



# Late 20<sup>th</sup> Century Antarctic climate change in CCSM4

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Polar Climate Working Group, February 28<sup>th</sup>, 2011



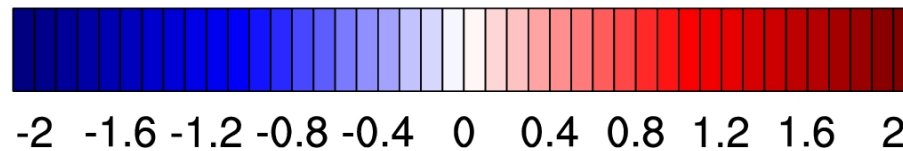
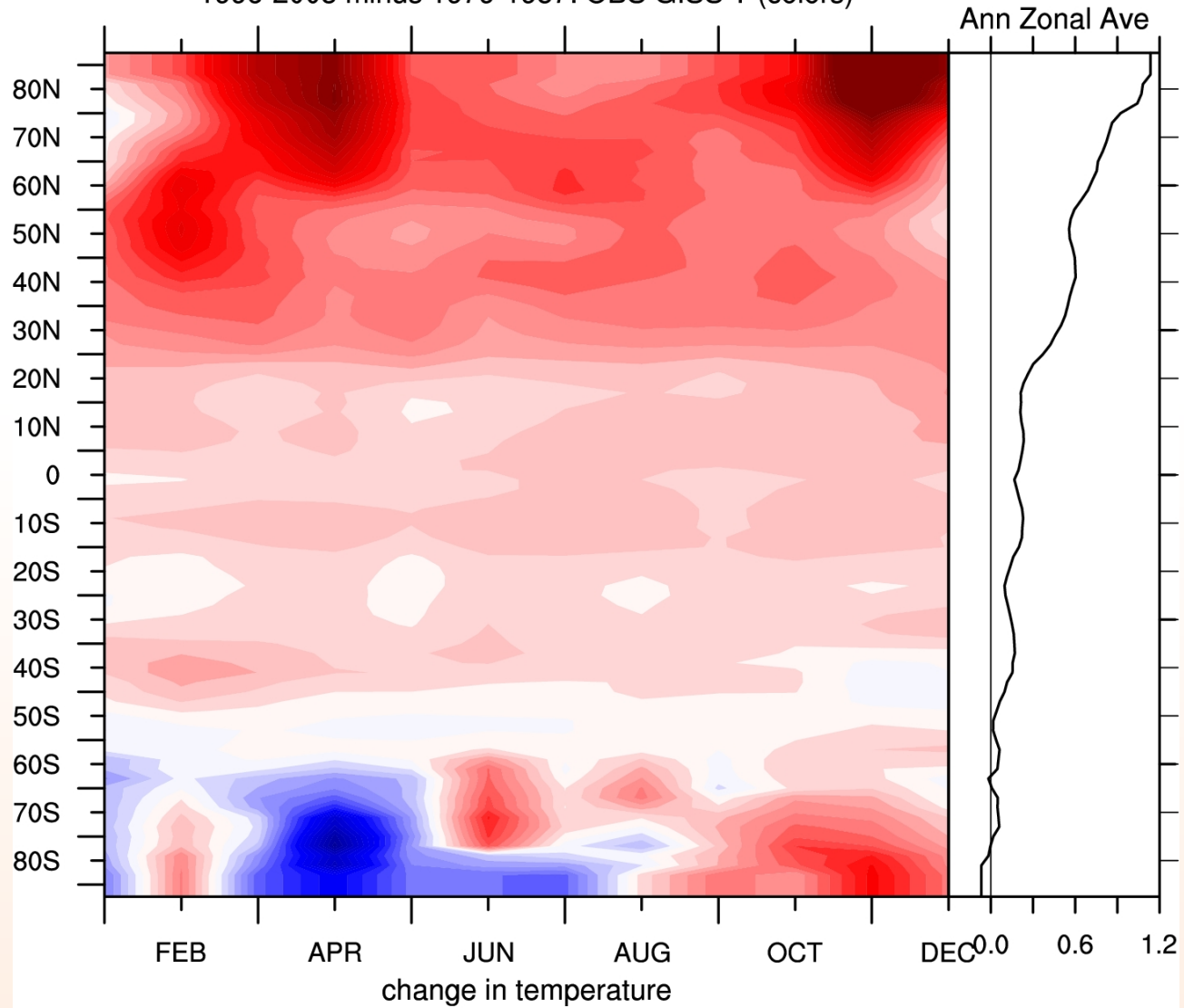
## Data & models compared:

- CCSM4 20<sup>th</sup>-Century simulation
  - 1°, 6-member ensemble 1850-2005
- CAM4 AMIP experiment
  - 1°, 5-member ensemble 1979-2005
  - observed SST & sea ice are prescribed
- Observations
  - Surface temperature (GISTEMP 2°)
  - SLP (Hadley Center HadSLP2)
  - Sea ice concentration (compiled by Hurrell et al. (2008))



