



**The Abdus Salam  
International Centre for Theoretical Physics**



**1968-26**

**Conference on Teleconnections in the Atmosphere and Oceans**

*17 - 20 November 2008*

**Issues on teleconnection**

KANG In Sik

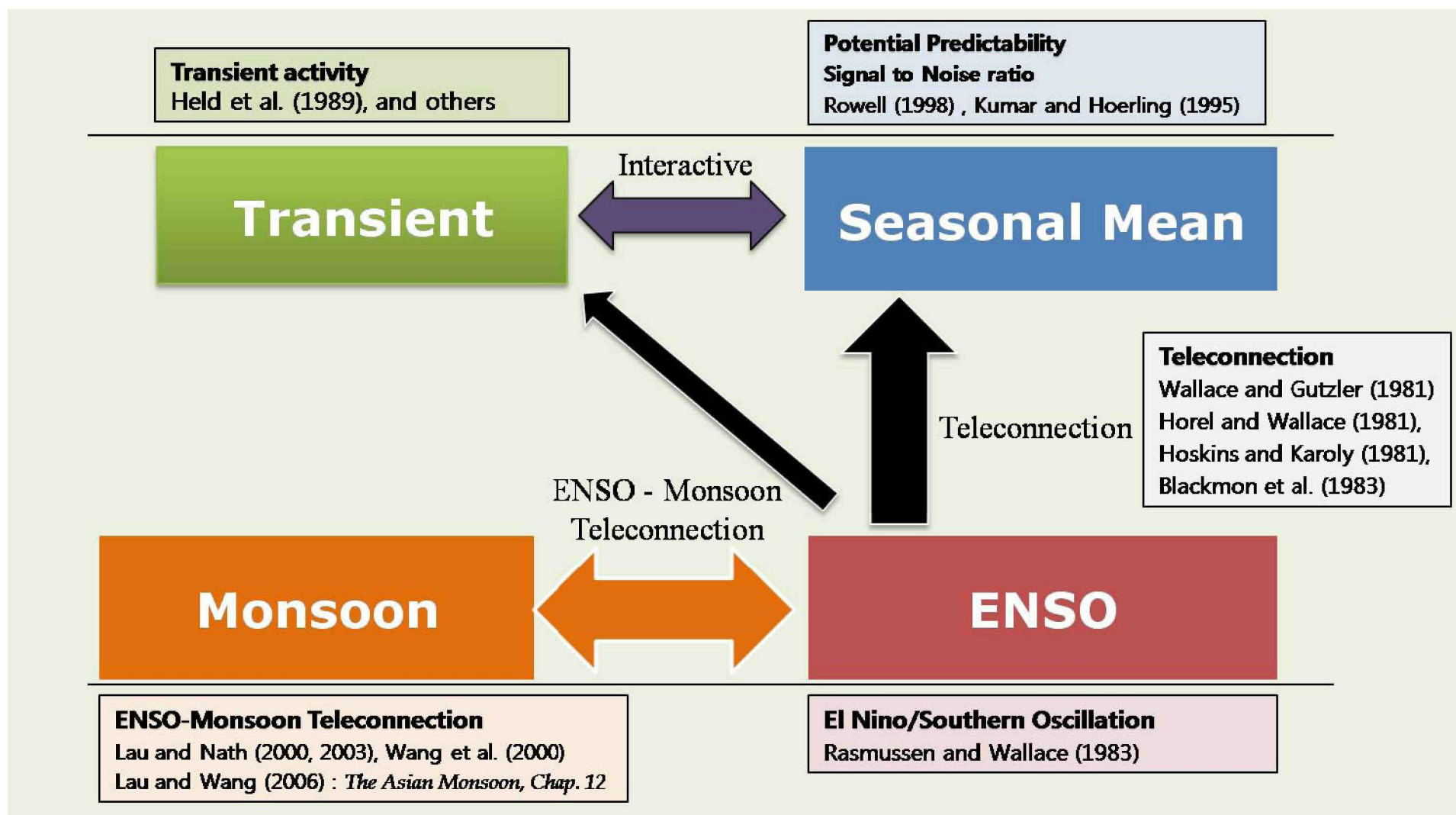
*Seoul National University, School of Earth and Environmental Sciences,  
Division of Atmospheric Sciences  
San 56-1 Shillim-dong, Kwanak-ku, Seoul 151-742  
REPUBLIC OF KOREA*

***Modeling and Seasonal Prediction Aspects of  
Teleconnection***

**In-Sik Kang**

**Seoul National University, Korea**

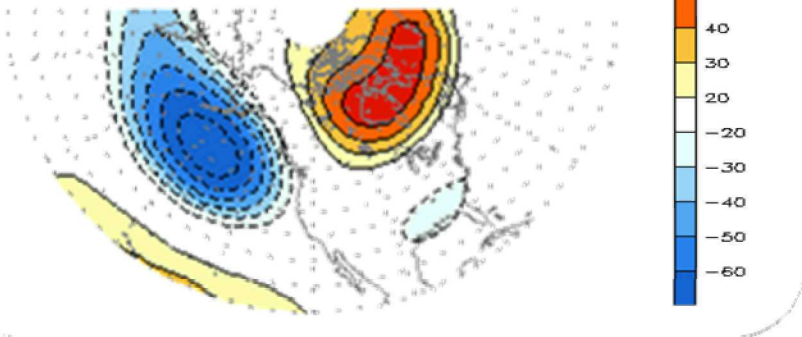
# ENSO Teleconnection



# Observation

External Forcing

NCEP [37.90%]

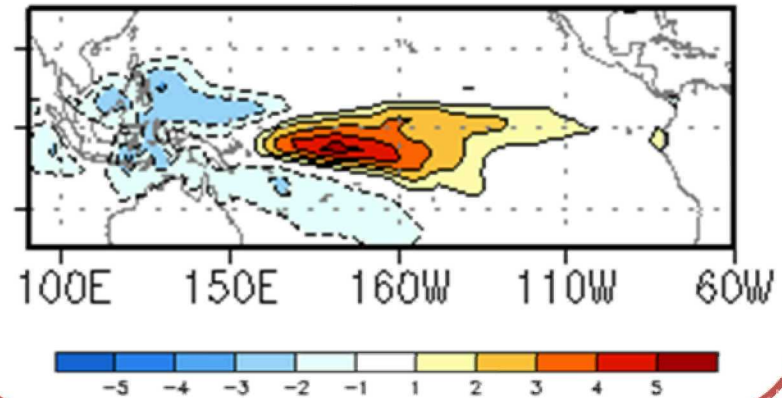


EOF 1<sup>st</sup> mode

Transient Forcing

Precipitation

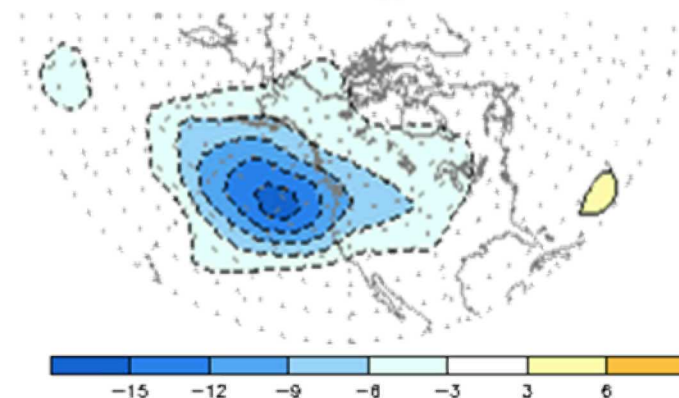
CMAP [51.73 %]



200mb transient eddy forcing

NCEP [25.59 %]

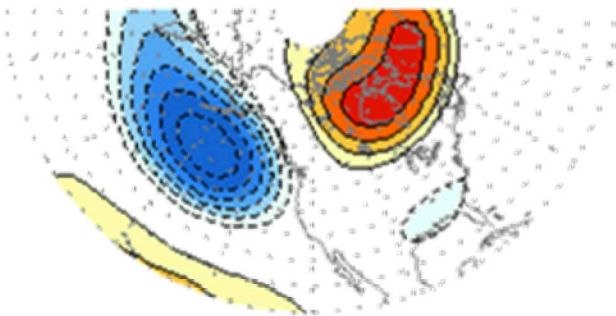
$$\frac{\partial \bar{\psi}^a}{\partial t} = -\nabla^{-2}[\nabla \cdot (\bar{V}' \zeta'^a)]$$





# Observation

NCEP [37.90%]



