DRIVERS AND CONSTRAINTS ON ANTARCTIC SEA ICE VARIABILITY

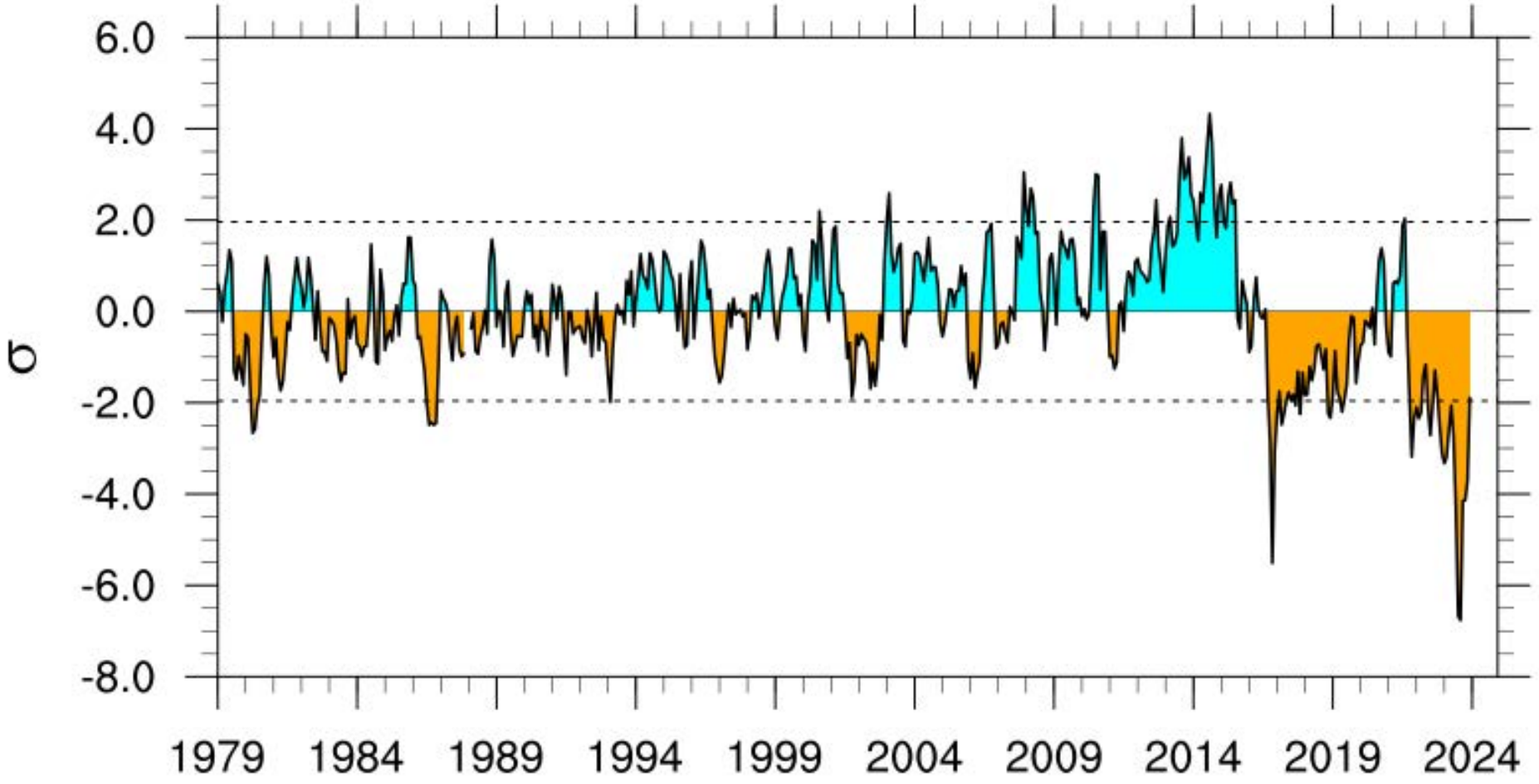
Dr Will Hobbs

AAPP
Australian Antarctic Program Partnership

The Australian Antarctic Program Partnership is funded by the Australian Government Department of Industry, Science, Energy and Resources through the Antarctic Science Collaboration Initiative.

The Australian Antarctic Program Partnership is led by the University of Tasmania, and includes the following partner agencies

STANDARDISED ANTARCTIC MONTHLY SIA



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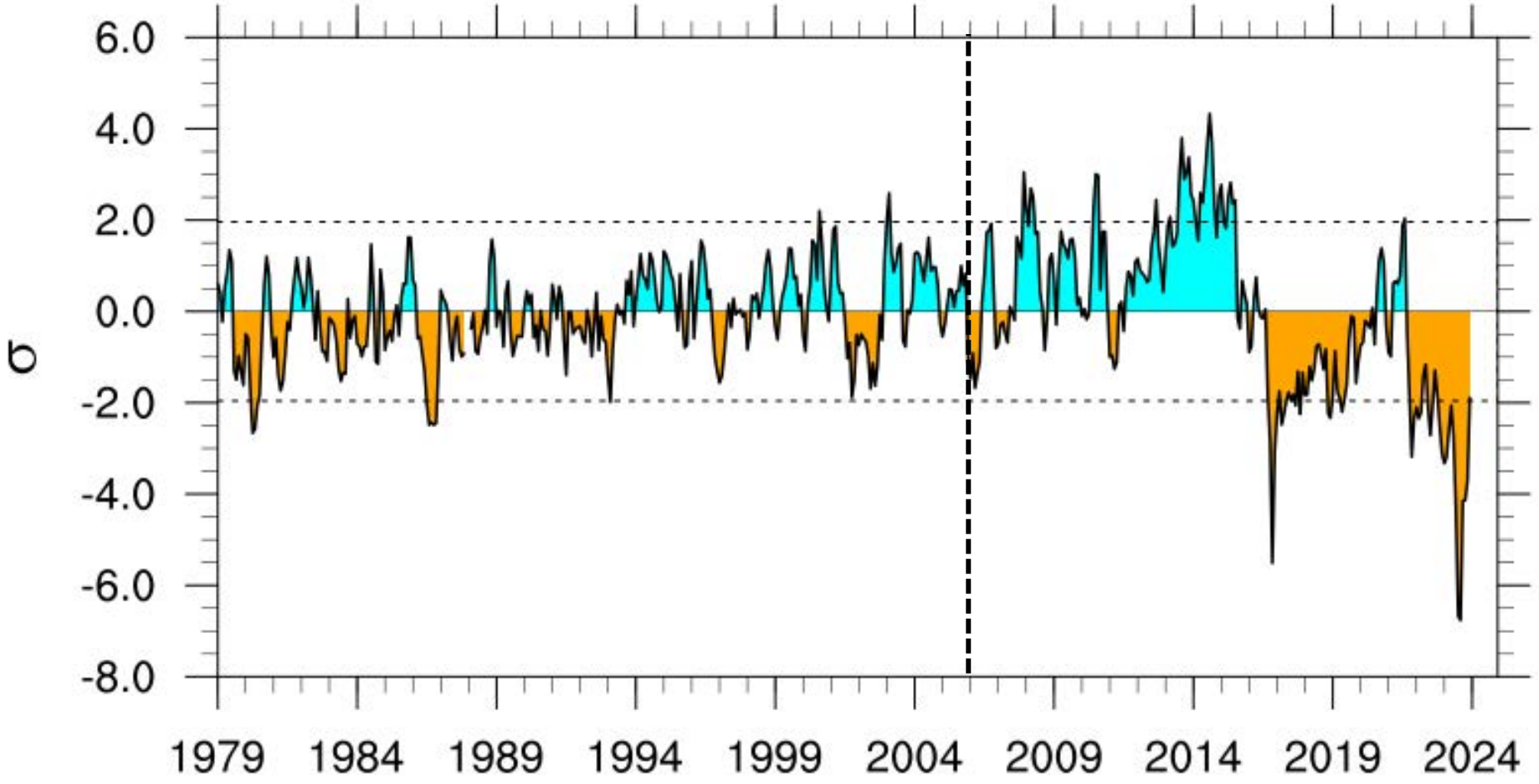

[Purich and Doddridge, 2023]

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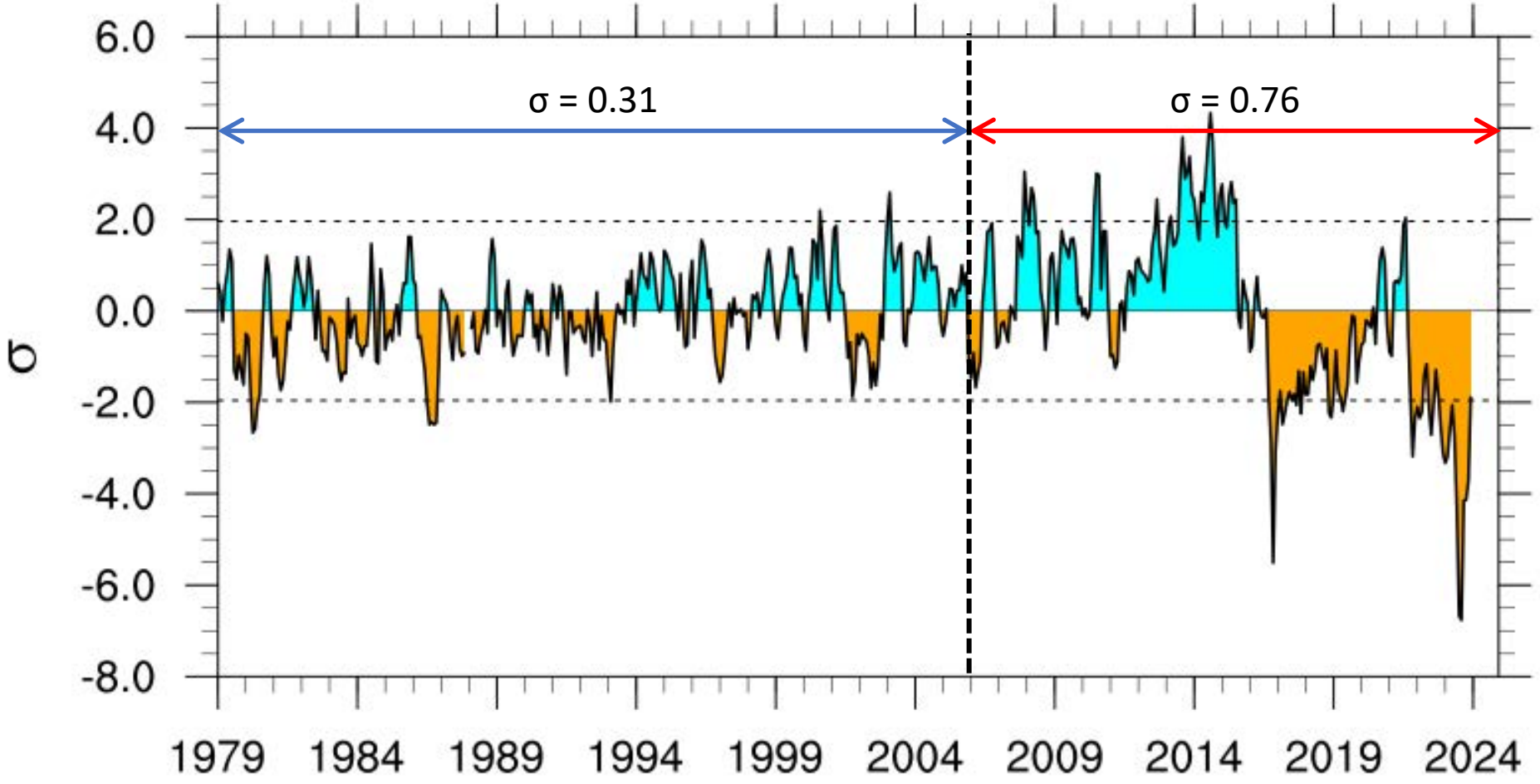

