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12-16 November 2012, Trieste, Italy

Boreal Summer Convection Oscillations over the Indo-Western Pacific and their Relationships with Asian Summer Monsoon

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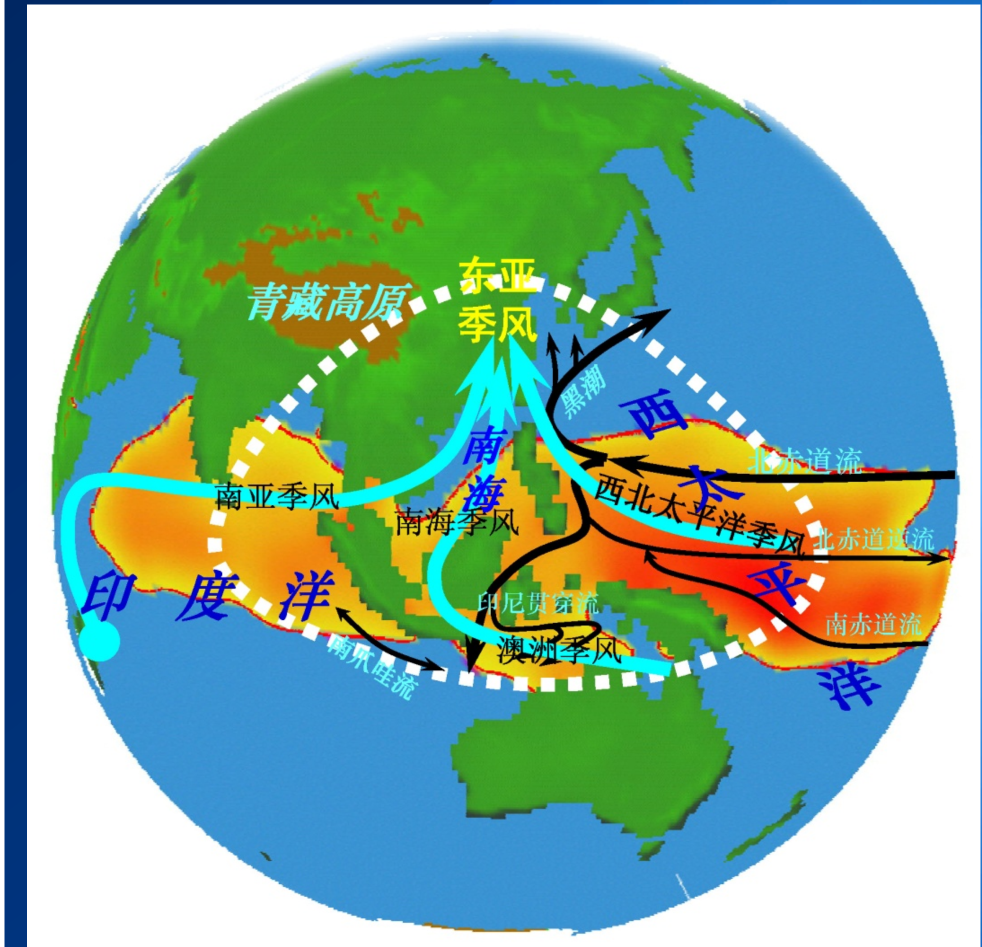
Contents

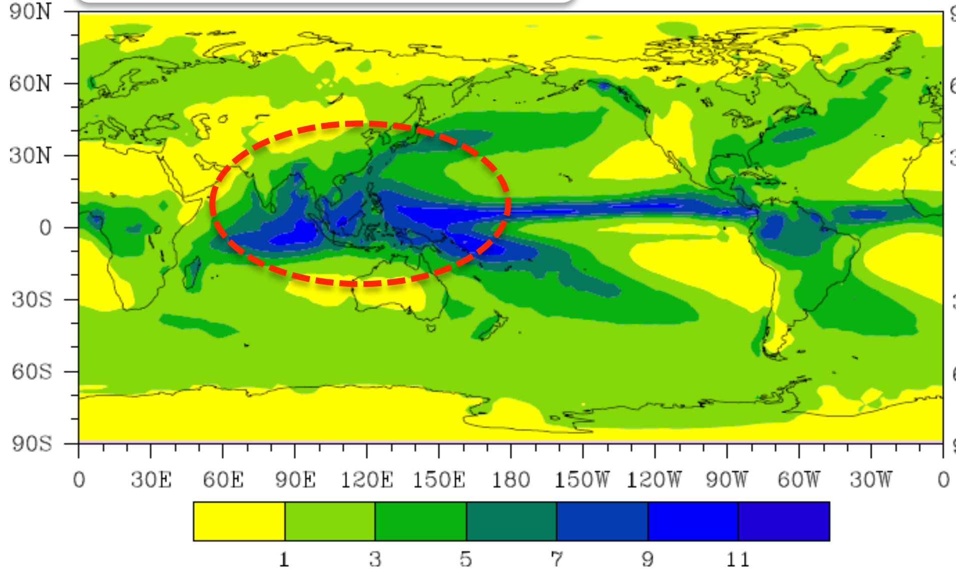
The Indo-Western Pacific is a key region of air-sea interaction



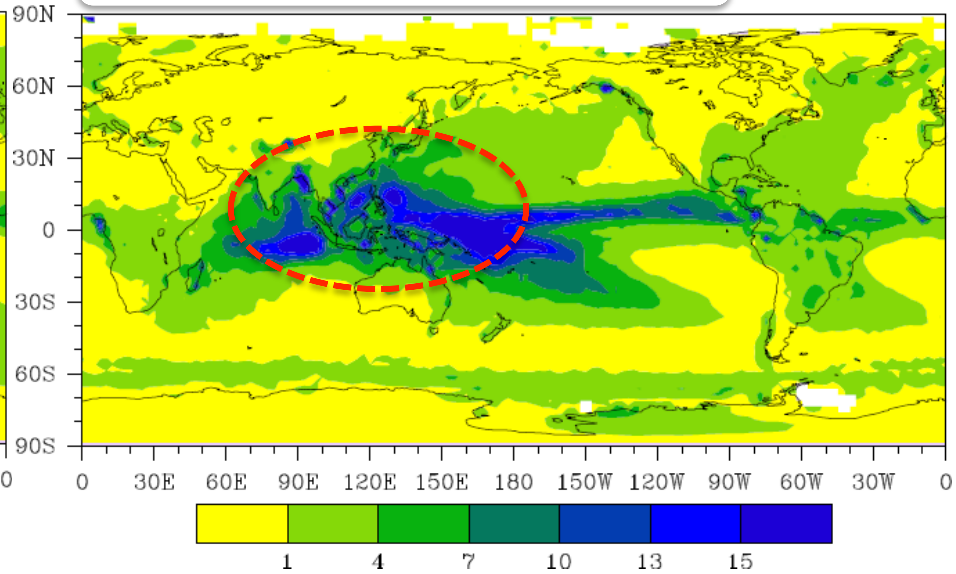
- The largest warm pool
- Tibetan Plateau
- Strongest convection
- Maximum latent heating
- The largest water vapor content
- Strong interannual variability
- Key monsoon components: SASM, EASM, CSCSM, ASM

(Li et al, 2011)

Annual rainfall

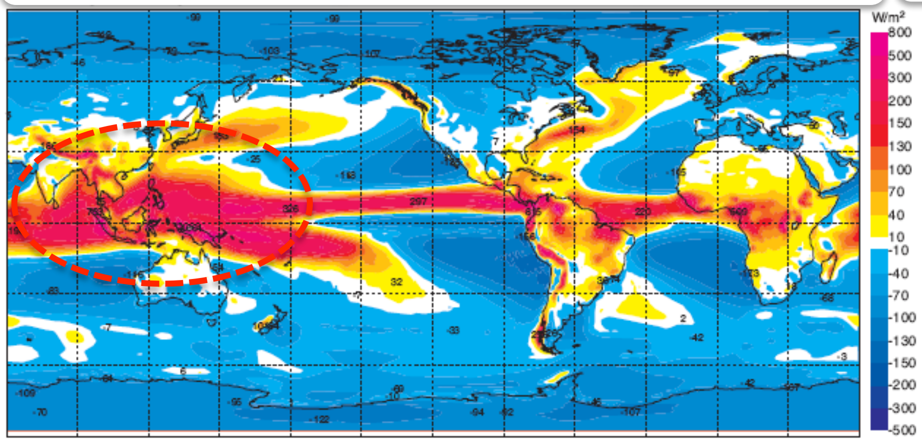


SD of annual rainfall

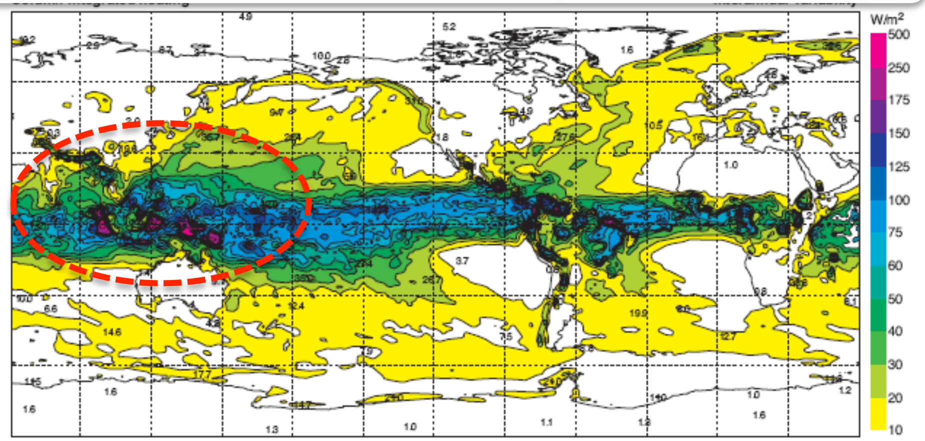


An important modulator of global water and energy cycle

Column integrated heating, Annual

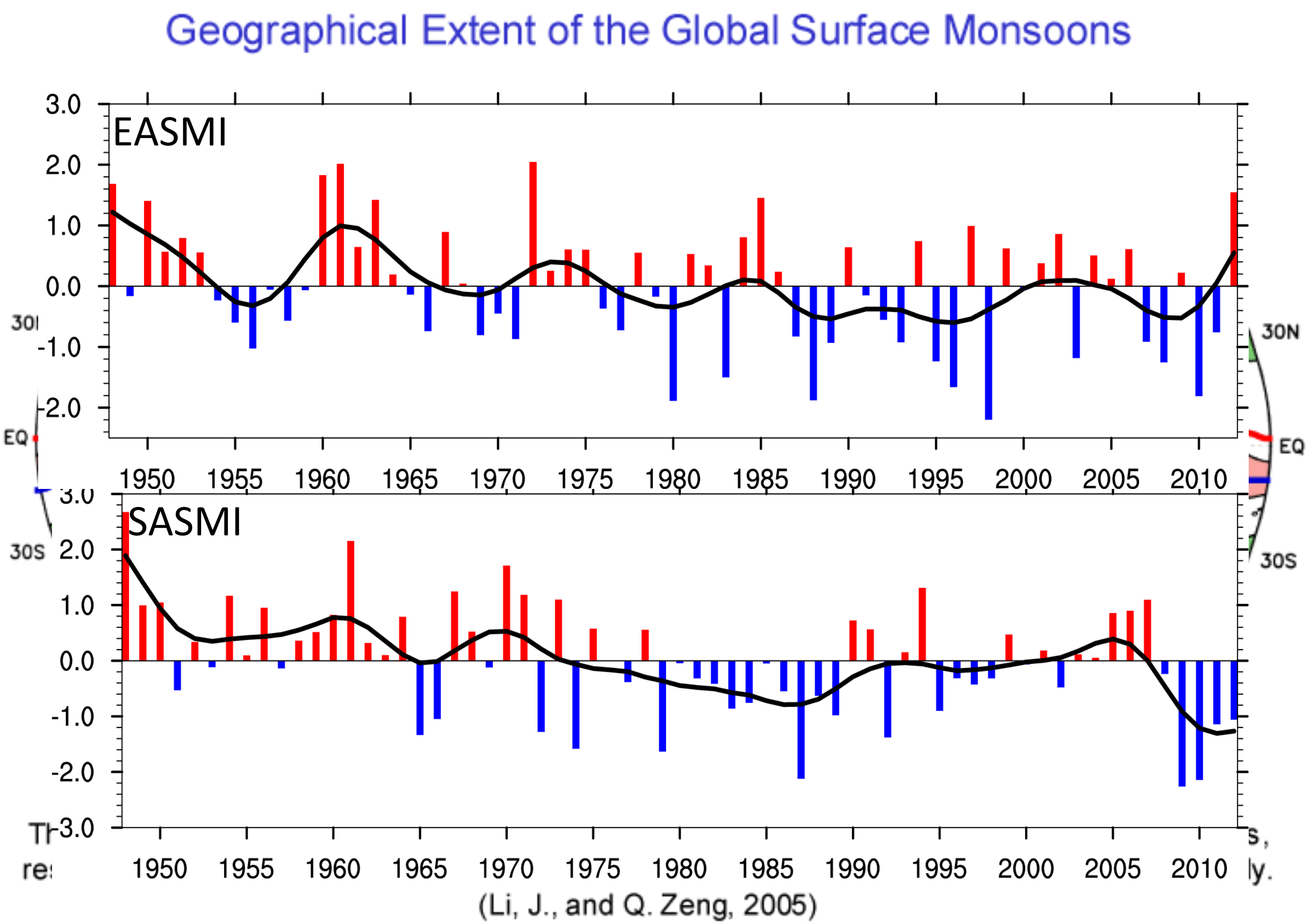


SD of ann. column integrated heating

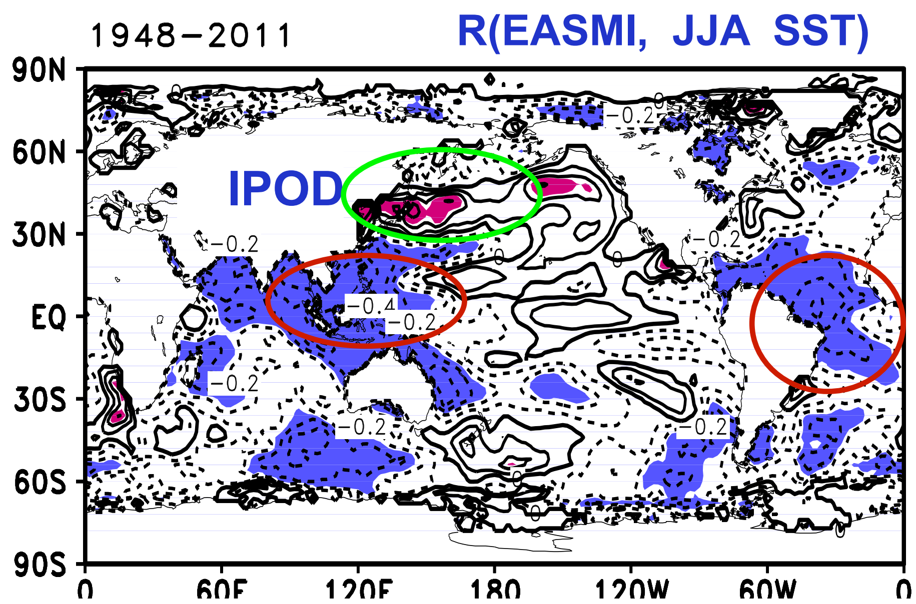


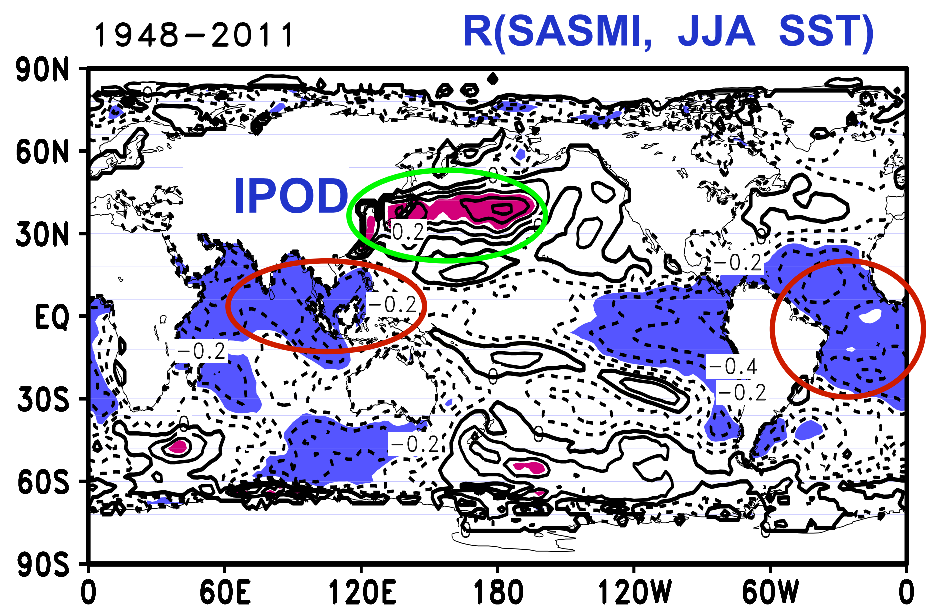
(Kalberg et al, 2005)

