

A wide-angle photograph of an Antarctic sea ice landscape. The foreground is dominated by a large, flat expanse of white sea ice, with a prominent, dark, jagged crack or lead running diagonally from the bottom center towards the middle ground. The background shows a vast, flat horizon line under a pale, overcast sky with soft, diffused light. The overall color palette is cool, consisting of various shades of white, light blue, and grey.

Antarctic Sea Ice Variability - Insights from the Large Ensemble

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Other contributors:

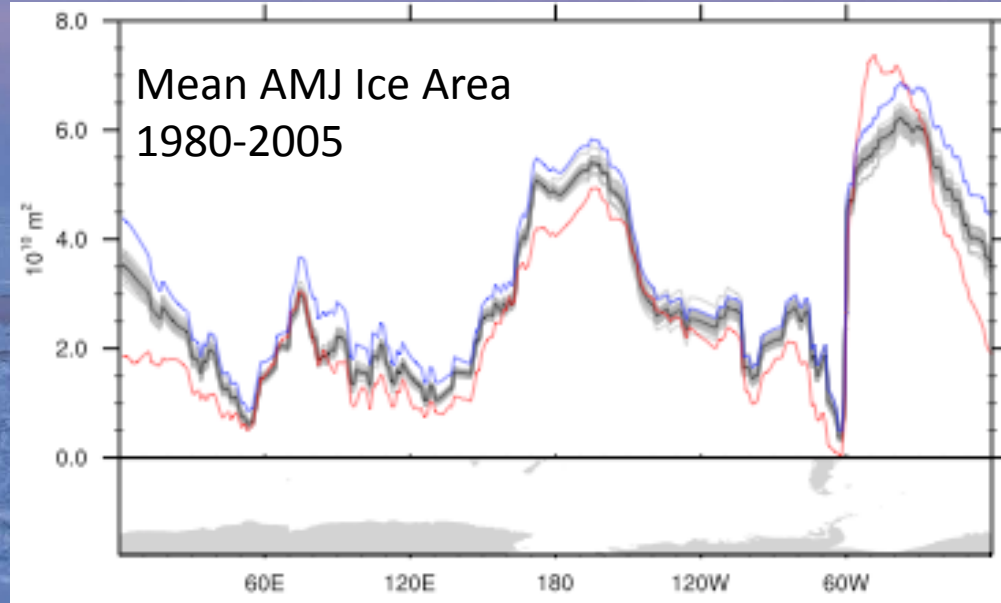
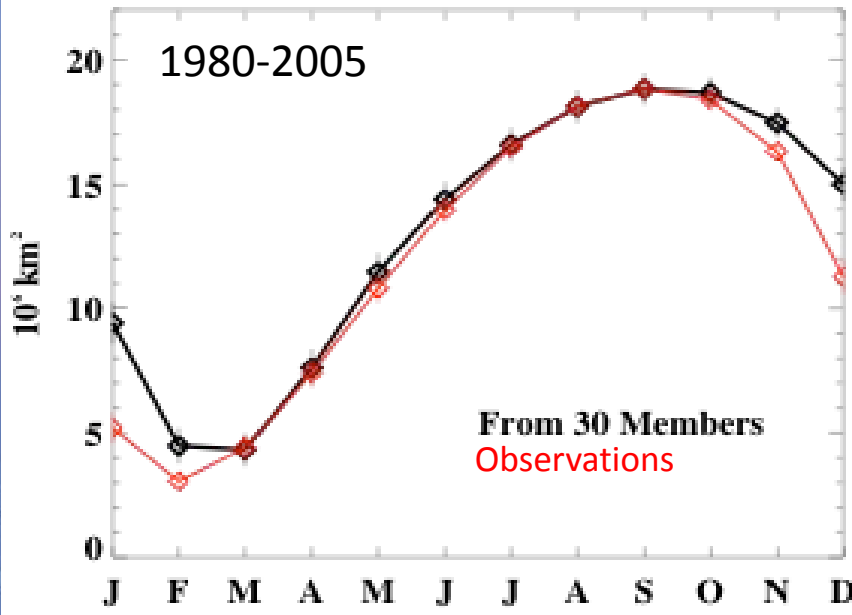
Lorenzo Polvani, Columbia; Marilyn Raphael, UCLA

CESM Integrations

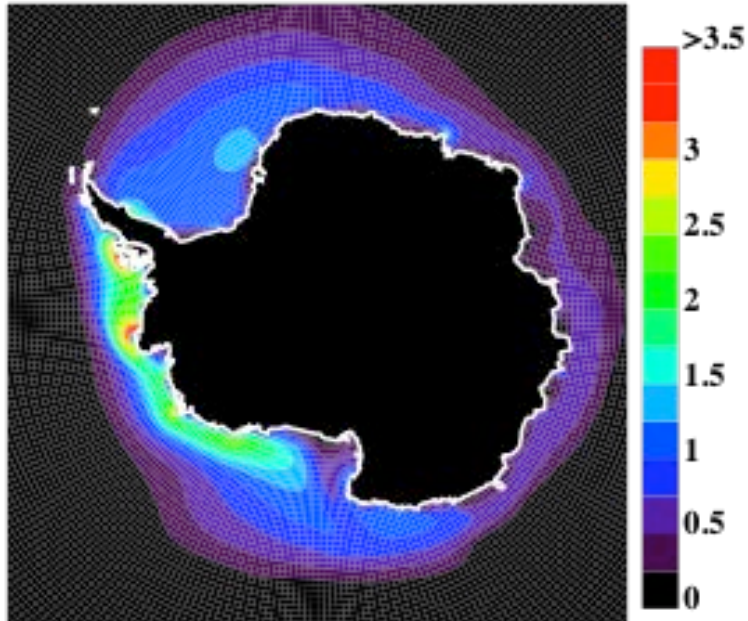
- CESM Large Ensemble (CESM-CAM5-BGC)
 - 30 members from 1920-2080 (one run 1850-2080)
 - Uses the WACCM ozone instead of SPARC – larger ozone loss; Uses RCP8.5 forcing for 2005-2080
- Complimentary 1850 Pre-industrial Control Run
 - 2200 years in length
 - Have analyzed years 500-1500 currently
- Fixed ozone ensemble
 - 8 simulations from 1955-2005 with ozone fixed at 1955 levels

