SST forcing of Australian rainfall trends

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(with thanks to David Karoly & colleagues at NCAR and BoM)

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The Centre for Australian Weather and Climate Research

A partnership between CSIRO and the Bureau of Meteorology

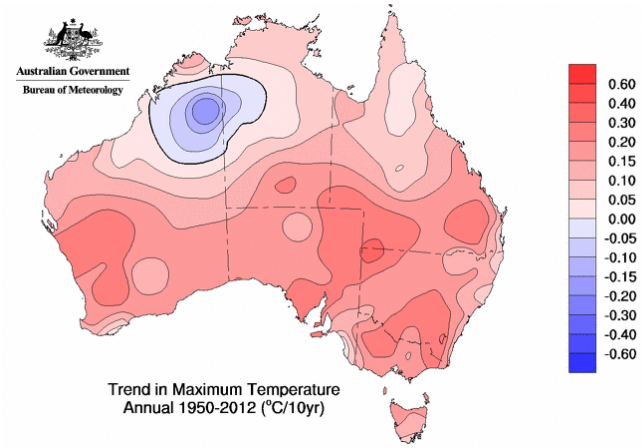
CSIRO

How well do SST-forced AGCMs capture trends in Australian climate?

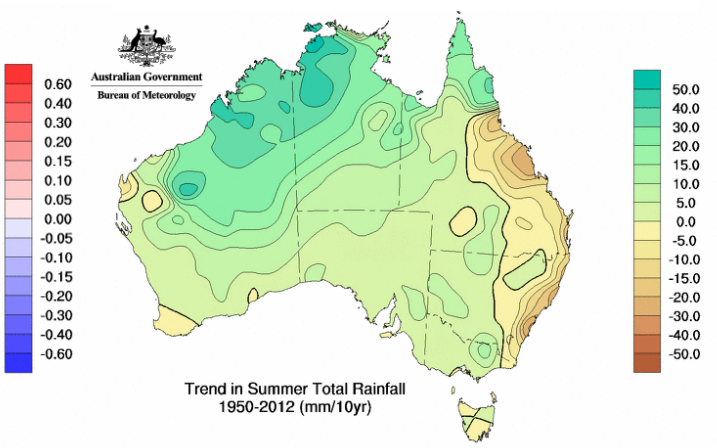
- ✓ A comprehensive look at the ability of AGCMs (forced with observed SSTs) to simulate past climate trends over Australia has yet to be done
- ✓ Expected that these will capture the regional patterns of change better than AOGCMs

1950-2012 trends in temperature and rainfall from BoM

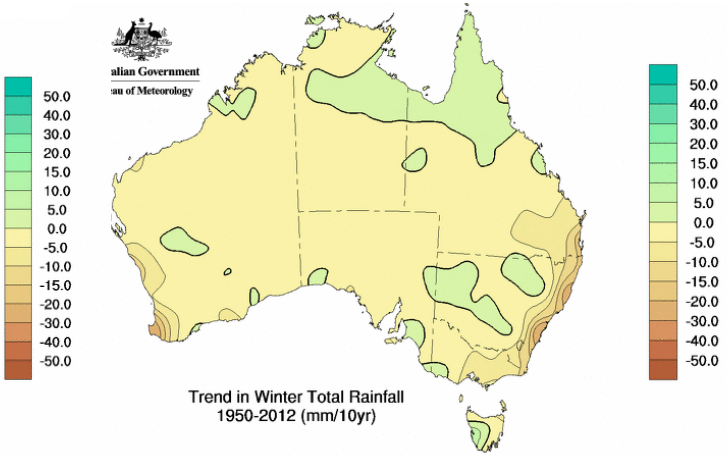
Annual T



Summer Pr



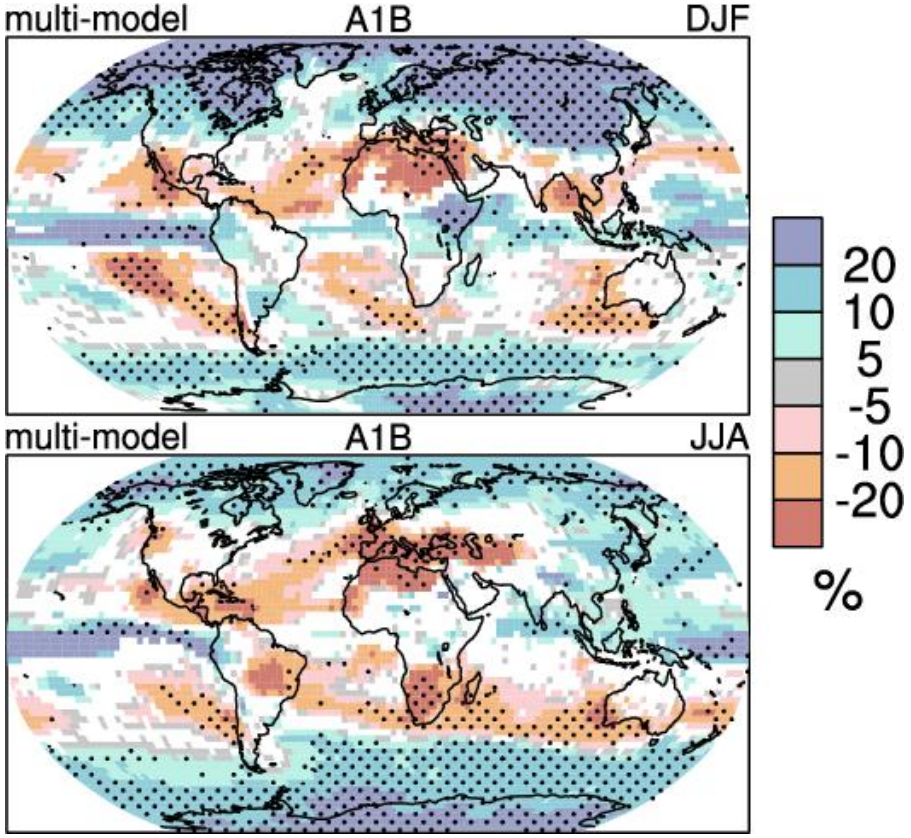
Winter Pr



Motivation

Recent autumn/winter rainfall decreases in southern Australia are of much concern

- ✓ Some recent studies linking these decreases to changes in observed modes such as the IOD and SAM
- ✓ Yet similar rainfall decreases are projected by models in the future, irrespective of their projected SST patterns



Experiments

Climate of the 20th Century (C20C) project

— AGCMs forced with observed SSTs & sea-ice
— from ~1950-1999
— some also include observed radiative forcing changes such as greenhouse gases, aerosols, stratospheric ozone depletion, solar, land use change
— > 10 ensemble members available for most

Supplemented with some U.S. CLIVAR drought working group experiments

C20C	Country
BAM	Australia
CES/SNU	Korea
NCEP	USA
GFDL	USA
MetUM	UK
ICTPAGCM	Italy
GAMIL	China
MRI	Japan
NSIPP	USA
CSIRO	Australia
CABO	USA
MGO	Russia
SOCOL	Switzerland
UKMO-HadGEM1	UK

Reference:
—Scaife et al, 2008: The CLIVAR C20C project: selected twentieth century climate events, *Climate Dynamics*

Method

Historical climate event

Consistent with ensemble means?

