Exploring changing variance and persistence of Antarctic sea ice anomalies in CESM

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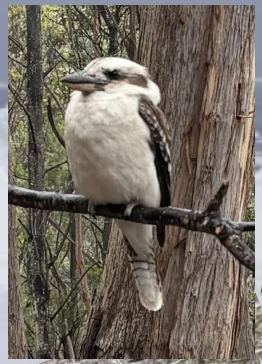
NSF NCAR

CESM PCWG 2025

This material is based upon work supported by the National Center for Atmospheric Research, which is a major facility sponsored by the National Science Foundation under Cooperative Agreement No. 1852977.

Or what I did on my mini-sabbatical in Hobart

Dangerous wild animals!



A hazardous environment!

And some science!

Thanks to Will Hobbs for hosting me!

PCWG 202

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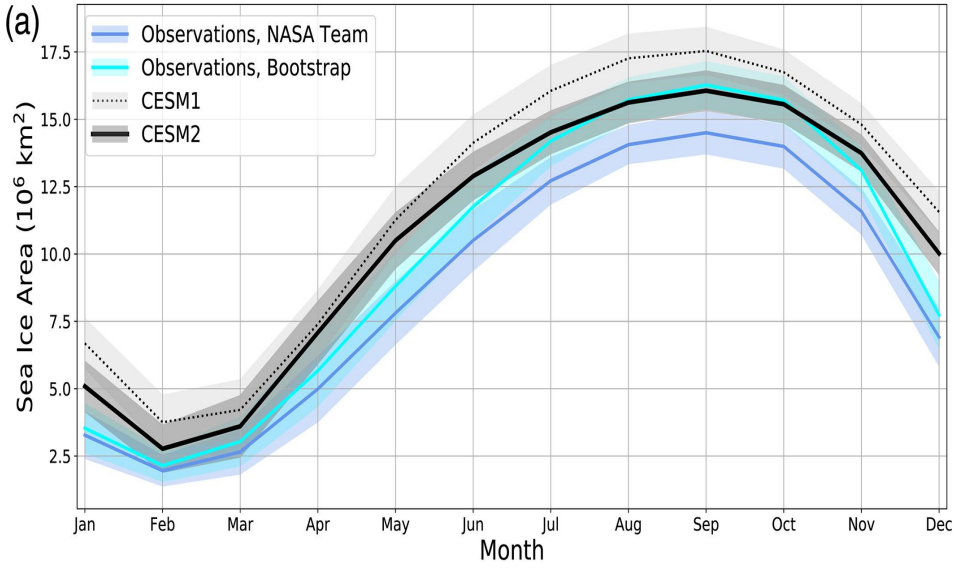
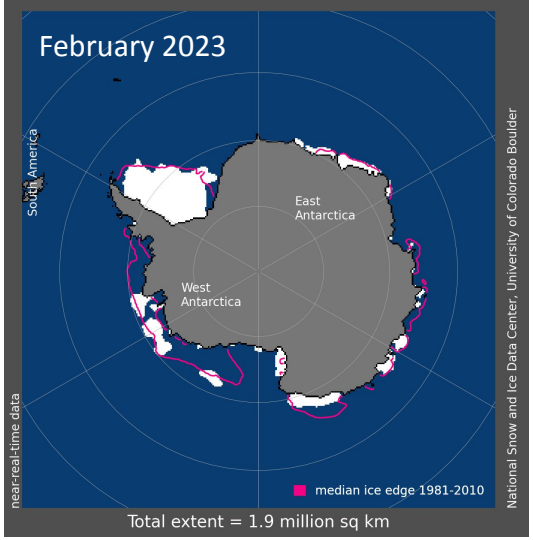
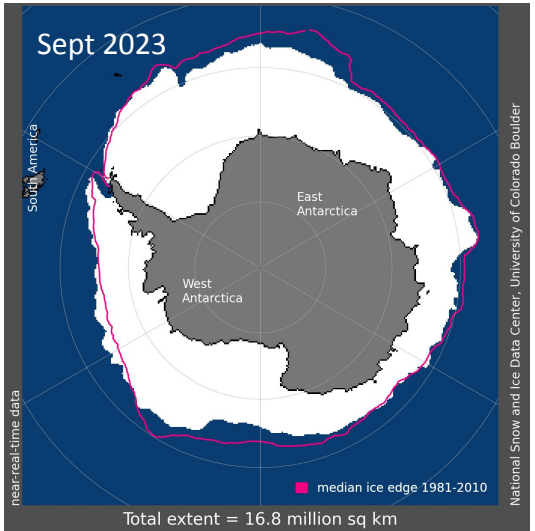
Antarctic Sea Ice

