Northward propagating ISO dynamics over East Asia and an association with ENSO

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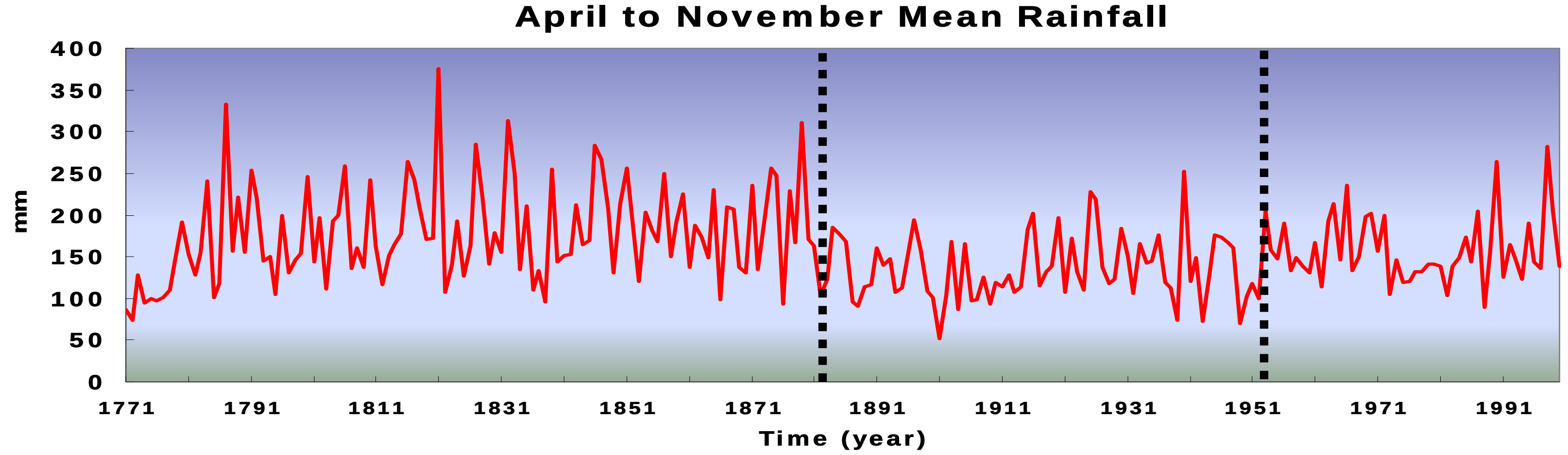
Introduction

- Climatic change : long-term record (230 years) of monthly precipitation for Seoul
  - Data : Monthly precipitation in Seoul from 1771 to 2000 : **Chukwookee rainfall**
  - The epochs were determined on the basis of **Pettitt's change point detection test**



- The interannually anomalous fluctuations are significant

Total variance = **Variances of annual mean** + (Mean of annual standard deviations)^2 + **Variances of annual standard deviations**

	1771-1881	1882-1952	1953-2000
Variance of annual means	**3384.9**	**1528.8**	**1576.2**
Variance of annual standard deviations	**6516.2**	**4230.2**	**3328.3**

Ha, K.-J., and E. Ha, 2006: Climatic change and interannual fluctuations in the long-term record of monthly precipitation for Seoul. *Int. J. Climatol.*, **26**, 607-618.

Introduction

➢ EOFs in sub-seasonal structure (Shifting toward delayed tendency)

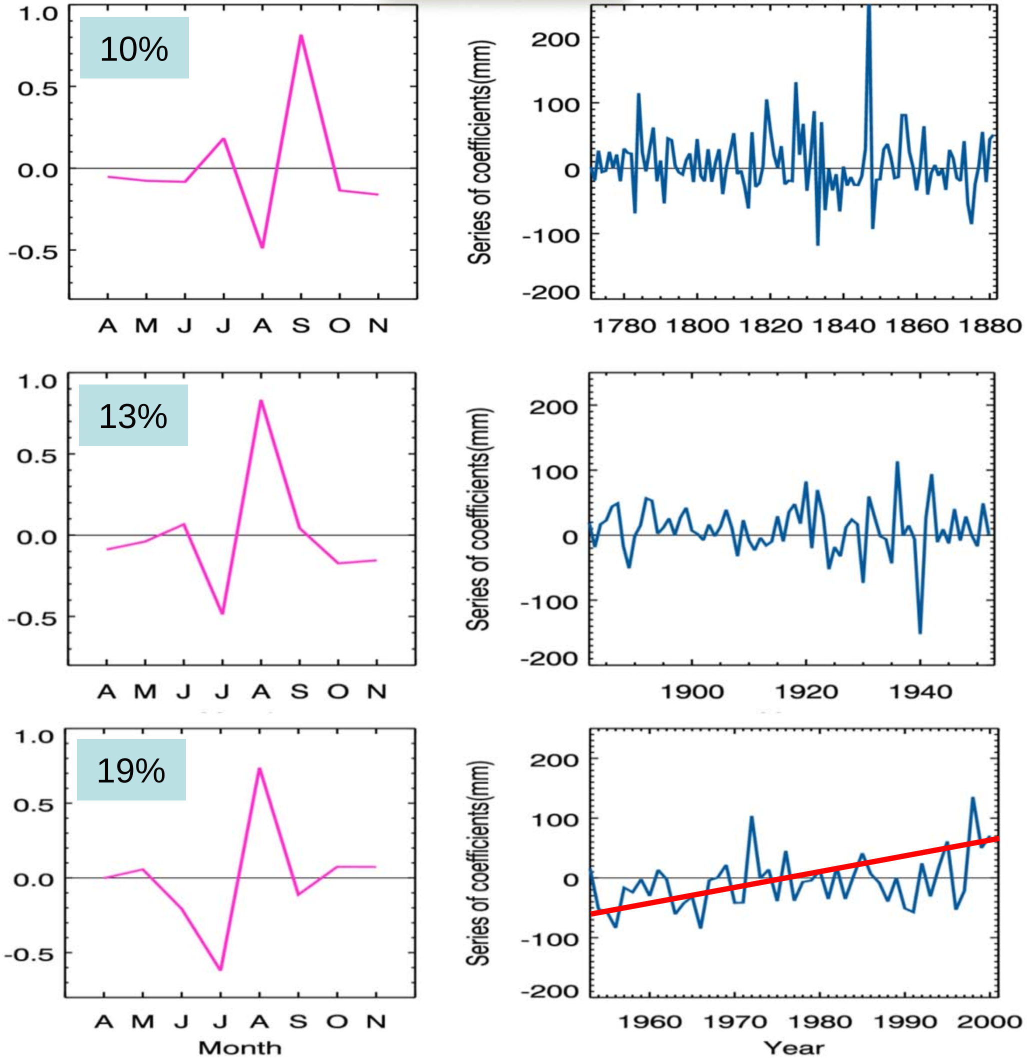
- EOF1 : Maximum in July

EOF2

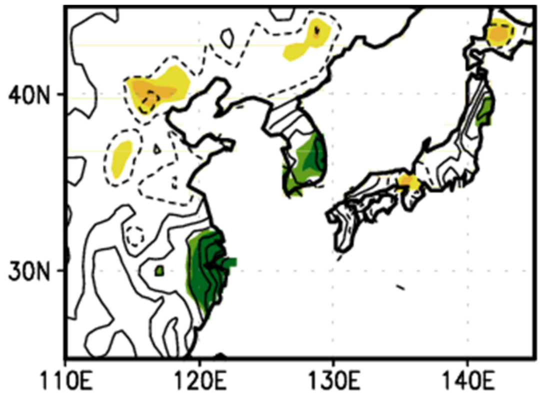
1771-1881

1882-1952

1953-2000



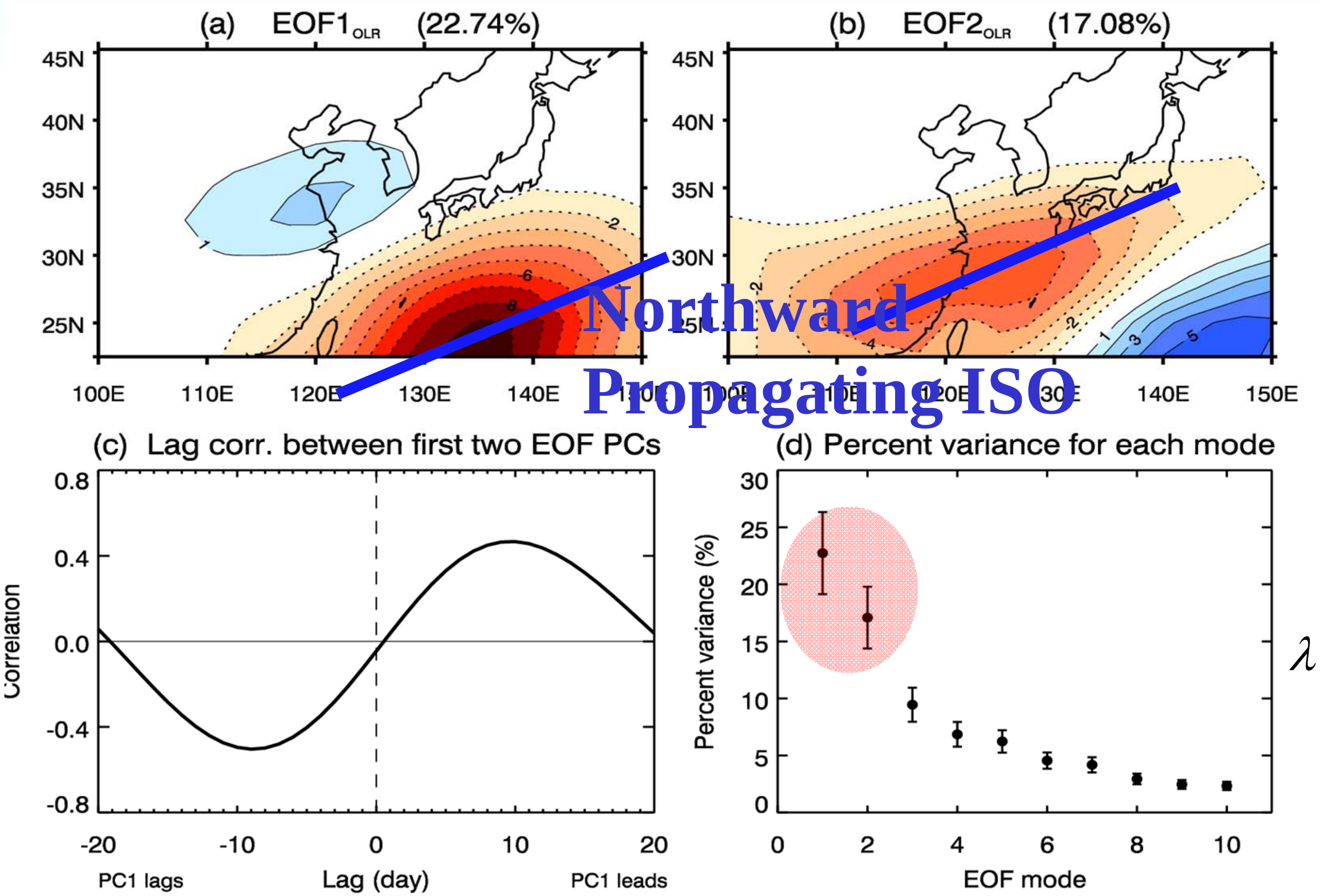
[1976~2002] - [1954~1975]



Lee, S.-S., P. N. Vinayachandran, K.-J. Ha, and J.-G. Jhun, 2010b: Shift of peak in summer monsoon rainfall over Korea and its association with ENSO. *J. Geophys. Res.*,**115**, D02111.

