Will There Be A Significant Change to El Niño in the 21st Century?

Samantha Stevenson[1]

with Baylor Fox-Kemper[1], Markus Jochum[2], Richard Neale[2], Clara Deser[2], and Gerald Meehl[2]

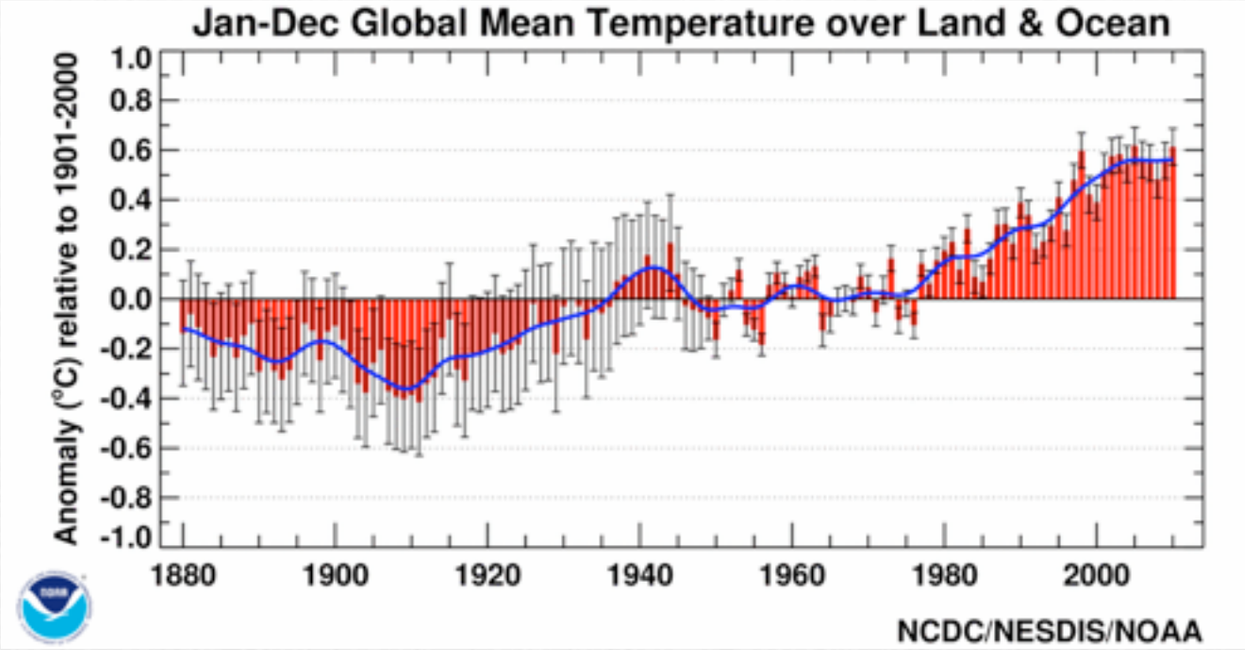
[1]ATOC/CIRES, University of Colorado at Boulder
[2]National Center for Atmospheric Research

October 26, 2011

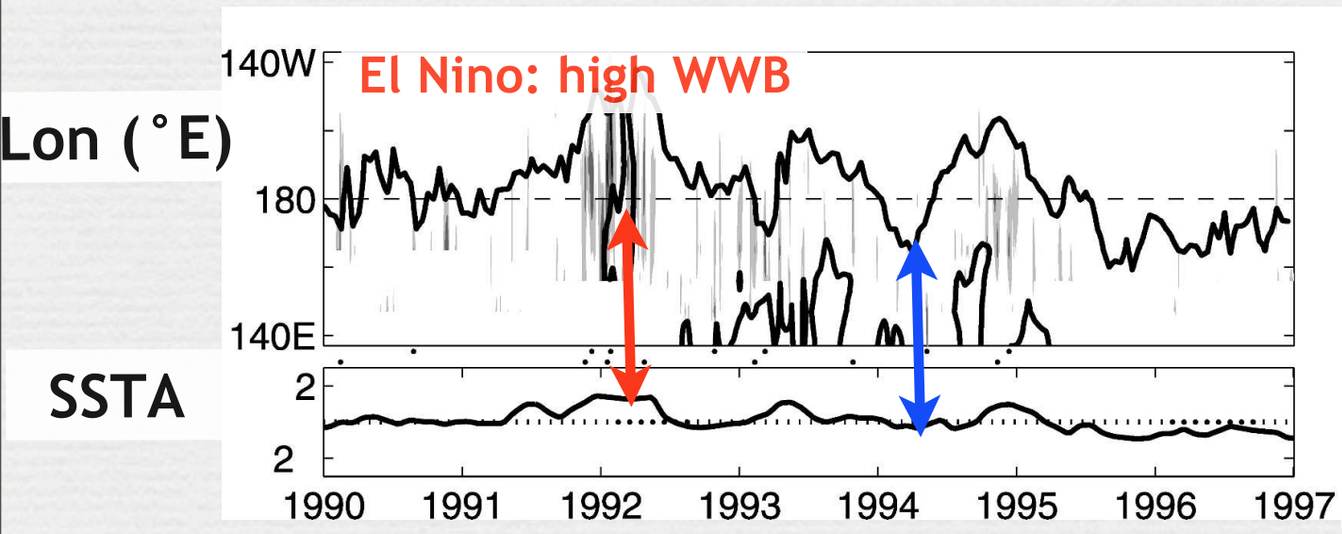
CIRES
Cooperative Institute for Research in Environmental Sciences

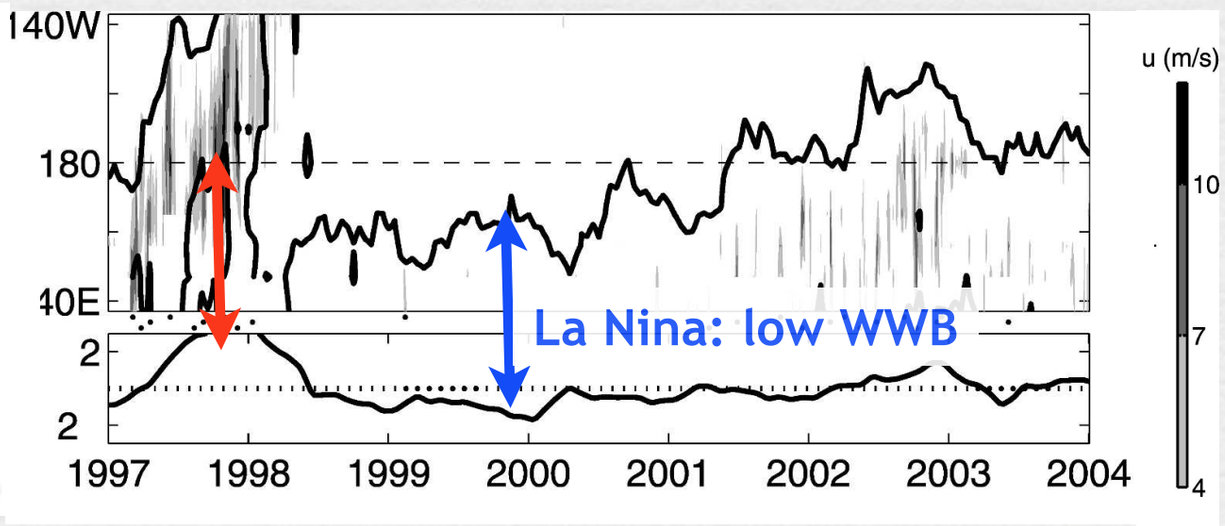
Why use coupled models for ENSO?

