The Two Types of ENSO in CMIP5 Models and Their Different Impacts on North America Winter Temperature

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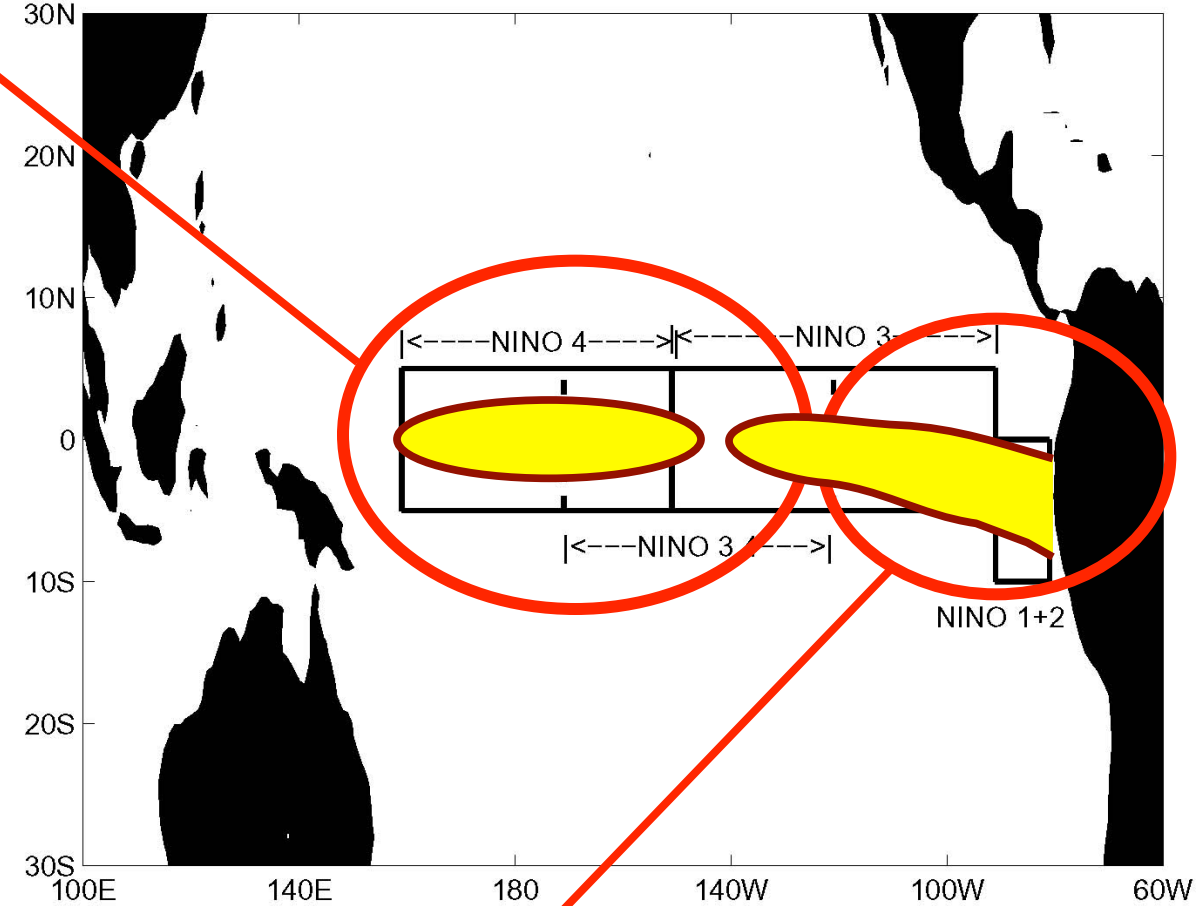
The Two Types of ENSO

Central-Pacific ENSO (related to atmospheric forcing)

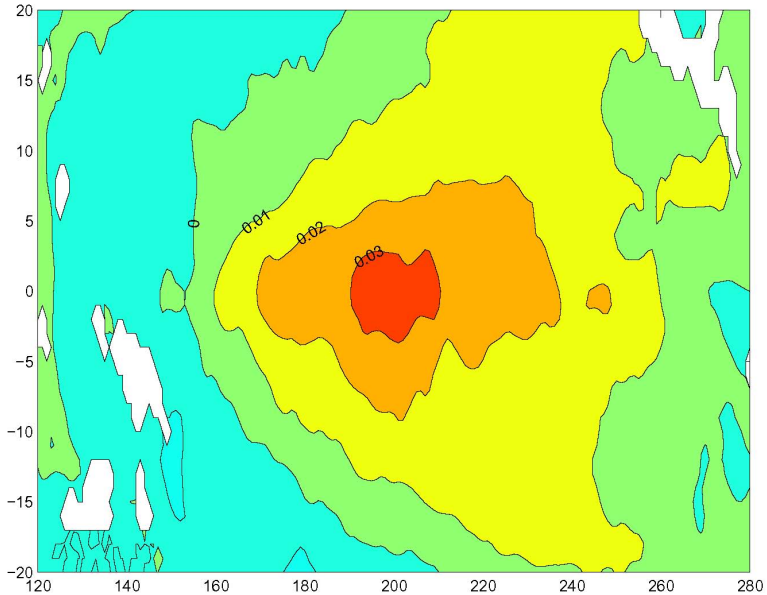


Eastern-Pacific ENSO (related to thermocline variation)

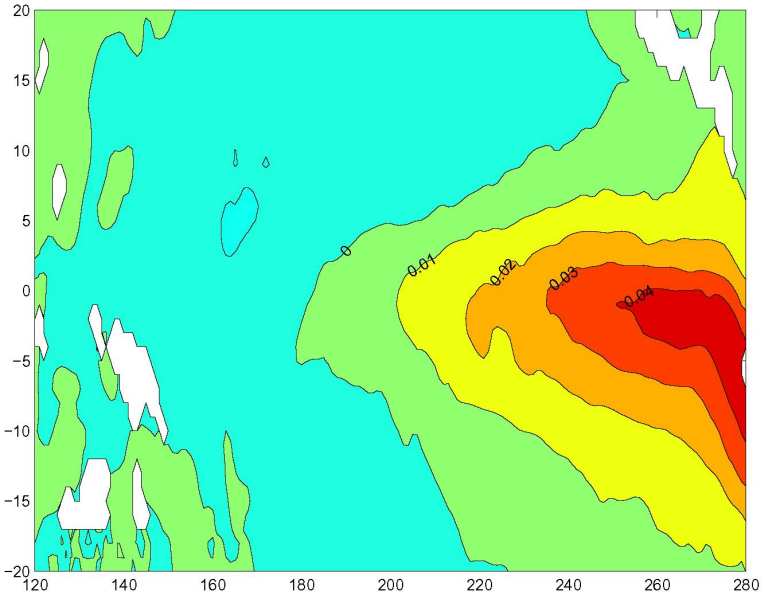
Regression-EOF Method for EP- and CP-ENSO

(Kao and Yu 2009; Journal of Climate)

