A photograph of an Antarctic sea ice landscape. In the foreground, there is a field of small, broken ice floes floating in dark blue water. In the middle ground, a large, flat-topped ice shelf or iceberg extends across the frame. The sky is a pale, hazy blue with soft, wispy white clouds. The overall scene is serene and cold.

Antarctic Sea Ice in the CESM2: *Seasonality, Predictability, and Atmosphere-Ocean Interactions*

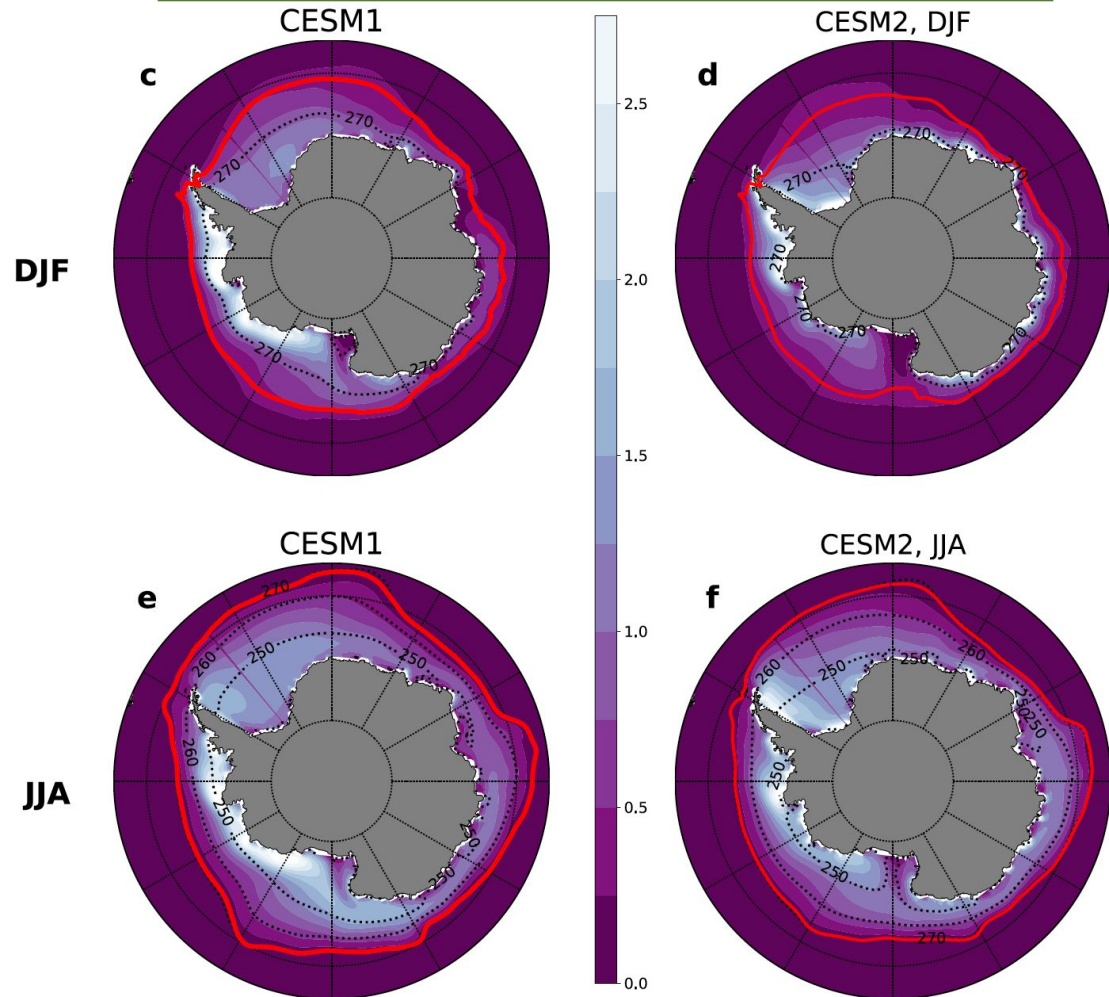
HA Singh, LL Landrum, and MM Holland

CESM Polar Climate Working Group

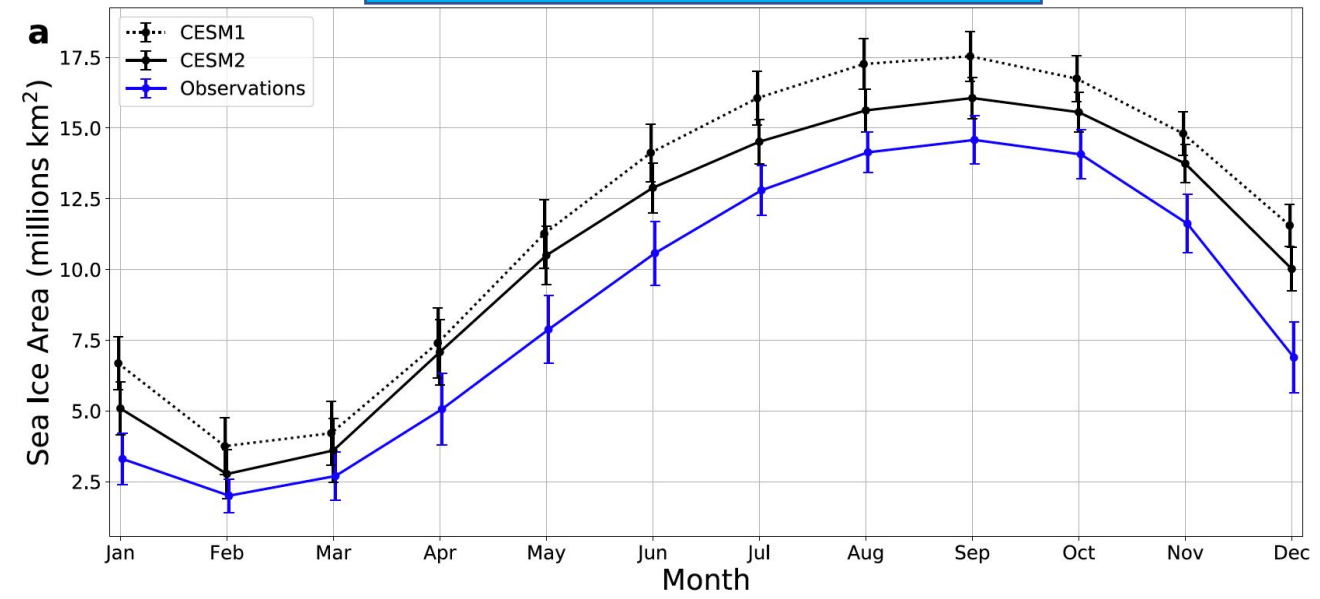
February 2020

Compared to the CESM1, Antarctic Sea Ice in the CESM2 is...

