Influence of two types of El Niños on the East Asian climate during boreal summer: A numerical study

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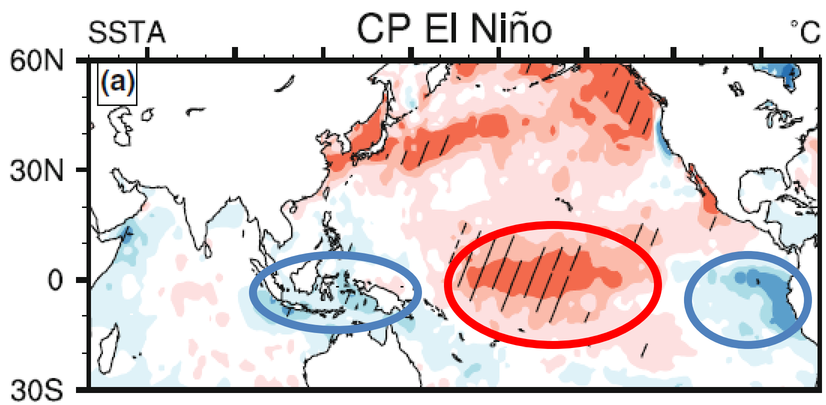
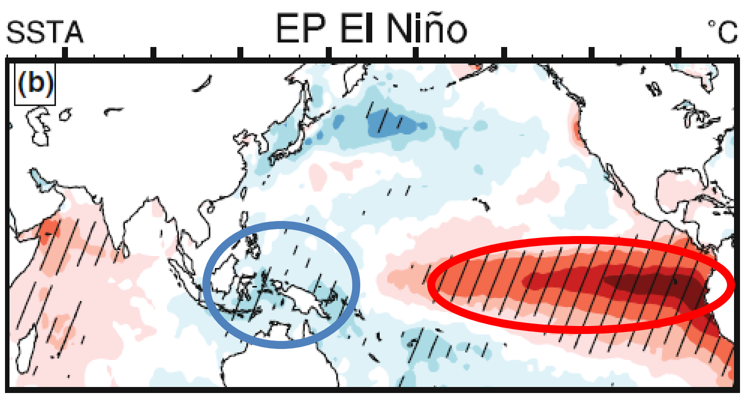
1. Introduction





Dateline El Niño (e.g. Larkin and Harrison 2005),
El Niño Modoki (e.g. Ashok et al. 2007),
Central Pacific El Niño (e.g. Yu and Kao, 2007)
Warm pool El Niño (e.g. Kug et al. 2009).

Typical El Niño
(e.g. Rasmusson and Carpenter 1982)

Anomalous Walker circulation : **two cells** or **single cell**

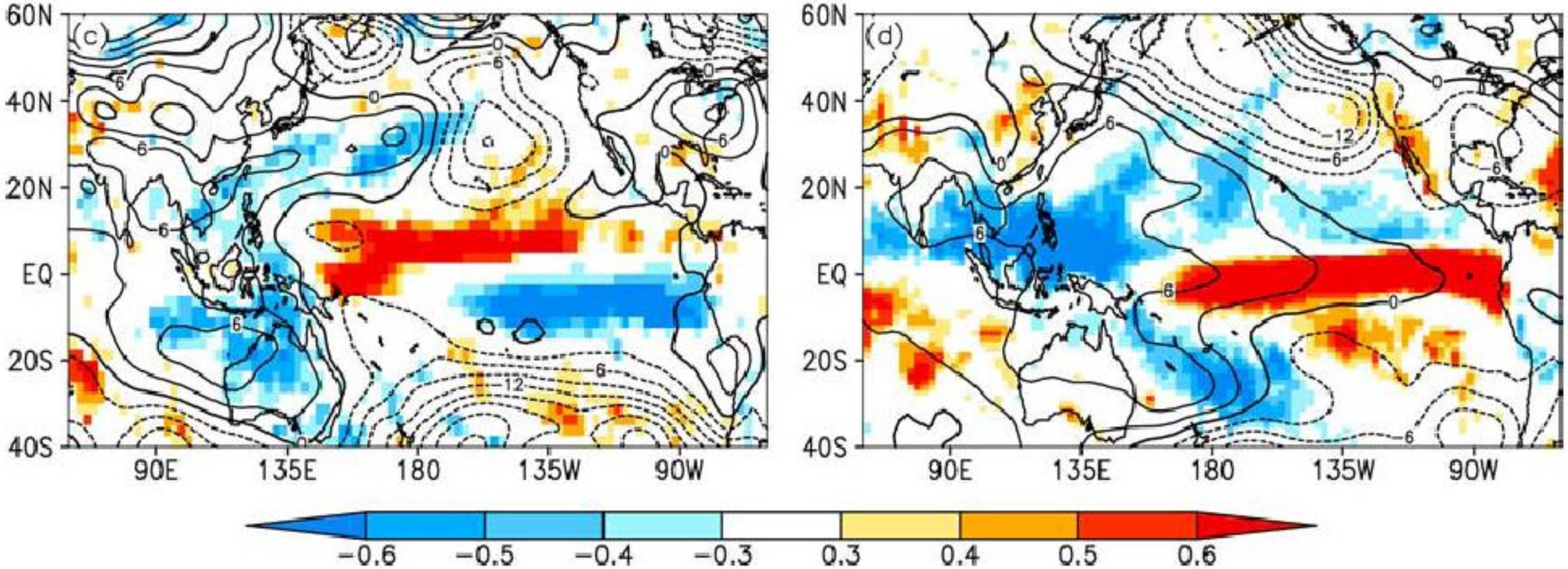
Different performance of **Teleconnections**, such as Pacific-Japan (**PJ**) pattern and the Pacific North American (**PNA**) pattern (Ashok et al. 2007; Weng et al. 2007)

The two types of El Ninos may exert different influences on regional climate

(e.g. Weng et al. 2007, 2011, Feng and Li 2011, Yuan and Yang 2012, Chen and Tam 2010; Wang et al. 2012)

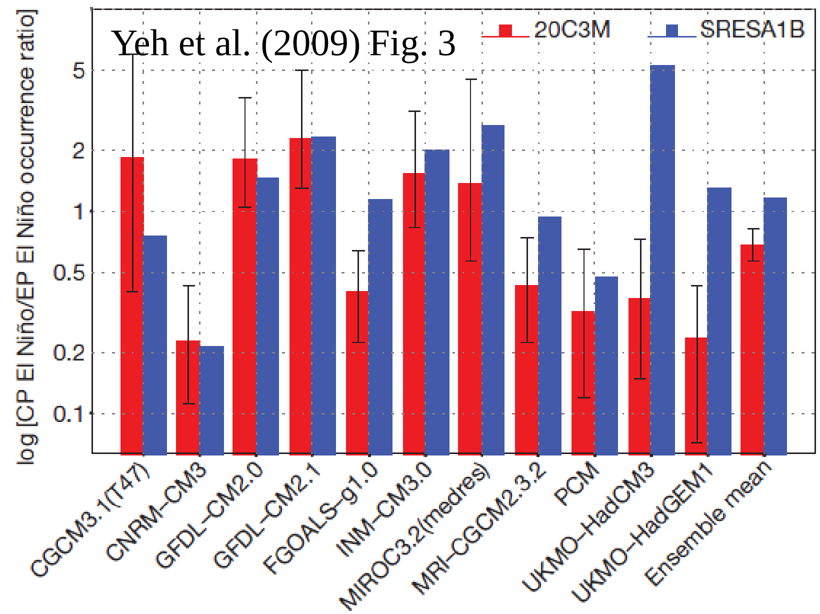
Feng and Li (2011): are accompanied by a significant reduction / enhance in spring rainfall over southern China for CP El Nino / EP El Nino.

CP El Niño EP El Niño

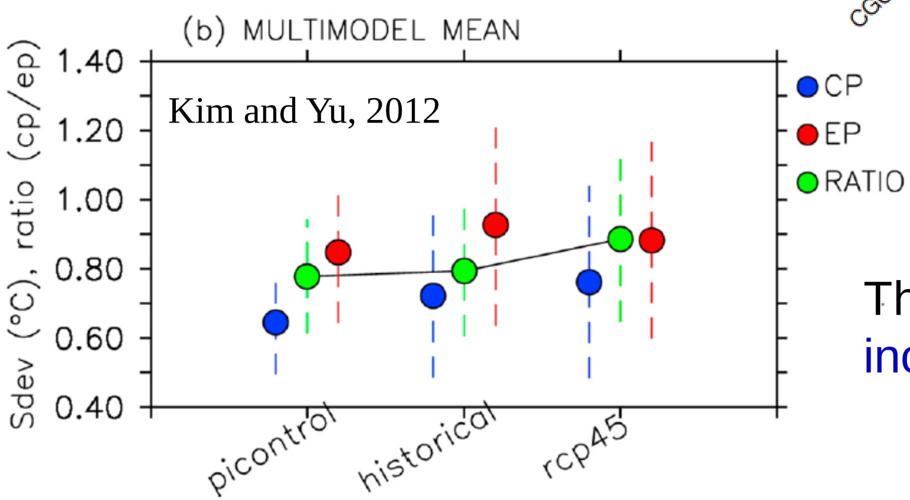


Yangtze River Valley suffers less rain and higher temperature during the boreal summer of CP El Niño , but it suffers the opposite situation during the EP El Niño scenario (**Weng et al. 2007, 2011**).