1. To represent future mean-state changes



2. To account for dependency of stochastic forcing on mean conditions

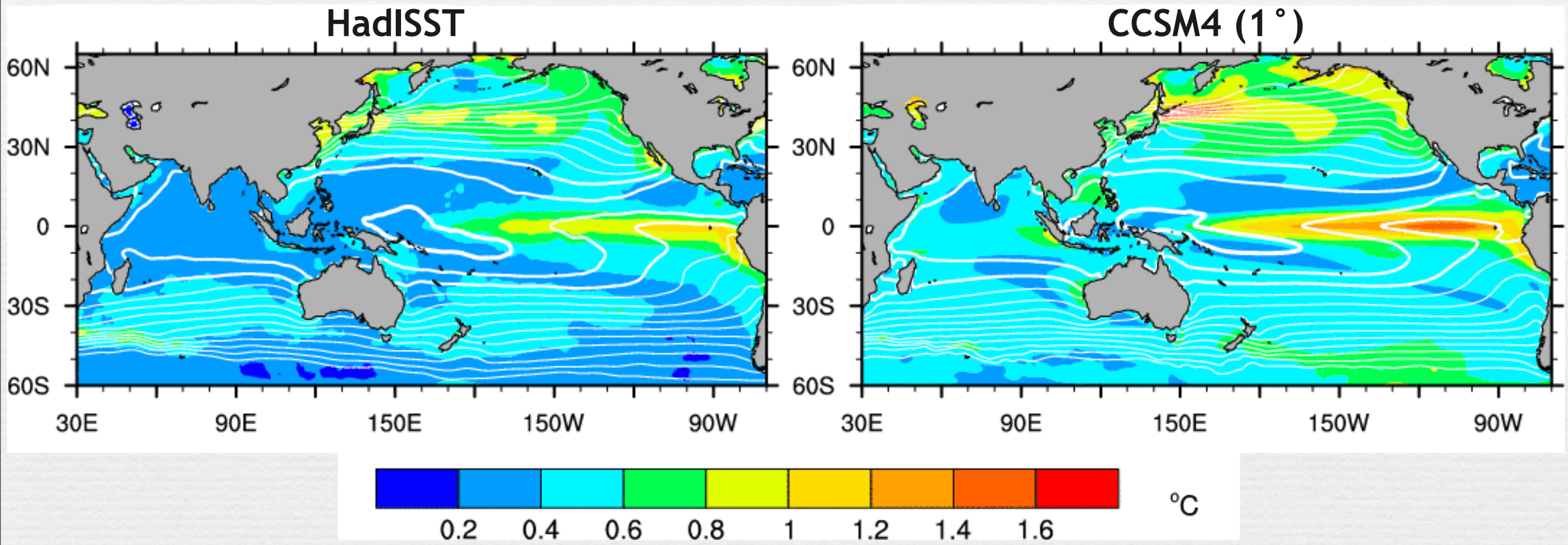




Eisenman et al. (2005): ENSO, westerly wind bursts (WWBs) modulate one another

Problems with coupled approach

Coupled models are biased: for example, CCSM4



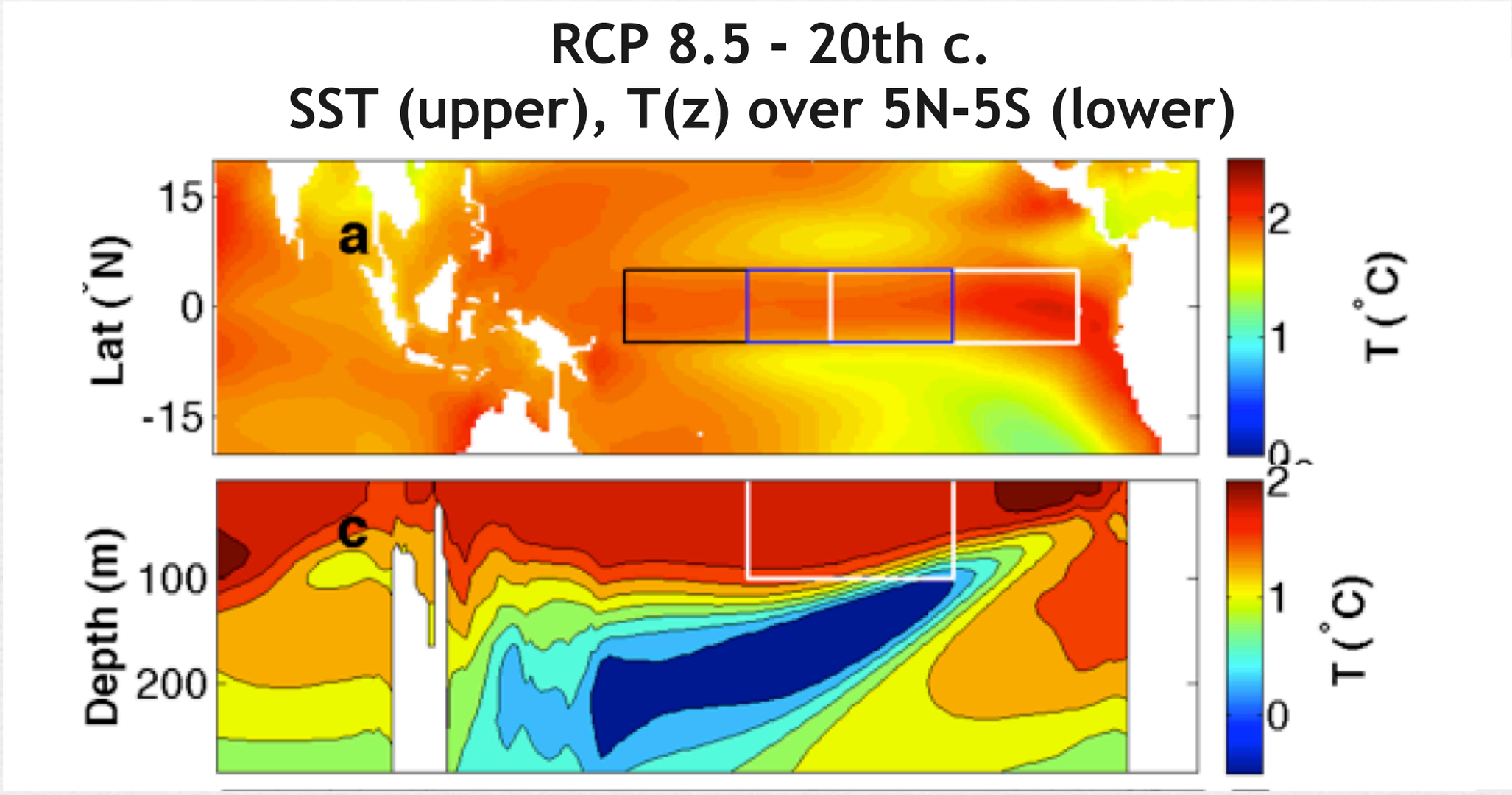
Deser et al. (2011): SST mean (contours), std. dev. (colors)