Ice thickness (m, colors), extent (pink line), & surface temperatures (K, dotted lines)



Sea ice area (millions of km²)

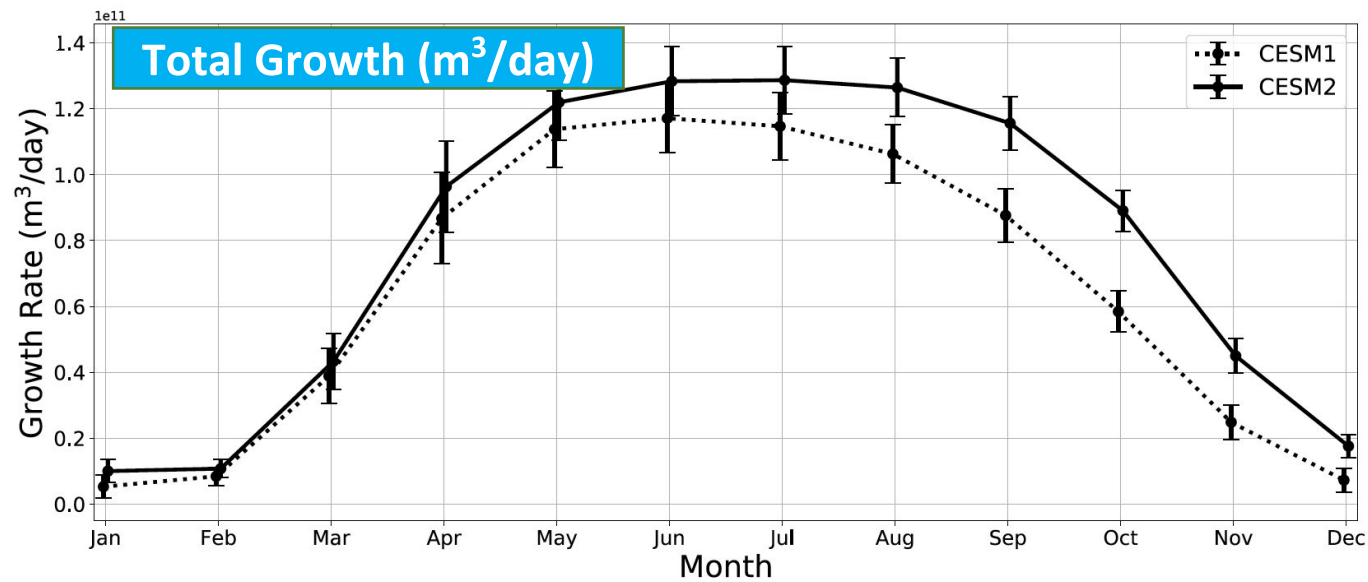


... less extensive.

... thinner and warmer at the surface.

I will show that...

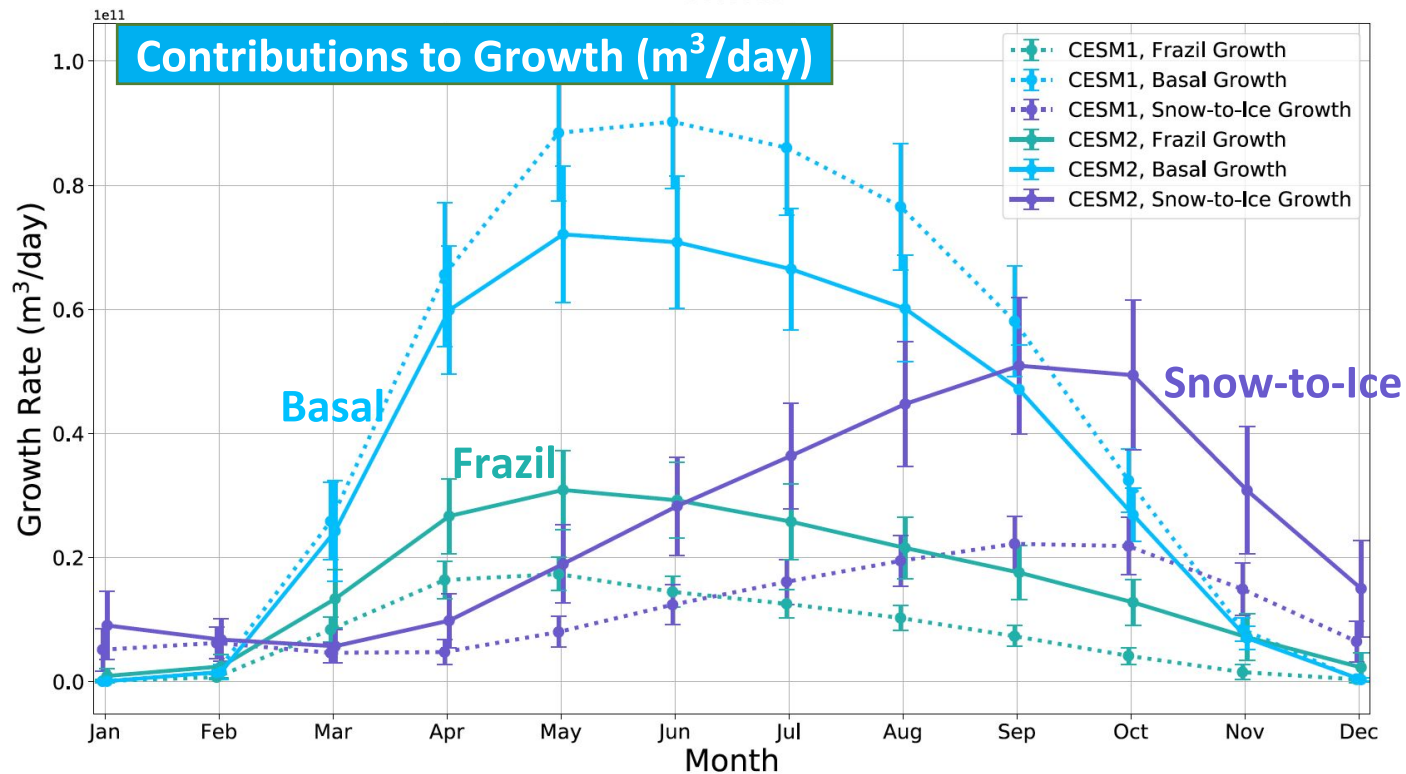
- The **mushy-layer thermodynamics** scheme implemented in the CICE7 alters the modes of sea ice growth in the new CESM2 compared to the CESM1.
- Differences in **atmosphere and ocean dynamics** between the CESM2 and the CESM1 explain differences in sea ice thickness and extent.
- For unknown reasons, Antarctic sea ice in the CESM2 is **less persistent and predictable** than Antarctic sea ice in the CESM1.
- At *some* latitudes, **the ocean** may confer some measure of predictability to September sea ice area. At other latitudes, good luck.



