Antarctic Sea Ice Variability - Insights from the Large Ensemble

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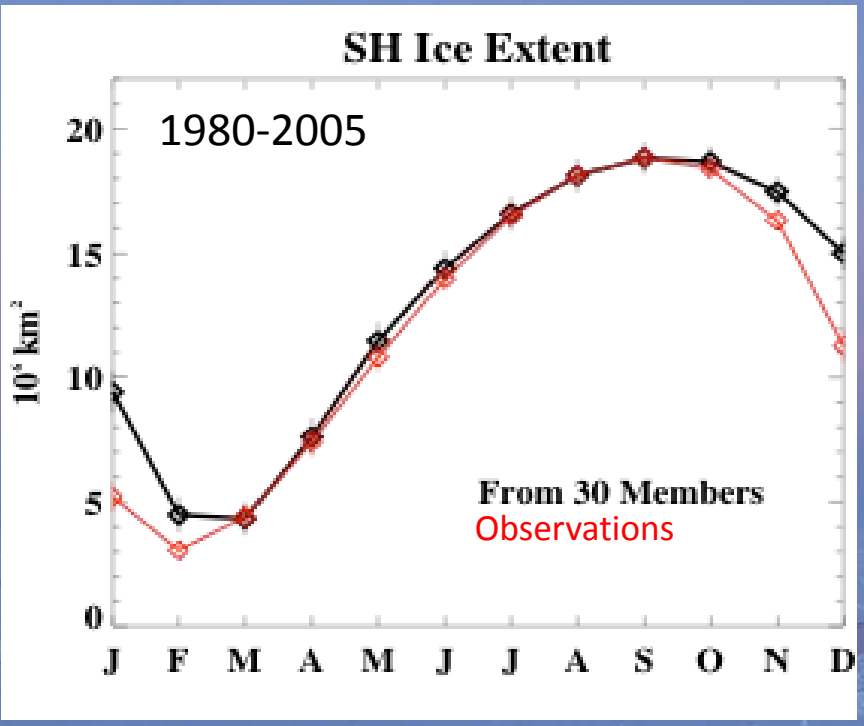
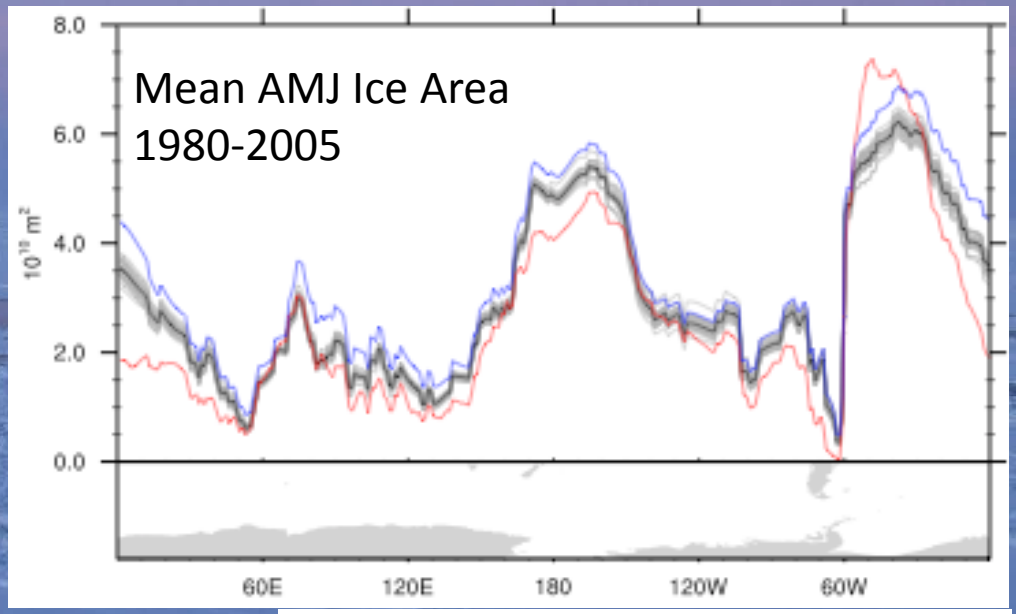
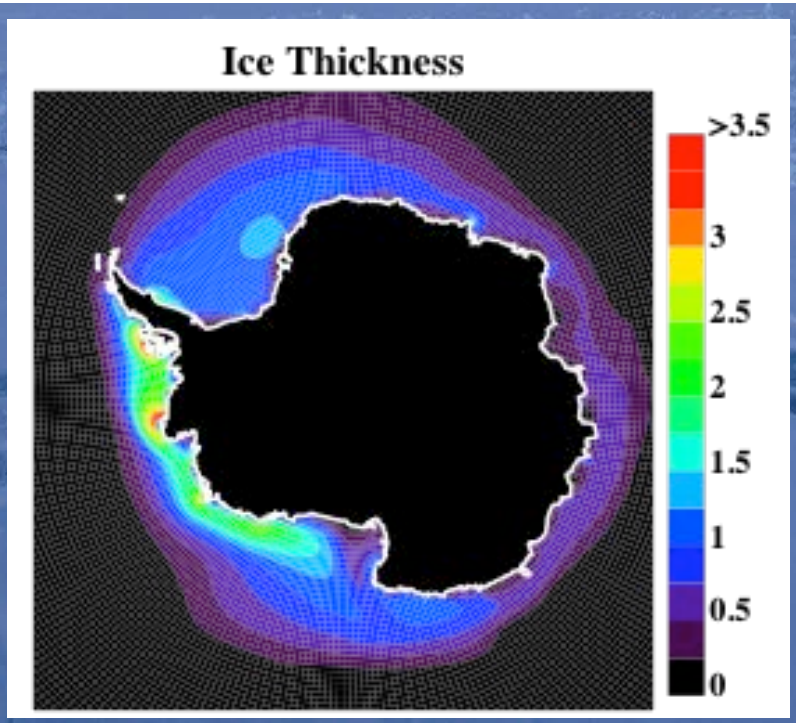
CESM Integrations