Northward Propagating ISO: NPISO

➢ First two modes of 30-60 day filtered OLR anomaly from 1958 to 2001 years



ISO activity

- The variance of the leading two (1st and 2nd) EOF timeseries

▪ **The rule of thumb of North *et al.* (1982)**

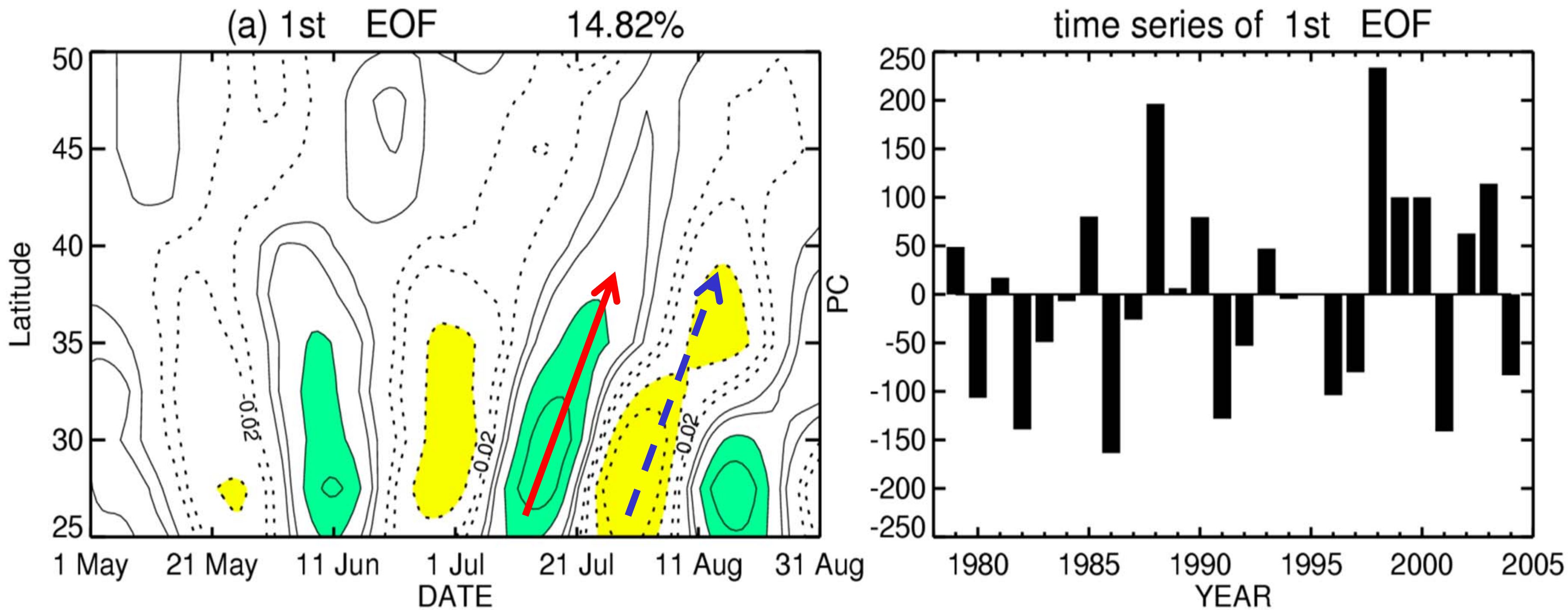
$$\lambda_\alpha \pm \lambda_\alpha (2/N)^{1/2}$$

- Eigenvalue λ_α
- DOF N

Yun, K.-S., K.-H. Seo, and K.-J. Ha, 2008: Relationship between ENSO and Northward Propagating Intraseasonal Oscillation in the East Asian Summer Monsoon System, *Journal of Geophysical Research*, **113**, D14120, doi:10.1029/2008JD009901.

NPISO in time-space structure

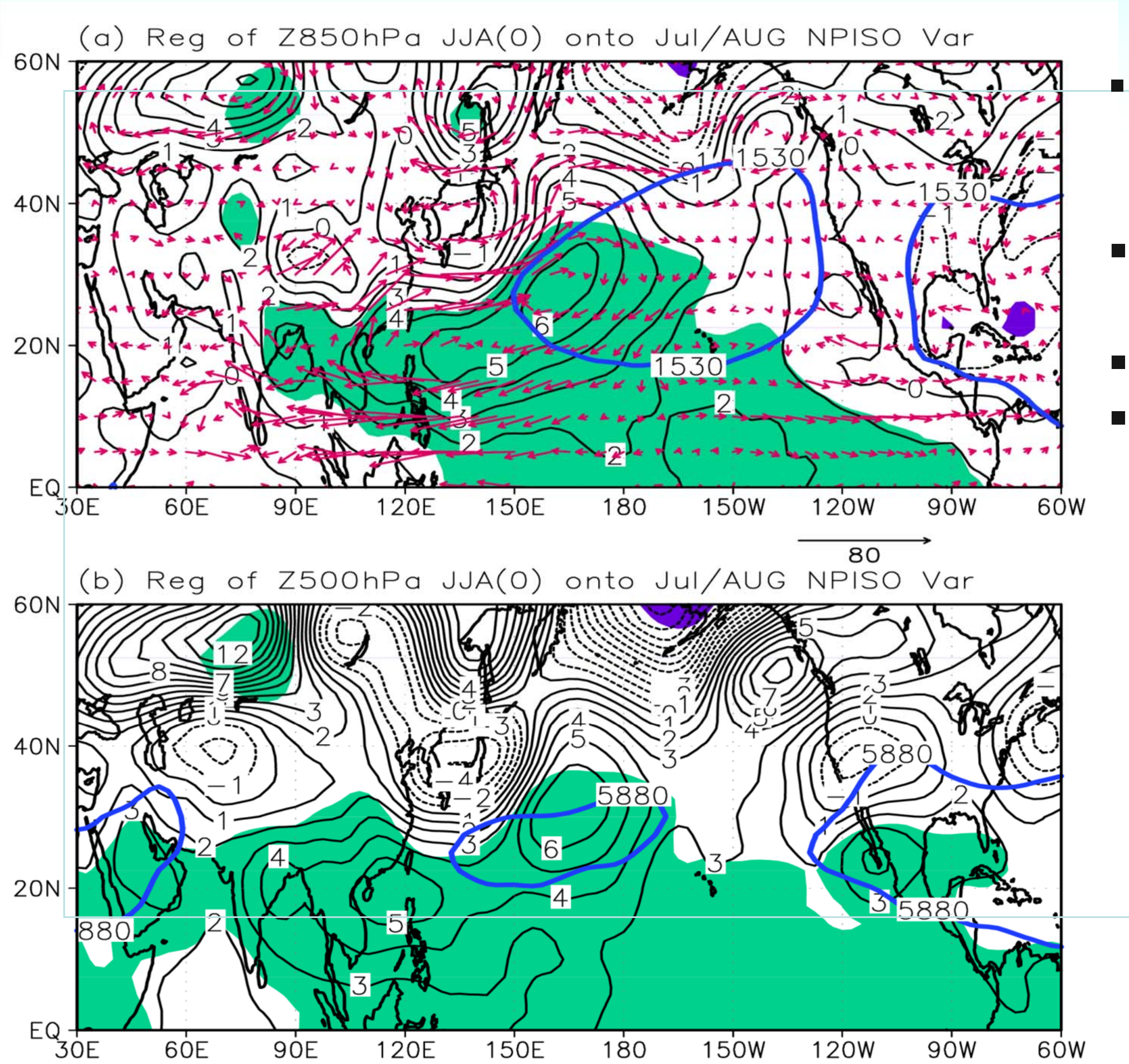
➤ Principal structure of the NPSIO



• 1st EOF mode: Well-organized northward propagating structure with ~40 day period

Yun, K.-S., B. Ren, K.-J. Ha, J. C.L. Chan, and J.-G. Jhun, 2009: The 30-60 day Oscillation in the East Asian Summer Monsoon and its Time-dependent Association with the ENSO, *Tellus*, **61A**, 565-578..

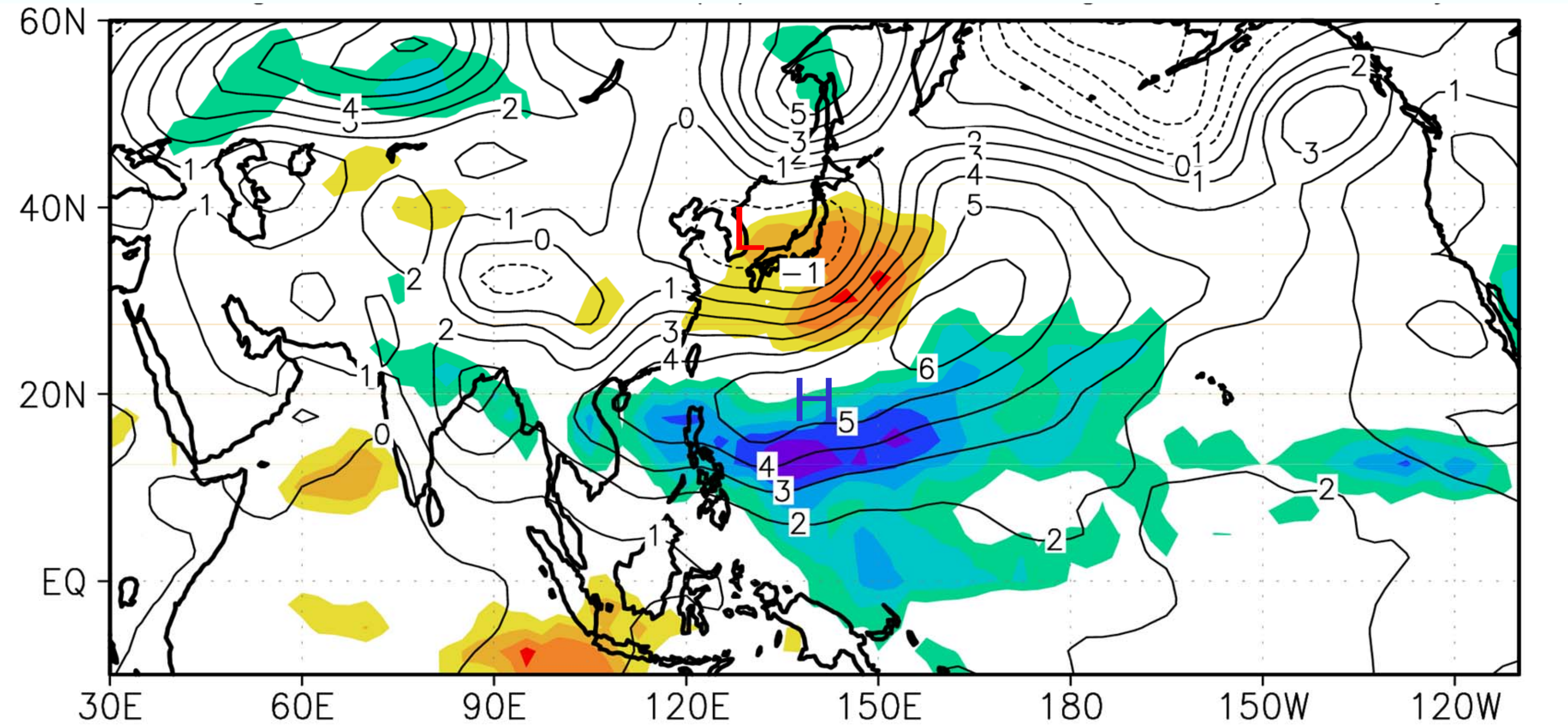
What drives and steers the NPISO? Possible mechanism: WNPSH



- low-level circulation regressed with NPISO index
- westward enhancement of high off the center
- surface divergence
- strong moisture-laden flow on the northern flank of the high

- Shading: Significant value at the 95% confidence level
- Contour: Z850 and Z500 regressed on NPISO activity
- Thick blue line: climatology

OLR regressed with NPISO index: Coupling in convection-circulation

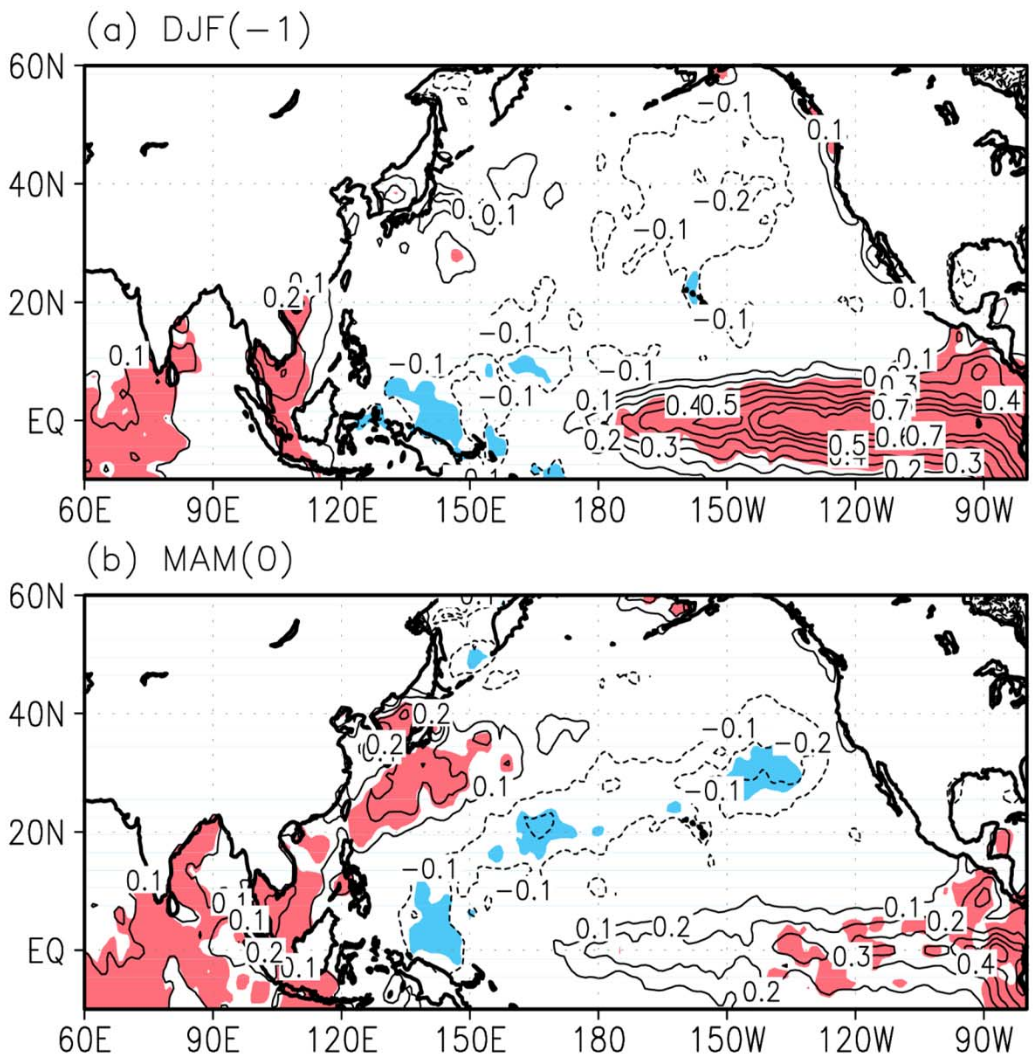


Shading: OLR anomalies regressed onto NPISO activity, contour: Z850 anomalies

- The suppressed convection over the Philippine Sea and enhanced convection to its north
- The coupling in the convection and circulation, implying the Rossby wave response to the reduced heating

