



**APEC Climate Symposium 2012**  
**8-11 Oct 2012, St. Petersburg, Russia**

**A timescale decomposition (TSD)  
statistical downscaling model  
—An application to prediction of  
summer rainfall over North China**

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# Outline

**1** Background

**2** Time-scale decomposition (TSD) model

**3** A case study to statistically downscale North China summer rainfall

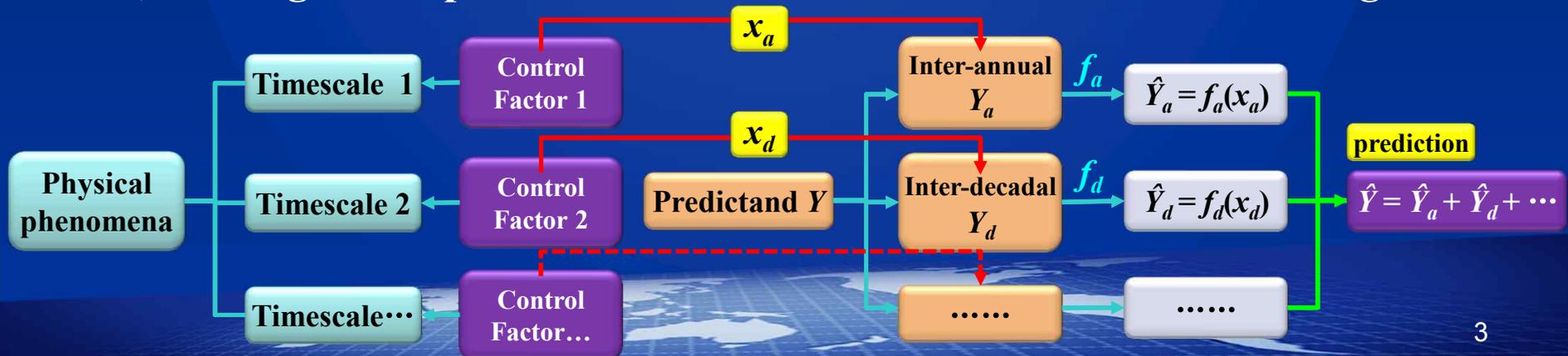
**4** An application to seasonal prediction of JA NC rainfall NC in 2011 & 2012

**5** Summary

# Physical basis of timescale decomposition (TSD)

- **Statistical downscaling** is one of important methods that can potentially assist in the assessment of climate models and overcoming model uncertainties accompanying future climate projections as well.
- **Feature of multi-timescale variability:** Physical phenomena are usually characterized by **multi-timescale variability**;
- **Physical cause:** Variations at different scale are controlled or driven by **different climate factors**;
- **Timescale decomposition (TSD) model:** a downscaling model used without TSD will make multi-timescale signals to disturb each other, could not find real casual factors and will introduce spurious signals and noise into the model, and finally lead to low prediction skill.

Thus, it is of great importance to introduce TSD statistical downscaling model

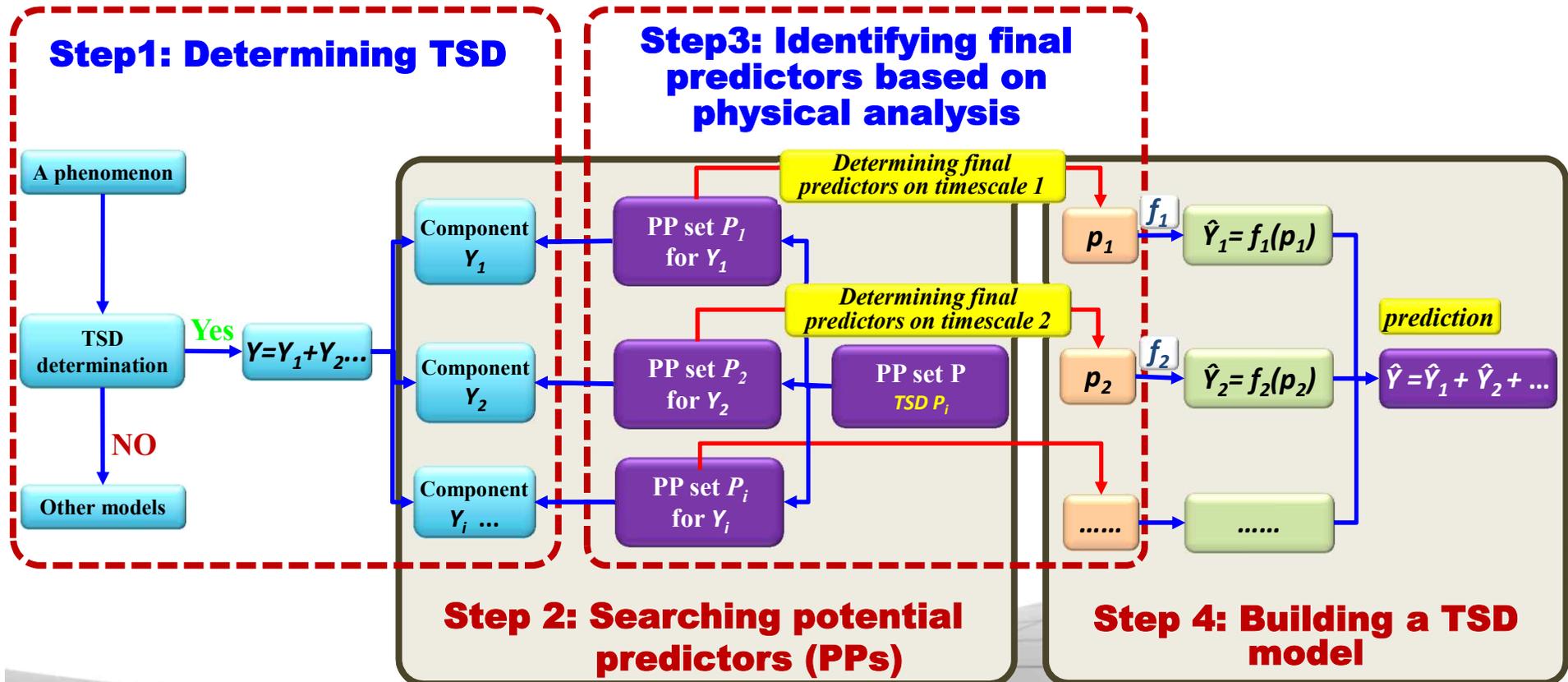


# TSD statistical downscaling model

Variability at different timescale is controlled by different climate factors

TSD statistical downscaling model

## Flowchart for Building a TSD Model



## Some key downscaling schemes

- **C\_CVSR:**
- **PC\_CVSR:**
- **CSD (Conditional statistical downscaling)**

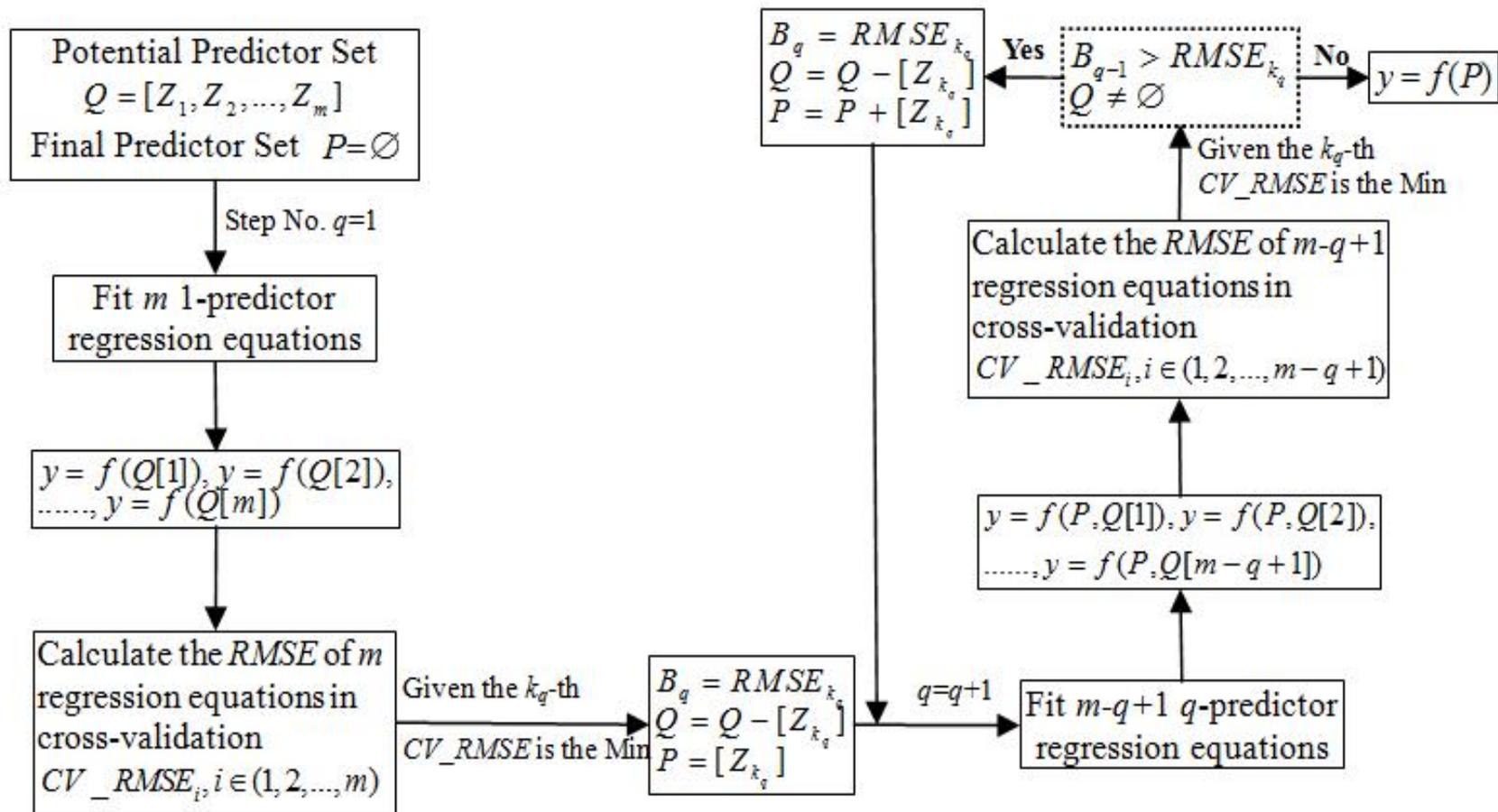
### • *Shortcoming in traditional downscaling schemes :*

