



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



1968-44

Conference on Teleconnections in the Atmosphere and Oceans

17 - 20 November 2008

Boreal summer tropical extratropical teleconnection.

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Boreal Summer
Circumglobal Teleconnection:
Tropical-Extratropical Interaction

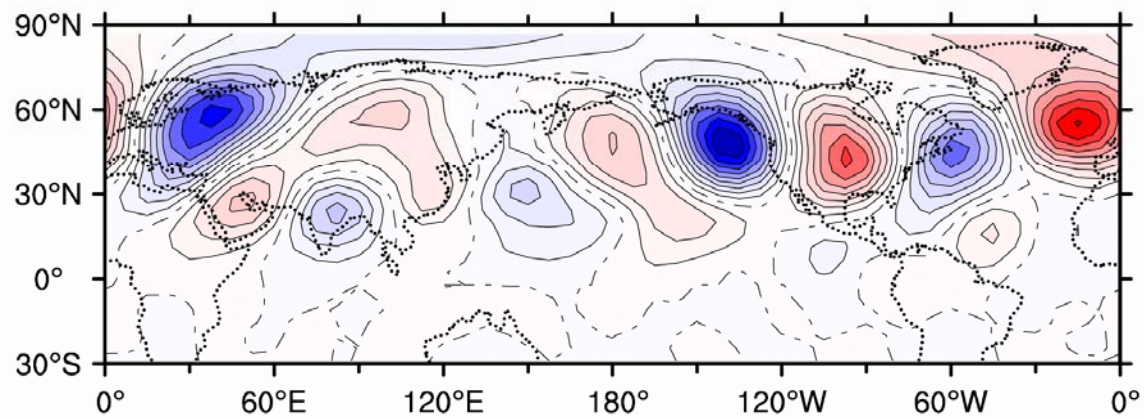
Bin Wang and Qinghua Ding

**Department of Meteorology and IPRC
University of Hawaii**

*Conference on Teleconnections in the
Atmosphere and Oceans
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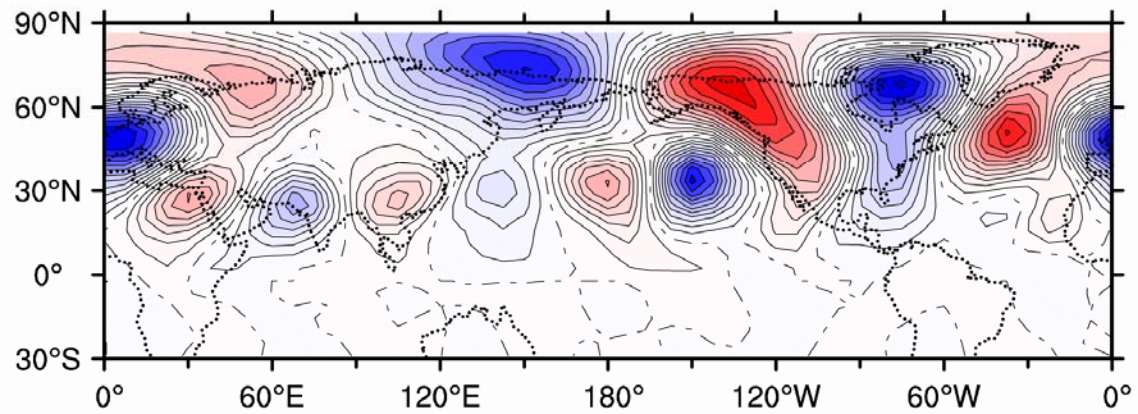
45yr Nature v300 D-J-F*

EOF1 15.1%



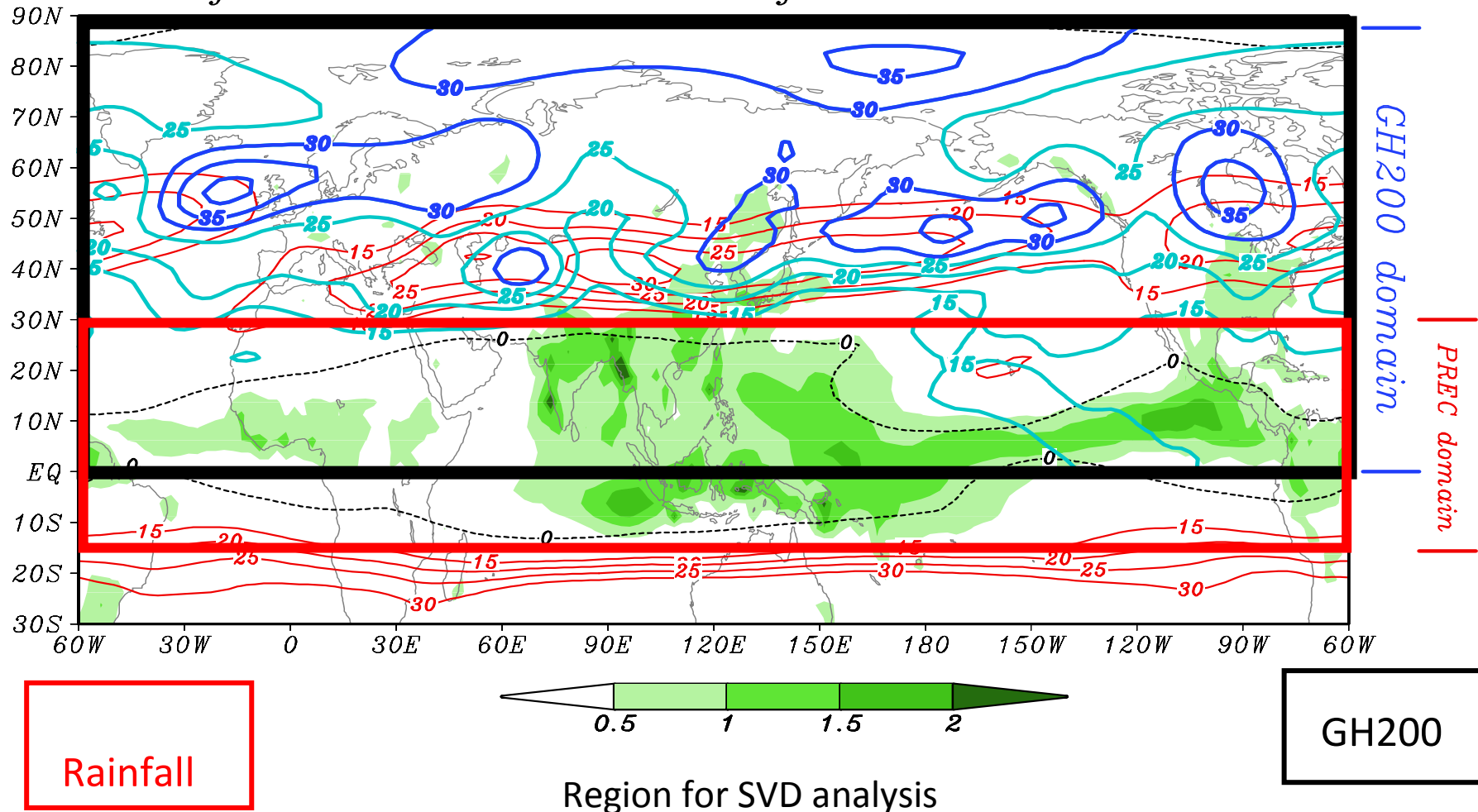
45yr Nature v300 D-J-F*

EOF3 8.6%



Interannual variability of JJAS precipitation and GH200 (1948-2005)