Sea Ice Growth is More Vigorous in the CESM2 than the CESM1

In the CESM2, there is

- More frazil growth
- More snow-to-ice growth
- Less basal growth



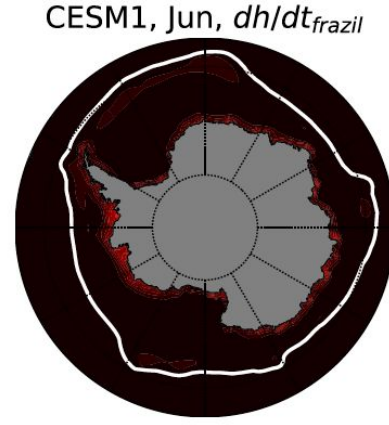
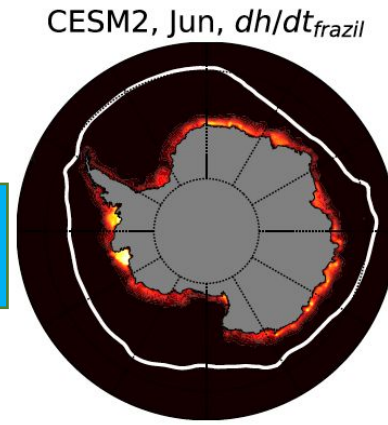
Mushy-Layer Thermodynamics

Spatial Distribution of Sea ice Growth in the CESM2 vs CESM1

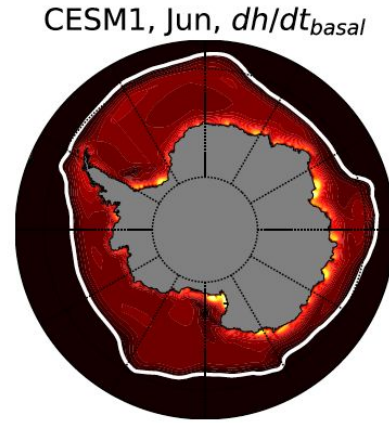
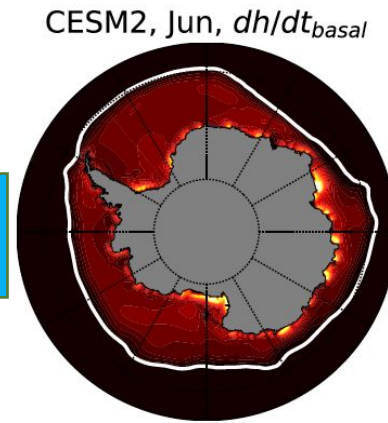
Frazil growth in coastal polynyas increases in the CESM2.

Snow-to-Ice growth increases at the center and edge of the ice pack in the CESM2.

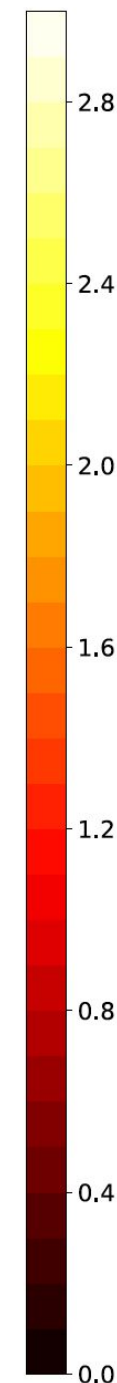
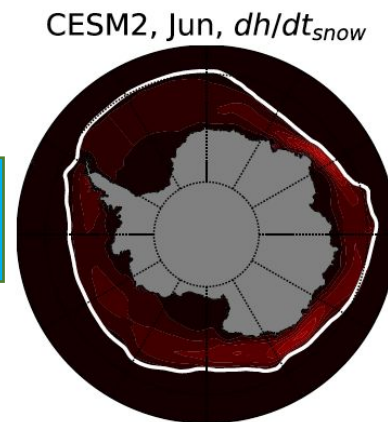
Frazil Growth (cm/day)



Basal Growth (cm/day)



Snow-to-Ice Growth (cm/day)

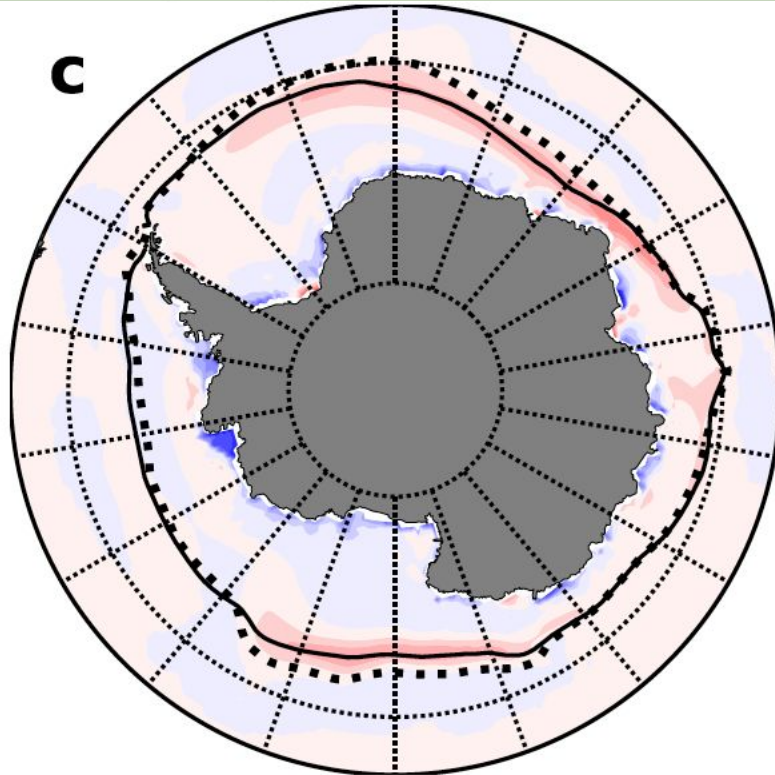


Ice Volume Tendencies during the Growth Season Differ between the CESM2 and CESM1

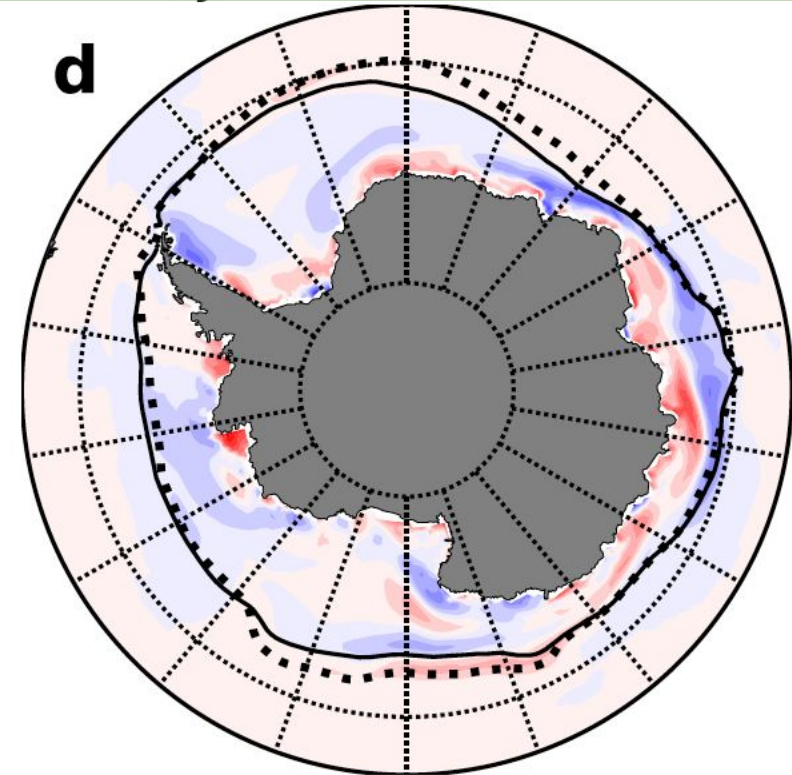
dV/dt due to Thermodynamics, CESM2-CESM1