It is reported that CP El Niño is rarely observed before the1980s, and its frequency increases in the past three decades (Ashok et al. 2007; Yeh et al. 2009).



Besides, Yeh et al. (2009) concluded that the ratio of occurrence of the CP El Niños to the EP El Niños increases in the global warming scenario



The CP-to-EP ENSO intensity ratio increases in the RCP4.5 simulation

However, the number of CP El Ninos observed during boreal summer is still small

Why need numerical study ?

Most of the aforementioned studies **rely on linear statistical methods**, such as partial correlation and regression.

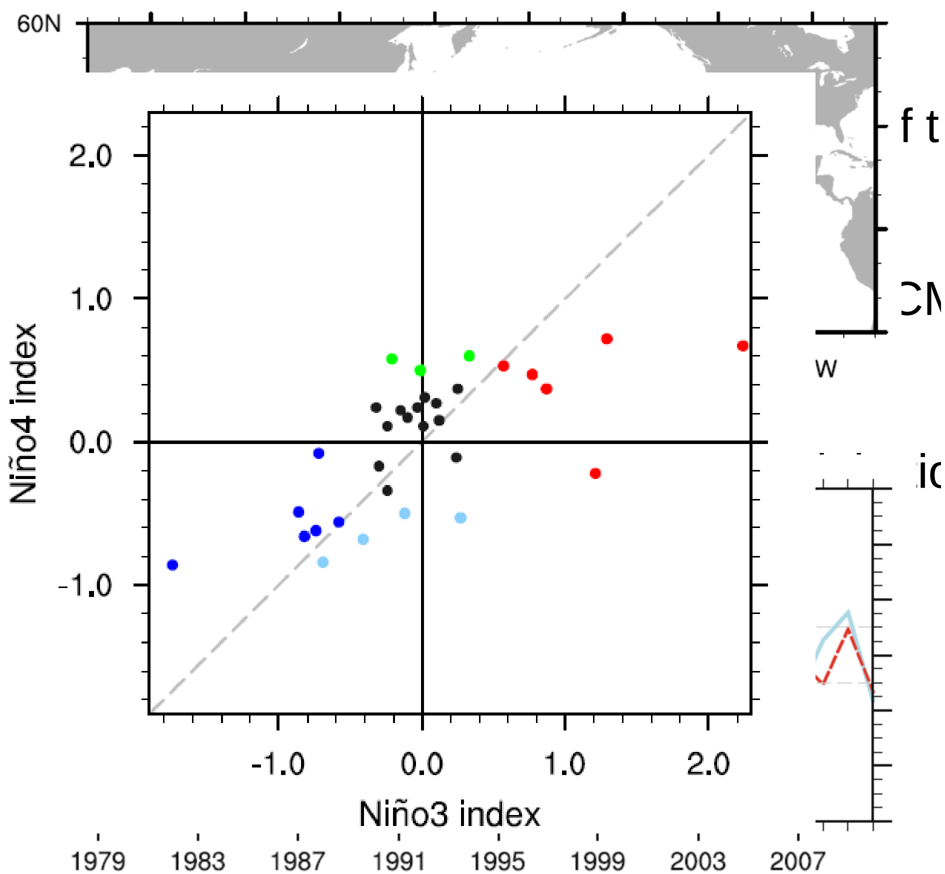
Few studies have been done **on the impacts of negative phase** of CP/EP ENSO during boreal summer.

the SST and precipitation patterns between the two types of La Nina are much less distinctive or less independent compared to the two types of warm events and **there is a strong asymmetric character between warm and cold events.**

- the robustness of the obtained results is an issue that needs to be addressed.
- In addition, the impacts of negative phase of ENSO (CP and EP La Niña) will also be investigated
- Is there an asymmetric influence on East Asian between warm and cold events during summertime?

2. Data and methods

2.1 Observational data



Following Yeh et al. (2009)

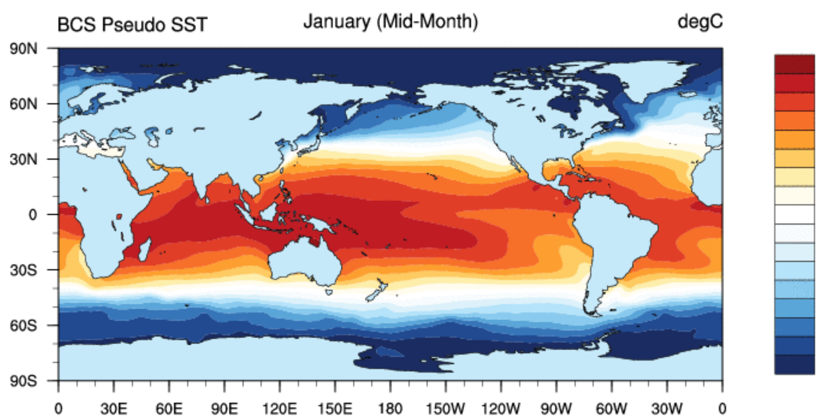
Table 1 The definitions of CP and EP El Niño (La Niña) and the respective selected years during 1979–2010

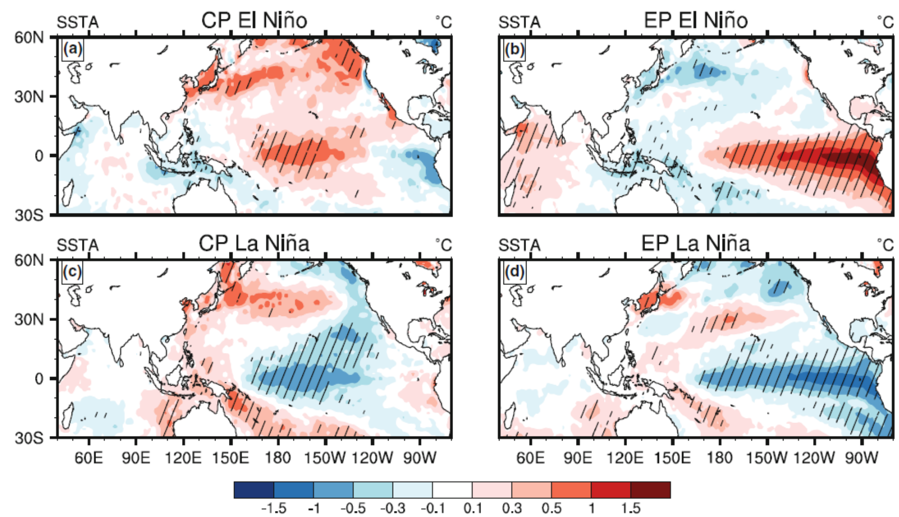
Category	Criteria (JJA)	Years
Central Pacific	Niño4 SST index >0.5	1994, 2002, 2004
El Niño	Niño4 SST index >Niño3 SST index	
Eastern Pacific	Niño3 SST index >0.5	1982, 1983, 1987, 1991, 1997, 2009
El Niño	Niño3 SST index >Niño4 SST index	
Central Pacific	Niño4 SST index <−0.5	1989, 1998, 1999, 2008
La Niña	Niño4 SST index <Niño3 SST index	
Eastern Pacific	Niño3 SST index <−0.5	1984, 1985, 1988, 2000, 2007, 2010
La Niña	Niño3 SST index <Niño4 SST index	

2.2 Model data

6-member ensemble of CAM4 simulations run forced with monthly observed SSTs (Hurrell et al. 2008) from 1979 to 2010 (**CAM4-AMIP runs**, http://www.earthsystemgrid.org/dataset/ucar.cgd.ccsm4.output.html).

5 extra experiments using CAM4 model: one is a 50-year integration forced with climatological mean seasonal cycle of SST, referred as control run (**CAM4-CTL**) and the other four 50-year integrations were conducted with climatological mean seasonal cycle of SST plus a global JJA SSTA of CP El Niño (La Niña) and EP El Niño (La Niña) from May to September (**CAM4-CPEL**; **CAM4-CPLA**; **CAM4-EPEL** and **CAM4-EPLA**), respectively.





