (branching off CESM-LENS runs)

A



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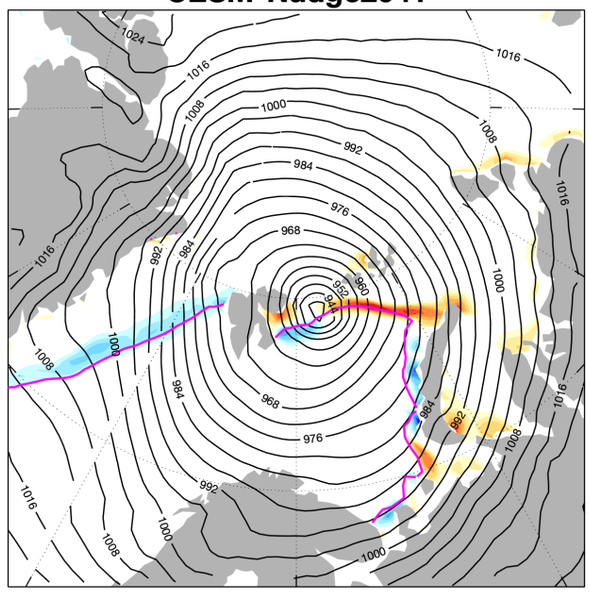

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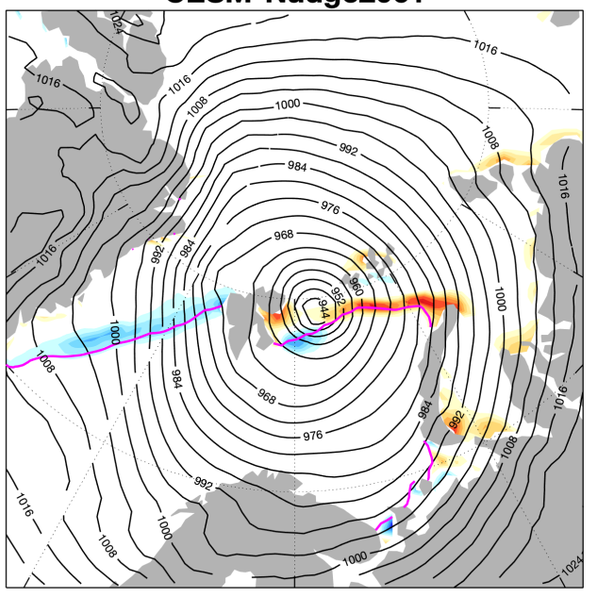

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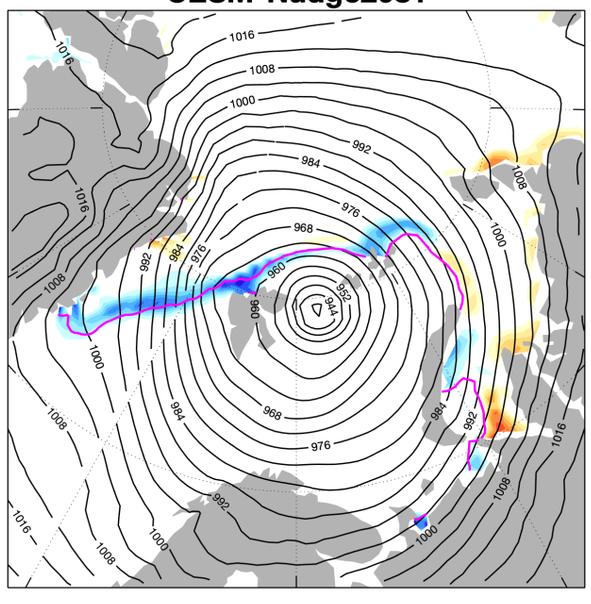
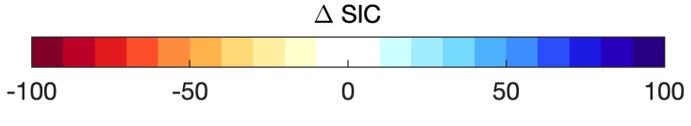
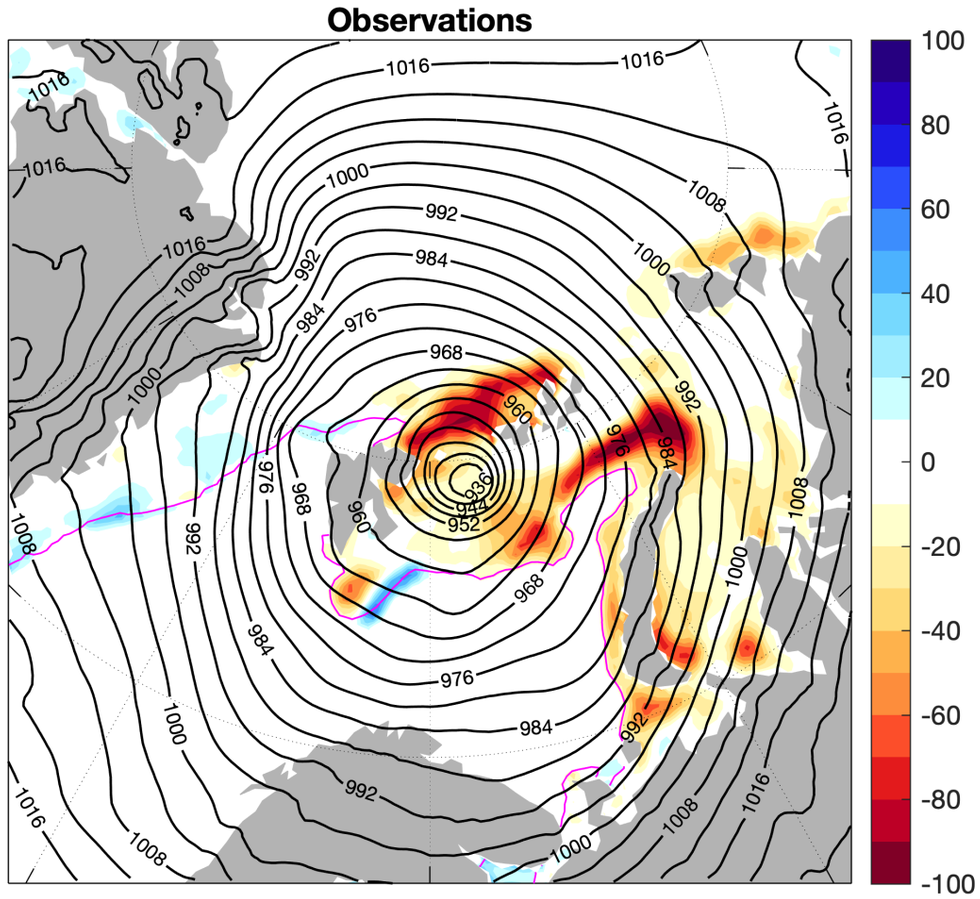
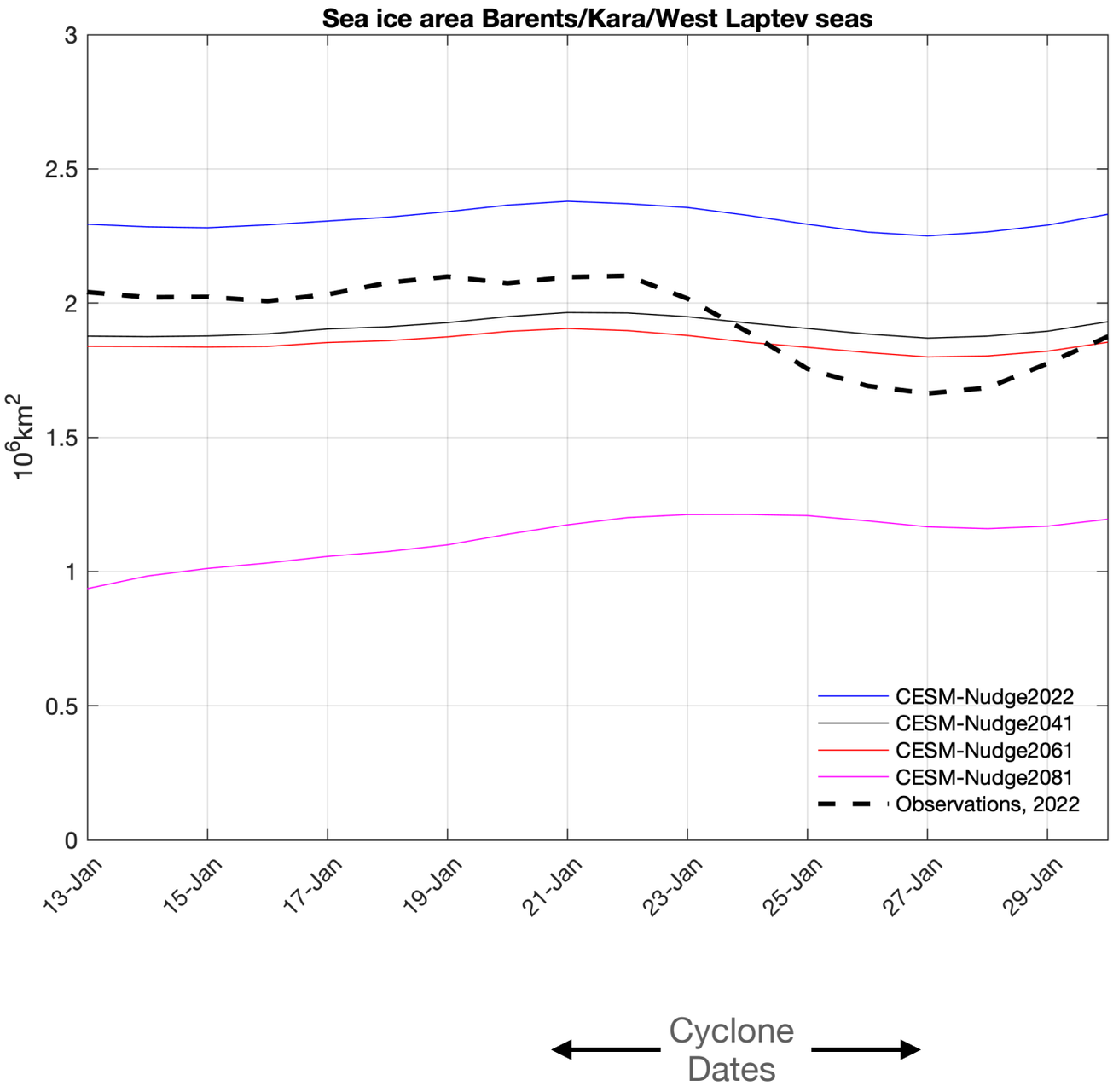