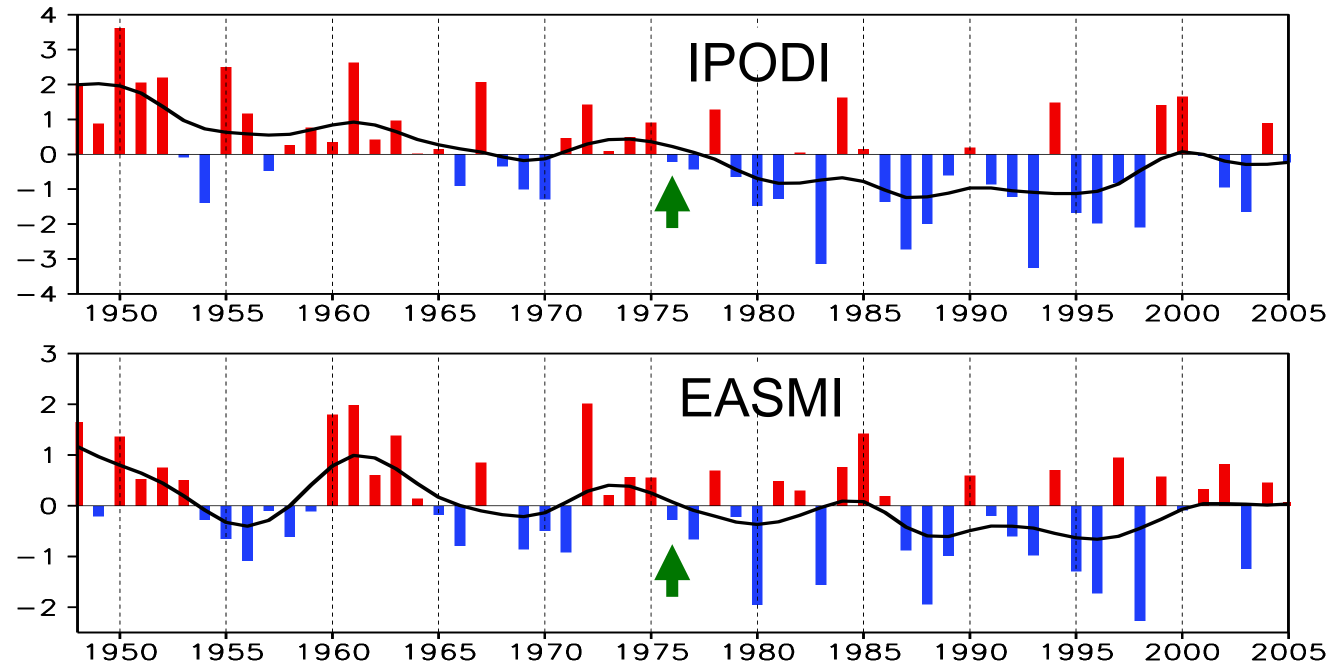
The ASM undergoes strong interannual variability



Variations of ASM are closely related to SST



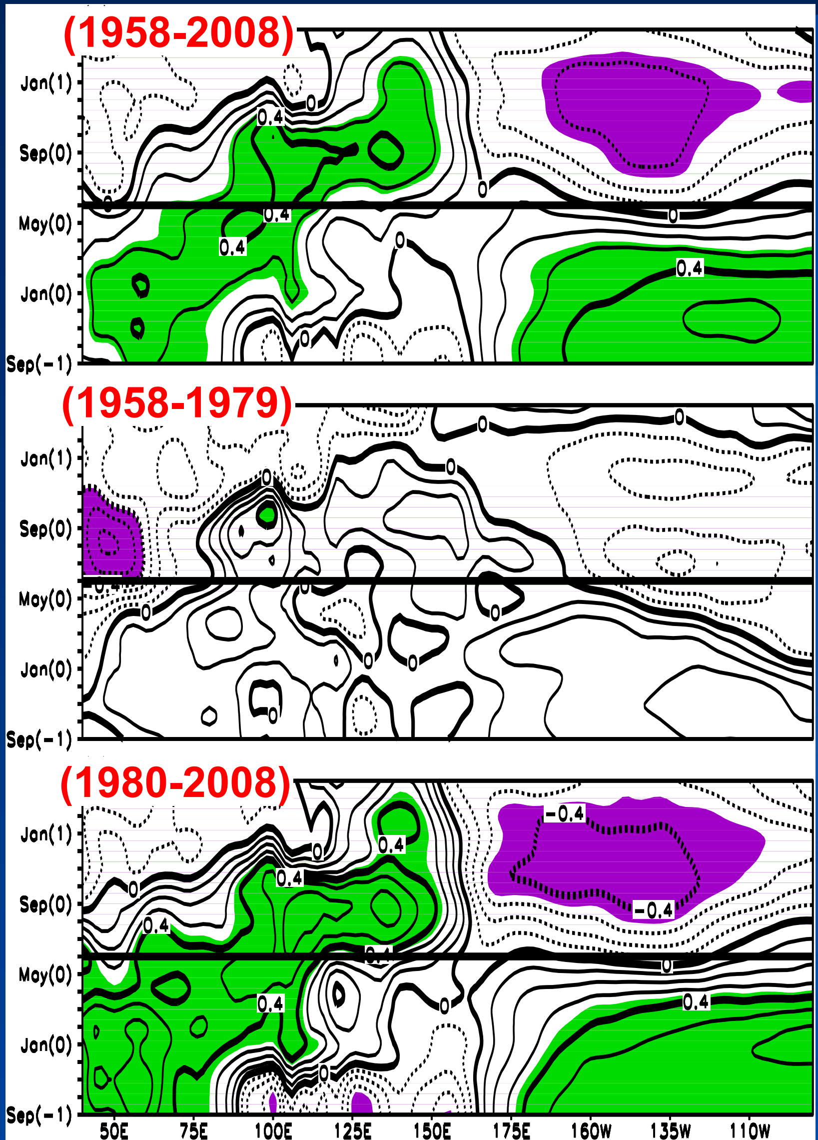




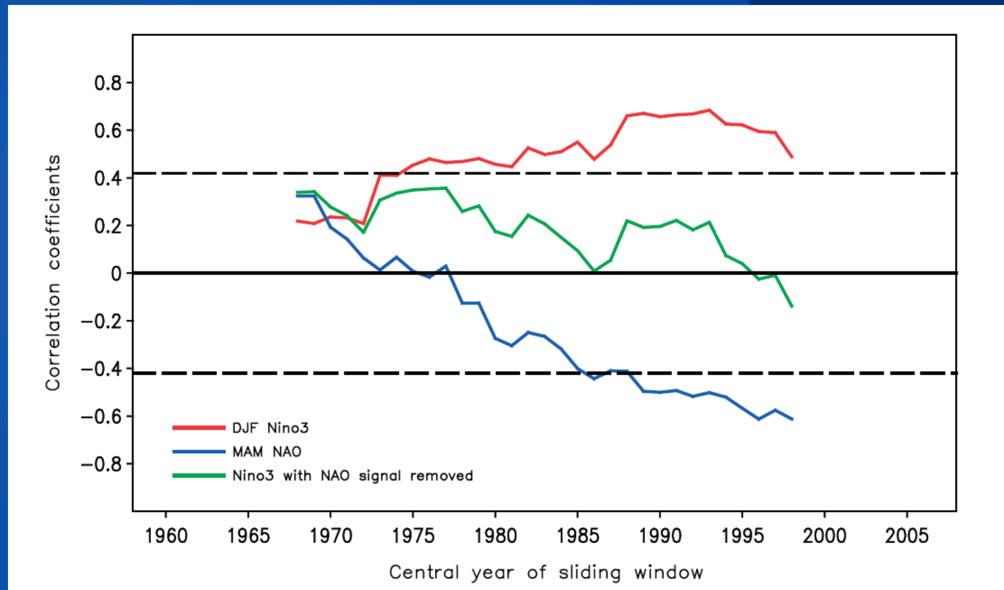
r =0.67

(Li et al, 2011)

Role of spring NAO in decadal strengthening relationship between EASM & ENSO



21-yr sliding correlations between EASMI and preceding DJF Nino3, MAM NAOI, and Nino3 with NAO removed



(Wu, Li, et al., *JOC*, 2012)

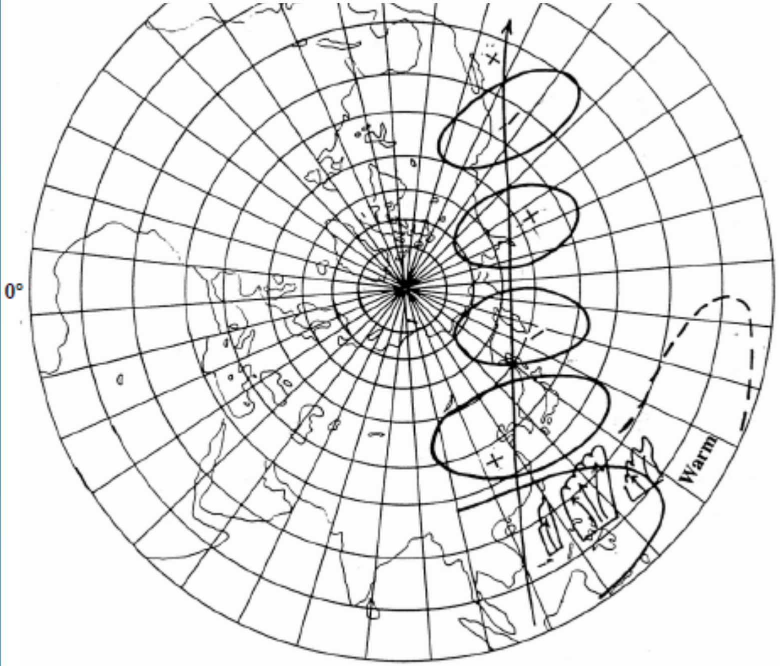
The lead-lag correlation coefficients between *ESAMI* and SSTA averaged between 5S and 5N from Sep(-1) to Apr(+1). Here, the sign of ESAMI is reversed.

(Li, Wu, Jiang, He, *J. Clim.*, 2010)

Convection plays an important role in the air-sea interaction processes, especially for the tropics

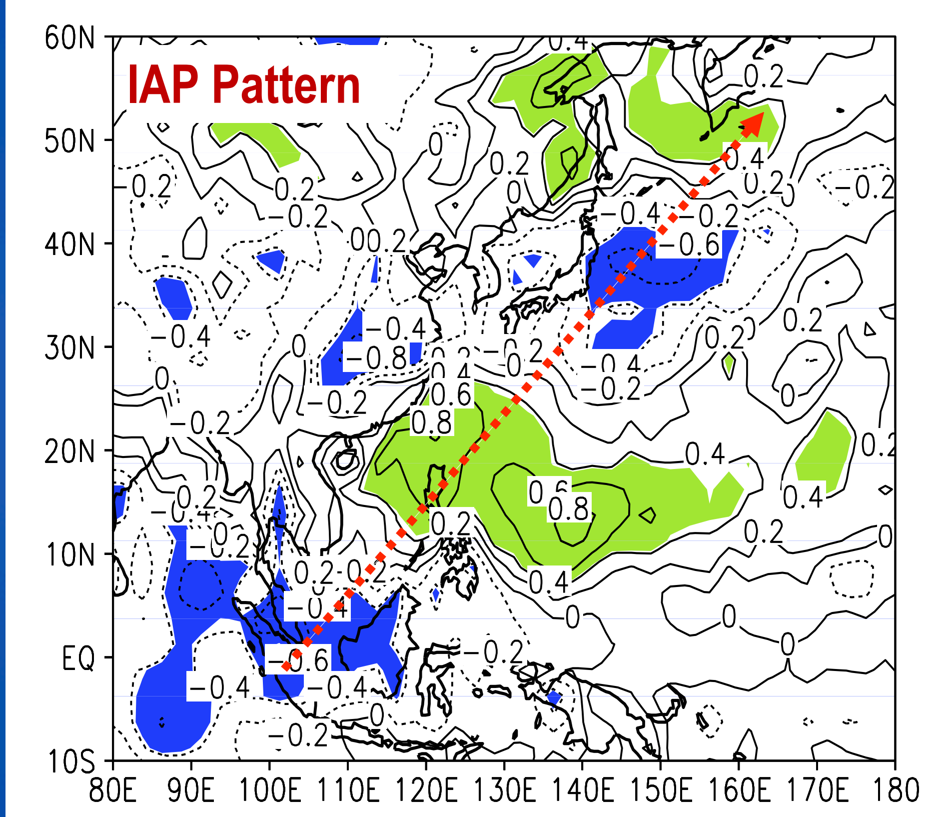
Western North Pacific (WNP)

PJ Pattern or EAP Pattern ***(Nitta, 1987; Huang & Li, 1987, 1988; Huang, 2004)***



EAP index (Huang, 2004)

Tropical North Indian Ocean (NIO)



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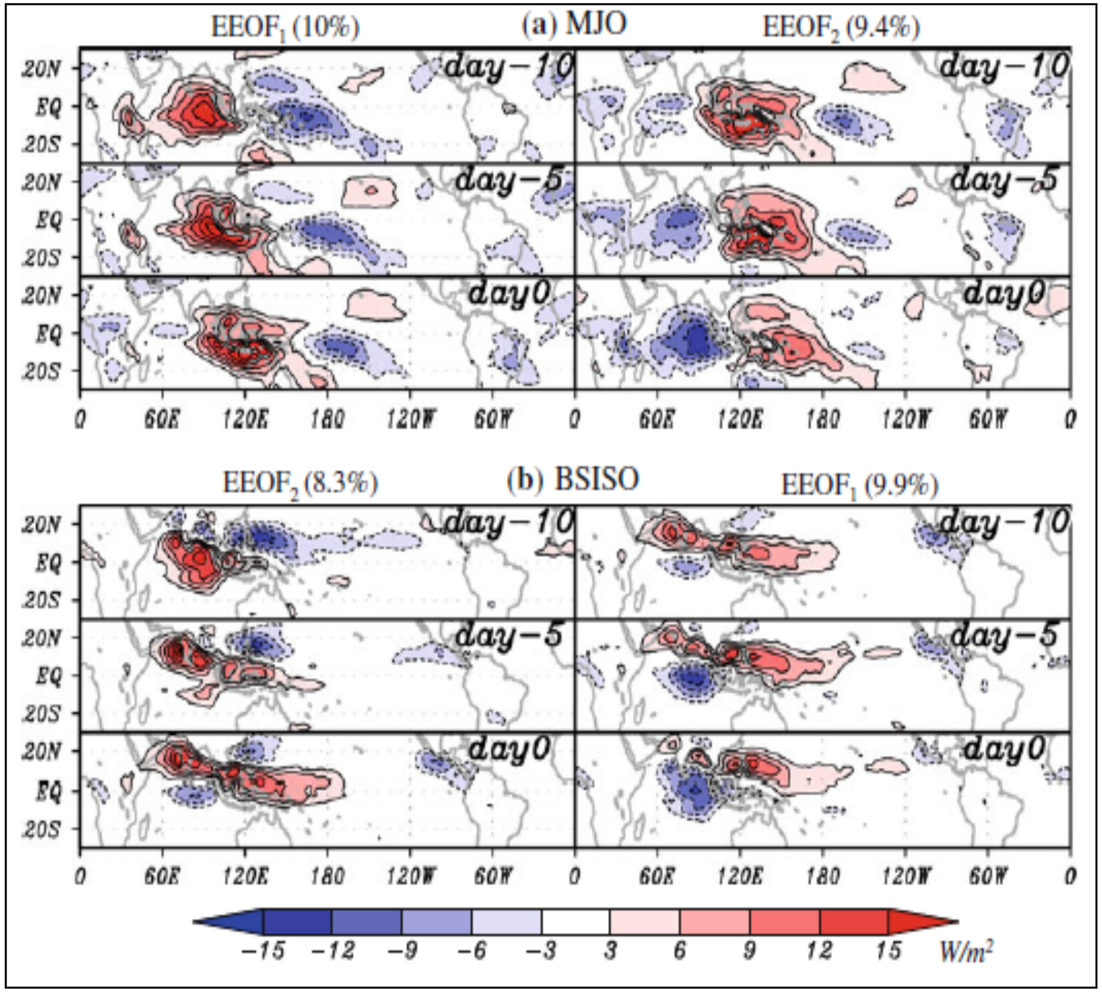
What is the linkage in convection between the Indian Ocean and Western Pacific?

Tropical convection is featured by prominent intraseasonal oscillation (ISO)



MJO in boreal winter:

predominantly eastward propagation ***(e. g. Madden and Julian 1972, 1994; Wheeler and Hendon 2004; Zhang 2005)***

ISO in boreal summer:

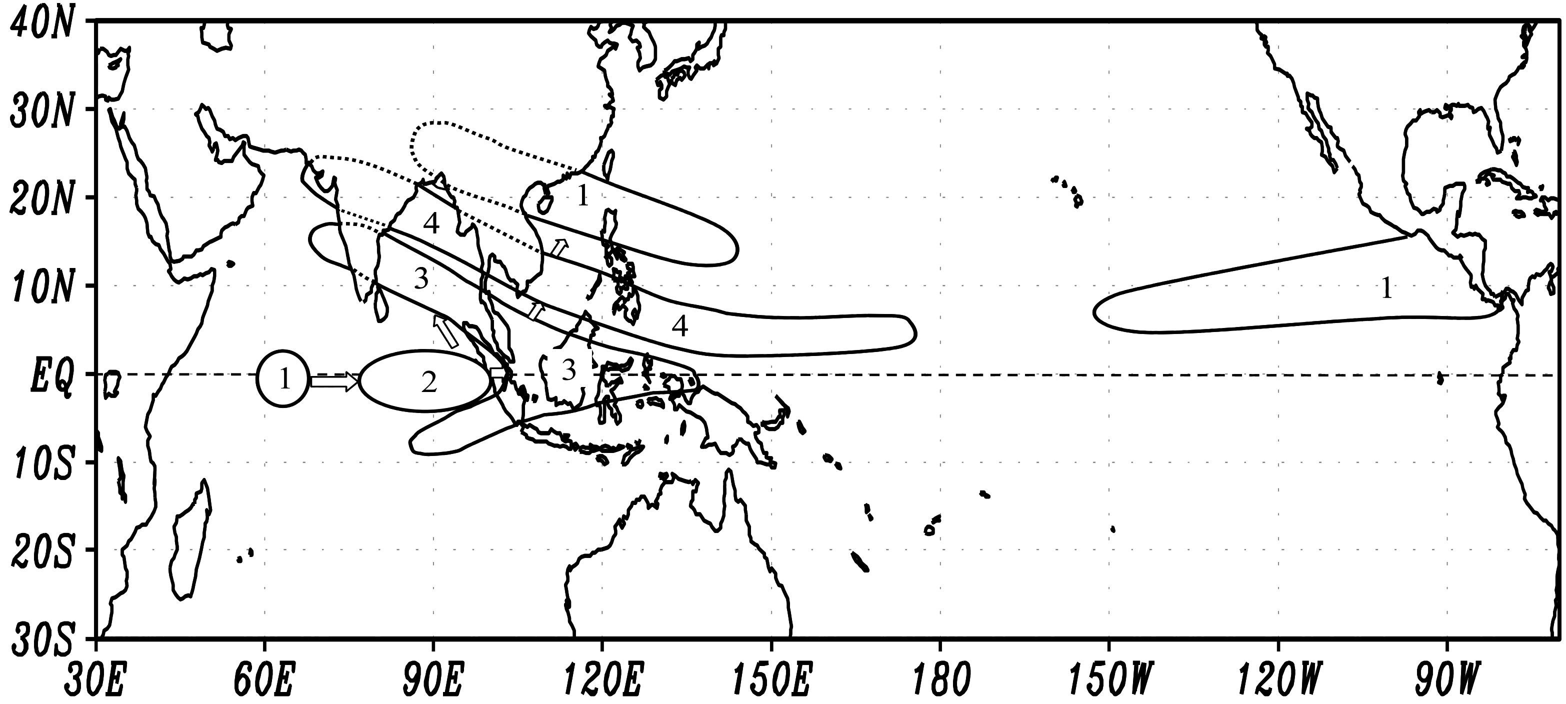
- **Northward and northeastward propagation over the ISM region** ***(e. g. Yasunari 79, 80; Krishnamurti & Subramanian 82; Lau & Chan 86; Wang et al. 05)***
- **Northward and northwestward propagation over the Western North Pacific-EASM region** ***(e. g. Murakami 84; Chen & Chen 93; Kemball-Cook & Wang 01; Kajikawa & Yasunari 05; Yun et al. 09)***
- **MJO-like propagation along the equator** ***(e. g. Lawrence and Webster 2002).***

Spatial-temporal pattern of OLR anomaly associated with the intraseasonal oscillation during (a) boreal winter (DJF) and (b) boreal summer (JJA) by means of the extended EOF (EEOF) analysis. ***(Kikuch et al., 2011)***

Tropical ISO provides one major predictability source for the short-term climate variability

He et al. (2011) examined influences of the MJO on the wintertime East Asian weather. The NH branch of equatorial trapped Rossby wave forced by MJO heating is associated with the processes that influence the East Asia.

