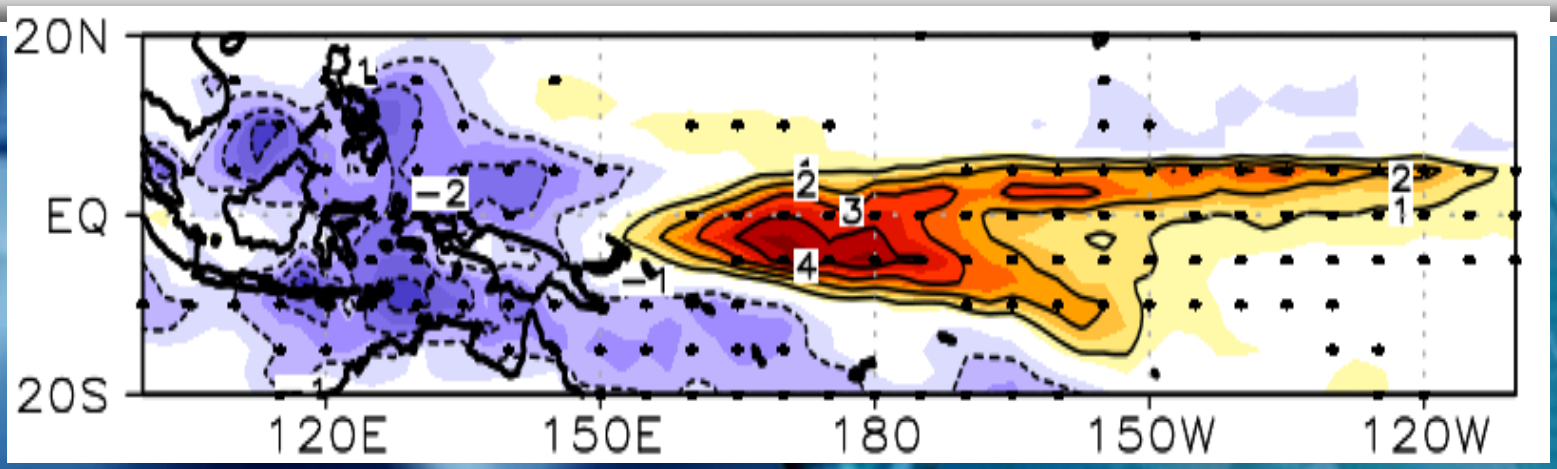
What controls ENSO teleconnection to East Asia?

Jong-Seong Kug and Sunyong Kim

POSTECH, Pohang, Korea

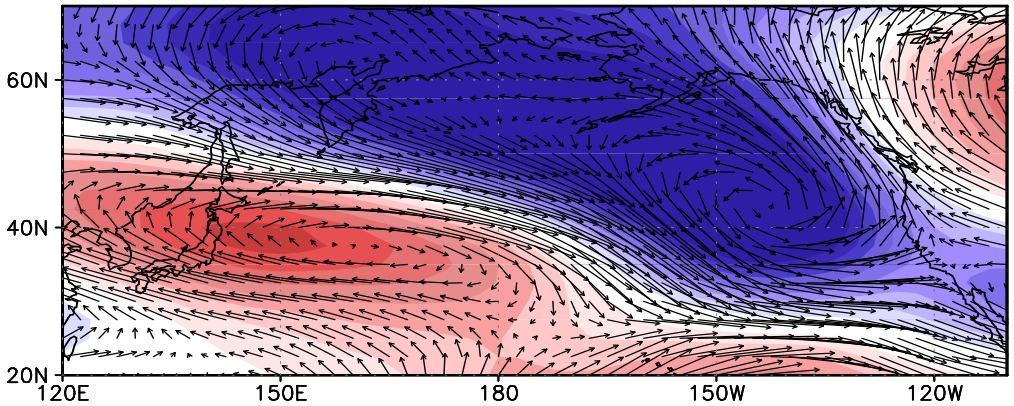


Motivation: El Nino Teleconnection Pattern

Linear Regression w.r.t NINO3.4.SST

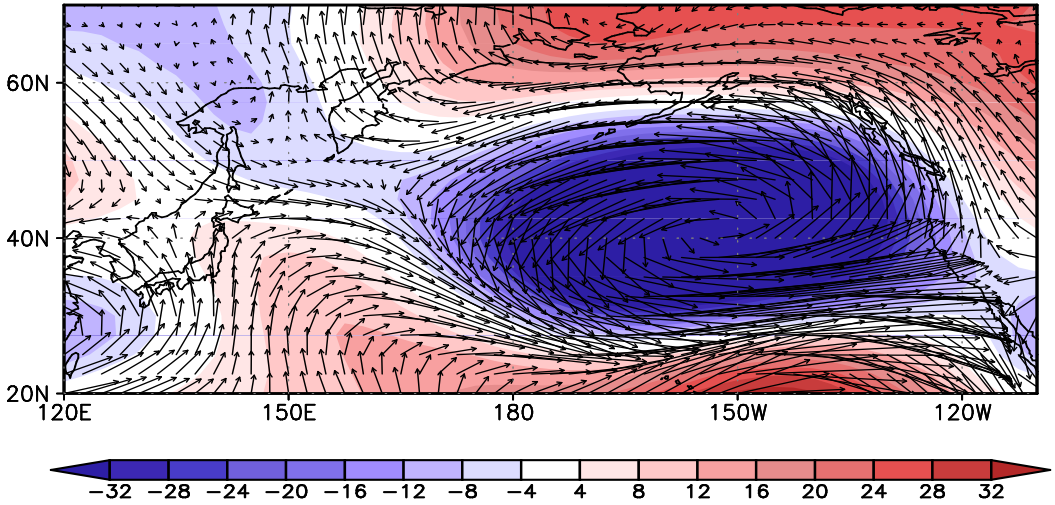
Z300, and Winds

December



PCOR=0.46

January



Kuroshio Anticyclone/Cyclone!!

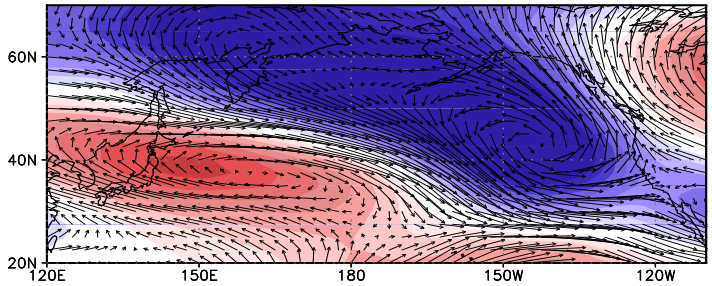
Son et al. (2014, Clim. Dyn.)

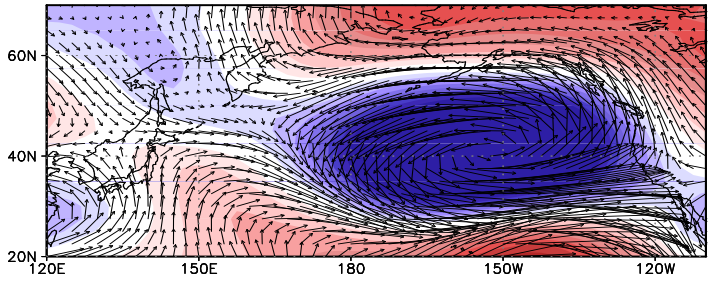
What makes the teleconnetion differences?