1. Only focus on the local predictive signals surrounding the target region, miss the remote predictive signals that exert their influences through teleconnection
2. Lack relevant explanation of the physical mechanism in statistical model

### **Propose a correlation analysis based cross-validation stepwise regression downscaling scheme (C\_CVSR)**

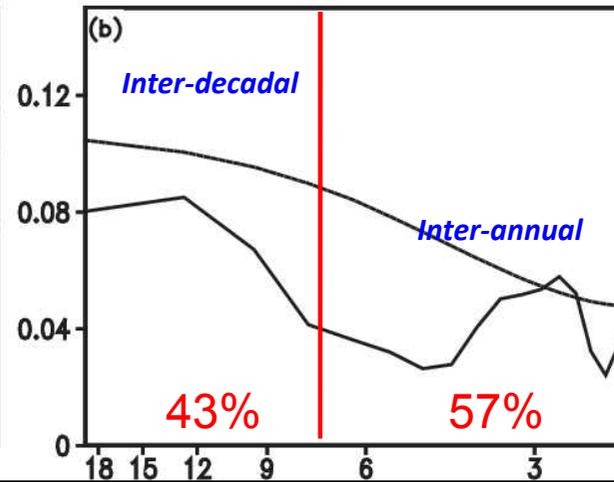
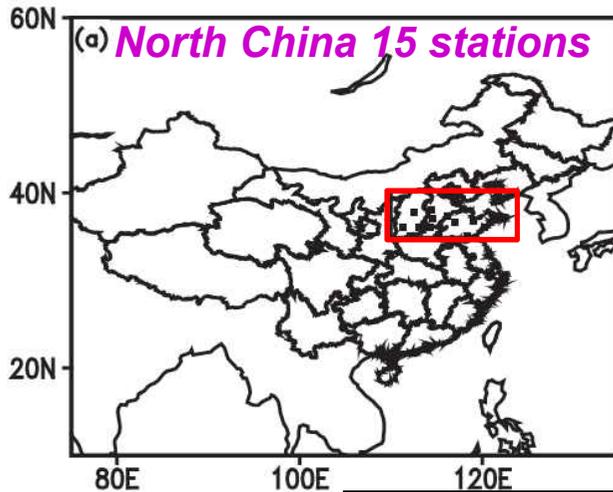
- Key steps:**
1. To identify potential predictors at global scale via correlation analysis
  2. To select effective predictor from potential predictor set by a ‘forward’ cross-validation stepwise regression (CVSR) method;
  3. To determine the final predictor through physical analysis;
  4. To fit regression equation by least square method.

# Flowchart of cross-validation stepwise regression (CVSR)



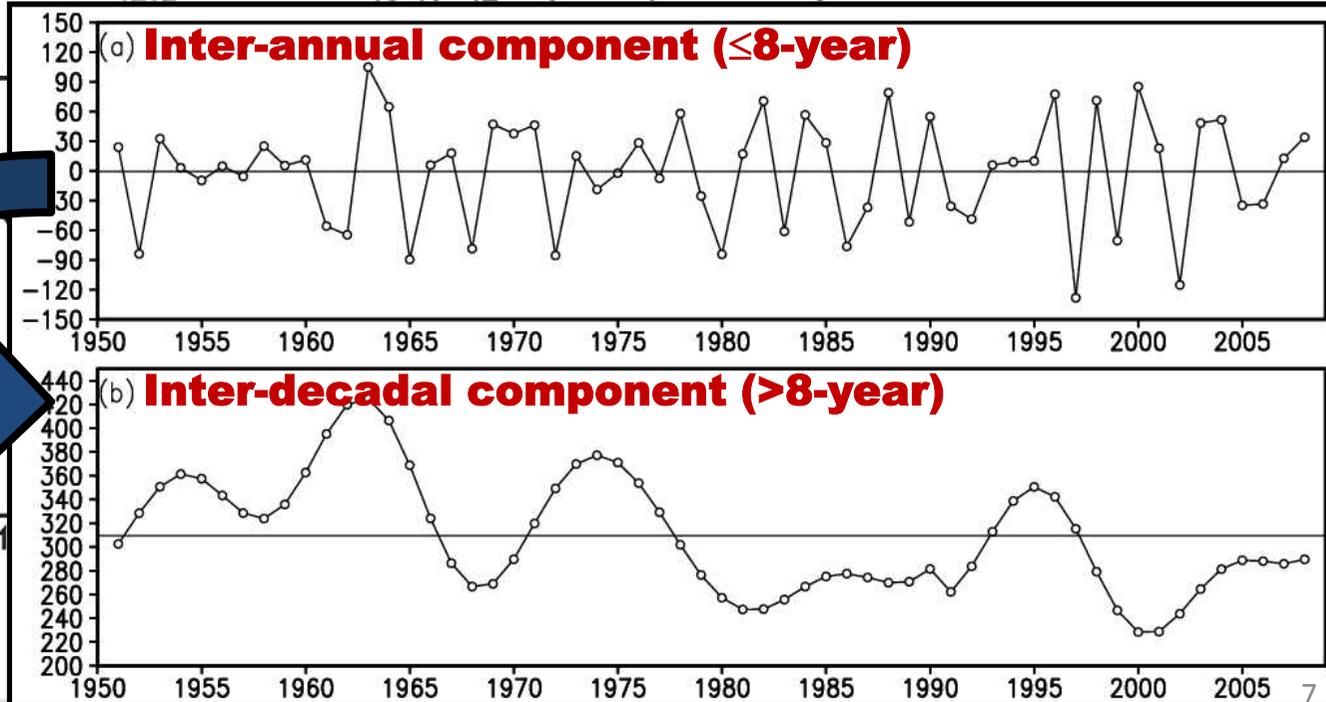
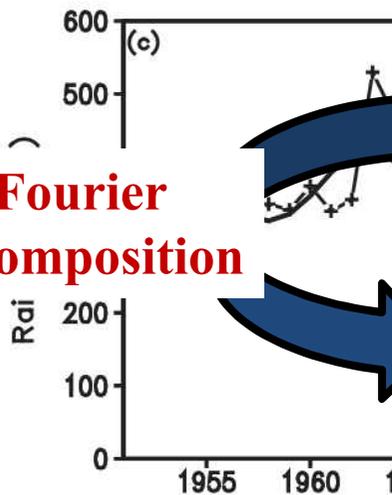
# S1. TSD Determination

## A case study of JA rainfall over North China



*Power spectrum of North China summer (JA) rainfall index ( $R_{NC}$ )*

**Fourier decomposition**



## S2. Searching Potential Predictors

### ➤ Large-scale Climate Indices:

- SAMI, NAMI, Nino3, PDOI, AMOI, etc.

### ➤ Atmospheric circulation:

- SLP, geopotential height, horizontal winds, etc.

### ➤ Lower boundary forcings:

- SST, sea ice, snow cover, etc.

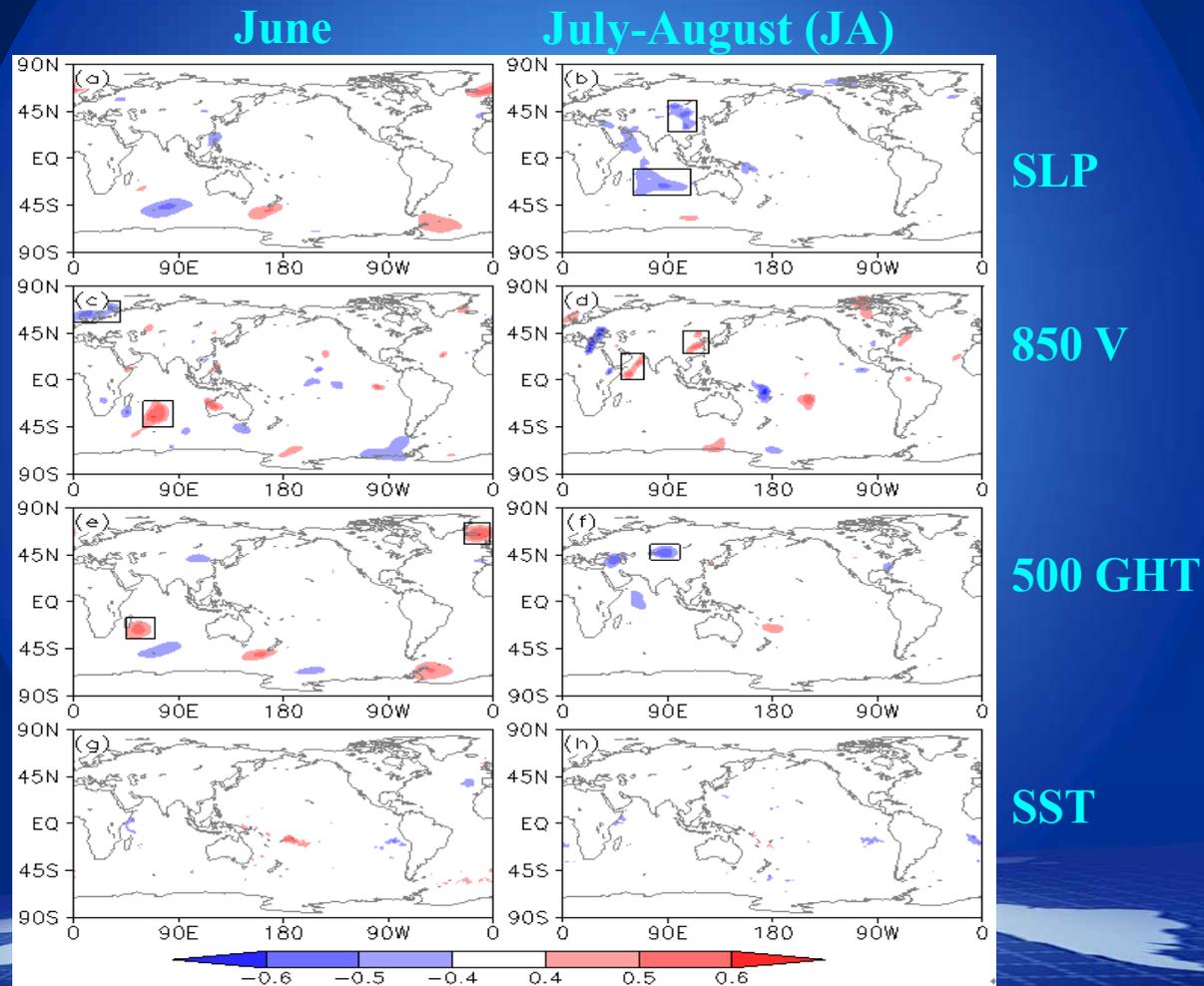
### ➤ Preceding signals

- Decomposition into inter-annual ( $\leq 8a$ ) and inter-decadal ( $> 8a$ ) components by Fourier filter
- Training period: 1951—1990
- Validation period: 1991—2008