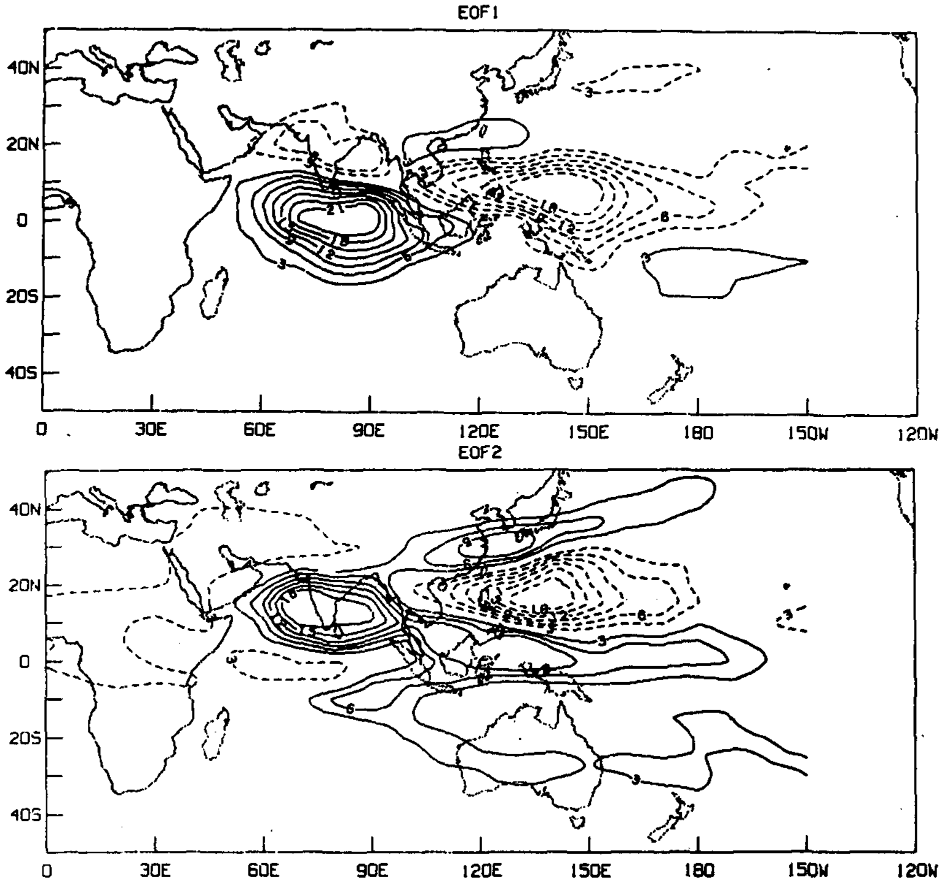
The boreal summer rainfall anomalies over Asia exhibits quasi-monthly oscillation (QMO).

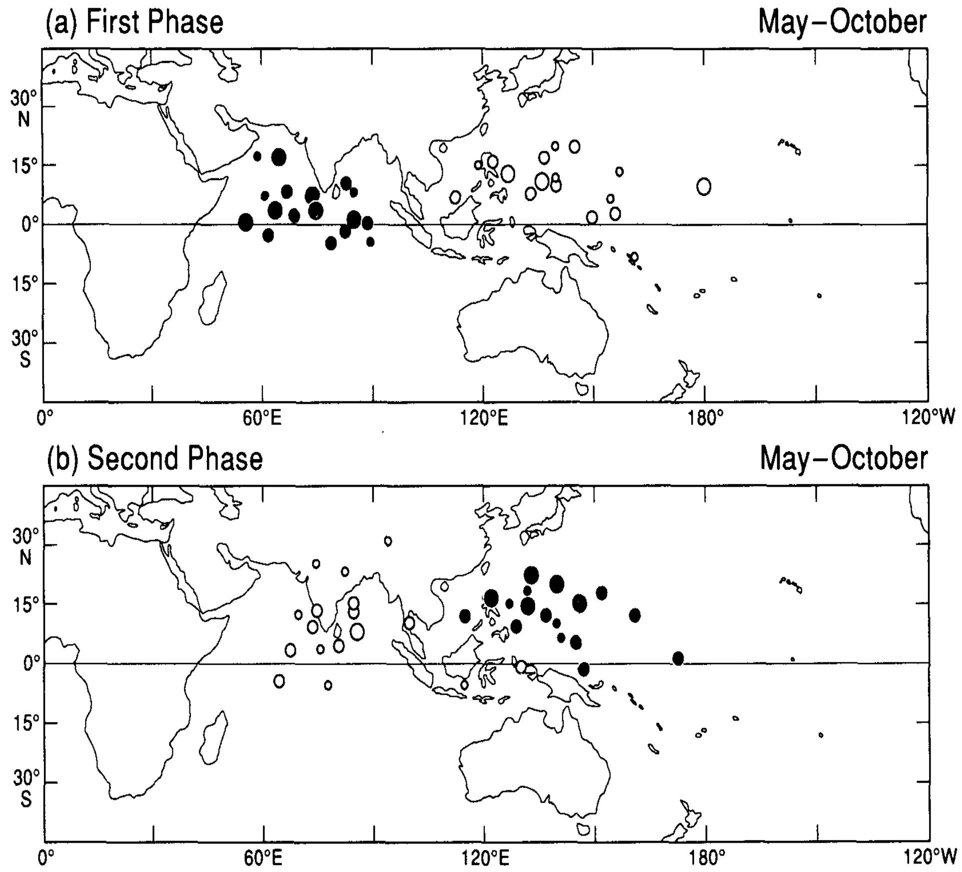


Schematic evolution of tropical QMO rain anomalies showing four stages of the boreal summer QMO wet and dry anomalies: (1) initiation, (2) maturity, (3) formation of the slanted precipitation band, and (4) northeastward propagation. Each stage lasts about 8 days.

(From Wang et al., 2006.)

Dipole pattern links Indian Ocean and Western Pacific: the convection seesaw





Daily OLR data during summertime (May to October) from 1975-1982 (except 1978).

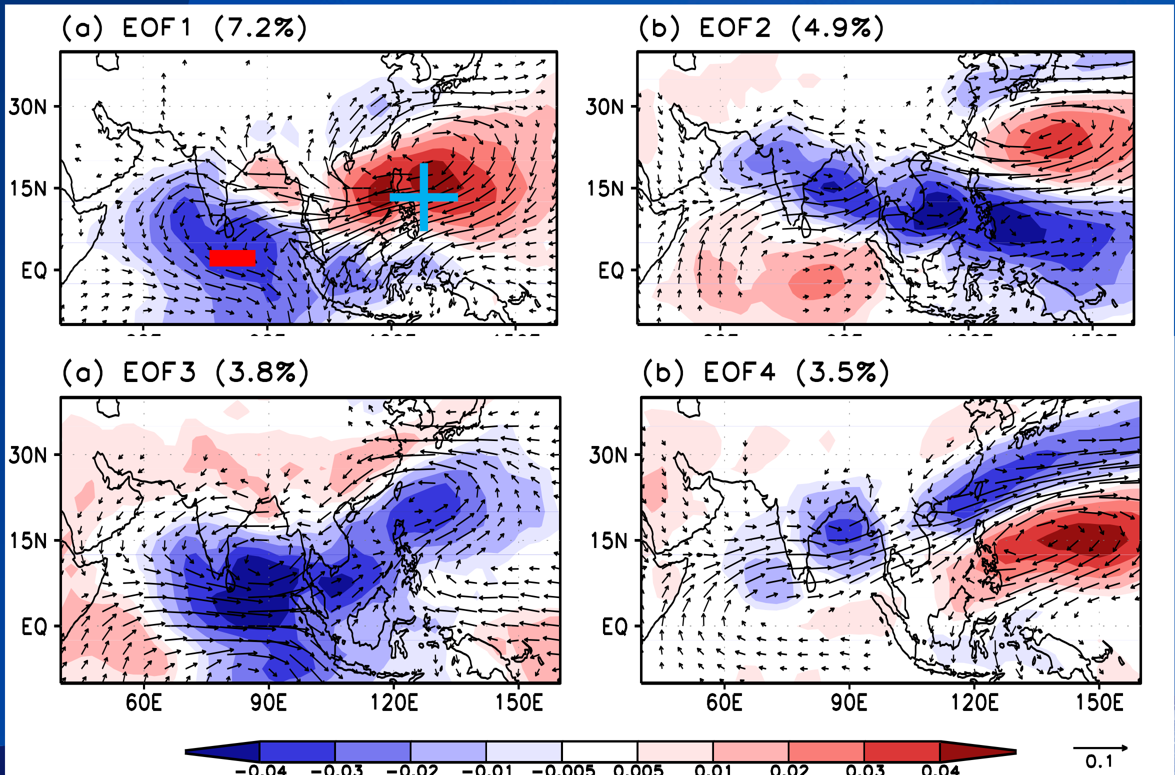
(Lau and Chan, 1986)

The seesaw events case by case. Distributions of the central locations of the enhanced (closed circle) and suppressed (open circle) convection at the strongest stages of the first and second phases of seesaw (1981-85).

(Zhu and Wang, 1993)

- **BSISO1, consisting of EOF1 and EOF2**, represents the canonical northward and north-eastward propagating ISO over the ASM region during the entire warm season from May to October with quasi-oscillating periods of 30-60 days in conjunction with the eastward propagating MJO.
- **BSISO2, consisting of EOF3 and EOF4**, captures the northward/ northwestward propagating variability with periods of 10-30 days during primarily the pre-monsoon and monsoon-onset season.

EOF1: An east-west seesaw pattern



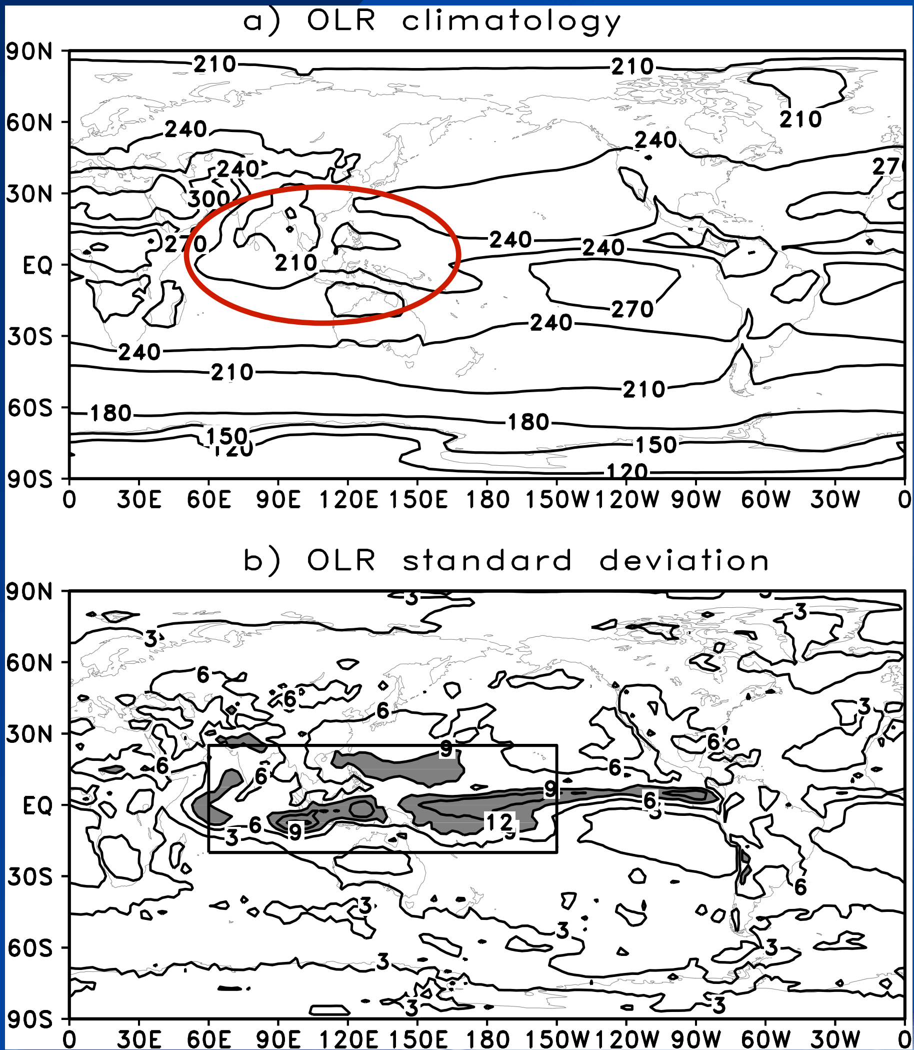
Rossby wave like pattern with a northwest to southeast slope

Elongated and front-like pattern with a southwest to northeast slope

(Lee et al., 2012)

Questions

JJA



Q1: Relation in summer convection between the Indian Ocean and Western Pacific on seasonal scale? Seesaw pattern in summer convection?

Q2: Variability, its relationships with ASM and other atmospheric and ocean systems?

Contents

Data and Methodology

- **Jun-July-August data derived from monthly datasets:**

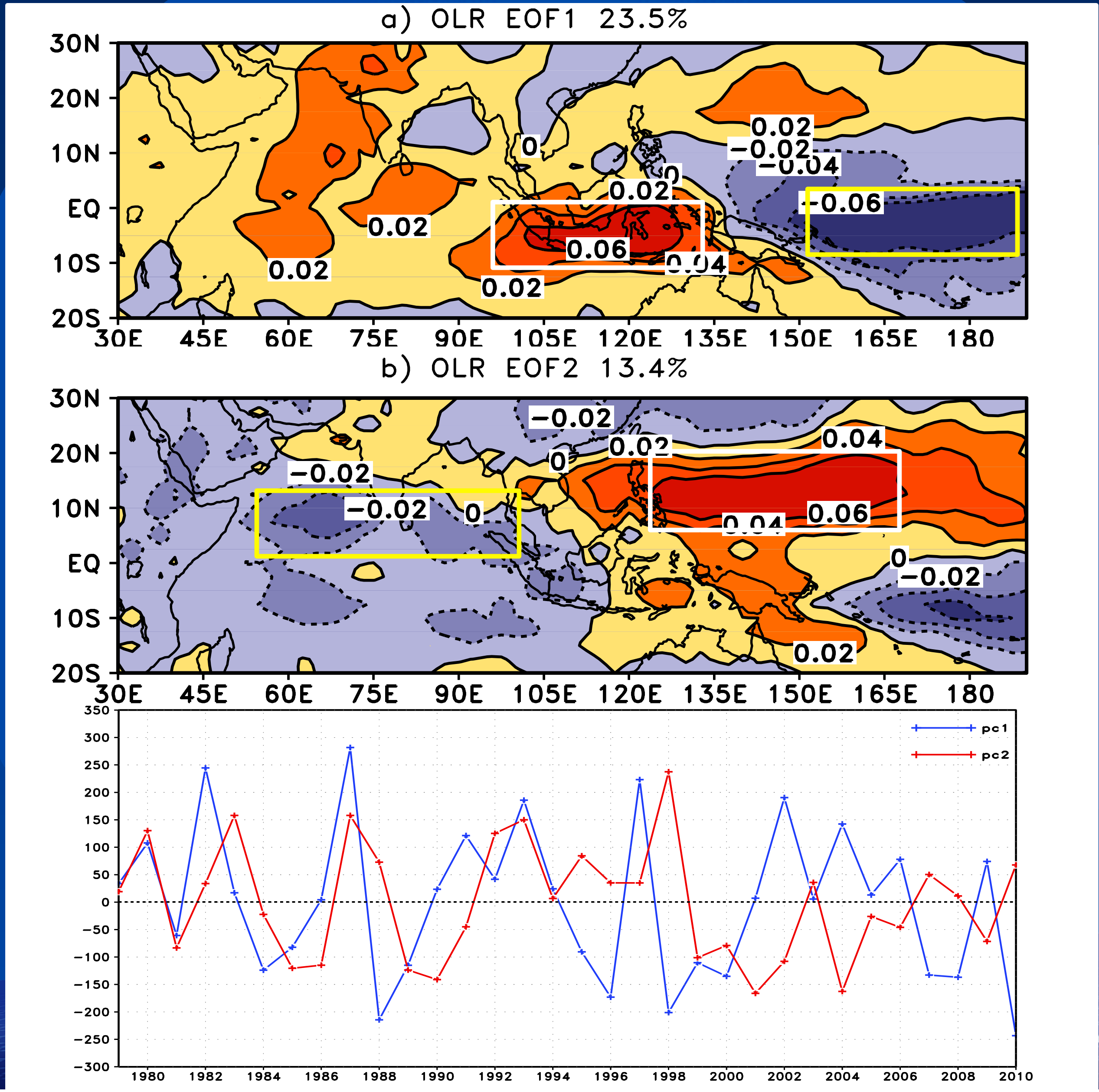
NOAA Interpolated OLR data (1979-2010);