Linear Regression

December

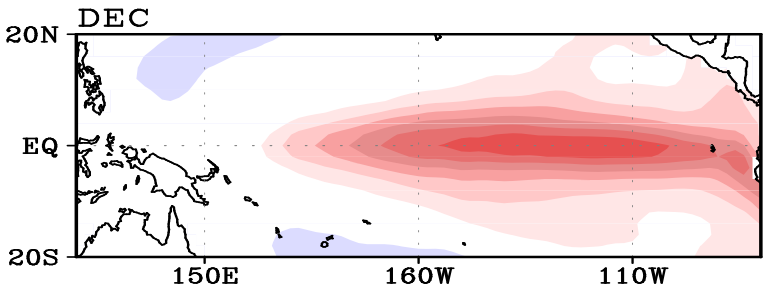
January

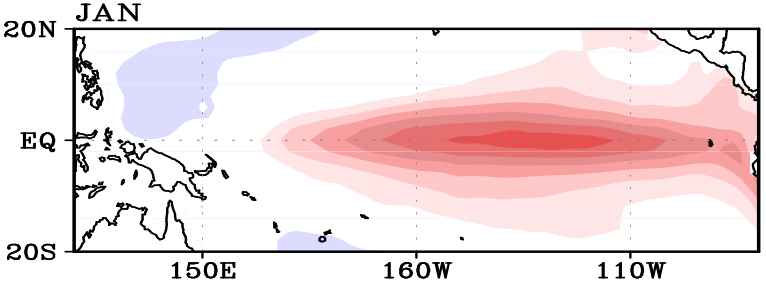




Teleconnection

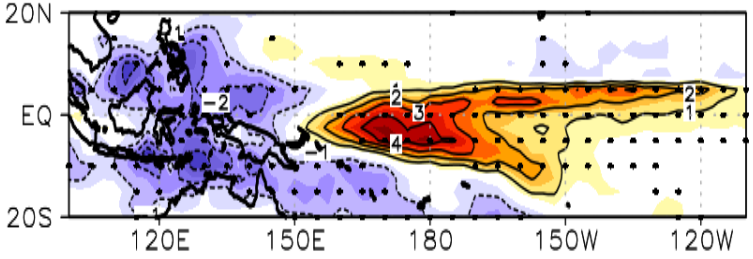
PCOR=0.46

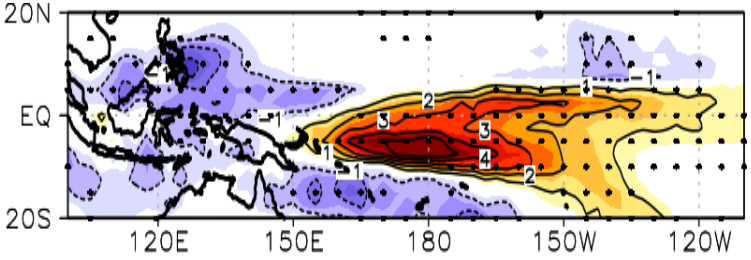




SST

PCOR=0.99



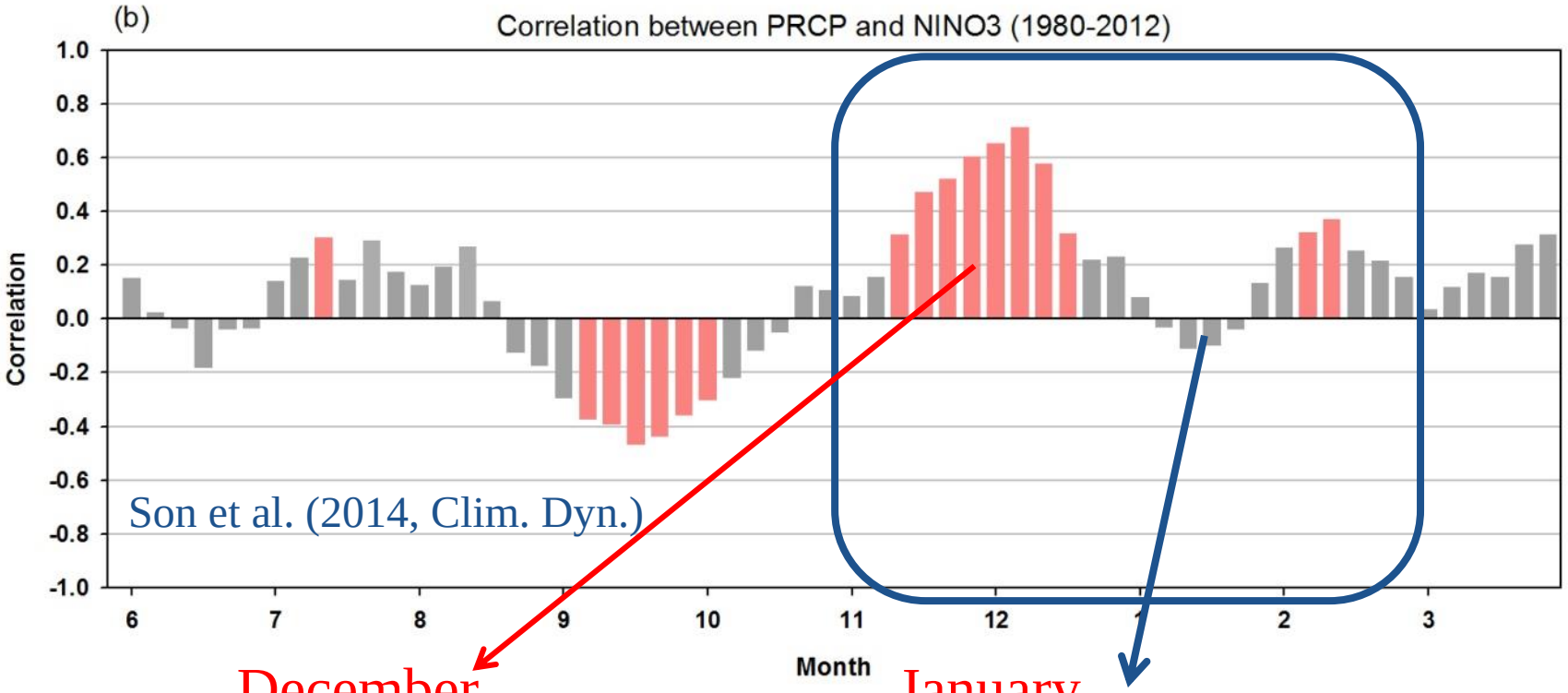


PRCP

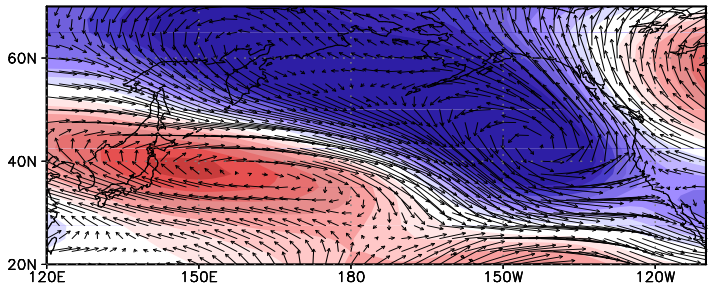
PCOR=0.86

Precipitation over the Korean Peninsula

Correlation between NINO3 SST and 5-pentad mean PRCP



December



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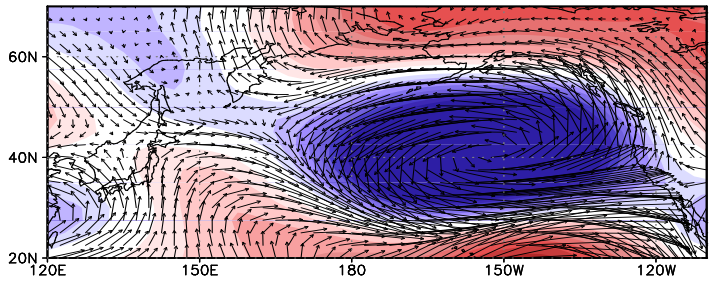
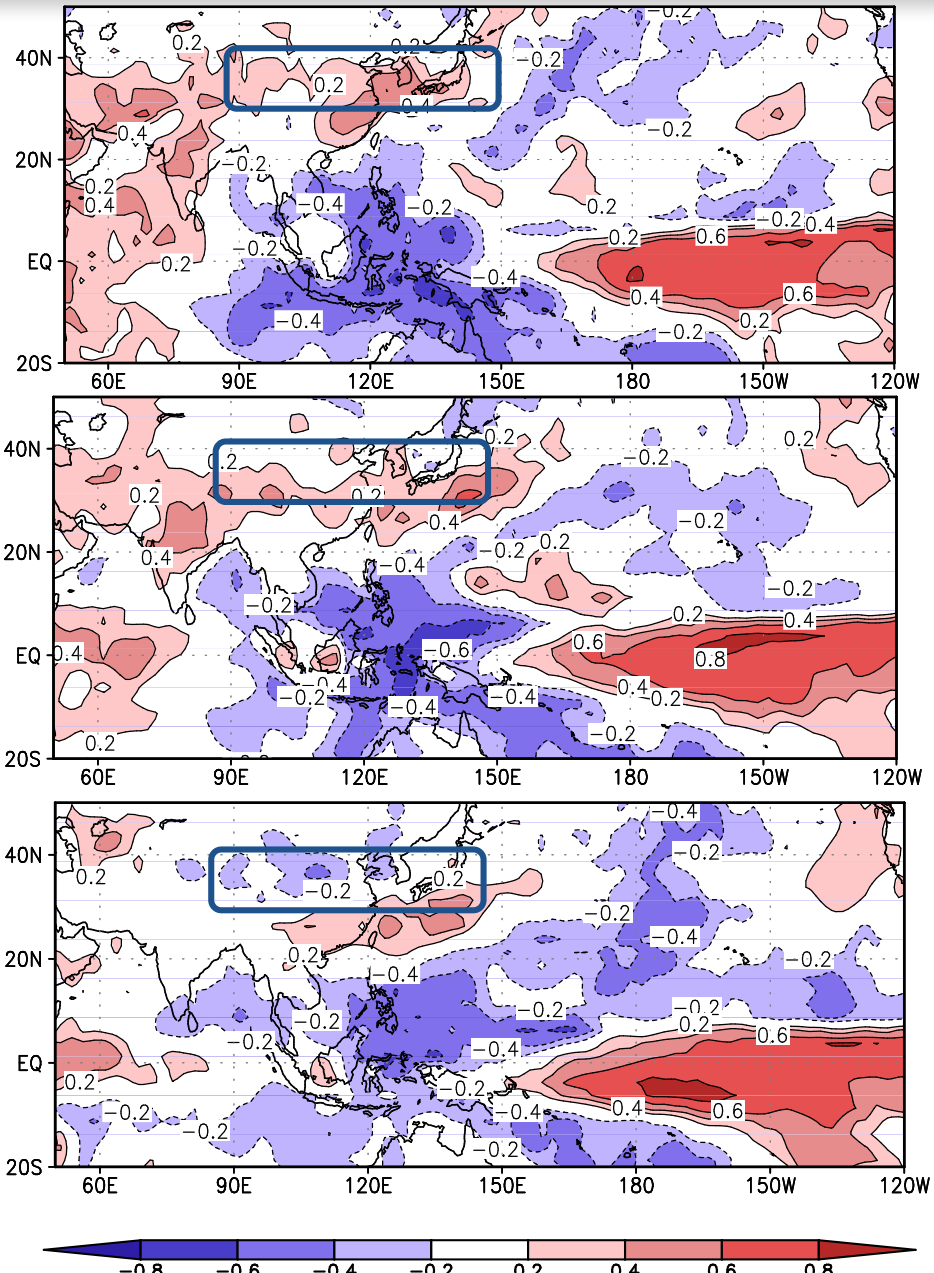


