Interannual Variability

- Main Target of Climate Monitoring -

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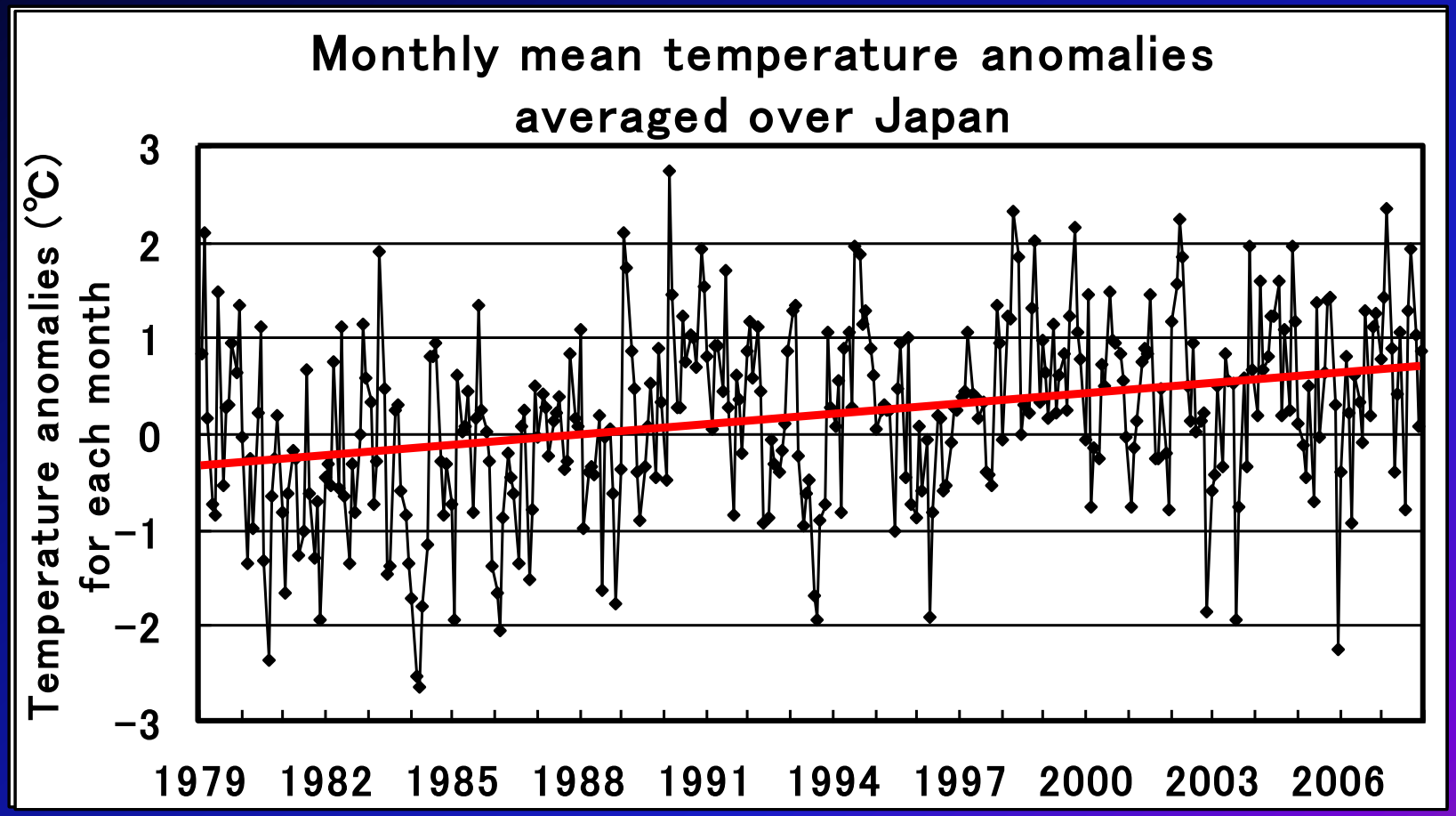
Climate Prediction Division
Japan Meteorological Agency

What and Why ?

