



CGD Laboratory

February 6, 2026

Decadal changes in the variance & persistence of Antarctic sea ice

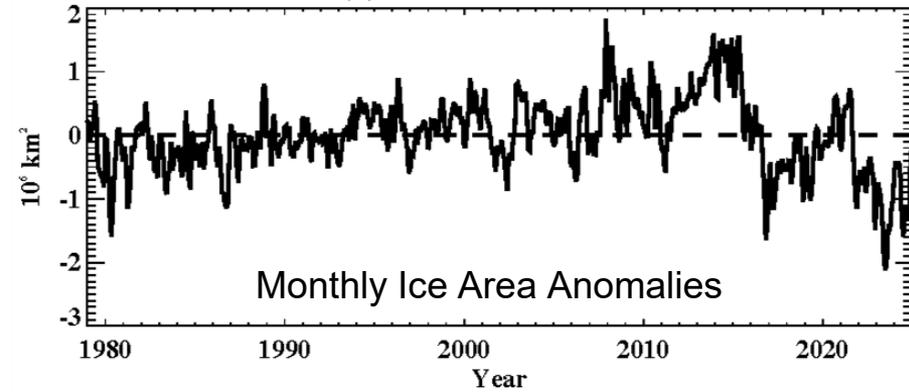
Marika Holland

With contributions from: Alice DuVivier, Will Hobbs, Laura Landrum, Marilyn Raphael, Sharon Stammerjohn

