Systematic Errors in El Niño Teleconnections and Associated Extreme Events over North America

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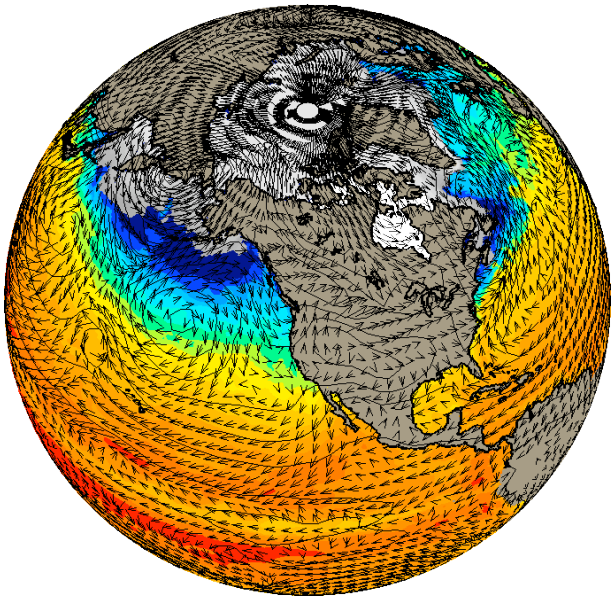
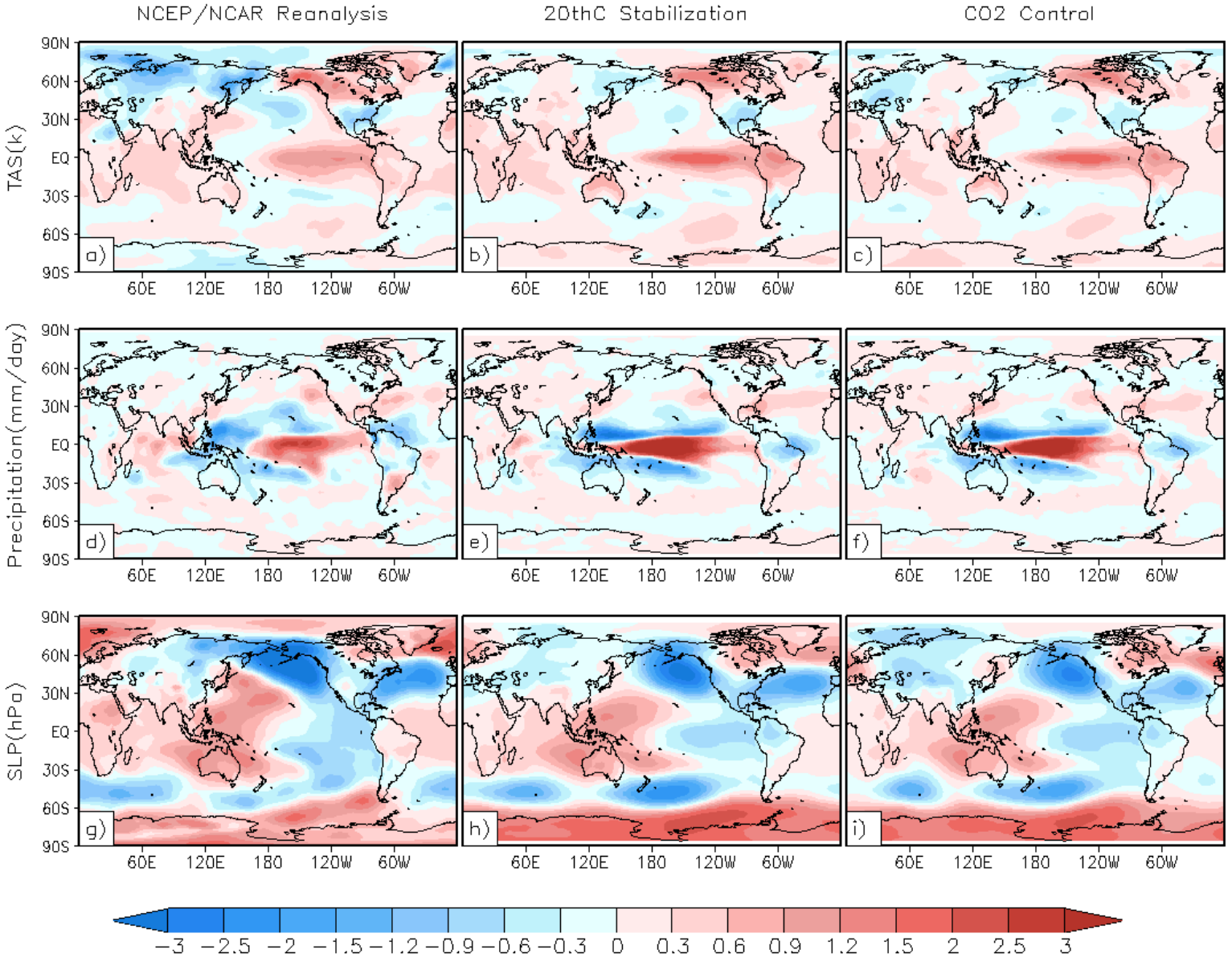
NCAR