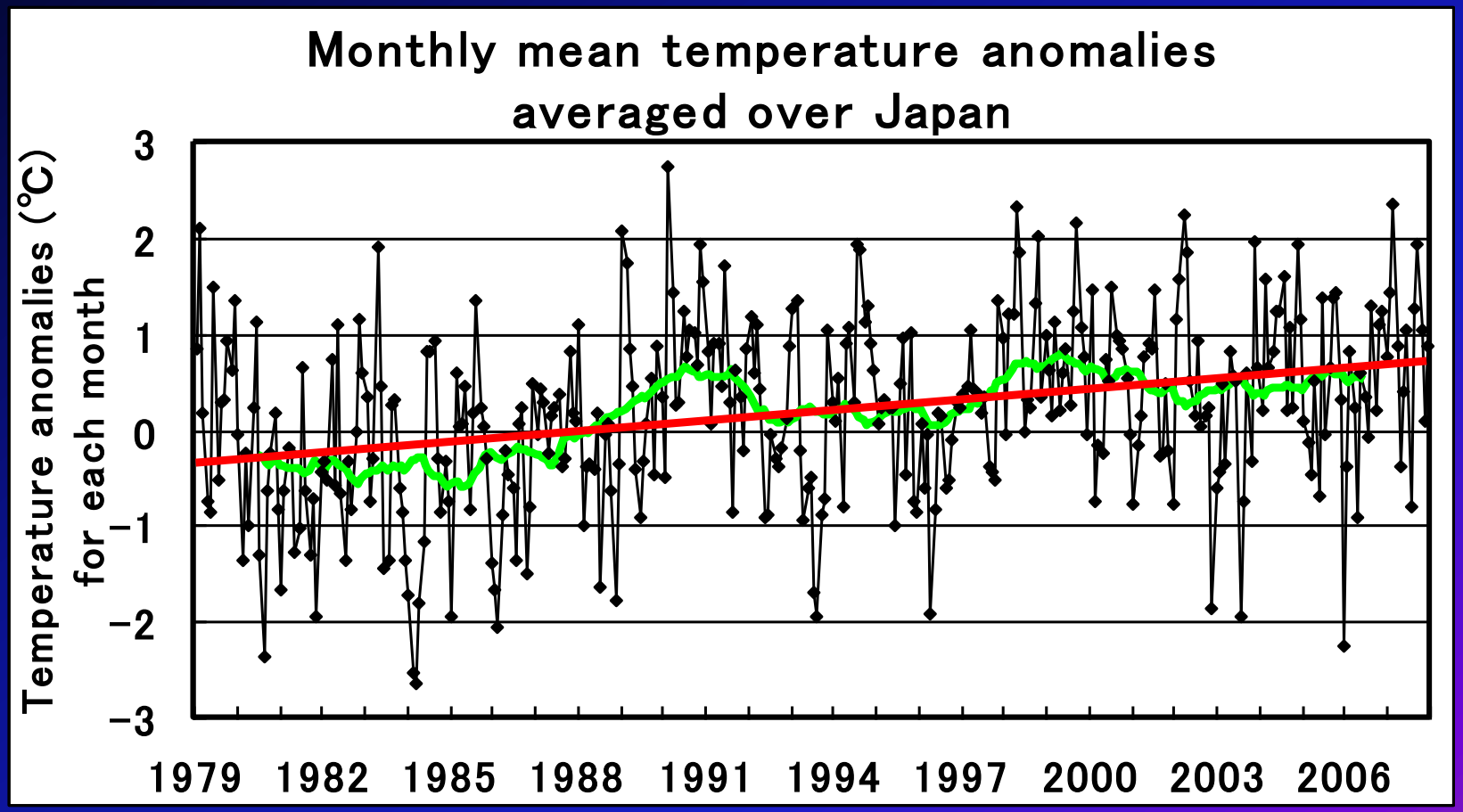
Climate variability – Long term variation -