CCSM4 improves greatly over CCSM3, but mean-state biases still remain

Variability in both CCSM4, obs. should include error estimates: when do biases become statistically significant?

Mean-state response in CCSM4 is robust, well understood

Ensembles: 20th century (6 members), RCPs (21st century; 5 members),
1850 control (1 member)

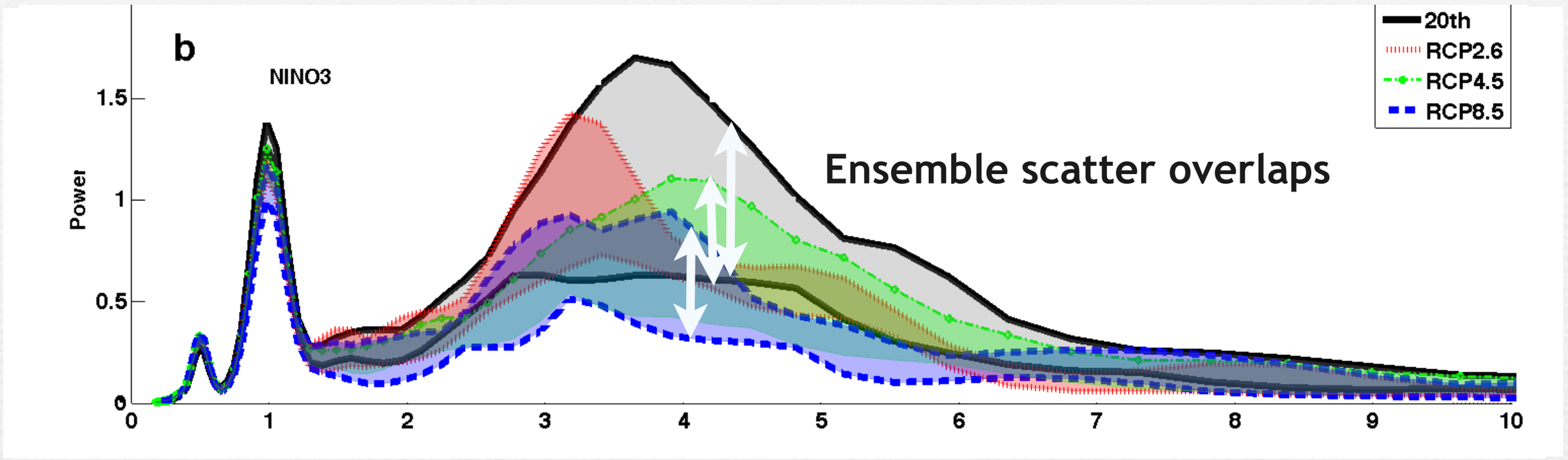


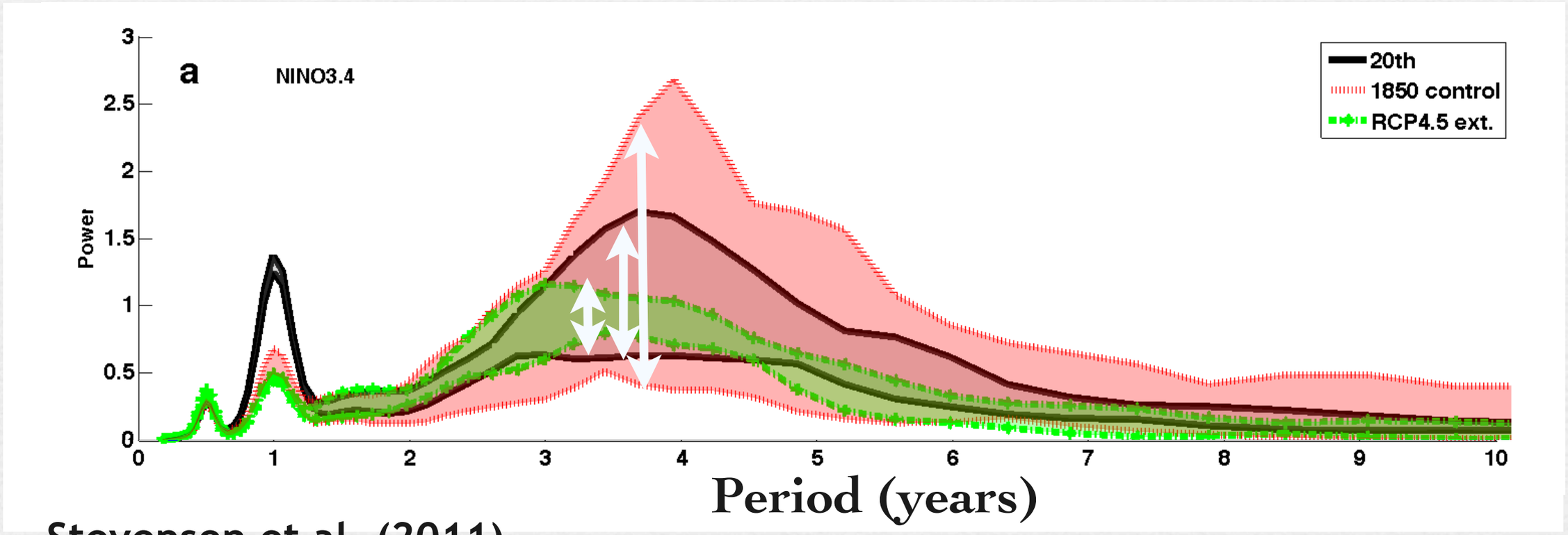
Stevenson et al. (2011)

Tendencies with increased CO_2:

- Decreased zonal SST gradient
- Increased vertical thermal stratification
- Weaker Walker circulation

NINO3 and 3.4 spectra are indistinguishable...