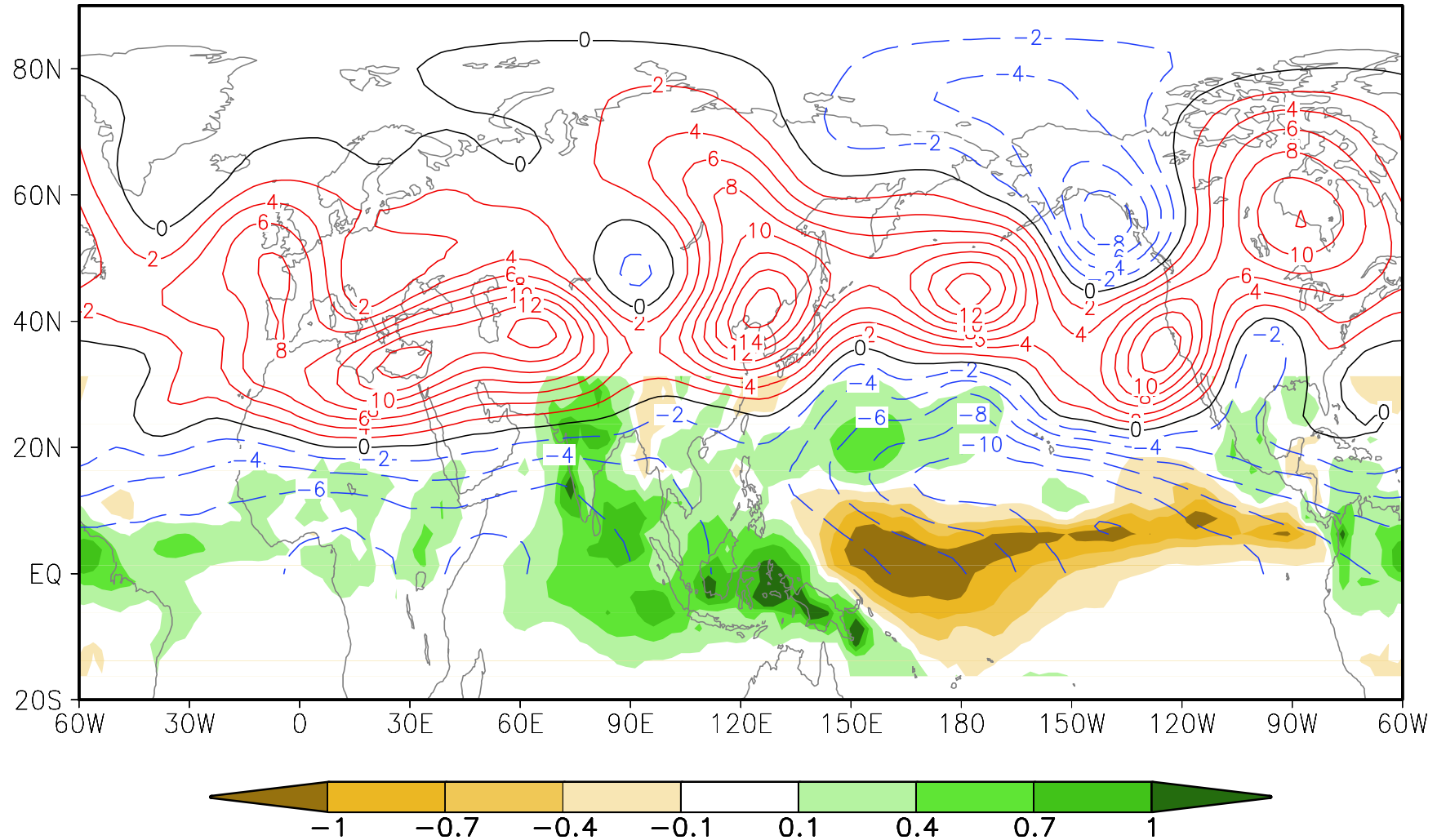
Std of 200hPa GH and rainfall



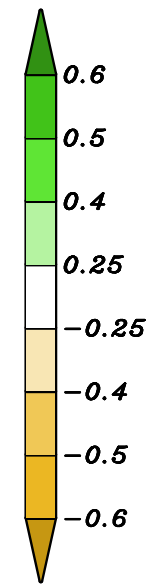
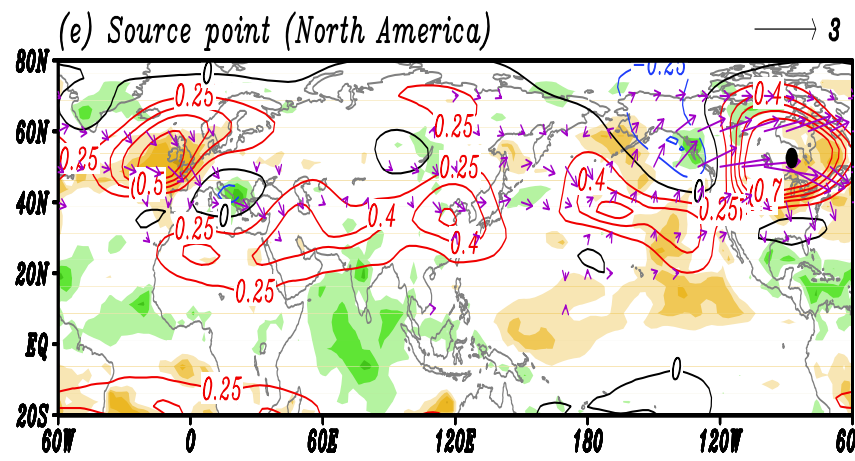
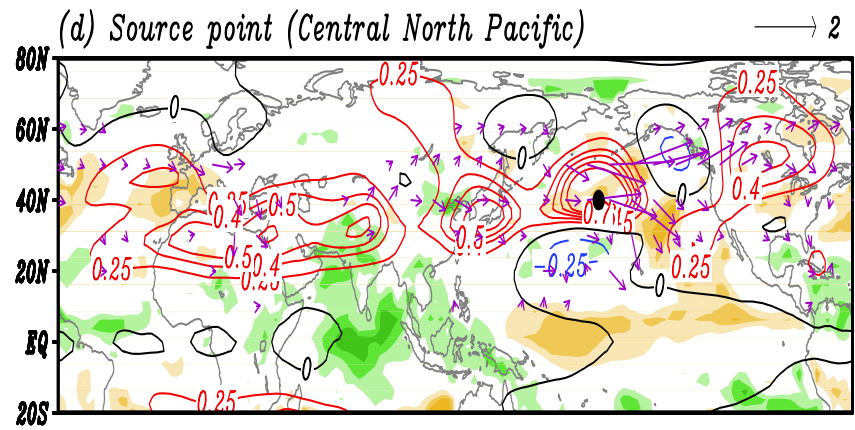
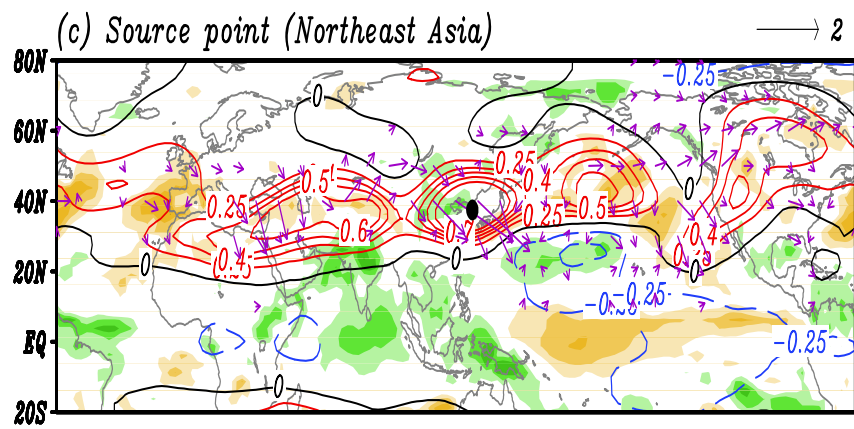
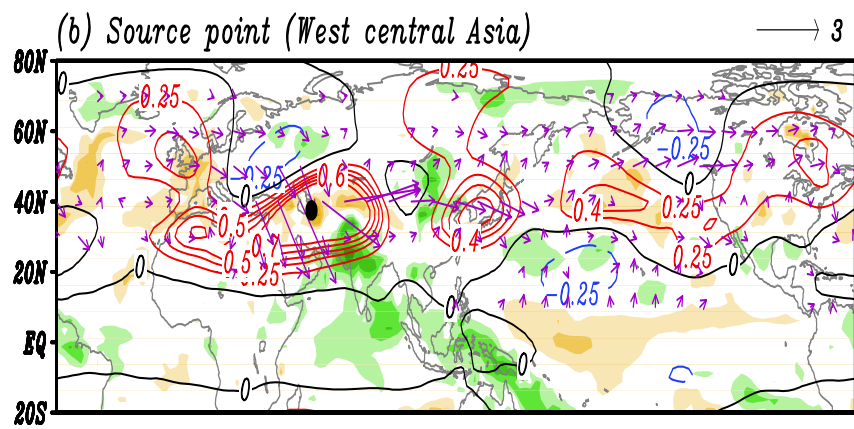
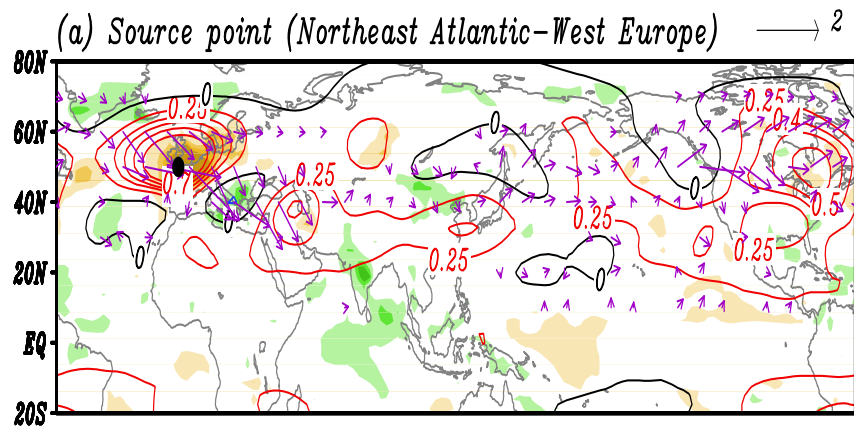
Shading: Std of Rainfall, blue: Std of GH200; Red: Climatological 200hPa Jetstream, Black dotted line: zero line of zonal wind.

Dominant coupled pattern: GH200 and Tropical Rainfall

SVD1 (GH200 and rainfall) SCF=59% Corr=0.82

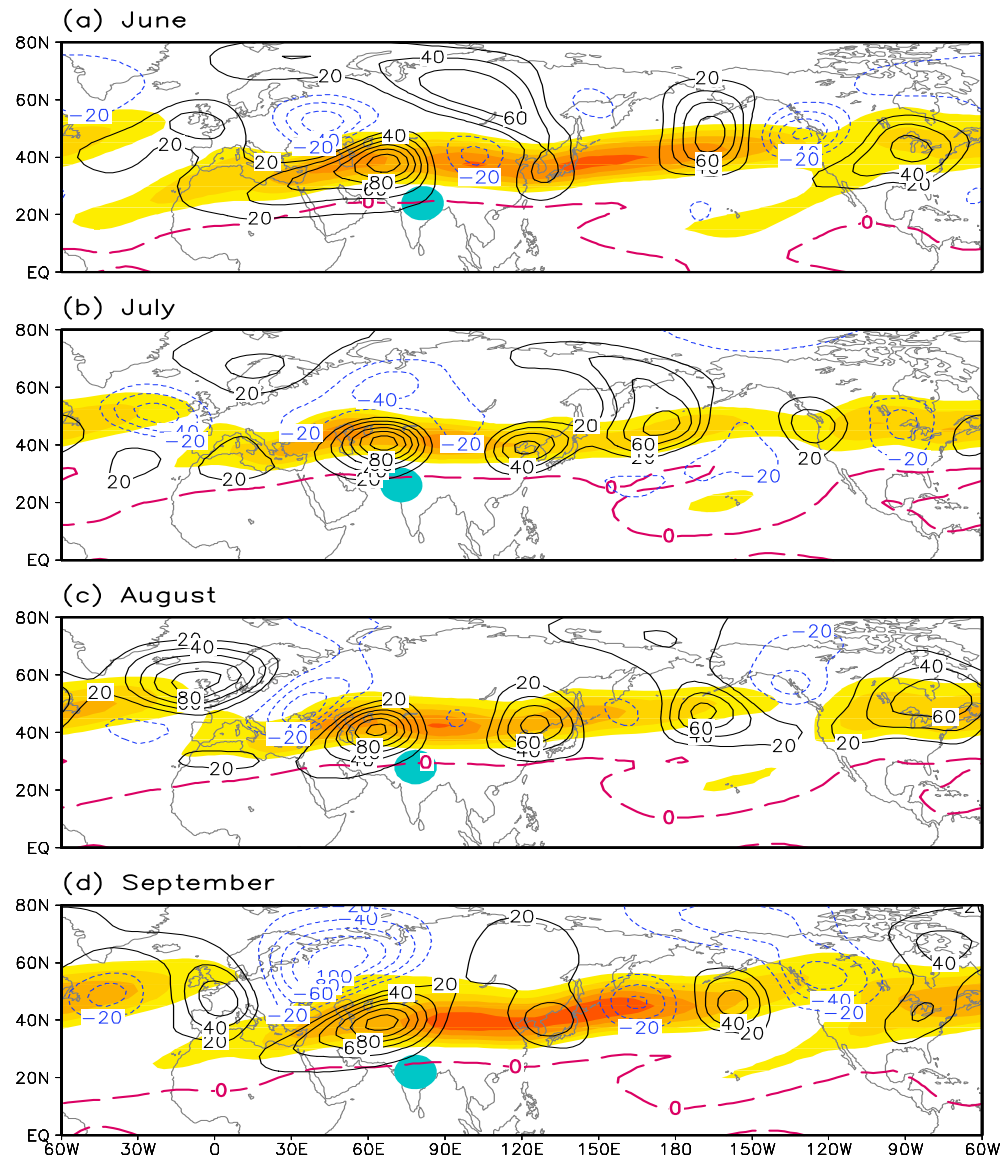


The first SVD mode: GH200 and rainfall (JJAS, 1948-2005)



CGT Pattern is seen in each One-point correlation map with reference to each variability center. The associated tropical rainfall anomaly is always associated with the strengthened ISM.

Monthly CGT

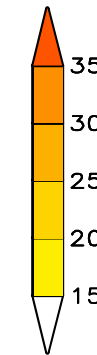


June

July

Aug

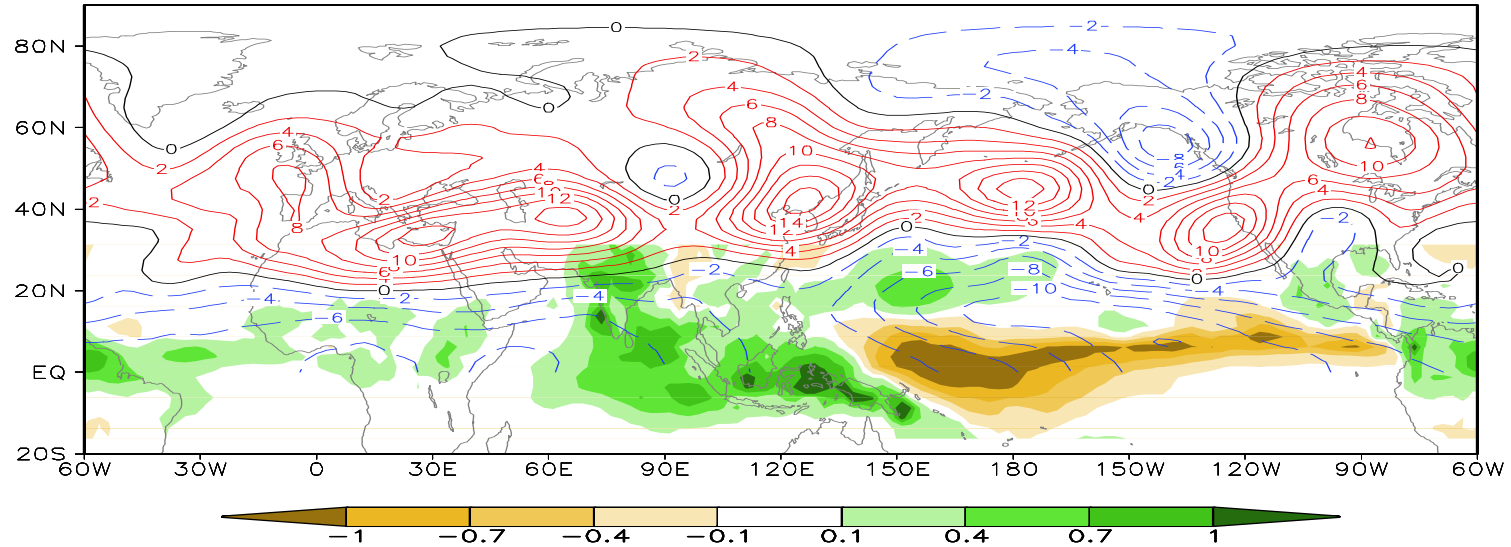
Sep



Ding and Wang 2005)

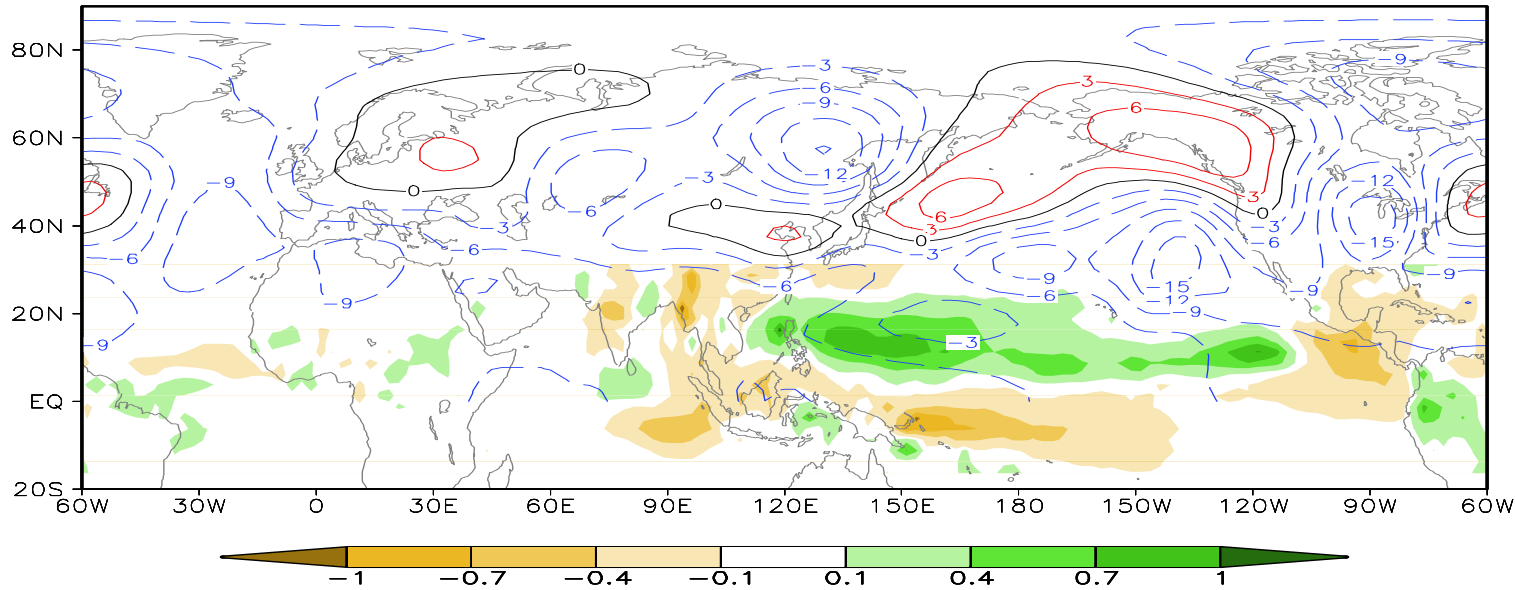
Composite of GH200 based on each month CGT index H200(35-40°N,60-70°E)

