

Trends in Antarctic Surface Climate and the Role of the Atmospheric Circulation

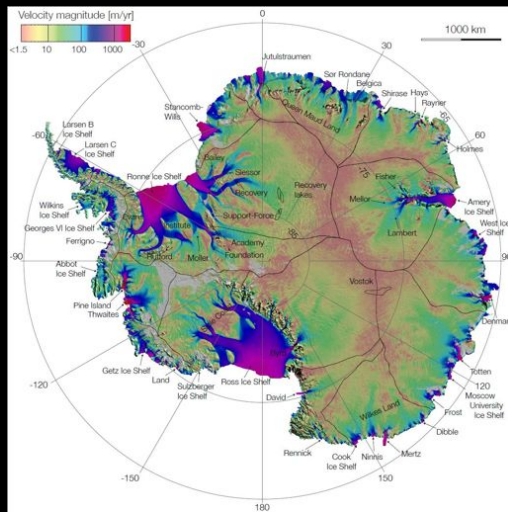
David P Schneider, Clara Deser, Yuko Okumura

CLIVAR Southern Ocean Panel Meeting, 20 October, 2011

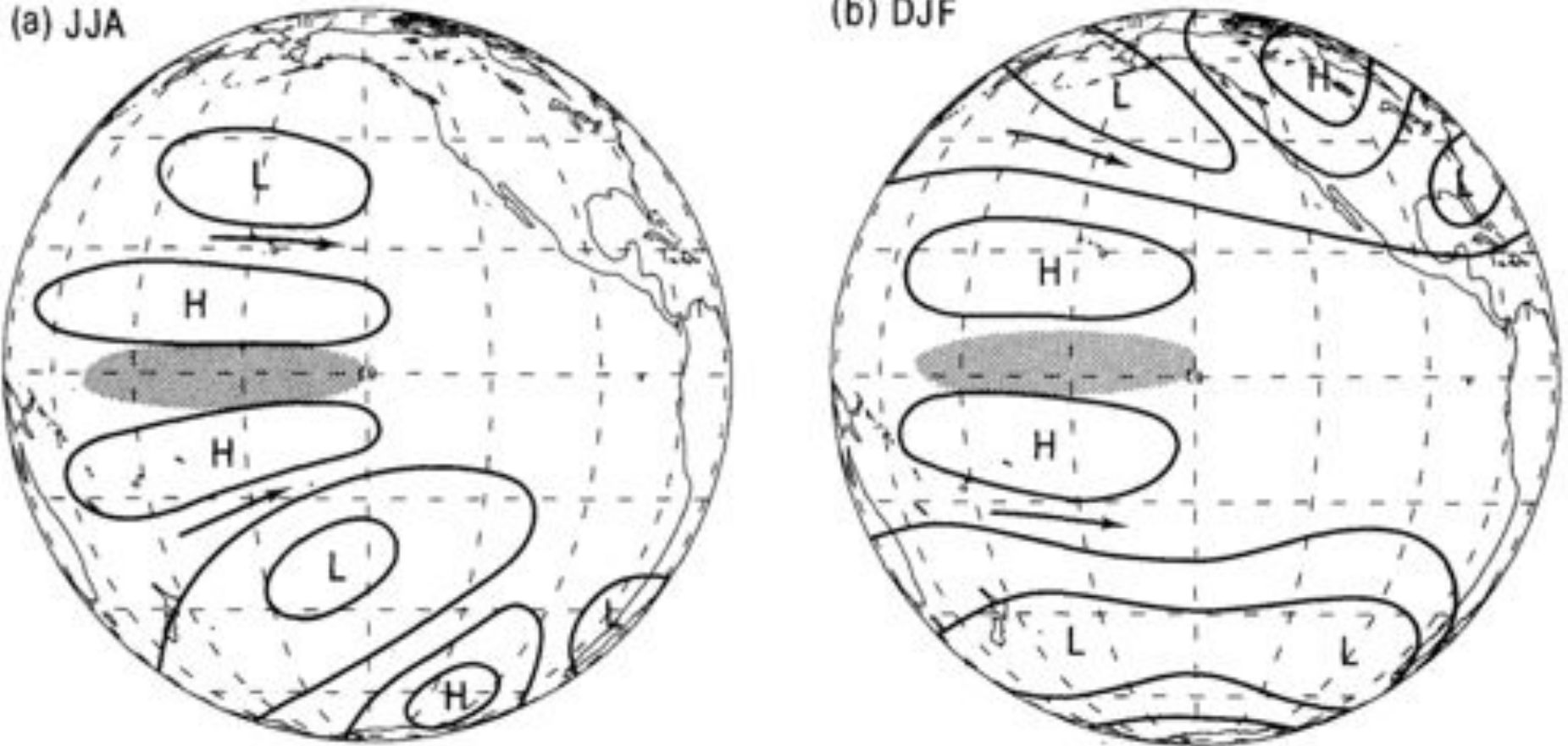


Outline

- Tropical teleconnections and their impact in Antarctica
- Recent trends in Antarctic surface climate
- Are the trends explained by changes in the atmospheric circulation?



Teleconnections: Rossby Waves



Karoly (1989)

Southern Annular Mode (SAM)

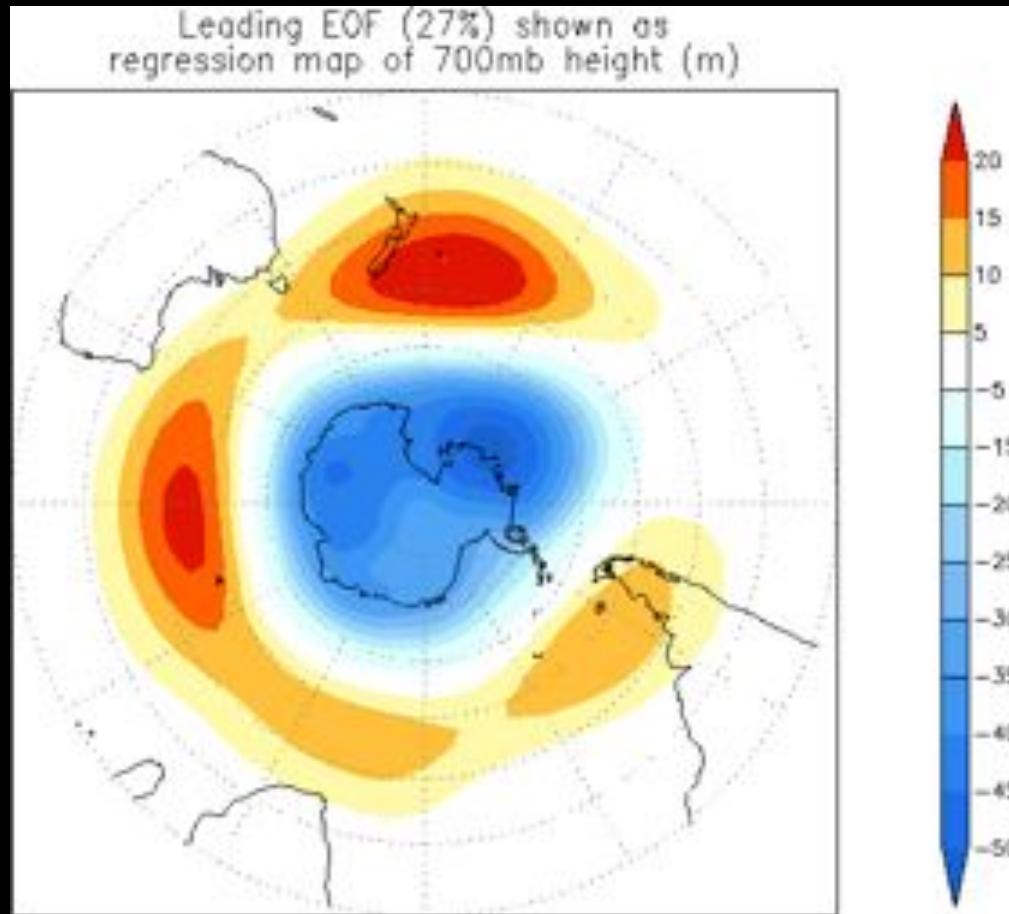
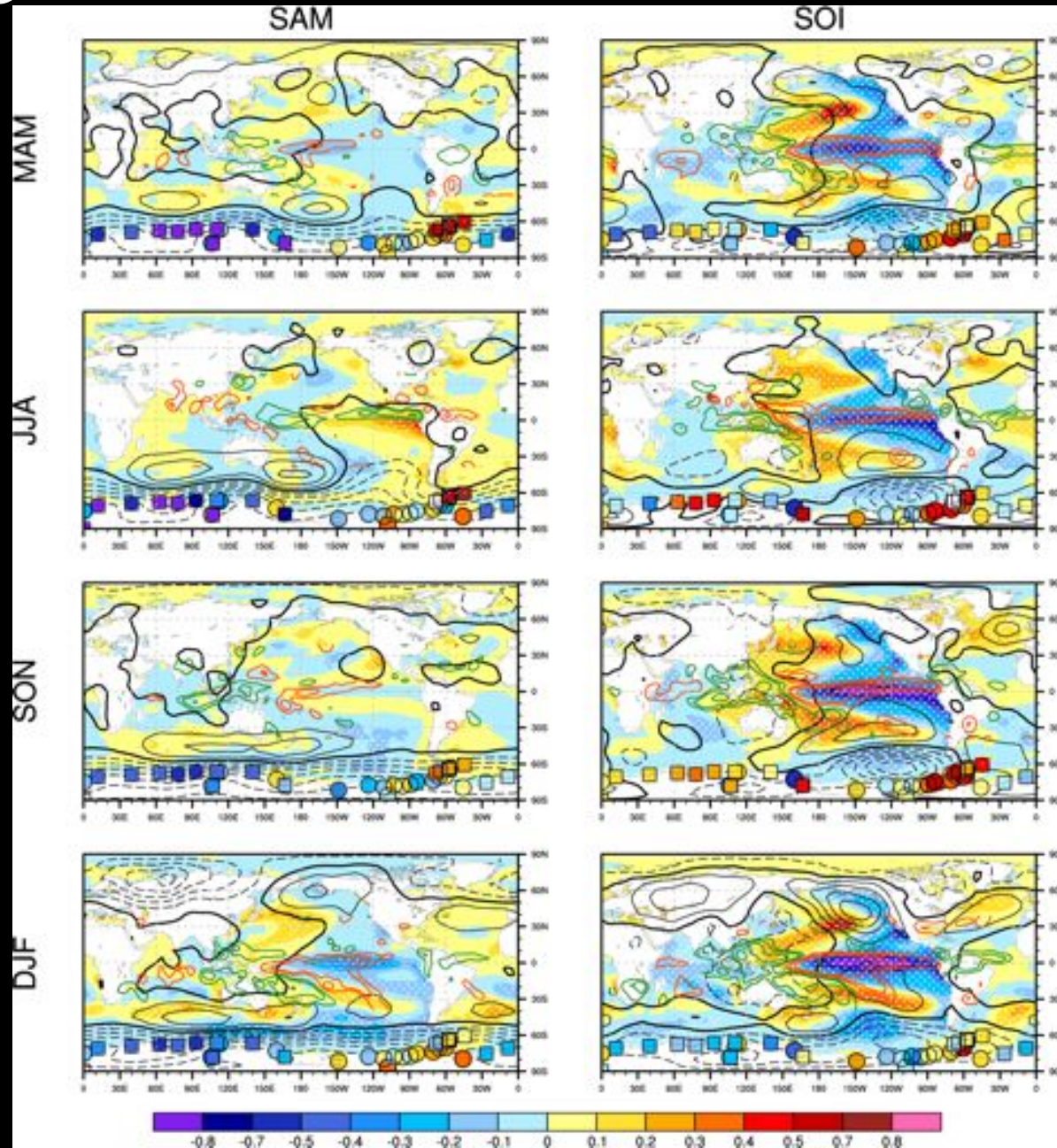


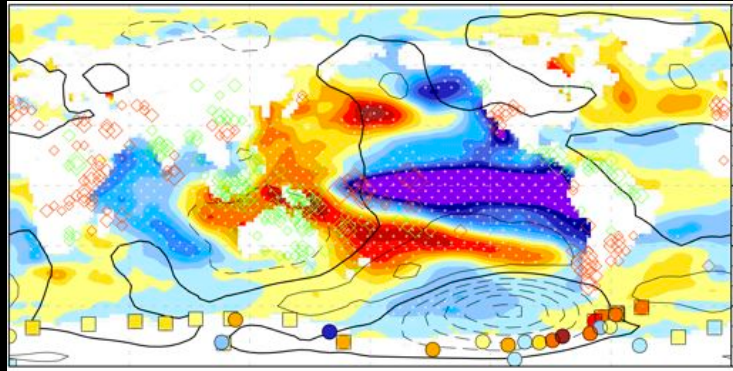
Figure by Ryan Fogt

Regressions: SAM index and SOI



Schneider et al.
(acc. pending
minor revisions)