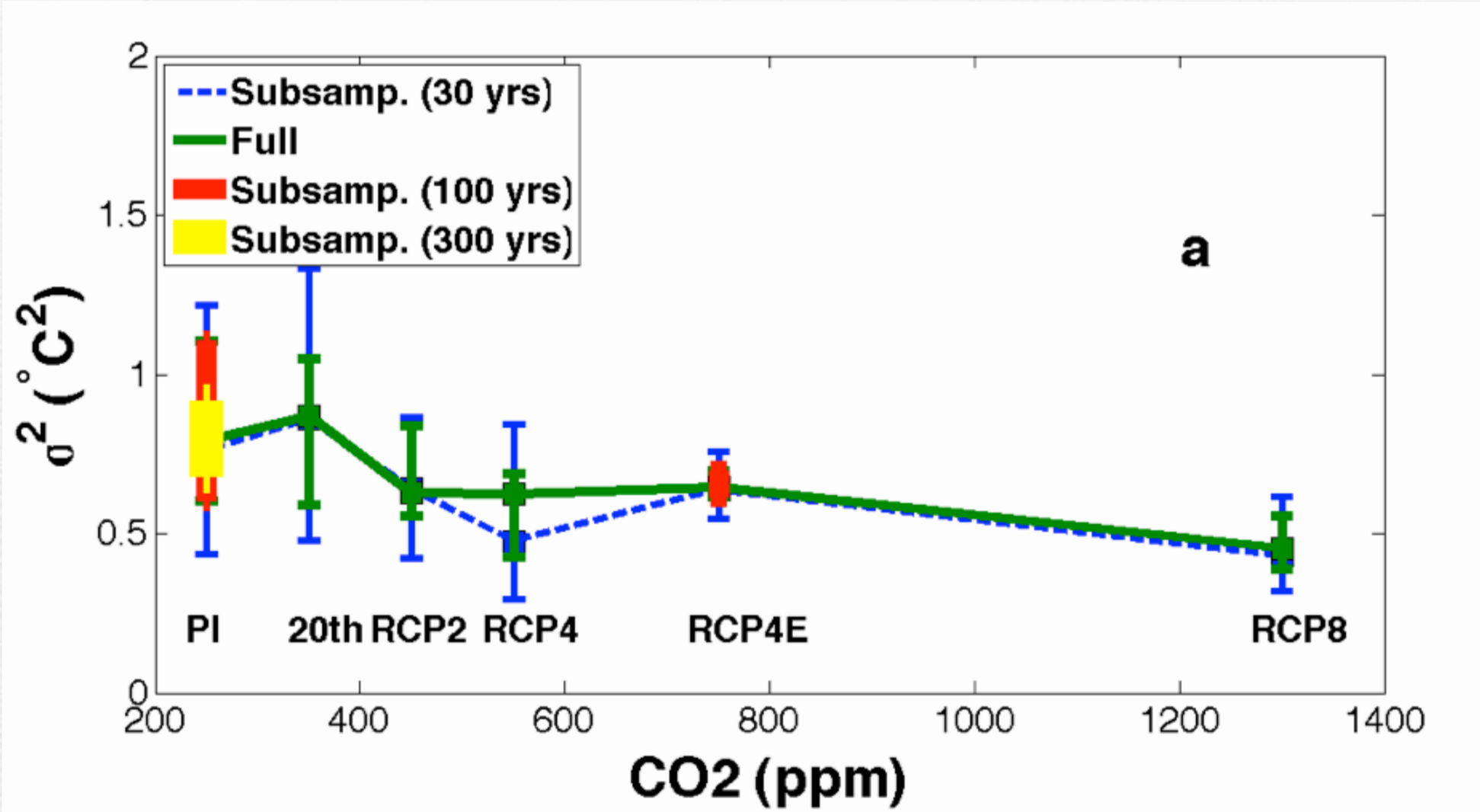




Stevenson et al. (2011)

...even for the RCP4.5 extension.

2-7 year NINO3.4 variance: ENSO is statistically identical between 20th, 21st centuries



Stevenson et al. (2011)

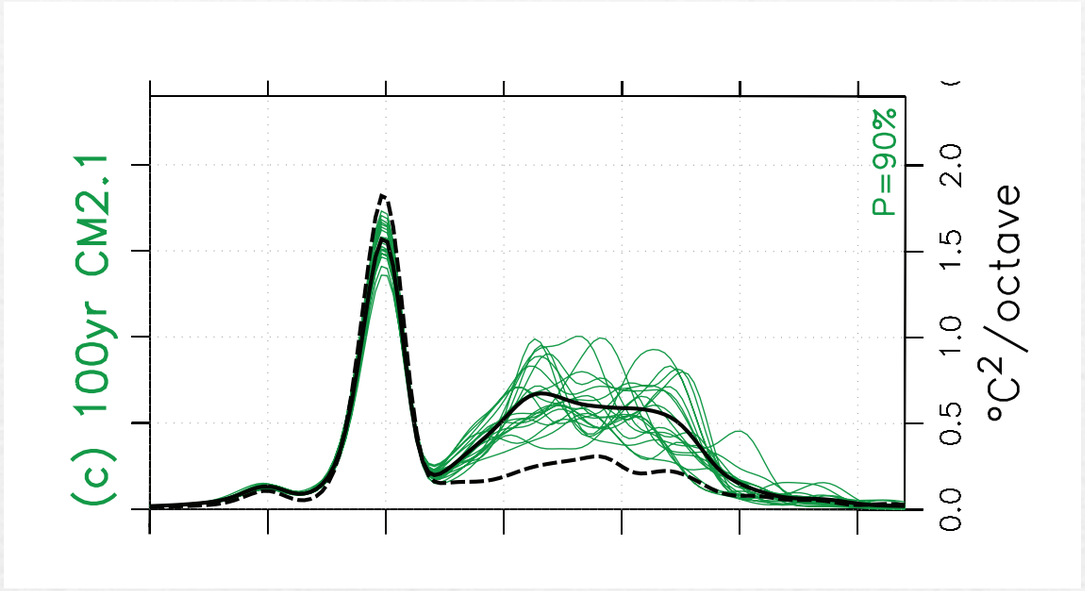
Long control simulations -> ENSO changes likely will become statistically significant, but not for several hundred years (Stevenson et al. 2012)

Reasons for “null result”

Signal-to-noise ratio

i.e. Wittenberg (2009): large spectral variability between centuries in GFDL CM2.1