SVD1 (GH200 and rainfall) SCF=59% Corr=0.82



SVD 1

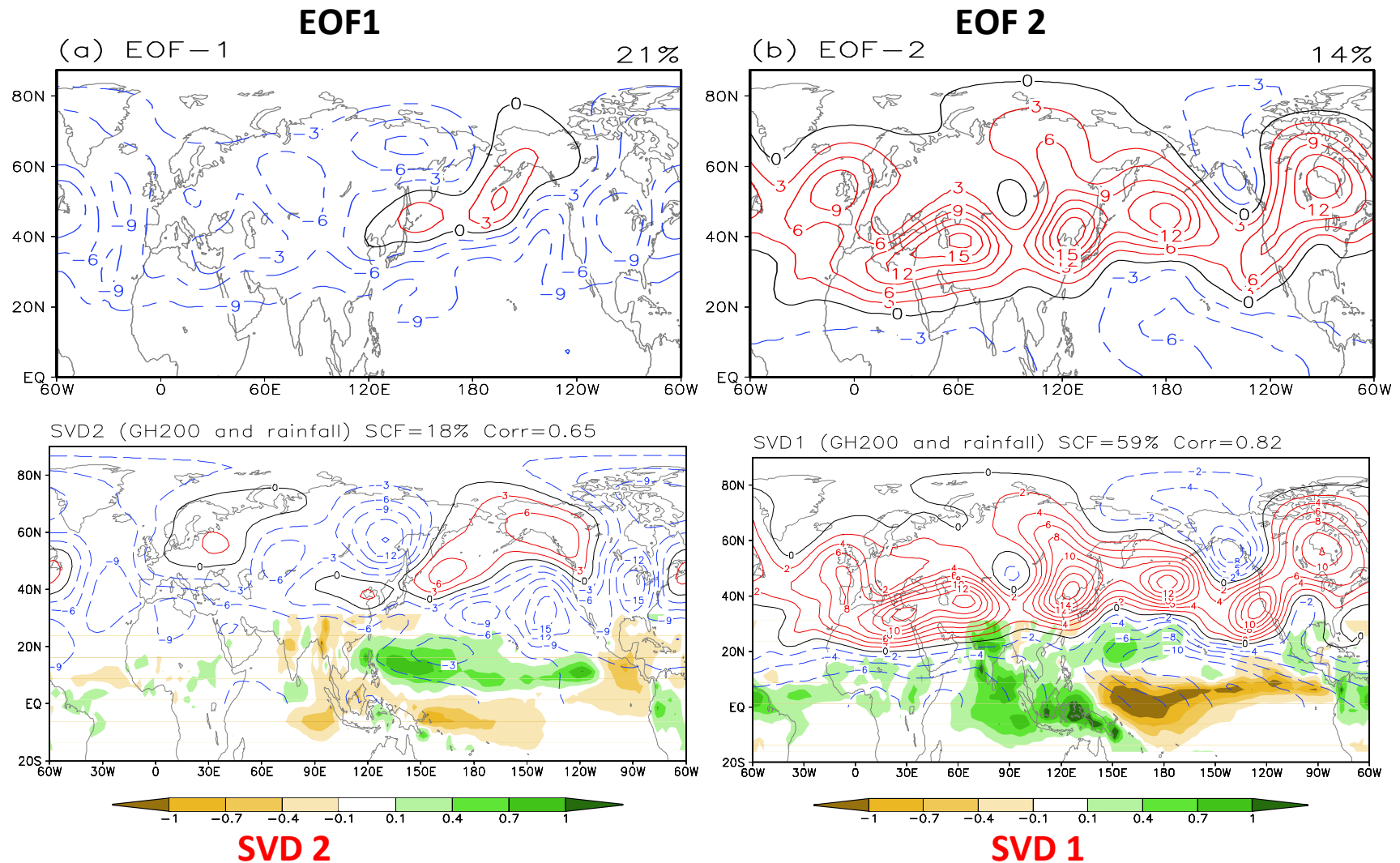
SVD2 (GH200 and rainfall) SCF=18% Corr=0.65



SVD 2

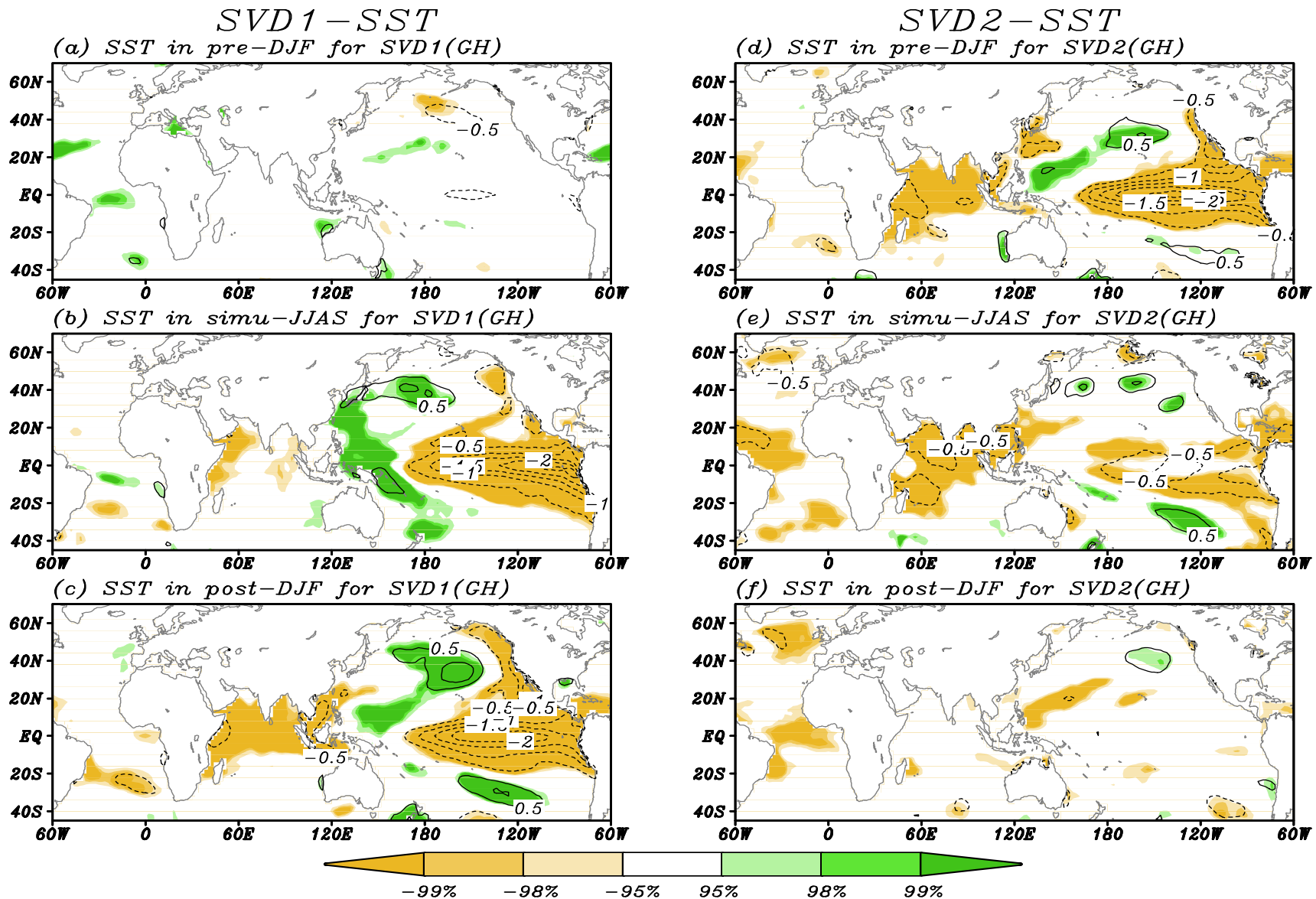
SVD-2: a coupling between enhanced tropical Western North Pacific rainfall and a meridional circulation anomaly pattern over the North Pacific.

How important are the coupled patterns?



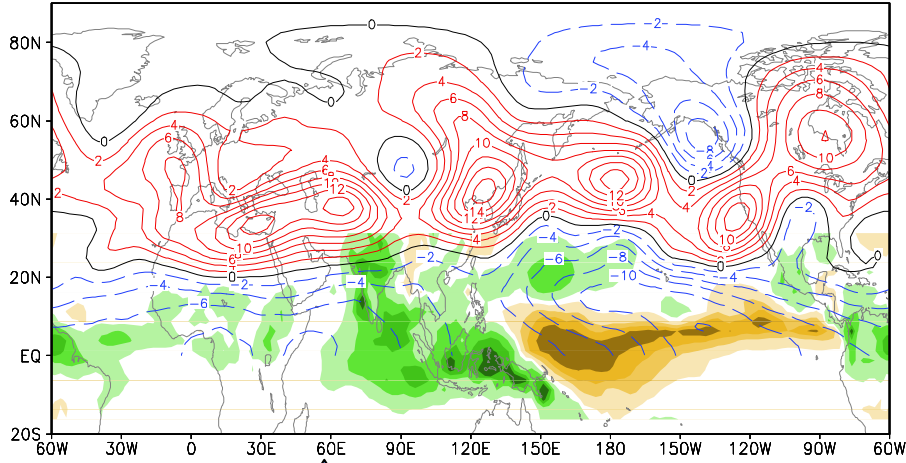
The extratropical circulation patterns represented by the SVD1 and SVD2 modes closely resemble, respectively, the EOF2 and EOF1 modes of the upper-level extratropical circulation.

How are CGT and SVD 2 related to tropical SST variations?

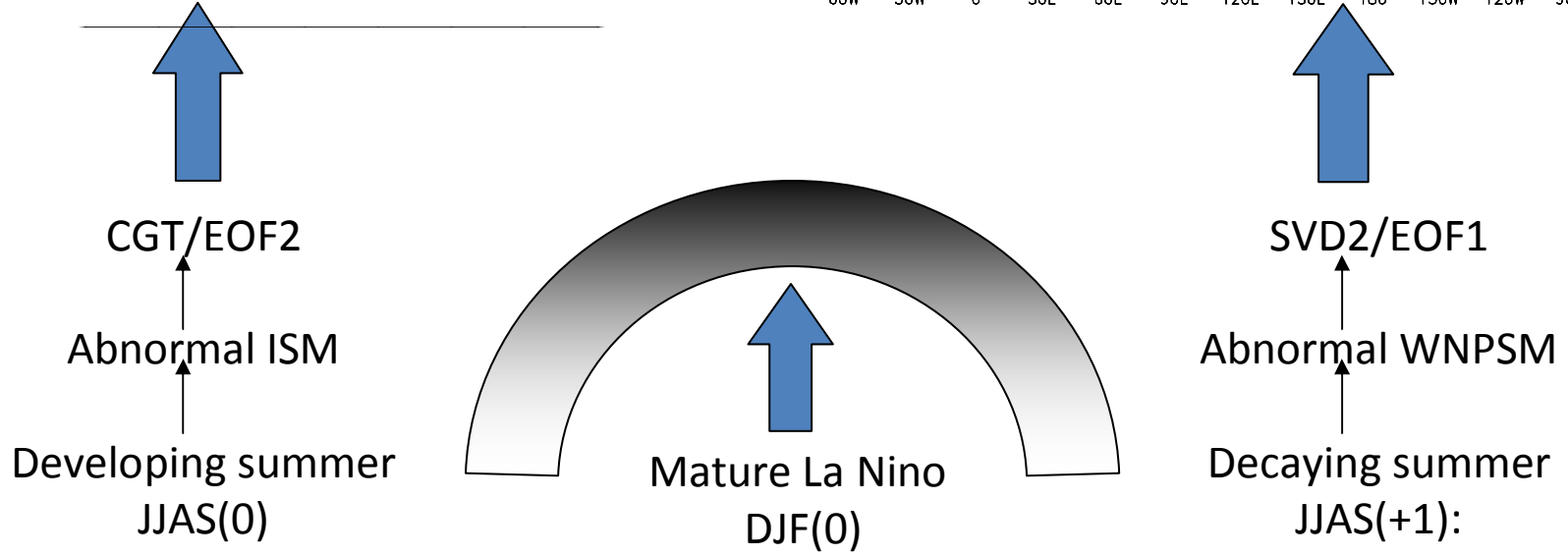
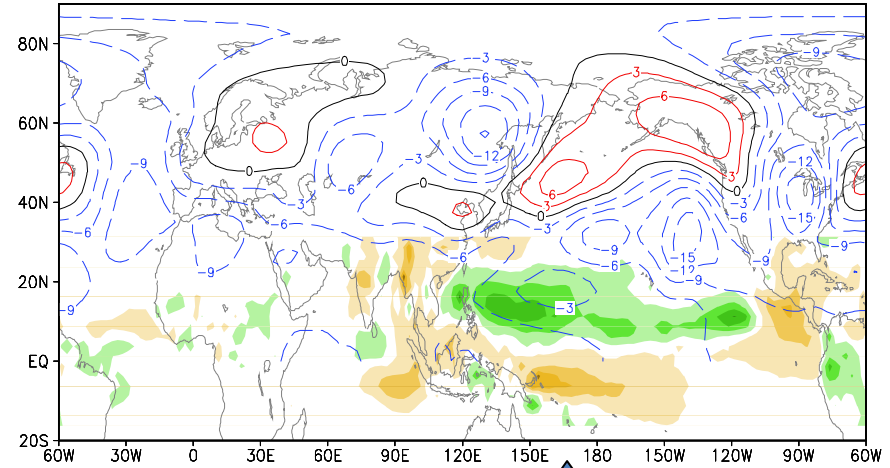


ERSST corresponding to SVD1 & 2 (DJF, JJAS, DJF(+1) 1948-2005)

SVD1 (GH200 and rainfall) SCF=59% Corr=0.82



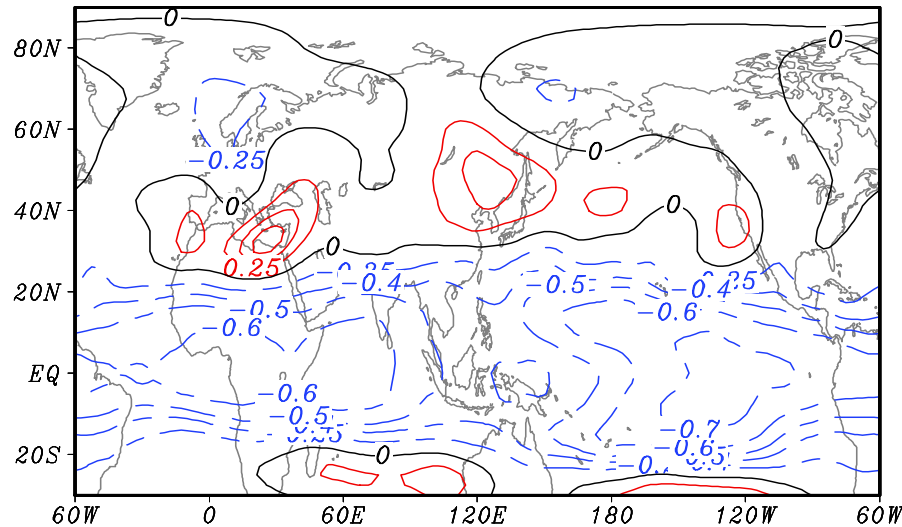
SVD2 (GH200 and rainfall) SCF=18% Corr=0.65



ENSO relocates tropical precipitation heat source and affects the extratropical response in developing and decaying summer.