Correlation between NINO3 SST and PRCP

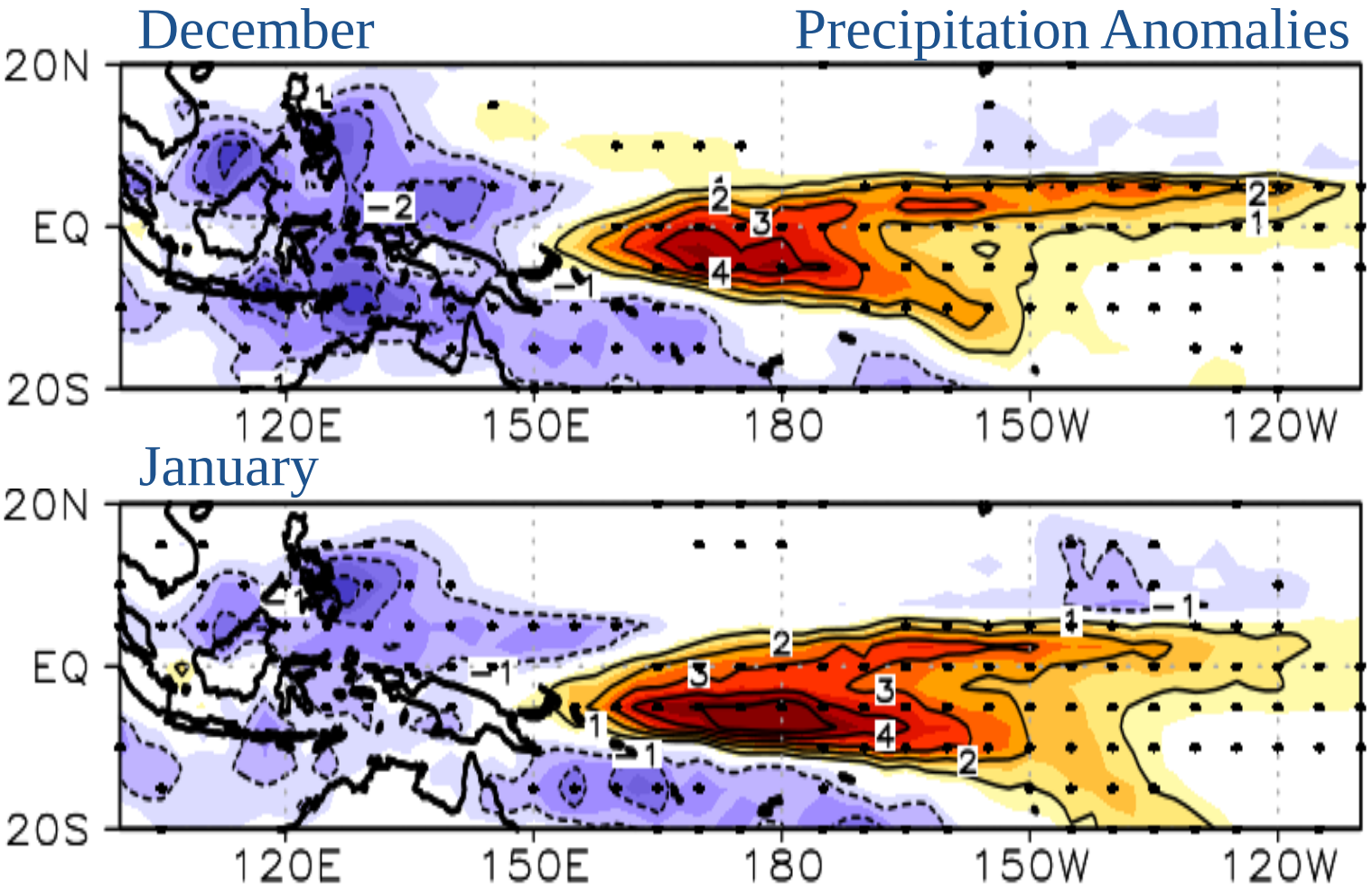
November

December

January



What makes teleconnetion differences?



Question!! What are relative roles of CP and WNP precipitation anomalies in ENSO teleconnections?

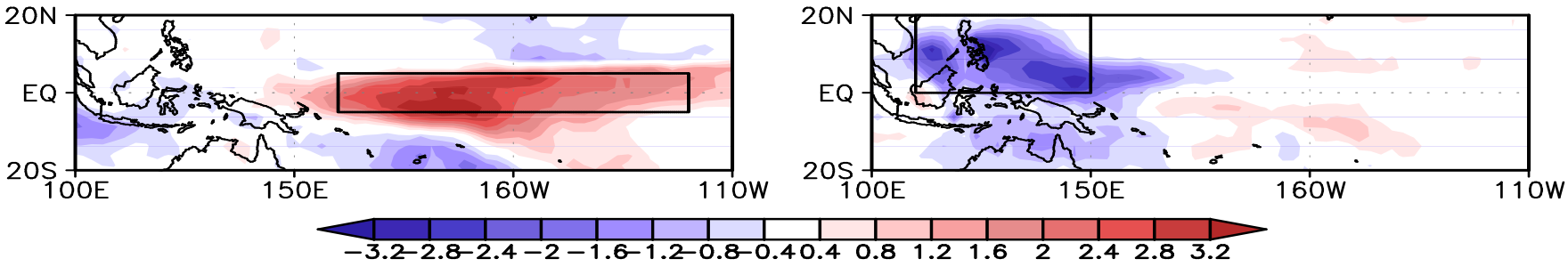
Multiple Regression

Kim et al. (2017, GRL)

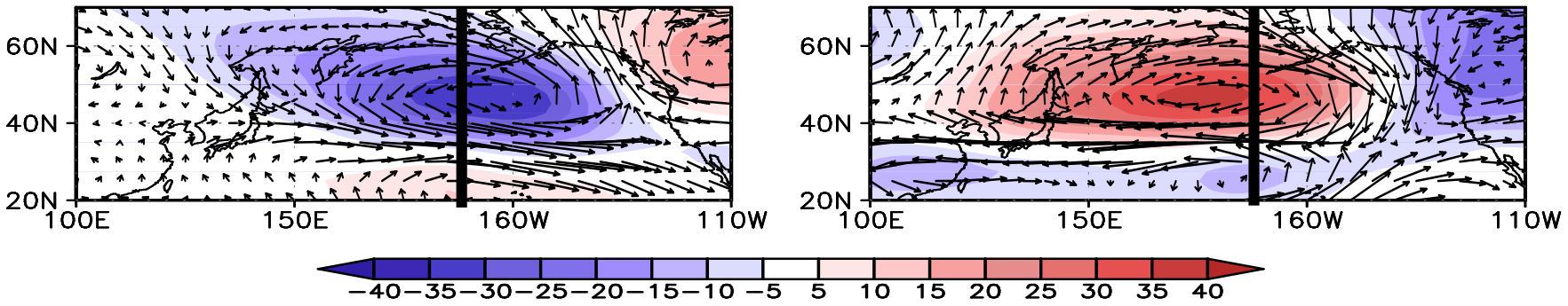
$$Z300 = \alpha \cdot PRCP_{CP} + \beta \cdot PRCP_{WNP}$$

CP Precipitation

WNP Precipitation



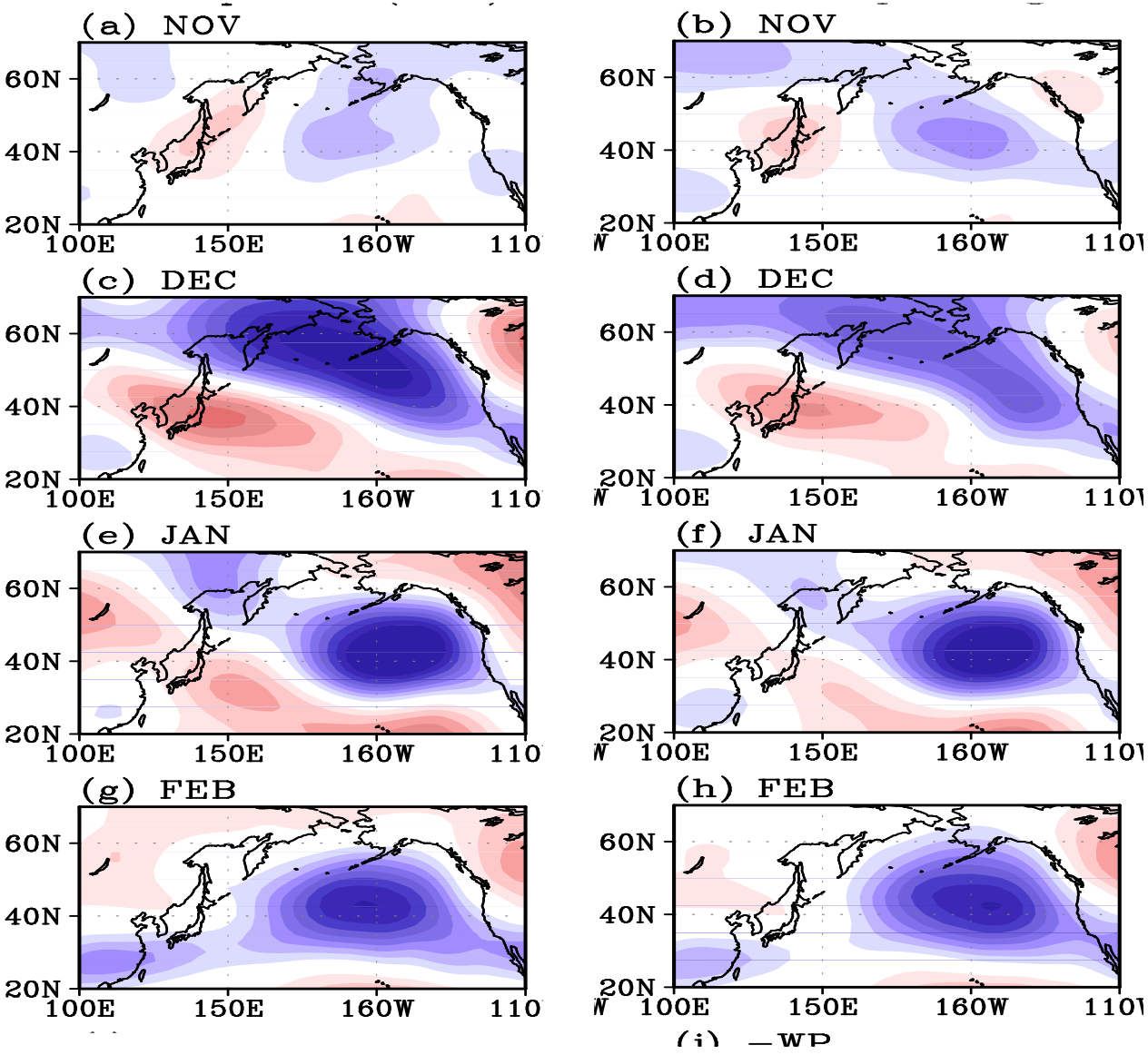
[α] Z300 [β]