NCEP/NCAR Reanalysis V1：zonal wind, meridional wind, omega, sea level pressure, geopotential height;

EASMI (Li and Zeng, 2002, 2003, 2005)

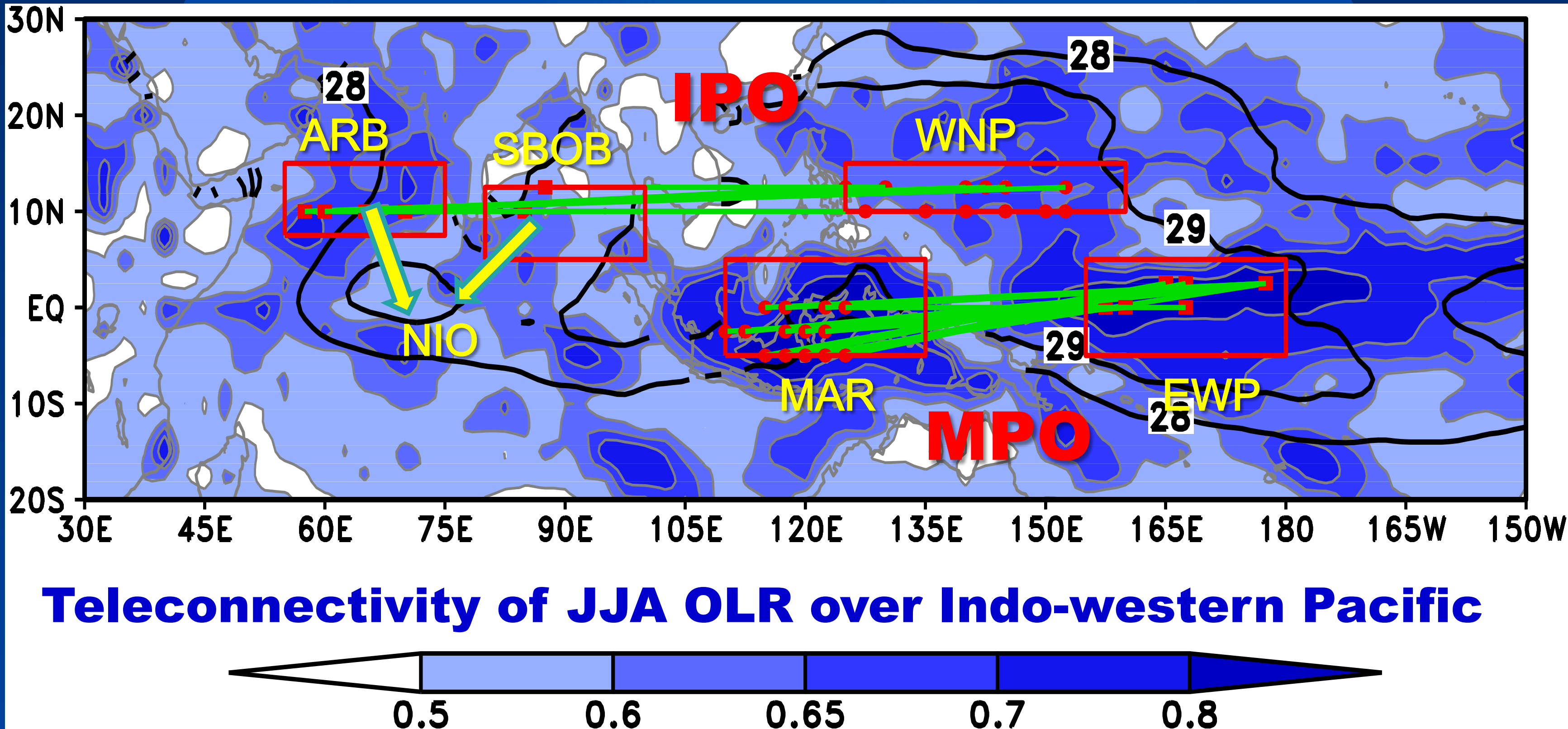
- **Method:**
- **Empirical orthogonal function (EOF)**
- **Teleconnectivity analysis (Wallace and Gutzler, 1981)**
- **Spectrum analysis**
- **Composite analysis**
- **Rossby wave ray theory (Hoskins and Karoly, 1981; Karoly, 1983; Schneider and Watterson, 1984; Li and Nanth, 1994, 1997; Li and Li, 2012)**

The first two leading modes of interannual variability in boreal summer convection over the Indo-Western Pacific



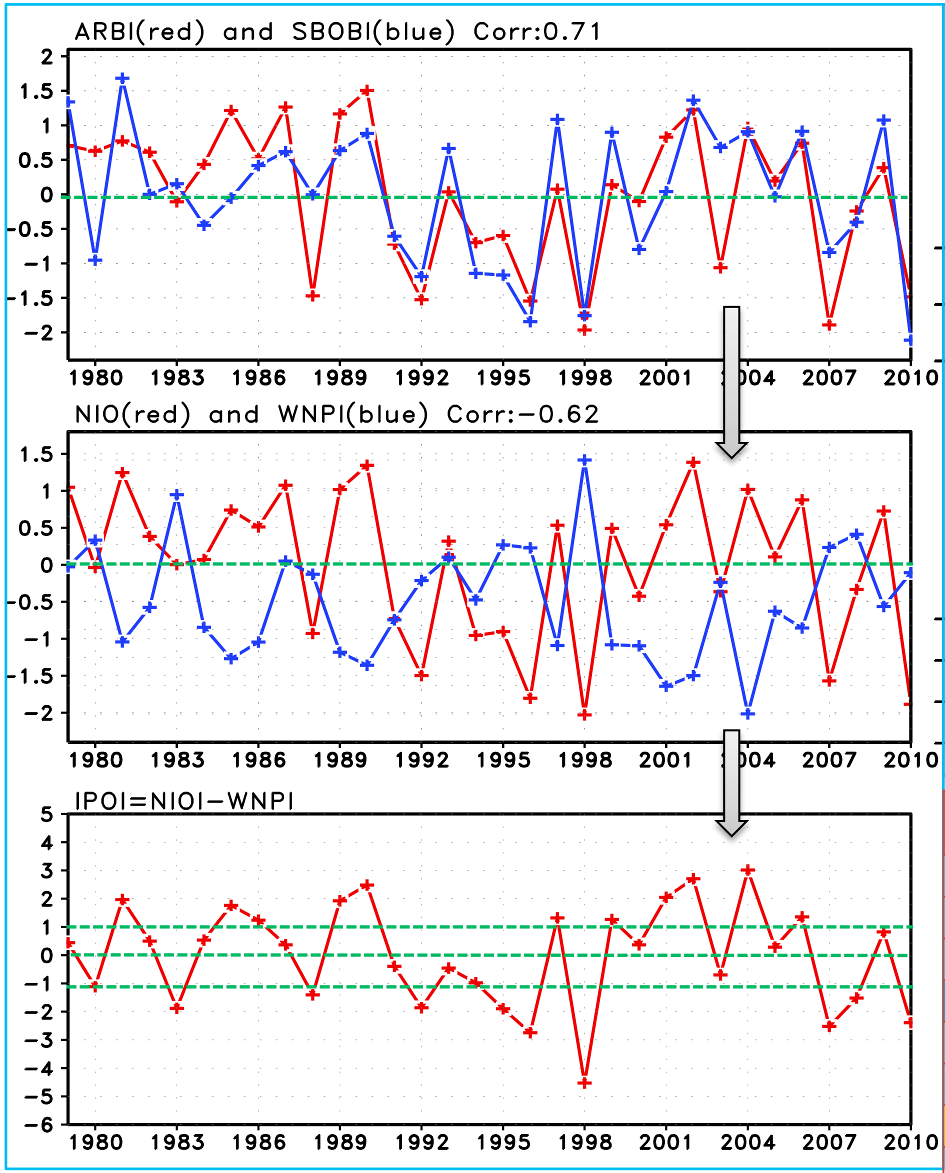
Two dipole patterns: Indo-Pacific oscillation (IPO) and Maritime continent-Pacific oscillation (MPO)

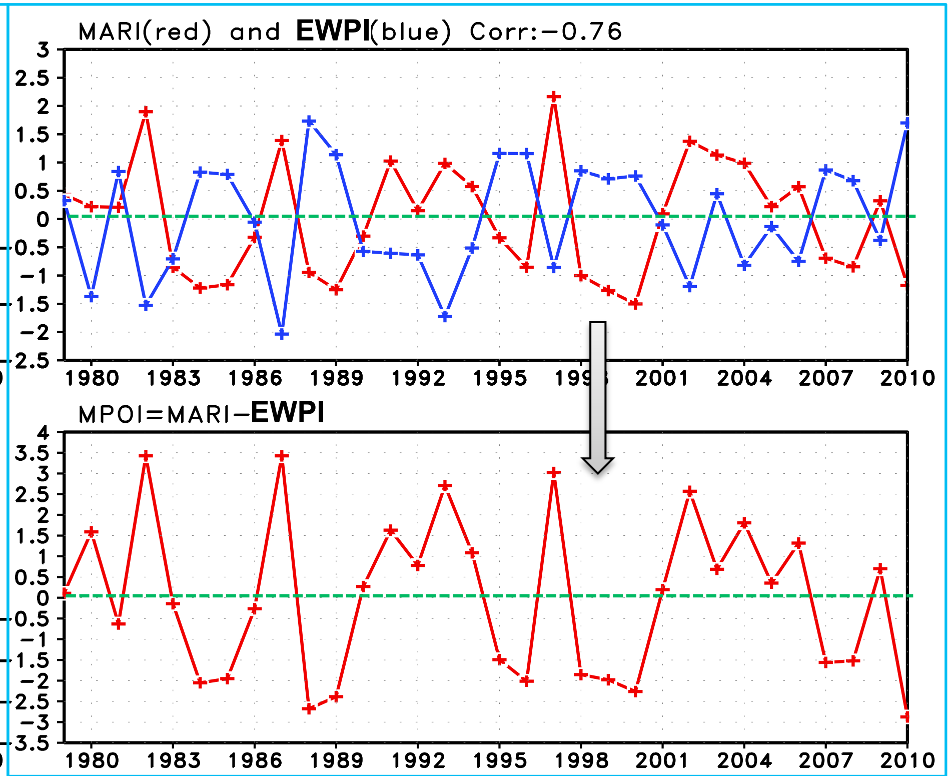
IPO: out-of-phase fluctuation between convection anomalies over NIO and WNP
MPO: out-of-phase fluctuation between convection anomalies over MAR and EWP



ARB (55°E-75°E, 7.5°N-15°N) ; SBOB (80°-100°E, 5°N-12.5°N);
NIO = ARB + SBOB; WNP (125°E-160°E, 10°-15°N);
MAR (110°E-135°E, 5°S-5°N); EWP (155°E-180°, 5°S-5°N);

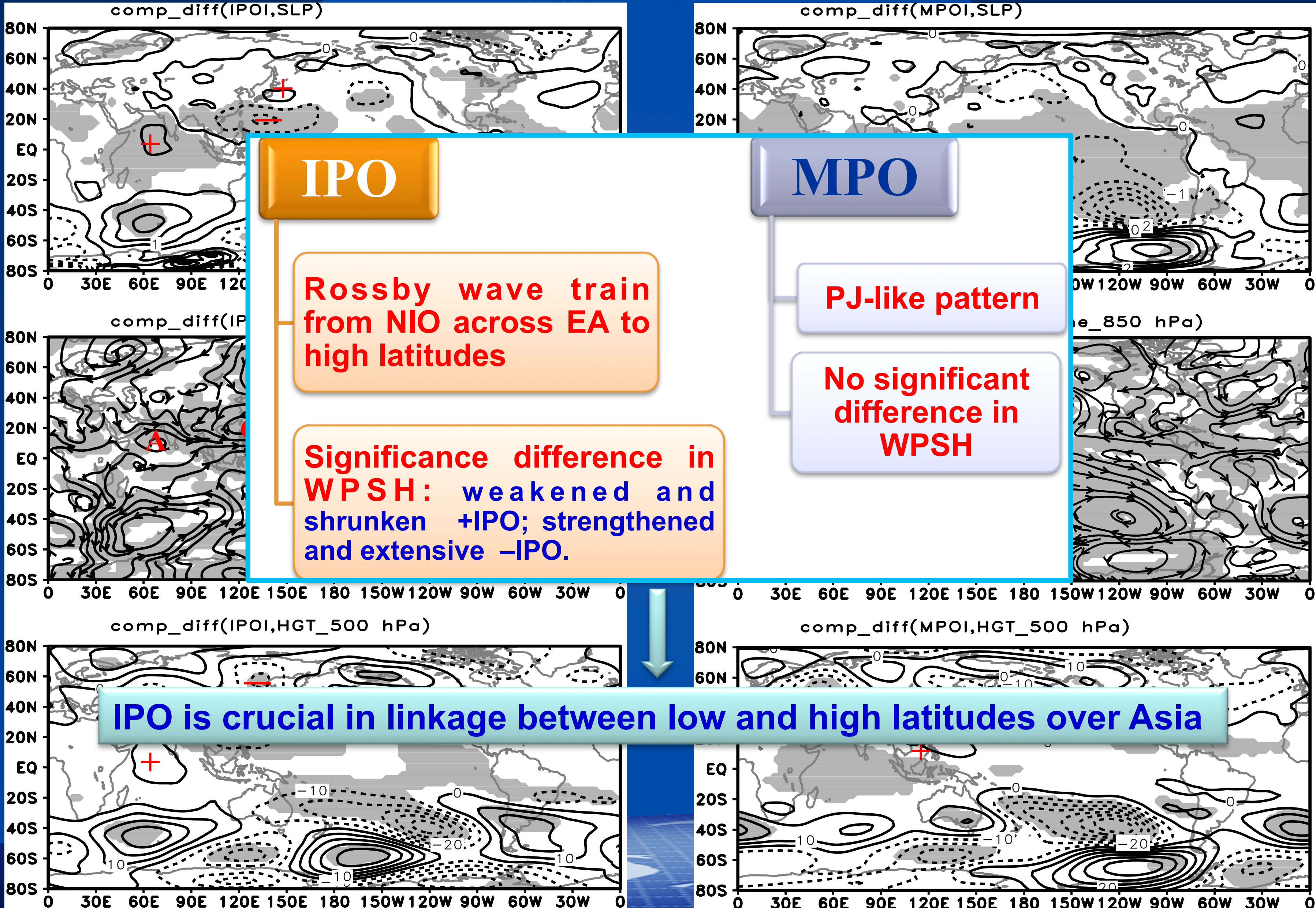
Definition of IPO and MPO indices: to depict the interannual variability of IPO and MPO





Period(a)	Spectrum_IPOI	Spectrum_MPOI
10	0.117	0.116
6.667	0.042	0.117
5	0.072	0.143
4	0.108	0.148
3.333	0.079	0.107
2.857	0.082	0.072
2.5	0.144	0.09
2.222	0.132	0.089

Circulation anomalies associated with IPO and MPO



IPO

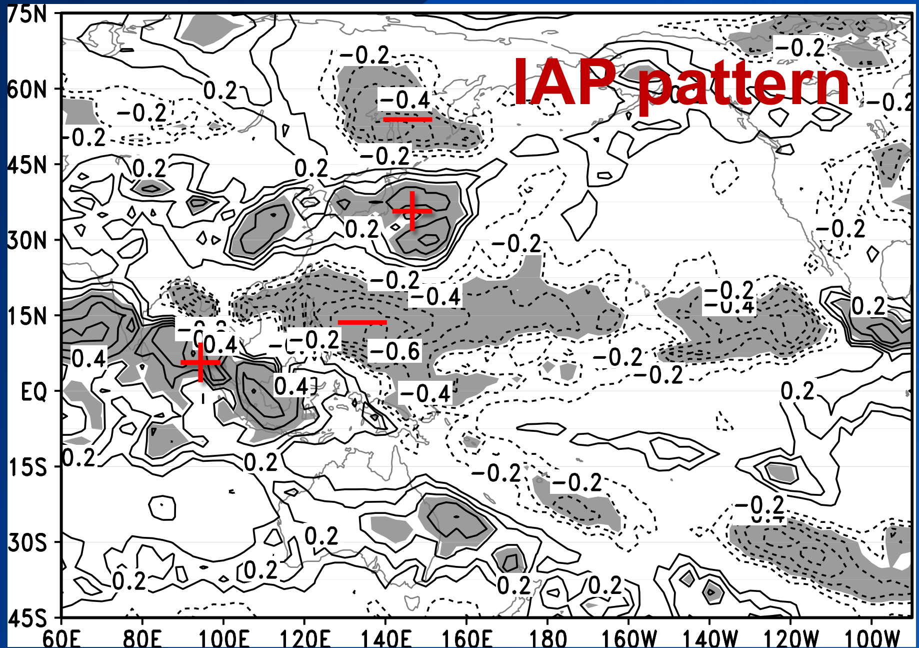
- Rossby wave train from NIO across EA to high latitudes
- Significance difference in WPSH: weakened and shrunken +IPO; strengthened and extensive –IPO.