YES

Potentially predictable, "forced" and well modelled

NO

Consistent with ensemble members?

YES

Unpredictable internal variation but well modelled

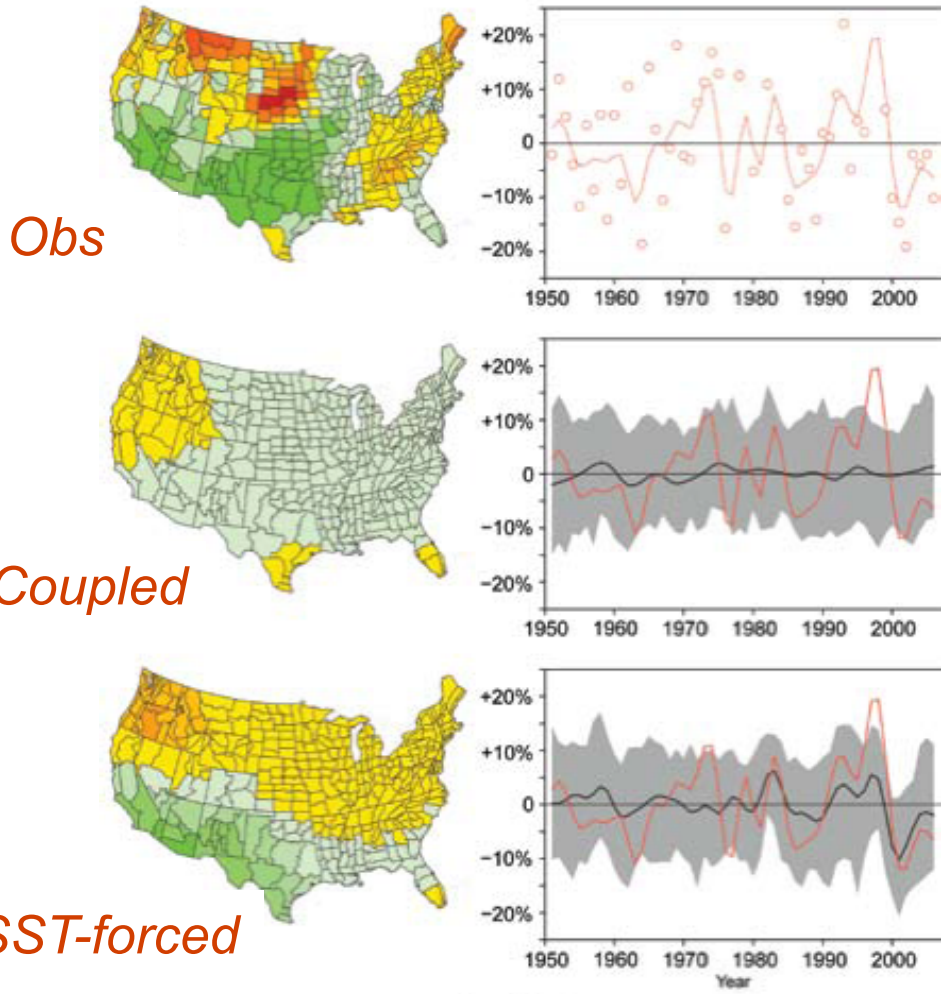
NO

Poorly modelled in this experiment: missing process/forcing

Rainfall trends in other regions

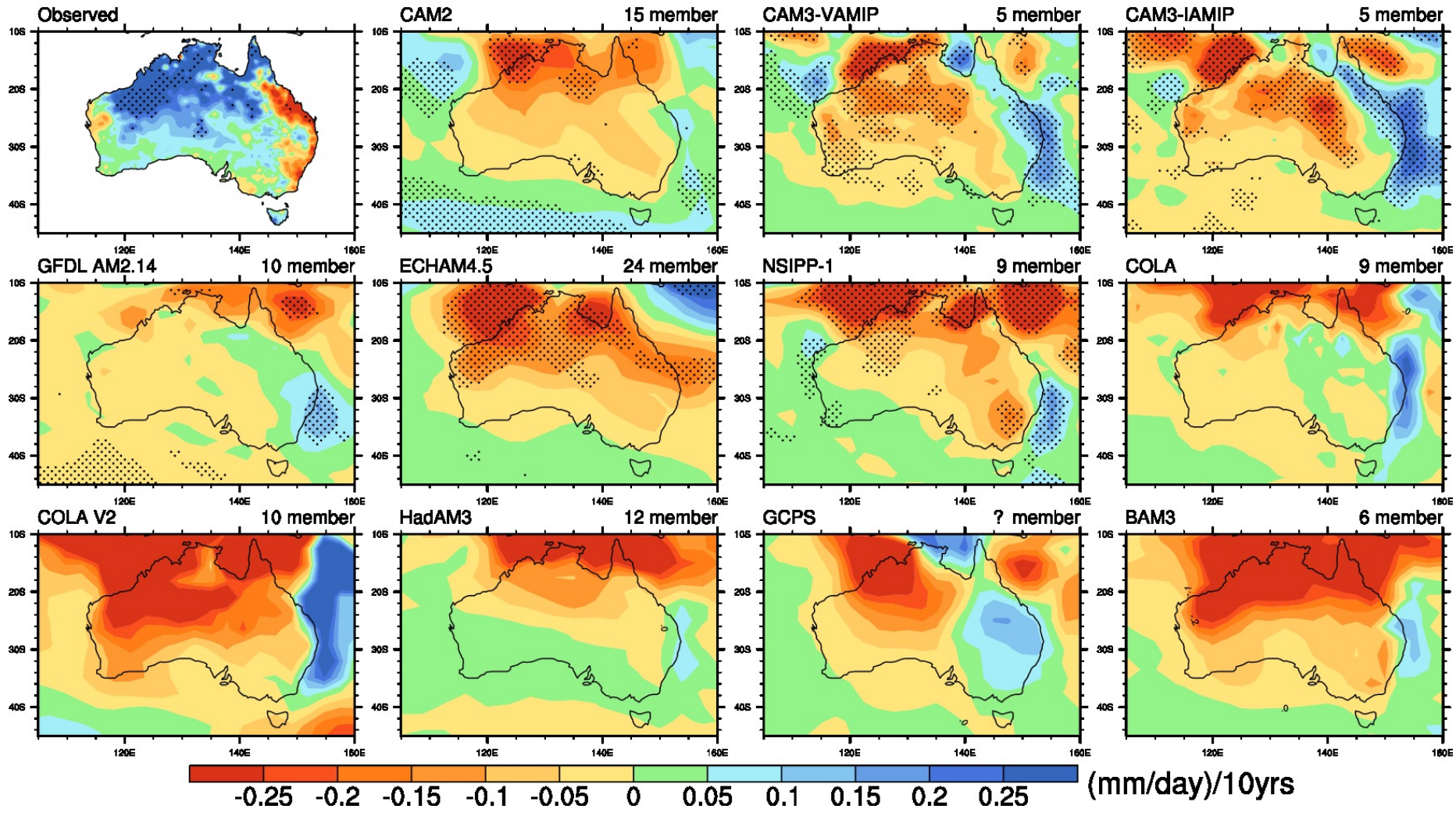
SST-forced runs are capable of reproducing rainfall trends in other regions e.g. USA and Sahel regions

