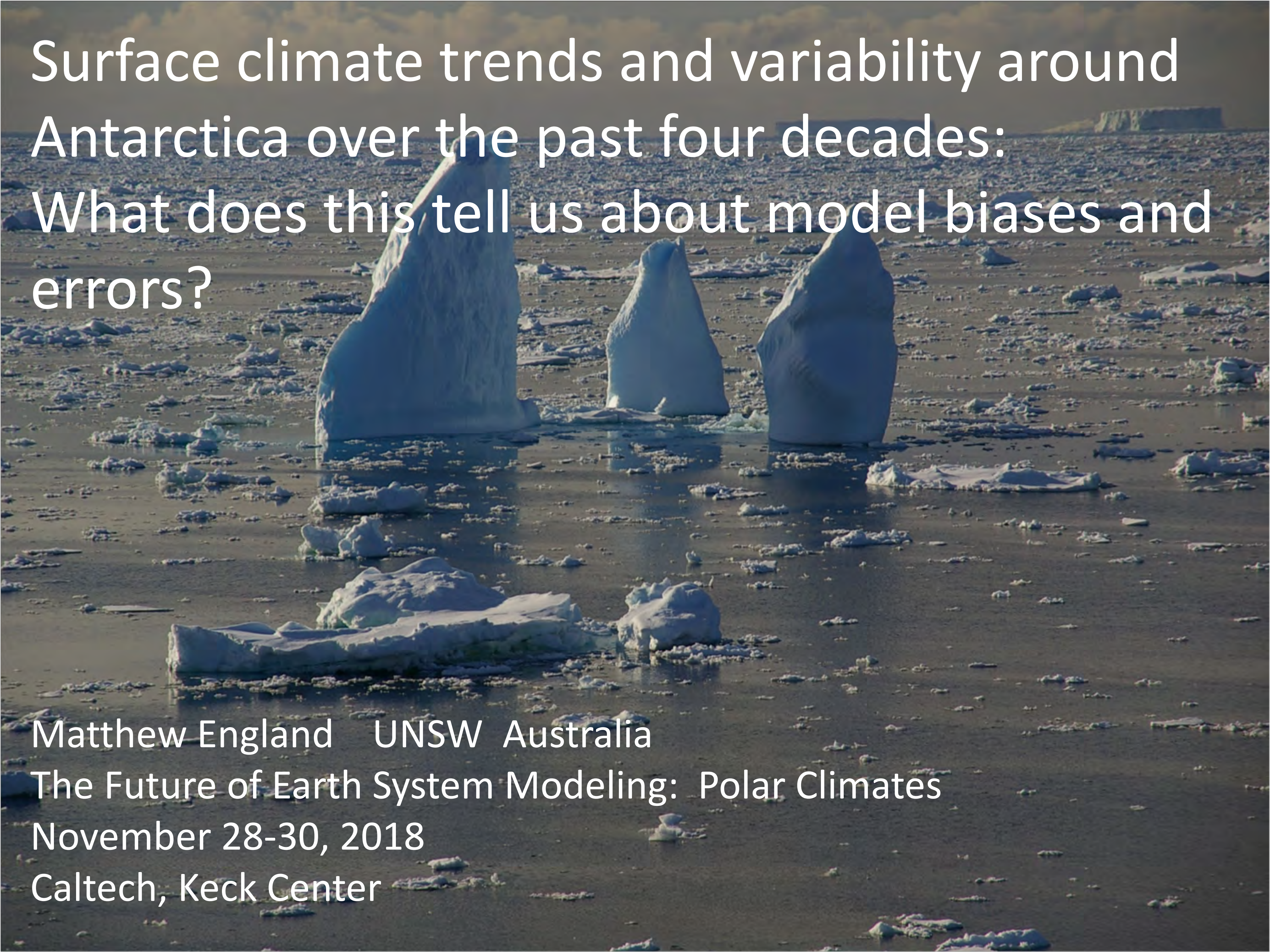

Surface climate trends and variability around Antarctica over the past four decades: What does this tell us about model biases and errors?

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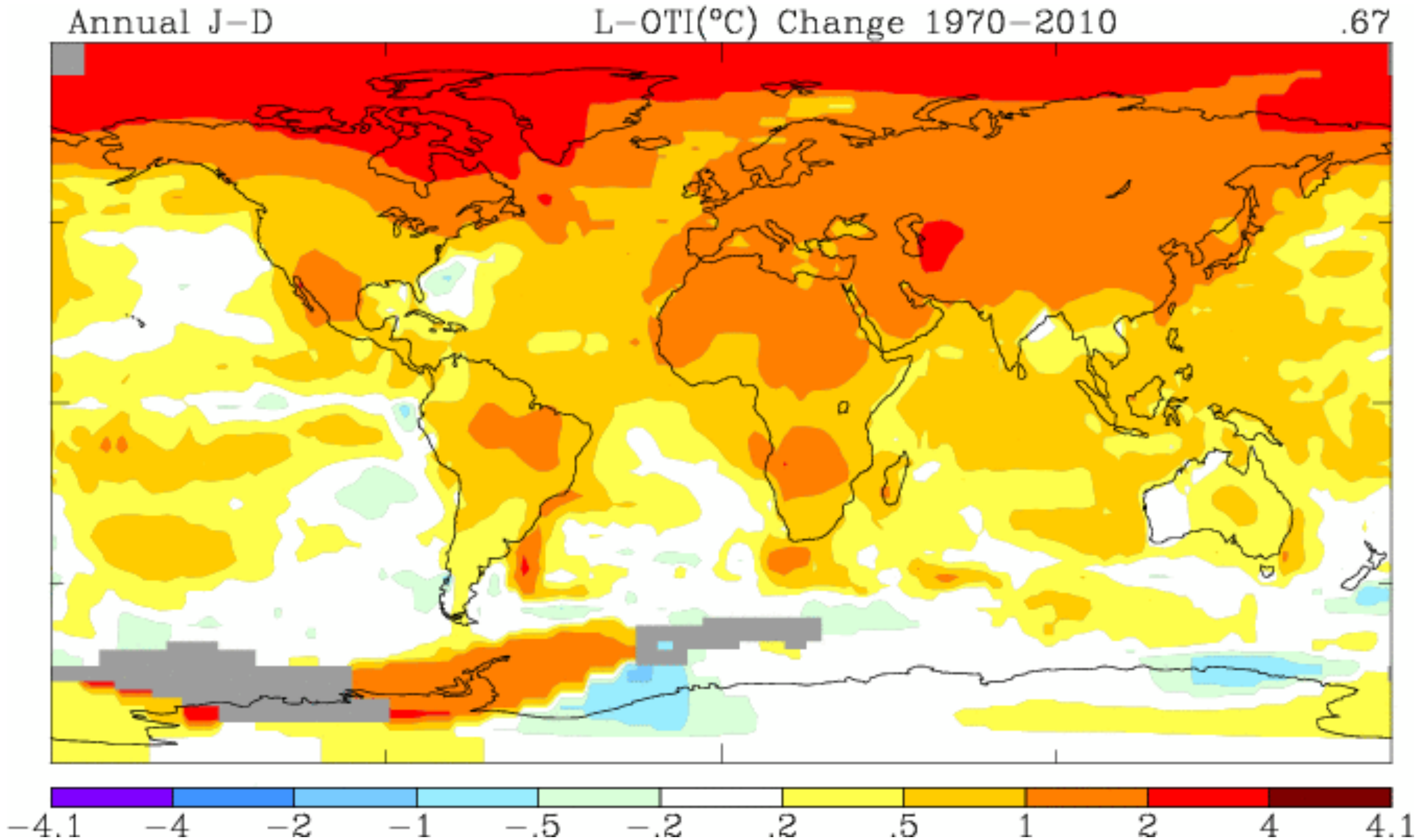
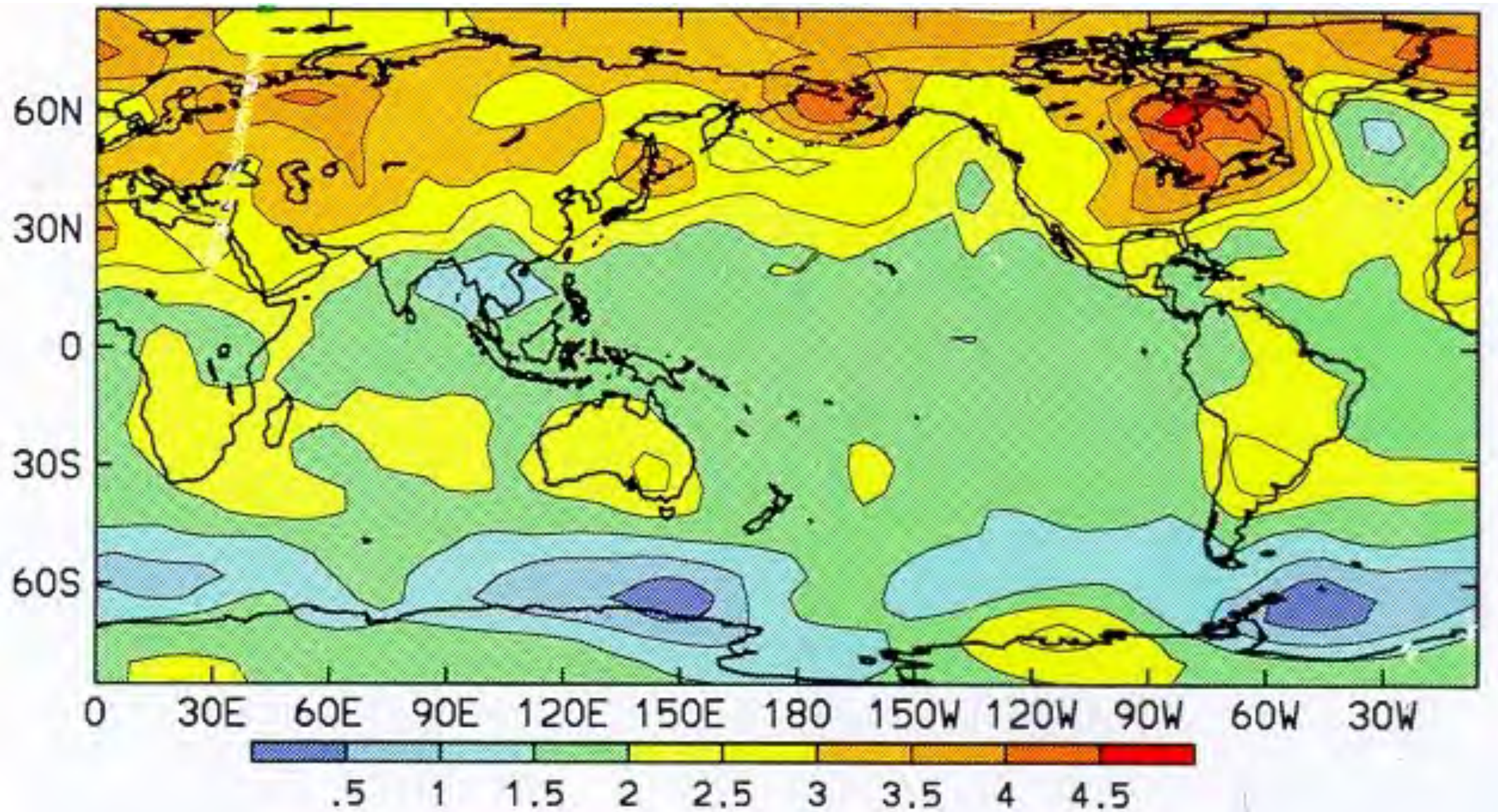
Observed surface T trends….



1970 – 2010 trends in annual mean SST

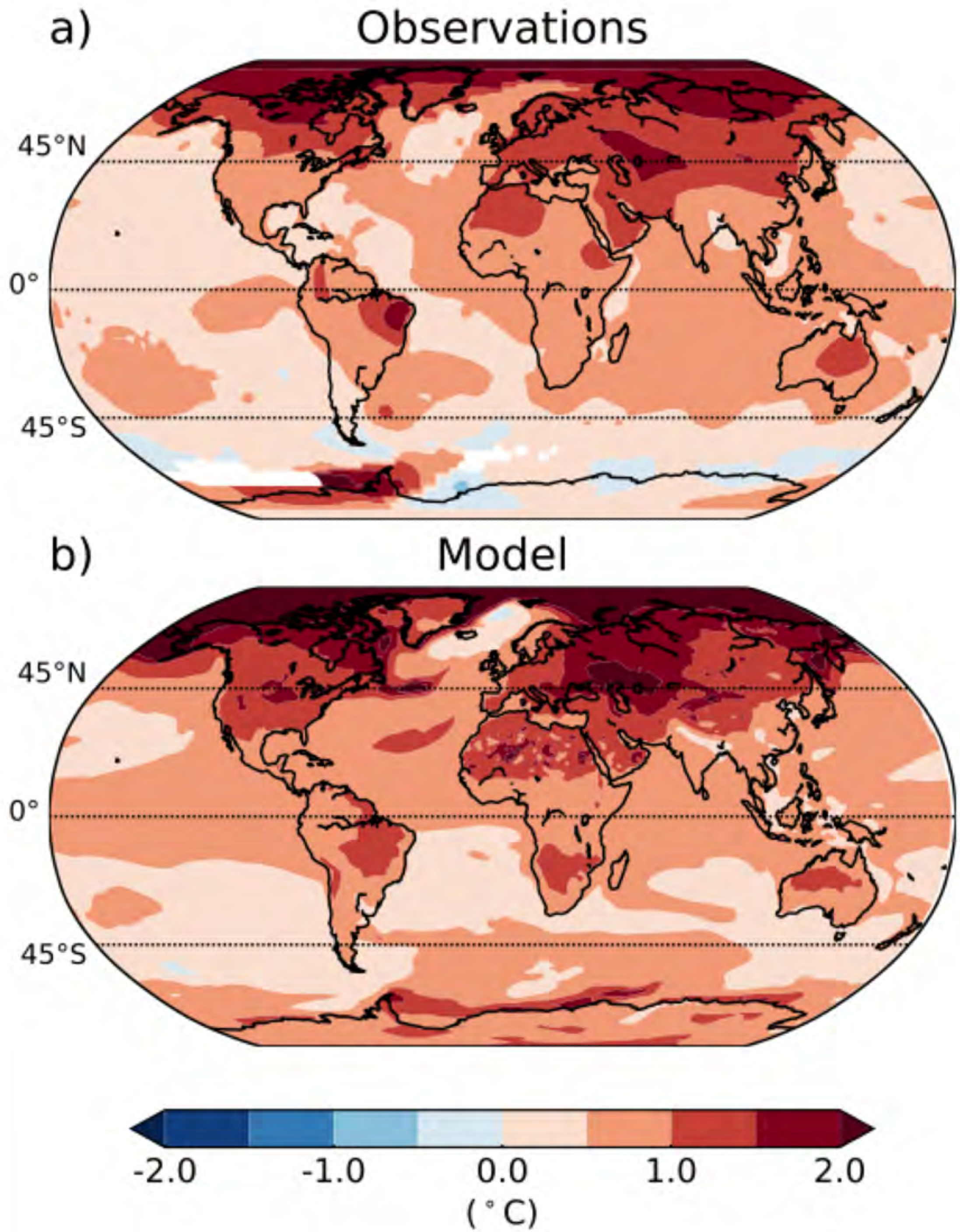
http://data.giss.nasa.gov/gistemp/maps/

Global surface climate trends progressing largely as expected



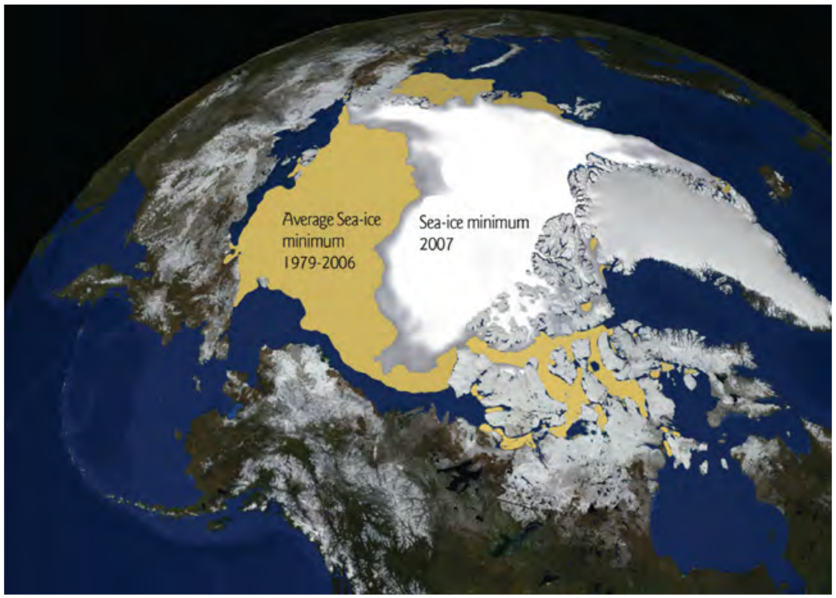
Annual-mean temperature change predicted for ~2030 in the GFDL coupled climate model experiment.

