

Looking back at 2022, a year of polar extremes

A record Arctic cyclone in January 2022

Record low Antarctic sea ice in February 2022

Record heat wave in East Antarctica in March 2022

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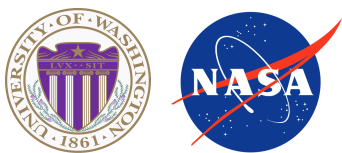


Tyler Cox
Atmos. sci., University of Washington



Zac Espinosa
Atmos. sci., University of Washington



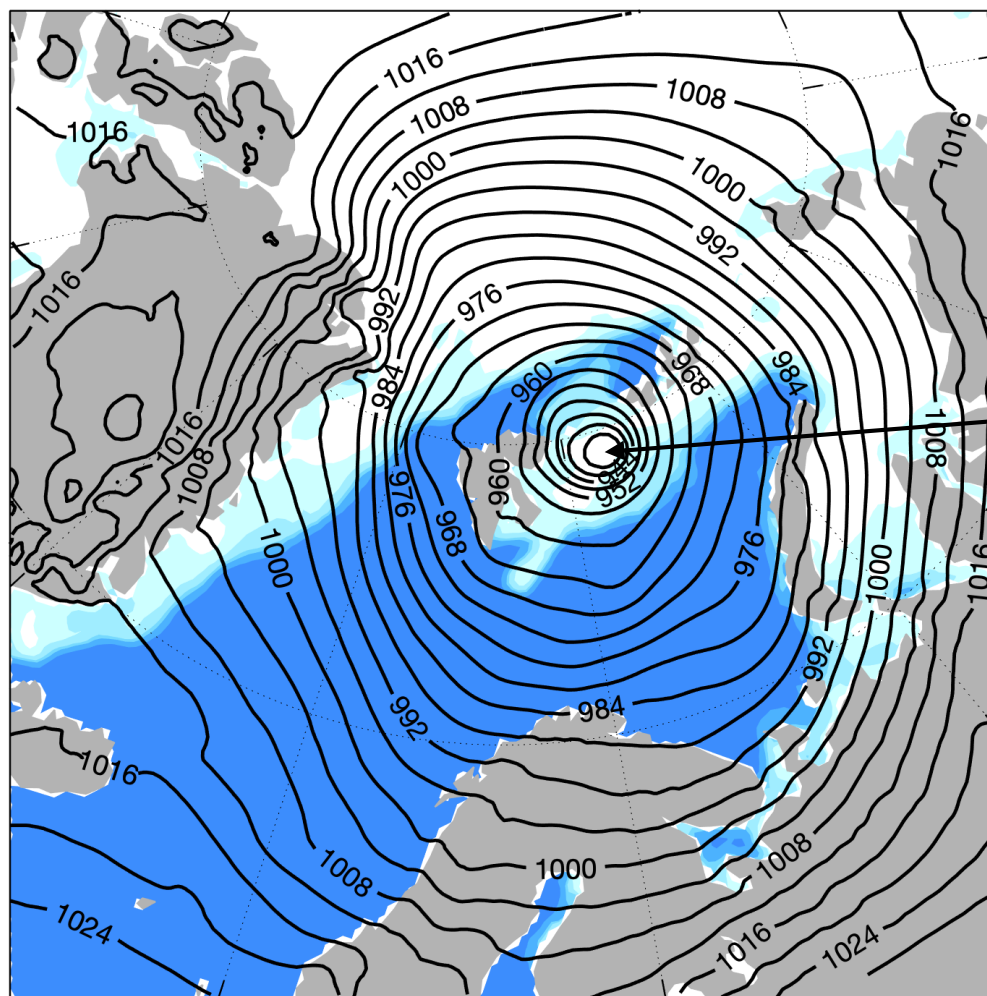


Record Arctic Cyclone of January 2022: Characteristics, Impacts, and Predictability

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Chelsea Parker^{4,5} , and Christopher Horvat^{6,7} 



24-Jan-2022 13UTC



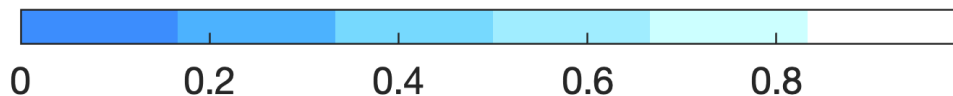
932mb!



**Previous record:
938mb (80N-90N)**

(ERA-5 for atmos/waves, passive microwave for sea ice)

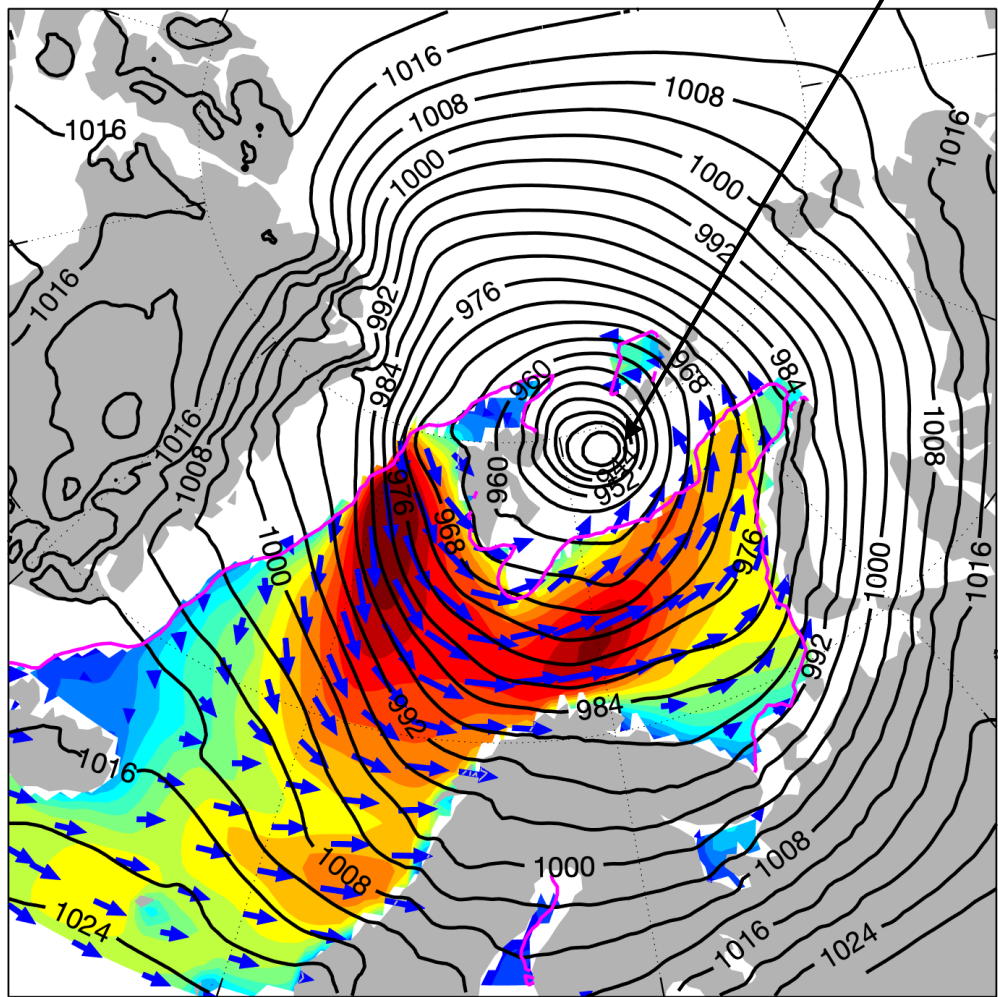
Sea ice concentration



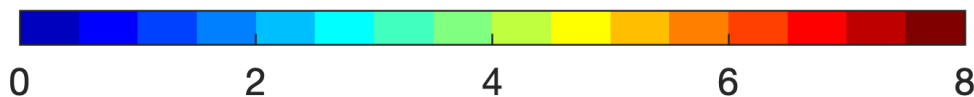
Windy and wavy

24-Jan-2022 13UTC

100km/h
1-hr winds



Significant Wave Height (m)

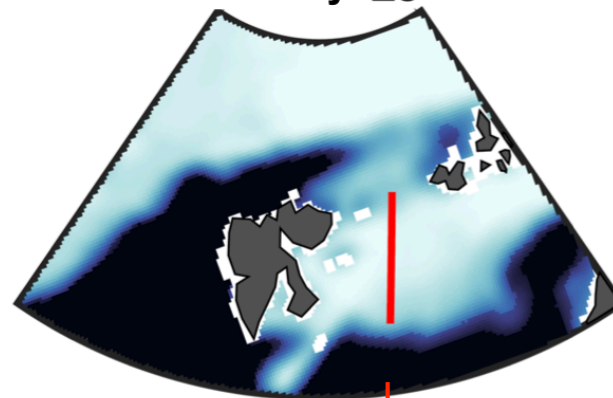


Wave direction

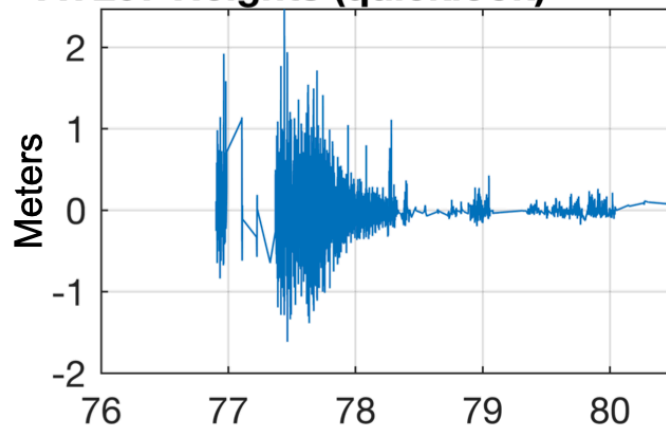


ICESat-2 observed
waves in sea ice

January 23

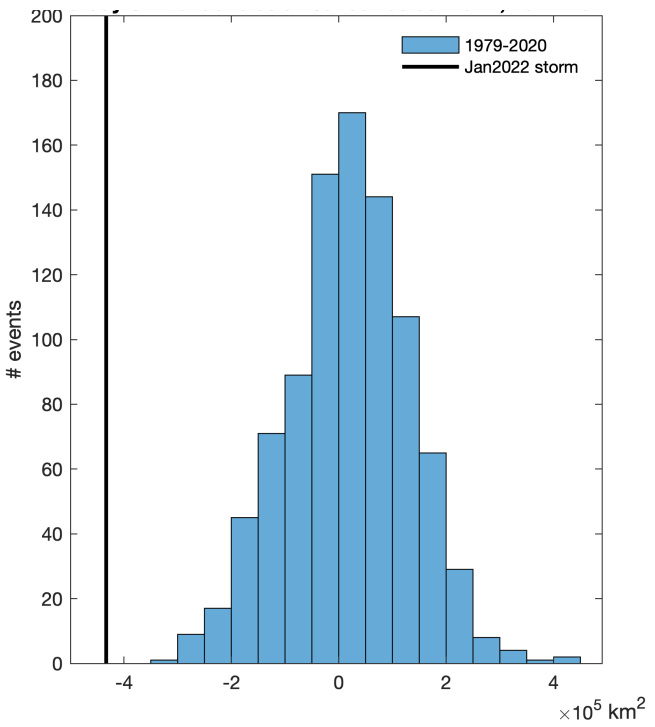
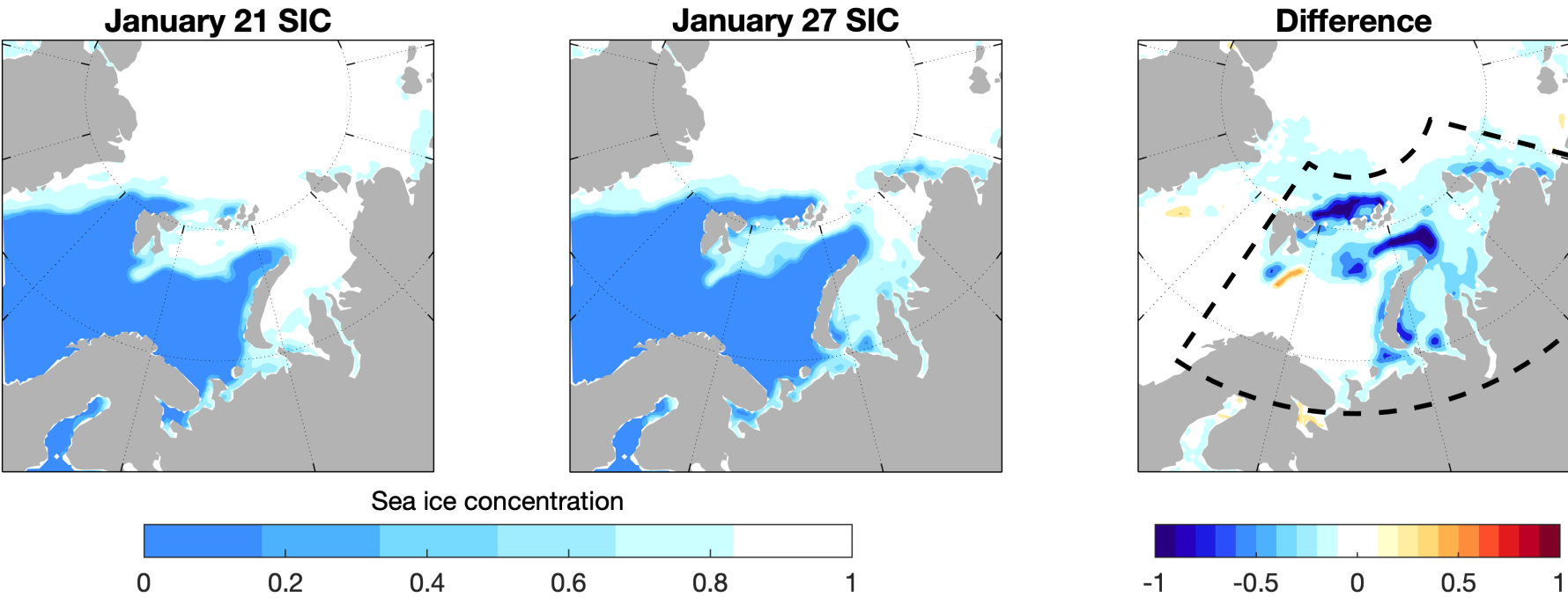