- Possible predictors for inter-annual (IA) variability**

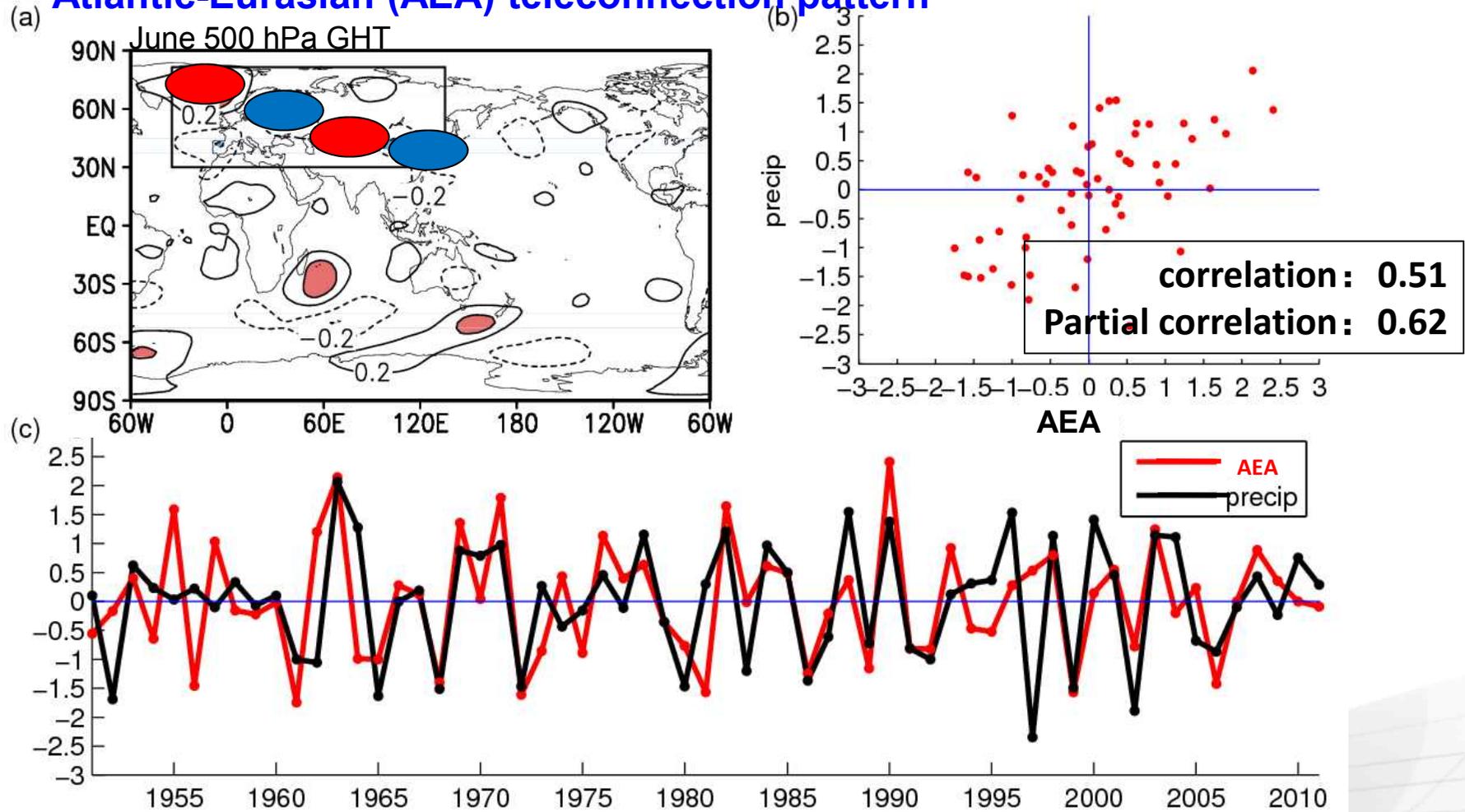
**Correlations between JA  $R_{NC}$  and climate indices as well as other factors at inter-annual timescale**

	SAMI	NAMI	NAOI	PDO	Niño3
June	-0.06	-0.27	-0.37*	0.12	-0.35*
JA	-0.09	0.08	0.24	-0.25	-0.29



# PC\_CVSR

## Atlantic-Eurasian (AEA) teleconnection pattern



Normalized series of AEA index and inter-annual NCSR

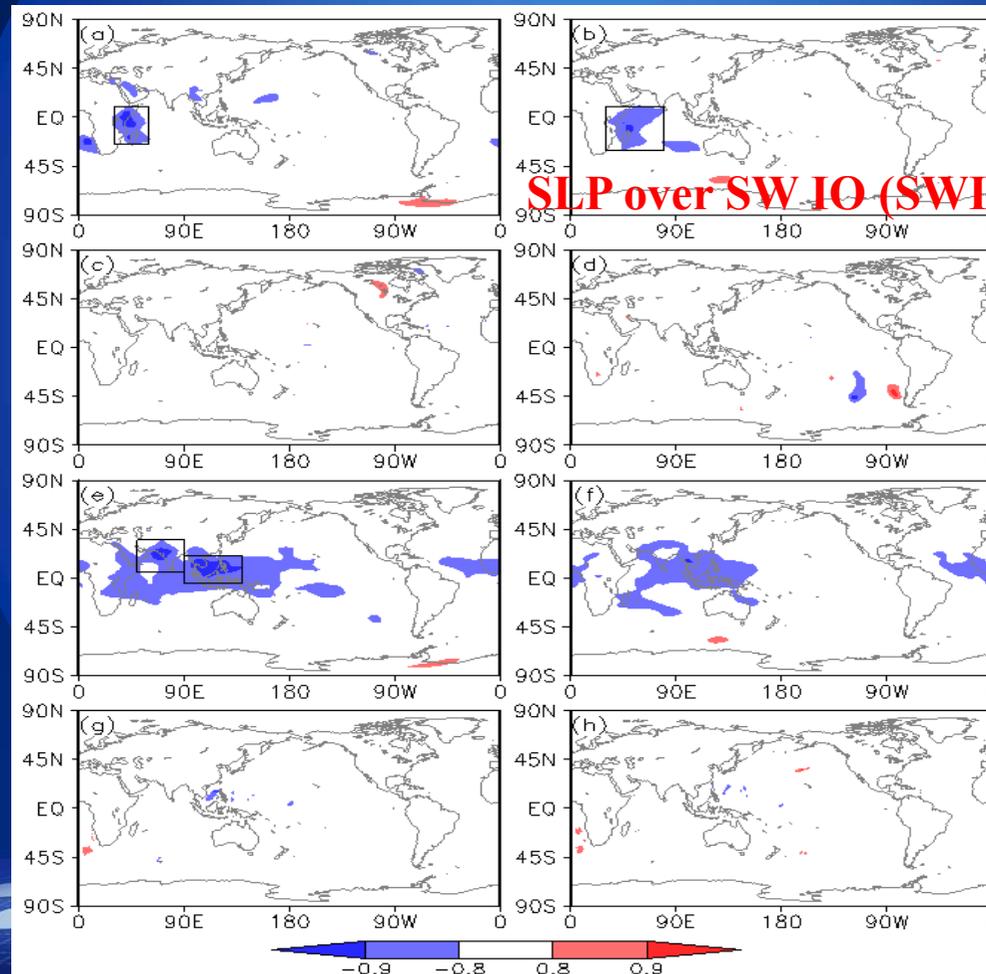
- Possible predictors for inter-decadal (ID) variability

Correlations between  $JA R_{NC}$  and climate indices as well as other factors at inter-decadal timescale

	SAMI	NAMI	NAO	PDO	Niño3
June	-0.83**	0.04	0.19	-0.66**	-0.52
JA	-0.54*	-0.37	-0.31	-0.54**	-0.12

