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)

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

EP > CP

strong group

weak group

CP > EP

single group
Amplitudes of the Two Types of ENSO

![Graph showing the amplitudes of the two types of ENSO: CMIP3 and CMIP5. The graph compares the multimodel mean with observed values (OBS). The x-axis represents CP and EP phases, while the y-axis shows the maximum SDEV (°C). The CMIP3 and CMIP5 data points are indicated with blue and red circles, respectively.](image)
CMIP5 Projection of the Two Types of ENSO

![Graph showing Sdev (°C), ratio (cp/ep) for different scenarios. The graph includes data points for picontrol, historical, and rcp45, with CP, EP, and RATIO represented by different colors and symbols. The multimodel mean is highlighted.](image)
Traditional View of El Nino Impacts on US Winter Temperature

(from NOAA)
Results from Mo (2010)

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**
  - 1997: (N3:2.95, N4:0.89)
  - 1982: (N3:2.74, N4:0.78)
  - 1972: (N3:1.71, N4:0.86)
  - 1986: (N3:1.12, N4:0.67)

- **Weak EP Events**
  - 2006: (N3:0.88, N4:0.85)
  - 1976: (N3:0.76, N4:0.12)
  - 1969: (N3:0.61, N4:0.48)
  - 1951: (N3:0.35, N4:0.13)
Case Studies with **CP El Nino Events**

Strong Events

<table>
<thead>
<tr>
<th>Year</th>
<th>N3</th>
<th>N4</th>
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<tr>
<td>2009</td>
<td>1.23</td>
<td>1.35</td>
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<tr>
<td>1994</td>
<td>0.8</td>
<td>1.13</td>
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<tr>
<td>1957</td>
<td>1.34</td>
<td>1.02</td>
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<tr>
<td>2002</td>
<td>1.02</td>
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Weak Events

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<tr>
<th>Year</th>
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<tbody>
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<td>2004</td>
<td>0.4</td>
<td>0.99</td>
</tr>
<tr>
<td>1965</td>
<td>0.97</td>
<td>0.72</td>
</tr>
<tr>
<td>1968</td>
<td>0.58</td>
<td>0.99</td>
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<tr>
<td>1977</td>
<td>0.23</td>
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<td>1991</td>
<td>1.27</td>
<td>0.97</td>
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<td>1963</td>
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<td>1958</td>
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<td>0.4</td>
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<tr>
<td>1987</td>
<td>0.66</td>
<td>0.72</td>
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</table>
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
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
(e) Conventional El Nino
(f) Modoki El Nino
(g) Cold Tongue El Nino
(h) Warm Pool El Nino

Kao and Yu (2009) Regression-EOF Method
Ashok et al. (2007) Regular EOF Method