# Late 20<sup>th</sup> Century Surface temperature change

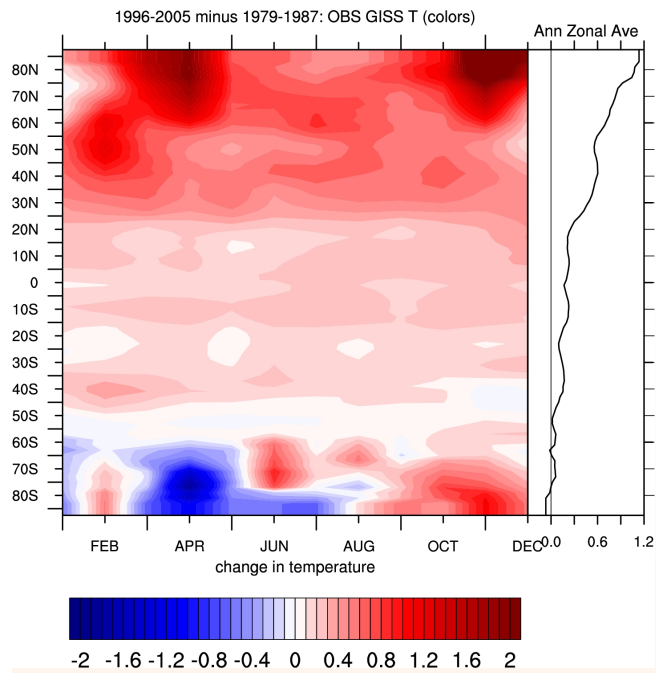
1996-2005 minus 1979-1987: OBS GISS T (colors)



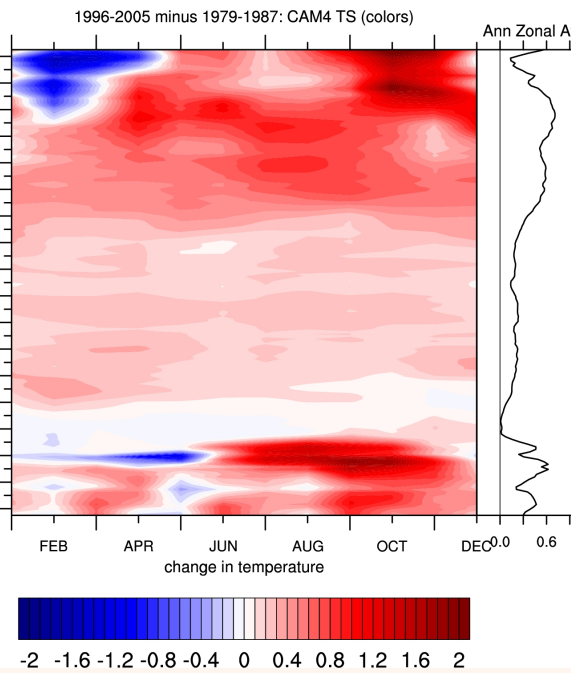


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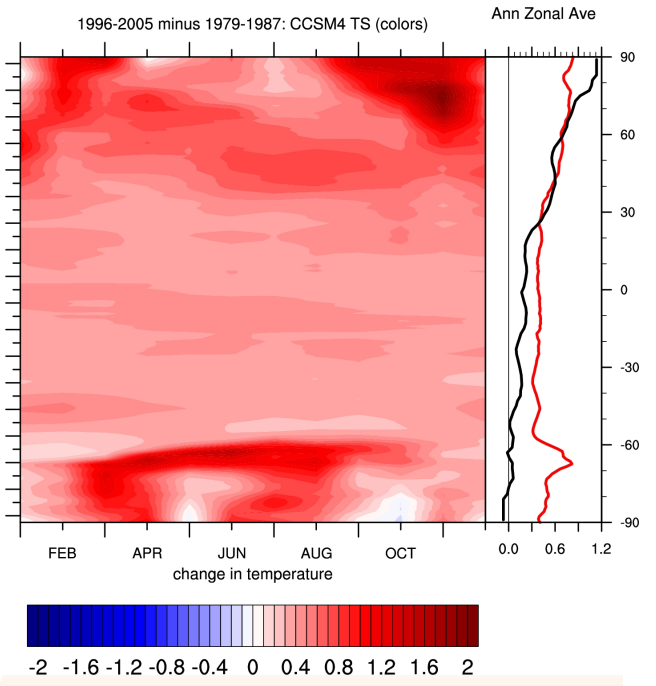
## OBSERVED