MPO

- PJ-like pattern
- No significant difference in WPSH

IPO is crucial in linkage between low and high latitudes over Asia

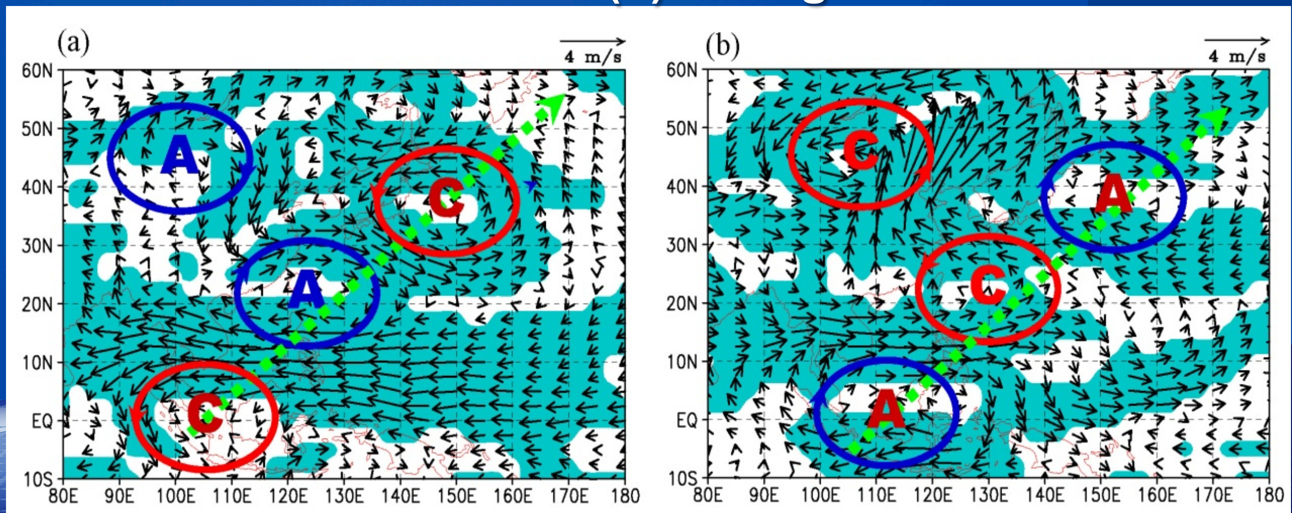
Teleconnection associated with IPO: Indo-Asia-Pacific (IAP) pattern



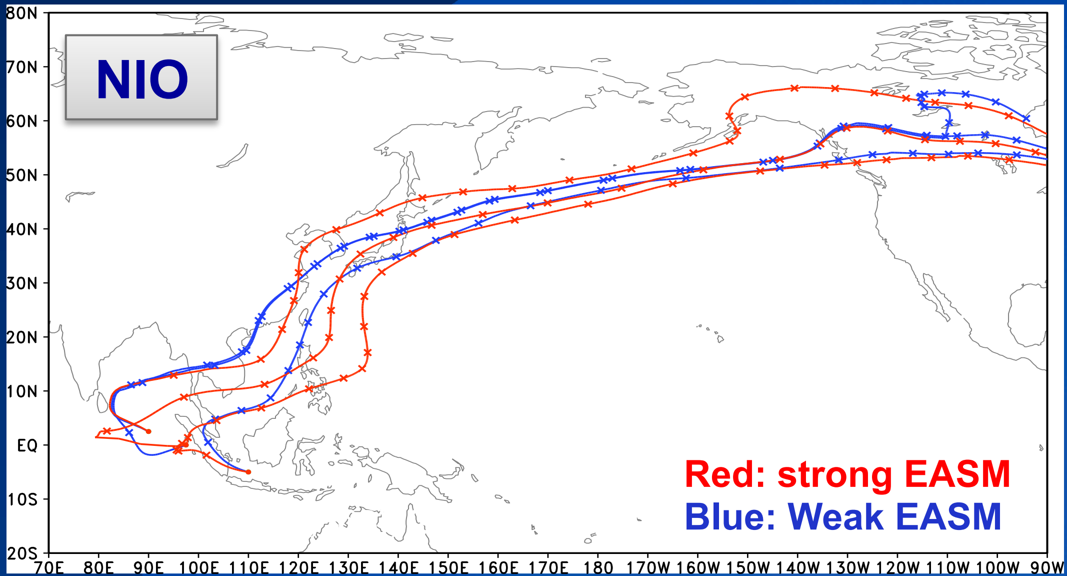
Correlation between EASMI and OLR field

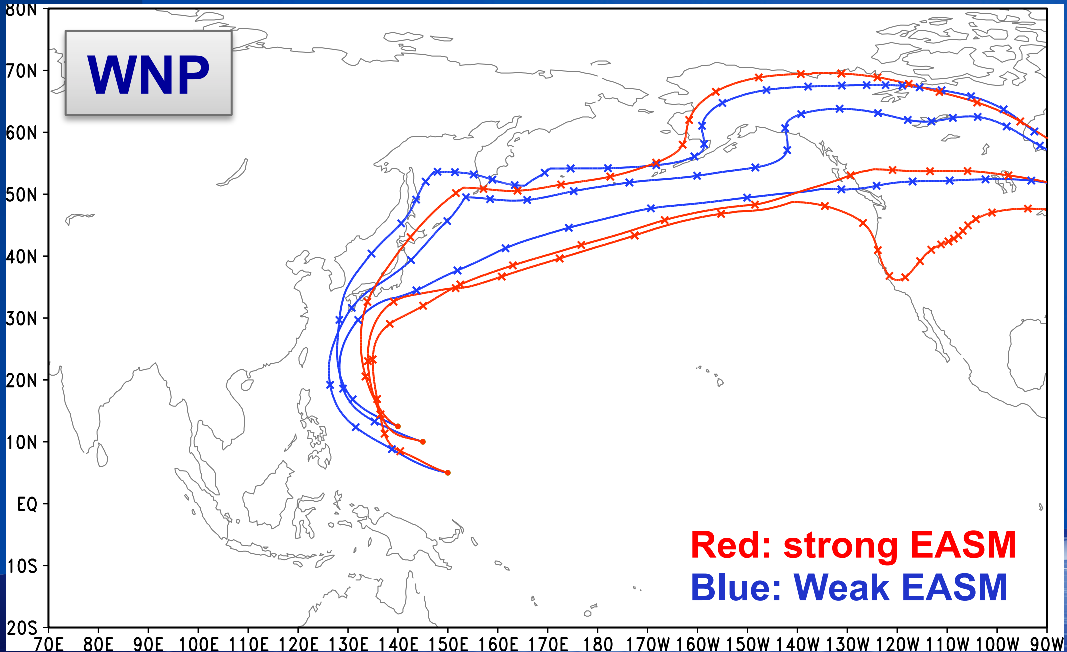
Composite 850 hPa circulation anomalies (Li et al., 2011)

(a) weak EASM: westward shift (b) strong EASM: eastward shift



Rossby wave ray paths in horizontal non-uniform basic flow





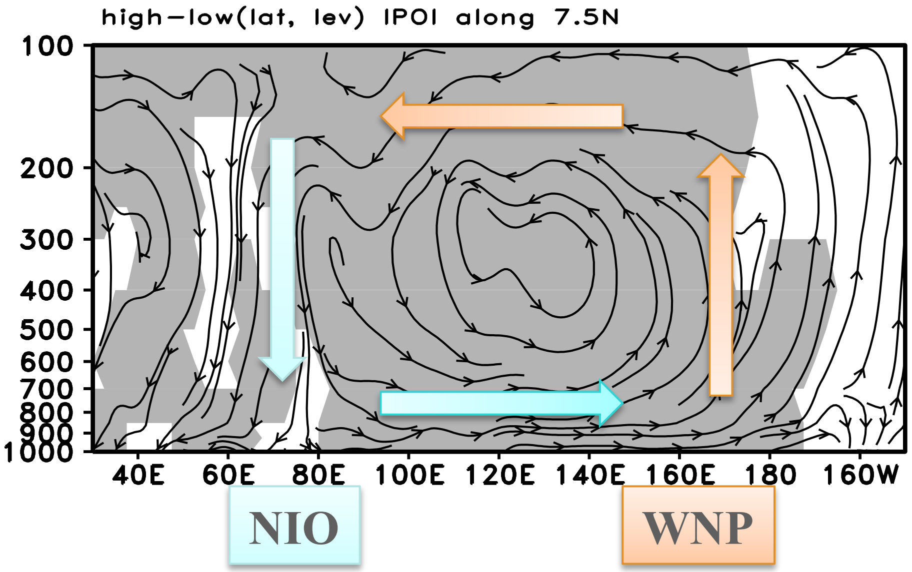
Disturbance source over NIO can excite Rossby waves which propagate to Philippine sea, and further northward to East Asia, even to higher latitudes.

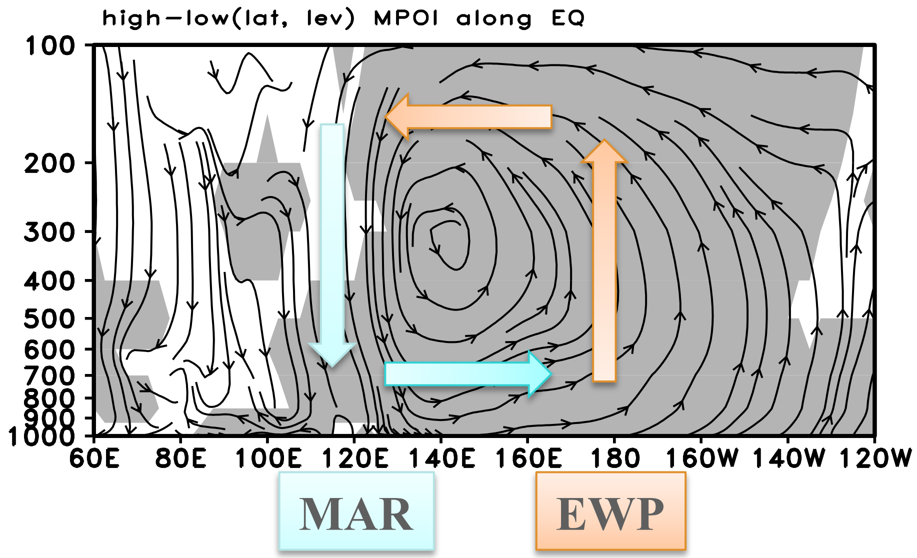
The wave dispersion paths tend to shift eastward in strong EASM years, and westward in weak EASM years.

Crosses indicate 2 day interval.

(Li and Li, 2012)

Vertical circulation anomalies associated with IPO and MPO





Shading indicates >95% confidence

Contents

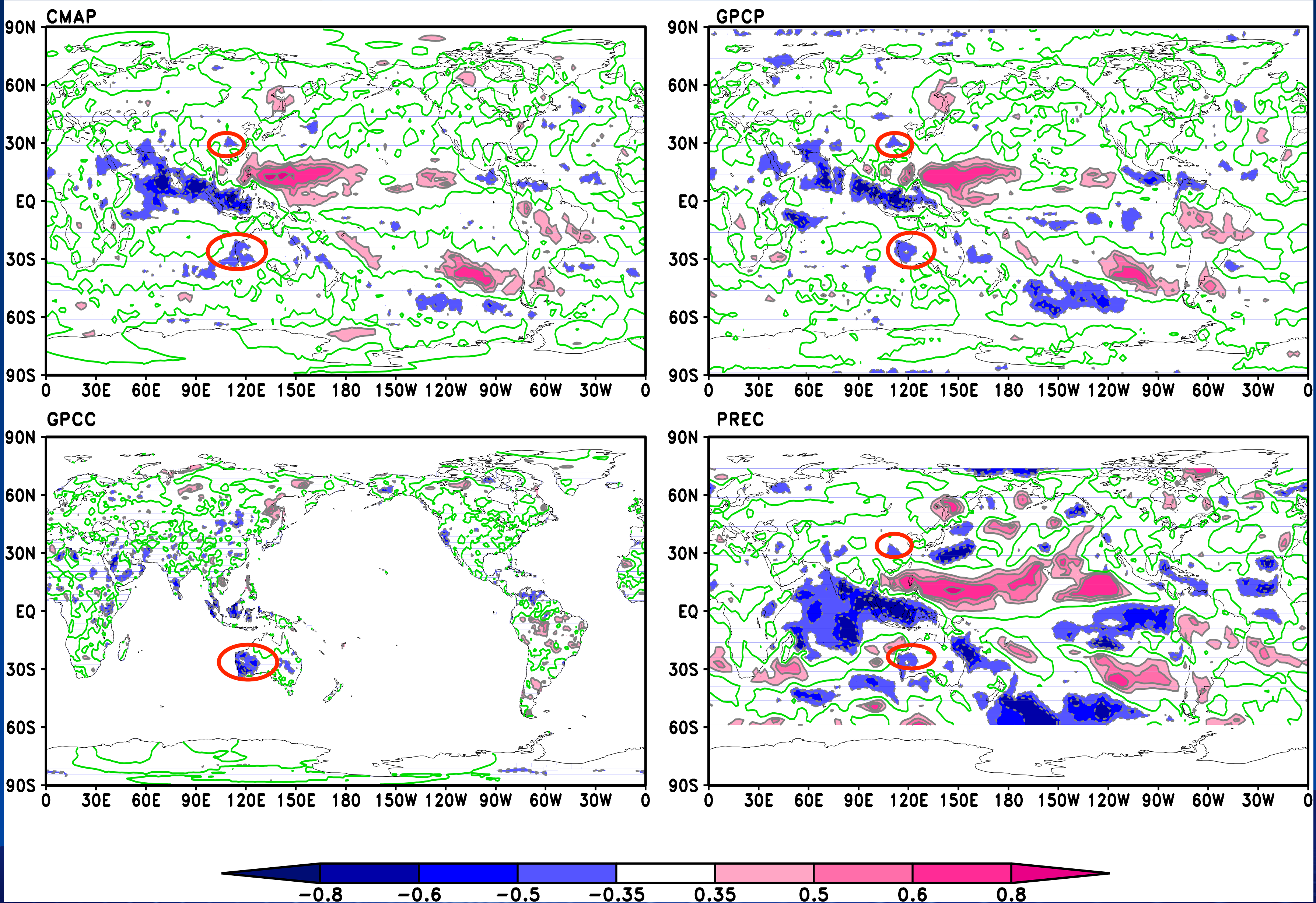
Data and Methodology

- **Jun-July-August data derived from monthly datasets:**

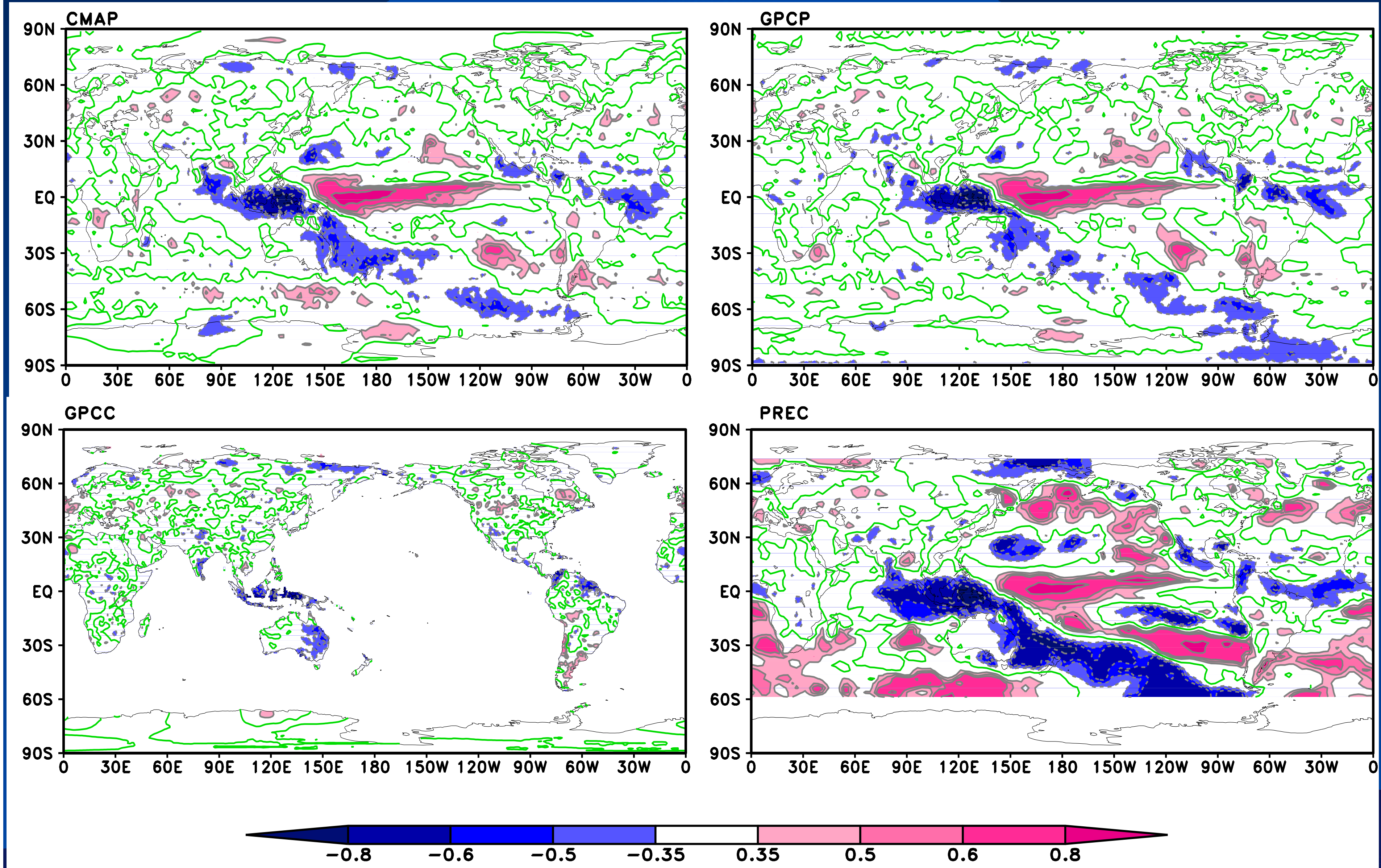
NOAA Interpolated OLR data (1979-2010);
Precipitation data: CMAP, GPCP, GPCC, PREC;
China 160-station rainfall data;
EASMI, SASMI, SASMI1, SASMI2 (Li and Zeng, 2002, 2003, 2005);
All-Indian Rainfall index;
Extended Reconstructed Sea Surface Temperature data (ERSST).