Model replicates cyclone, but sea ice response is biased/too small

Much smaller loss of sea ice in CESM-Nudge (~0.1 m km2 SIA) compared to observations



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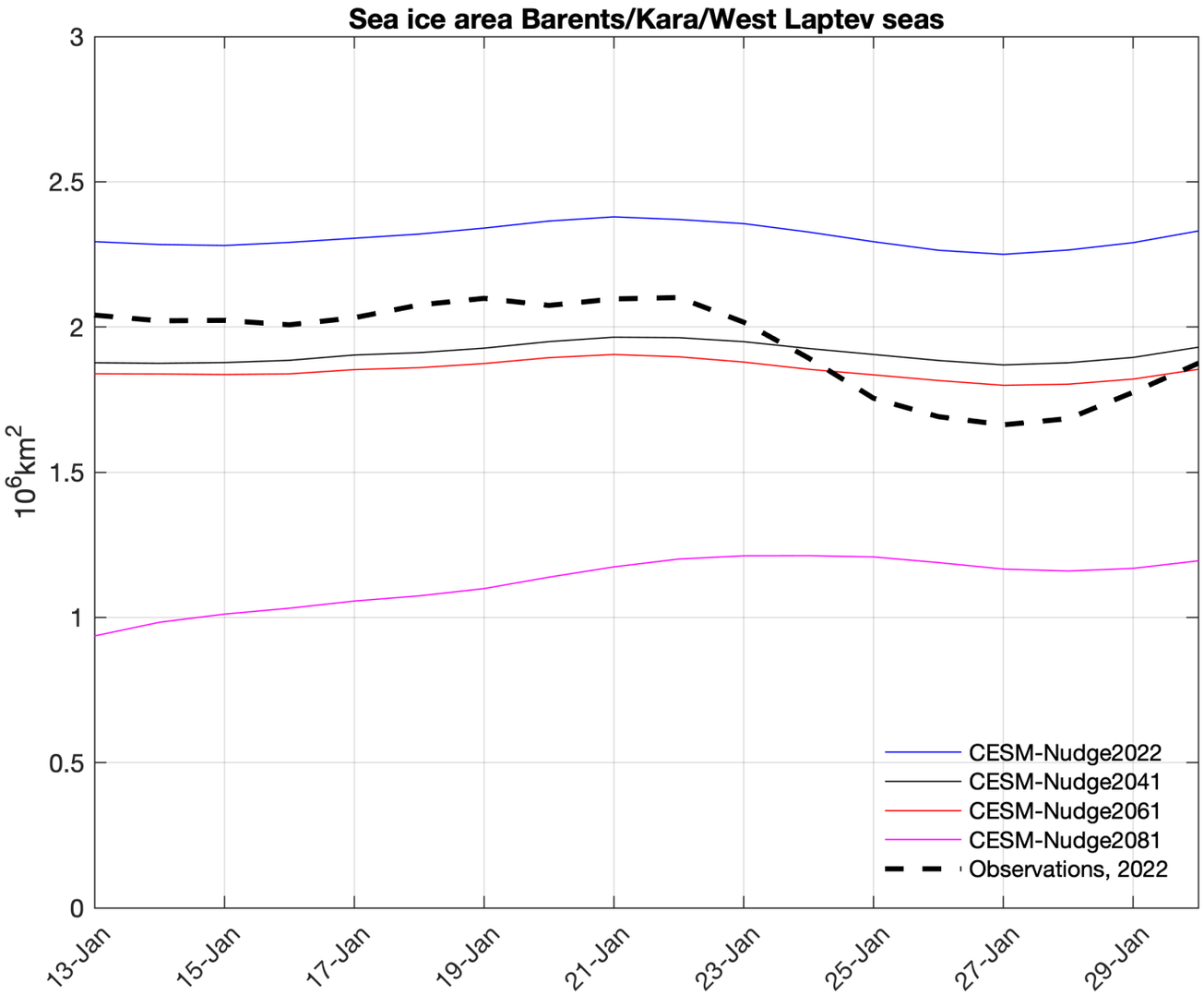
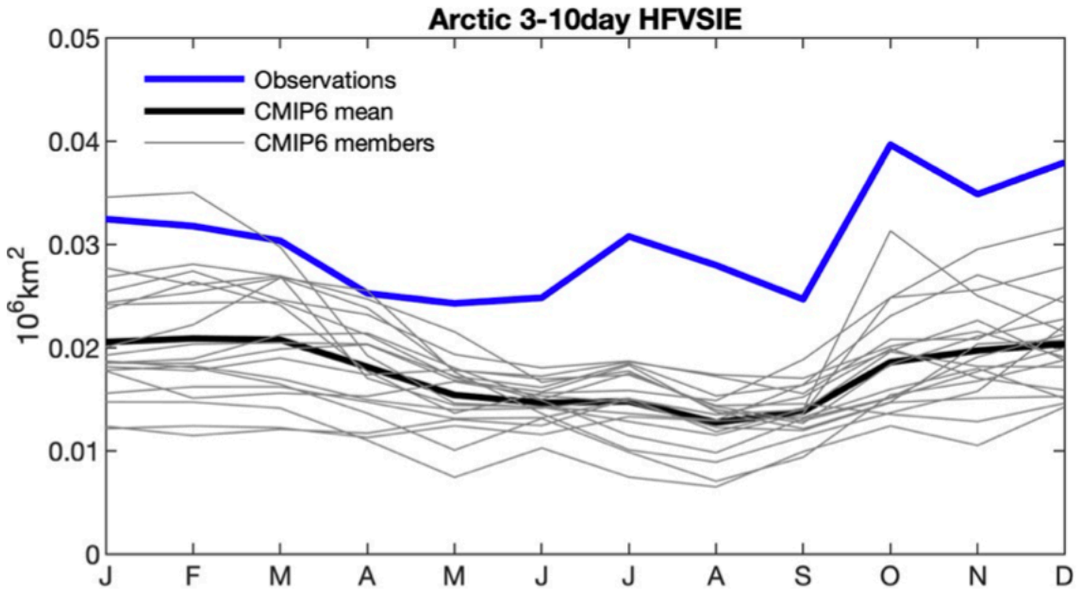