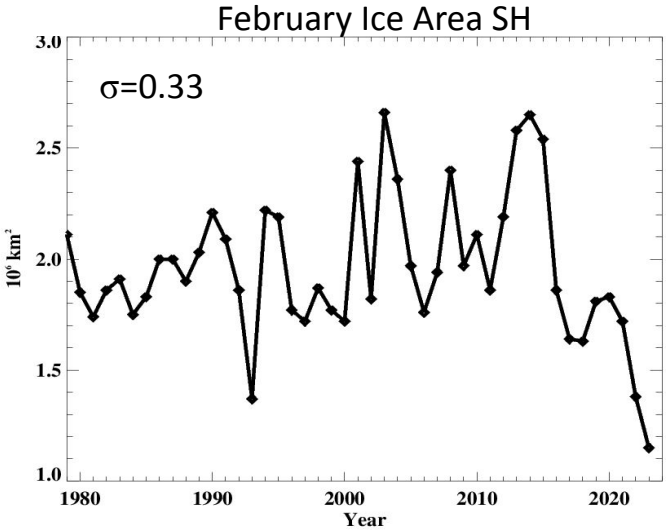


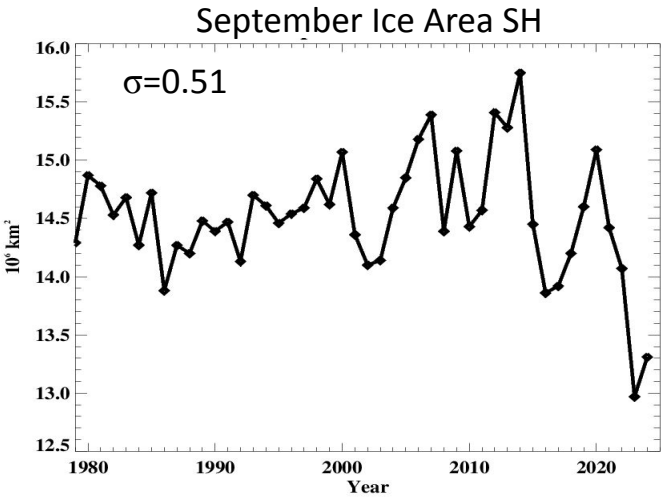
Singh et al., 2020

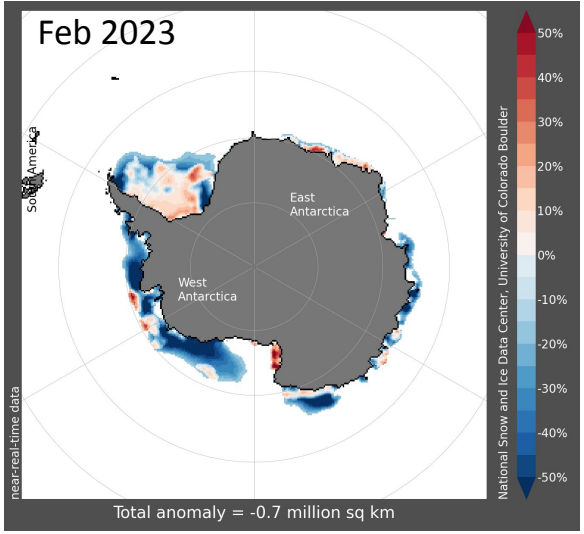


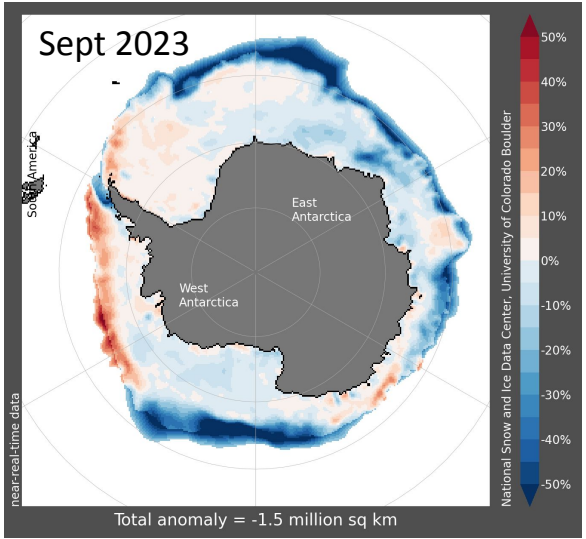


NSIDC Sea Ice Index



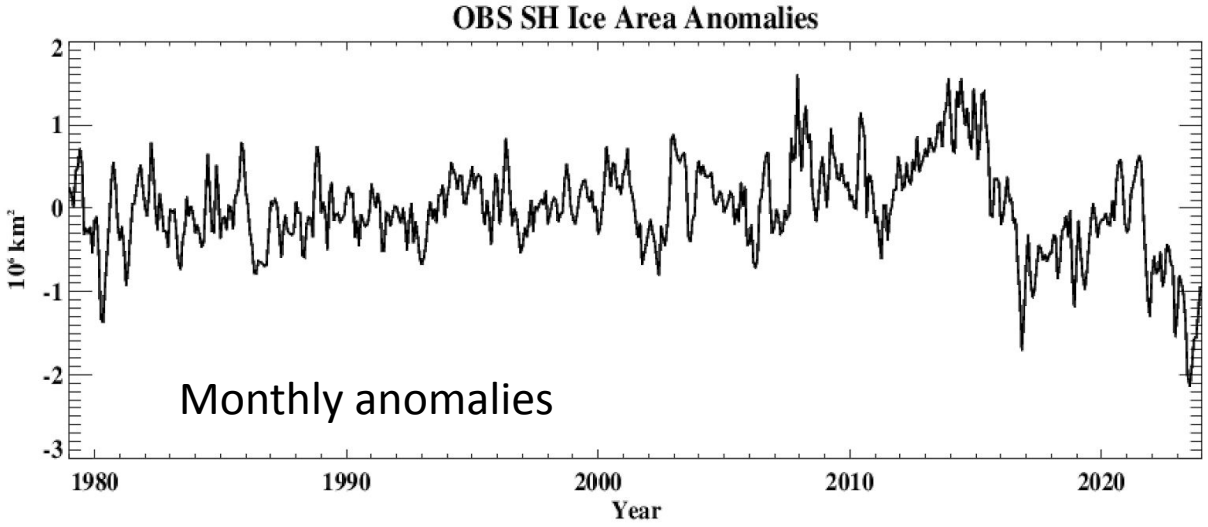




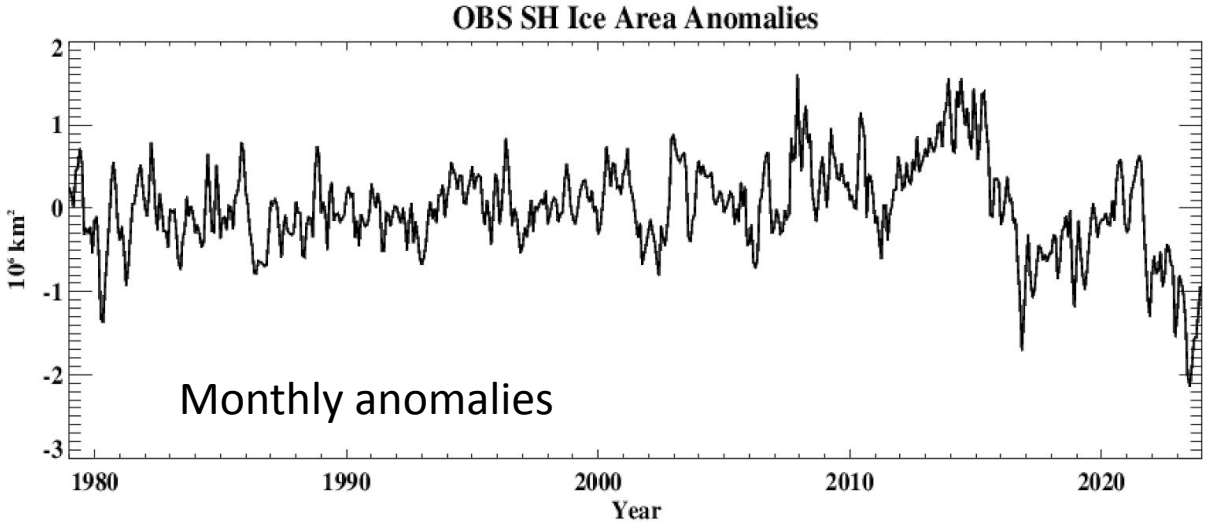


Observed sea ice variations

NSIDC Sea Ice Index Anomalies



Observed monthly sea ice anomalies



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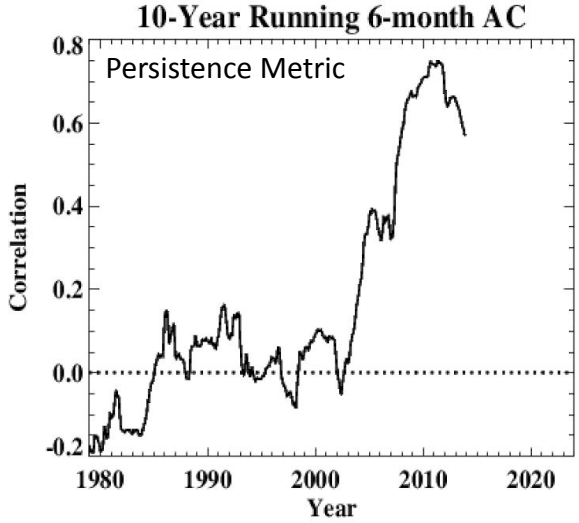

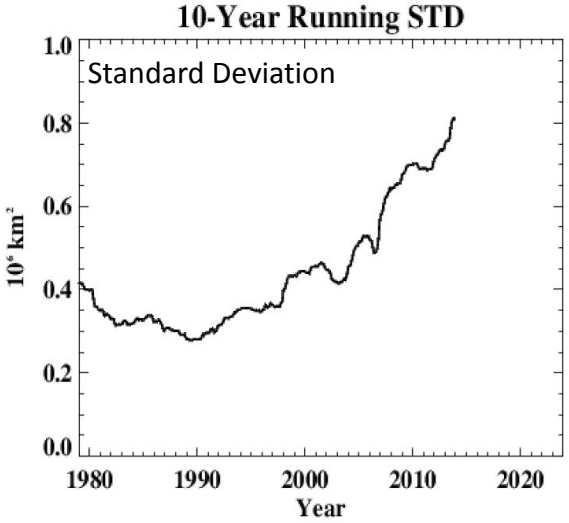

- Recent decades exhibit more persistence and variance