Central-Pacific (CP) ENSO

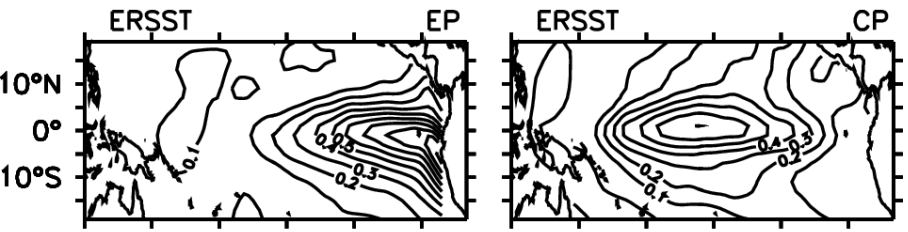


Eastern-Pacific (EP) ENSO

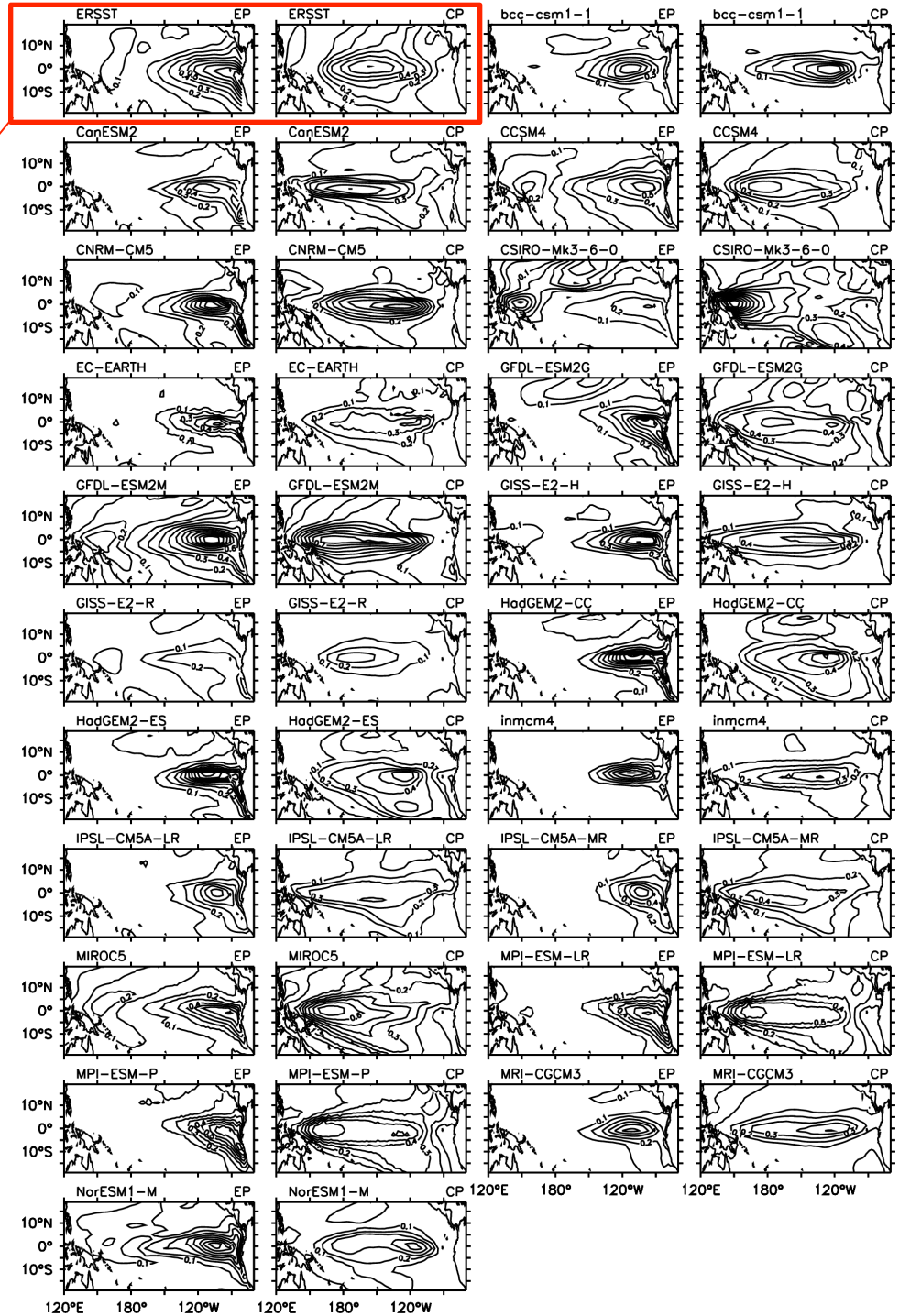


EOF applied to Residual SSTA = (SSTA) – (Regressed SSTA with Nino1+2/Nino4)

EP and CP ENSO in CMIP5 Models: Pre-Industrial Simulations

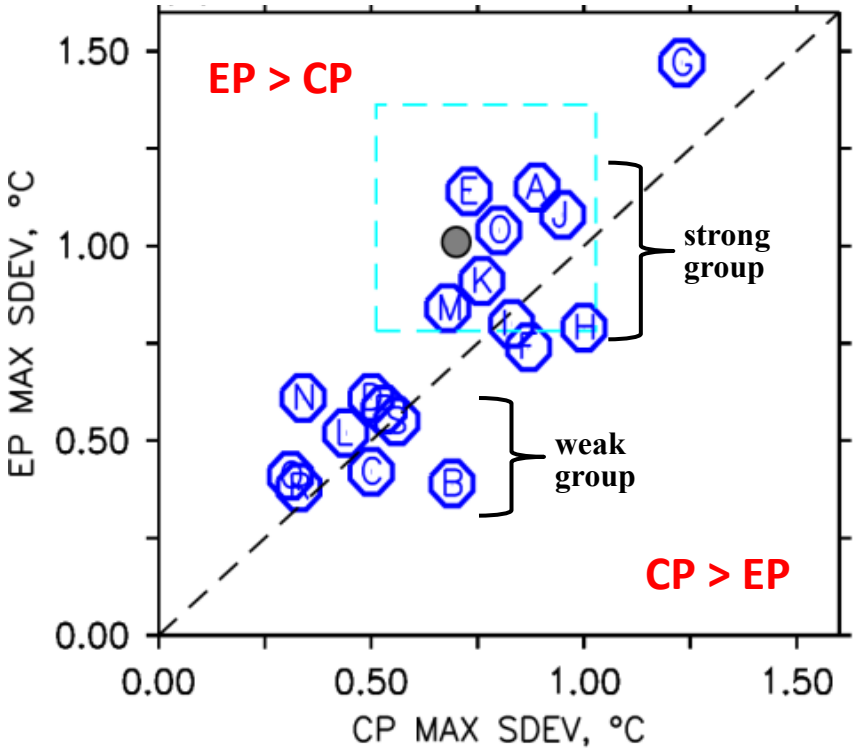


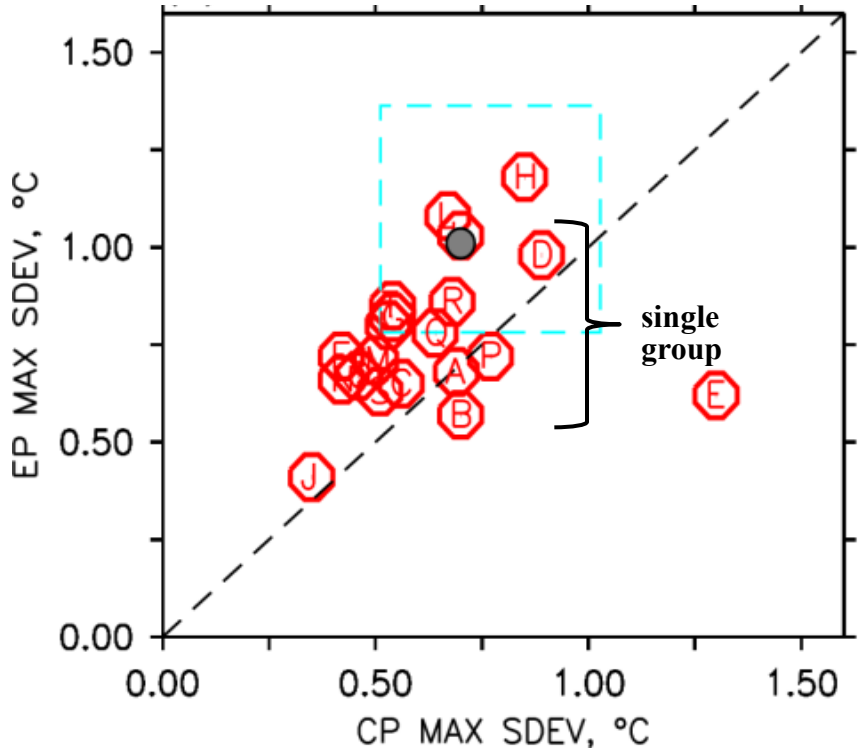
STD = loading coefficient * sqrt(eigen value)