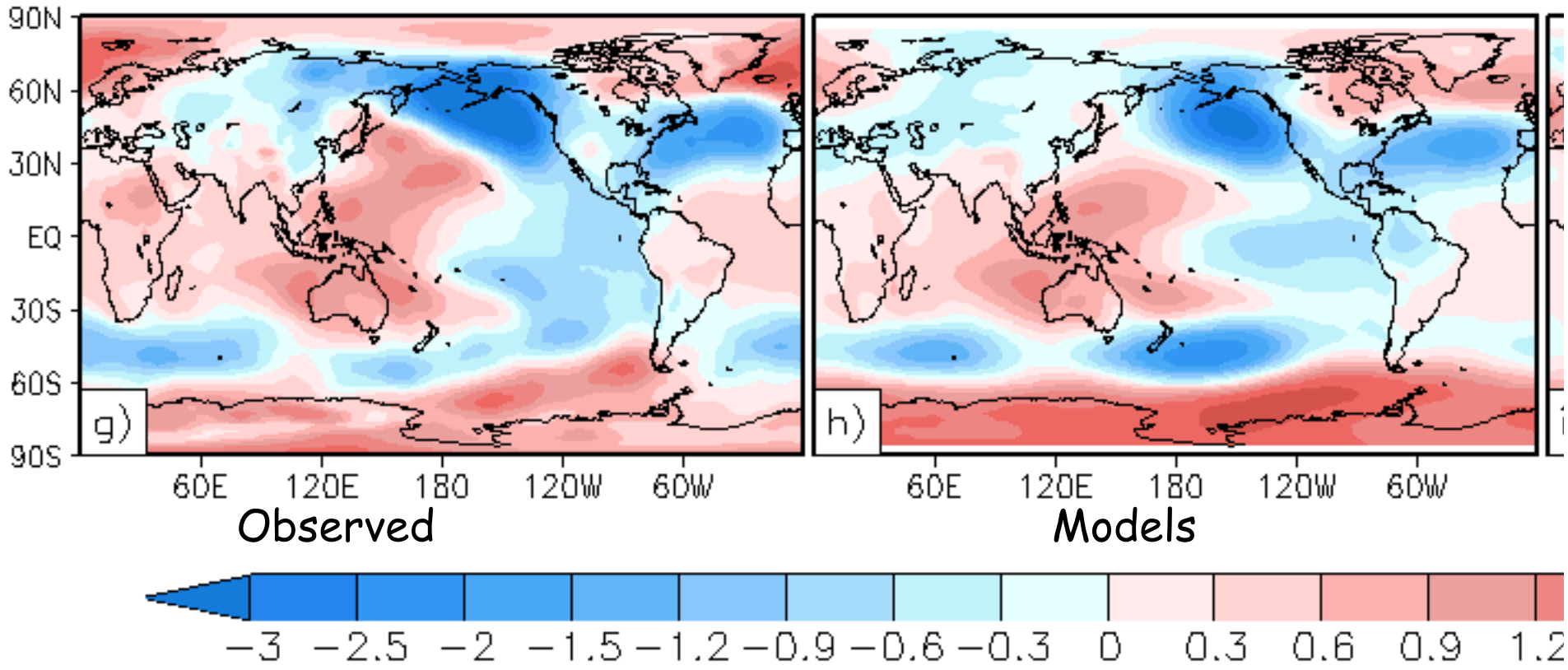


NCAR

First order aspects of present-day El Niño events are simulated by current global coupled climate models (6 member multi-model ensemble)



(Meehl and Teng, 2007, *Clim. Dyn.* Submitted)