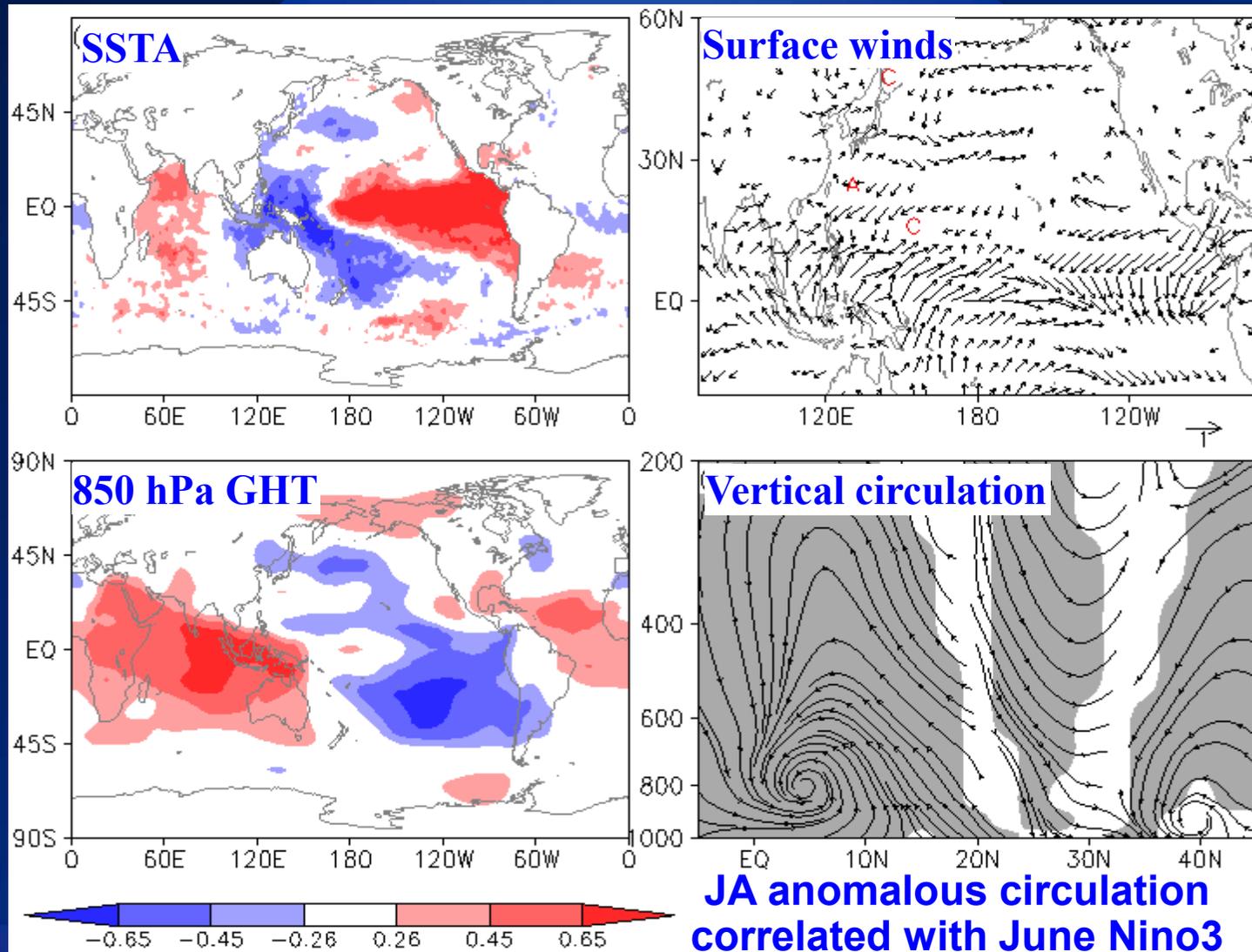
June

JA

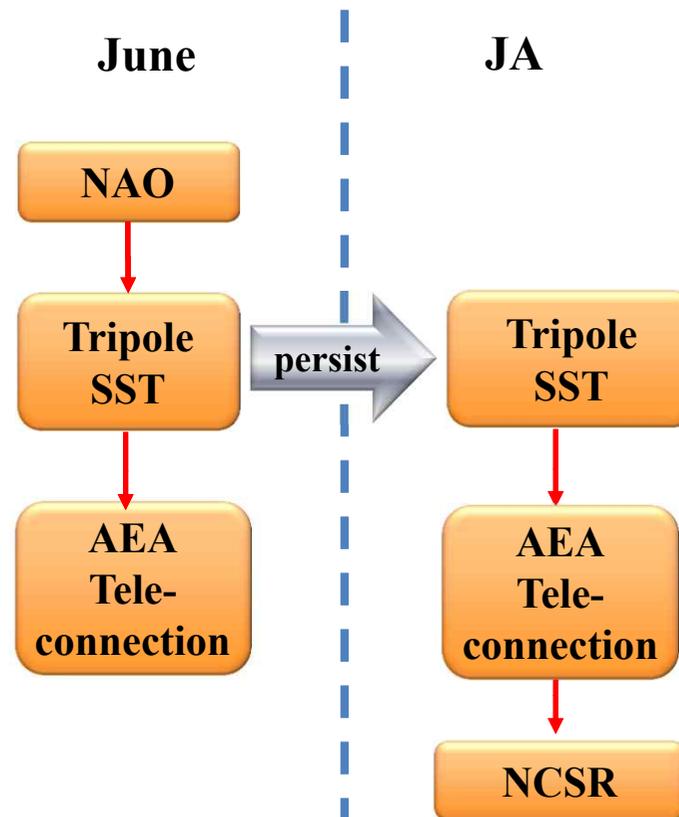
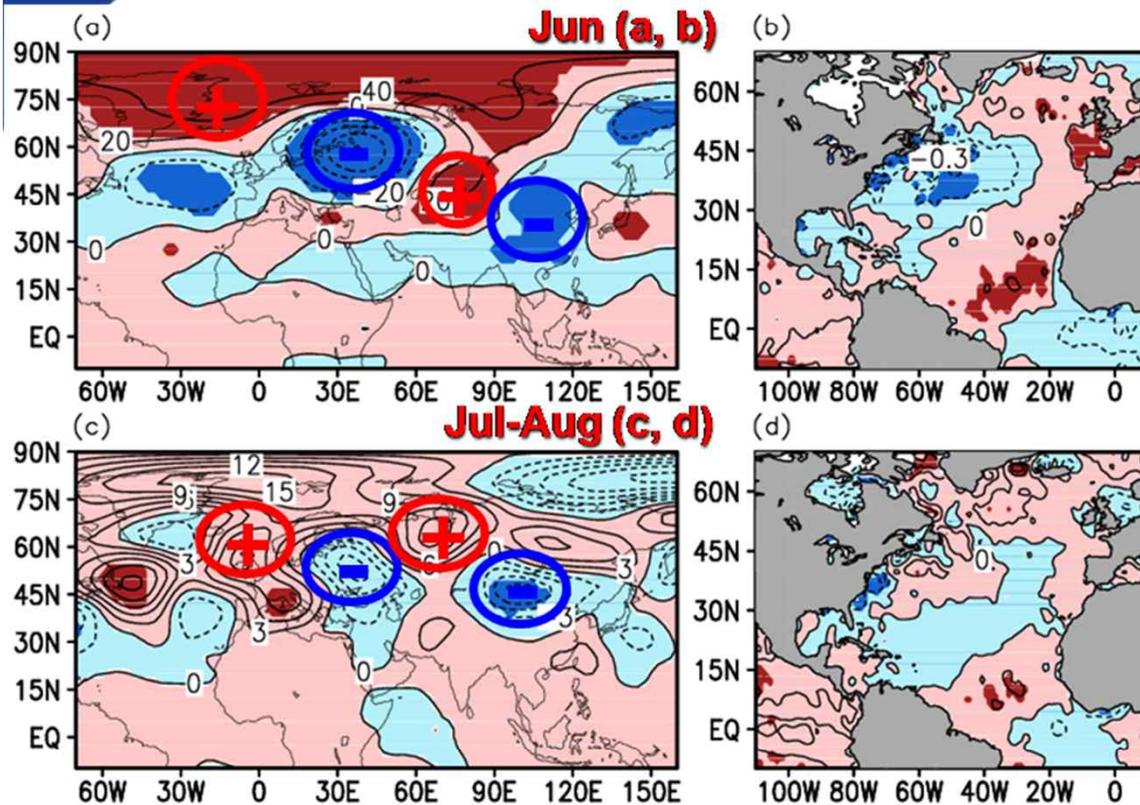