Data Sets



- Antarctic stations (air temperature), ~1958-present
- Antarctic ice cores (annually resolved stable isotopes), ~1958-1999 for this study, but available further back
- GPCP Precipitation, 1979-present
- NOAA ERSSTv3b, SST
- HADSLP2, Precipitation
- NCEP R2 Reanalysis (2-m winds, 850hPA height, zonal winds, 3D temperature)
- ◇ Hulme et al. (1998) Precipitation, gridded station data ~1900-1998, substitute for GPCP

Data Sets

Gridded Antarctic Temperature Reconstructions:

- NASA GISTEMP (Hansen et al., 2010)
- Chapman and Walsh (2007)
- Monaghan et al. (2008)
- Steig et al. (2009)
- O'Donnell et al. (2011)

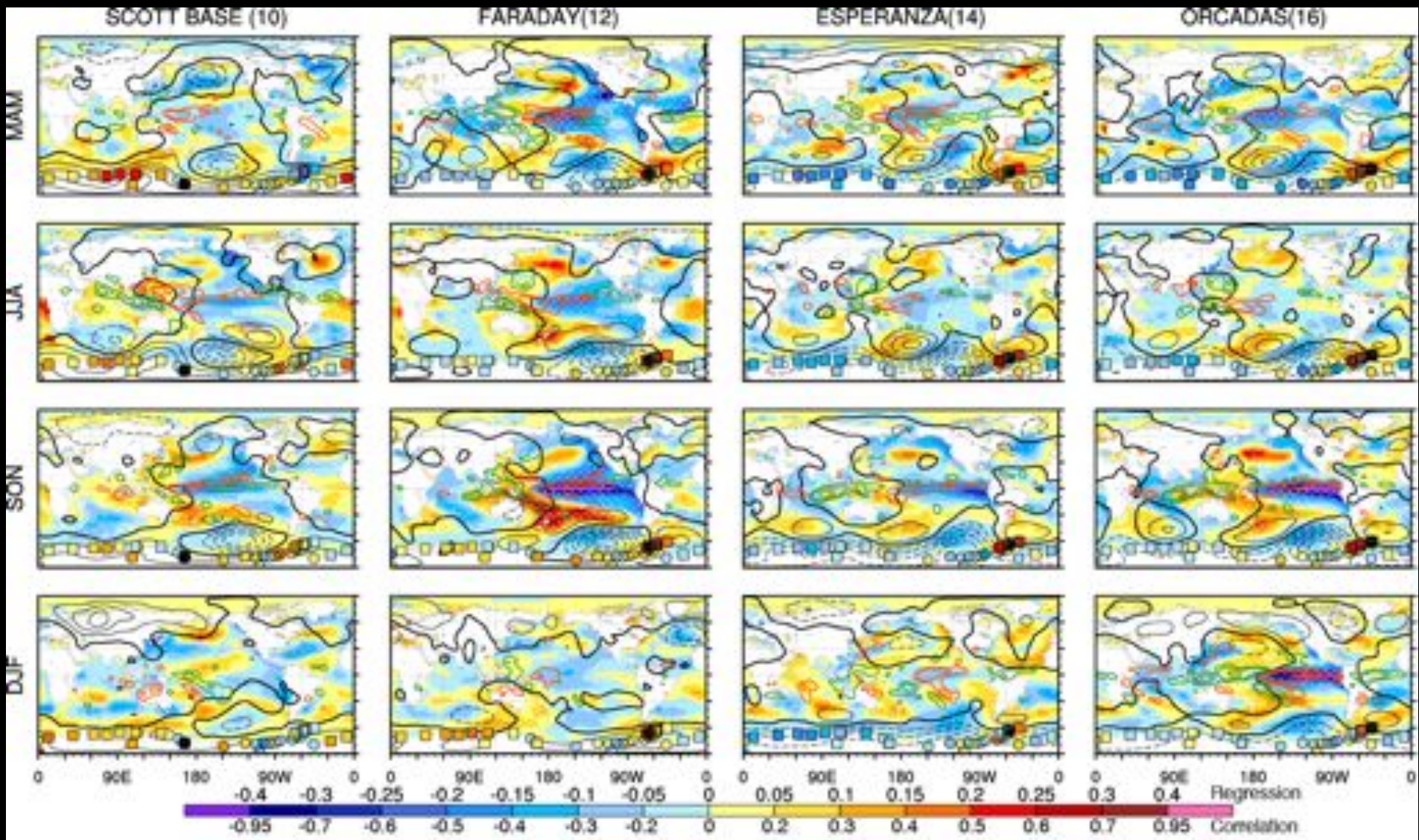
Other Stuff

- SAM Index (mostly use Marshall (2003))
- SOI Index (constructed from HadSLP2)
- Niño3.4 Index (constructed from ERSSTv3b)
- Sea Ice (extent) Index, NSIDC
- Sea Ice Concentration (Hurrell et al., 2008)
- Ozone (Jean-Francois Lamarque)
- Antarctic temperature from AVHRR (Comiso)
- Tropospheric temps from MSU (Johanson and Fu, 2007)
- CCSM4 Preindustrial Control Runs
- AMIP Runs with CAM3

Schneider et al. (2011; acc. pending minor revisions)

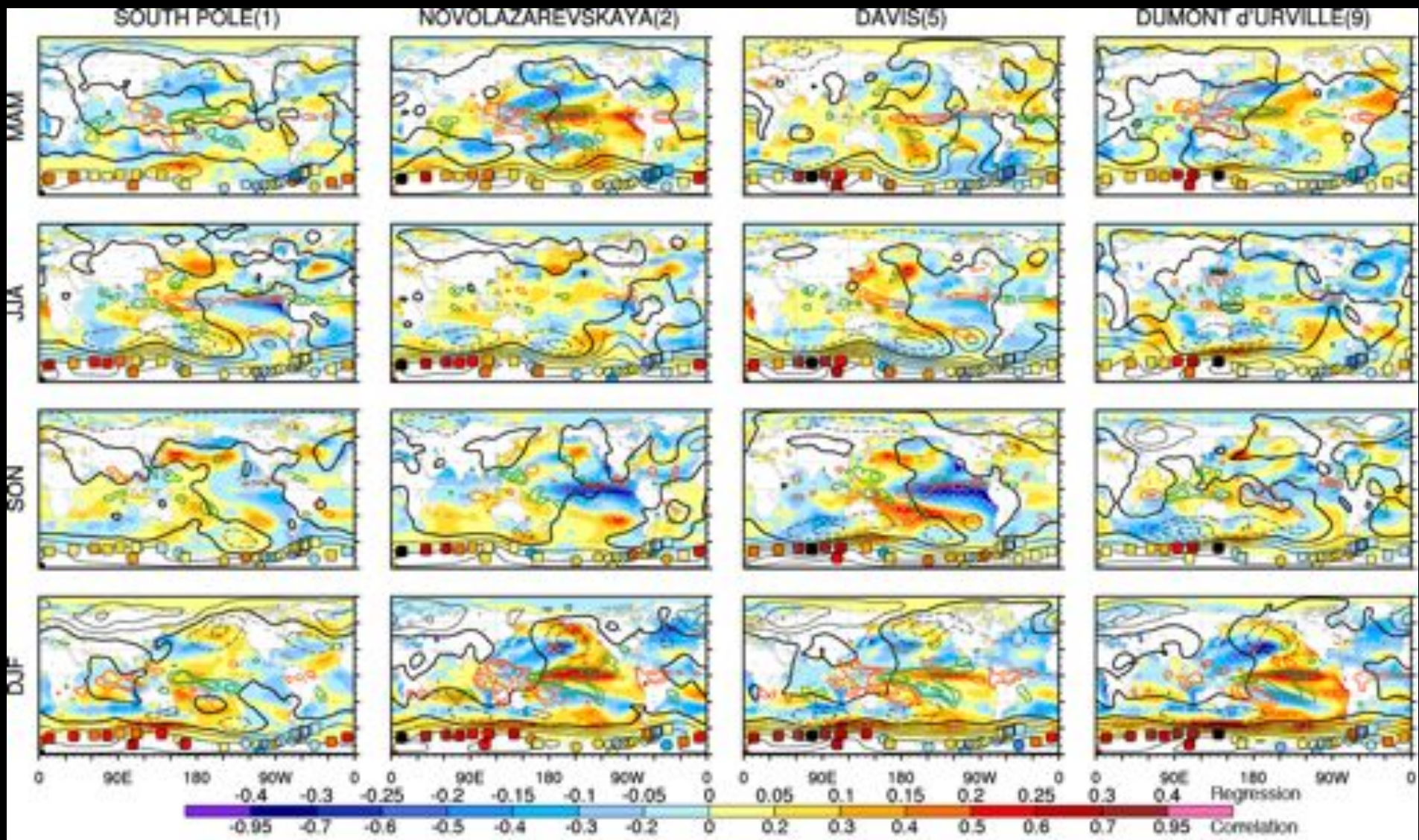


One-point Regressions, Antarctic stations



Fields: SST, SLP, Precip
Schneider et al. (acc. pending minor revisions)

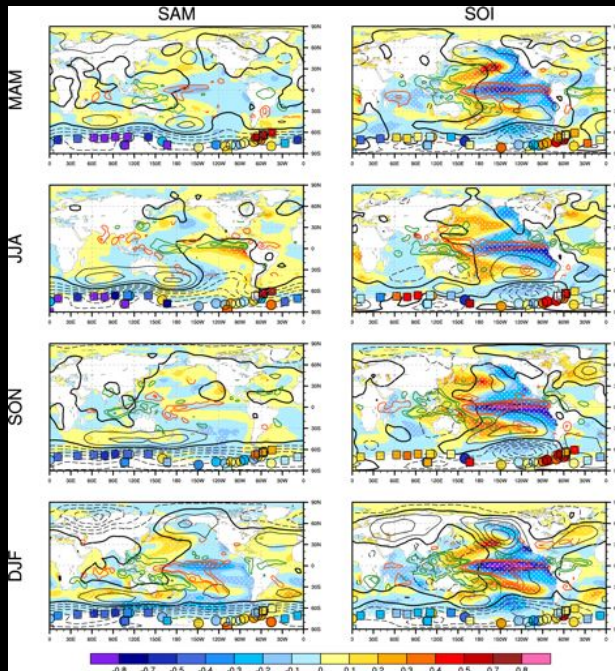
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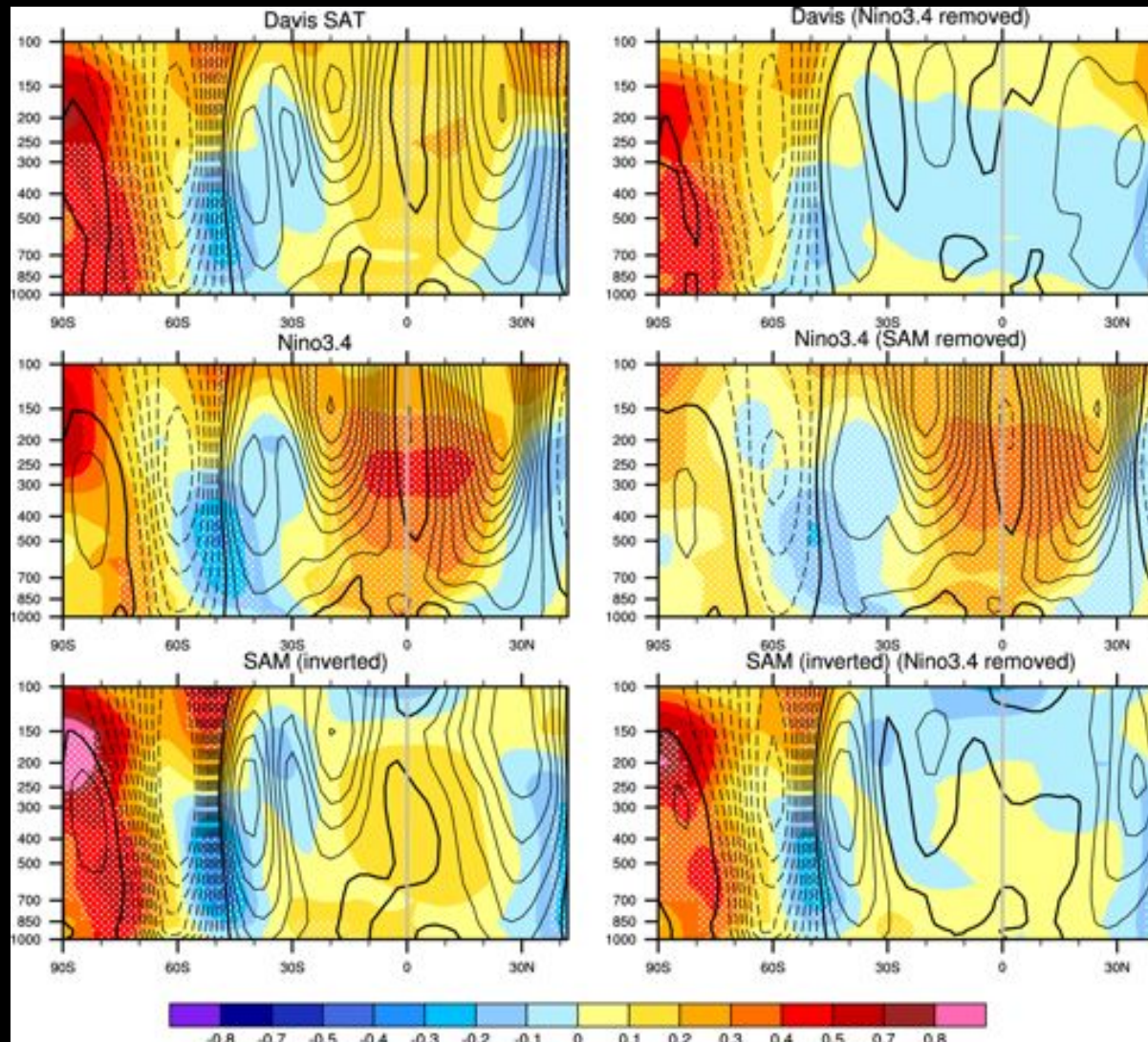
So Far...