Observed Antarctic Sea Ice



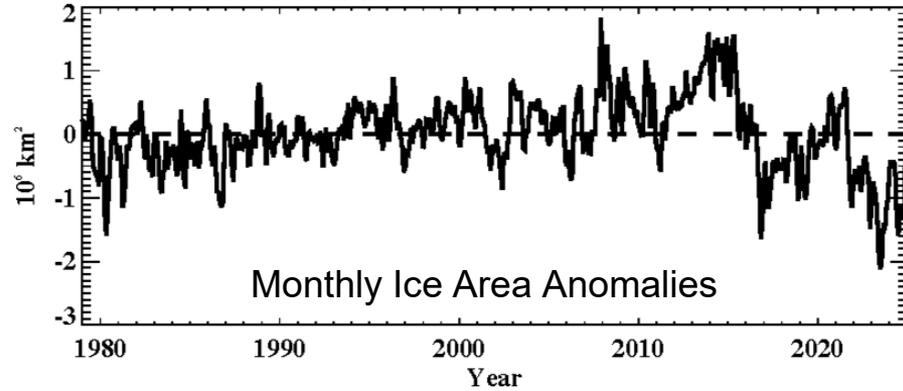
(a) Ice Area Anomalies



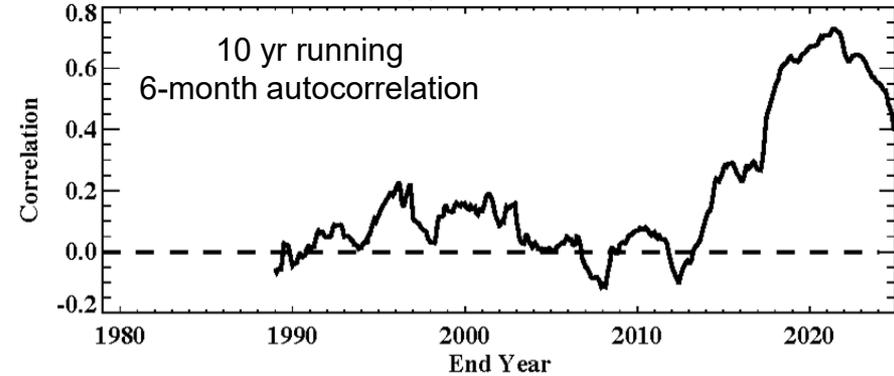
Observed Antarctic Sea Ice Statistics



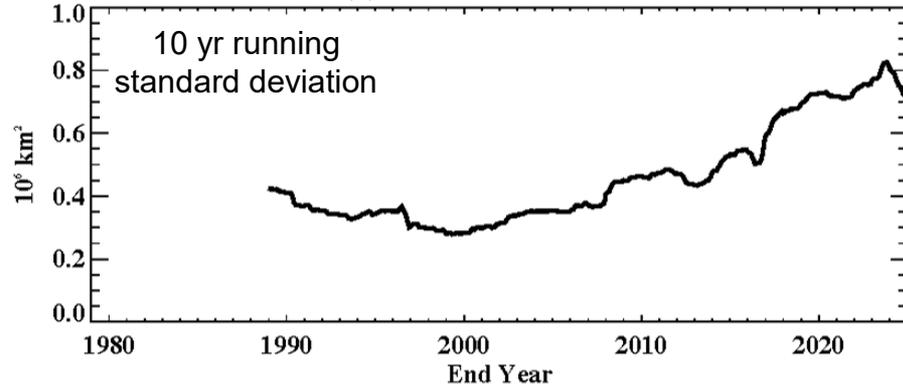
(a) Ice Area Anomalies



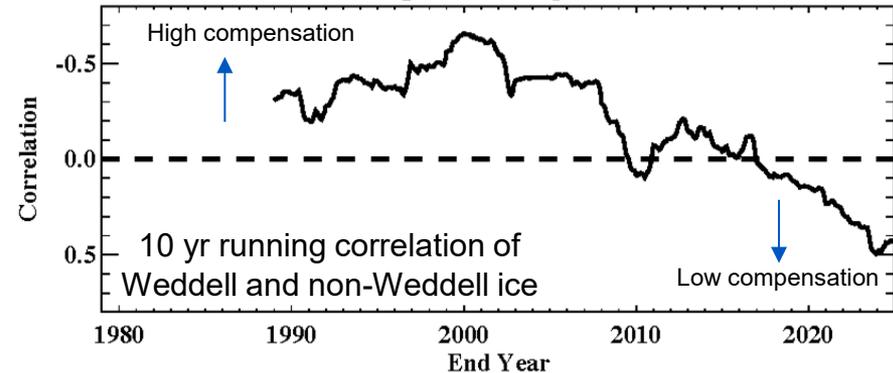
(b) Persistence



(c) Standard Deviation



(d) Regional Compensation

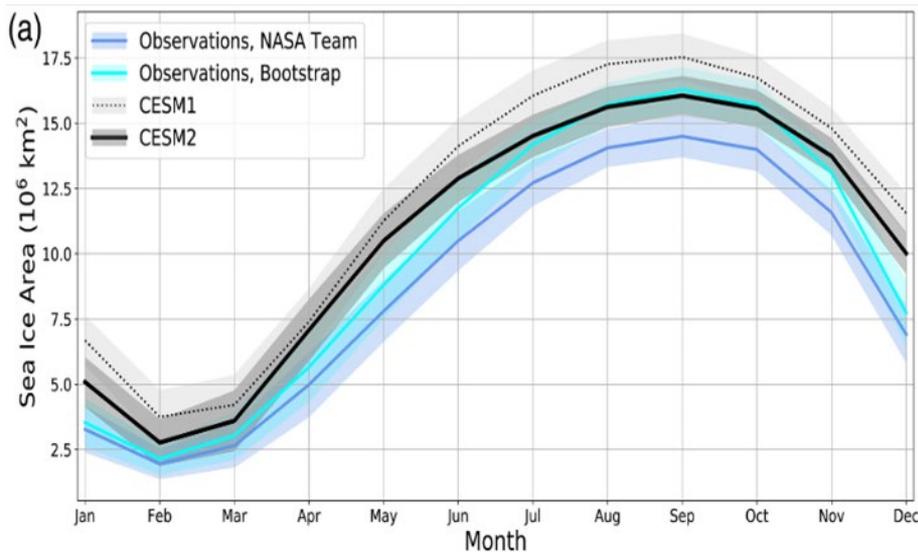


What Factors Drive Decadal Changes in Antarctic Sea Ice Variance and Persistence?



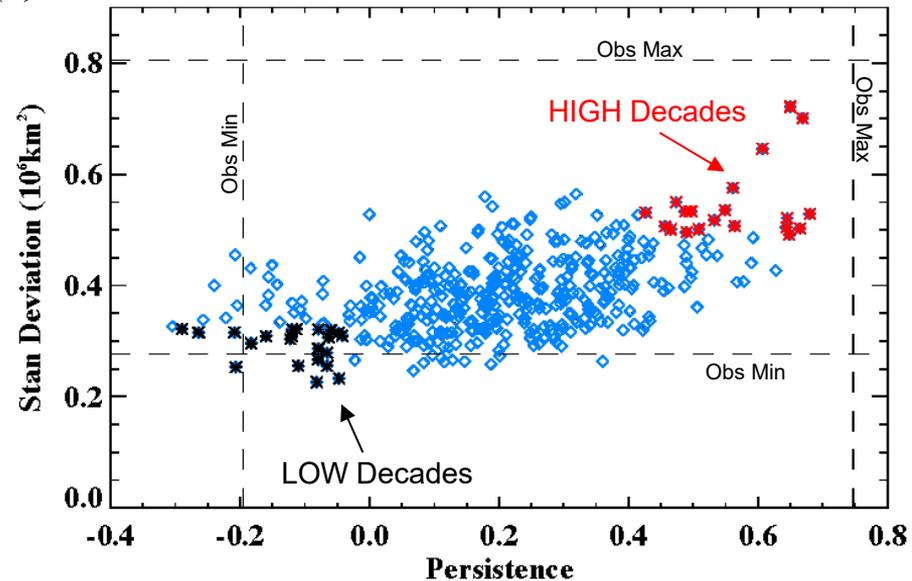
Investigations using CESM2-LE

Antarctic Sea Ice Area



From Singh et al., 2020

(a) CESM2 Sea Ice Variance and Persistence

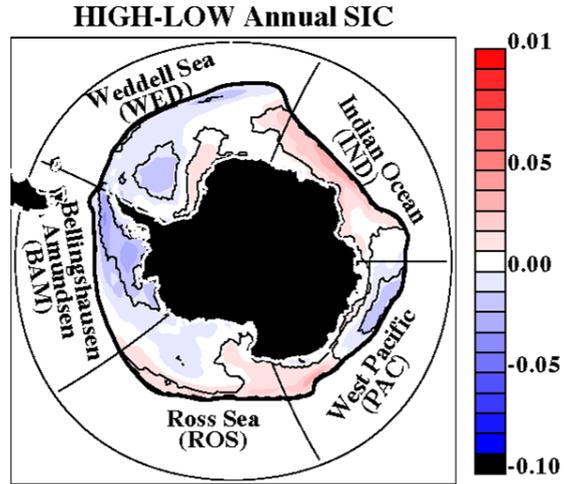


Assessed from Internal Variability in
CESM2-LE from 1870-1959

Importance of Different Regions?