El Nino Composites: Seasonal Evolution

Composites

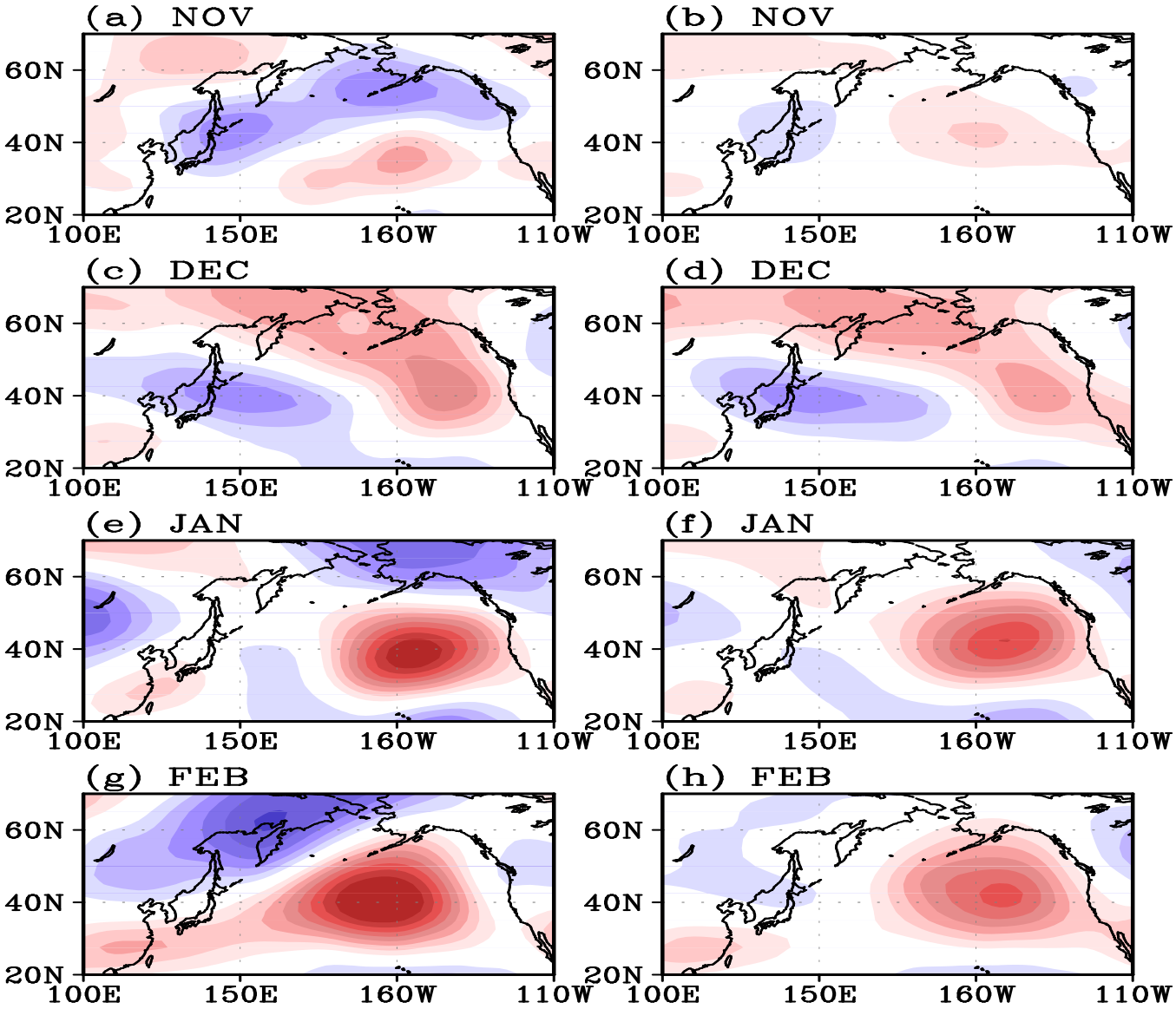
$$Z300 = \alpha \cdot PRCP_{CP} + \beta \cdot PRCP_{WNP}$$



La Nina Composites: Seasonal Evolution

Composites

$$Z300 = \alpha \cdot PRCP_{CP} + \beta \cdot PRCP_{WNP}$$



Evolution of Precipitation Anomalies

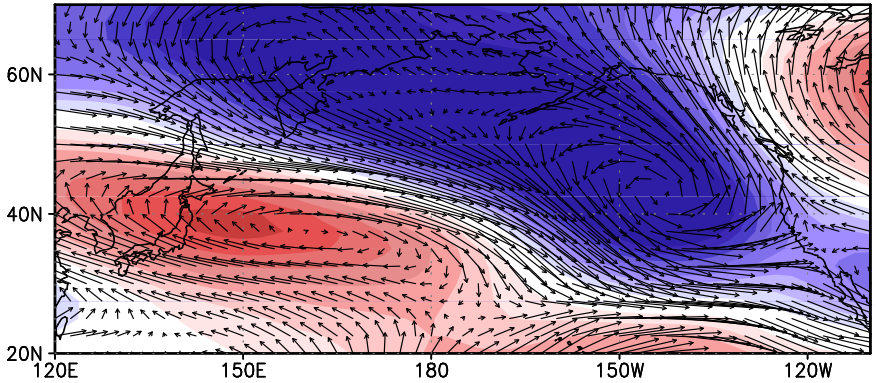
El Nino Composites

	December	January	
CP PRCP	3.02	3.51	**Increase!! (16%)**
WNP PRCP	-1.71	-1.34	**Decrease!! (22%)**

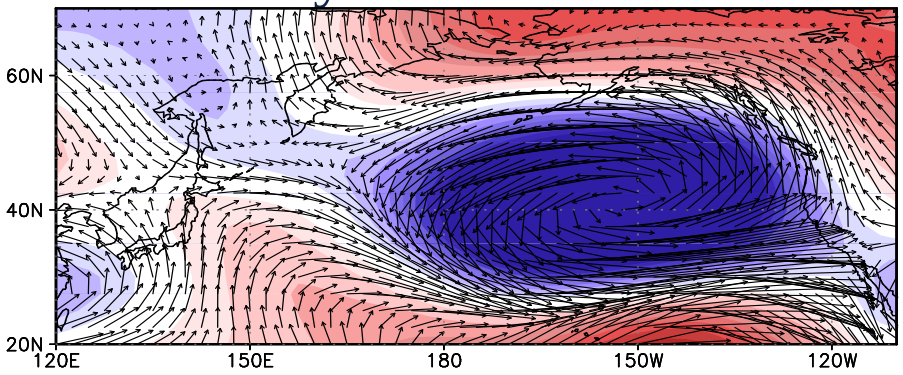
La Nina Composites

	December	January	
CP PRCP	-2.22	-2.36	**Increase!! (6%)**
WNP PRCP	1.47	1.11	**Decrease!! (24%)**

December



January



Dramatic changes in teleconnection to a slight change of forcings

- Why are the teleconnections dramatically changed to the slight change of the tropical precipitation pattern?

  - Suppose that at a given month, teleconnection is determined by P_{CP} and P_{WNP}

$$\Psi = L_1(P_{CP}) + L_2(P_{WNP}) \qquad L_1(P_{CP}) \approx -L_2(P_{WNP}),\ P_{CP}{}^{*}\ P_{WNP}<0$$

$$O\left(\frac{\Psi}{L_1(P_{CP})}\right) \sim 0.1$$

  - For a slight different month, changes in teleconnection ($\delta\Psi$) is determined by seasonal precipitation differences, δP_{CP} and δP_{WNP}

$$\Psi + \delta\Psi = L_1(P_{CP} + \delta P_{CP}) + L_2(P_{WNP} + \delta P_{WNP})$$

$$\delta\Psi = L_1(\delta P_{CP}) + L_2(\delta P_{WNP}) \quad \delta P_{CP}{}^{*}\ \delta\ P_{WNP} > 0$$

$$O\left(\frac{\delta\Psi}{\Psi}\right) \sim 1$$

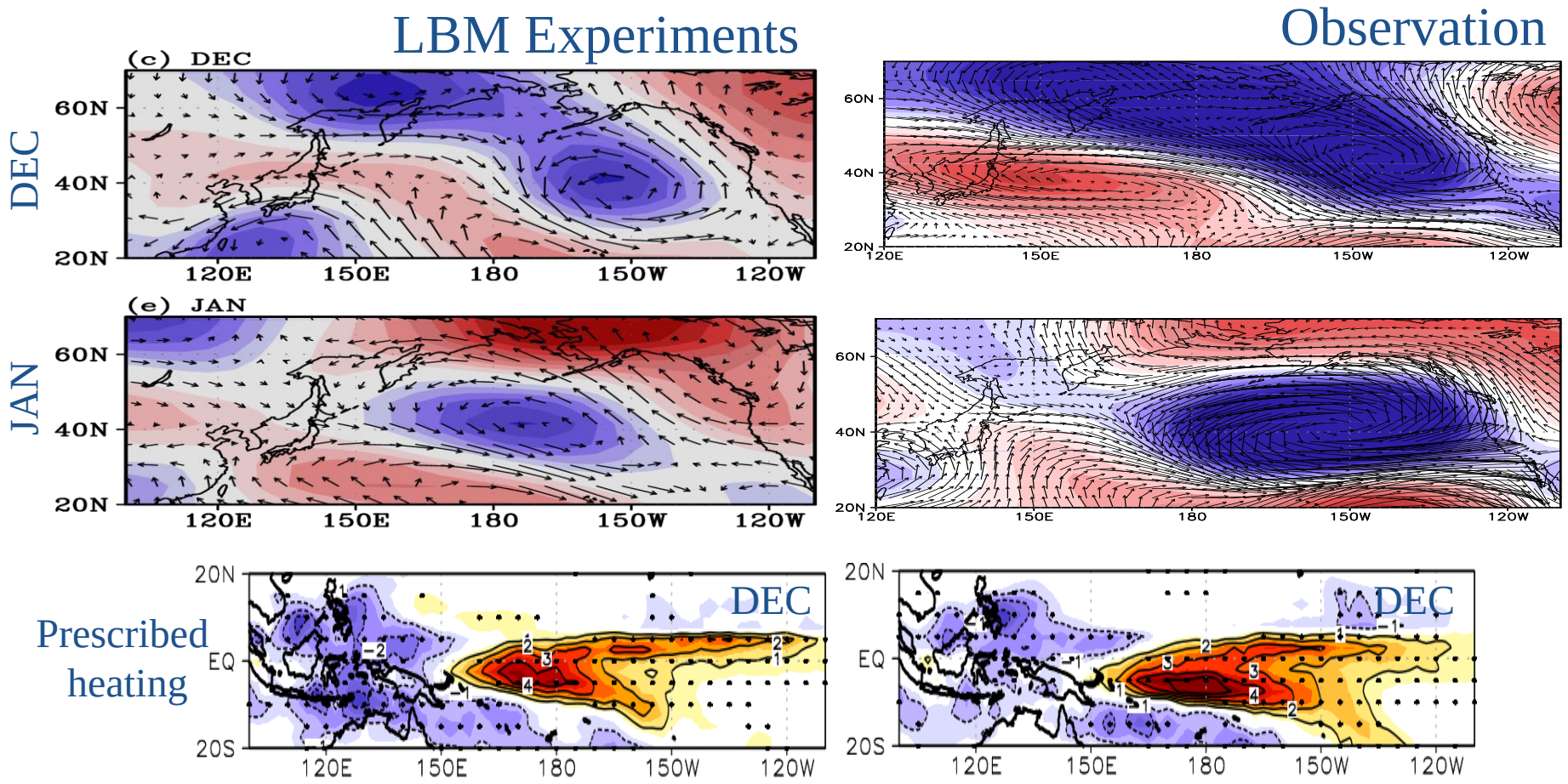
$$O\left(\frac{\delta P_{CP}}{P_{CP}}\right) \sim 0.1 \quad O\left(\frac{\delta P_{WNP}}{P_{WNP}}\right) \sim 0.1$$