# S3. Identifying final predictors based on physical analysis

## Drivers for IA variability: (1) ENSO

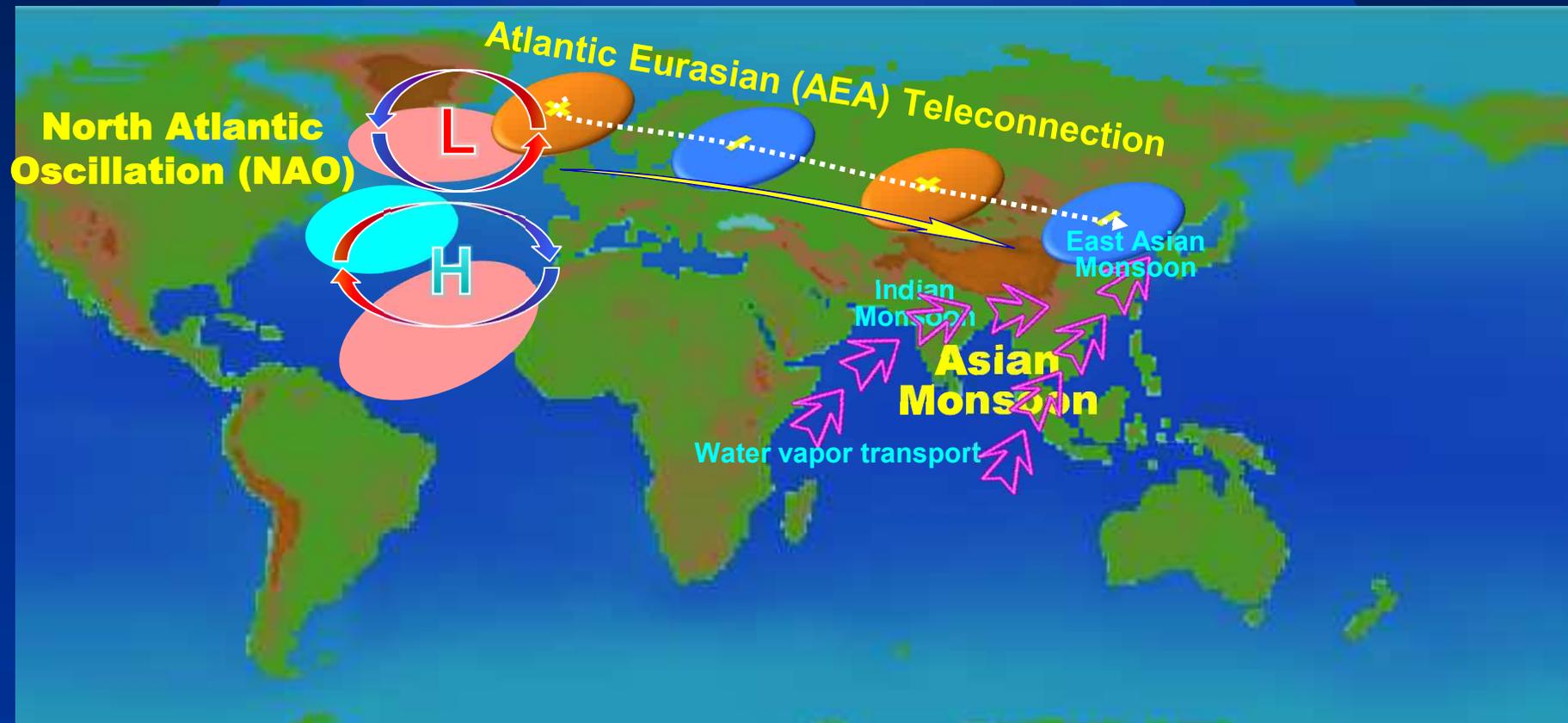


## Drivers for IA variability: (2) NAO and AEA



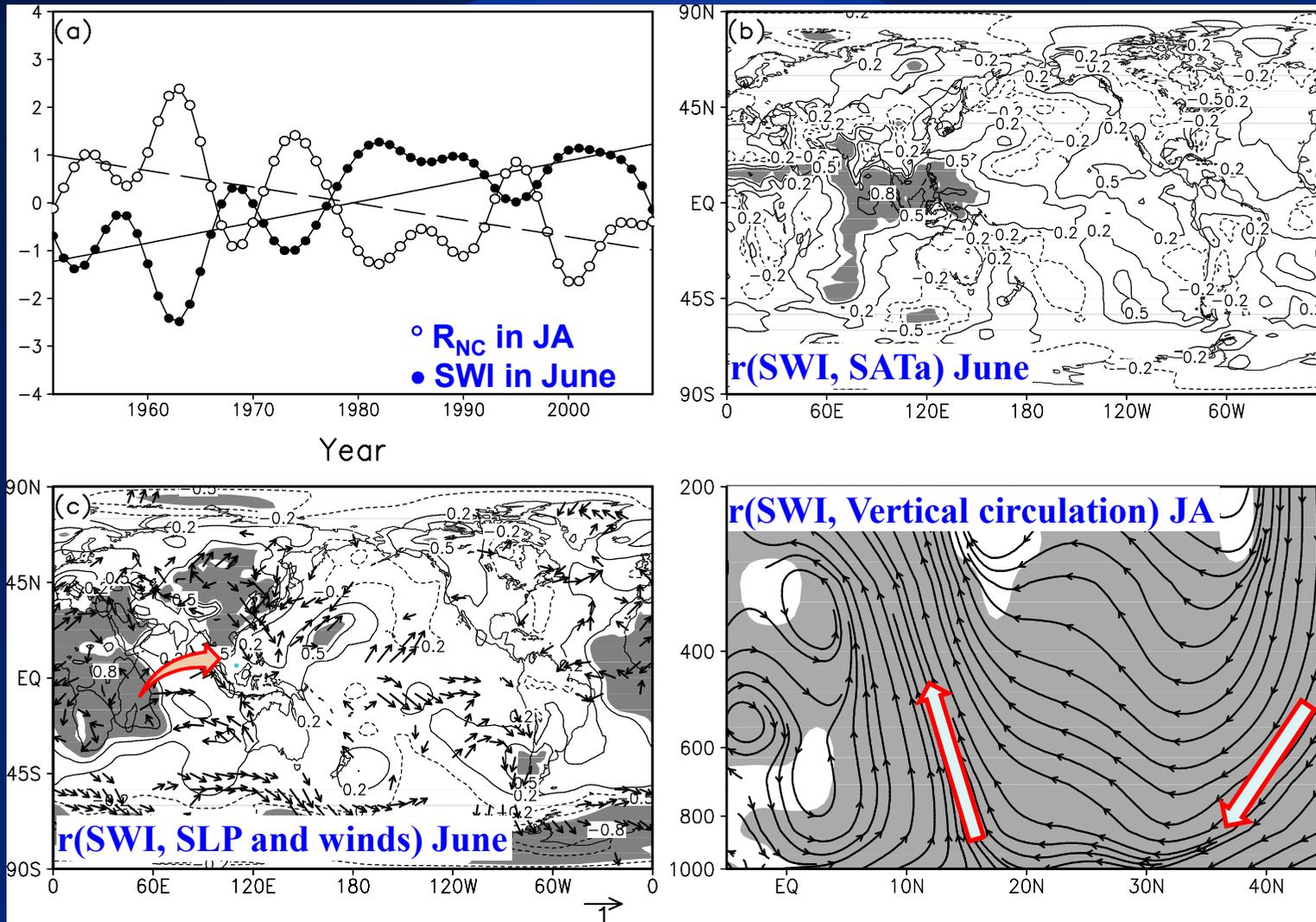
## Drivers for IA variability: (2) NAO and AEA

NAO in June → SSTA tripole in June → Tripole in JA  
→ Atlantic Eurasian (AEA) teleconnection → North China



(Wu, Wang, Li and Jin, 2009)

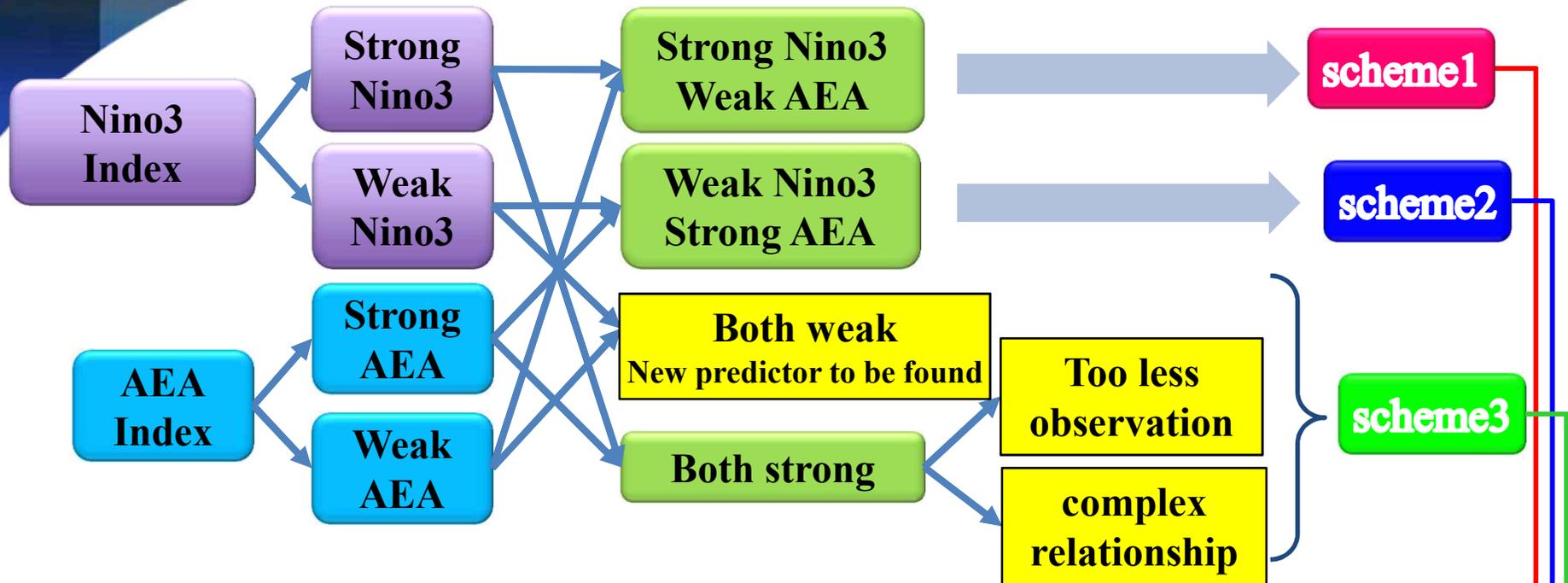
# Drivers for ID variability: Indo-Warm pool SST and SWI SLP