- Peninsula stations, such as Faraday/Vernadsky, exhibit strong correlations with tropical SSTs and with the Rossby wave-train in austral spring
- East Antarctic stations, such as Davis, exhibit significant correlations with tropical SSTs in austral summer; otherwise east Antarctic stations are dominated by SAM
- SAM exhibits ENSO-like patterns in SST, SLP and precip in austral summer; no tropical connections evident in other seasons



Another side of SAM

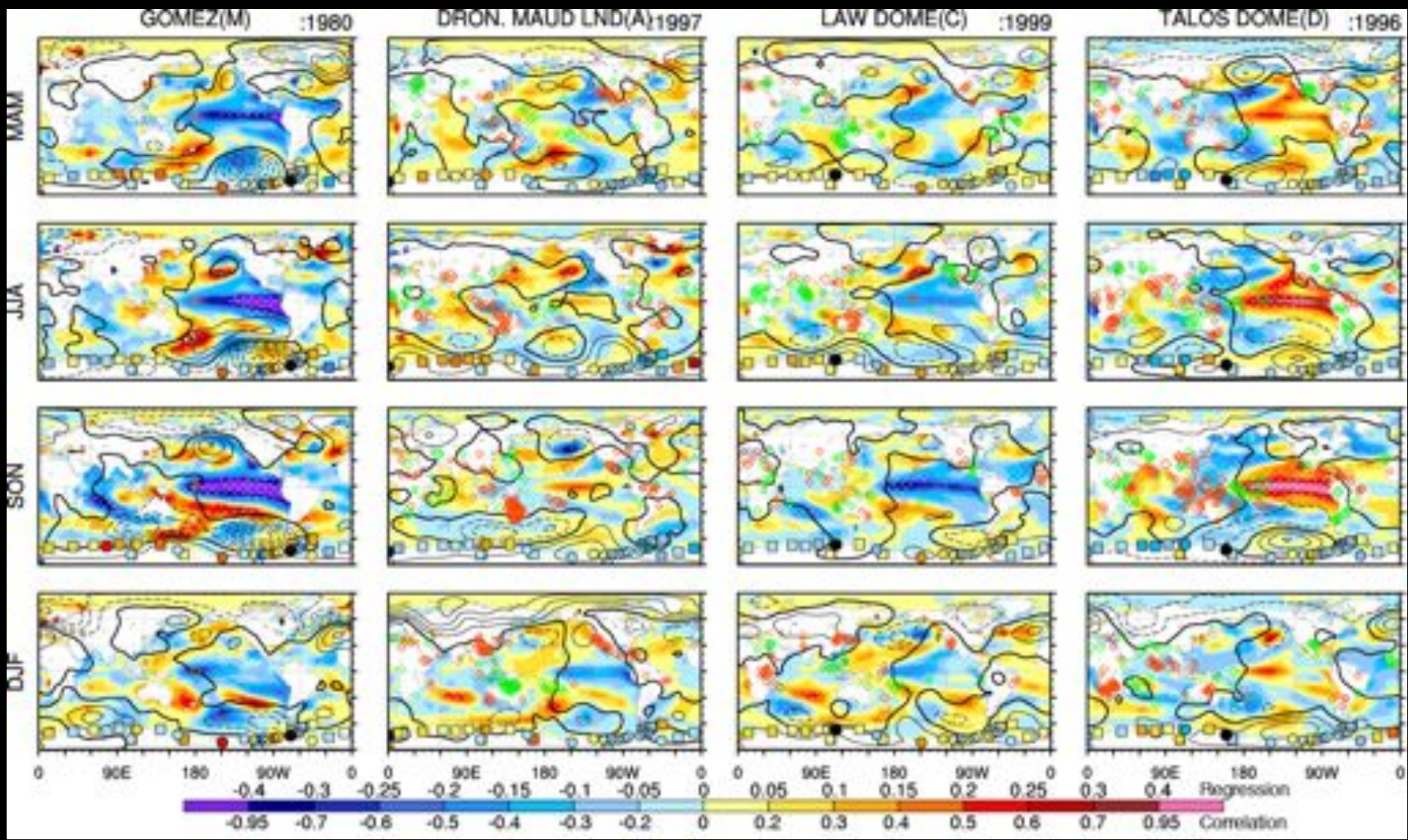
Latitude-height regressions with Davis SAT, Niño3.4 and SAM in zonal wind and temperature for DJF



Teleconnections: Supporting work

- Tropical – Antarctic teleconnections also evident using ice cores (Schneider et al., submitted)
- Tropical – Antarctic teleconnections explain the dominant decadal scale variability in Antarctica (Okumura et al., in prep)
- SH ENSO teleconnections are well simulated in CCSM4 (Deser et al., in press)
- ENSO teleconnections dominate the variability of Antarctic sea ice in CCSM4 (Landrum et al., submitted)

One-point Regressions, ice cores



Fields: SST, SLP, Precip
Schneider et al. (acc. pending minor revisions)

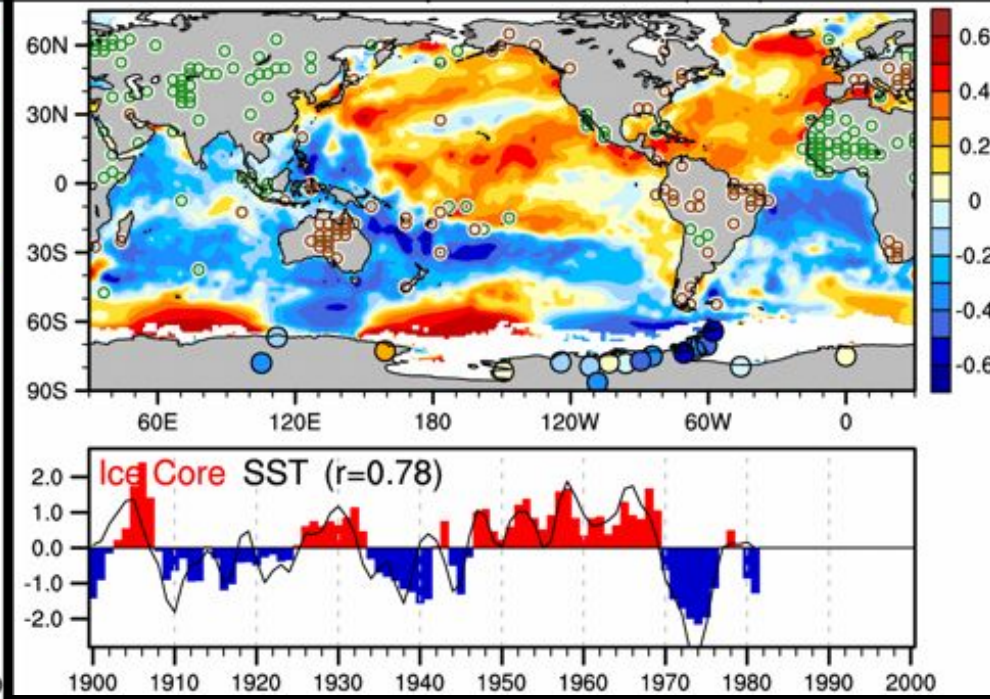
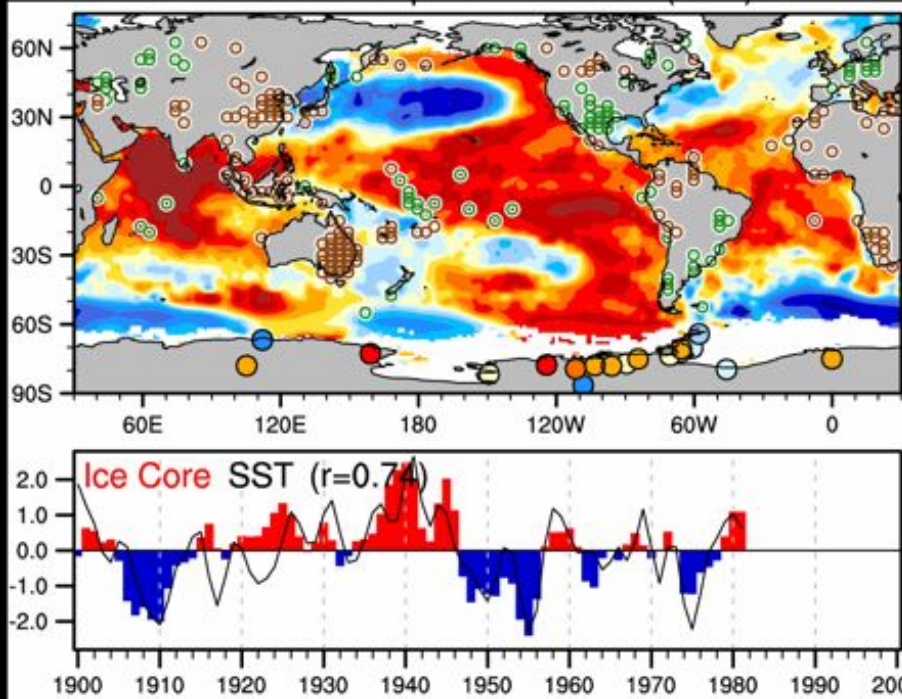
Decadal Variability

SVD analysis of ice cores & tropical SSTs, 1900-1981

Correlations: SST, ice core, precip (wet/dry)

SVD Mode 1 (50%)

SVD Mode 2 (24%)



Okumura et al. (in prep)

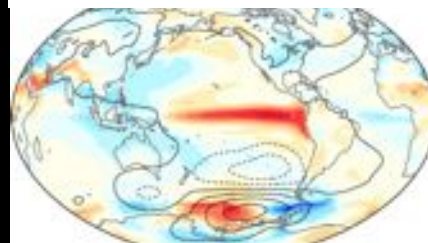
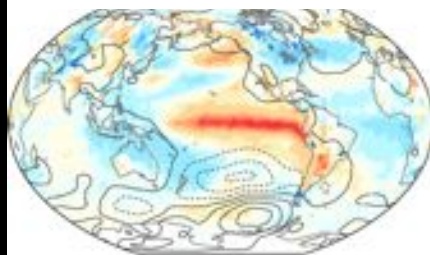
El Niño minus La Niña Composites in CCSM4

DATA

MODEL

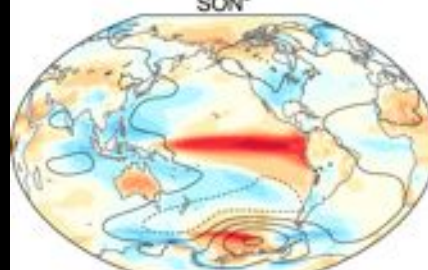
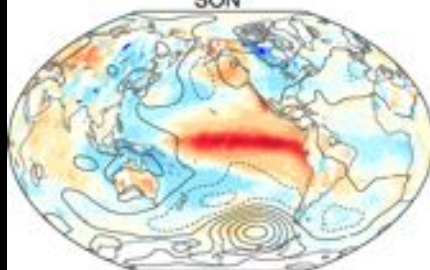
NCEP SLP/T2M

SLP/T2M (land)/ T 5m depth (ocean)



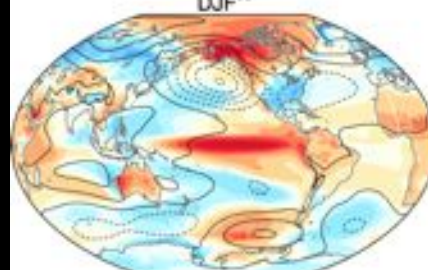
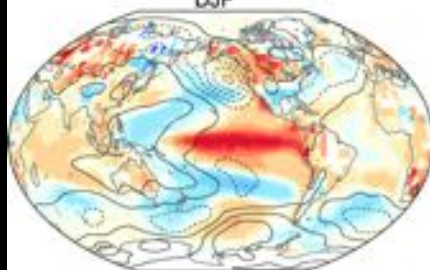
SON⁰