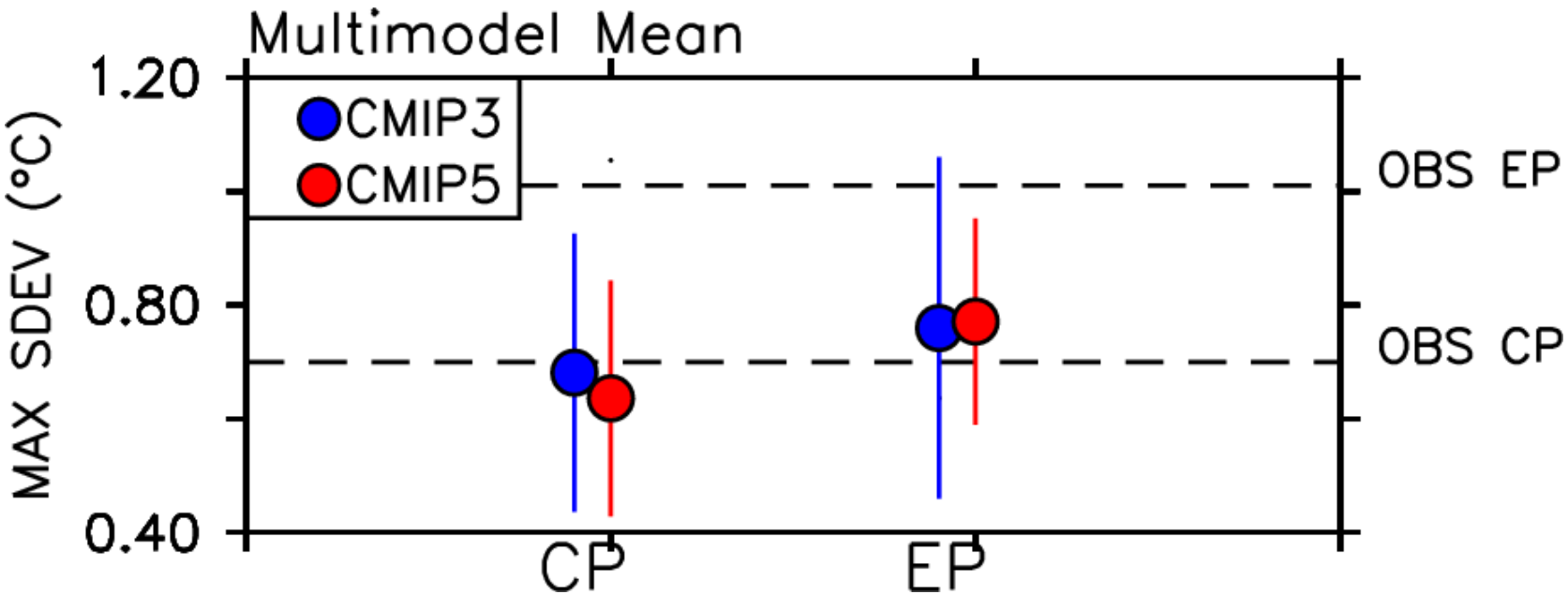
Two Types of ENSO in CMIP Models

CMIP3 → CMIP5

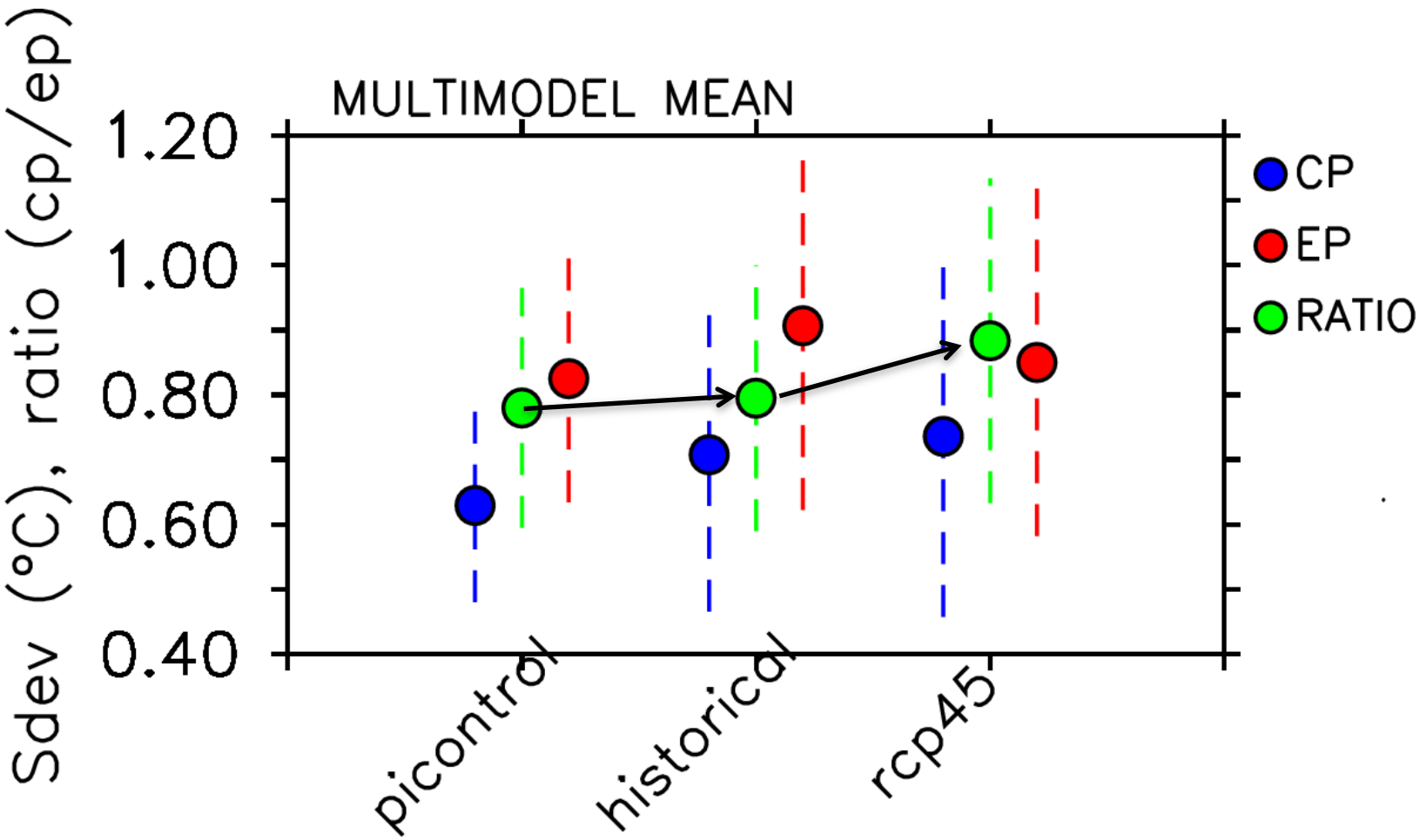




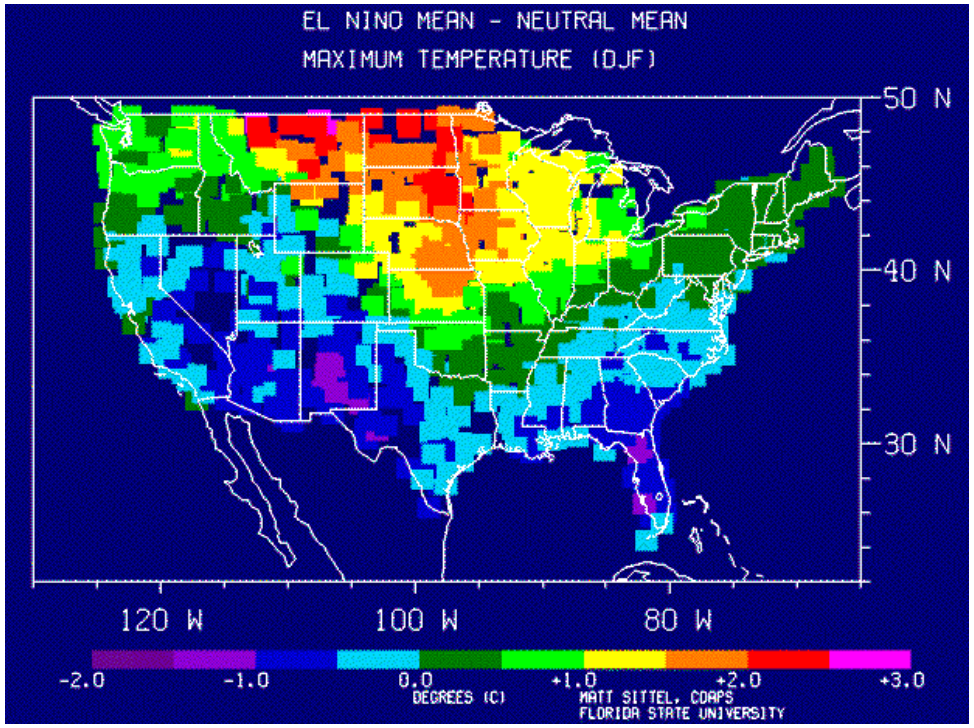
Amplitudes of the Two Types of ENSO



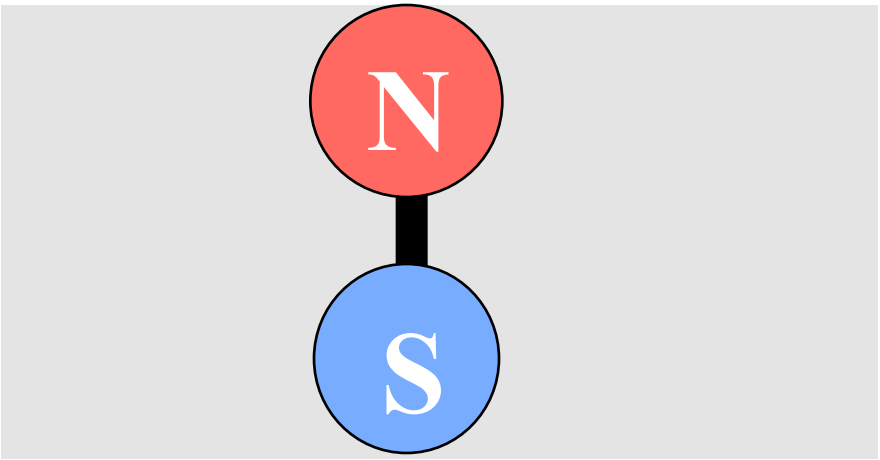
CMIP5 Projection of the Two Types of ENSO