Stouffer et al., 1989

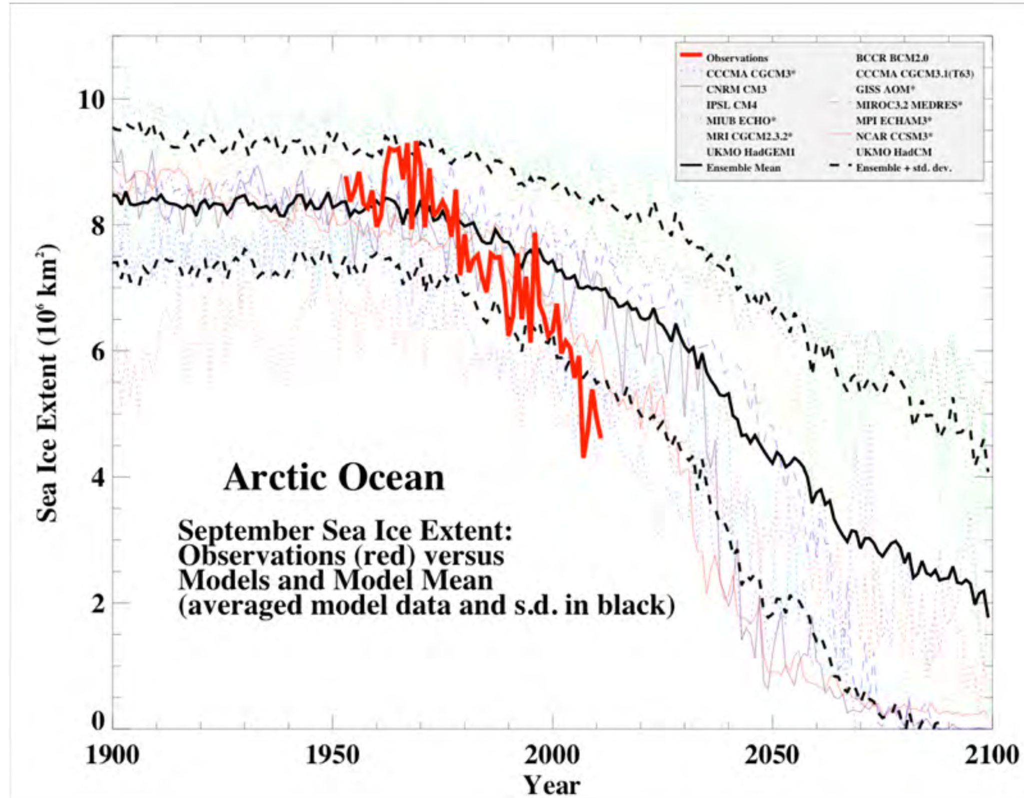


2008-2017
minus
1979-1988

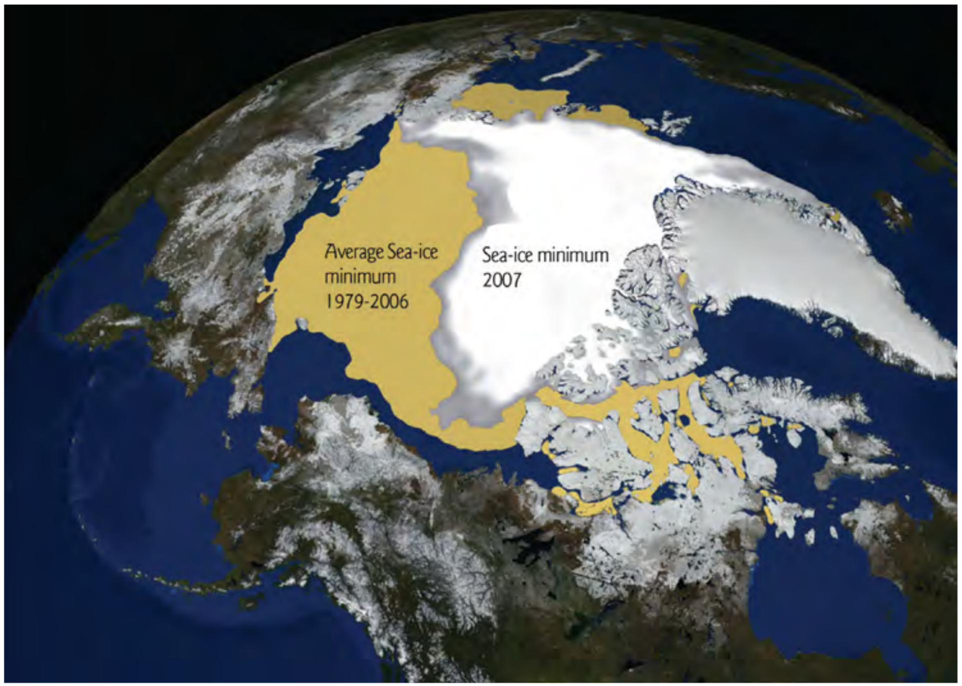
Arctic sea-ice trends has outpaced expectations.....



Average sea-ice 1979–2006 and then in 2007



Marked trend contrast across the hemispheres



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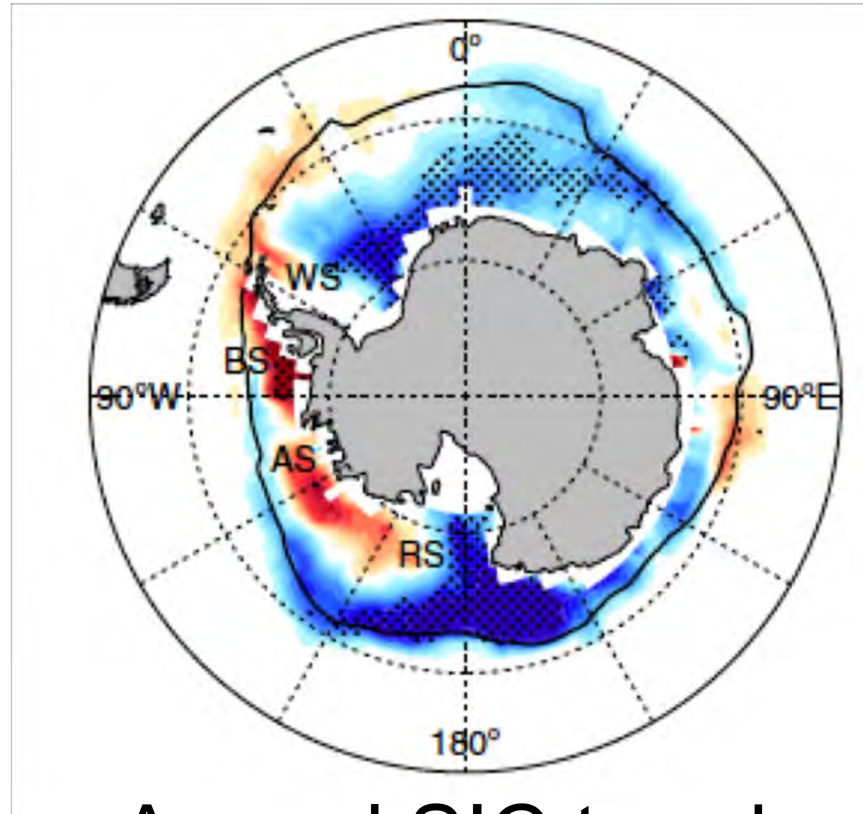
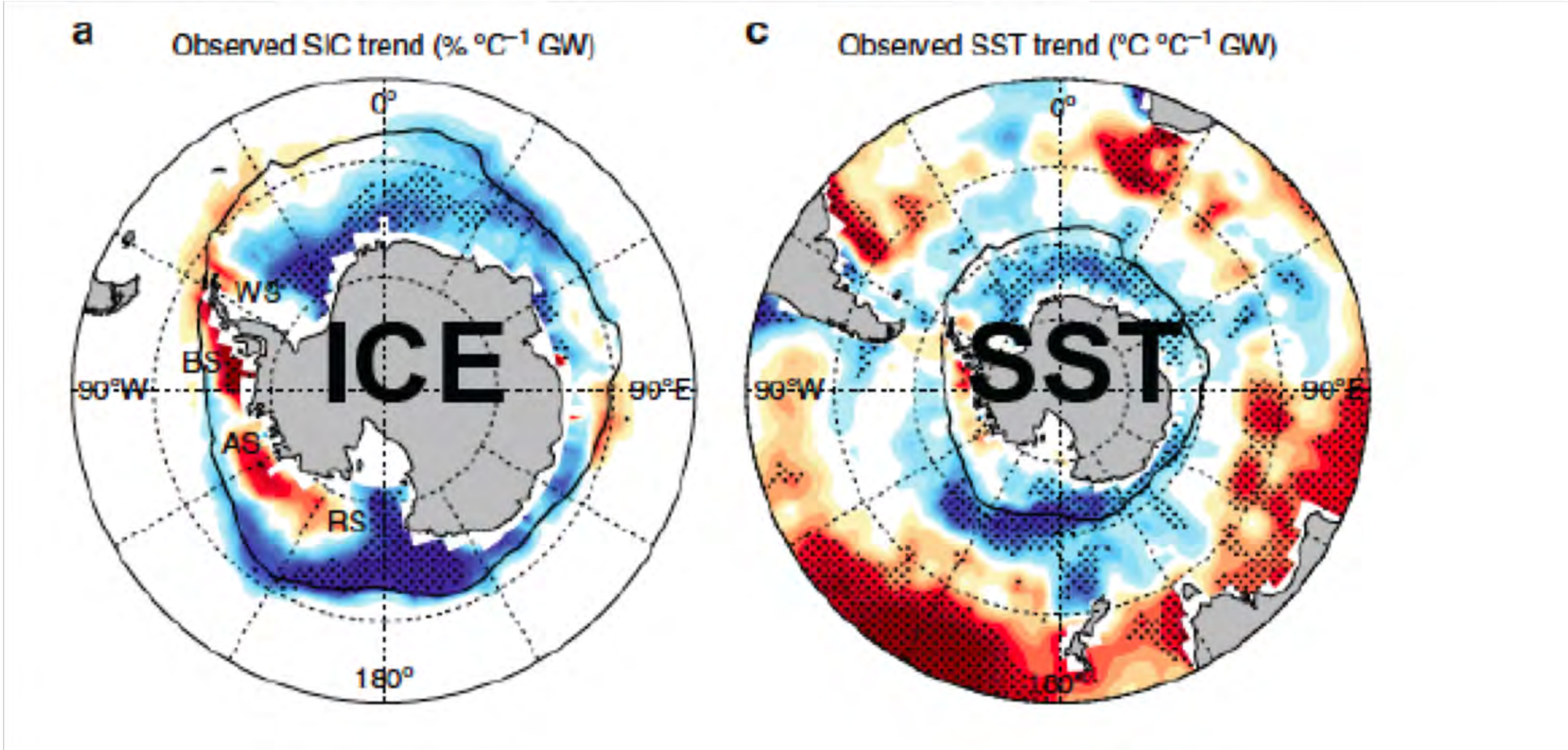
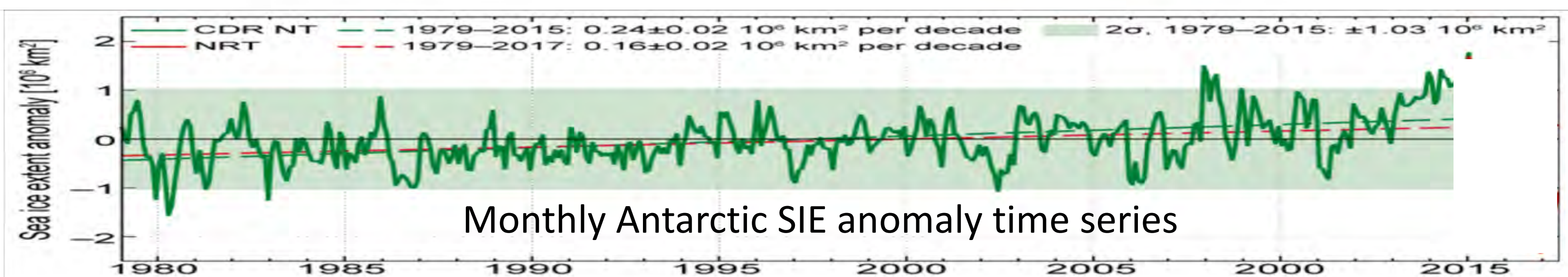


Annual SIC trends 1979–2013

Purich et al. 2016

Annual trends: 1979–2013



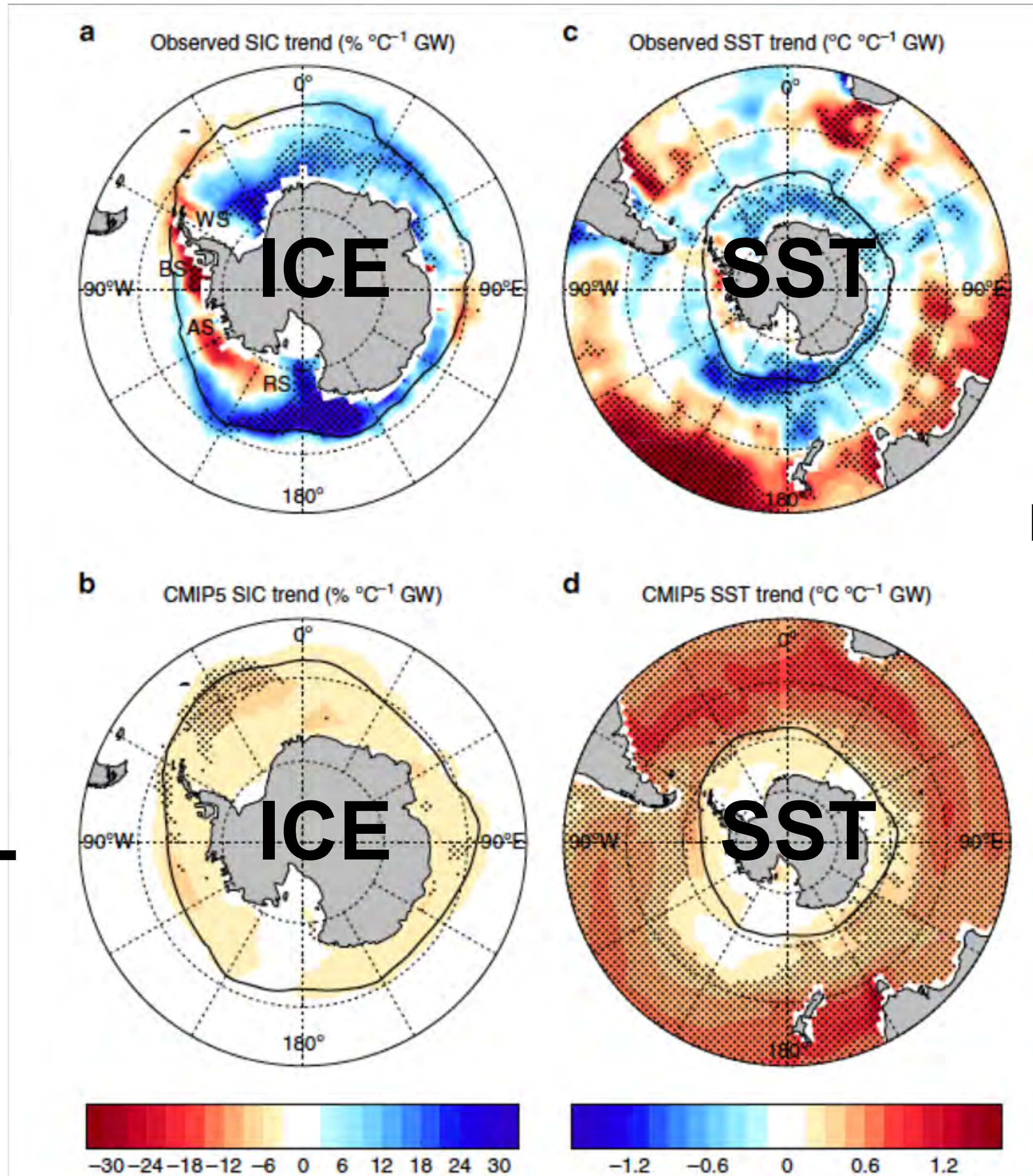


Schlosser et al. (2018)

Antarctic surface climate trends go against "expectations"

OBS

MULTI MODEL MEAN

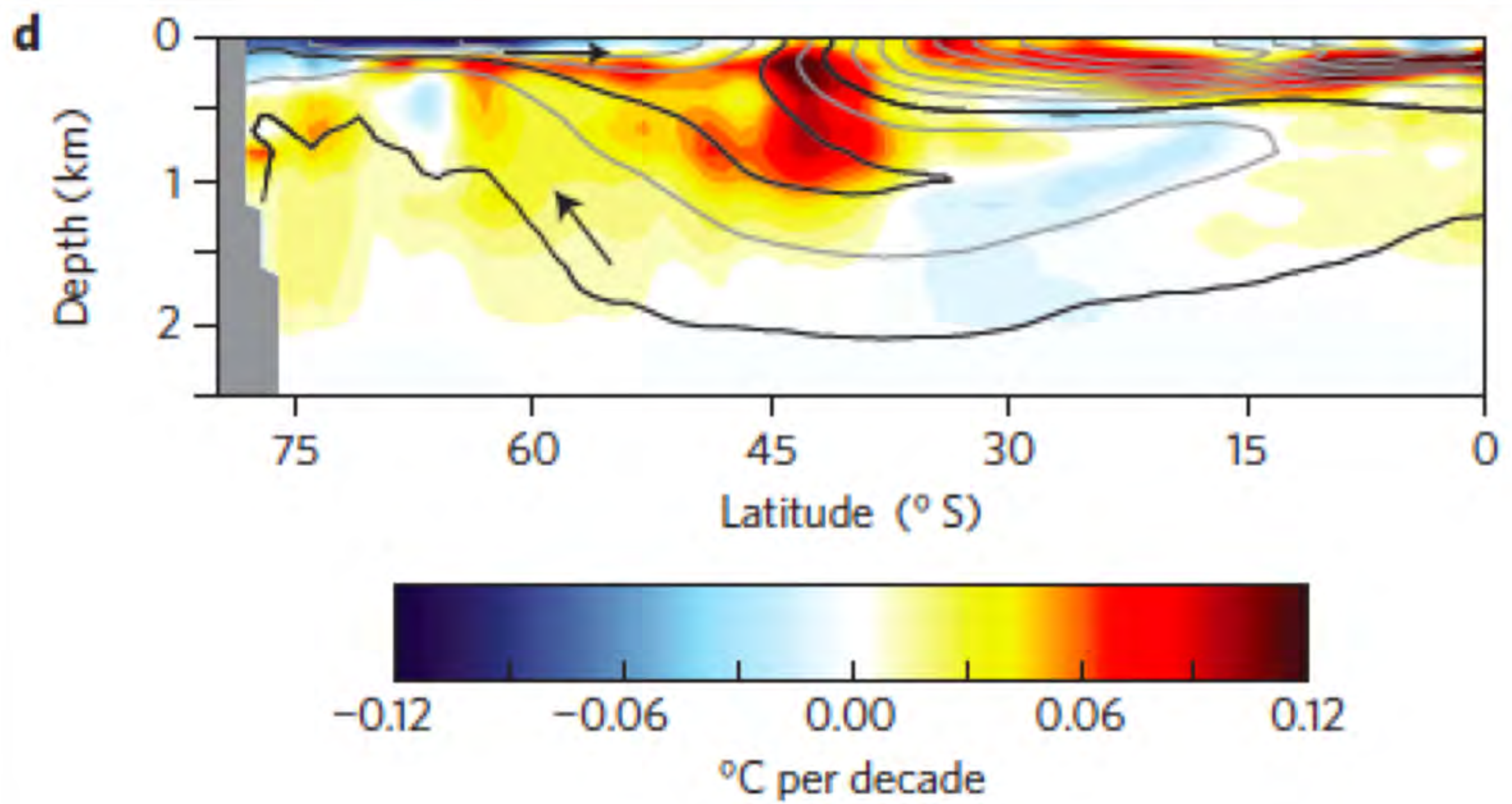


Purich, England, et al. (2016) Nature Comms

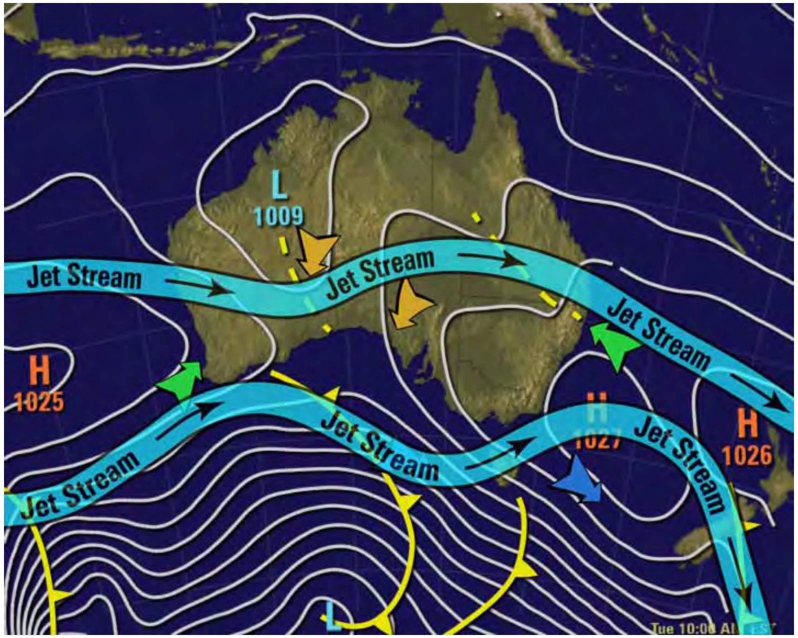
nature geoscience
ARTICLES
PUBLISHED ONLINE: 30 MAY 2016 | DOI: 10.1038/NGEO2731