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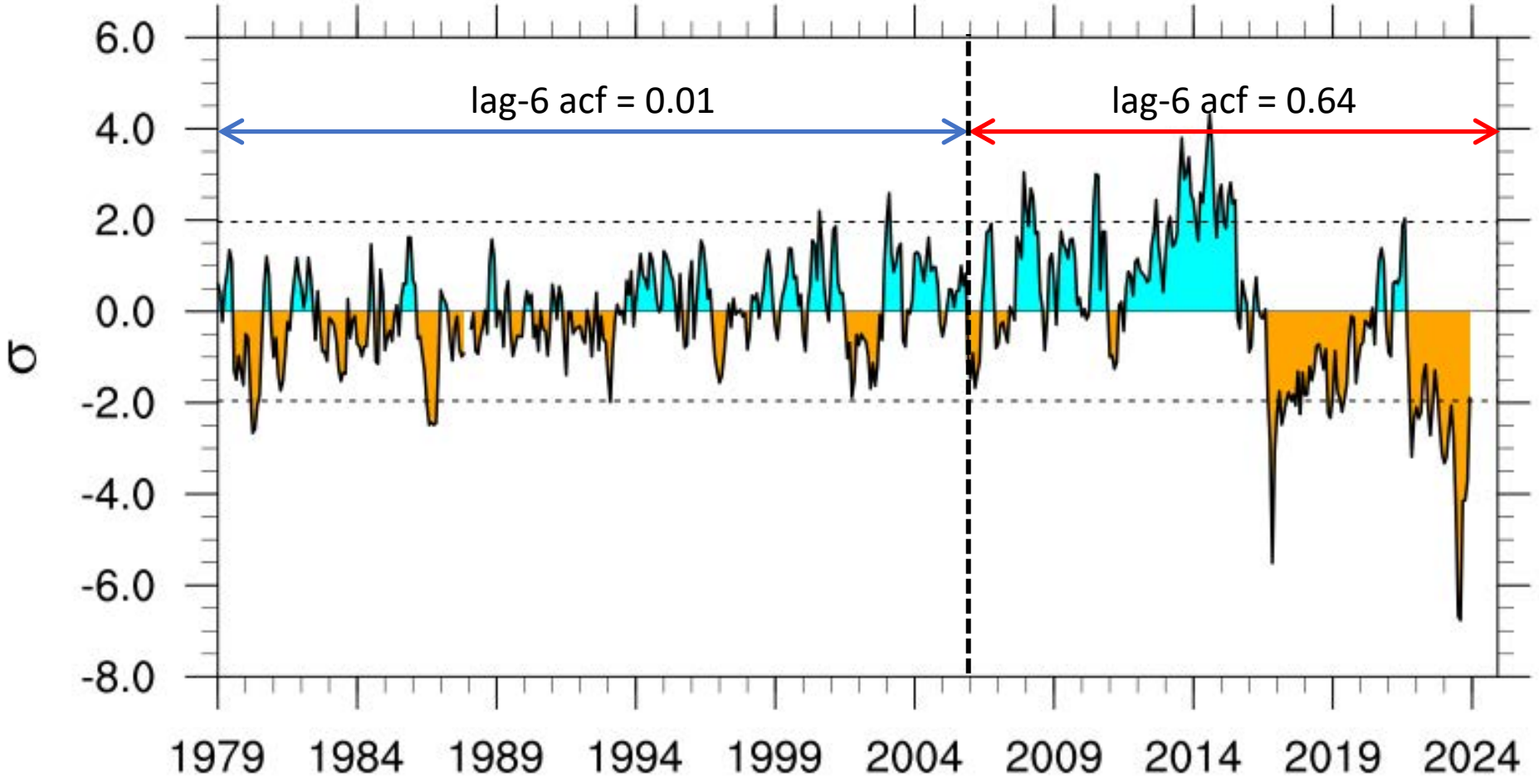
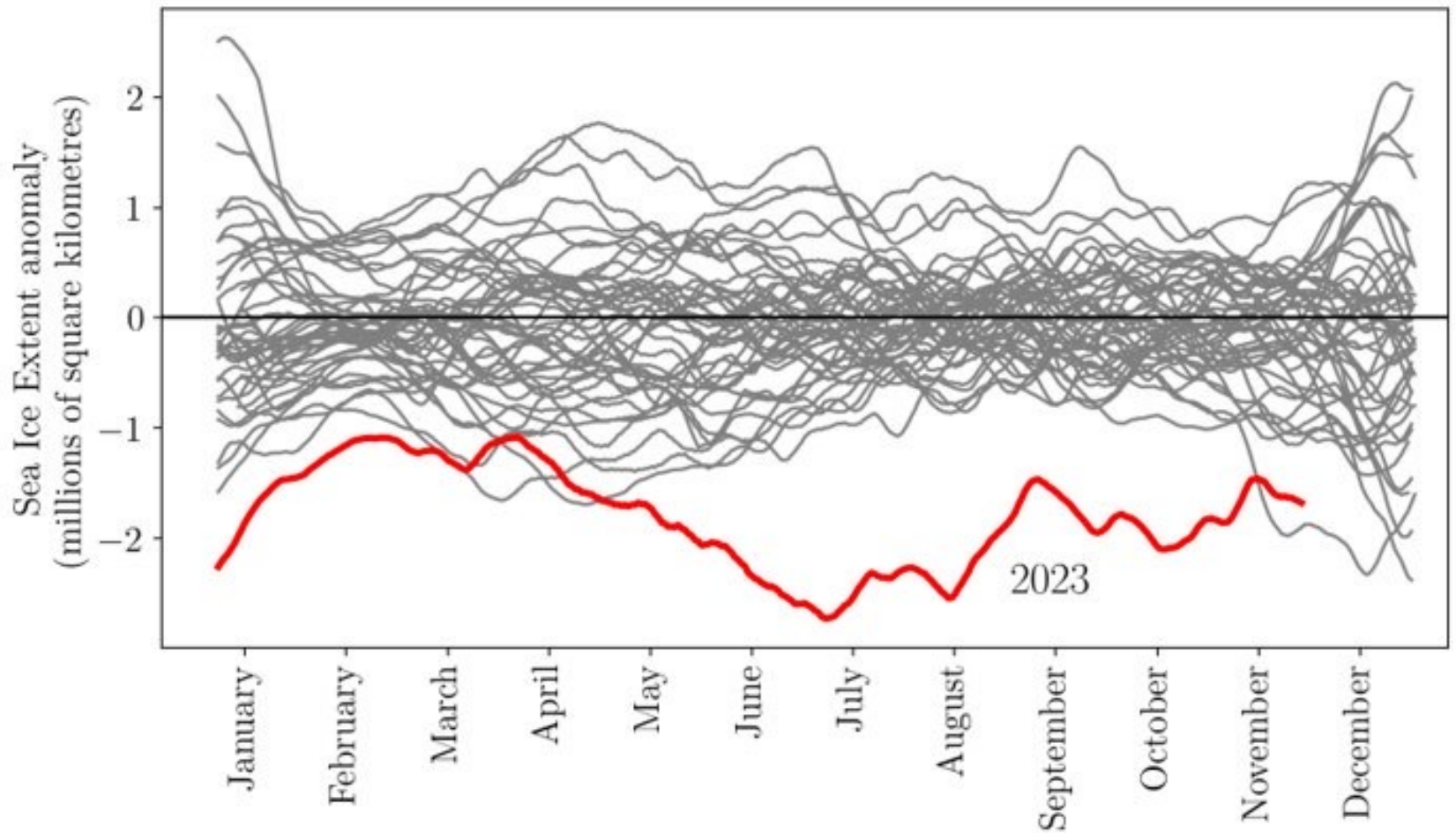
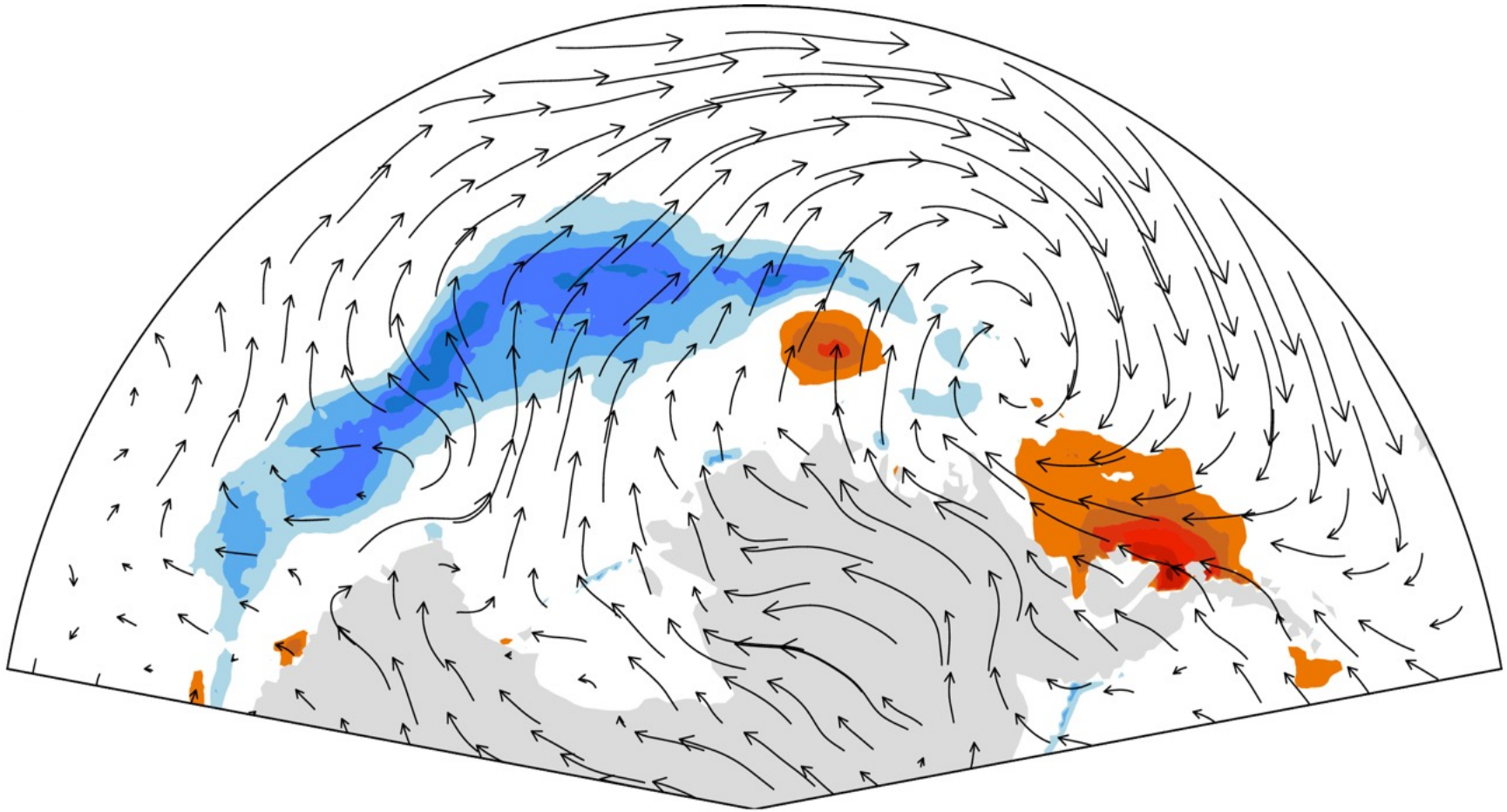


AN ABRUPT CRITICAL TRANSITION?



MOST SEA ICE RESEARCH IN THE LAST TWO DECADES



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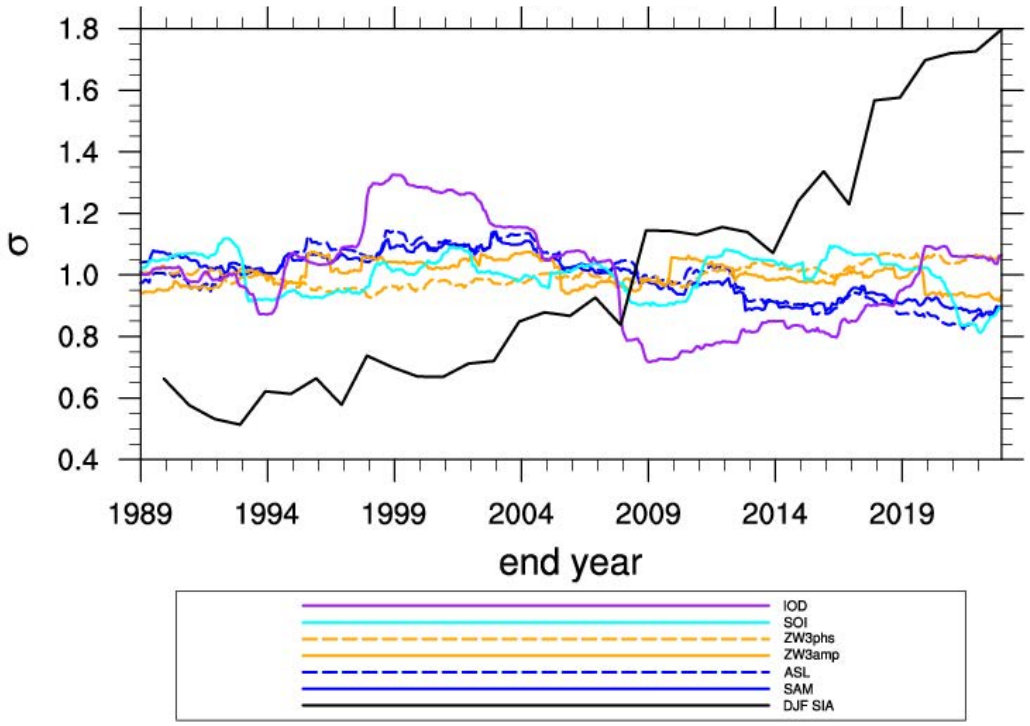
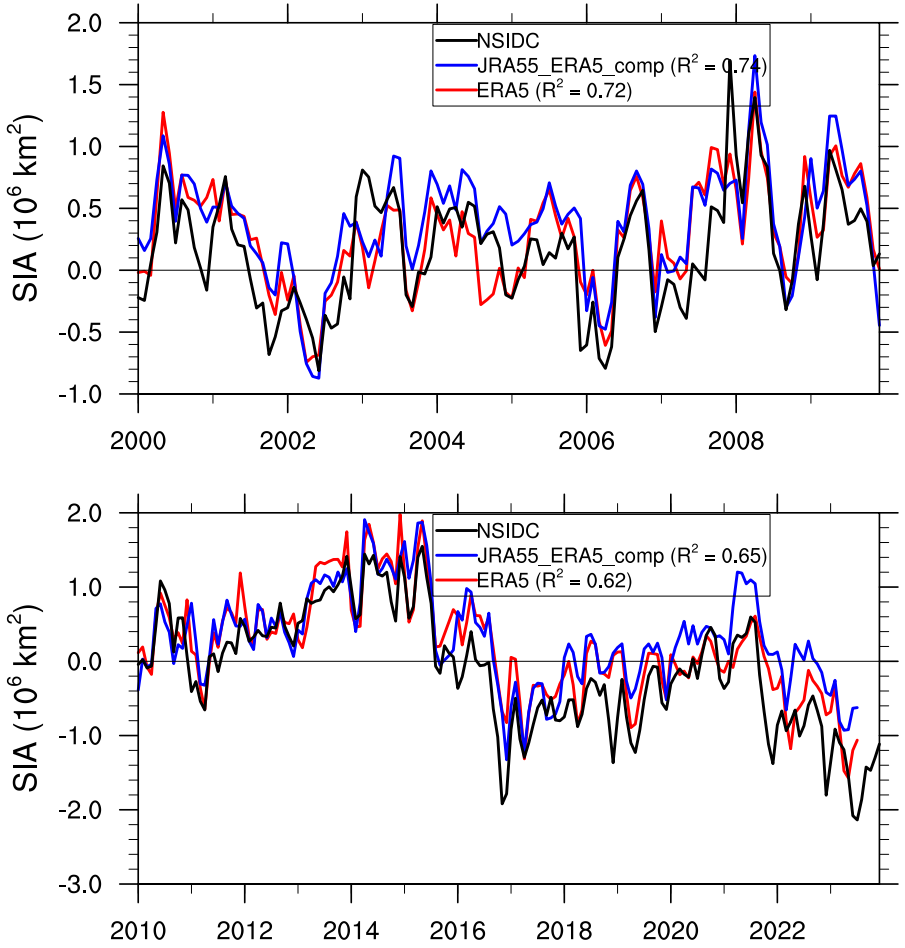
IS THE ATMOSPHERE LOSING ITS DOMINANCE?

