Conference on Teleconnections in the Atmosphere and Oceans

17 - 20 November 2008

Issues on teleconnection

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Modeling and Seasonal Prediction Aspects of Teleconnection

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ENSO Teleconnection

Transient activity
Held et al. (1989), and others

Interactive
Seasonal Mean

Potential Predictability
Signal to Noise ratio

Wallace and Gutzler (1981)
Horel and Wallace (1981),
Hoskins and Karoly (1981),
Blackmon et al. (1983)

Monsoon
ENSO

ENSO - Monsoon Teleconnection

El Nino/Southern Oscillation
Rasmussen and Wallace (1983)
Observation

External Forcing

Precipitation

EOF 1st mode

NCEP [37.90%]

200mb transient eddy forcing

NCEP [25.59%]

\[
\frac{\partial \psi^a}{\partial t} = - \nabla^2 \left[ \nabla \cdot \left( \psi \zeta^a \right) \right]
\]
Observation

NCEP [37.90%]

EOF 1st mode
(a) Black: 200mb geopotential height
(b) Red: Precipitation
(c) Green: 200mb transient eddy forcing

T.Corr Skill (a,b) = 0.47
T.Corr Skill (a,c) = 0.73
Seasonal Prediction

◆ Predictable part
  ✓ Responses to external forcing (tropical anomaly) and transient forcing on seasonal mean anomaly

◆ Unpredictable part
  ✓ Internal variability mainly by transients

- Assessment of predictability using Ensemble predictions
- Signal to Noise Ratio
Model

Seasonal Mean, 200mb streamfunction (Ensemble Mean)

Dominant variability: EOF 1st mode

DEMETER/ECMWF
(Tier 1 Prediction System)

NCEP [37.90%]

INGV [52.31%]

MAXP [62.67%]

ECMW [53.79%]

LODY [48.47%]

UKMO [45.21%]

METF [40.60%]

Unit: [10^5 m^2 s^-1]
Potential Predictability of Seasonal Prediction

EOF 1st mode
Ensemble mean

Signal Variance
Ensemble mean

Noise Variance
Ensemble deviation

Signal to Noise
Signal (External) Part: Ensemble Mean

1. EOF 1st mode
   Ensemble mean
   - INGV [52.31%]
   - MAXP [62.67%]
   - ECMW [53.79%]
   - LODY [48.47%]

2. Regression to Precipitation
   - INGV
   - MAXP
   - ECMW
   - LODY

3. Regression to 200mb Transient eddy forcing
   - INGV
   - MAXP
   - ECMW
   - LODY
Empirical estimate of eddy feedback contribution effect

\[
\frac{\partial \psi^a}{\partial t} = - \nabla^{-2} \left[ \nabla \cdot \left( \overline{\nabla \psi^a} \right) \right]
\]

\[
\lambda(t) = \frac{\iint \left( \text{Reg}(\psi^a, \text{PNAindex}) \cdot \nabla^{-2} \left[ - \nabla \left( \overline{\nabla \psi^a} \right)(t) \right] \right) \, dx \, dy}{\iint \left[ \text{Reg}(\psi^a, \text{PNAindex}) \right]^2 \, dx \, dy}
\]

X-axis: PNA Index / Y-axis: $\lambda [\text{day}^{-1}]$

**SE group**
[INGV/ MAXP/ UKMO]

**WE group**
[ECMWF/ LODY/ METF]

PNA area 150E-300E, 30N-70N

Slope = 0.14
SSE = 0.008

Slope = 0.04
SSE = 0.002
Noise (Internal) Part: Ensemble Deviation

EOF 1st mode
Ensemble deviation

Precipitation

200mb Transient eddy forcing

INGV, MAXP, ECMW, LODY
Potential Predictability of Seasonal Prediction

About the extra-tropical anomaly

<table>
<thead>
<tr>
<th></th>
<th>External Part</th>
<th>Internal Part</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tropical Forcing</strong></td>
<td>![Red Circle]</td>
<td>-</td>
</tr>
<tr>
<td><strong>Transient Forcing</strong></td>
<td>![Green Circle]</td>
<td>![Green Circle]</td>
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</table>
Current Prediction Skill: Temporal Correlation

200mb Streamfunction [NCEP]