3. Anomalies of two types of ENSO

3.1 Atmospheric response to two types of El Niños

observed precipitation anomalies

CAM4 AMIP runs

sensitivity modeling results

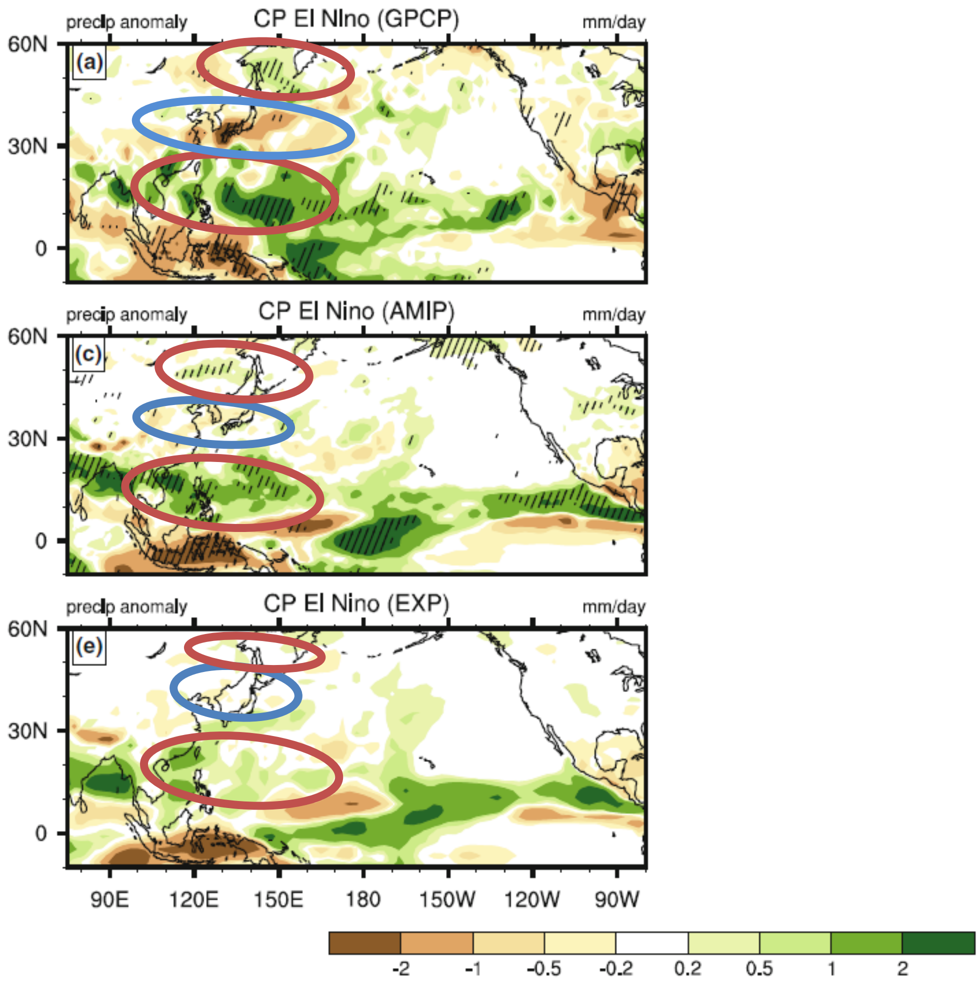


Fig.5 Composites of summer precipitation anomalies for two types of El Ninos.

The different impacts of the two types of El Ninos on 850 hPa wind anomalies

observed low level wing anomalies

CAM4 AMIP runs

sensitivity modeling results

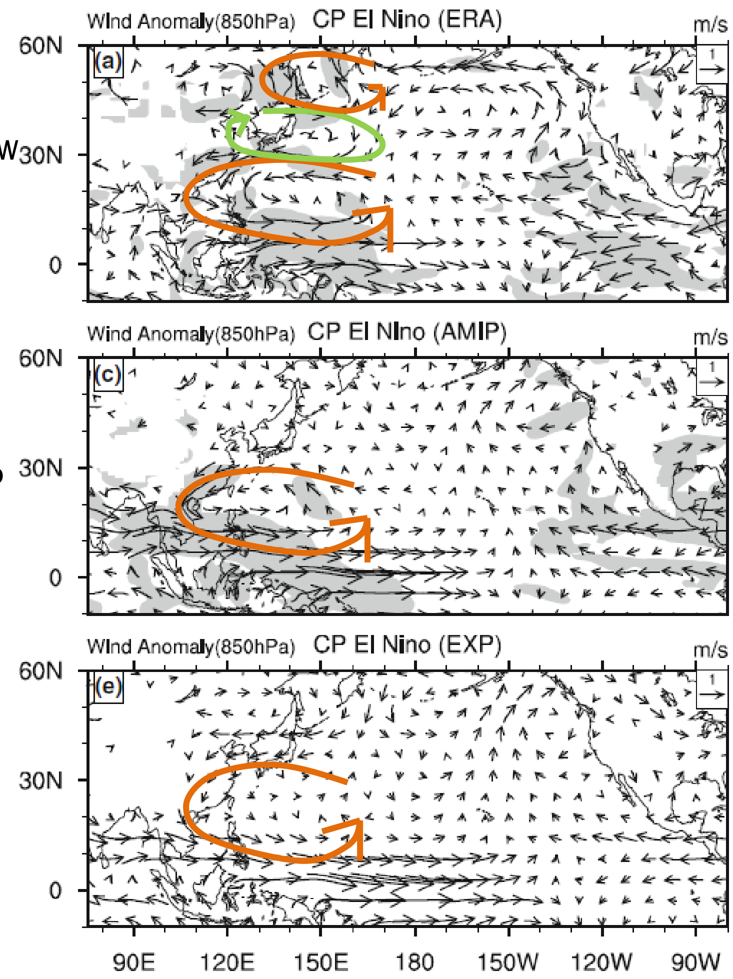


Fig.6 Composites of summer 850 hPa wind anomalies for two types of El Ninos.

3.2 Atmospheric response to two types of La Niñas

observed precipitation anomalies

CAM4 AMIP runs

sensitivity modeling results

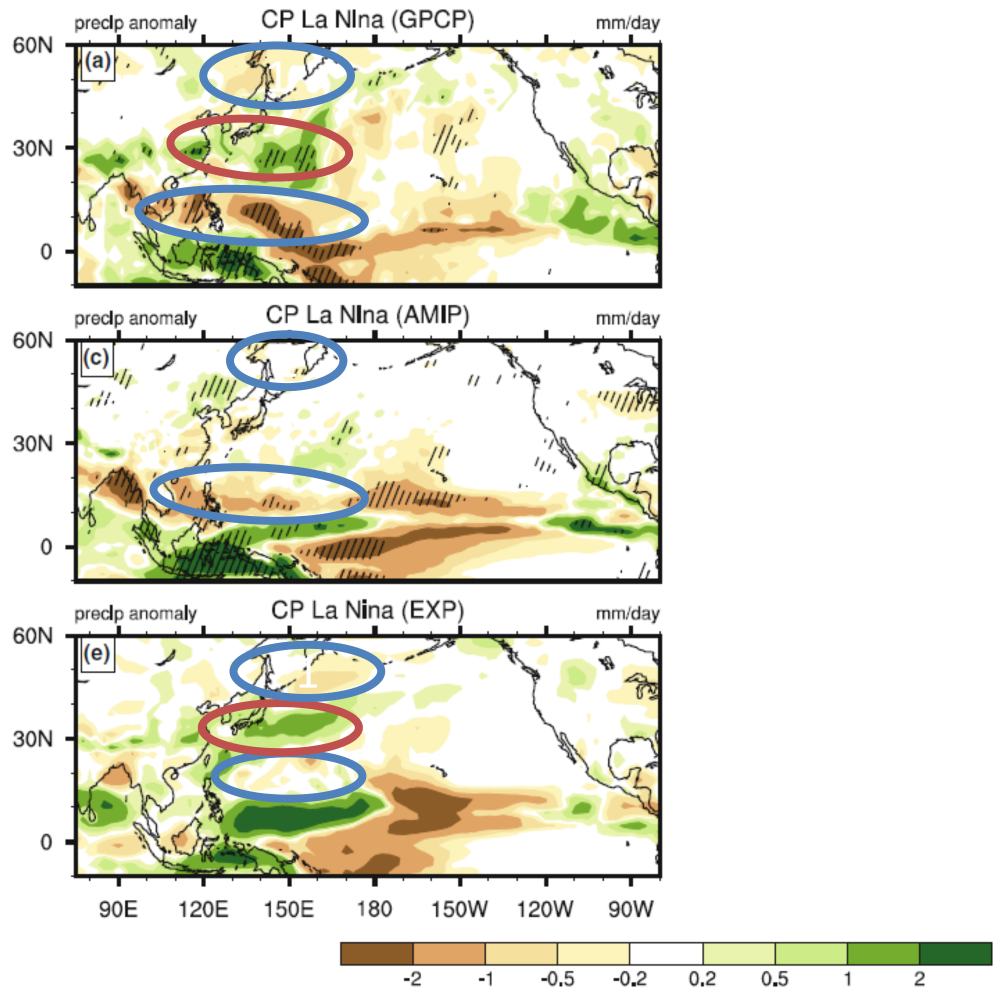


Fig.8 Composites of summer precipitation anomalies for two types of La Ninas.