## CAM4

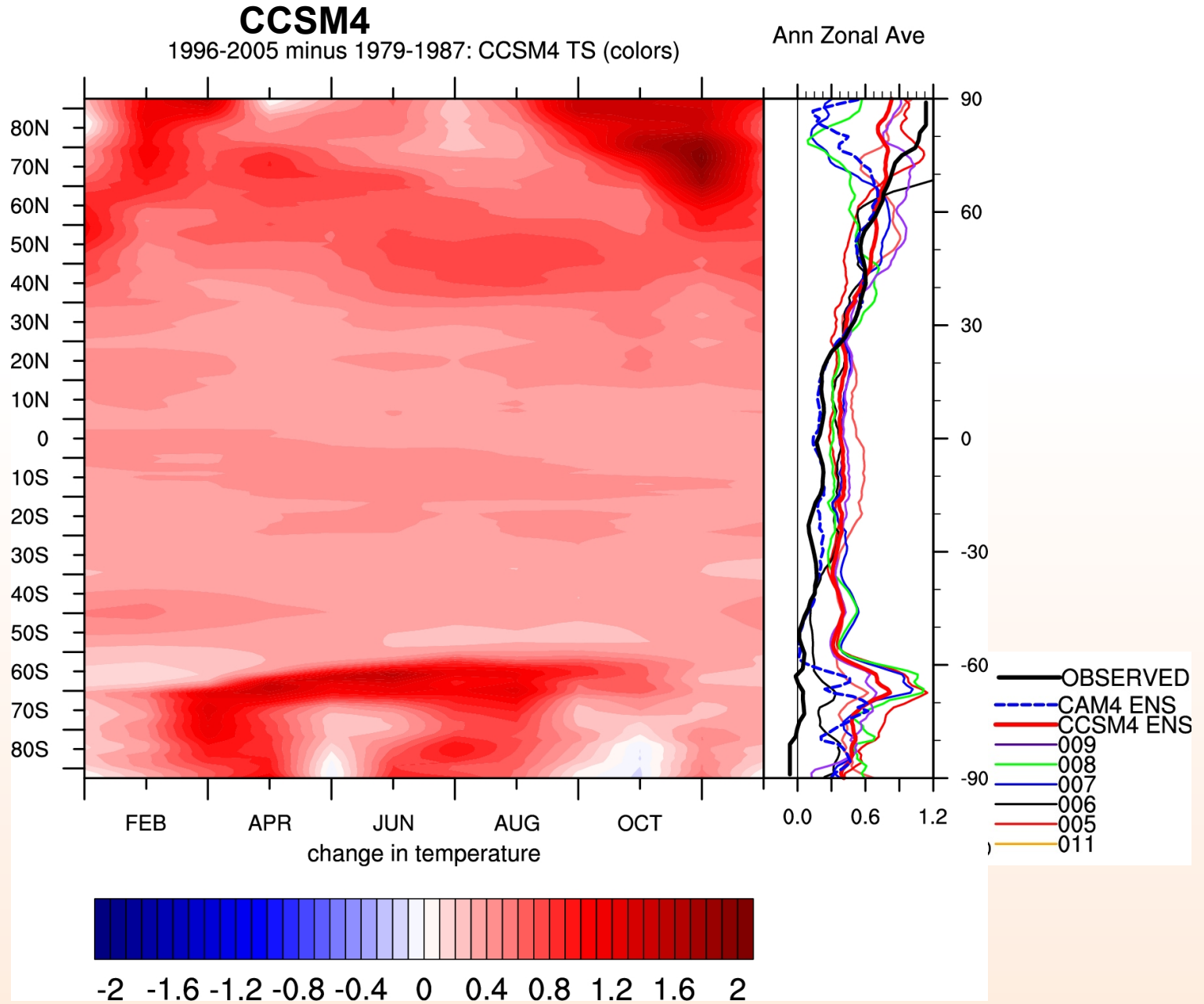


## CCSM4





# Late 20<sup>th</sup> Century Surface temperature change





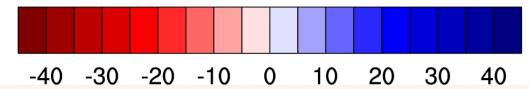
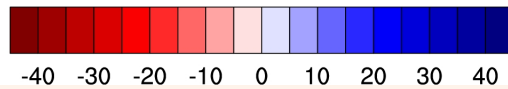
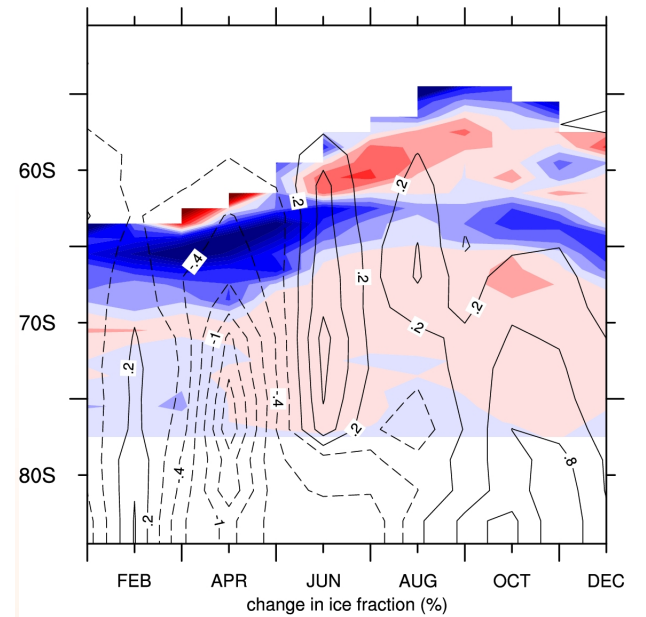
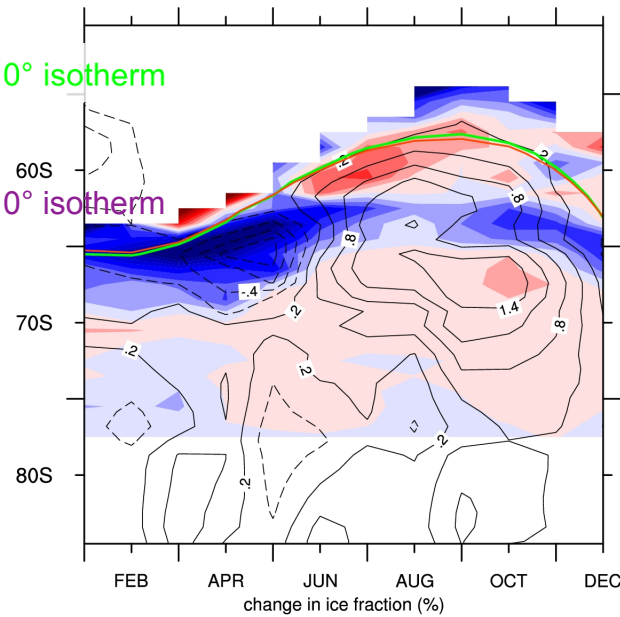
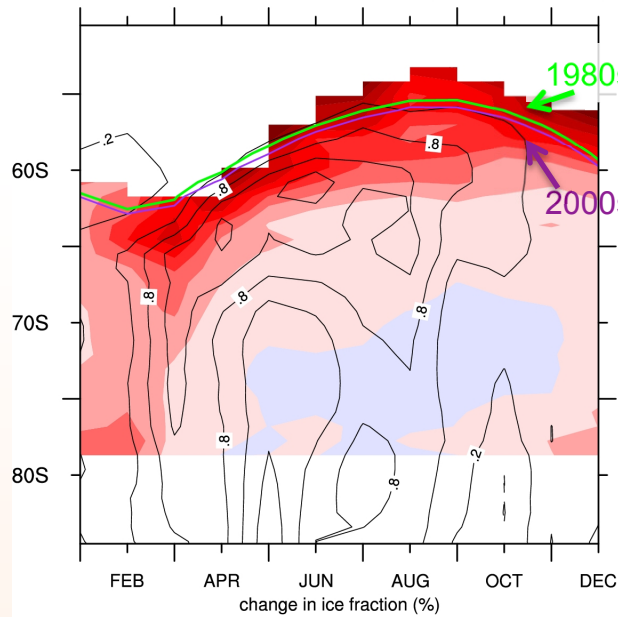
# Late 20<sup>th</sup> Century Sea ice & Surface temperature change