Large Ensemble Sea Ice Climatology

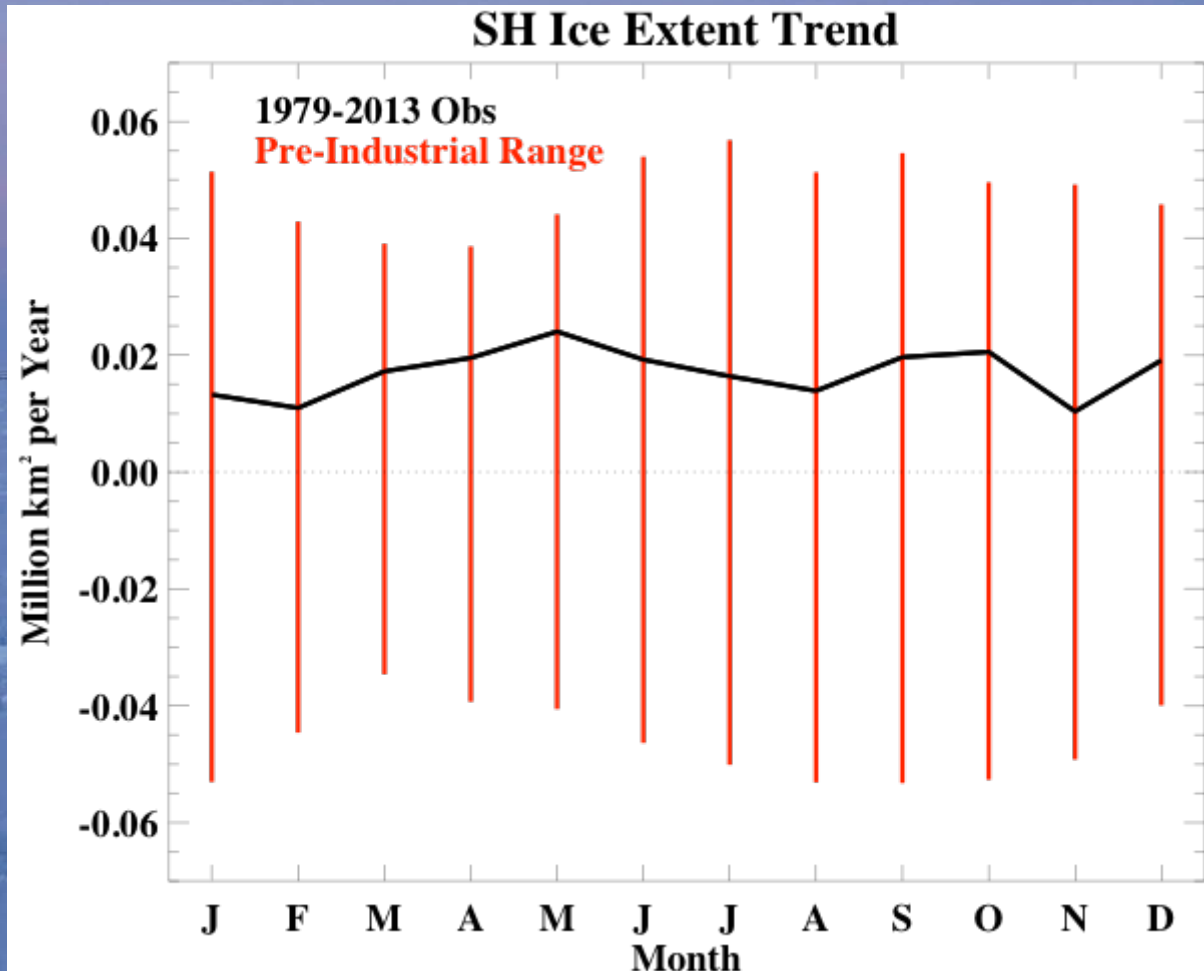
SH Ice Extent



Ice Thickness



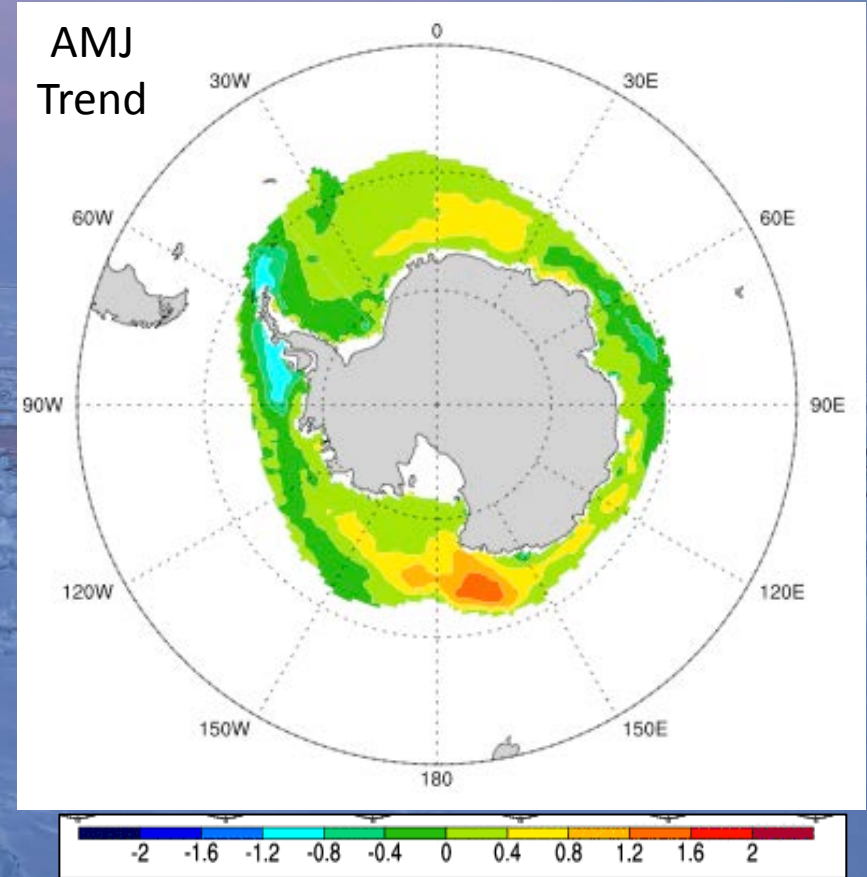
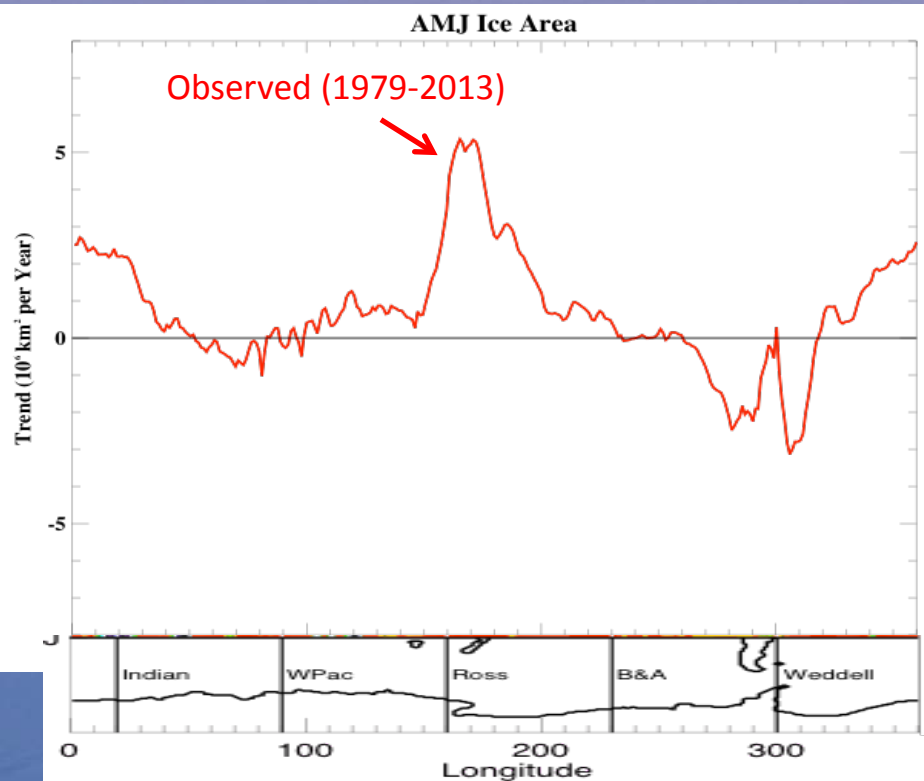
Trends in Antarctic Sea Ice



Trends in observed total SH ice extent are well within the Pre-Industrial control run variability for all months

Trends in Antarctic Sea Ice

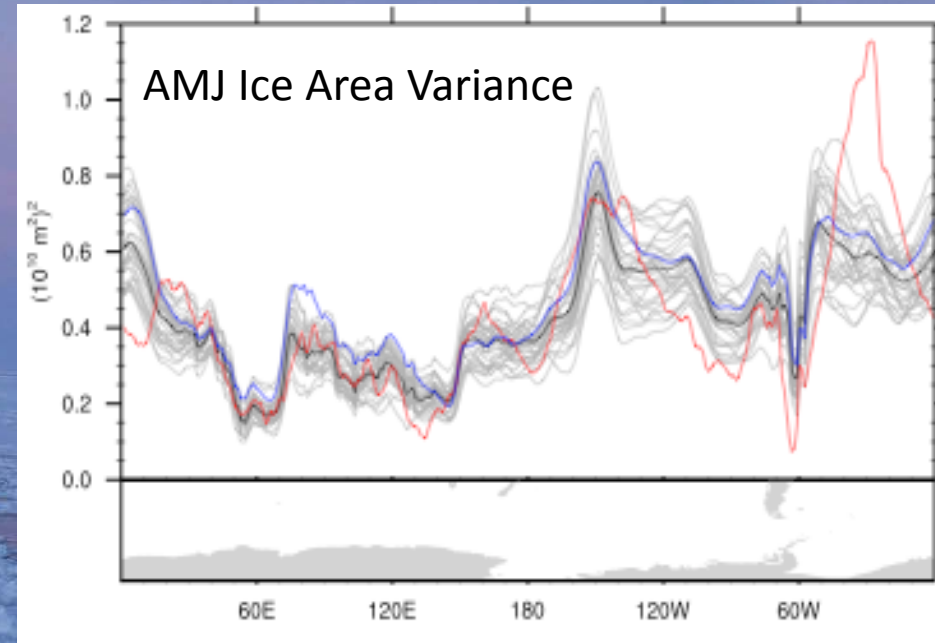
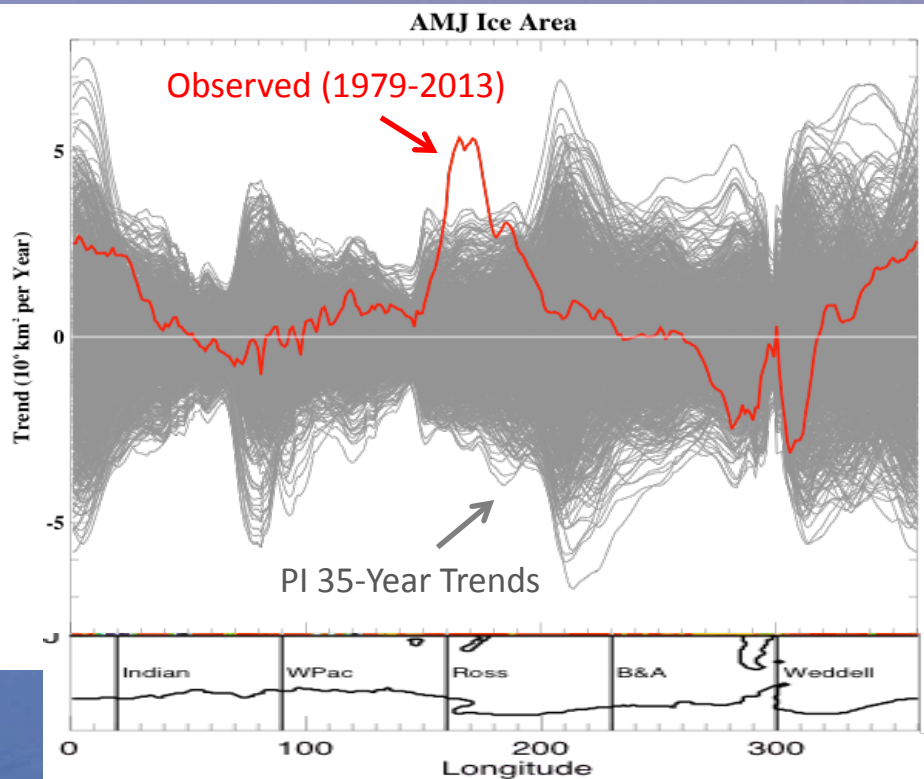
Trends in AMJ Ice Area with Longitude