dV/dt due to Dynamics, CESM2-CESM1

May



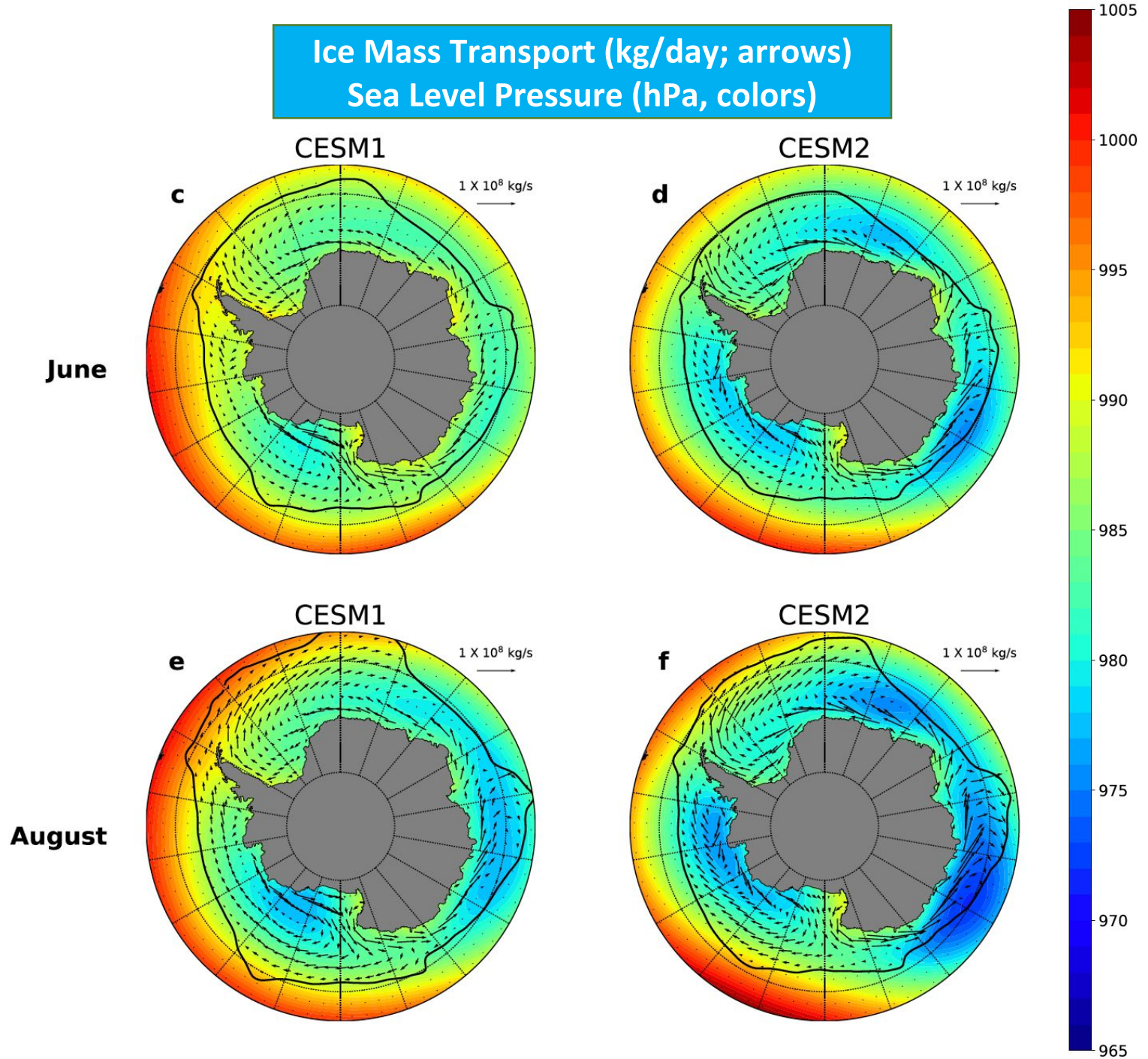
There is greater melt at the ice edge in the CESM2.



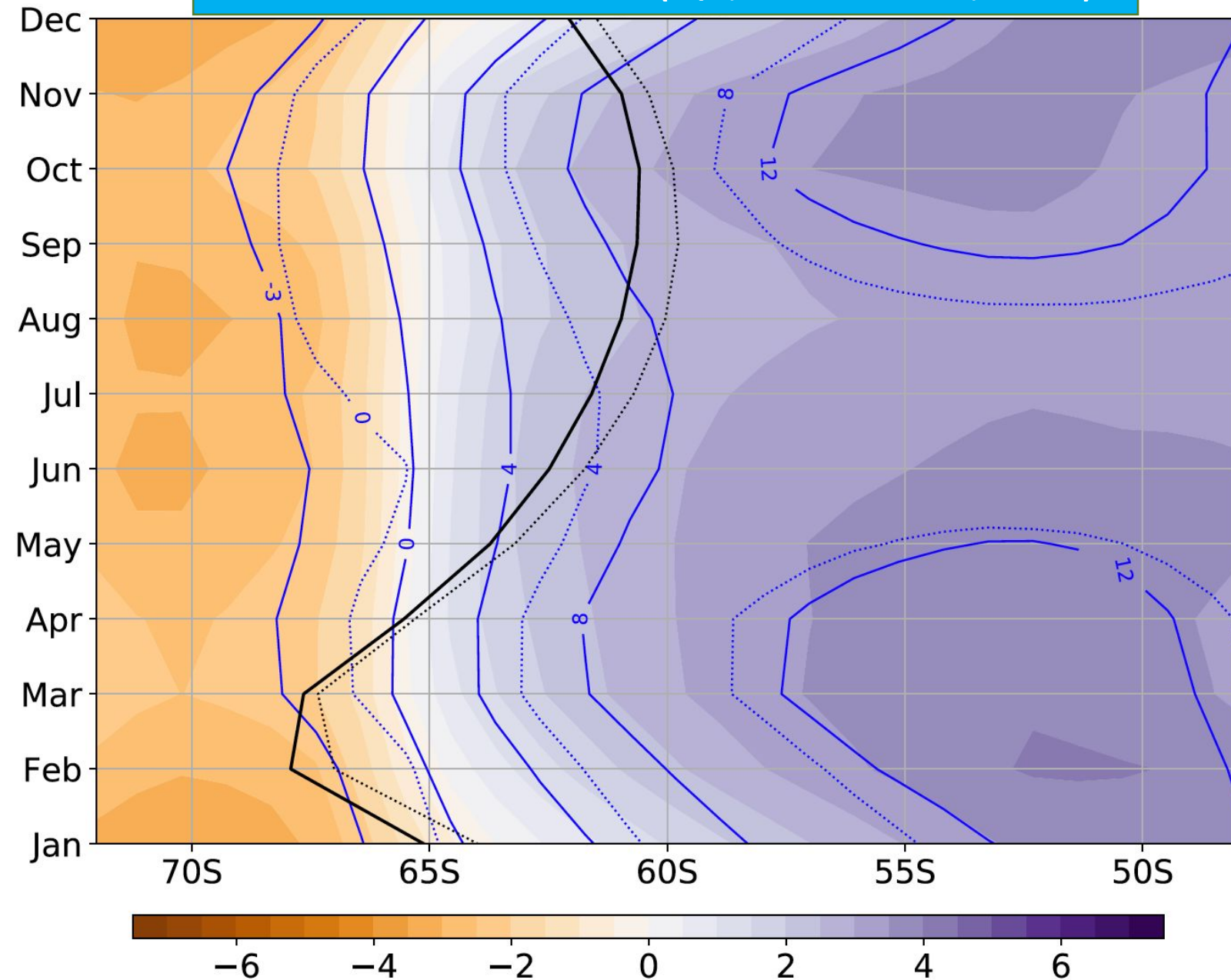
There is greater divergence at the center of the ice pack, and greater convergence at the edge of the ice pack, in the CESM2.