Global warming



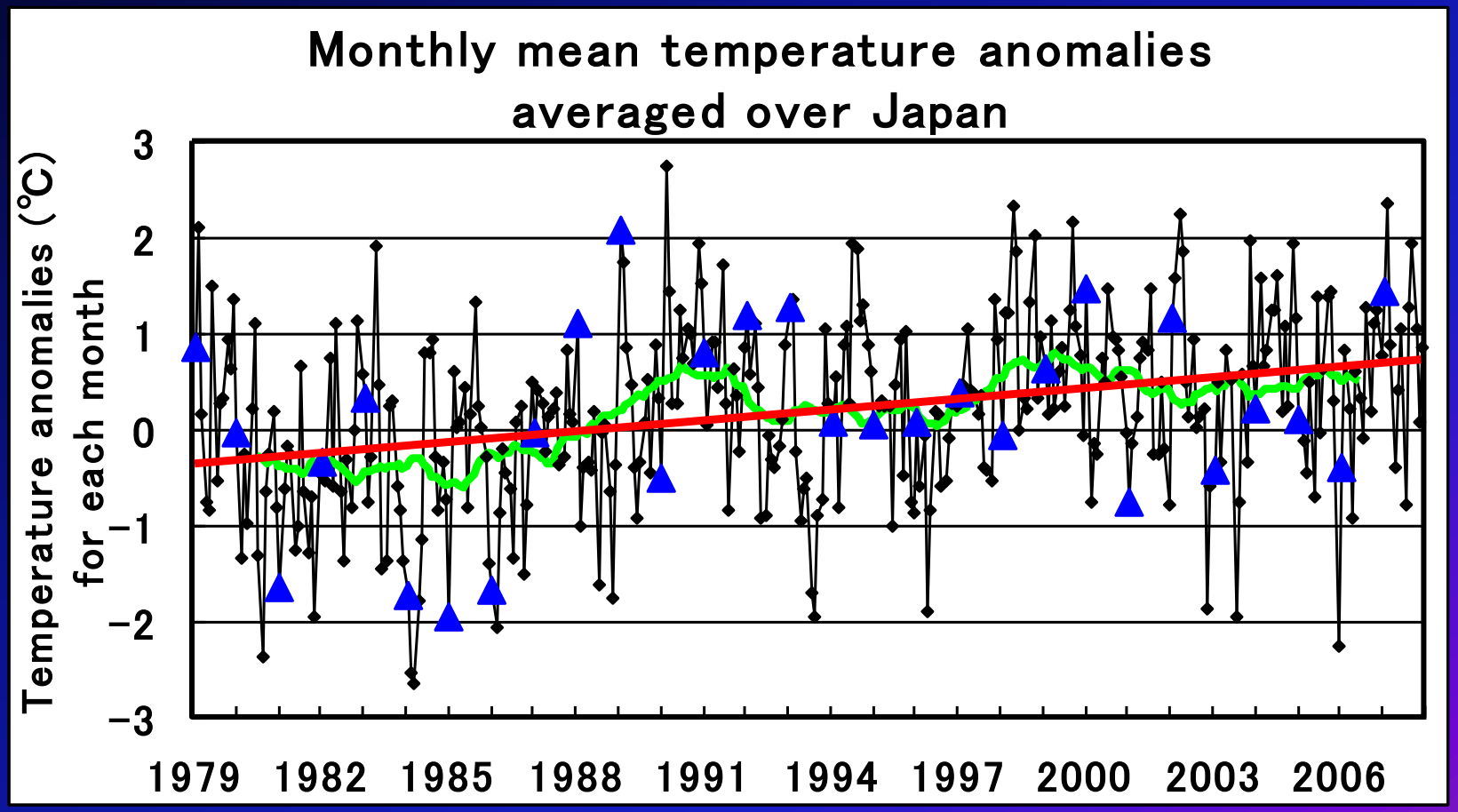
Climate variability – Long term variation -

Decadal Oscillation



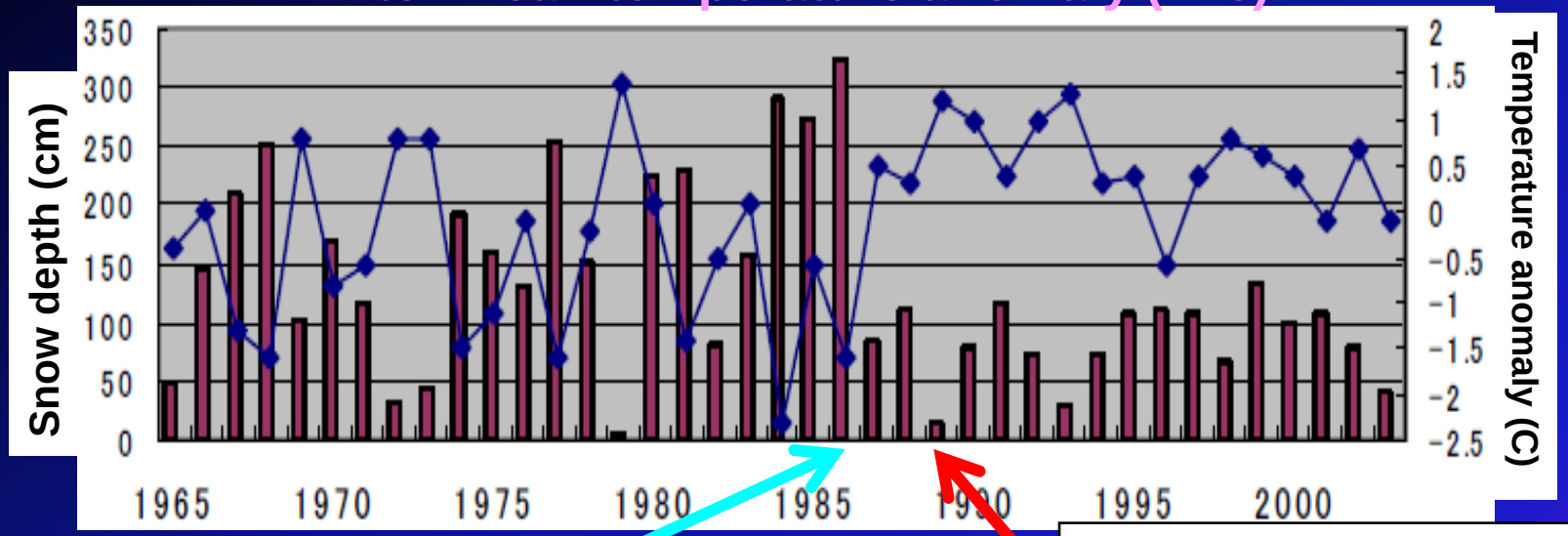
Climate variability – Long term variation -