Cyclone Dates

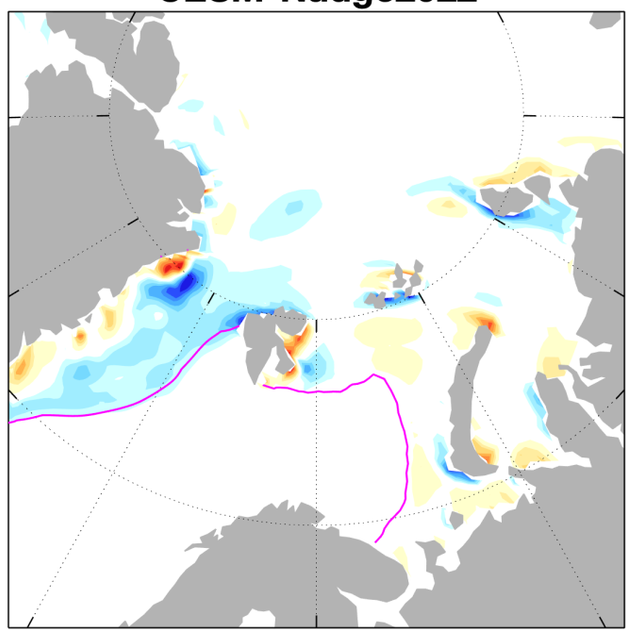


Variability of Arctic SIE at 3-10 timescales… models have too little variability (BW et al 2021)

SIT difference January 21 -> January 27

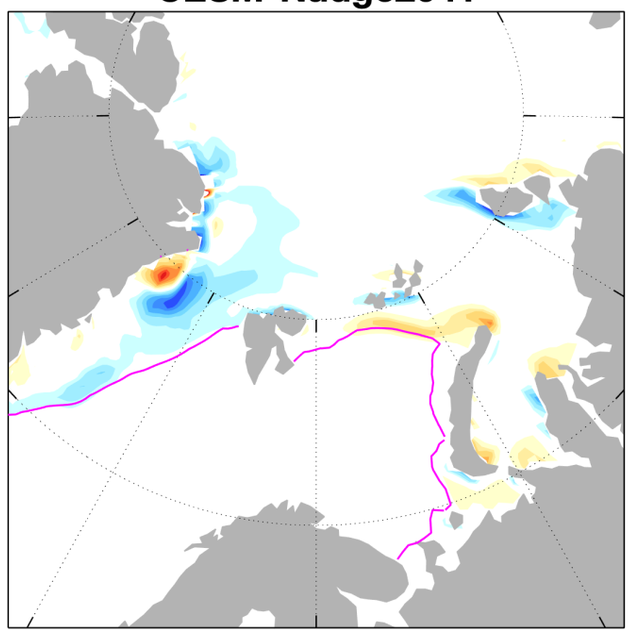
A

CESM-Nudge2022



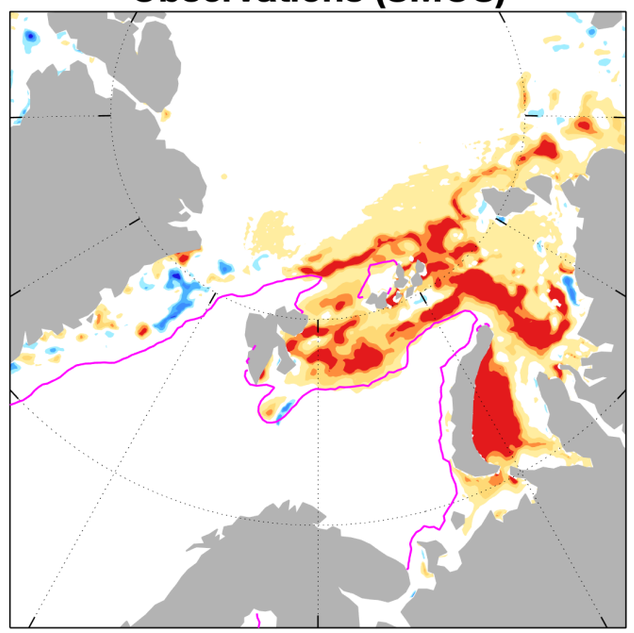
B

CESM-Nudge2041



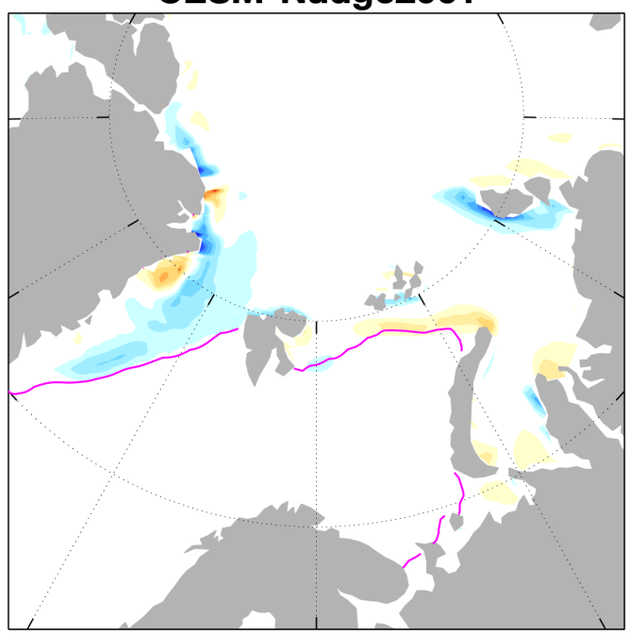
C

Observations (SMOS)