- 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







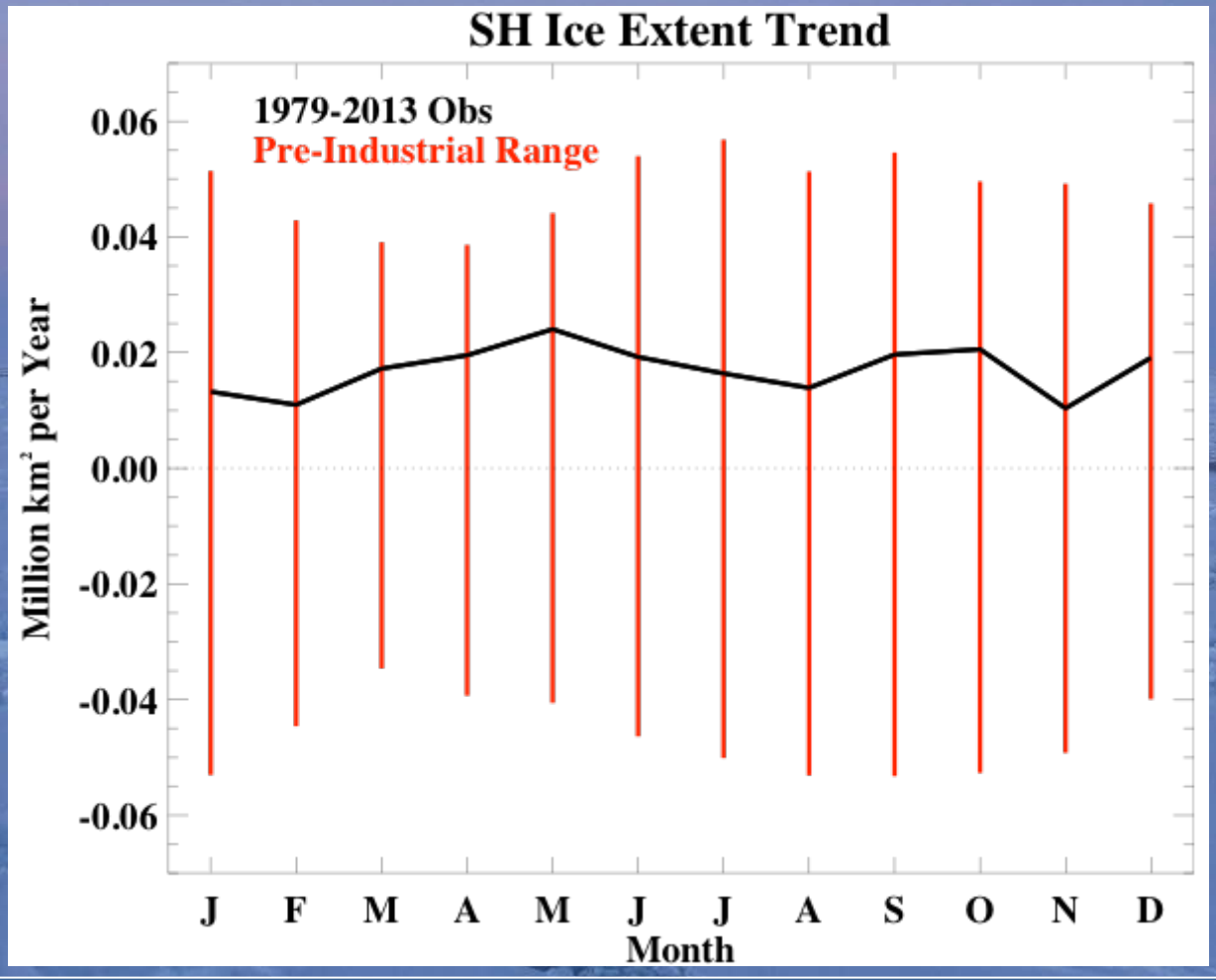
Observed

PI Control

20th Century Large Ensemble Mean

Individual Members

Trends in Antarctic Sea Ice

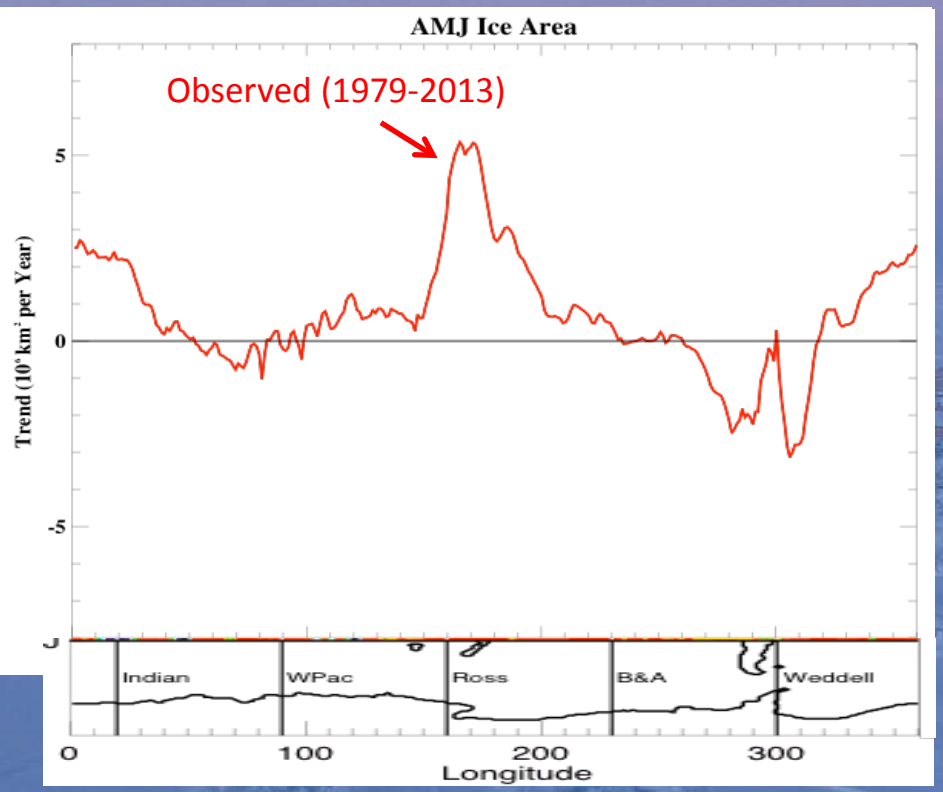


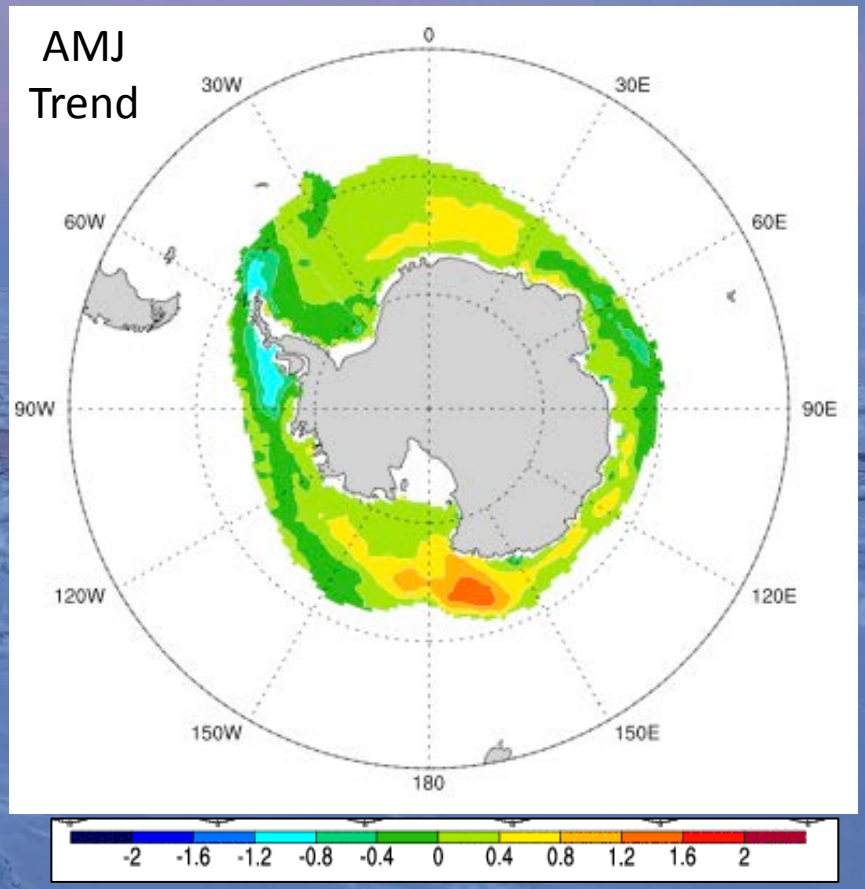
Trends in observed total SH ice extent are well within the Pre-Industrial control run variability for all months

Consistent with Polvani and Smith 2013

Trends in Antarctic Sea Ice

Trends in AMJ Ice Area with Longitude

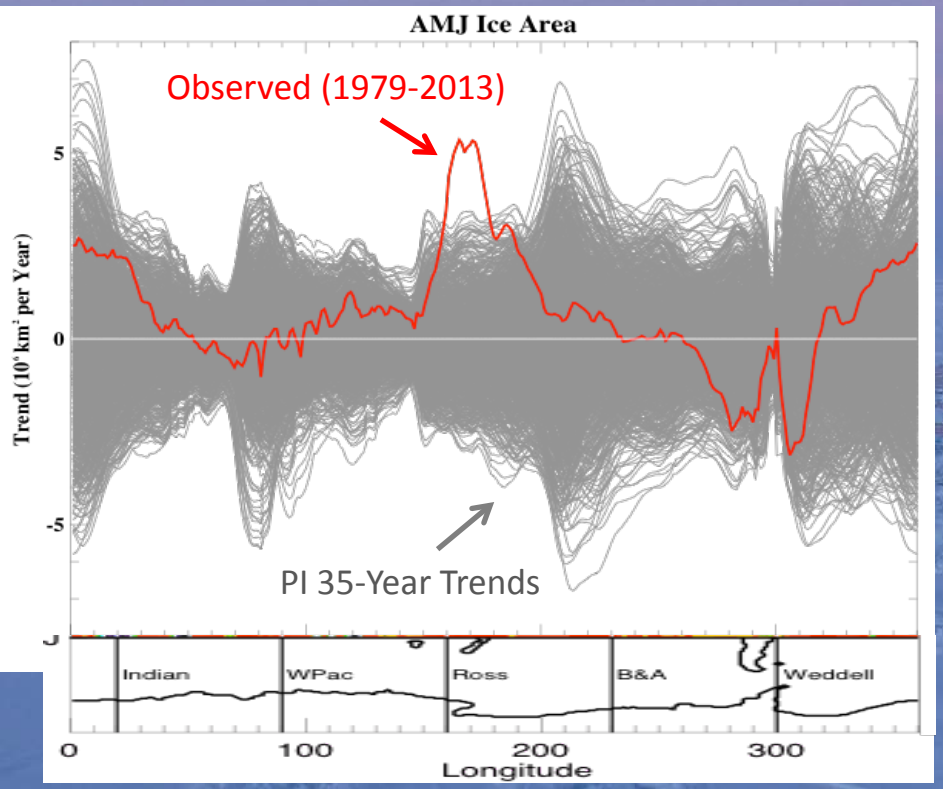


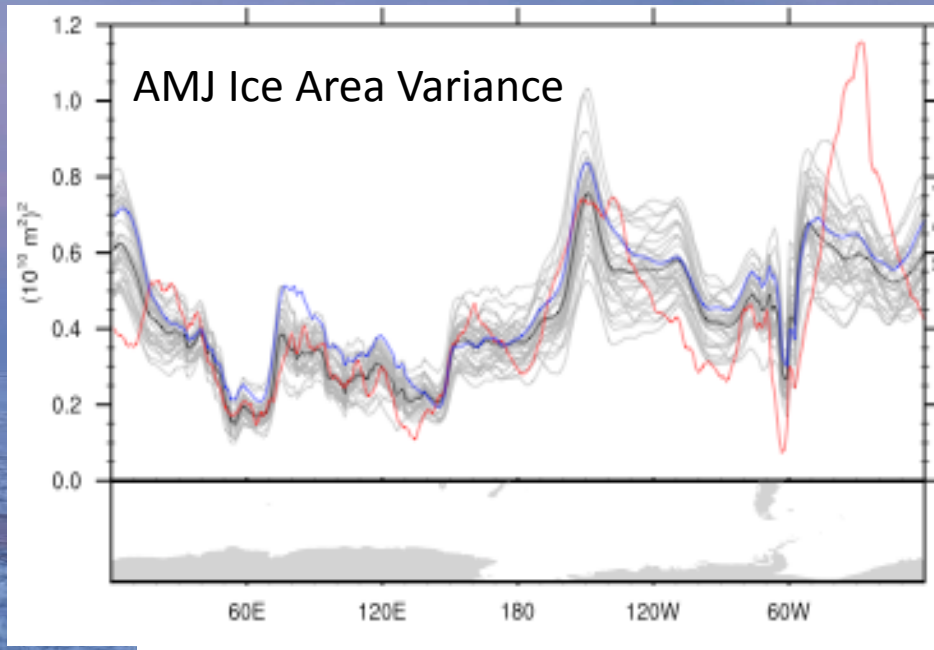


Observed Trends

Trends in Antarctic Sea Ice

Trends in AMJ Ice Area with Longitude





Observed

PI Control

20th Century Large Ensemble Mean

Individual Members (1980-2005)