ATL07 Heights (quicklook)



2m+ waves in sea ice

The cyclone resulted in a record weekly sea ice area loss in the Barents/Kara/west Laptev

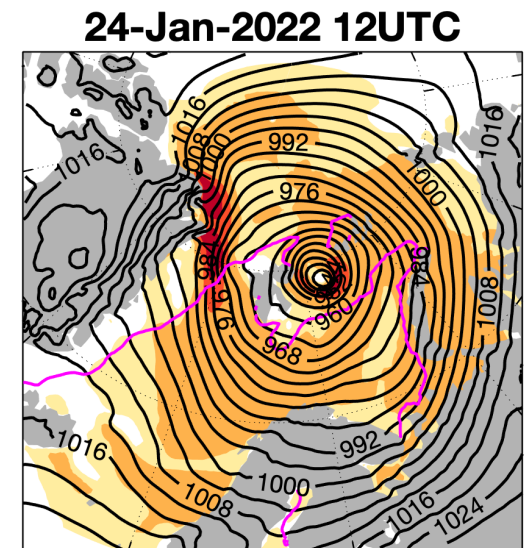
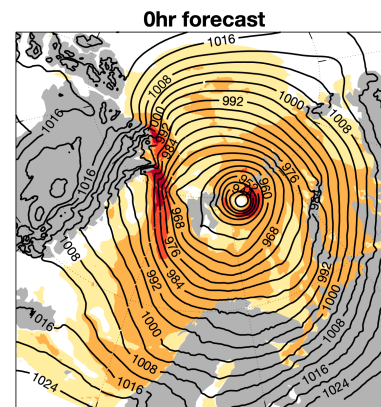
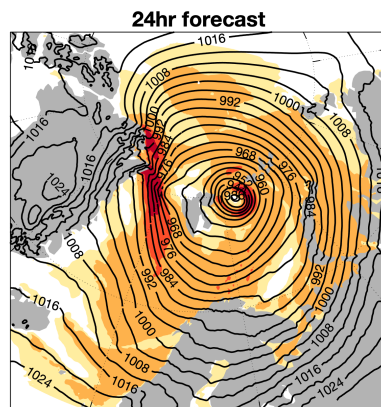
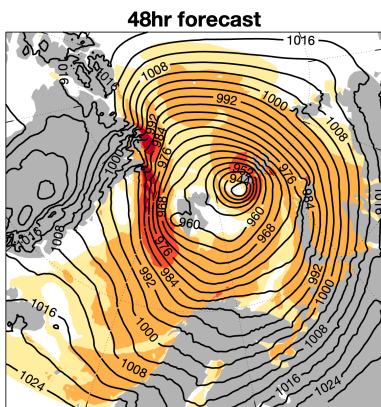
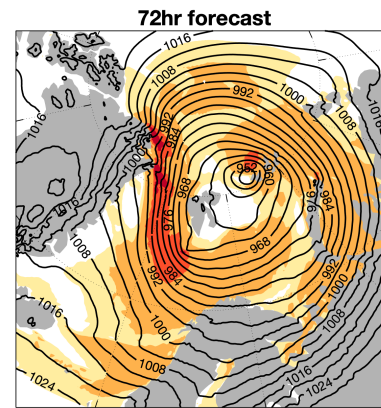
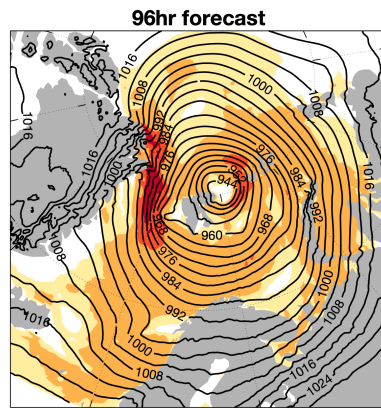
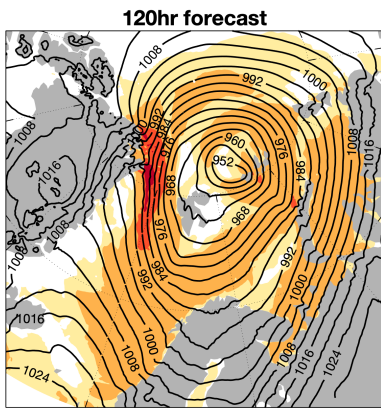
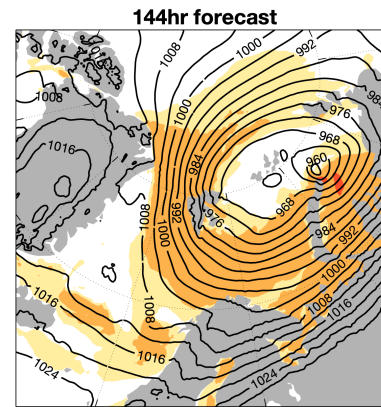
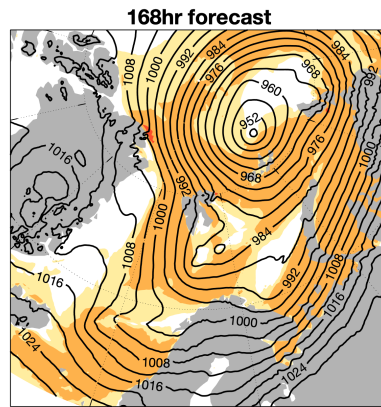
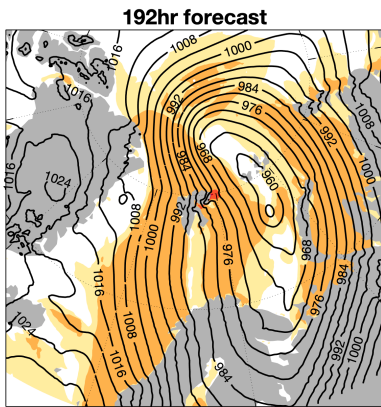


Six-day loss of SIA in January 2022 cyclone: 30% greater than previous record

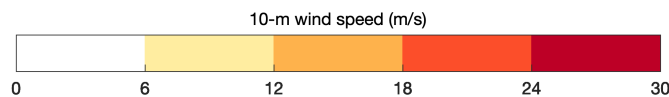
Almost 0.5 million square km

The cyclone was forecast really well (ECMWF IFS hi-res forecasts), especially at 5 day and shorter leadtimes

8-to-0 day leadtime forecasts of **SLP** and **winds** for 24 January 12UTC

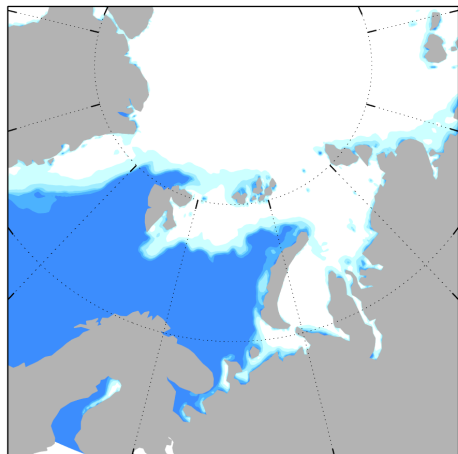


(Target)

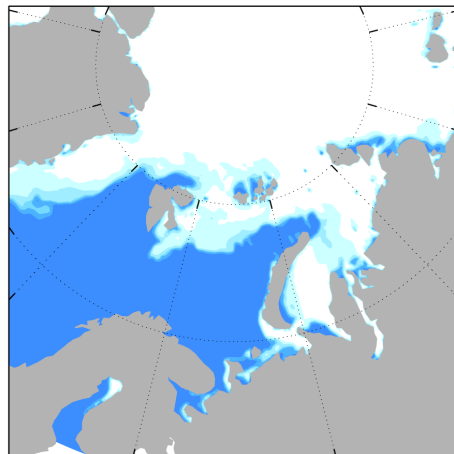


But the sea ice changes were not forecast as well

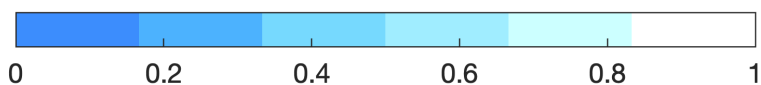
Forecast initialized
21-Jan-2022



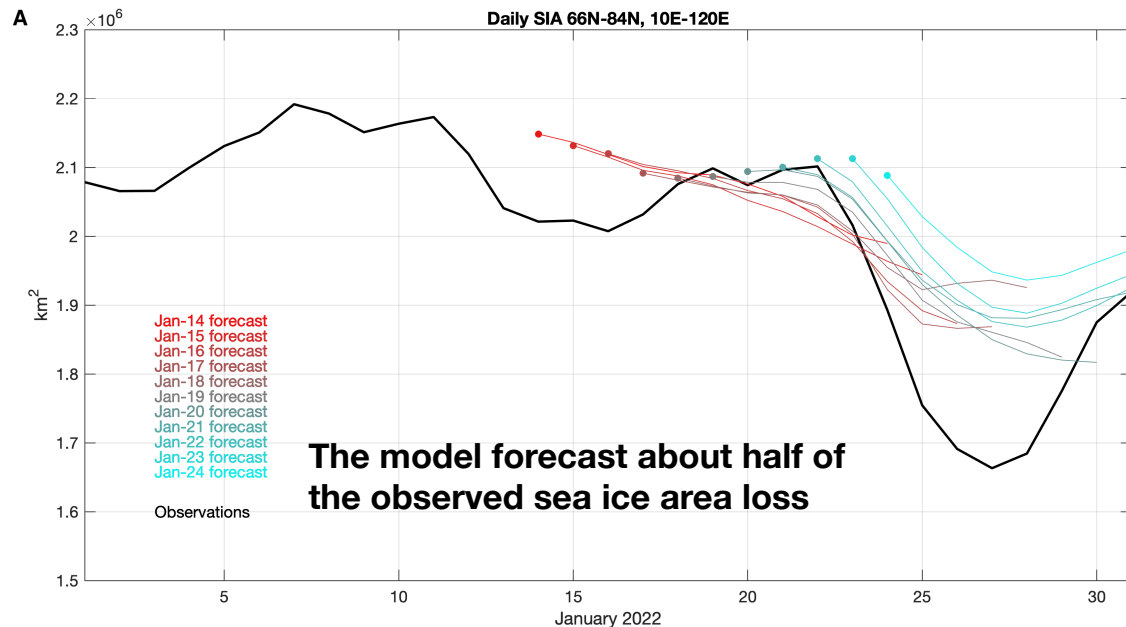
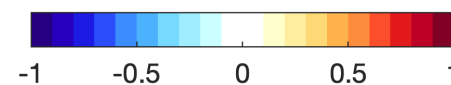
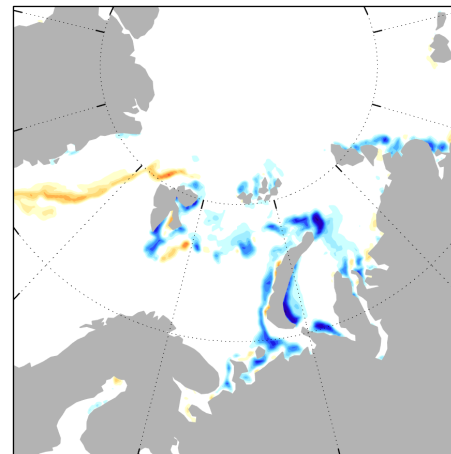
Forecast on
27-Jan-2022



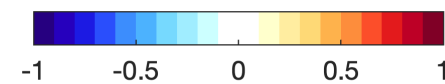
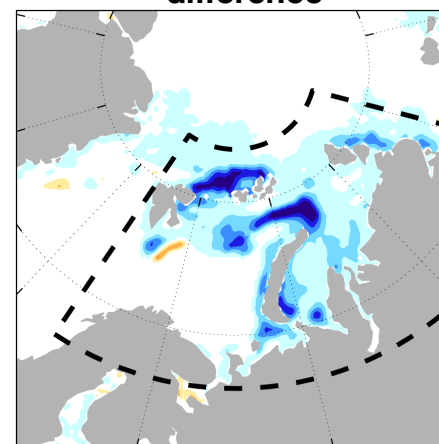
Sea ice concentration



Forecast
Difference



Observed
difference



Summary Part I

A record low SLP Arctic cyclone occurred in January 2022, reaching a depth of 932mb.

This low resulted in a record weekly loss of sea ice (and record surface wind speeds), despite non-record warm conditions.

Despite anomalous thermodynamics, dynamics likely played main role. Very large waves observed deep into sea-ice pack

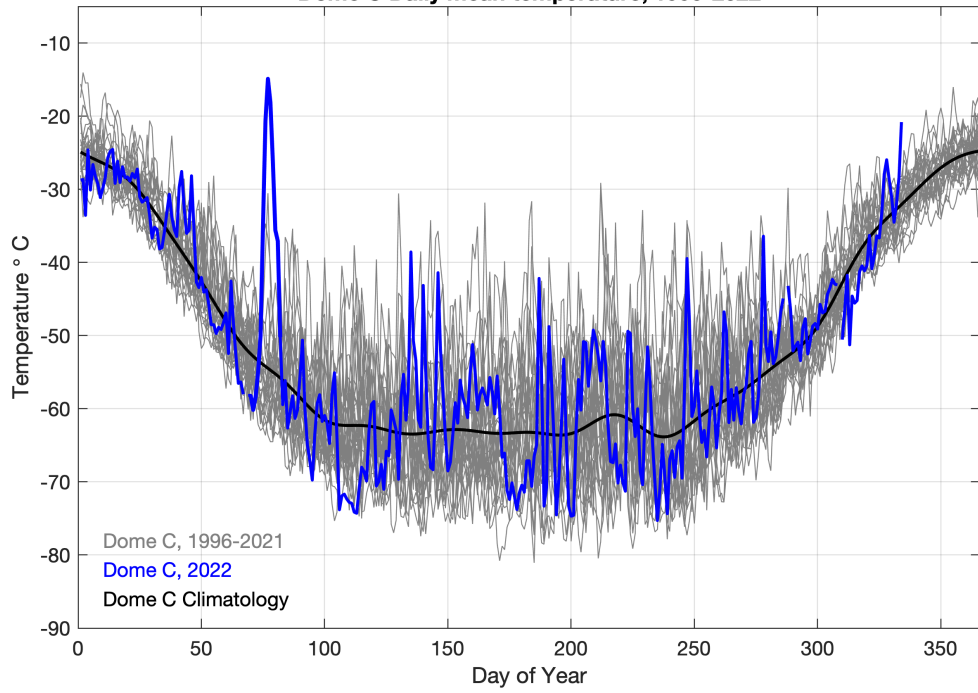
While the storm was well predicted, the large loss in sea ice was not.