- Some have suggested that this may be indicative of a new regime (e.g. Hobbs et al., 2024; Purich and Doddridge, 2023)

Research Questions

- Do similar decadal changes in variance and persistence occur within climate simulations?
- How are these changes expressed regionally?
- What are the atmosphere and/or oceanic drivers of decadal changes?
- What is the role of anthropogenic forcing?

Research Questions

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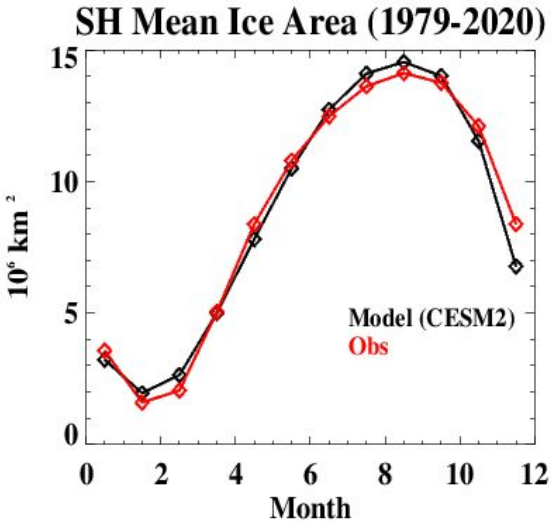
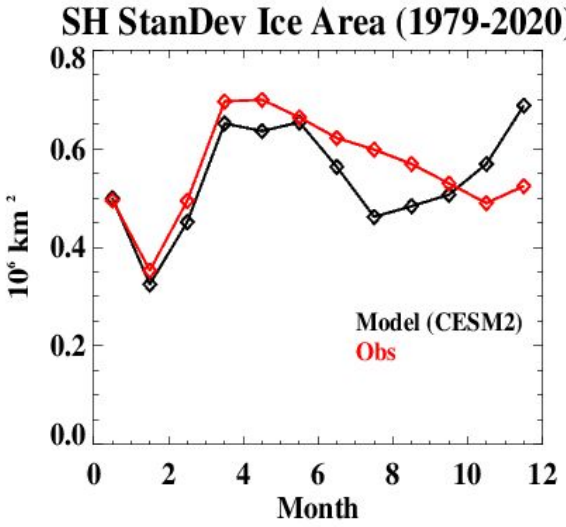
Very much work in progress