SON⁰



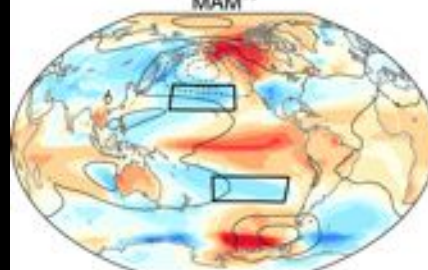
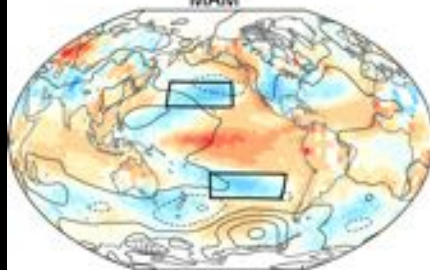
DJF⁻¹

DJF⁻¹



MAM⁻¹

MAM⁻¹



Deser et al. (in press)

ENSO variance in sea ice in CCSM4

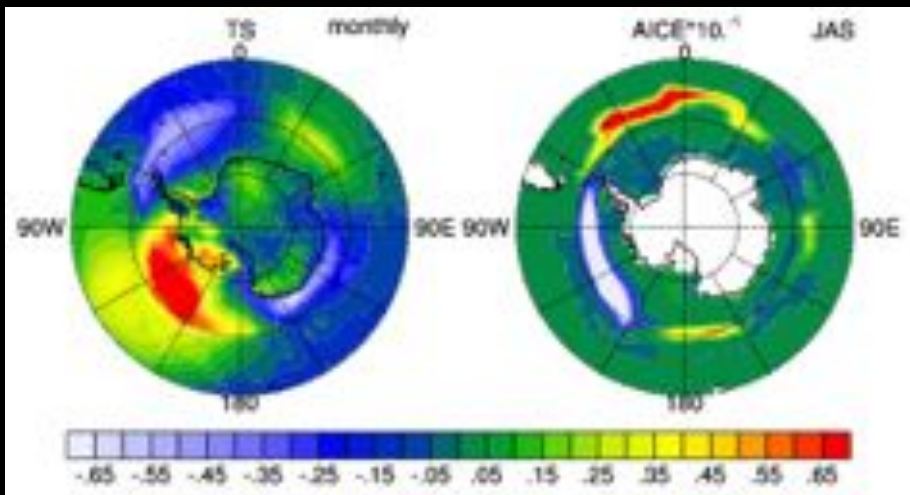
SIC EOFs

TS, SIC regressed onto Niño3.4.

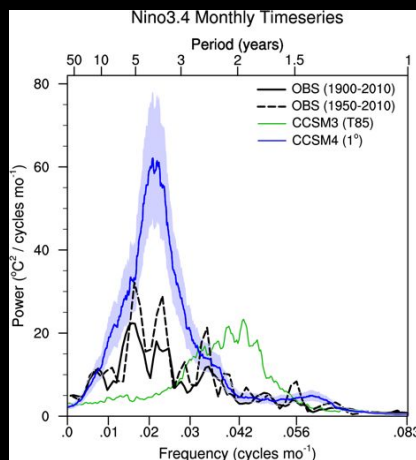
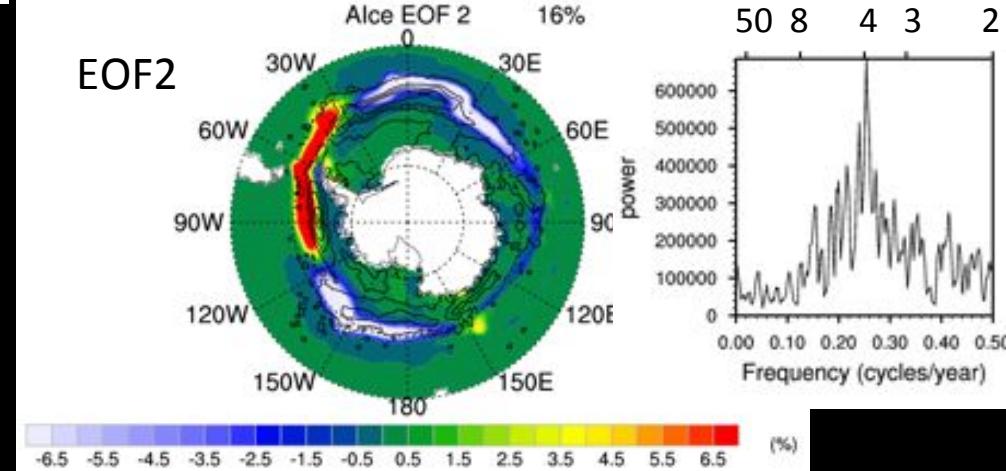
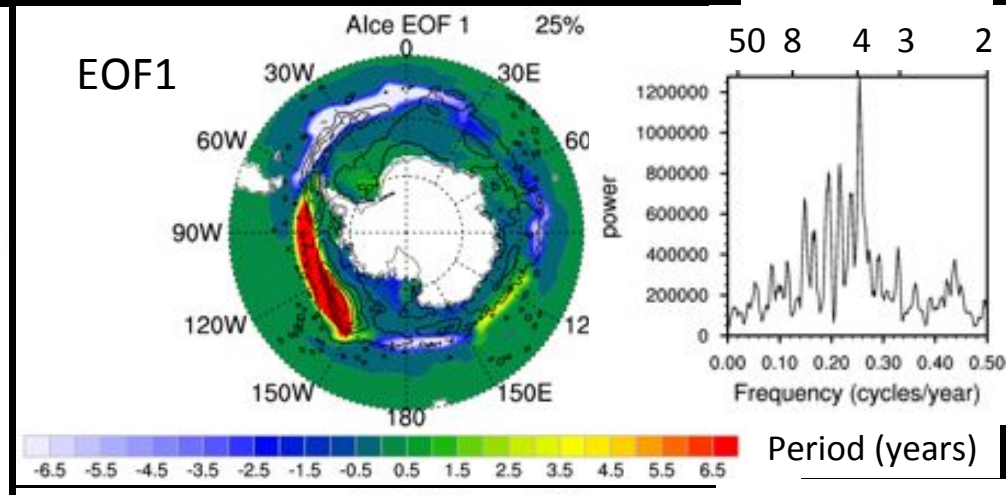
Model: colors

SSMI: contours

Period (years)



Landrum et al. (submitted)



Deser et al. (in press)

TRENDS

Observed trends in Ozone, SAM and Sea Ice

Magnitude of trends starting in 1979 and their significance

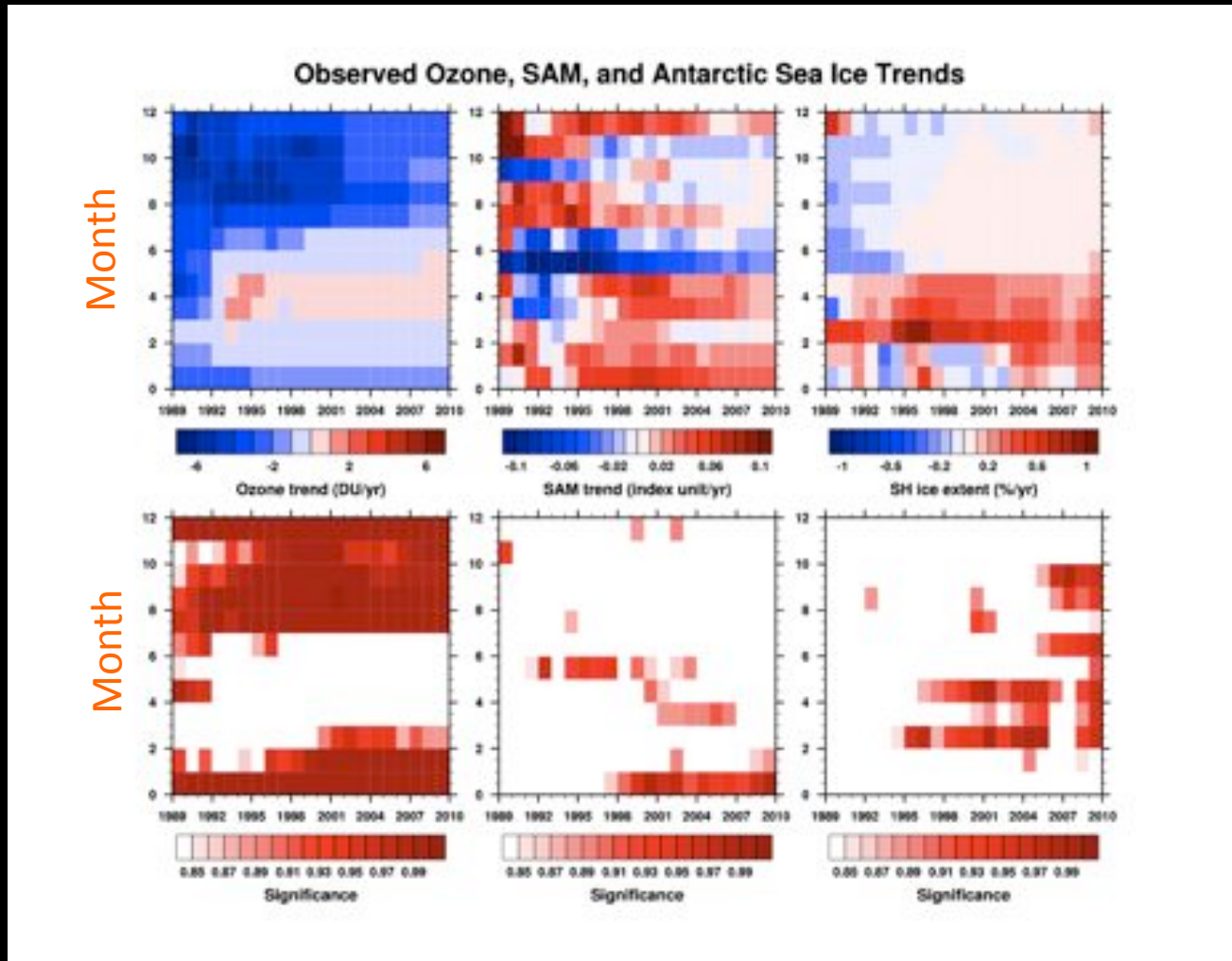


figure by Jennifer Kay, NCAR

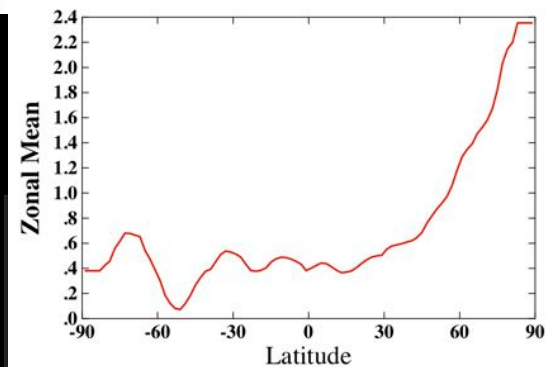
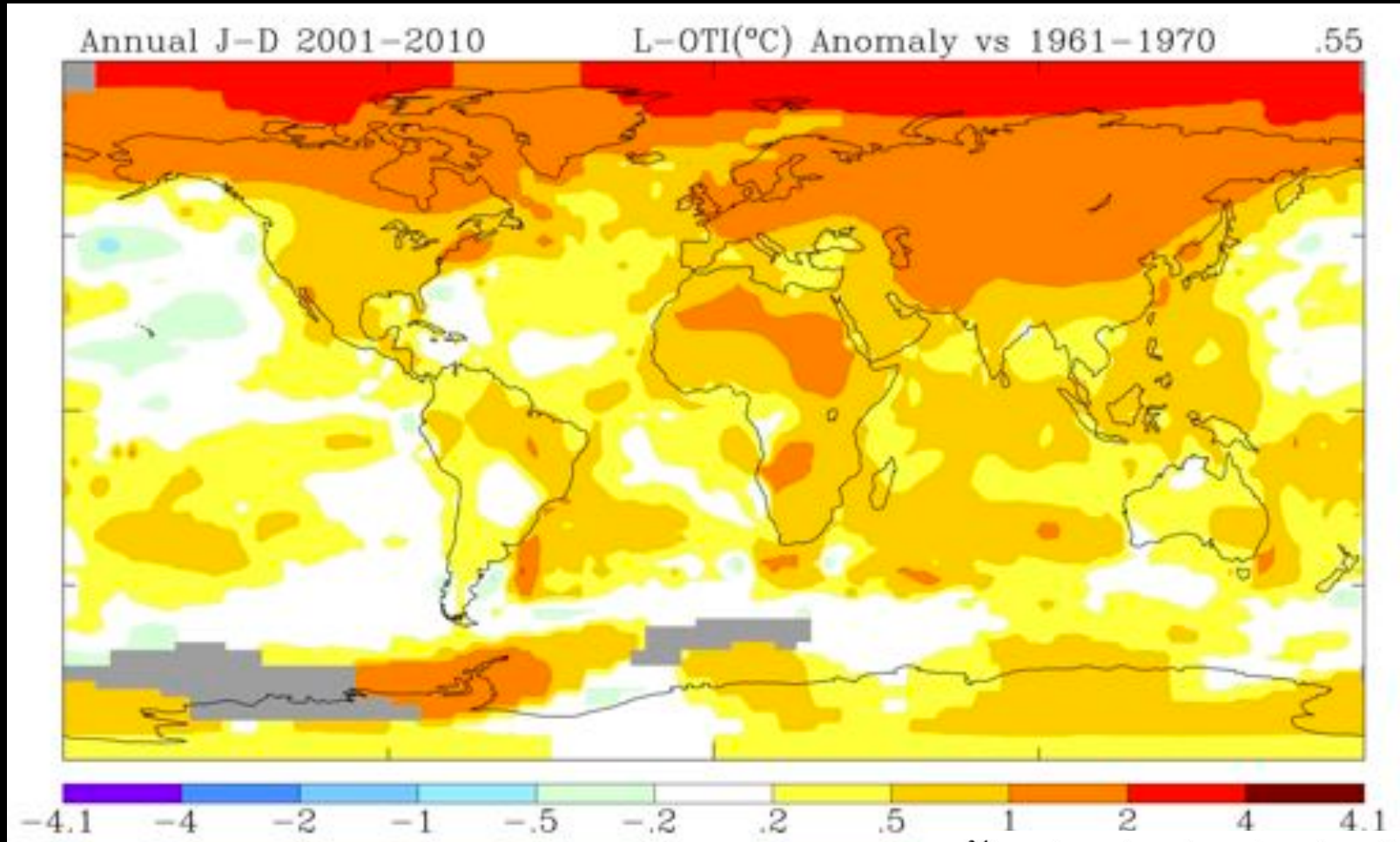