Was this due to biases in sea ice initial conditions (e.g., too thick sea ice) and/or missing physics (e.g., no wave-sea ice interaction). Unknown ocean heat flux/melt (maybe significant due to wind-stirring?).

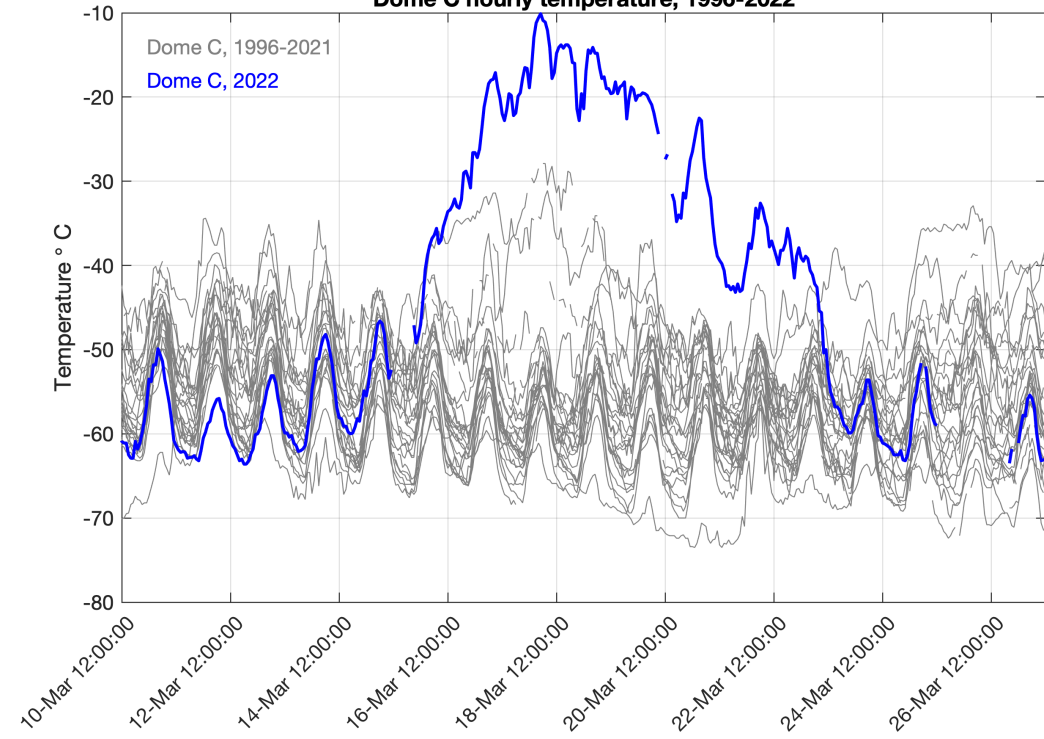
Blanchard-Wrigglesworth, E., Webster, M., Boisvert, L., Parker, C. and Horvat, C., 2022. Record Arctic Cyclone of January 2022: Characteristics, Impacts, and Predictability. *Journal of Geophysical Research: Atmospheres*, 127(21), p.e2022JD037161.

March 2022 heat wave

Dome C Daily mean temperature, 1996-2022

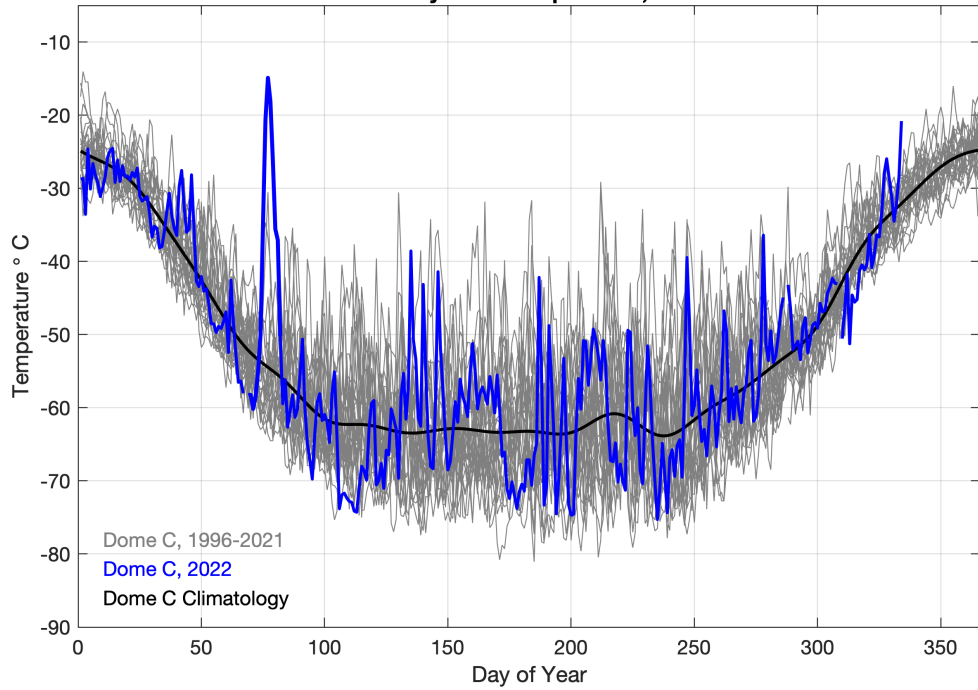


Dome C hourly temperature, 1996-2022

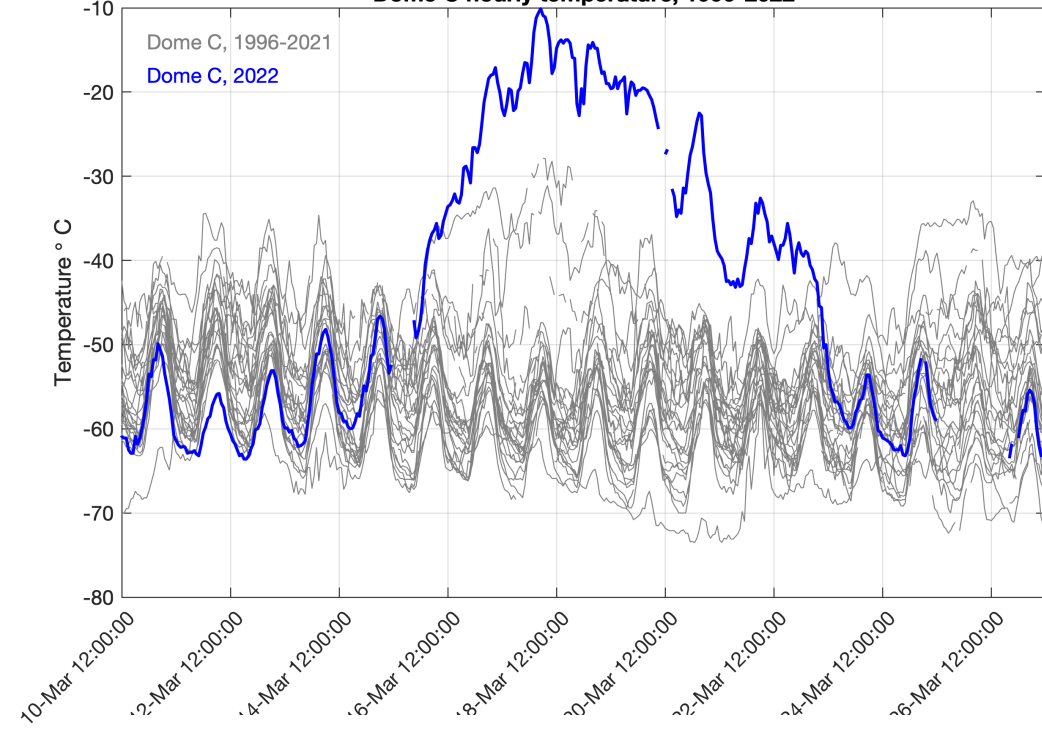


March 2022 heat wave

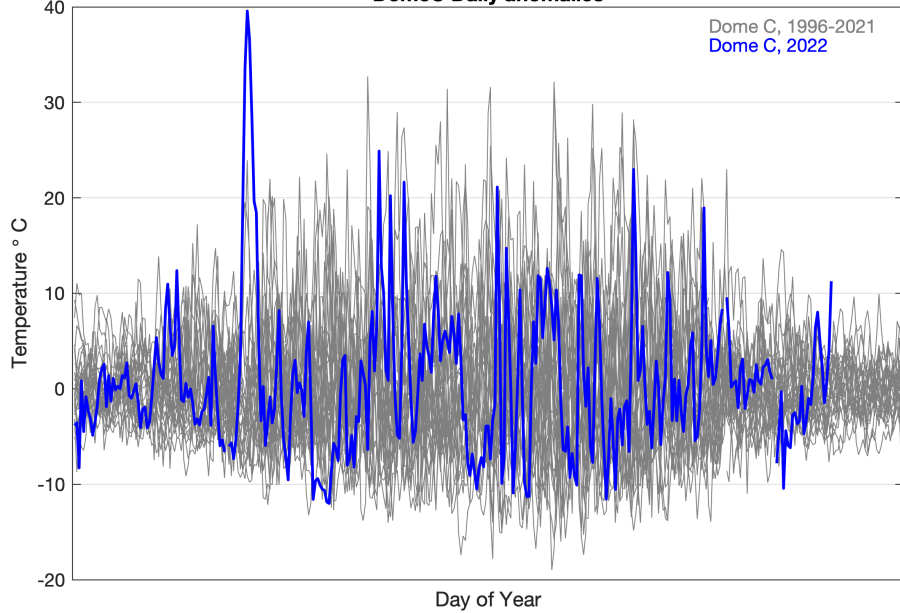
Dome C Daily mean temperature, 1996-2022