From Dec to Jan
$\delta P_{CP} > 0$: Strengthed
$\delta\ P_{WNP} > 0$: Weakened

✓ Teleconnection can be dramatically changed with seasonal evolution

LBM Experiments

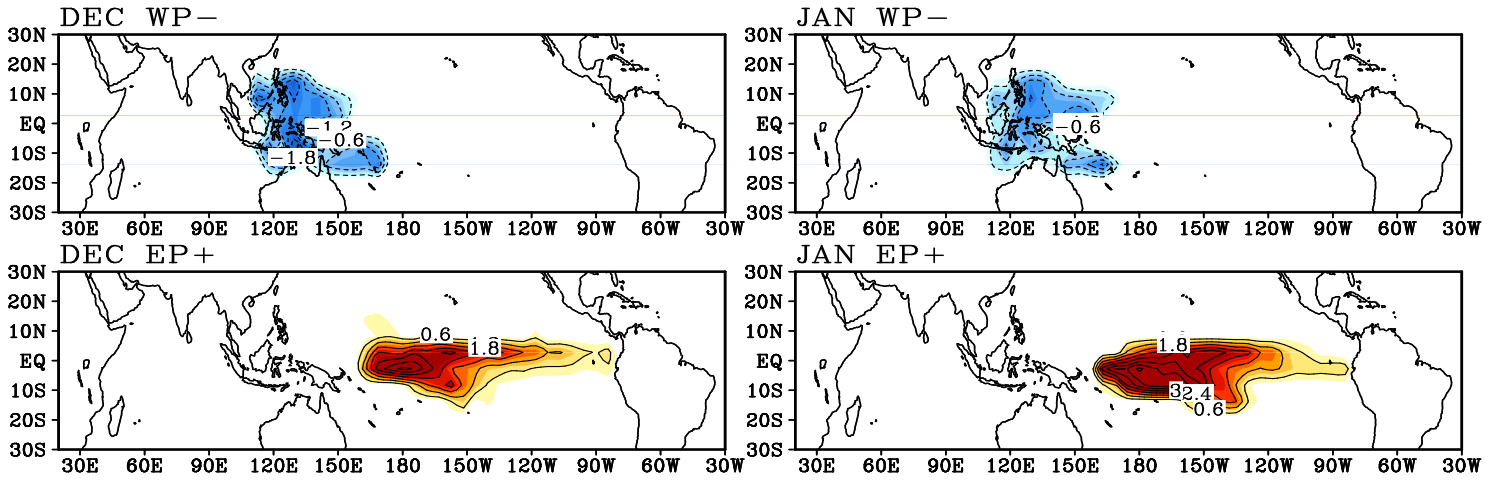
- ✓ Linear Baroclinic Model (developed by Prof. M. Watanabe)
- ✓ Prescribed heating from observed precipitation patterns



Son et al. (2014, Clim. Dyn.)