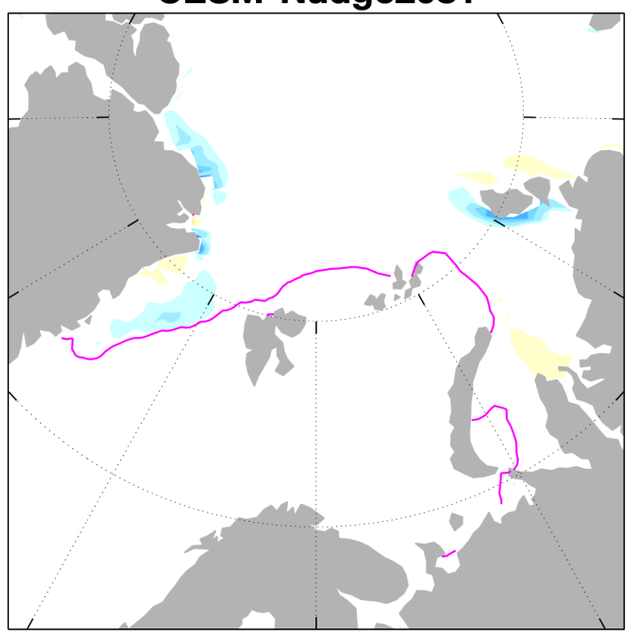
D

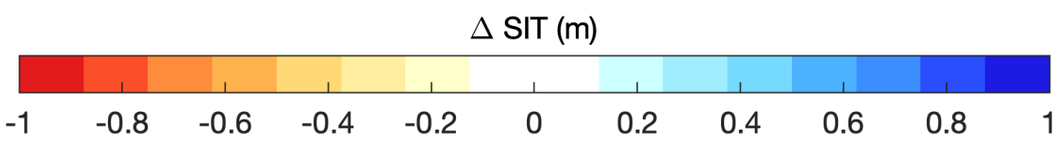
CESM-Nudge2061



E

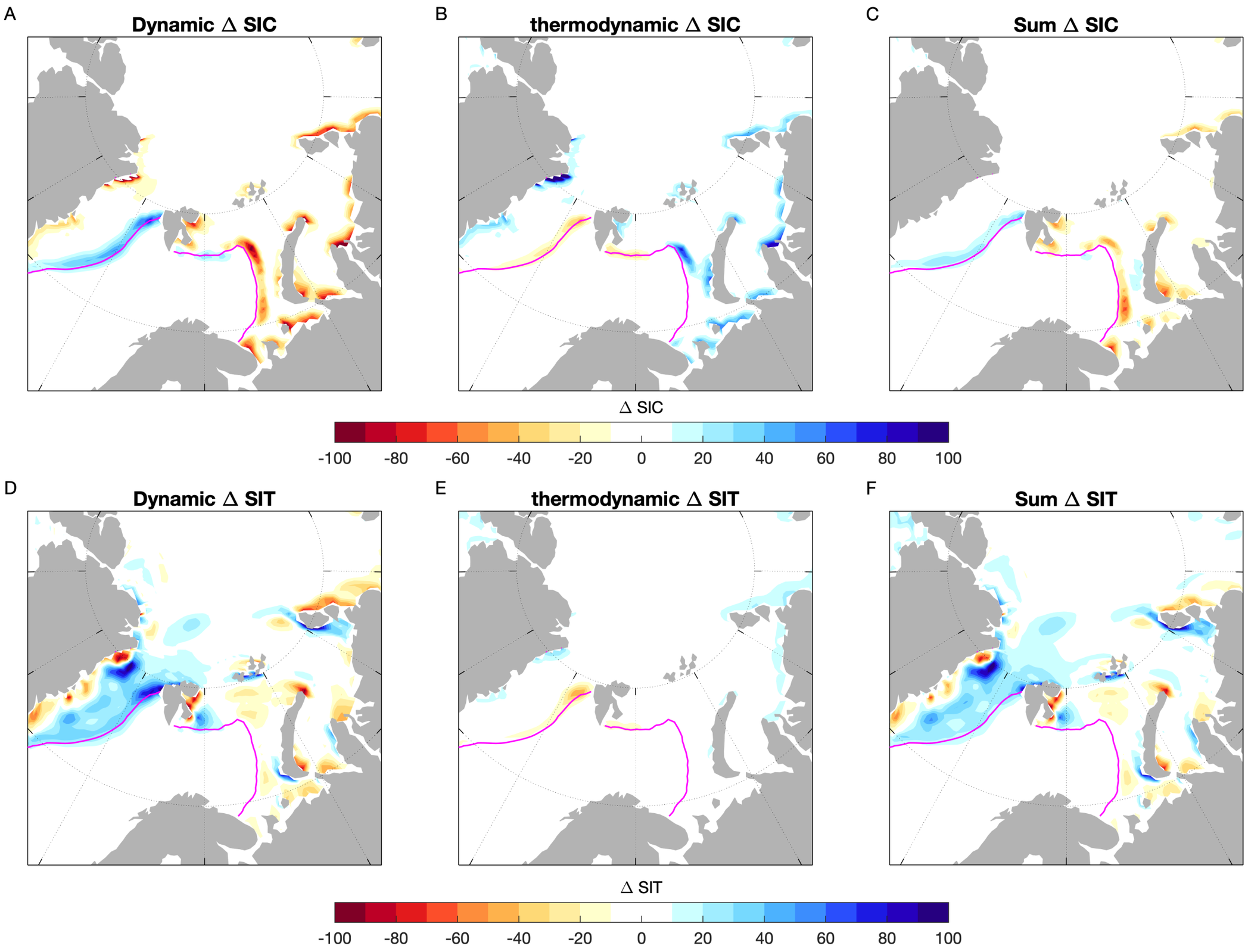
CESM-Nudge2081





Most changes in CESM-Nudge are dynamic

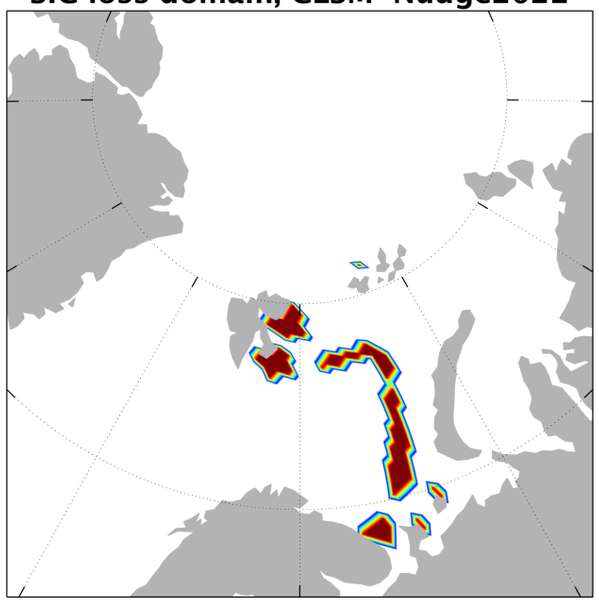
Dynamic and thermodynamic SIC and SITs, January 21-> January 27, CESM-Nudge2021