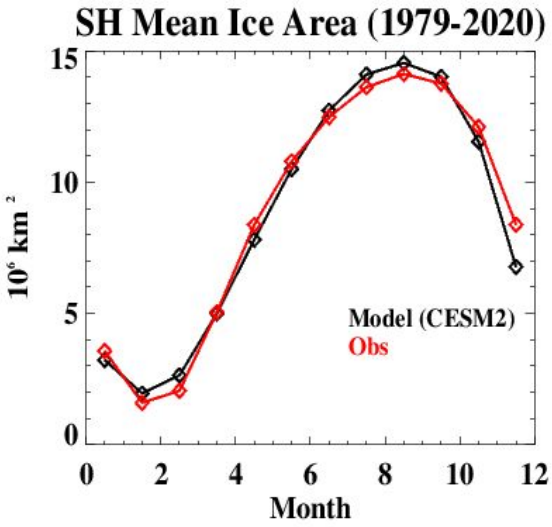


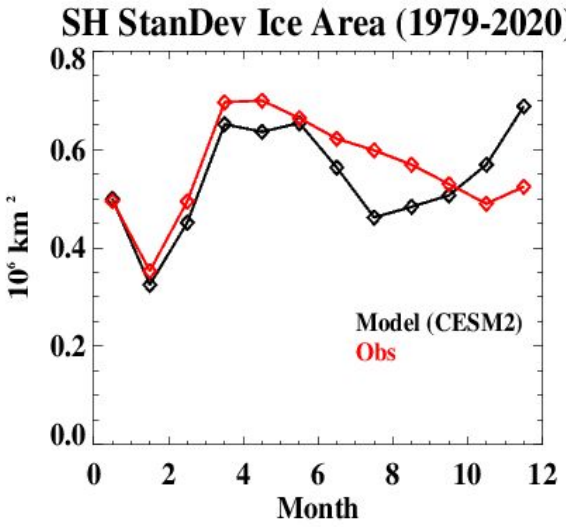


CESM2 LE

- Excellent ice area annual cycle
- Good total ice area variability

CESM2 LE





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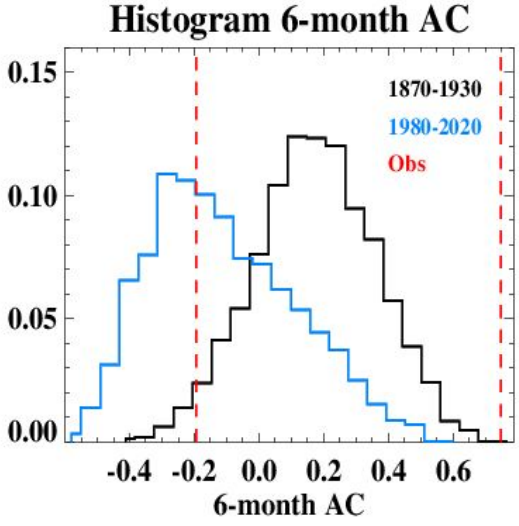
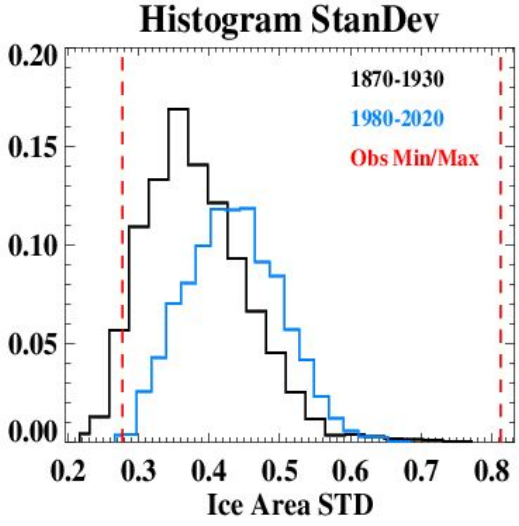
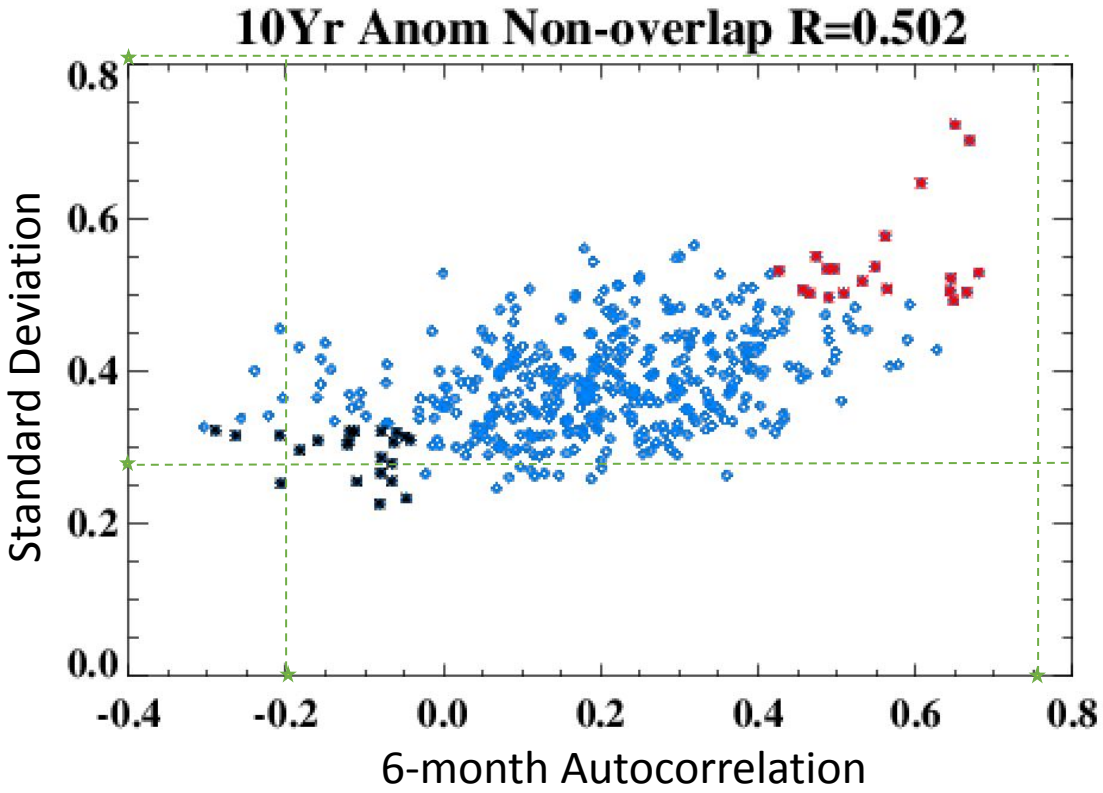