EP, IO warming, and WP cooling

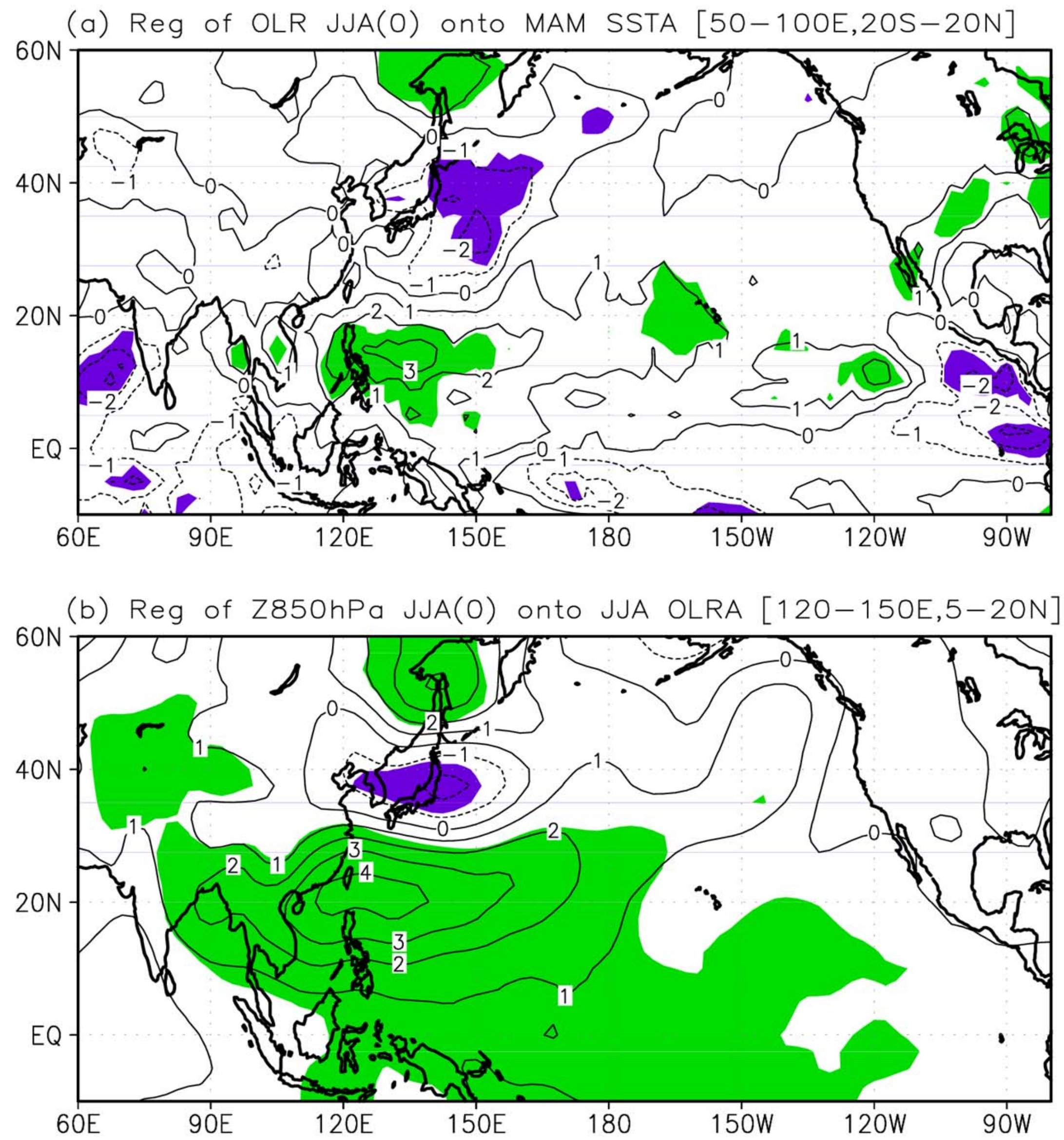
➢ Regression of SST anomalies onto July/August NPISO activity



- During the preceding winter (DJF(-1)), the evident warm anomalies in the eastern Pacific.
- In the Indian Ocean, weak warm (cold) anomalies (western Pacific) appear.
- During the MAM, the warm anomalies appear over South China Sea and Indian Ocean, through a tropical atmospheric bridge process such as the Walker and Hadley circulations [Klein *et al.*, 1999]
- IO has lingering and capacitor effects of ENSO on east Asian monsoon climate.

How does the ENSO affect NPISO? Lagged

NPISO index : MAM SSTA -> JJA OLRA -> JJA Z850A



- JJA OLRA regressed with MAM SSTA

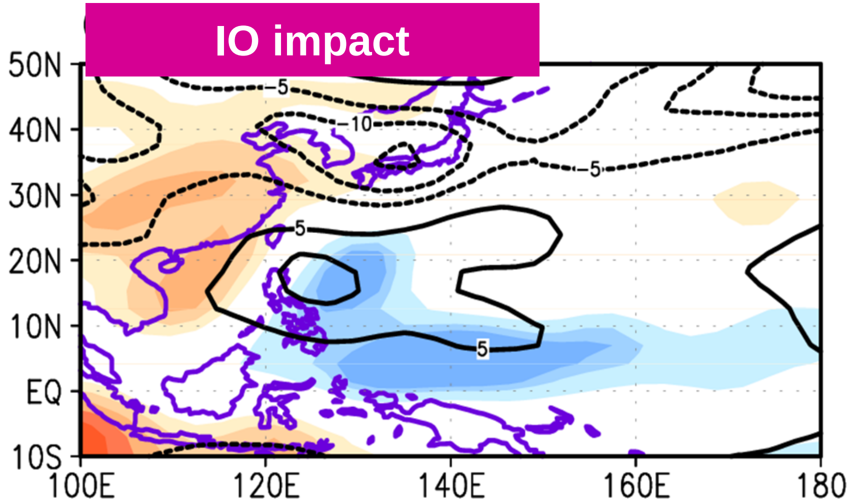
▪The preceding (-DJF) El Nino, the springtime Indian Ocean warming leads to the suppressed convection over the Philippine Sea, which is attributed to a weakened Walker circulation (Lee *et al.*, 2006).

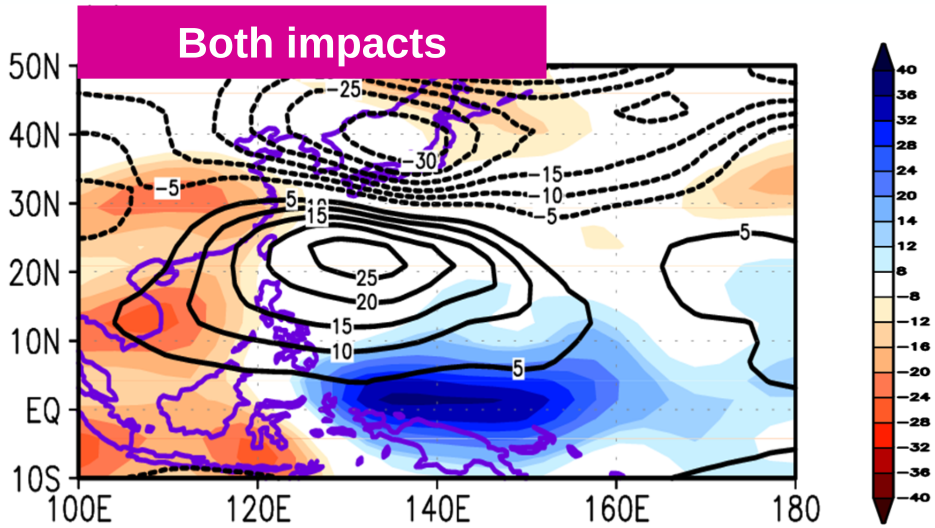
- Z850A regressed with JJA OLRA

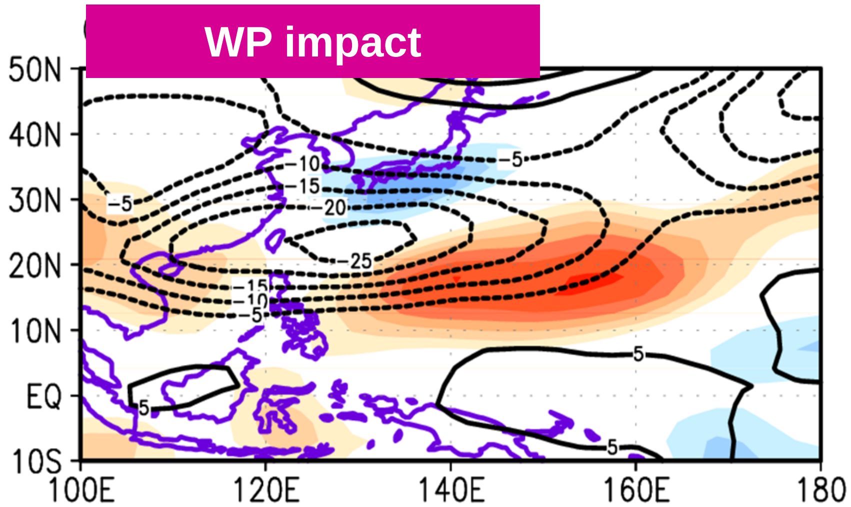
▪ The suppressed convection over the Philippine Sea induces a strong wave train extending northeastward in Asia (enhanced WNPSH and cyclonic anomalies), resembling the PJ pattern (Nitta, 1987).

Numerical experiment on the IO and WP SST

➢ EXP minus CTL difference of the 850hPa geopotential height and OLR during strong NPISO days, using the POEM (POP-OASIS-ECHAM model, Xiang et al., 2010) with EP warmimg