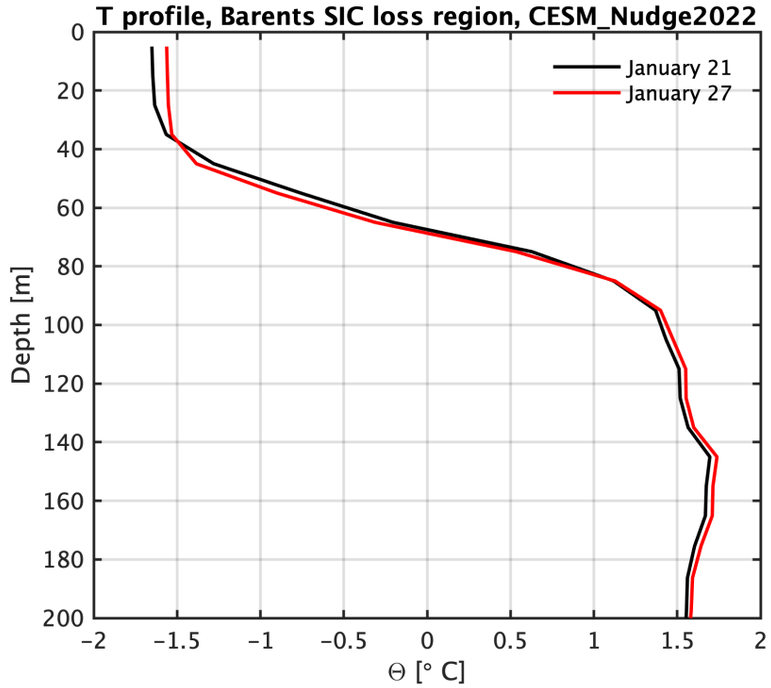
While the model's ocean barely reacts to the cyclone…

CESM-Nudge2022 T & S Profiles

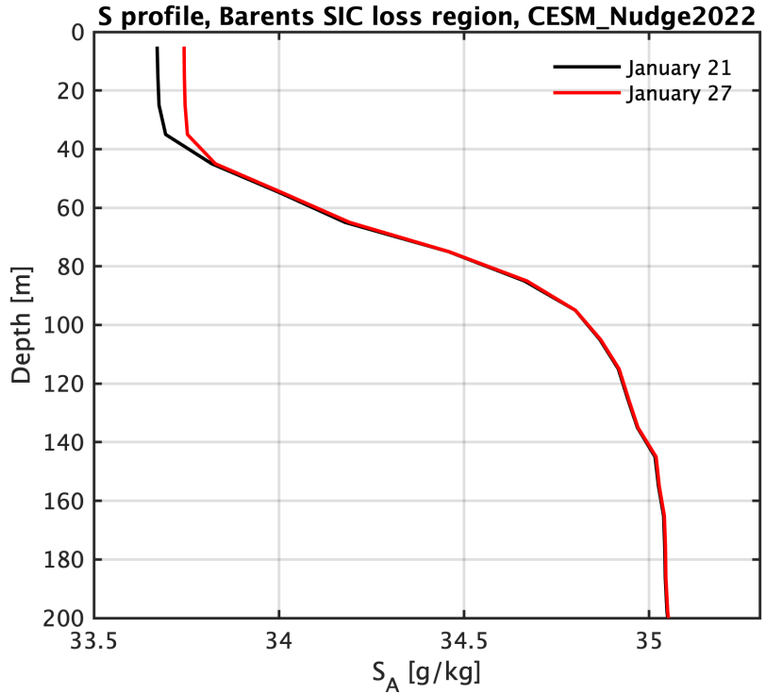
SIC loss domain, CESM-Nudge2022



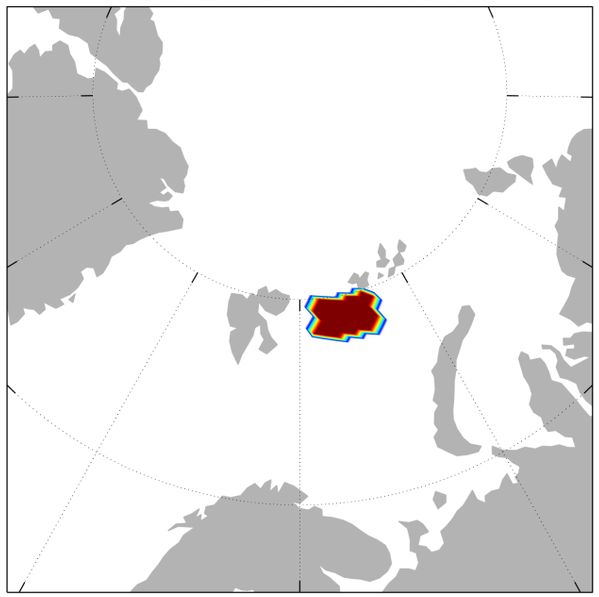
T profile, Barents SIC loss region, CESM_Nudge2022



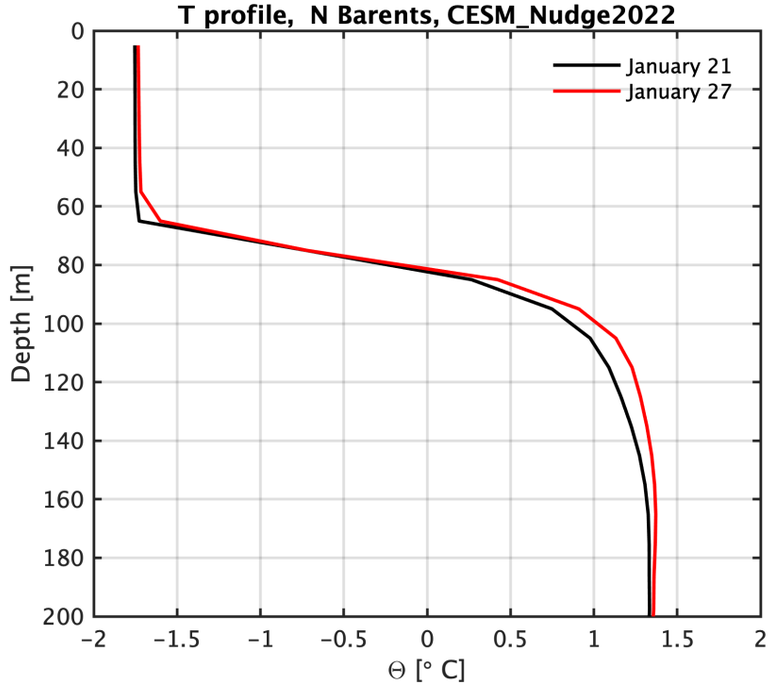
S profile, Barents SIC loss region, CESM_Nudge2022