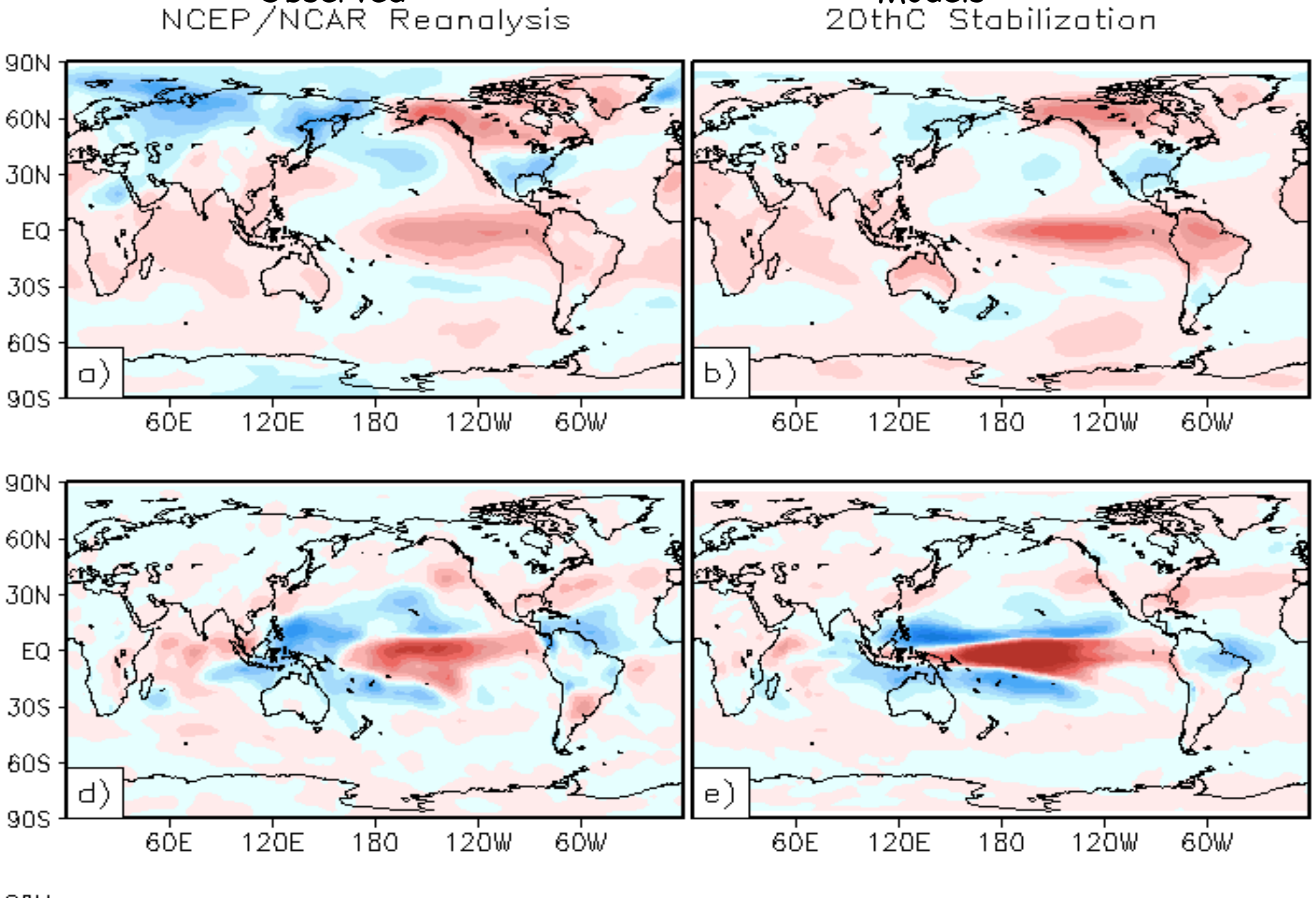


El Nino sea level pressure anomalies

El Nino surface temperature and precipitation anomalies

Observed

Models



All models have not submitted extremes indices for all experiments

We focus on one model (the Parallel Climate Model, PCM) that has been shown to simulate 20th century extremes reasonably well:

Frost days (Meehl, G. A., C. Tebaldi, and D. Nychka, 2004: Changes in frost days in simulations of 21st century climate. *Climate Dynamics,* **23**, 495–511. doi: 10.1007/s00382-004-0442-9)

Heat waves (3 warmest nights) (Meehl, G. A., and C. Tebaldi, 2004: More intense, more frequent and longer lasting heat waves in the 21st century. *Science,* **305**, 994–997.)

Precipitation intensity (Meehl, G. A., J. M. Arblaster, and C. Tebaldi, 2005: Understanding future patterns of precipitation extremes in climate model simulations. *Geophysical Research Letters,* **32**, No. 18, L18719, doi:)

Model experiments and observed data:

Control run (200 years)
32 El Niño events, 35 La Niña events

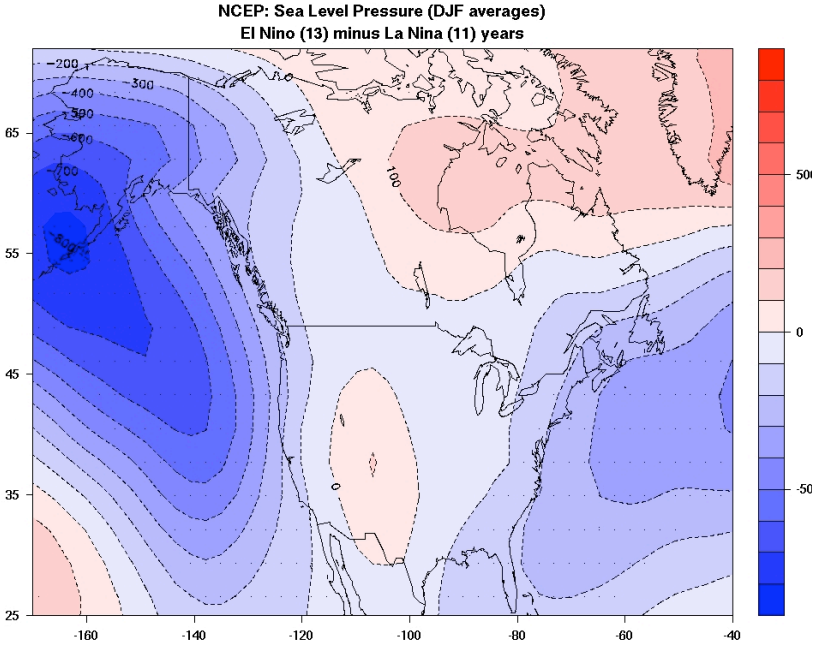
NCEP/NCAR reanalysis (1948-2004)
13 El Niño events, 11 La Niña events

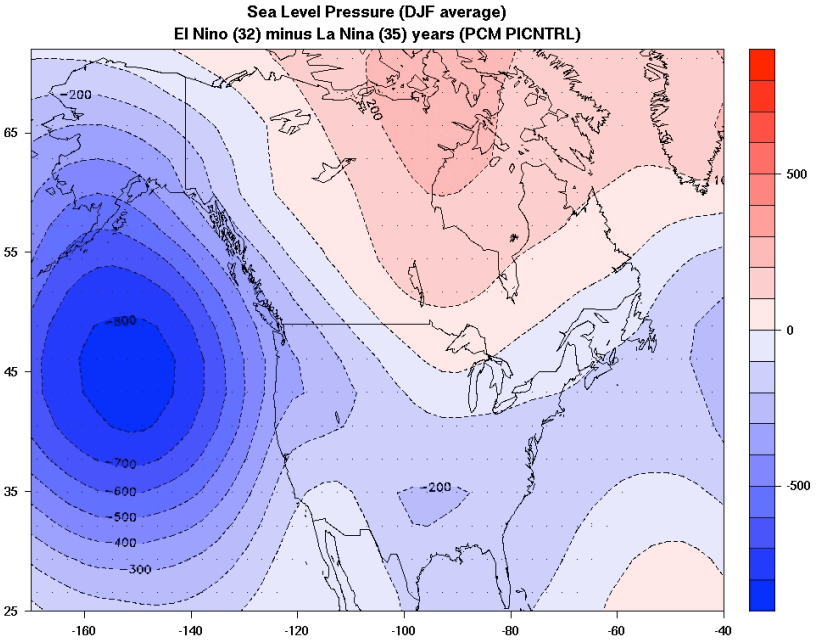
Daily data for extremes indices (1950-2004)
13 El Niño events, 11 La Niña events