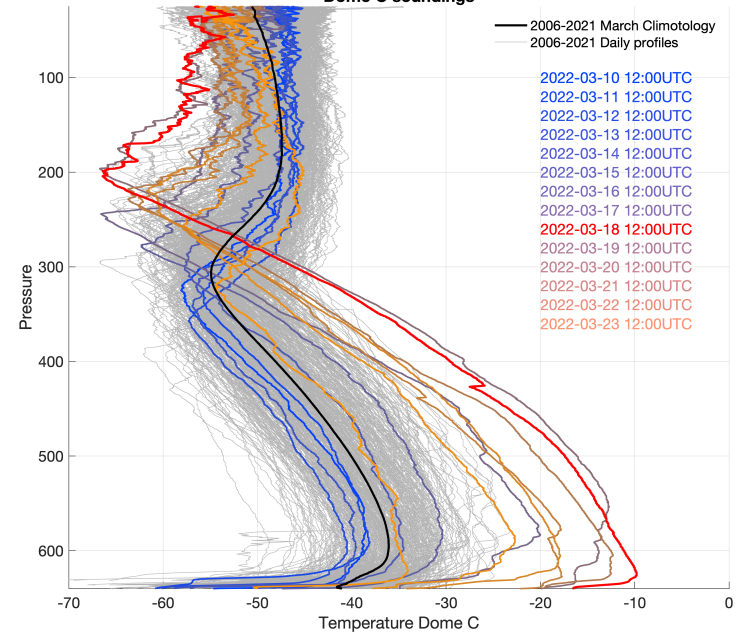
Dome C hourly temperature, 1996-2022



DomeC Daily anomalies



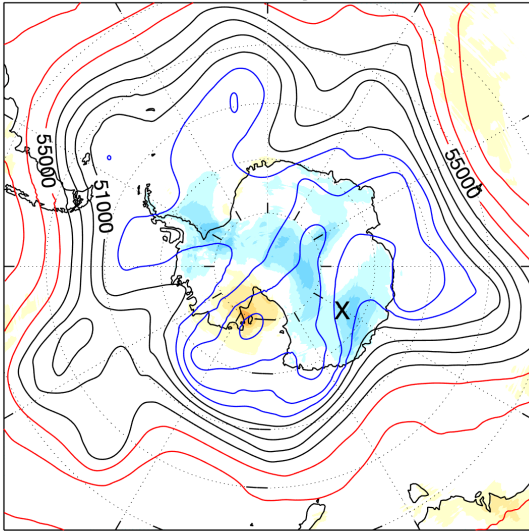
Dome C soundings



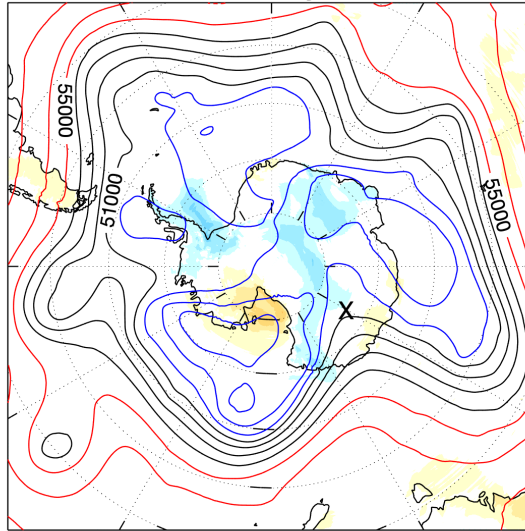
March 2022 heat wave

Z500 (contours) and T2m anomalies (shading), X=Dome C

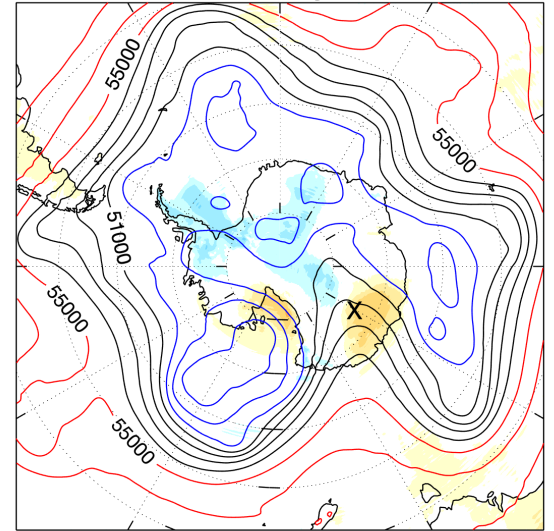
Z500 & T500 anomaly 14-Mar-2022



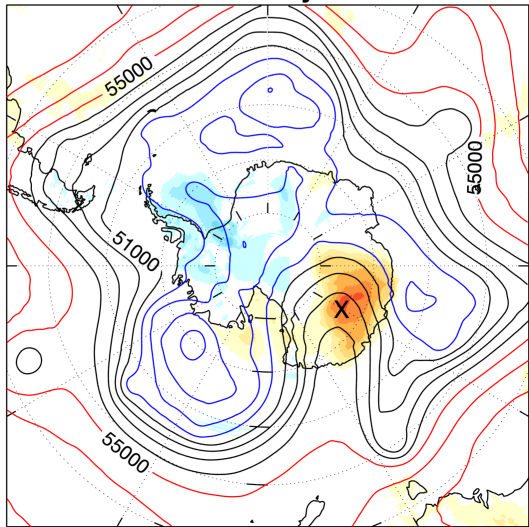
Z500 & T500 anomaly 15-Mar-2022



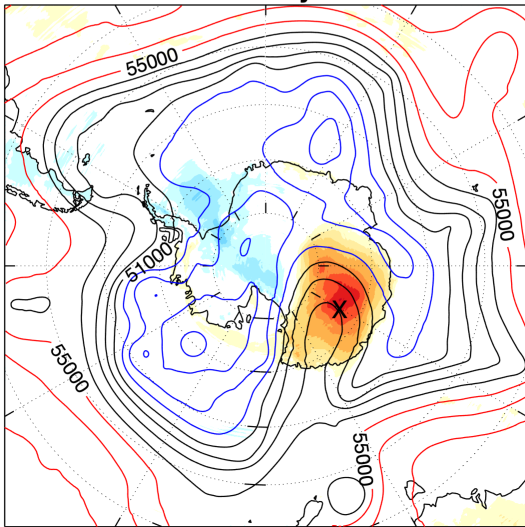
Z500 & T500 anomaly 16-Mar-2022



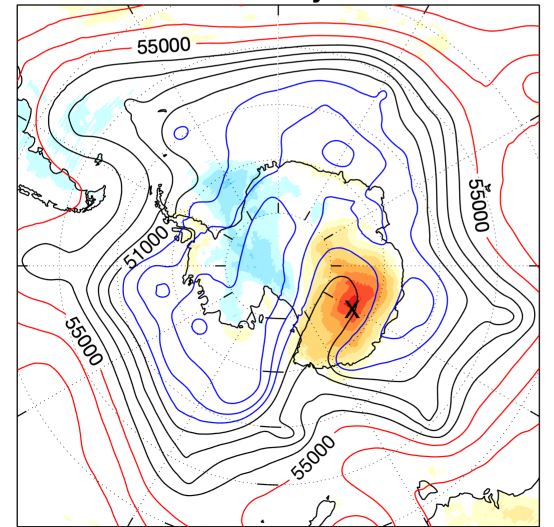
Z500 & T500 anomaly 17-Mar-2022



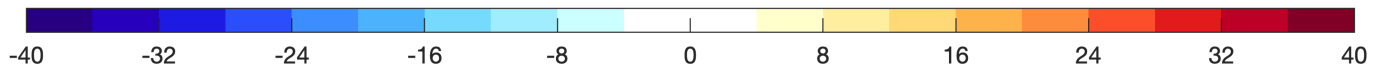
Z500 & T500 anomaly 18-Mar-2022



Z500 & T500 anomaly 19-Mar-2022



T2m anomaly ° C

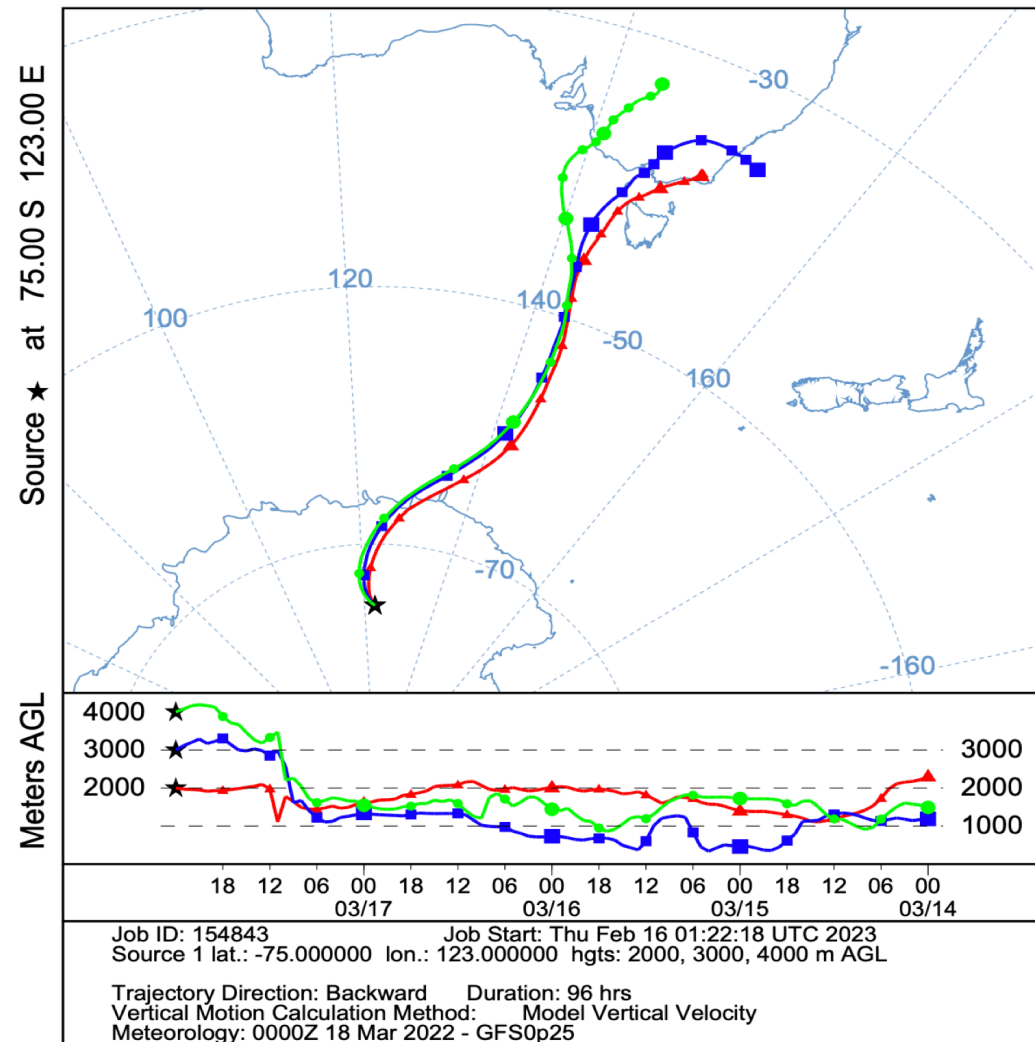
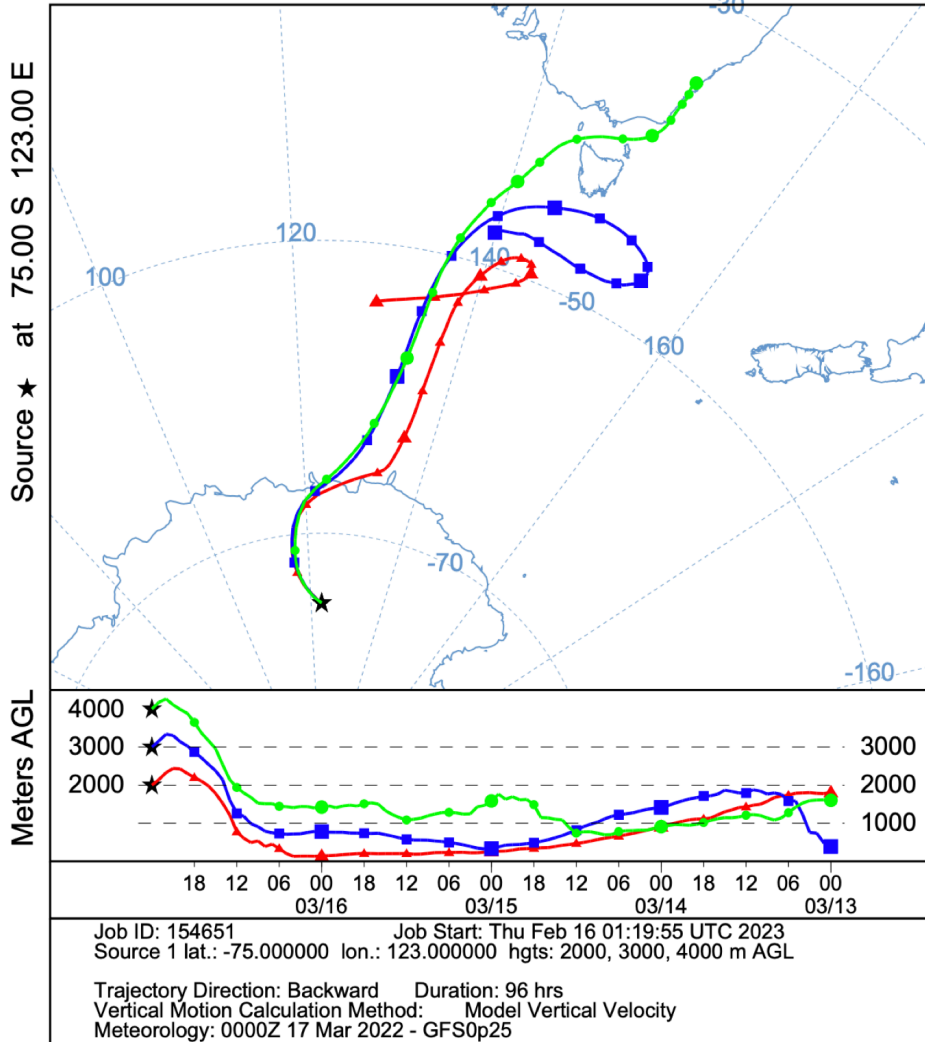


March 2022 heat wave

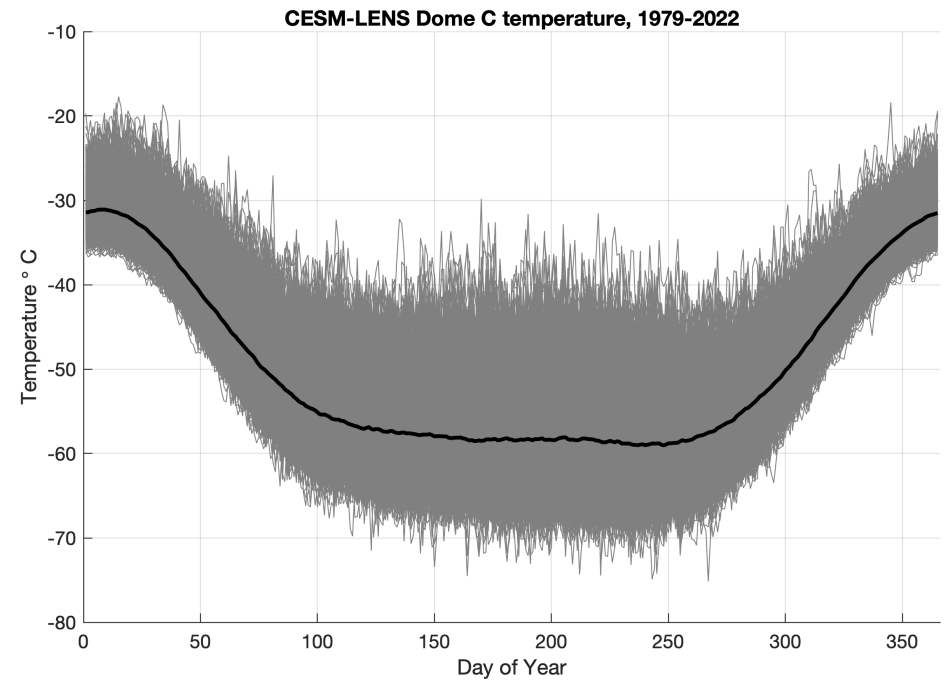
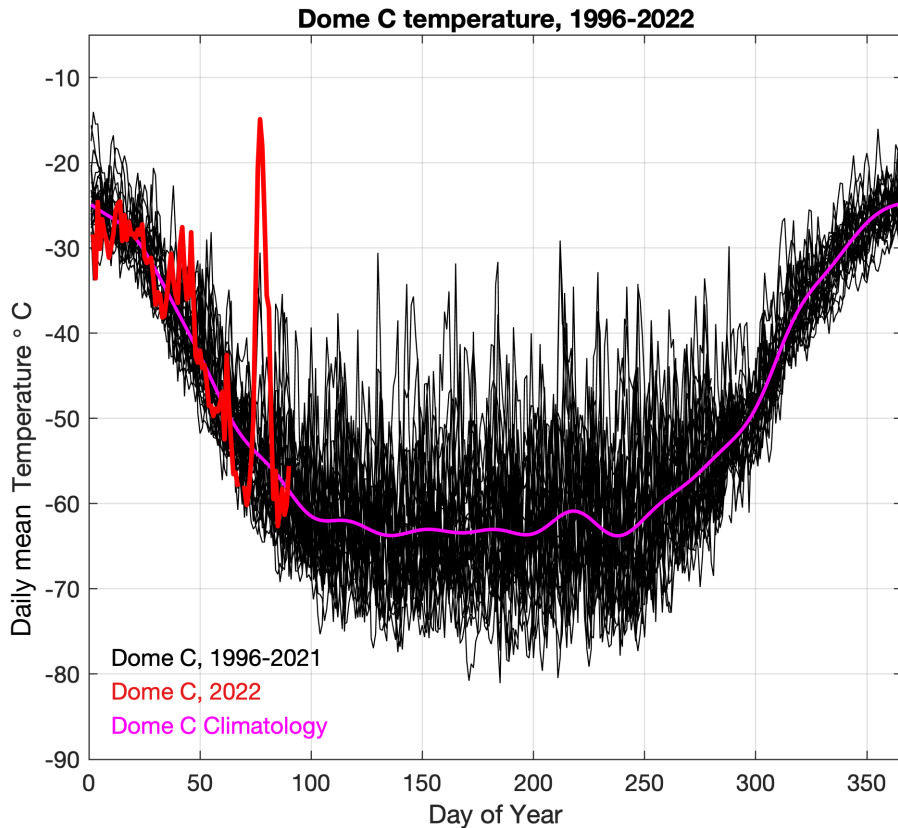
96 hour back-trajectories from Dome C