Southern Ocean warming delayed by circumpolar upwelling and equatorward transport

Kyle C. Armour[1*], John Marshall[2], Jeffery R. Scott[2,3], Aaron Donohoe[4] and Emily R. Newsom[5]

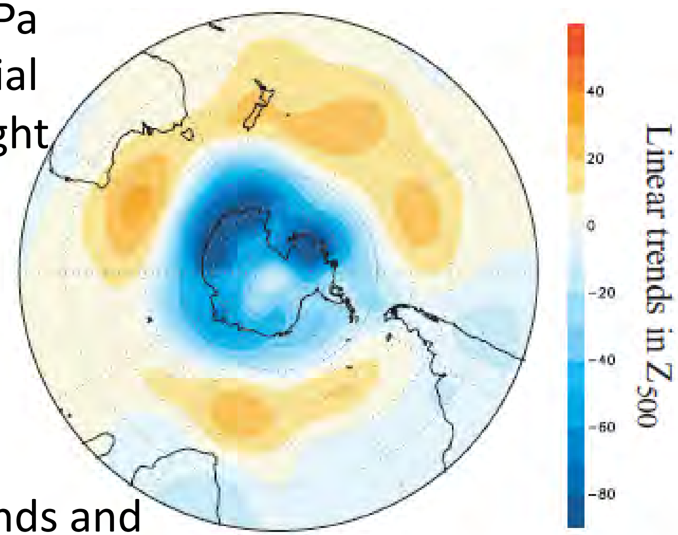


Recent surface forcing trends over the Southern Ocean

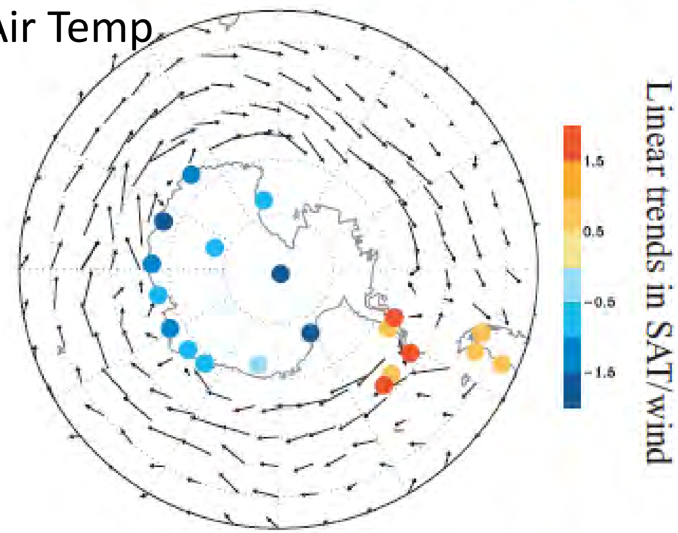


Thompson and Solomon (2002, *Science*)

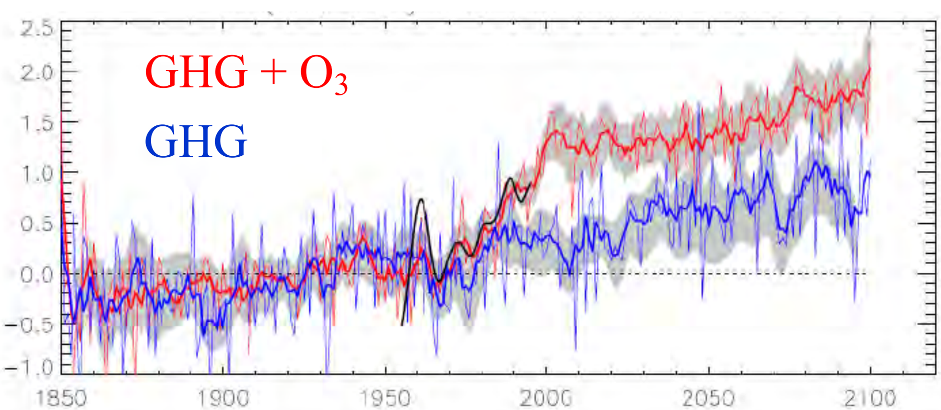
500 hPa geopotential height



Winds and Air Temp

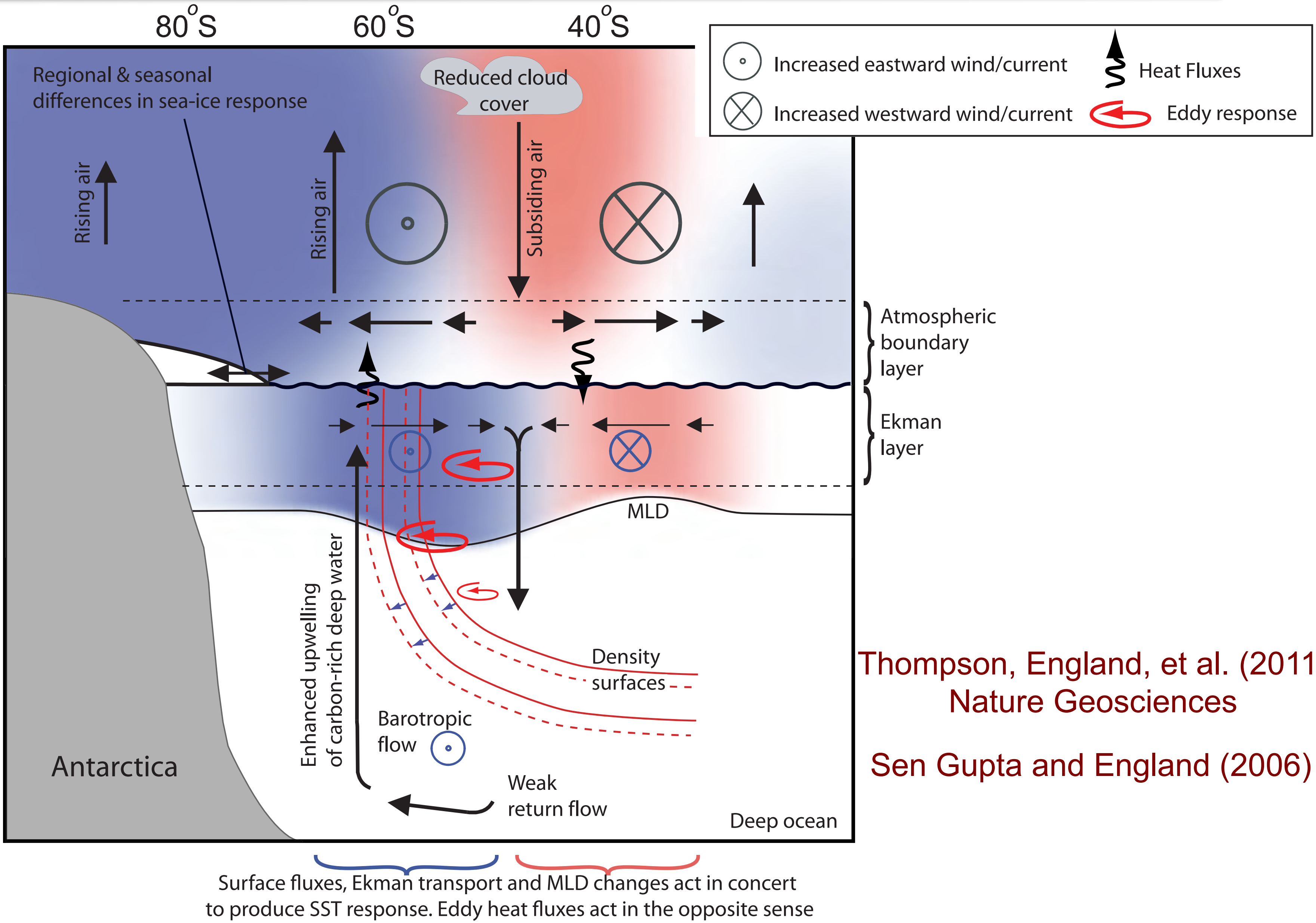


IPCC 2007



Multi-model SAM index (Nov-Feb)

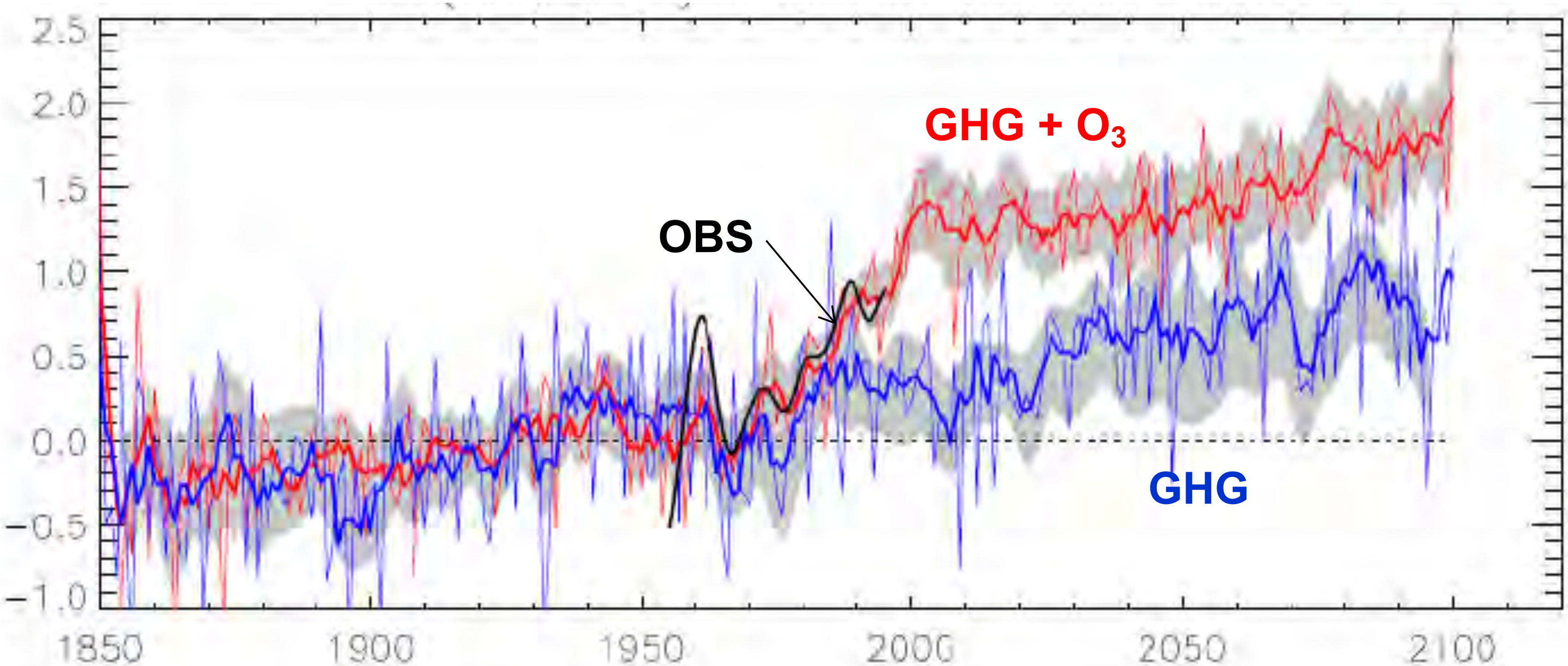
Ocean-atmosphere imprint of the Southern Annular Mode



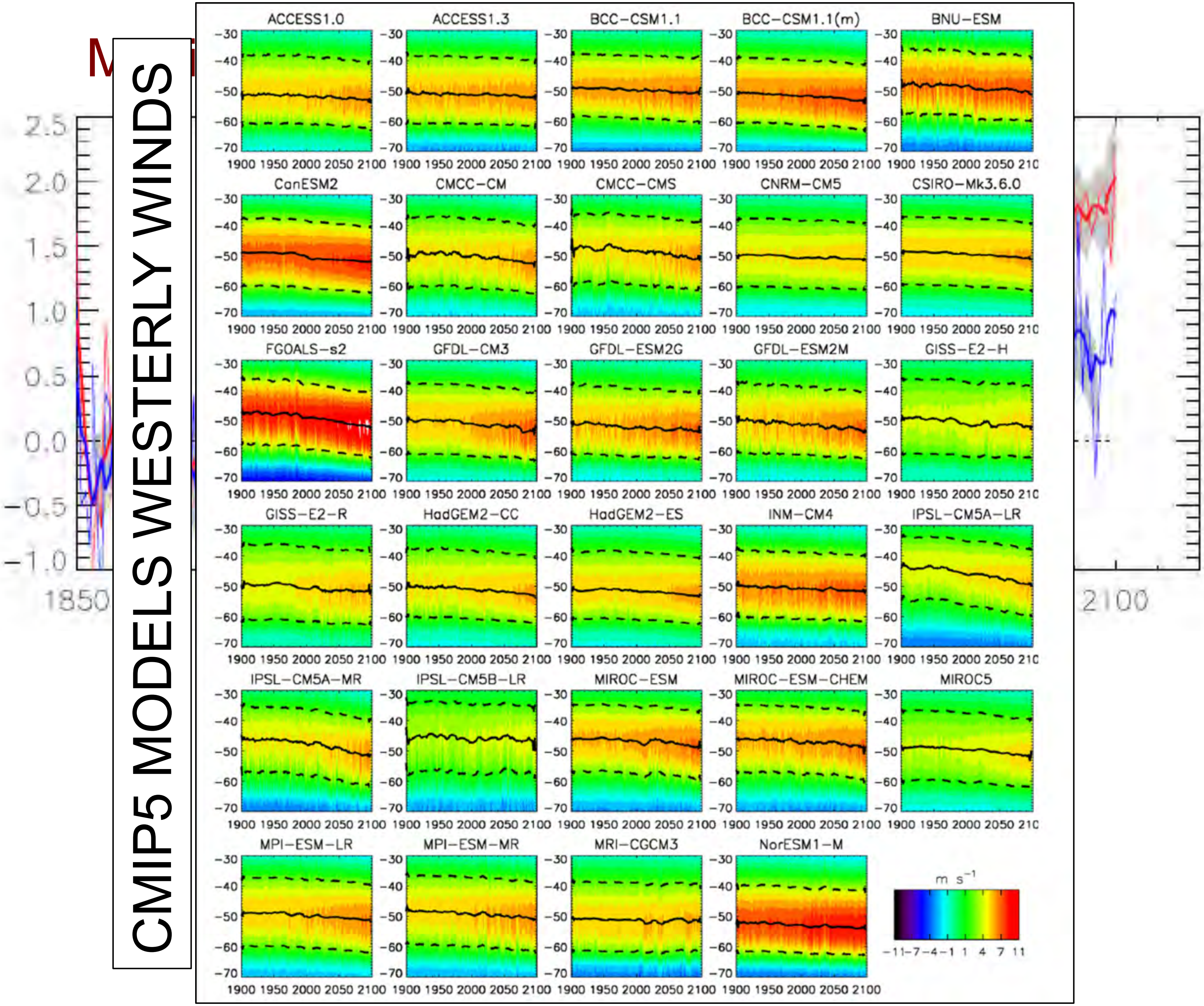
Thompson, England, et al. (2011) Nature Geosciences

Sen Gupta and England (2006)

Multi-model SAM index (Nov-Feb)