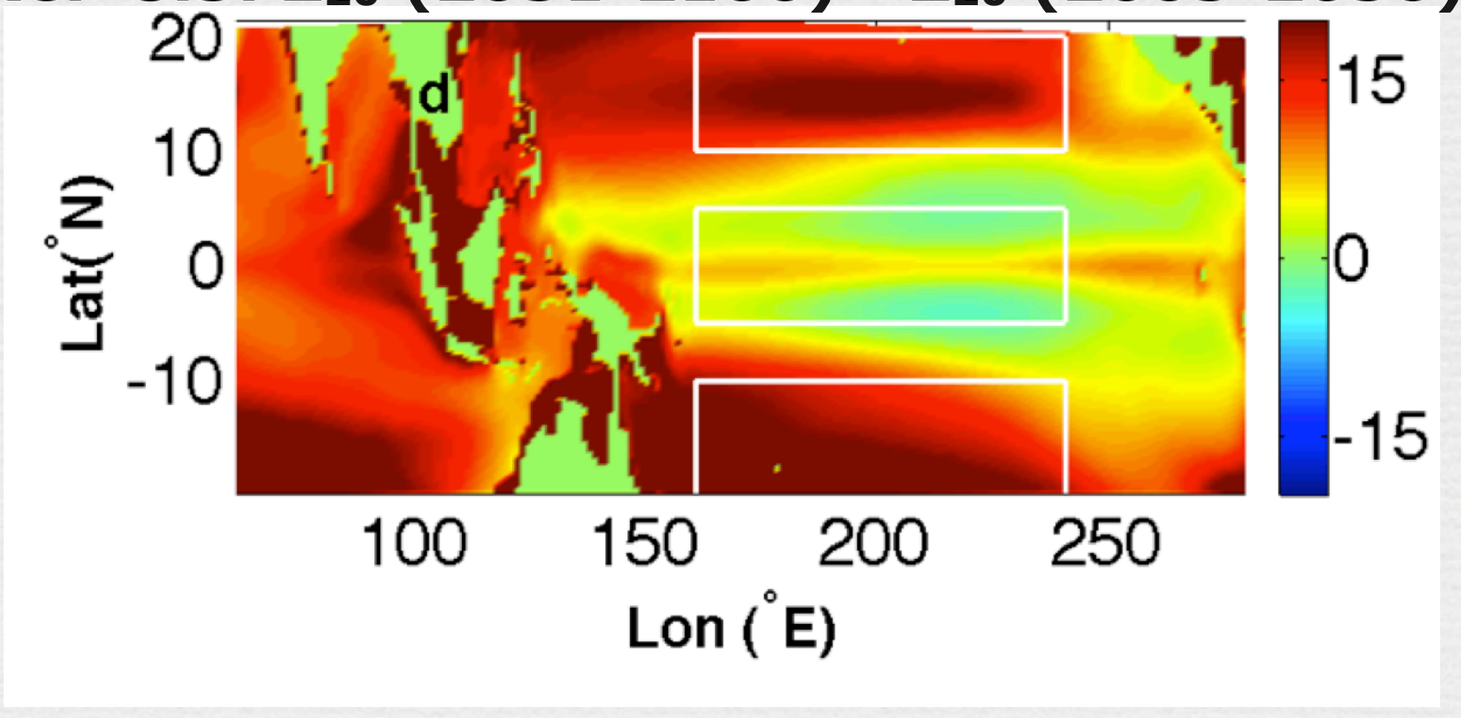
BUT climate change ensembles contain over 500 model years!



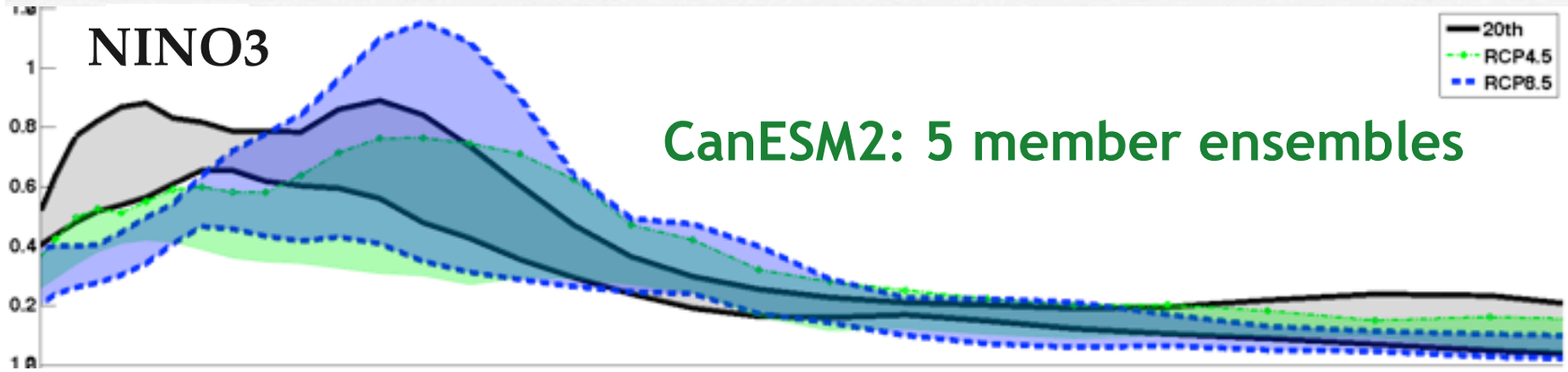
Ocean dynamical adjustment

Stevenson et al. (2011): large extratropical heating signal throughout 21st century

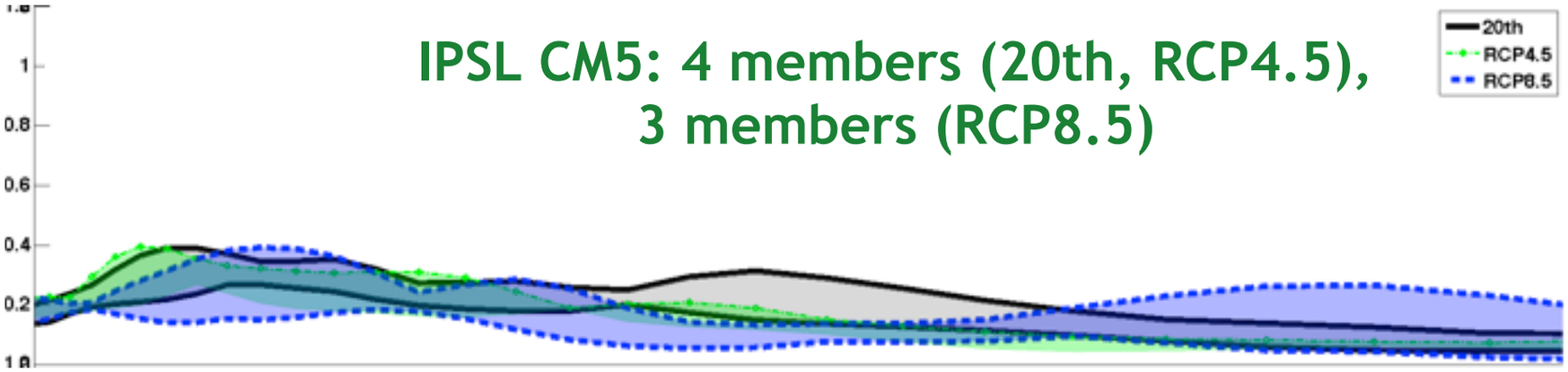
RCP 8.5: Z_{20} (2051-2100) - Z_{20} (2005-2050)