[Purich and Doddridge 2023; Hobbs *et al* (in review)]

OBS – no evidence of increased variance in atmospheric modes



MODEL – slavish to the atmosphere UNTIL 2017 [also Roach et al 2023]



STEP 1: COOL THE OCEAN

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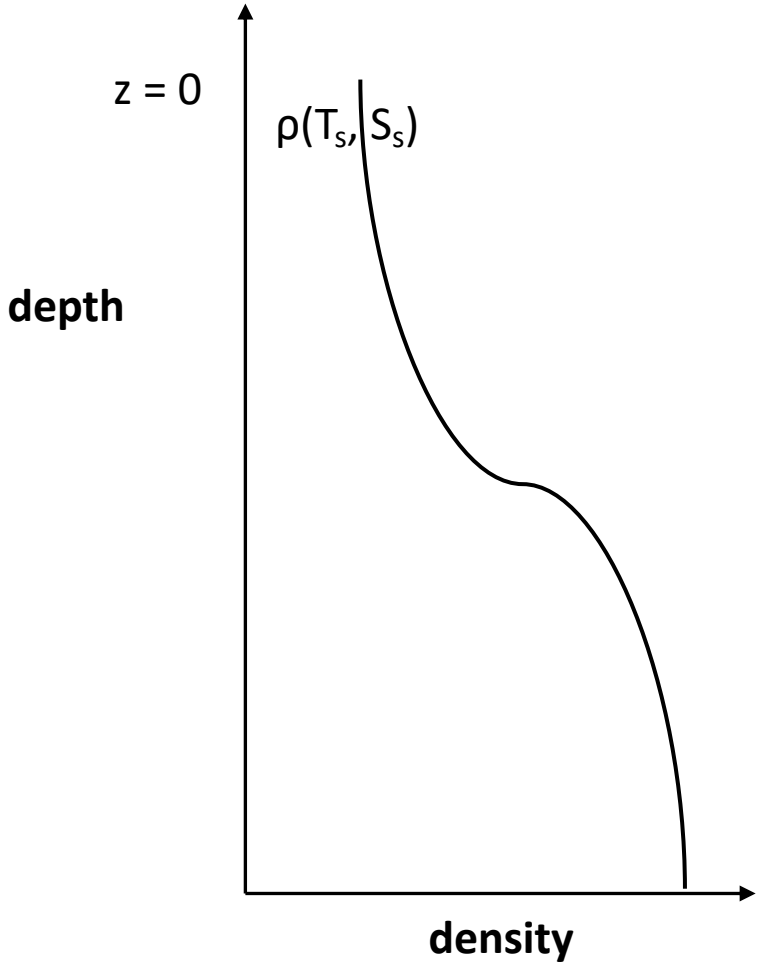
COOLING THE SURFACE



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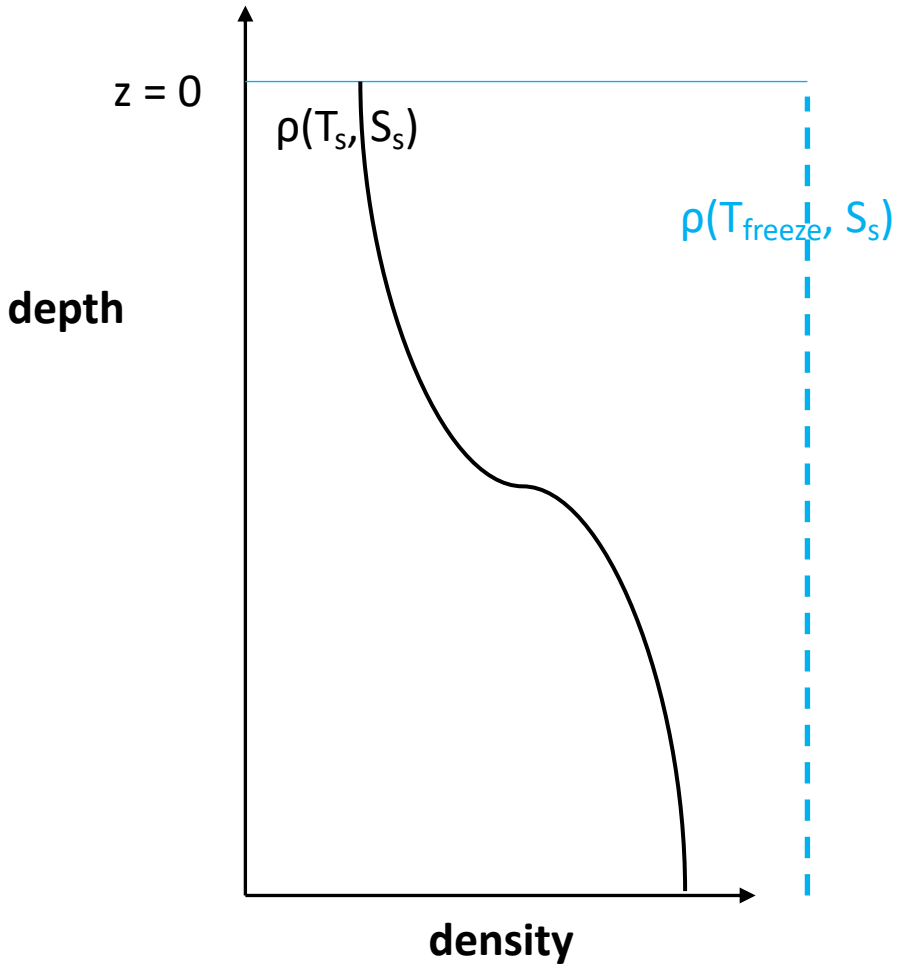
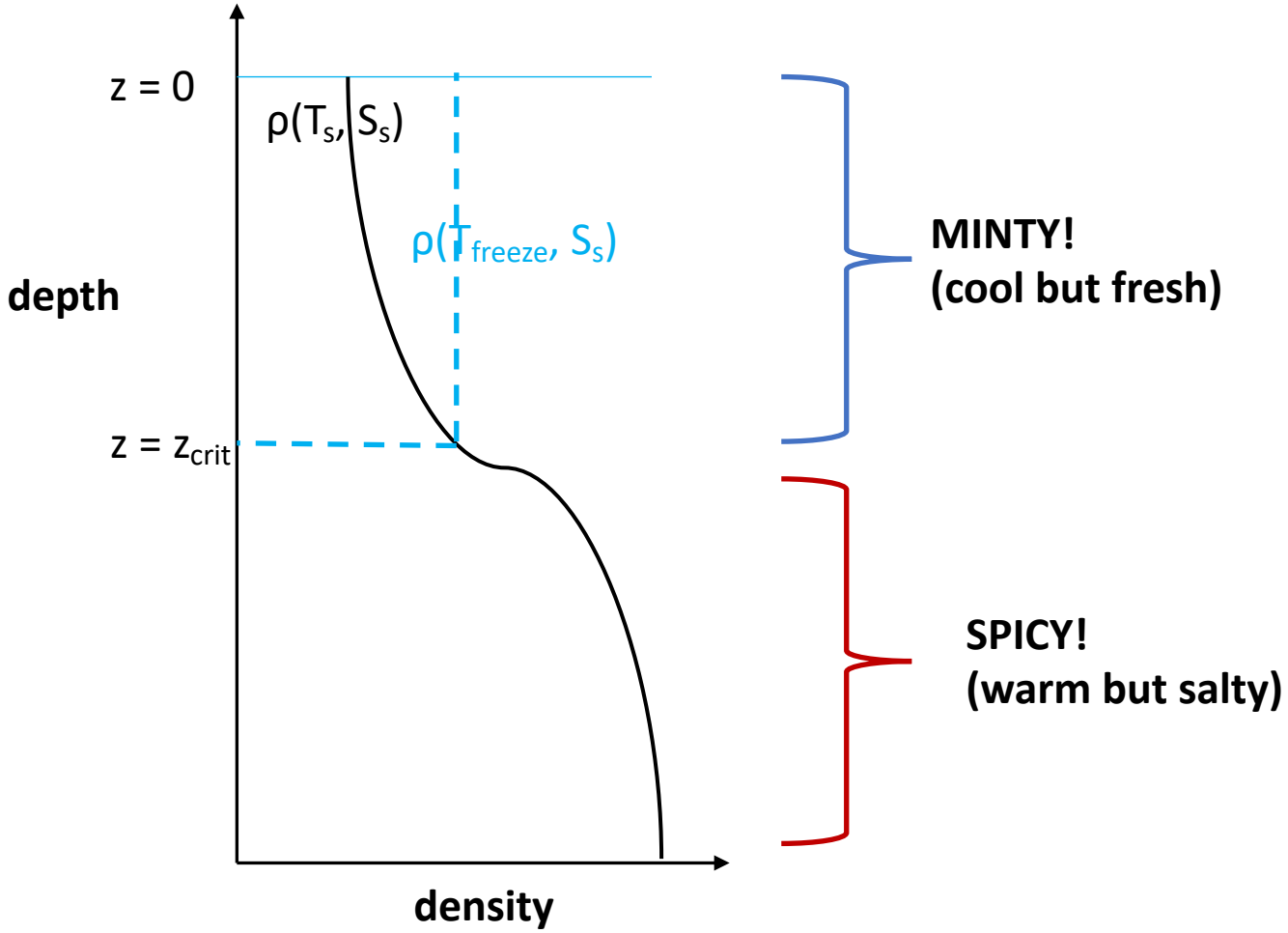