LBM Experiments

Forcing

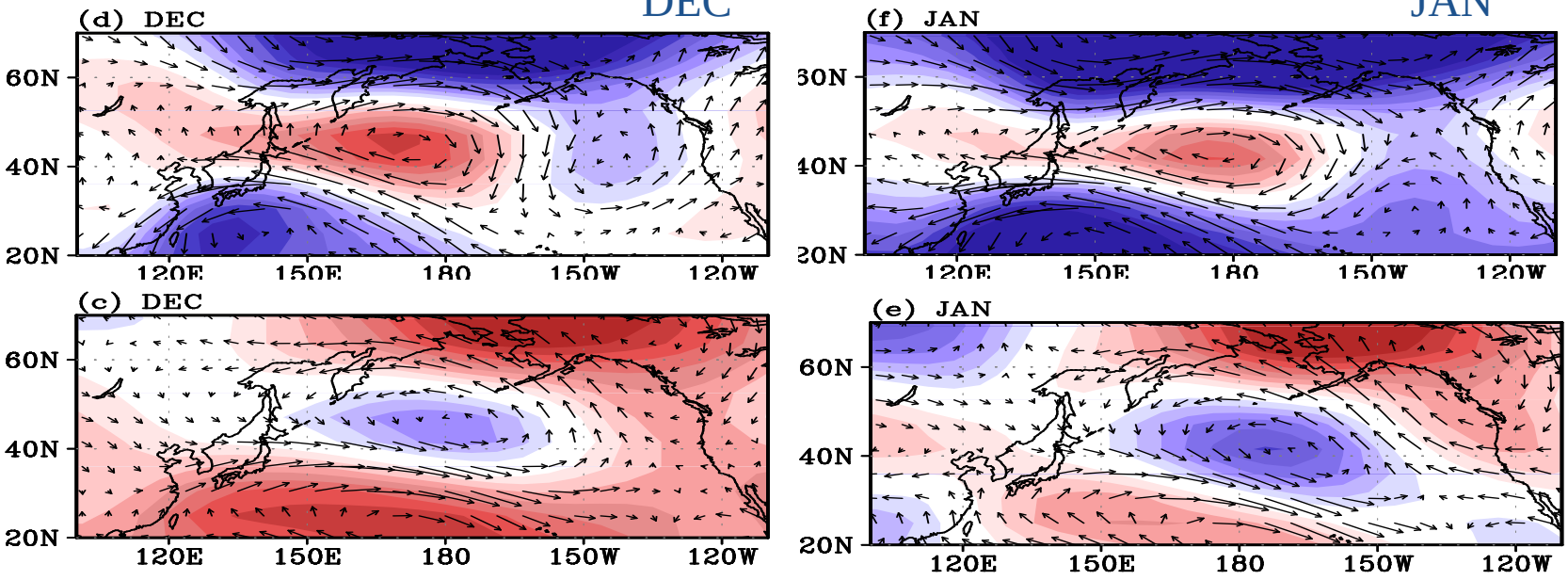


DEC

JAN

Western Pacific

Eastern Pacific

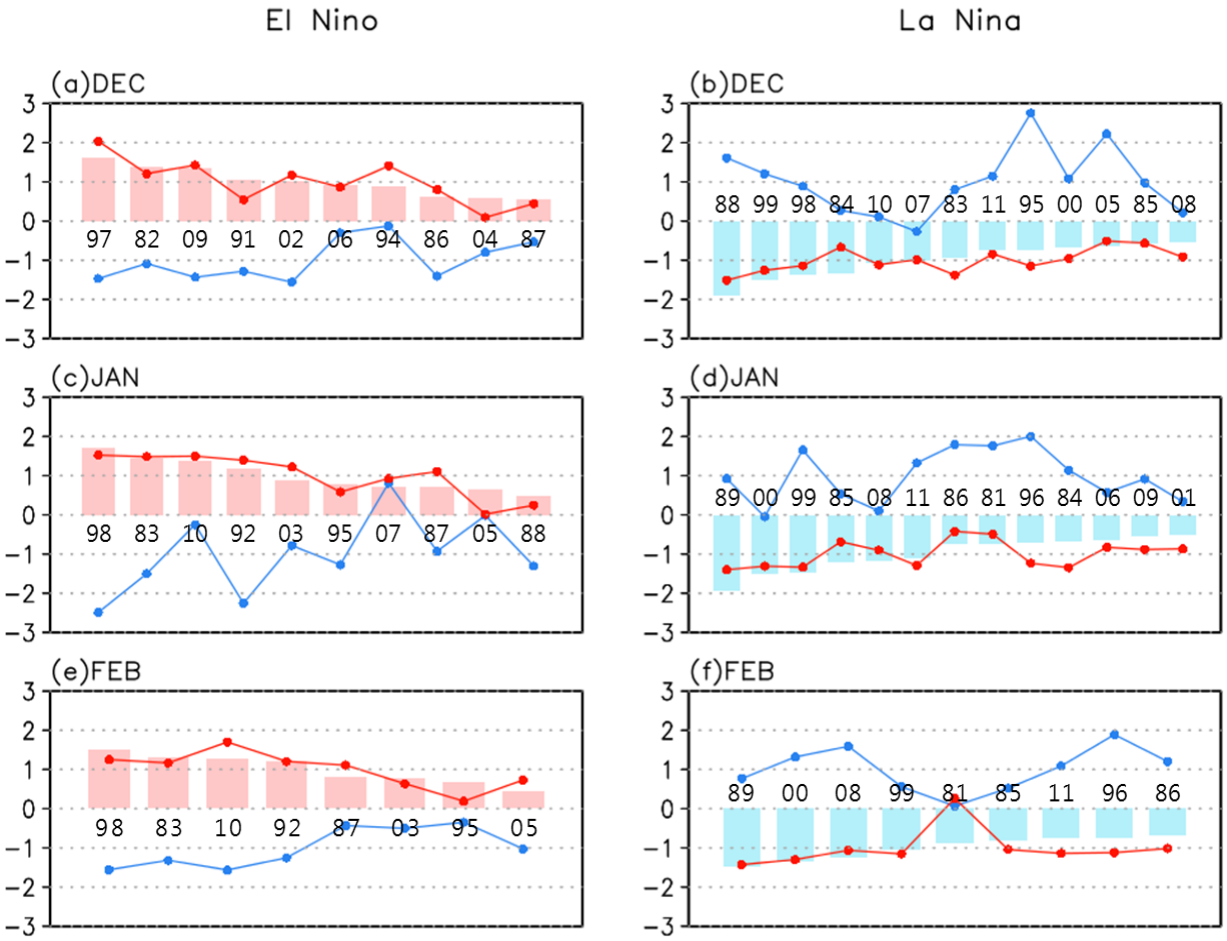


ENSO diversity: WNP and CP precipitation anomalies

NINO3.4 SST

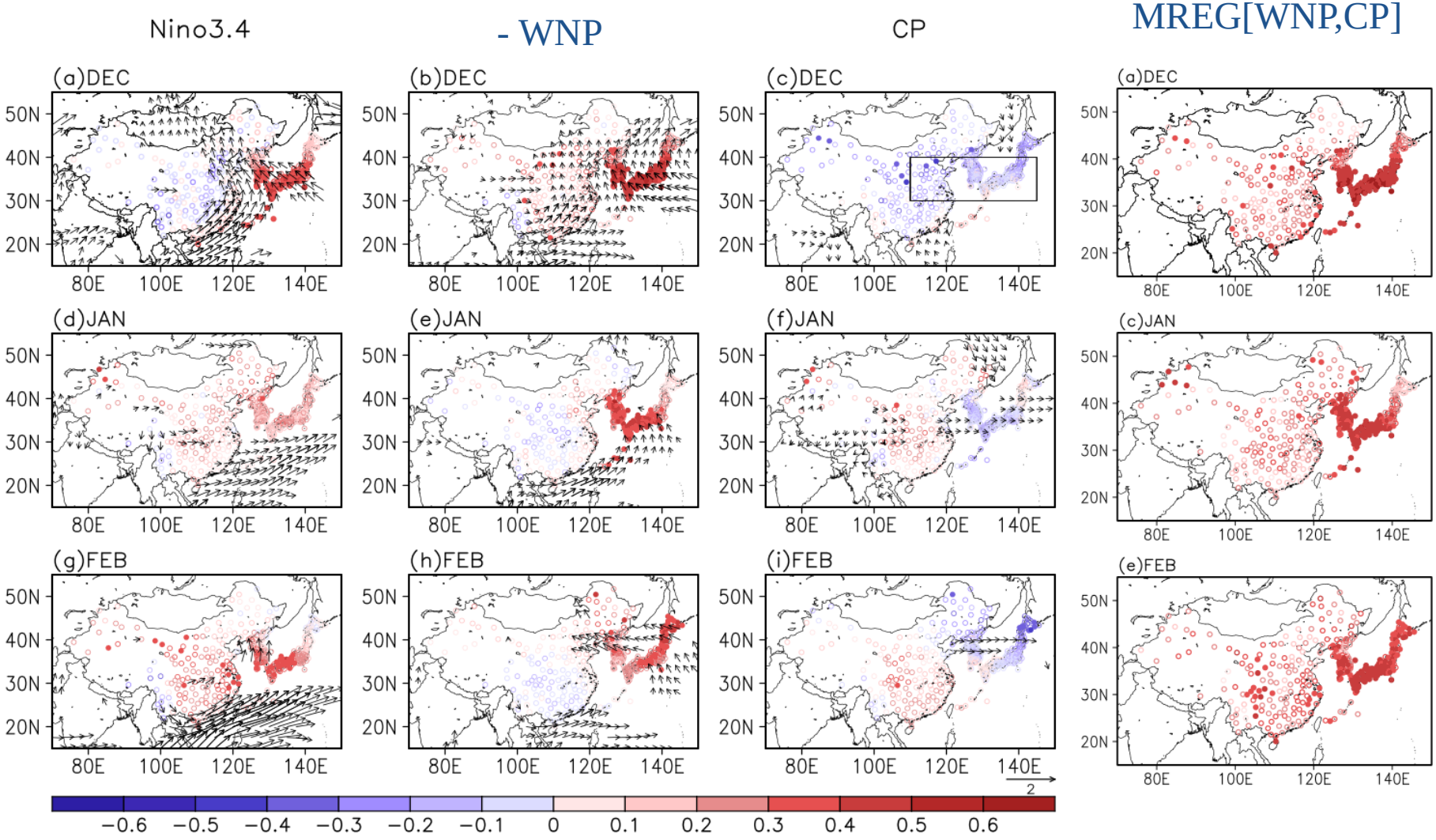
CP PRCP

WNP PRCP



Kim et al. (2018, JGR)

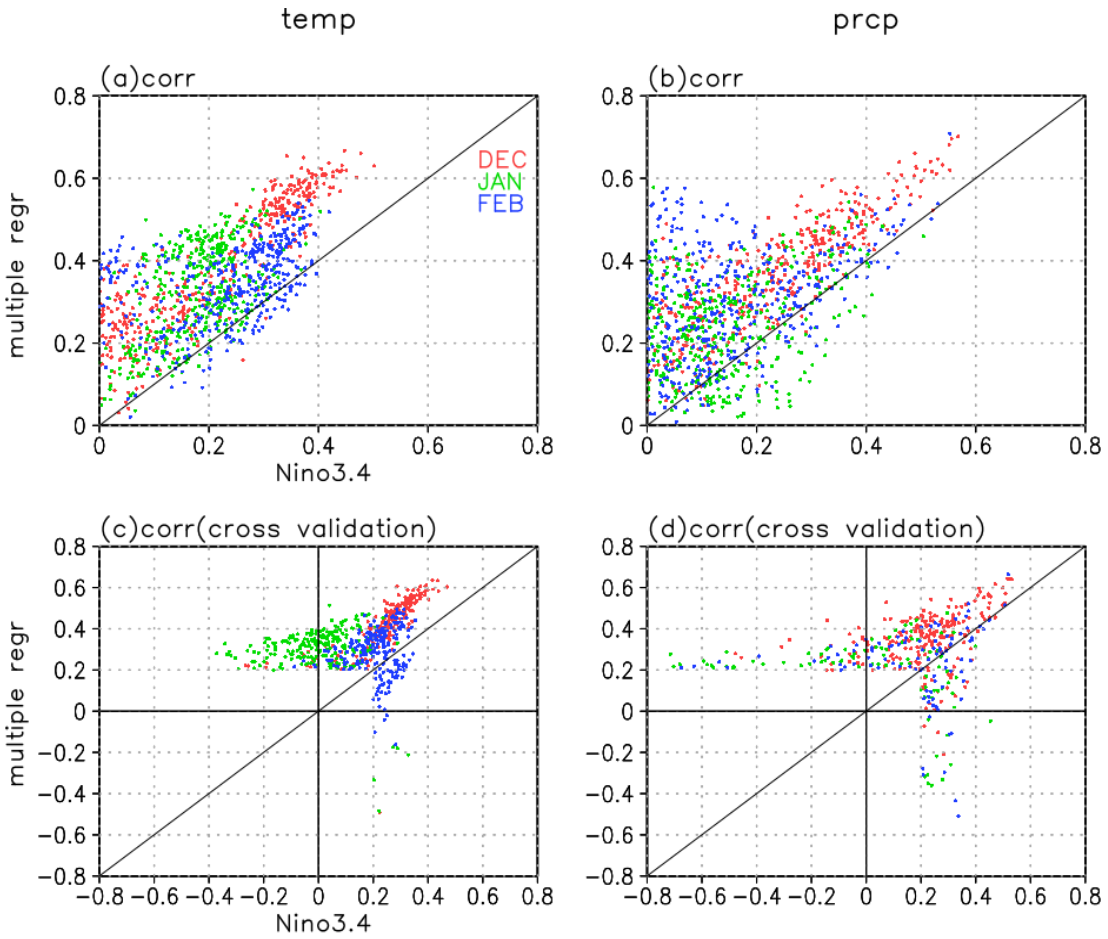
Impacts of ENSO on East Asian Temperature



Kim et al. (2018, JGR)

Comparison: NINO3.4 vs MREG[WNP,CP]

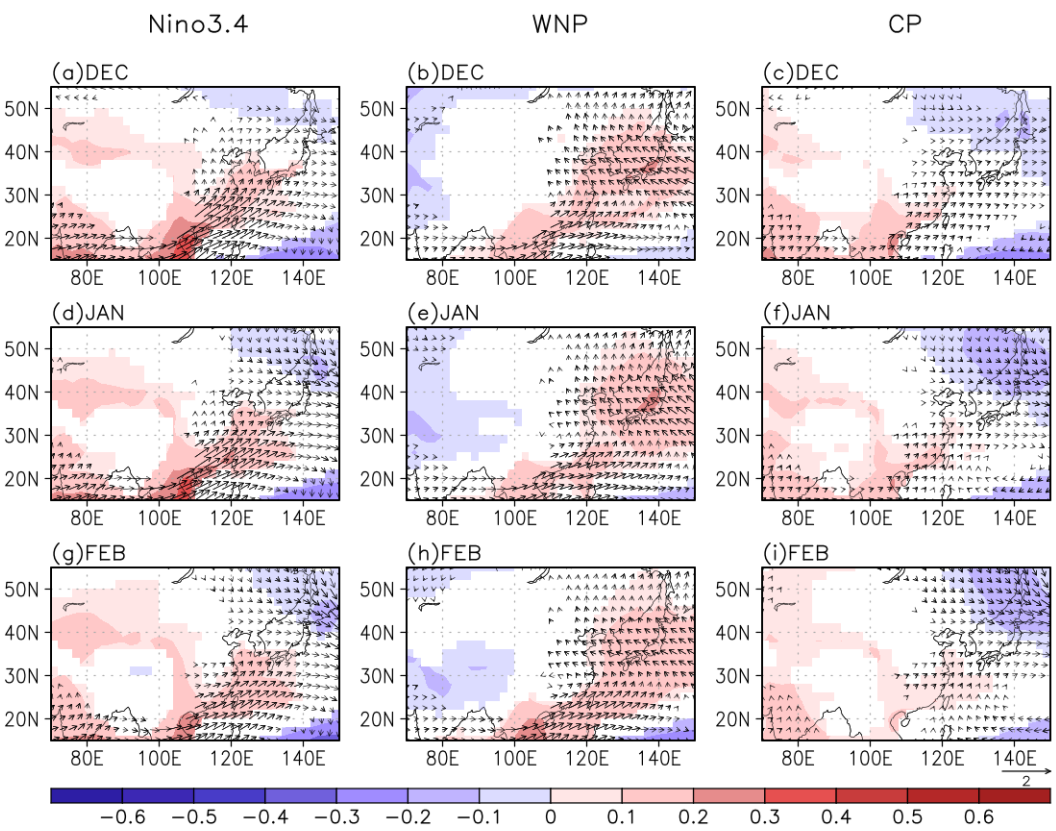
After
Cross-validataion



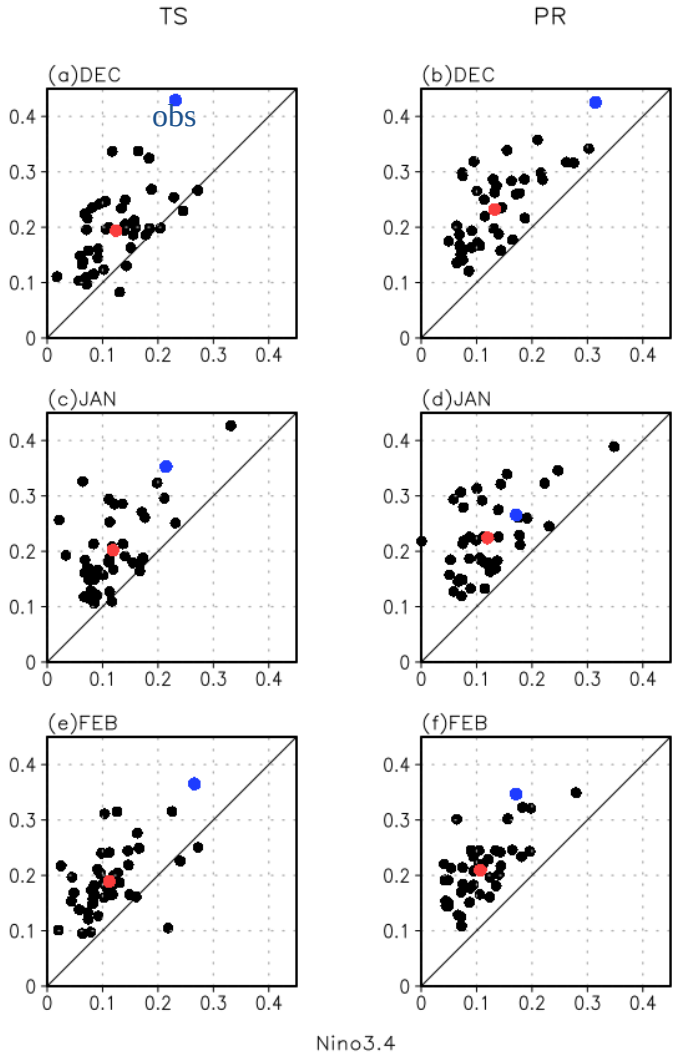
Kim et al. (2018, JGR)