NCAR

NATIONAL CENTER FOR ATMOSPHERIC RESEARCH



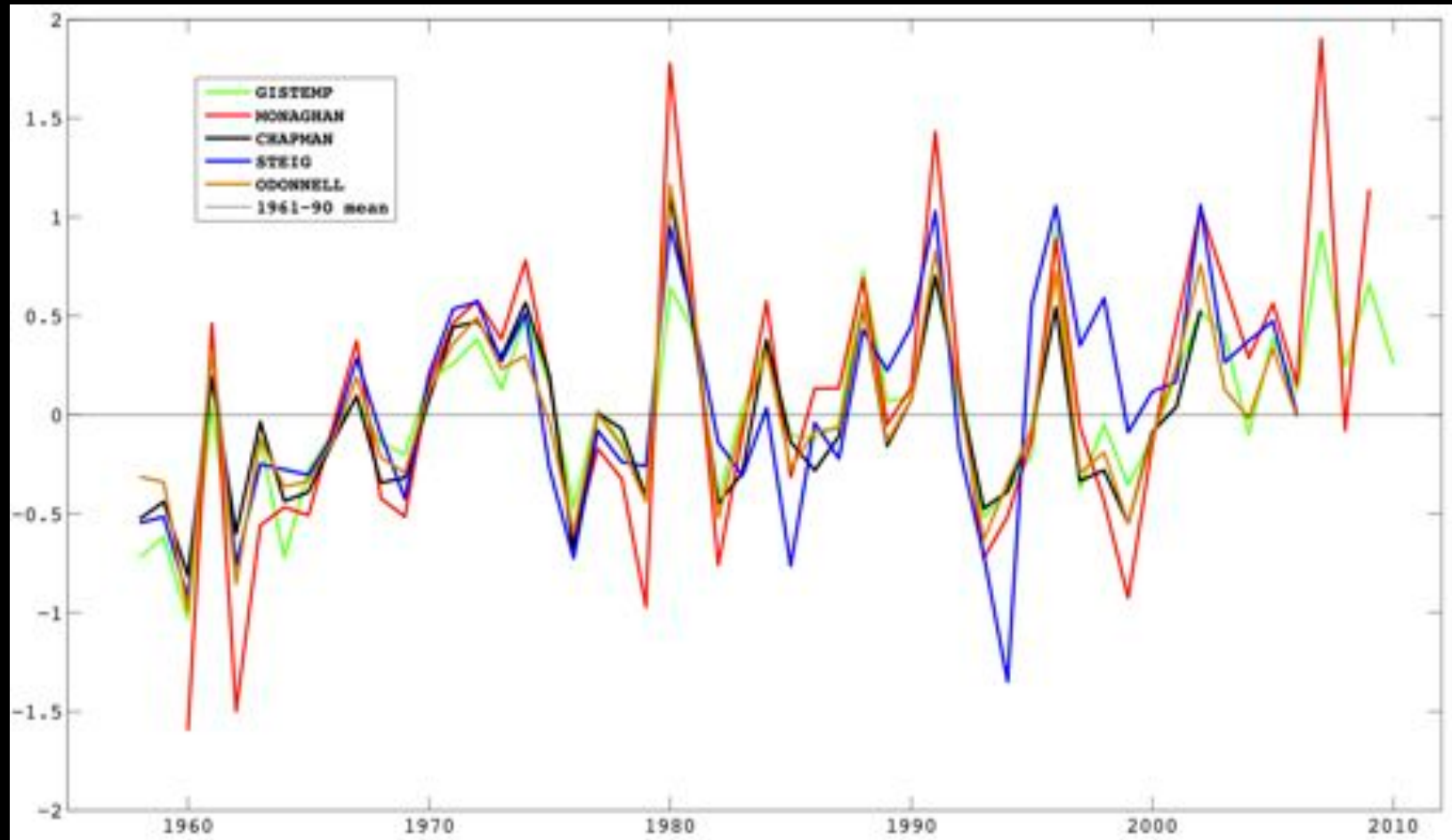
Surface temperature change (2000s minus 1960s)



Source: data.giss.nasa.gov/gistemp/maps



Antarctic Surface temperature change

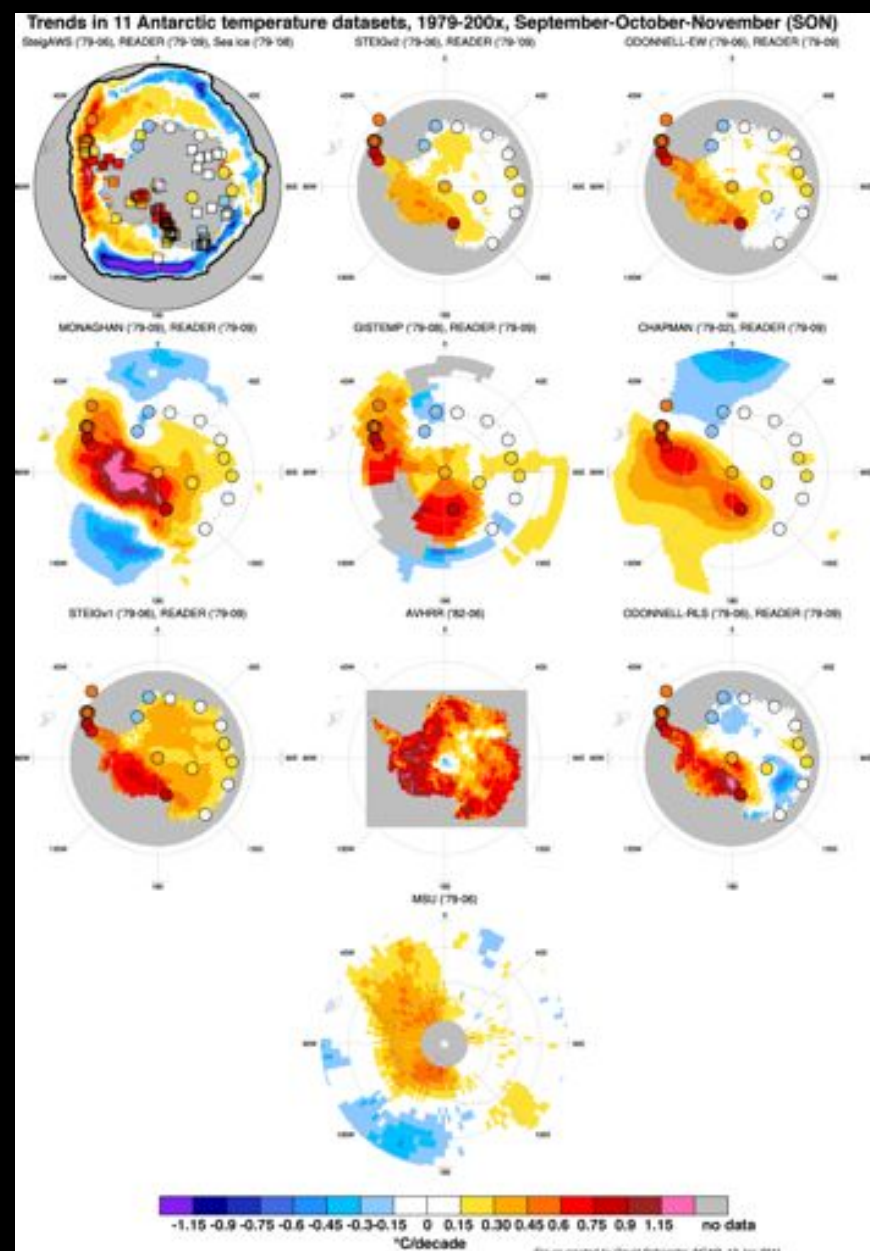
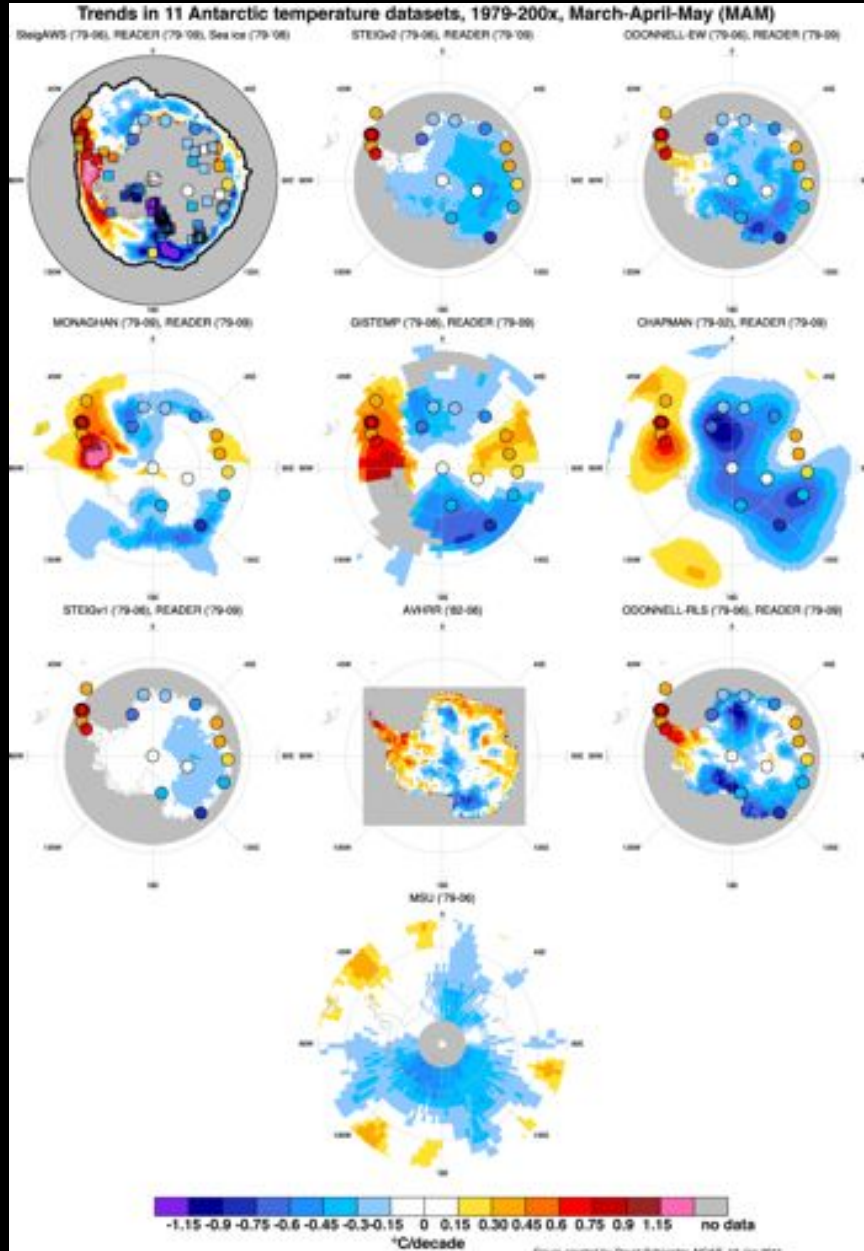