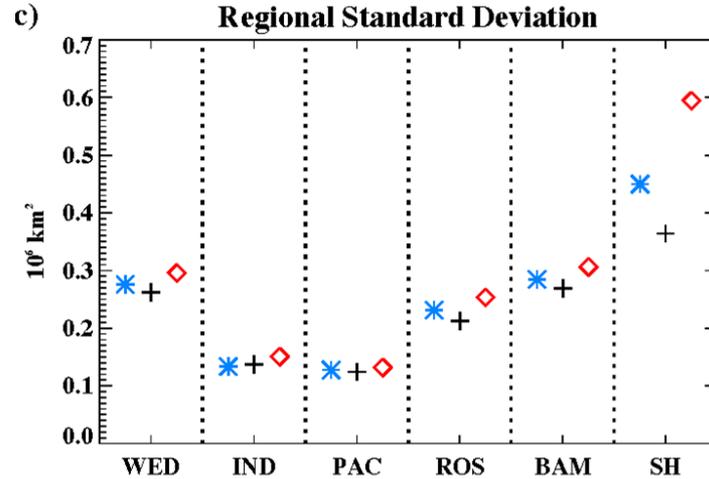
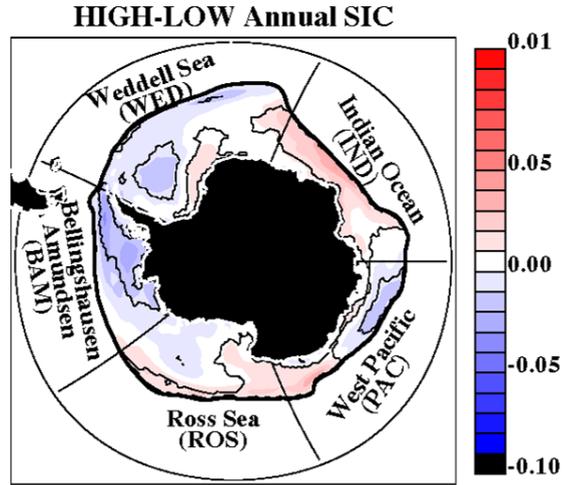


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Differences in the mean sea ice state between HIGH and LOW decades is small

Importance of Different Regions?



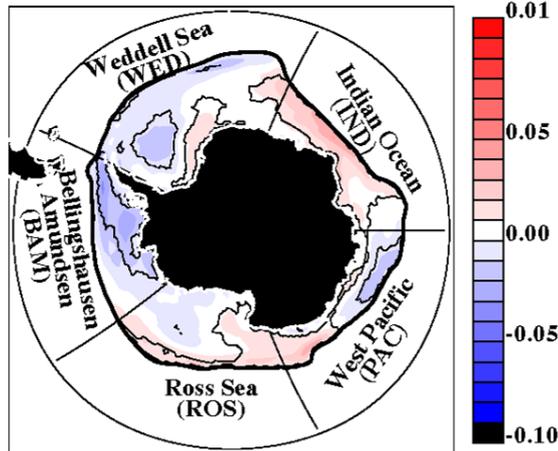
All Decades
LOW Decades
HIGH Decades

No region dominates in the increase in variance between the HIGH and LOW decades

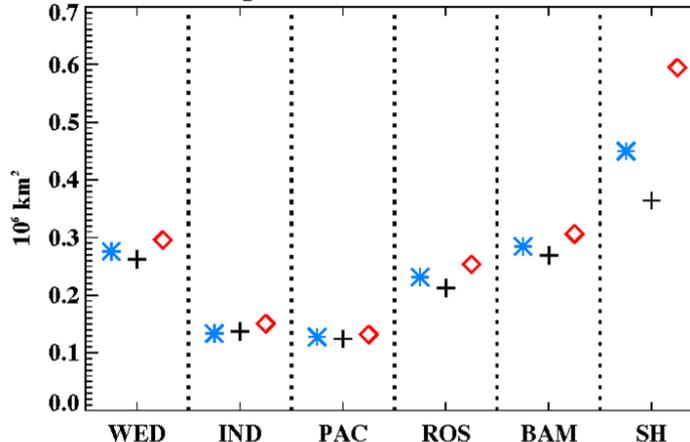
Importance of Different Regions?