- **Method:**
- **Correlation analysis**
- **Partial correlation analysis**
- **Lead-lag correlation analysis**

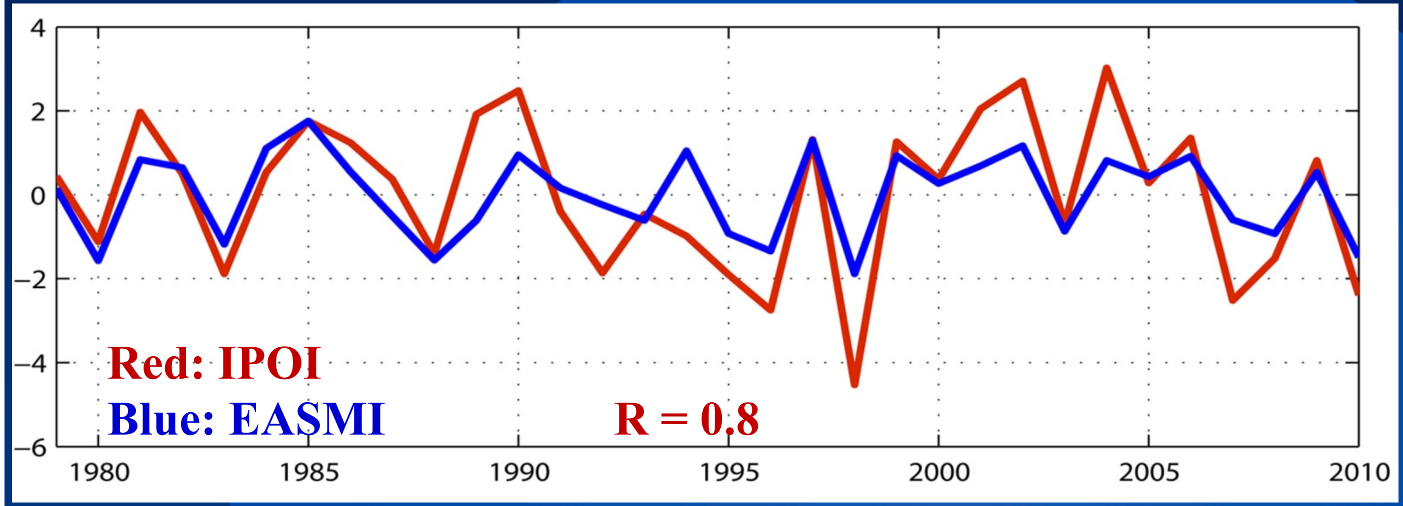
Correlation between IPOI and precipitation in JJA



Correlation between MPOI and precipitation in JJA

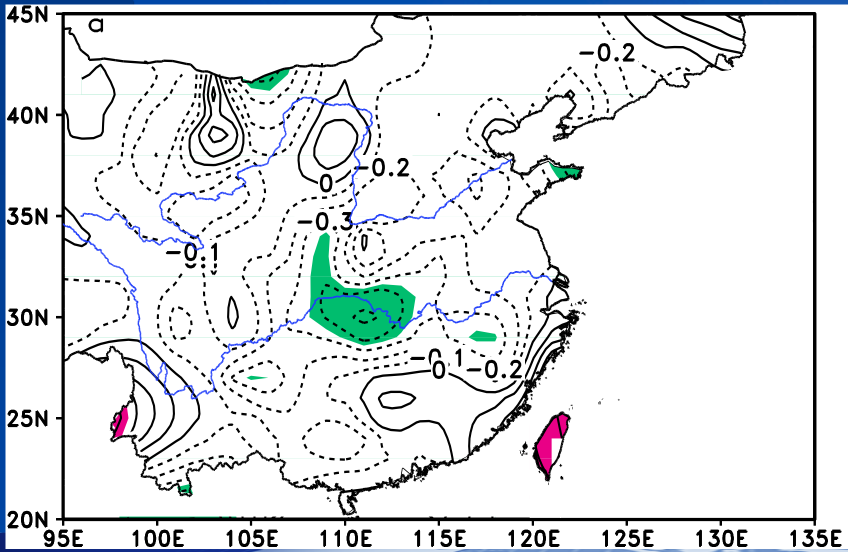


Relation between IPO and EASM

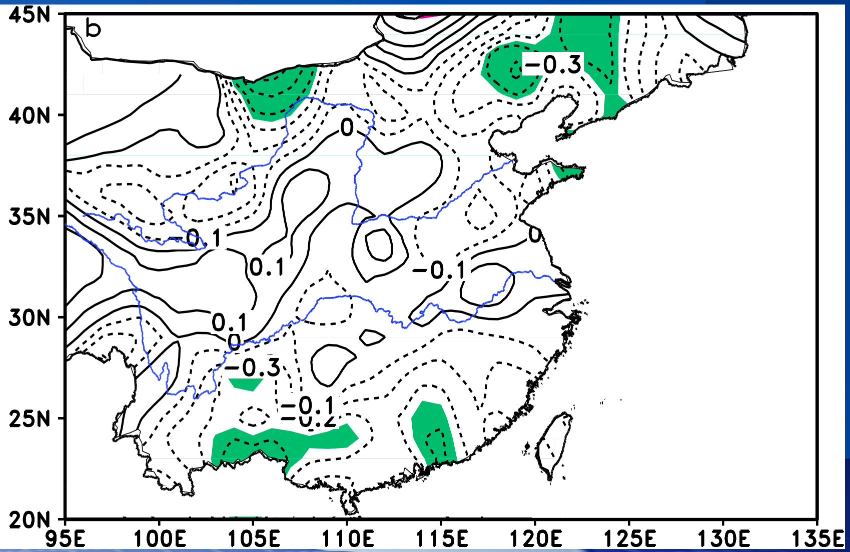


Quasi-biennial variability of EASM is closely related to IPO

r (JJA IPOI, rainfall)



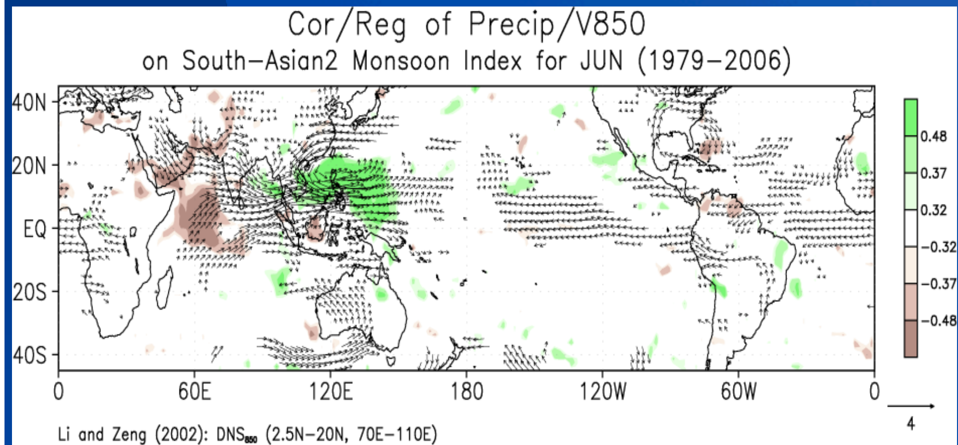
Partial correlation between IPOI and rainfall with EASM signal removed

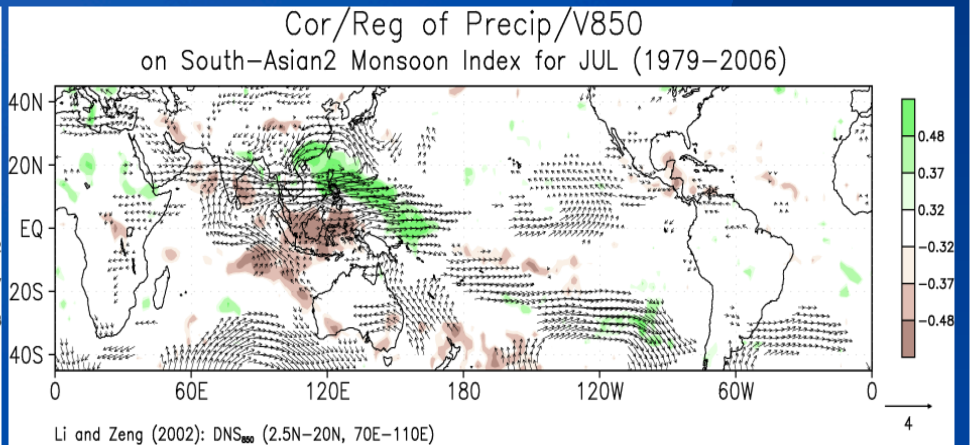


Correlations between OLR indices and monsoon indices

	IPOI	NIOI	WNPI	MPOI	MARI	EWPI
EASM	0.8	0.63	-0.8	0.31	0.31	-0.28
SASM	0.28	0.1	-0.41	0.11	0.09	-0.11
SASM1	-0.06	-0.21	-0.1	-0.07	-0.05	-0.08
SASM2	0.77	0.66	-0.72	0.43	0.35	-0.46
AIRI	-0.32	-0.38	0.19	-0.26	-0.26	0.22

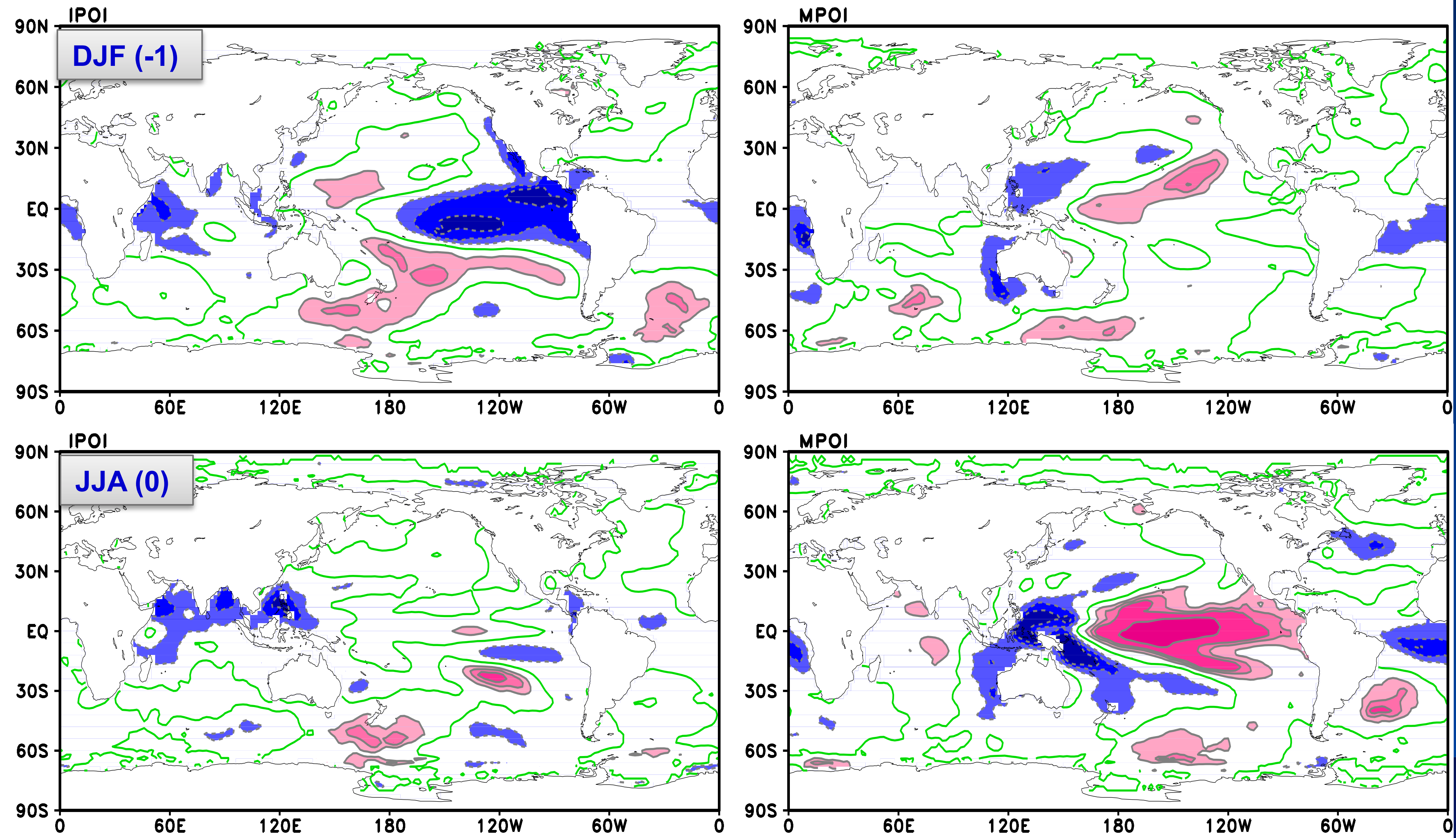
The southeast Asian summer monsoon is closely related to both IPO and MPO.





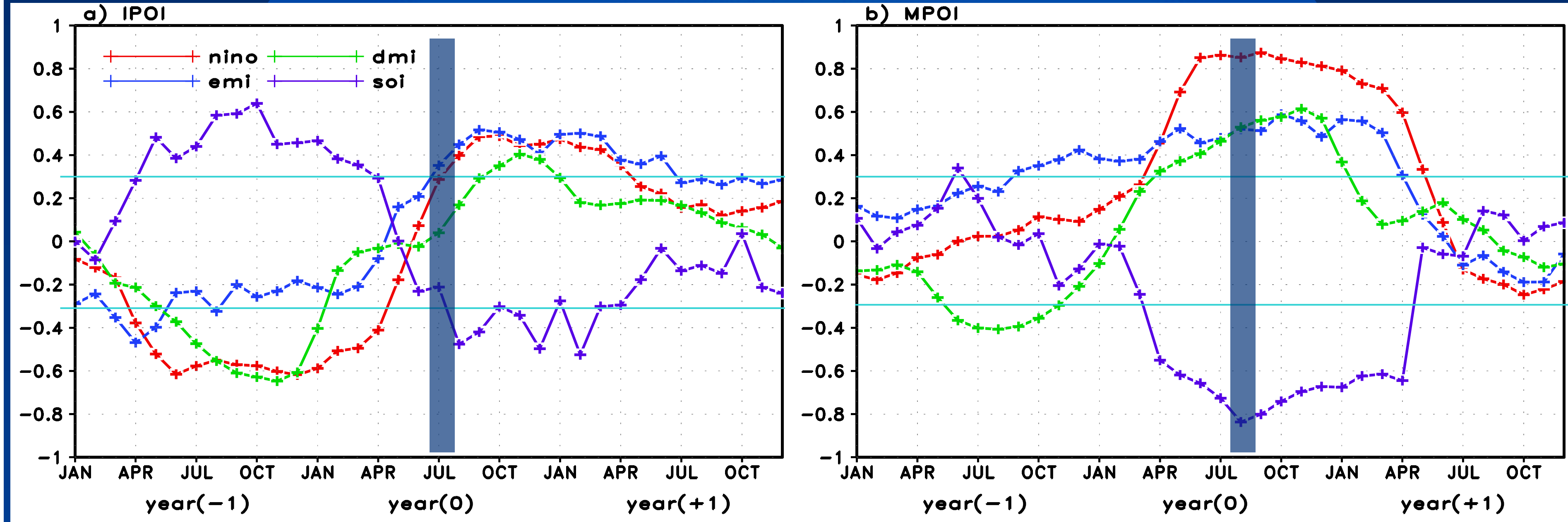
JJA 1979-2010, red indicates significant at the 95% confidence level;
- SASM: (5-22.5N, 35-97.5E); SASM1: Southwest Asia (2.5-20N, 35-70E);
- SASM2: Southeast Asia (2.5-20N, 70-110E); AIRI: All-Indian Rainfall index.b

Correlations between IPOI, MPOI and SST



Significant relationships between IPO and ENSO, Modoki, IOD show a quasi-biennial cycle

Significant relationships between MPO and ENSO, Modoki, IOD could persist to next spring



Lead-lag Correlations between IPOI, MPOI and monthly SST indices.
– /+ denotes SST leading/lagging.

Nino: SST index over nino3.4 (5°S-5°N, 170°W-120°W) region *(From NOAA/CPC)*
DMI: IOD index *(From JAMSTEC)*
EMI: El niño Modoki index *(From JAMSTEC)*
Soi: Southern Oscillation index *(From NOAA/CPC)*

Contents

Data and Methodology

- **Extended boreal summer (May-Oct) daily data:**

  NOAA Interpolated OLR data (1979-2008);

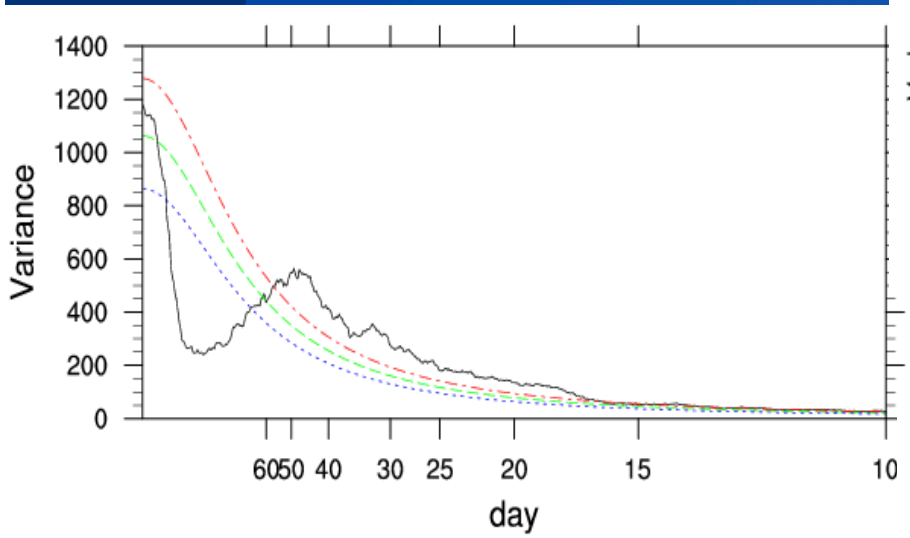
  EAMI (Li and Zeng, 2002, 2003, 2005);

  NCEP/NCAR Reanalysis data

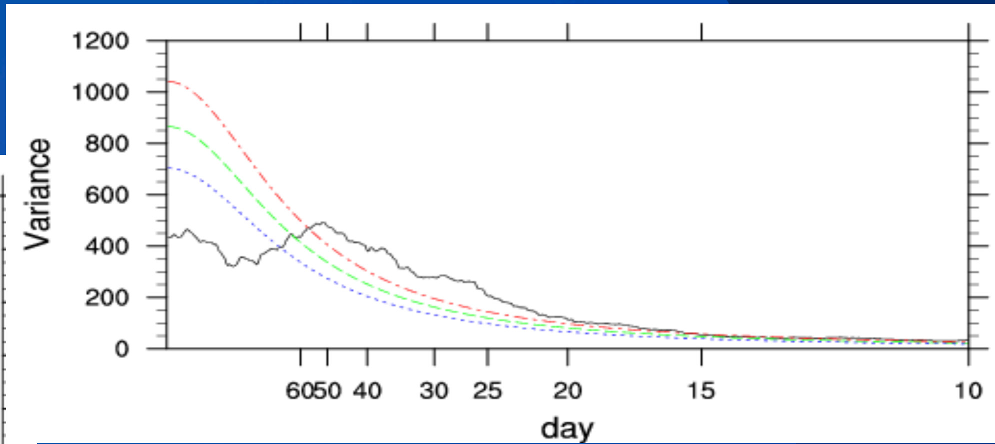
- **Method:**
- **Spectrum analysis**
- **Empirical orthogonal function**
- **Teleconnectivity analysis**
- **Correlation analysis**
- **Lead-lag correlation analysis**

All the spectral analyses of the whole year, boreal summer and boreal winter daily OLR series over the Indo-Pacific region show prominent 30-50d oscillation.