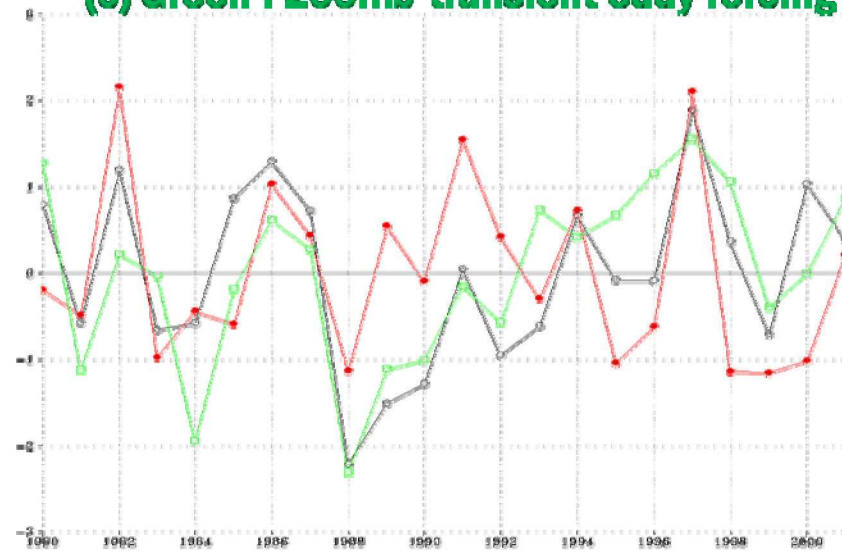
EOF 1<sup>st</sup> mode

## EOF 1<sup>st</sup> 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*

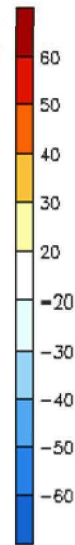
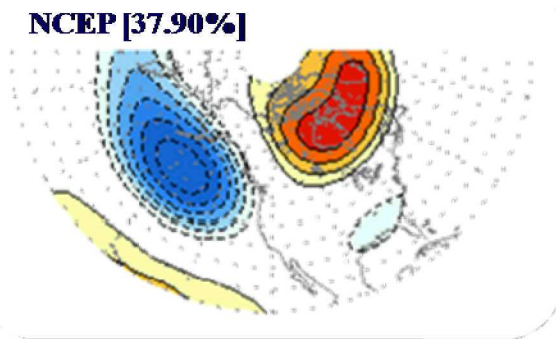
- ✓ Internal variability mainly by **transients**
- **Assessment of predictability using Ensemble predictions**
- **Signal to Noise Ratio**

# Model

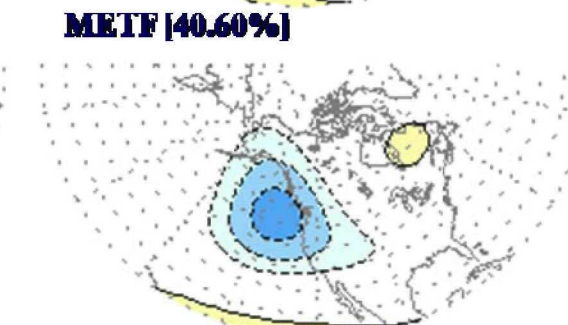
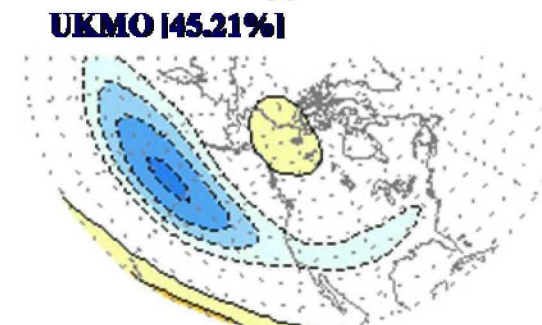
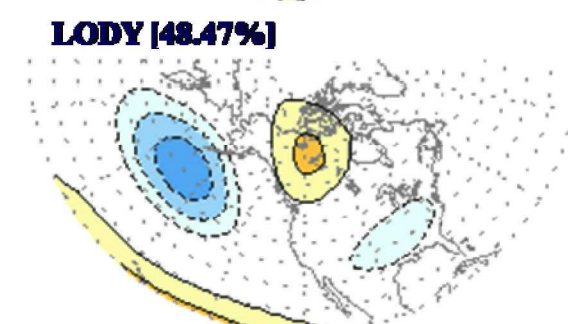
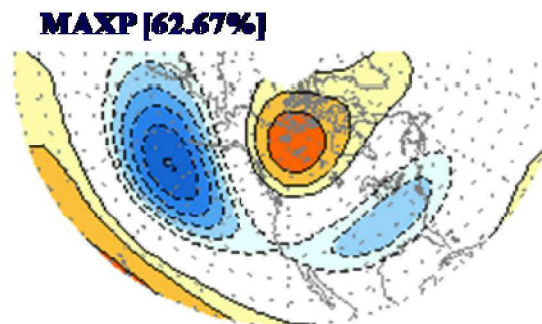
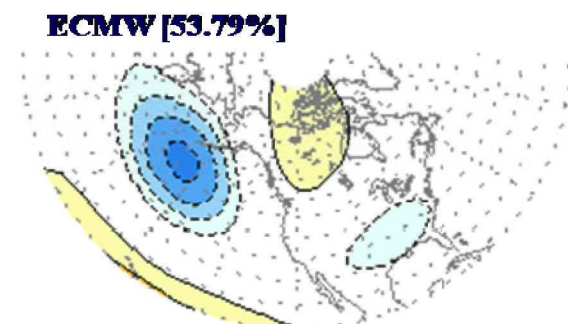
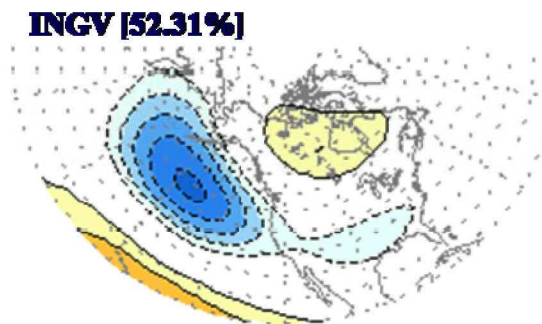
Seasonal Mean, 200mb streamfunction (Ensemble Mean)

**Dominant variability: EOF 1<sup>st</sup> mode**

**DEMETER/ECMWF**  
(Tier 1 Prediction System)



Unit: [ $\times 10^{10} \text{ m}^2 \text{ s}^{-1}$ ]