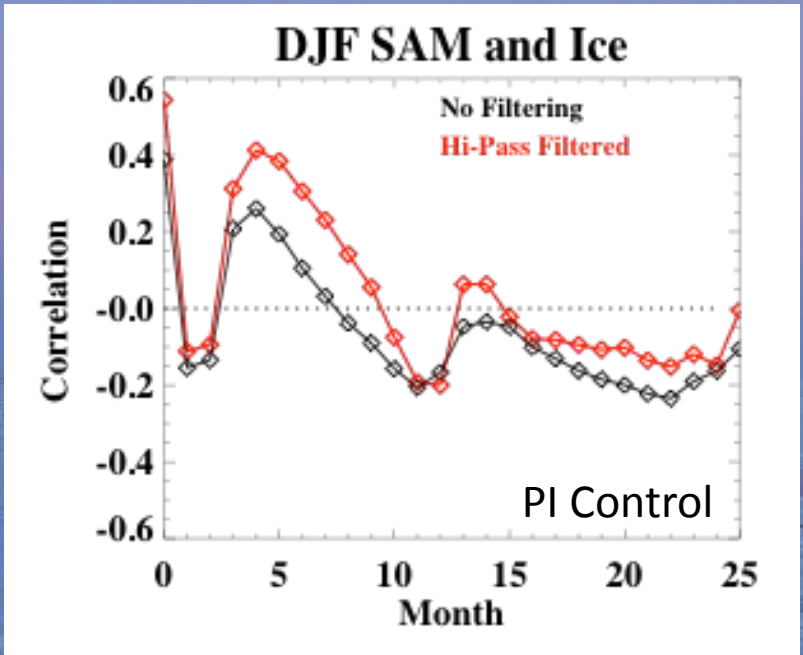
Regionally –

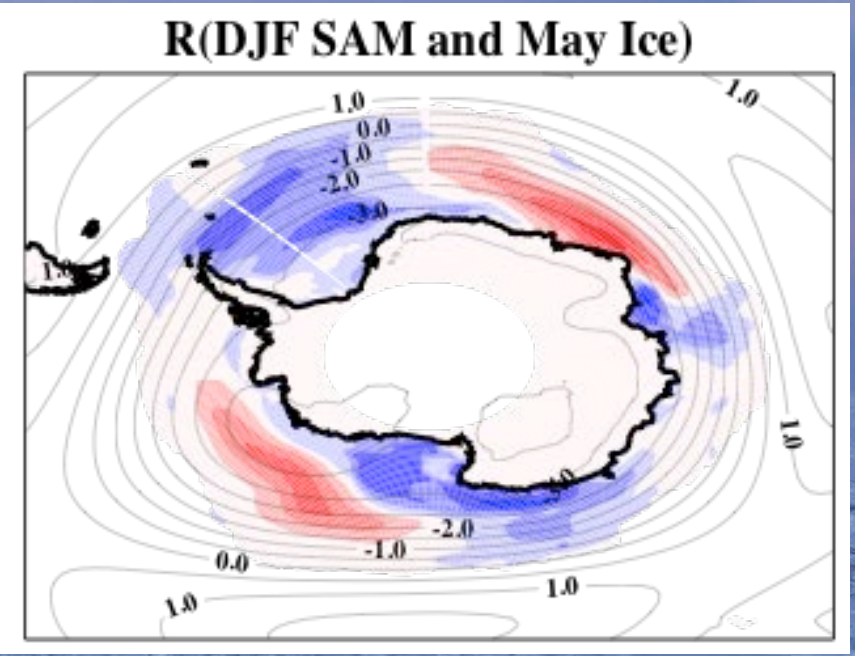
- Observed ice area trends are within PI control run
- Except in the Ross Sea where large ice increases are observed

For Ross Sea increases –

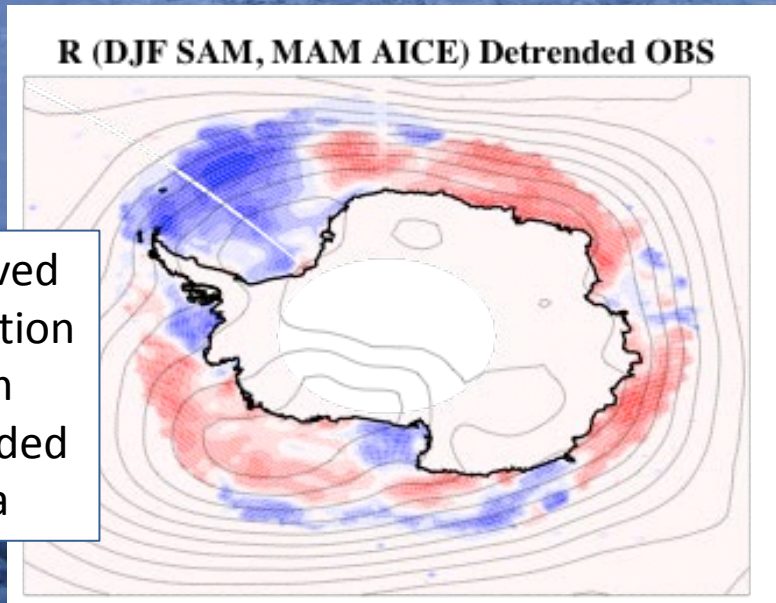
- could be anthropogenically driven
- or could be model biases

What contributes to ice trends/variability



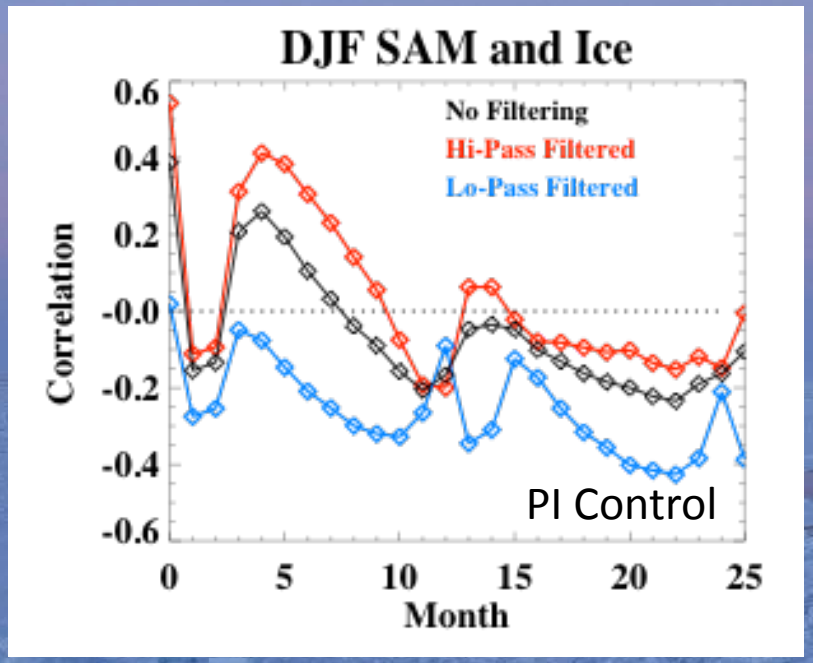


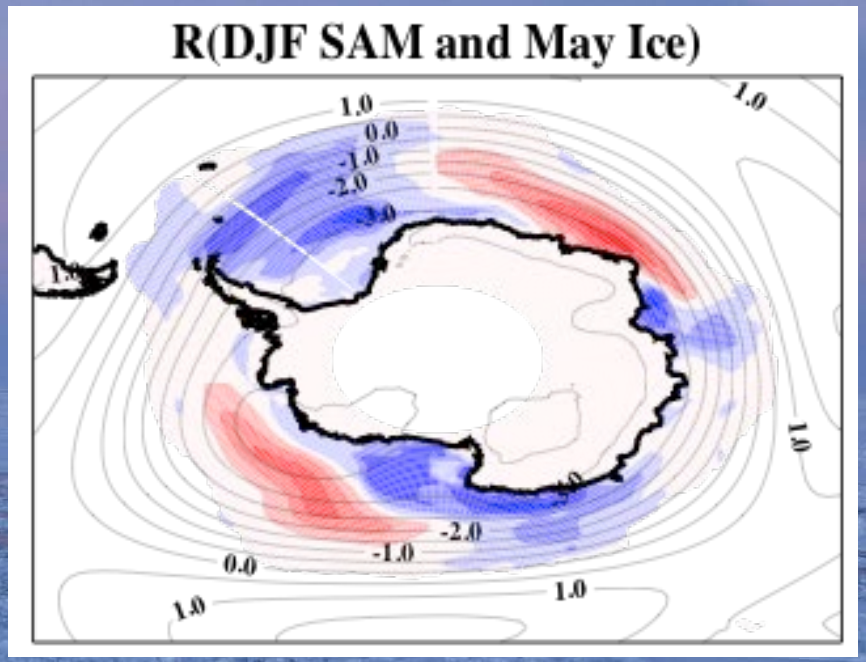
Within PI control: Summer SAM Variability has associated increases in total ice extent in the following ice advance period