Inter-annual Variability



Interannual Variability

Maximum snow depth during winter (bar) and winter mean temperature anomaly (line)



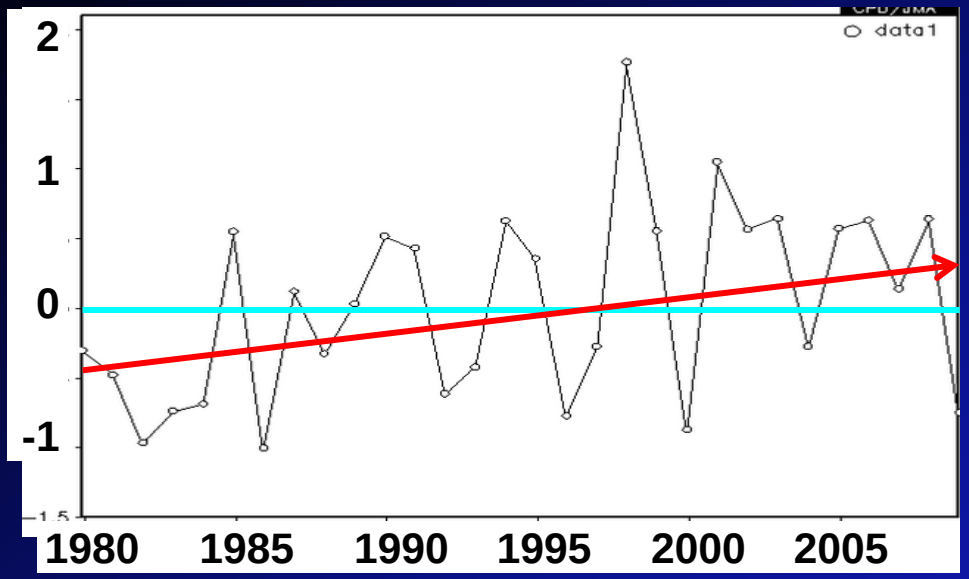
at Takada in Sea of Japan side of Japan

Over 300cm in 1986

The impact on society is quite different! Interannual variability is closely related to daily lives.

Only 15cm in 1989

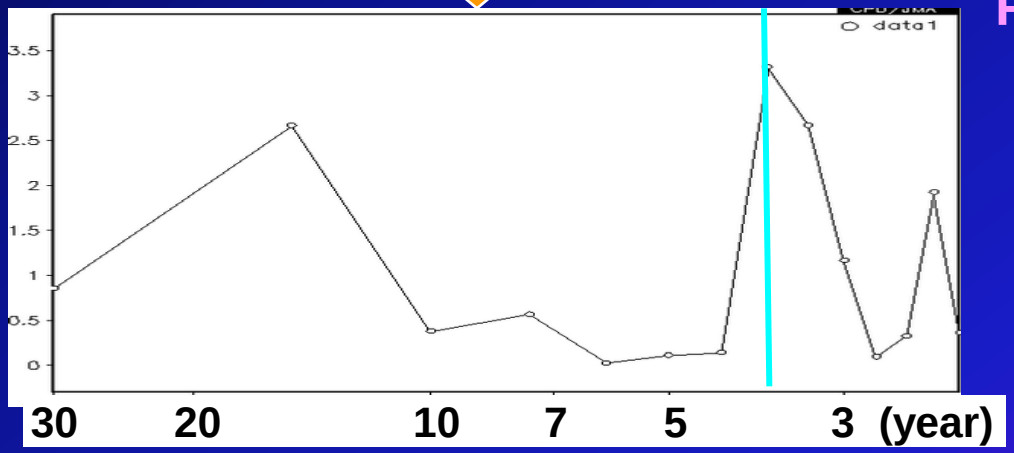
Interannual Variability at one grid (Temperature)



