What controls ENSO teleconnection to East Asia?

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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?

**December**

Teleconnection

PCOR=0.46

**January**

SST

PCOR=0.99

PRCP

PCOR=0.86

Linear Regression
Precipitation over the Korean Peninsula

Correlation between NINO3 SST and 5-pentad mean PRCP

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

December

January
Correlation between NINO3 SST and PRCP

November

December

January
What makes teleconnetion differences?

December

Precipitation Anomalies

January

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

\[ Z_{300} = \alpha \cdot PRCP_{CP} + \beta \cdot PRCP_{WNP} \]

Kim et al. (2017, GRL)
El Niño Composites: Seasonal Evolution

\[ Z_{300} = \alpha \cdot PRCP_{CP} + \beta \cdot PRCP_{WNP} \]
La Nina Composites: Seasonal Evolution

\[ Z300 = \alpha \cdot PRCP_{CP} + \beta \cdot PRCP_{WNP} \]
## Evolution of Precipitation Anomalies

### El Nino Composites

<table>
<thead>
<tr>
<th></th>
<th>December</th>
<th>January</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP PRCP</td>
<td>3.02</td>
<td>3.51</td>
<td>Increase!! (16%)</td>
</tr>
<tr>
<td>WNP PRCP</td>
<td>-1.71</td>
<td>-1.34</td>
<td>Decrease!! (22%)</td>
</tr>
</tbody>
</table>

### La Nina Composites

<table>
<thead>
<tr>
<th></th>
<th>December</th>
<th>January</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP PRCP</td>
<td>-2.22</td>
<td>-2.36</td>
<td>Increase!! (6%)</td>
</tr>
<tr>
<td>WNP PRCP</td>
<td>1.47</td>
<td>1.11</td>
<td>Decrease!! (24%)</td>
</tr>
</tbody>
</table>

## December

![Map for December](image1)

## January

![Map for January](image2)
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 $P_{WNP}$

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

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

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

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

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

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

Teleconnection can be dramatically changed with seasonal evolution.

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

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

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

Western Pacific

Eastern Pacific

Forcing

DEC

JAN

(d) DEC

(e) JAN

(f) JAN
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-validation

Kim et al. (2018, JGR)
Impacts of ENSO in CMIP5 models

Temperature

Nino3.4

(a) DEC

(b) DEC

(c) DEC

(d) JAN

(e) JAN

(f) JAN

(g) FEB

(h) FEB

(i) FEB

MREG[WP,CP]

TS

(b) DEC

(c) JAN

(d) JAN

(e) FEB

(f) FEB

PR

Kim et al. (2018, JGR)
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
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 given month, assume that extratropical teleconnection is determined by $P_{CP}$ and $P_{WNP}$

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

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

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

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

$$O\left(\frac{\psi}{L_1(P_{CP})}\right) \approx 0.1$$

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

$$\Psi + \delta\Psi = L_1(P_{CP} + \delta P_{CP}) + L_2(P_{WNP} + \delta P_{WNP}) \quad O\left(\frac{\delta P_{CP}}{P_{CP}}\right) \approx 0.1 \quad O\left(\frac{\delta P_{WNP}}{P_{WNP}}\right) \approx 0.1$$
Effect of Seasonality in Multiple Regression Coefficients

Teleconnection Pattern

From Multiple Regression with Seasonality

From Multiple Regression without Seasonality
Explained Variance: Correlation

\[ Z_{300} = \alpha \cdot \text{PRCP}_{\text{CP}} + \beta \cdot \text{PRCP}_{\text{WNP}} \]
Systematic Errors in ENSO precipitation

CMIP5 - OBS

(a) NOV

(b) DEC

(c) JAN