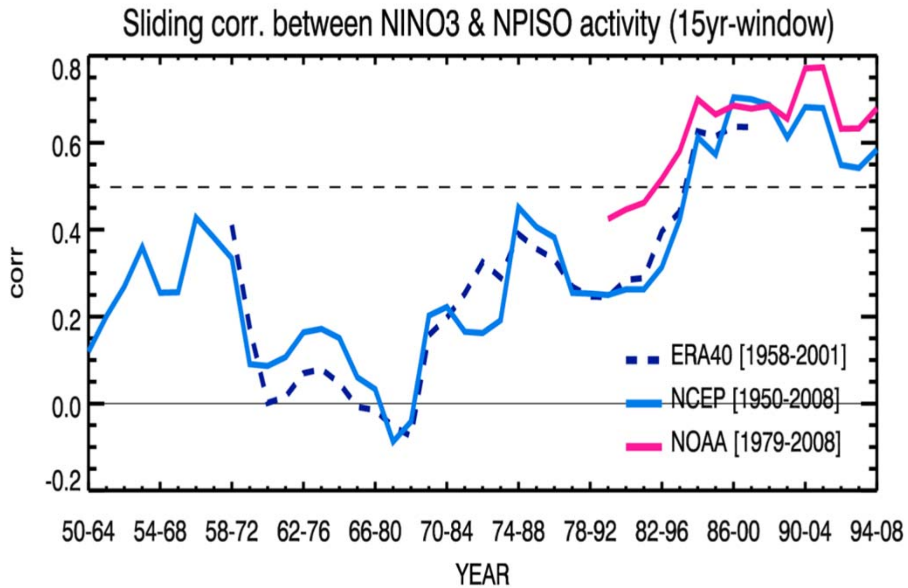


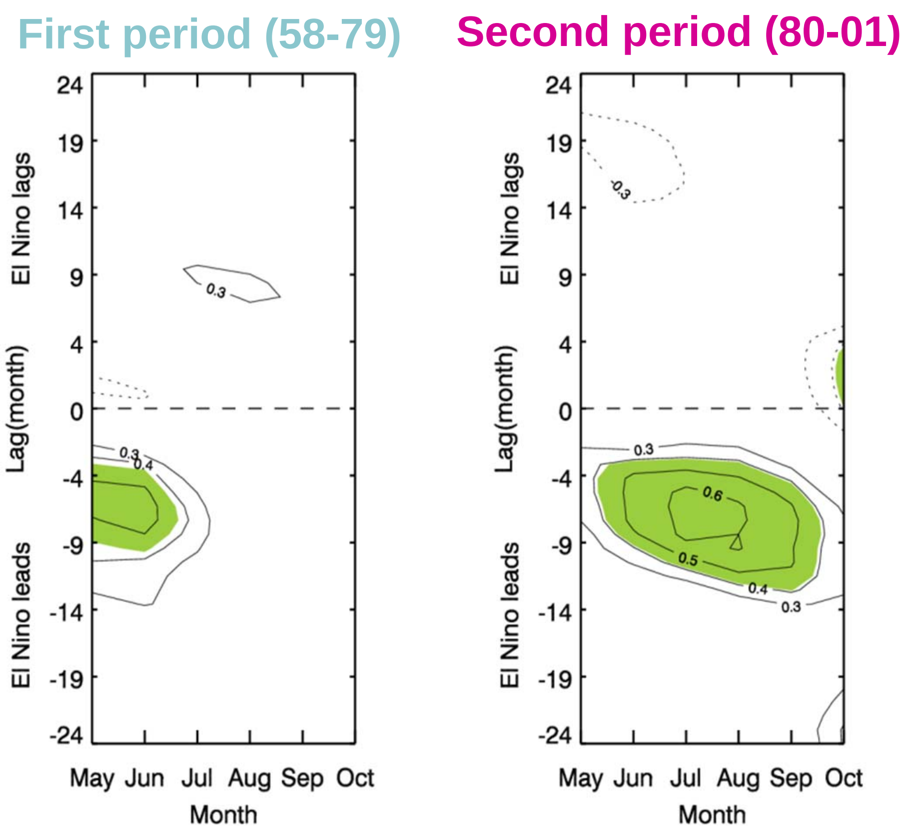
Contour: 850hPa geopotential height, Shading : OLR anomaly

- The IO and WP SST significantly represent the suppressed convection over WNP and the enhanced WNPSH.
- In the EXP_noWP run, the anticyclone anomaly shifted southward, which may be due to a earlier decay of the local SST forcing (Wu *et al.*, 2010)
- IO has lingering and capacitor effects of ENSO on east Asian monsoon climate.

Interdecadal change (58-79/ 80-01) in NPISO-ENSO relationship

- Sliding correlation coefficient between the NPISO activity and monthly NINO3 index





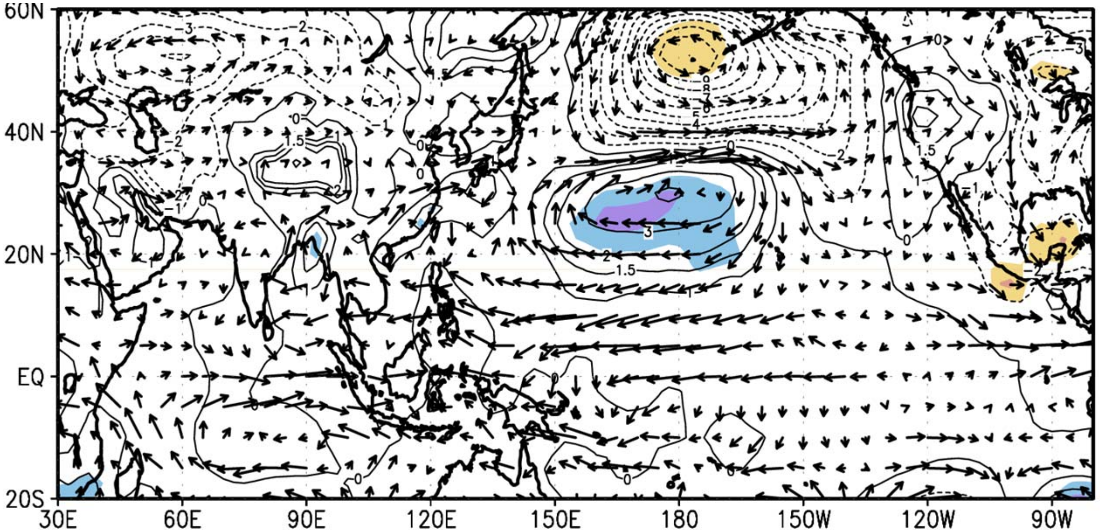
- In the years 1958-1979, ENSO affect the early summer NPISO, while in the years 1980-2001, the boreal summer NPISO activity in July-August is affected by the preceding winter ENSO.

- Since the late 1970s, the dynamical relationship between the NPISO and ENSO becomes later and stronger in comparison to that in before the late 1970s.

Yun, K.-S., K.-H. Seo, and K.-J. Ha, 2010: Interdecadal change in the relationship between ENSO and the intraseasonal oscillation in East Asia, *Journal of Climate*, **23**(13), 3599-3612.

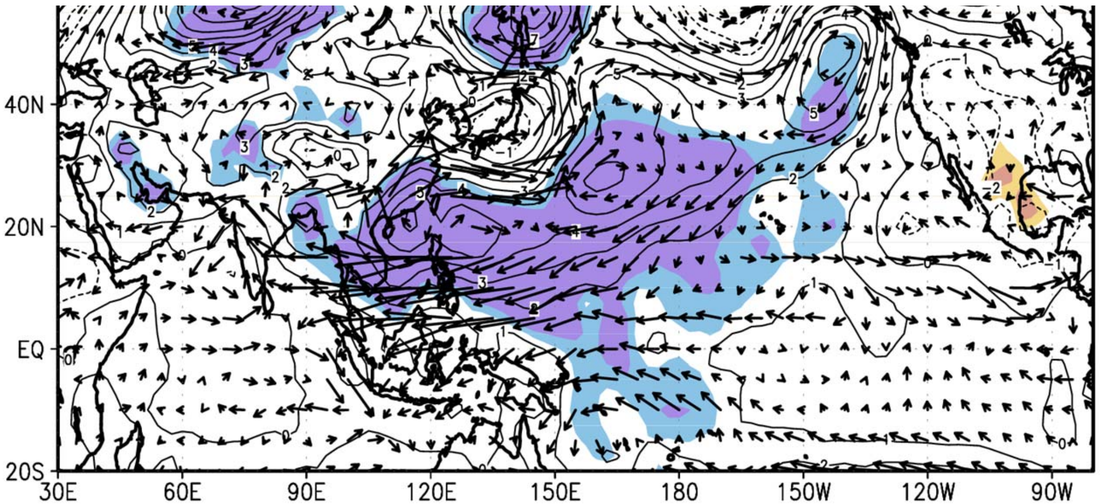
Change in the NPISO-WNP circulation

➢ Regression of AMJ Z850hPa against MJ NPISO during 1958-1979



➢ During 1958-1979 years, the early summer (i.e., May-June) NPISO is related to a north-south dipole of anomalies over the North Pacific, resembling the west Pacific (WP) pattern.

➢ Regression of JJA Z850hPa against JA NPISO during 1980-2001



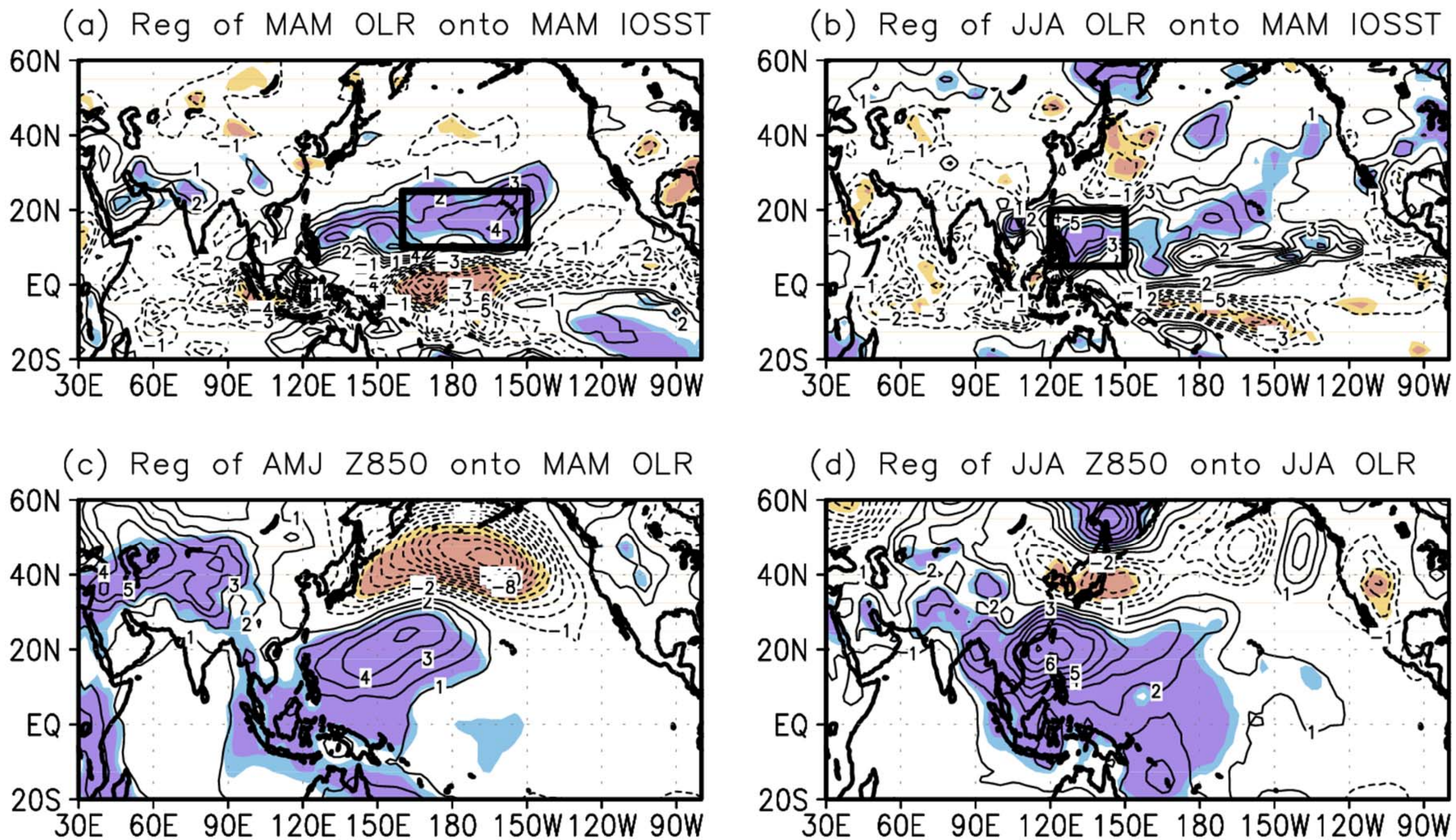
➢ During 1980-2001 years, the July-August NPISO is related to the western North Pacific subtropical high (WNPSH), forming the Pacific-Japan (PJ) pattern.