Greater Sea Ice Divergence is due to Greater Stationary Wave Activity in the CESM2

Circumpolar tripole of low pressure centers are deeper in the CESM2 than the CESM1.

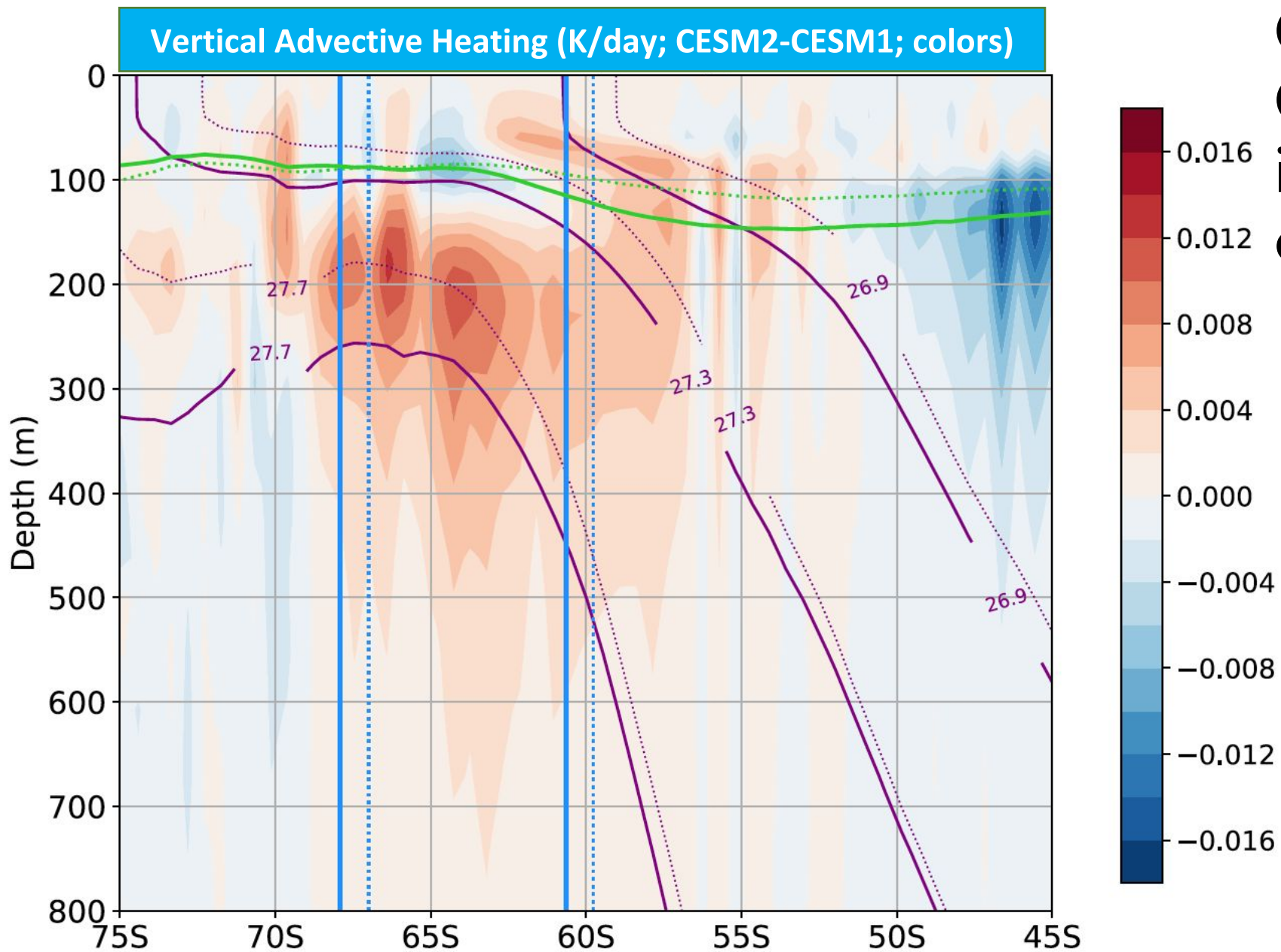


Zonal Winds at the Surface (m/s; CESM2-CESM1; colors)



Surface Zonal Winds are Stronger in the CESM2

Stronger surface winds (easterlies and westerlies) implies greater wind stress curl in the CESM2 than the CESM1.