Decadal variations of persistence and standard deviation

- Range similar to observed
- Although variability of most recent observed decade is not reached

Composite analysis of CESM2 runs



Analysis of
non-overlapping decades
of CESM2 from 1870-1950

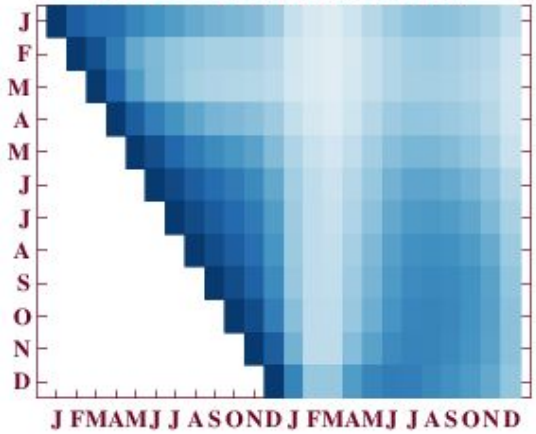
<u>Comparison of decades with:</u>

High variance and persistence

Low variability and persistence

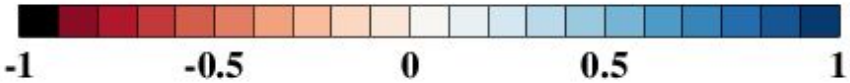
Expression of persistence in total ice area

All Years



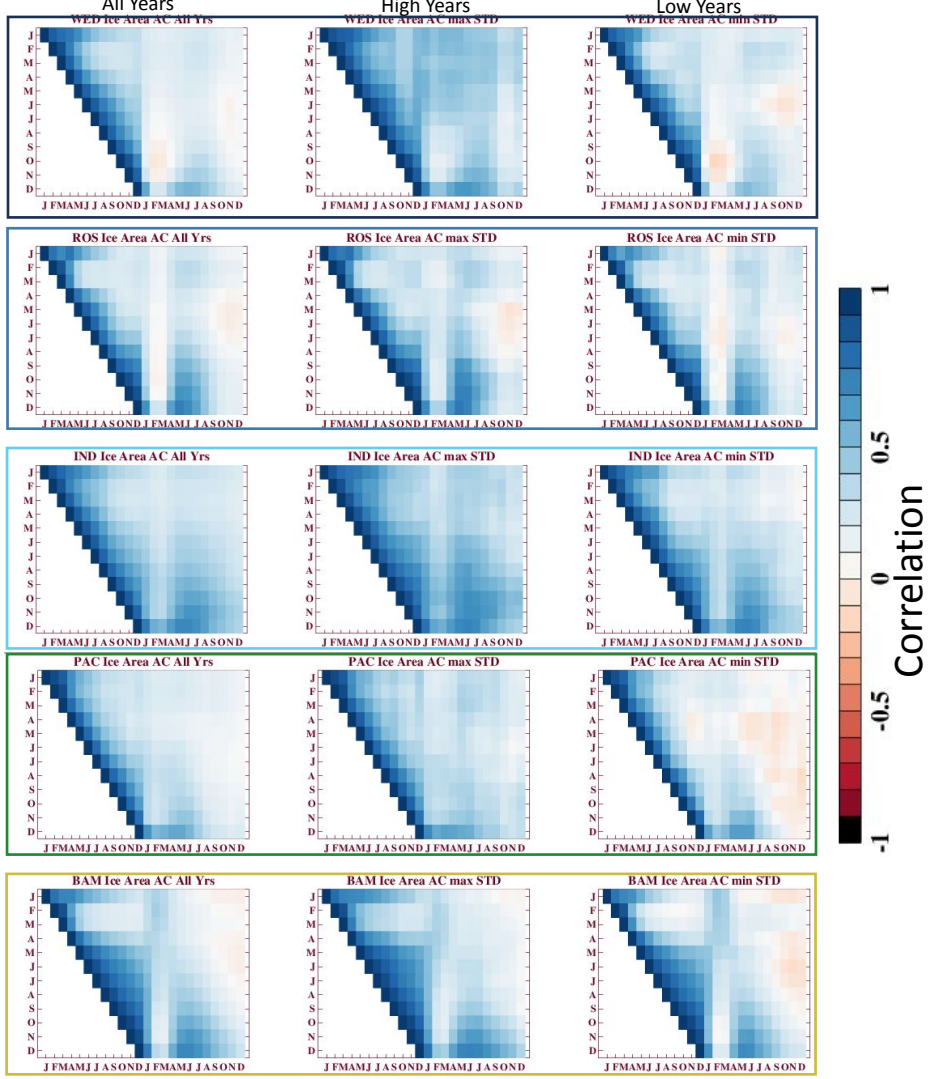
Decades with high variance & persistence