United States Winter Precipitation 1951-2006



CCSP 2008

How well do SST-forced AGCMs capture rainfall trends (1957-1999) over Australia?



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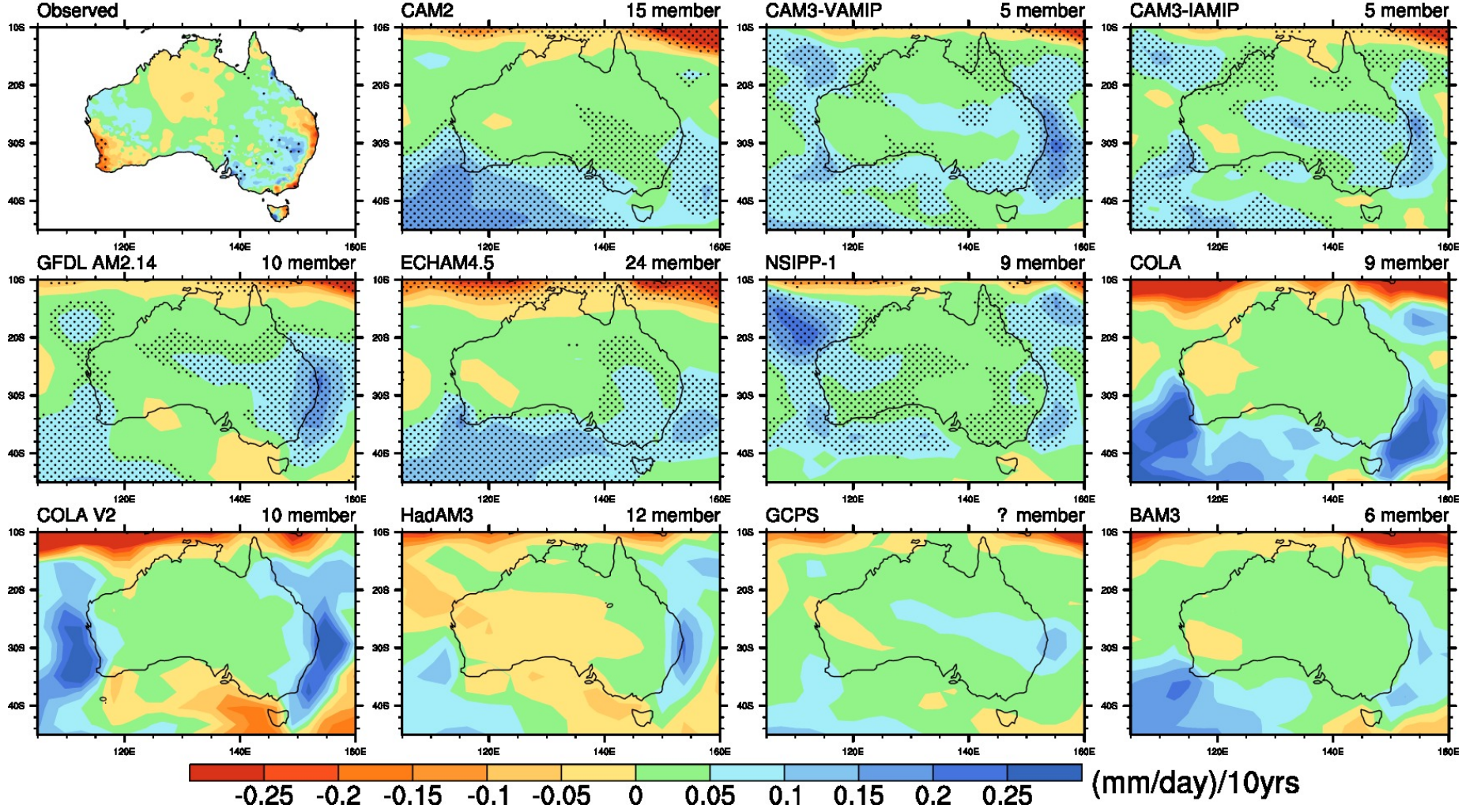
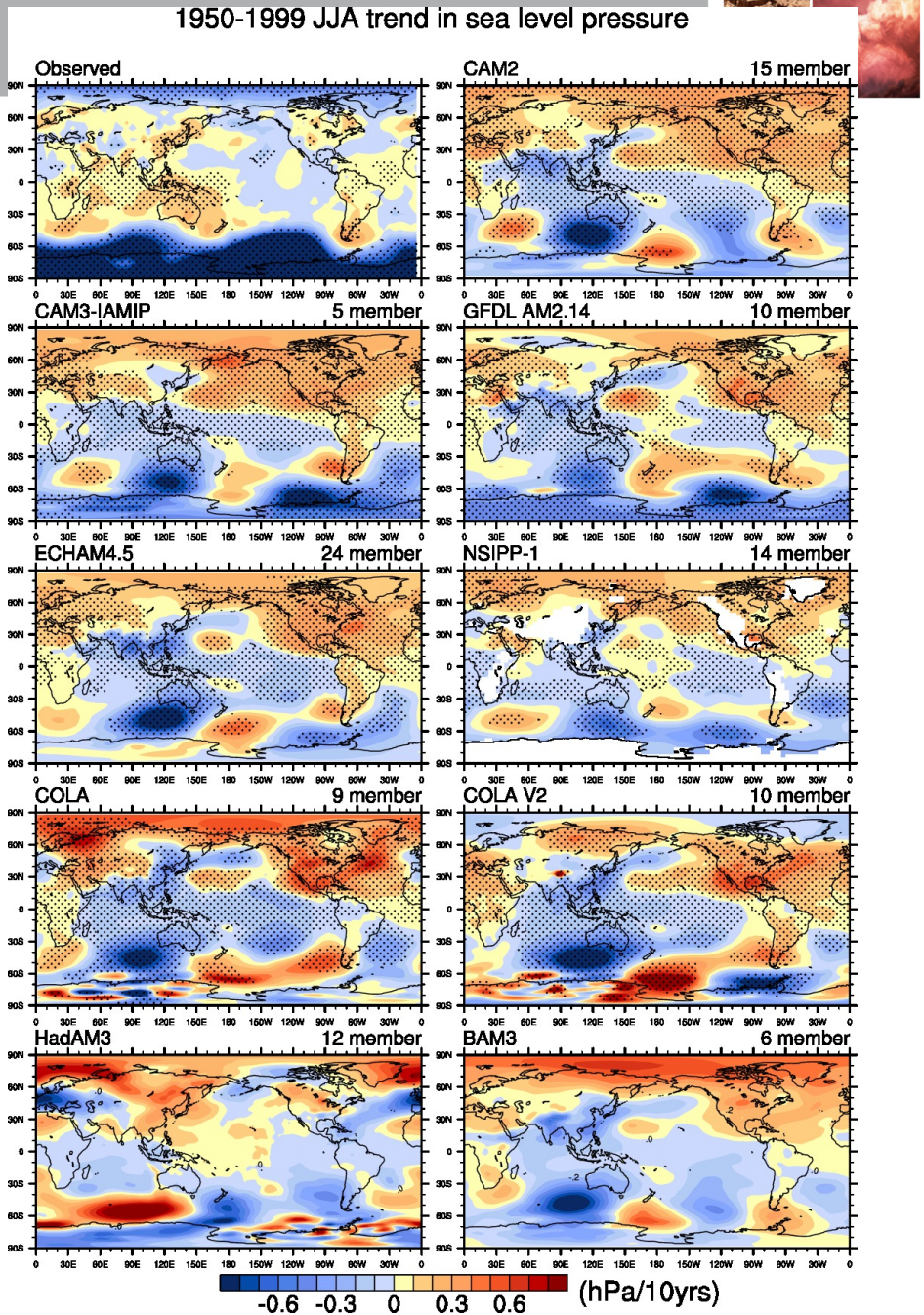