The different impacts of the two types of La Ninas on low level wind anomalies

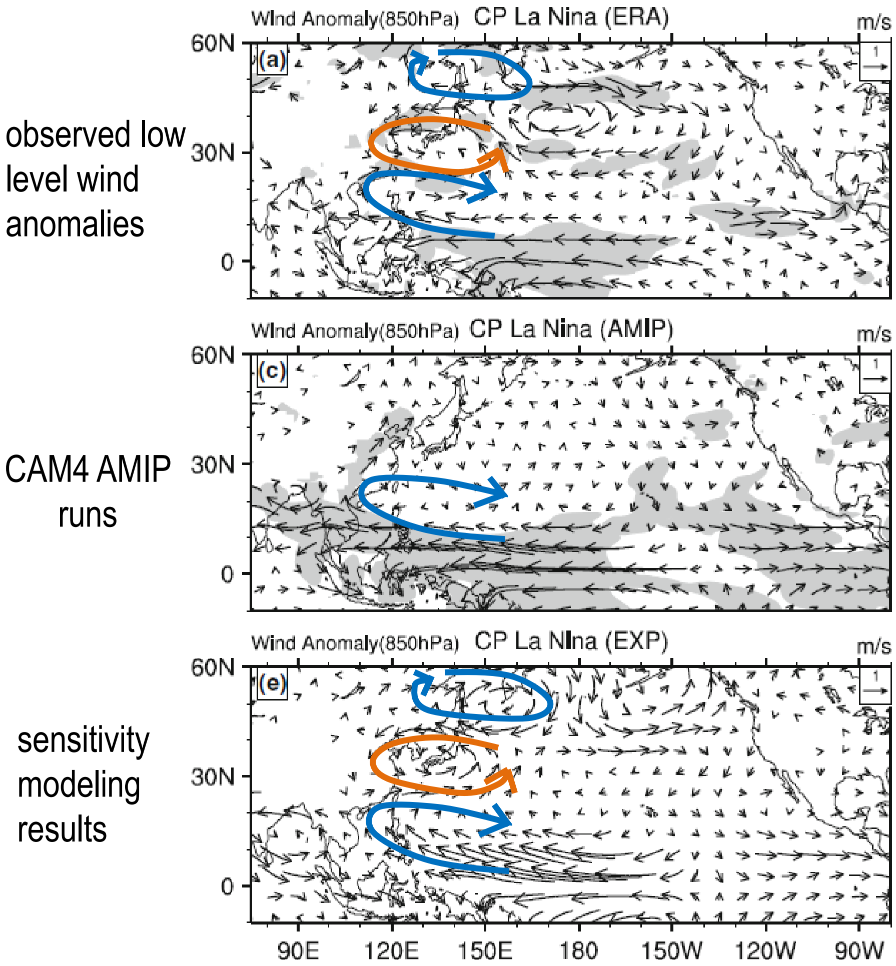


Fig.9 Composites of summer 850 hPa wind anomalies for two types of La Ninas.

4. Asymmetry influence of CP ENSO

The above analysis shows that CP El Nino (La Nina) has a more significant influence on East Asia climate compared to EP El Nino (La Nina).

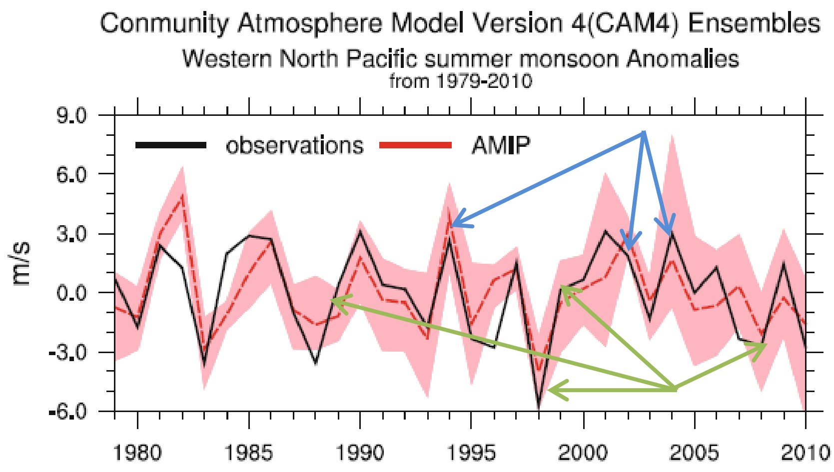
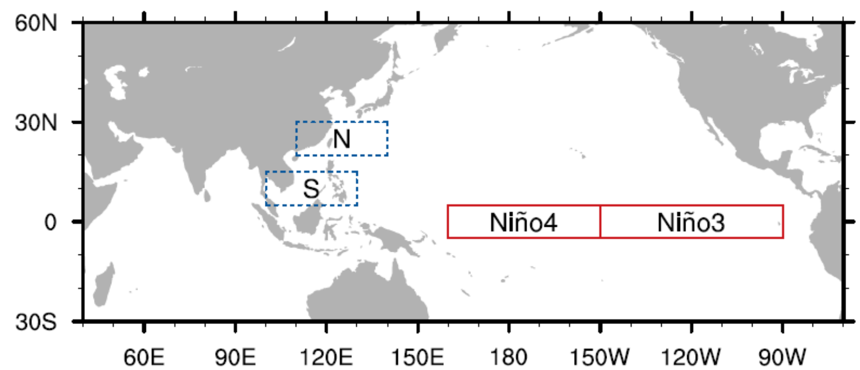


Fig. 10 six-member ensemble mean (*dash line*) and ensemble member range (*gray shading*) for western north Pacific summer monsoon anomalies (m/s; anomalies are formed by subtracting the 1979–2010 mean from each run from its time series of annual values) for observed SST forcing; *black line* is observations

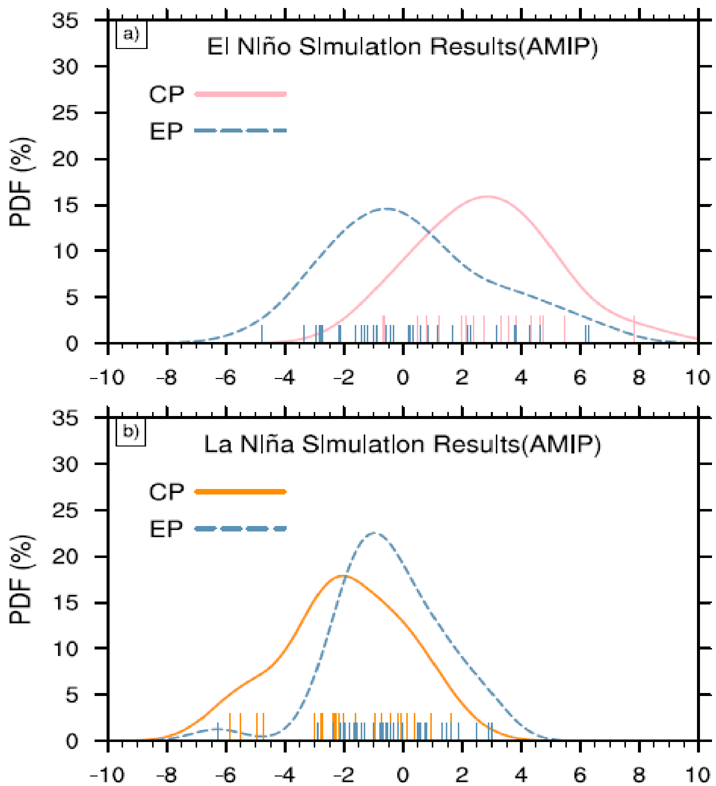
WNPMI = U850S minus U850N

Wang and Fang (1999)



Surprisingly, these CP El Nino years are all associated with enhanced WNP summer monsoon, while 2 out of the 4 CP La Nina years (1998 and 2008) are associated with weak WNP summer monsoon and the other two are associated with slightly positive WNPMI

It seems that the positive phase of CP ENSO (i.e. CP El Nino) may have more robust influence on East Asia compared to the negative phase of CP ENSO (i.e. CP La Nina).