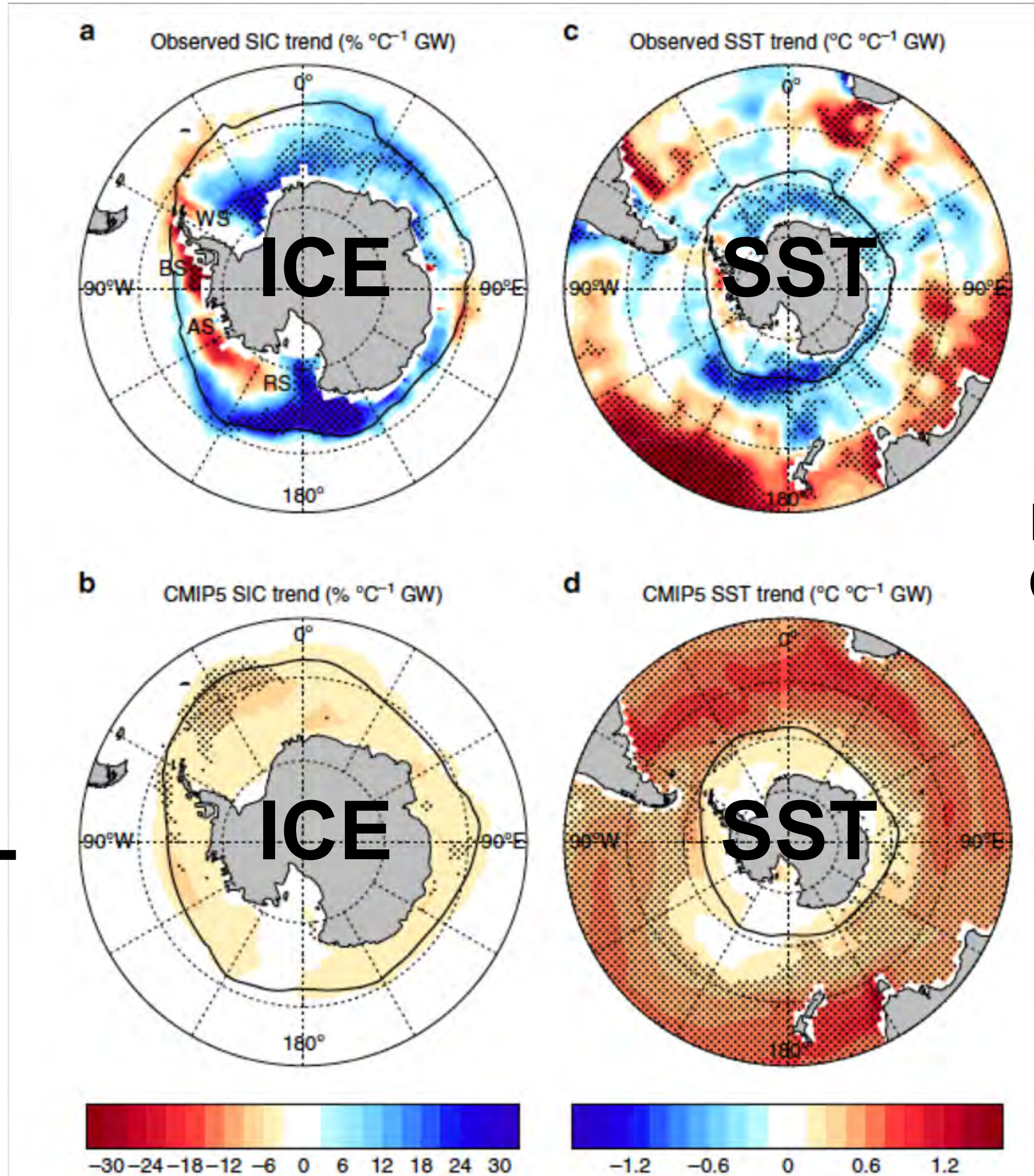
CMIP5 MODELS WESTERLY WINDS



But model mean does not match OBS transient cooling

OBS

MULTI MODEL MEAN



Purich, England, Cai, et al. (2016) Nature Comms

nature geoscience

ARTICLES

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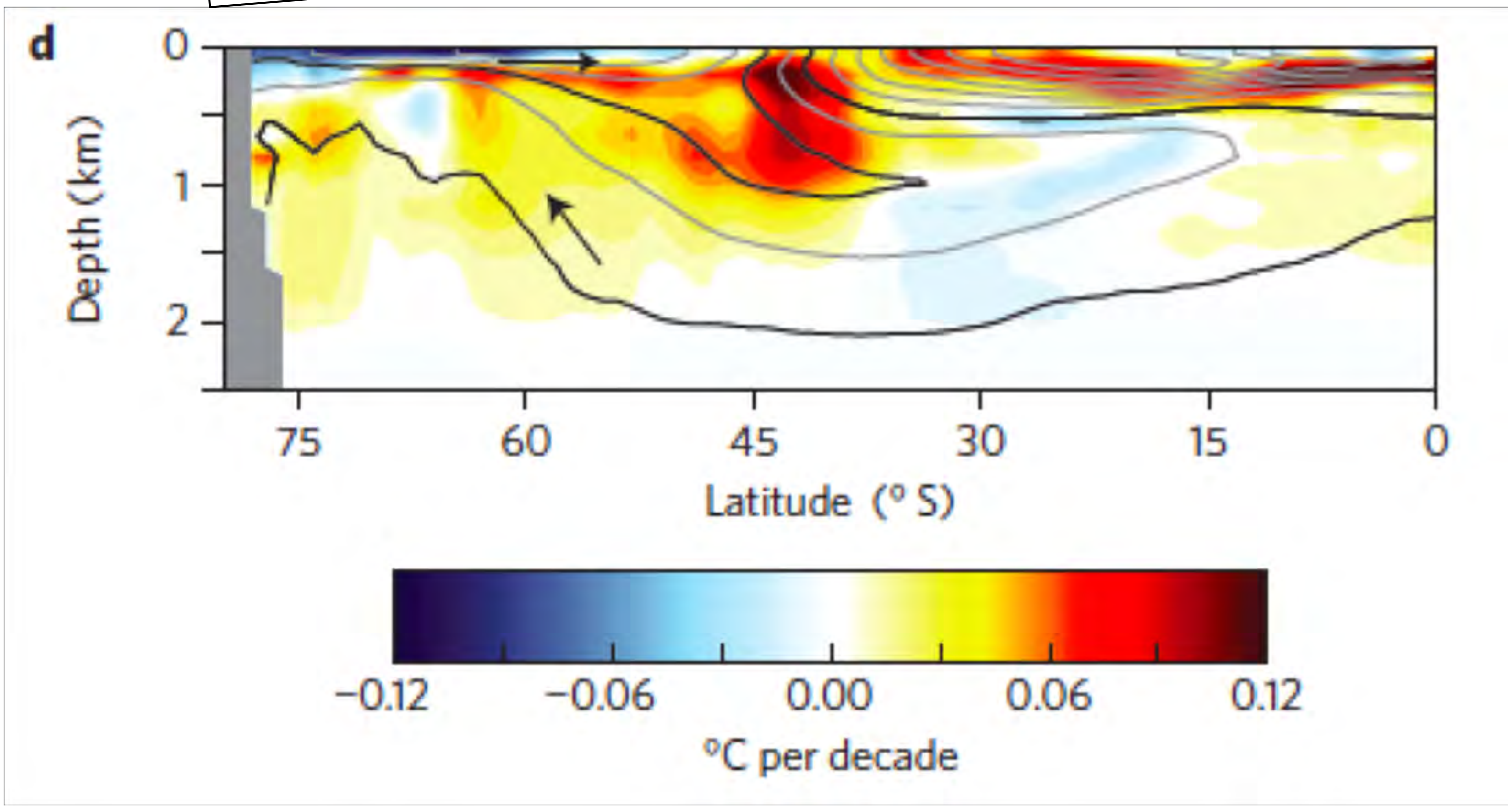
Southern Oc
upwelling ar

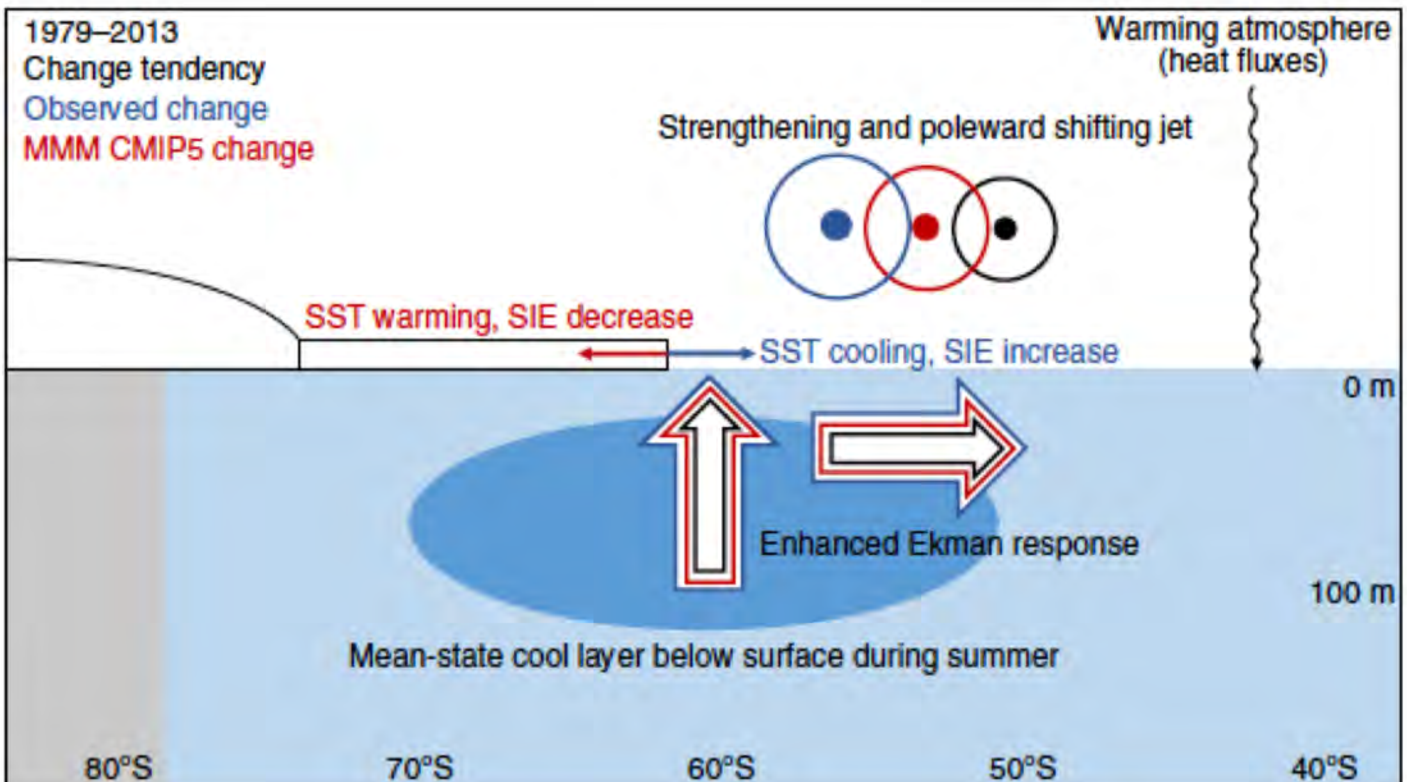
Kyle C. Armour[1*], John M ... and Emily R. Newsom[5]

Models should resolve these basic ocean physics……



So why don’t models capture this transient cooling?

Purich, England, et al. (2016) Nature Comms



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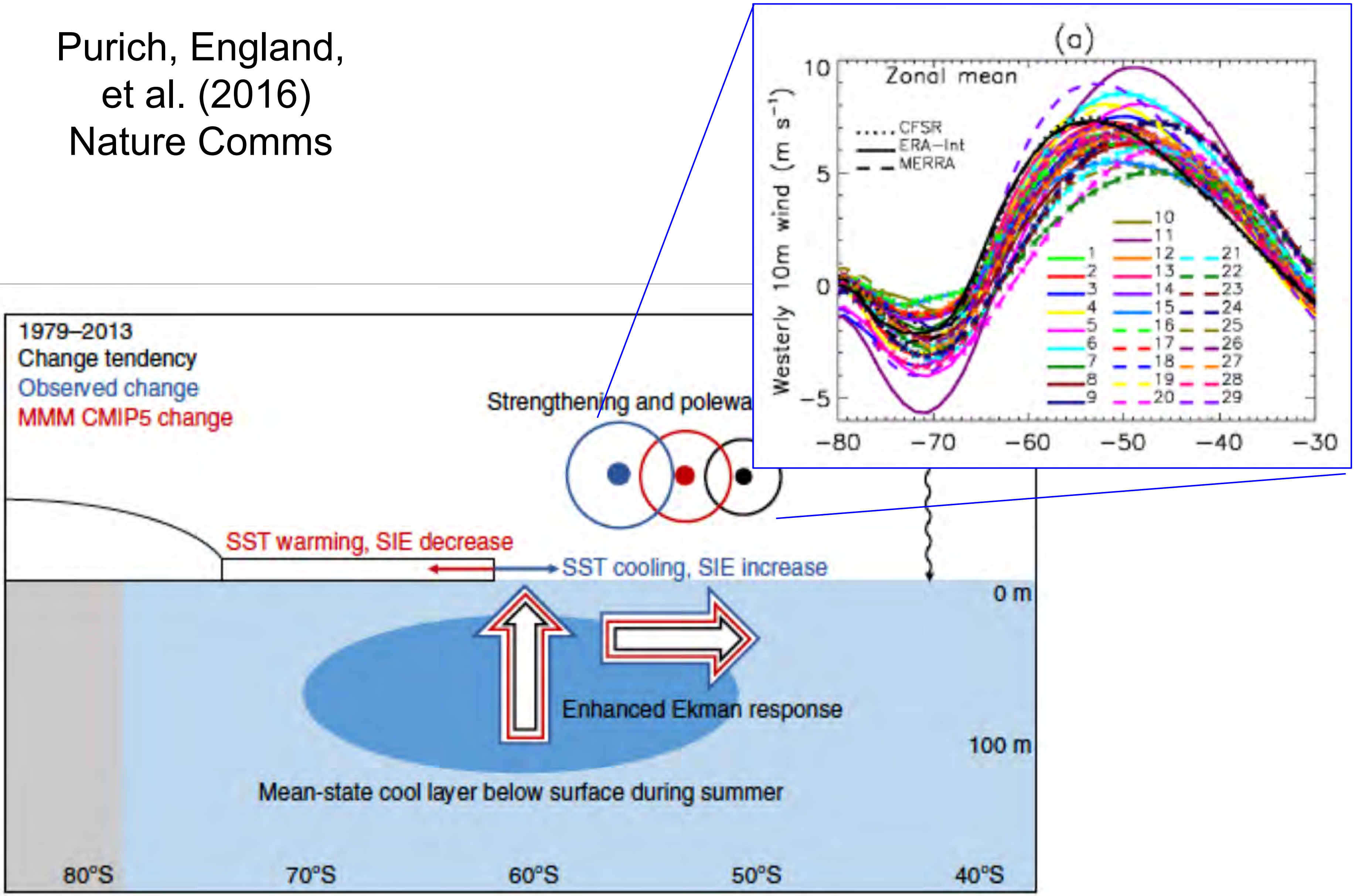

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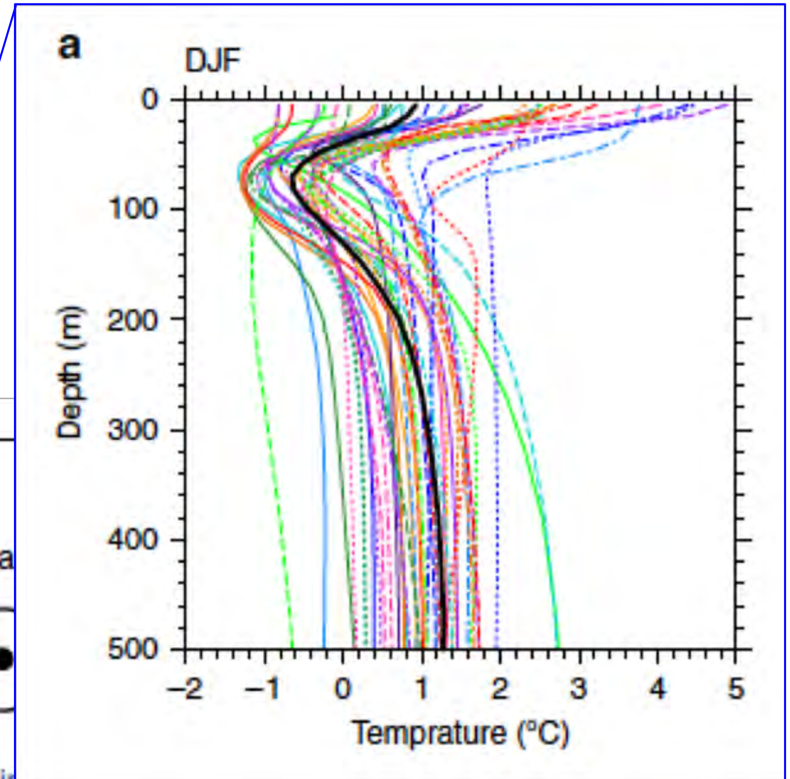

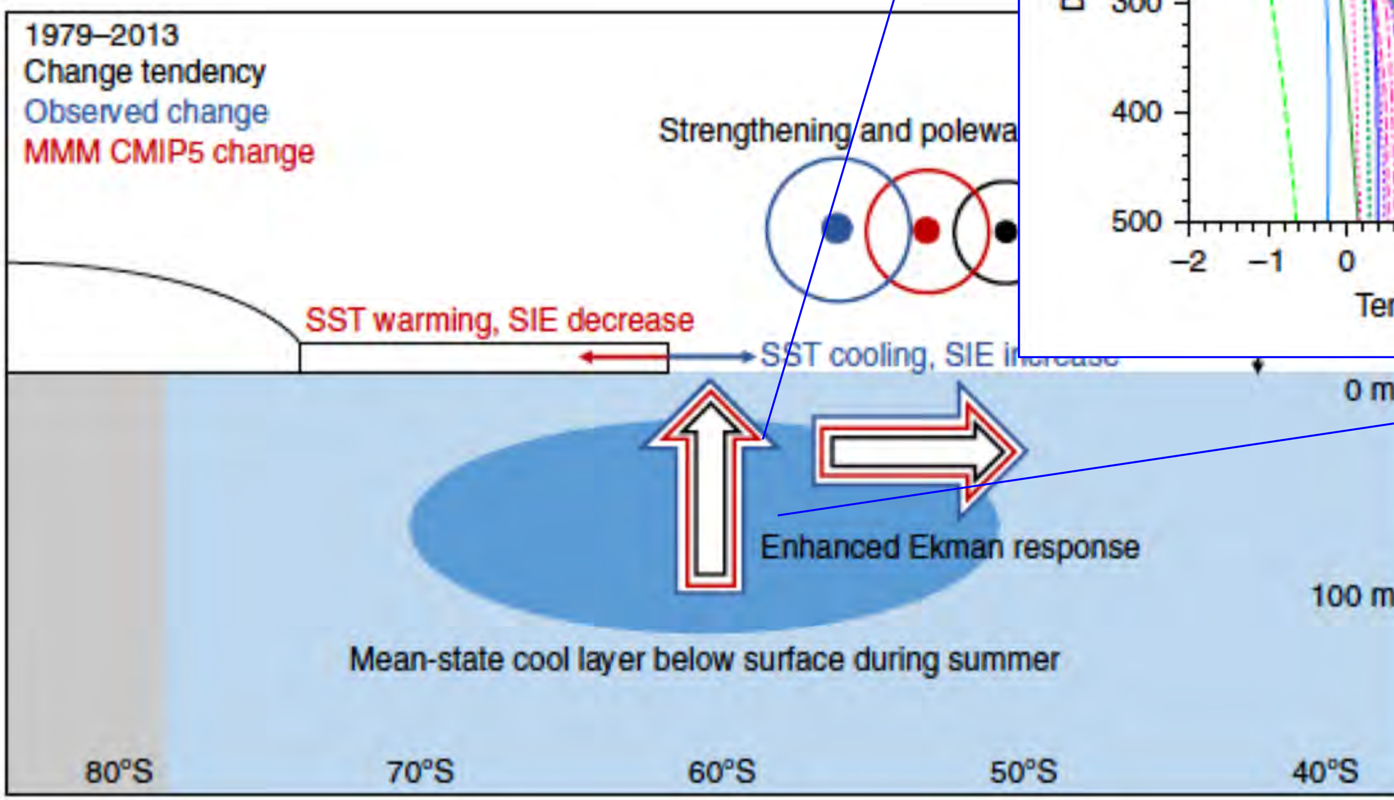

We can only observe one planet but we can simulate 100's.....