Greater Wind Stress
Curl in the CESM2
increases Upwelling
of Warm Waters

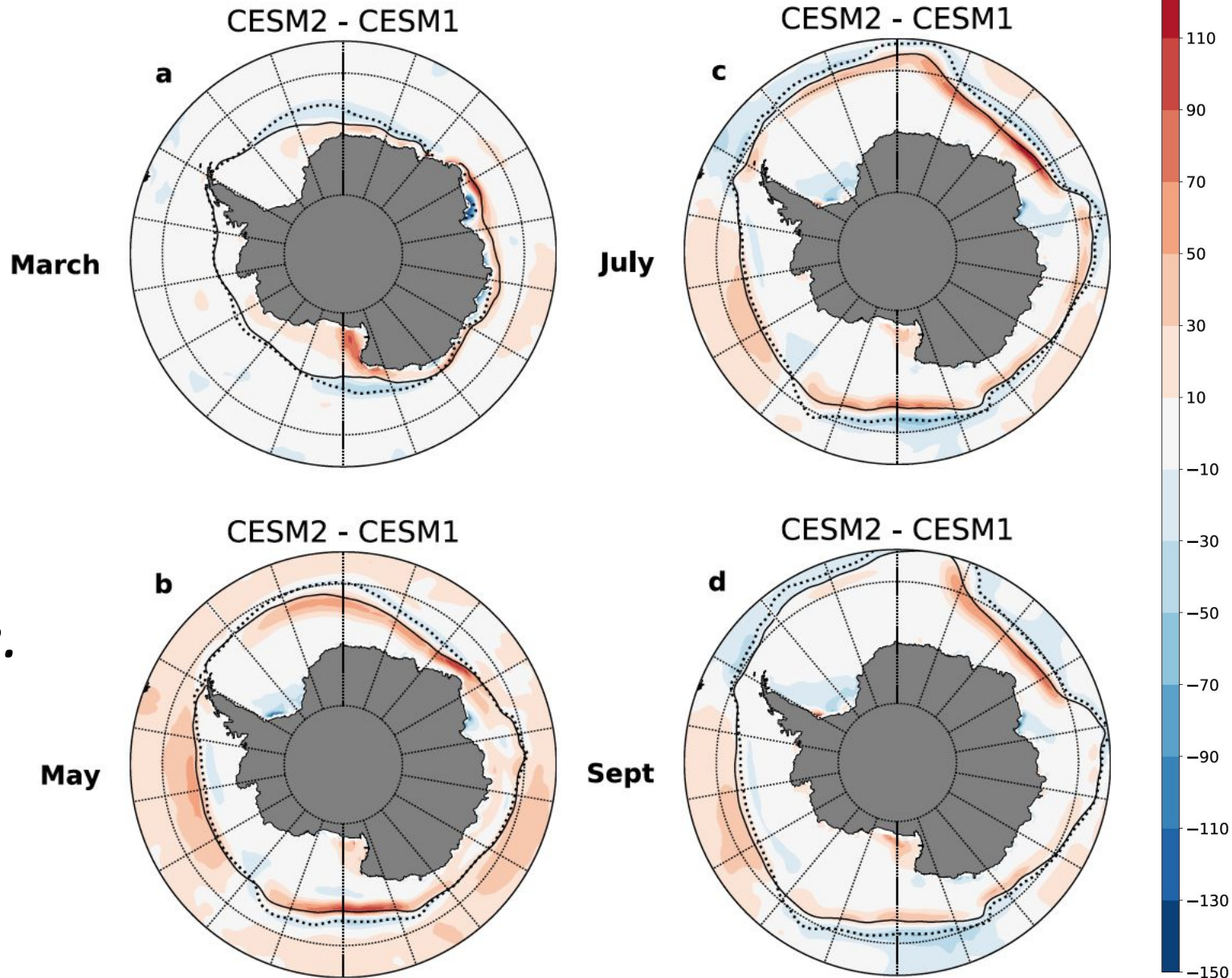
*Increased vertical
advective heating
under the seasonal
ice pack and at the
ice edge.*

Ocean Heat Flux Convergence Under (esp. at the edge) of the Ice Pack is Greater in the CESM2

As a result, the ice pack is thinner and less extensive.

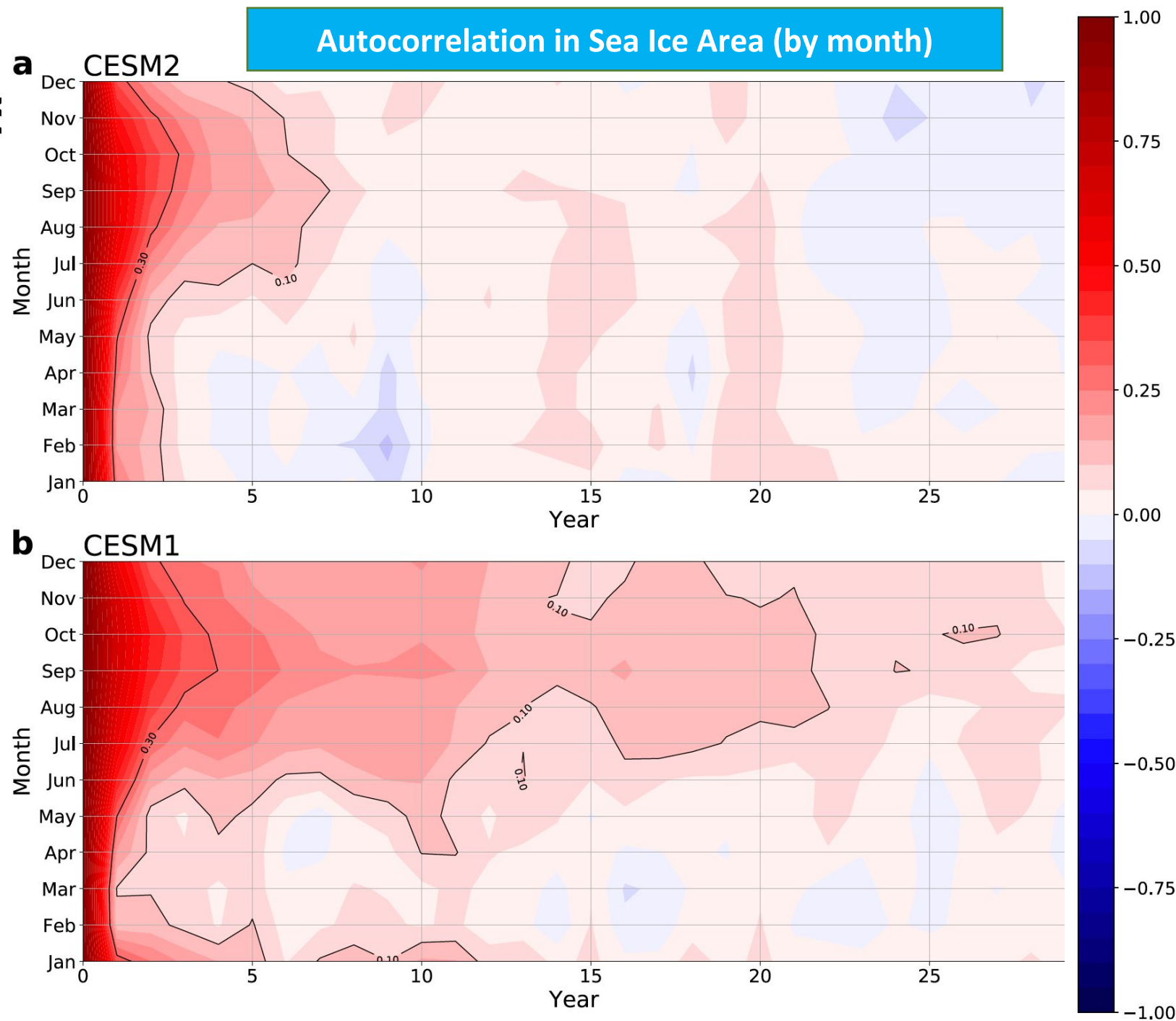
Atmosphere and Ocean States

Ocean Heat Flux Convergence in the Mixed Layer (W/m²; CESM2-CESM1; colors)