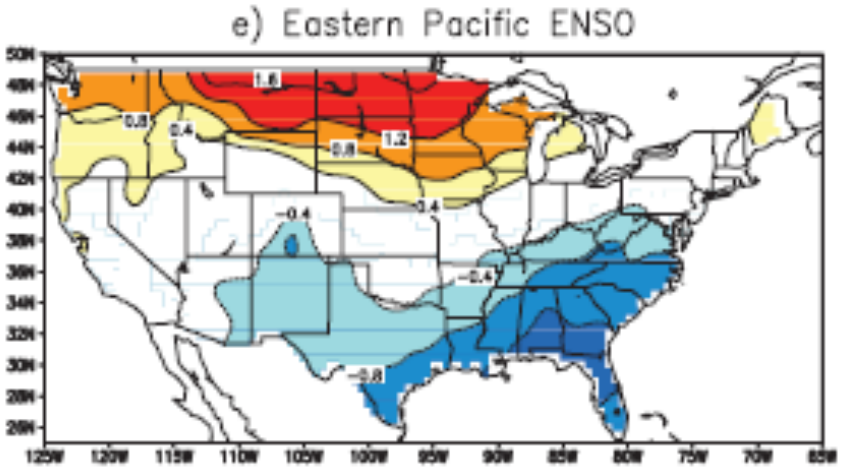
Traditional View of El Nino Impacts on US Winter Temperature

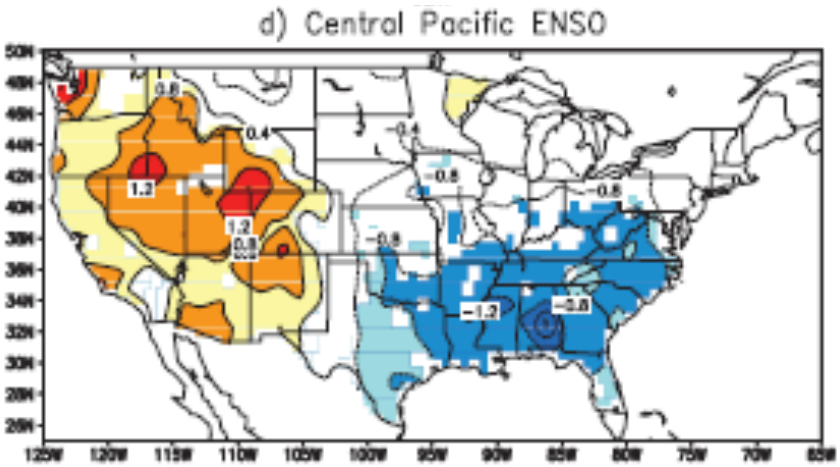


(from NOAA)



Results from Mo (2010)



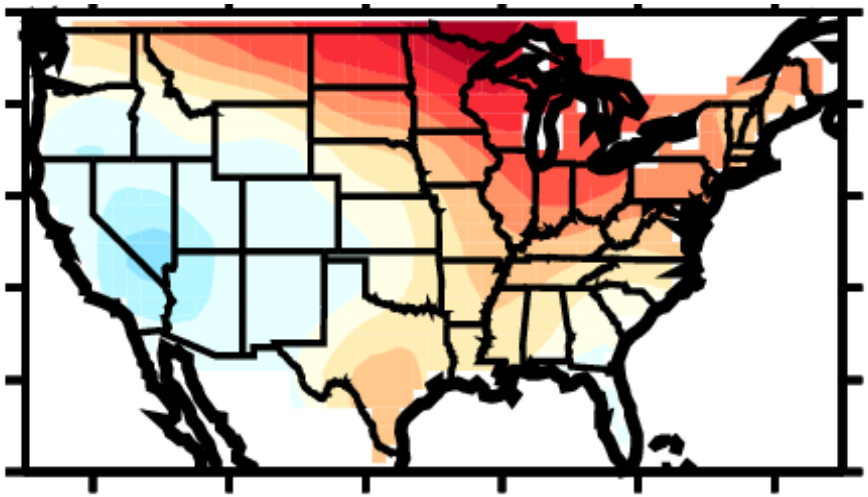


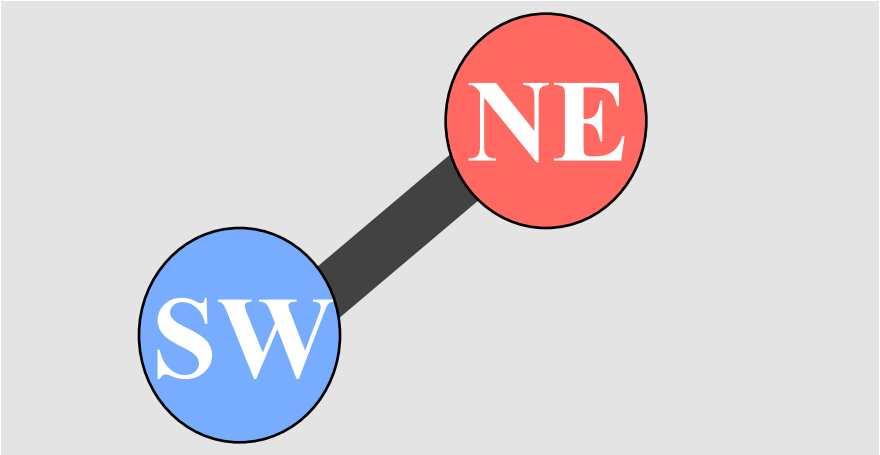
EP winters: 1964, 1966, 1970, 1973, 1977, 1980, 1987, 1988, 1991, 1998, 2004
CP winters: 1969, 1978, 1991, 1995, 2002, 2003

Regressed US Winter (JFM) Temperature

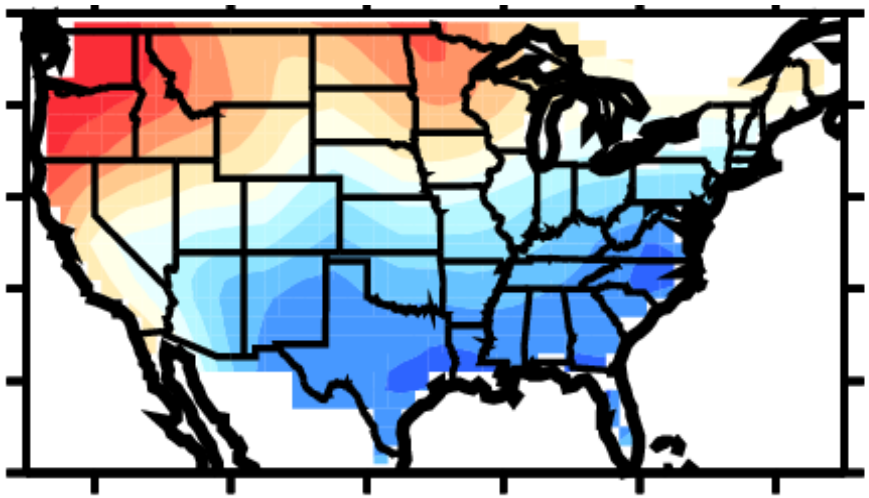
(1948-2010)