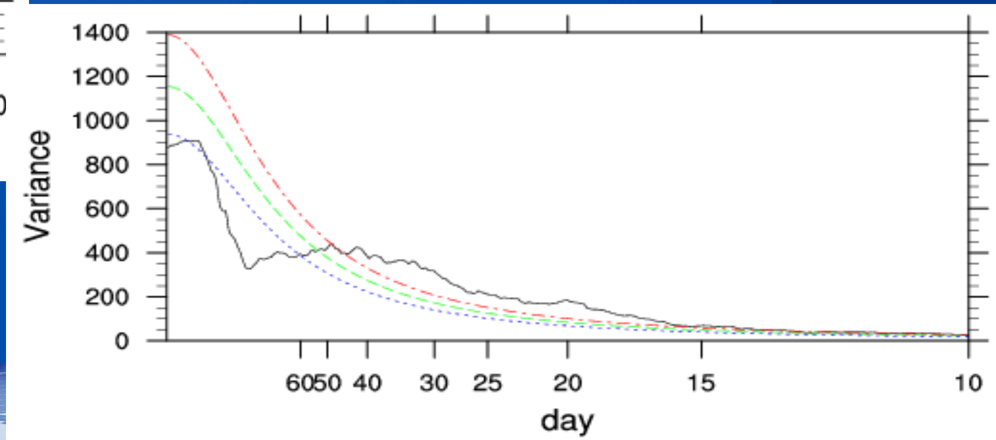
OLR whole year



OLR summer



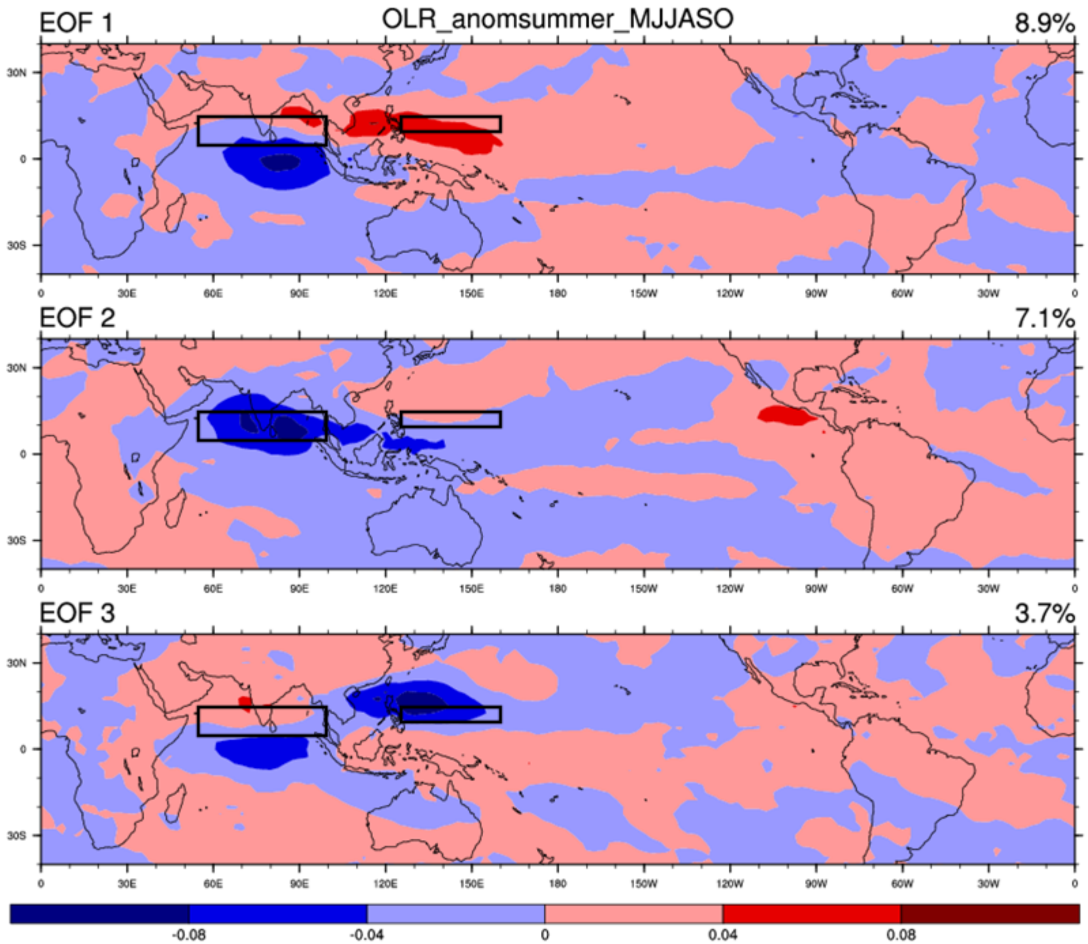
OLR winter



Entire daily series (1979-2008)

Indo-Pacific (20°S-20°N, 60°E-150°W)

All the three modes for 30-60d-filtered OLR indicate a seesaw pattern over NIO and WNP



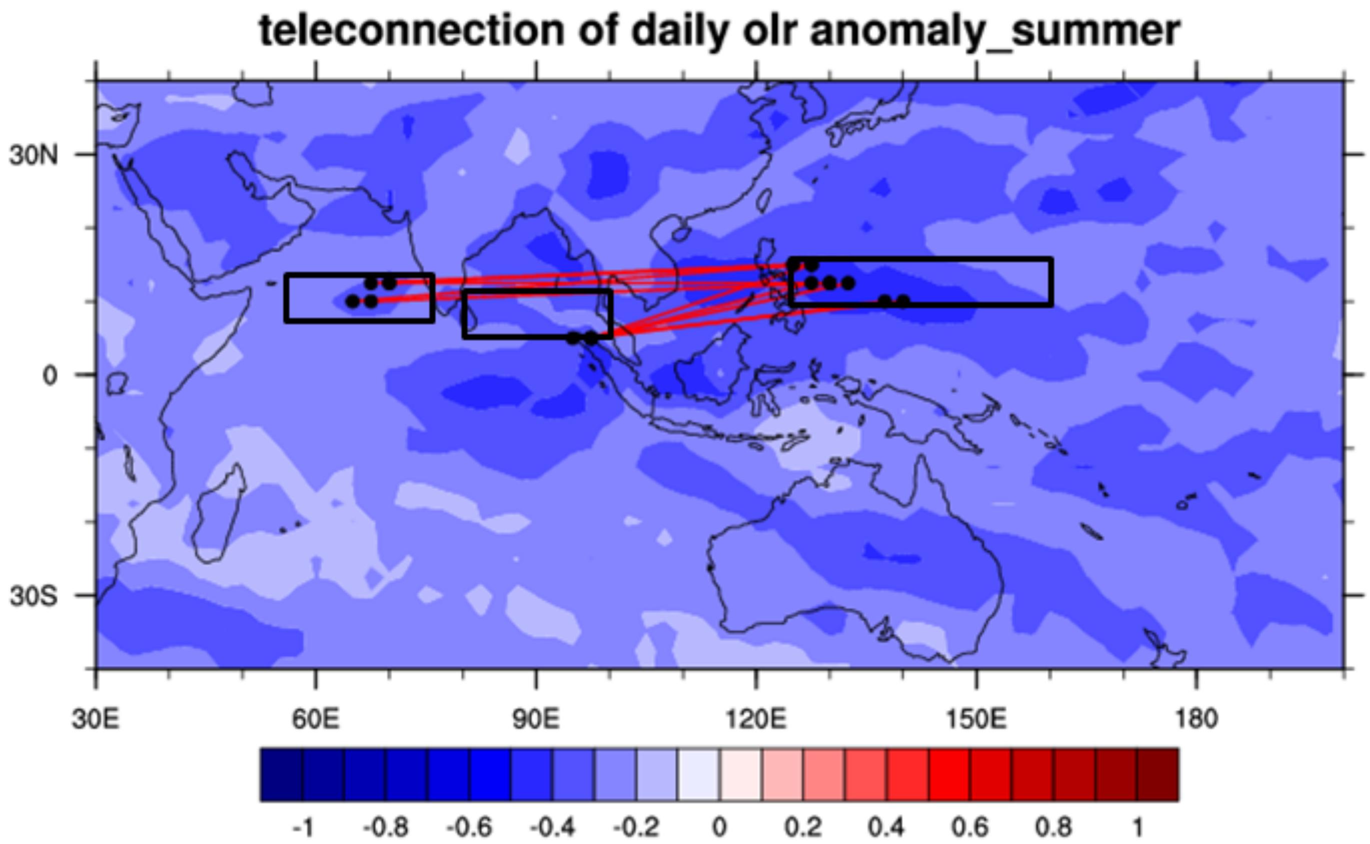
Dipole over the equatorial Indian Ocean and the South China Sea to WNP

Center over the NIO region

Centers over the WNP and equatorial Indian Ocean

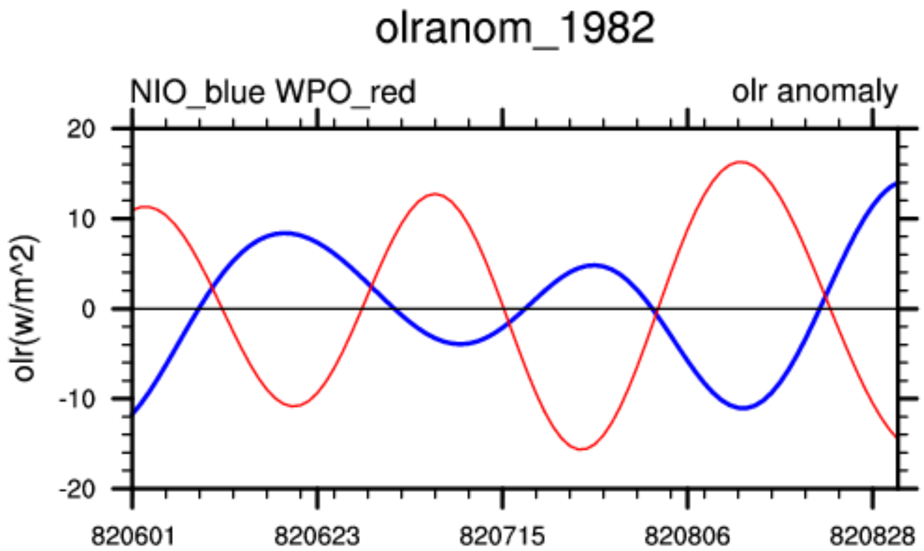
NIO (5°N-15°N, 55°E-100°E)
WNP (10°N-15°N，125°E- 160°E)

IPO pattern is also observed in the intraseasonal variability of convection

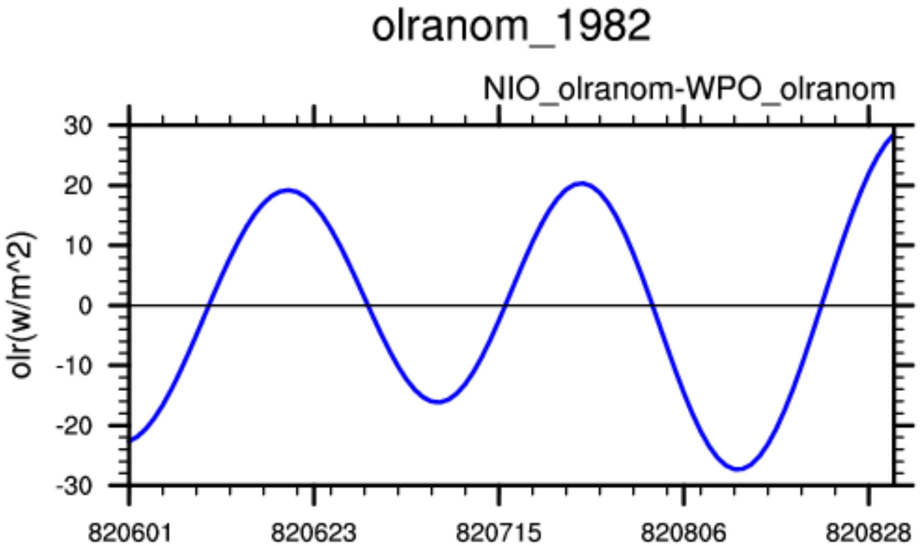


The 30-60 day band pass filter is applied to the summer daily data during the period 1979-2008. Shading indicates >95% significance.

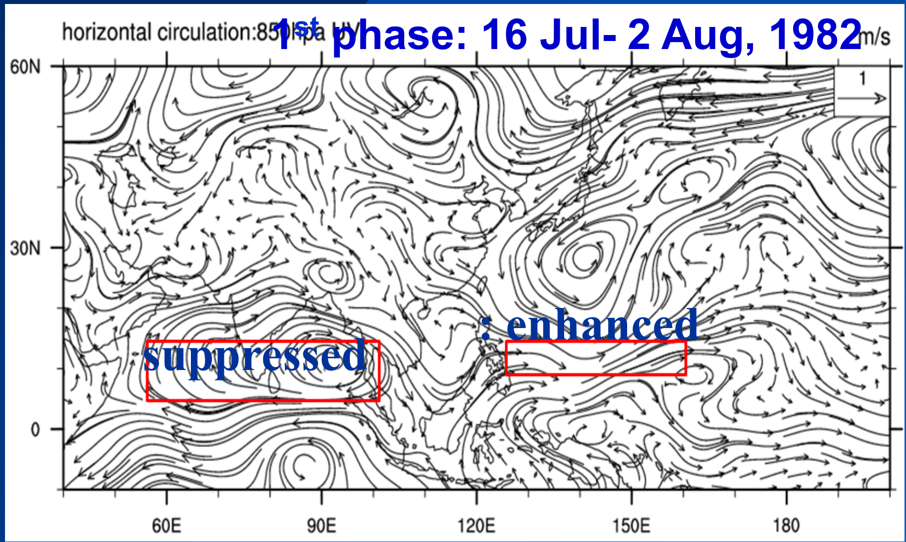
The daily IPO index is defined as same as the seasonal IPO index except for the daily resolution