From 17 March 12 UTC

From 18 March 12 UTC



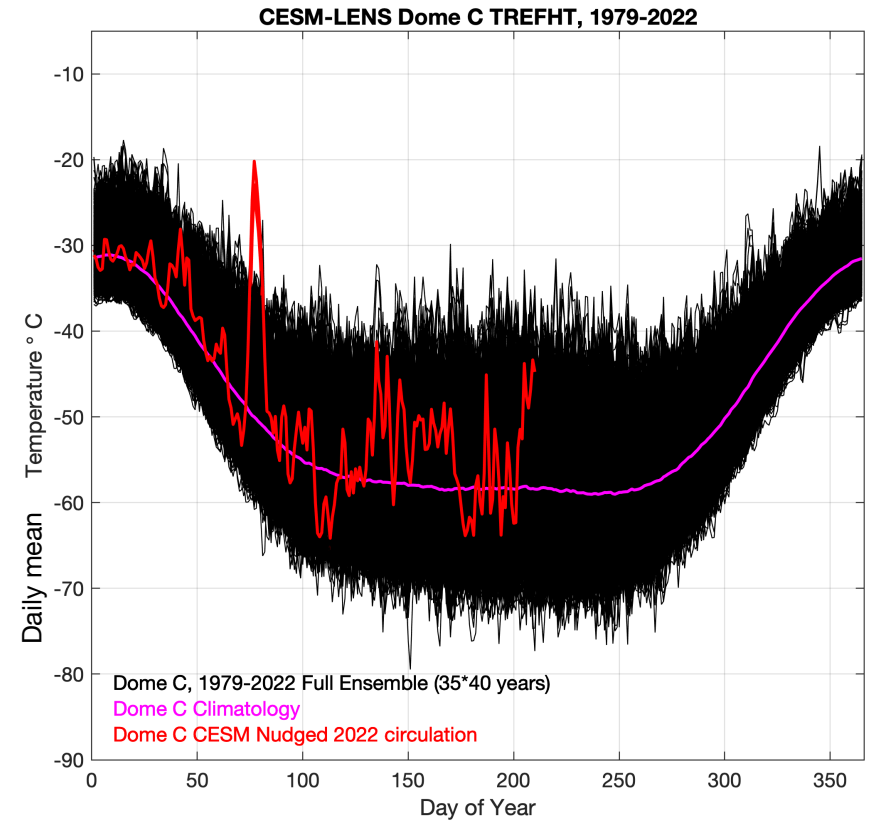
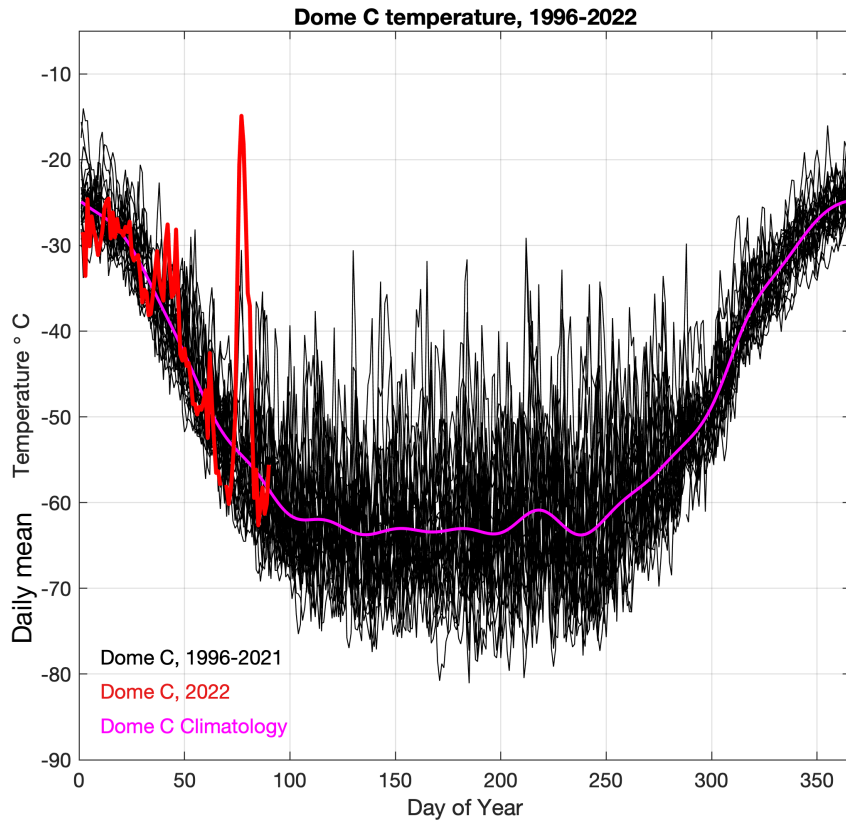
How well do climate models do?



CESM-LENS, $44 \times 35 = 1540$ years

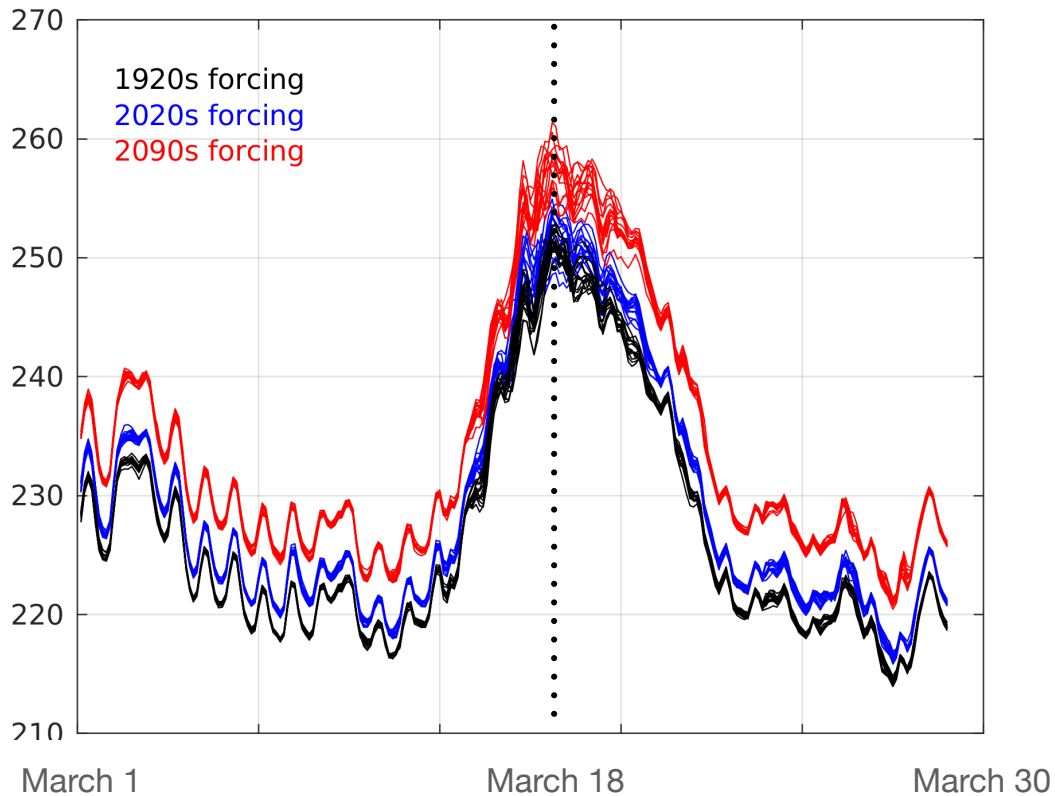
March 2022 event outside anything CESM-LENS simulates
Why? Bias in large scale circulation? Cloud physics/phase?
Boundary layer physics? Radiation?

How does CESM-LENS do if nudge winds to observations?

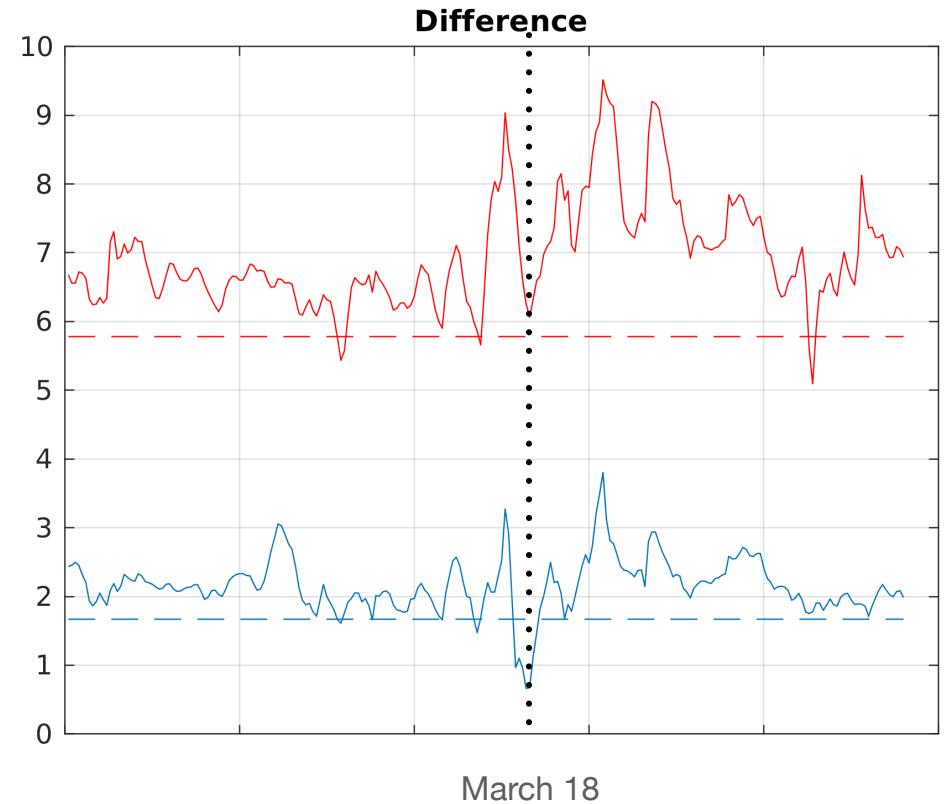


CESM-LENS captures most of observed anomaly when nudged to observations, and simulates a much larger extreme than free-running ensemble extremes

'Storyline' approach to climate change impact on heatwave



Nudge CESM-LENS to 2022 winds
under different forcing scenarios



Difference:

2020s-1920s

2090s-1920s

Dashed: local March climate change in
CESM-LENS

Summary Part II

East Antarctic heat wave of March 2022: unprecedented anomaly, throughout whole atmospheric column

Clearly associated to large scale circulation

CESM-LENS does not simulate comparable events, but gets close when nudged to observed circulation (thus, model biases in circulation variability?)