# Potential Predictability of Seasonal Prediction

**EOF 1<sup>st</sup> mode**

**Ensemble mean**

**Signal Variance**

**Ensemble mean**

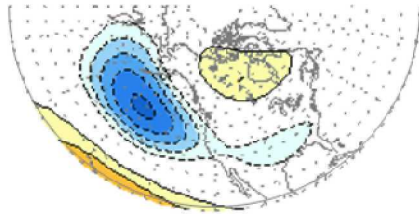
**Noise Variance**

**Ensemble deviation**

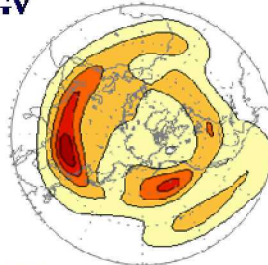
**Signal to Noise**

.....●

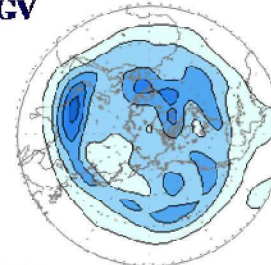
**INGV [52.31%]**



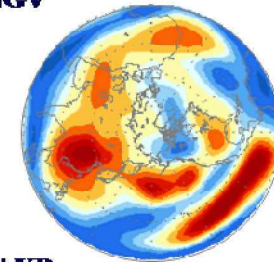
**INGV**



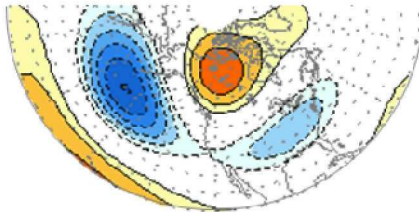
**INGV**



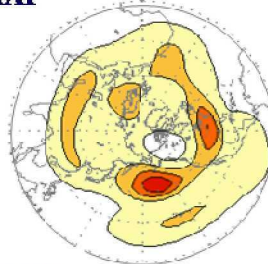
**INGV**



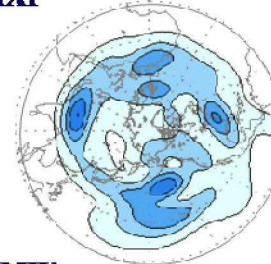
**MAXP [62.67%]**



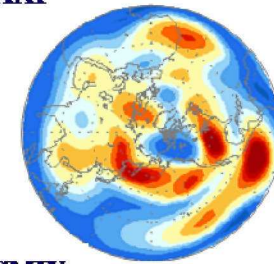
**MAXP**



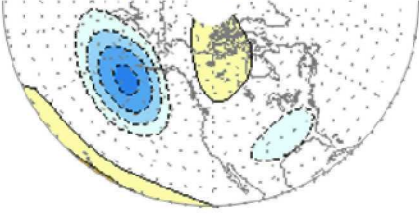
**MAXP**



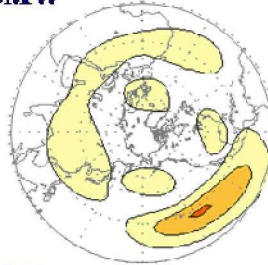
**MAXP**



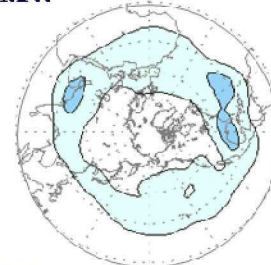
**ECMW [53.79%]**



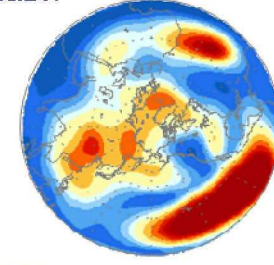
**ECMW**



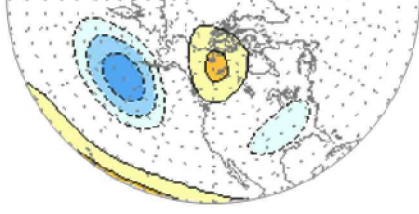
**ECMW**



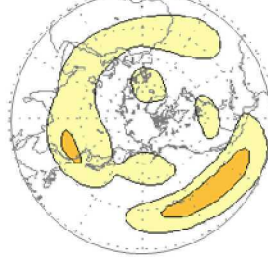
**ECMW**



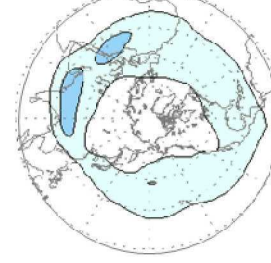
**LODY [48.47%]**



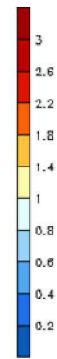
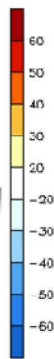
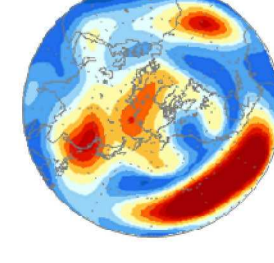
**LODY**



**LODY**



**LODY**



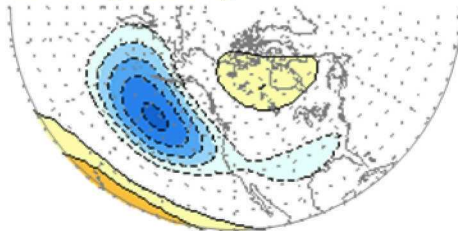
# Signal (**External**) Part : Ensemble Mean

**EOF 1<sup>st</sup> mode**  
**Ensemble mean**

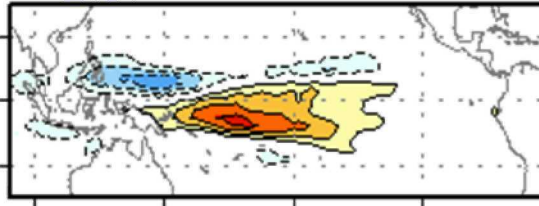
**Regression to**  
**Precipitation**

**Regression to**  $\langle -\nabla^{-2}[\nabla \cdot (\overline{V' \zeta'})] \rangle$   
**200mb Transient eddy forcing**

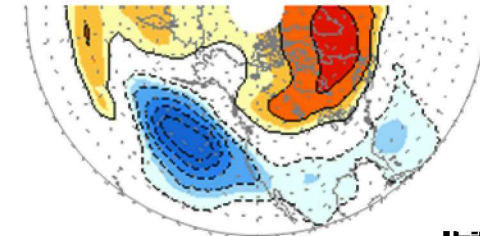
**INGV [52.31%]**



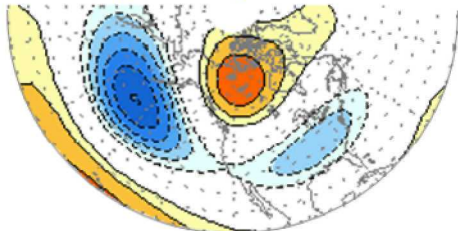
**INGV**



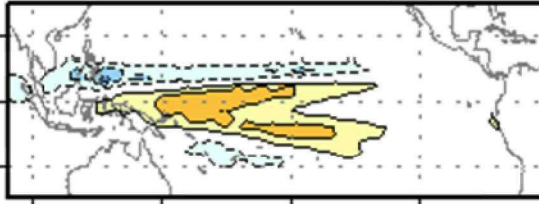
**INGV**



**MAXP [62.67%]**

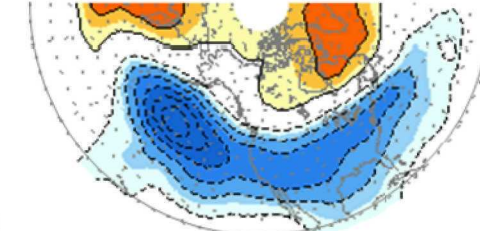


**MAXP**



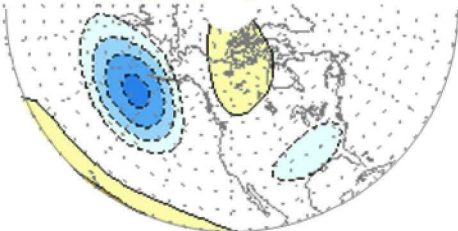
Unit : [mm]

**MAXP**

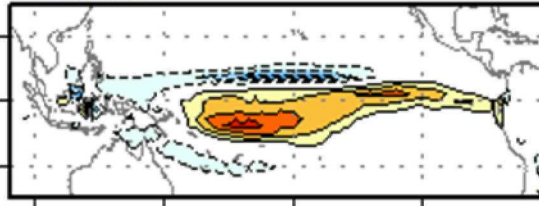


Unit : [ $m^2 s^{-2}$ ]

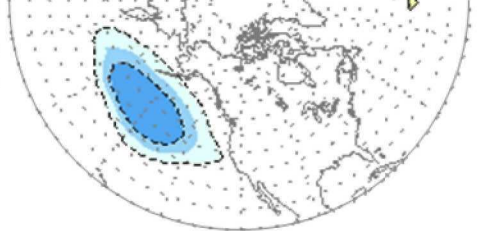
**ECMW [53.79%]**



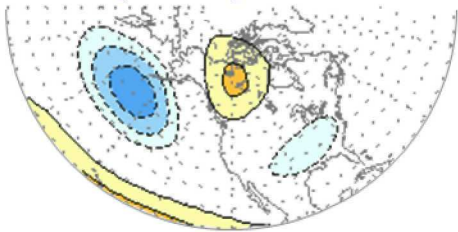
**ECMW**



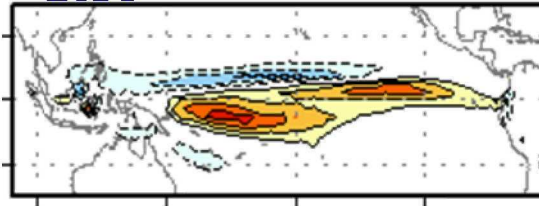
**ECMW**



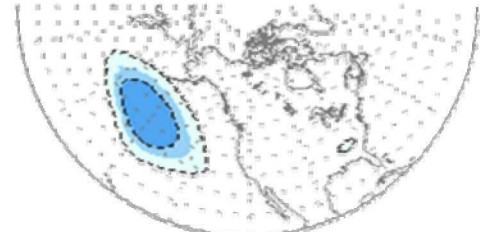
**LODY [48.47%]**



**LODY**



**LODY**



100E 150E 160W 110W 60W



# Empirical estimate of eddy feedback contribution effect

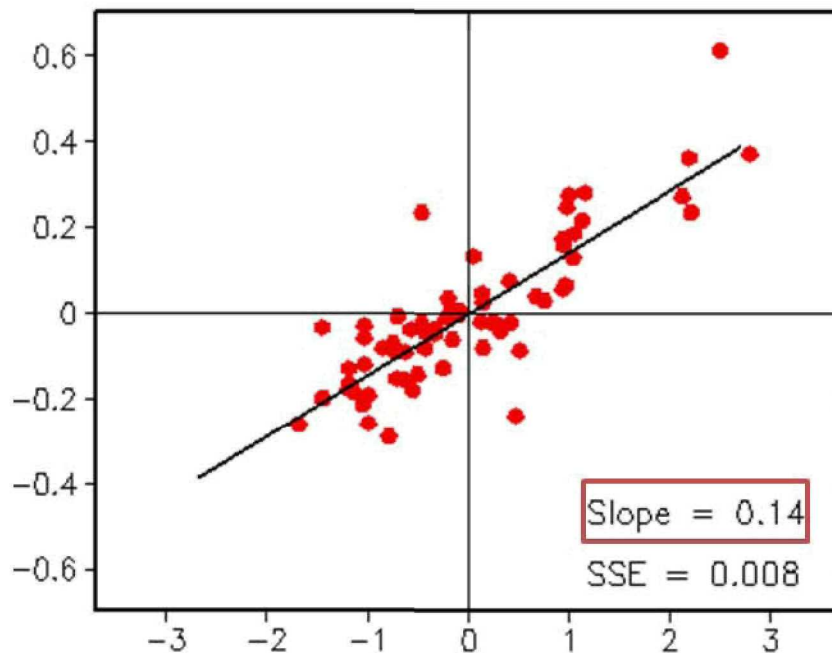
$$\frac{\partial \bar{\psi}^a}{\partial t} = -\nabla^{-2} [\nabla \cdot (\bar{V}' \zeta'^a)] \quad \rightarrow \quad \lambda(t) = \frac{\iint \left( \text{Reg}(\bar{\psi}^a, \text{PNAindex}) \cdot \nabla^{-2} \left[ -\nabla \cdot (\bar{V}' \zeta'^a) \right] \right) dx dy}{\iint \left[ \text{Reg}(\bar{\psi}^a, \text{PNAindex}) \right]^2 dx dy}$$