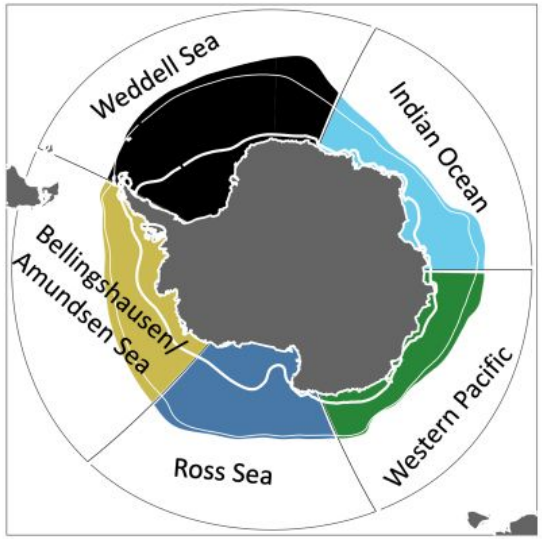
Decades with low variance & persistence



Correlation

Regional Expression of Persistence

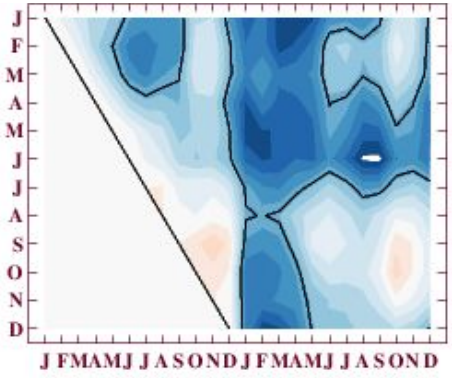




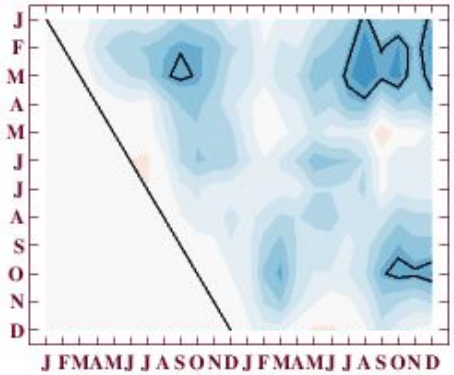
Regional Expression of Persistence

(Decades with Max Persistence) minus (Decades with Min Persistence)