Dataset	timespan	Domain	Trend °C/decade
GISTEMP	1958-2010	64°S-90°S	<u>0.13±0.07</u>
MONAGHAN	1960-2009	Antarctic land	<u>0.19±0.14</u>
STEIG	1958-2006	Antarctic land	<u>0.14±0.13</u>
CHAPMAN	1958-2002	Antarctic land	0.07±0.11
O'DONNELL	1958-2006	Antarctic land	0.08±0.08



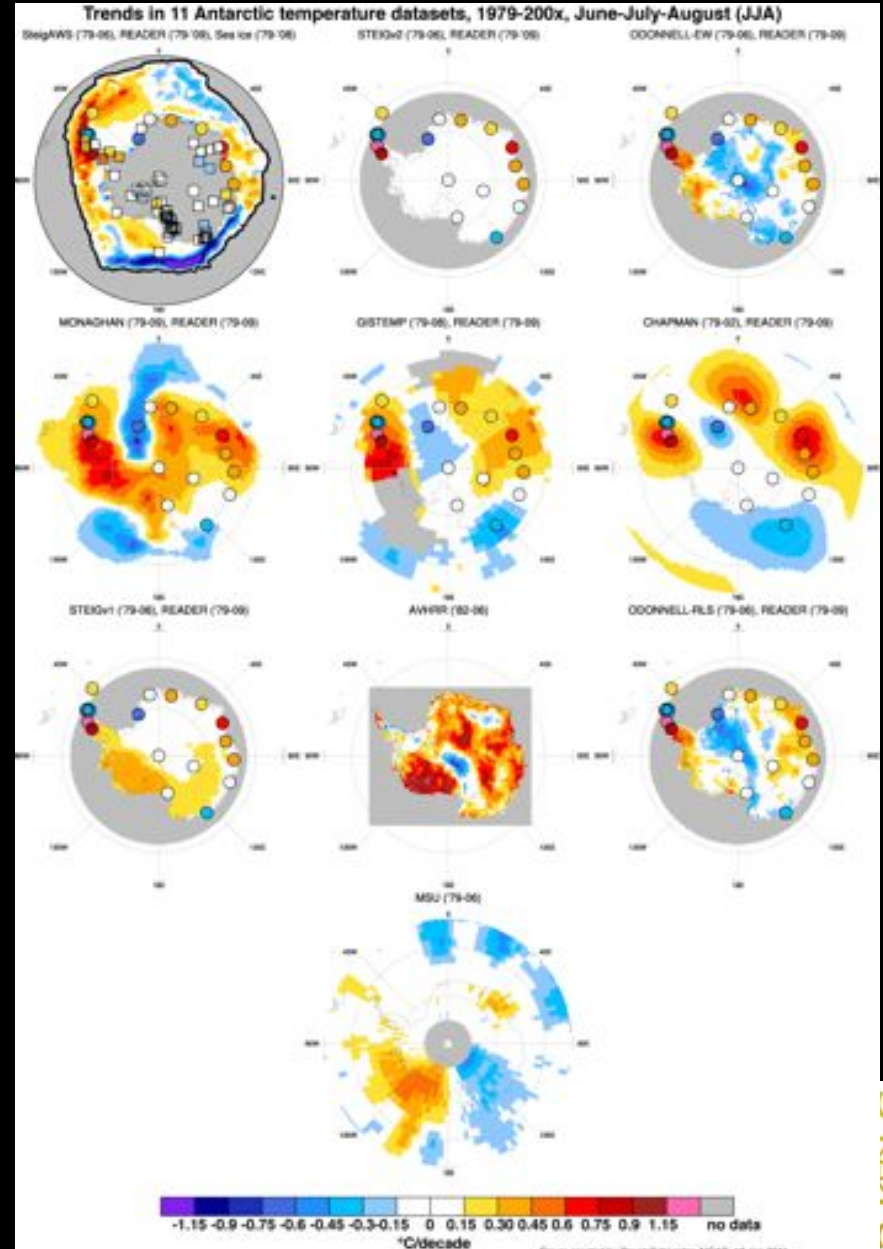
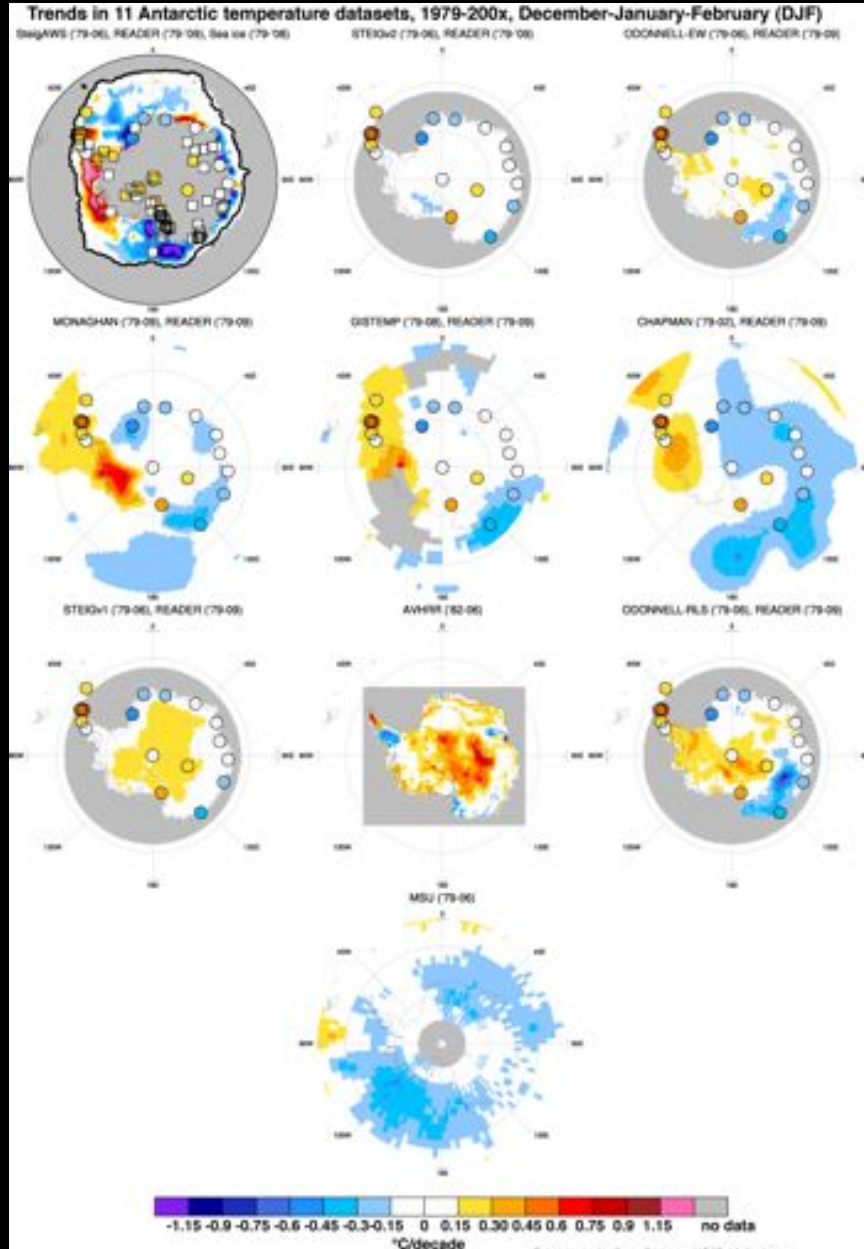
Austral autumn (MAM) & spring (SON)

Trends 1979-200x



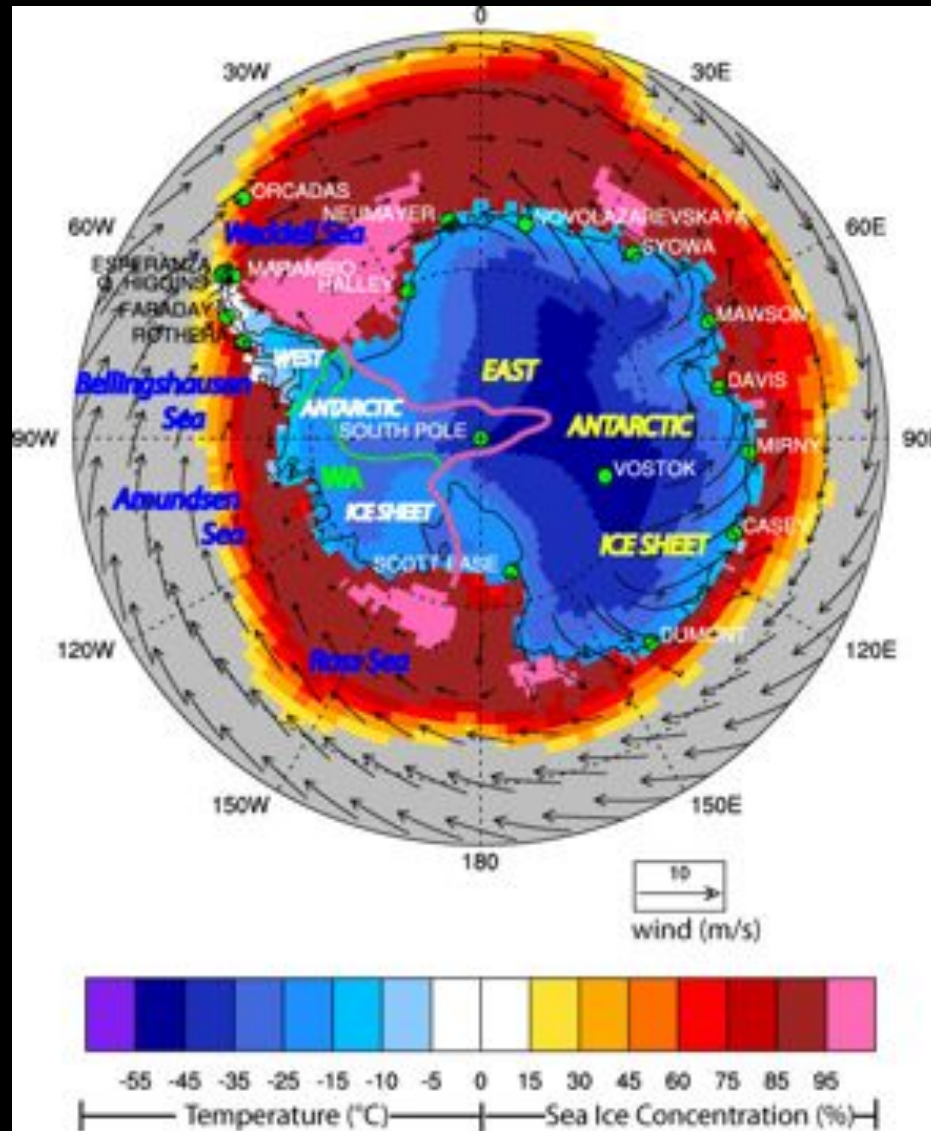
Austral summer (DJF) & winter (JJA)