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

X-axis : PNA index / Y-axis :  $\lambda$  [day<sup>-1</sup>]

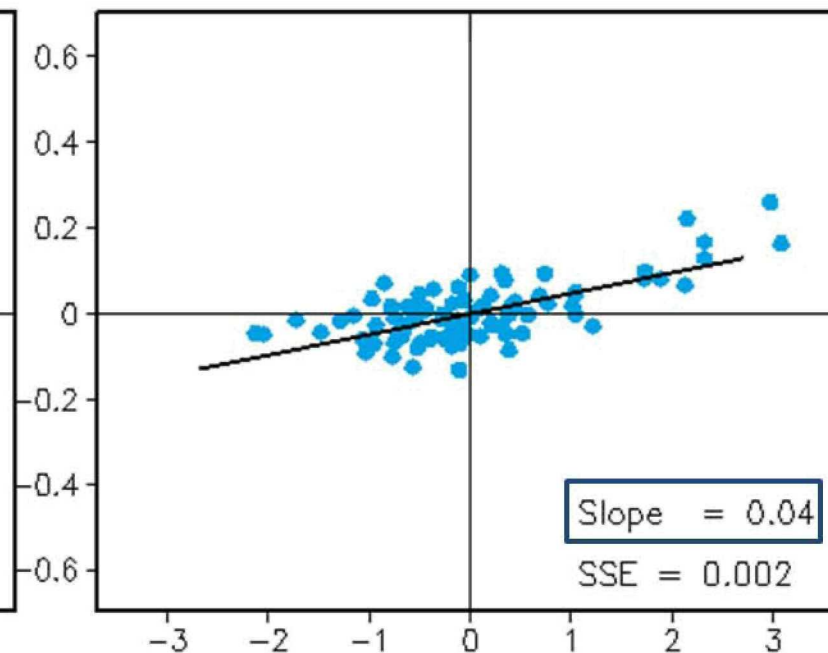
**SE group**

[INGV/ MAXP/ UKMO]



**WE group**

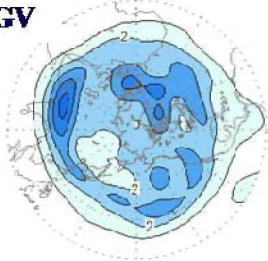
[ECMW/ LODY/ METF]



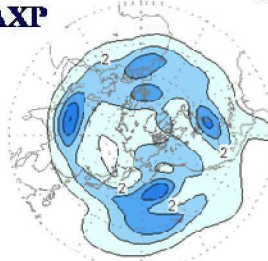
# Noise (Internal) Part : Ensemble Deviation

**Noise Variance  
Ensemble deviation**

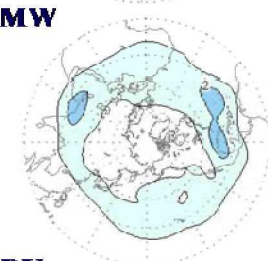
INGV



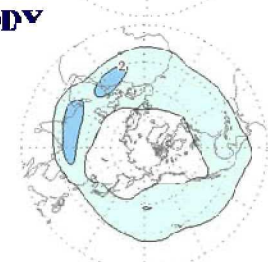
MAXP



ECMW

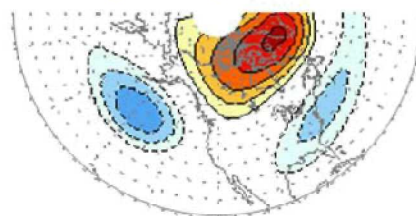


LODY

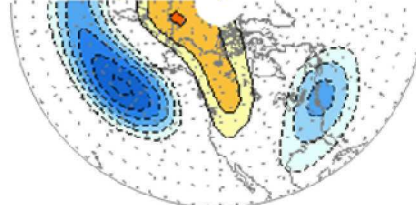


**EOF 1<sup>st</sup> mode  
Ensemble deviation**

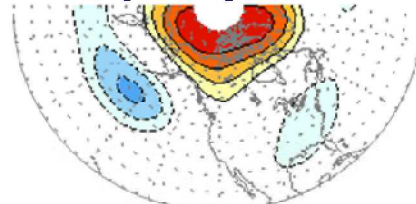
INGV [31.69%]



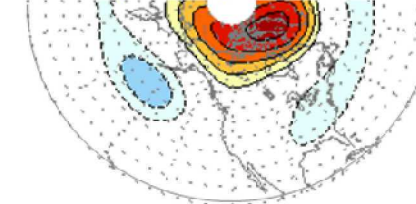
MAXP [32.97%]



ECMW [32.38%]



LODY [34.66%]

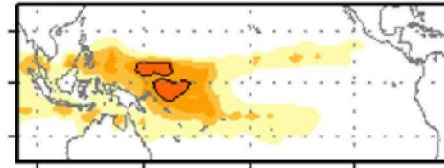


Unit: [ $\text{m}^2\text{s}^{-2}$ ]

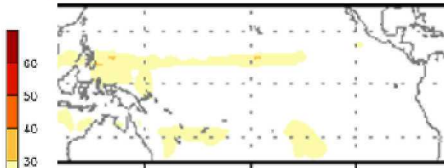


**Noise variance  
Precipitation**

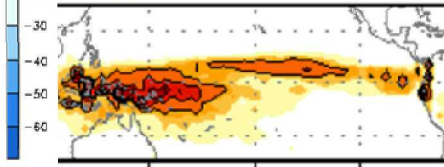
INGV



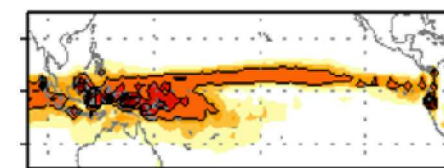
MAXP



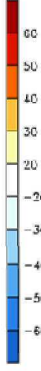
ECMW



LODY

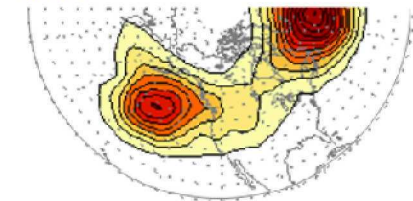


Unit: [ $\text{mm}^2$ ]

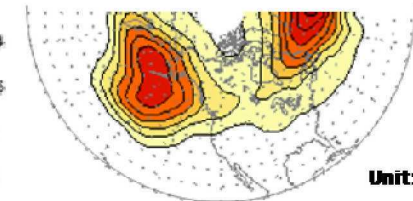


**Noise variance  $\langle -\nabla^{-2}[\nabla \cdot (\bar{v}'\zeta')] \rangle^2$   
200mb Transient eddy forcing**

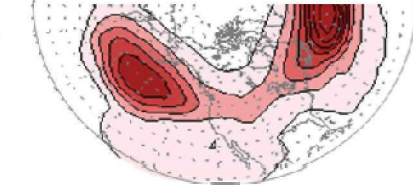
INGV



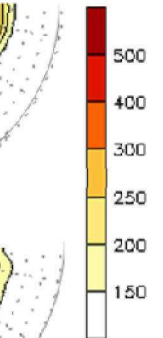
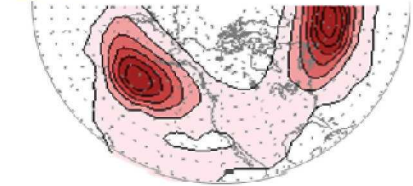
MAXP



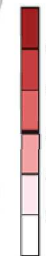
ECMW



LODY

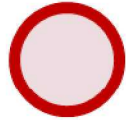

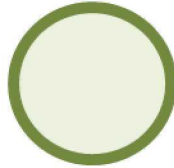


Unit: [ $\text{m}^2\text{s}^{-4}$ ]



# Potential Predictability of Seasonal Prediction

*About the extra-tropical anomaly*

	External Part	Internal Part
<b>Tropical Forcing</b>		-
<b>Transient Forcing</b>		



# Current Prediction Skill : Temporal Correlation

1980~2001, seasonal mean (winter)