Observed Trends

Trends in Antarctic Sea Ice

Trends in AMJ Ice Area with Longitude



Observed

PI Control

20th Century Large Ensemble Mean

Individual Members (1980-2005)

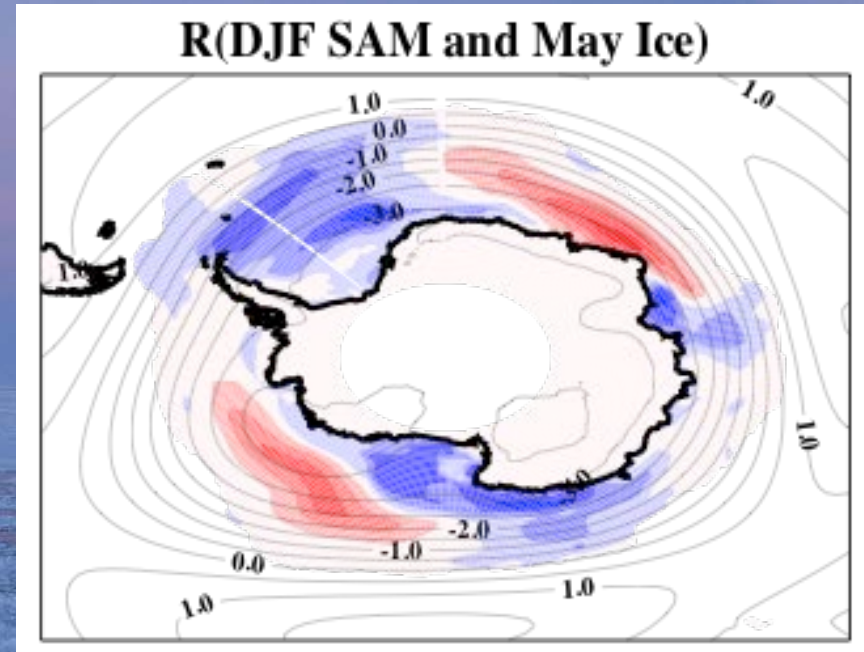
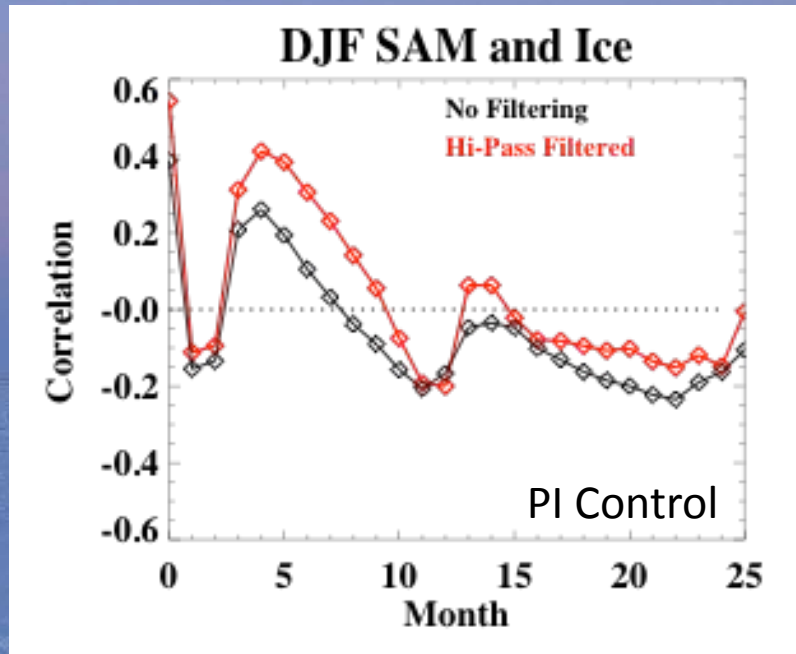
Regionally –

- Observed ice area trends are within PI control run
- Except in the Ross Sea where large ice increases are observed

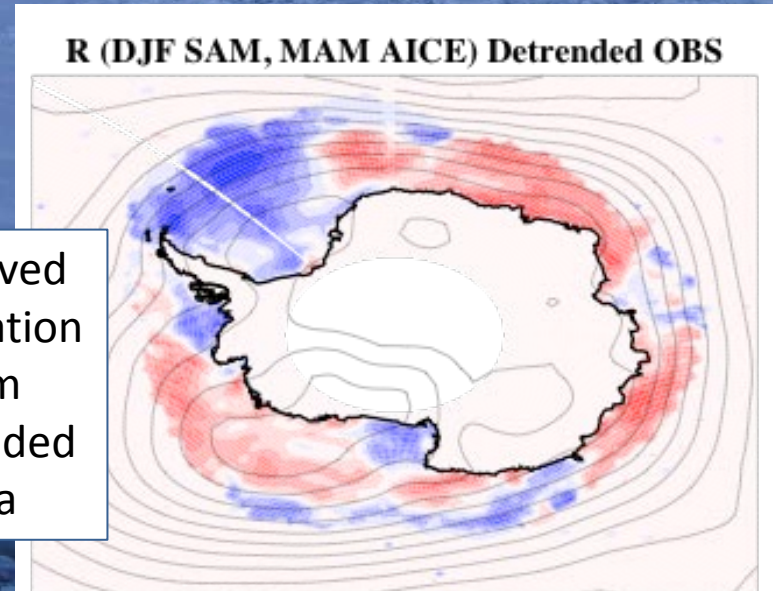
For Ross Sea increases –

- could be anthropogenically driven
- or could be model biases

What contributes to ice trends/variability

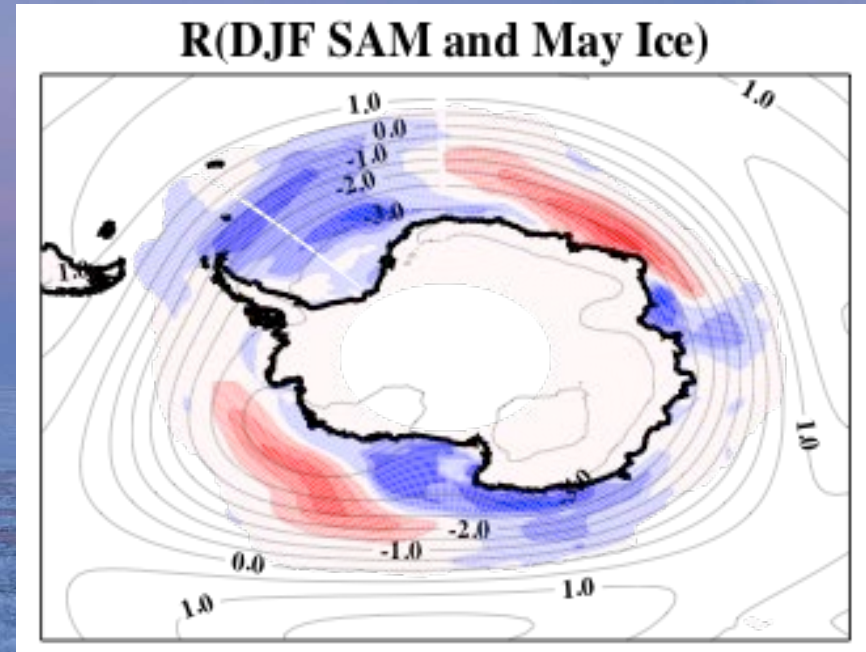
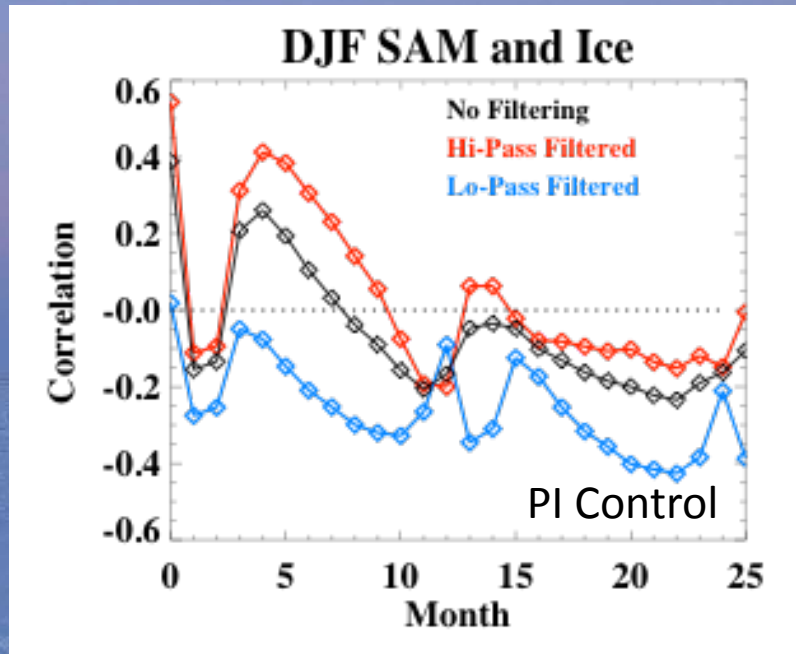