Can use the 'storyline' approach, nudging under different forcing, to estimate thermodynamic contribution of climate change

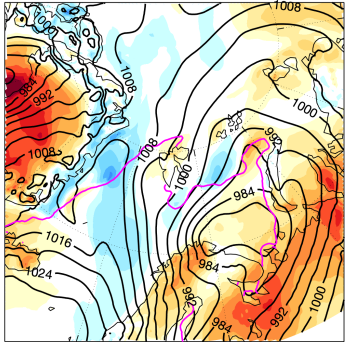
Event was ~2K larger due to forcing, up to 8-9K larger by 2090s

Extra slides Part I

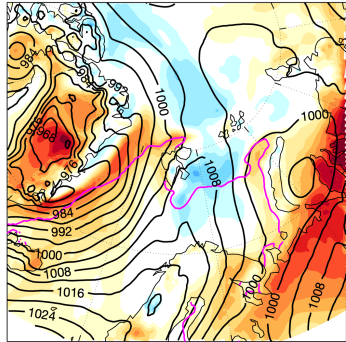
Hot too (but not record hot, maxed out at ~95% percentile)

2m-air temperature anomalies

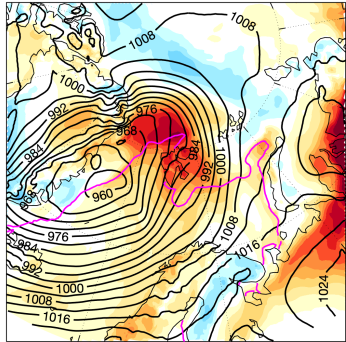
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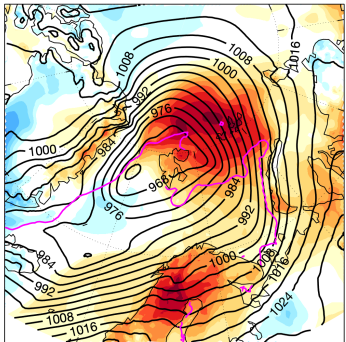
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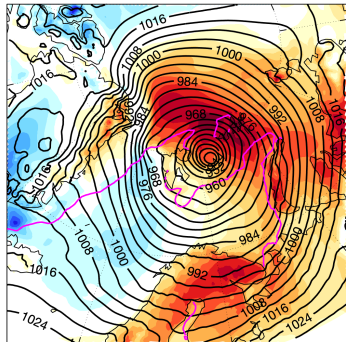
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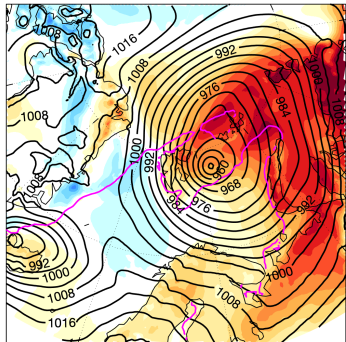
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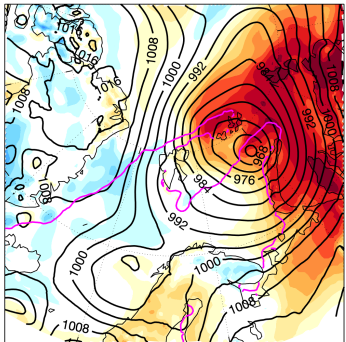
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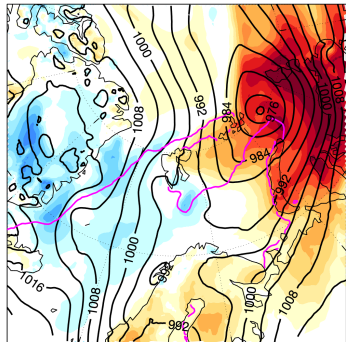
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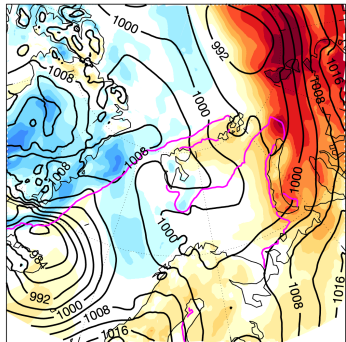
26-Jan-2022 12:00:00



27-Jan-2022 12:00:00



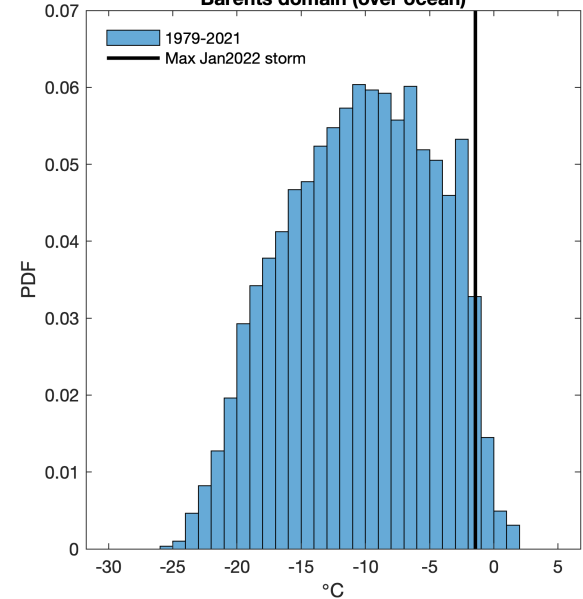
28-Jan-2022 12:00:00



T2m (C)

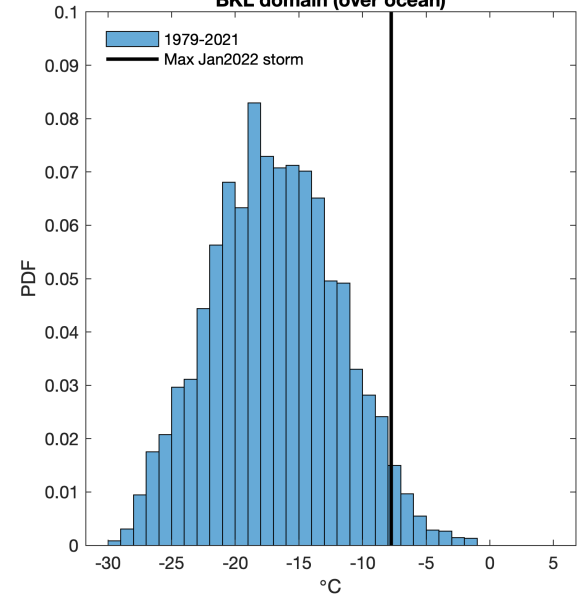


Hourly January T2m 72N-83N,10E-60E
Barents domain (over ocean)



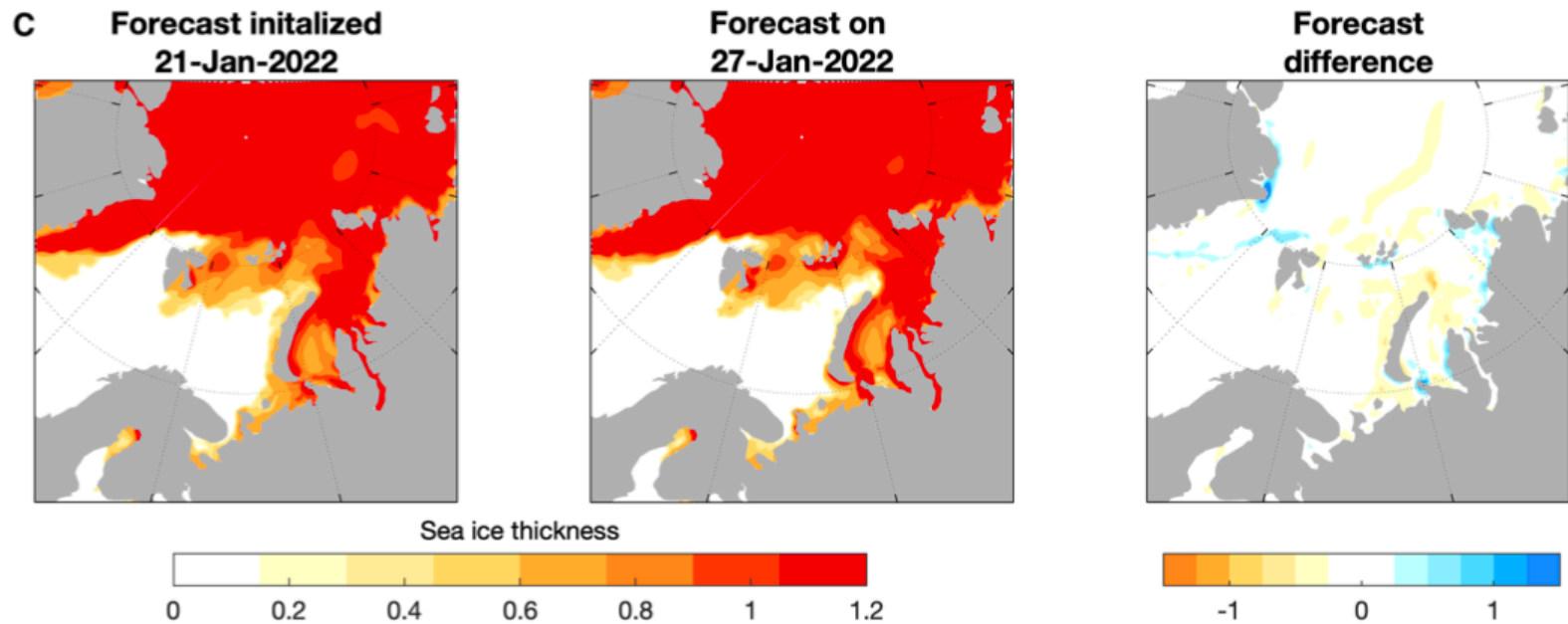
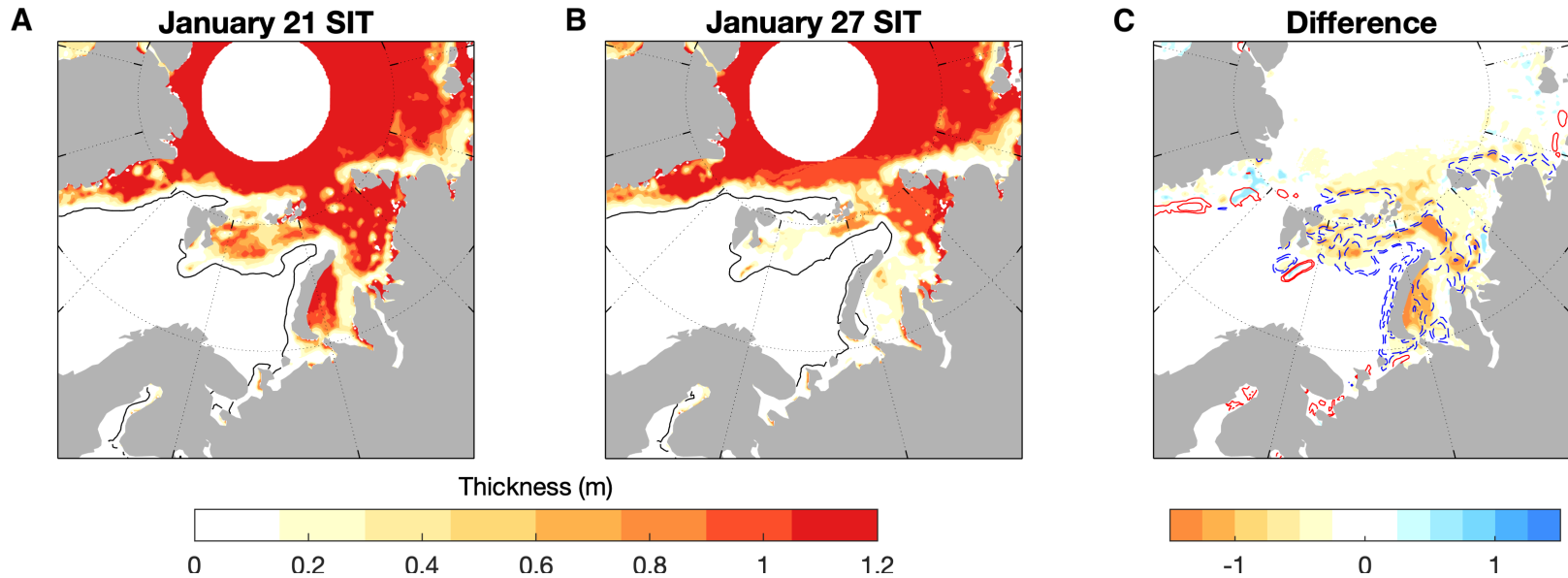
Barents Sea domain Temp

Hourly January T2m 72N-84N,10E-120E
BKL domain (over ocean)

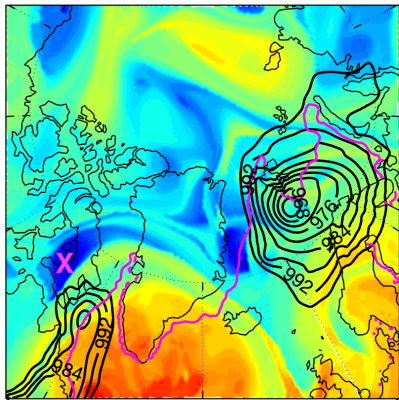


Barents/Kara/west Laptev domain Temp

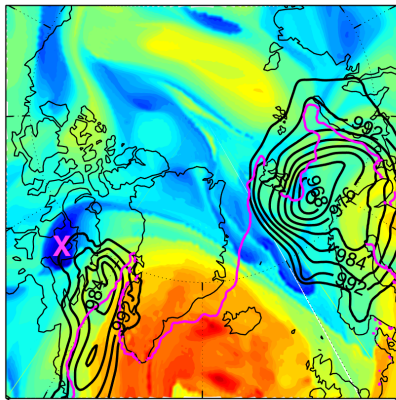
Sea ice thickness was also significantly impacted by cyclone