Trends 1979-200x

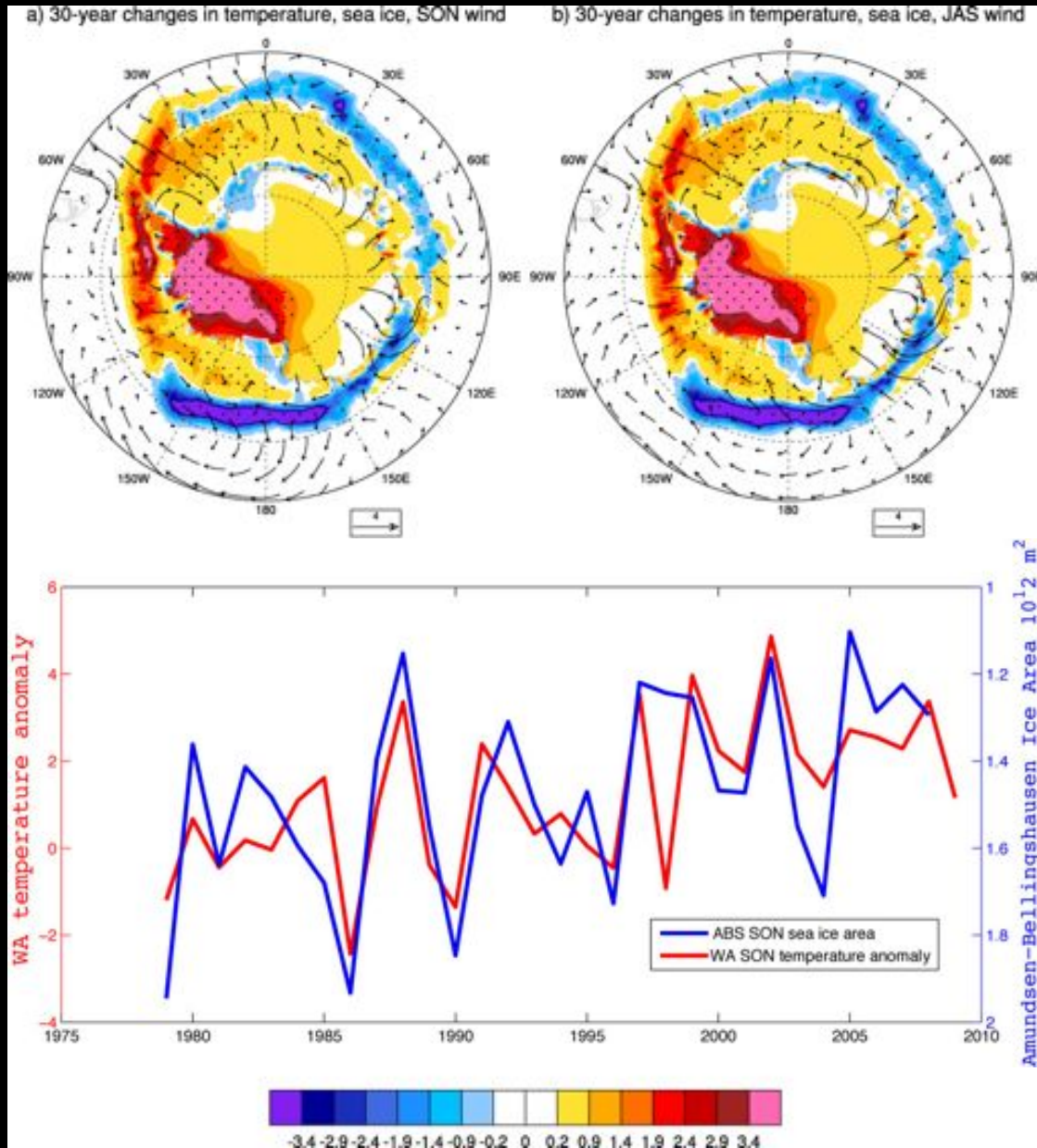


More about Spring trends

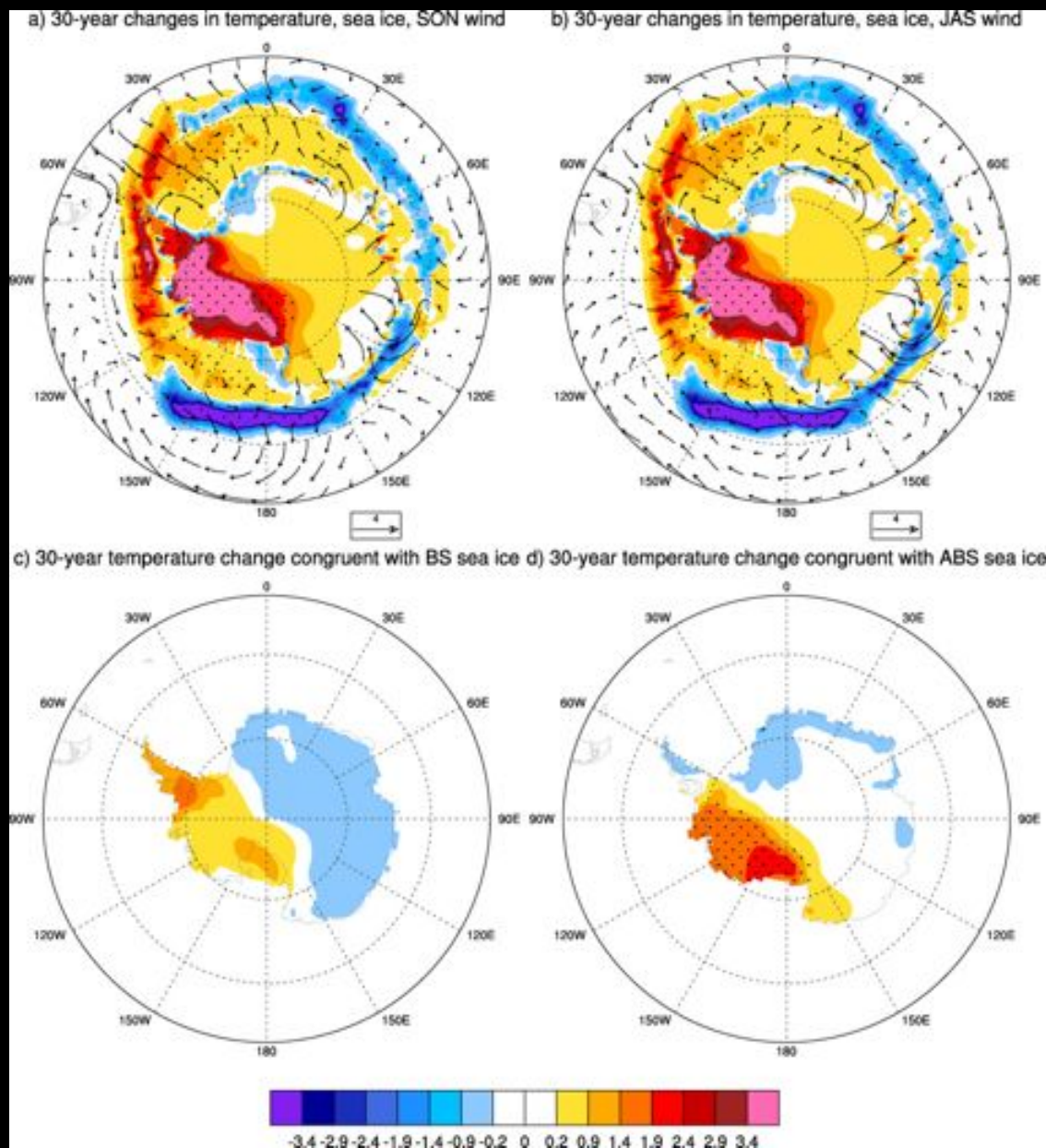
Austral spring (SON) average temperature & sea ice concentration



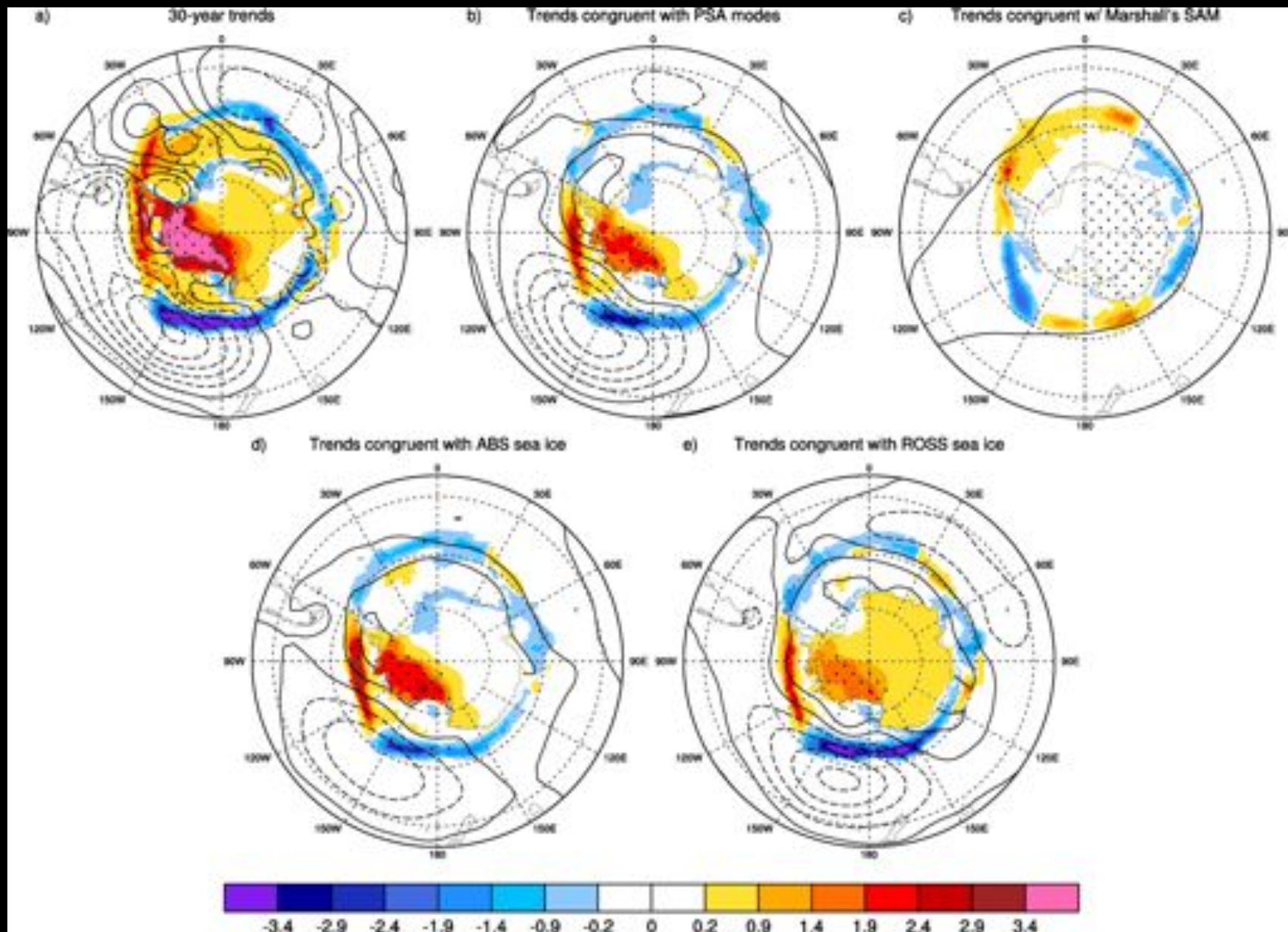
Temperature trends, relation to sea ice trends



Temperature trends, relation to sea ice trends



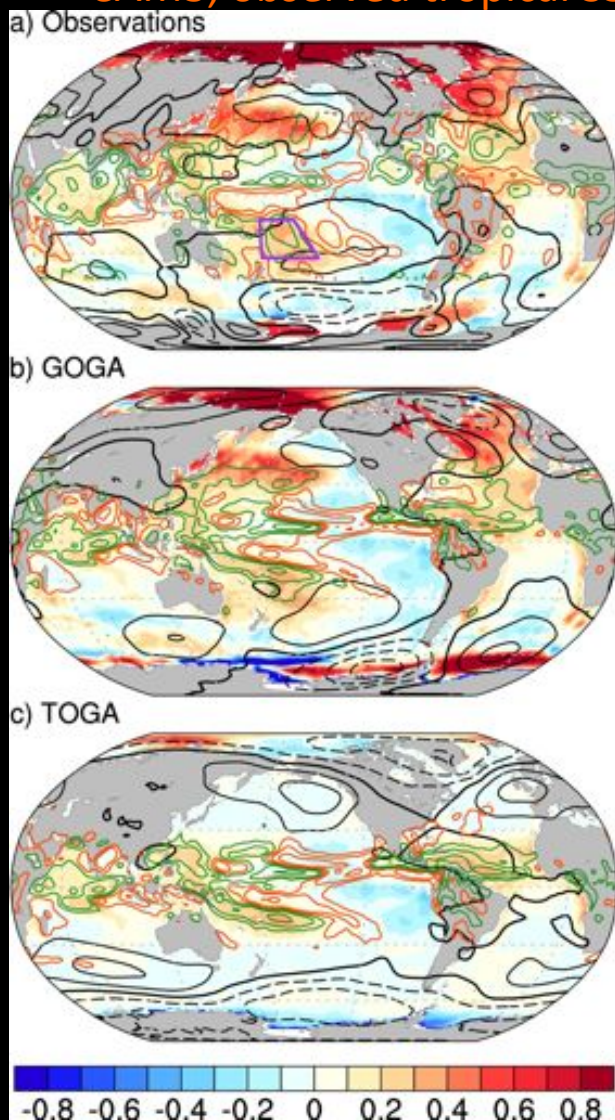
Trends congruent with PSA, SAM and sea ice: SON



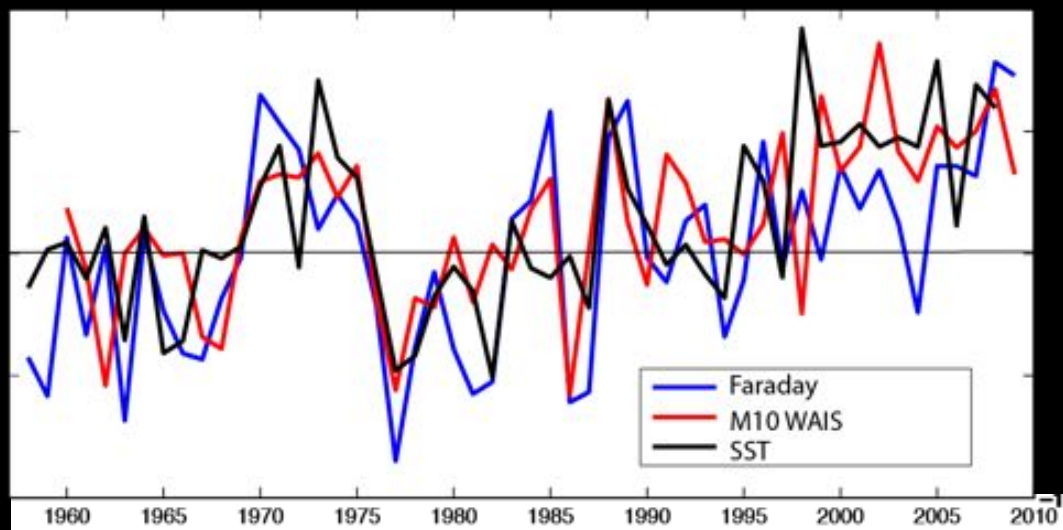
PSA 'wins' in SON: Are these trends explained by SSTs?