Within PI control:
Summer SAM Variability
has associated
increases in total ice
extent in the following
ice advance period

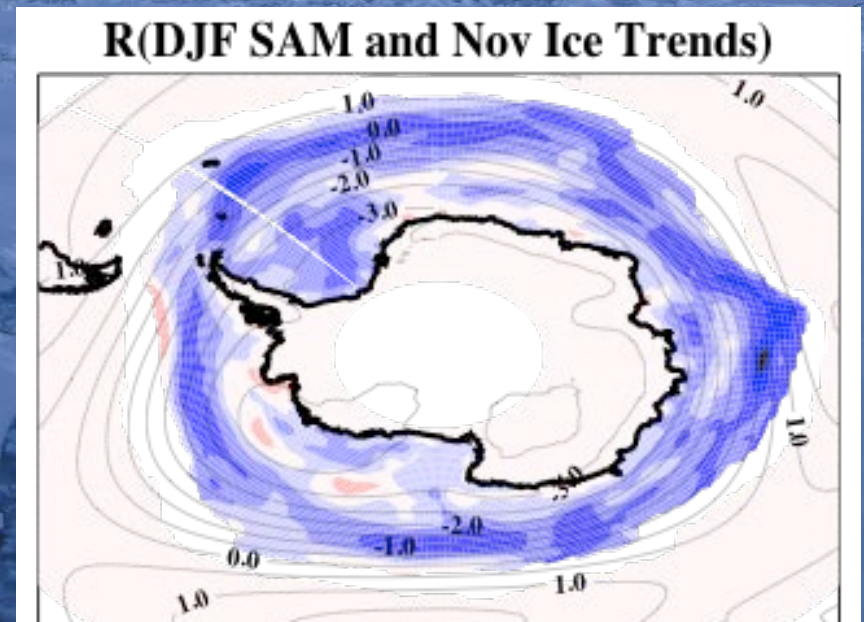
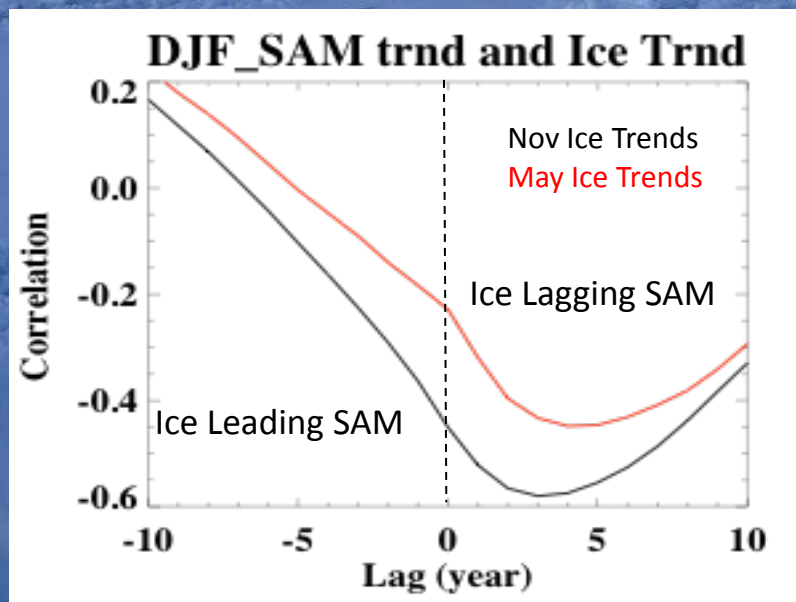
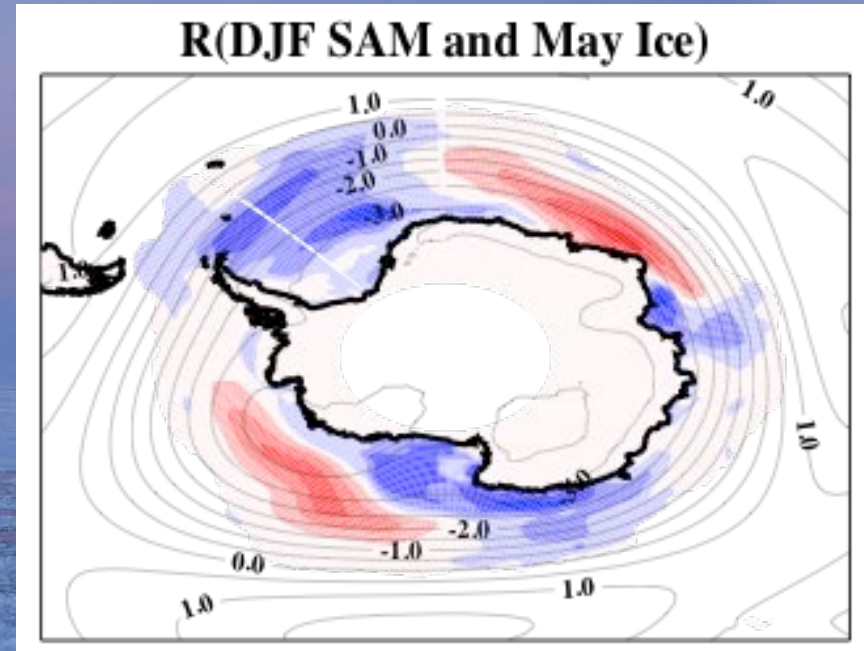
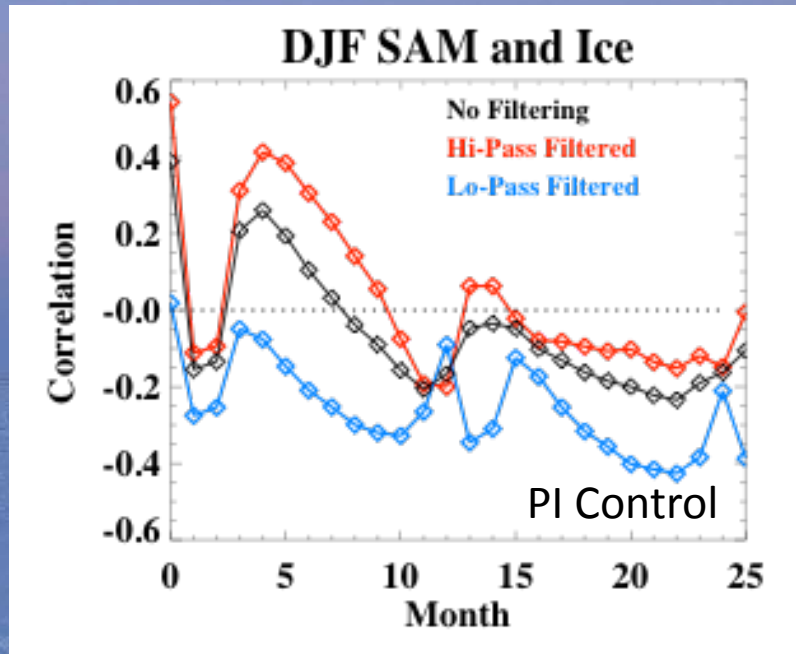