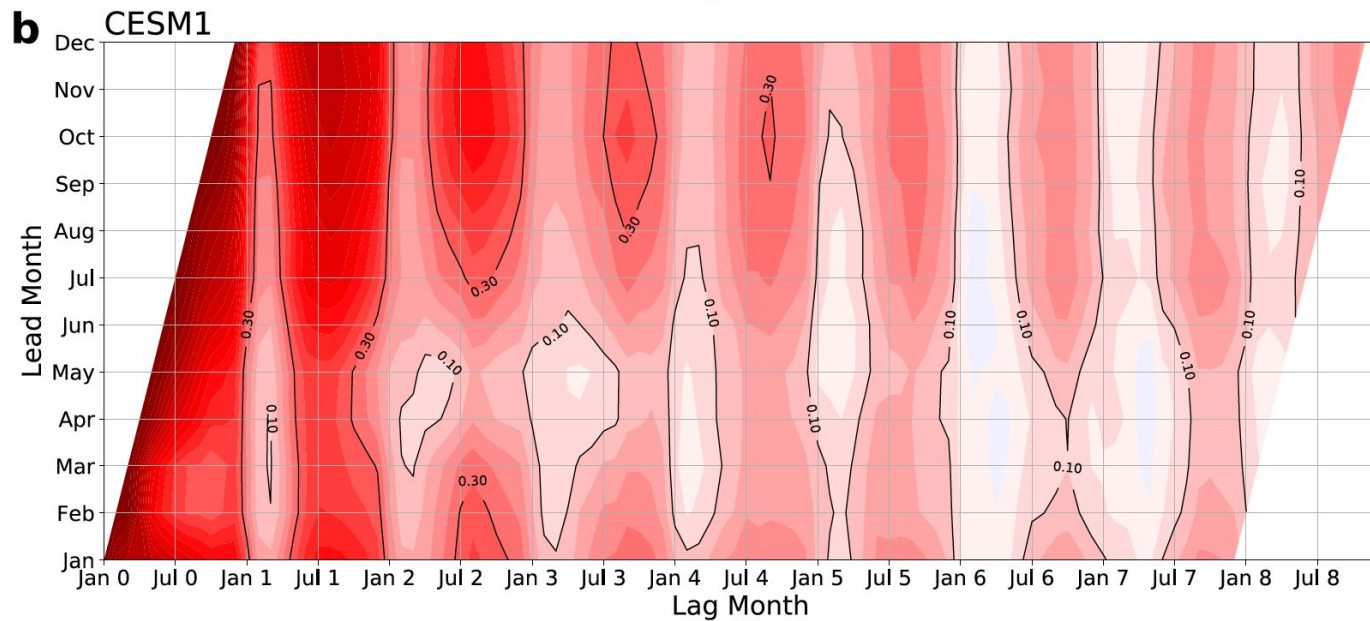
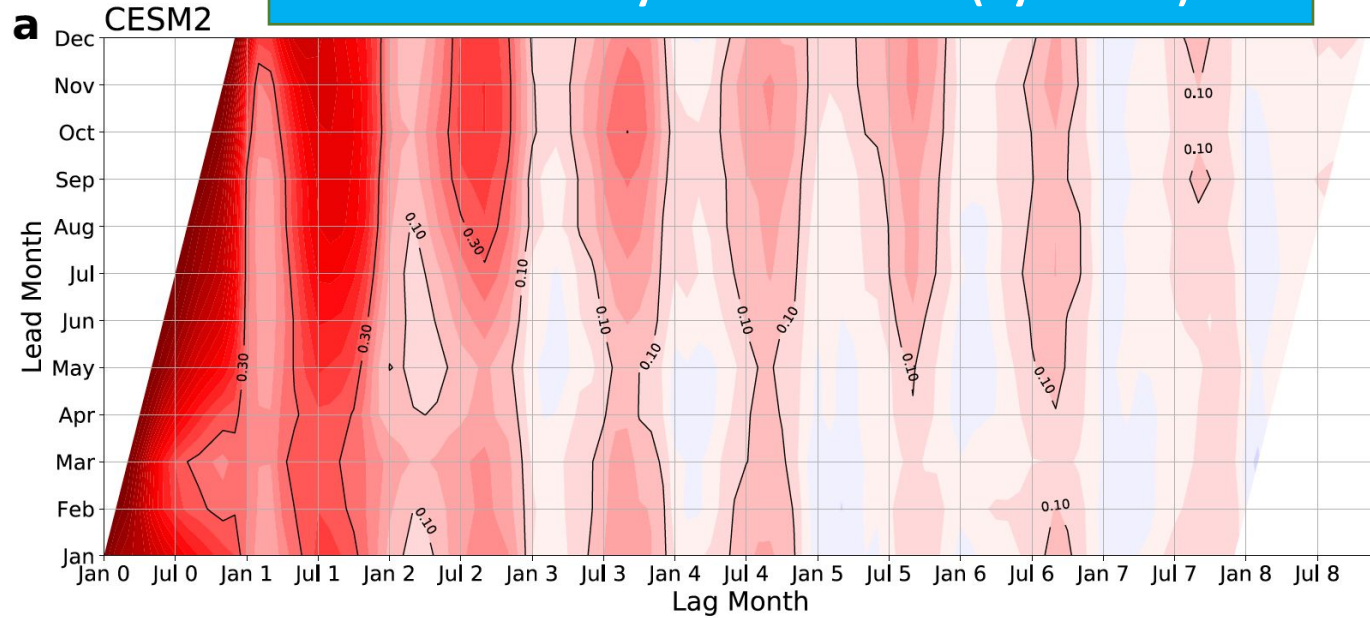


Antarctic Sea Ice is Less Persistent in the CESM2

The autocorrelation of monthly sea ice area decays more rapidly in the CESM2



Predictability in Sea Ice Area (by month)