SEA ICE CAN ONLY EXIST WHERE BUOYANCY IS DOMINATED BY SALINITY



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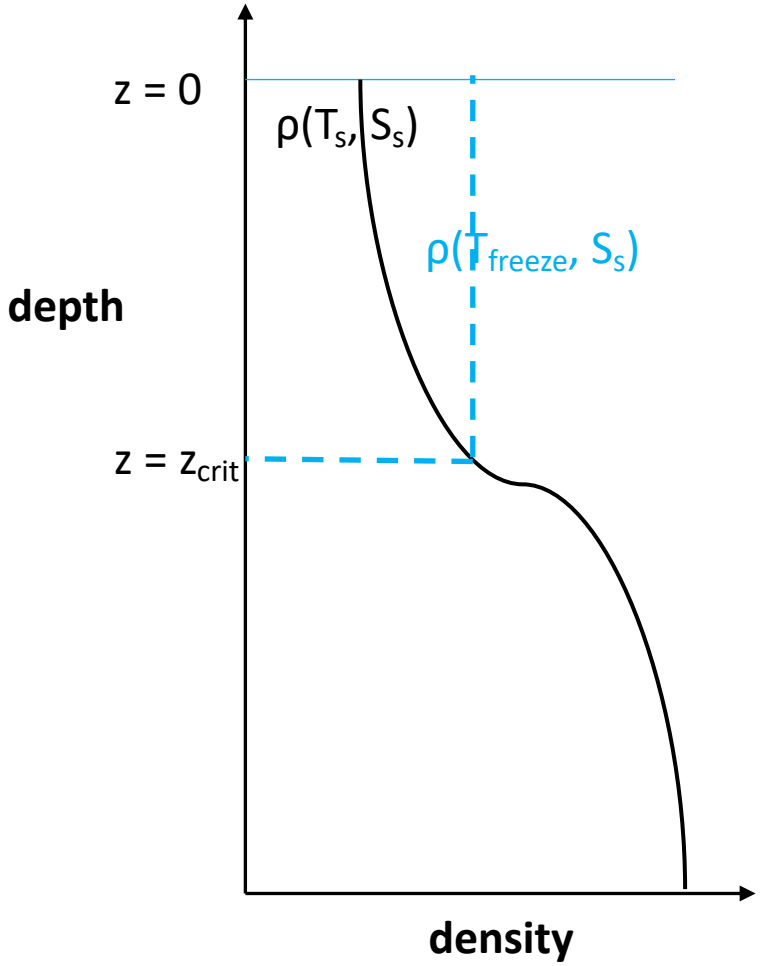
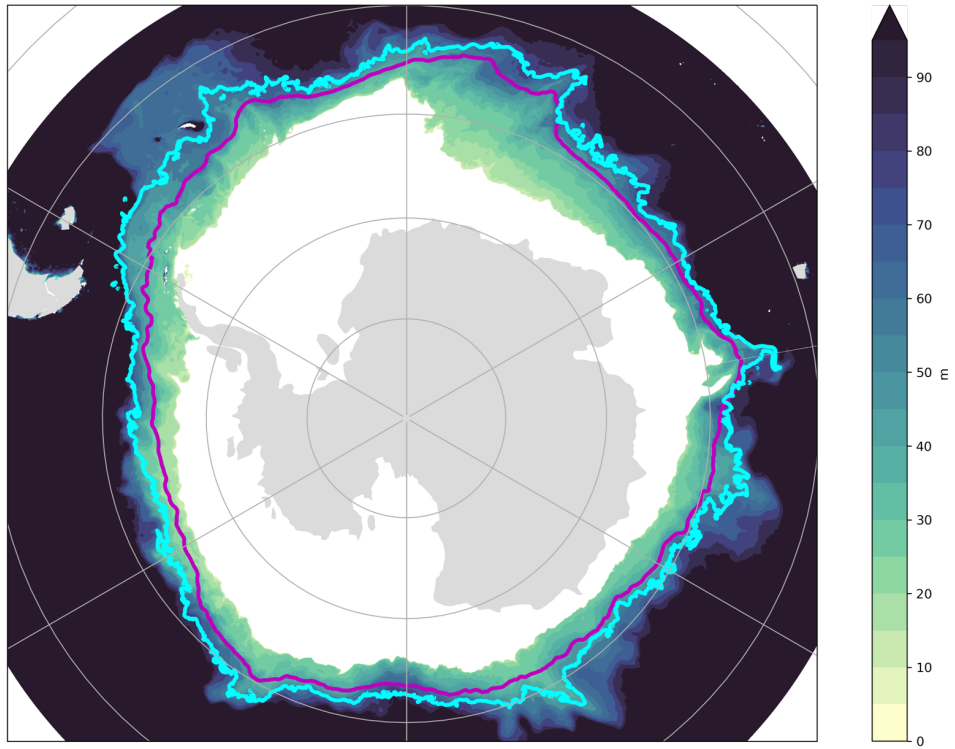
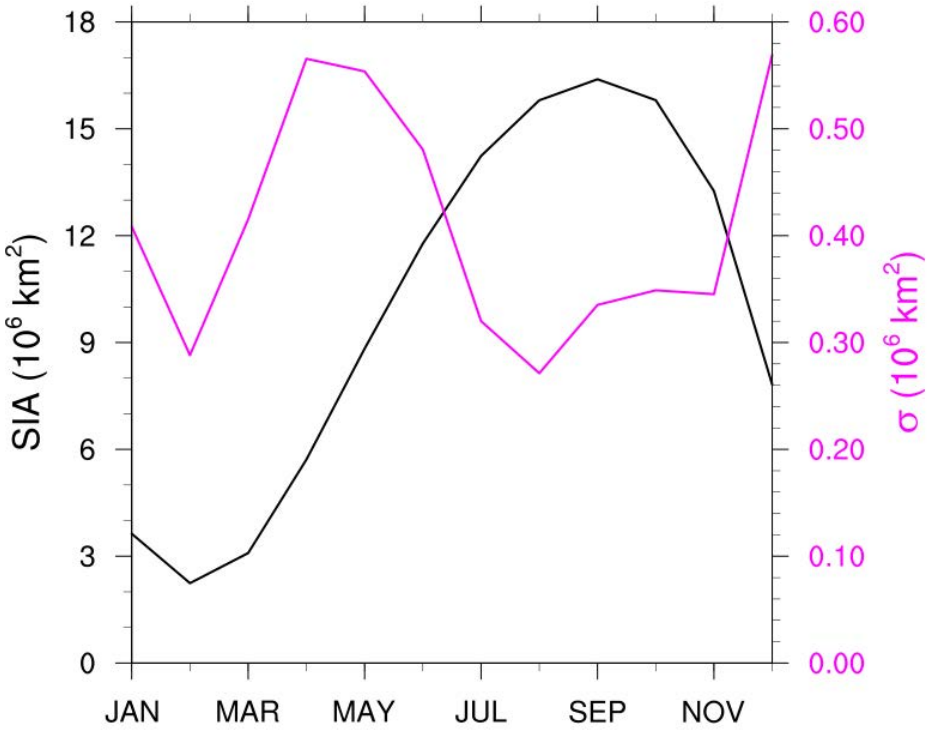


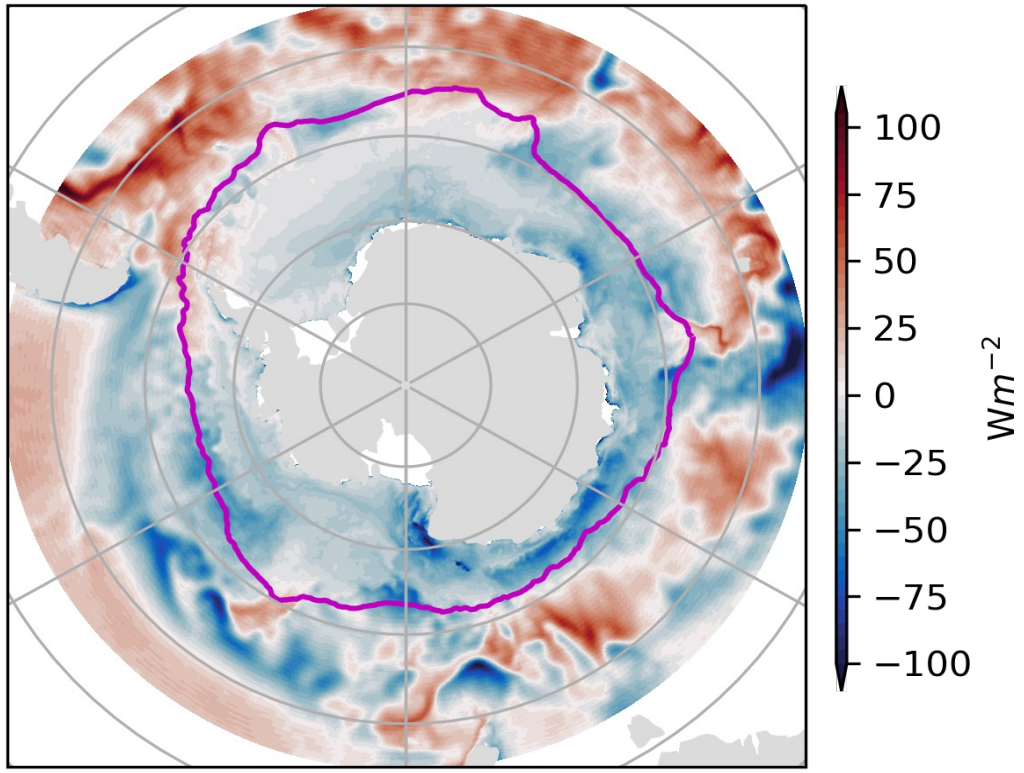


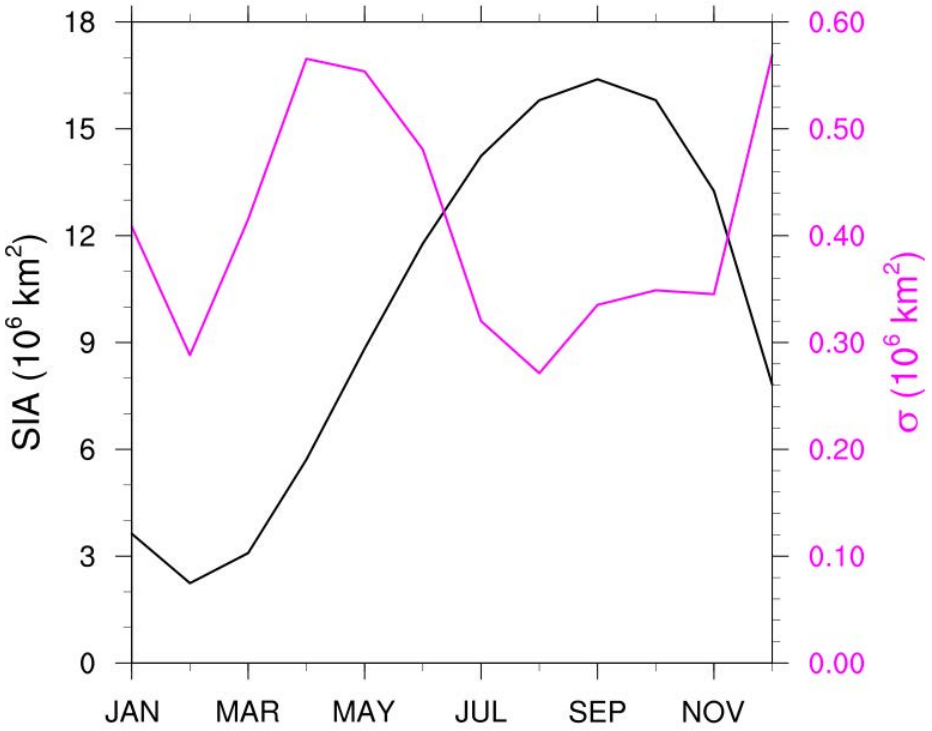
WHAT CONSTRAINS MAXIMUM ICE EXTENT?



WHAT CONSTRAINS MAXIMUM ICE EXTENT?

Annual-mean surface cooling





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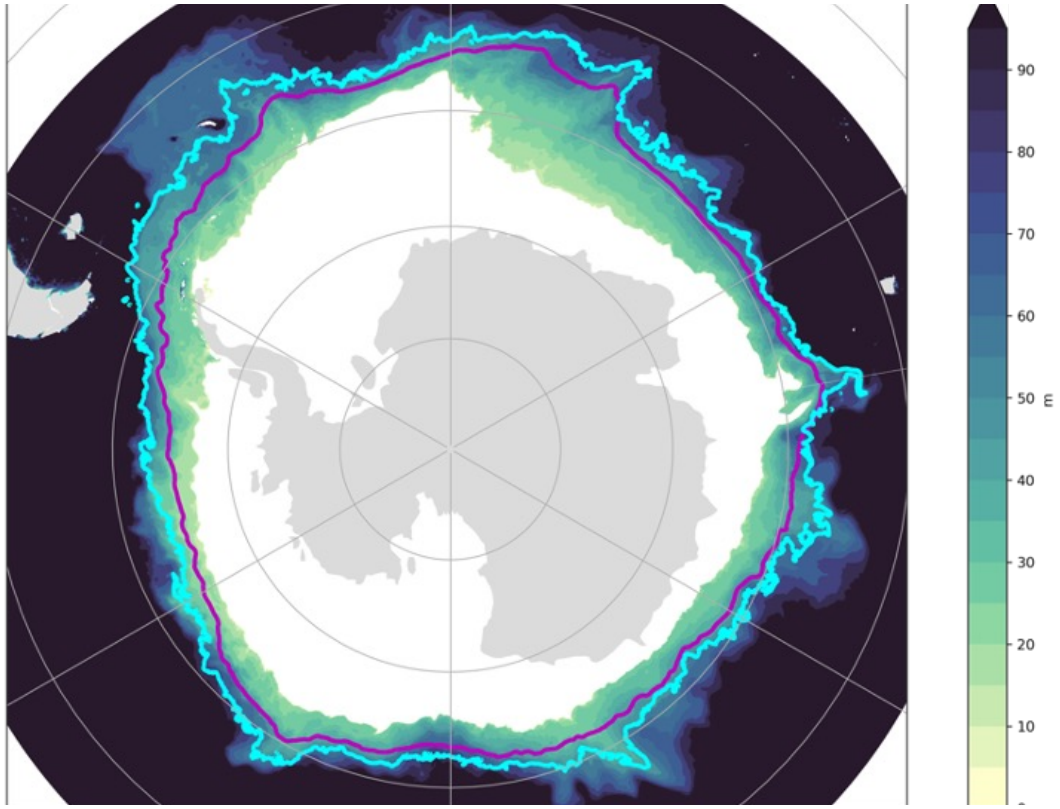