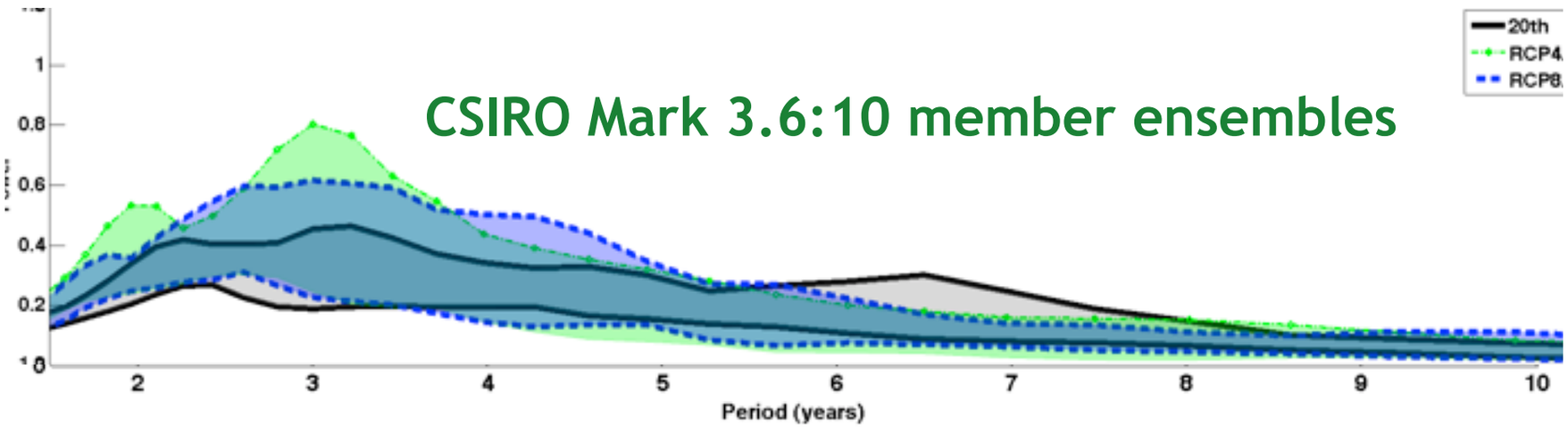
21st c.: too short for ENSO to respond to climate change?



CanESM2: 5 member ensembles



IPSL CM5: 4 members (20th, RCP4.5), 3 members (RCP8.5)



CSIRO Mark 3.6:10 member ensembles

Insignificant response in all CMIP5 models with sufficient (>3) ensemble members

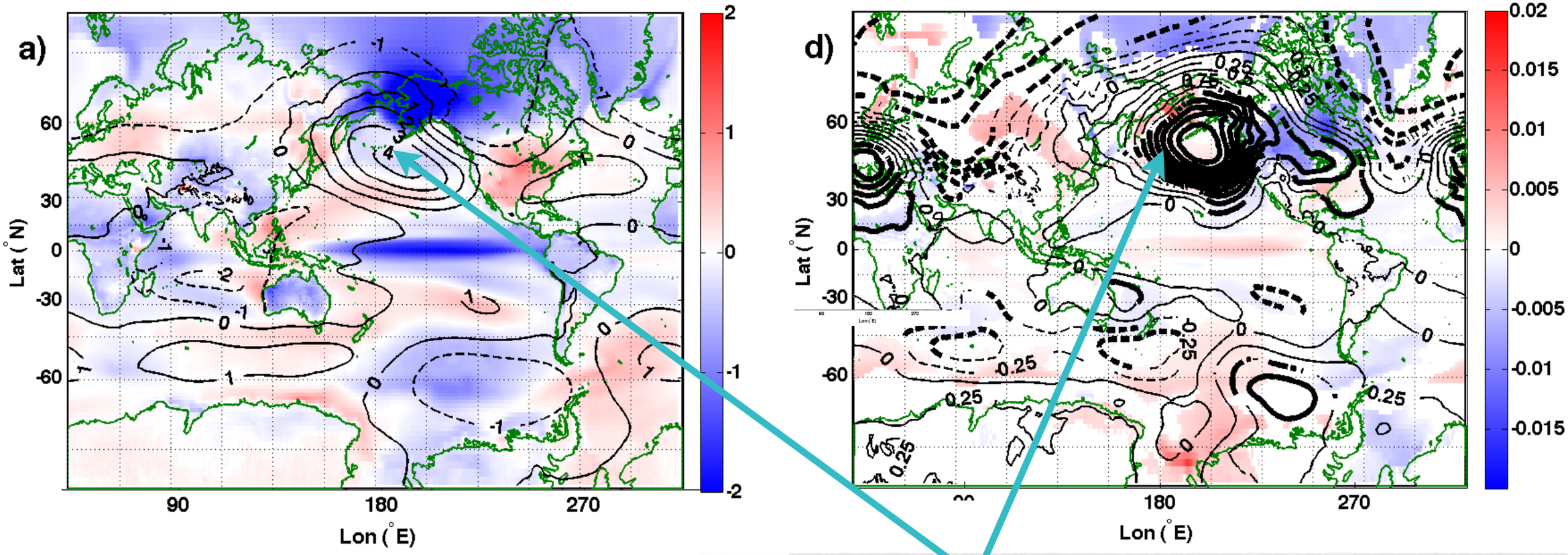
Note: ensemble means do not differ either

Atmospheric teleconnections may change much faster than the ocean

1) La Niña DJF

20th c.

RCP 8.5 - 20th c.



Stevenson et al. (2011)