Observed
Correlation
from
detrended
data

What contributes to ice trends/variability

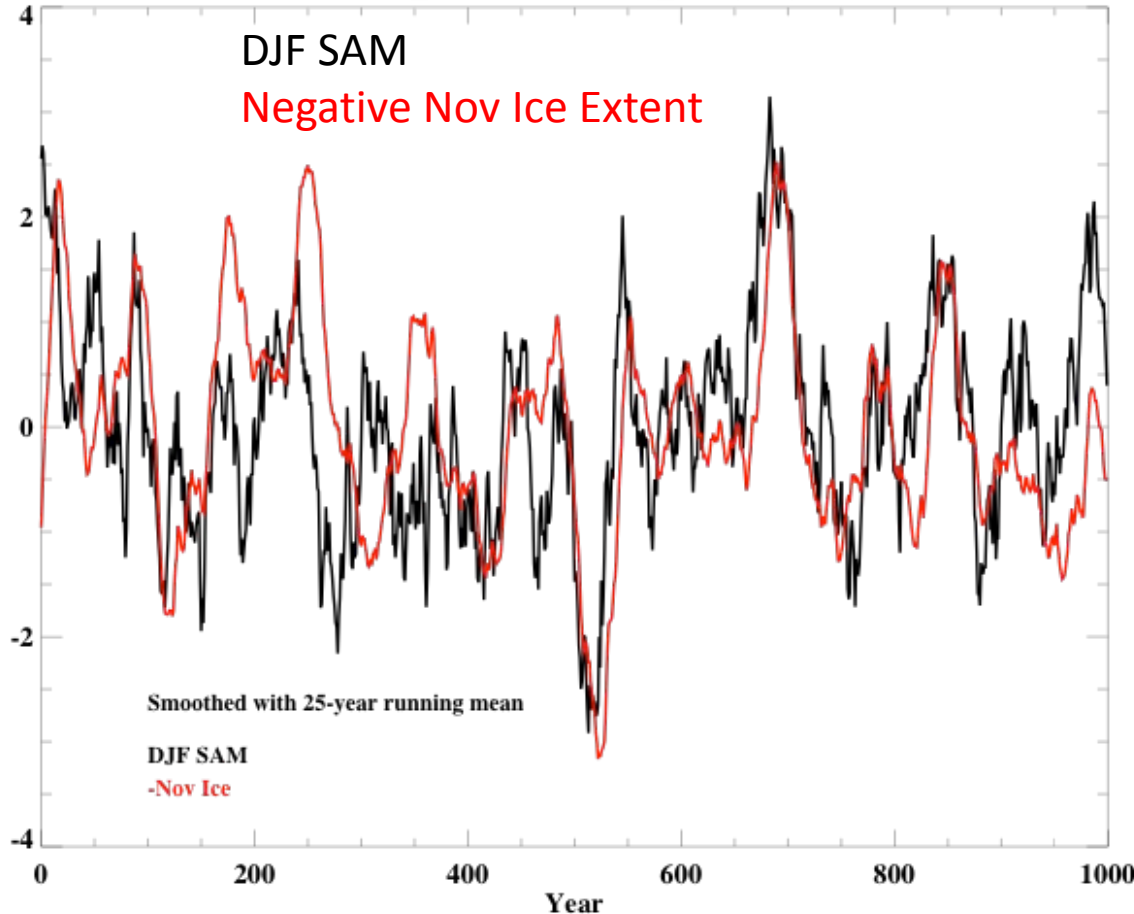


What contributes to ice trends/variability



What contributes to PI trends/variability

DJF_SAM and NOV_Ice (red)



PI Control Run

On multi-decadal scales:

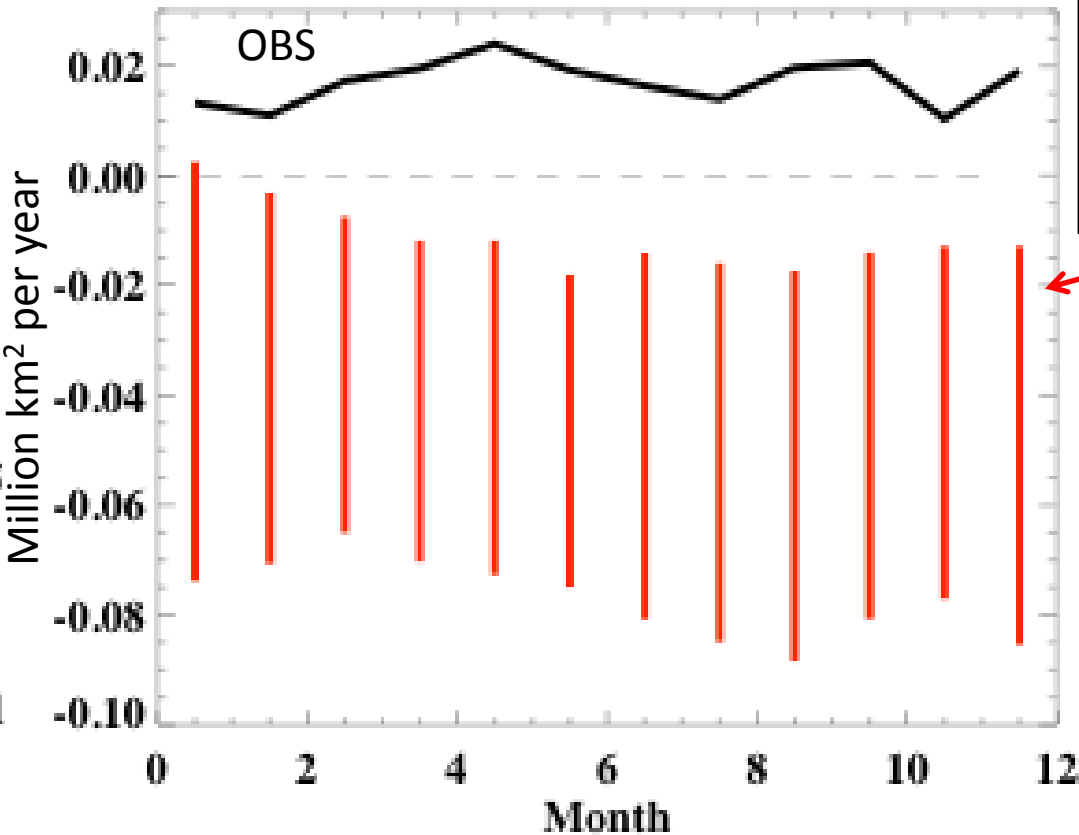
- Positive Summer SAM trends are associated with a loss of sea ice
- Correlated ice loss throughout SH
- Correlations are strongest for ice conditions in November
- This is consistent with ozone-sensitivity runs:
 - Sigmund and Fyfe, 2010
 - Bitz and Polvani, 2012
 - Ferreira et al., in press

An aerial photograph of a frozen body of water, likely a lake or sea, showing a network of ice floes and channels. The ice is a pale, translucent blue, and the water in the channels is a darker blue. A dark blue semi-transparent banner is overlaid in the center of the image, containing the text "20th Century Runs" in white. The sky in the background is a pale, hazy blue.