El Niño (La Niña) events defined as Niño3.4 anomaly that exceeds one standard deviation for the DFJ season

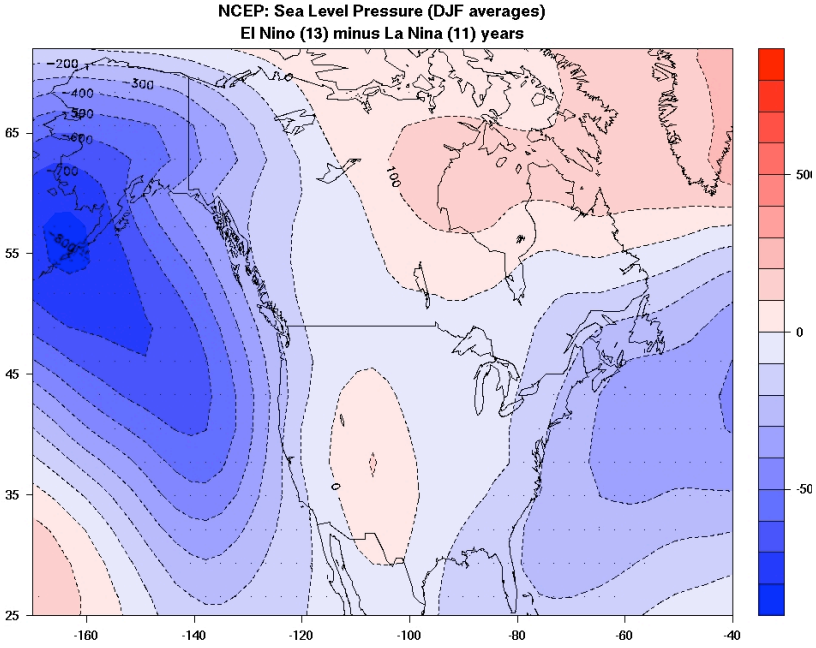
Differences computed as El Niño minus La Niña