Strengthening of blocking high

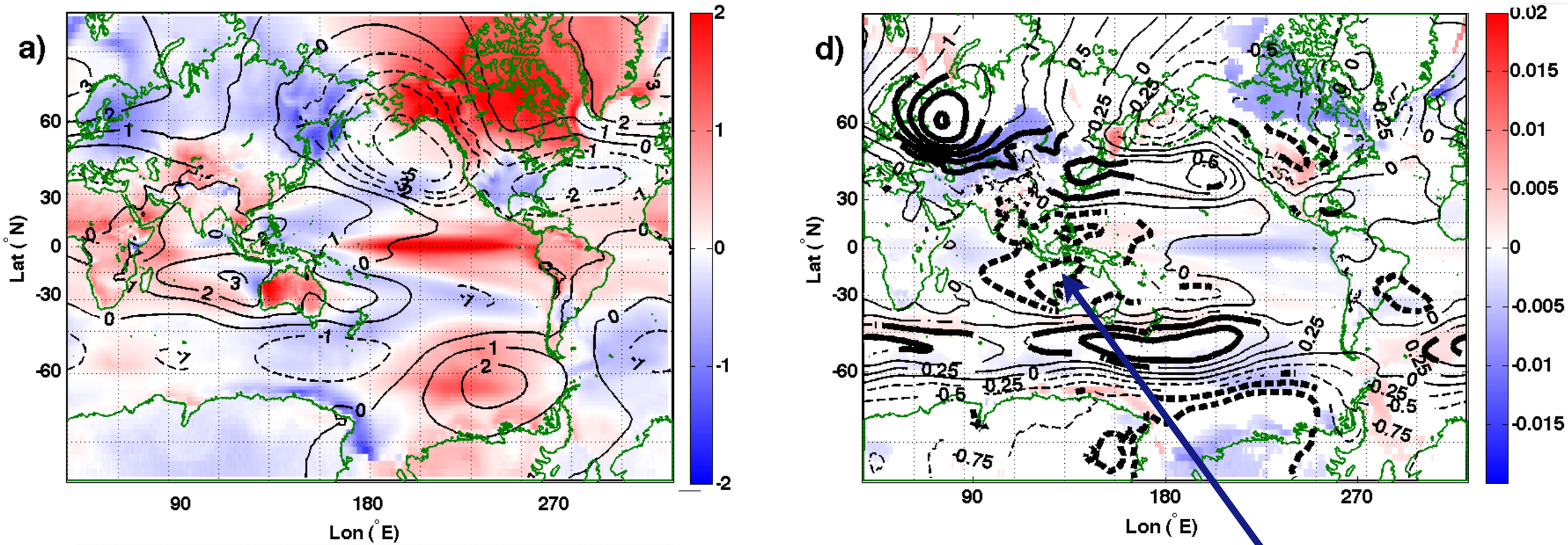
Colors: surface air temperature
Contours: sea level pressure
RCP 8.5 - 20th c: Significant SLP differences -> thick contours

Atmospheric teleconnections may change much faster than the ocean

2) El Niño DJF

20th c.

RCP 8.5 - 20th c.



Stevenson et al. (2011)

Weaker Australasian teleconnection

Colors: surface air temperature
Contours: sea level pressure
RCP 8.5 - 20th c: Significant SLP differences -> thick contours

Conclusions

The ENSO response to 21st century climate change is insignificant in 4 of the CMIP5 models... maybe more

Averaging multiple 20th/21st century ensemble members does not equal longer simulations:
ocean spinup persists throughout the simulation period

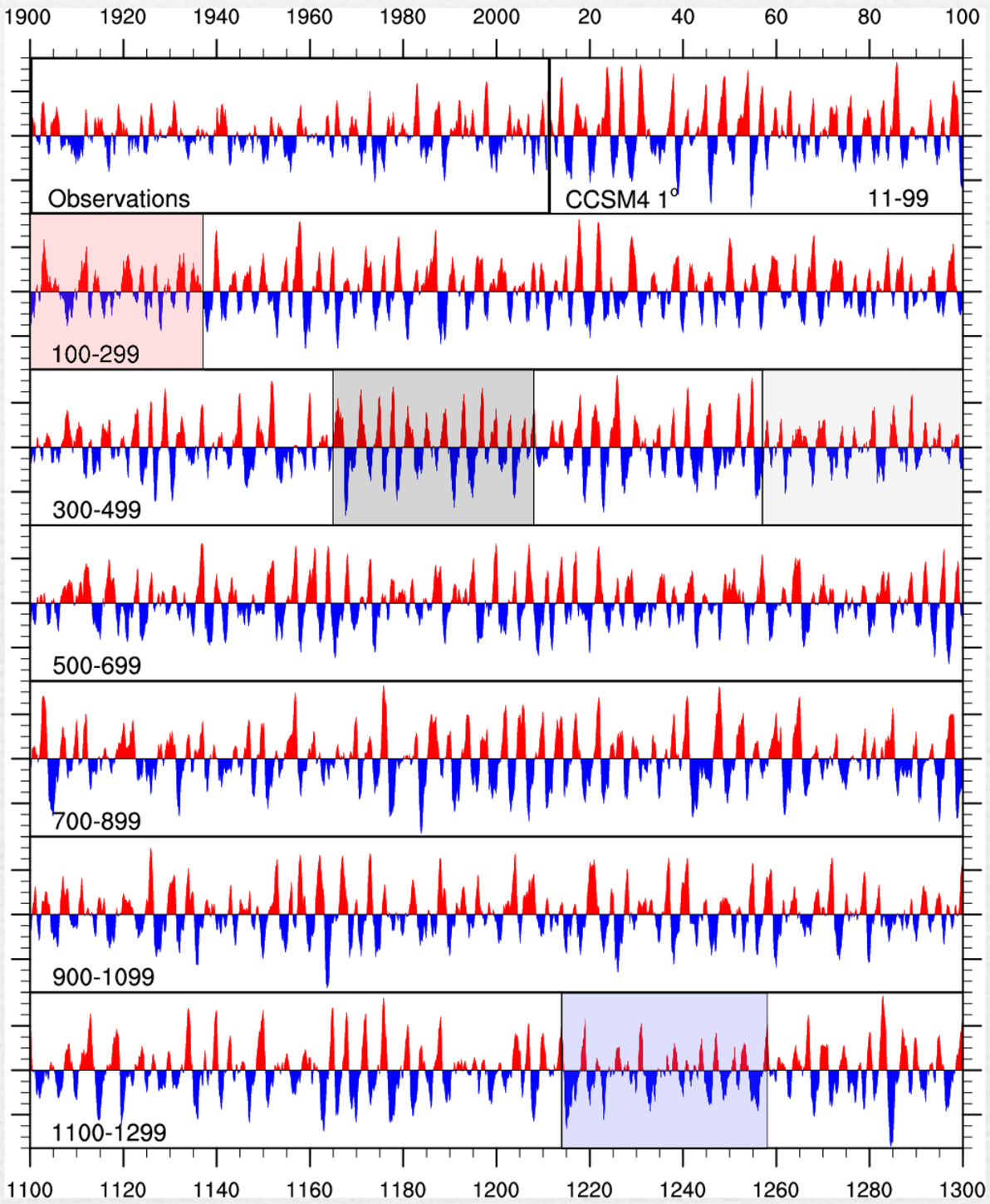
CMIP5 model ENSO sensitivity to climate change is STILL AN UNKNOWN:
millennial control simulations are required for diagnosis