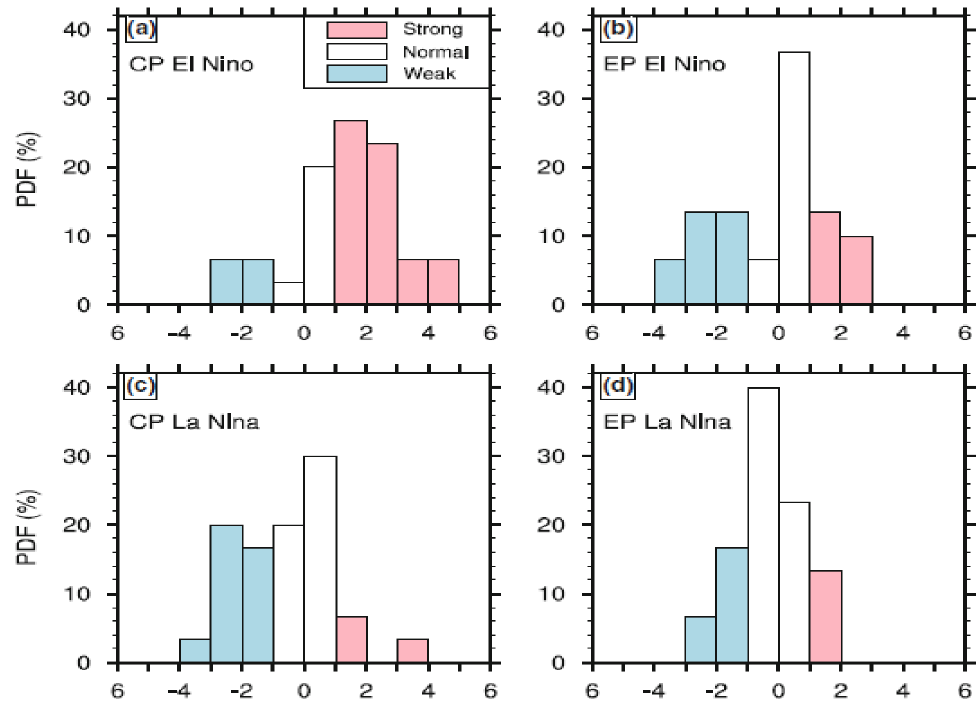
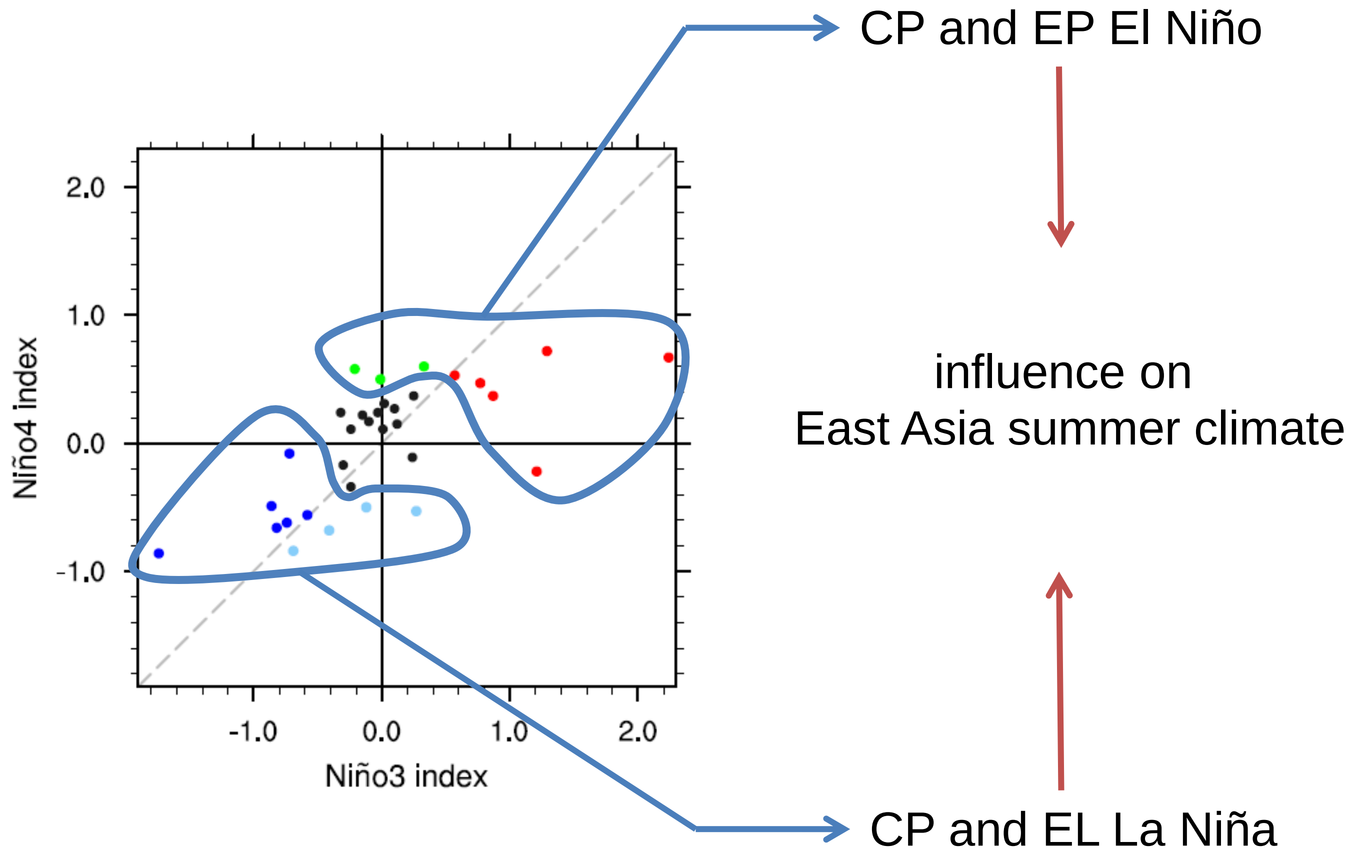


Fig. 11 The probability distribution functions of Western North Pacific summer monsoon index anomalies (compared to the last

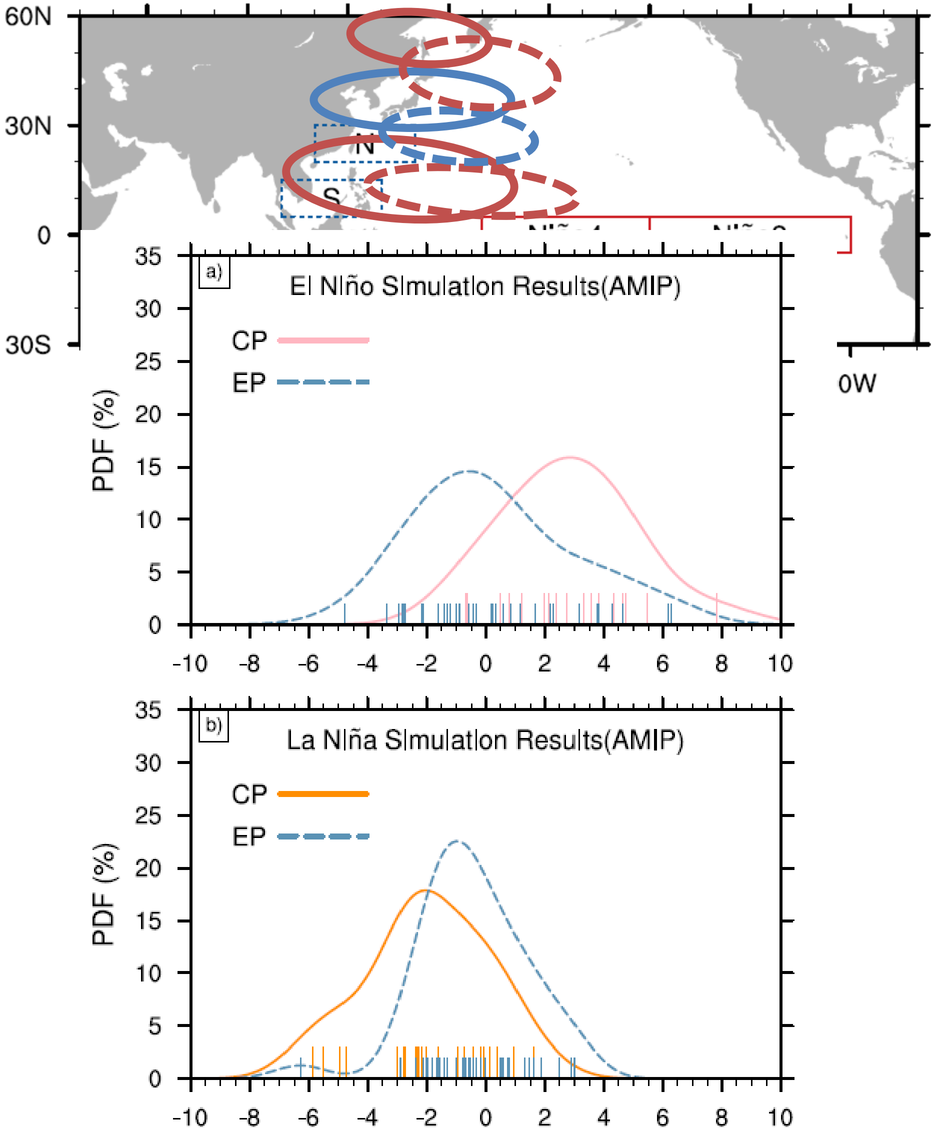
The PDFs of the simulated **WNPMI for CP El Nino** are far above those of control experiment, and the simulated WNPMI tends to below those of control experiment **during CP La Nina**.