Systematic bias in rainfall & SLP trends in SST-forced runs

Errors in rainfall trends are related to errors in sea level pressure

Consistent decrease in winter sea level pressure over Australia in ALL models

=> model biases, poorly constrained SSTs, bad framework or large atmospheric noise?

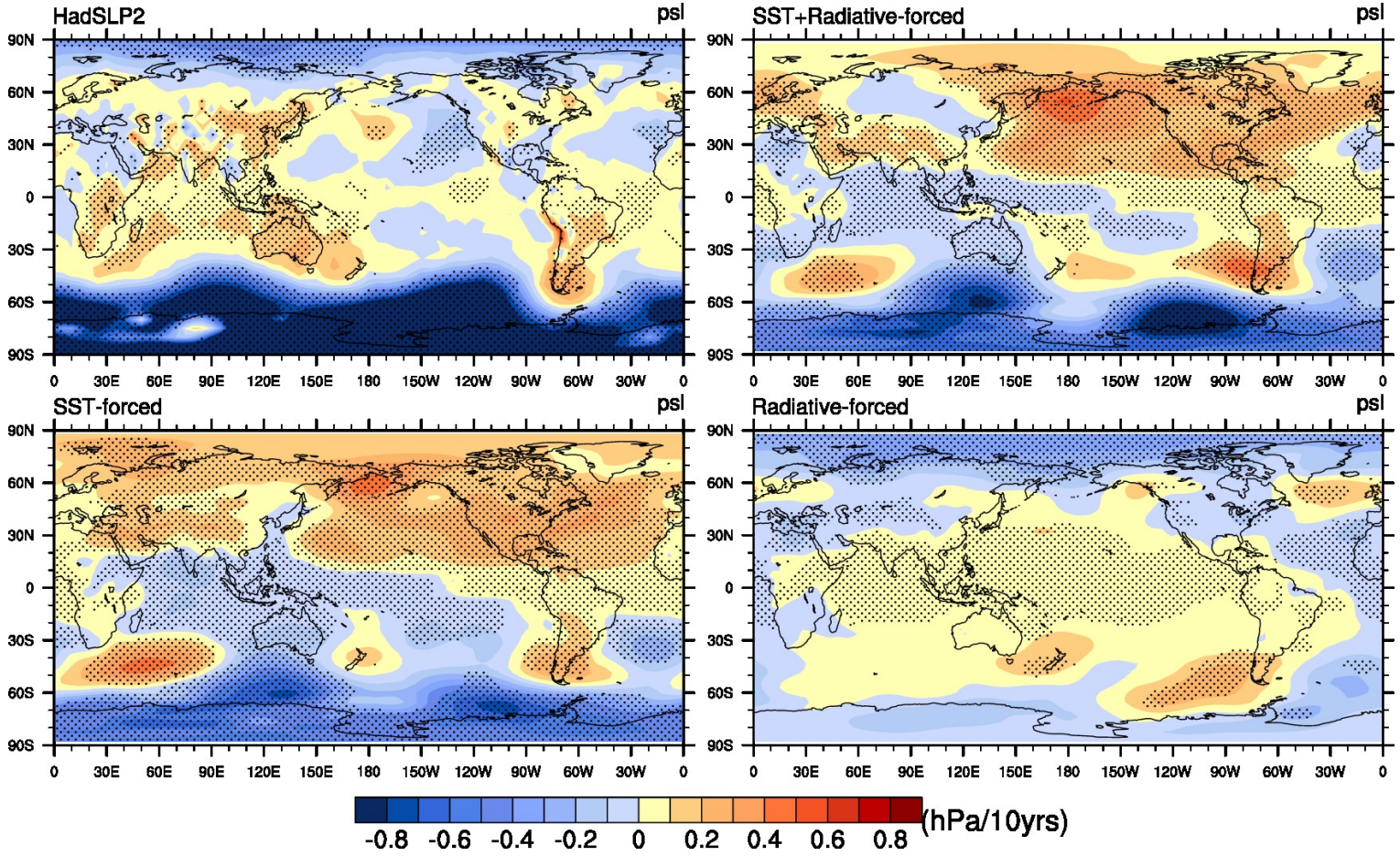


Role of radiative forcings vs SSTs in winter