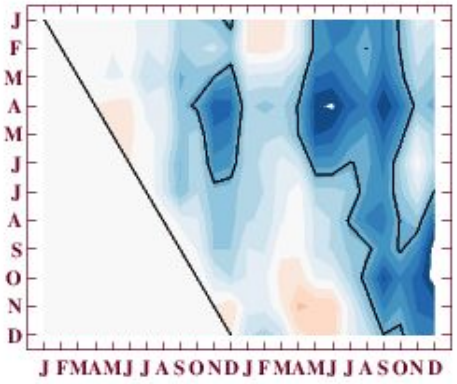
Weddell



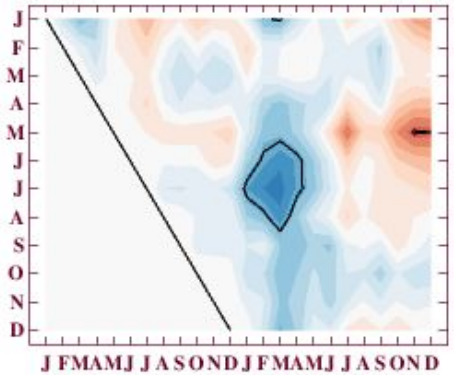
Indian



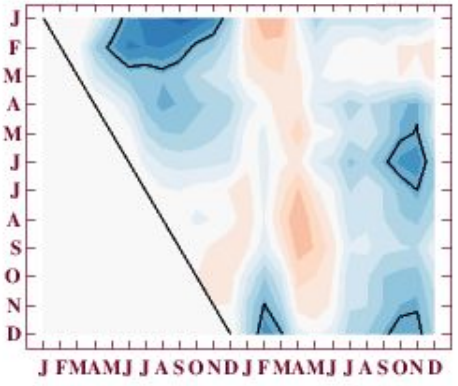
Pacific

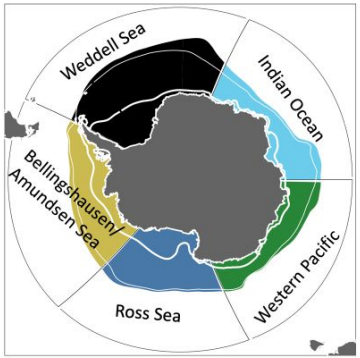


Ross



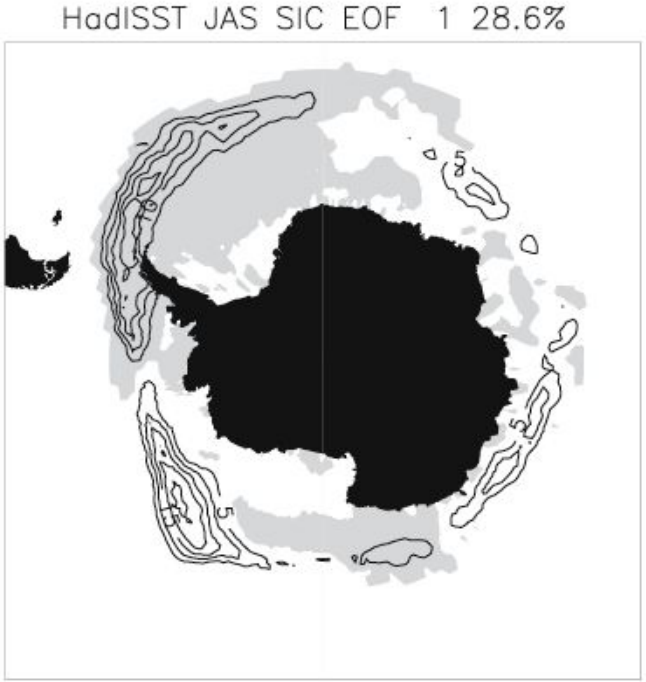
B&A Sea





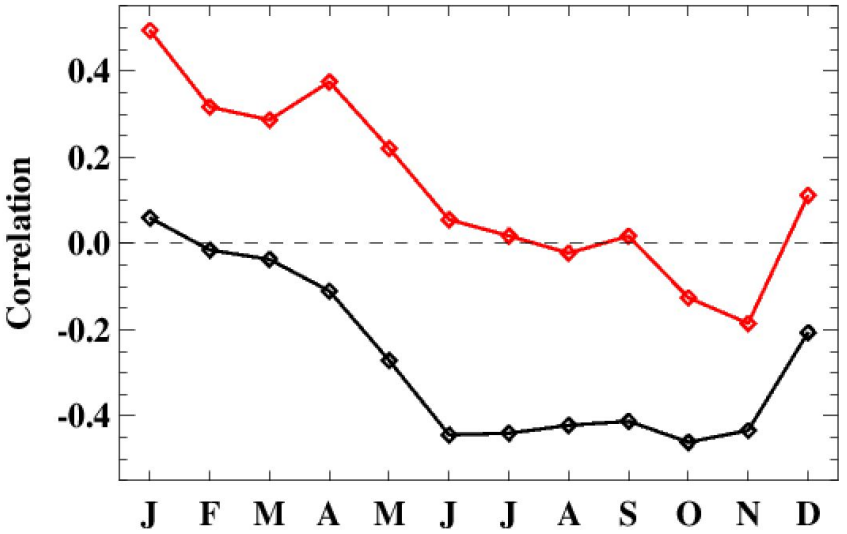
Regional compensation of anomalies

1st EOF of JAS Sea Ice 1979-1999



From Holland Raphael, 2006

R(Weddell and non-Weddell Ice Area)



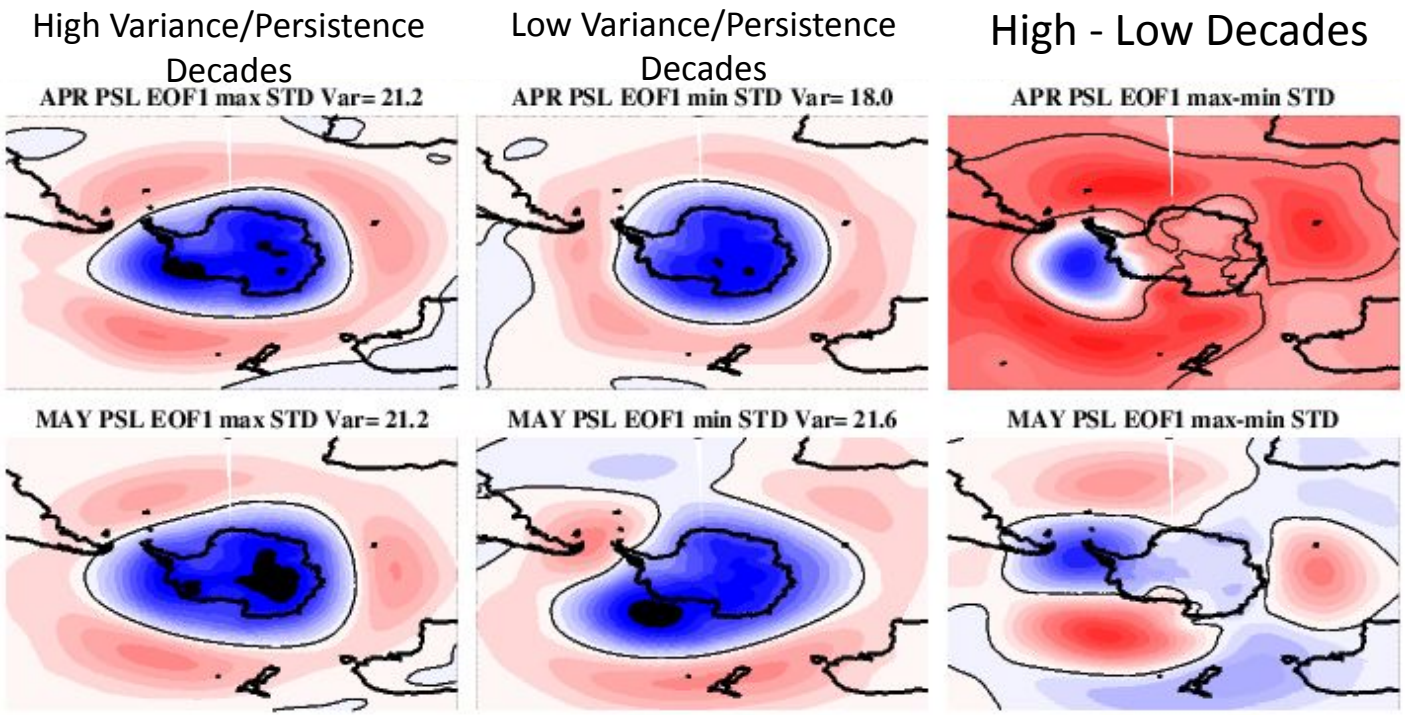
High variance/persistence decades:

- Little regional compensation of anomalies

- Low variance/persistence decades:
  High regional compensation of anomalies

A role for atmospheric drivers?