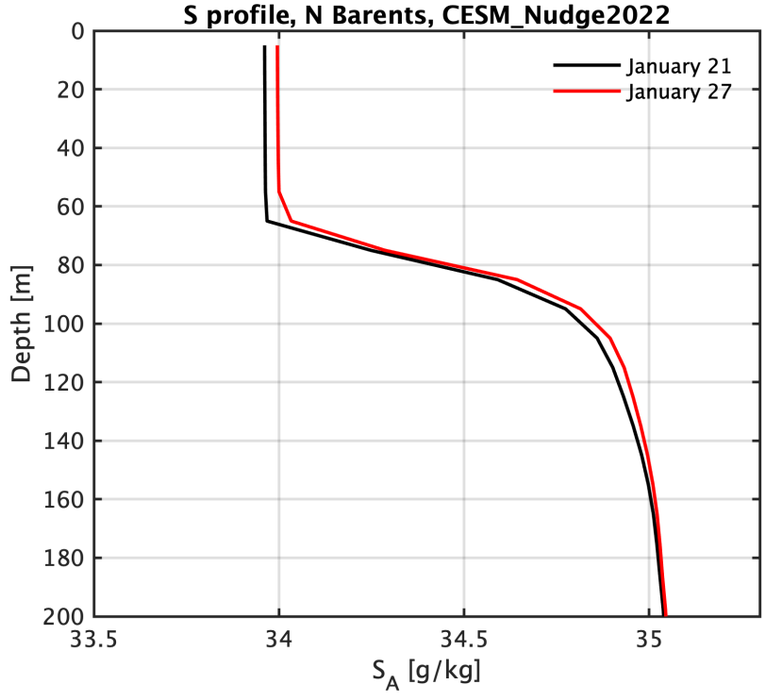
North Barents Sea domain



T profile, N Barents, CESM_Nudge2022

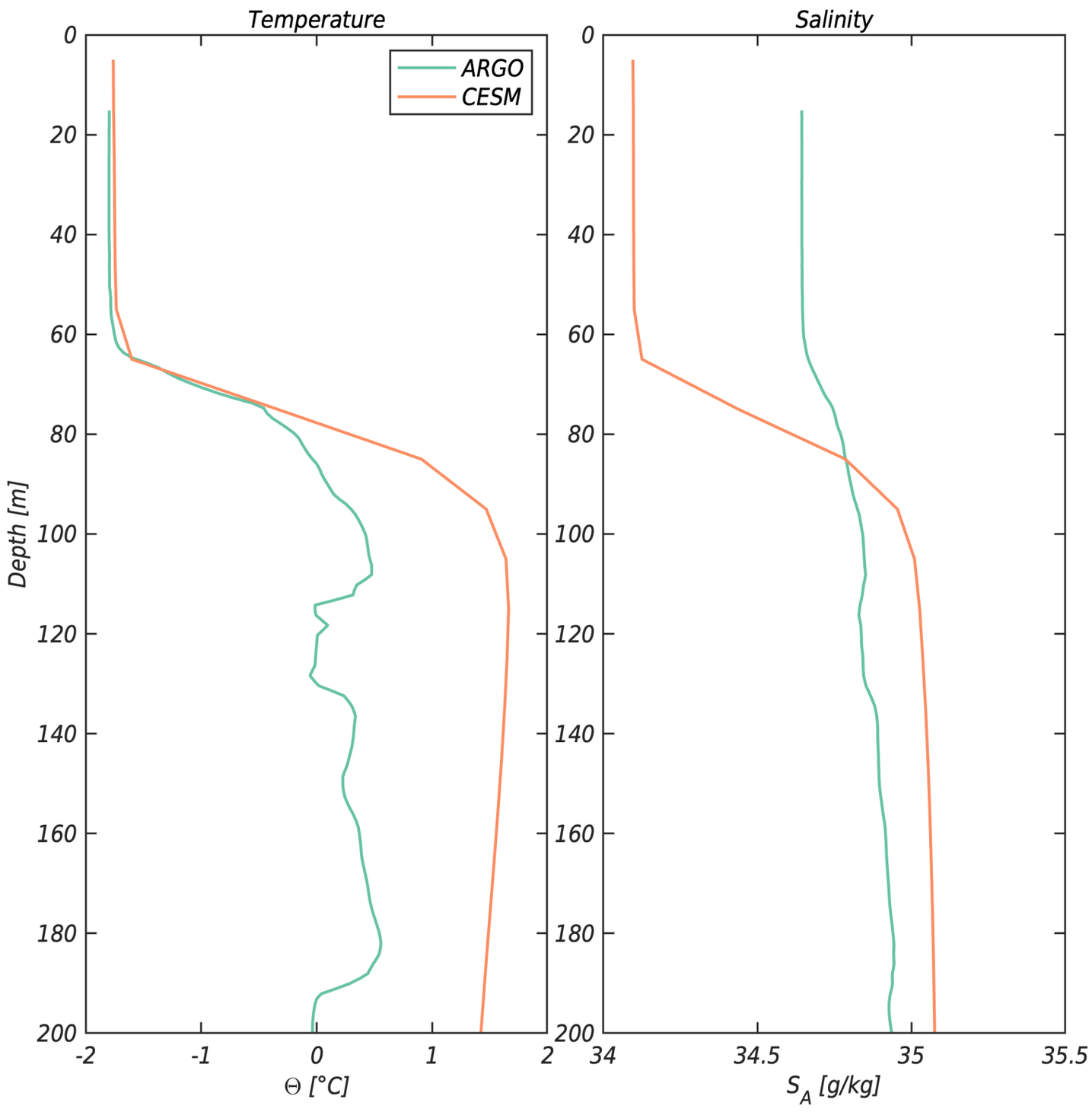


S profile, N Barents, CESM_Nudge2022



too strongly stratified to start with, and not enough momentum transfer? (No waves in sea ice in model)

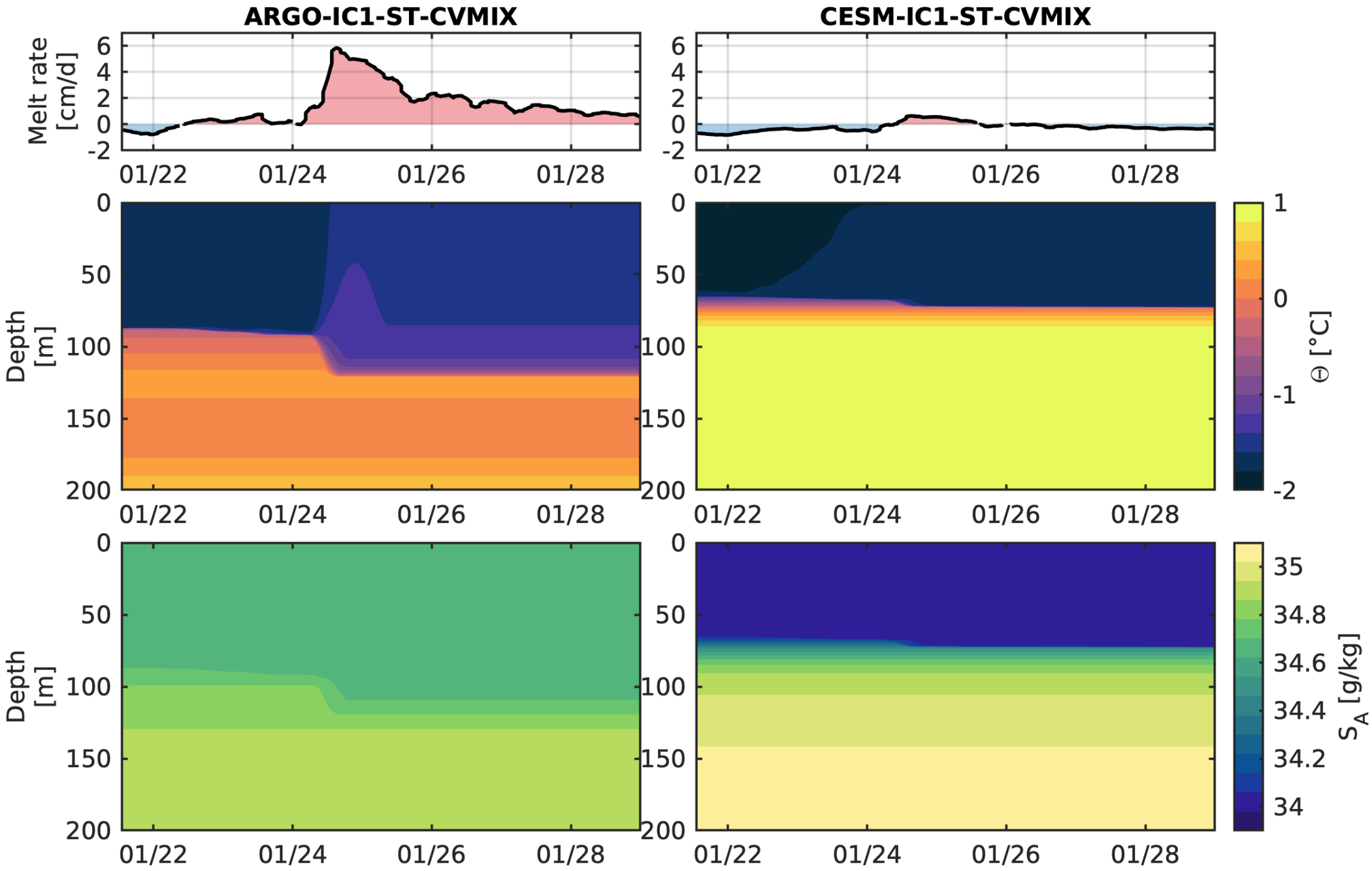
CESM1 is too strongly stratified in the Barents