Models
- Single models
- CMIP5, CMIP6...

OBS MMM

Purich, England et al. 2018

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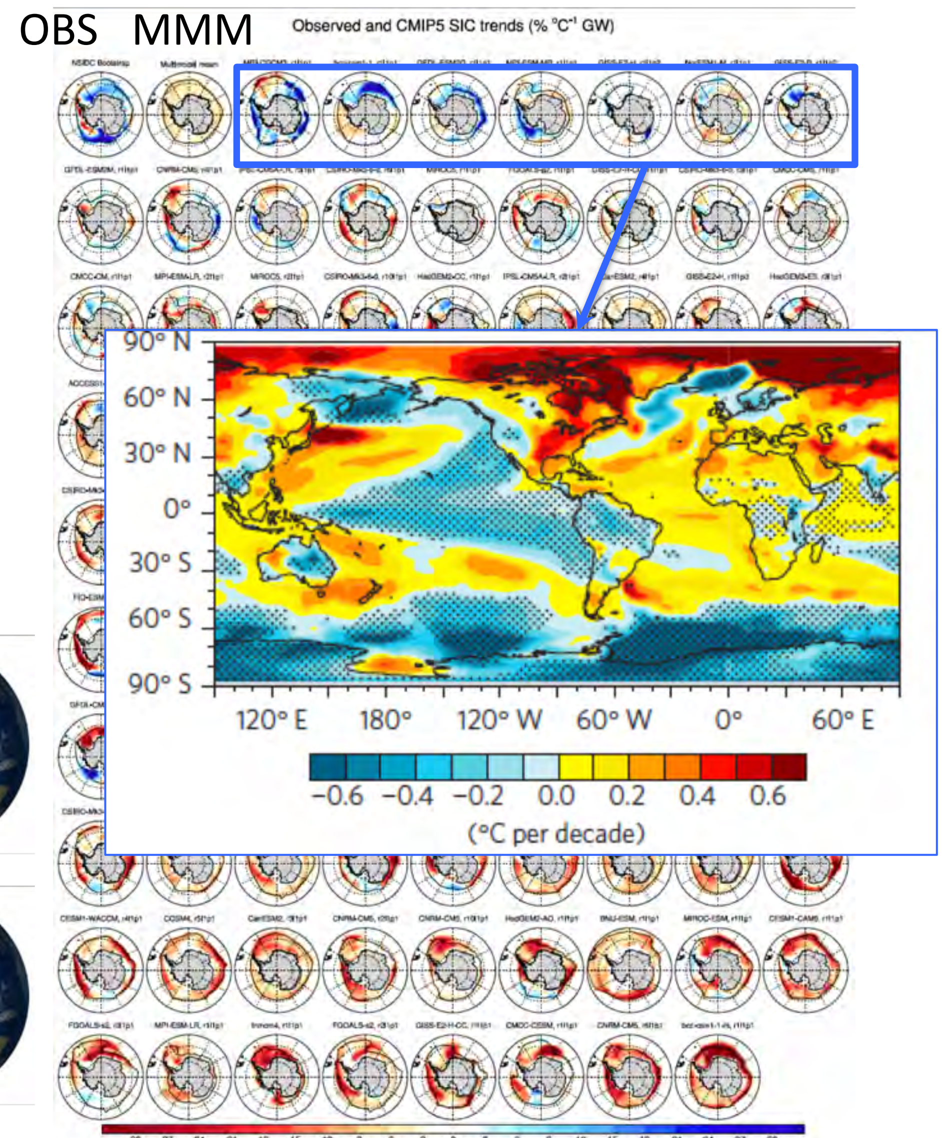
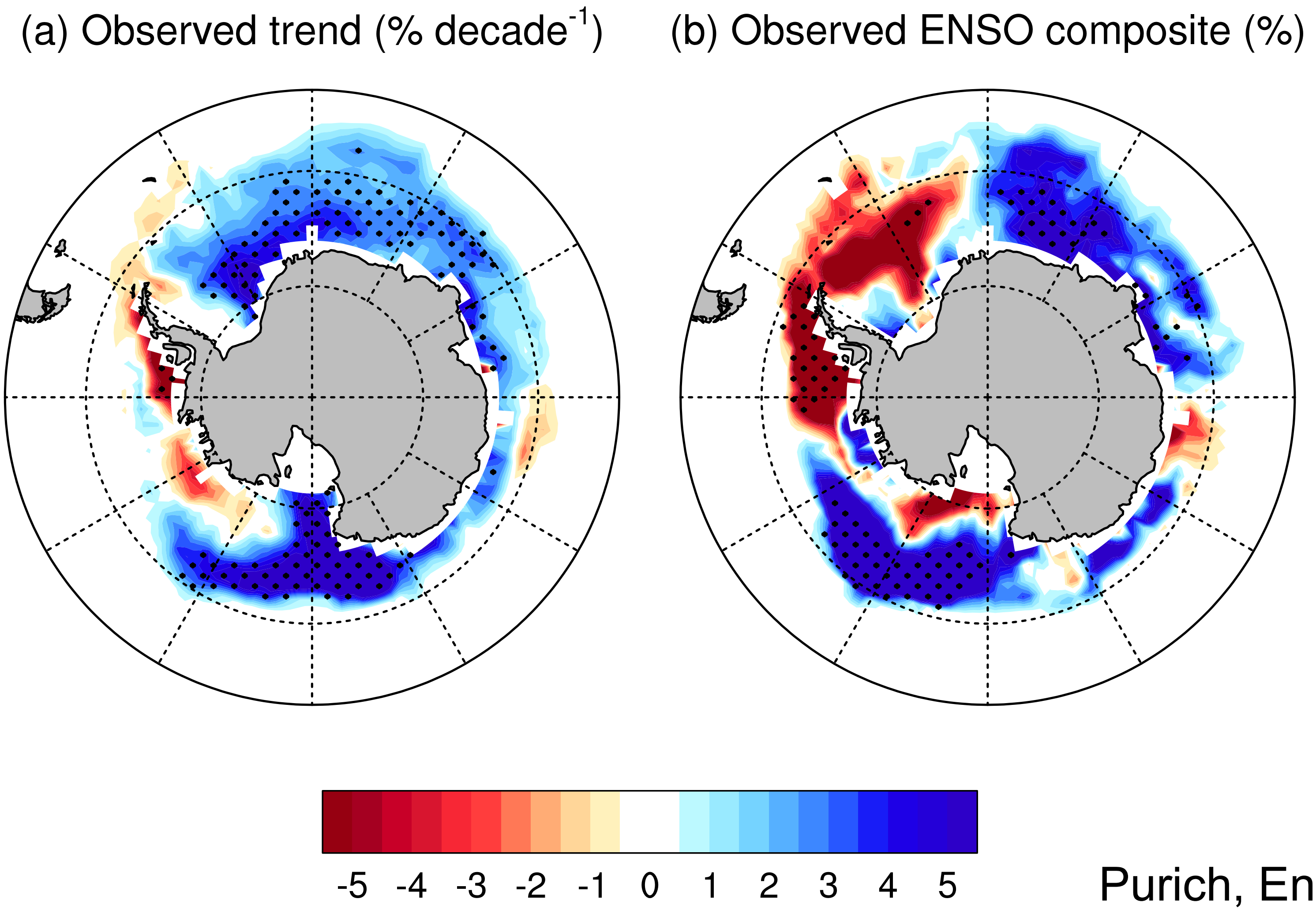


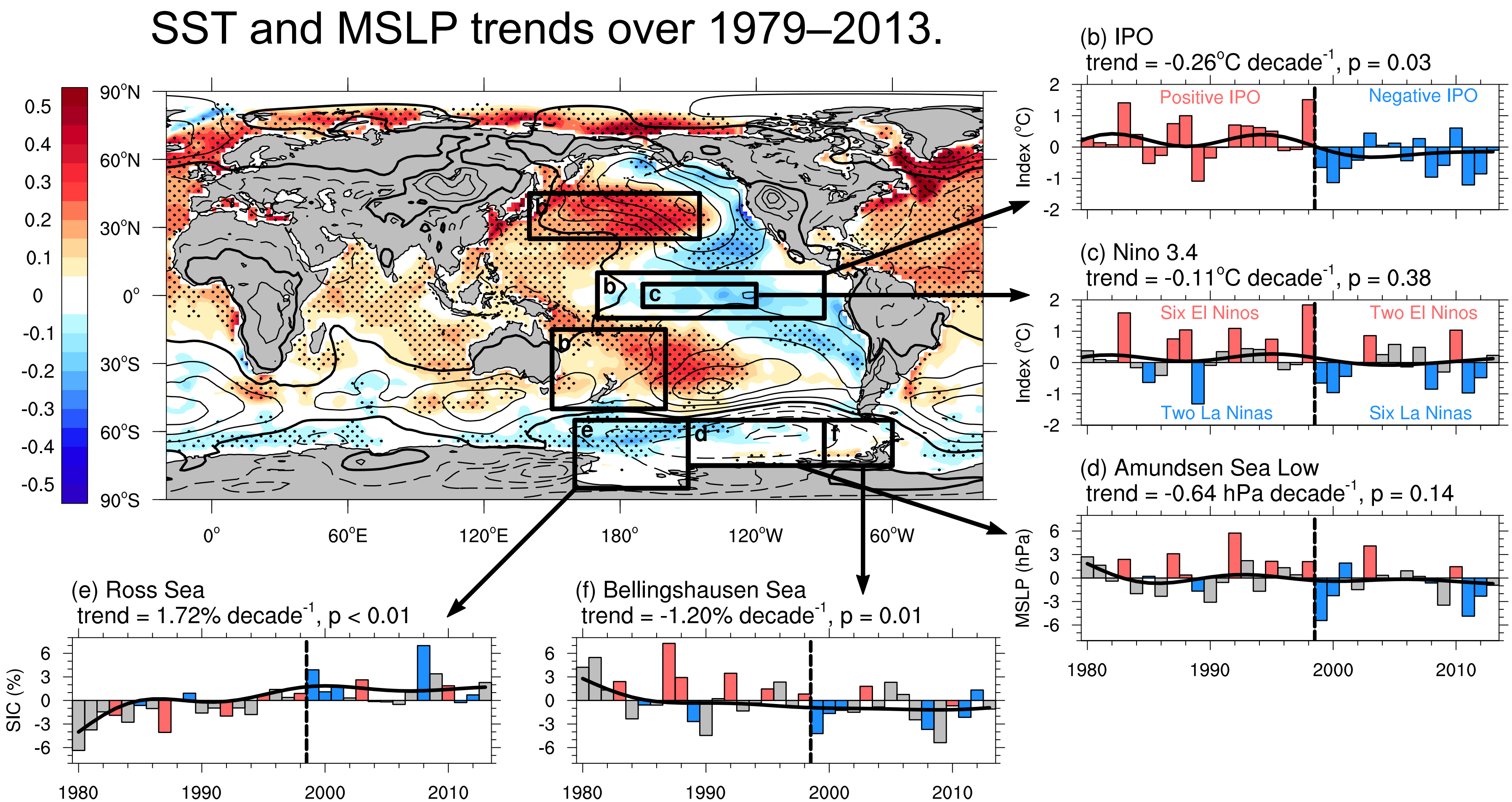
Purich, England et al. 2018

So, variability appears to be playing a role….

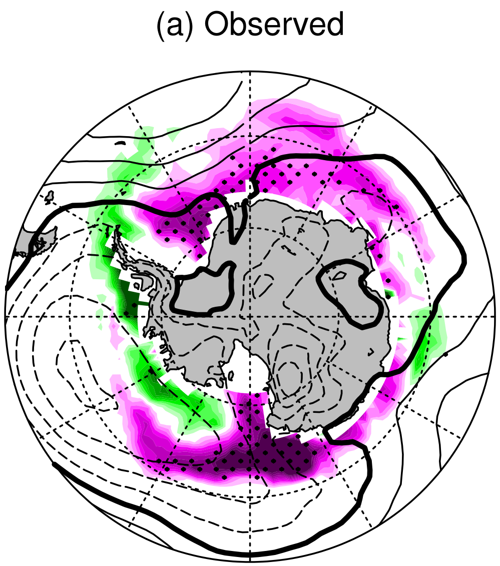


Purich, England, Cai, et al. (2016) Journal of Climate

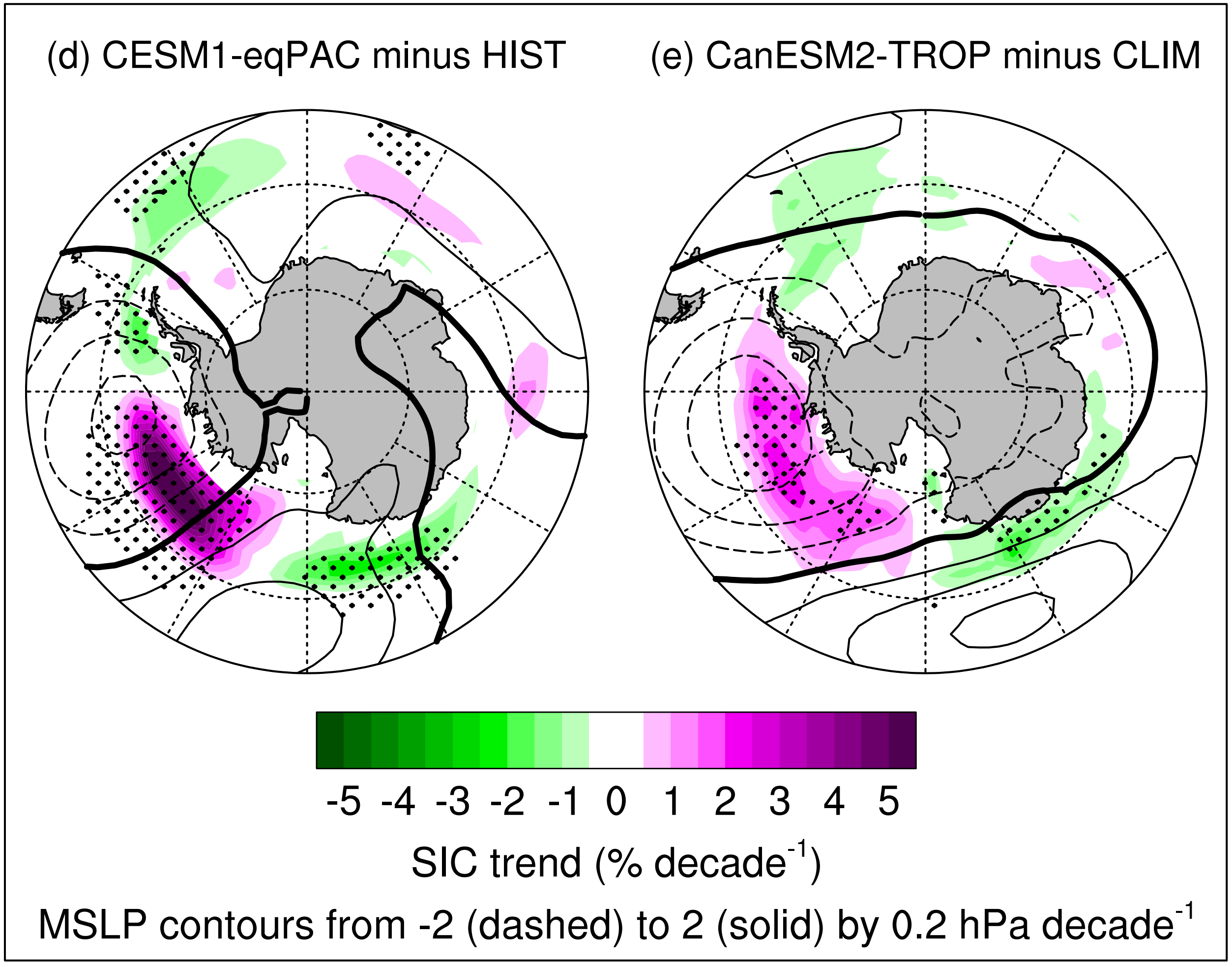
Pacemaker experiments help us understand how….