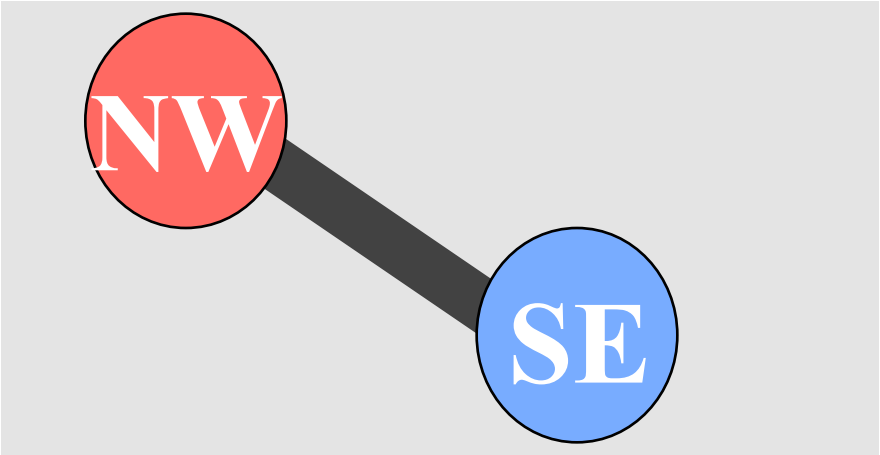
With EP El Nino Index





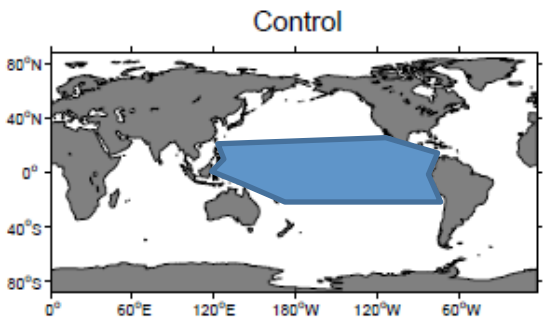
With CP El Nino Index





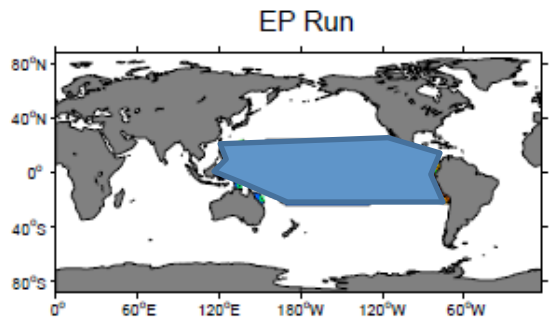
Three Ensembles AGCM (CAM4) Experiment

Control



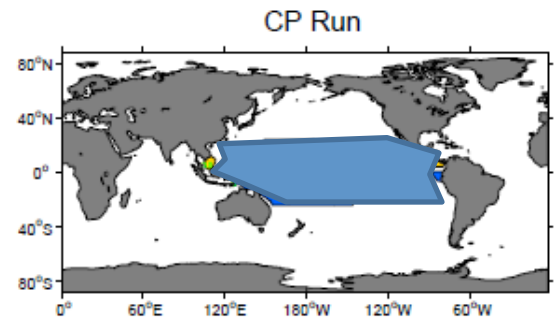
Climatological SST

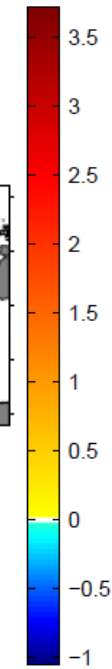
EP Ensemble



Climatological SST + EP Anomaly

CP Ensemble



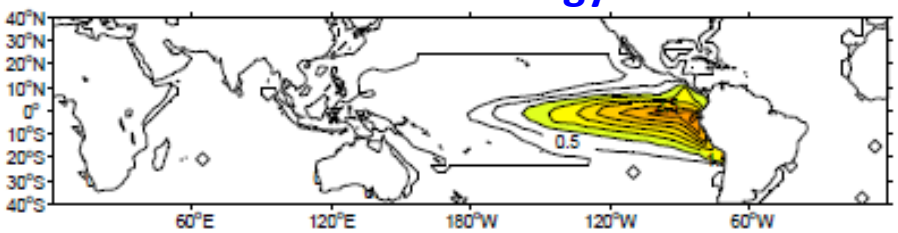


Climatological SST + CP Anomaly

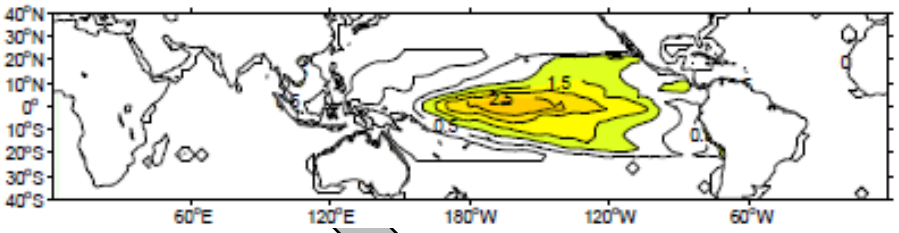
Forced CAM4 Experiments

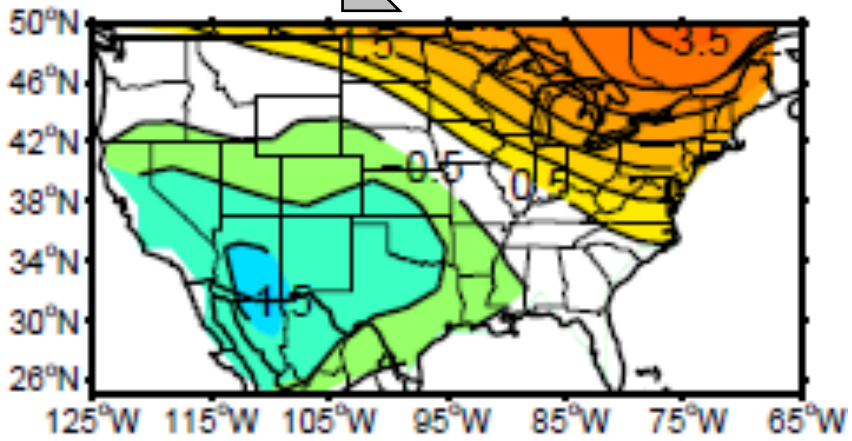
NCAR CAM4
Forced by the SST from

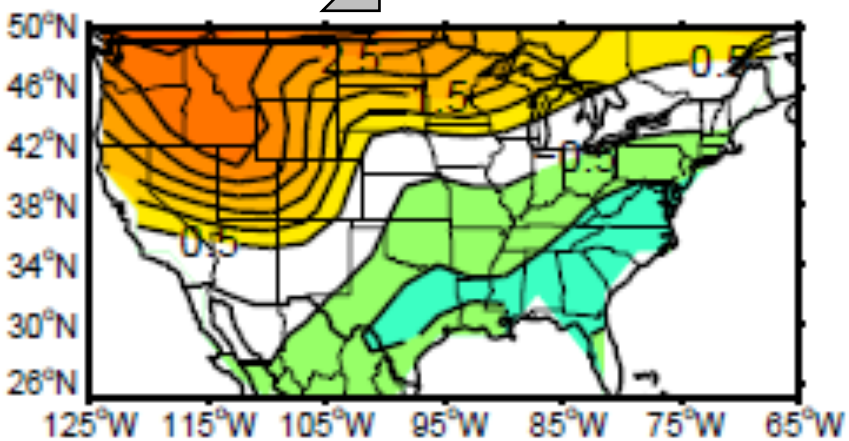
EP ENSO SSTA + Climatology