Atmospheric impacts may be felt much sooner than the ocean changes

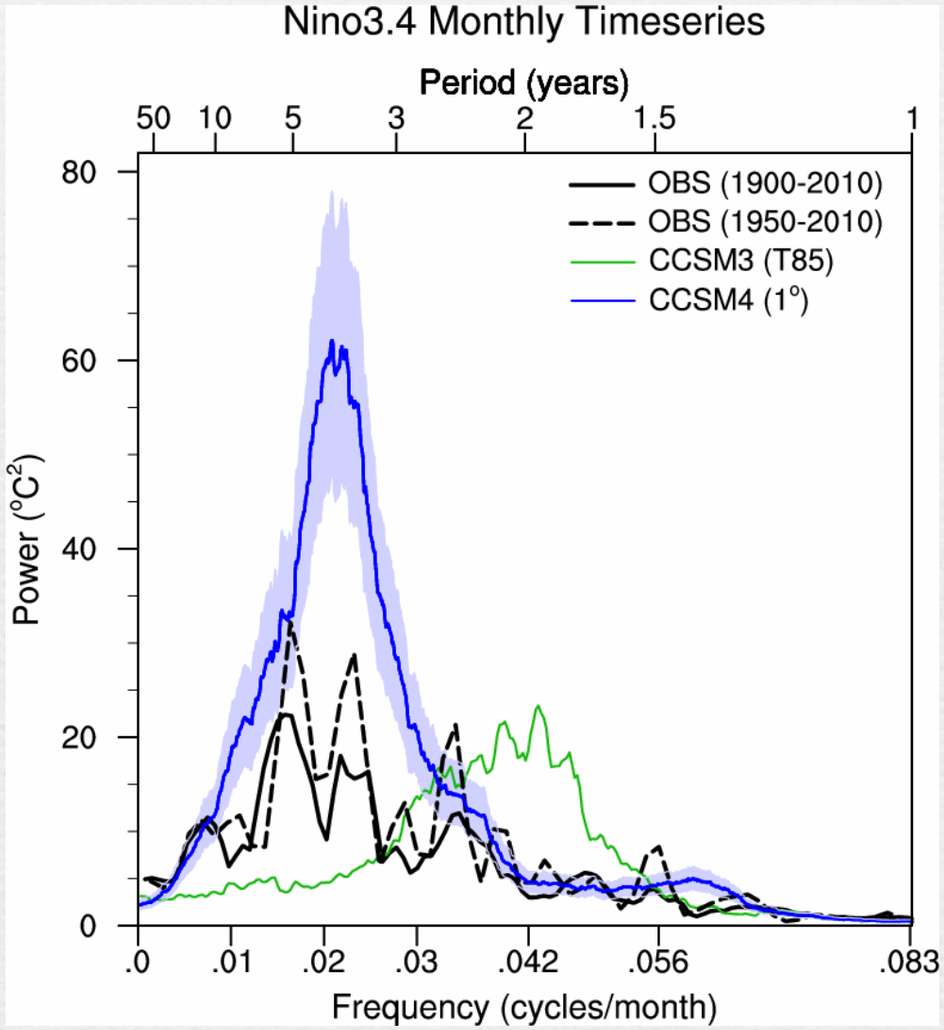
Papers available at: http://cires.colorado.edu/~sstevenson/

Problems with coupled approach

Model bias may not always be statistically significant

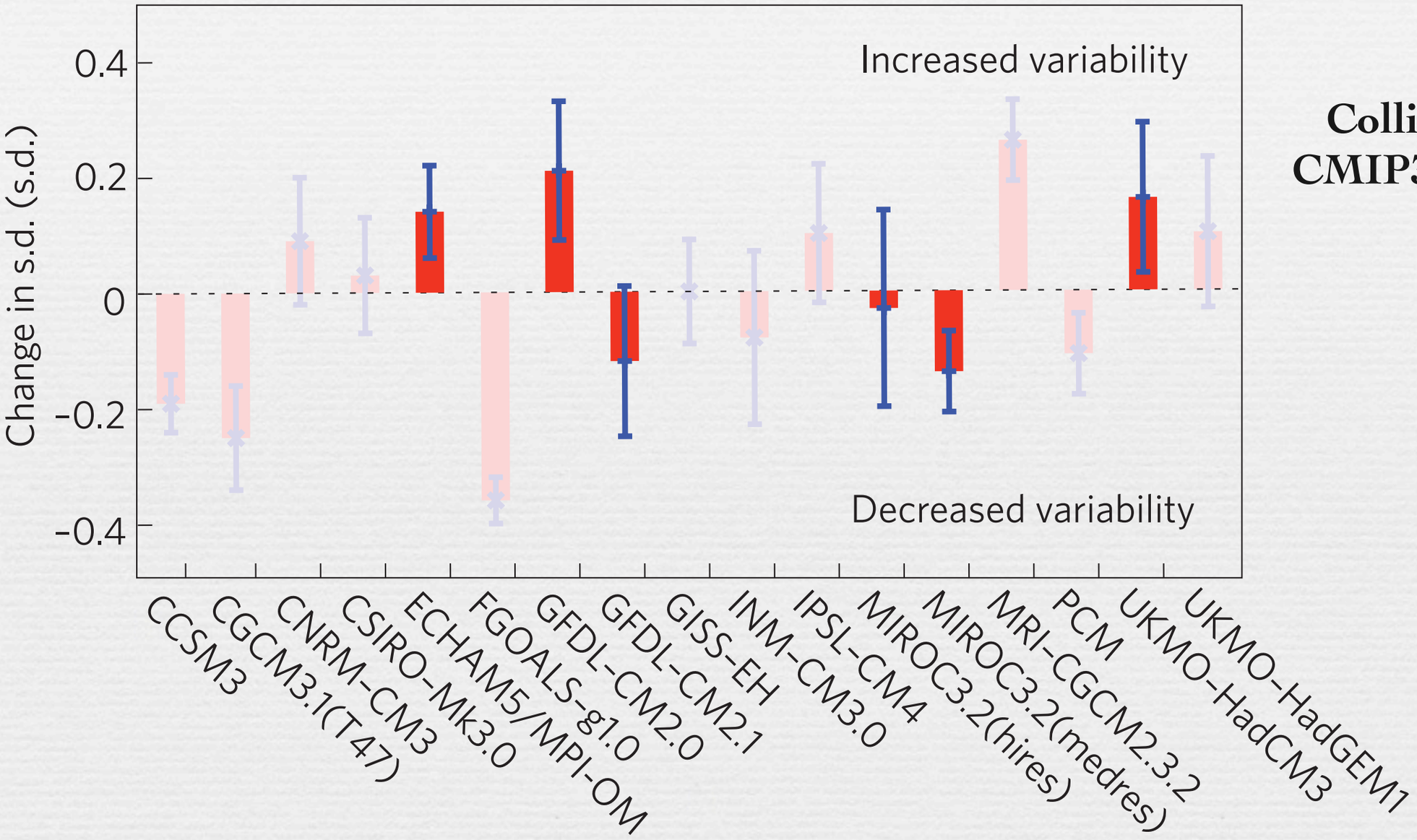


Deser et al. (2011): CCSM4 shows large decadal/centennial variability



Stevenson et al. (2010): ~250 years of observations required for stable ENSO statistics

This has implications for CMIP ENSO climate change responses...



Collins et al. (2010): CMIP3 models disagree

...How much disagreement is due to internal variability?