Distinct mechanism in NPISO-ENSO relationship

➢ Regression of IOSST-related convection and geopotential height

First period (1958-1979)

Second period (1980-2001)



➢ **During 1980-2001, IOSST warming -> WNP suppressed convection -> Pacific-Japan (PJ) pattern**

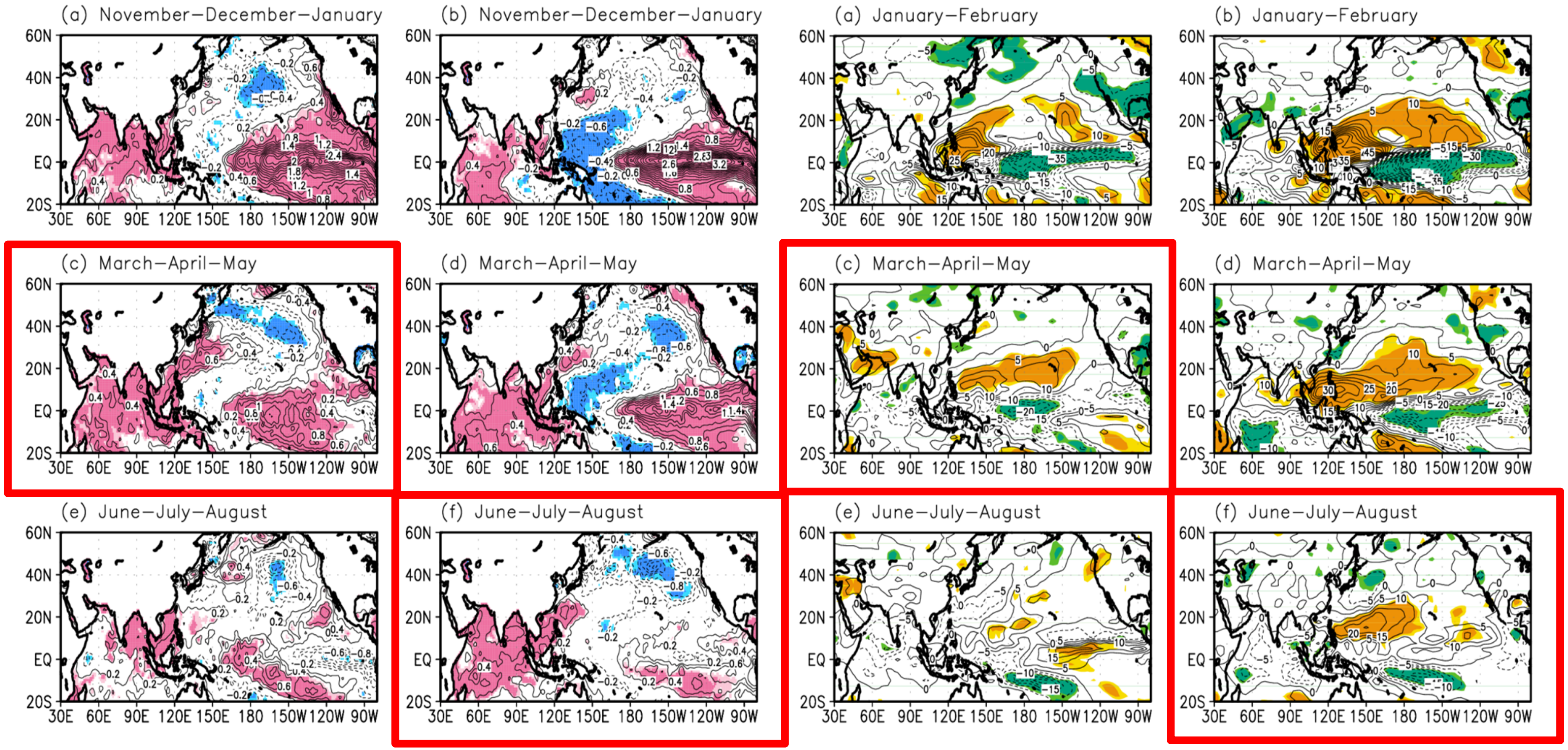
➢ **During 1958-1979, IOSST warming->central Pacific suppressed convection->west Pacific (WP) pattern**

Enhanced ENSO response in SST and convection

➢ Composite difference between El Nino and La Nina during 1958-1979 and 1980-2001

SST anomaly | OLR anomaly

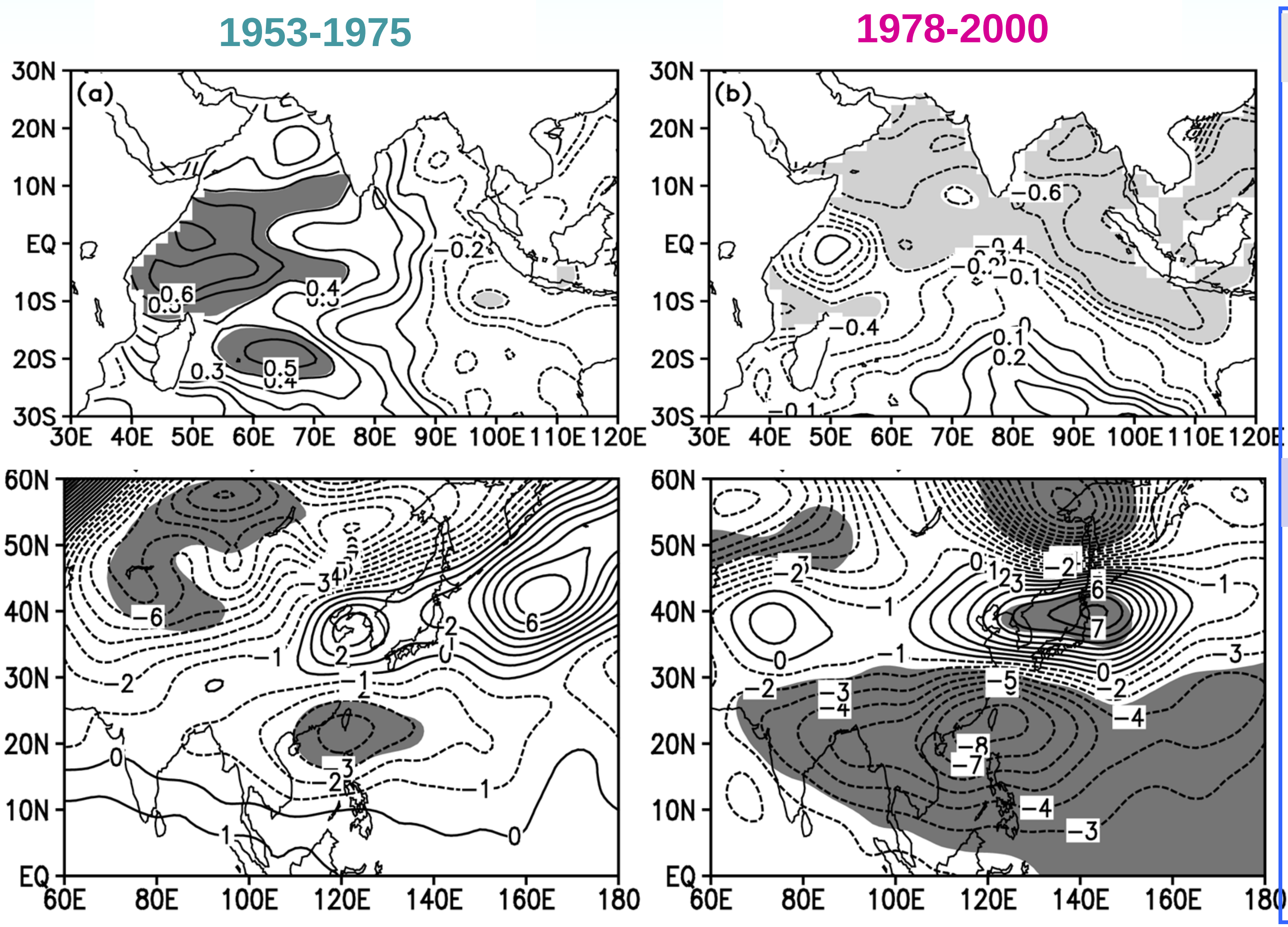
First period (58-79) | Second period (80-01) | First period (58-79) | Second period (80-01)

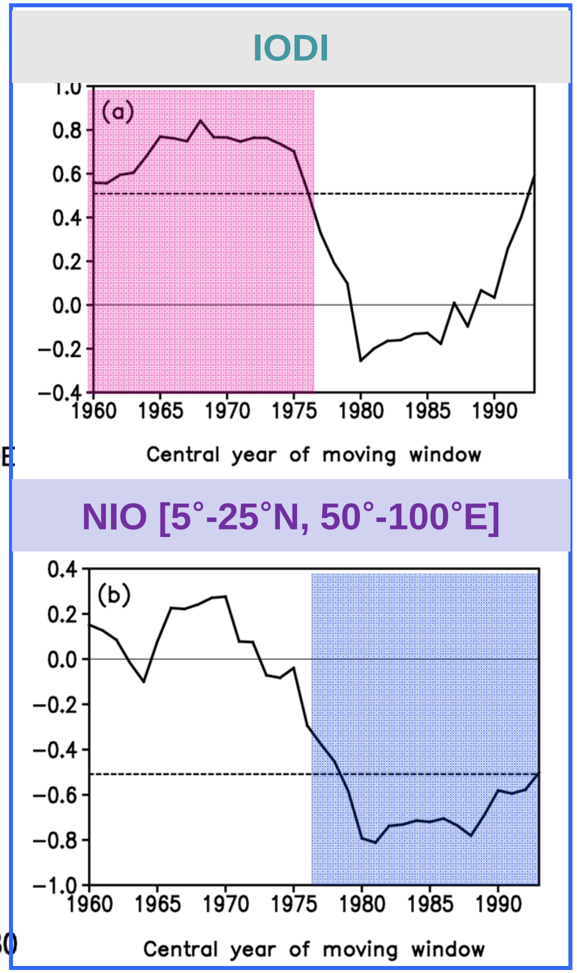


➢ In the second period, the IOSST warming and suppressed convection pattern is quite similar to the springtime pattern in the first period.

Change in the IO-EASM relationship

➢ Relationship of SST and Z500 anomaly with EASMI





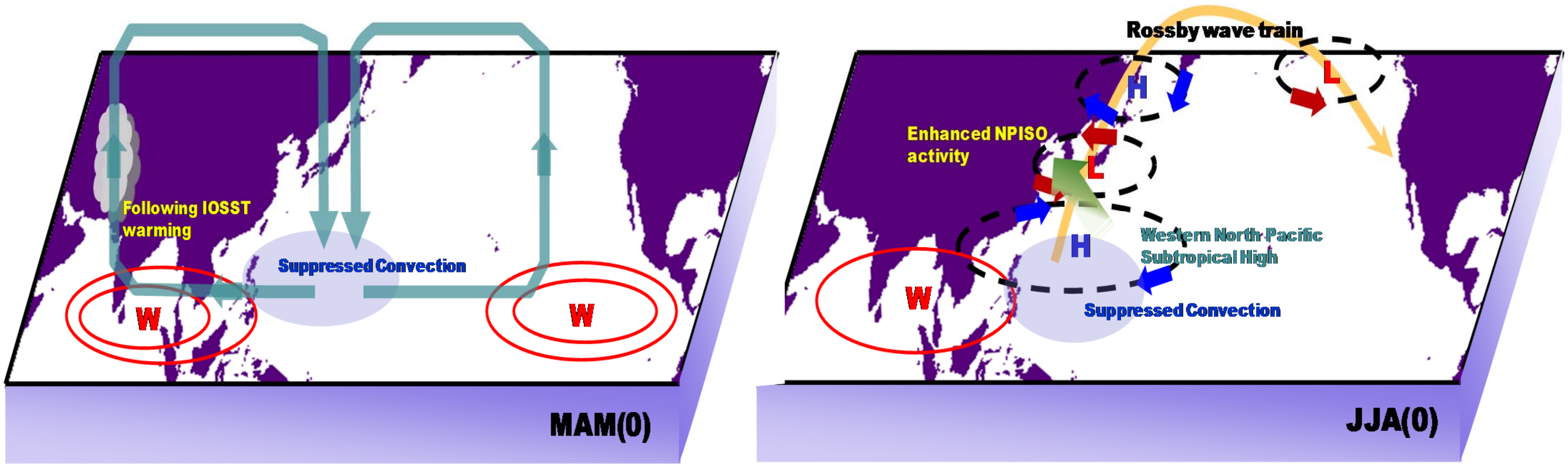
Ding, R.,K.-J. Ha, and J. Li, 2010: Interdecadal shift in the relationship between the East Asian summer monsoon and the tropical Indian Ocean, *Clim. Dyn.*, **34**, 1059-1071.

Summary and Discussion

➢ The possible mechanism on the NPISO activity over East Asia

- Western North Pacific subtropical high (WNPSH)
- Coupling process in the convection-circulation
- IO warming, WP cooling, and EP warming

➢ Dynamics on the NPISO-ENSO relationship



Summary and Discussion

➢ Interdecadal change in NPISO-ENSO relationship

- In the 1958-1979 years, a preceding winter ENSO influences the early summer NPISO activity. The May-June NPISO is modulated by the springtime IOSST warming and central North Pacific suppressed convection anomalies, and consequently, related to the ENSO-induced WP pattern in winter through spring.