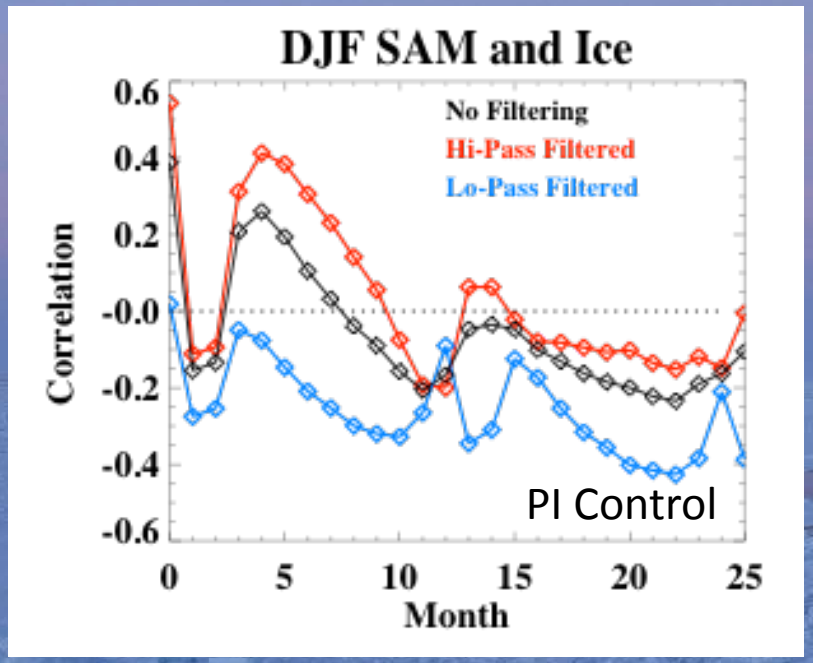
Observed Correlation from detrended data

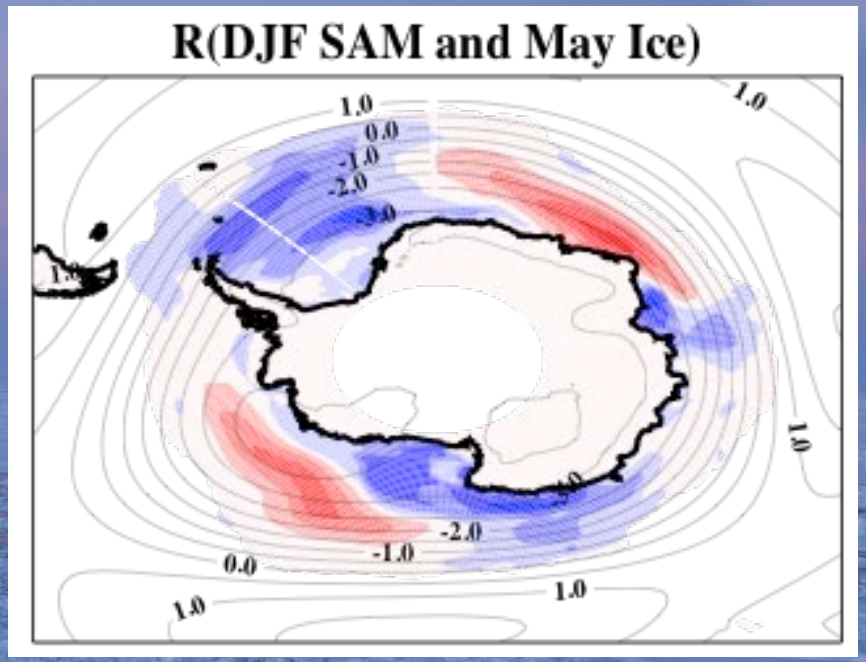
What contributes to ice trends/variability