The PDFs for **EP El Nino (La Nina**) are not well separated and the simulated mean WNPMI is only slightly more (less) than the control experiment.

5. Discussions and concluding remarks



CP El Niño (La Niña) may have more significant influence on East Asia summer climate than EP El Niño (La Niña), as the associated low-level anomalous wind pattern is more distinct and closer to the Asian continent compared to EP El Niño (La Niña)



CP El Niño (La Niña) may have more significant influence on East Asia summer climate than EP El Niño (La Niña)

The impact of CP El Niño is likely to be more robust than that of CP La Niña

The impact between the two types of La Nina seem to be less independent compared to the two types of warm events

Thank you !

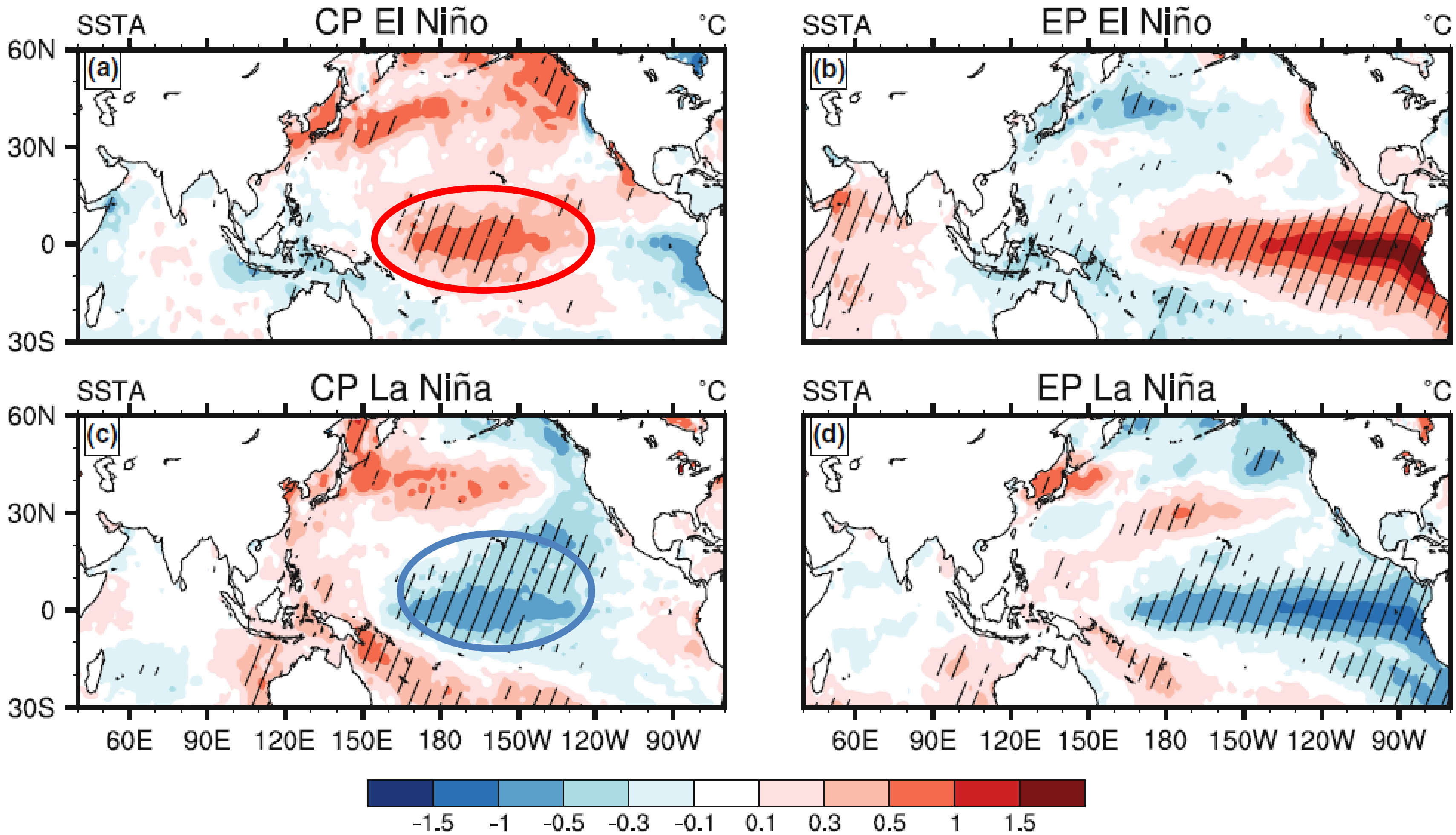


Fig.3 Composites of sea surface temperature anomalies (SSTA) for (a) CP El Nino, (b) EP El Nino, (c) CP La Nina and d EP La Nina during boreal summer (JJA) Anomalies that are significant at the 90 % level are shaded

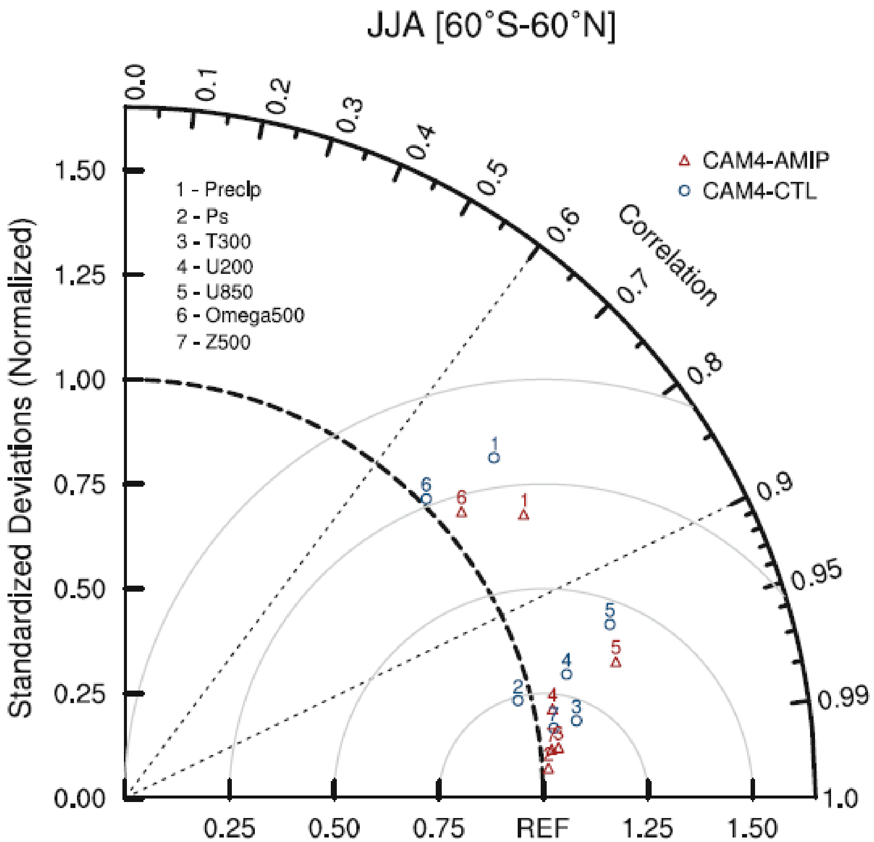
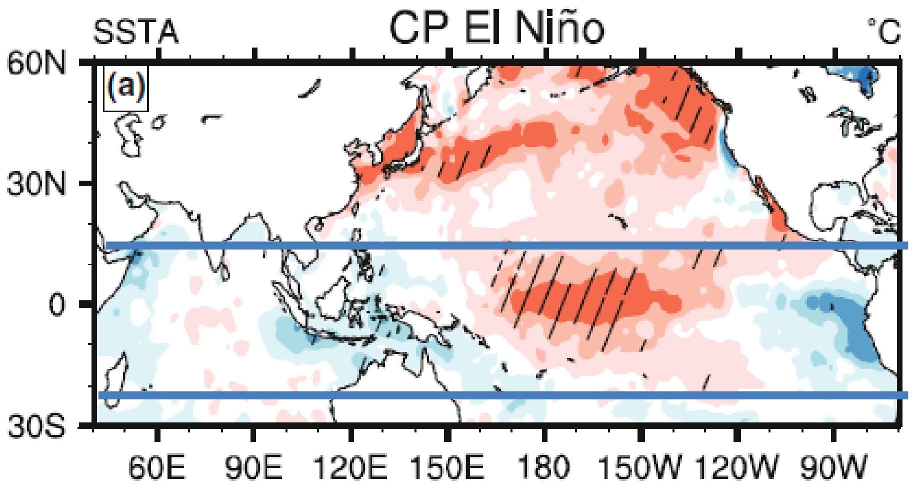


Fig. 4 Taylor diagram displaying a statistical comparison with observations of seven selected variables of the global pattern of summer climatology

To quantify the ability of the CAM4 model simulation, we select some simulated variables and compare to those in observation.