**ID:**  $Y_D = 320.5 - 47SWI_D$

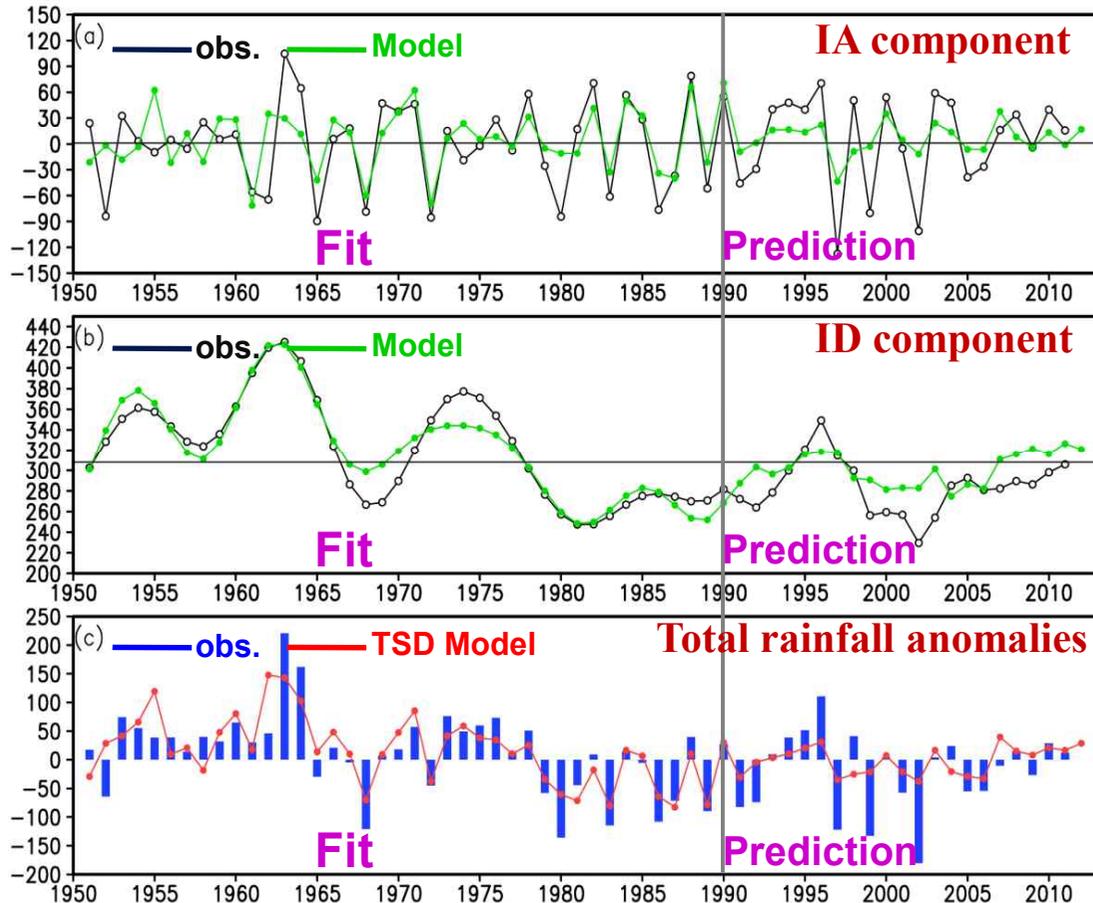
Detrended

# Conditional statistical downscaling (CSD) Scheme for multi-factors (e.g. IA variability)



$$Y_A = \begin{cases} -34.8 \cdot Nino3_A + 13.0, & |Nino3_A| > \frac{1}{2} S_{Nino3_A}, \text{ and } |AEA_A| < \frac{1}{2} S_{AEA_A} \\ 2.89 \cdot AEA_A - 22.4, & |Nino3_A| < \frac{1}{2} S_{Nino3_A}, \text{ and } |AEA_A| > \frac{1}{2} S_{AEA_A} \\ -26.4 \cdot Nino3_A + 2.89 \cdot AEA_A + 6.26, & \text{others} \end{cases}$$

# TSD model for JA Rainfall over NC



## Prediction of JA $R_{NC}$ in 2012

① IA rainfall component:

**positive anomaly**

Nino3=0.45, AEA=7.75,  
both strong ( $> 0.5$  STD)

② ID rainfall component:

**positive anomaly**

SWI is negative anomaly

JA  $R_{NC}$  has a decadal increasing  
after 2000

**JA  $R_{NC}$  in 2012: more rainfall**

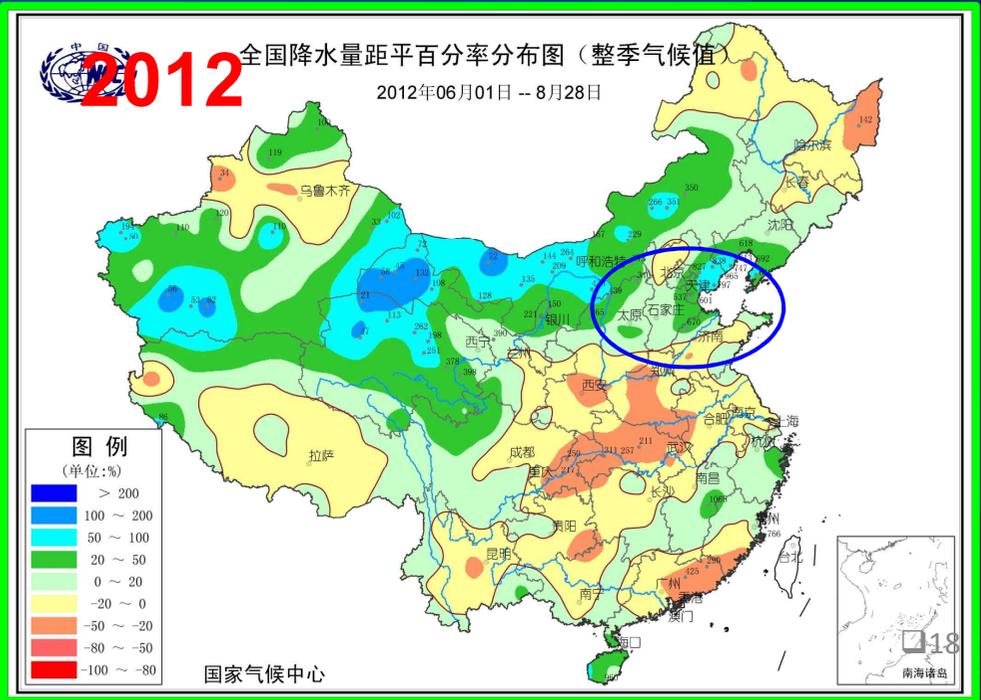
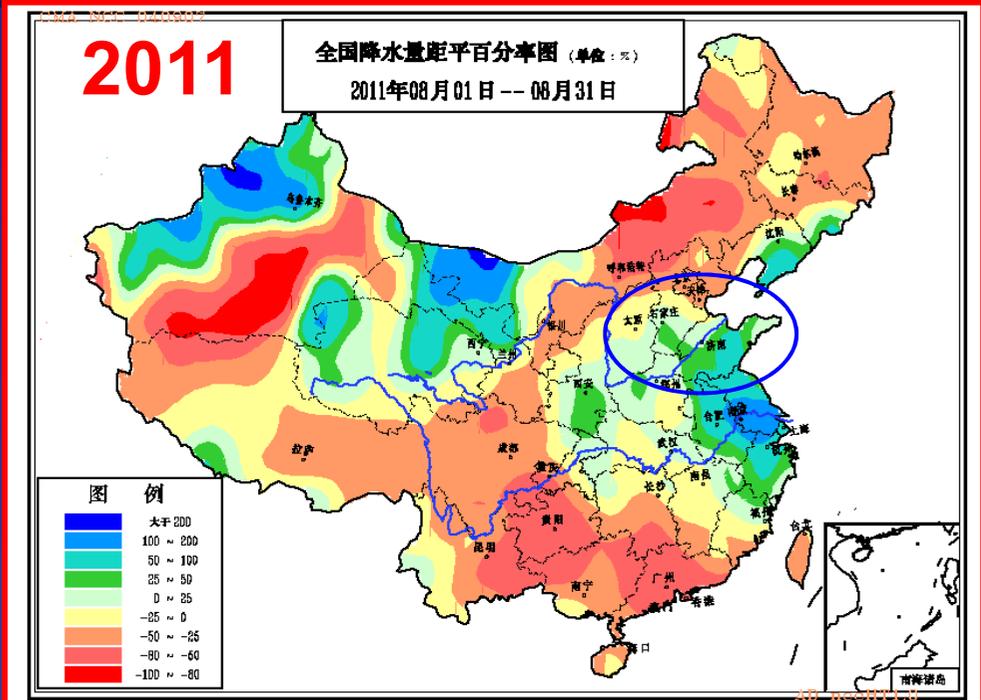
# Application to operational seasonal prediction

## Certification from NCC

### 业务应用证明

对华北雨季降水异常的预测是国家气候中心汛期业务预测的重要内容。由国家重点基础研究发展计划(973计划)项目“亚洲区域海陆气相互作用机理及其在全球变化中的作用”(2010CB950400)所研制的时间尺度分解降尺度预测法(研制人为中国科学院大气物理研究所李建平研究员及其课题组),在针对2011年8月份华北降水异常趋势的业务预测中,得到了应用。该方法考虑了华北雨季年际和年代际变化的特点及其不同影响因子的作用,给出了2011年华北雨季(7-8月)降水的总体趋势是正常略偏多,与实际的趋势相符(2011年7月华北降水偏少,8月异常偏多,7-8降水总体偏多),为8月份华北降水气候预测与服务的成功,起到了积极作用。

特此证明。



# Summary

- A **time-scale decomposition (TSD)** statistical downscaling model is proposed. It makes use of distinct downscaling models respectively corresponding to different time-scale variability with distinct different mechanisms.
- Objective techniques: C\_CVSR, PC\_CVSR and CSD schemes
- A case study of JA rainfall over NC
  - **Inter-annual (IA) timescale** : related with ① June *Nino3*, and ② June AEA pattern.
  - **Inter-decadal (ID) timescale**: under related with June SST over Indo-Pacific warm pool, represented by SLP over SW IO.
- Good performance of the TSD model for seasonal prediction of JA rainfall over NC in 2011 and 2012 implies it could be a useful tool for seasonal prediction.