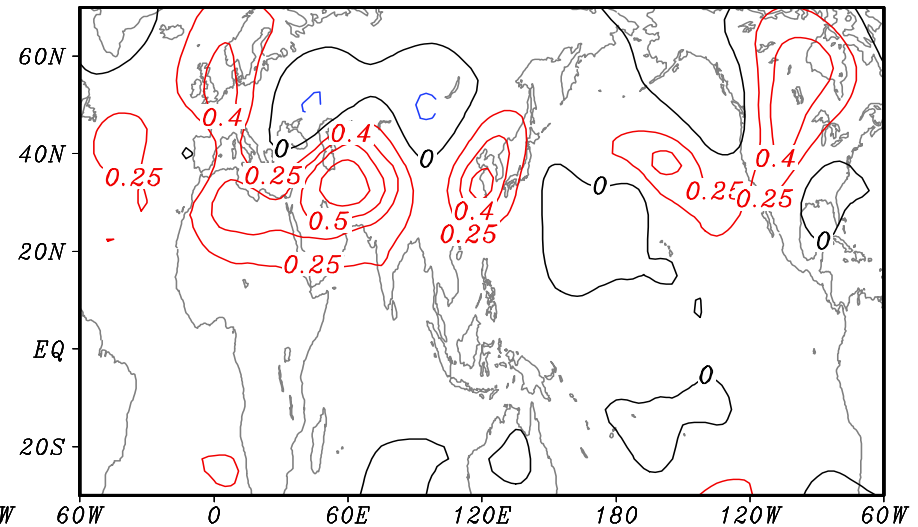
Partial Correlation between AIRI/Nino3 and GH200 (JJAS, 1948-2005)

(c) Partial corr. (GH200 - Nino3)



Correlation with ENSO (sign reversed)
(effect of ISM removed)

(d) Partial corr. (GH200 - AIRI)

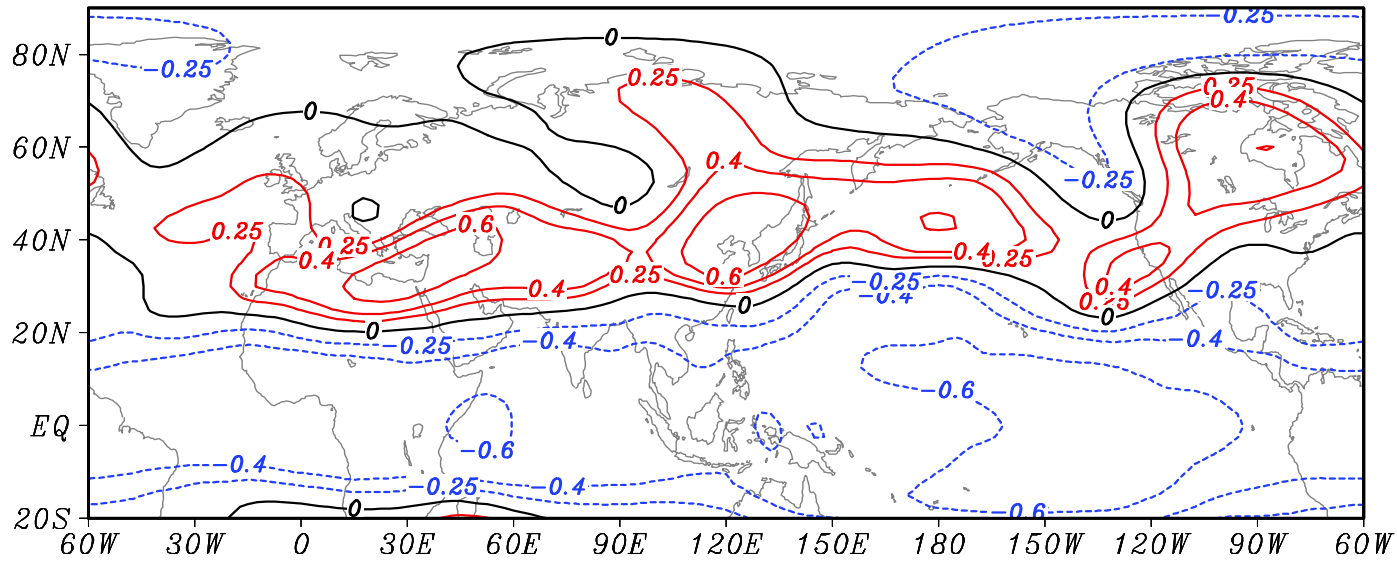


Correlation with ISM
(ENSO effect removed)

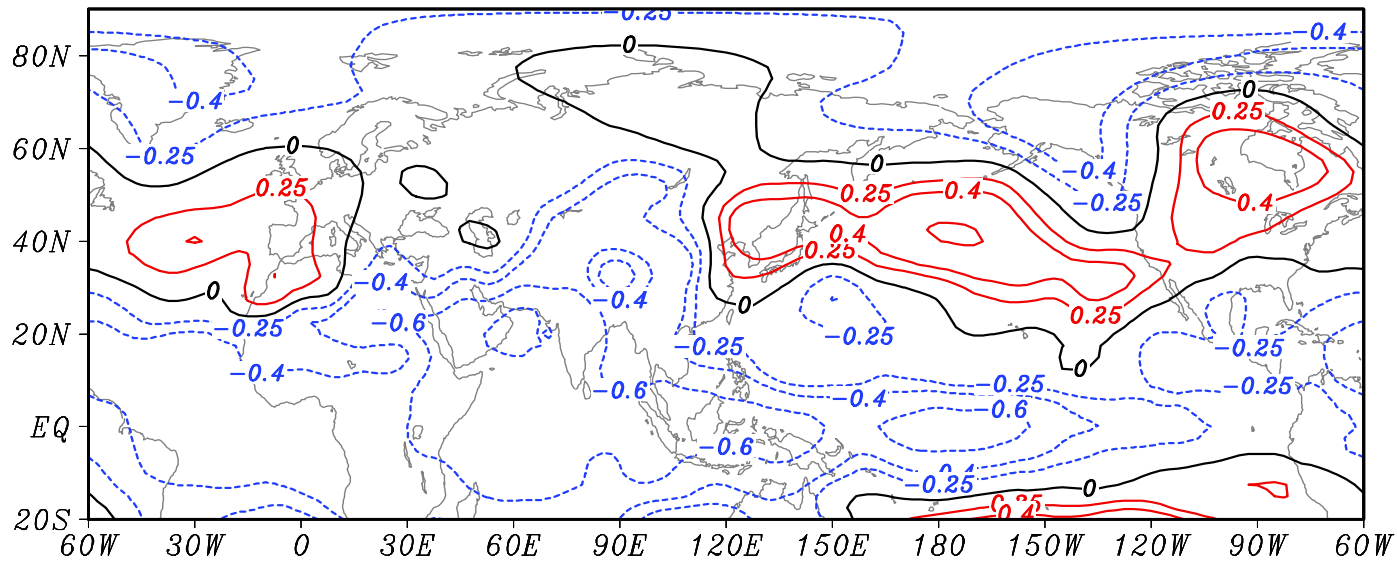
- ISM connects directly with CGT.
- ENSO may indirectly connect with CGT through changing ISM.
- The connection of ENSO (without ISM) with extratropical circulation is weak and confined to an elongated area stretching from northeast china via central North Pacific to California.

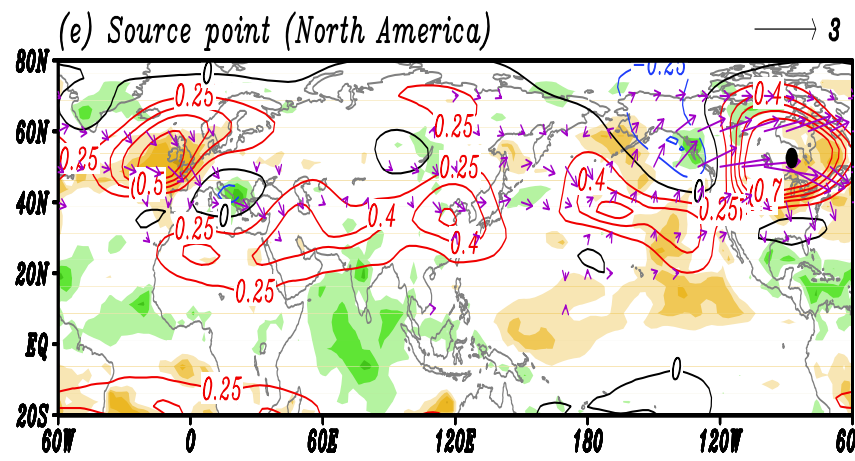
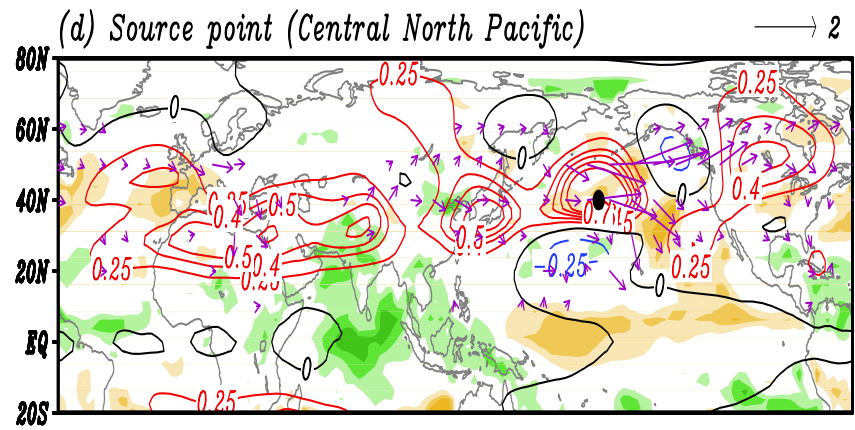
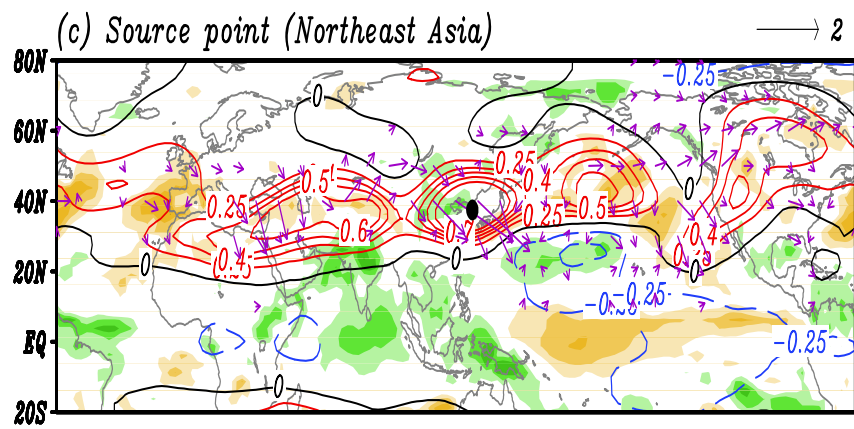
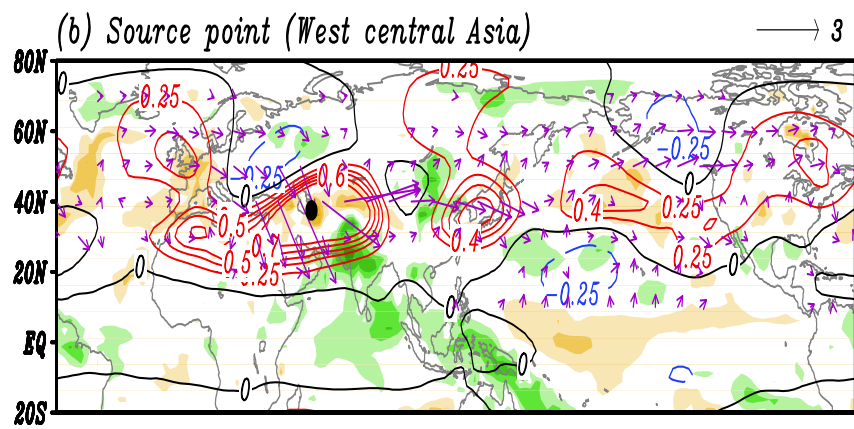
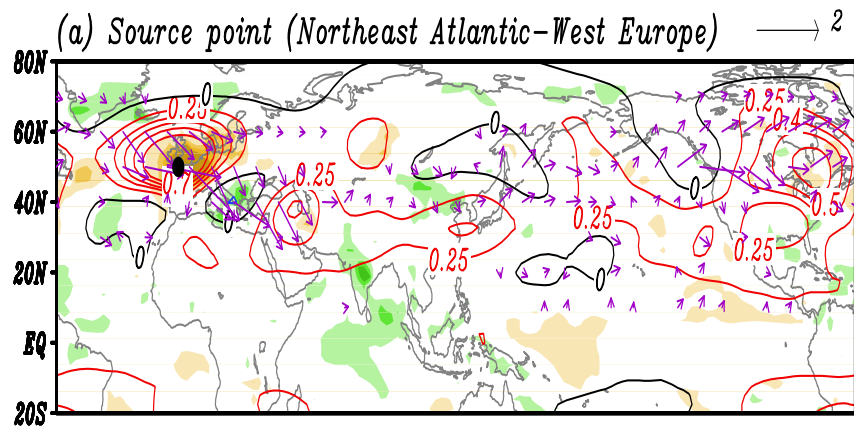
Vertical structure of CGT