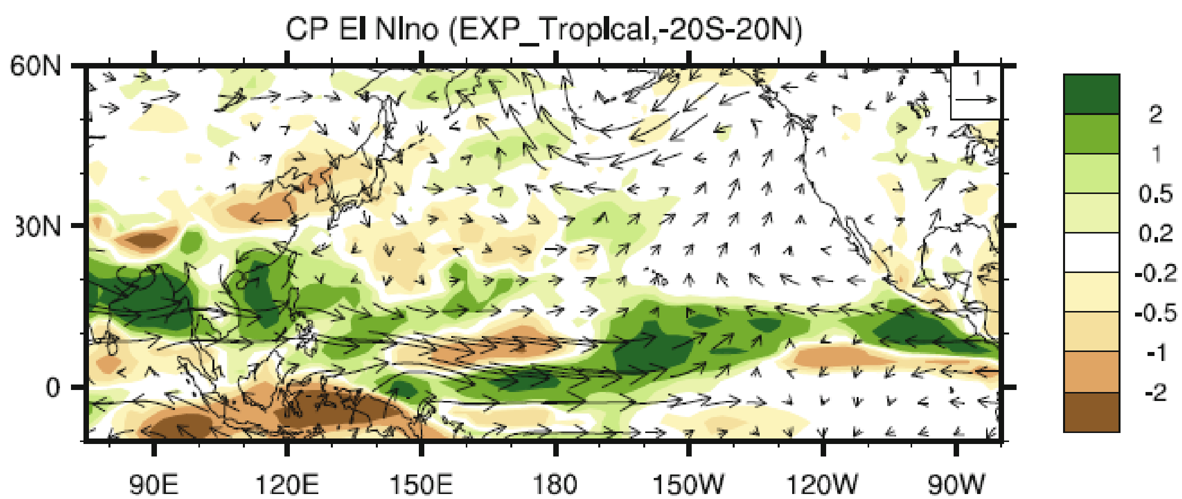
Figure 4 illustrates the Taylor diagram (2001) displaying a statistical comparison with observations for seven selected variables of the global pattern of summer climatology over the tropics and extratropics (60S–60N).

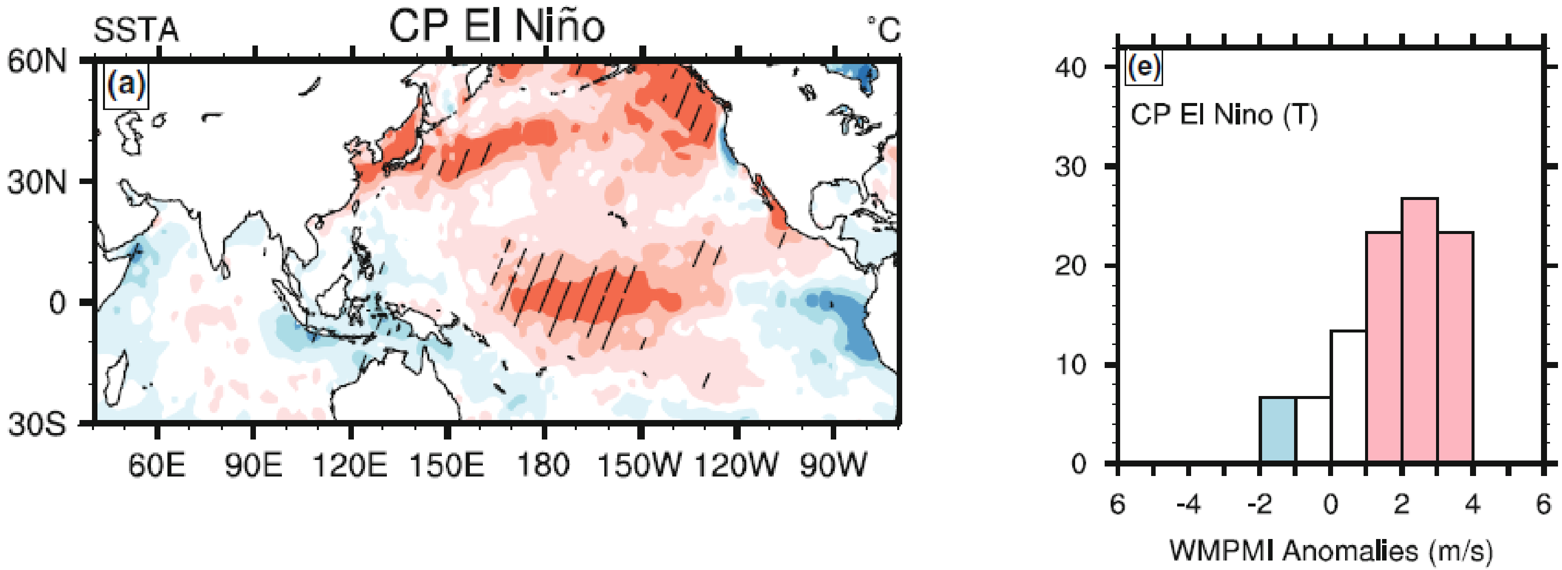
Overall, both of the CAM4 AMIP run and control **run can well capture the spatial feature** of the summer climatology in observations.



Considering the SST as boundary conditions for CAM4 model, warm SSTA around Japan may excite an anomalous cyclone in situ. This cyclone may merge with subtropical cyclone excited by central Pacific warming, so the subtropical cyclonic wind anomalies in the CPEL sensitivity experiment are slightly northward

Fig. 7 The simulation results of CP El Niño (Tropical) sensitivity experiments.
30 years composite of mean precipitation anomalies and 850 hPa wind anomalies (compared to the last 30 years control runs ensemble mean)