20th Century Runs

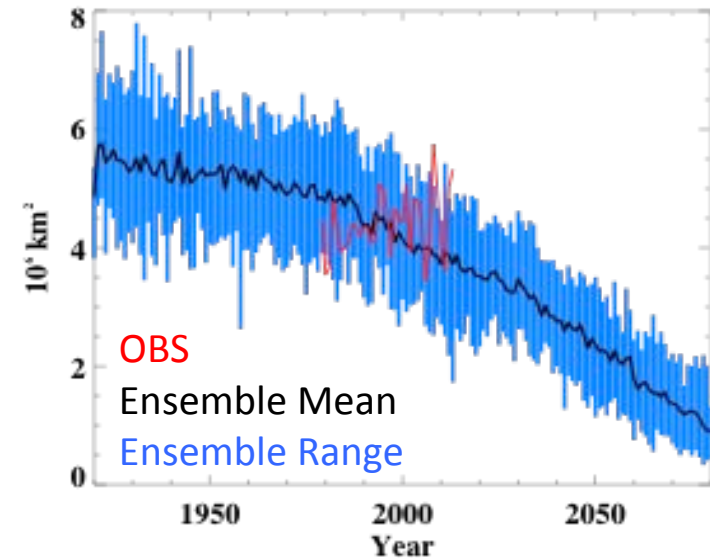
SH Ice Extent Trends

Trend from 1979-2013



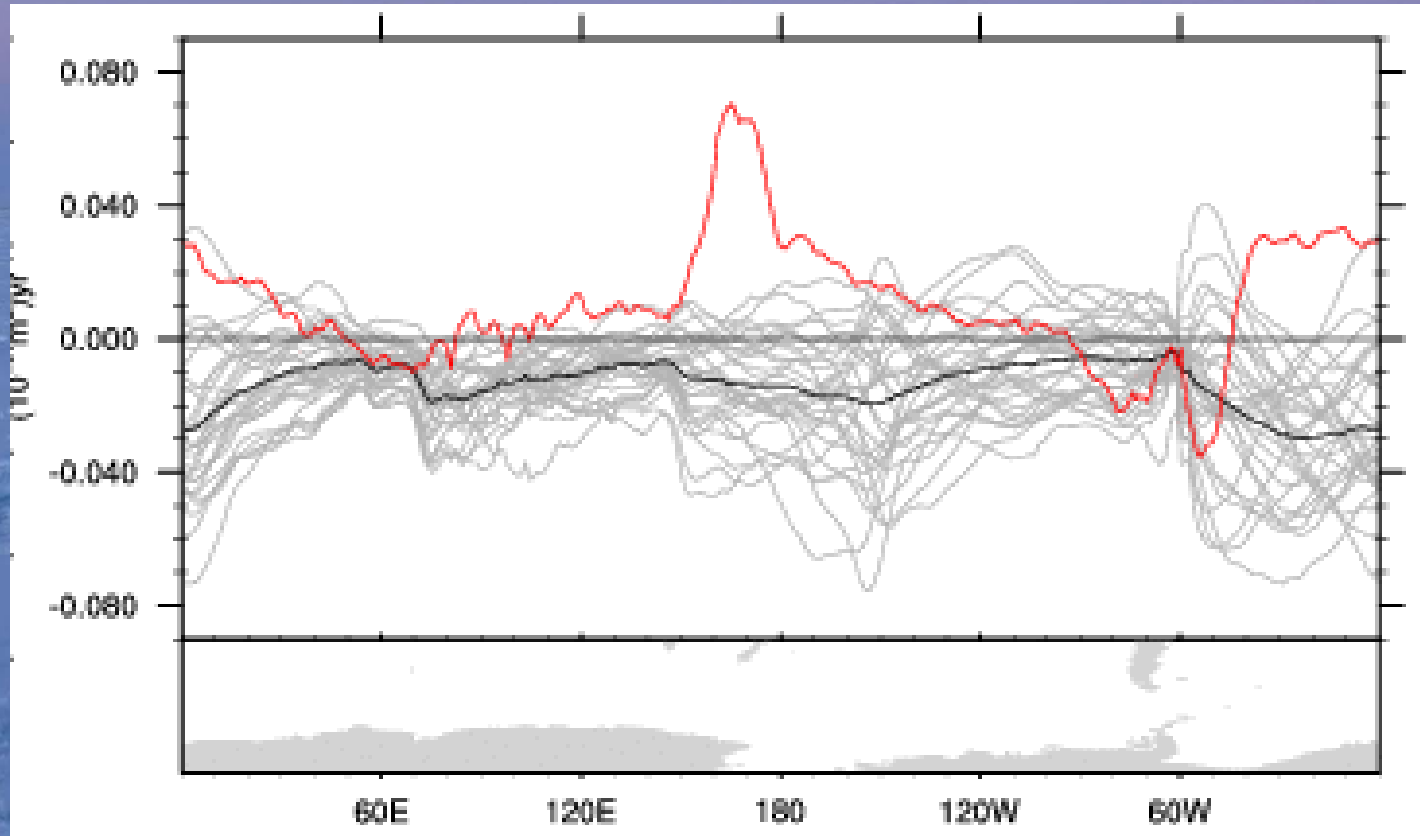
Range across ensemble members 1979-2013

March SH Ice Extent



Late 20th Century Trends

AMJ Ice Area Trends 1980-2005



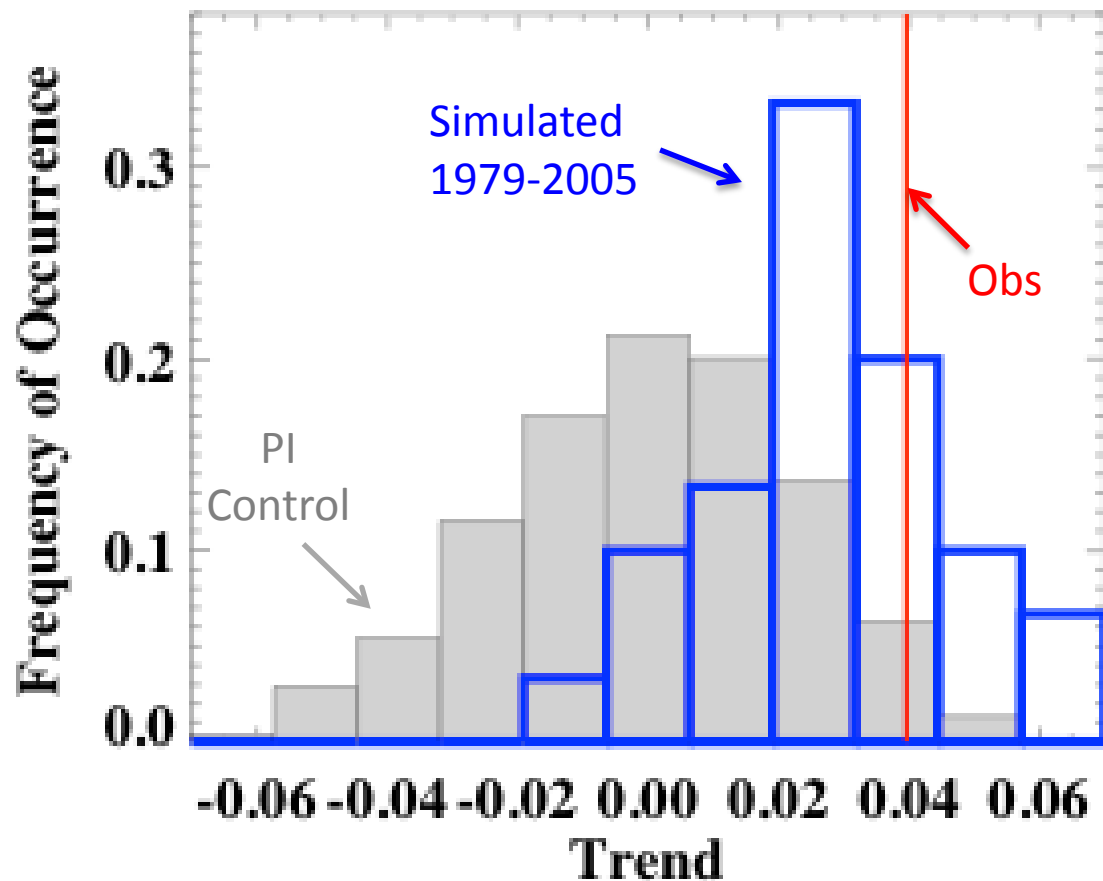
Observed

20th Century Large Ensemble
Mean

Individual Members (1980-2005)

DJF Southern Annular Mode Trends

SAM DJF Trend 1979-2005

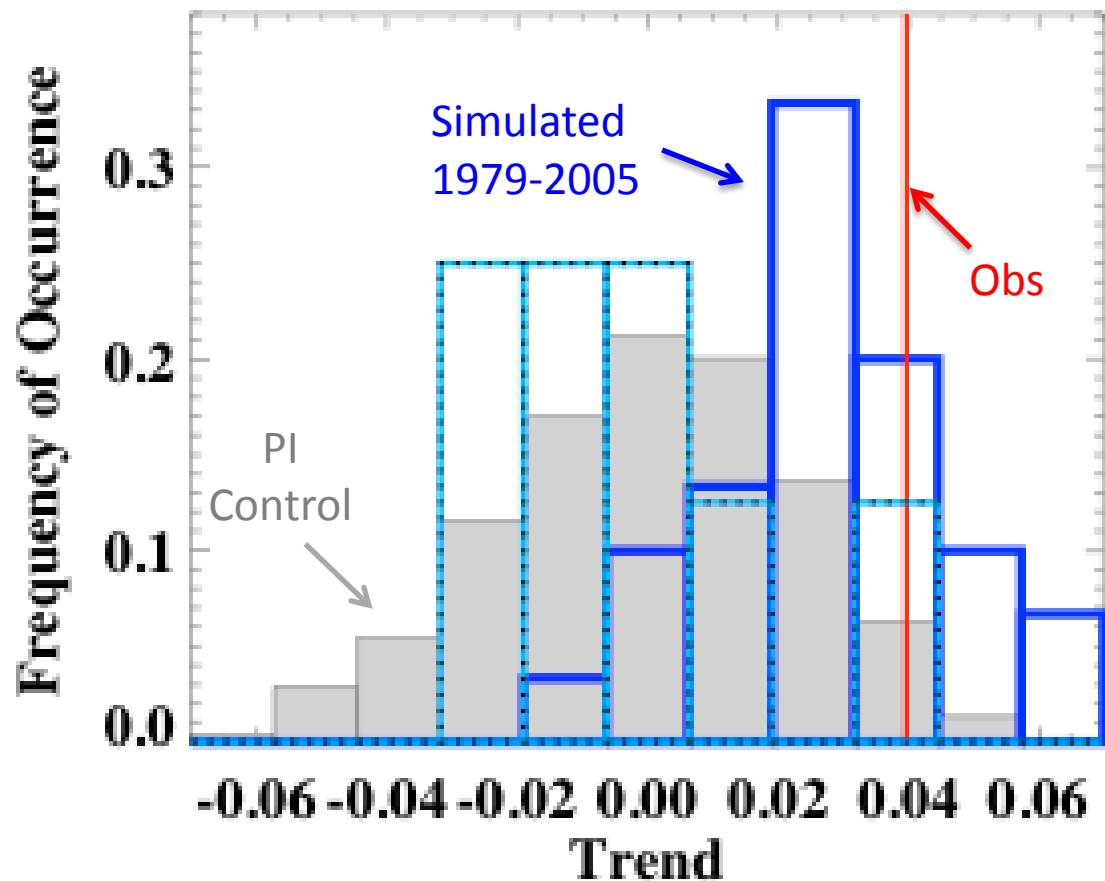


- 26 year trends
- Discernible positive shift in the late 20C trend distribution
- Simulations bracket observations

Thanks to Adam Phillips for variability metrics (via CUPD)