## CCSM4

## CAM4

## OBSERVED

1996-2005 minus 1979-1987: CCSM4 TS (contours), CCSM4 ICEFRAC (colors)    1996-2005 minus 1979-1987: CAM4 TS (contours), OBS ICEFRAC (colors)    1996-2005 minus 1979-1987: OBS GISS T (contours), OBS ICEFRAC (colors)





# Late 20<sup>th</sup> Century Sea ice & Surface temperature change

go back to 1940s

## CCSM4

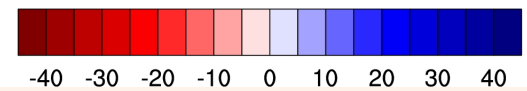
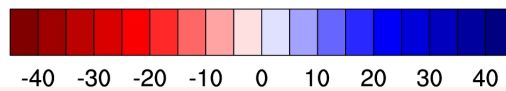
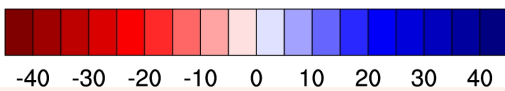
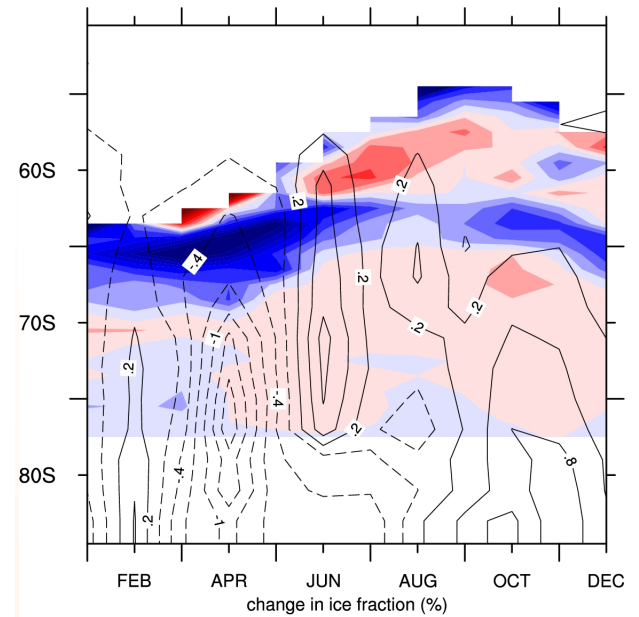
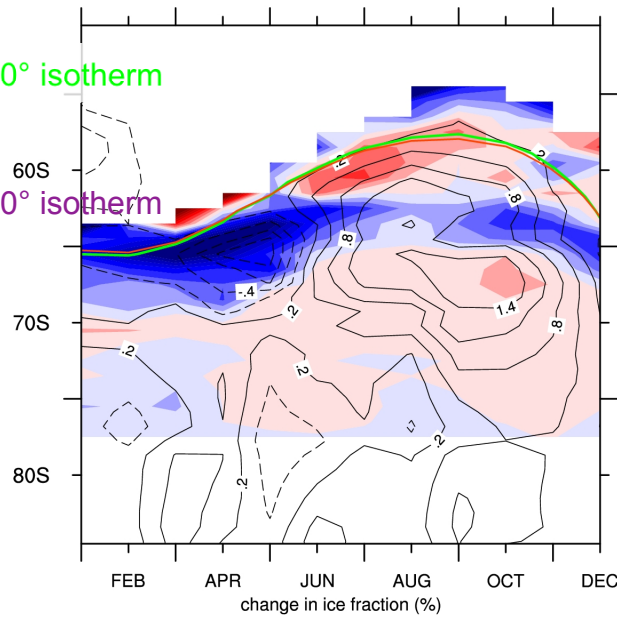
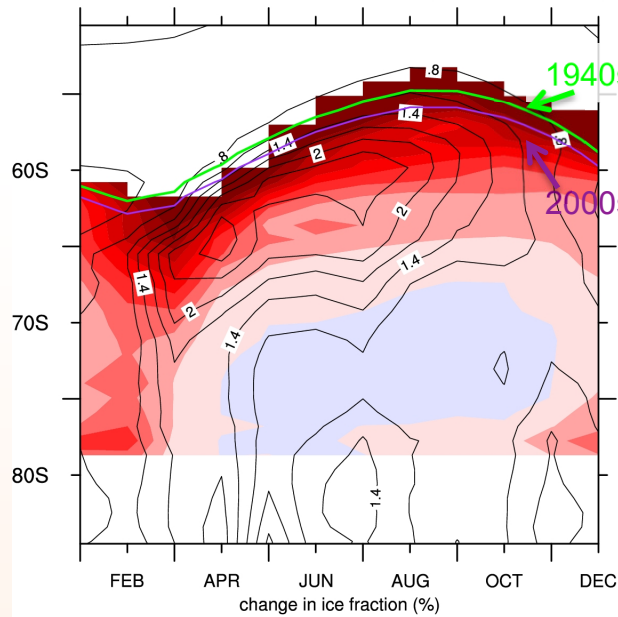
## CAM4