NCAR CAM3 experiments

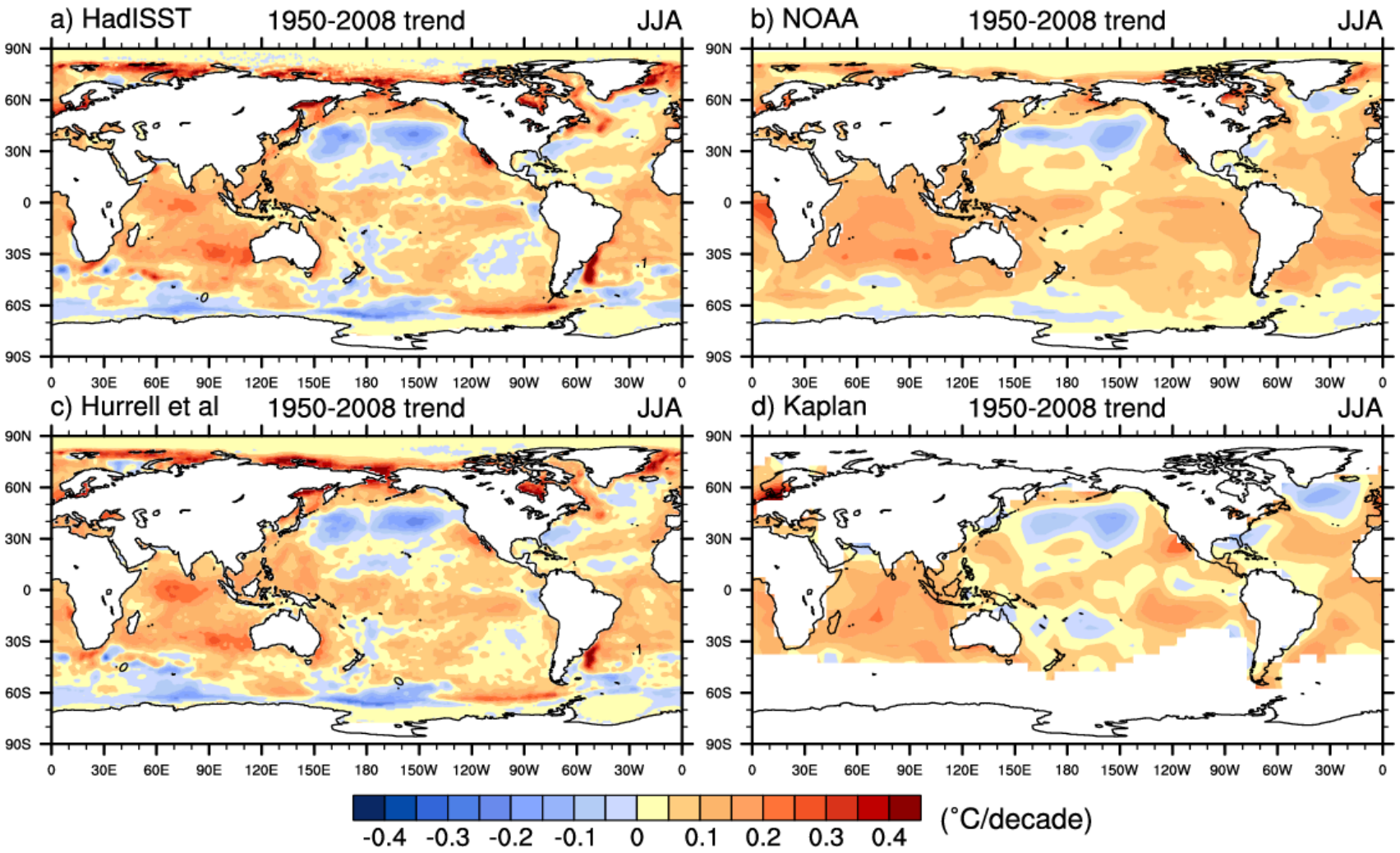
— extended runs to 2008 with observed SSTs & sea-ice from Hurrell et al (2008) and SRES A1B radiative forcings

— JJA sea level pressure trends similar with radiative forcings added



Trends in JJA SLP from 1950 to 2007

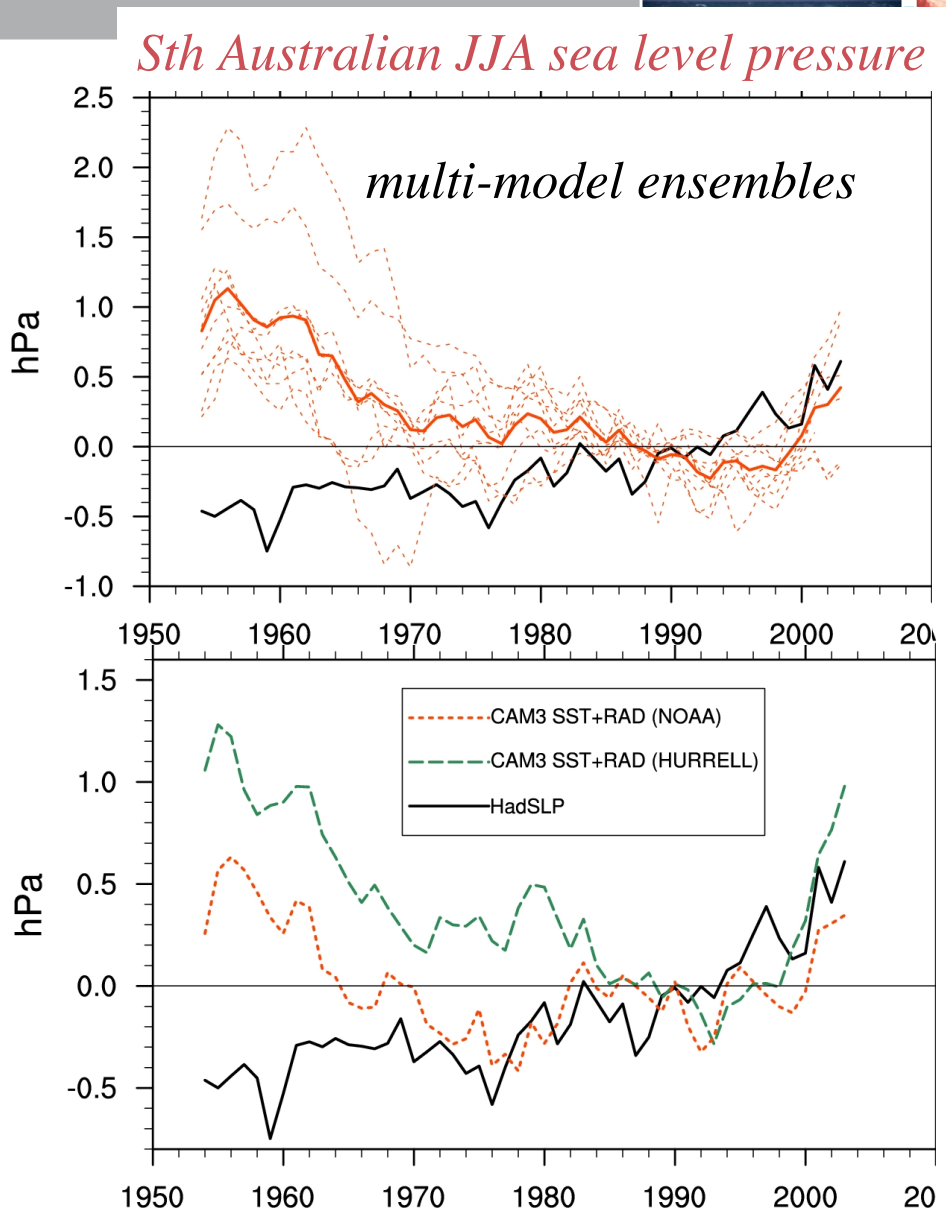
Errors in observed SSTs?