DJF Southern Annular Mode Trends

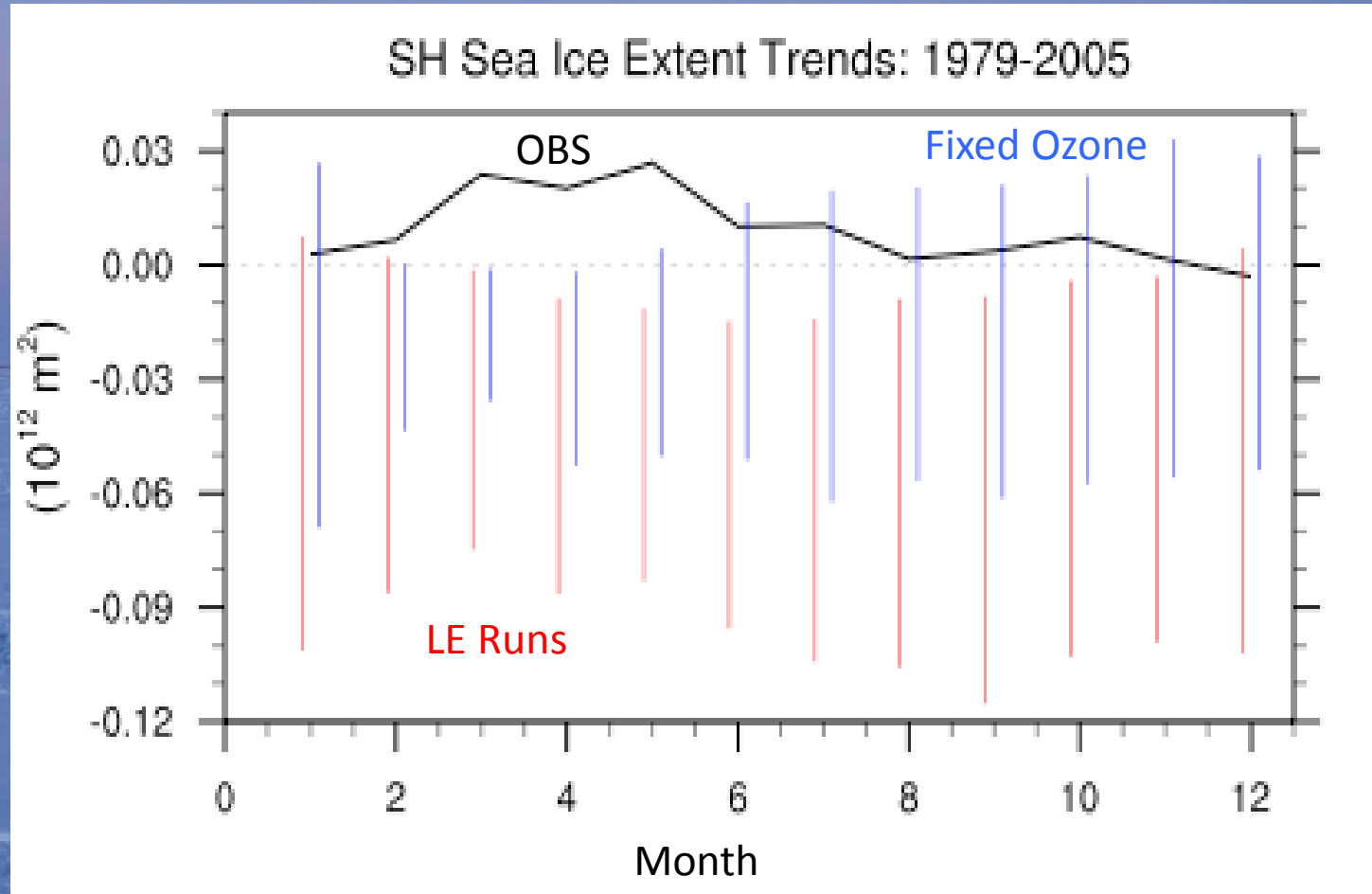
SAM DJF Trend 1979-2005



- 26 year trends
- Discernible positive shift in the late 20C trend distribution
- Simulations bracket observations
- Fixed ozone runs show no shift

Thanks to Adam Phillips for variability metrics (via CUPD)

Ice Extent Trends

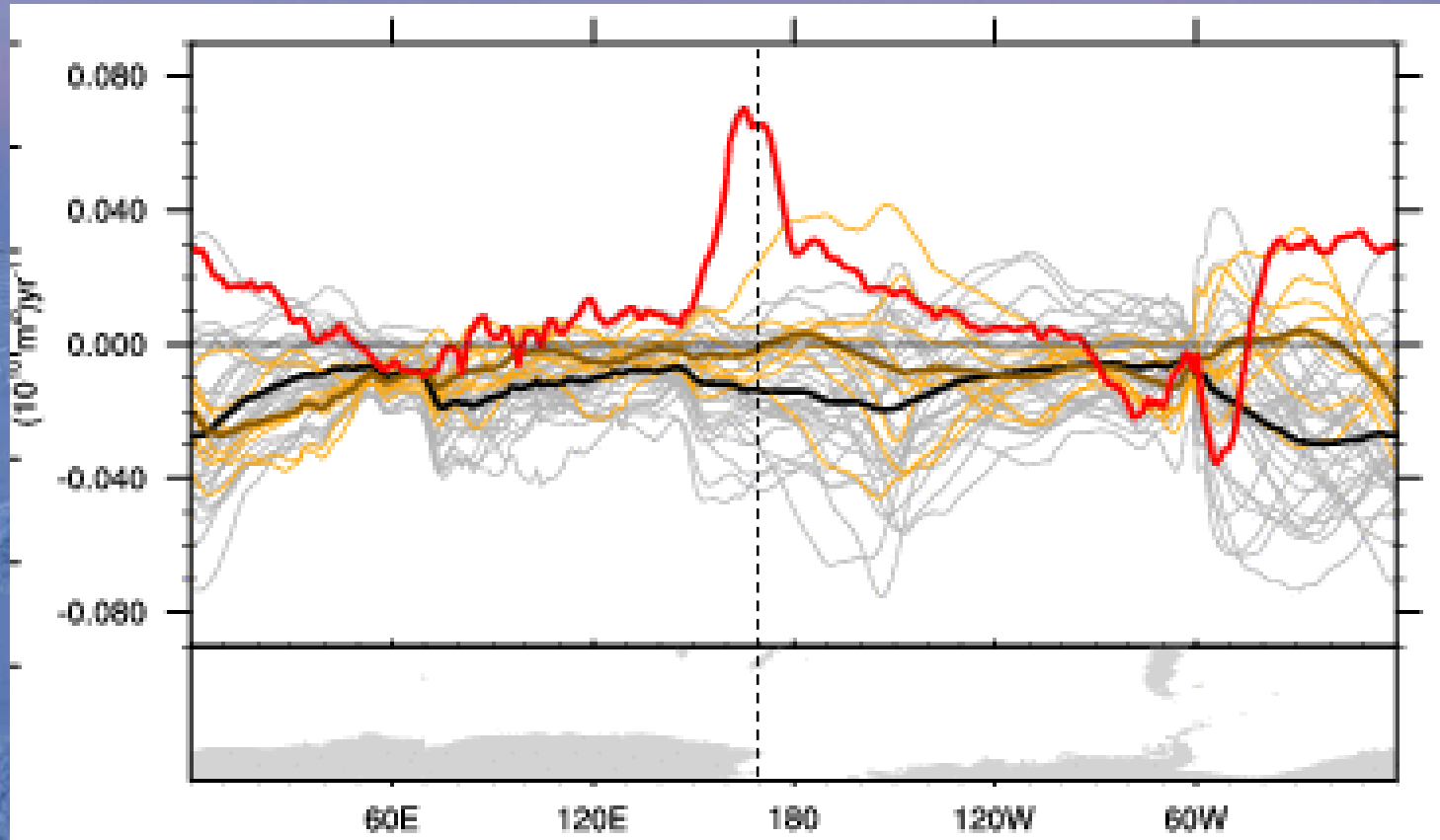


Similar to previous work:

- Simulations with no ozone loss have less sea ice loss
- Consistent with PI runs which show ice reductions during periods with positive SAM trends

Regional Ice Area Trends

AMJ Ice Area Trends 1980-2005



Observed

20th Century Large Ensemble
Mean

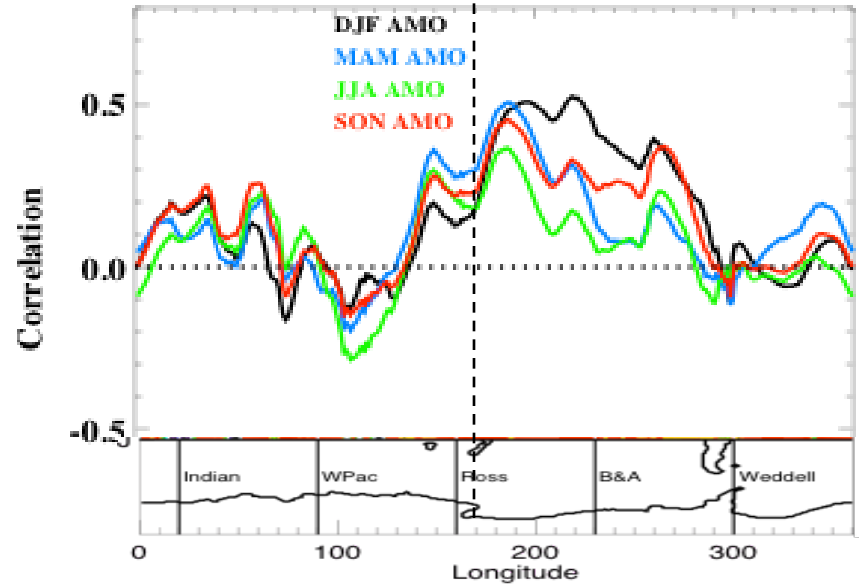
Individual Members (1980-2005)