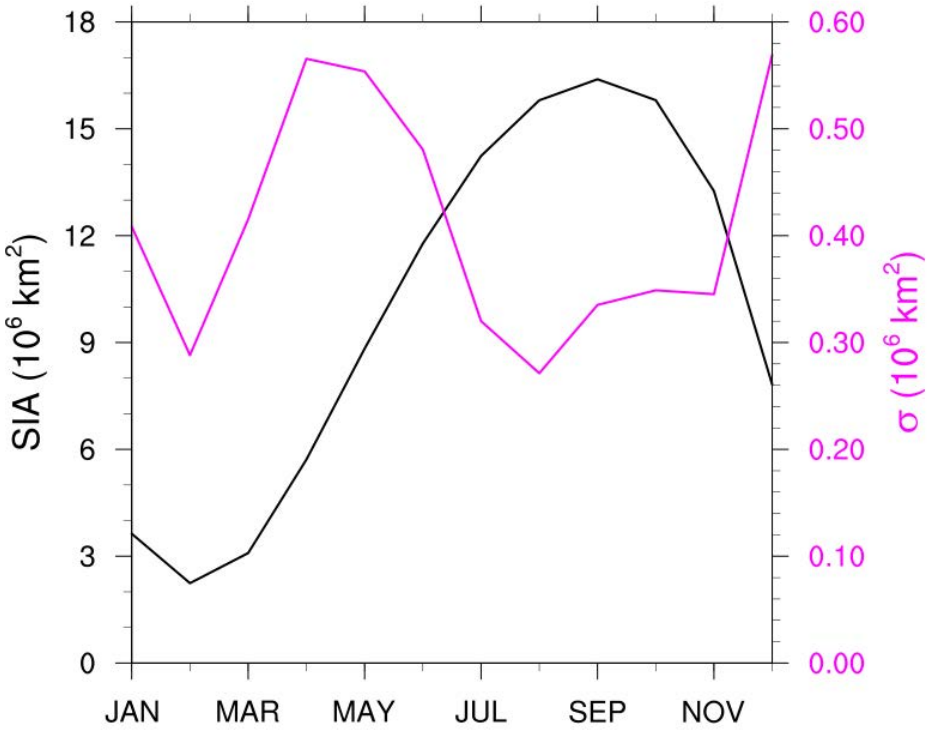

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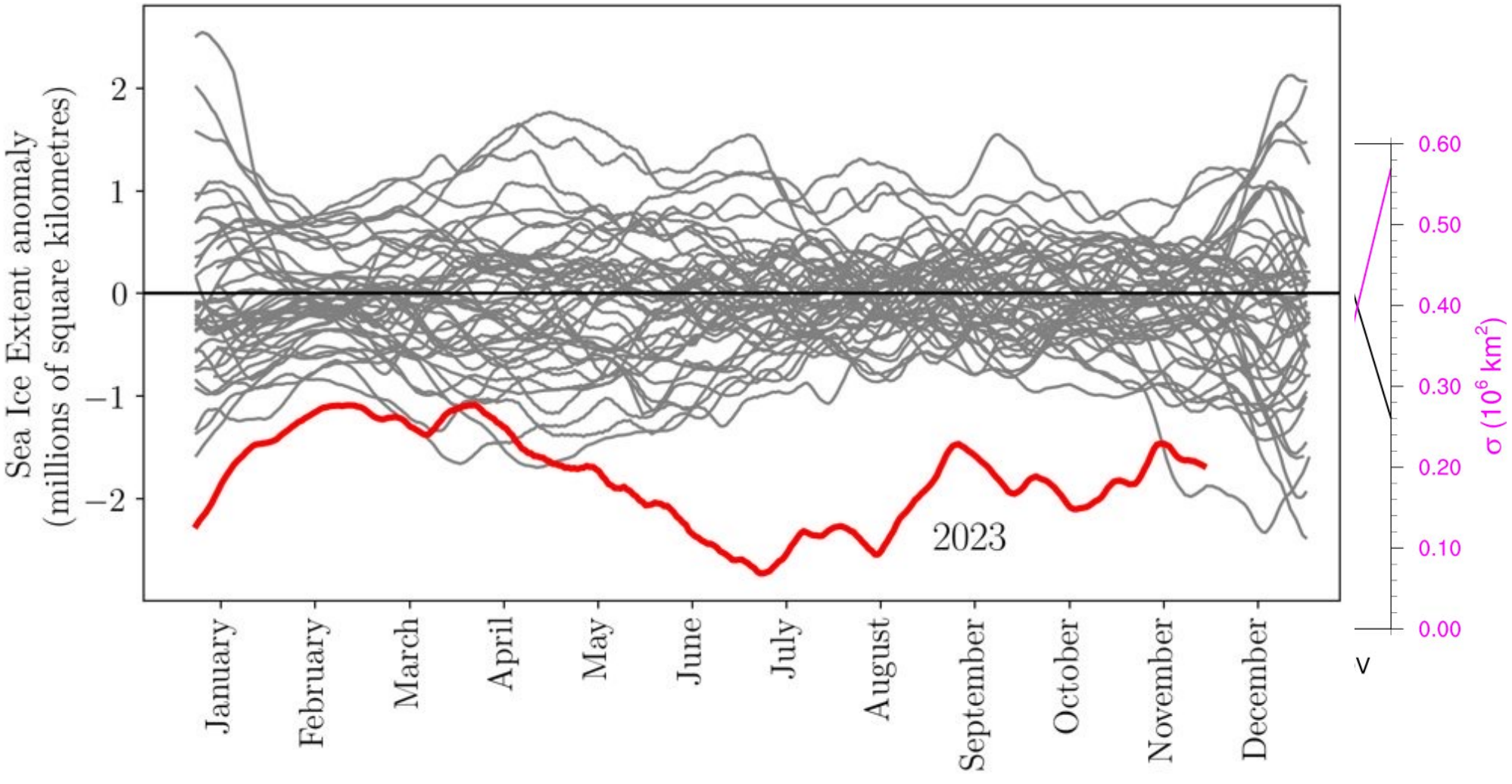

STEP 2: FREEZE SOME ICE

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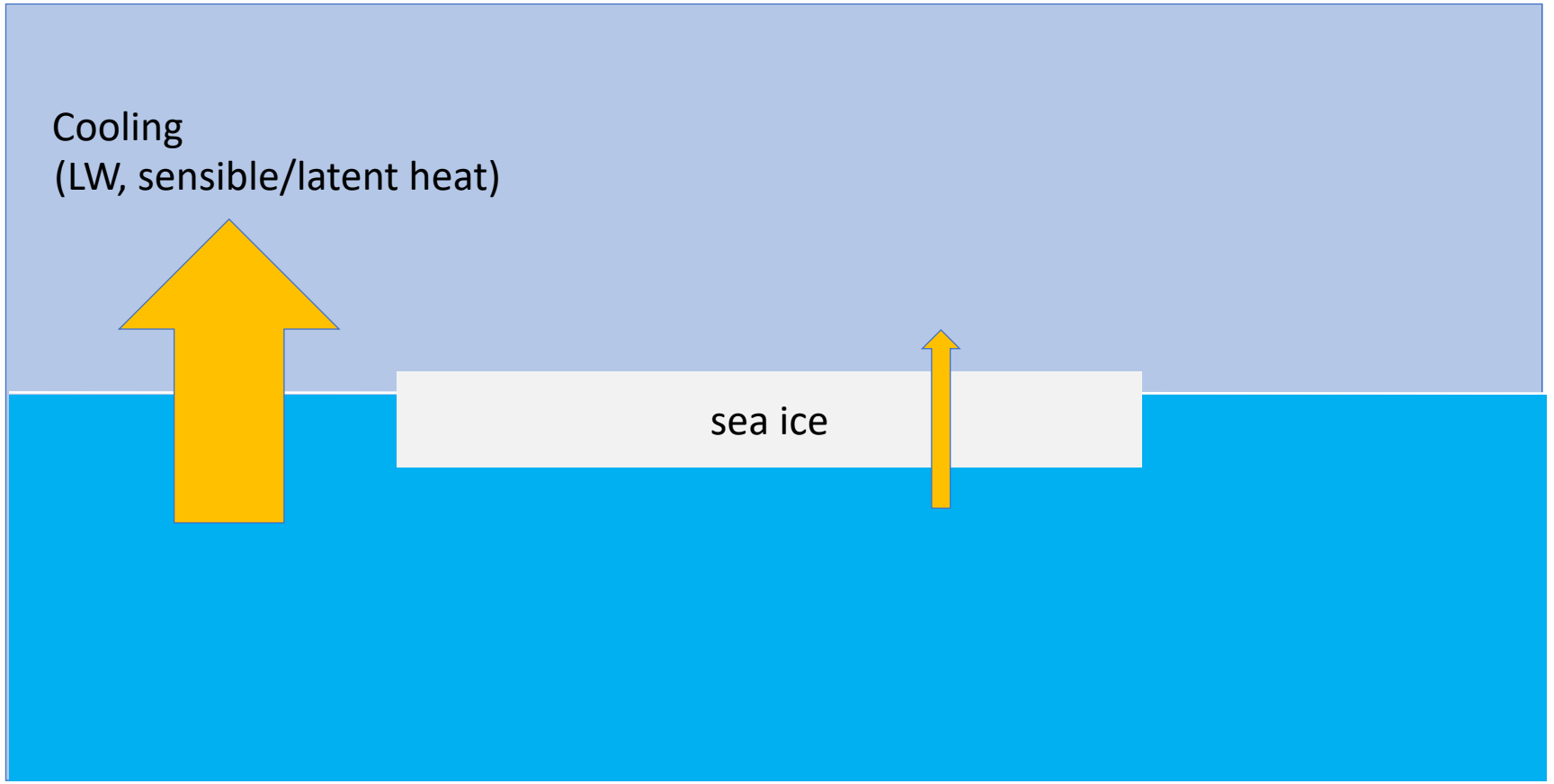
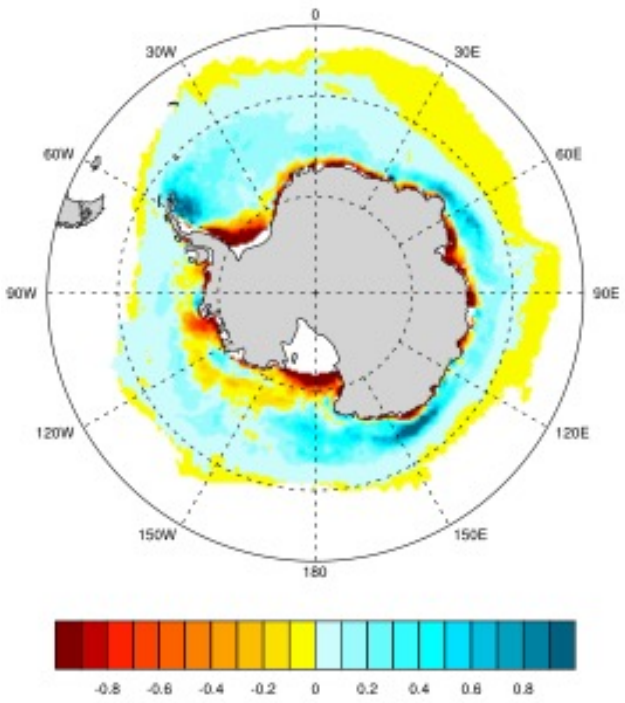
CONSTRAINTS ON SEA ICE THICKNESS



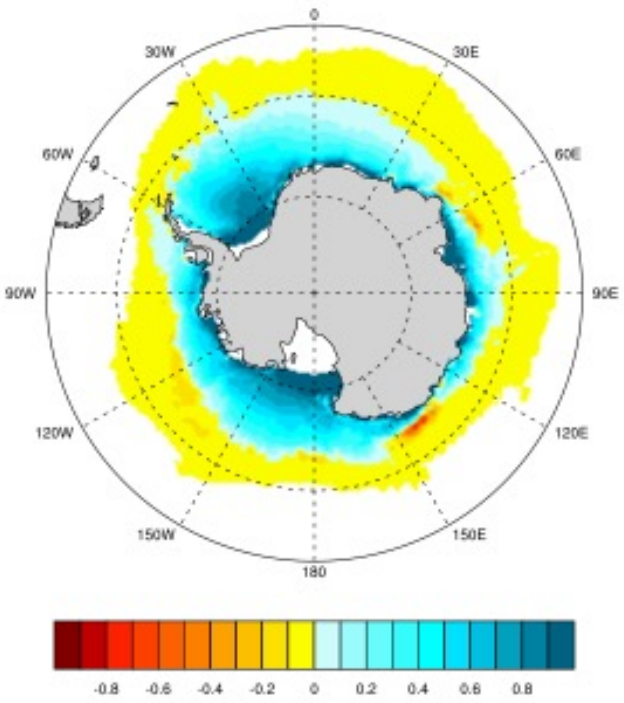
DYNAMICS vs THERMODYNAMICS

(model SIV tendencies, April-June)