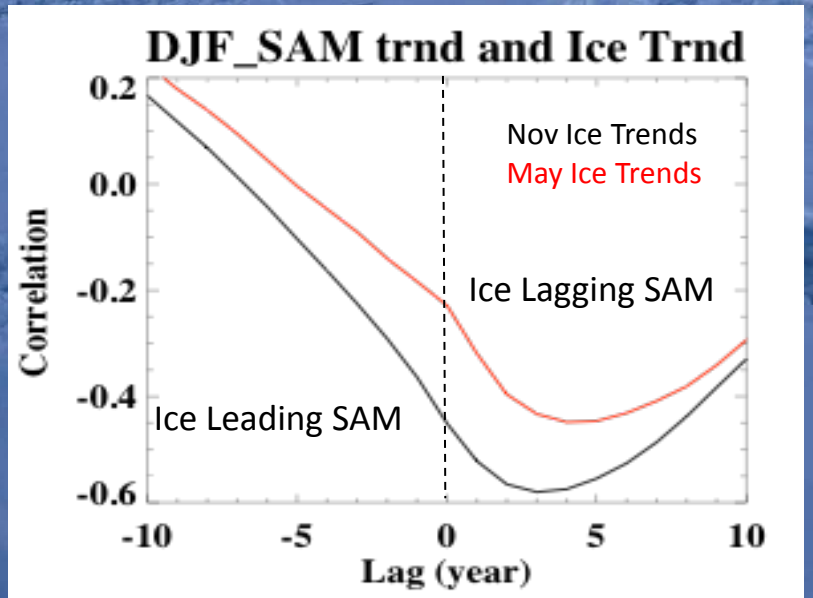


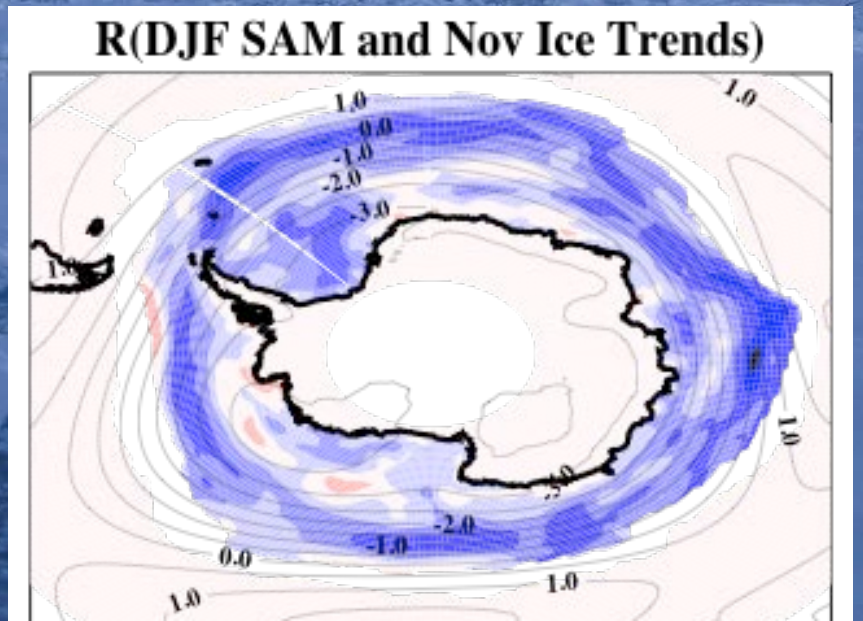


What contributes to ice trends/variability

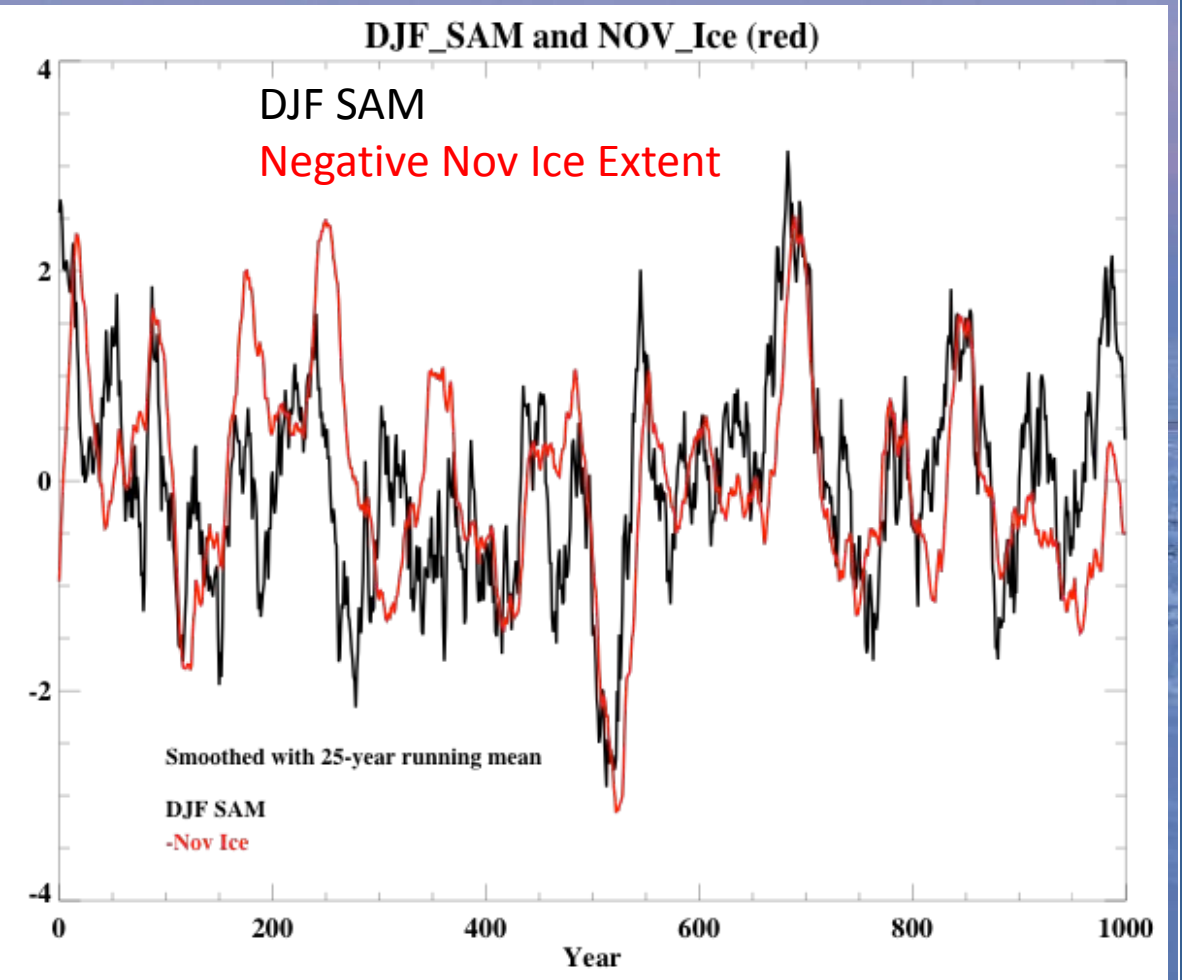








What contributes to PI trends/variability



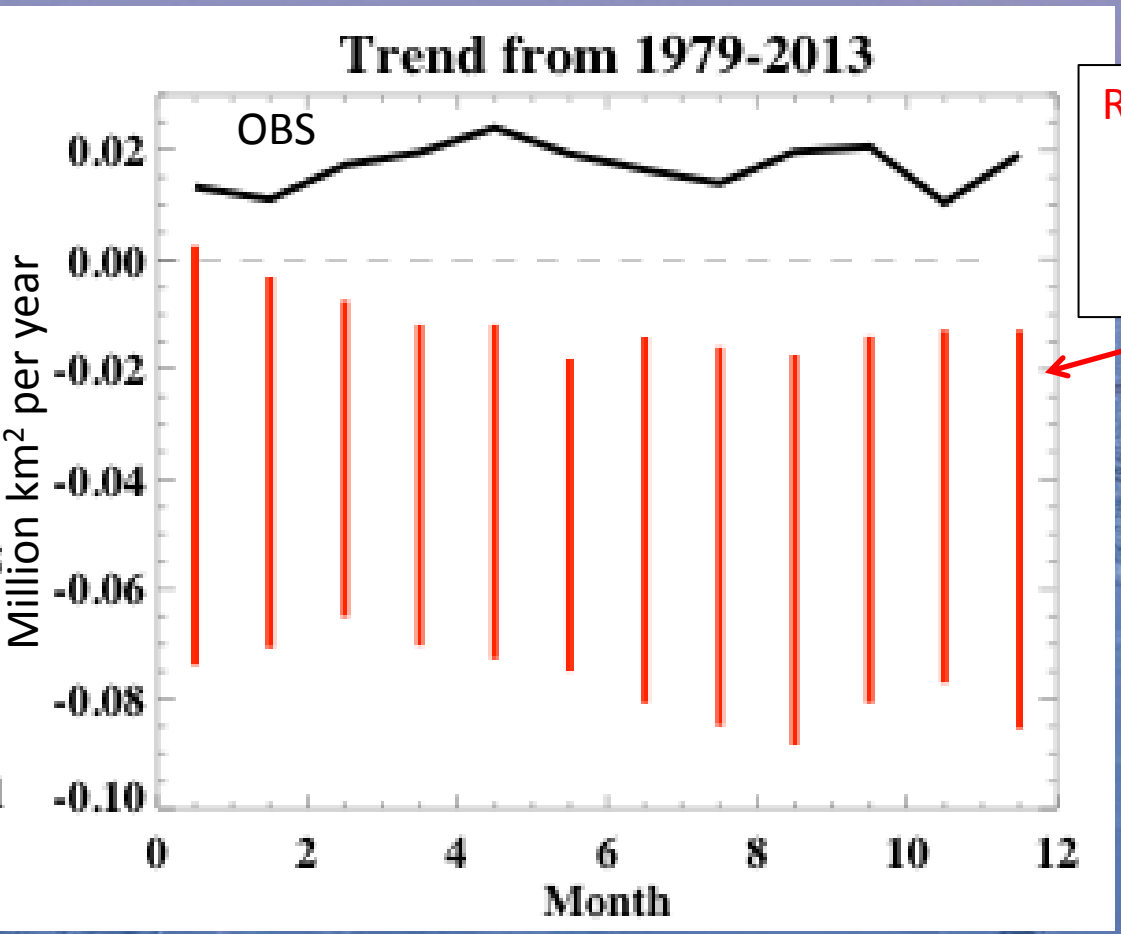
PI Control Run

On multi-decadal scales:

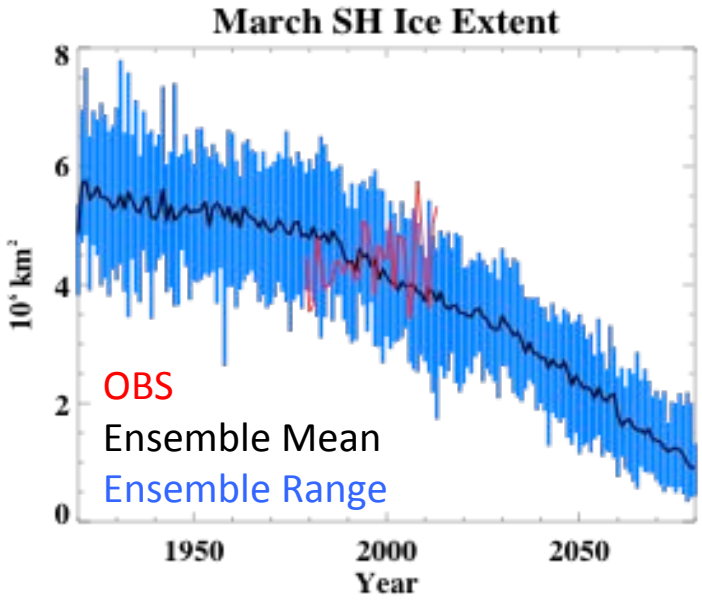
- Positive Summer SAM trends are associated with a loss of sea ice
- Correlated ice loss throughout SH
- Correlations are strongest for ice conditions in November
- This is consistent with ozone-sensitivity runs:
  - Sigmond and Fyfe, 2010
  - Bitz and Polvani, 2012
  - Ferreira et al., in press