## OBSERVED

1996-2005 minus 1940-1950: CCSM4 TS (contours), CCSM4 ICEFRAC (colors)

1996-2005 minus 1979-1987: CAM4 TS (contours), OBS ICEFRAC (colors)

1996-2005 minus 1979-1987: OBS GISS T (contours), OBS ICEFRAC (colors)



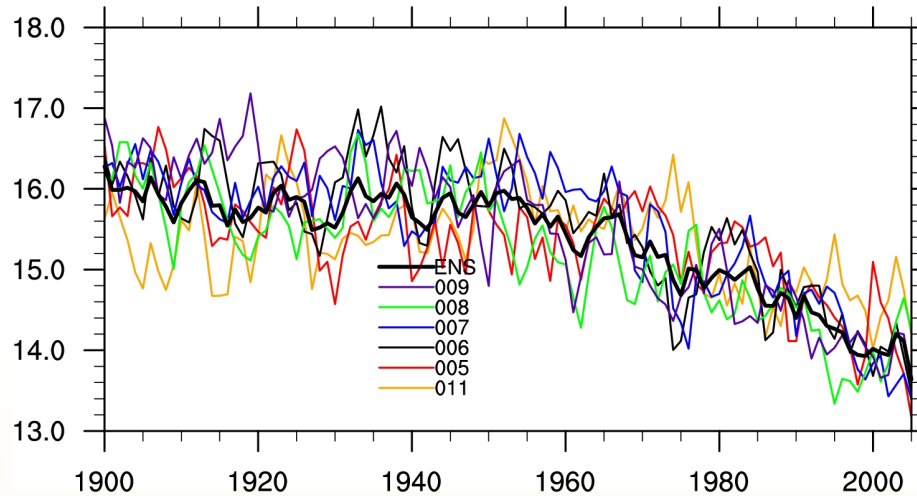




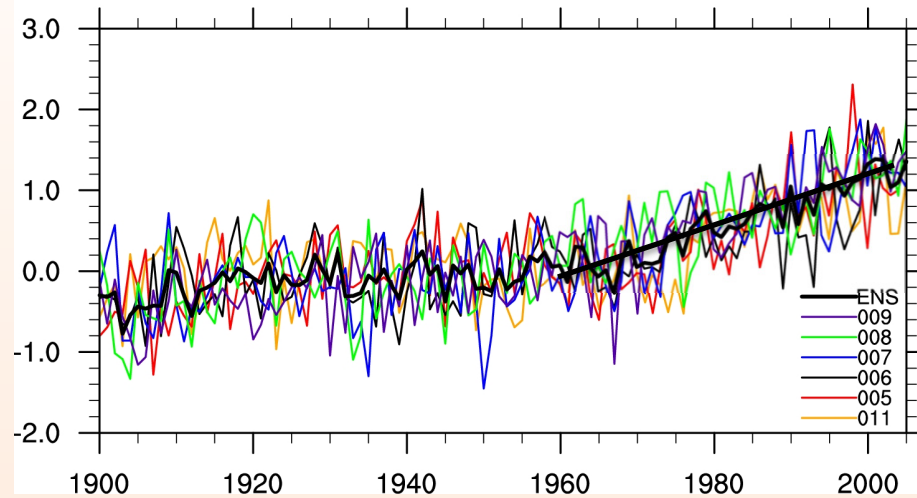


# Late 20<sup>th</sup> Century Sea ice & Surface temperature change

## SH ANN ice area



## 65-90S ANN TS



**1958-2005 trends**

**CCSM4: 0.3 °C/decade**

**OBS: ≈ 0.1 °C/decade**

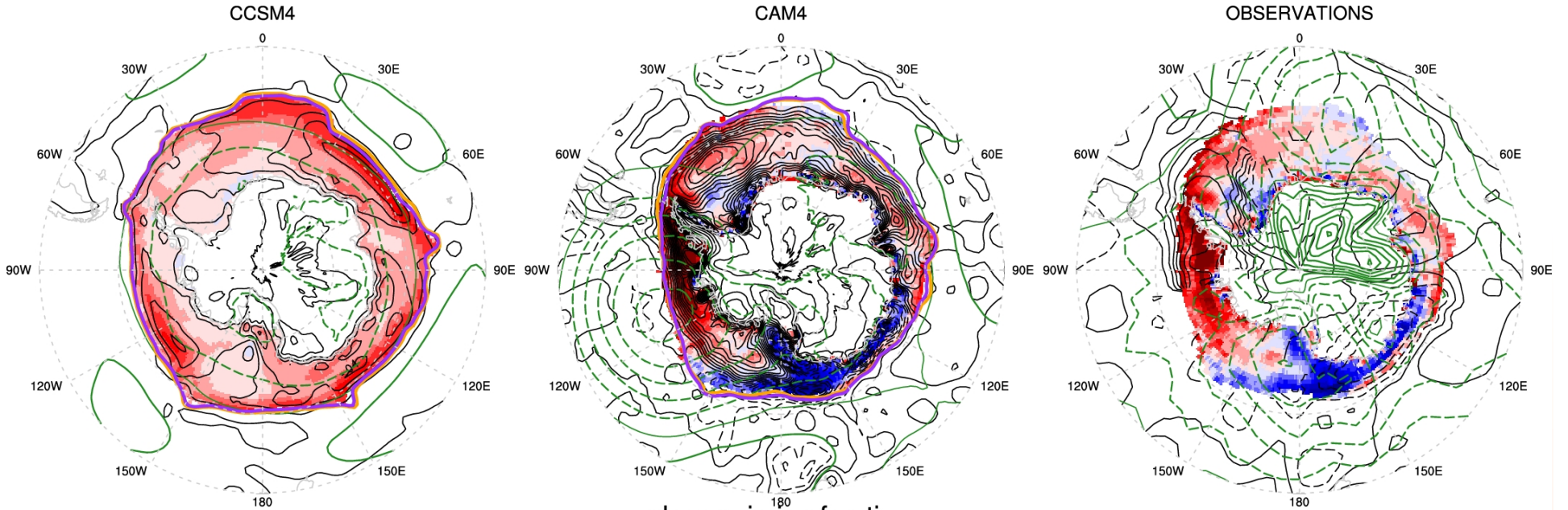