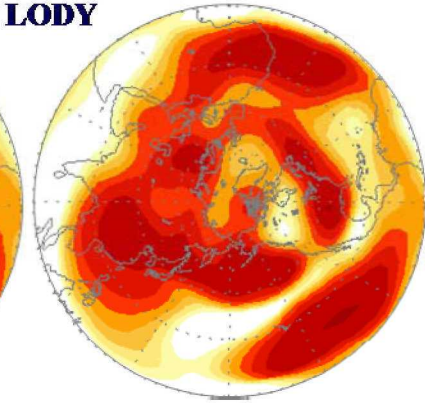
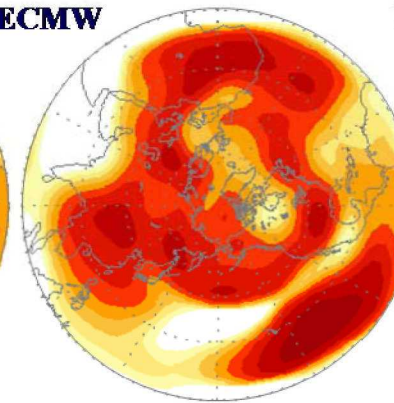
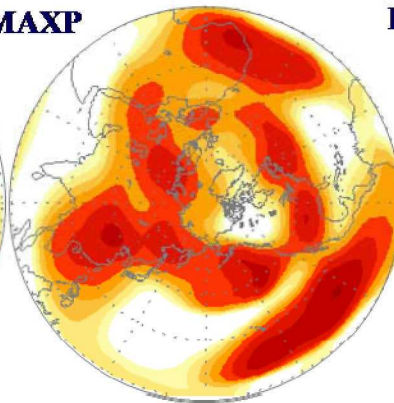
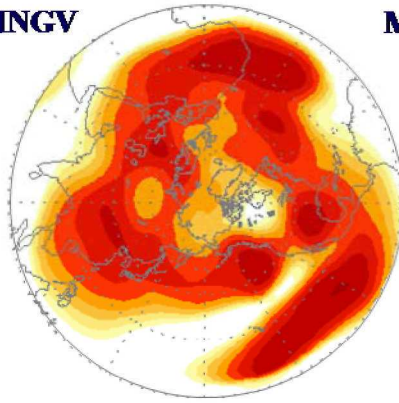
200mb Streamfunction [NCEP]

INGV

MAXP

ECMW

LODY



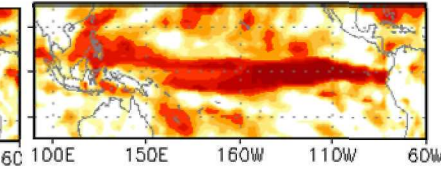
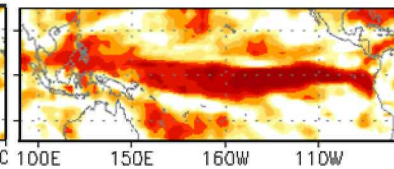
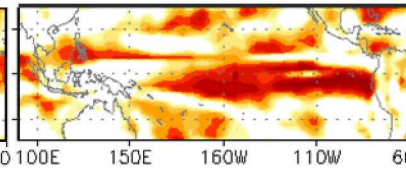
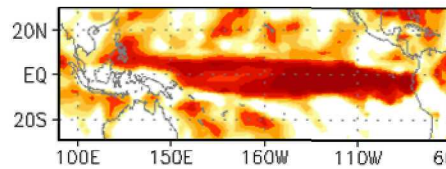
Precipitation [CMAP]

INGV

MAXP

ECMW

LODY



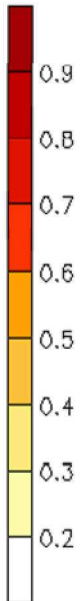
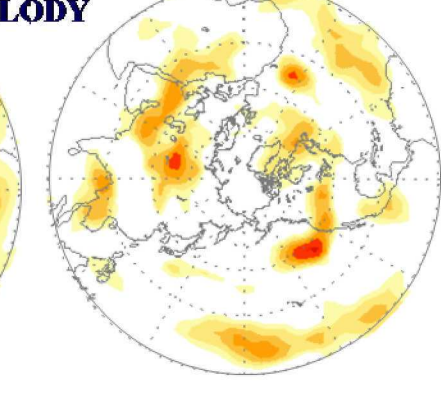
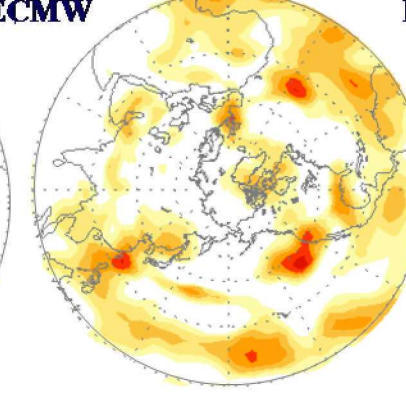
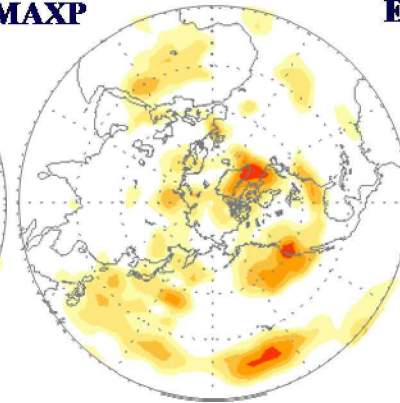
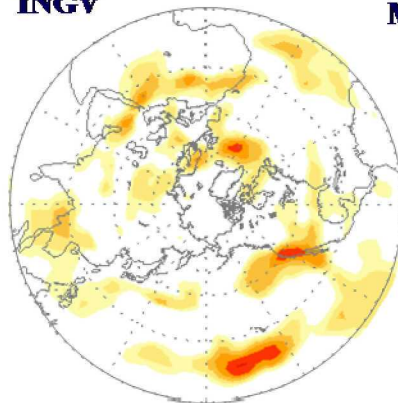
200mb transient eddy forcing [NCEP]

INGV

MAXP

ECMW

LODY



# **Issues :**

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## **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 ?