HIGH-LOW Annual SIC

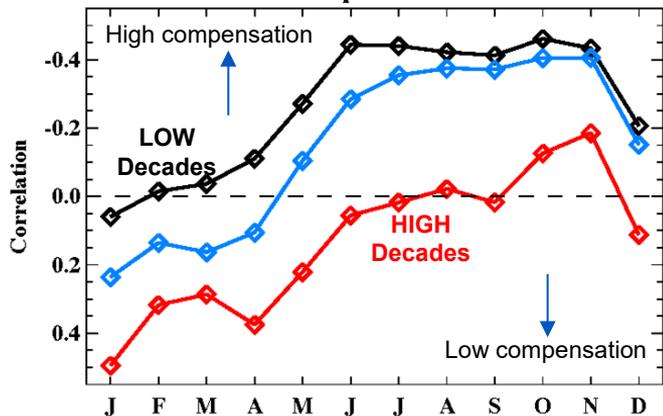


c) Regional Standard Deviation



All Decades
LOW Decades
HIGH Decades

(d) Compensation

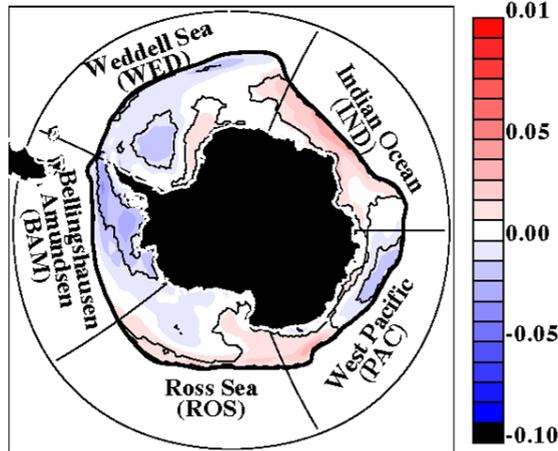


- However, there is a big difference in the regional compensation of anomalies.
- HIGH decades have less regional compensation
- This would contribute to the high standard deviation in total Antarctic ice

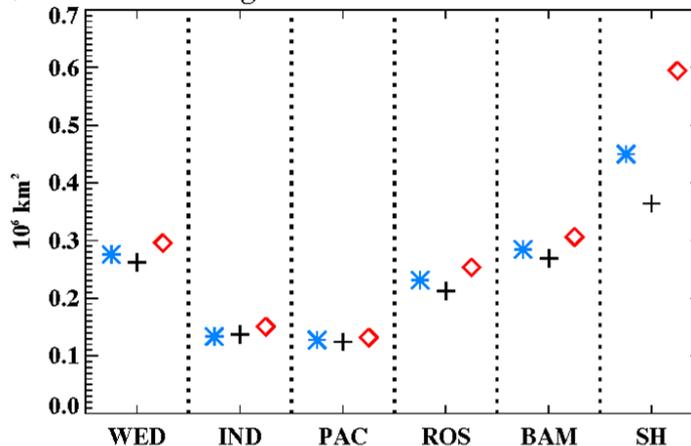
Importance of Different Regions?