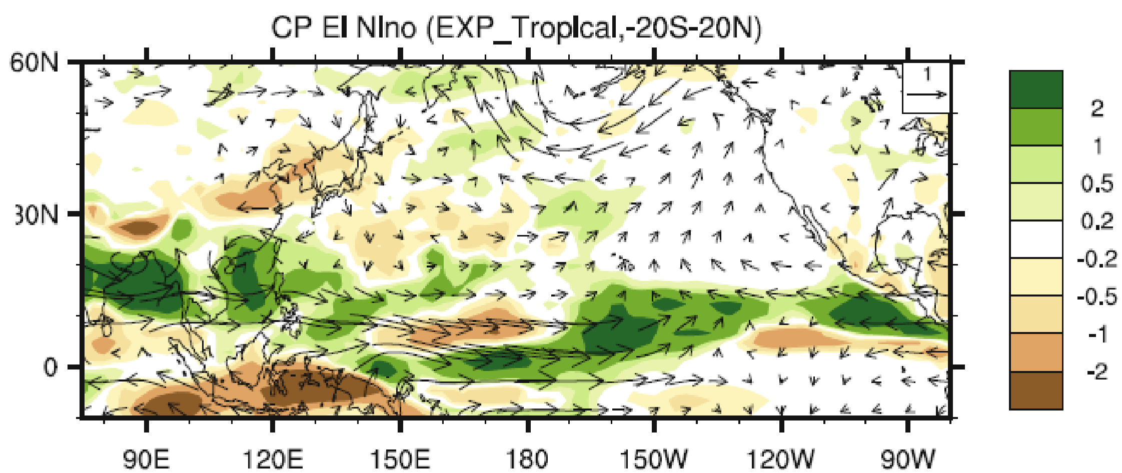
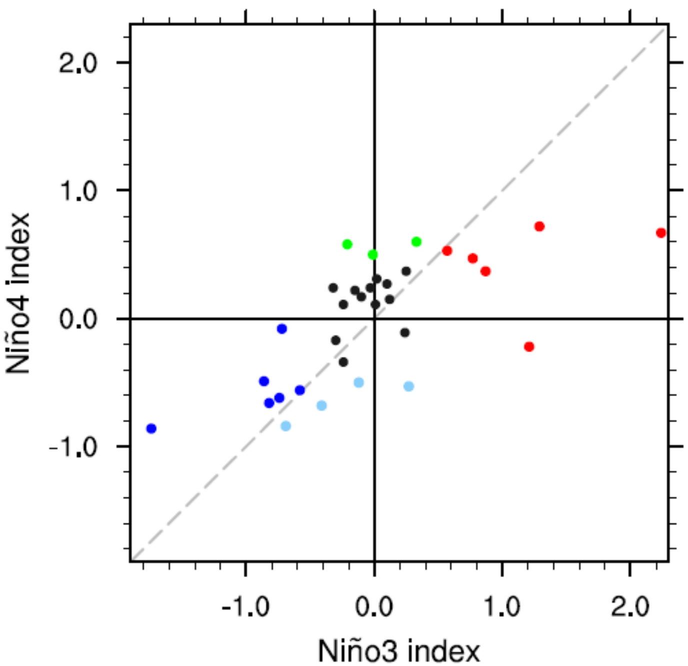
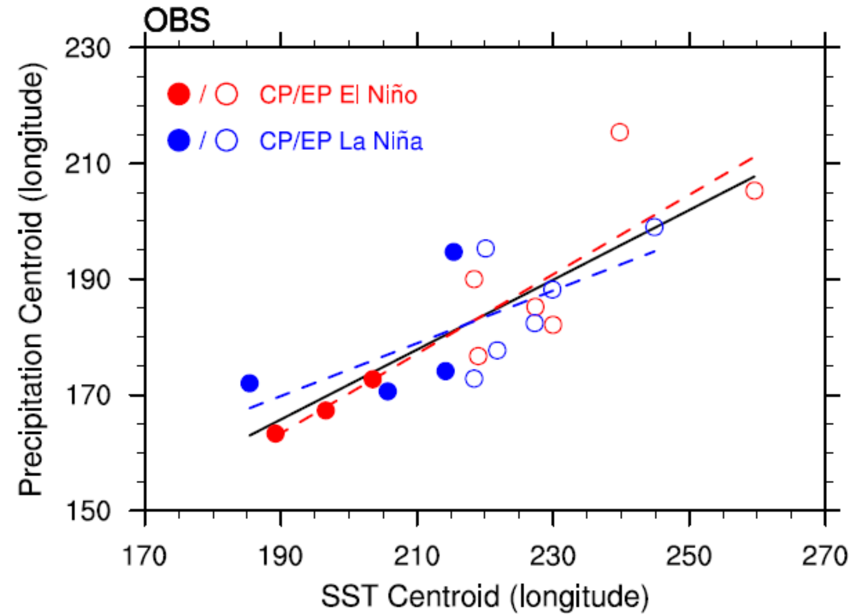
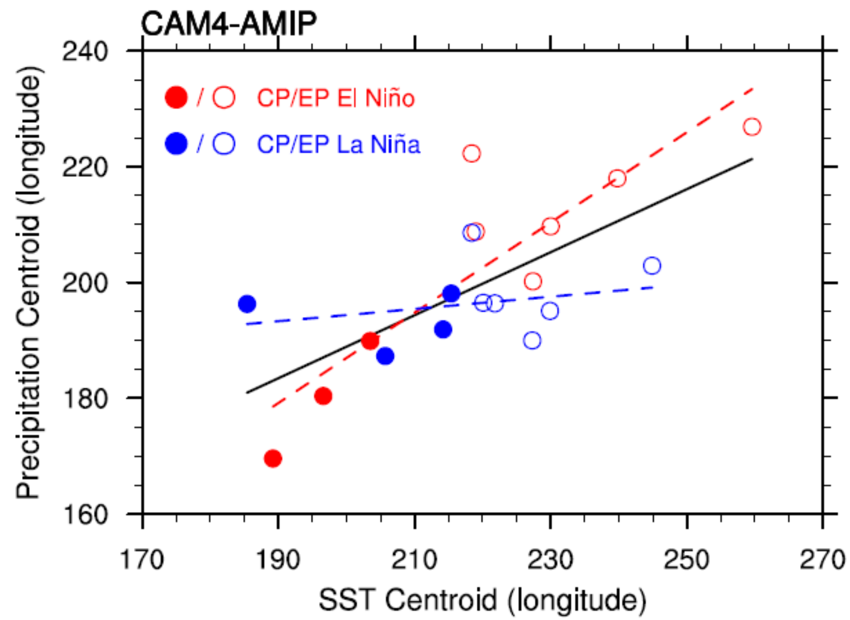


Fig. 7 The simulation results of CP El Niño (Tropical) sensitivity experiments. 30 years composite of mean precipitation anomalies and 850 hPa wind anomalies (compared to the last 30 years control runs ensemble mean)



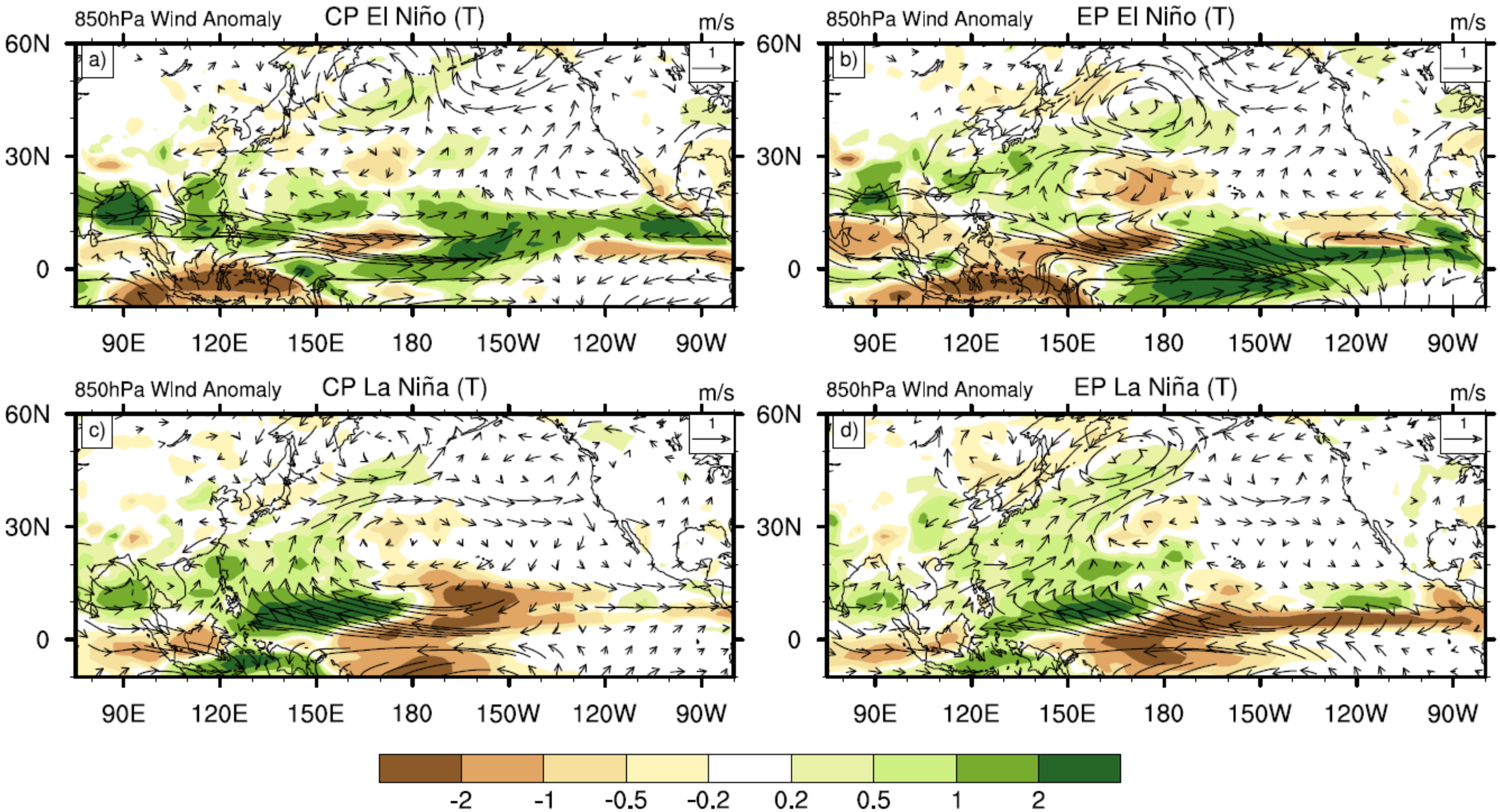




$$\text{PRCP centroid} = \frac{\int \text{PRCP}(x)\,x\,dx}{\int \text{PRCP}(x)\,dx},$$

Kug et al. (2009, 2010a)

- 5S-5N meridional mean
- Integrate from 120E to 80W


850hPa Wind Anomaly
CP El Niño (T)
m/s
a)
850hPa Wind Anomaly
EP El Niño (T)
m/s
b)
850hPa Wind Anomaly
CP La Niña (T)
m/s
c)
850hPa Wind Anomaly
EP La Niña (T)
m/s
d)
60N
30N
0
90E
120E
150E
180
150W
120W
90W
-2
-1
-0.5
-0.2
0.2
0.5
1
2