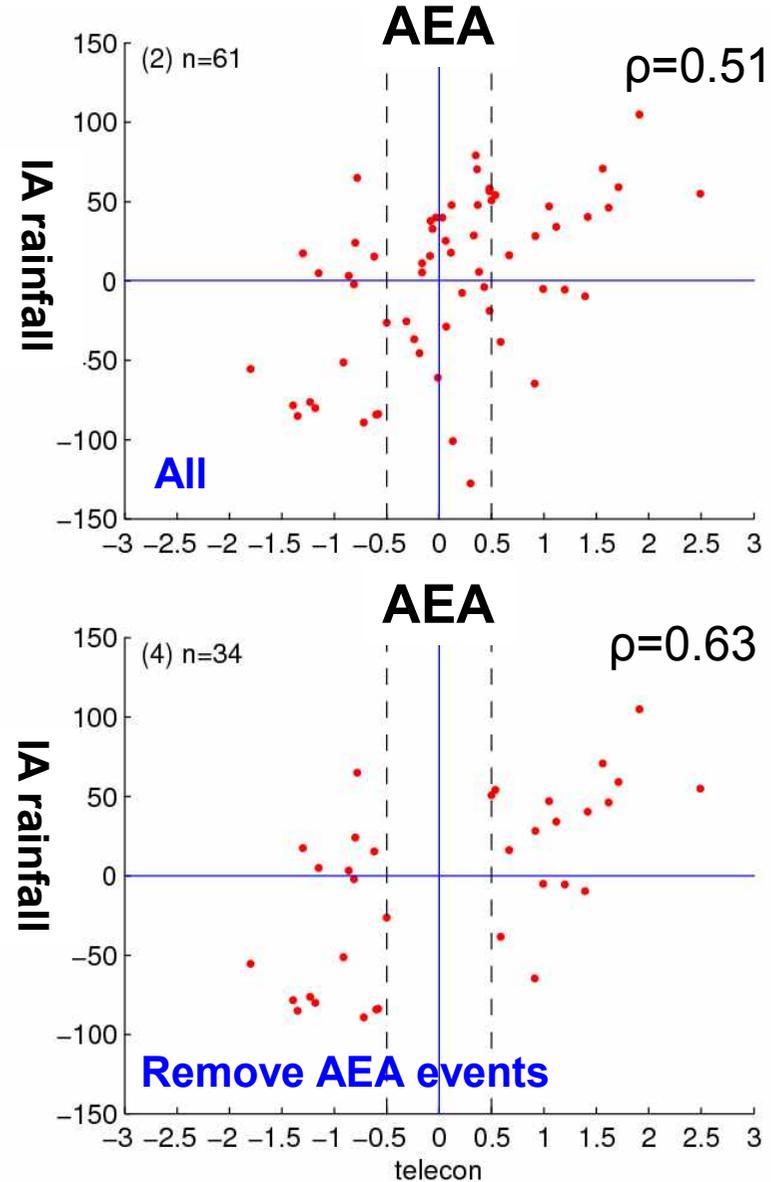
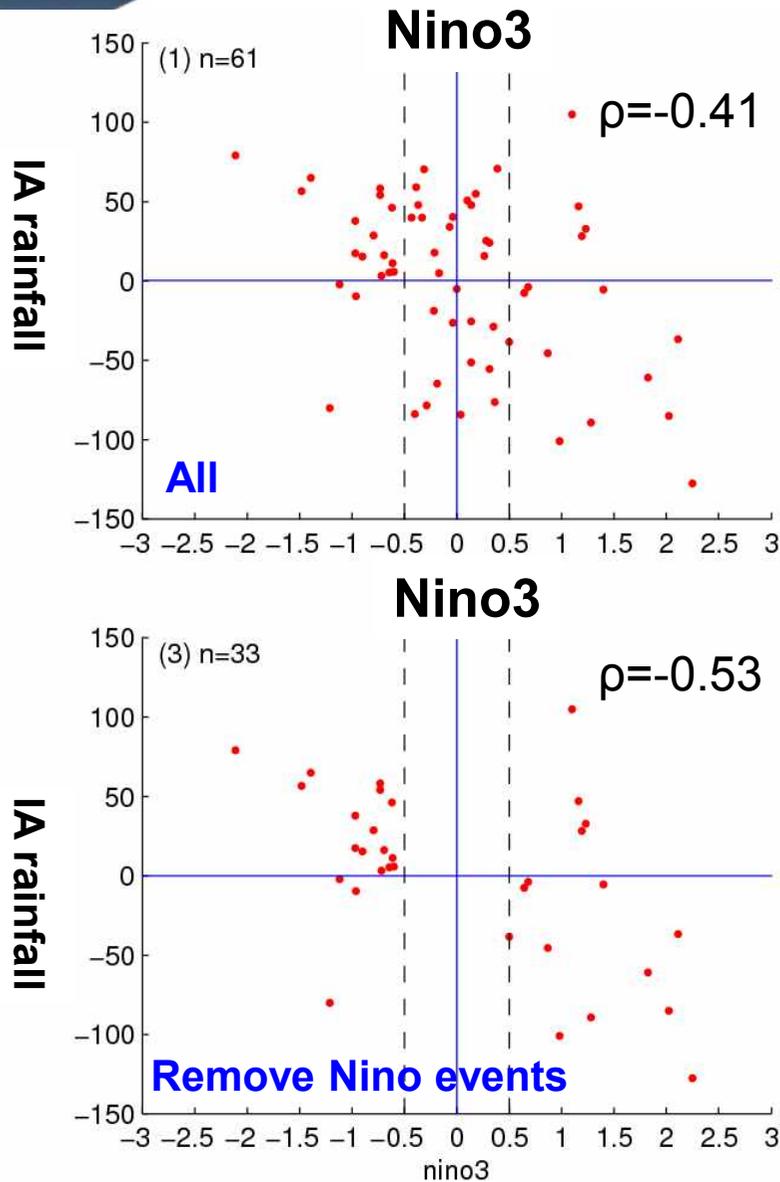


# Thanks !

Guo, Y., **J. Li**, and Y. Li, 2012: A time-scale decomposition approach to statistically downscale summer rainfall over North China. *J. Climate*, **25**, 572-591.

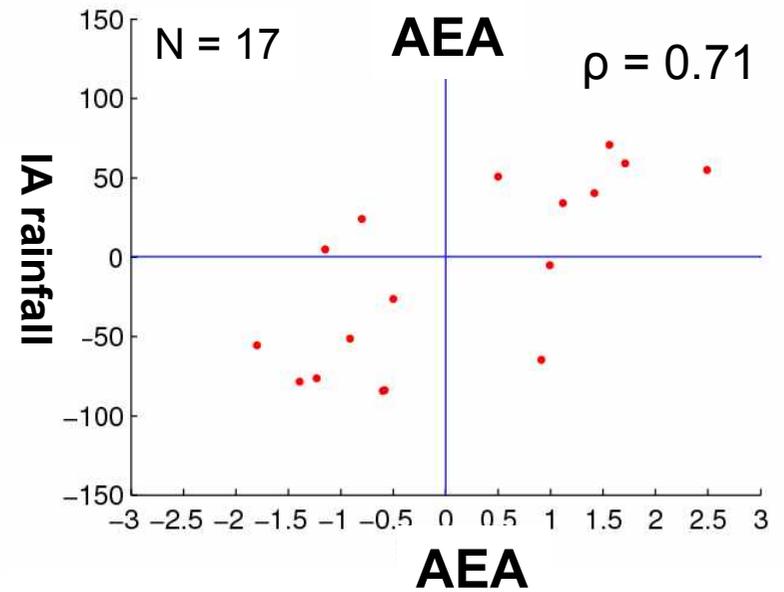
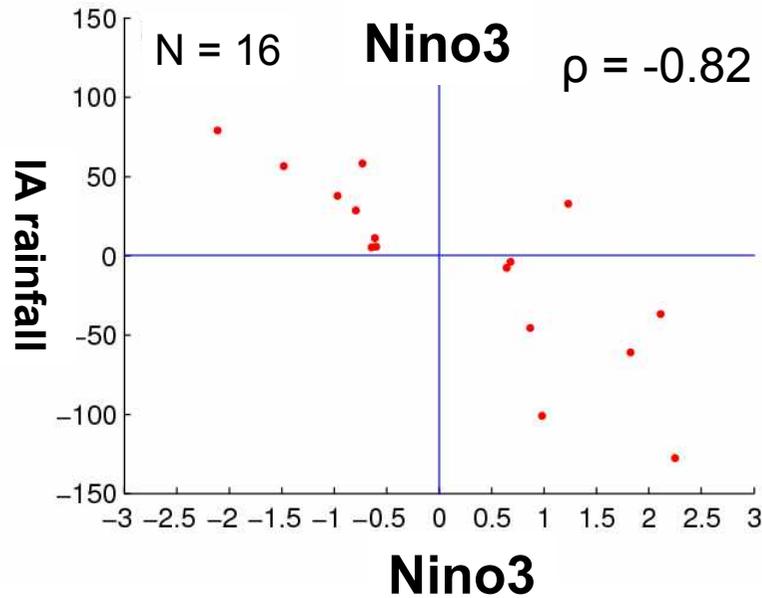
Guo Yan, Li Jianping. 2012. A time-scale decomposition statistical downscaling model: case study of North China rainfall in rainy season. *Chinese Journal of Atmospheric Sciences*, 36(1), 385-396. (in Chinese)

# Correlation of El Nino and AEA with NCSR at strong and weak event year

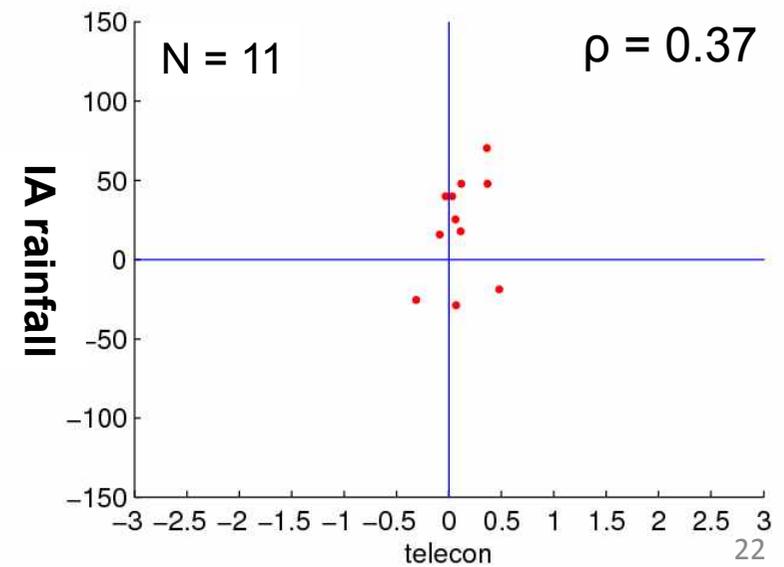
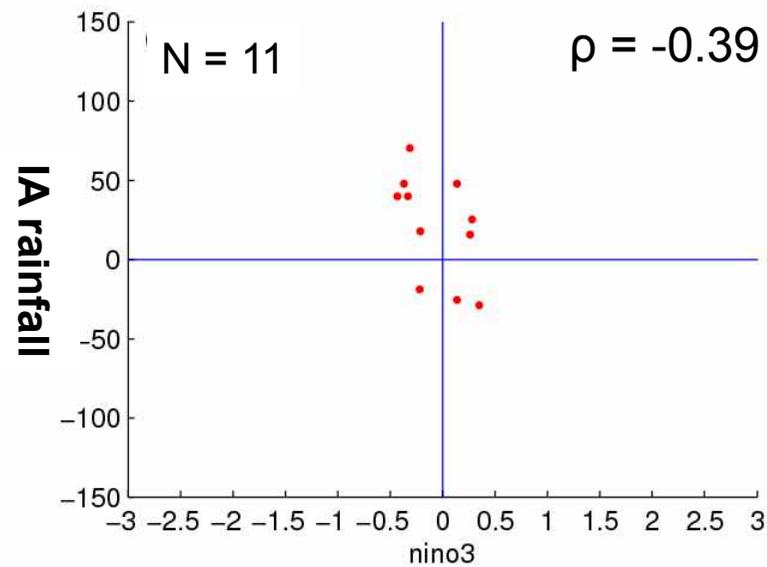