Purich, England, Cai, et al. (2016) Journal of Climate



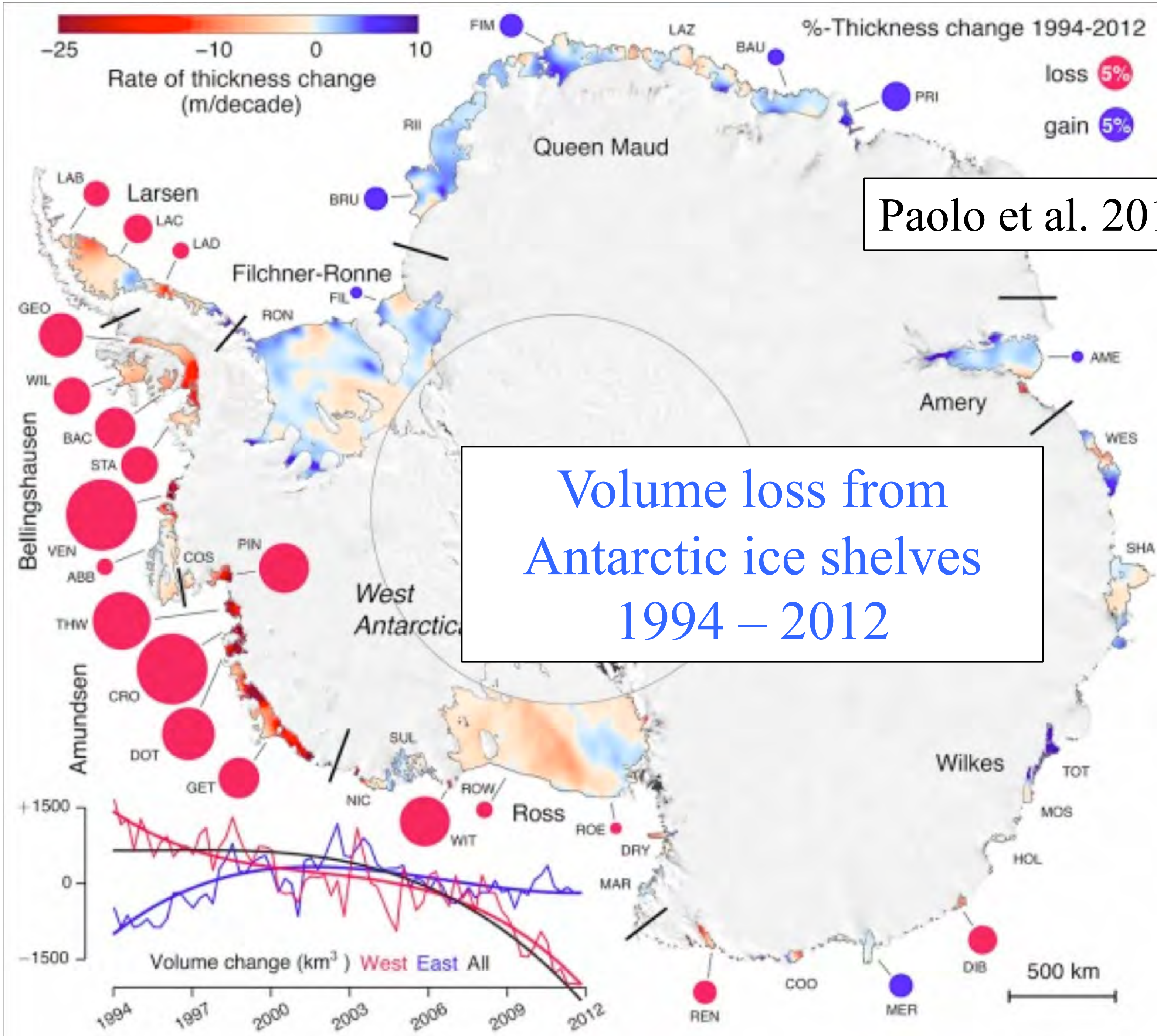
Pacemaker experiments



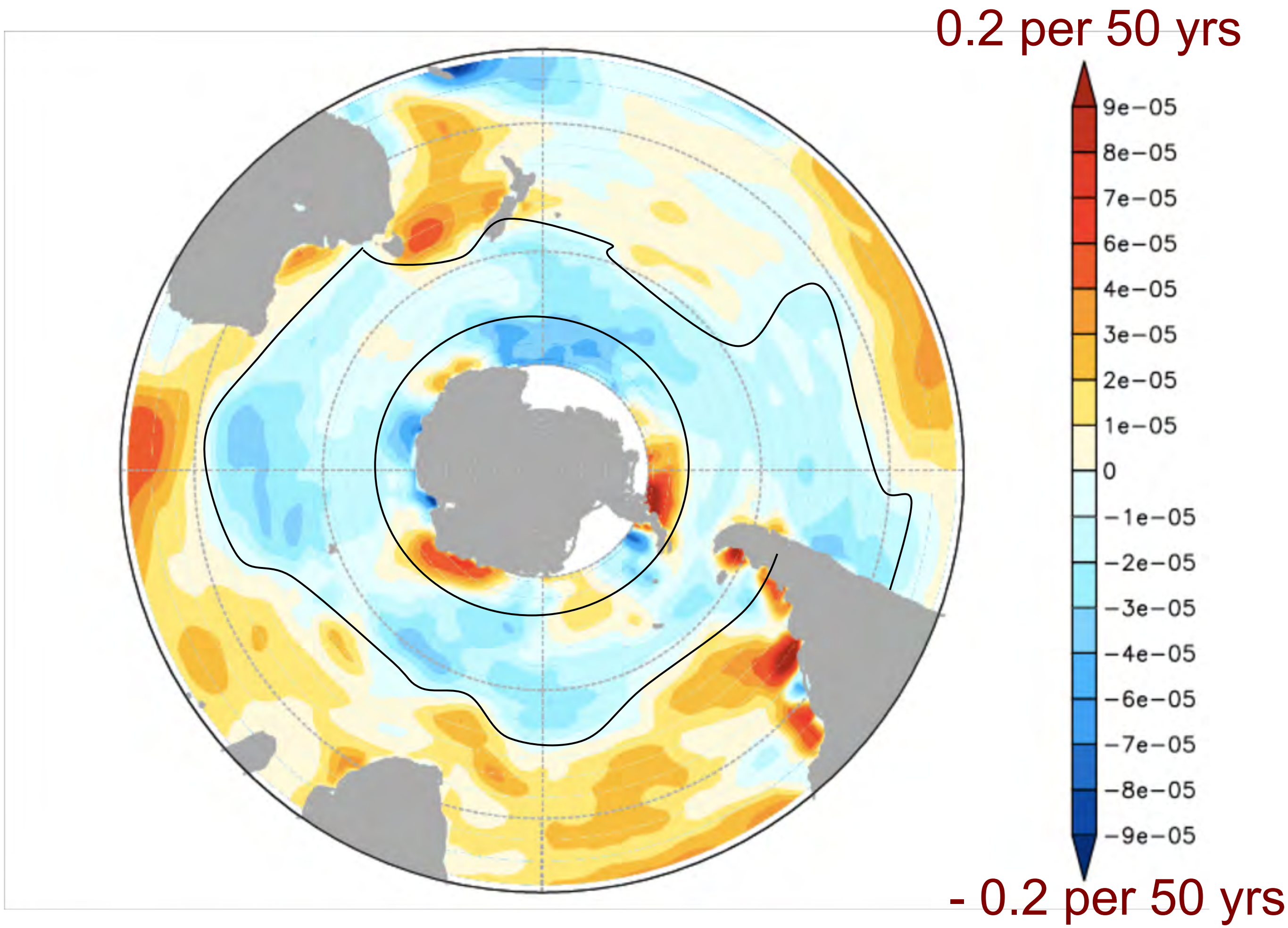
Purich, England, Cai, et al. (2016) Journal of Climate

Volume loss from Antarctic ice shelves 1994 – 2012

Paolo et al. 2015



Salinity trends 1950-2000



Durack and Wijffels (2010)

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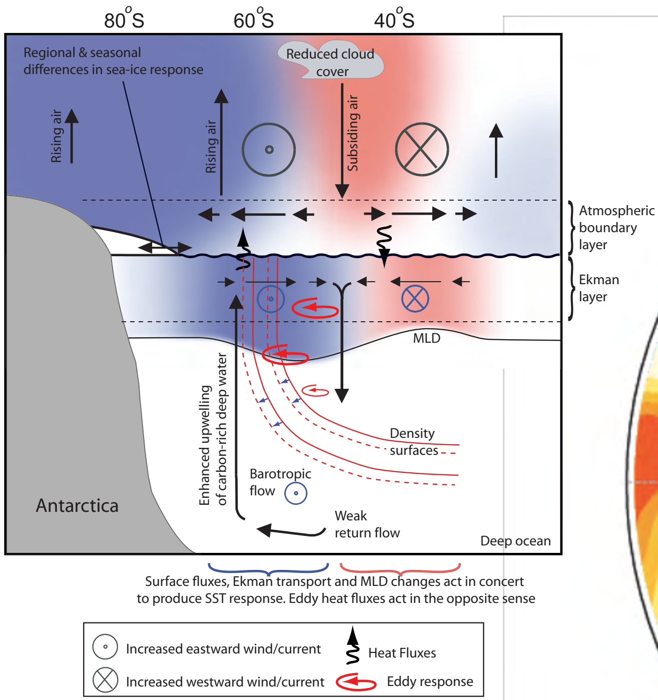
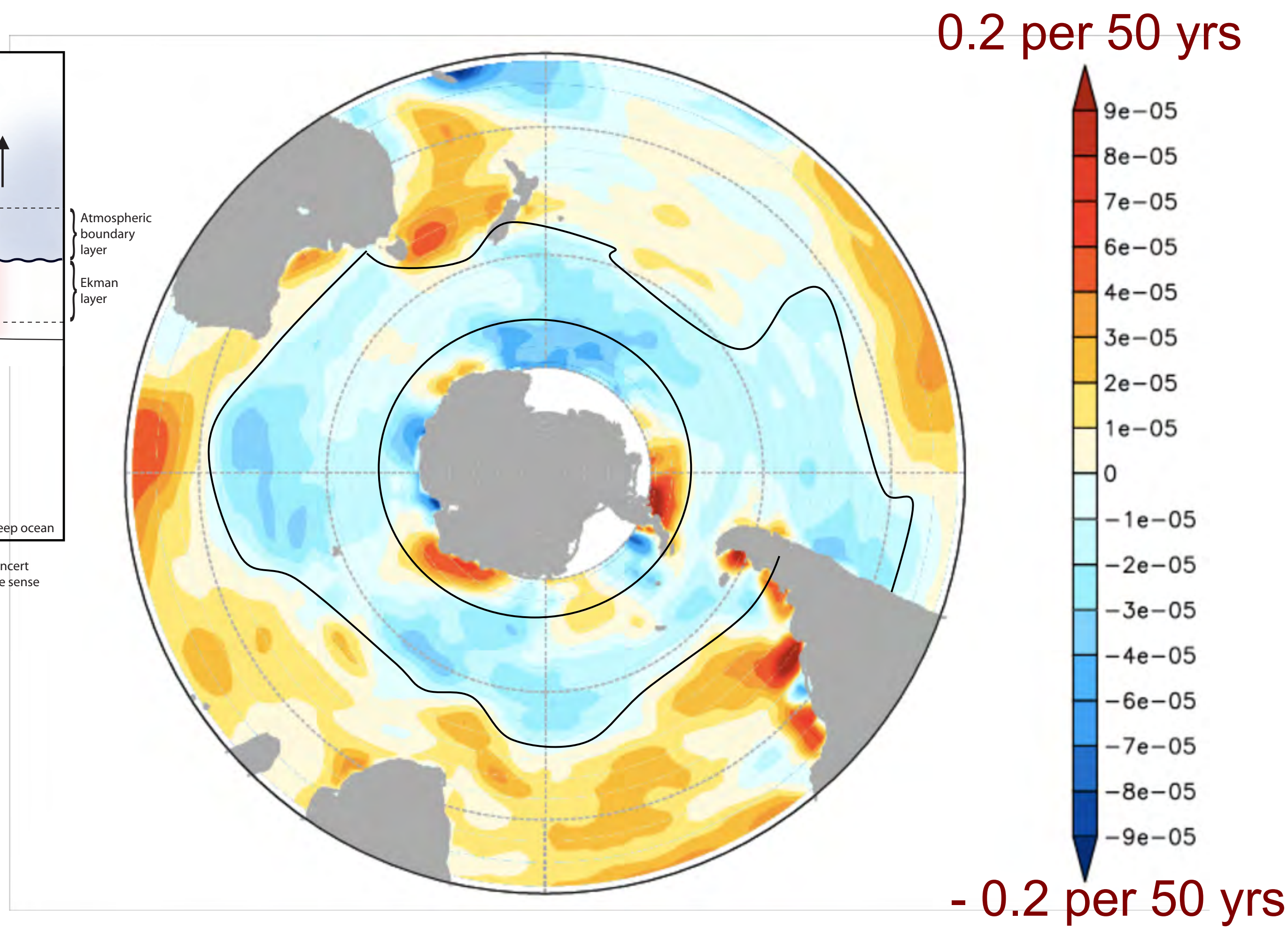
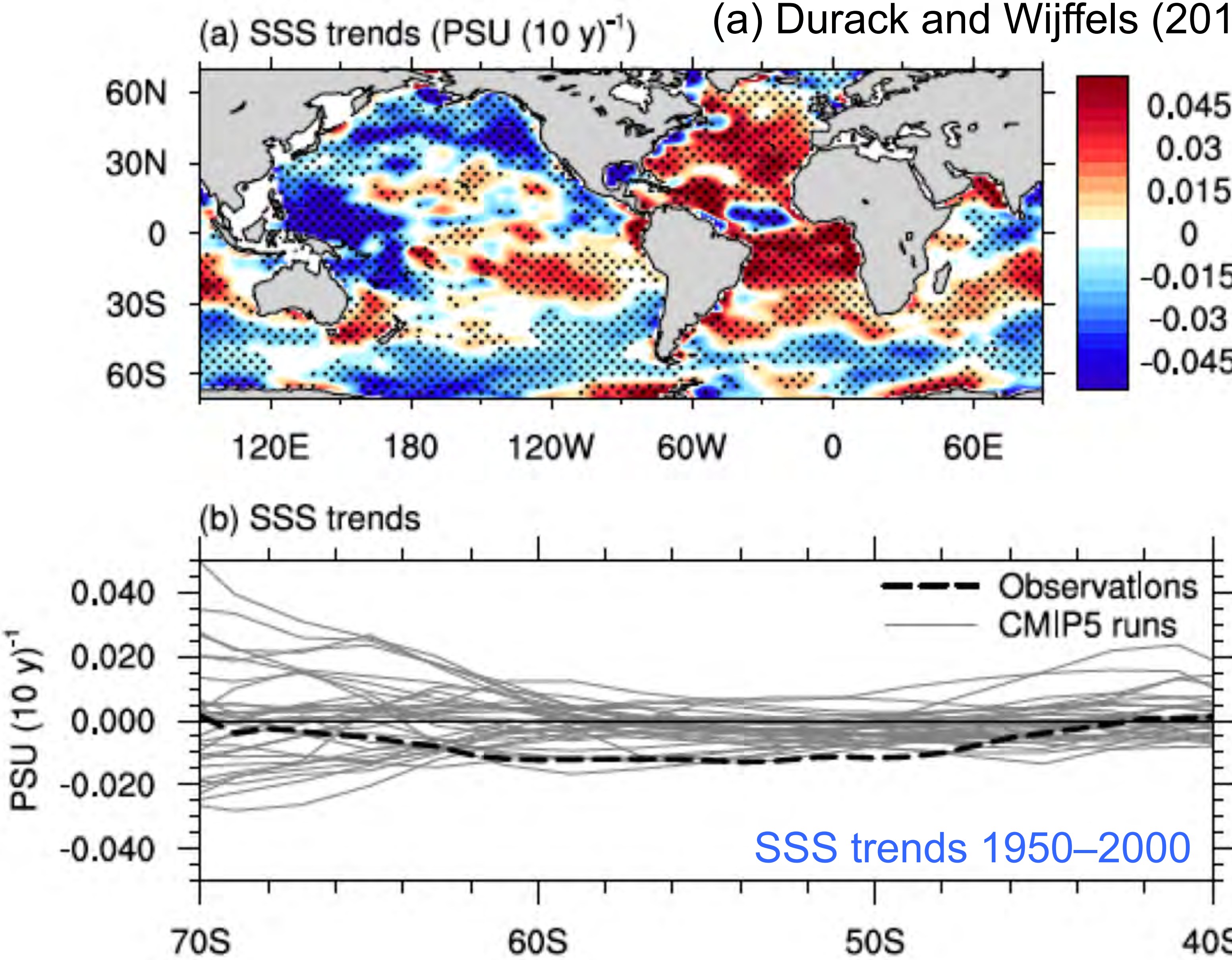




Durack and Wijffels (2010)

SSS trends over 1950–2000

(a) Durack and Wijffels (2010)



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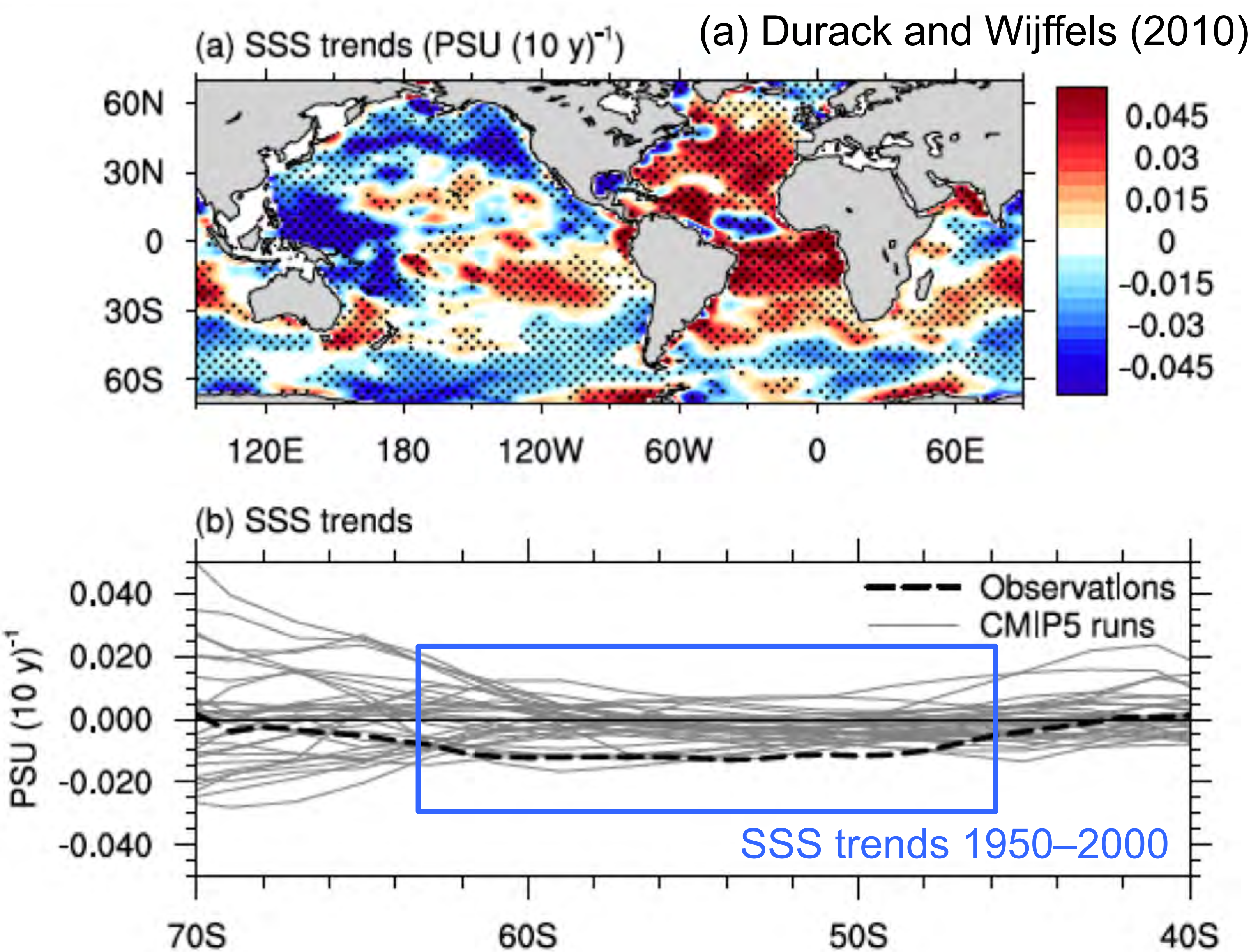