20th Century Runs

SH Ice Extent Trends

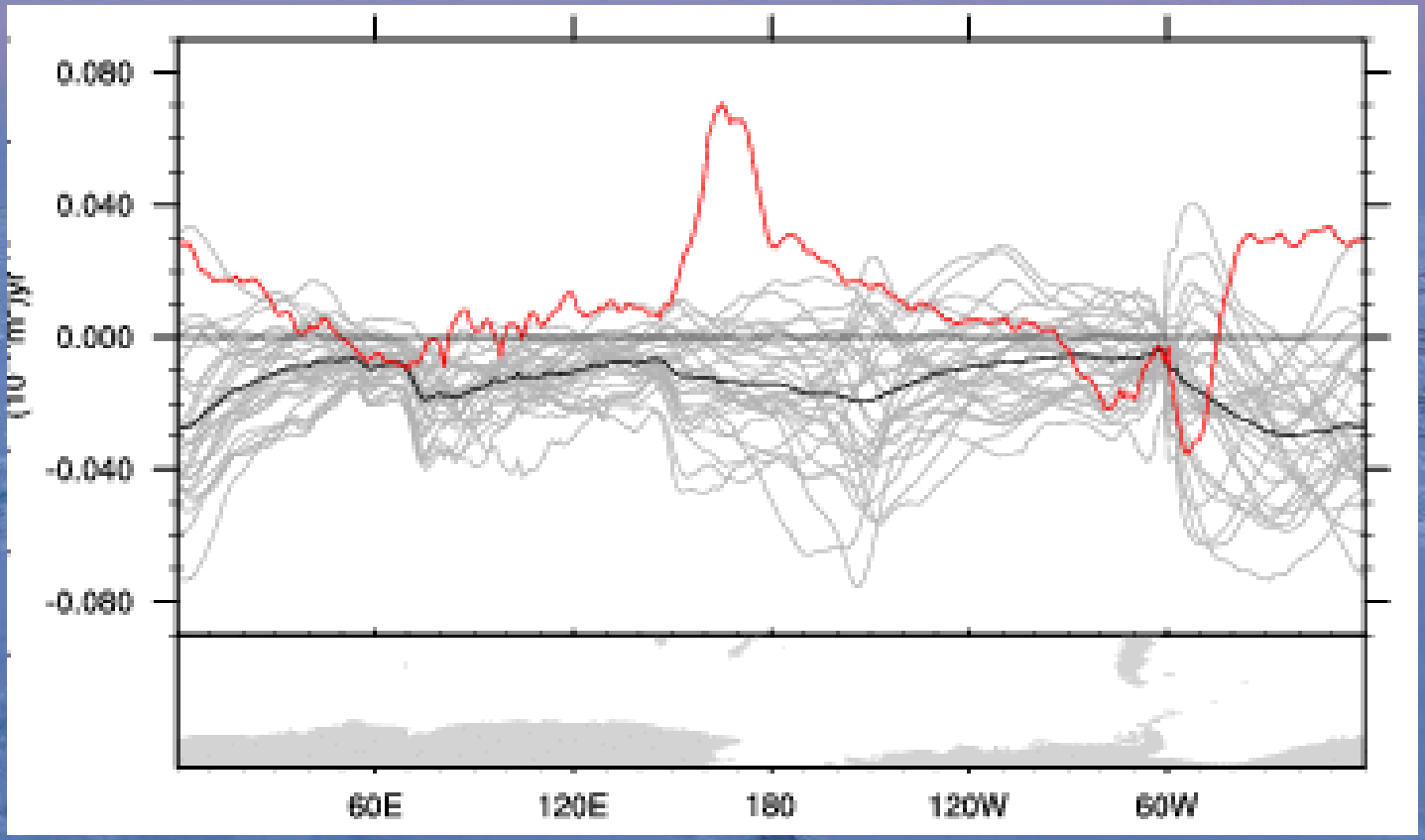


Range across ensemble members 1979-2013



Late 20th Century Trends

AMJ Ice Area Trends 1980-2005

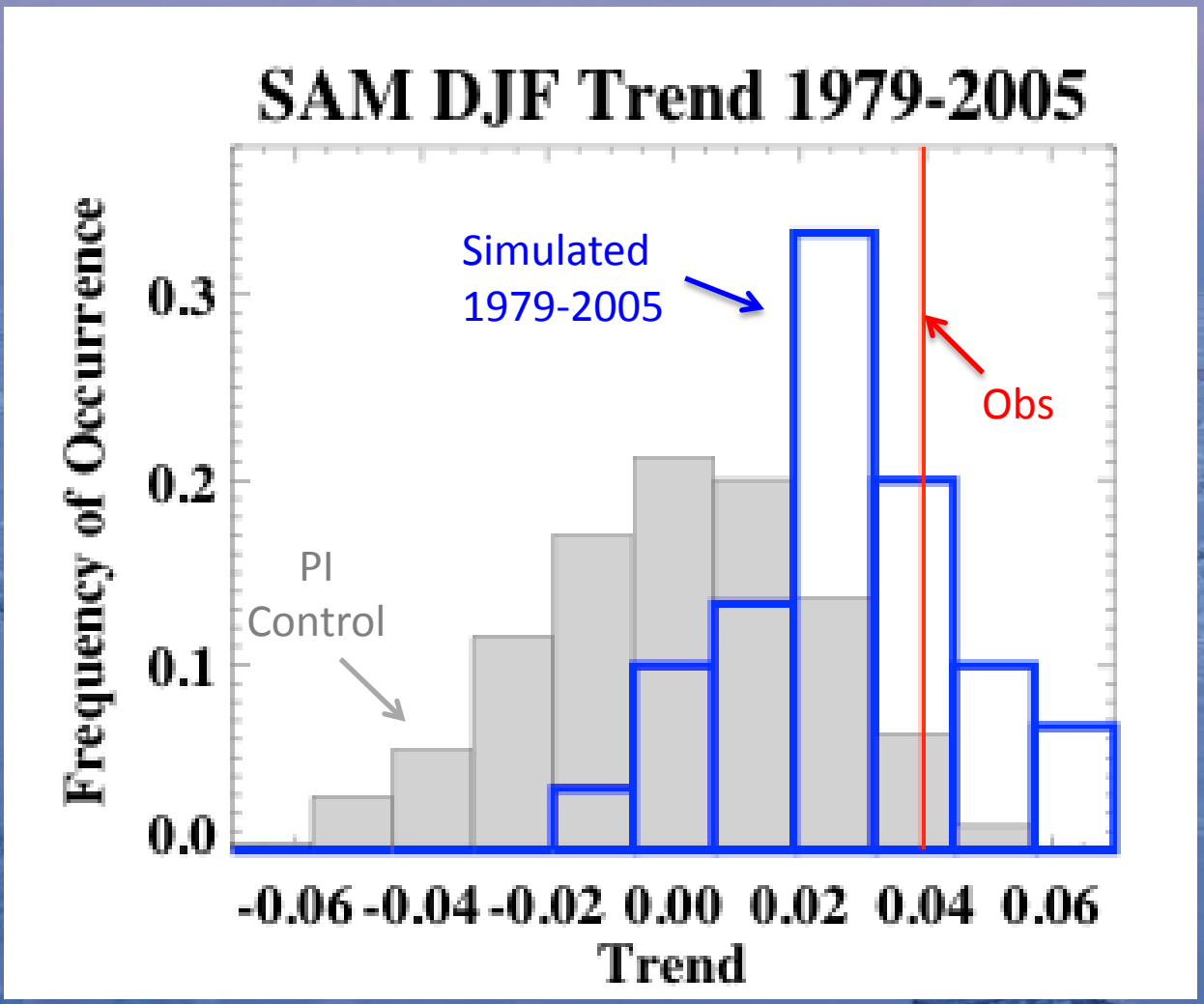


Observed

20th Century Large Ensemble Mean

Individual Members (1980-2005)