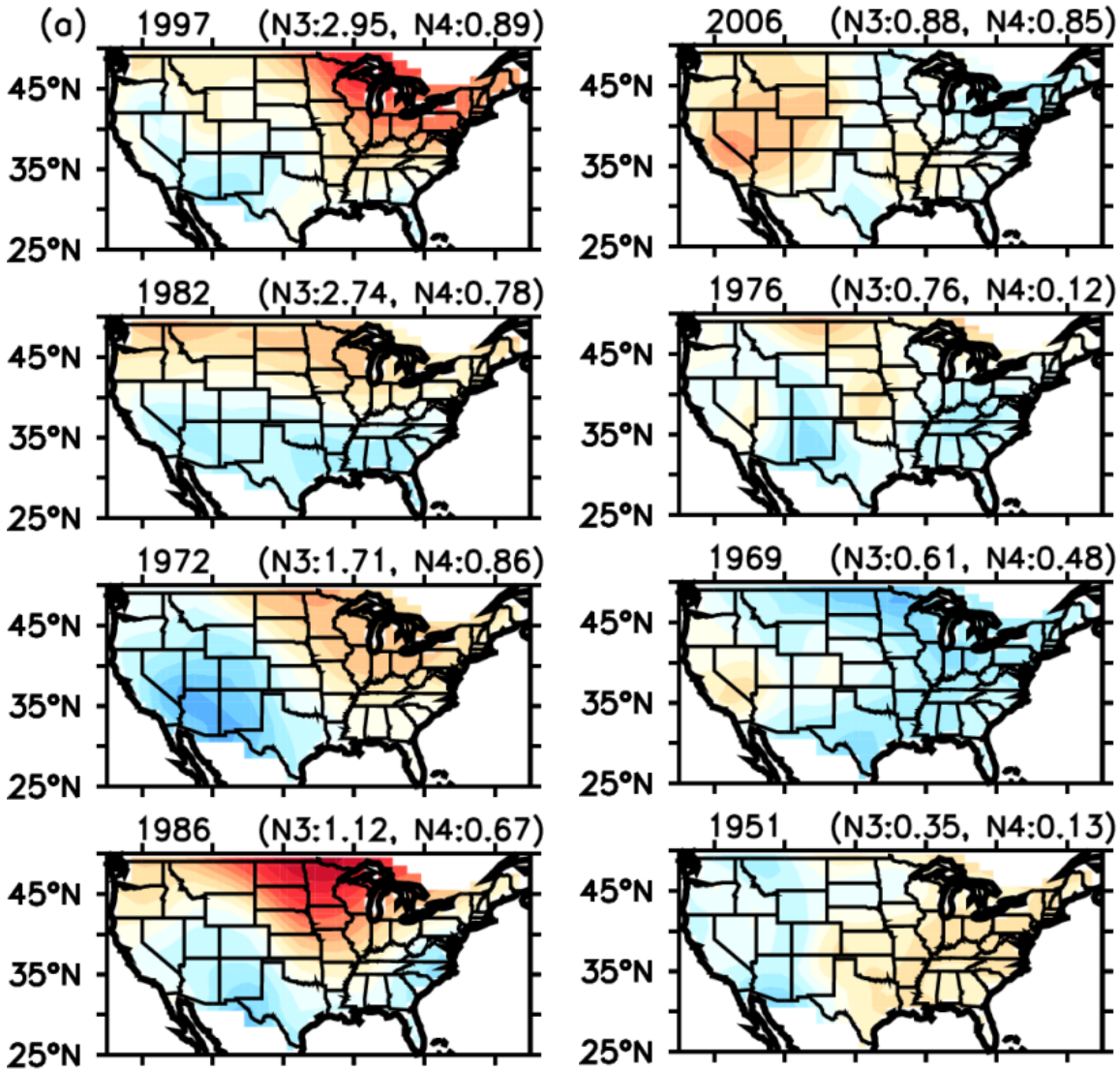
CP ENSO SSTA + Climatology







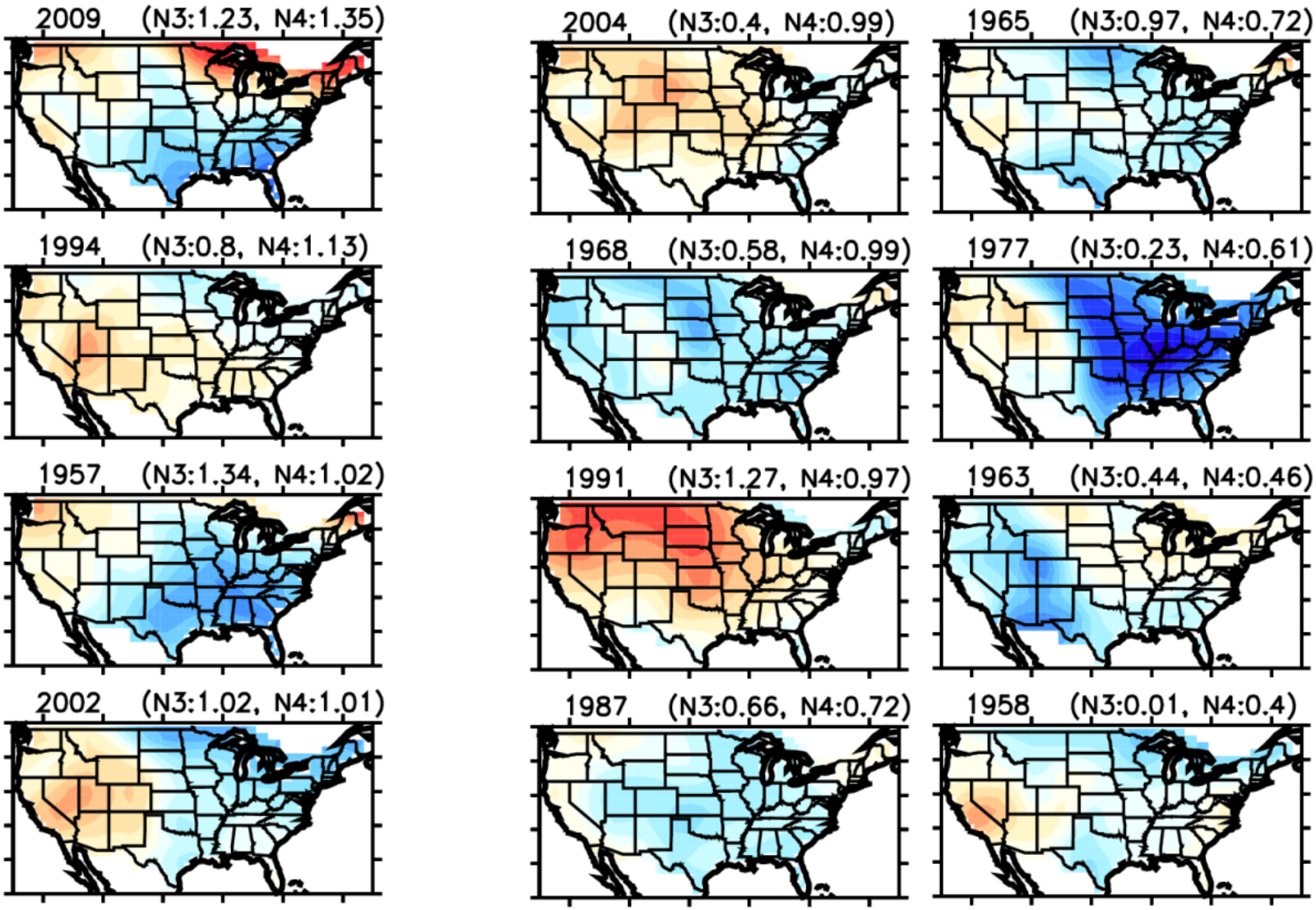
Case Studies with EP El Nino Events



Strong EP Events

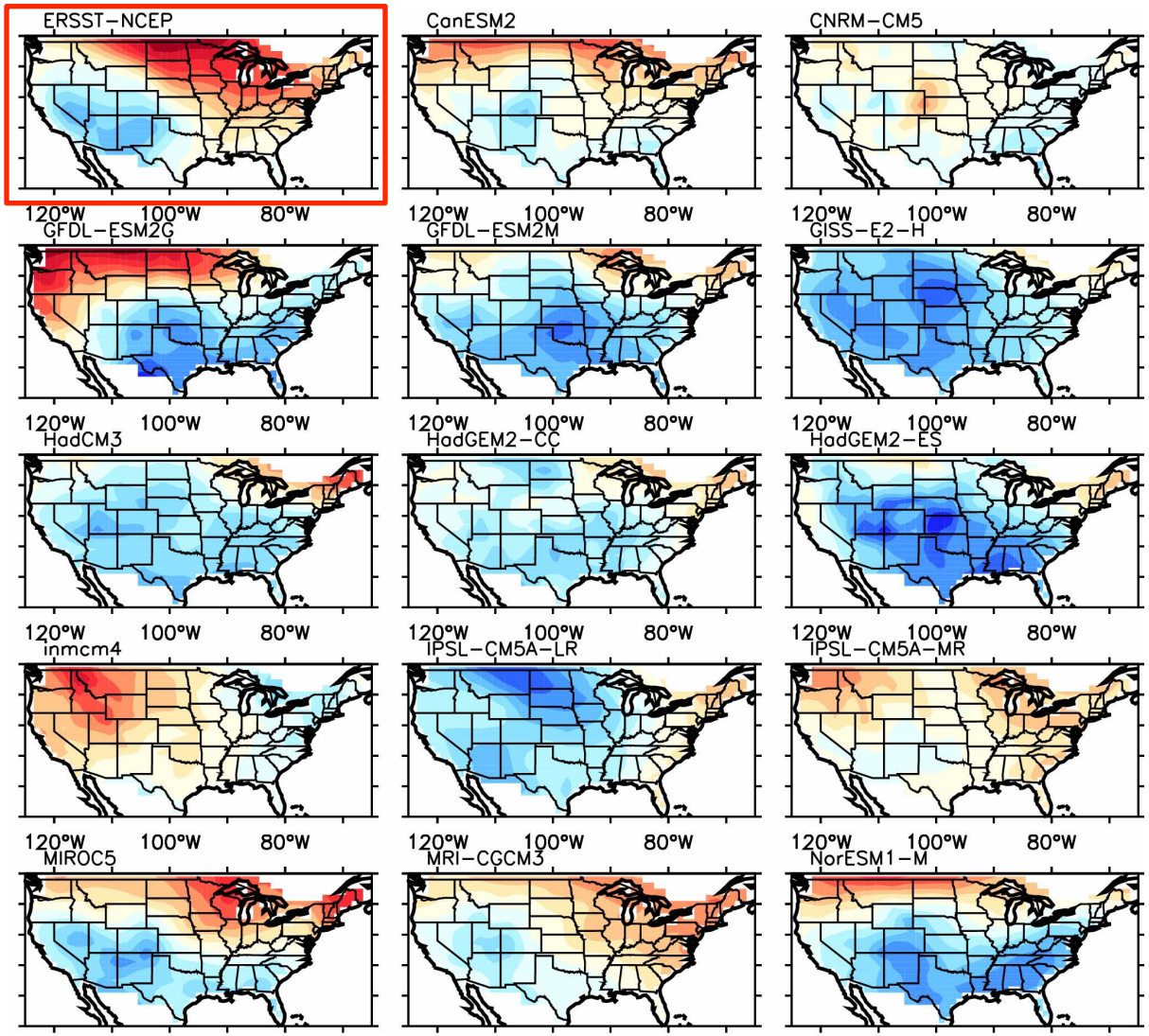
Weak EP Events

Case Studies with CP El Nino Events

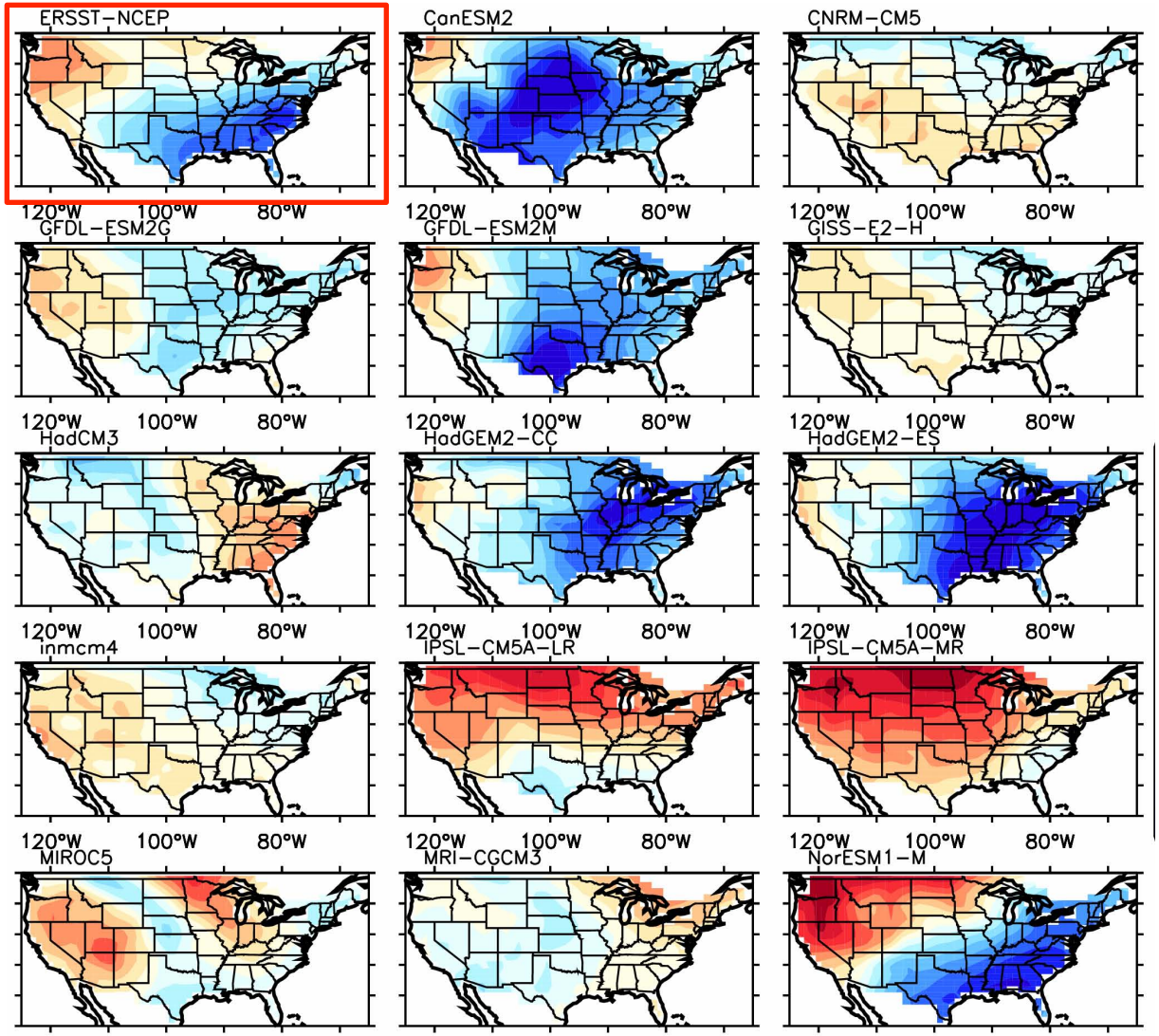


Strong Events **Weak Events**

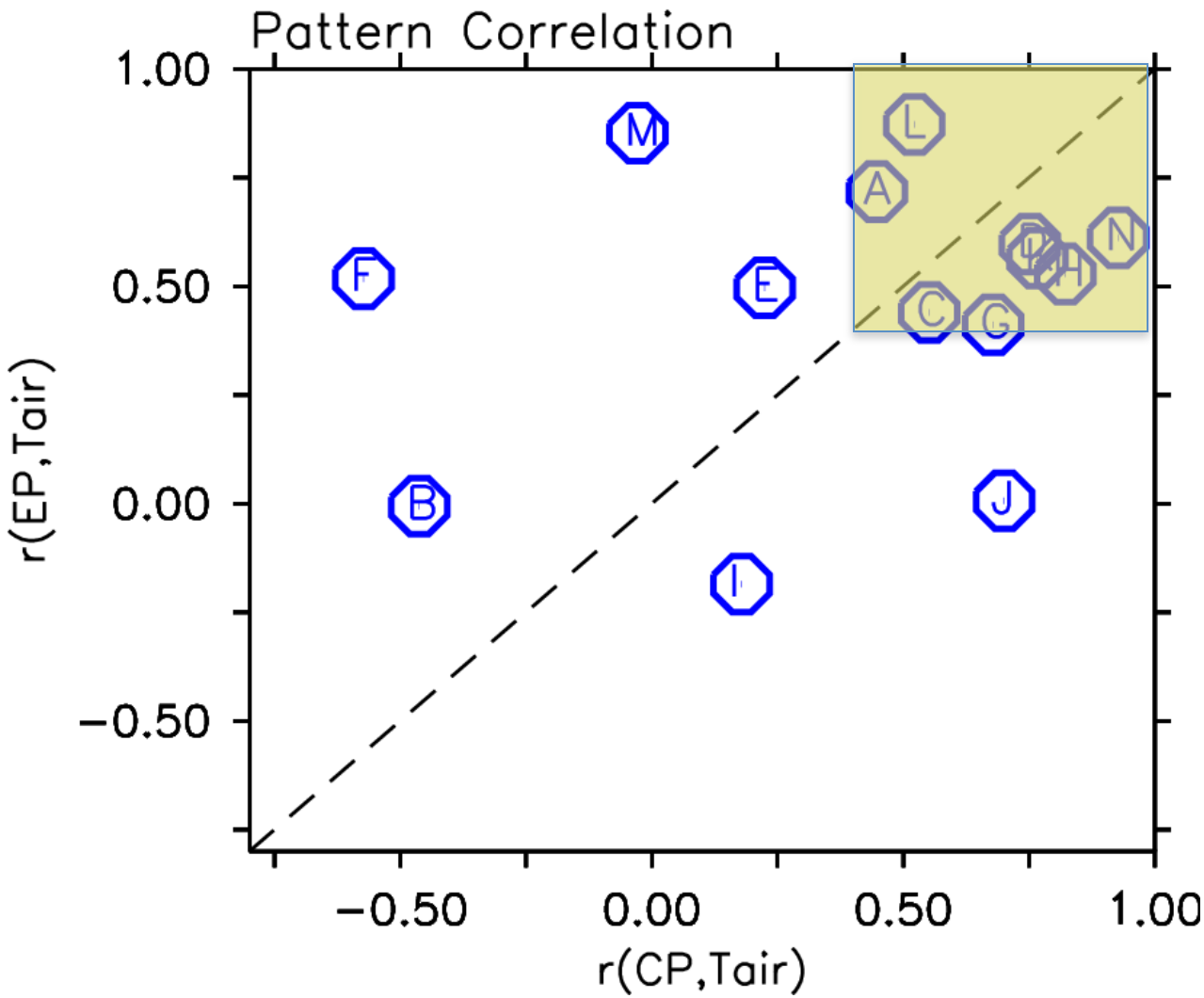
CMIP5 Simulations of the EP Impacts



CMIP5 Simulations of the CP Impacts



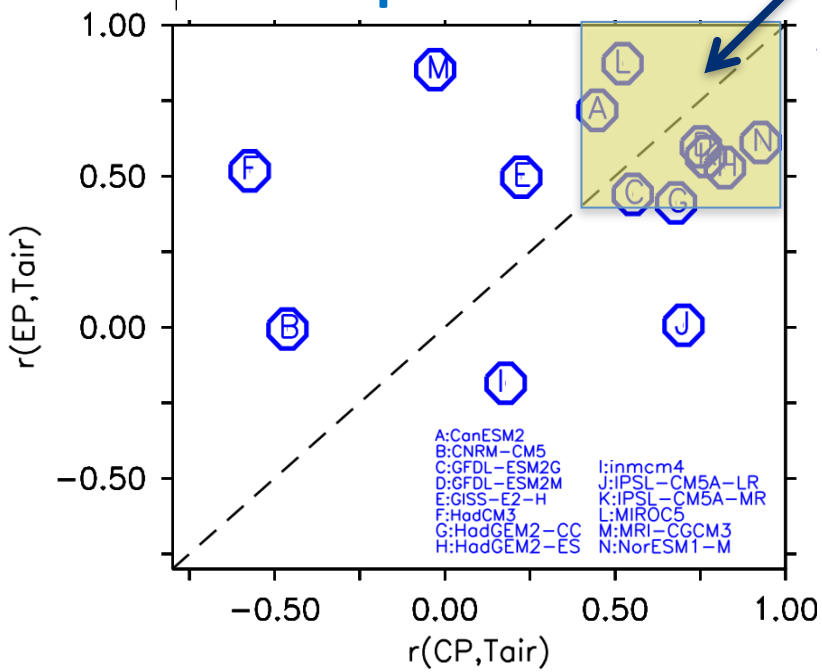
Pattern Correlation of El Nino Impact



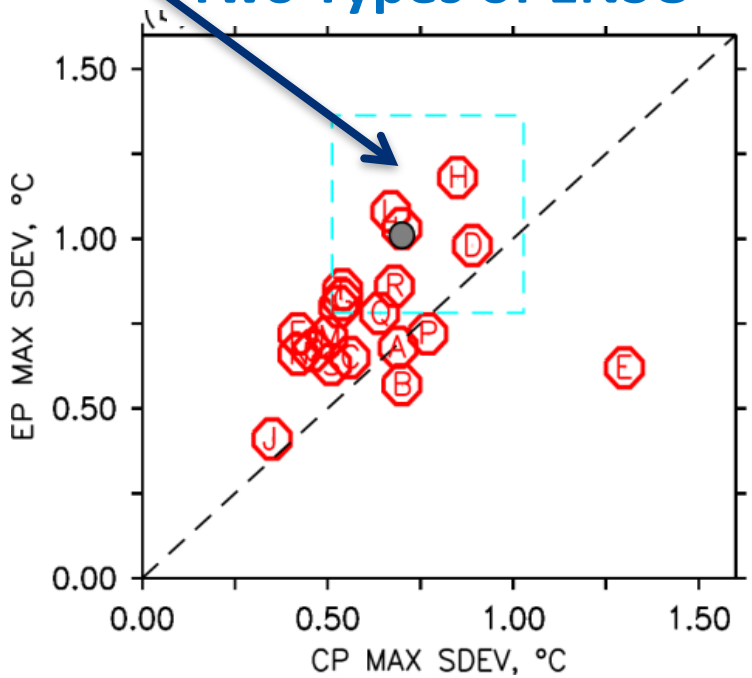
"Best" CMIP5 Models for North America Climate Projections

SIX CMIP5 Models that can simulate the two types of ENSO and their different impacts on US winter temperature