HIGH-LOW Annual SIC

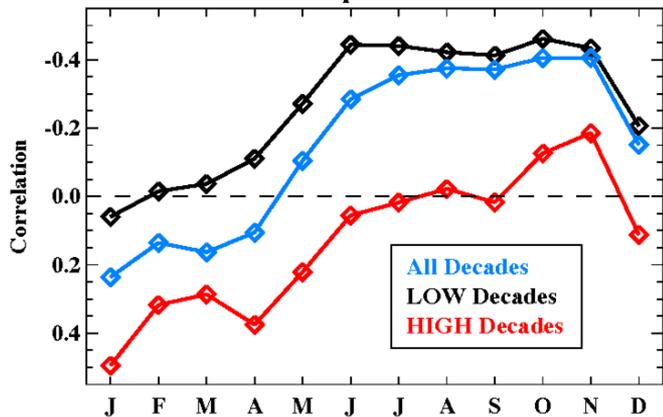


c) Regional Standard Deviation

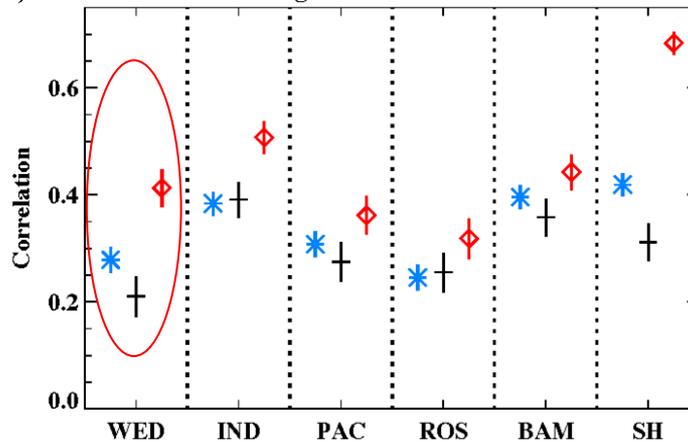


All Decades
LOW Decades
HIGH Decades

(d) Compensation

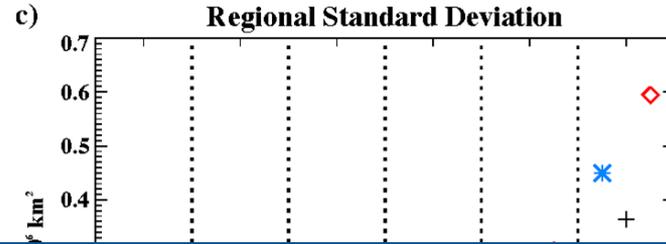
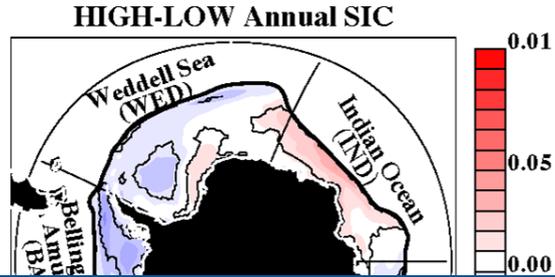


(b) Regional Persistence



For differences in persistence, the Weddell Sea dominates

Importance of Different Regions?

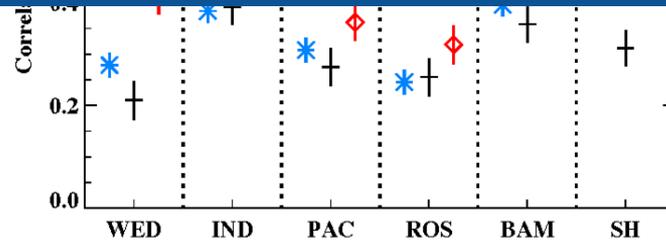
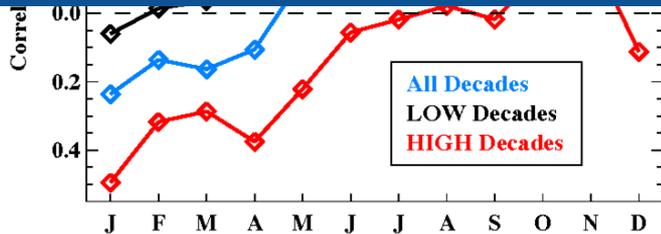


All Decades
 LOW Decades

Differences in variance result from differences in regional compensation

Differences in persistence are associated with changes in the Weddell Sea

WHAT FACTORS DRIVE THIS?



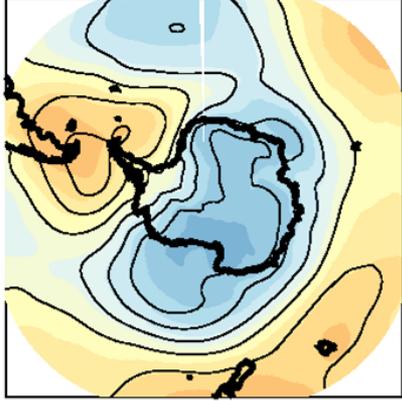
the Weddell Sea dominates

The Changing Role of Winds

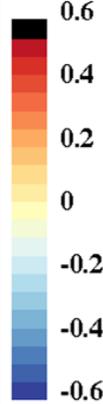
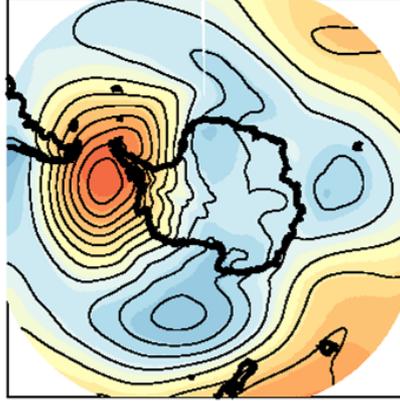


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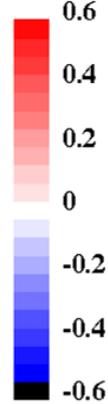
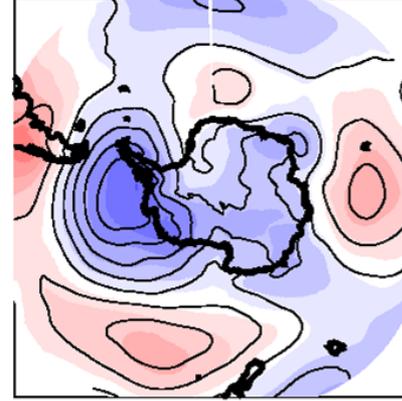
HIGH Decades
(a) AMJ HIGH DECADES



LOW Decades
(b) AMJ LOW DECADES



HIGH-LOW Decades
(c) AMJ HIGH-LOW DECADES



Correlation
of AMJ SLP
and Weddell
Sea Ice
Area

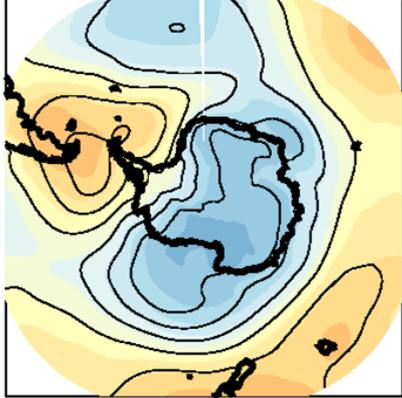
In HIGH Decades:

- Weddell Sea Ice Area is more weakly correlated to wind variations
- This helps to explain the weaker regional compensation of sea ice anomalies in those decades

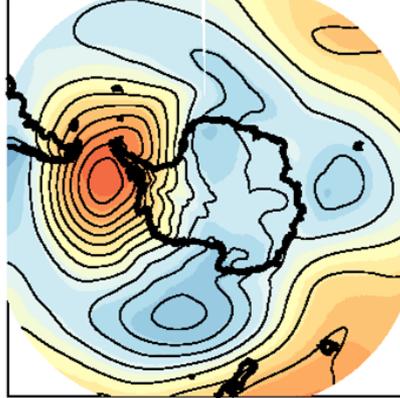
The Changing Role of Winds



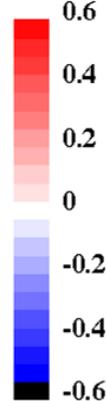
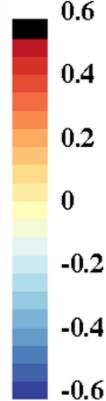
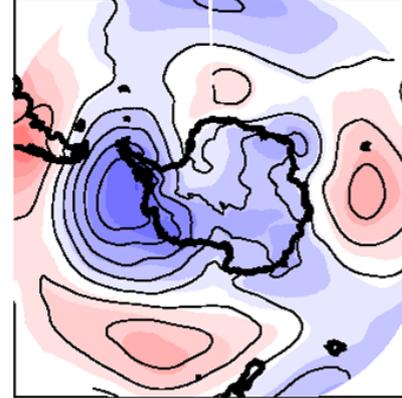
HIGH Decades
(a) AMJ HIGH DECADES



LOW Decades
(b) AMJ LOW DECADES

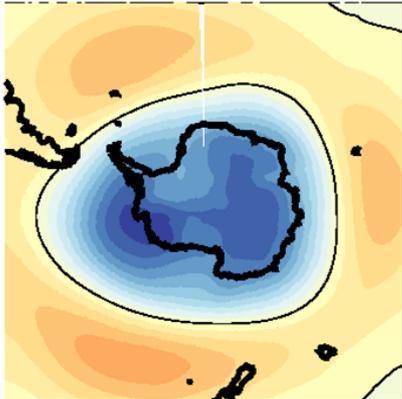


HIGH-LOW Decades
(c) AMJ HIGH-LOW DECADES

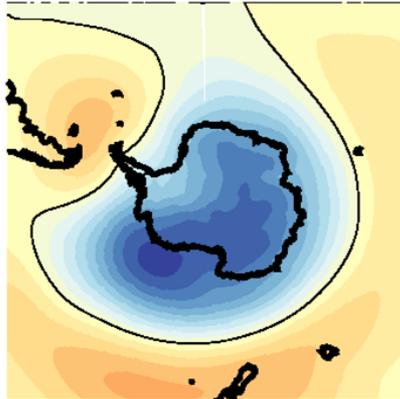


Correlation
of AMJ SLP
and Weddell
Sea Ice
Area

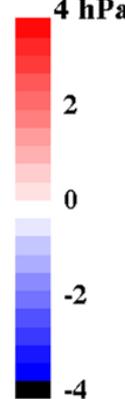
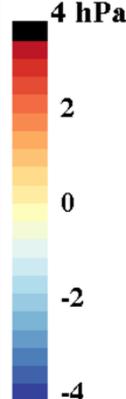
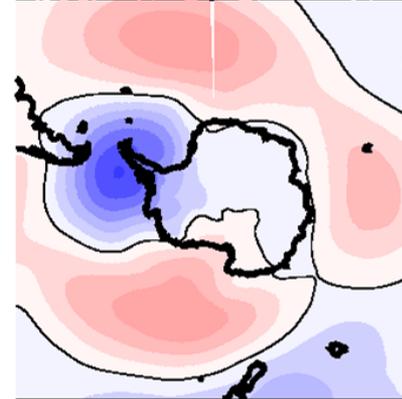
(d) AMJ SAM HIGH DECADES