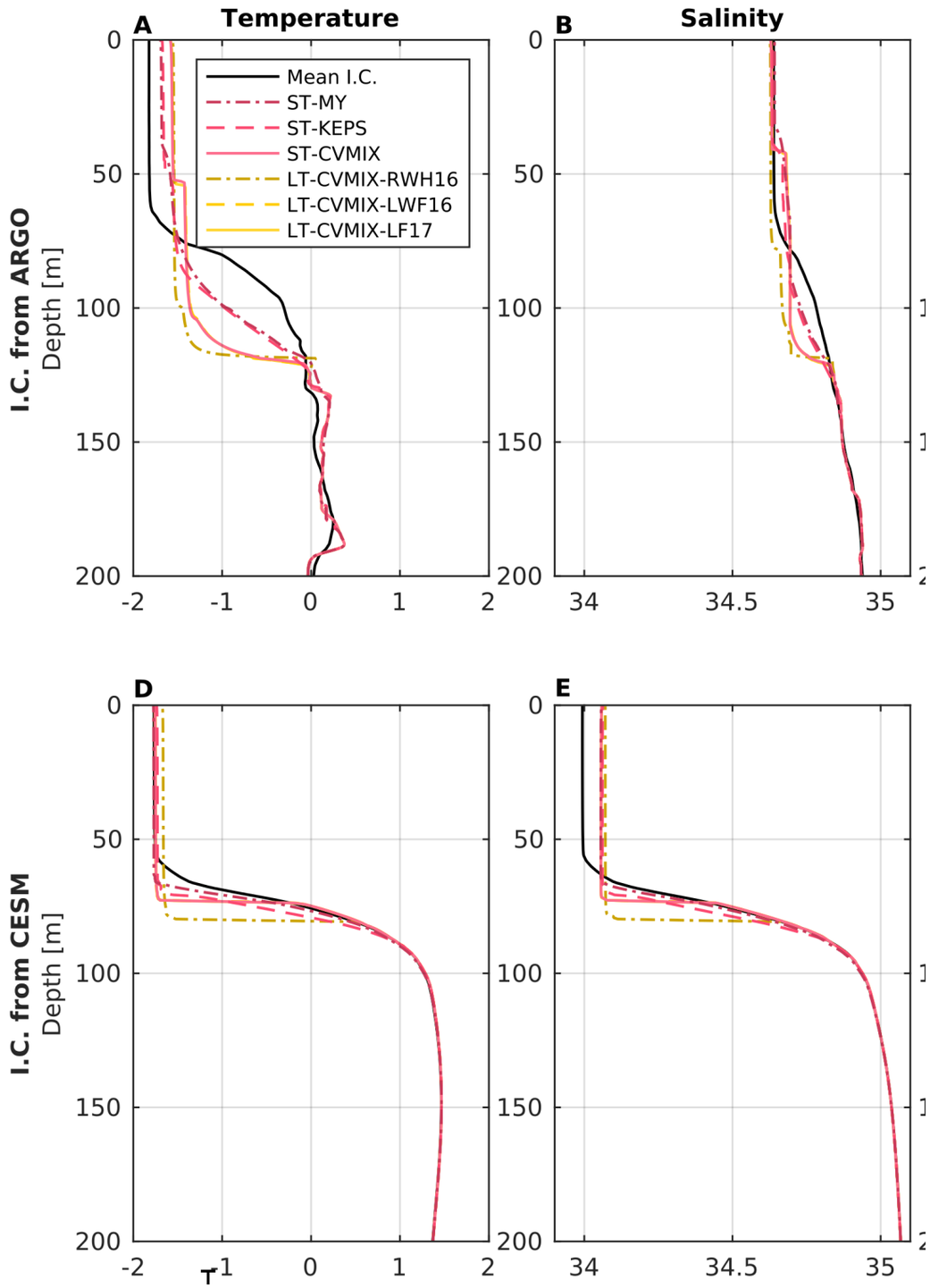


1-D ocean/sea ice model (General Ocean Turbulence model coupled with 3-layer Winton sea ice model) shows impact of initial stratification