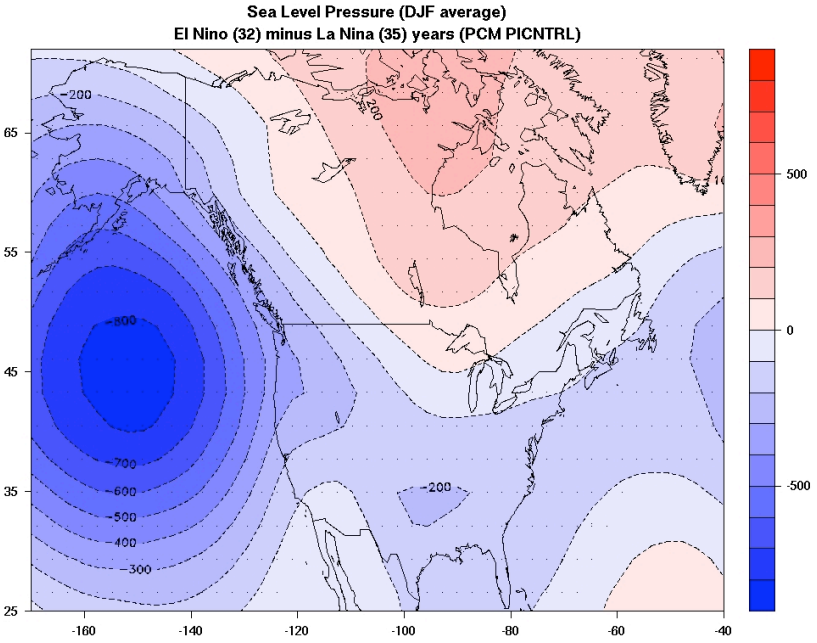
SLP: NCEP/NCAR reanalyses PCM control

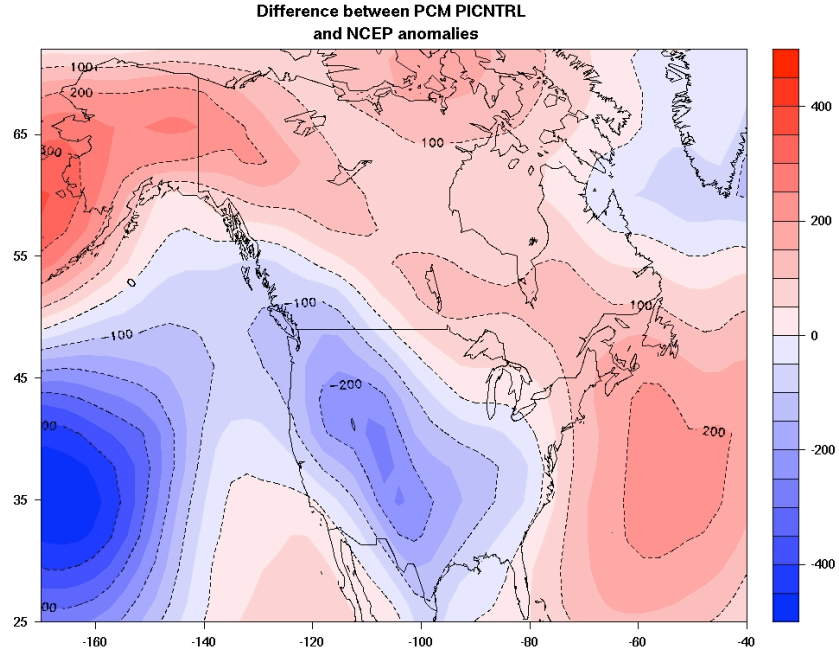




SLP: NCEP/NCAR reanalyses PCM control



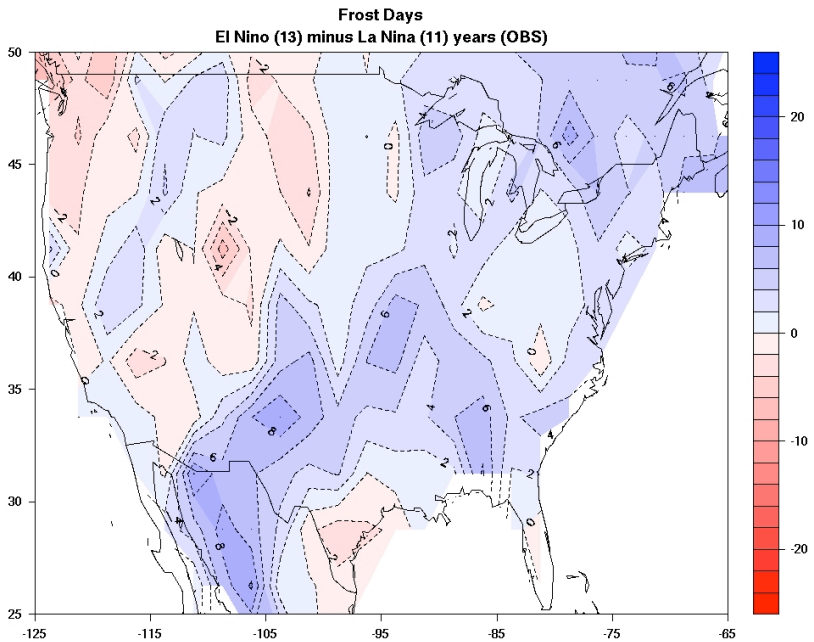




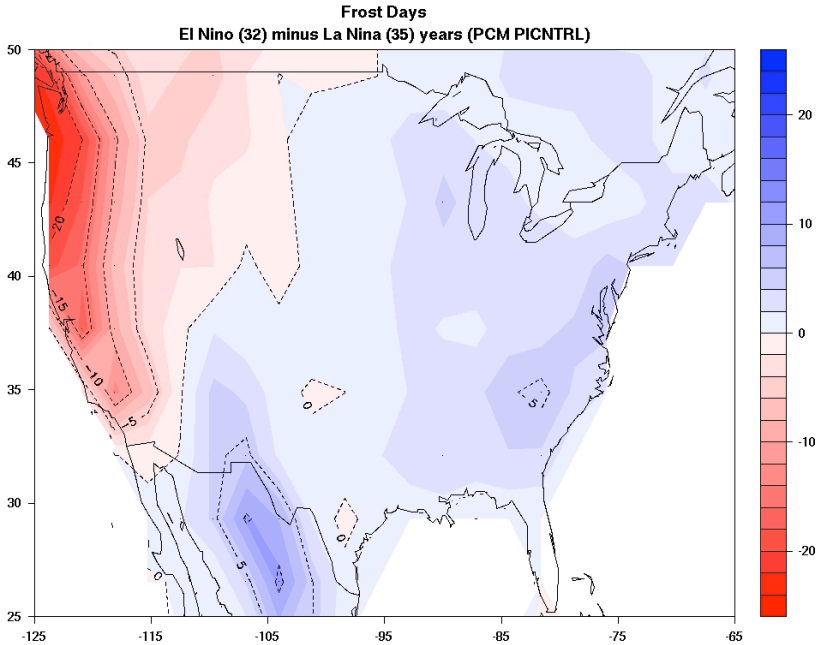
the PCM shows typical present-day El Niño teleconnection systematic errors

(anomalous low shifted south)