Errors in observed SSTs?

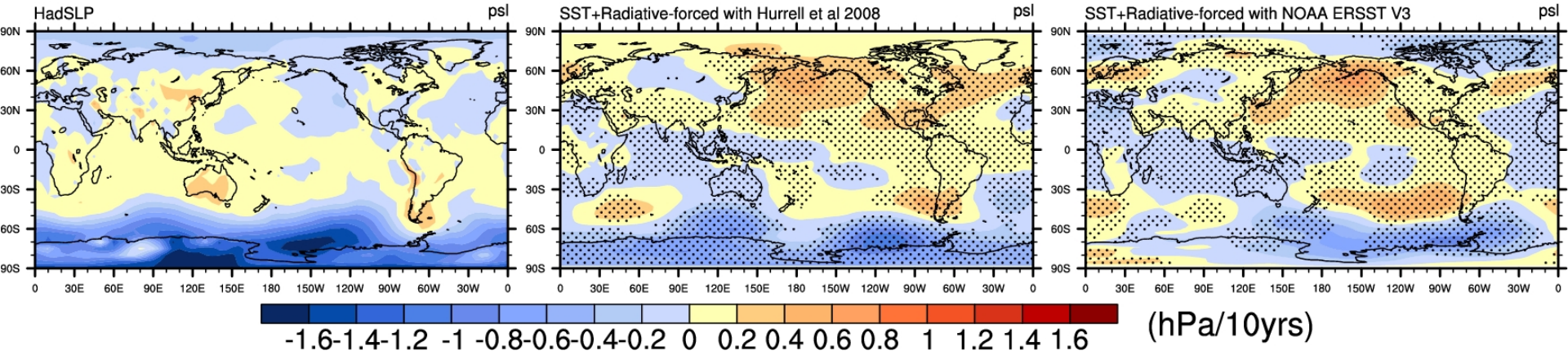
- Timeseries of Southern Australian SLP show a consistent *decrease* until ~2000 in model, *increase* in obs

- Forcing CAM3 with NOAA SSTs shows some improvement in earlier decades



Errors in observed SSTs?

JJA sea level pressure trends (1950-2008)