Fixed Ozone Members

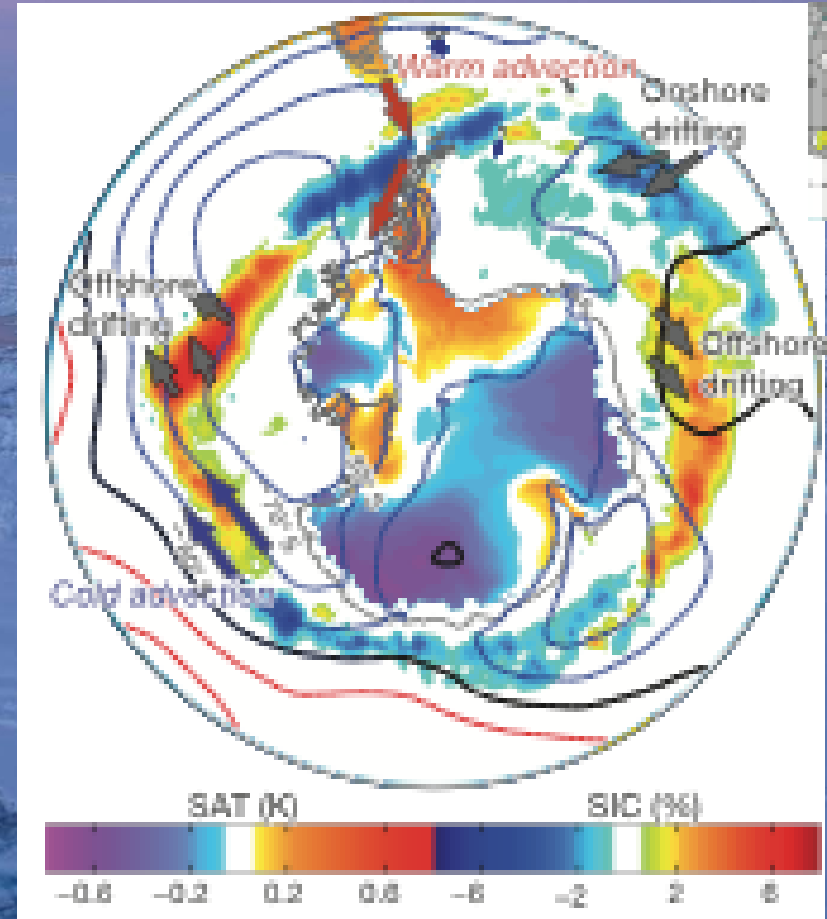
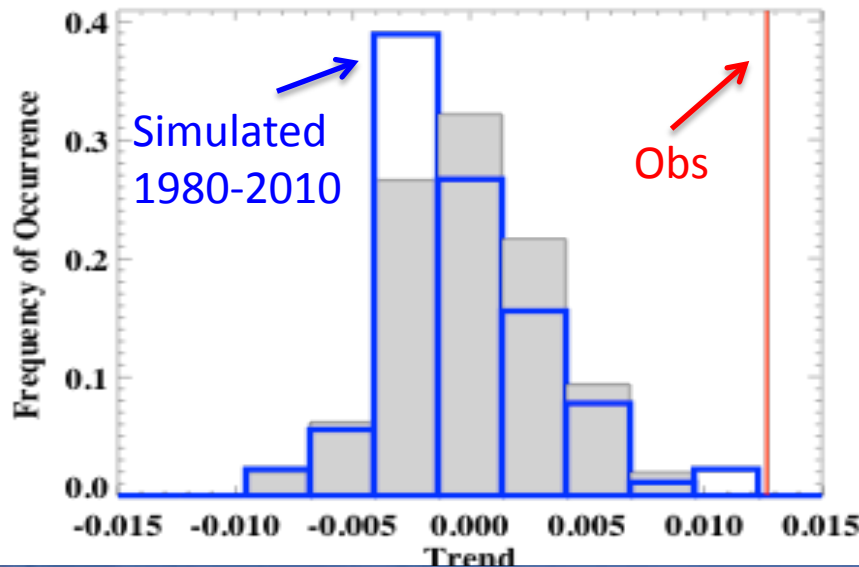
Importance of other modes of variability?

Atlantic SST Variability

R (Trend of AMO, MAM AICE)



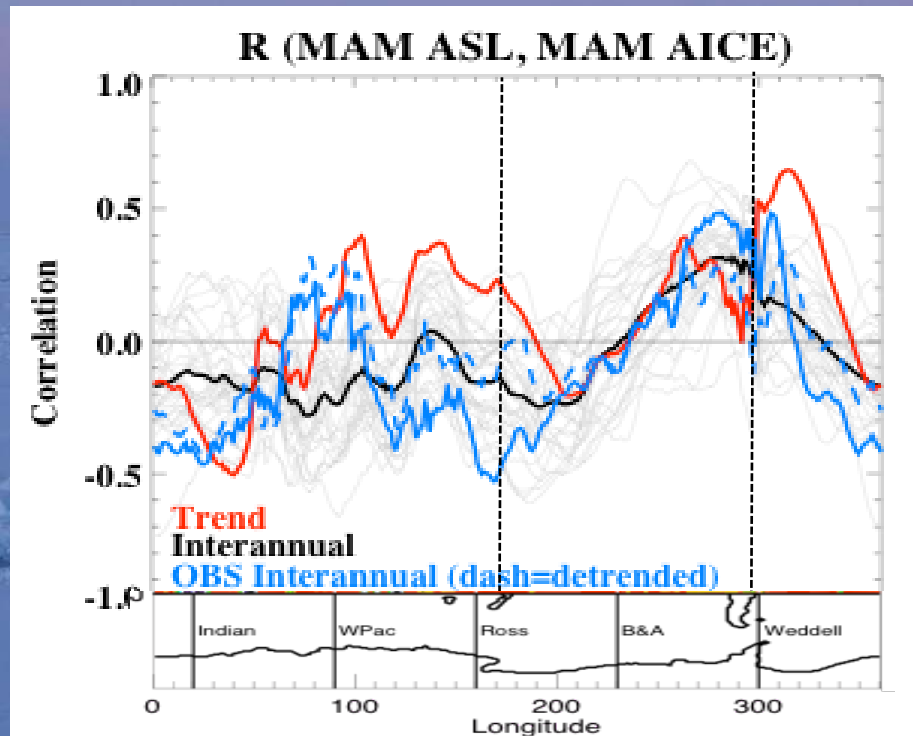
AMO ANN Trend



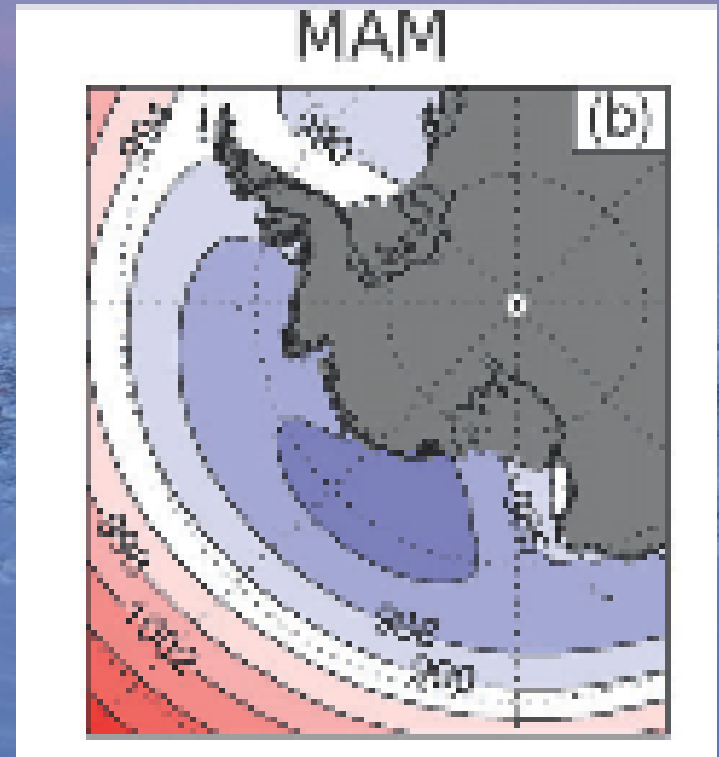
(From Li et al., 2014)

Importance of other aspects of variability?

Amundsen Sea Low Variability



Correlation with ASL minimum pressure



(From Hosking et al, 2013)

Conclusions

- Antarctic sea ice in CESM has many aspects that are well-simulated
- Observed trends consistent with internal variability from pre-industrial control run except in Ross Sea
- The 30-member ensemble has no simulations with increasing ice from 1979-2013
 - Ross Sea ice trends are small compared to obs
- As in previous studies, with fixed ozone less ice loss occurs
- Investigating other modes/aspects of variability that may affect Ross Sea multi-decadal ice variations

A wide-angle photograph of a desolate, icy landscape. The ground is covered in a thick layer of snow and ice, with some darker patches visible. The horizon is flat and extends across the entire width of the image. The sky is a mix of light blue and purple, suggesting a sunset or sunrise. The word "Questions?" is written in a large, white, sans-serif font in the center of the image.

Questions?