INGV  MAXP  ECMW  LODY

Precipitation [CMAP]

INGV  MAXP  ECMW  LODY

200mb transient eddy forcing [NCEP]

INGV  MAXP  ECMW  LODY

1980~2001, seasonal mean (winter)
Issues:

1. Assessment of potential predictability
   - External vs Internal modes

2. What determines the transient activities?

3. Processes related to transient-mean flow interaction
   - How are the internal modes generated?
Improvement of Transients

Dependency of model resolution

- 3 hourly precipitation

300km resolution

125km resolution

25km resolution

Time: 06Z JUN 12 1999
Very High resolution GCM simulation – 25km resolution

- 1997 JJA (El Nino) – 1999 JJA (La Nina)

CMAP

25km SNUGCM

300km SNUGCM
Very High resolution GCM simulation – 25km resolution

- The 200 hPa streamfunction: 1997 El Nino case – 1999 La Nina case (Difference)

NCEP

25km SNUGCM

300km SNUGCM

Perturbation from the zonal mean & seasonal mean
High Frequency eddy activity $\overline{u^2}$

- 1997 El Nino case

NCEP

25km SNUGCM

300km SNUGCM

The standard deviation of 2~8 day filtered 200hPa zonal wind
Transient eddy forcing

1997 El Nino case (JJA mean) - 200 hPa filtered zonal/meridional wind

Using quasi-geostrophic approximation,

\[ \frac{\partial \psi}{\partial t} = -\nabla^{-2}[\nabla \cdot (V' \zeta')] \]

NCEP

25km SNUGCM
125km SNUGCM
300km SNUGCM
THANK YOU!
Empirical estimate of eddy feedback contribution effect

1980~2001 winter
NAO area 90W~30E, 30N~80N

Using model NAO index

\[
\lambda = \frac{\iint \left( \Re g(Z^a, \text{NAO index}) \cdot \nabla^2 \left[ -\frac{f}{g} \nabla \left( \overline{V^a} \right) (t) \right] \right) dxdy}{\iint \left( \Re g(Z^a, \text{NAO index}) \right)^2 dxdy}
\]

SE group
[INGV/ MAXP/ UKMO]

WE group
[CERF/ ECMW/ LODY/ METF]

X-axis: NAO index / Y-axis: \( \lambda \)

Slope = 0.15
SSE = 0.017

Slope = 0.02
SSE = 0.003
Empirical estimate of growth rate contribution of eddy feedback

\[ \frac{\partial \overline{\psi}^a}{\partial t} \sim \overline{T}^a = \nabla^2 \left( -\nabla \cdot \overline{\nabla} \zeta^a \right) = \lambda \overline{\psi}^a : \text{Transient eddy forcing} \]

\[ \lambda : \text{Growth rate contribution of eddy feedback} \]

\[ \lambda = \frac{\iint (\overline{\psi}^a \cdot \overline{T}^a) \, dx \, dy}{\iint \overline{\psi}^a \, dx \, dy} \]

### PNA mode

**Growth Rate [day\(^{-1}\)]**

<table>
<thead>
<tr>
<th></th>
<th>OBS</th>
<th>SE group</th>
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<tr>
<td></td>
<td>0.12</td>
<td>0.15</td>
<td>0.09</td>
</tr>
<tr>
<td></td>
<td>0.10</td>
<td>0.14</td>
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<td>0.06</td>
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### NAO mode

**Growth Rate [day\(^{-1}\)]**

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<td></td>
<td>0.18</td>
<td>0.16</td>
<td>0.04</td>
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<td>0.16</td>
<td>0.14</td>
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<td>0.10</td>
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<td>14.12 days</td>
<td>9.67 days</td>
<td>14.38 days</td>
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<td>16.55 days</td>
<td>5.79 days</td>
<td>39.85 days</td>
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Potential Predictability of Seasonal Prediction

EOF 1st mode
Ensemble mean

Signal (External) Part
Noise (Internal) Part
Precipitation

INGV 52.31%
ECMW 53.79%

Unit: [m]

INGV
ECMW

INGV
ECMW

INGV
ECMW

INGV
ECMW

INGV
ECMW

INGV
ECMW

INGV
ECMW

Transient eddy forcing
Potential Predictability of Seasonal Prediction

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