(e) AMJ SAM LOW DECADES

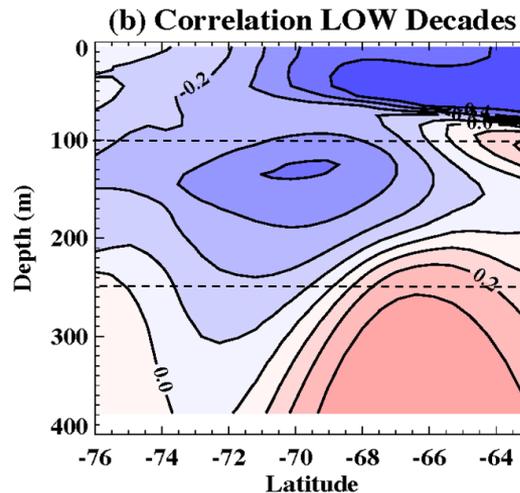
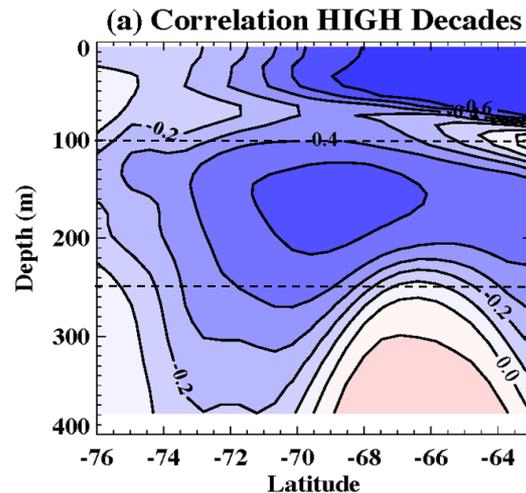


(f) AMJ SAM HIGH-LOW

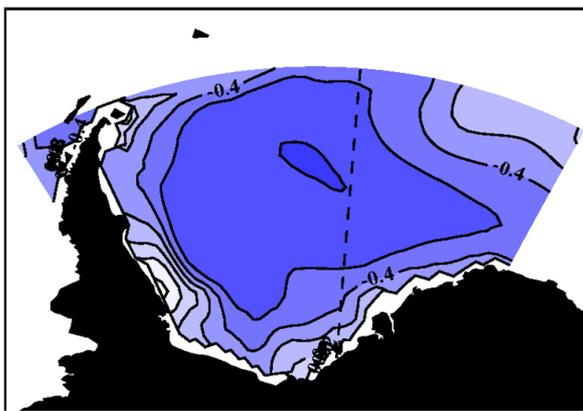


AMJ SAM
Structure

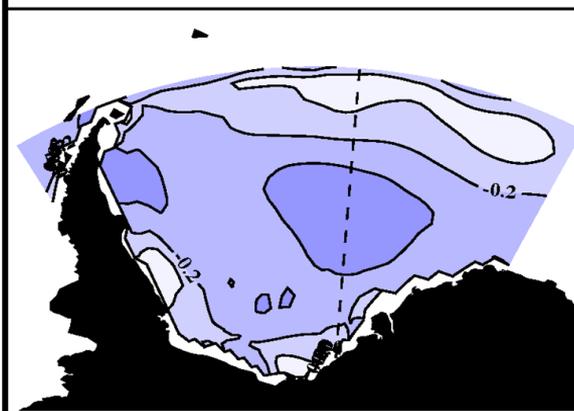
The Changing Role of Ocean Variations



(c) Correlation HIGH Decades



(d) Correlation LOW Decades



Correlation of Weddell Sea ice Area with Ocean Temperatures

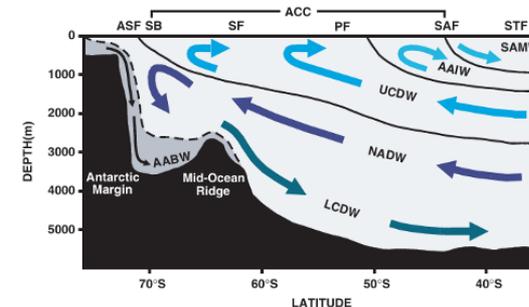
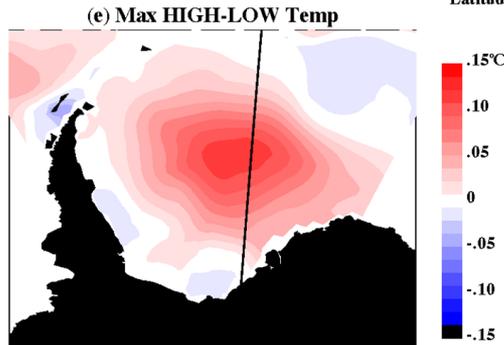
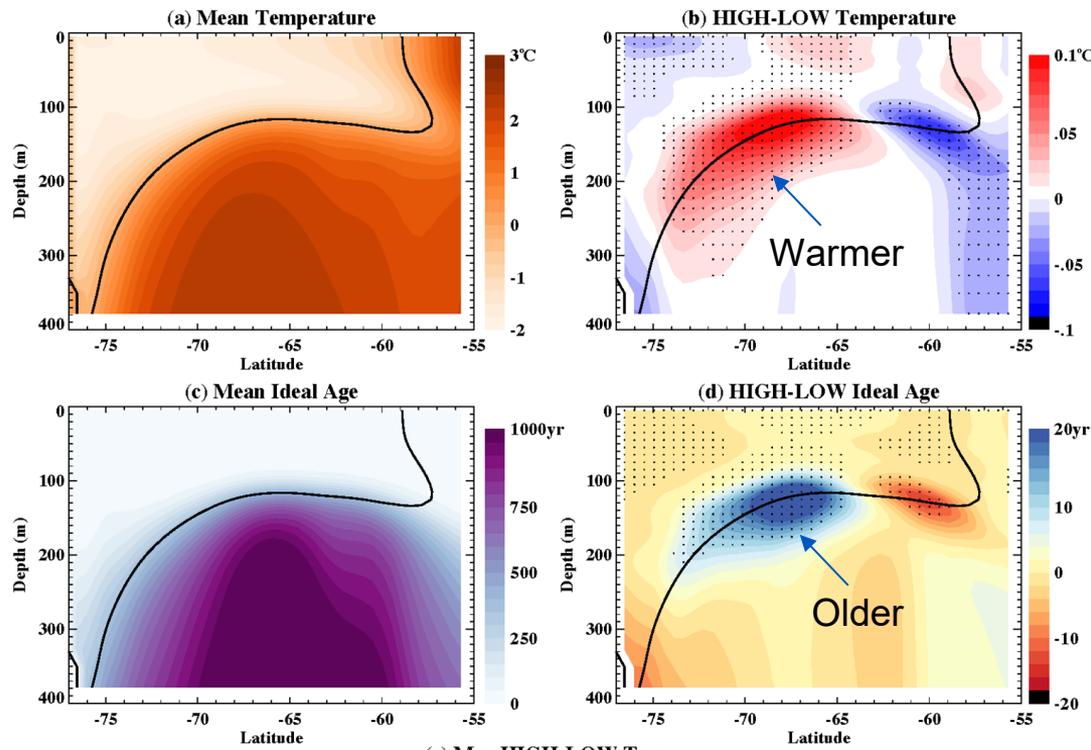
In HIGH Decades:

- Weddell ice is more strongly related to subsurface ocean temperatures
- A stronger ocean influence can help explain the increased persistence

The Changing Role of Ocean Variations

Mean ocean changes:

- In HIGH decades, warmer and older subsurface waters suggest a shoaling of upper circumpolar deep water
- Greater accessibility to CDW heat anomalies may allow for a bigger influence on sea ice



From Carter et al., 2009

Key Takeaways

CESM2-LE simulates sizable decadal differences in persistence & variance of Antarctic sea ice

In comparing HIGH and LOW persistence/variance decades we find that HIGH decades:

- Have less **regional compensation** of sea ice anomalies
 - Associated with a **reduced influence of winds** on Weddell Sea ice area
 - May be related to a different spatial structure of the SAM
- Have **more persistence Weddell Sea** ice anomalies
 - Associated with a stronger relationship with **sub-surface ocean anomalies**
 - Possibly related to shallower Circumpolar Deep Water

Does this relate to recent observations?

- SAM structure is different in recent years (Schroeter et al., 2023)
- Studies suggest a stronger role for the sub-surface ocean in driving recent sea ice anomalies (Meehl et al., 2019; Purich and Doddridge, 2023; Hobbs et al., 2024; and more)

Questions?



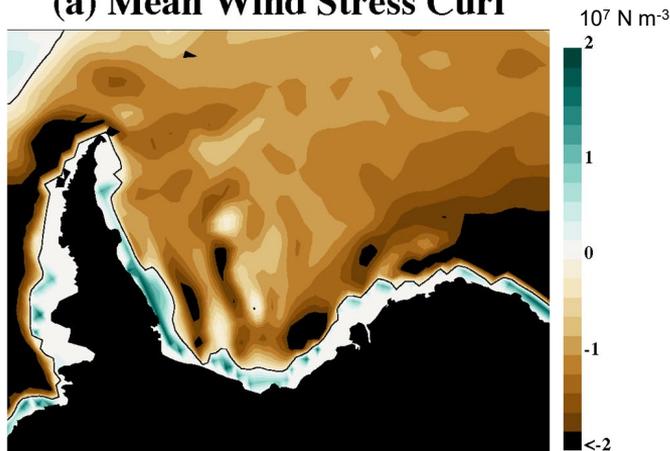
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Extra Slides

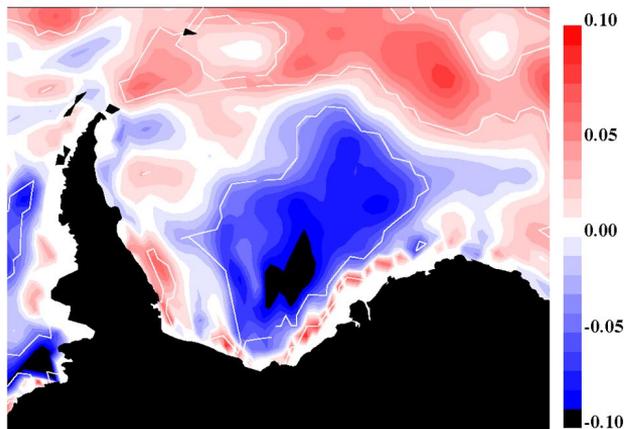
An Atmospheric Driver of Ocean Change?



(a) Mean Wind Stress Curl



(b) HIGH-LOW Wind Stress Curl



In HIGH decades,

- There is a stronger negative wind stress curl in the Weddell Sea
- This could help explain the shallower Circumpolar Deep Water
- It is unclear how this might correspond or interact with other atmospheric changes (such as the SAM structure)