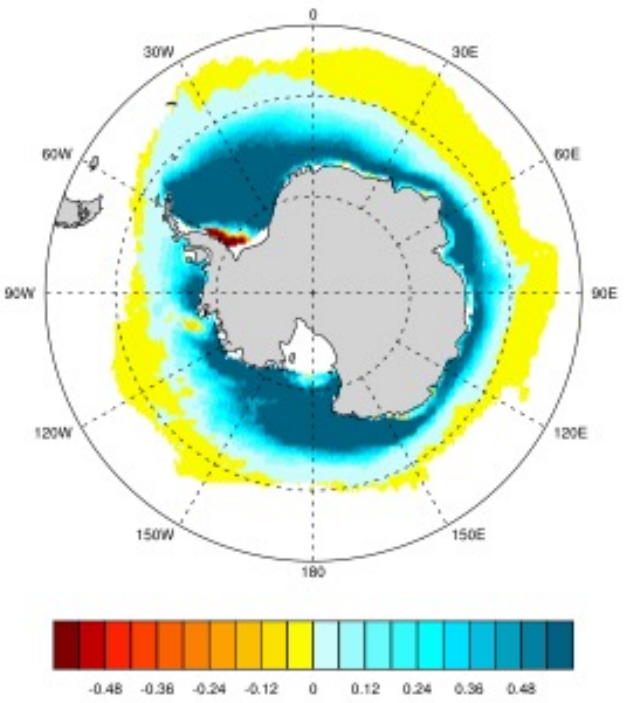
Dynamic



Thermodynamic



Net



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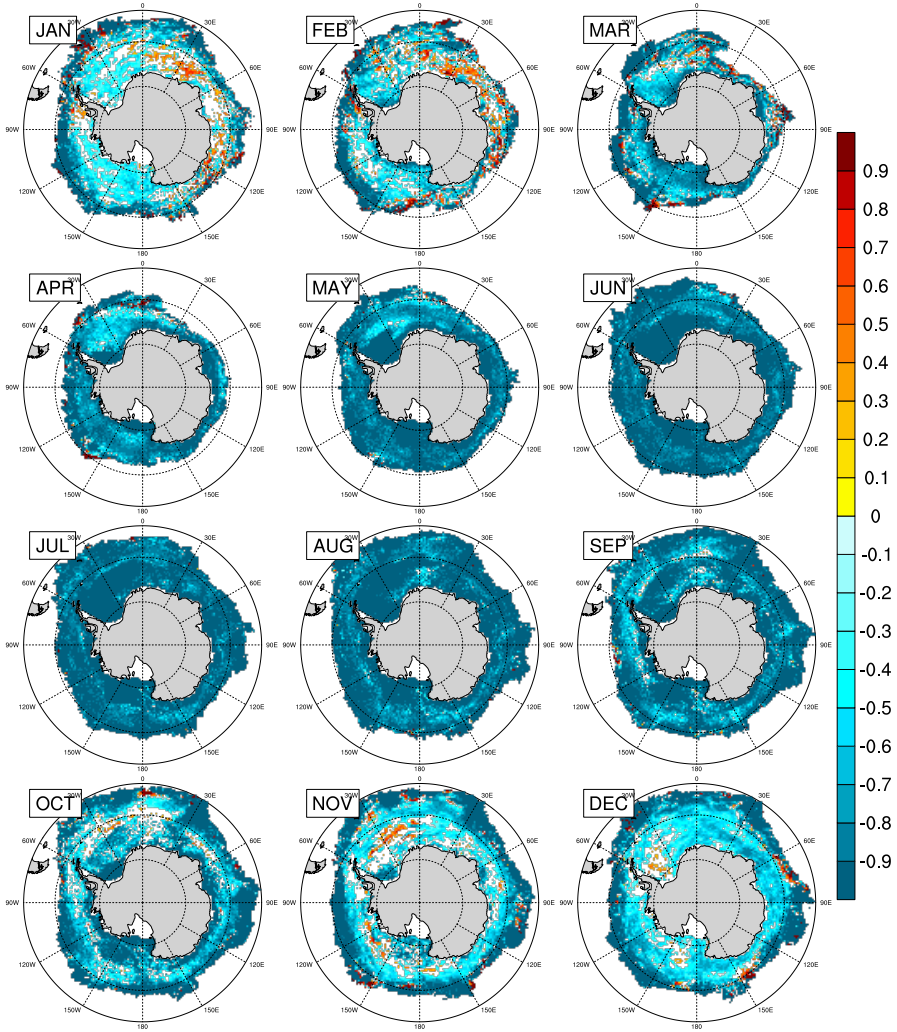
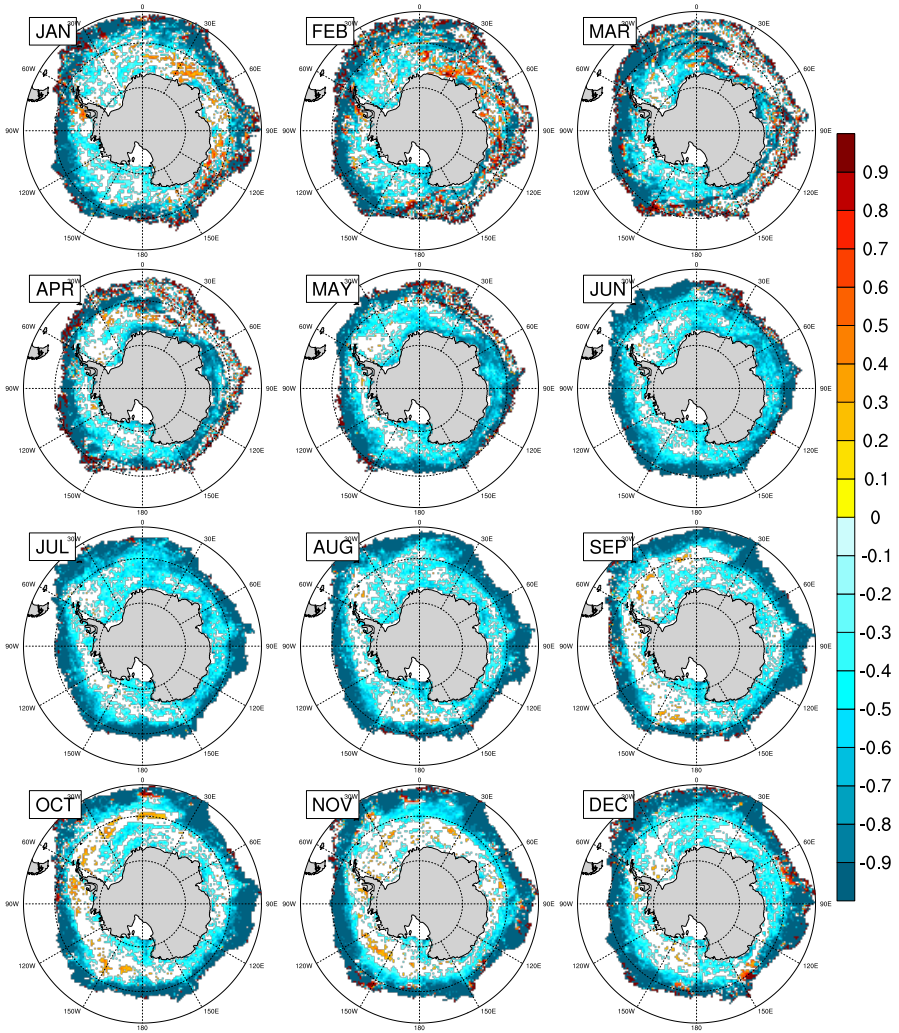
DYNAMICS/THERMODYNAMIC CORRELATIONS

Area



Volume



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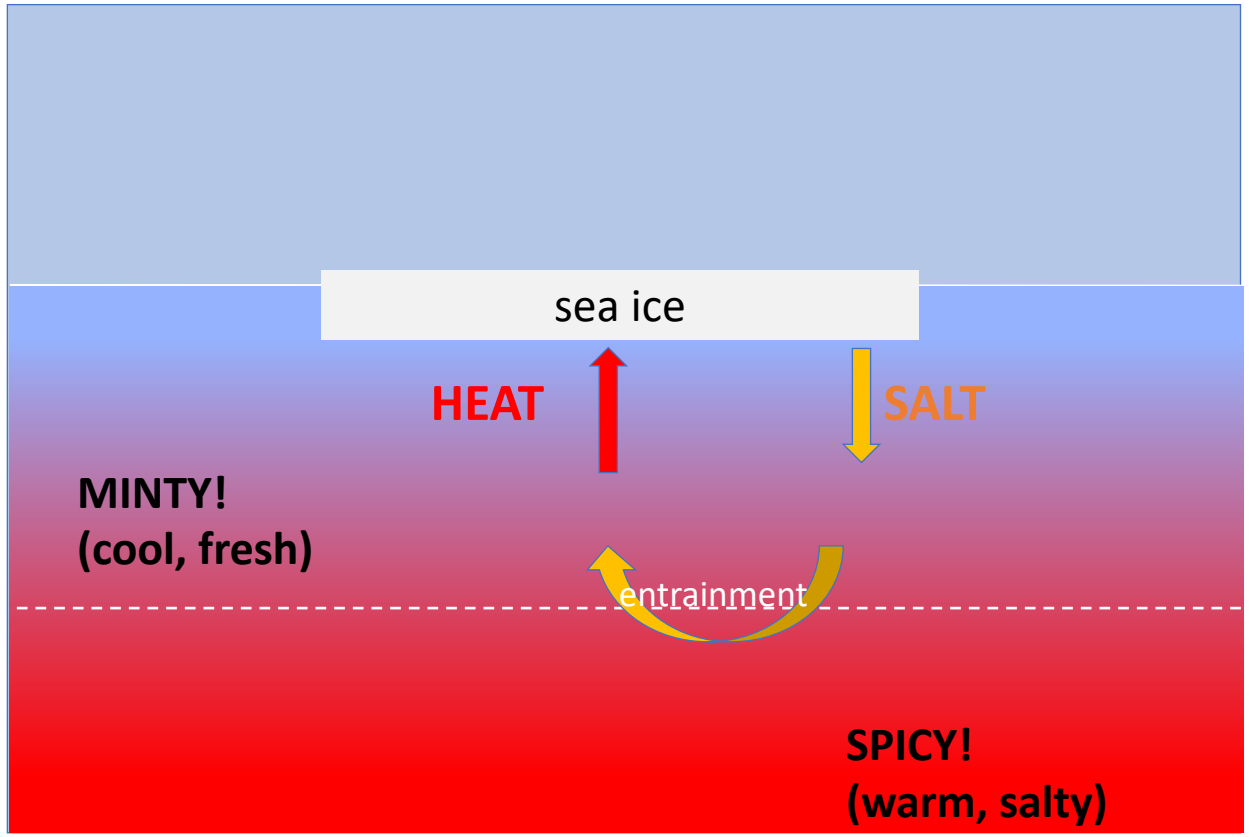
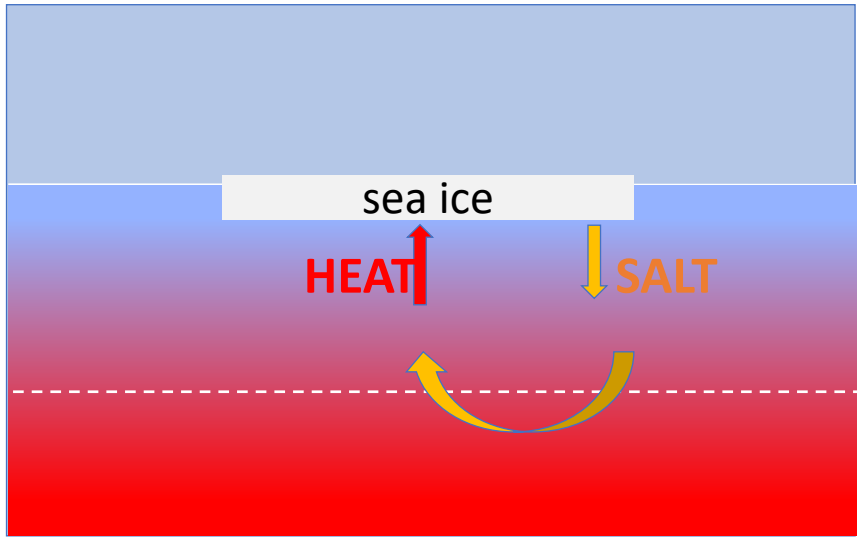
OCEAN CONSTRAINTS ON SEA ICE GROWTH