Frost days during El Niño: observed

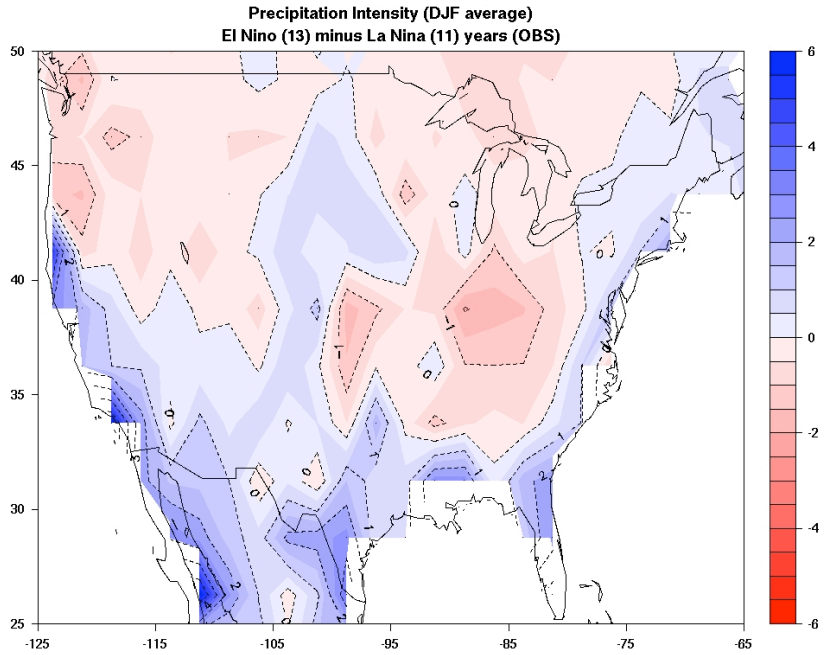


model control

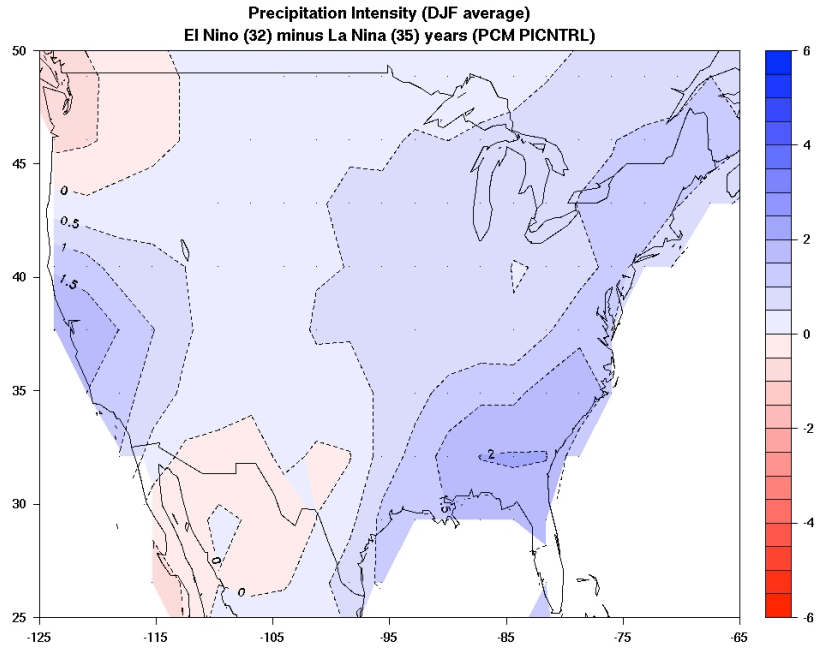


Decreases of frost days in the west are expanded south and west associated with the southward-shifted anomalous Aleutian Low