(a) Corr. between SVD1(height) and GH200



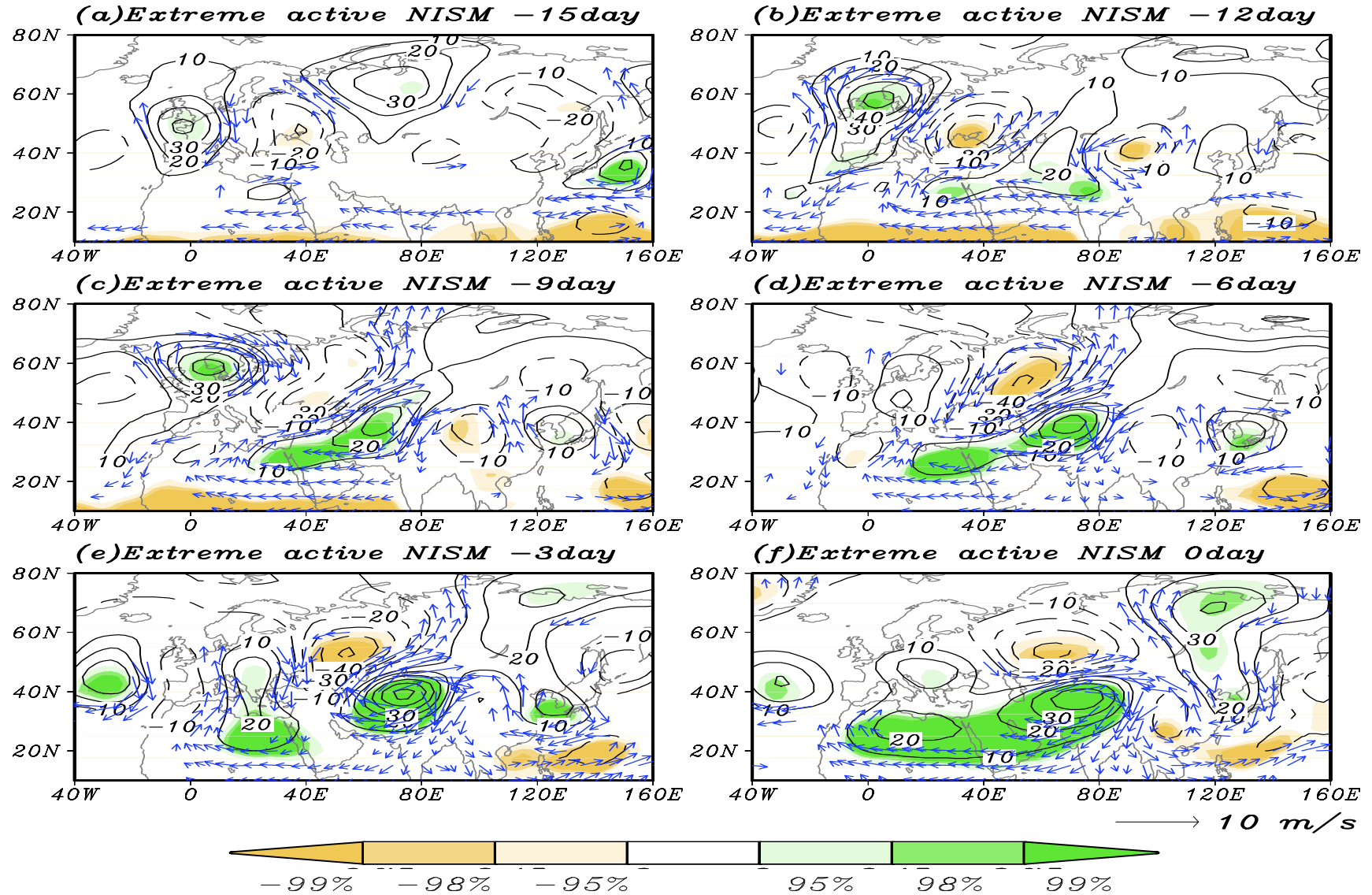
(b) Corr. between SVD1(height) and GH700



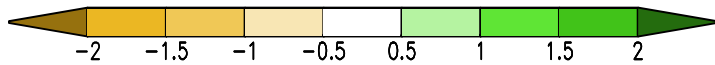
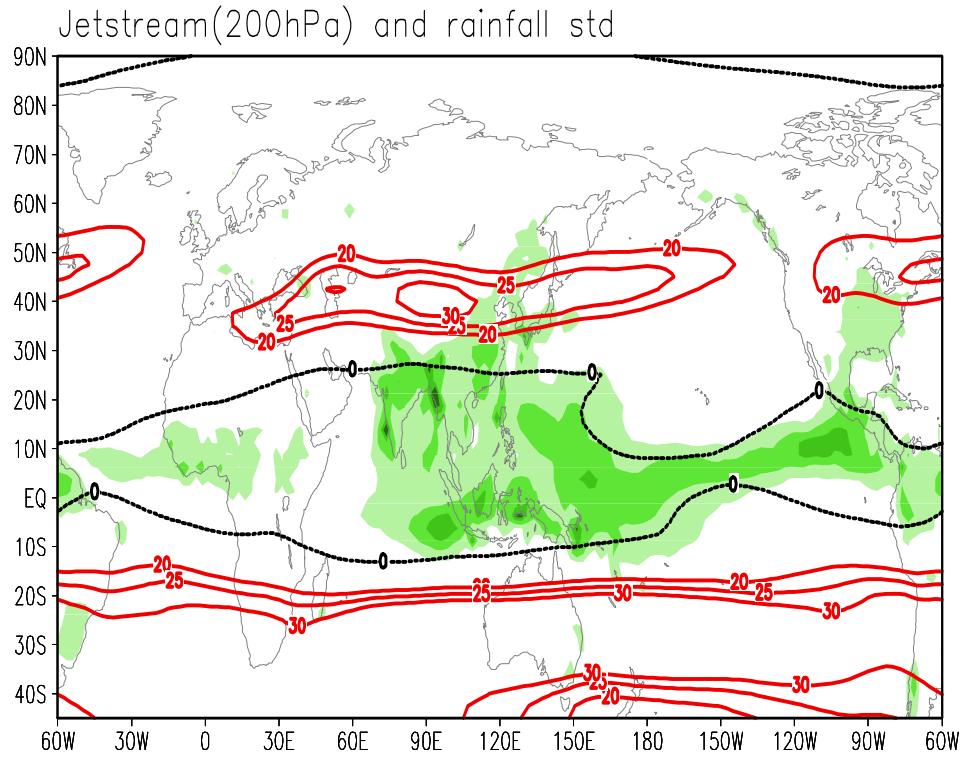


Rossby wave energy propagation
Wave action flux

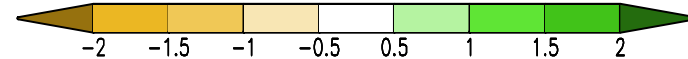
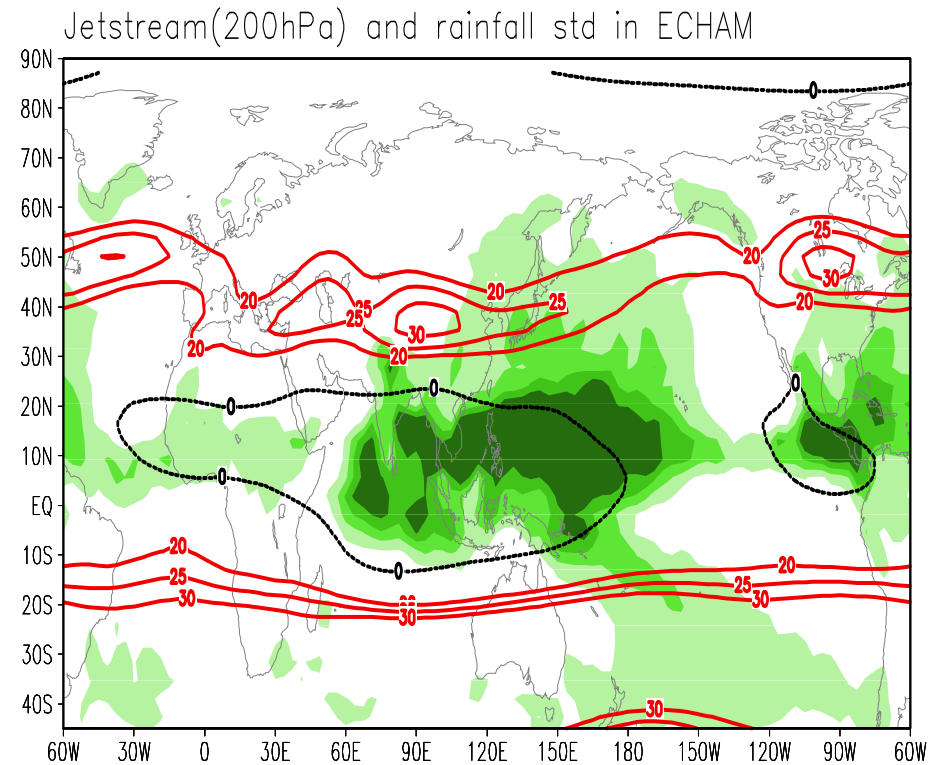
Intraseasonal Eurasian wavetrain leads ISM by 10-15 days



Observed

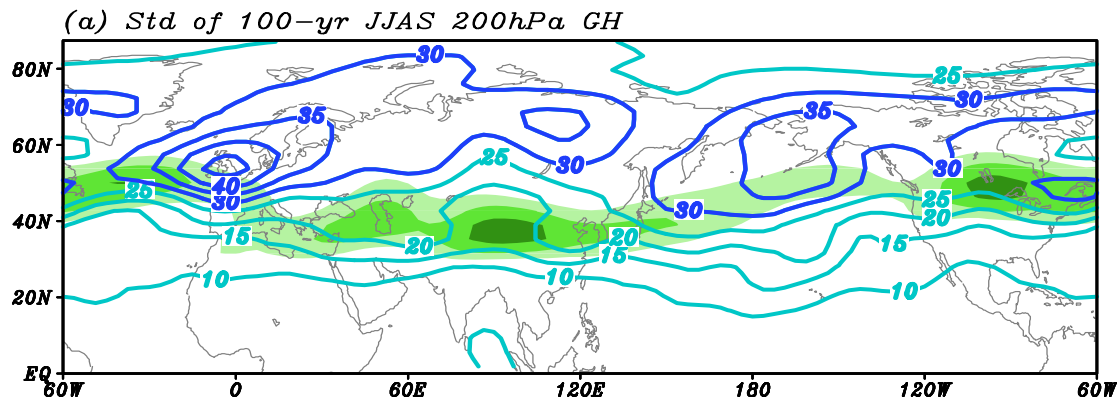


Echam-4 model Simulated climatology

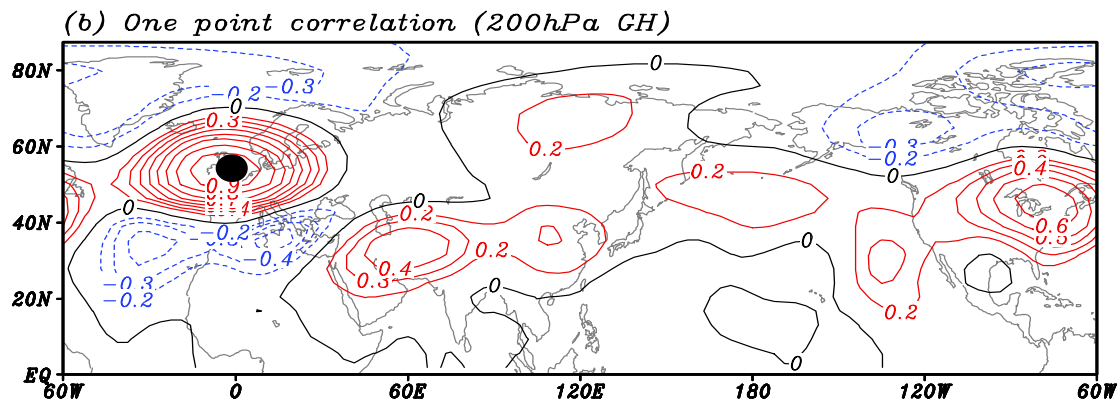


Shading: Std Rainfall (JJAS, 100-yr run), Red: 200hPa zonal wind speed (highlight the Jet stream)