PSL EOF 1 (Southern Annular Mode)

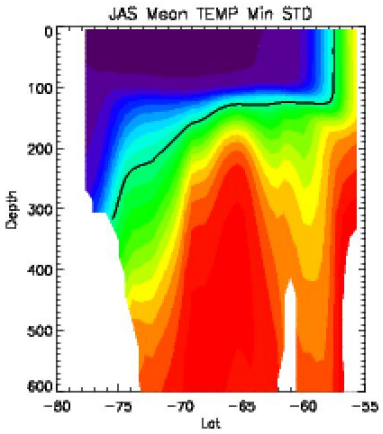


Decades with high variance/persistence have less annular April (maybe May) SAM

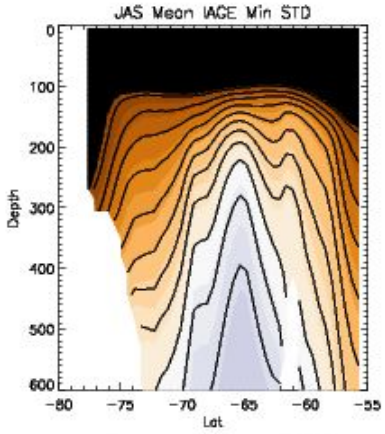
See Campitelli et al., 2022; Schroeter et al., 2023 for related observational analysis

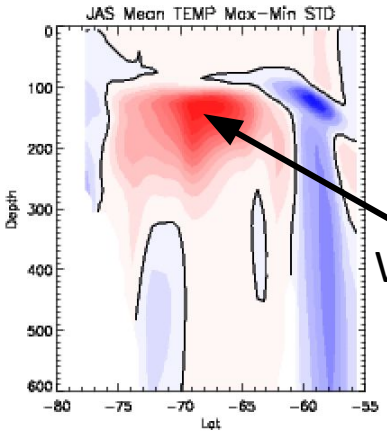
Some hints that there may also be a role for ocean drivers?

TEMP

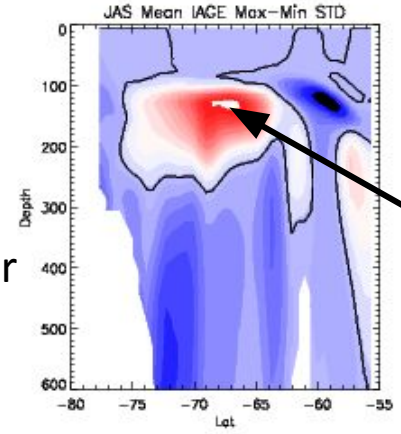


Ideal Age





Warmer



Older

Weddell Sea Transects suggest:

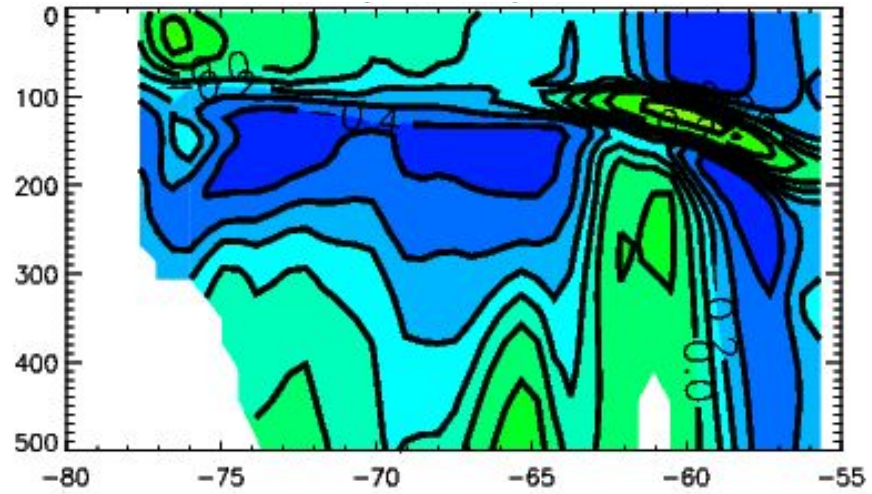
Decades with higher variance & persistence have:

- Warmer and older waters from 100-200m.
- Perhaps a shift in the properties or location of circumpolar deep water

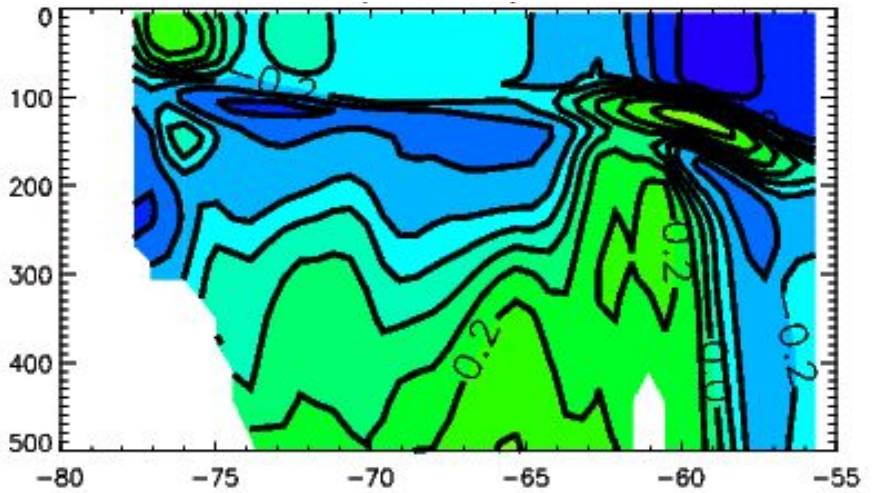
Some hints that there may also be a role for ocean drivers?

Weddell Sea transect correlation of ocean temperature and ice area

High variance/persistence decades



Low variance/persistence decades



Ice variability appears more responsive to sub-surface ocean temperatures in the high variance/persistence decades

Final thoughts

- CESM2 has decadal variations in the persistence and variability of sea ice
- Indications that **Weddell Sea** in particular has more persistence
- There is less **regional compensation** during high variance decades
- Suggestion that **SAM structure** plays a role
  - Less annular in the high variance/persistence decades
- Suggestions that Weddell Sea **ocean structure** plays a role
  - In high variance/persistence decades: Possible shoaling of CDW? Subsurface waters more influential for ice anomalies?
- Additional work needed to better quantify ocean influence, tie things back to observations, etc.

Thanks for your attention!
Questions?

Regional expression of persistence