Impacts of ENSO in CMIP5 models

Temperature



MREG[WNP,CP]



Kim et al. (2018, JGR)

Summary and Discussion

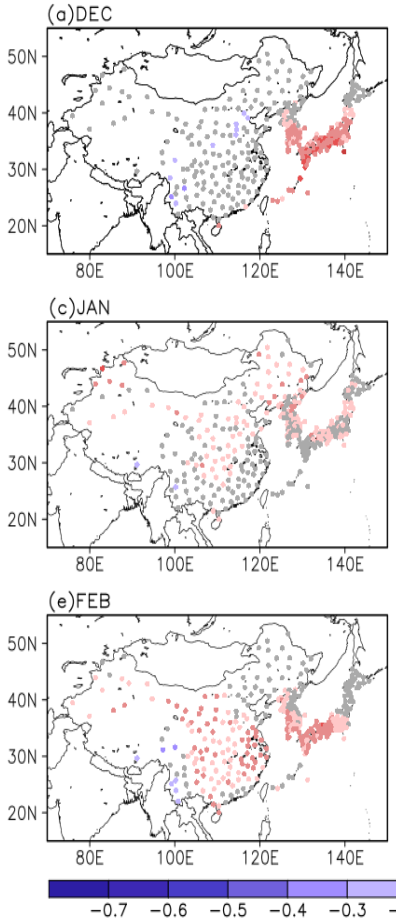
- ✓ The WNP and CP precipitation anomalies associated with ENSO have opposite effects on teleconnection patterns over North Pacific and East Asia, which makes strong sensitivity/seasonal dependency of ENSO teleconnection.
- ✓ The WNP precipitation plays an important role in generating El Nino impacts over East Asia.
- ✓ Relative roles of WNP and CP precipitation anomalies can explain the diversity of El Nino impacts on East Asian climate to some extent.

Thank You !!!

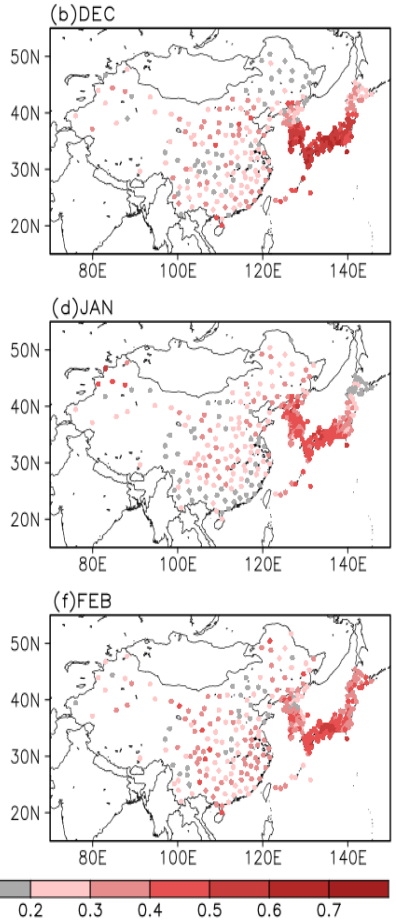
Impacts of ENSO

Precipitation

Nino3.4

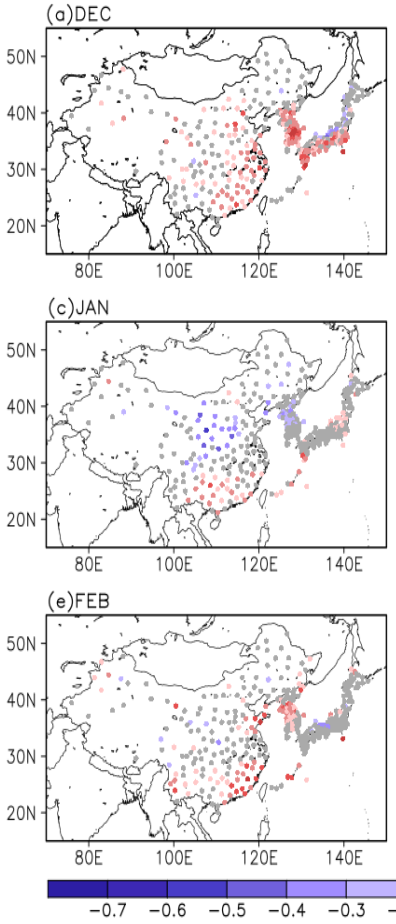


MREG[WNP,CP]

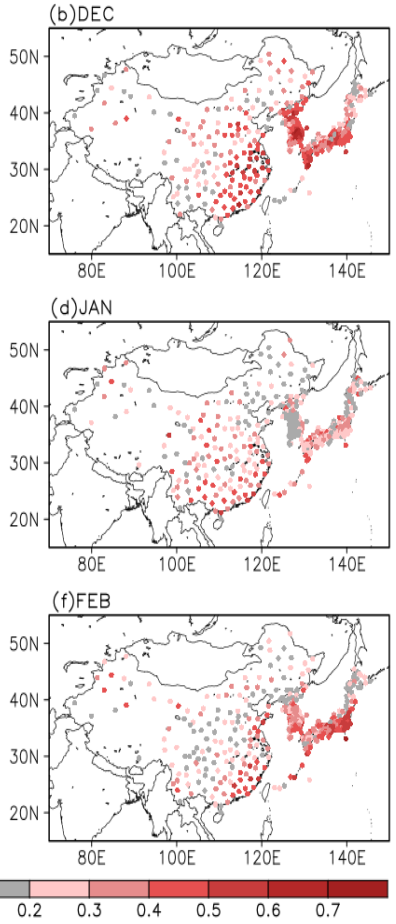


Temperature

Nino3.4



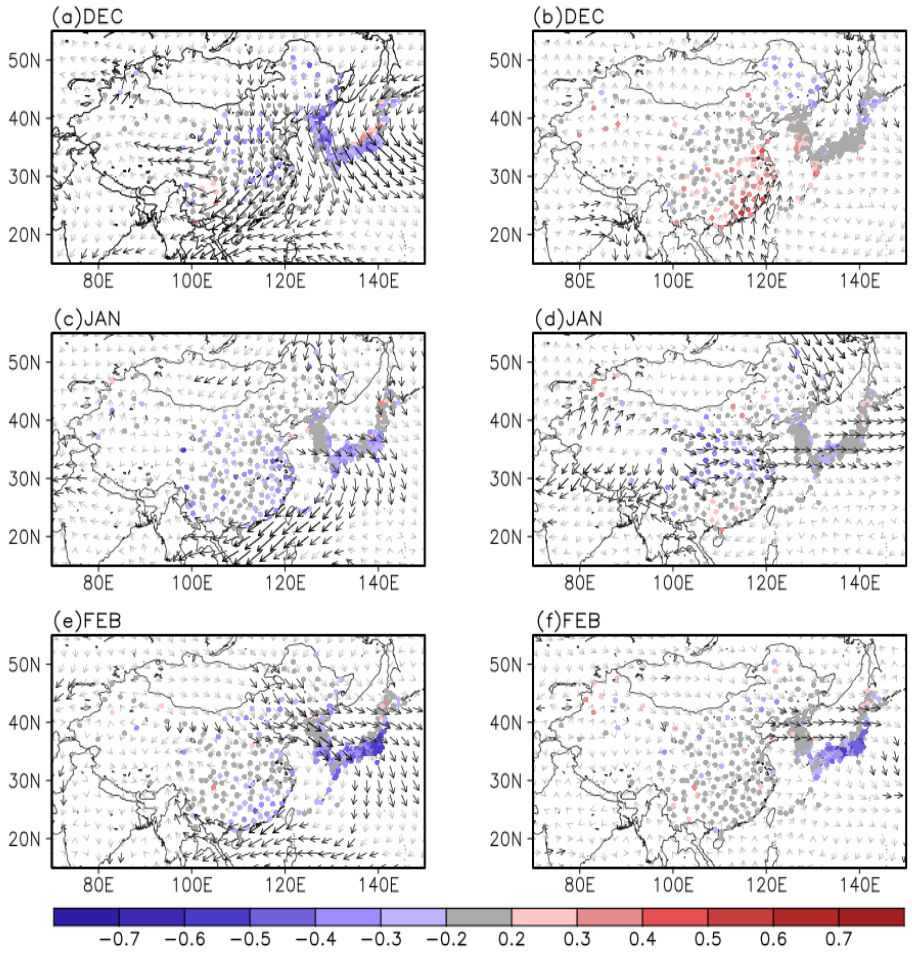
MREG[WNP,CP]



Partial Correlation

Precipitation

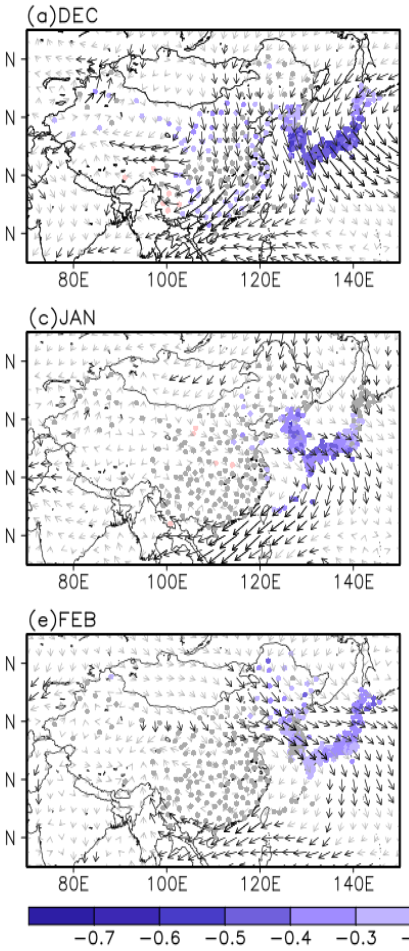
Effect of WNP



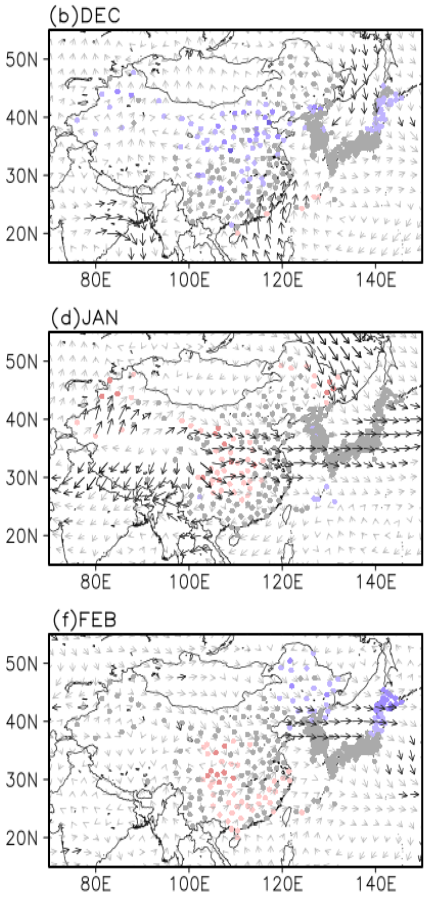
Effect of CP

Temperature

Effect of WNP



Effect of CP



Take-Home Messages

- **ENSO teleconnections and impacts are very sensitive to a detail structure of tropical precipitation anomalies**

- **Precipitation anomalies over WNP play a critical role in modulating ENSO teleconnections and impacts, particularly on East Asia Climate.**

Why are the teleconnections dramatically changed to the slight change of the tropical precipitation?