# Late 20<sup>th</sup> Century **Sea ice**, Surface temperature, & **SLP** changes

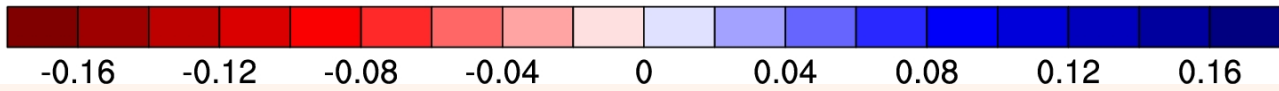
## CCSM4

## CAM4

## OBSERVED



change in ice fraction





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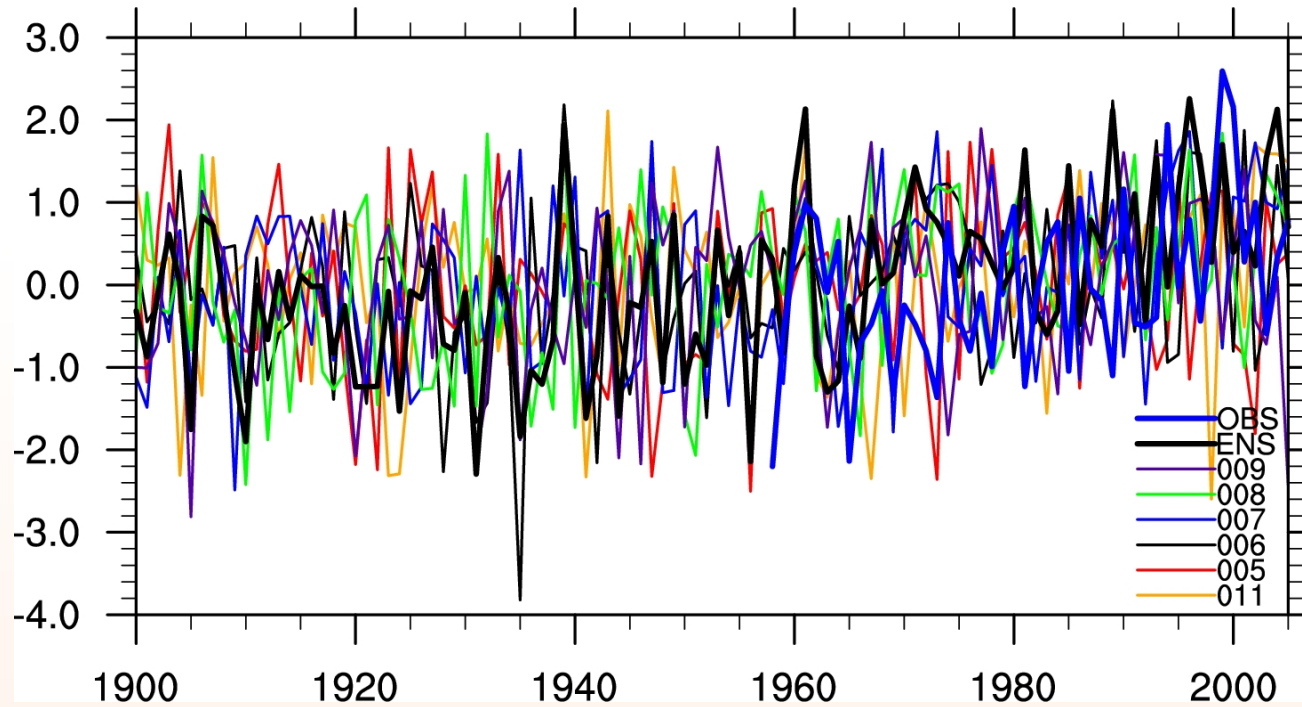
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8. Climate sensitivity is too high, globally
9. The Antarctic observations are completely inadequate for evaluating models. The model actually doesn't have any biases in the Antarctic.