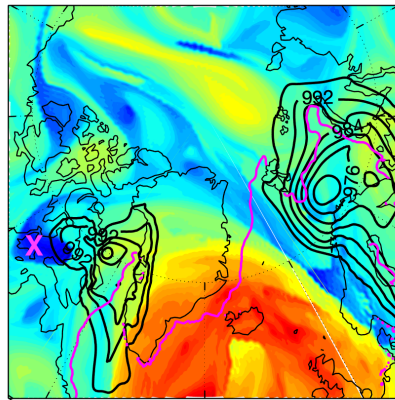
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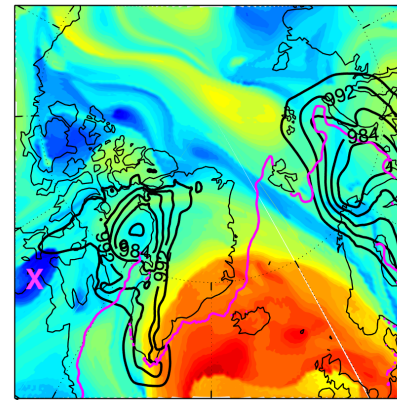
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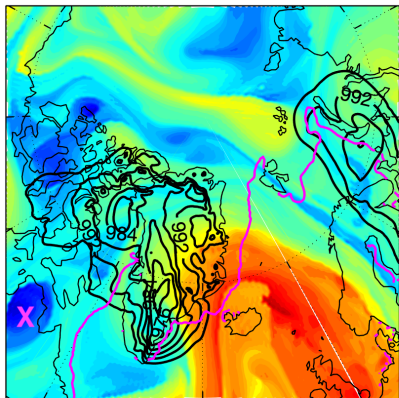
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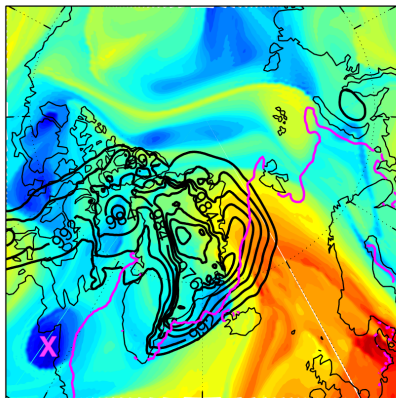
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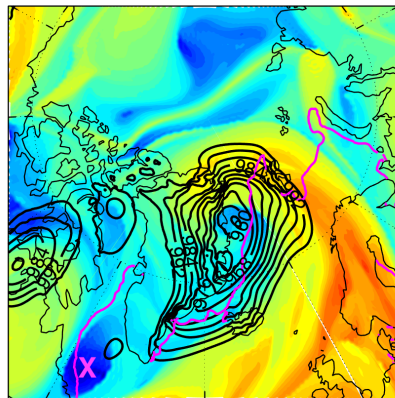
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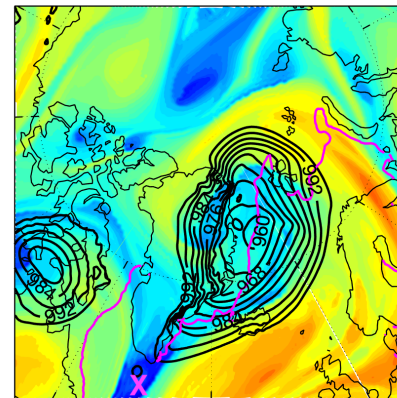
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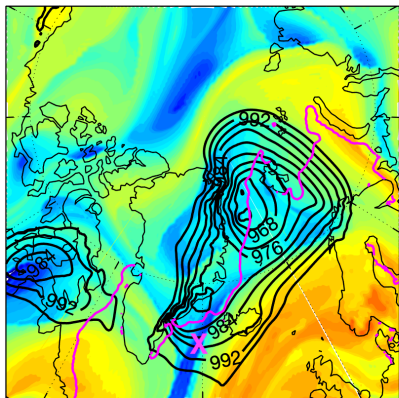
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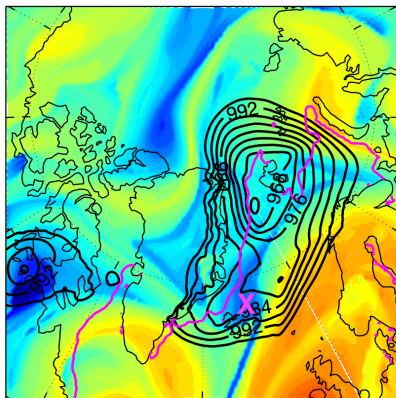
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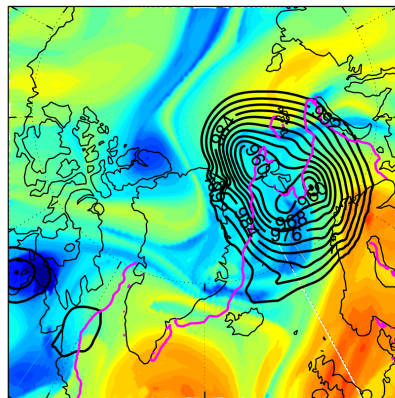
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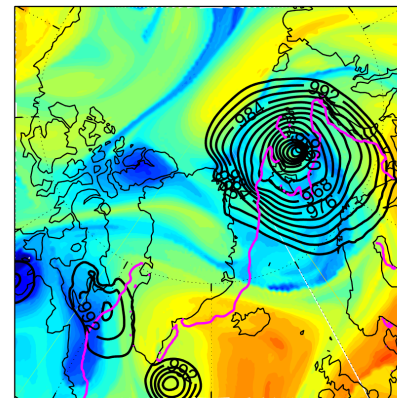
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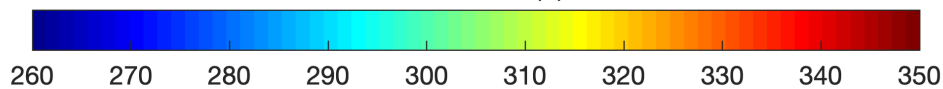
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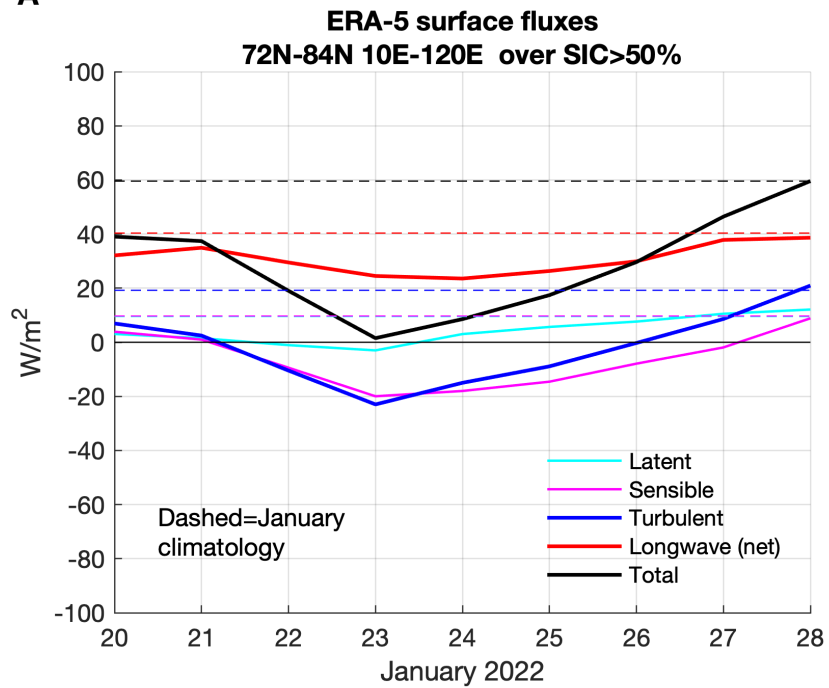
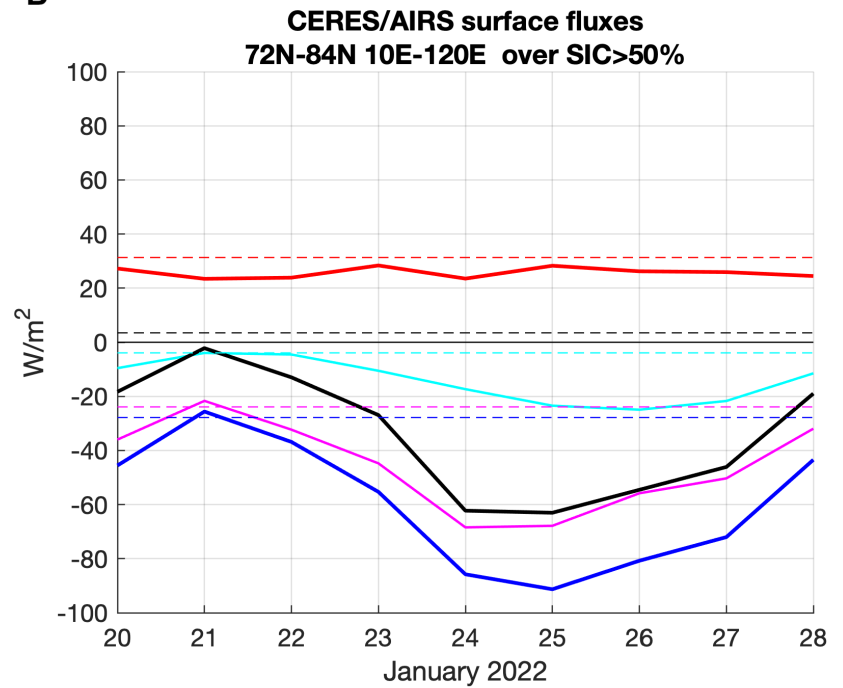
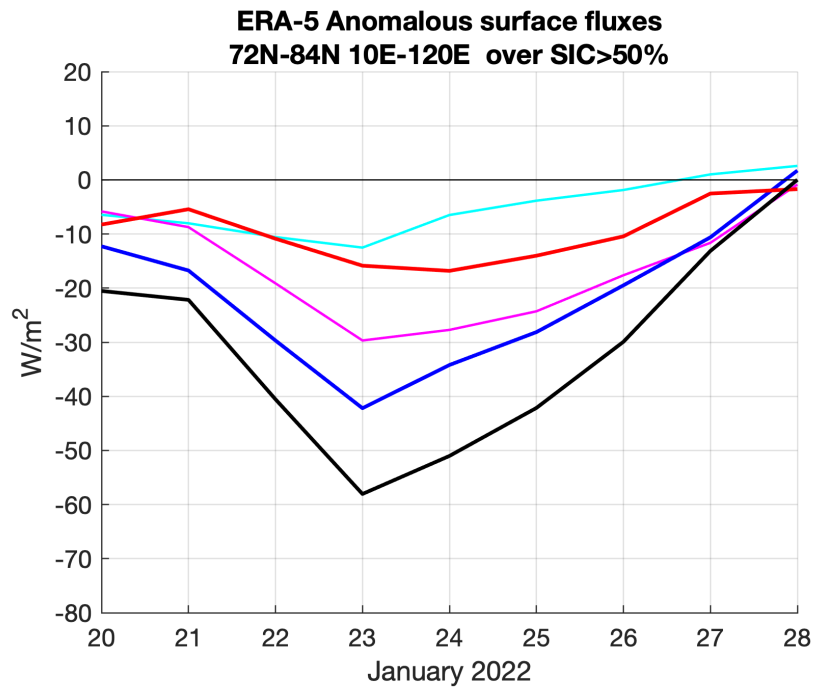
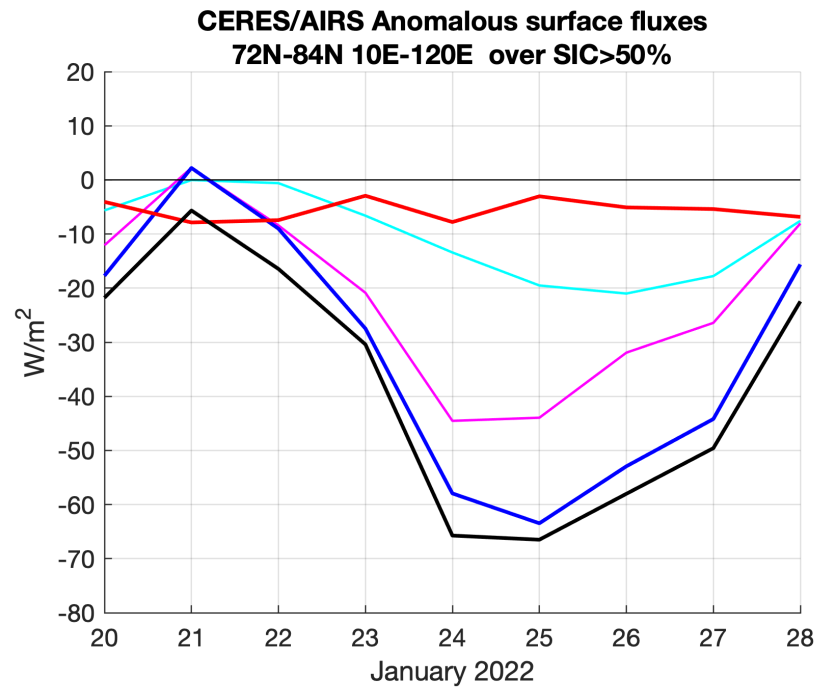