US Response to ENSO



Two Types of ENSO



Summary

- CMIP5 Models still underestimate the intensity of EP ENSO, but their inter-model differences have been reduced compared to CMIP3 models.

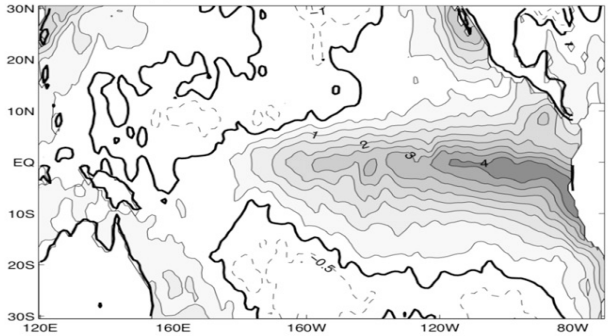
- CP and EP ENSOs respond differently to global warming, and the CP ENSO is projected to become nearly as important as the EP ENSO in RCP4.5.

- The increasing occurrence of the CP ENSO may make the northwestern and southeastern parts of the US more vulnerable to ENSO influences.

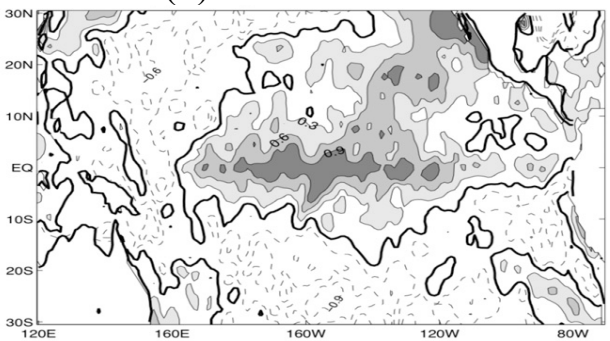
- Five CMIP5 models are identified to produce the two types of ENSO and their different impacts on US winter temperatures and are suitable for the projections of future ENSO impacts on US winter climate.