## SAM trend & sensitivity to SAM trend

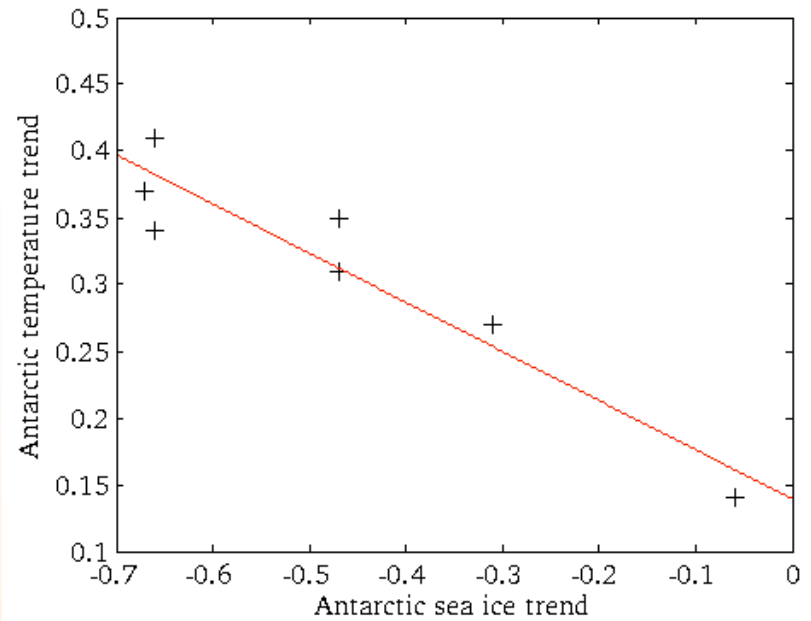
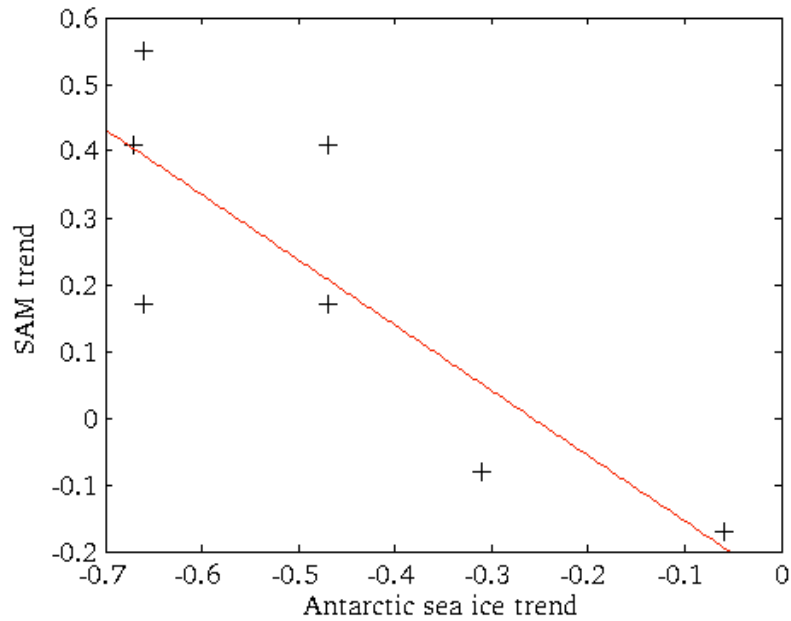
### ANN SAM





## SAM trend & sensitivity to SAM trend

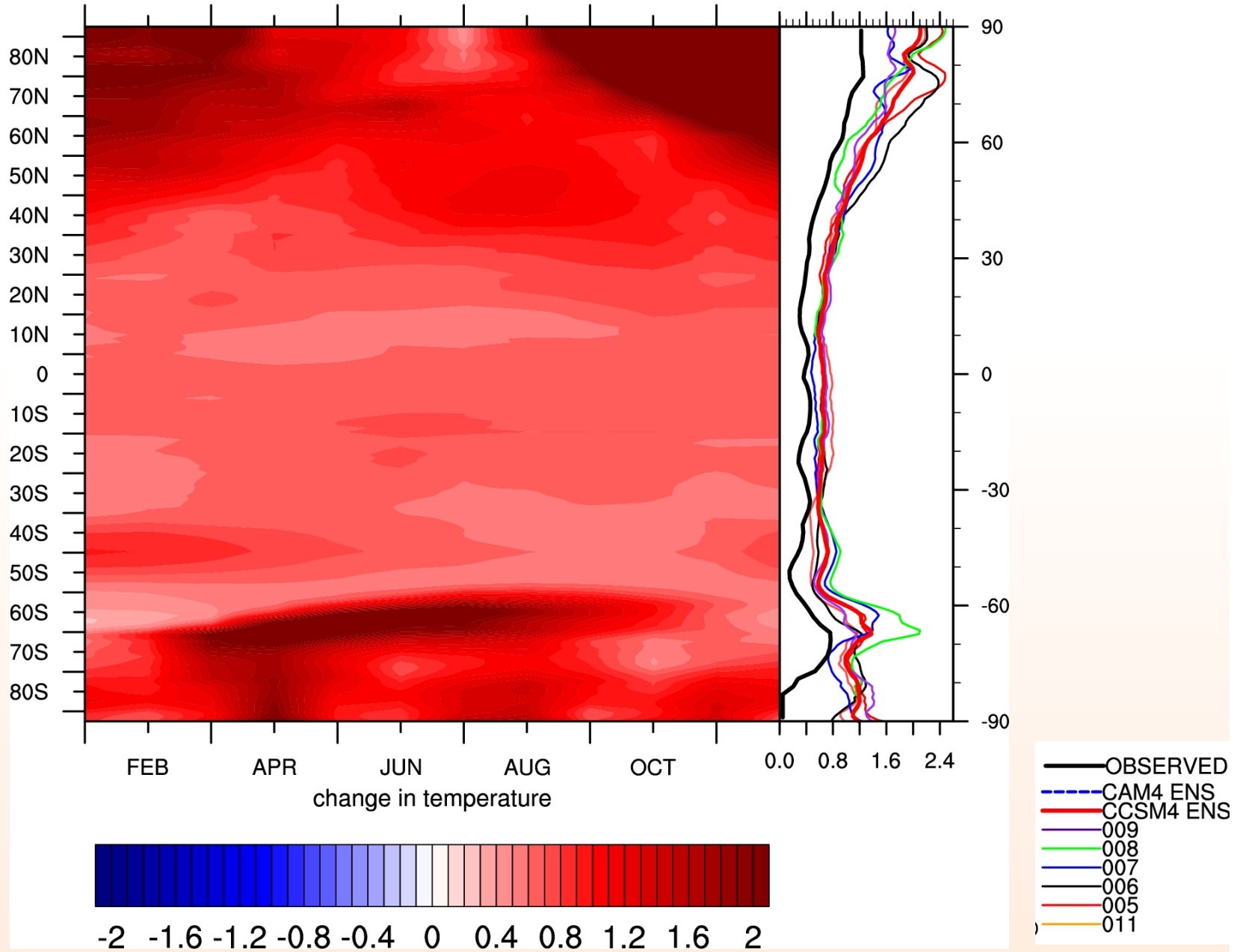
1979-2005 trends in each CCSM4 ensemble member