Intense precipitation: observed

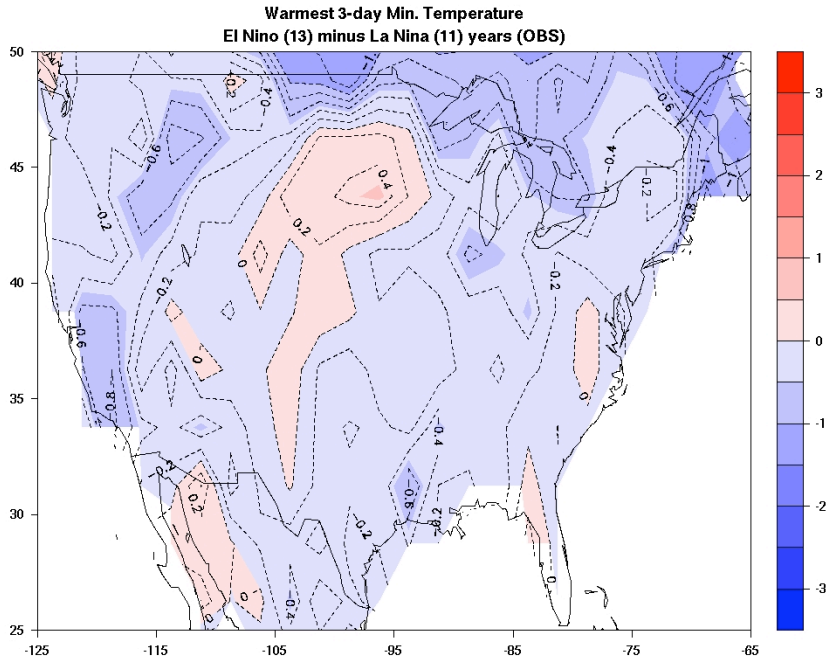


model control

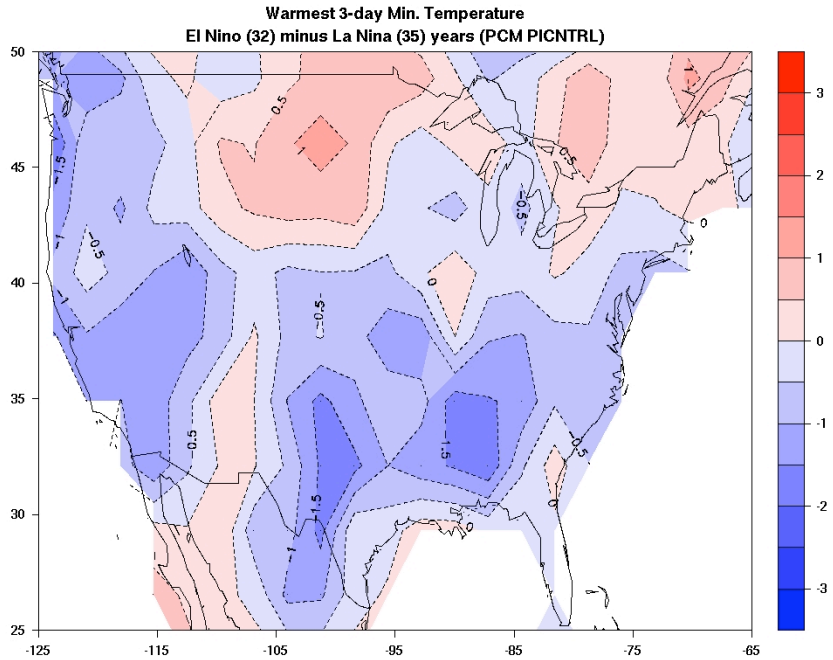


Anomalously intense precipitation in the SW U.S. is expanded eastward, and there are more extensive areas of intense precipitation in the eastern U.S.

Heat waves/warm spells: observed



model control



Southward shift of anomalous Aleutian Low associated with expanded area of increased warm spells in the north central U.S., and stronger decreases of warm spells in the southern U.S.

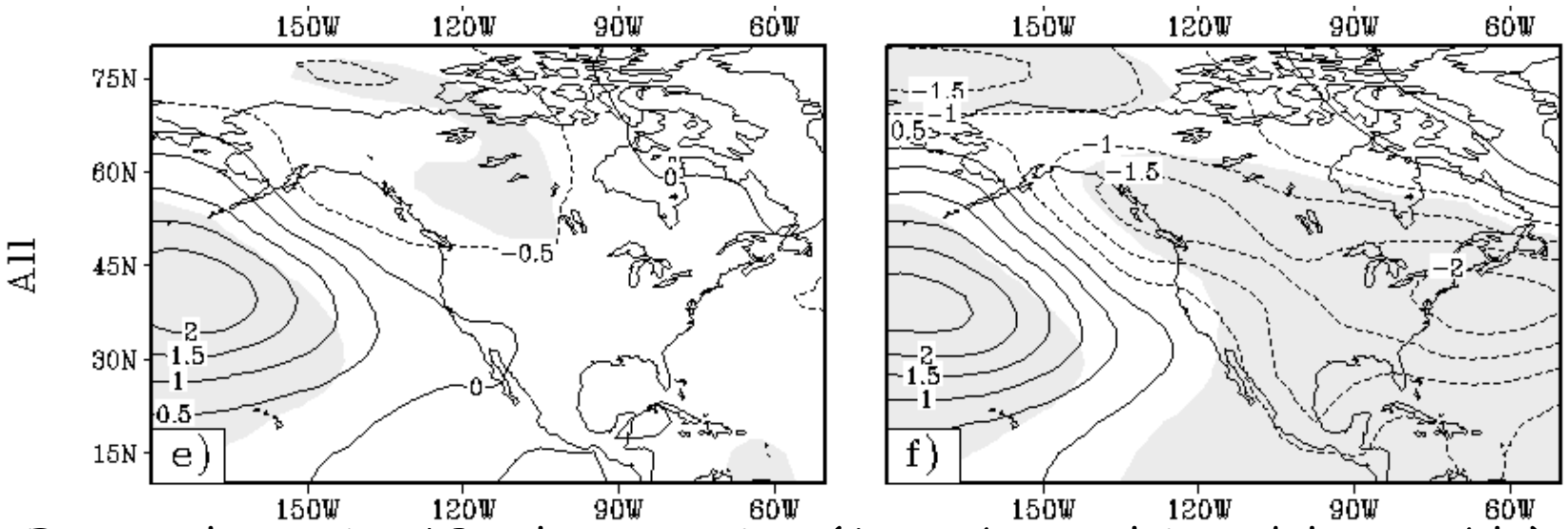
Conclusions

Anomalous temperature and precipitation extremes over the U.S., with associated impacts, are associated with El Niño events (decreased frost days in the west, increased precipitation intensity over the SW and SE, decreased heat waves/warm spells over the southern tier)

Climate models simulate most first order aspects of El Niño events and their teleconnections over North America in present-day climate, but with a systematic southward and eastward shift of the anomalous Aleutian Low over the North Pacific

Simulated extreme events associated with El Nino events reflect the systematic error of a southward and eastward shift in the El Nino teleconnections

(Future El Niño teleconnection patterns and associated extreme events over the U.S. are projected to shift eastward and northward due in part to the different midlatitude base state atmospheric circulation in a warmer climate)