EP/CP ENSO: SST Anomaly Structure

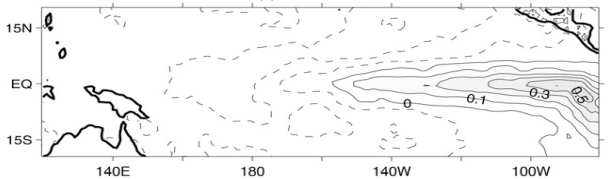
(a) 1997/98 El Nino



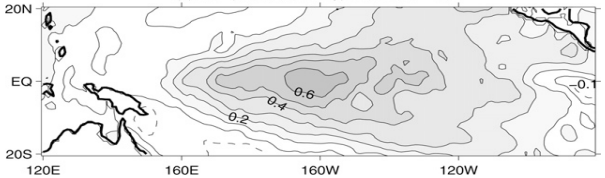
(b) 1977/78 El Nino



(c) **EP El Nino**

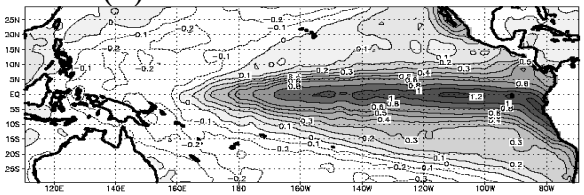


(d) **CP El Nino**

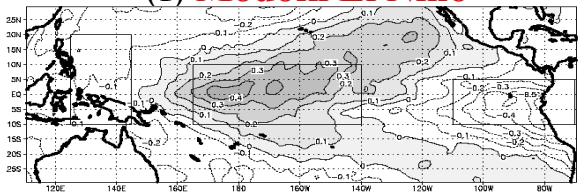


Kao and Yu (2009)
Regression-EOF Method

(e) Conventional El Nino

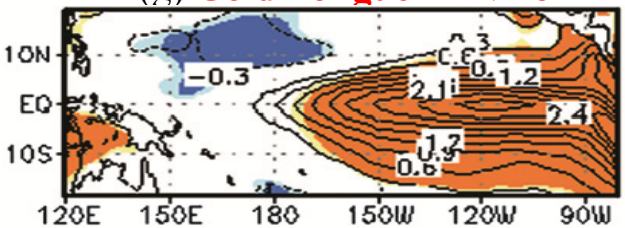


(f) **Modoki El Nino**

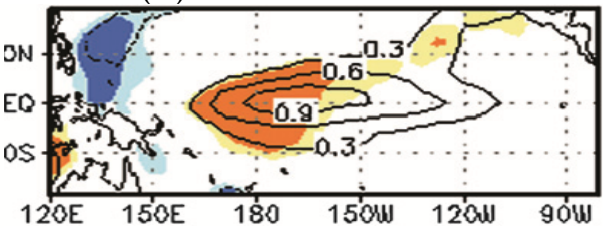


Ashok et al. (2007)
Regular EOF Method

(g) **Cold Tongue El Nino**



(h) **Warm Pool El Nino**



Kug et al (2009)
Nino4 vs. Nino4 Method