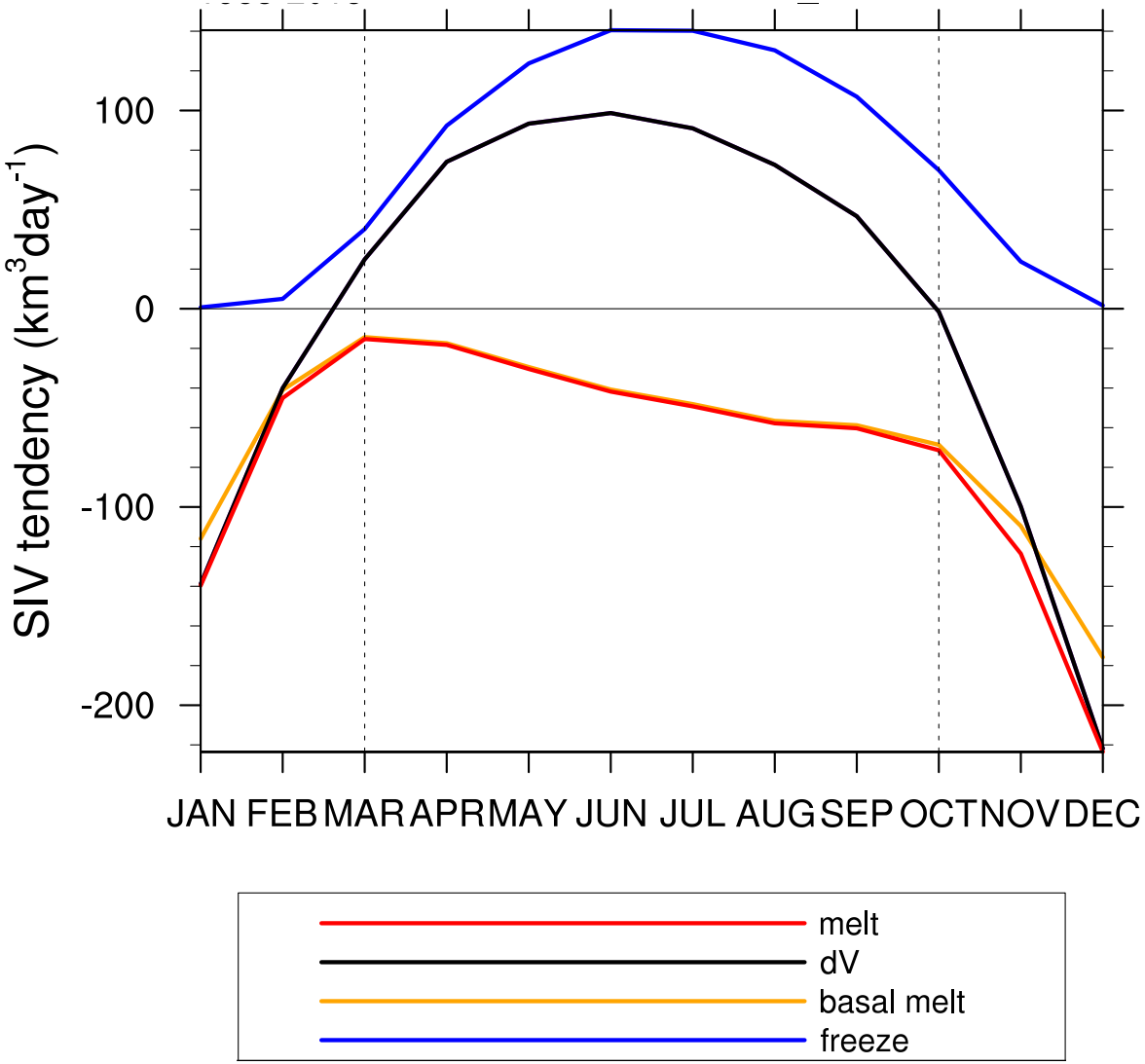
[Martinson and Ianuzzi, 1998; Singh et al, 2020]



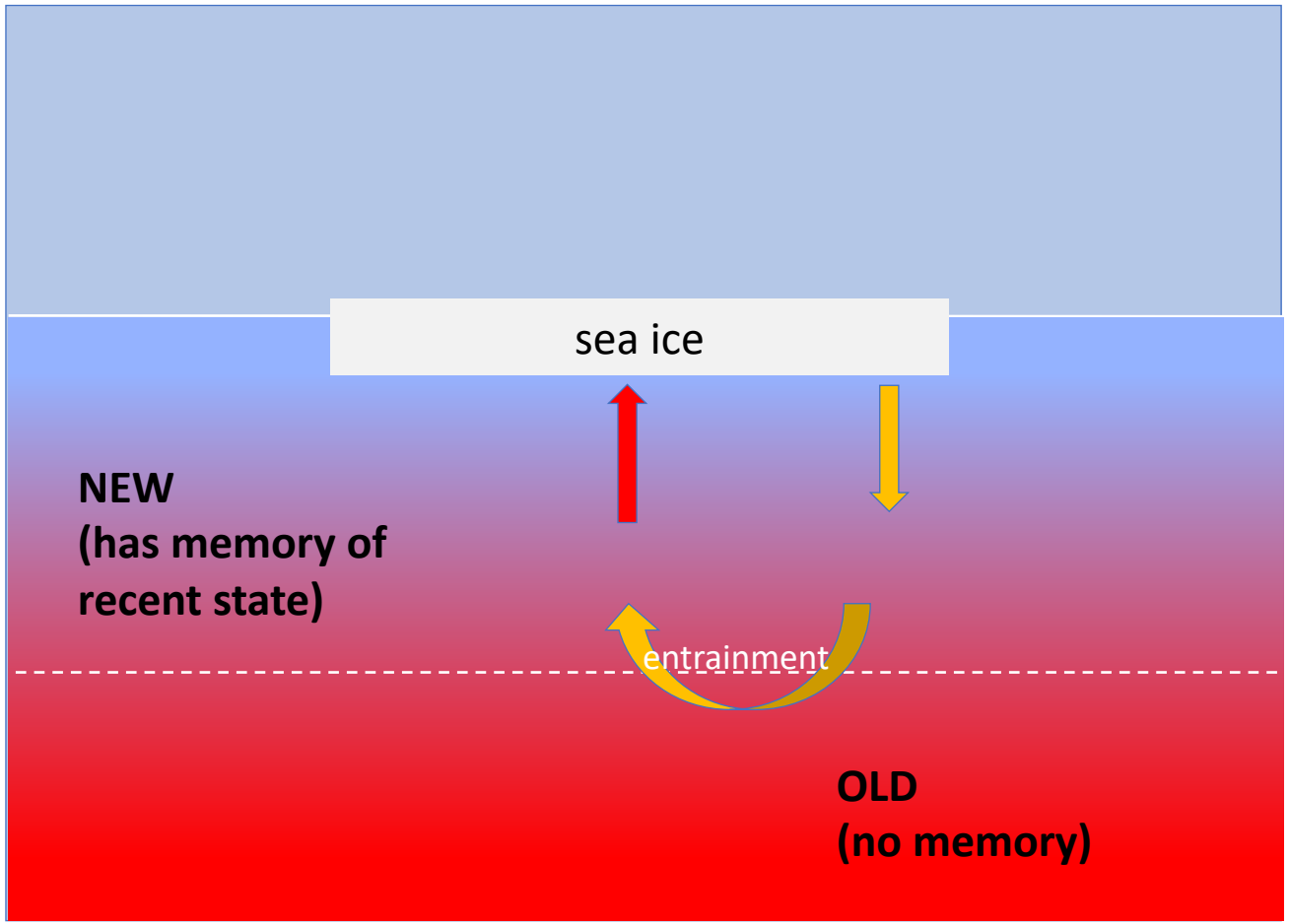
OCEAN CONSTRAINTS ON SEA ICE GROWTH

[Martinson and Ianuzzi, 1998; Singh et al, 2020]



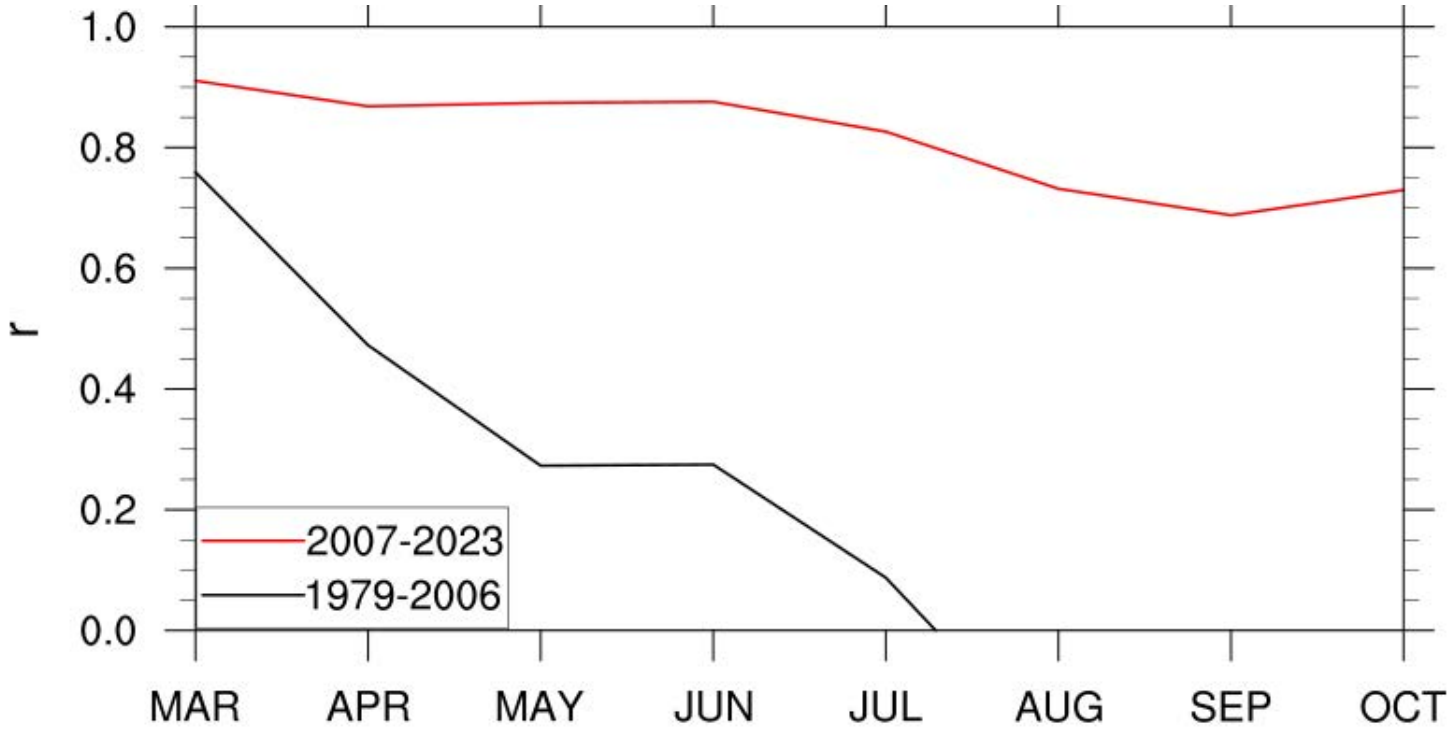


ENTRAINMENT IS ALSO A LIMIT ON PERSISTENCE [Libera et al, 2022]



ENTRAINMENT IS ALSO A LIMIT ON PERSISTENCE [Libera et al, 2022]

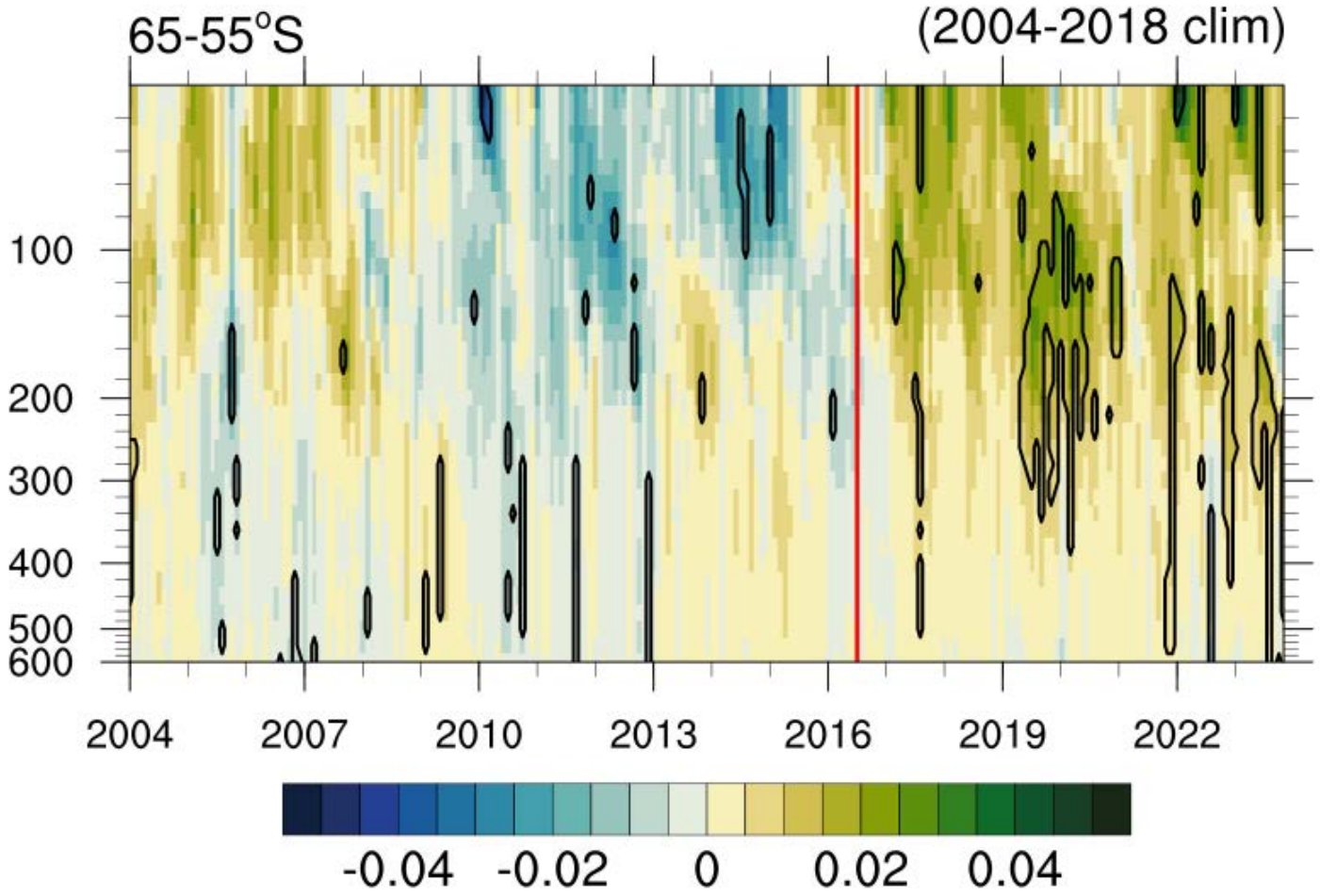
Lagged correlation with February



BUT WHAT ABOUT THE INCREASED VARIANCE/PERSISTENCE?