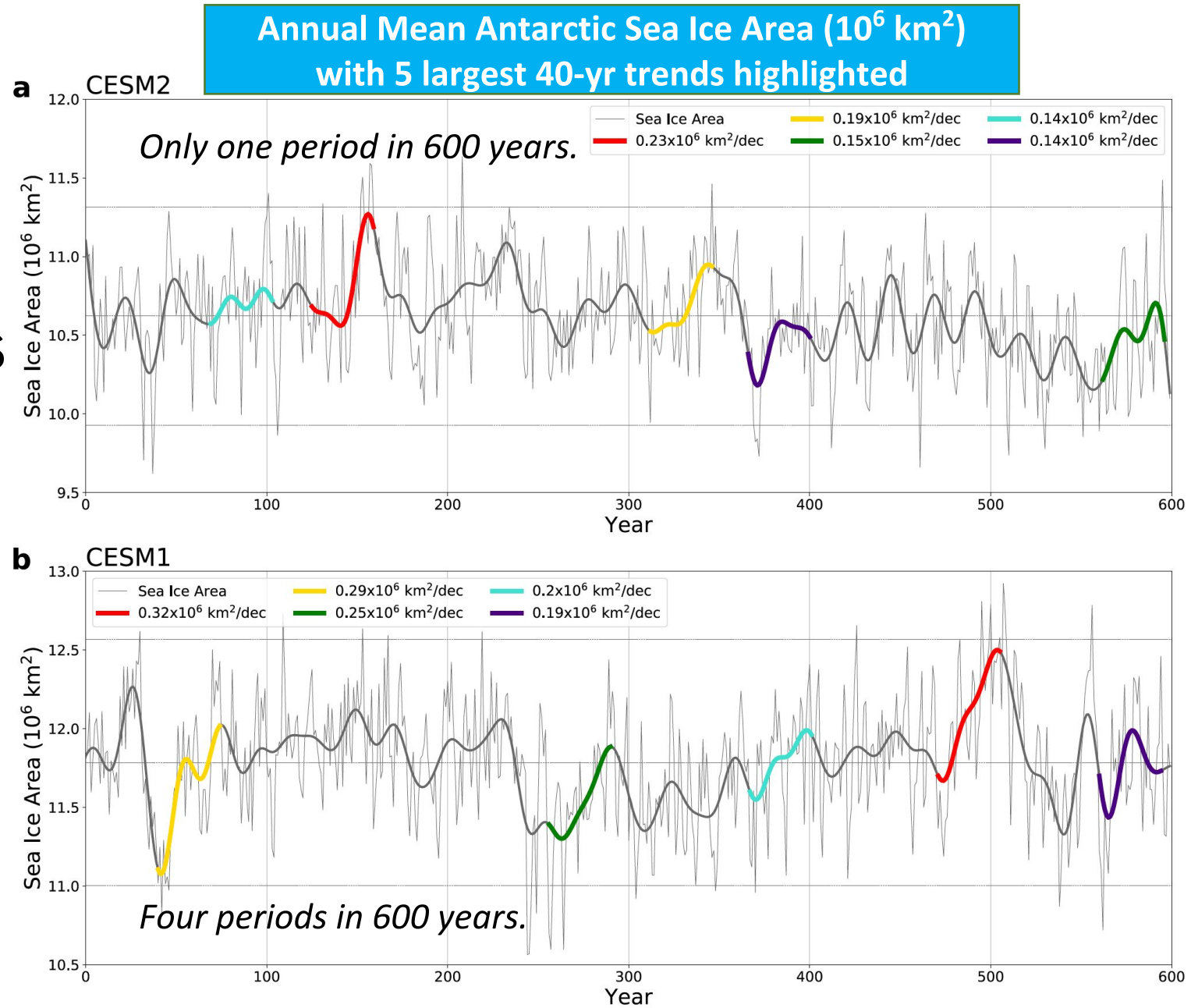


Antarctic Sea Ice is Less Predictable in the CESM2

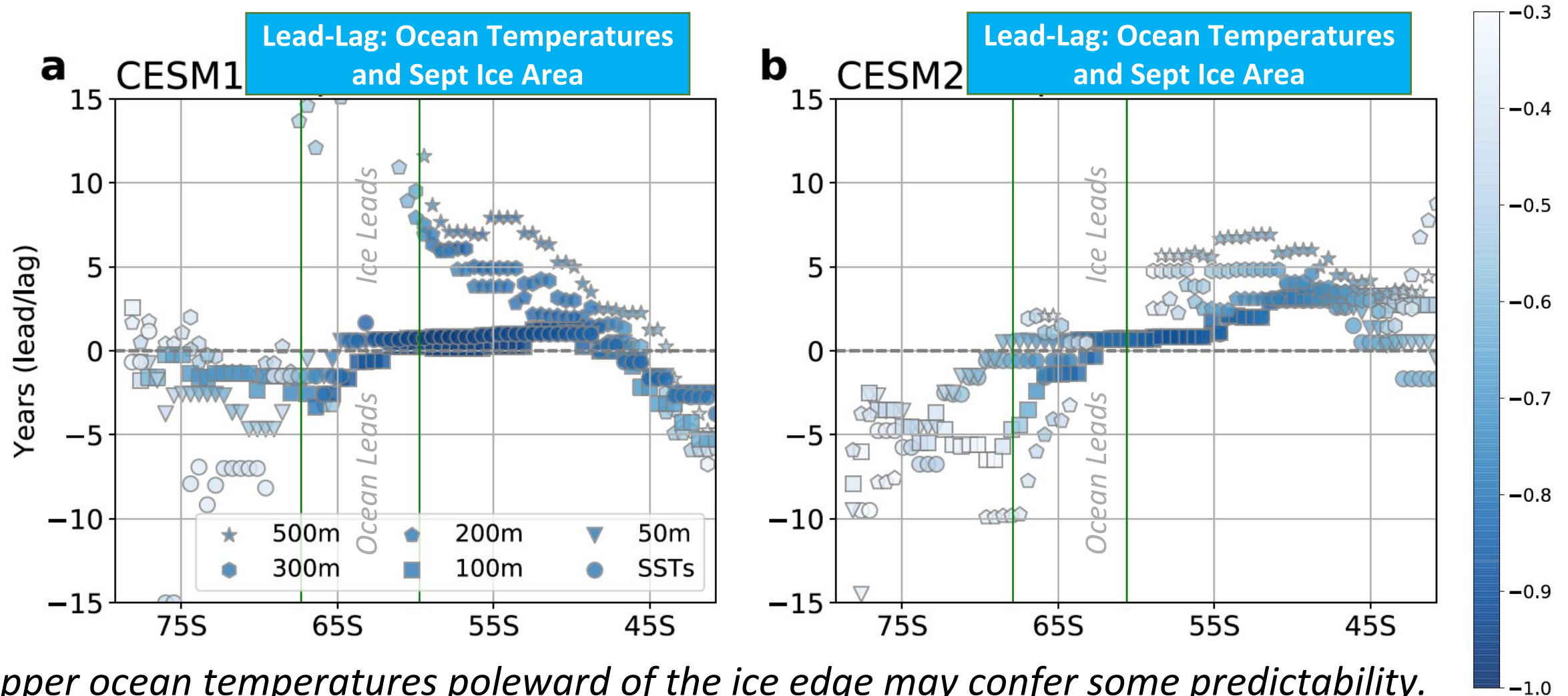
Predictability tapers away more rapidly in the CESM2 than the CESM1.

Antarctic Sea Ice in the CESM2 is Less Likely to exhibit Multidecadal Periods of Area Expansion

This may be a consequence of decreased persistence.



At some Latitudes, Ocean Temperatures may be useful for Predicting the September Ice Area Maximum



*Upper ocean temperatures poleward of the ice edge may confer some predictability.
Upper ocean temperatures equatorward of the ice edge may not.*

Thank you!

Questions?

- The **mushy-layer thermodynamics** scheme implemented in the CICE7 alters the modes of sea ice growth in the new CESM2 compared to the CESM1.
- Differences in **atmosphere and ocean dynamics** between the CESM2 and the CESM1 result in differences in sea ice thickness and extent.
- For unknown reasons, Antarctic sea ice in the CESM2 is **less persistent and predictable** than Antarctic sea ice in the CESM1.
- At *some* latitudes, **the ocean** may confer some measure of predictability to September sea ice area. At other latitudes, good luck.