HadSLP2

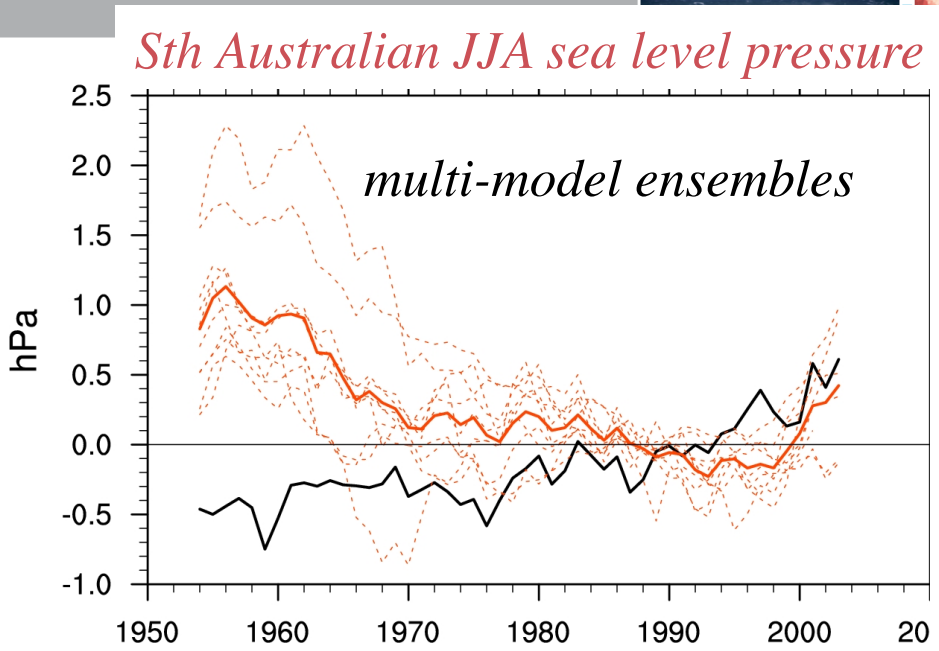
CAM3
Hurrell SSTs

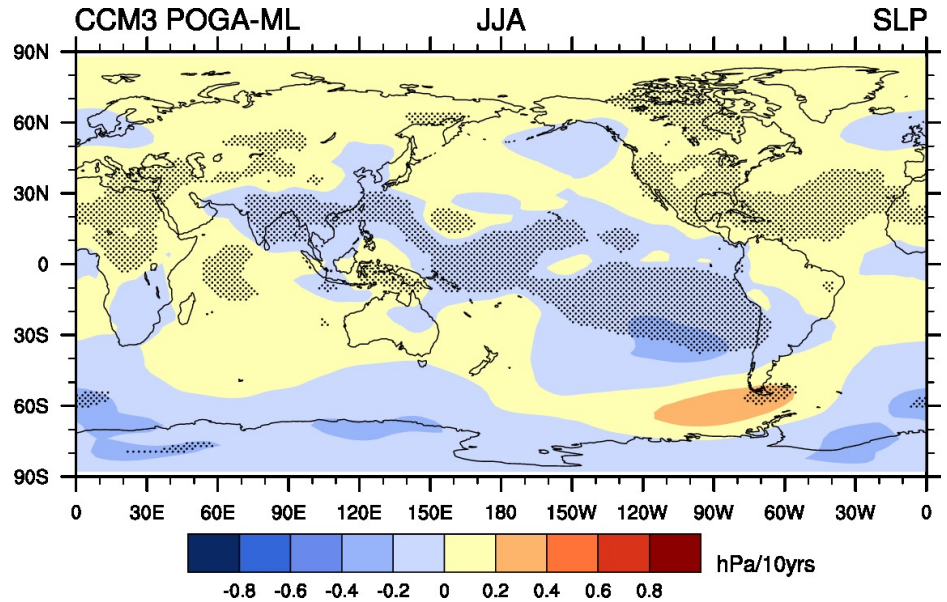
CAM3
NOAA SSTs

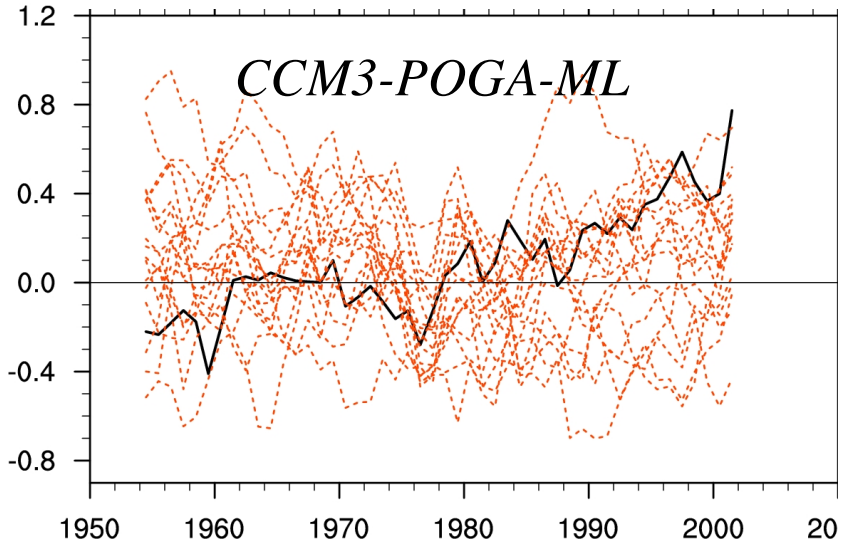
Errors in modelling framework?

- Timeseries of Southern Australian SLP show a ➔consistent *decrease* until ~2000 in model, *increase* in obs

- POGA-mixed-layer runs have more realistic pattern➘

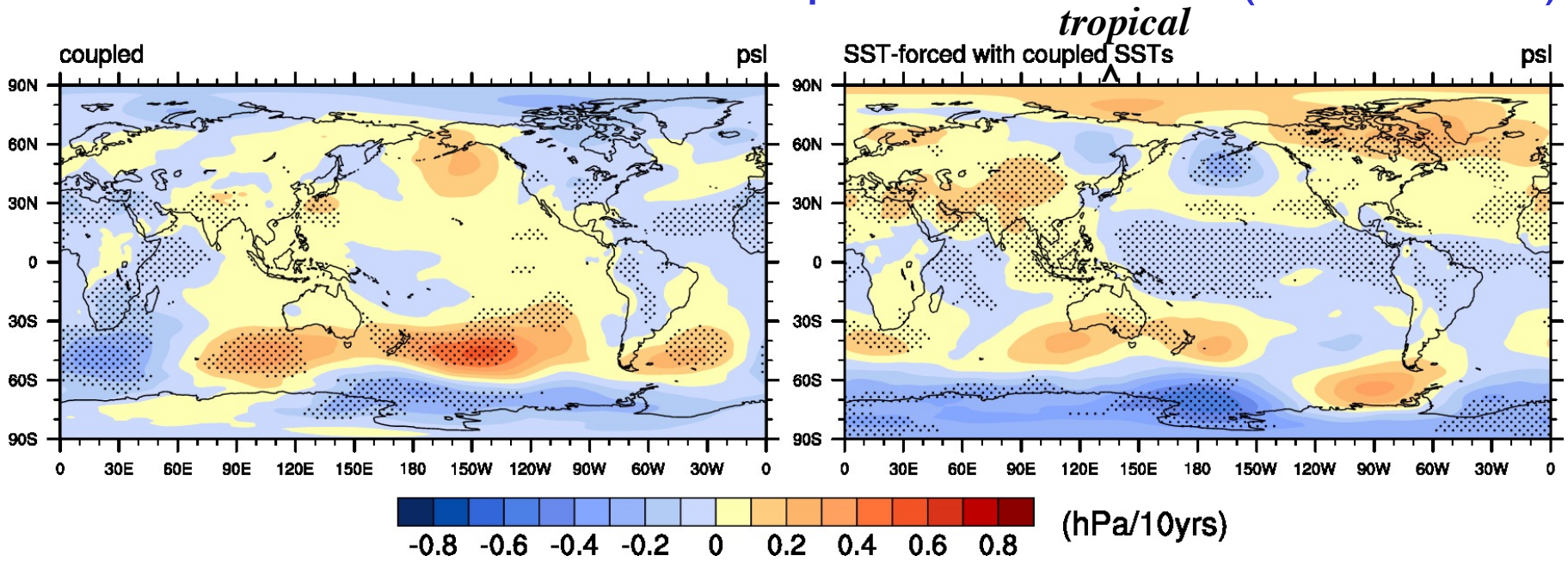






Importance of coupling?