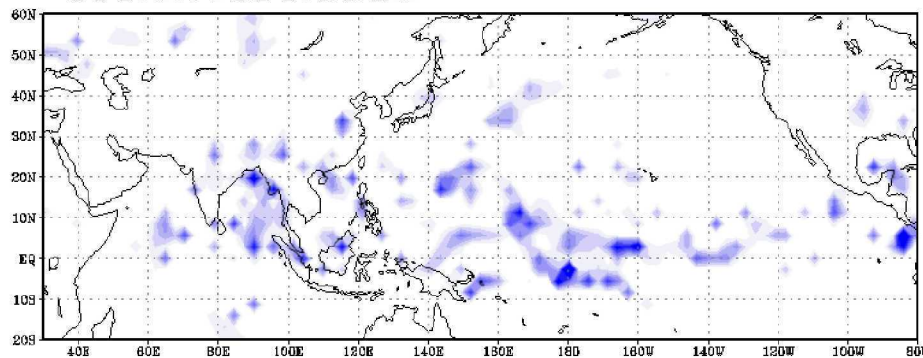
# Improvement of Transients

## ➤ Dependency of model resolution

■ 3 hourly precipitation

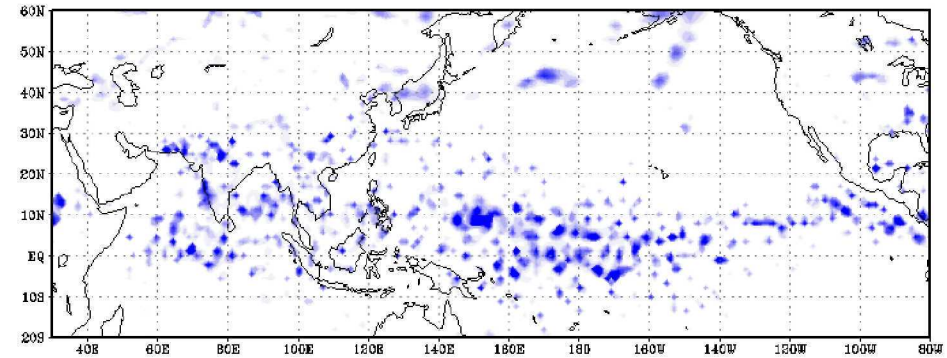
prep 1096hour T42

**300km resolution**



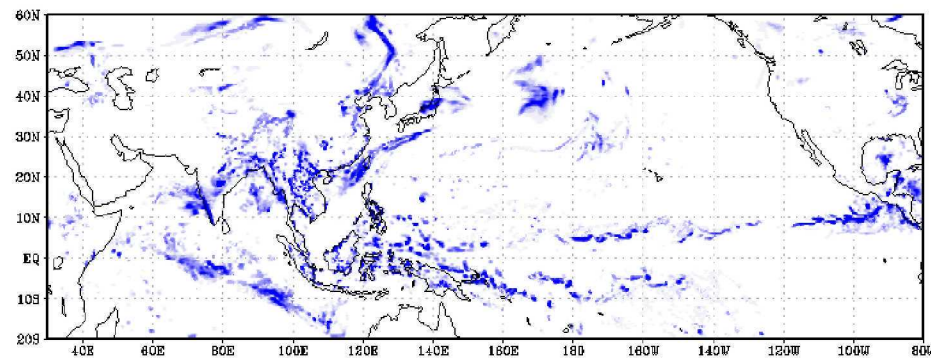
prep 1096hour T106

**125km resolution**



Time: 06Z JUN 12 1999

**25km resolution**

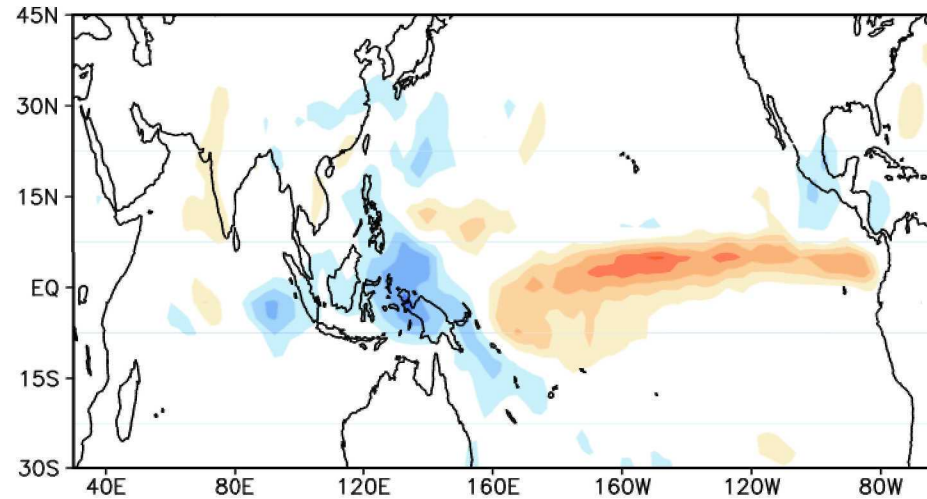




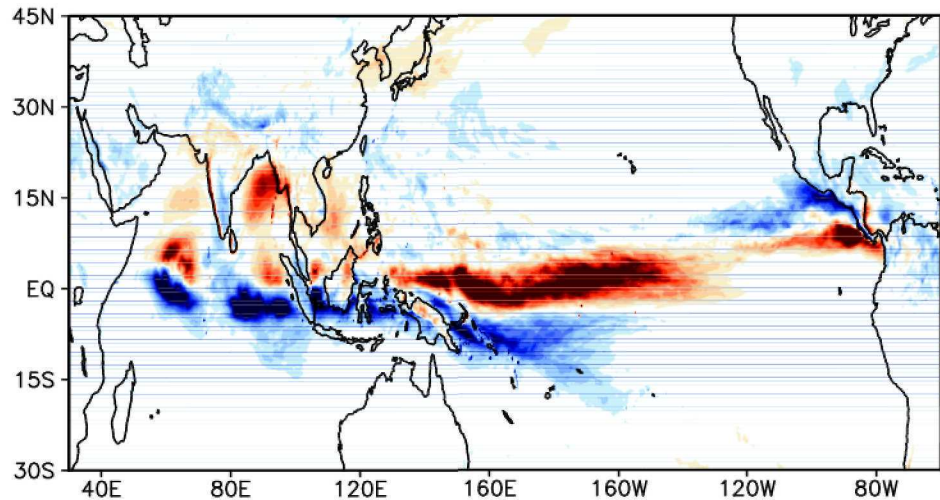
# Very High resolution GCM simulation – 25km resolution

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

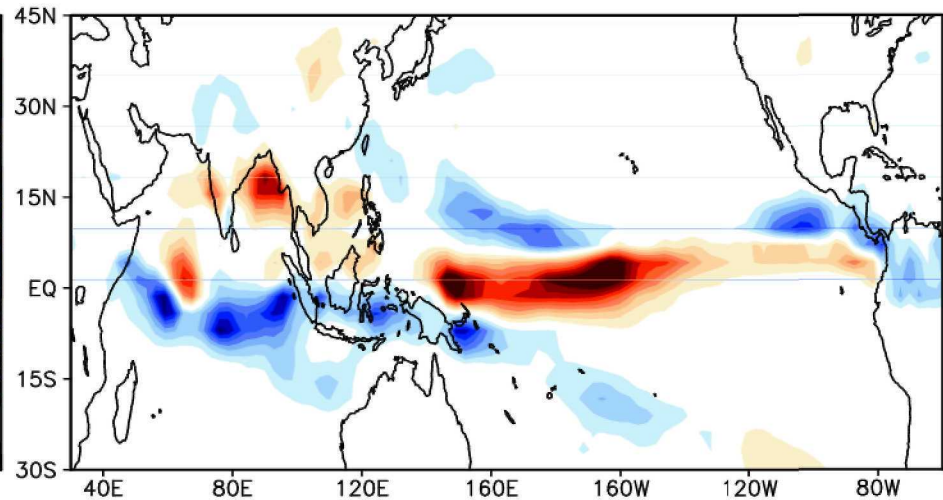
**CMAP**



**25km SNUGCM**



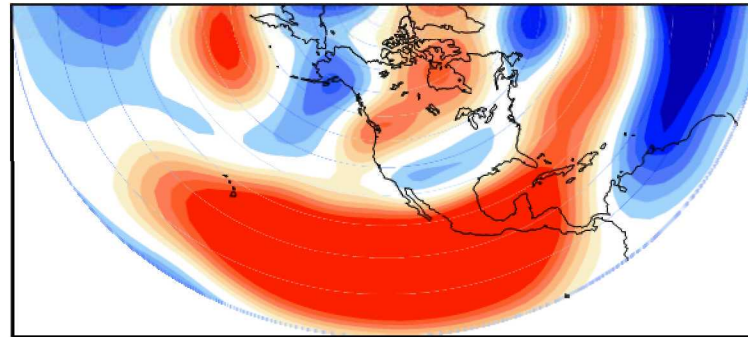
**300km SNUGCM**



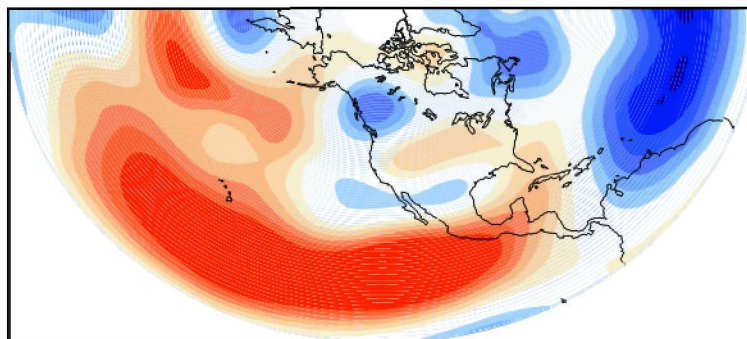
## Very High resolution GCM simulation – 25km resolution