# Four Cases

Only one index strong

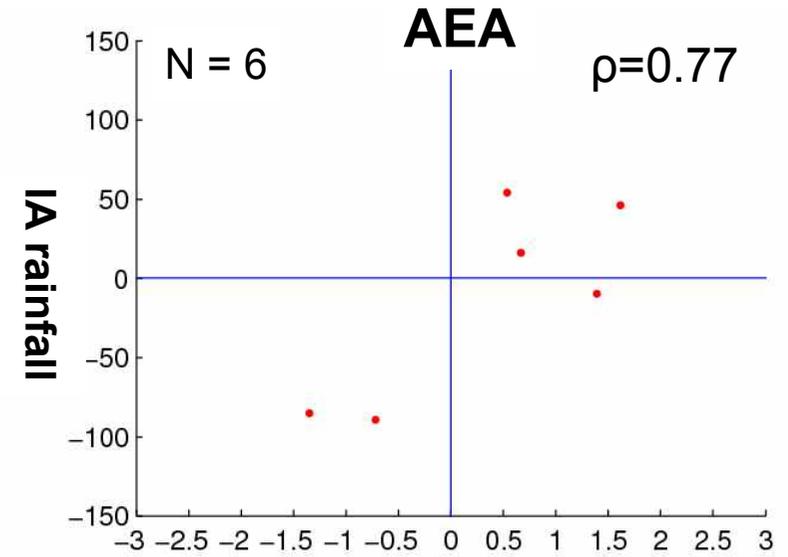
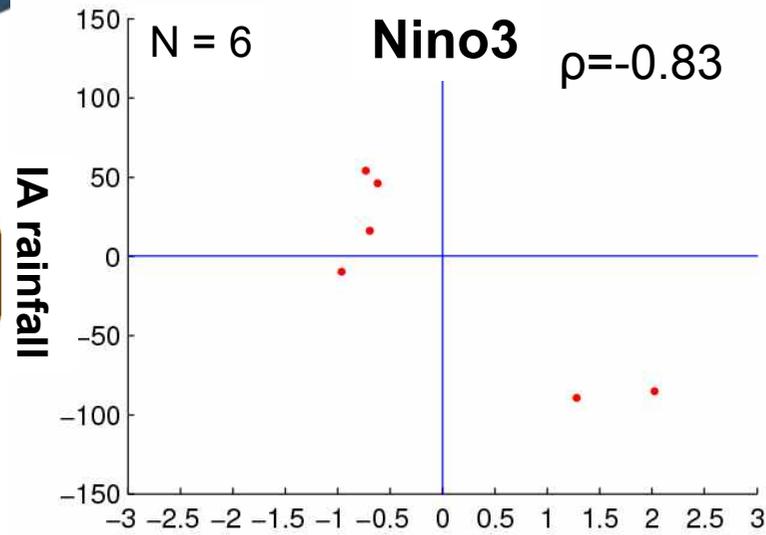


Both weak

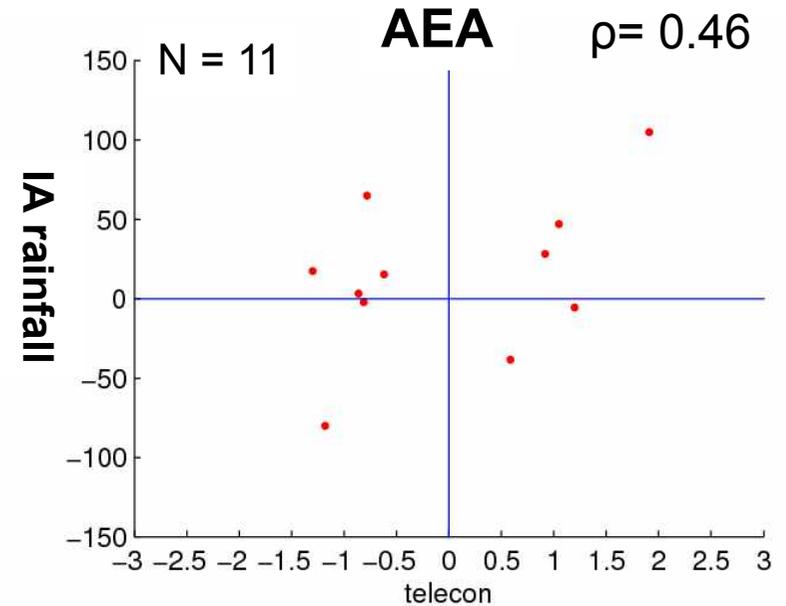
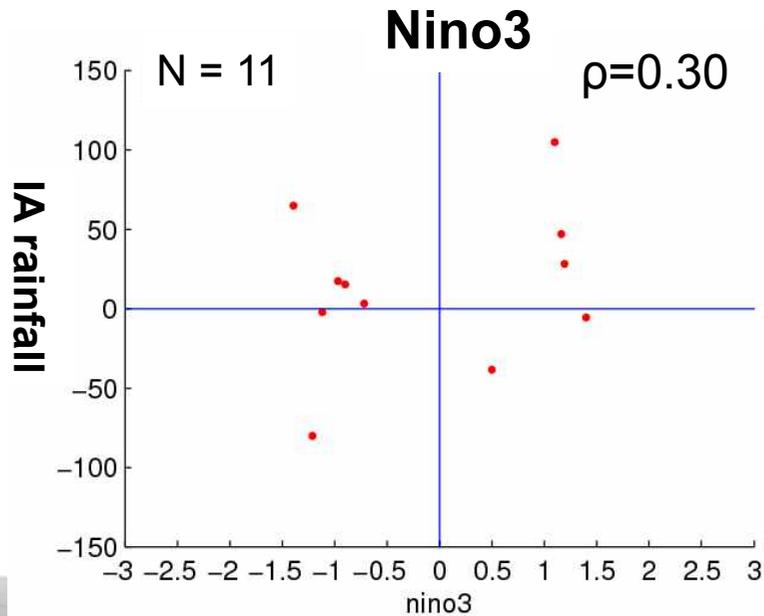


# Four Cases

Both strong  
Opposite sign

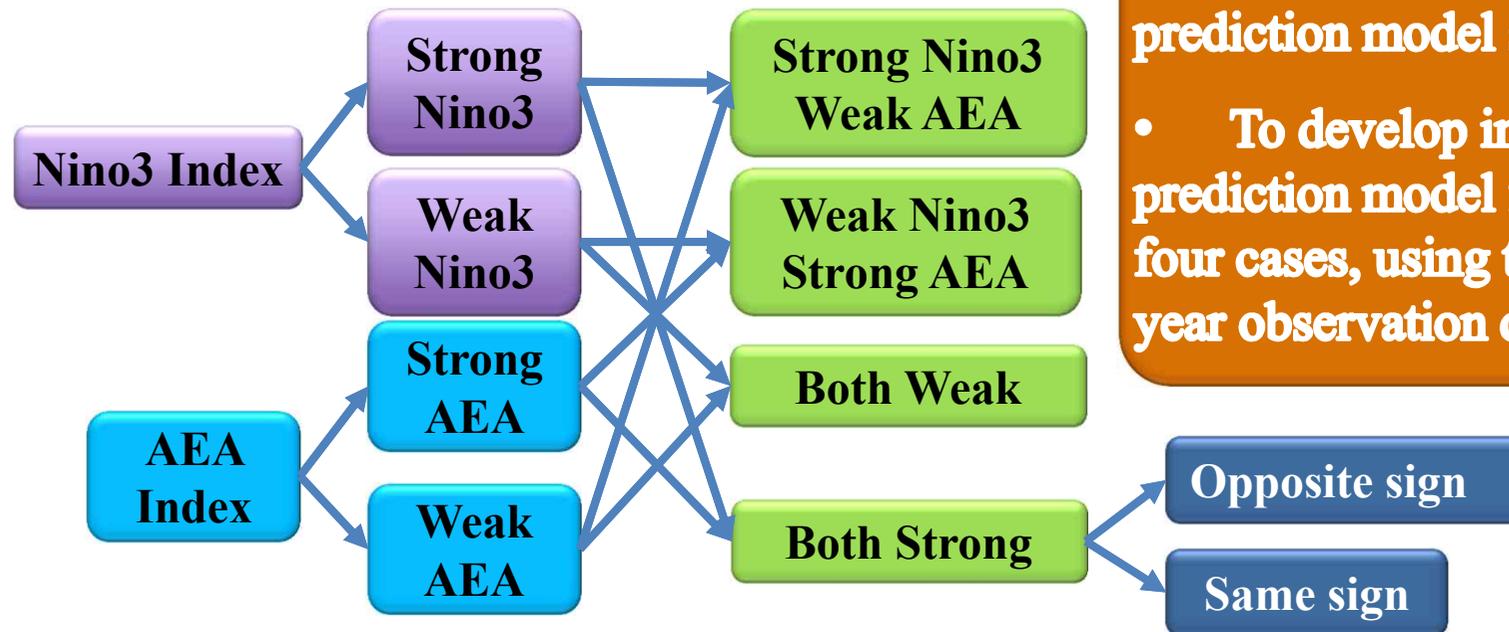


Both strong  
Same sign



# Conditional statistical downscaling (CSD) scheme

- Set 0.5 standard deviation as a criterion to find the strong and weak event year of El Nino and AEA, forming four cases as follows:



- For each case, distinct prediction model should be used
- To develop individual prediction model for each of the four cases, using the whole 61-year observation data

## Improvement in prediction model of NCSR

- **3.1 To identify new precursor with partial correlation method (PCM)**
- **3.2 Conditional statistical downscaling model**