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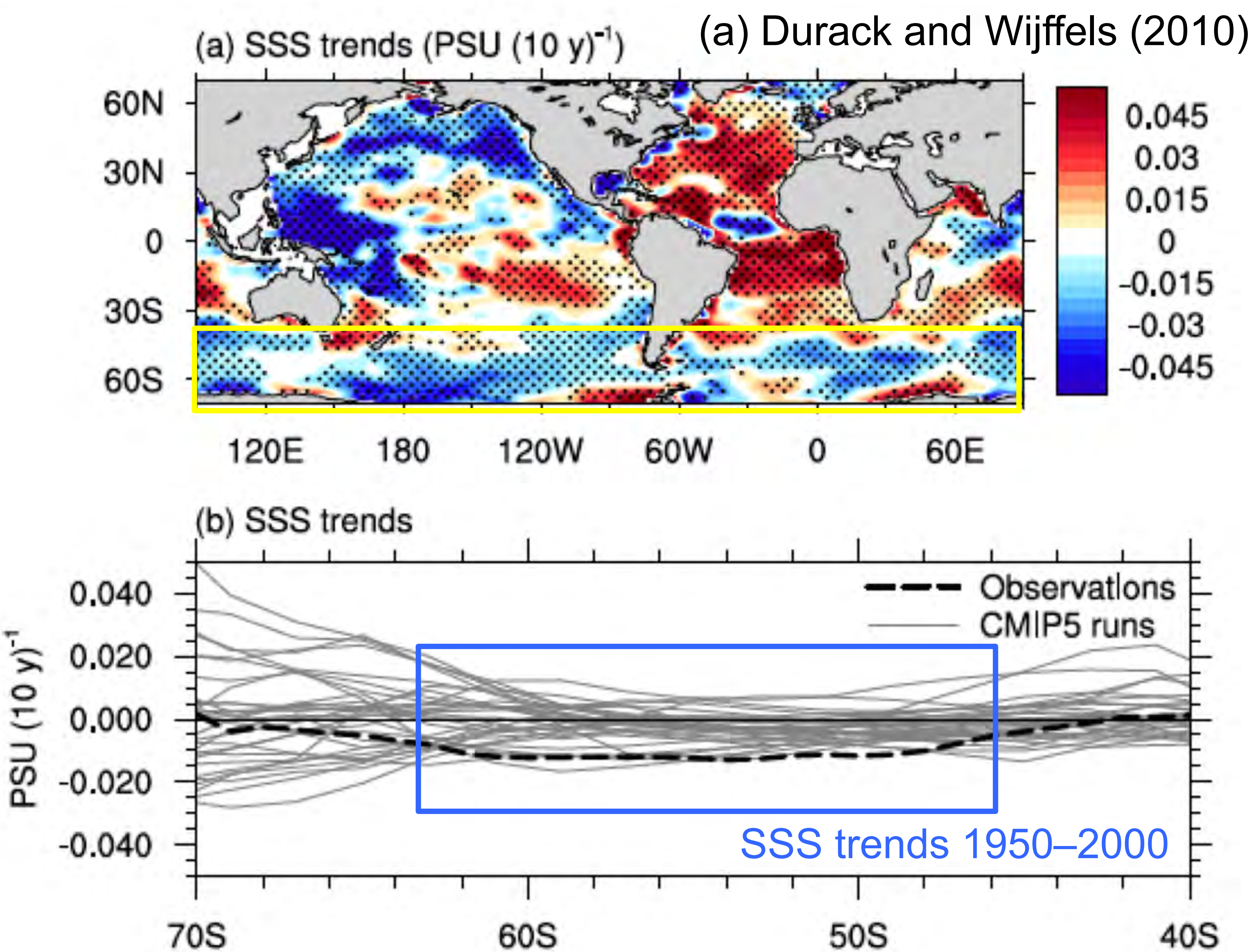
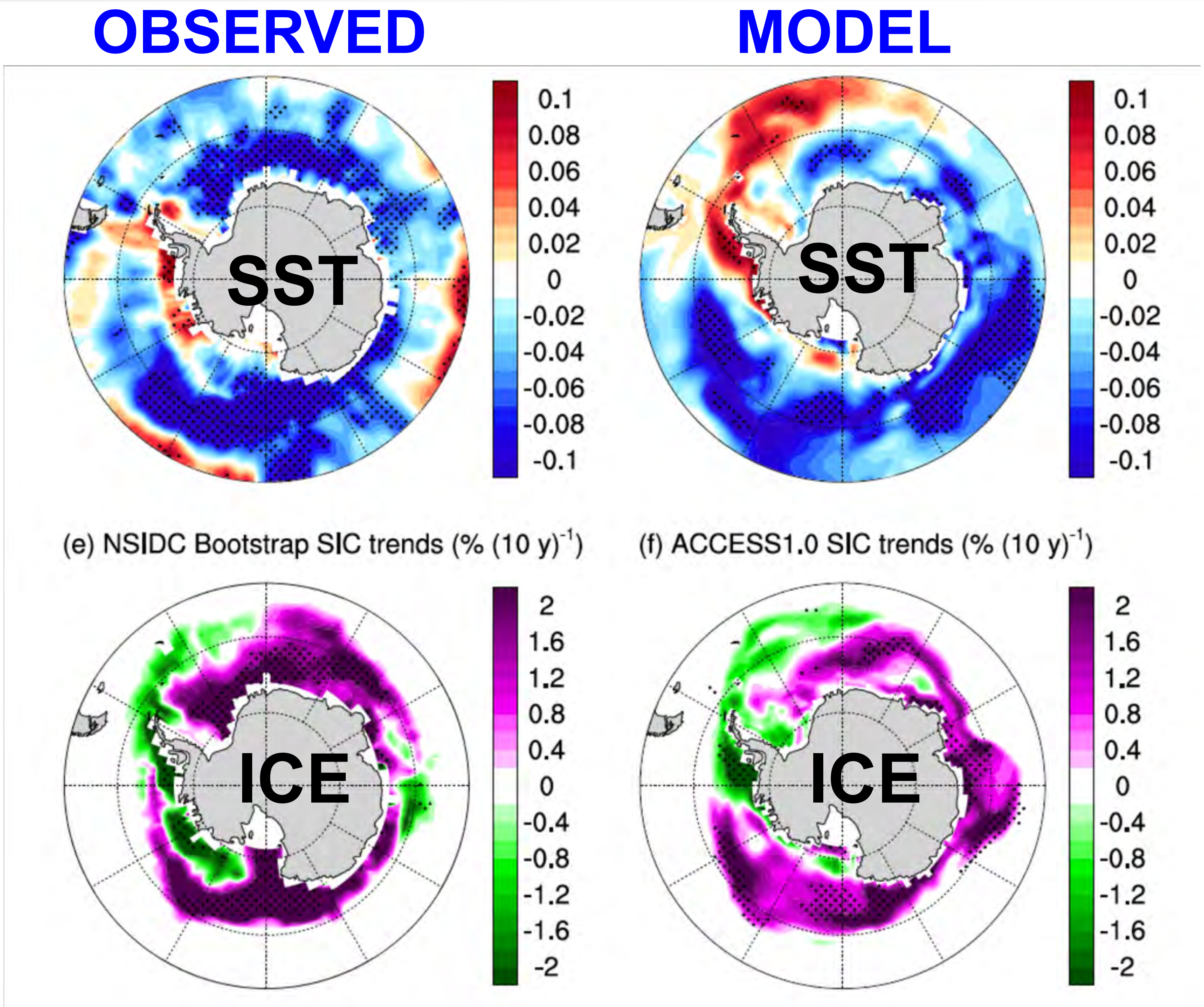


“Pacemaker” experiments with SO SSS restored to OBS



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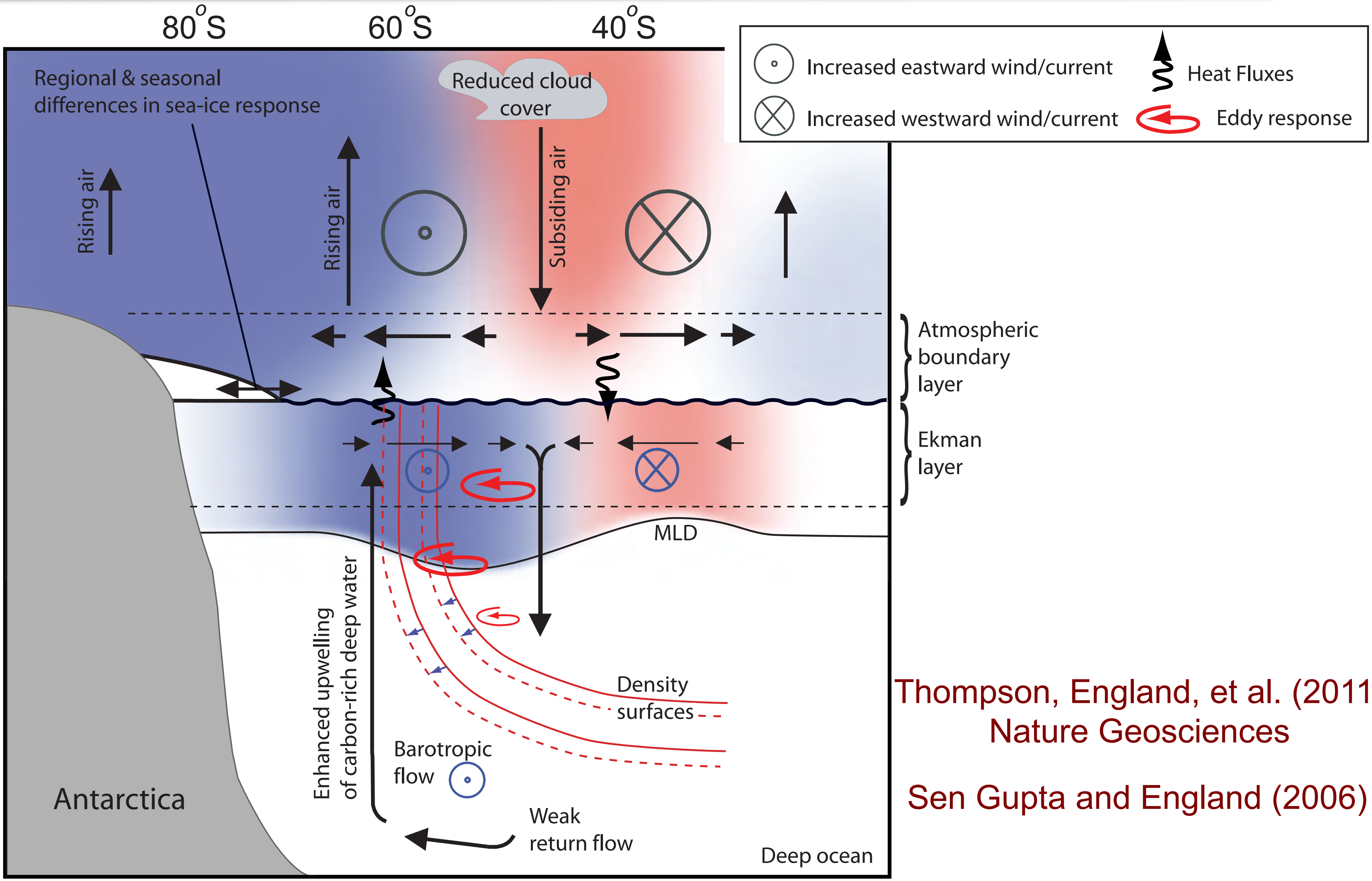


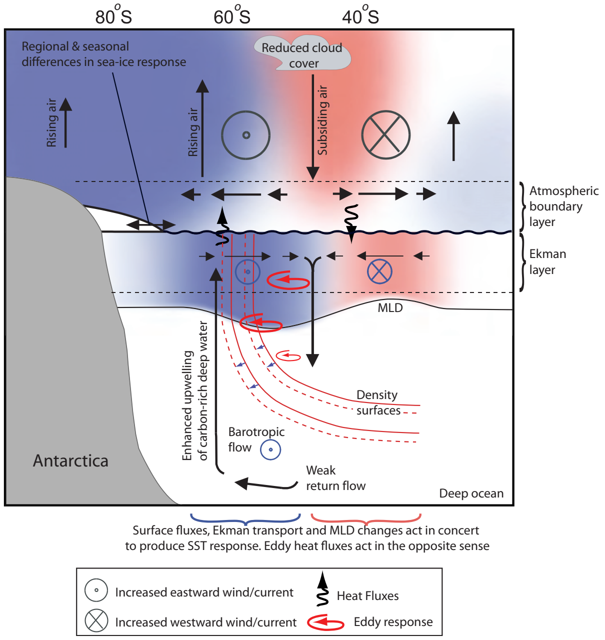
Surface fluxes, Ekman transport and MLD changes act in concert to produce SST response. Eddy heat fluxes act in the opposite sense

Thompson, England, et al. (2011) Nature Geosciences

Sen Gupta and England (2006)

Summing up....

- The **Southern Annular Mode** has made a major contribution to recent high-latitude cooling



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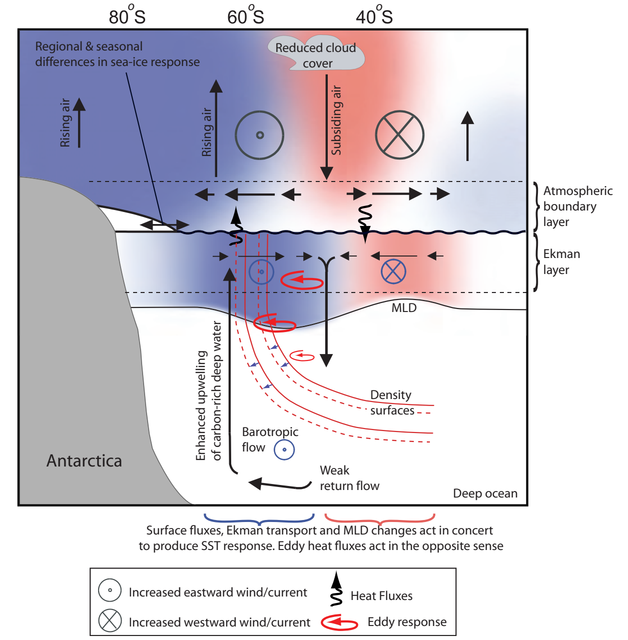
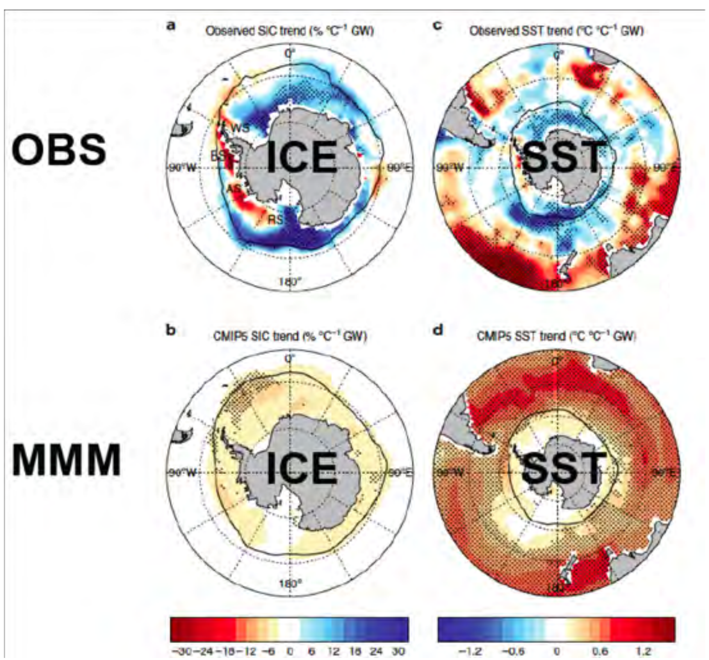
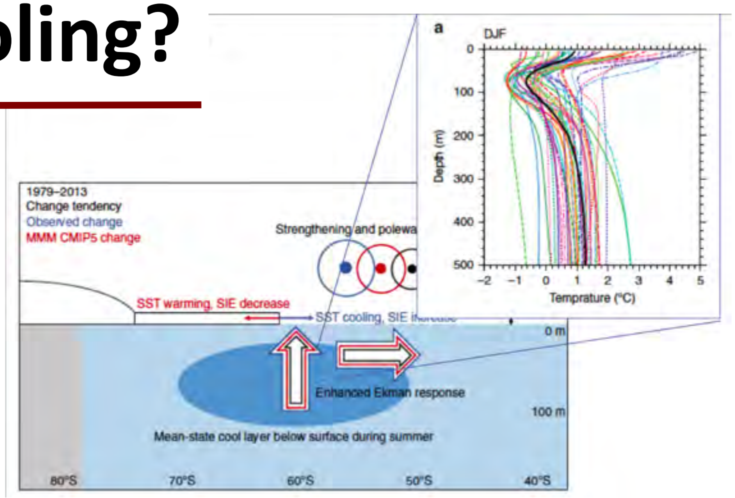


- Yet almost all **climate models fail to capture this cooling trend** and ice growth despite generally capturing a trend in the mid-latitude jet



Why do models “miss” the cooling?