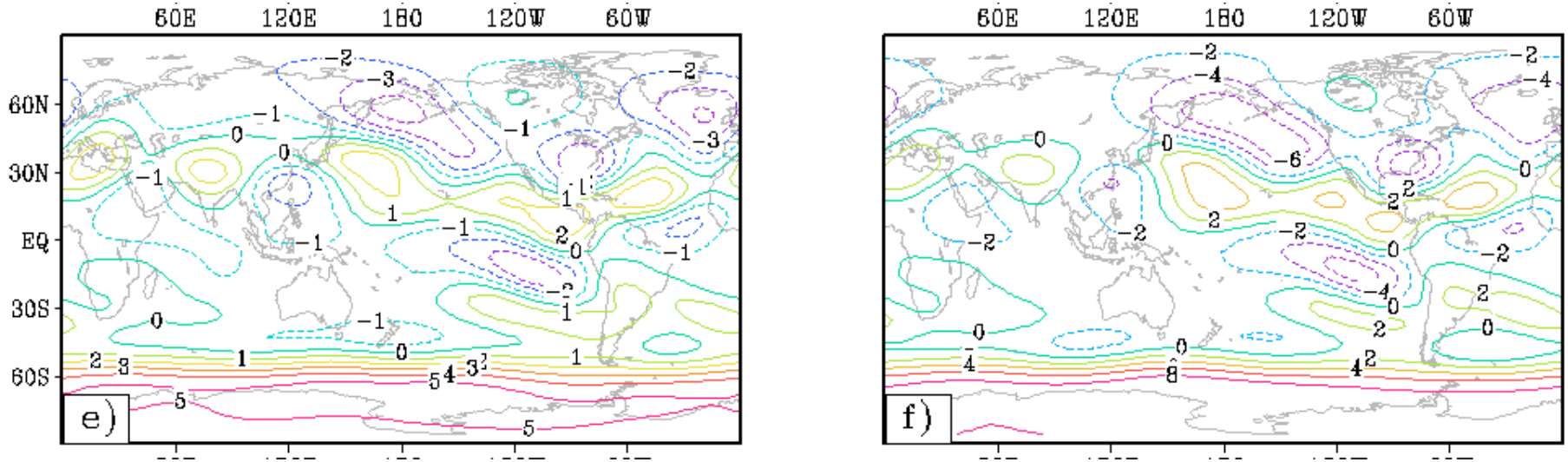


Future change in SLP teleconnection (6 member multi-model ensemble)

Stabilized A1B 4XCO2

Models project a change in El Niño teleconnections over the U.S. in a future warmer climate (an eastward and northward shift of the anomalously strengthened Aleutian Low)

(Meehl and Teng, 2007, *Clim. Dyn.* Submitted)



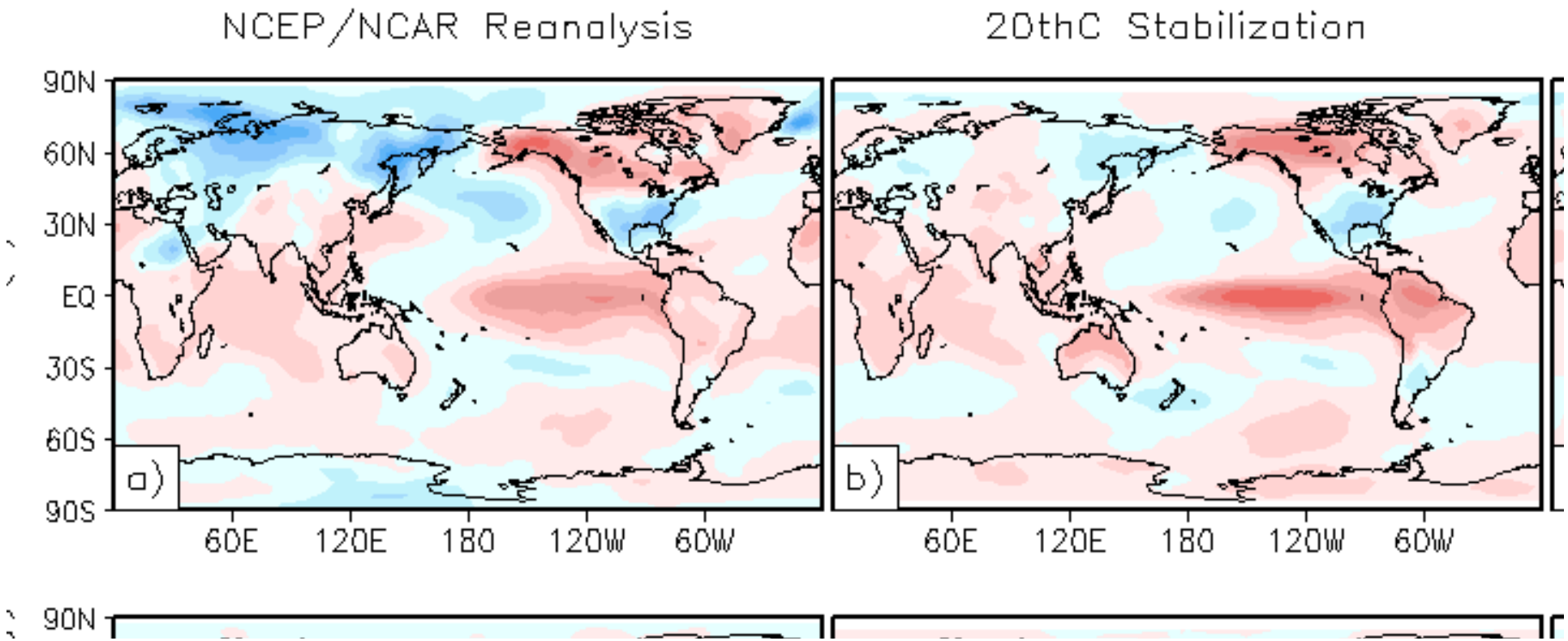
A1I

Future change in 300 hPa streamfunction (6 member multi-model ensemble)
Stabilized A1B 4XCO2

The changed base state atmospheric circulation in a future warmer climate (with an anomalous wave 5 pattern in the Northern Hemisphere) plays a major role in altering future El Niño teleconnections over North America

(Meehl et al., 2006, Clim. Dyn., 26, 549-566)

El Nino surface temperature anomalies

Observed

Models