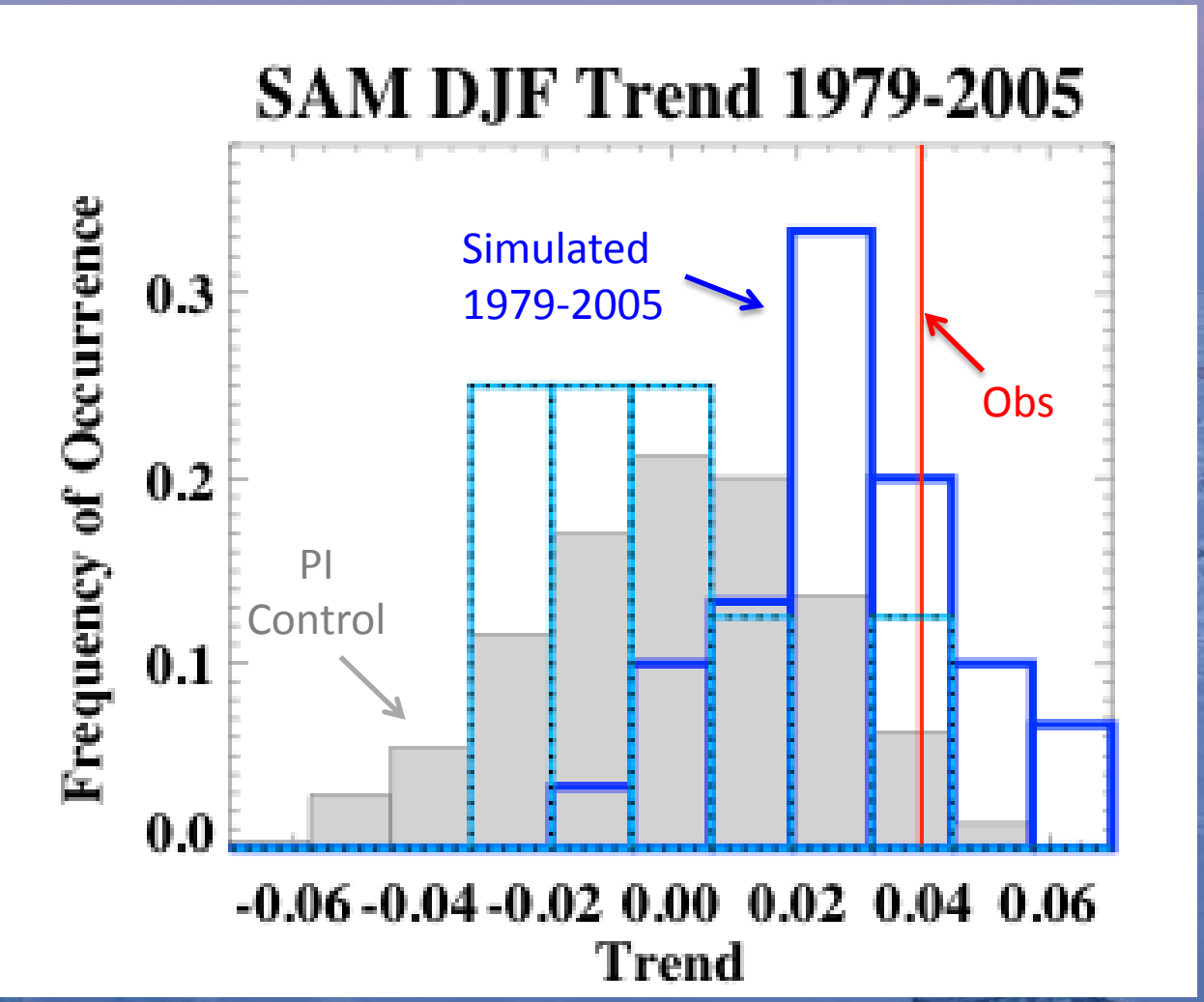
DJF Southern Annular Mode Trends



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

Thanks to Adam Phillips for variability metrics (via

DJF Southern Annular Mode Trends

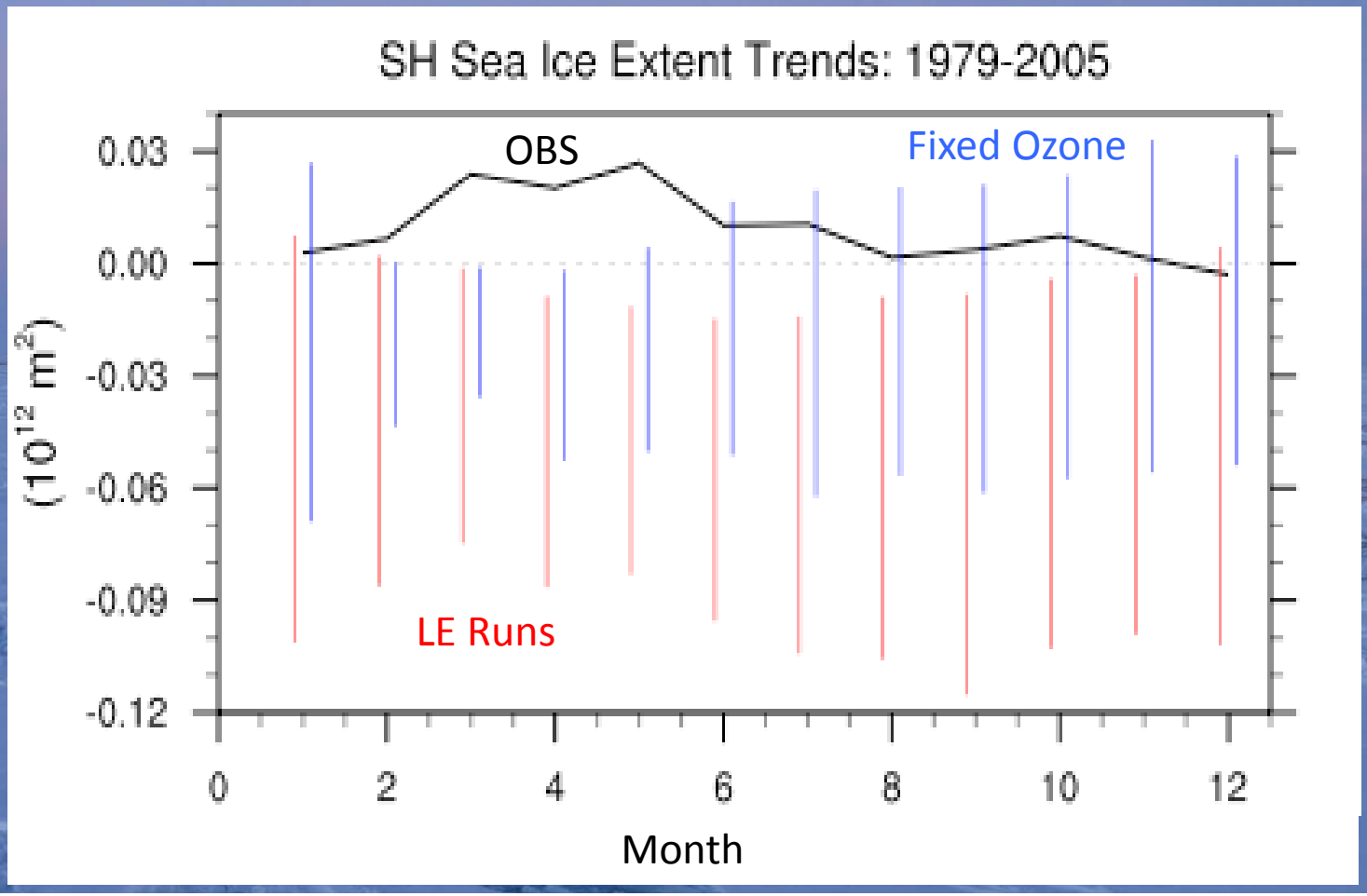


- 26 year trends
- Discernible positive shift in the late 20C trend distribution
- Simulations bracket observations

- Fixed ozone runs show no shift

Thanks to Adam Phillips for variability metrics (via

Ice Extent Trends

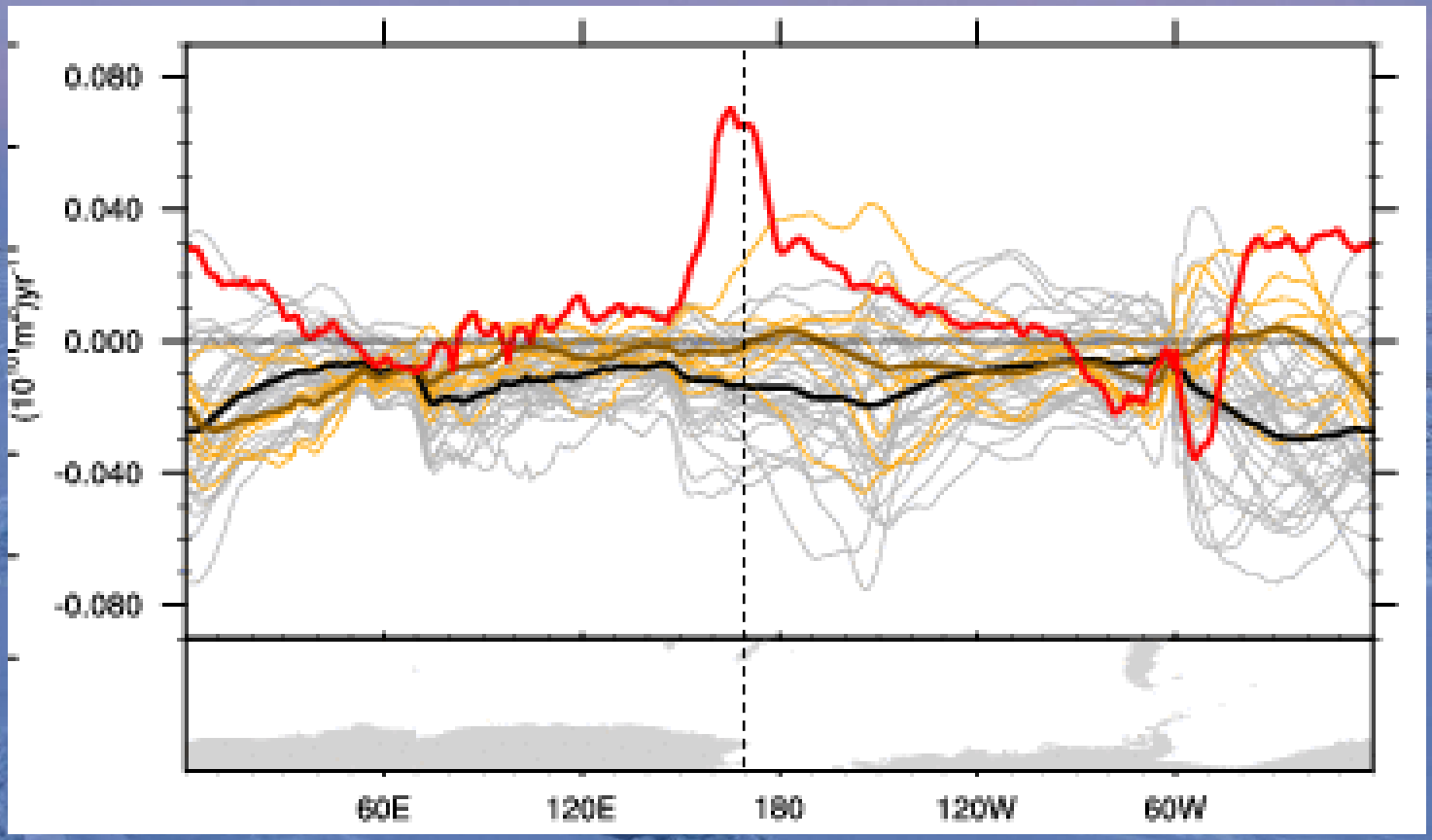


Similar to previous work:

- 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



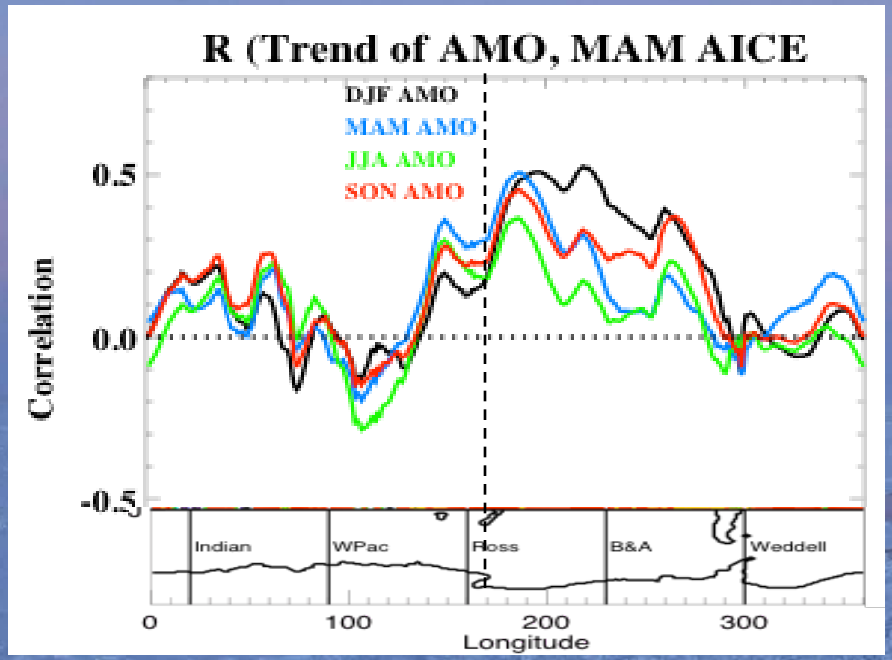
Observed

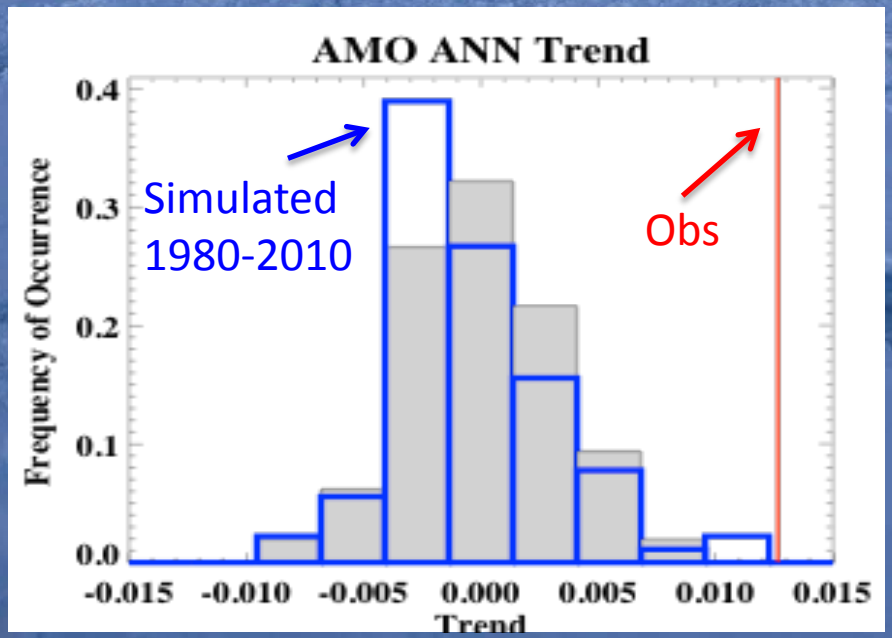
20th Century Large Ensemble Mean

Individual Members (1980-2005)

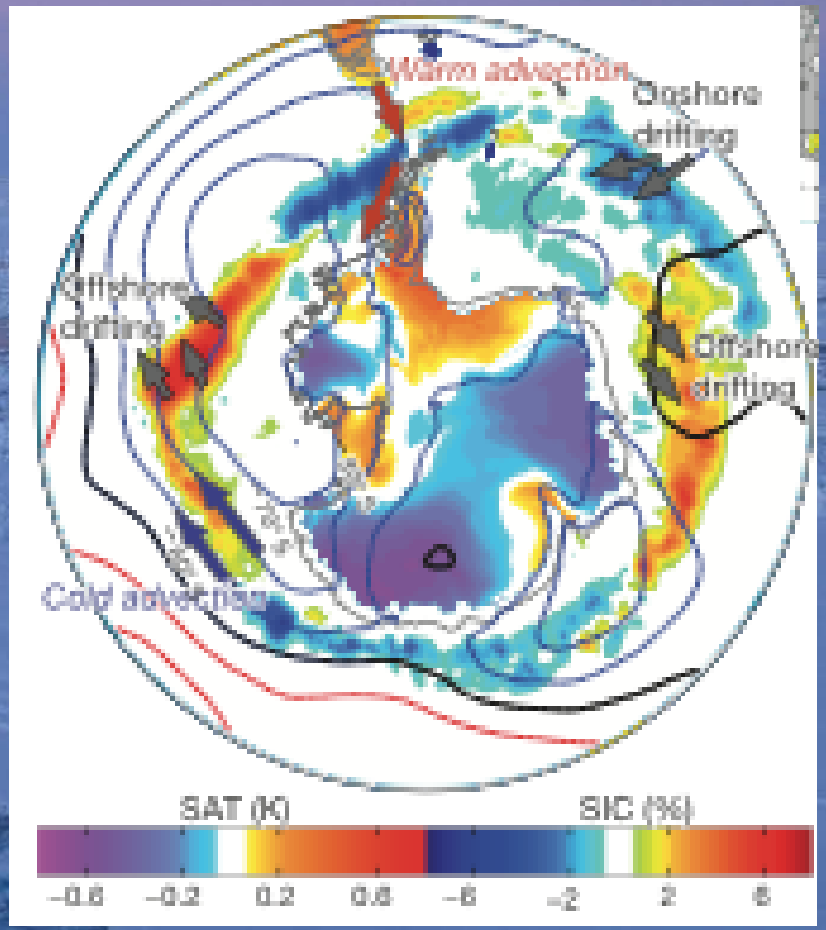
Fixed Ozone Members

Importance of other modes of variability?



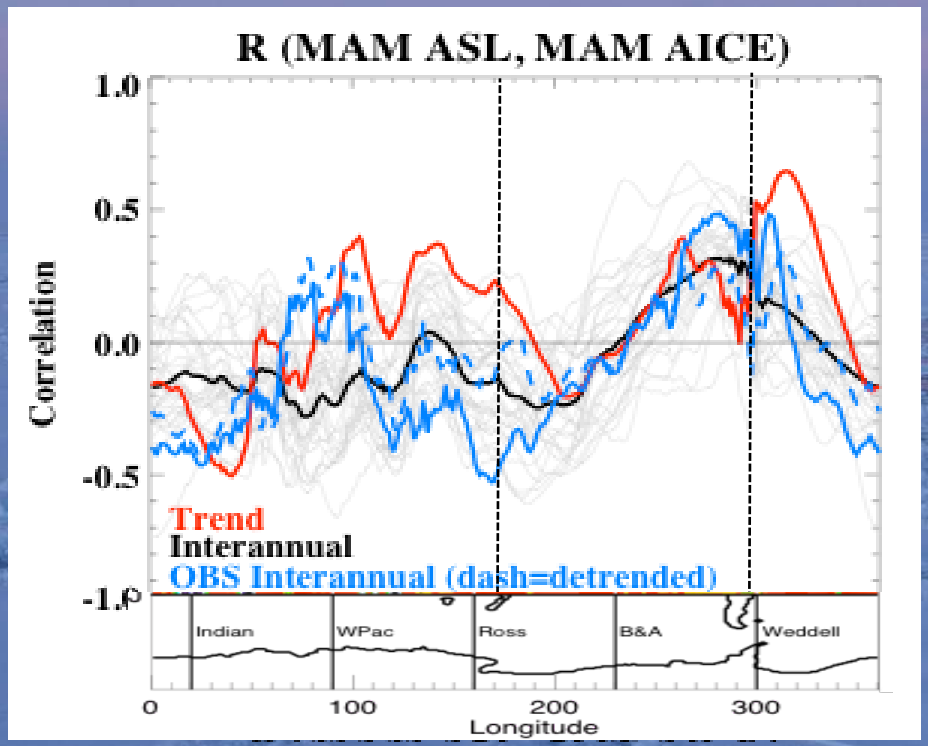


Atlantic SST Variability



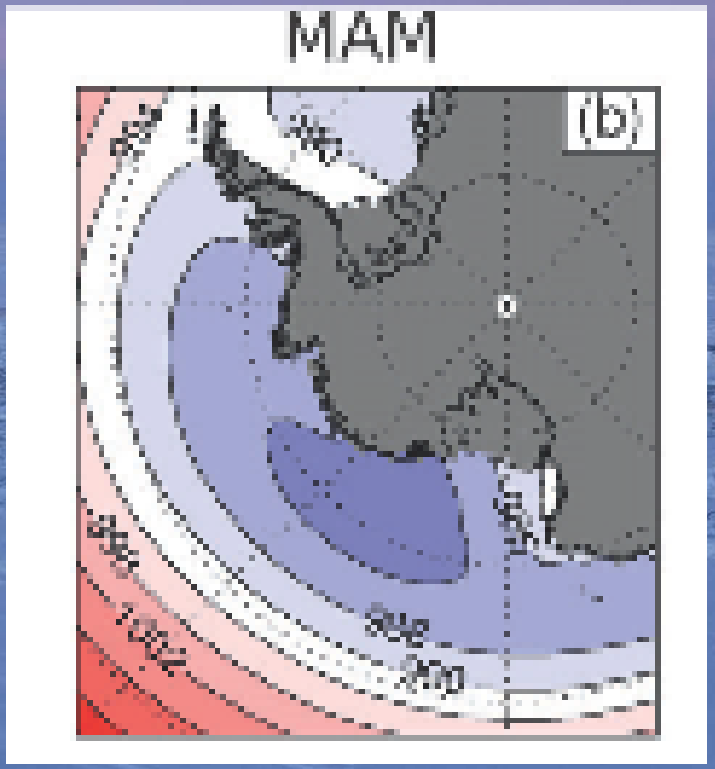
(From Li et al., 2014)

Importance of other aspects of variability?



Correlation with ASL minimum pressure

Amundsen Sea Low Variability



(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


Questions?