1979-2008 trends

- Observed
- CAM3, observed global SST & sea ice prescribed
- CAM3, observed tropical SST prescribed, climatology elsewhere

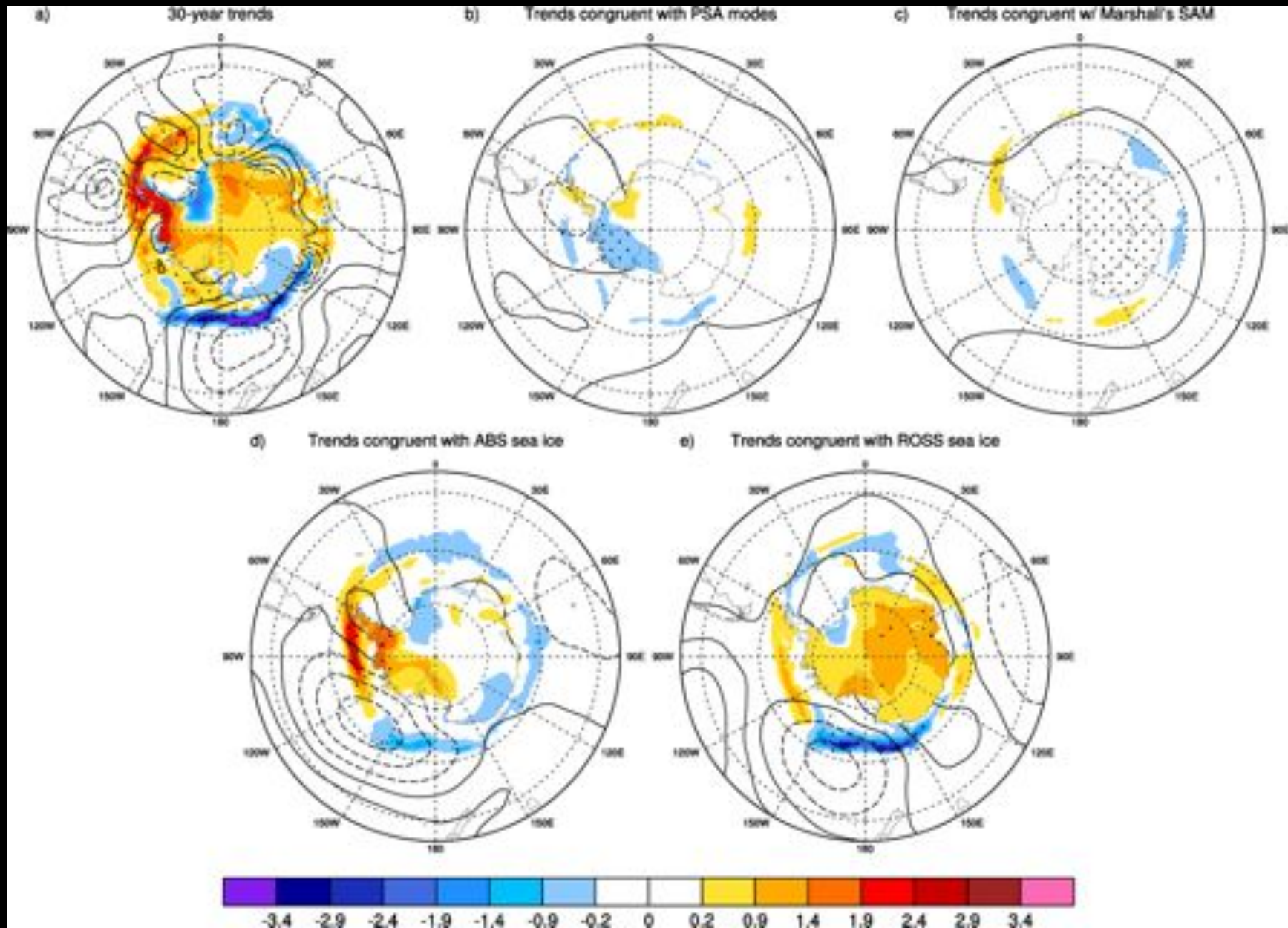


Faraday, WAIS & western Pacific SSTs warming together

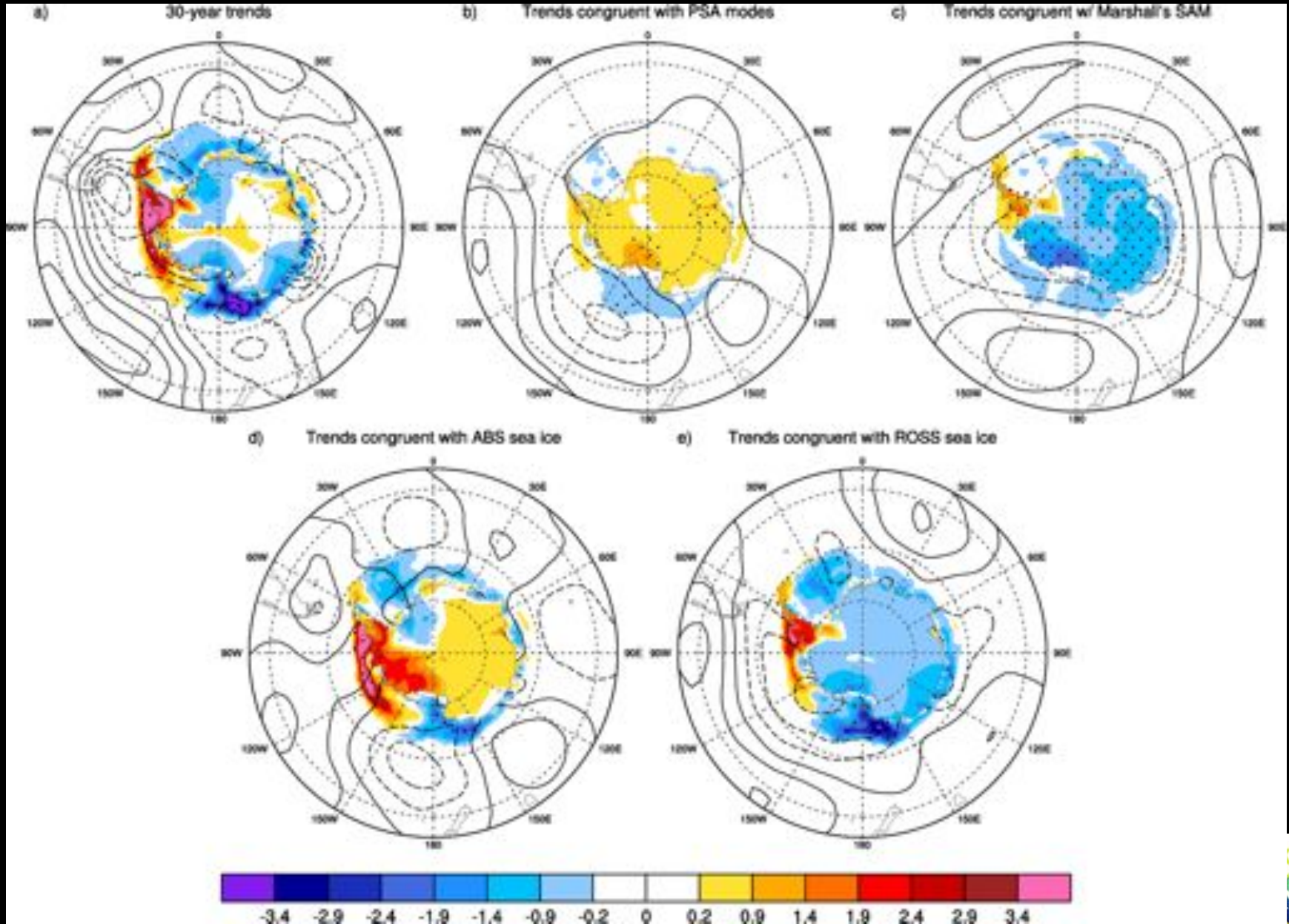


Schneider et al. (2011)

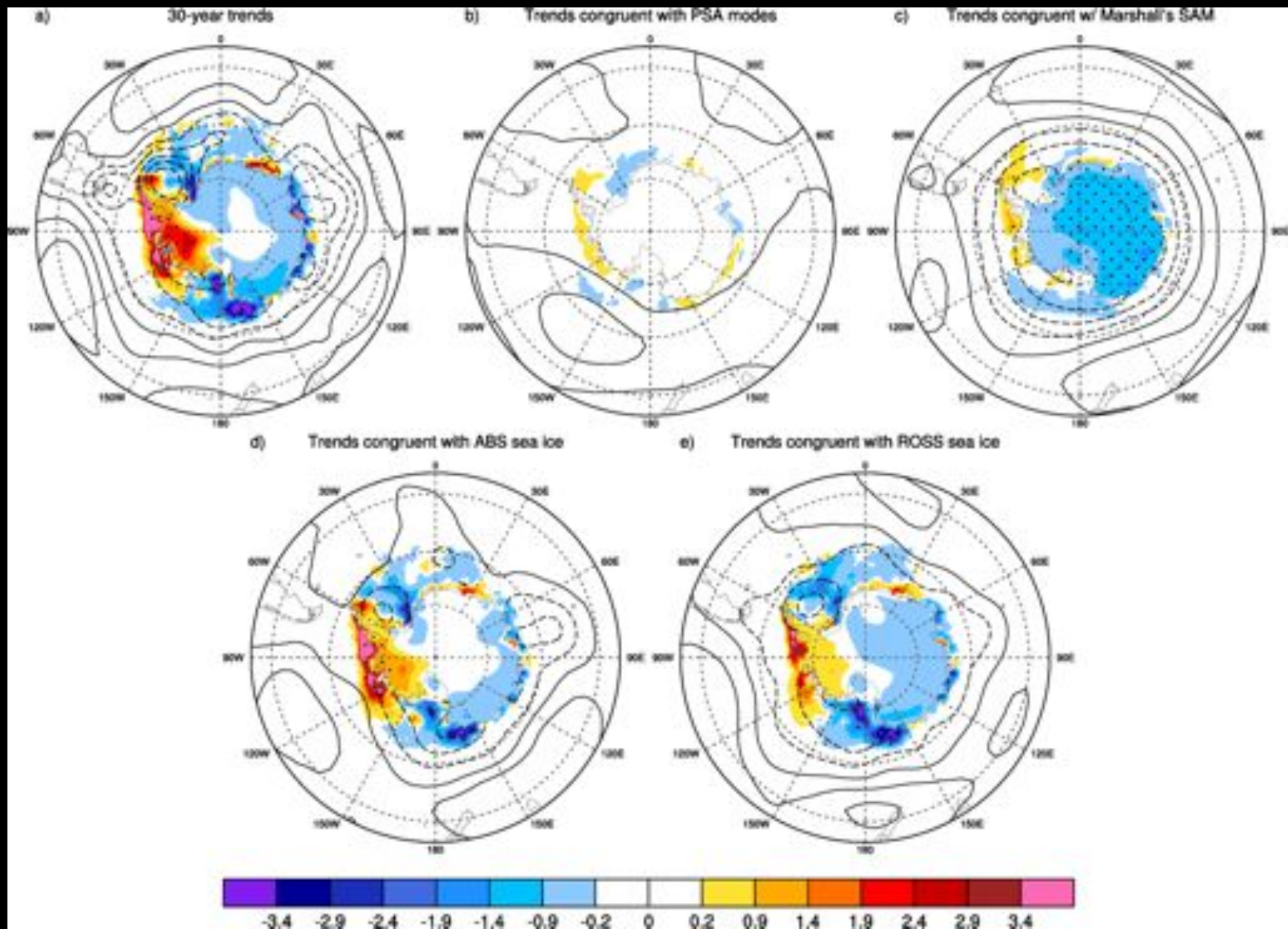
Trends congruent with PSA, SAM and sea ice: JJA



Trends congruent with PSA, SAM and sea ice: MAM



Trends congruent with PSA, SAM and sea ice: DJF



Summary

- Tropical signals are prevalent in Antarctic climate, evident in station data, ice cores, and models
- Mechanisms other than Rossby waves may be at work to explain SAM-ENSO connections in summer
- Antarctica is not cooling
- Strongest warming is over the western Peninsula, but is also significant over West Antarctica in spring
- Still some cooling evident and areas of sea ice increase, especially in the Ross Sea Sector in autumn
- PSA patterns, tropical forcing are the best explanations for spring warming
- SAM best explains lack of warming in summer and autumn