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

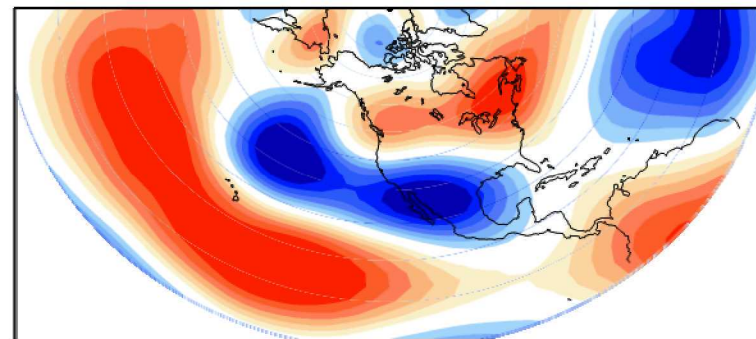
NCEP



25km SNUGCM



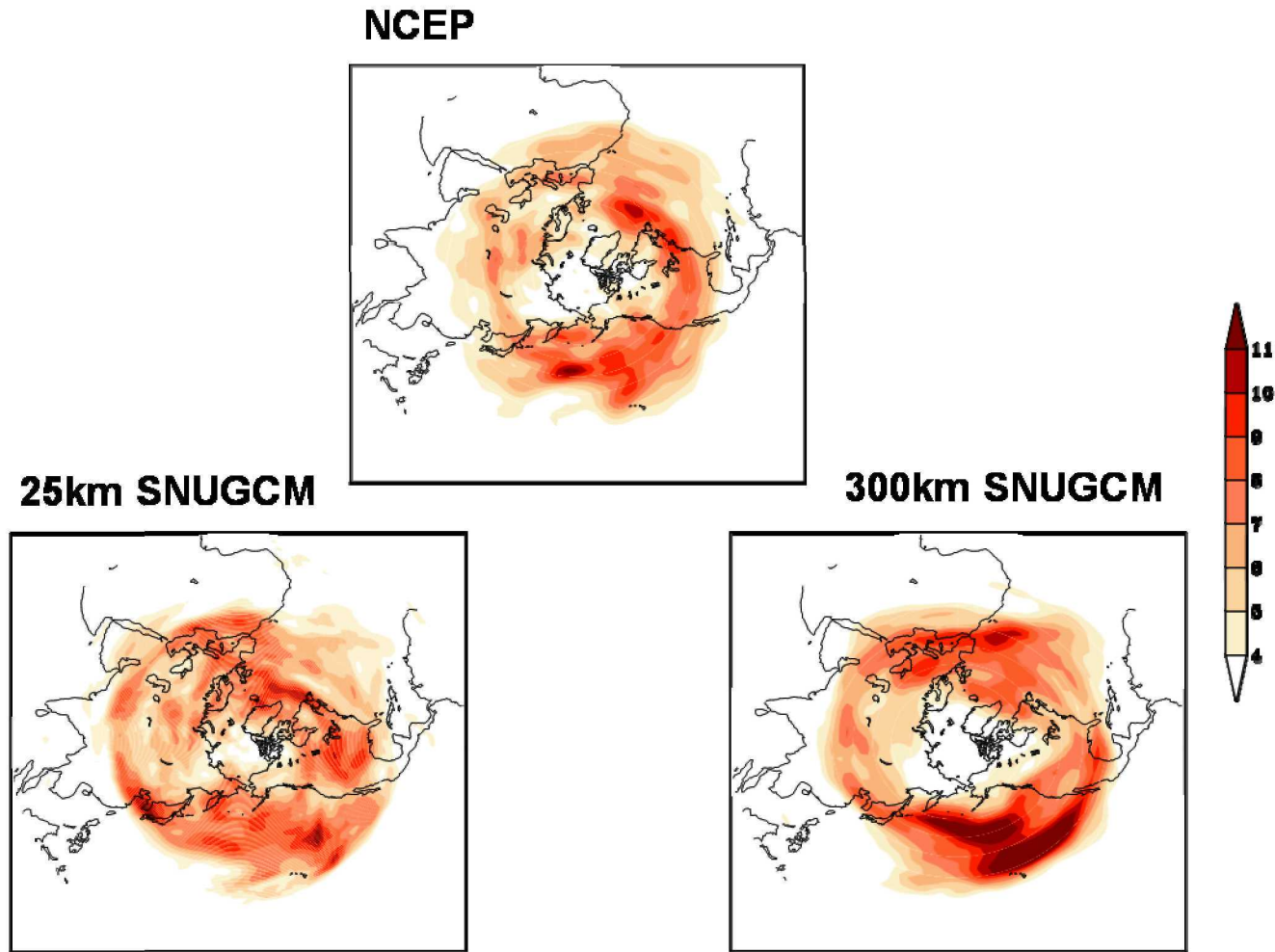
300km SNUGCM



Perturbation from the zonal mean & seasonal mean

# High Frequency eddy activity $\overline{u'^2}$

## ■ 1997 El Nino case



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

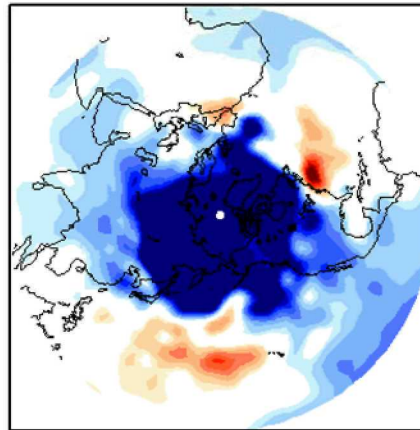


## Transient eddy forcing

✓ 6-ensemble mean

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

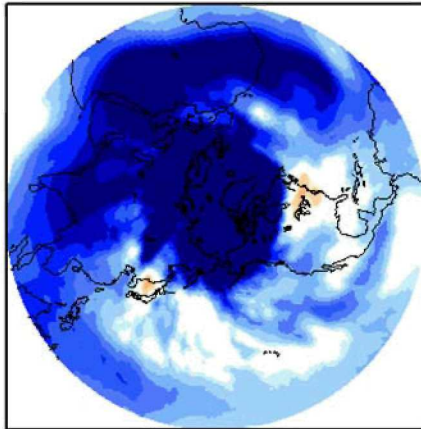
NCEP



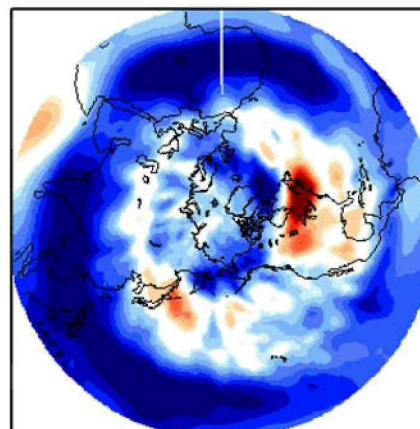
Using quasi-geostrophic approximation,

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

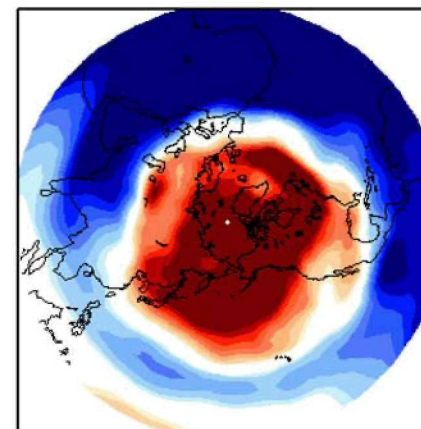
25km SNUGCM



125km SNUGCM



300km SNUGCM



**THANK YOU !**



# Empirical estimate of eddy feedback contribution effect

1980~ 2001 winter

NAO area 90W~30E, 30N~80N

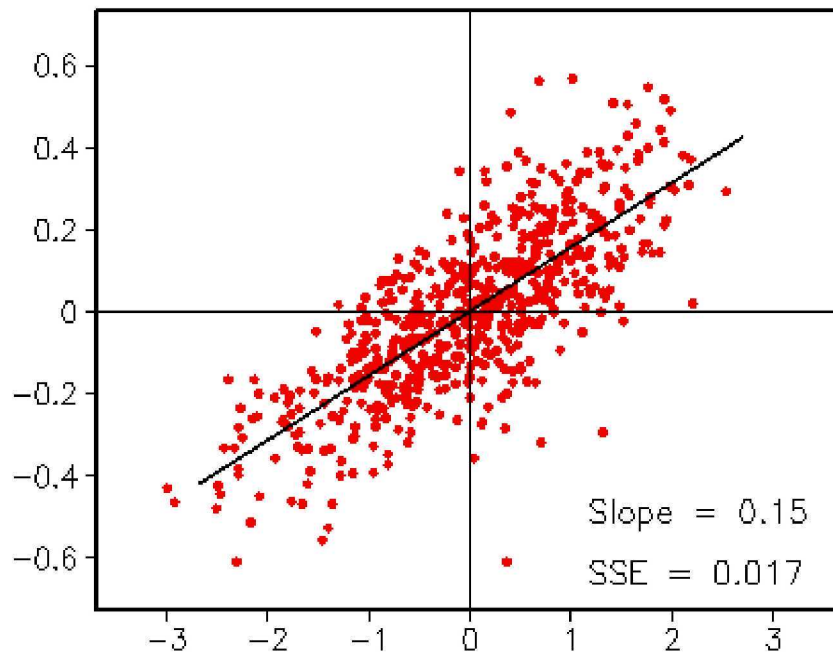
Using model NAO index

$$\lambda = \frac{\iint \left( \text{Re } g(\overline{Z^a}, \text{NAOindex}) \cdot \nabla^{-2} \left[ -\frac{f}{g} \nabla \left( \overline{\vec{V}' \zeta'} \right) (t) \right] \right) dx dy}{\iint \left[ \text{Re } g(\overline{Z^a}, \text{NAOindex}) \right]^2 dx dy}$$

X-axis : NAO index / Y-axis :  $\lambda$

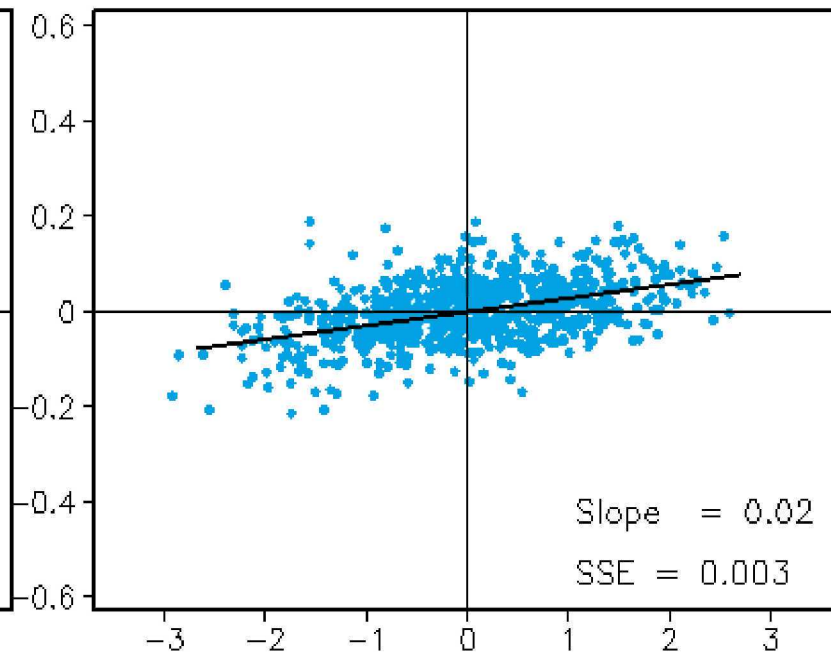
**SE group**

[INGV/ MAXP/ UKMO]