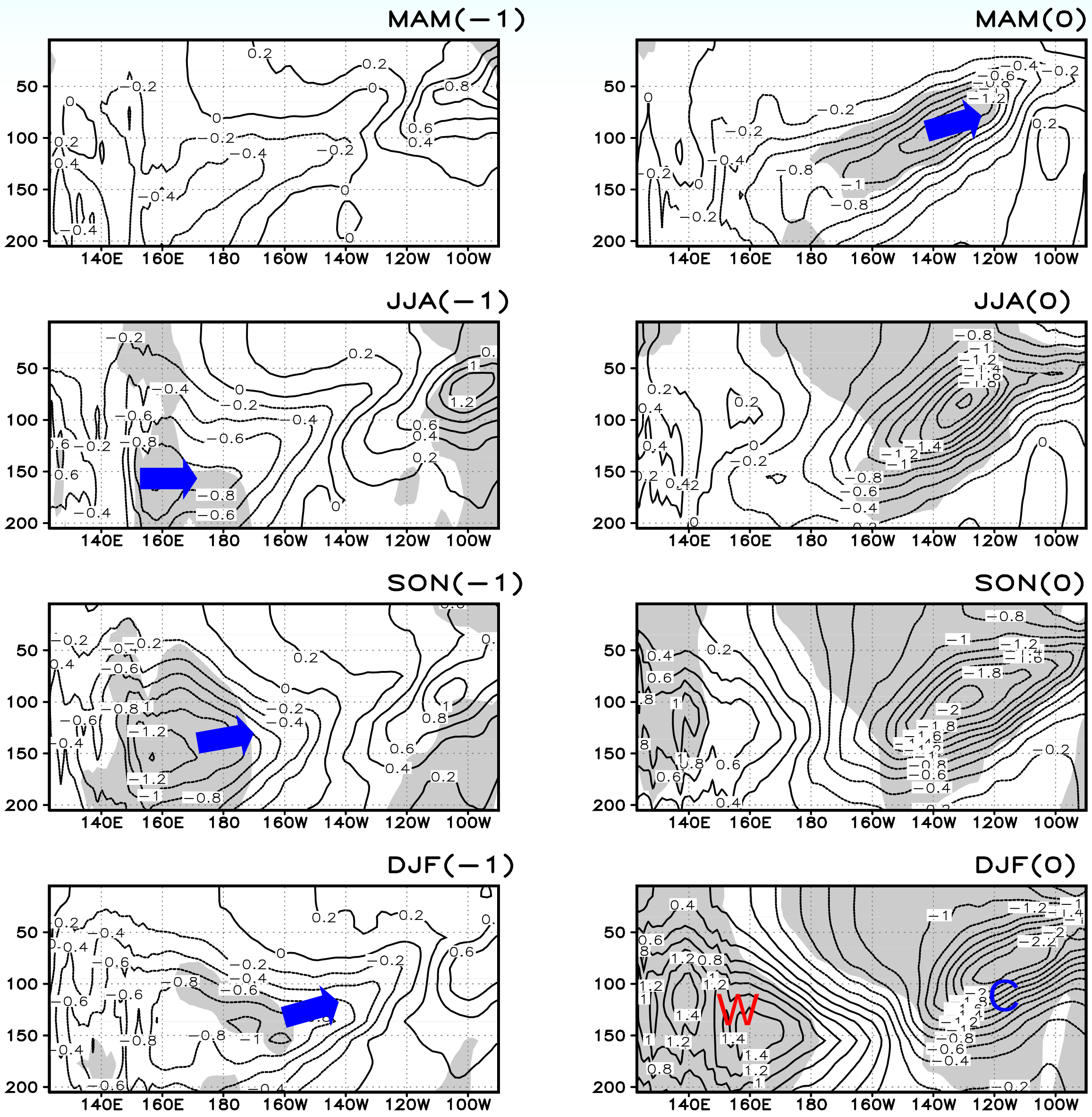
- Since the late 1970s, a stronger Walker-Hadley circulation is produced due to a warmer mean SST anomaly. It leads more persistent ENSO-induced IOSST warming and suppressed PSCA, WNPSH after El Nino itself has dissipated, which in turn enhances NPISO until mid-late summer.

➢The relationship between NPISO and ENSO (NPISO-> ENSO)

- Can the NPISO over East Asia affect ENSO?

➢ This sub-seasonal distinction in the NPISO-ENSO relationship and its interdecadal change contribute to understanding the climate change in the EASM.

Can the preceding NPISO affect ENSO? Yun et al 2009, Tellus A, The 30-60day oscillation in the EASM and its time-dependent association with the ENSO.



eastward propagation with the upwelling of oceanic Kelvin wave. NIPSO in the EASM may be link to the evolution of the QBO-type ENSO

Thank you

For your attention

Ha, K.-J., and E. Ha, 2006: Climatic change and interannual fluctuations in the long-term record of monthly precipitation for Seoul. *Int. J. Climatol.*, **26**, 607-618.

Ha, K.-J. and S.-S. Lee, 2007 : On the interannual variability of the Bonin high associated with the East Asian summer monsoon rain, *Climate Dynamics*, **28**(1), 67-83.

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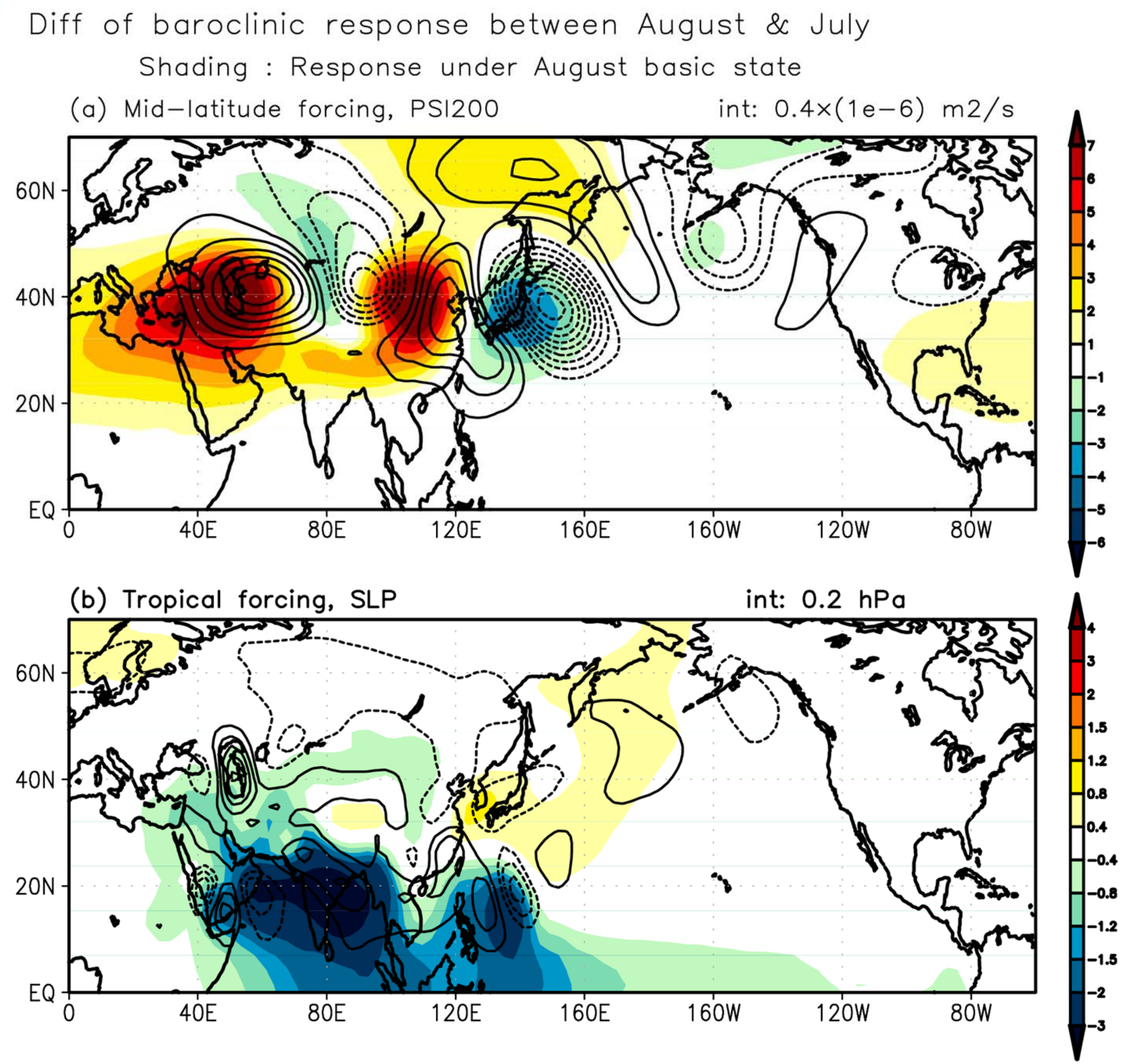
Yun, K.-S., K.-H. Seo, and K.-J. Ha, 2010: Interdecadal change in the relationship between ENSO and the intraseasonal oscillation in East Asia, *Journal of Climate*, **23**(13), 3599-3612.

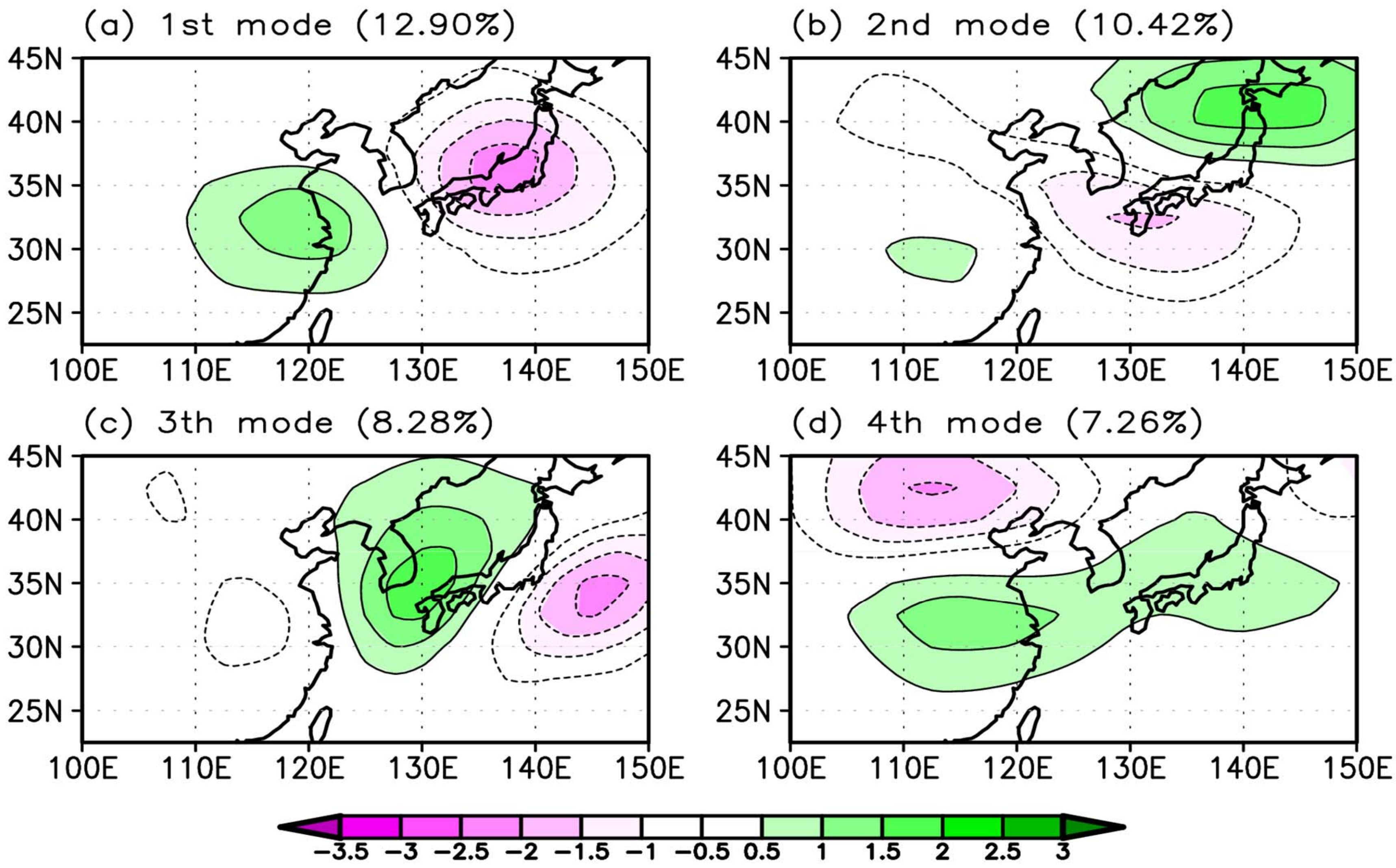
Intraseasonal change on Rossby wave propagation

➢ Difference of response between August and July basic state, using linear baroclinic model