1. **Model biases** in the midlatitude jet and interior temperature structure



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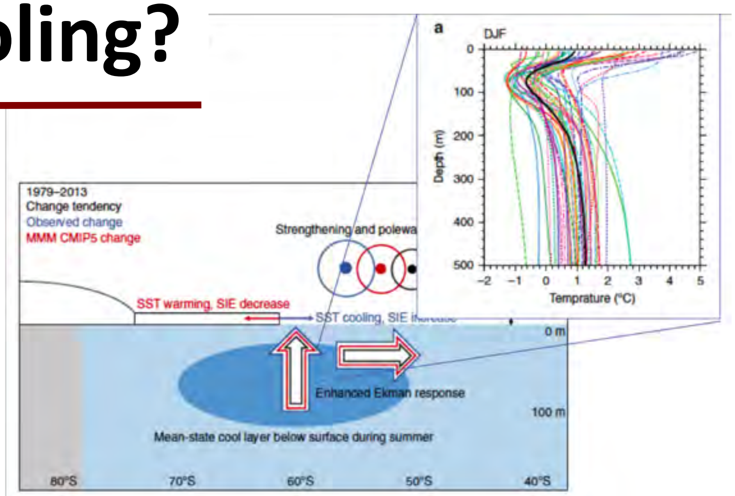

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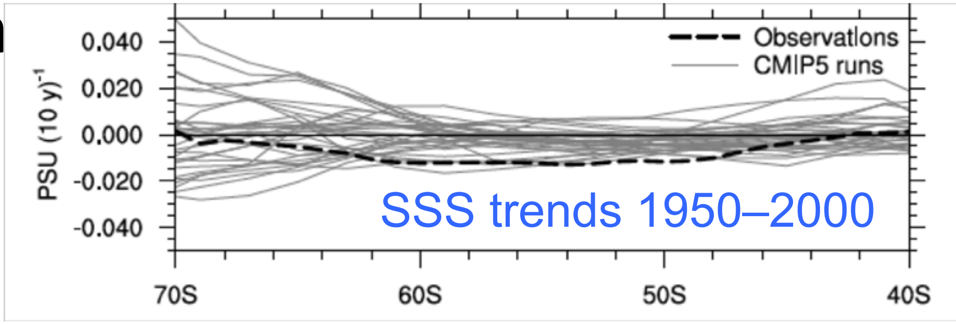

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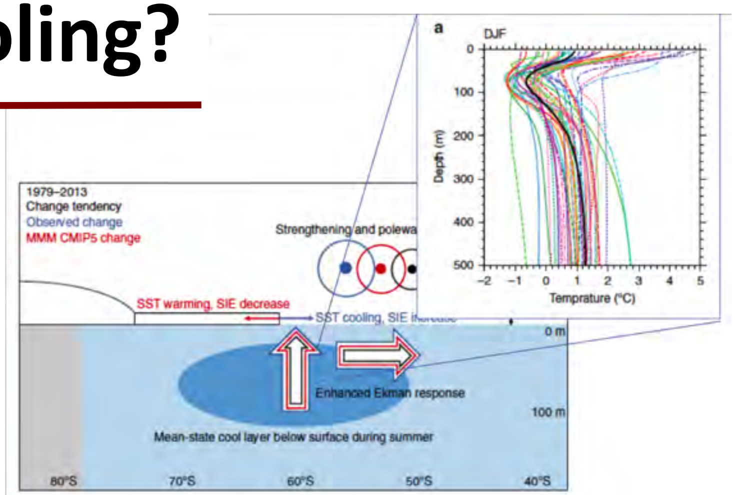

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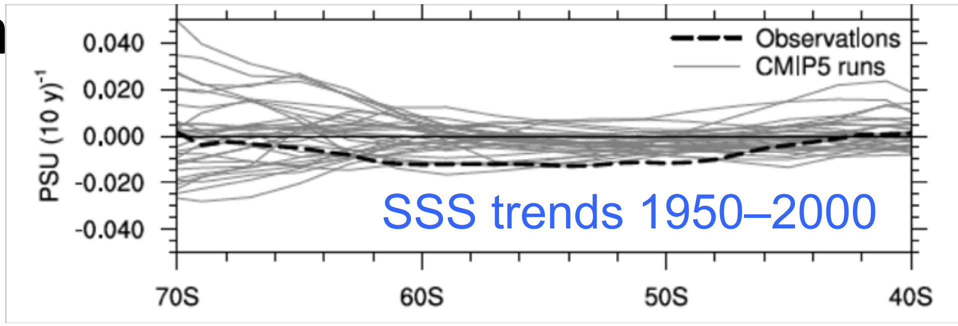
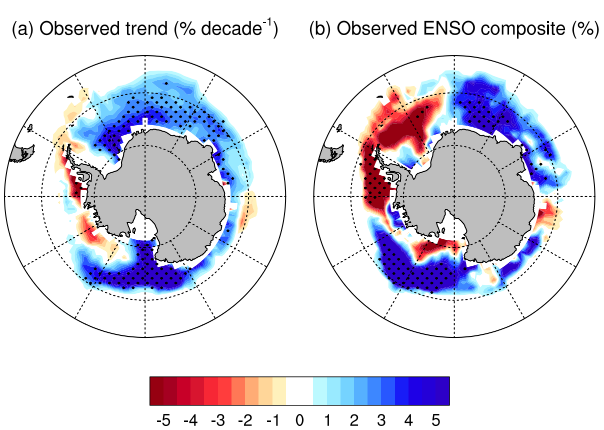


3. **Interannual – decadal variability** is also a significant player, via the IPO / ENSO / Atlantic



Workshop Questions:

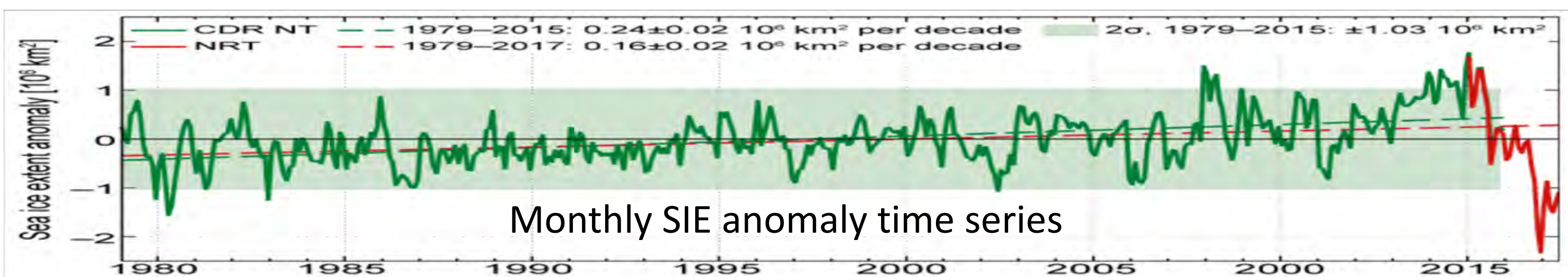
- How should we design a climate model to obtain better predictions of polar climates on timescales of decades?

  - Difficult bars keep getting set!
  - Mean state biases – OGCM, AGCM, sea-ice
  - Diversity remains critical
  - Tropical teleconnections also critical
  - SAM predictability so poor

....apart from forced signal?

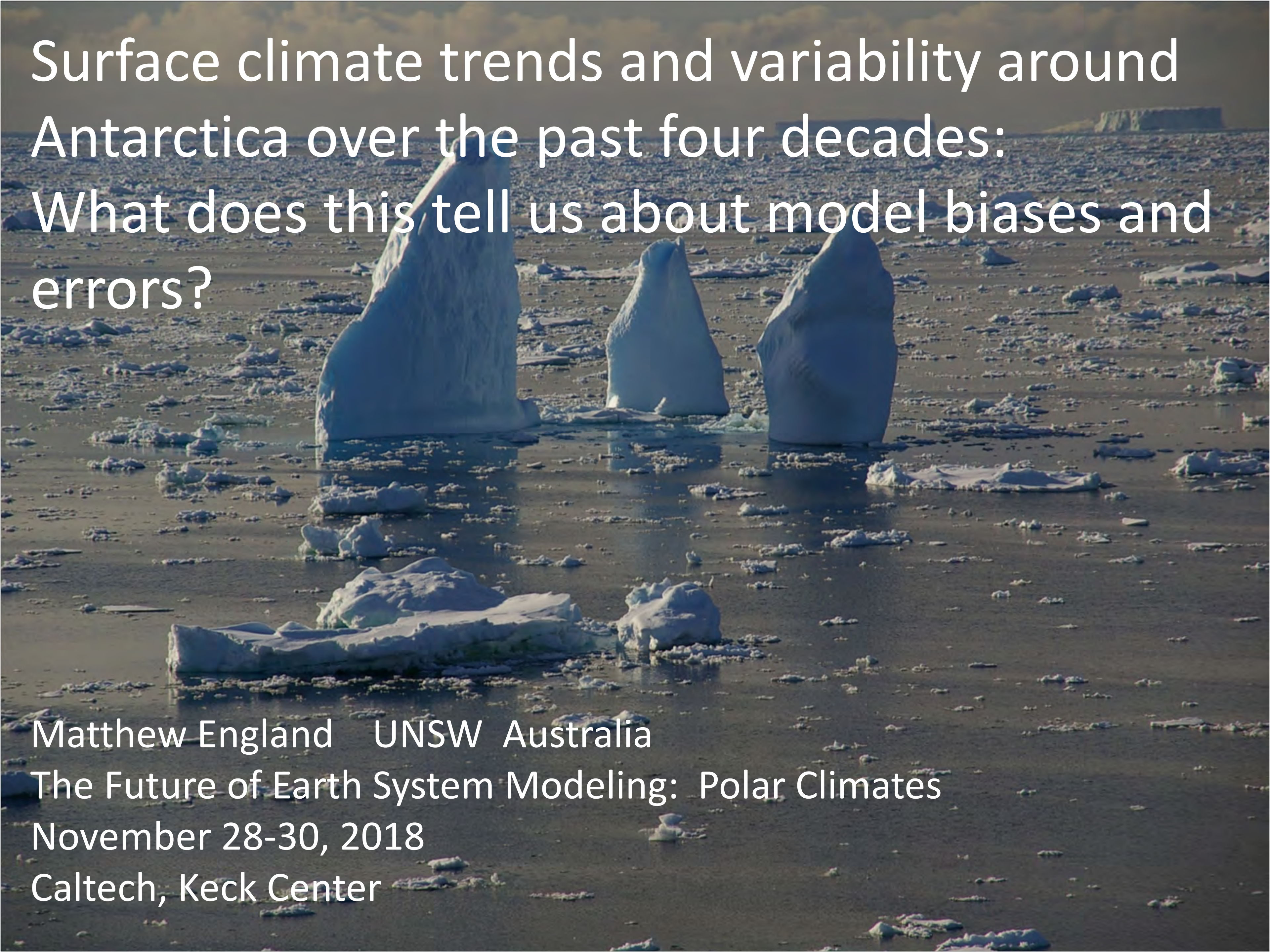
Workshop Questions:

- How can we integrate observations better with models?
  - For large-scale interannual – decadal processes and predictions, evaluate models against key metrics and 'predictable' events
- What additional observations would help improving models?



Monthly SIE anomaly time series

Schlosser et al. (2018)



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Matthew England   UNSW Australia

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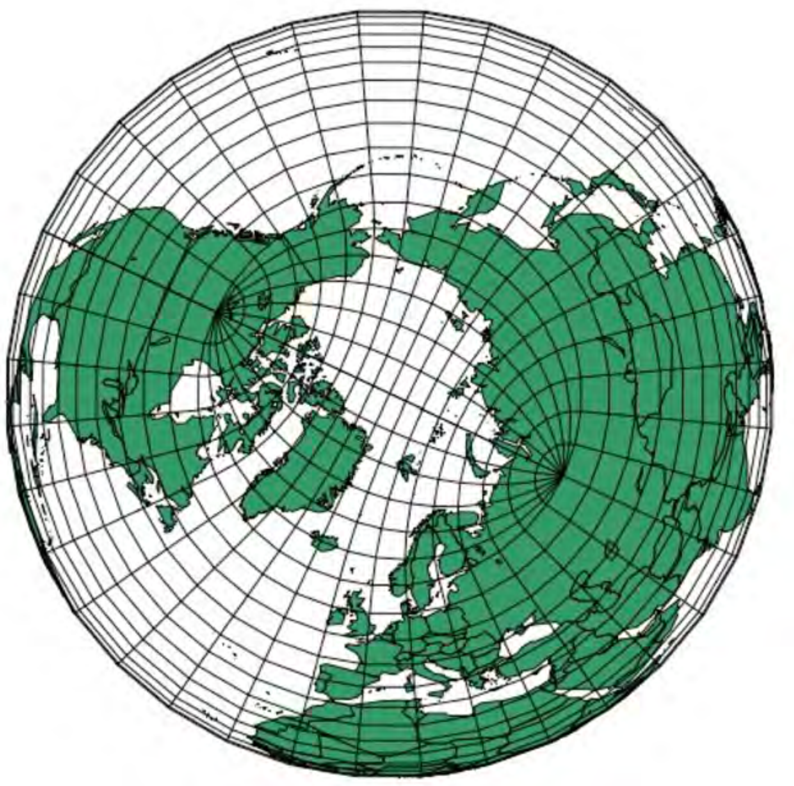
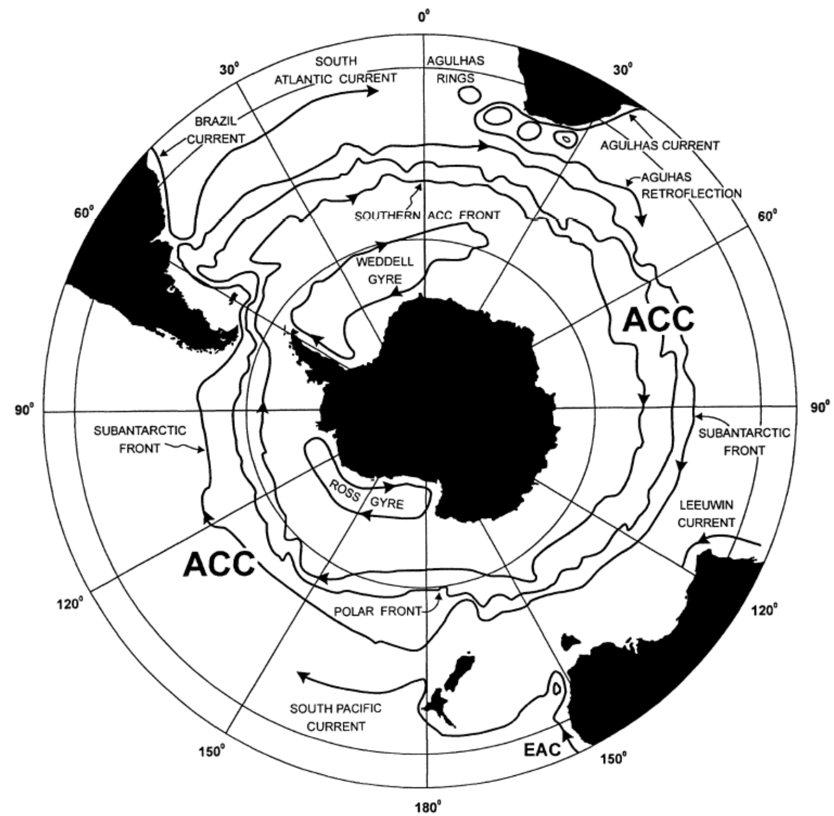
Marked geometry contrast across the hemispheres





North Pole:
Ocean + sea-ice
Surrounded by **land**

South Pole:
Land mass + Land ice
Surrounded by **oceans**

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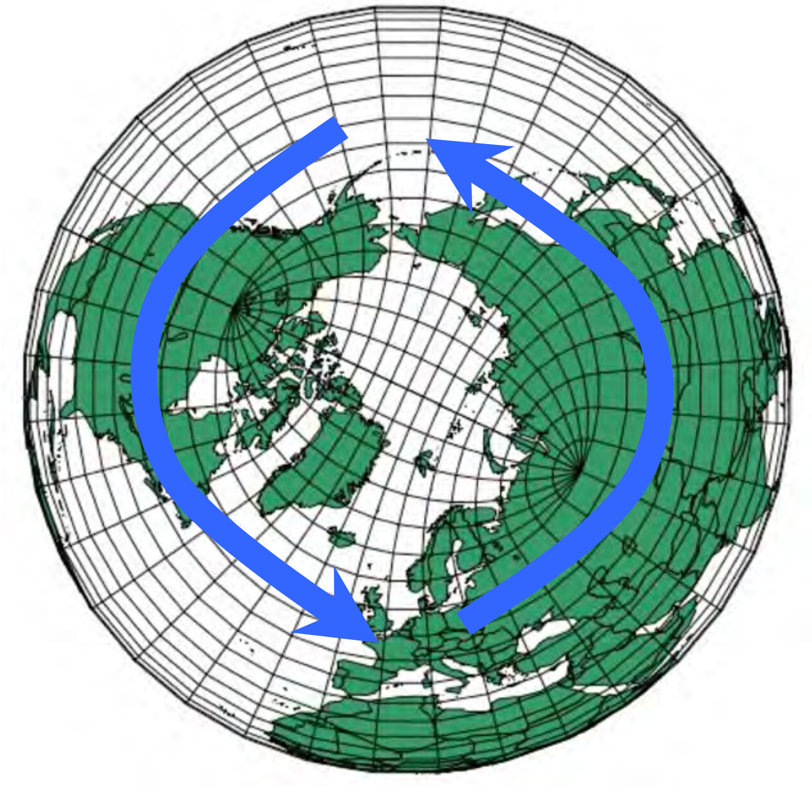

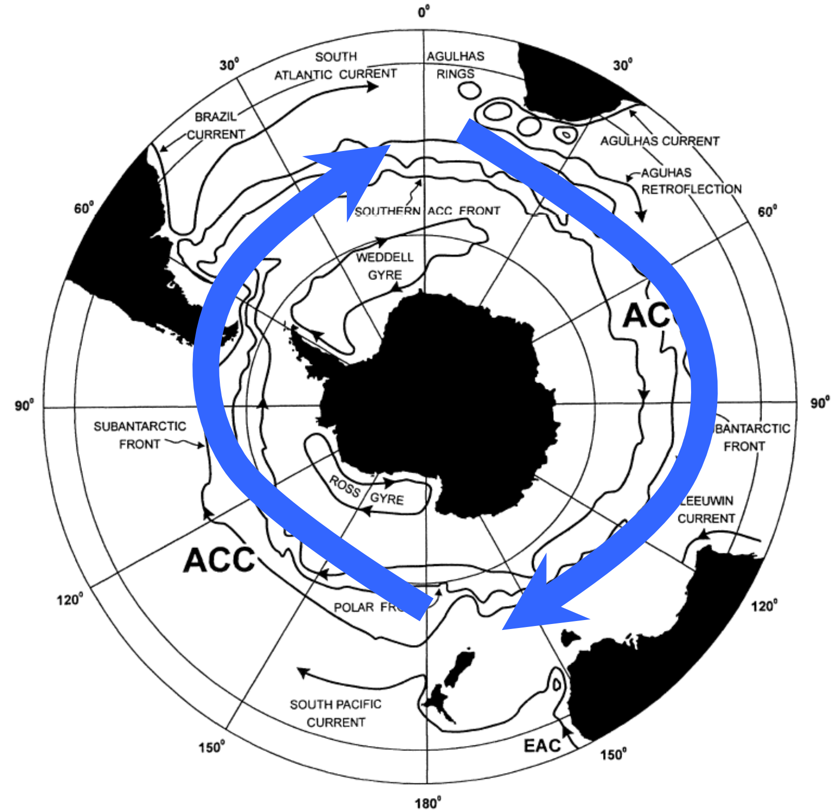

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