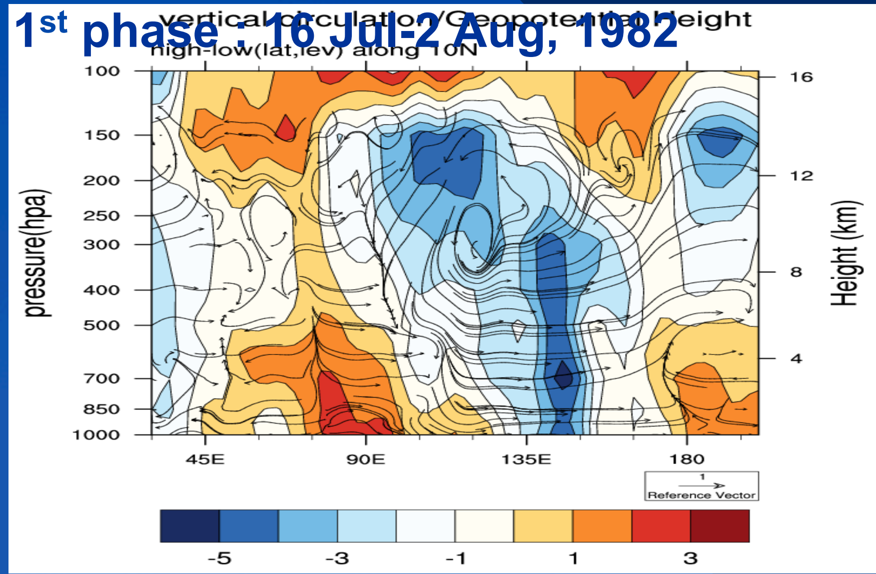


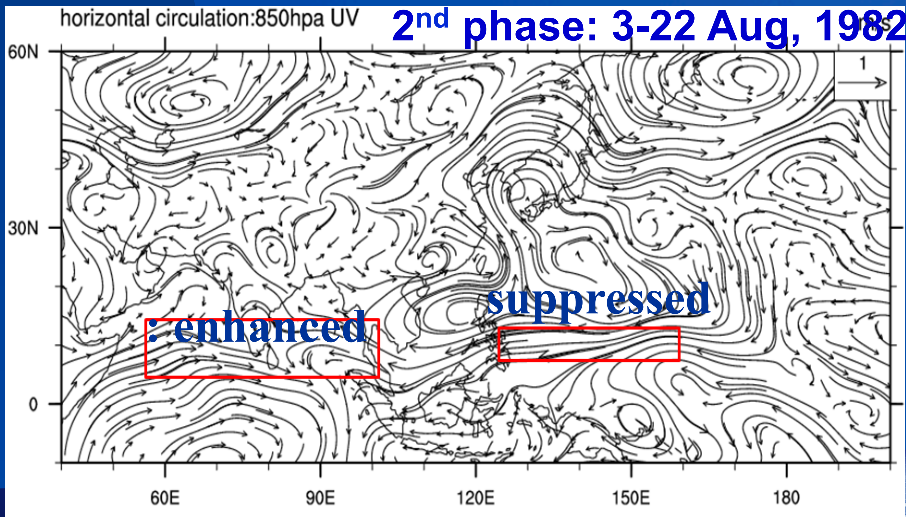
Correlation coefficient = − 0.87

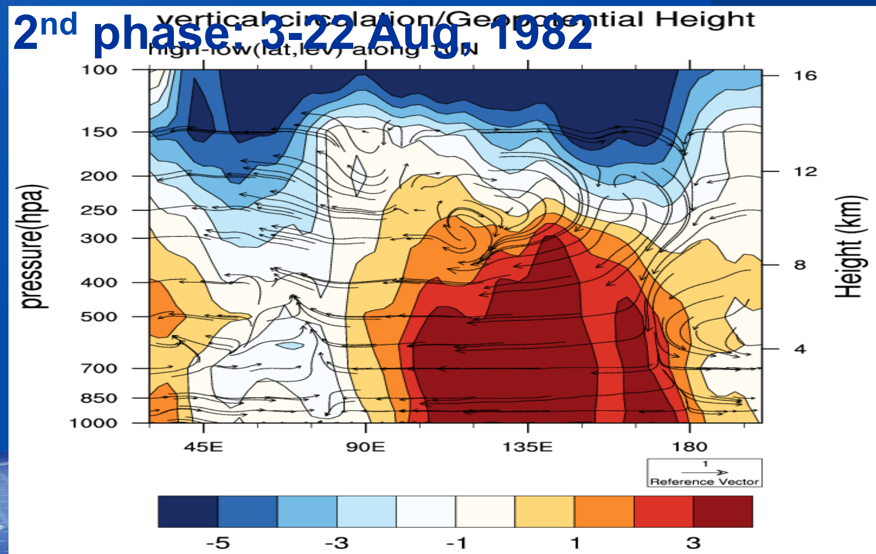


Circulation anomalies in the strongest stage of different IPO phases

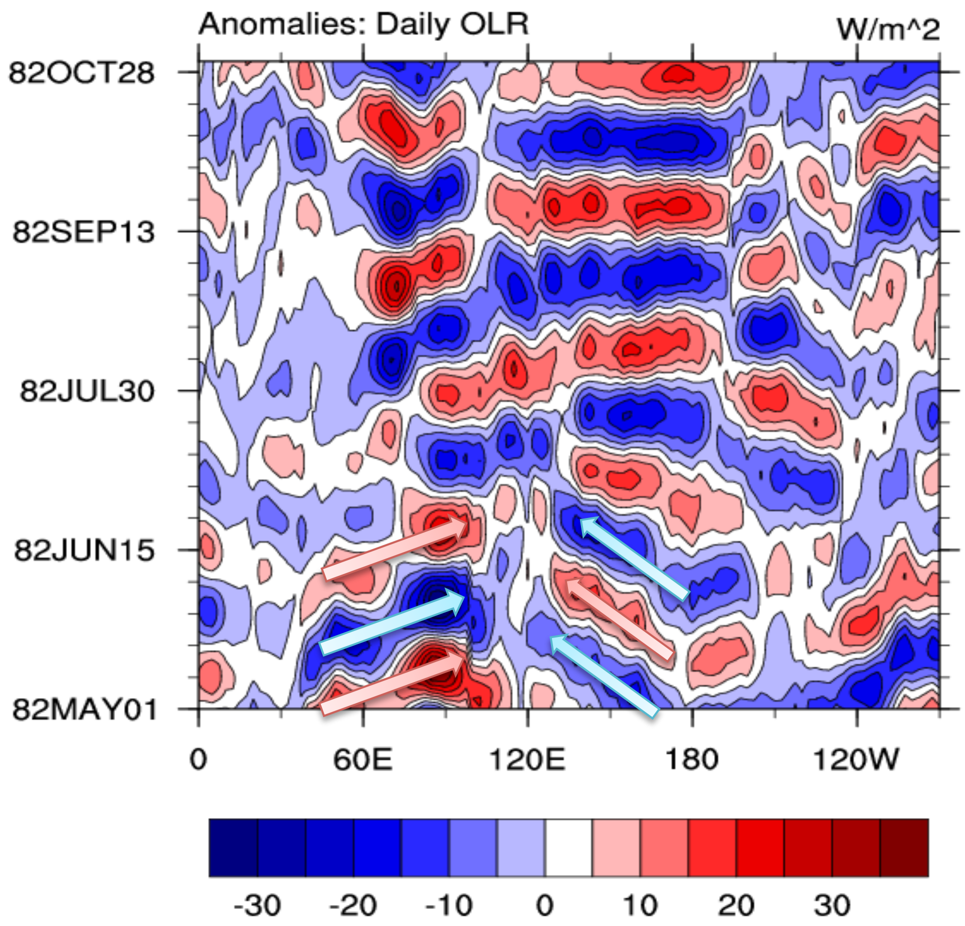








Longitude-time evolution of daily OLR anomalies along 10°N during May-Oct in 1982



Eastward propagation over NIO;
Westward propagation over WNP;

Out-of-phase variations over NIO and WNP;

30-60 day oscillation period

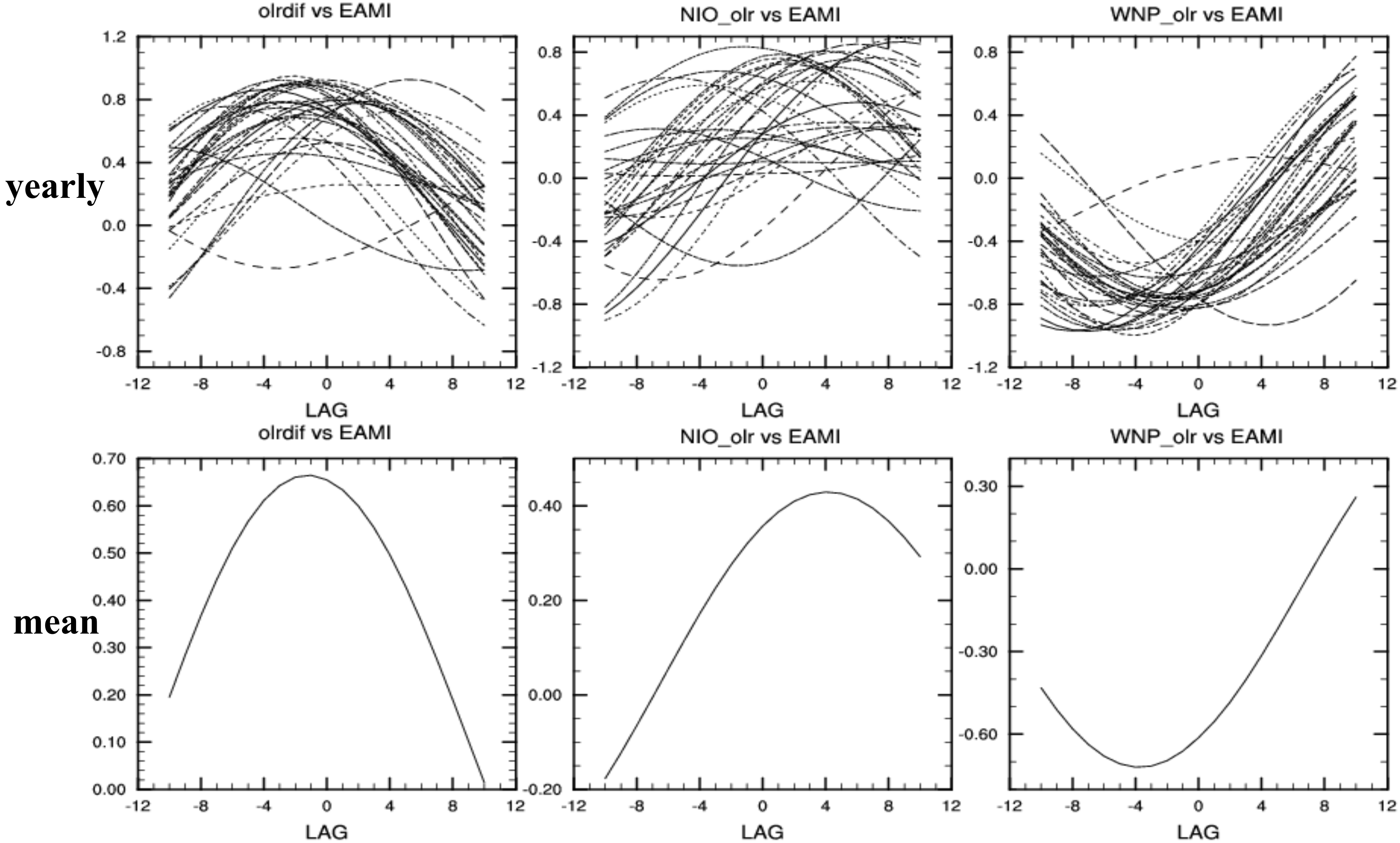
Contents

Summary

- **Two dipole patterns in boreal summer convection:**
  - IPO: Indo-Western Pacific convection oscillation
  - MPO: Maritime continent-EWP convection oscillation
- **IPO and EASM:**
  - IAP pattern
  - Rossby wave energy dispersion
- **SEASM and IPO and MPO:**
- **IPO and ENSO**
- **MPO and ENSO**

Li, Li and Feng, 2013: Boreal Summer Convection Oscillation over the Indo-Western Pacific and Its Relationship with the East Asian Summer Monsoon , **Atmos. Sci. Lett.**

Discussion: Lead-lag correlations between IPOI and the East Asian Monsoon Index

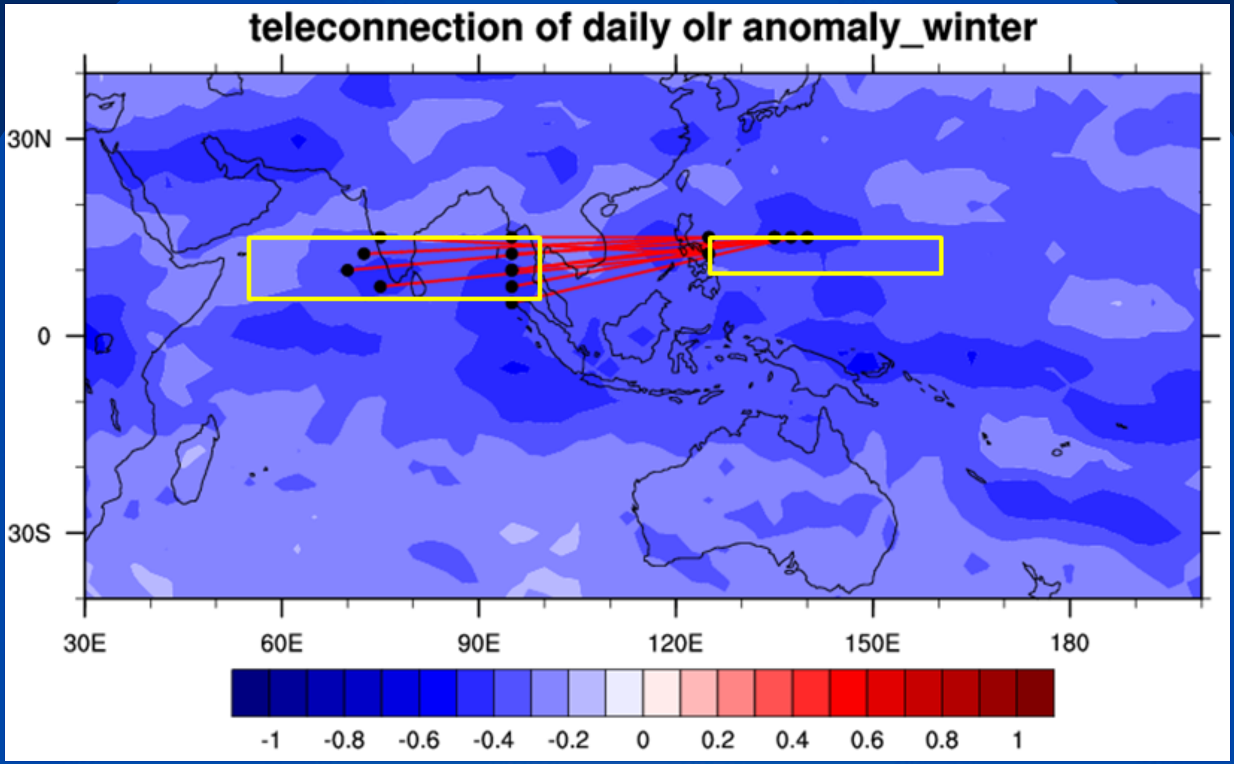


IPOI leads EAMI 1 day
R = 0.66

NIOI lags EAMI 4 days
R = 0.43

WNPI leads EAMI 4 days
R = -0.72

- intraseasonal IPO
- IPO in winter?



- North Pacific oscillator
- ENSO→ IPO; MPO→ ENSO
- Tropical Atlantic SST <-→ IPO & MPO
- Model simulation;
- ……

(1) EGU 2013, Vienna, Austria, 7- 12 April 2013

AS1.11: The global monsoon system: variability and dynamics

Convener: Jianping Li (China)

Co-conveners: Andrew Turner (UK); Annalisa Bracco (USA); Pascal Terray (France)

(2) Davos Atmosphere and Cryosphere Assembly 2013, An IUGG (IAMAS & IACS) Event

July 8-12, 2013, Davos, Smithland

http://www.daca-13.org/

DACA-13

Symposium B4: Global Monsoon, Tropical Cyclones and Tropical Dynamics

Symposium lead convener: Jianping Li

- **Session B4.1: Global monsoon system: Past, present and future**

  Jianping Li (China); Bin Wang (USA); Hugo Berbery (USA); Harry Hendon (Australia); Jun Matsumoto (Japan); Georg Kaser (Austria); Andrew Turner (UK)

- **Session B4.2: Tropical cyclones**

  Patrick A. Harr (USA); Elizabeth A. Ritchie (USA); Kristen L. Corbosiero (USA); Noel Davidson (Australia)

- **Session B4.3 Tropical dynamics**

  David S.Nolan (USA); Robert Burgman (USA); Eric Maloney (USA); Stefan Tulich (USA)

(3) Davos Atmosphere and Cryosphere Assembly 2013, An IUGG (IAMAS & IACS) Event

July 8-12, 2013, Davos, Smithland

http://www.daca-13.org/

DACA-13

Session A3.1 ENSO and decadal variability under climate change

Lead Convener: Jin, Fei-Fei

Co-convener: Jianping Li

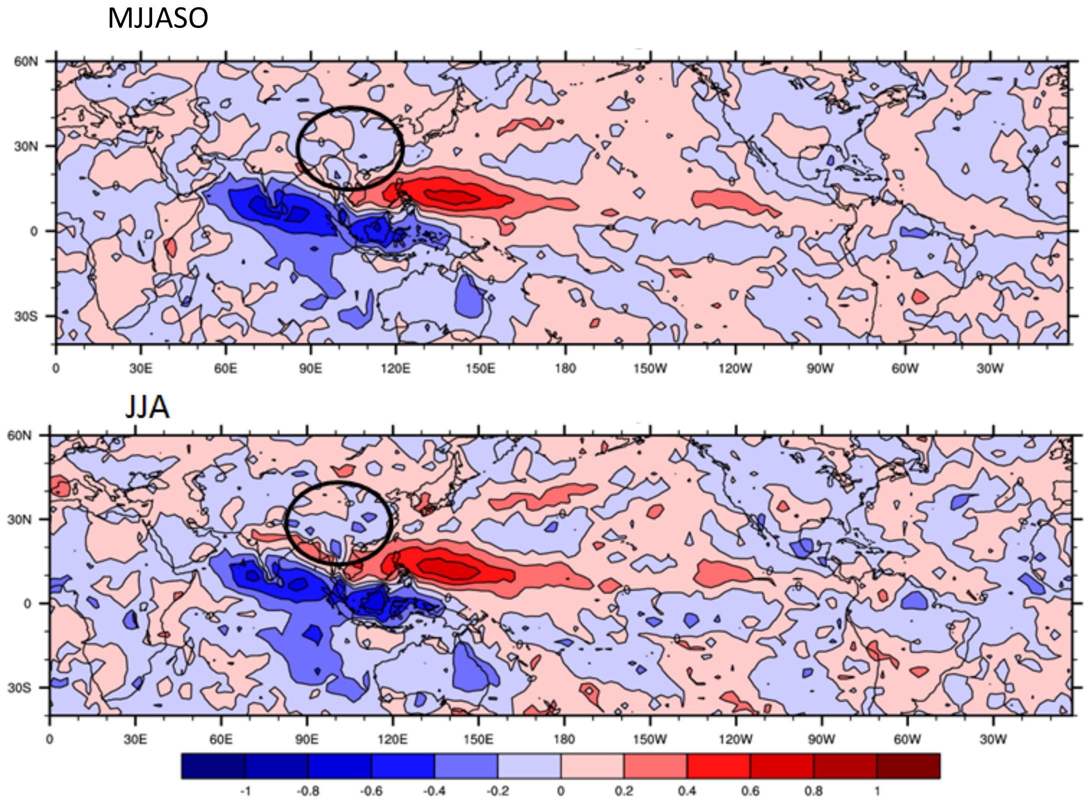
The El Niño-Southern Oscillation (ENSO), one of the most important drivers on climate variability, has profound climatic, environmental, societal, and economical impacts on both global and regional climate. Evidences, albeit limited, suggest that the basic characteristics of ENSO, including its sea surface temperature pattern, its amplitude and frequency, and its types and teleconnections etc., have been undergoing changes. However, projections for potential future changes are diverse and the whole issue how ENSO may respond to global warming and thus contribute to the global and regional climatic and environmental changes is far from understood and is an important subject of intense research worldwide.

This symposium invites contributions regarding the latest scientific advances on observational, theoretical and modeling studies on: ENSO dynamics, ENSO impacts, ENSO predictability and prediction, ENSO and its relation to decadal variability, and ENSO projected changes and the associated impacts due to anthropogenic forcing.

Thank you！

LASG

Discussion: intraseasonal IPO



R=0.2(indicates >95% significance)

High correlations over NIO and WNP, as well as East Asia