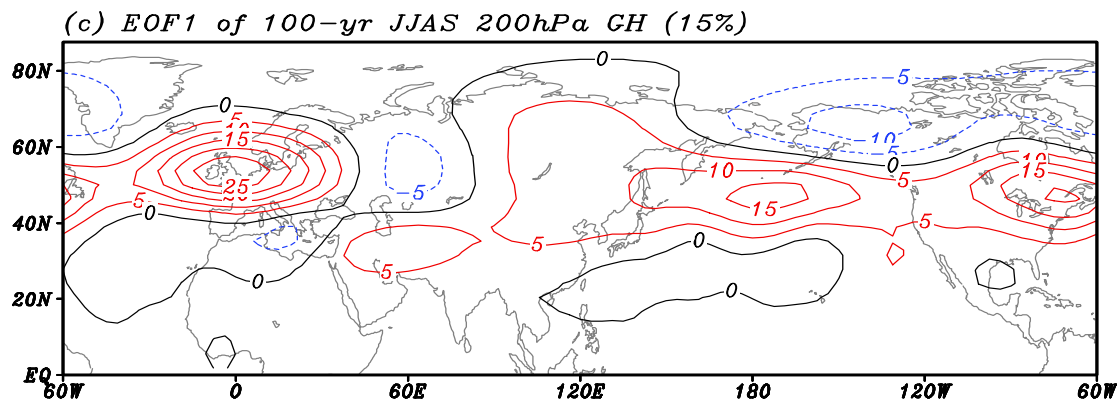
100-yr mean climate run (No ENSO)



Strong activity over the jet exit region: barotropic instability

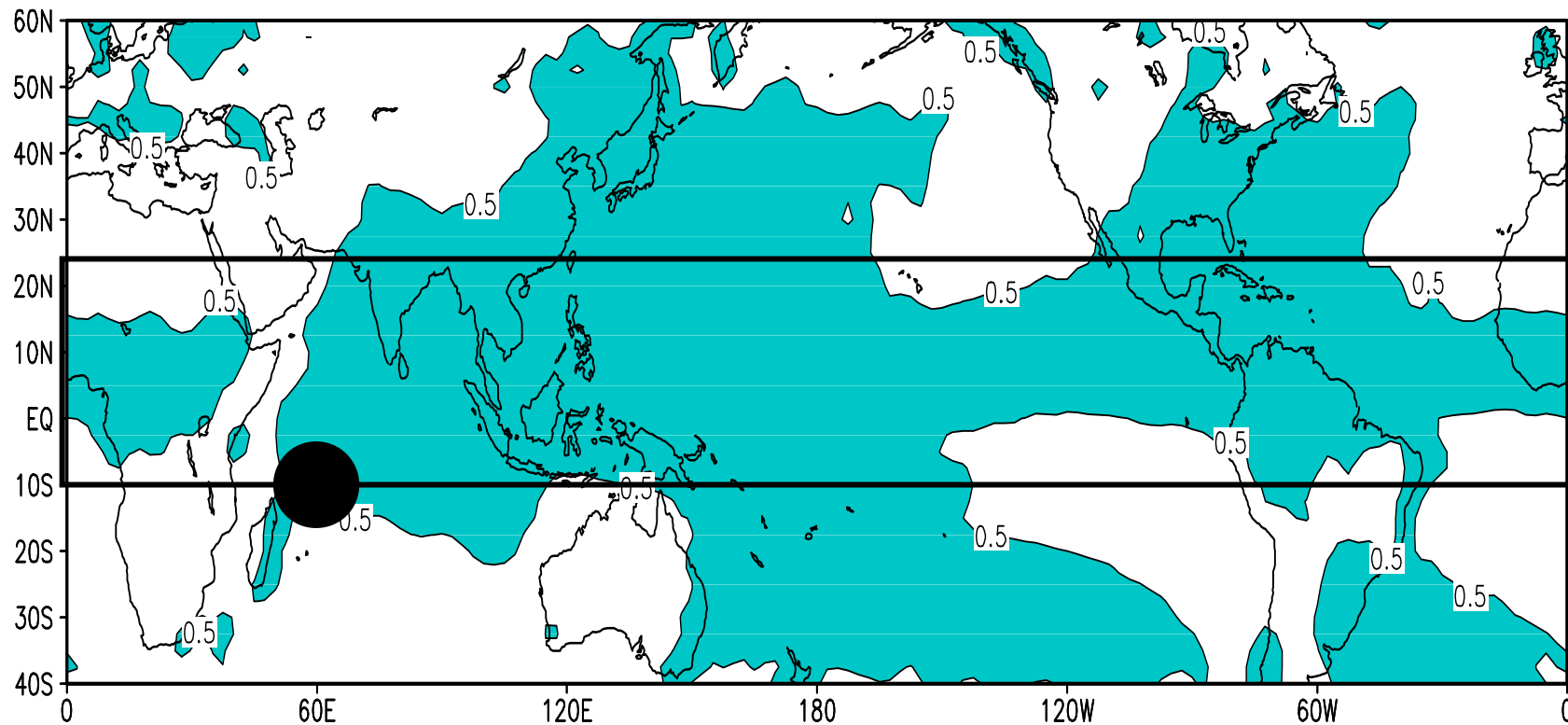


A CGT-like mode is strongly linked with variability over the jet exit region



Without external SST forcing, leading mode of internal variability is similar to CGT

Std of JJAS rainfall in CMAP



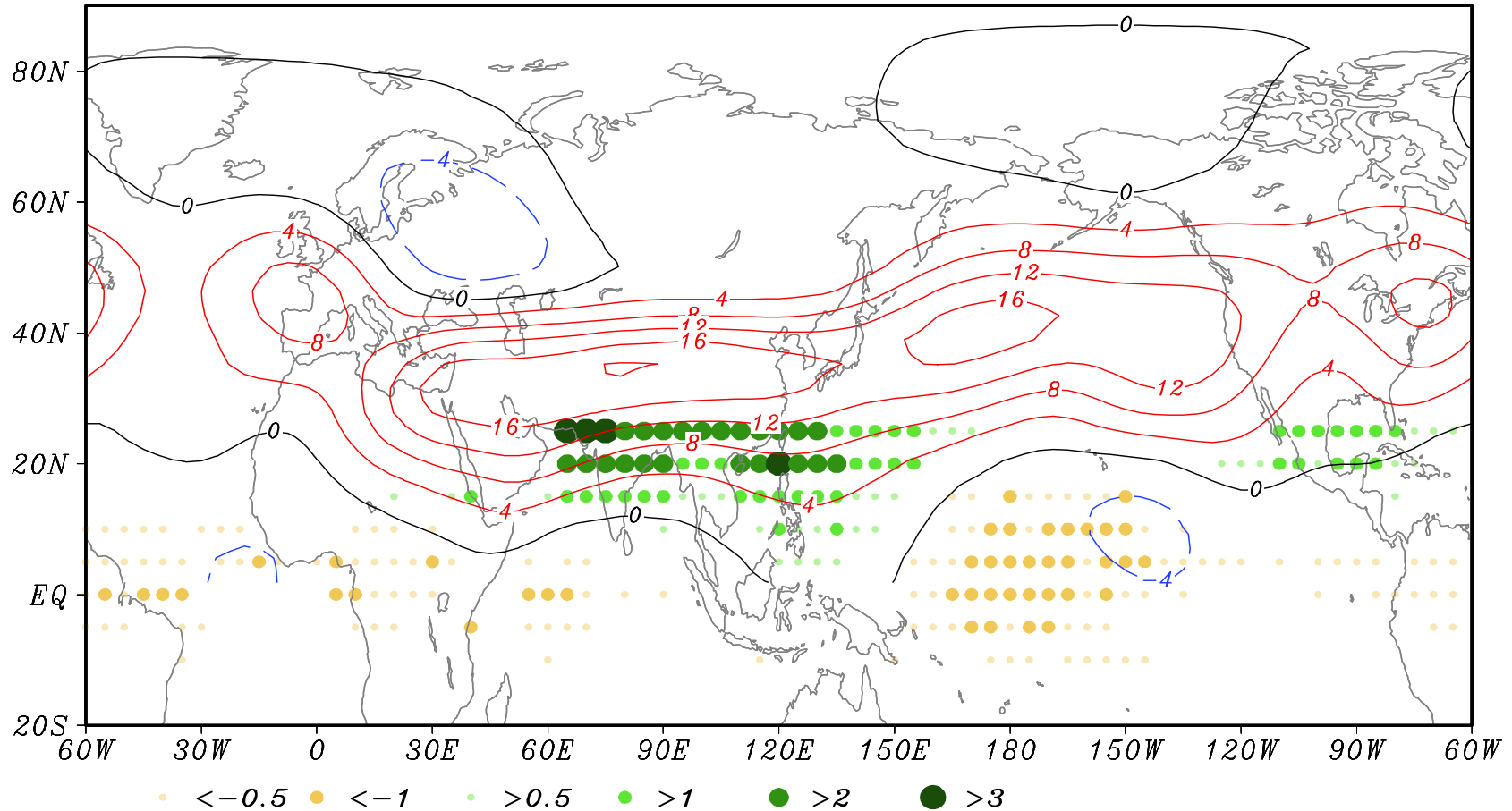
In each run , centers of specified heating is located within 0.5 Std region (5 degree apart between each run)

Total: 415 run

Each run have 10 members with different initial condition

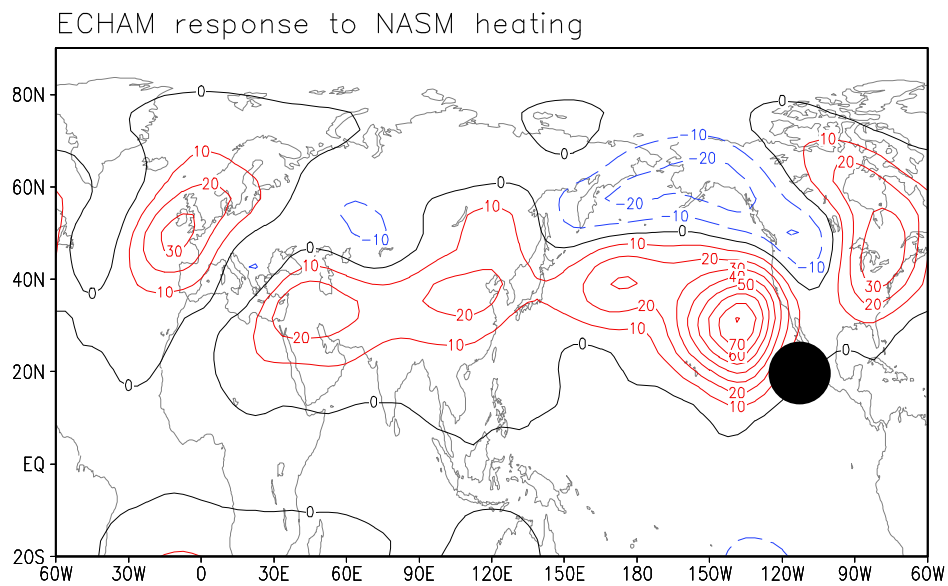
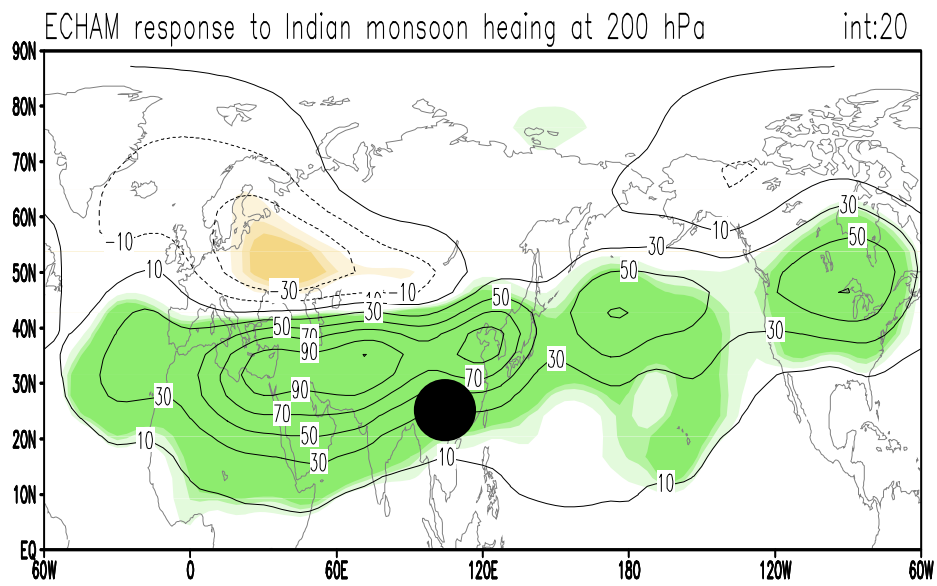
Ensemble average/ 10 members : Each run (JJAS) minus CTL(JJAS):

EOF1 of 415 run (within 0.5std -- 31%)