**WE group**

[CERF/ ECMW/ LODY/ METF]



# Empirical estimate of growth rate contribution of eddy feedback

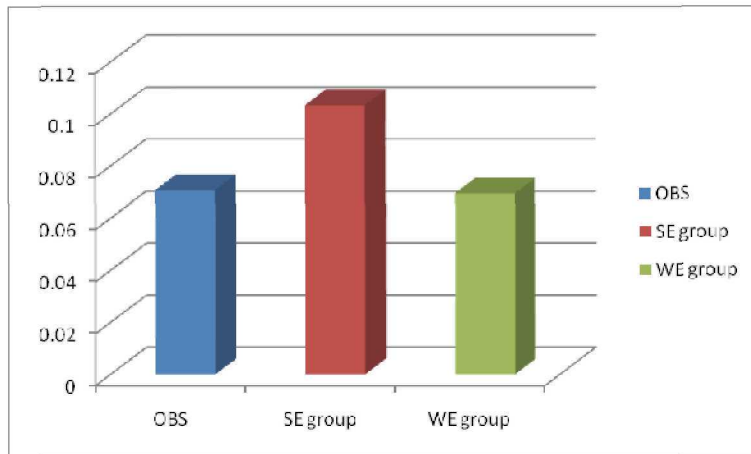
$$\frac{\partial \bar{\psi}^a}{\partial t} \sim \bar{T}^a = \nabla^{-2} \left( -\nabla \cdot \bar{\vec{v}}' \zeta'^a \right) = \lambda \bar{\psi}^a : \text{Transient eddy forcing}$$

$\lambda$ : Growth rate contribution of eddy feedback

$$\lambda = \iiint (\bar{\psi}^a \cdot \bar{T}^a) dx dy / \iiint \bar{\psi}^{a2} dx dy$$

## PNA mode

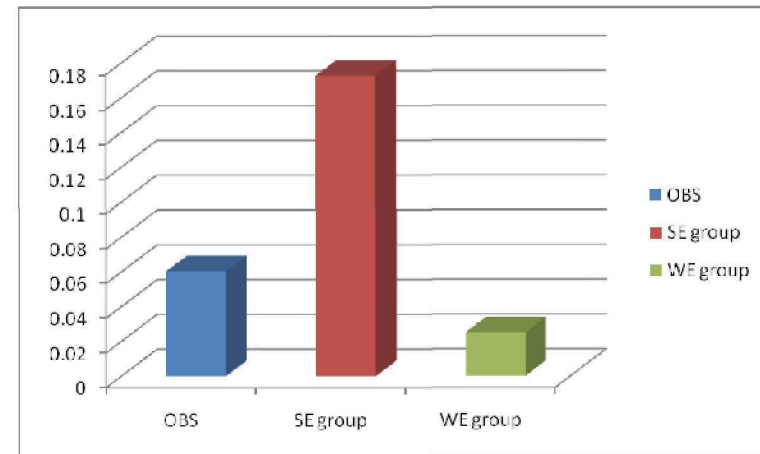
Growth Rate [day<sup>-1</sup>]



OBS	14.12 days
SE Group	9.67 days
WE Group	14.38 days

## NAO mode

Growth Rate [day<sup>-1</sup>]



OBS	16.55 days
SE Group	5.79 days
WE Group	39.85 days

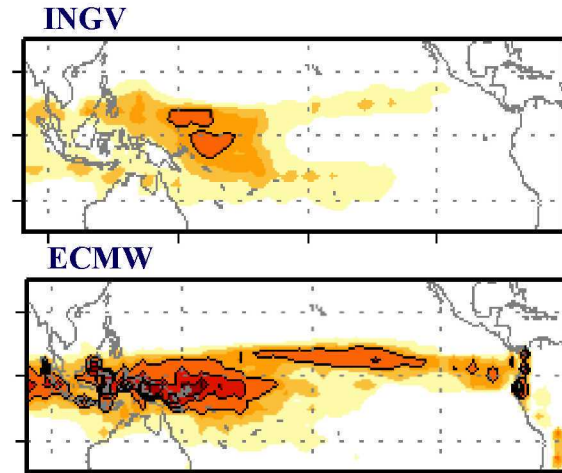
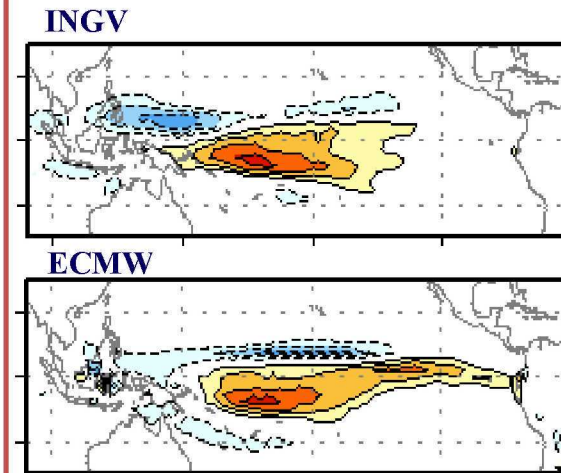
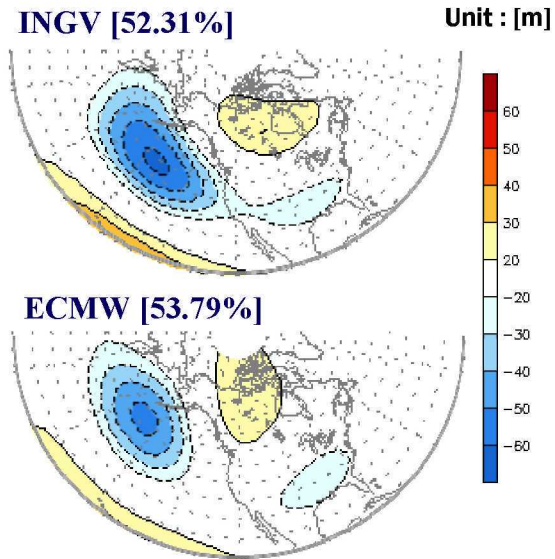
# Potential Predictability of Seasonal Prediction

Signal (**External**) Part

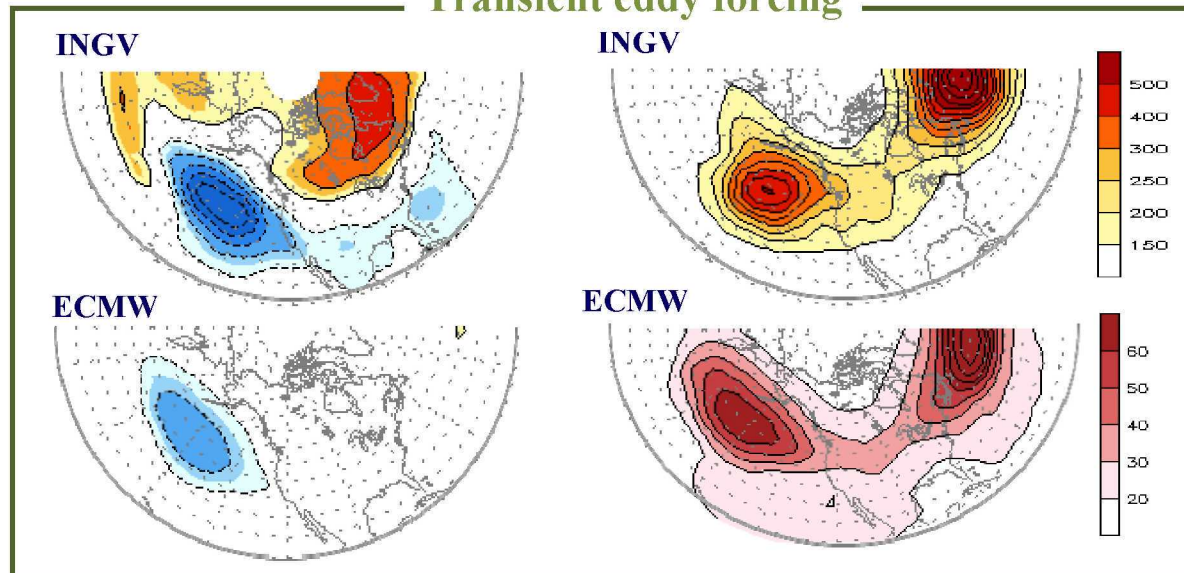
Noise (**Internal**) Part

Precipitation

**EOF 1<sup>st</sup> mode**  
Ensemble mean




Transient eddy forcing



# Potential Predictability of Seasonal Prediction

*About the extra-tropical anomaly*

	External Part	Internal Part
<b>Tropical Forcing</b>		-
<b>Transient Forcing</b>	