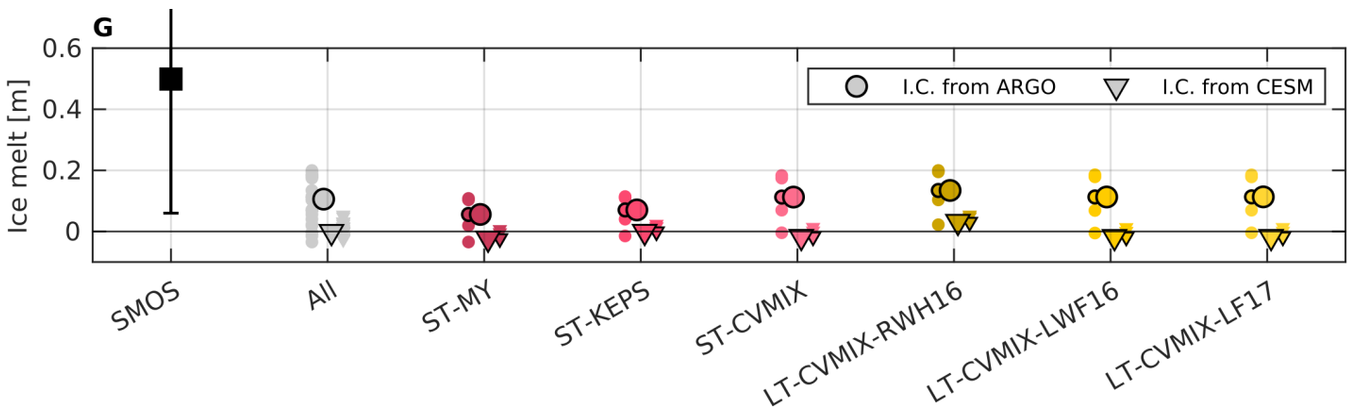
GOTM initialized with ARGO T-S profile

GOTM initialized with CESM1 T-S profile

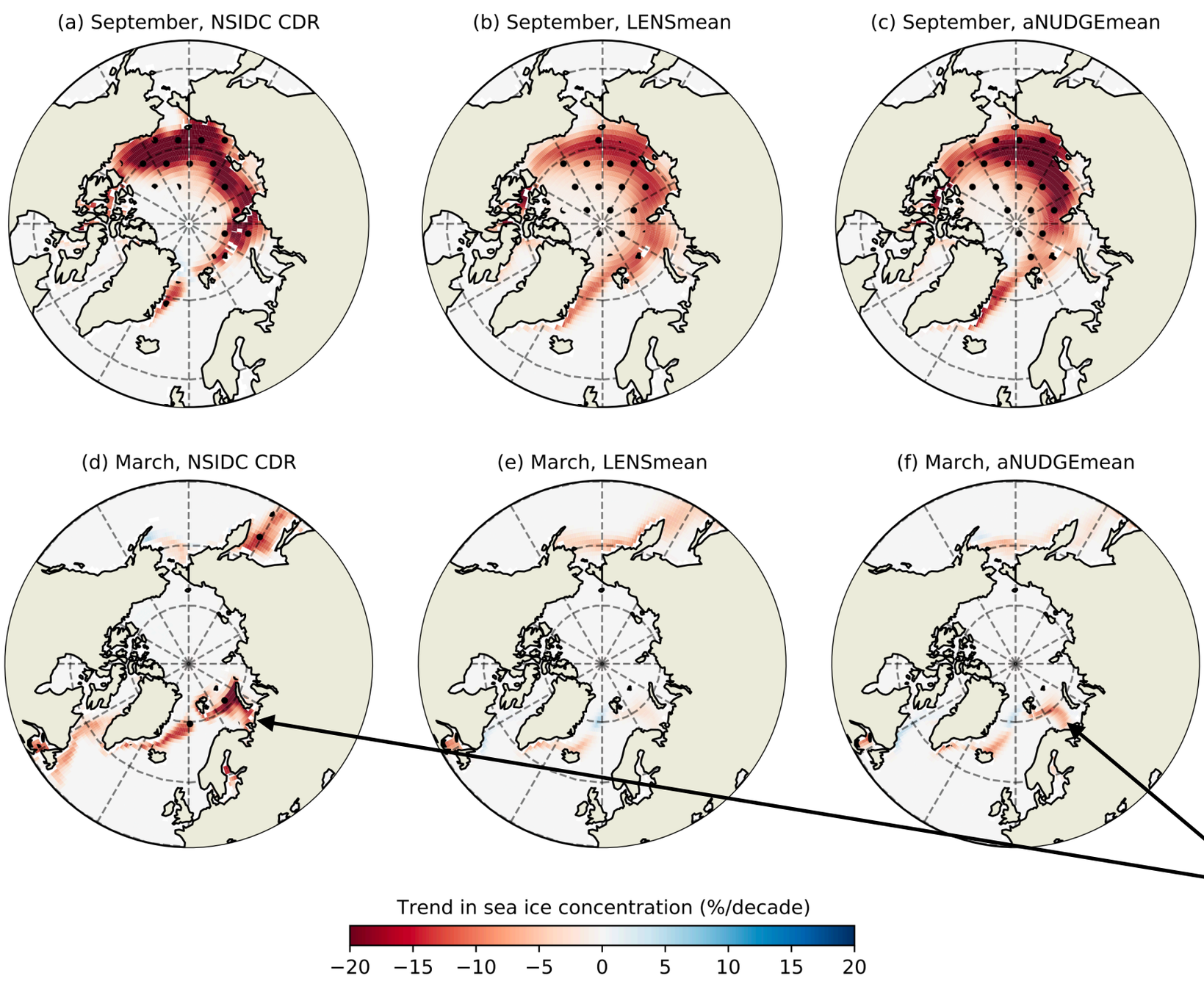




We run the 1-D model under six different turbulent mixing parameterizations associated with either shear-driven mixing (designated ST), or surface-wave-driven Langmuir turbulence (designated LT)



Are there also low frequency (long term trend) biases implications for Barents/Kara seas?

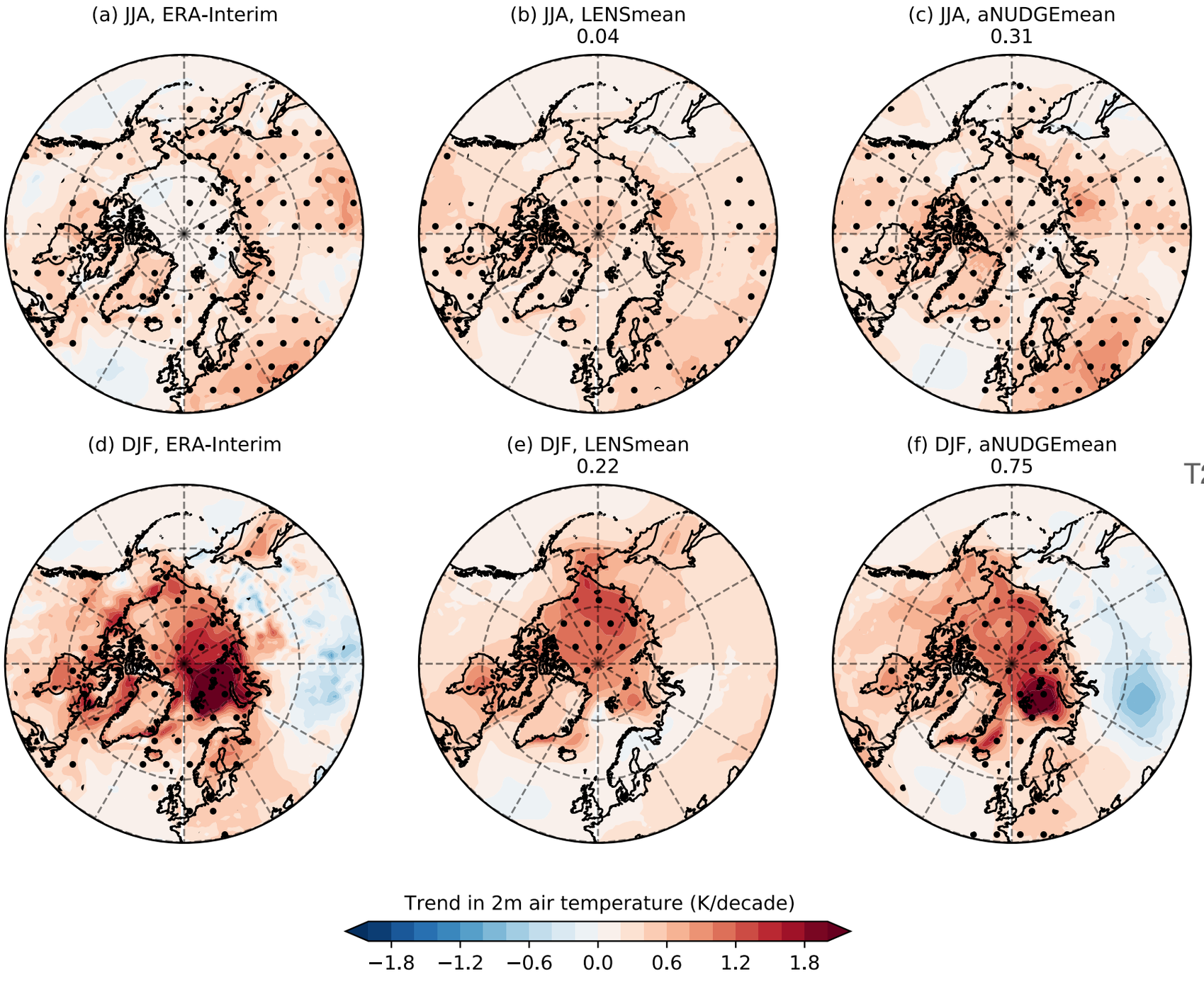


SIC trends in CESM-LENS and CESM-Nudge, 1979-2018

Why is long-term winter sea ice loss in Barents Sea biased low in CESM-Nudge, even if simulations have observed southerly wind trend

Roach and BW, 2022

Are there also low frequency (long term trend) bias implications for Barents/Kara seas?



T2m trends in CESM-LENS and CESM-Nudge, 1979-2018

Roach and BW, 2022