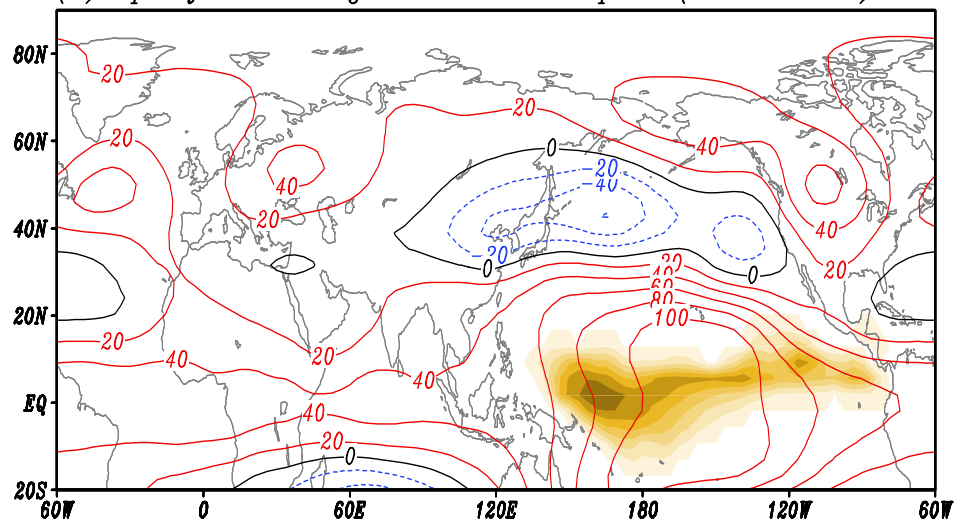


Circle: heating center location strongly linked to normal mode

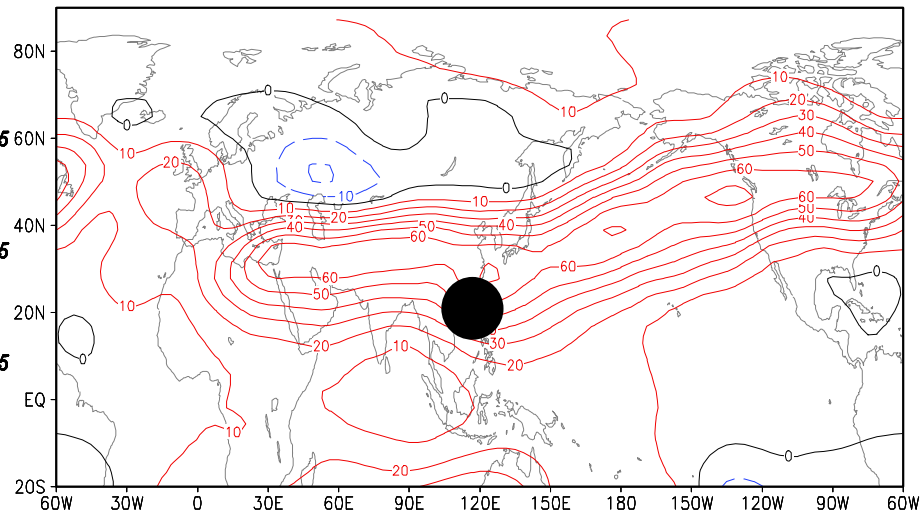
Contour: EOF1 of GH200 in JJAS



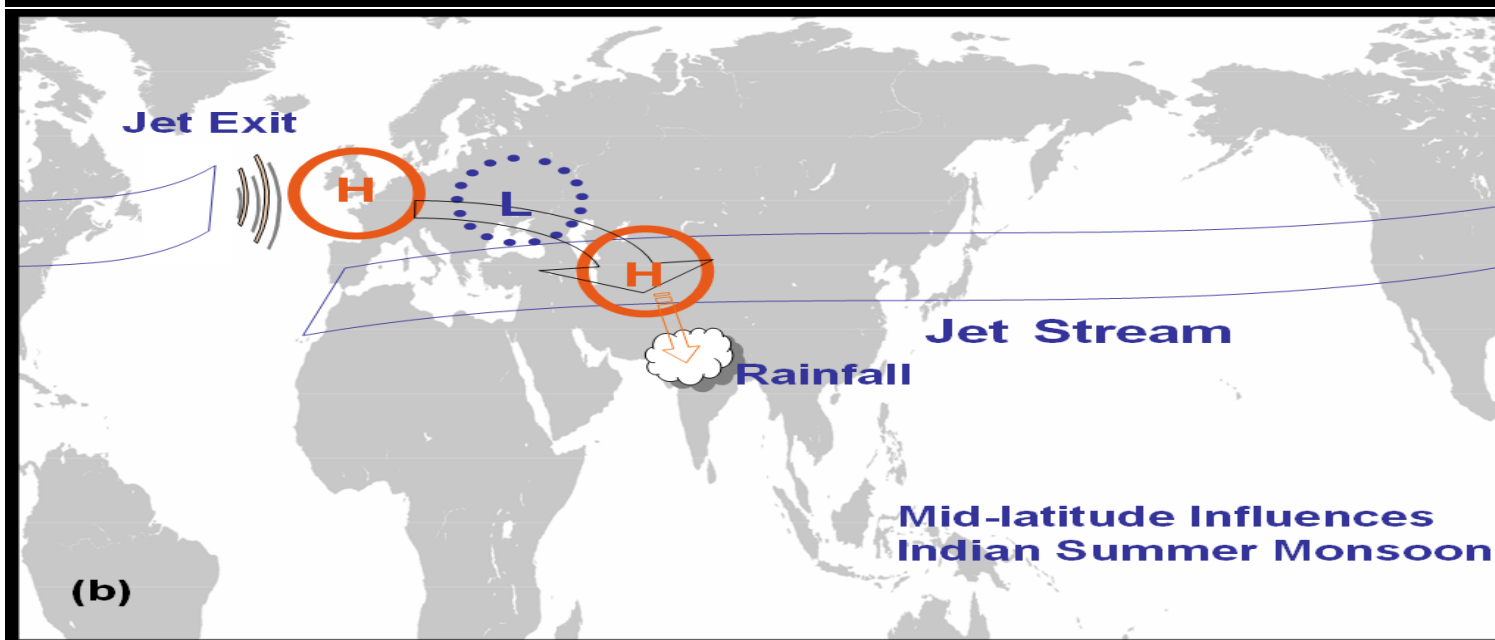
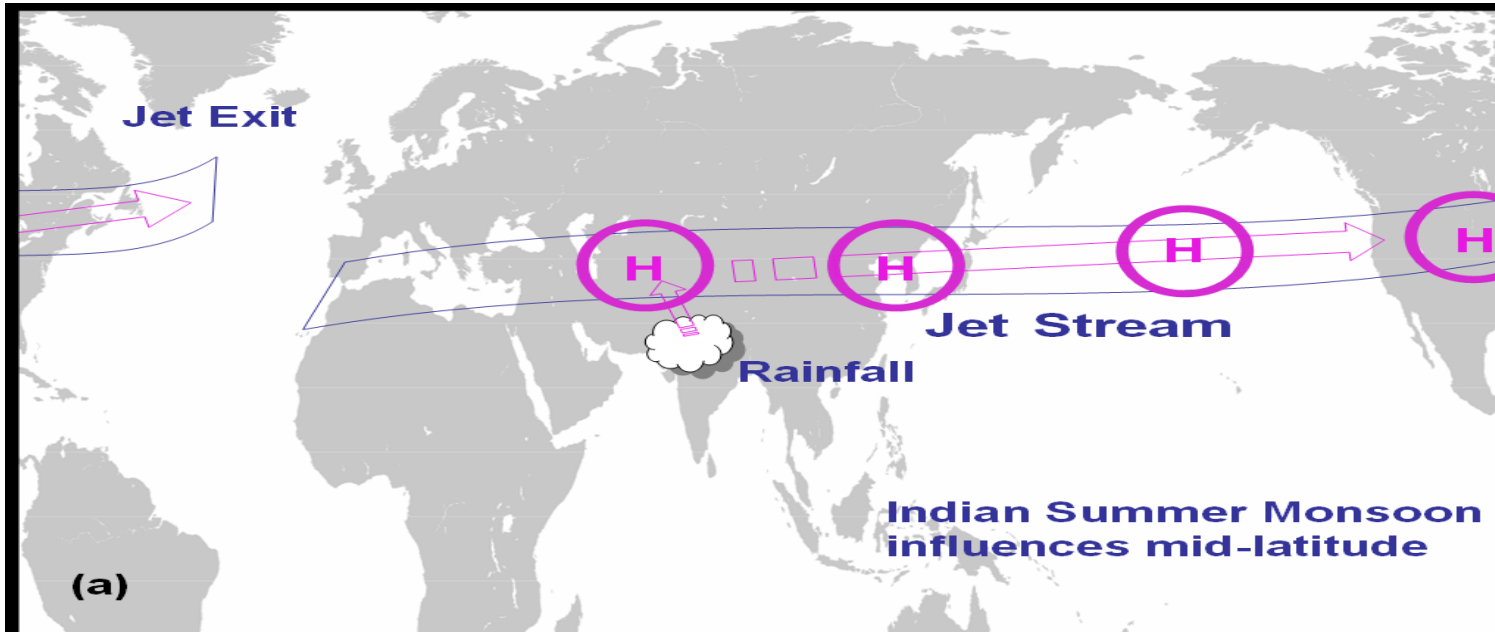
(a) Specified heating and ECHAM response(JJAS GH200)



ECHAM response to SCS heating

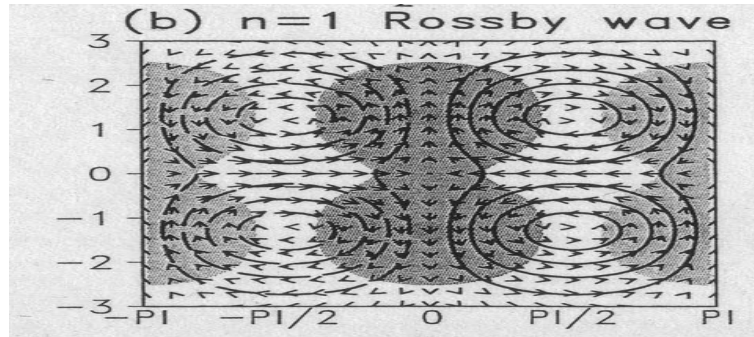


Hypothesis

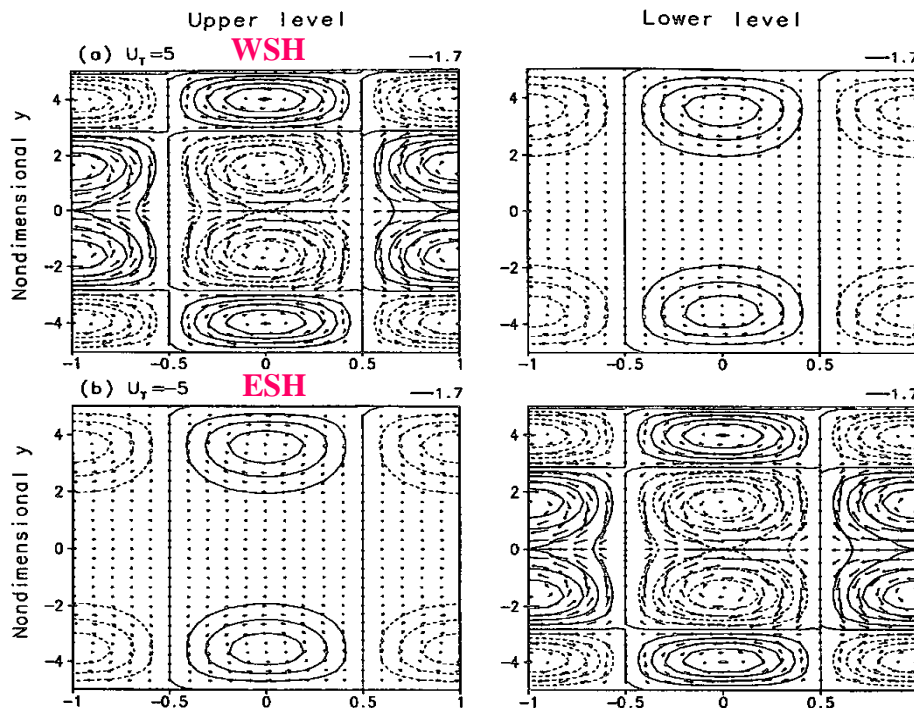


Effects Vertical shear on Rossby Waves

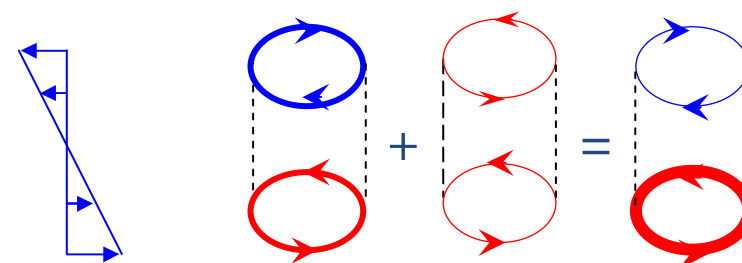
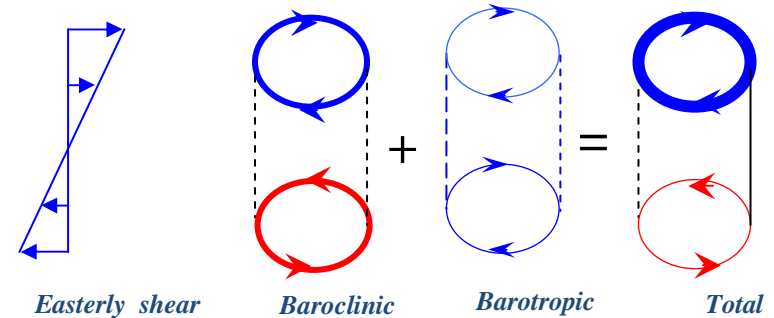
Coupling of baroclinic and barotropic modes in the presence of vertical shear



$$\frac{D\zeta_+}{Dt} = -v_+ + U_T \left(\frac{\partial D_-}{\partial y} - \frac{\partial \zeta_-}{\partial x} \right)$$



Westerly shear

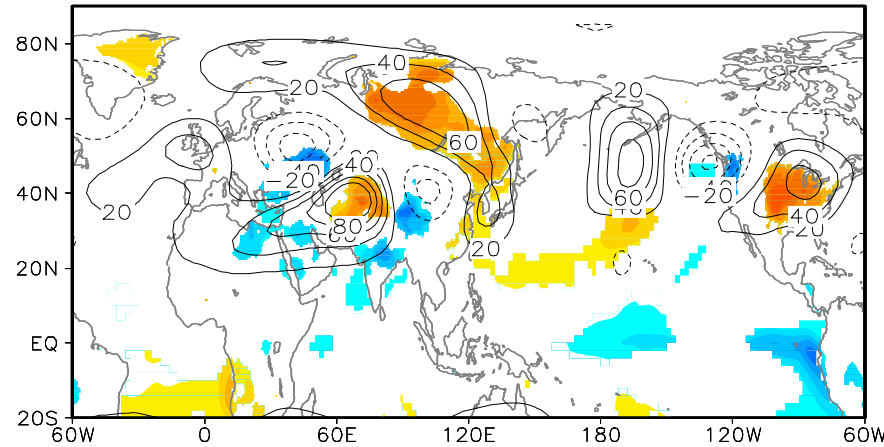


Wang and Xie (1996)

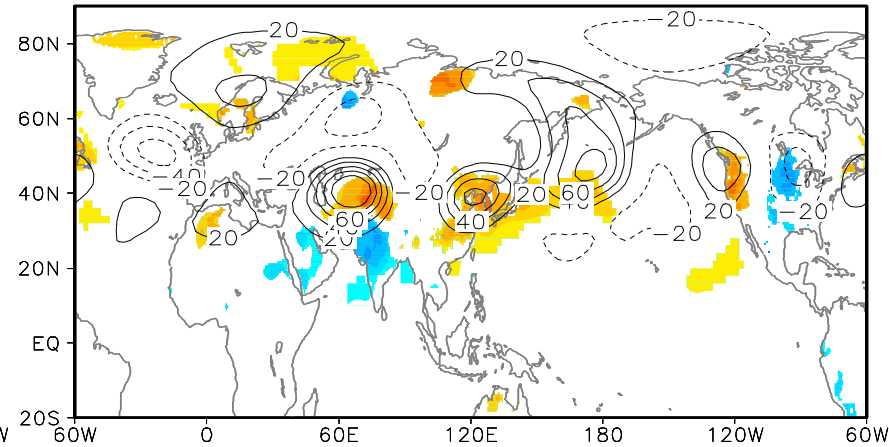
The baroclinic and barotropic modes are in phase (180° out of phase) in the westerly (easterly) shear. Therefore, an easterly (westerly) shear leads to the amplification of Rossby wave responses in the lower (upper) level.