1996-2005 minus 1958-1967: CCSM4 TS (colors)

Ann Zonal Ave





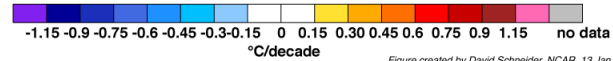
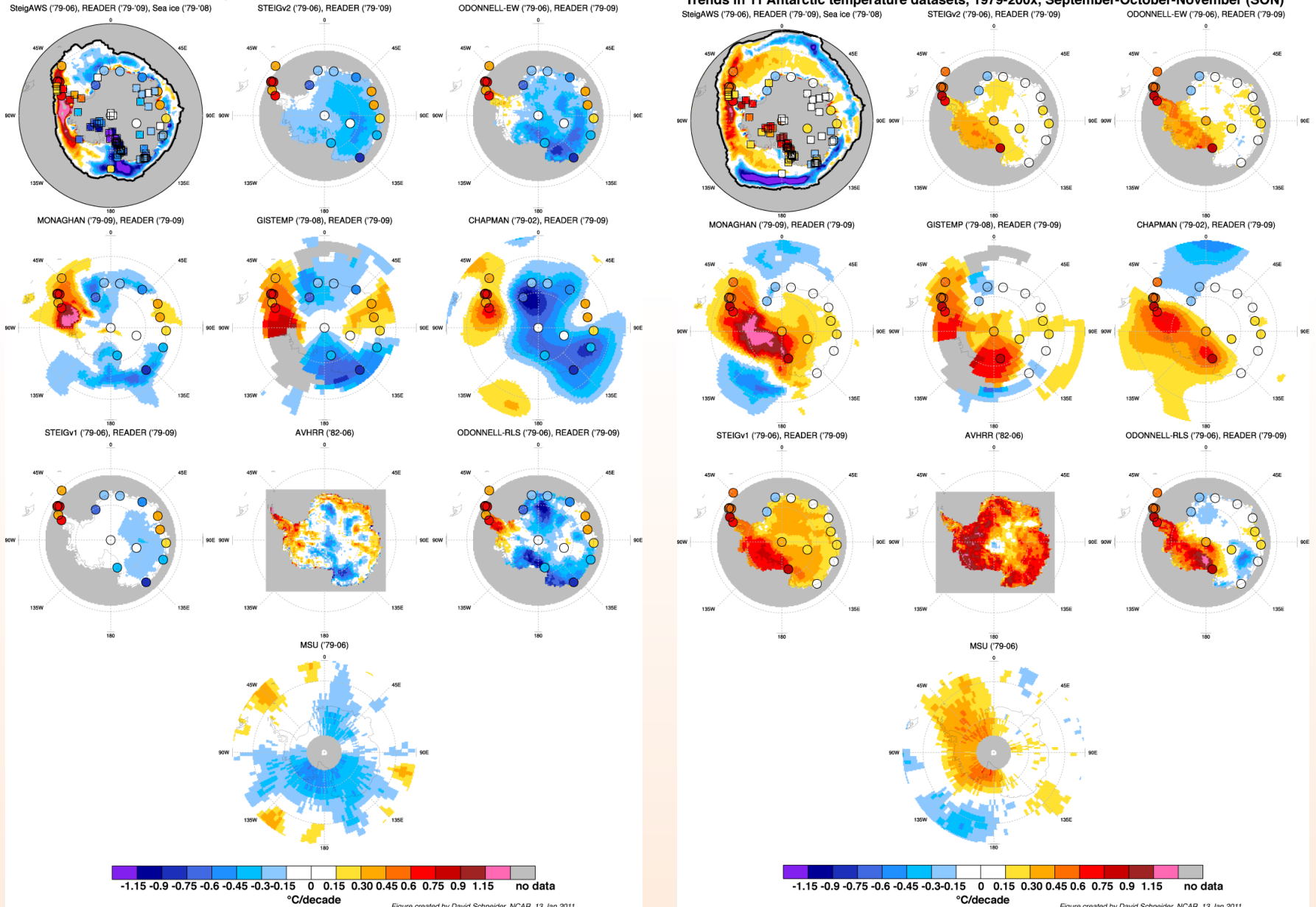
# Observations inter-comparison

## austral autumn (MAM)

## austral spring (SON)

Trends in 11 Antarctic temperature datasets, 1979-200x, March-April-May (MAM)

Trends in 11 Antarctic temperature datasets, 1979-200x, September-October-November (SON)





Why does the Antarctic loose too much sea ice & warm too much in CCSM4? ~~Not a problem~~; might be a problem; likely problem

1. ~~SAM, ozone forcing, stratospheric processes~~, and response
2. Tropical simulation and teleconnections are wrong
3. Bias in wind stress and westerlies
4. CAM4 response to sea ice loss is wrong
5. ~~Coupled model's internal variability is too weak~~, externally forced trends too large
6. ~~Sea ice model is missing essential physics~~
7. Ocean model is missing essential physics and/or is run at too low resolution
8. Climate sensitivity is too high, globally
9. ~~The Antarctic observations are completely inadequate for evaluating models. The model actually doesn't have any biases in the Antarctic.~~





## Conclusions

- In CCSM4, Antarctic sea ice and temperature trends are very closely linked
- Maximum warming occurs where maximum ice loss occurs, which is near the (too extensive) ice edge
- Ice loss and warming continues despite positive SAM trend
- Some of the spread among trends in ensemble members is due to SAM, but the relationship is opposite of that suggested by many researchers
- In addition to wind stress biases over the Southern Ocean, the excessive Antarctic trends are part in parcel of the CCSM4's 20thC warming being too strong everywhere
- Still many issues to figure out...