Implies more entrainment

- Consistent with sea ice loss
- Not really consistent with greater persistence



STEP 3: MELT

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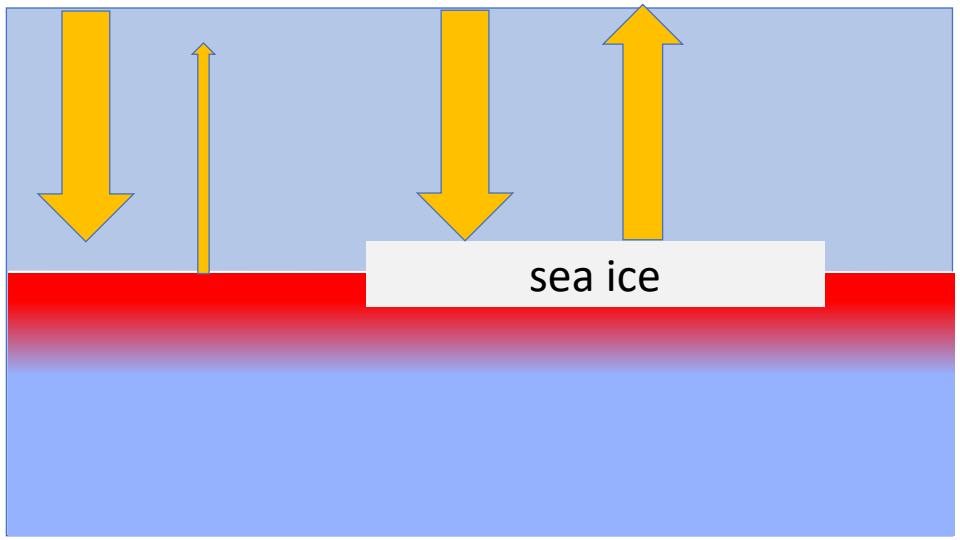
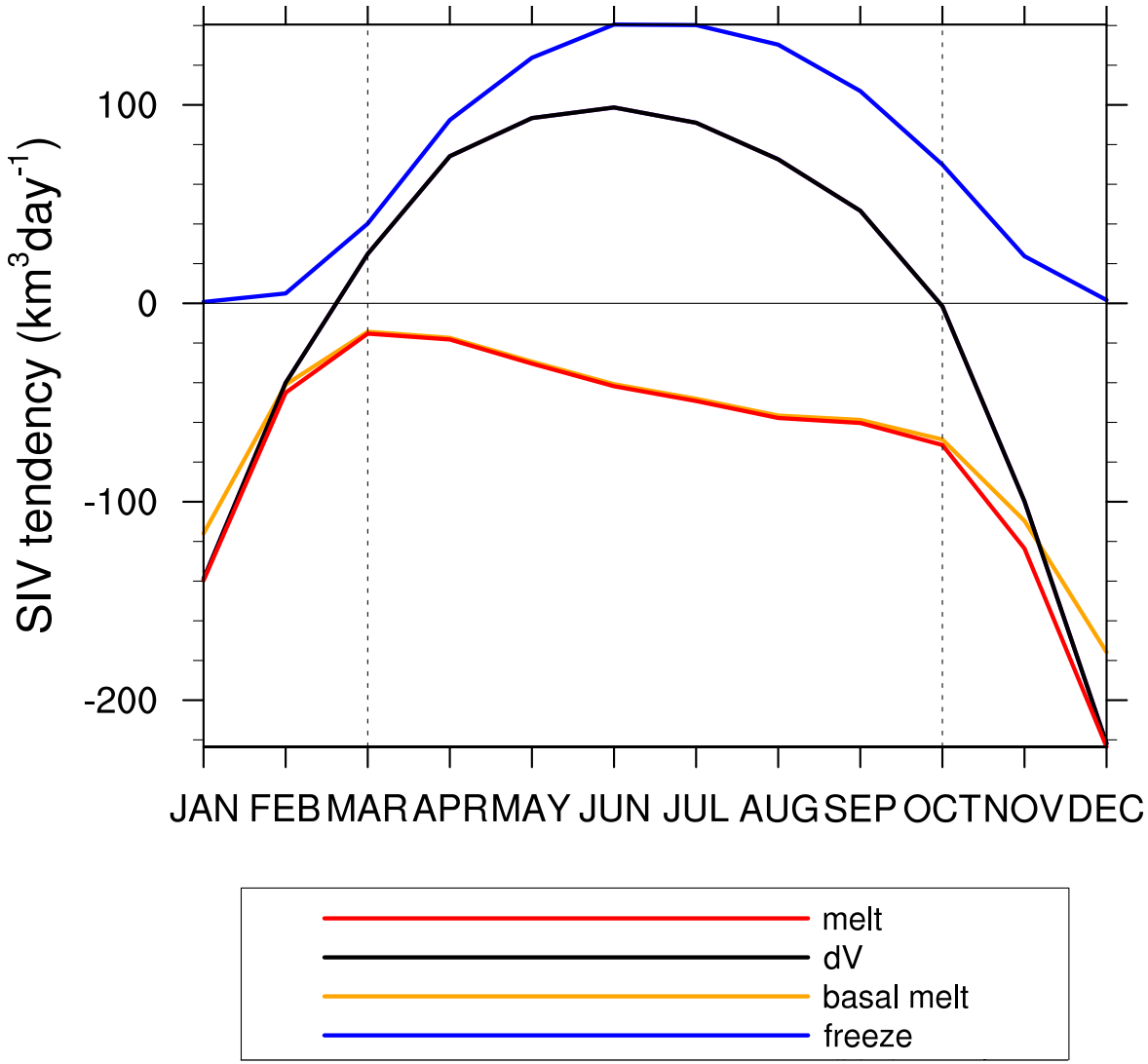
ALMOST ALL MELT IS BASAL (even in summer)

[Gordon, 1981]

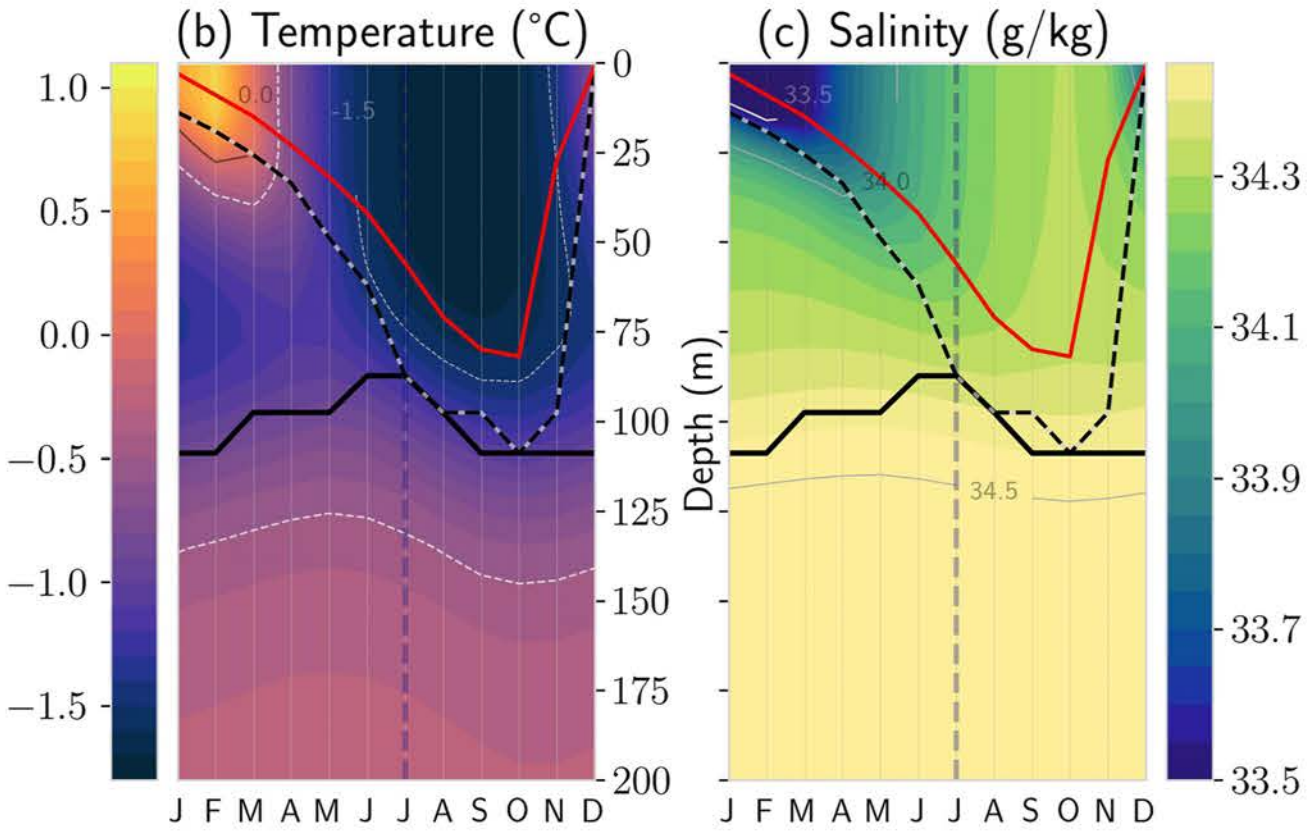




FREEZING DESTRATIFIES, MELTING RESTRATIFIES

Summer layer ‘locks away’ memory of autumn

[Holland et al, 2013]



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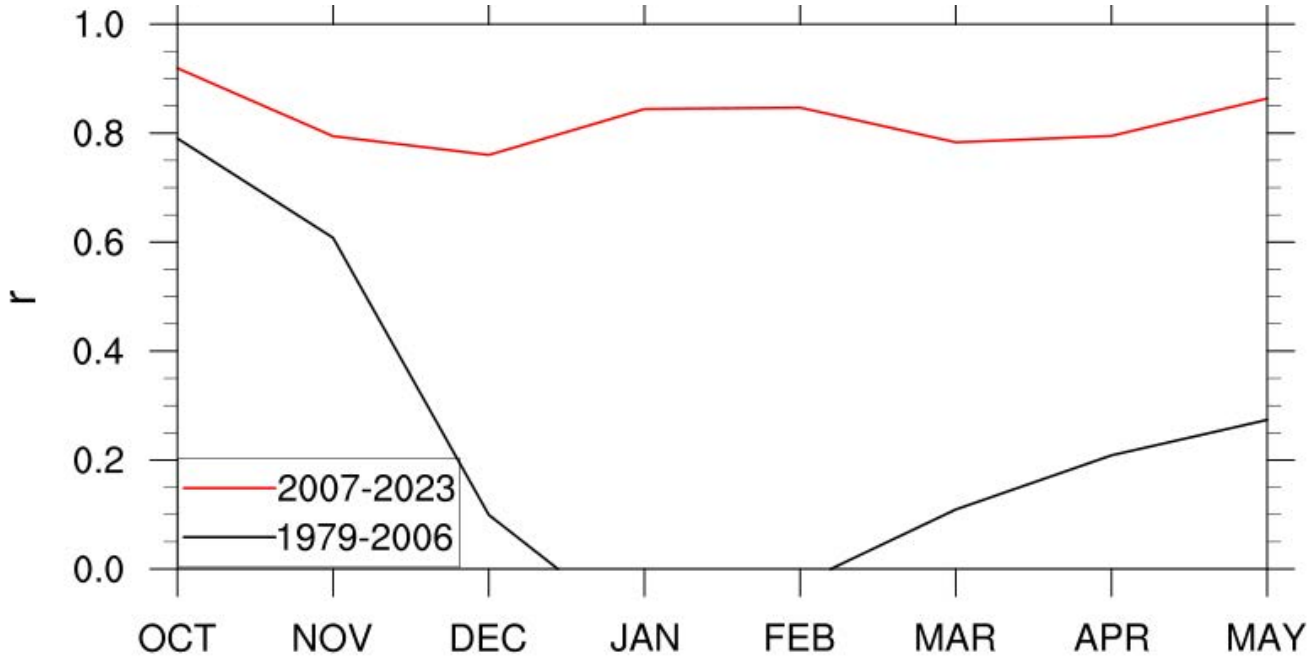

SUMMARY: ANTARCTIC SEA ICE AND POLAR AMPLIFICATION

1. Historically, Antarctic sea ice variability is dominated by the wind, but constrained by negative feedbacks with the ocean

2. The observational record shows increased variance and persistence in the last decade or more
   - ‘critical transition’ – [e.g. Dakos et al, 2008]

3. Changed behaviour isn’t readily explained by atmospheric drivers

4. Does this indicate a flip to a positive feedback system?