Surface Temp (land) and SST (ocean) anomalies associated with CGT from June to September

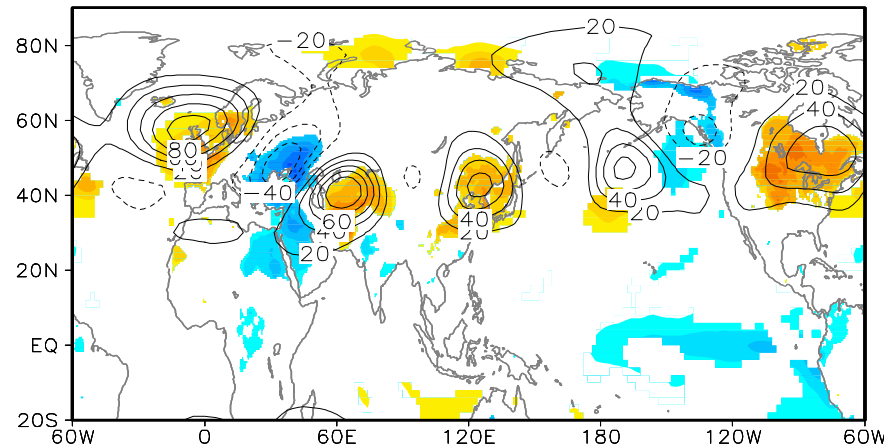
(a) June



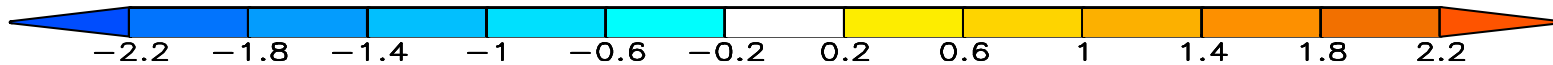
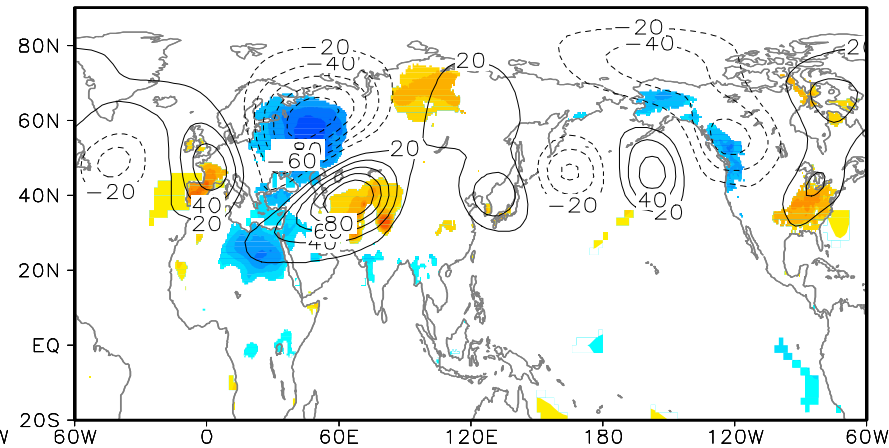
(b) July



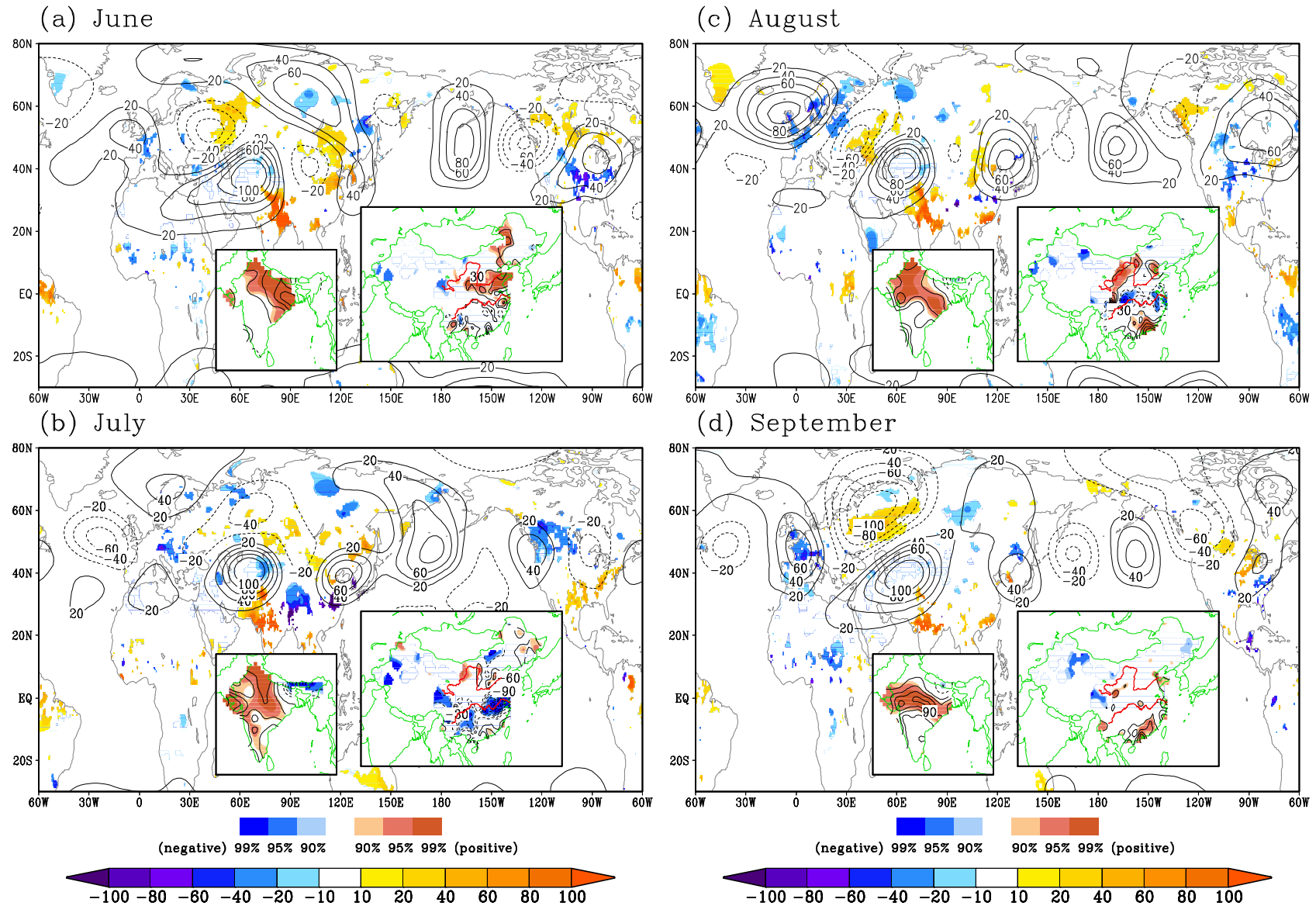
(c) August



(d) September



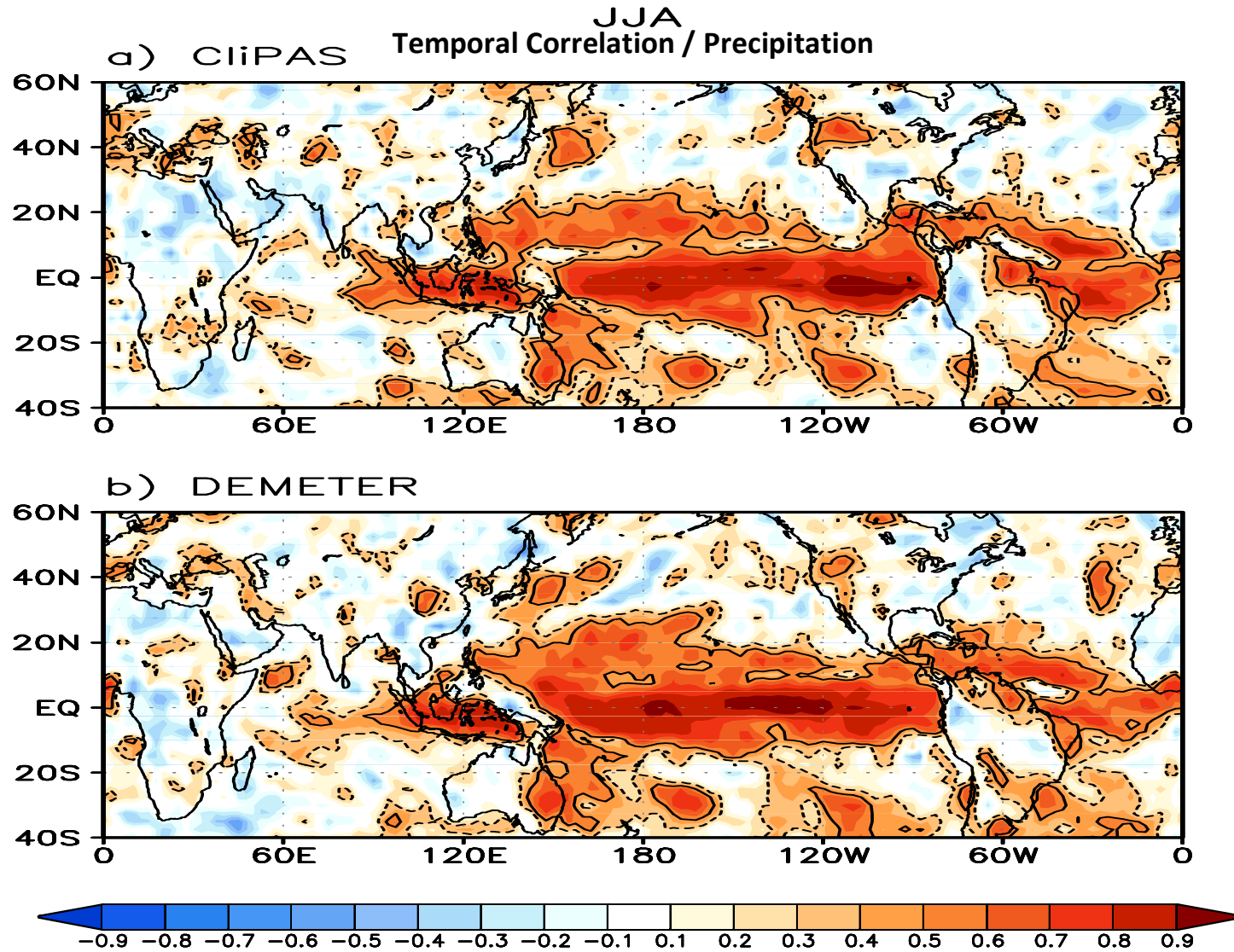
Precipitation anomalies associated with CGT from June to September



Implication

- CGT provides potential sources of predictability for seasonal forecast of boreal summer extratropical circulation anomalies.
- Accurate simulation of the CGT pattern and tropical monsoon rainfall appears to be critical in forecast of boreal summer extratropical circulation variability.

One-month lead Seasonal prediction skill of JJA precipitation



How much is the NH extratropical circulation variability related to tropical forcing?

Summary

- CGT is the most recurrent coupled pattern of the IAV between tropics and extratropics (SVD1).
- The circulation patterns represented by SVD1 and SVD2 modes reflect the EOF2 and EOF1 modes of the extratropical circulation, respectively.
- The CGT and SVD2 concur with the developing and decaying phase of ENSO cycle, respectively.
- The anomalous ISM acts as a primary tropical forcing to maintain the CGT; ENSO may modulate CGT through changing the ISM.

Summary

- Diabatic heating anomalies associated with the ISM can generate major part of the CGT emanating from western-central Asia to North America through Rossby wave energy propagation.
- Activity center of CGT over the northeast Atlantic-west Europe is attributed to strong internal dynamics associated with the Jet stream exit.
- The generation of CGT is governed by a joint effort of ISM effect and barotropic instability of basic flow.
- CGT acts as a primary agent to convey the tropical influence to the extratropical climate.

Thanks