At a give month, assume that extratropical teleconnection is determined by P_{CP} and P_{WNP}

$$\Psi = L_1(P_{CP}) + L_2(P_{WNP}) \qquad L_1(P_{CP}) \approx -L_2(P_{WNP}),\ P_{CP} * P_{WNP} < 0$$

Why are the teleconnections dramatically changed to the slight change of the tropical precipitation?

At a given month, teleconnection is determined P_{CP} and P_{WNP}

$$\Psi = L_1(P_{CP}) + L_2(P_{WNP}) \qquad L_1(P_{CP}) \approx -L_2(P_{WNP}),\ P_{CP} * P_{WNP} < 0$$

$$O\left(\frac{\Psi}{L_1(P_{CP})}\right) \sim 0.1$$

For slight different month , changes in teleconnection ($\delta\Psi$) is determined δP_{CP} and δP_{WNP}

$$\Psi + \delta\Psi = L_1(P_{CP} + \delta P_{CP}) + L_2(P_{WNP} + \delta P_{WNP})$$

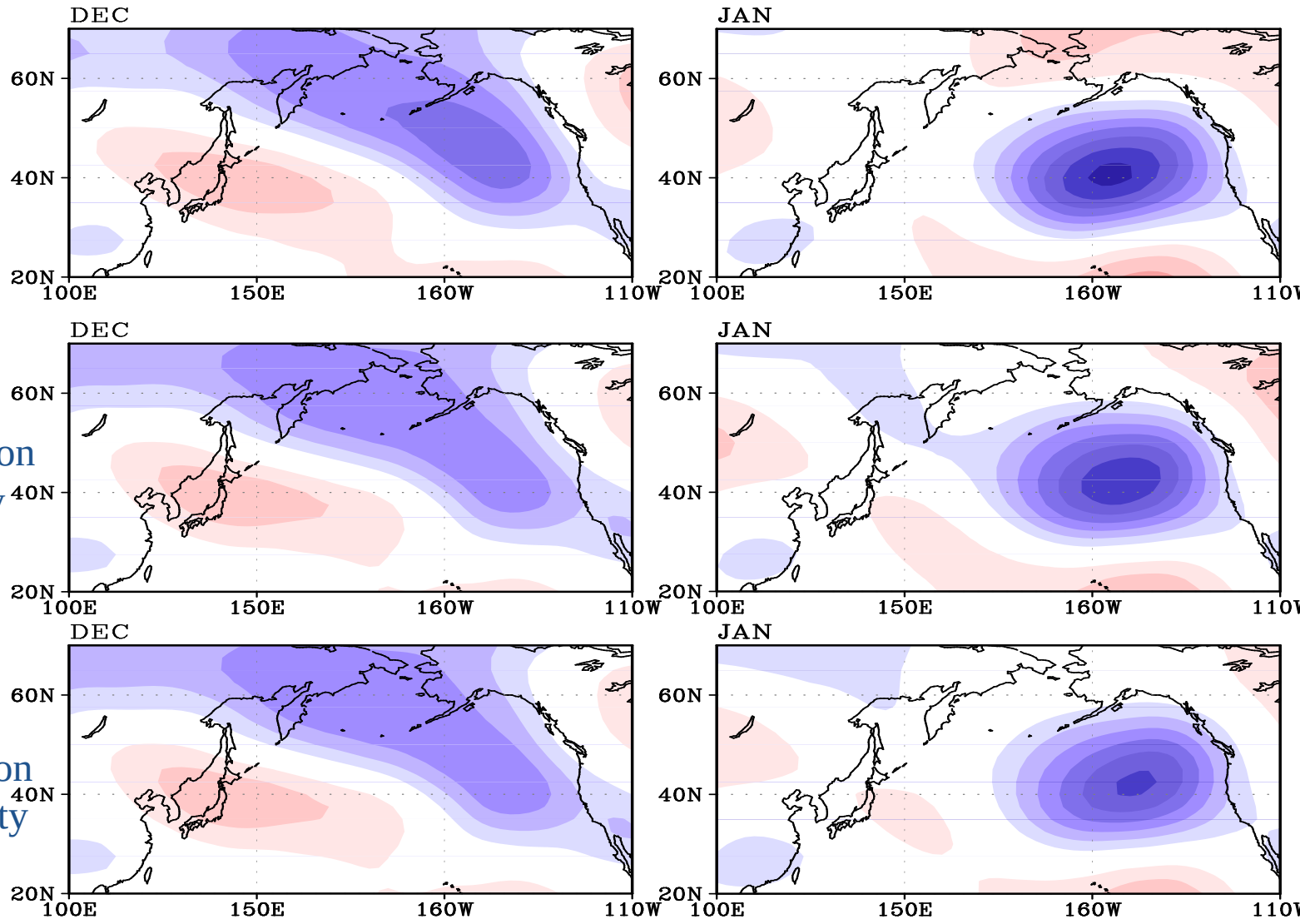
$$O\left(\frac{\delta P_{CP}}{P_{CP}}\right) \sim 0.1 \quad O\left(\frac{\delta P_{WNP}}{P_{WNP}}\right) \sim 0.1$$

Effect of Seasonality in Multiple Regression Coefficients

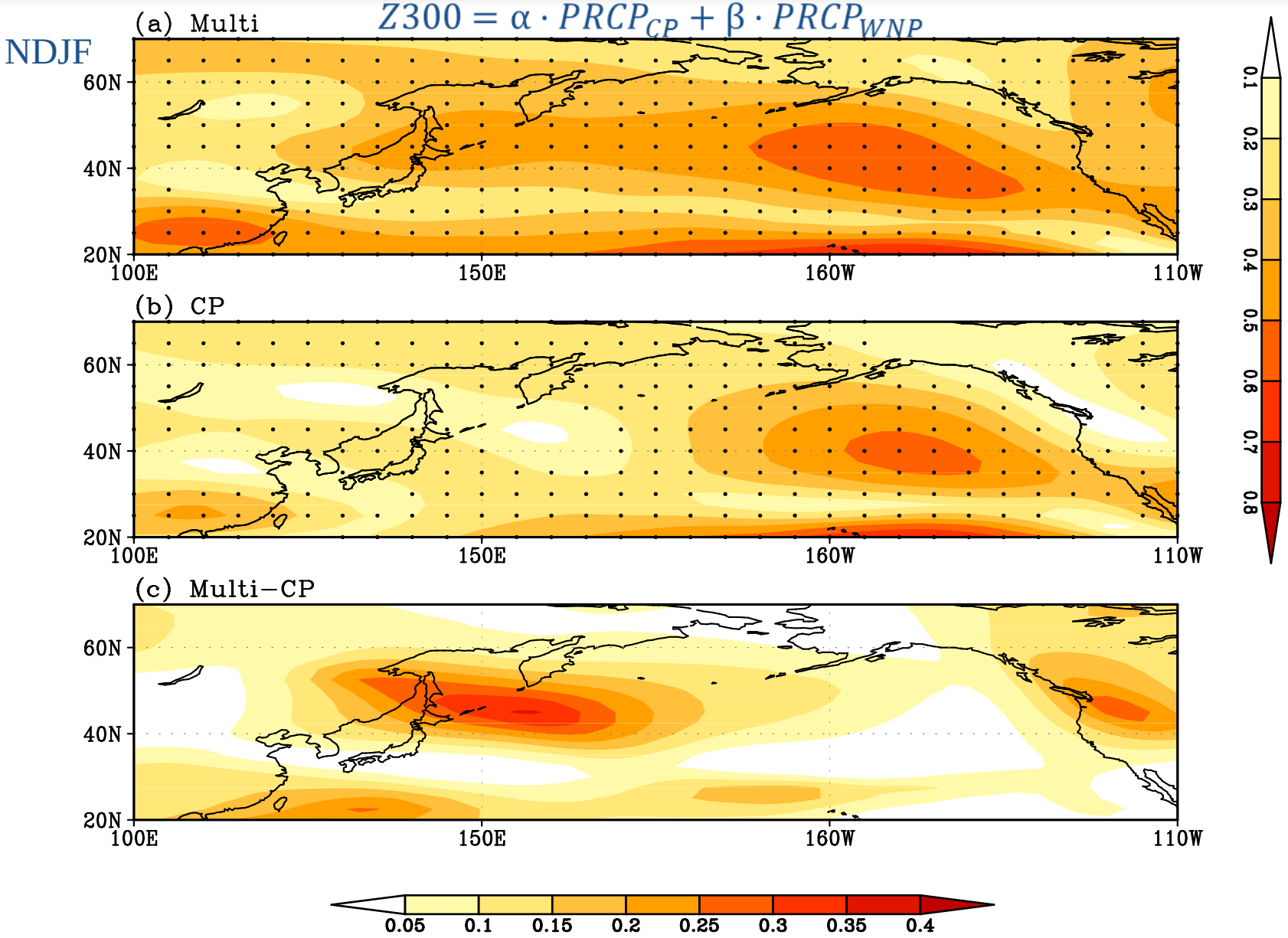
Teleconnection Pattern

From Multiple Regression with Seasonality

From Multiple Regression without Seasonality



Explained Variance: Correlation



Systematic Errors in ENSO precipitation

CMIP5 - OBS