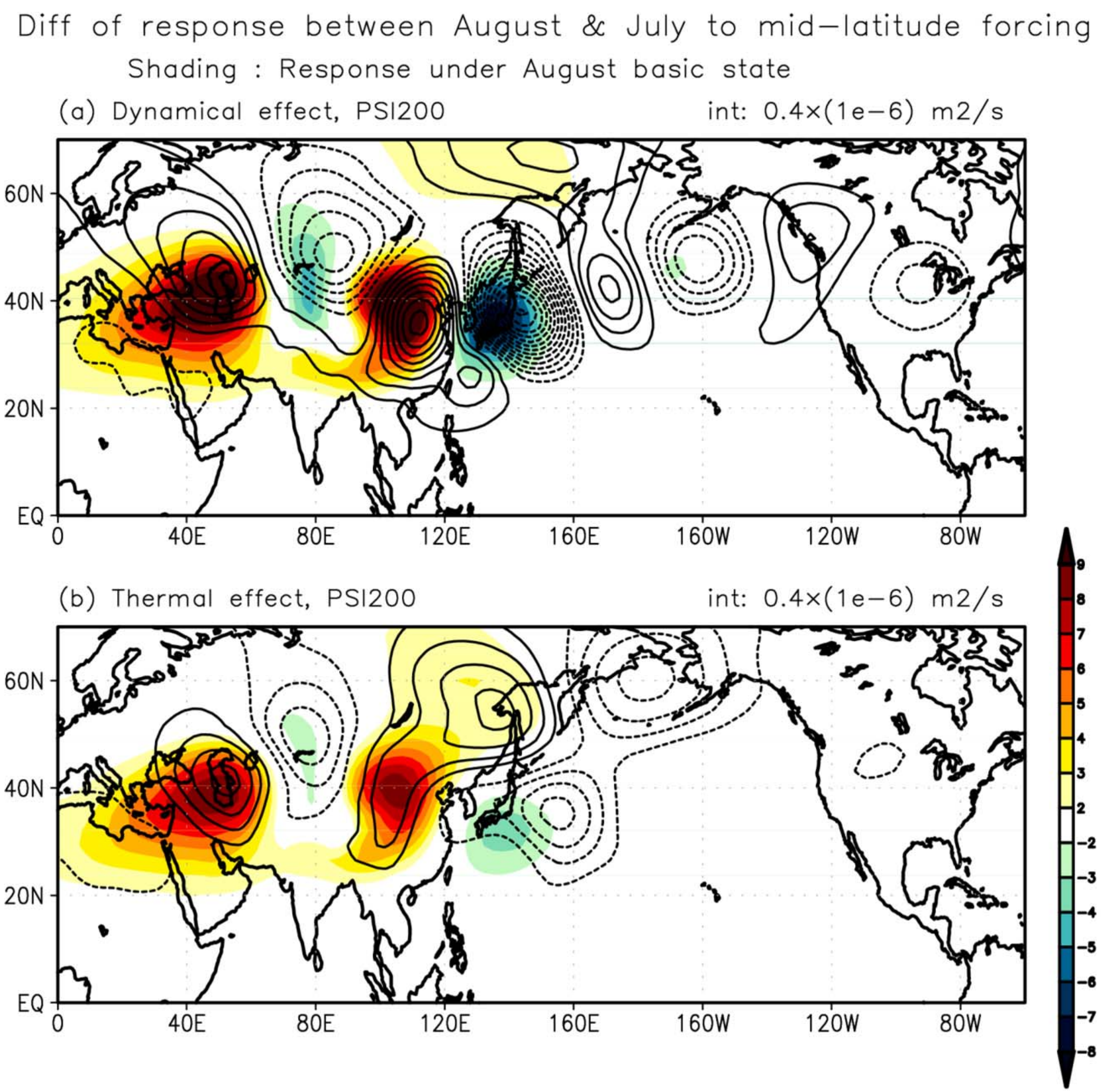
- The response to the mid-latitude forcing is stronger in August than in July.
- The response to the tropical forcing is stronger in July than in August.

Principal modes in 500hPa temperature advection



Jet-triggered dynamical effect

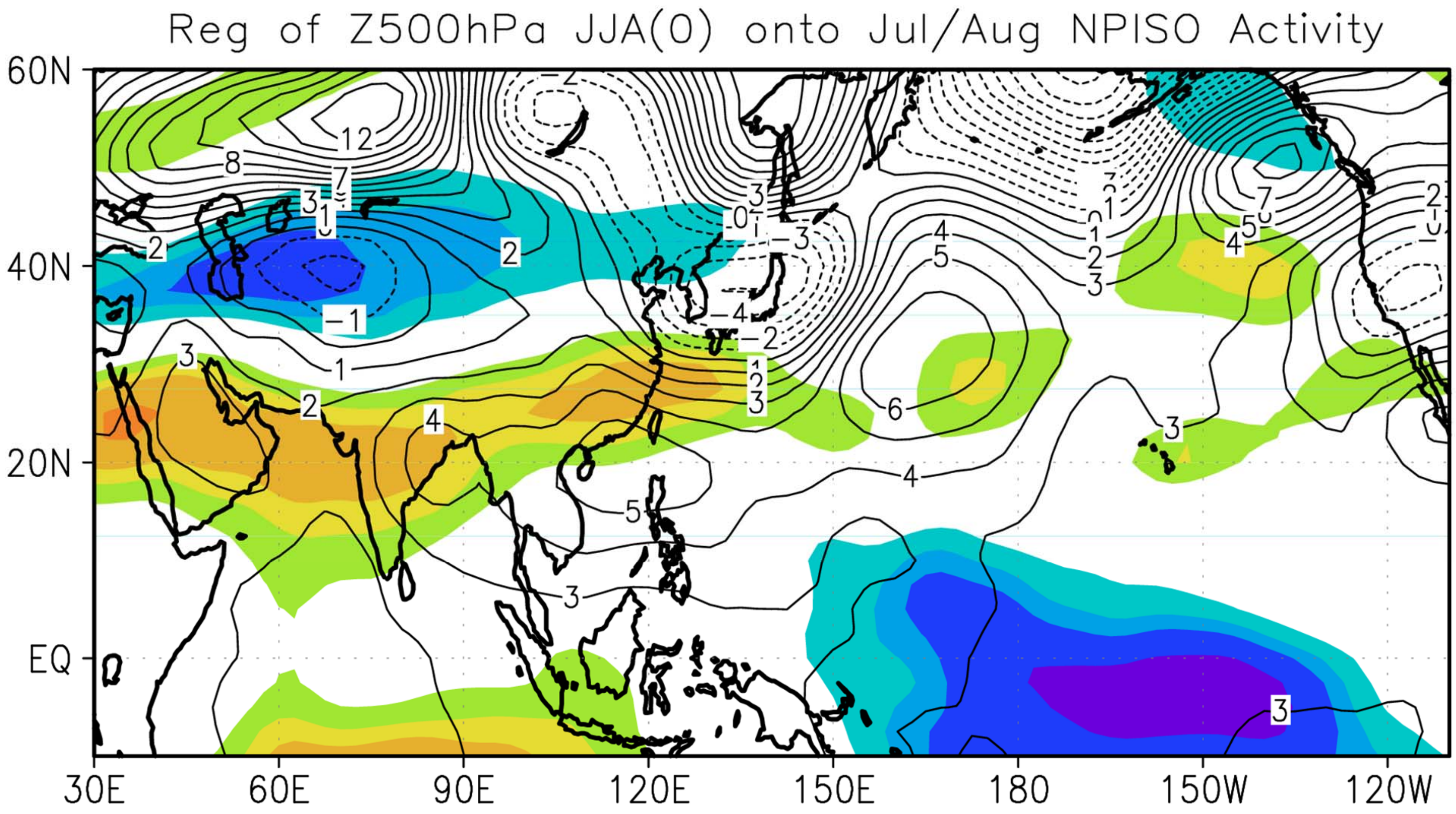
➢ Difference of response between August and July basic state, using linear baroclinic model



▪ A stronger response of Rossby wave propagation in August than in July, due to the Jet-triggered dynamical effect

Ha, K.-J. and S.-S. Lee, 2007 : On the interannual variability of the Bonin high associated with the East Asian summer monsoon rain, *Climate Dynamics*, **28**(1), 67-83.

Relationship with Jet stream

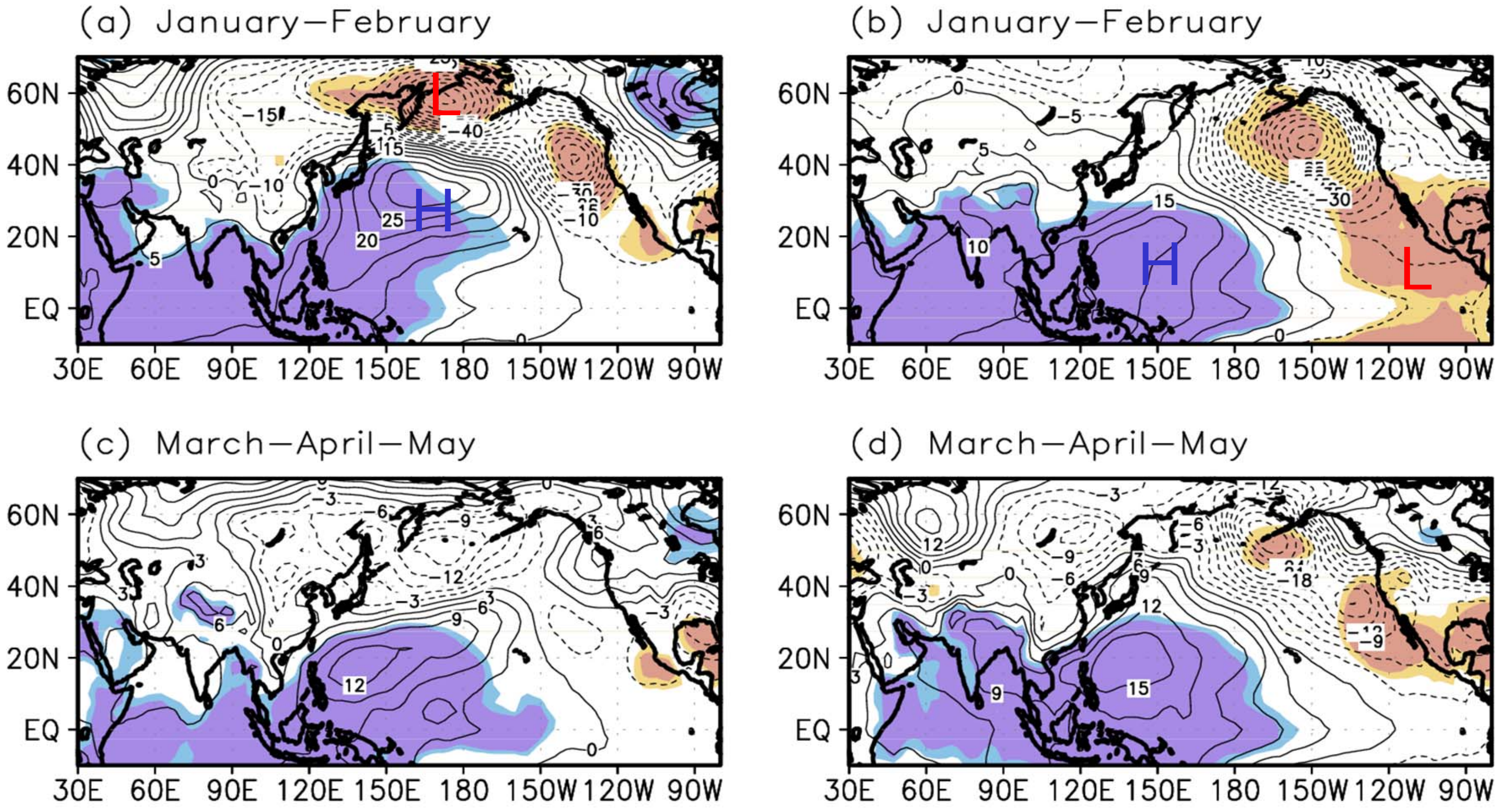


Shading: U200 anomalies regressed onto NPISO activity, contour: Z500 anomalies

Enhanced characteristics in Southern Oscillation

- Composite difference between El Nino and La Nina during 1958-1979 and 1980-2001

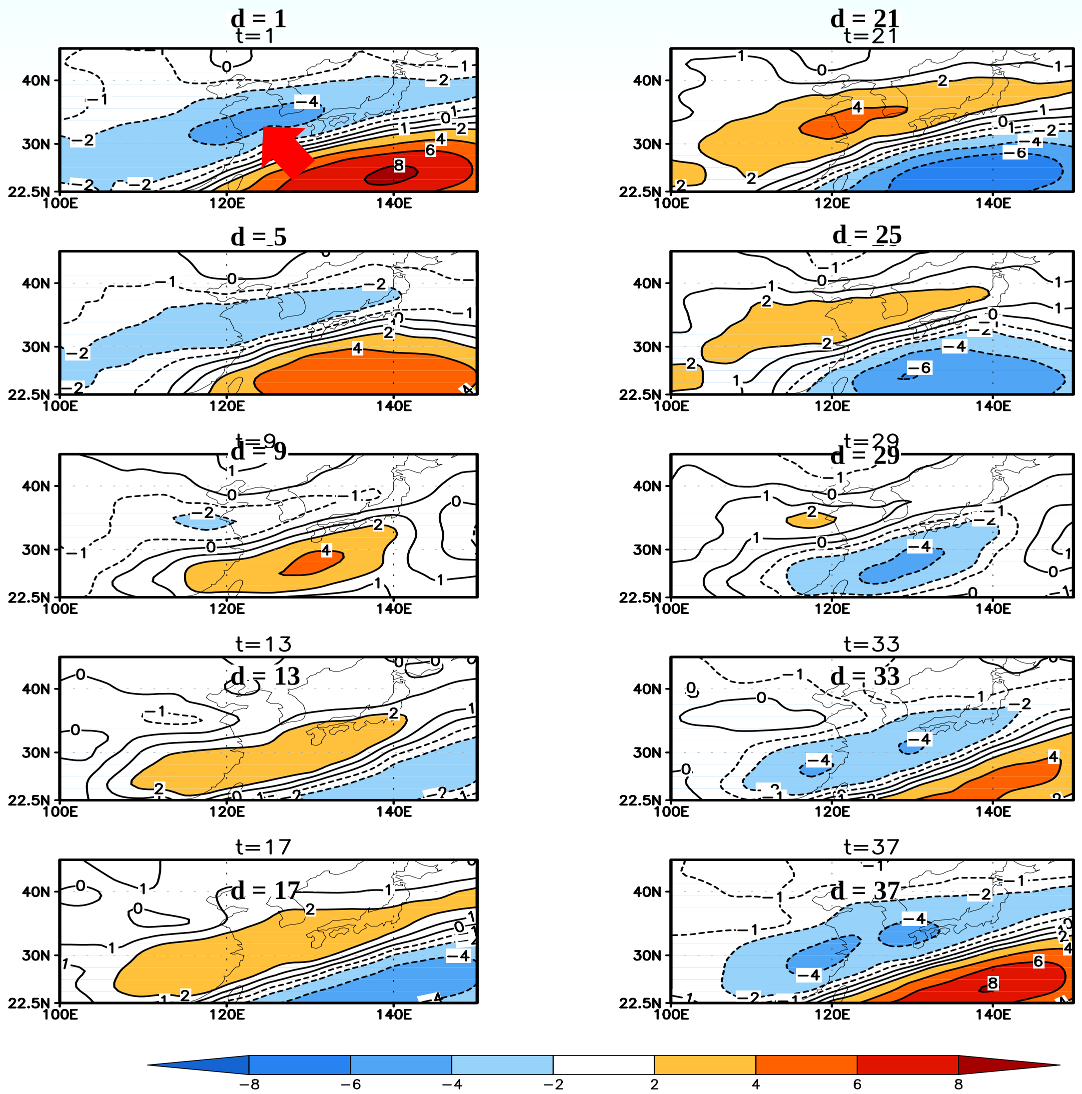
First period (1958-1979) | Second period (1980-2001)