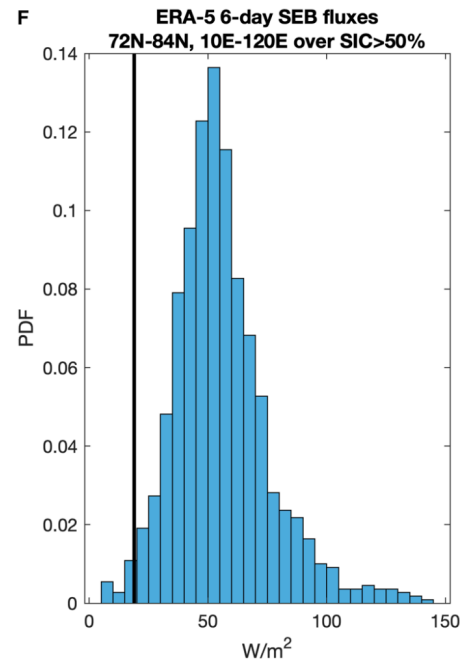
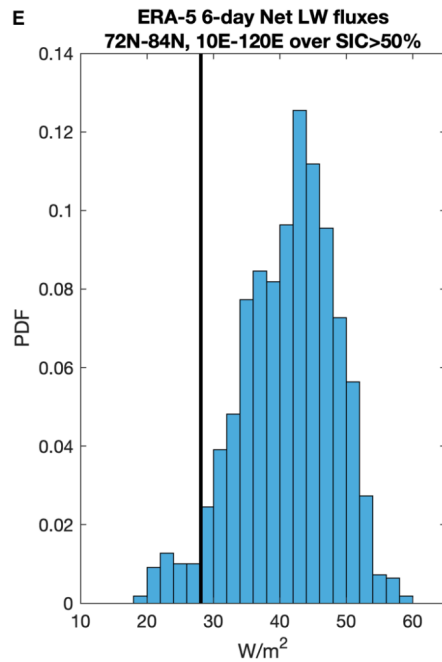
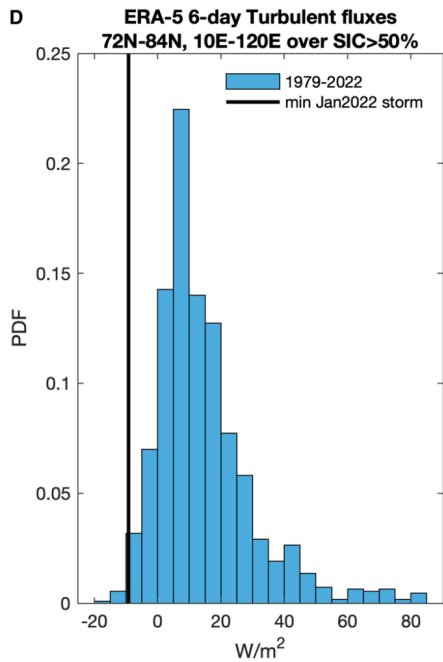
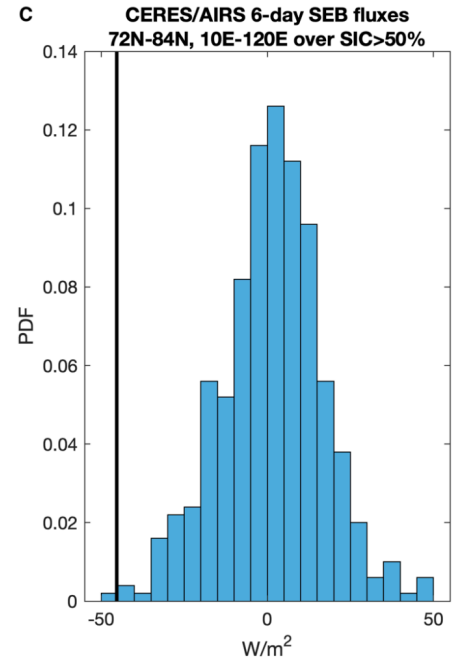
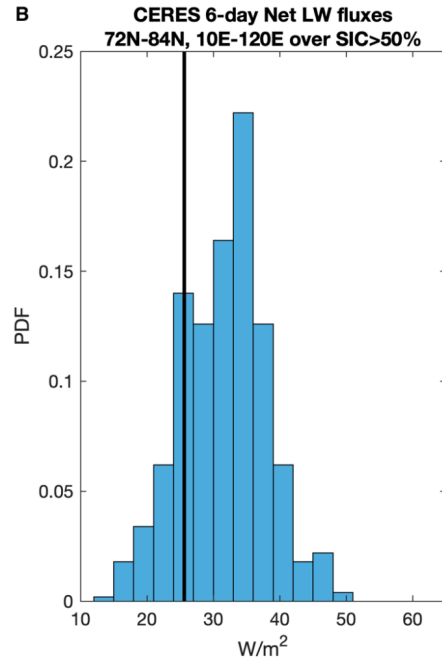
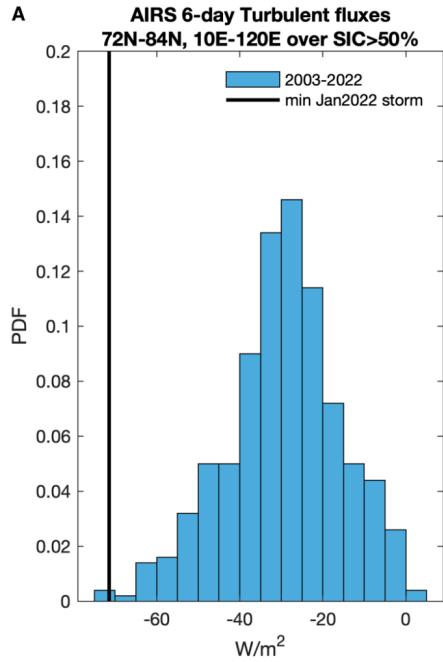
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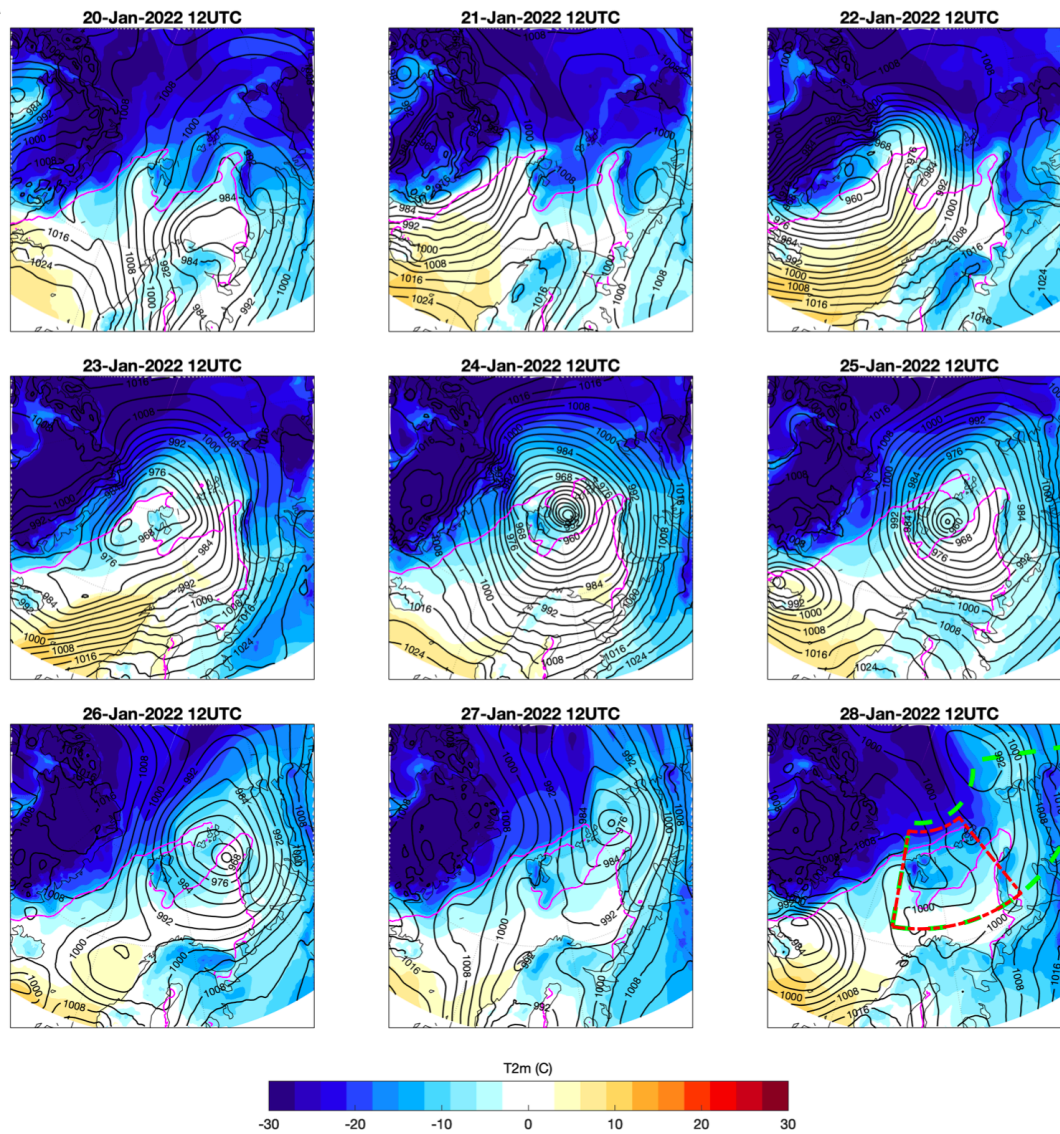
PT on 2PVU (K)



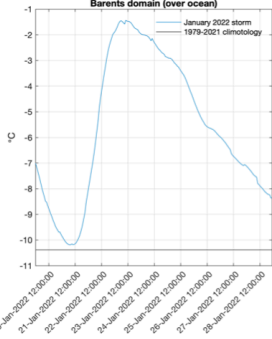
A**B****C****D**



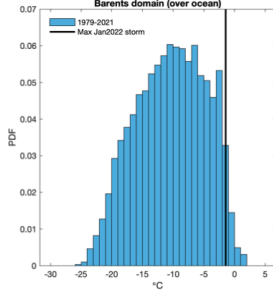
A



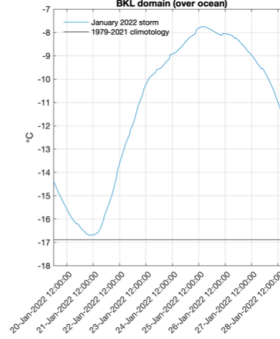
B Mean T2m 72N-83N,10E-60E
Barents domain (over ocean)



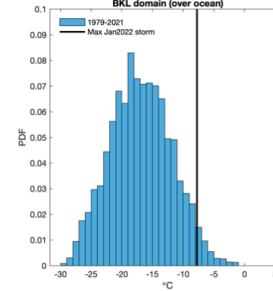
Hourly January T2m 72N-83N,10E-60E
Barents domain (over ocean)



C Mean T2m 72N-84N,10E-120E
BKL domain (over ocean)

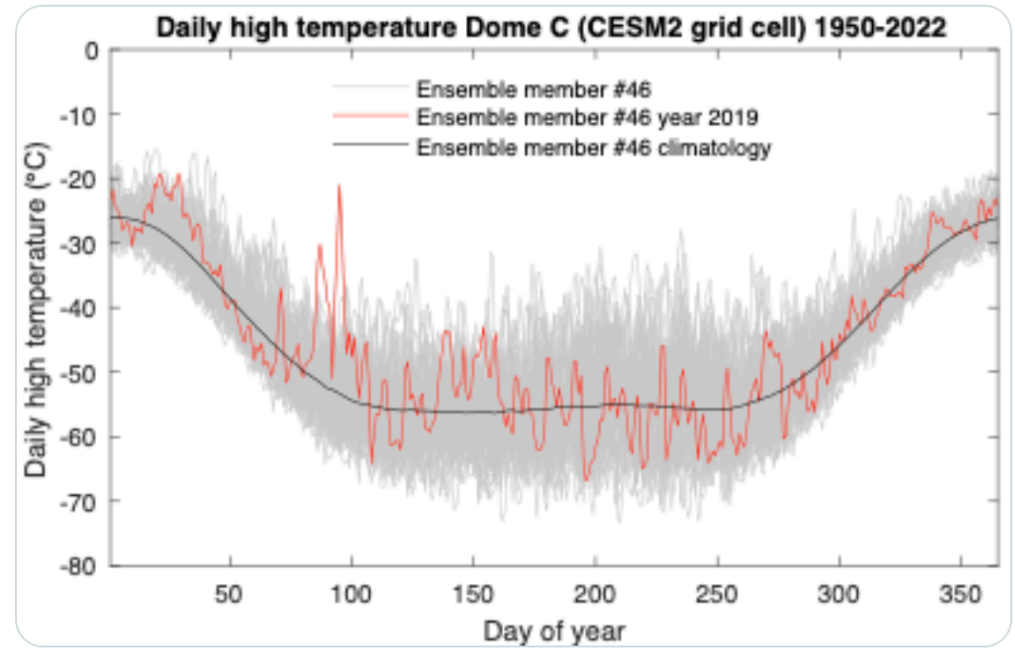
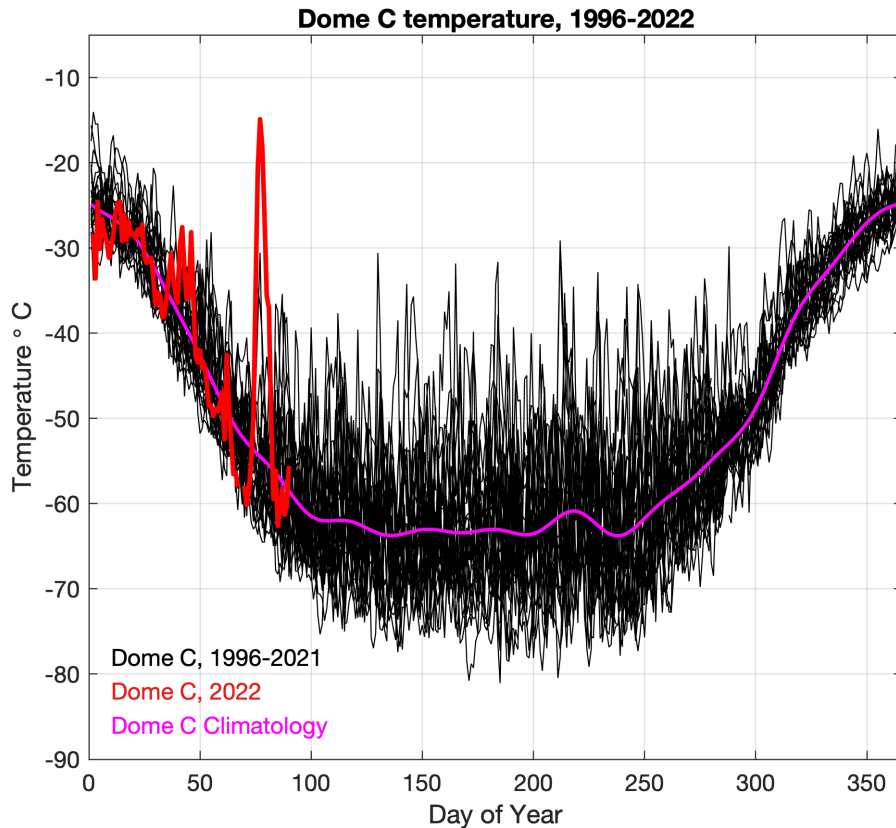


Hourly January T2m 72N-84N,10E-120E
BKL domain (over ocean)



Extra slides Part II

How well do climate models do?



CESM2-LE, $73 \times 100 = 7350$ years,
Figure Flavio Lehner

CESM2 simulates an event closer to March 2022
...Due to more cloud liquid water content?
Better circulation? Bigger sample size?