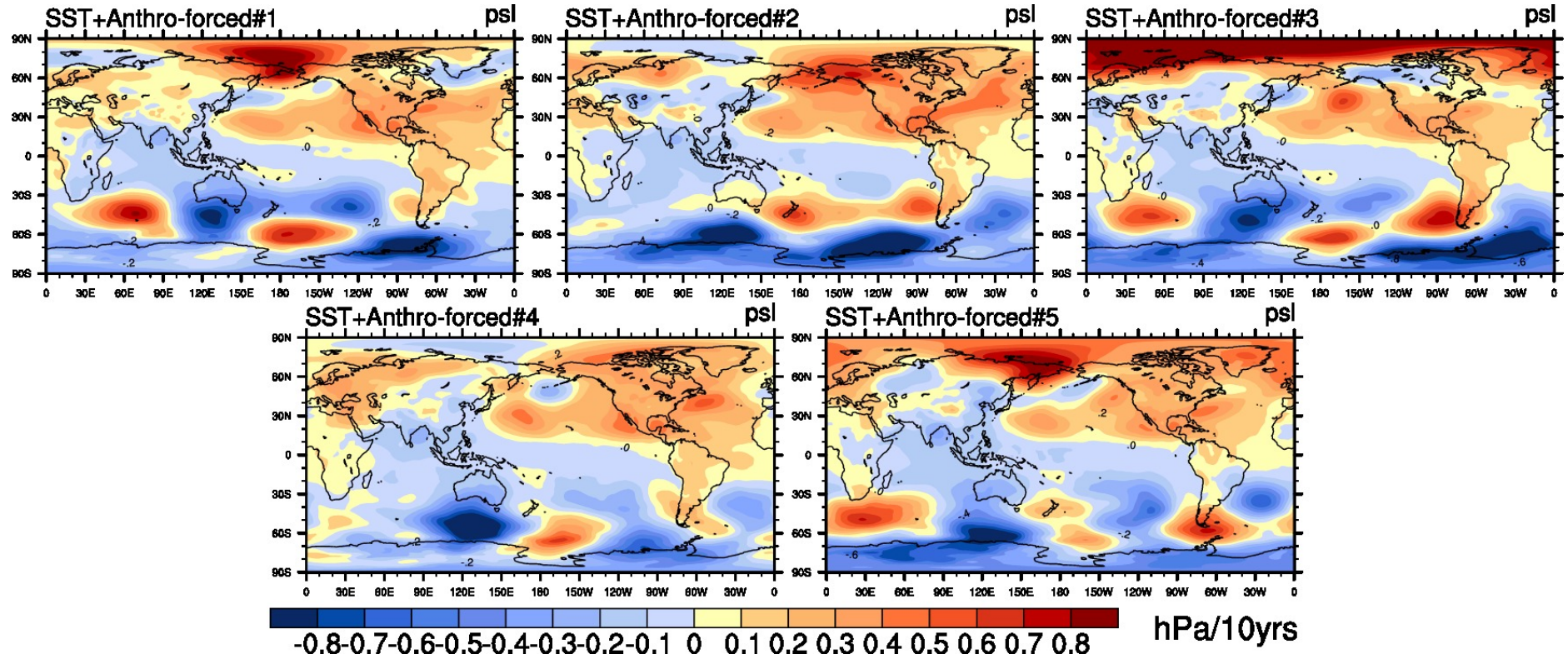
NCAR models JJA sea level pressure trends (1950-1999)



- coupled model produces more realistic trends
- forcing the AGCM with coupled model SSTs gives similar result ie. forced trend is reproducible with AGCM
- BUT tropical SST increases are mild in coupled runs, competing effects of SSTs and radiative forcings in real world?

Possibility of unpredictable internal variation?

NCAR CAM3 JJA sea level pressure trends (1950-1999)

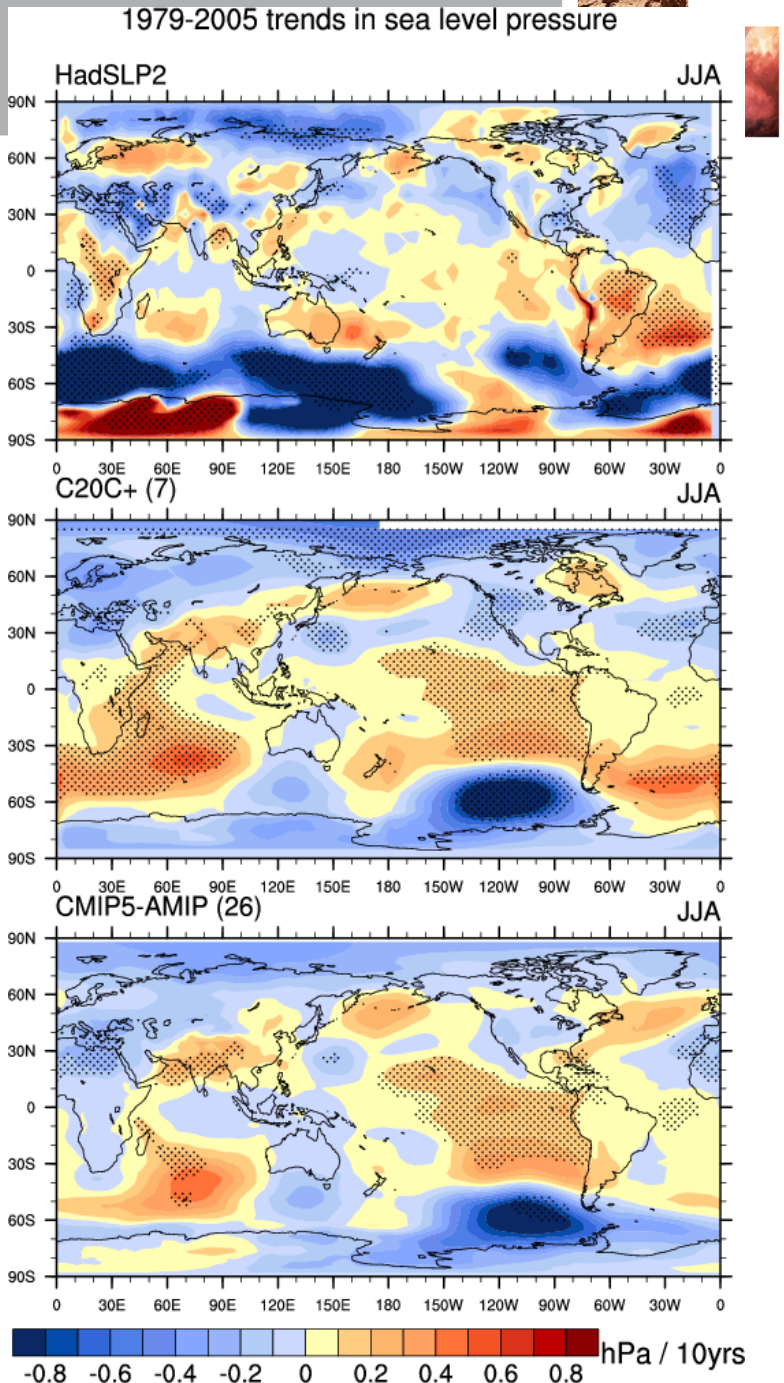


—one member from SST+Radiative T85 runs *does* show a positive SLP trend over Australia, albeit weaker than observed

Model version?

Many older models participating in C20C

=> could improvements in model physics in CMIP5 generation have led to improvement in these climate trends



Conclusions

- ✓ SST-forced simulations produce opposite rainfall *trends* over the Australian region to that observed

- ✓ Possible reasons explored:
  – importance of radiative forcings
  – errors in observed SSTs
  – errors in modelling framework e.g. coupling required
  – internal variation
  – none conclusive

- ✓ Potential implications for projections, especially if due to missing or problematic process

Next steps

Motivation is to understand the coupled model response to warming

Additional experiments planned:

– Use tropical diabatic heating, both idealised and from the coupled experiments, to force the AGCMs

– replace climatological SSTs with a slab ocean model to assess the role of coupling