➢ The strong SO characteristics may interrupt to generate an evident WP pattern, and consequently, the early NPISO activity is no longer related to ENSO via the WP pattern.

➢ The increasing relationship between NPISO and PJ pattern is contributed by the persistent ENSO-induced convection and circulation anomalies over the WNP.

The temporal evolution of the NPISO



Using the first Extended EOF mode with a window of 50 days for MJJASO

- Northwestward propagating convection anomalies with a period of ~40 days.

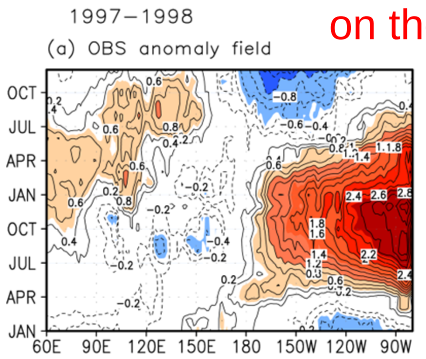
- Basically consistent with the EOF analysis

Numerical experiment on the IO & WP SST warming

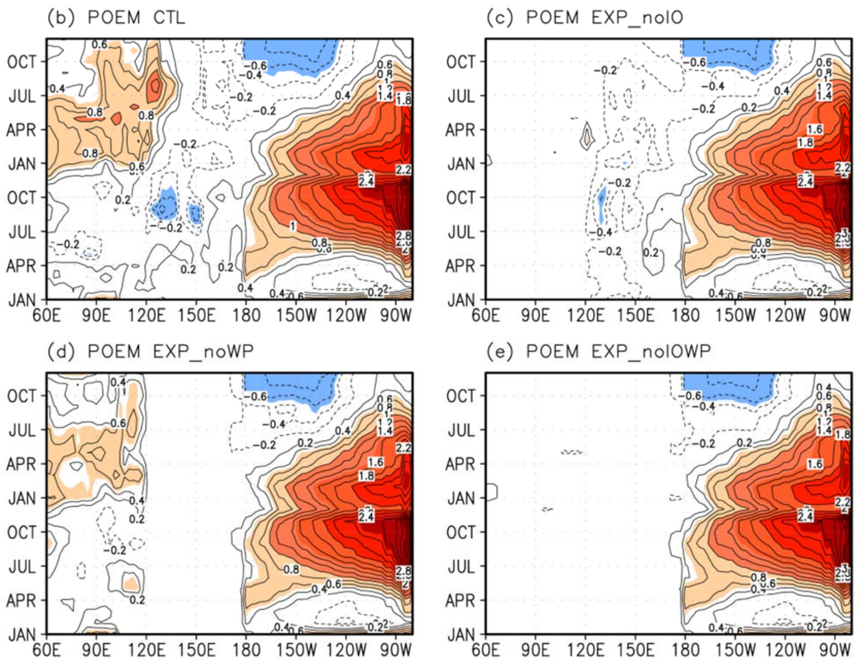
Using POEM (Coupled OAGCM based on POP and ECHAM model)

- Anomaly of SST averaged over longitude [10S-10N] during 1997-1998

- To investigate the influence of the local (WP)/remote (IO) tropical SST forcing on the ISO over East Asia



- To gain more evident ISO signal in the model, the model is integrated for the strongest El Niño event of 1997-1998.
- While in all experiments, the EP warming is prescribed as the anomalous SST forcing, the coupling and decoupling with the IO and WP are controlled in the sensitivity test.

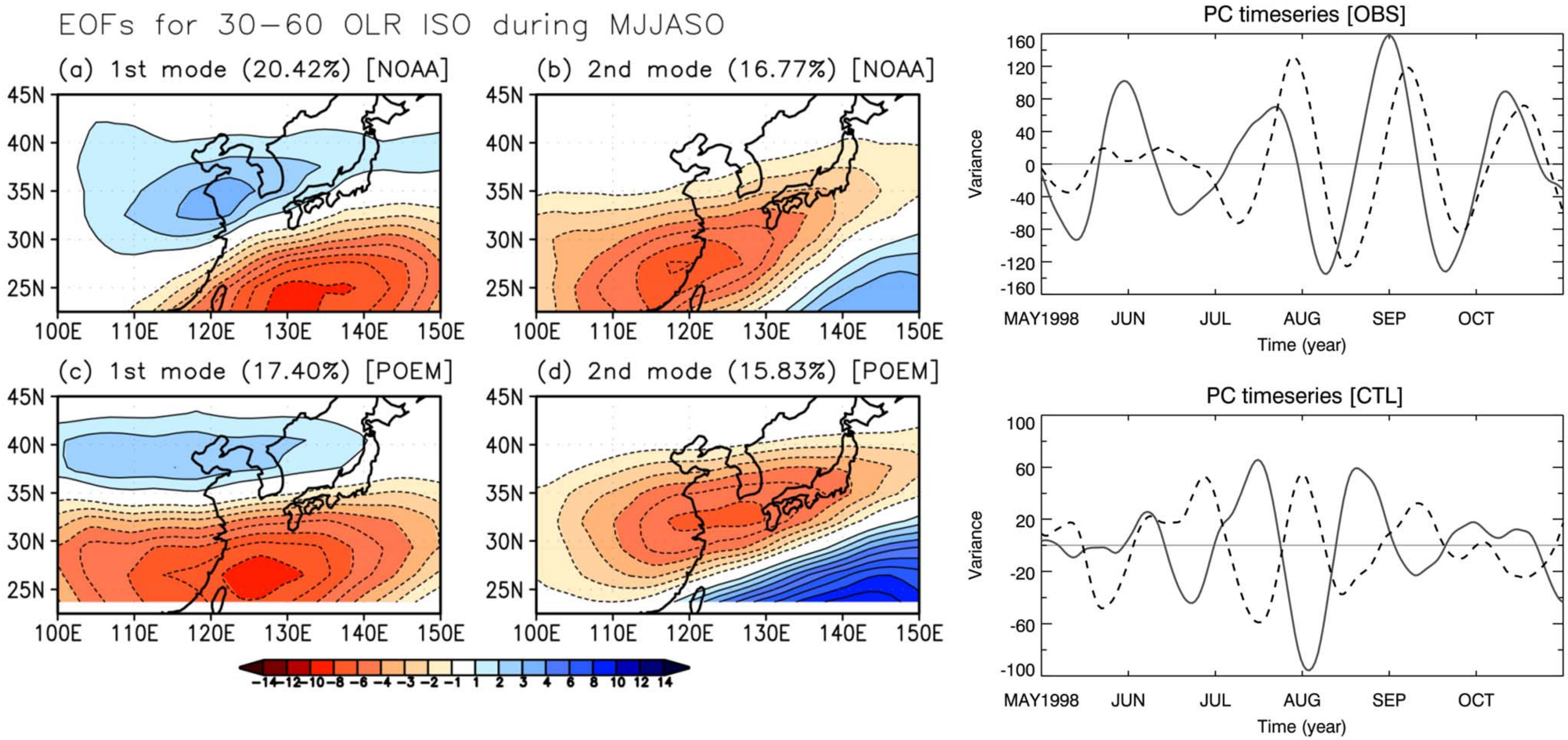


Model experiment design by POEM

	CTL	EXP_noIO	EXP_noWP	EXP_noIOWP
Coupling (air-sea interaction)	IO + WP	Western Pacific (WP)	Indian Ocean (IO)	N/A
Specified anomalous SST forcing	EP (i.e., dateline to eastern Pacific)			

30-60 day ISO over East Asia

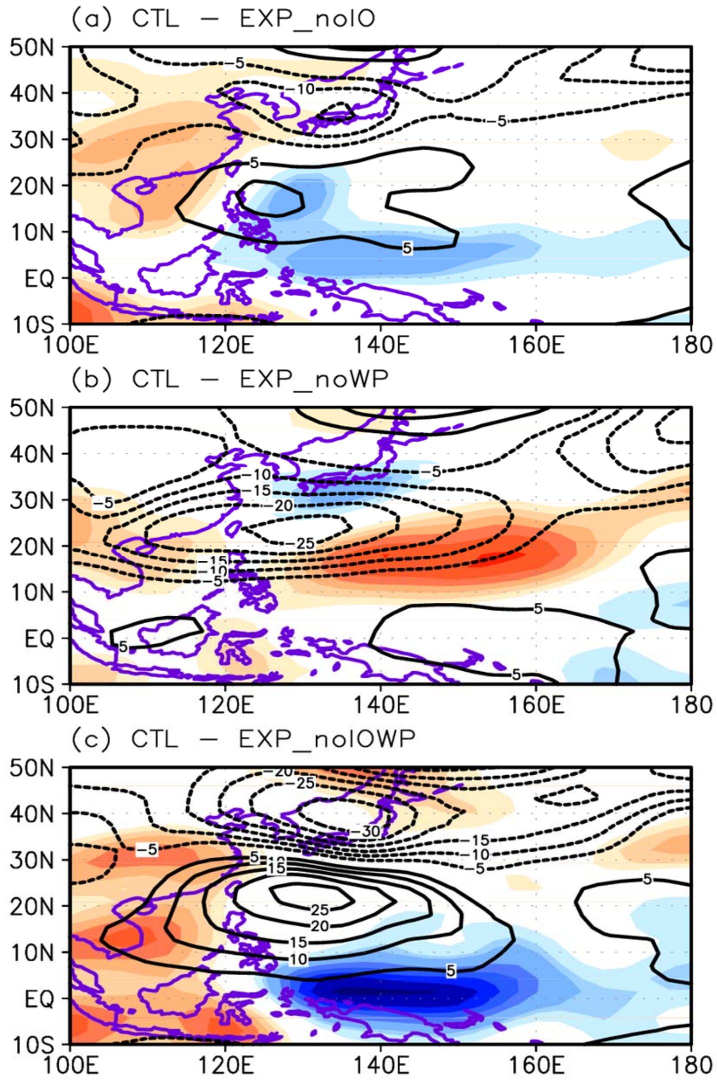
➢ First two modes of 30-60 day filtered OLR anomaly in observation and POEM



▪ In reasonable agreement with those in the observation data, the first two EOF modes in POEM represent a quadratic phase difference in the northwestward propagation. However, the model fails to simulate exactly the temporal evolution of the ISO and the ISO activity in the model is considerably weaker than that in the observation.

Impact of the IO and WP SST warming

- The composite difference of the 850hPa geopotential height and OLR between CTL and EXP during days when the ISO difference is greater than 1.0 standard deviation.



- In the EXP_noIO and EXP_noIOWP runs, the results significantly represent the suppressed convection over the WNP and the enhanced WNPSH to the northwest of the convection, implying the Rossby wave response on the reduced heating.

- In the EXP_noWP run, the simulated result shows the anticyclone anomaly shifted southward, with insignificant suppressed convection over the Philippine Sea.

- The distinct result (weakening of the simulated WNPSH) may be due to

- Systematic bias of model mean state in the equatorial western Pacific.

- A earlier decay of the local SST forcing [Wu *et al.*, 2010 (*JC*)]

➢ Contour: 850hPa geopotential height, Shading : OLR anomaly