Seasonal (DJF) mean surface temperature anomaly at 15N, 100E (hereafter “key grid”).

A warming trend with a large interannual variability is dominant.

FFT



Power spectrum

The period of peak is about 3.5-year.

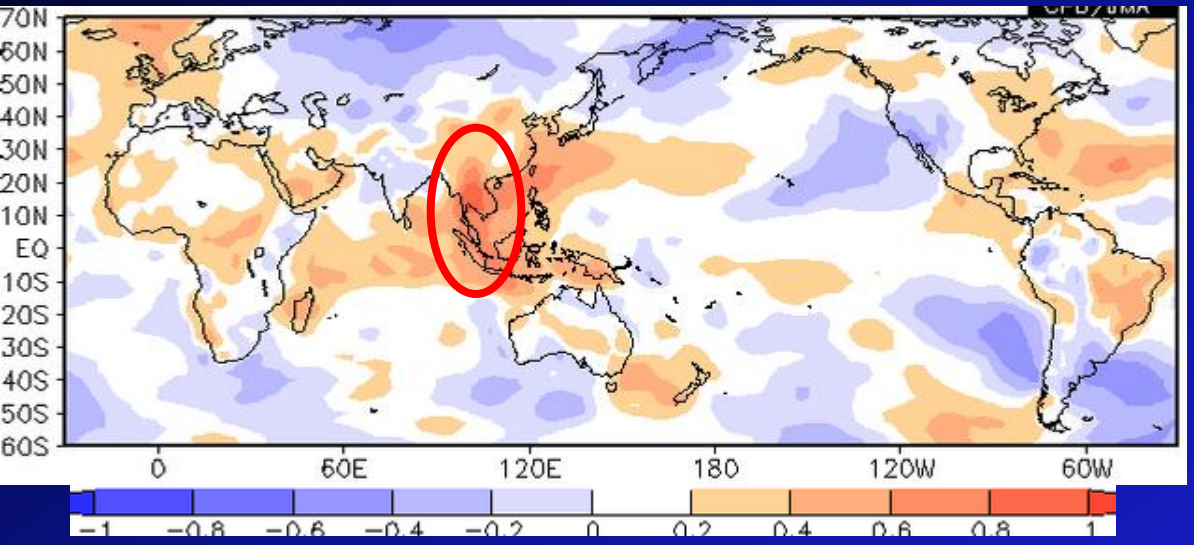
Is this related to ENSO?

(The peak around 15-year means warming trend)

Spatial Spread of Interannual Variability related to the variation at the key grid

One point correlation map

Correlation coefficient of world wide to the key grid for seasonal mean (DJF) 2m-temperature



The spread of same variation area is not global but within limited area, Southeast Asia. There is no correlation over India.

Spatial spread of Southern Oscillation

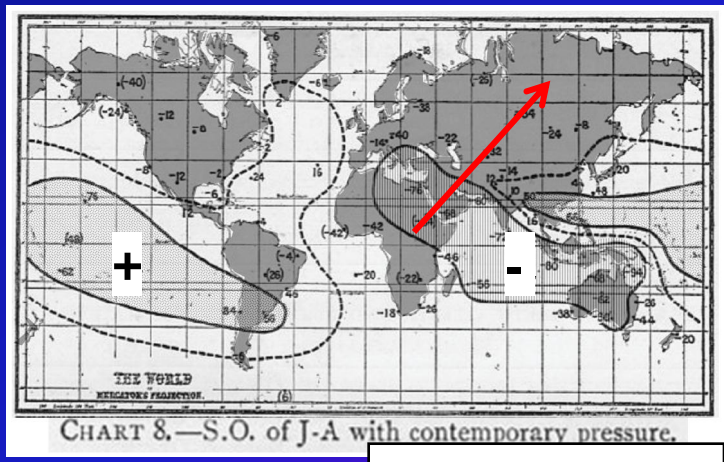
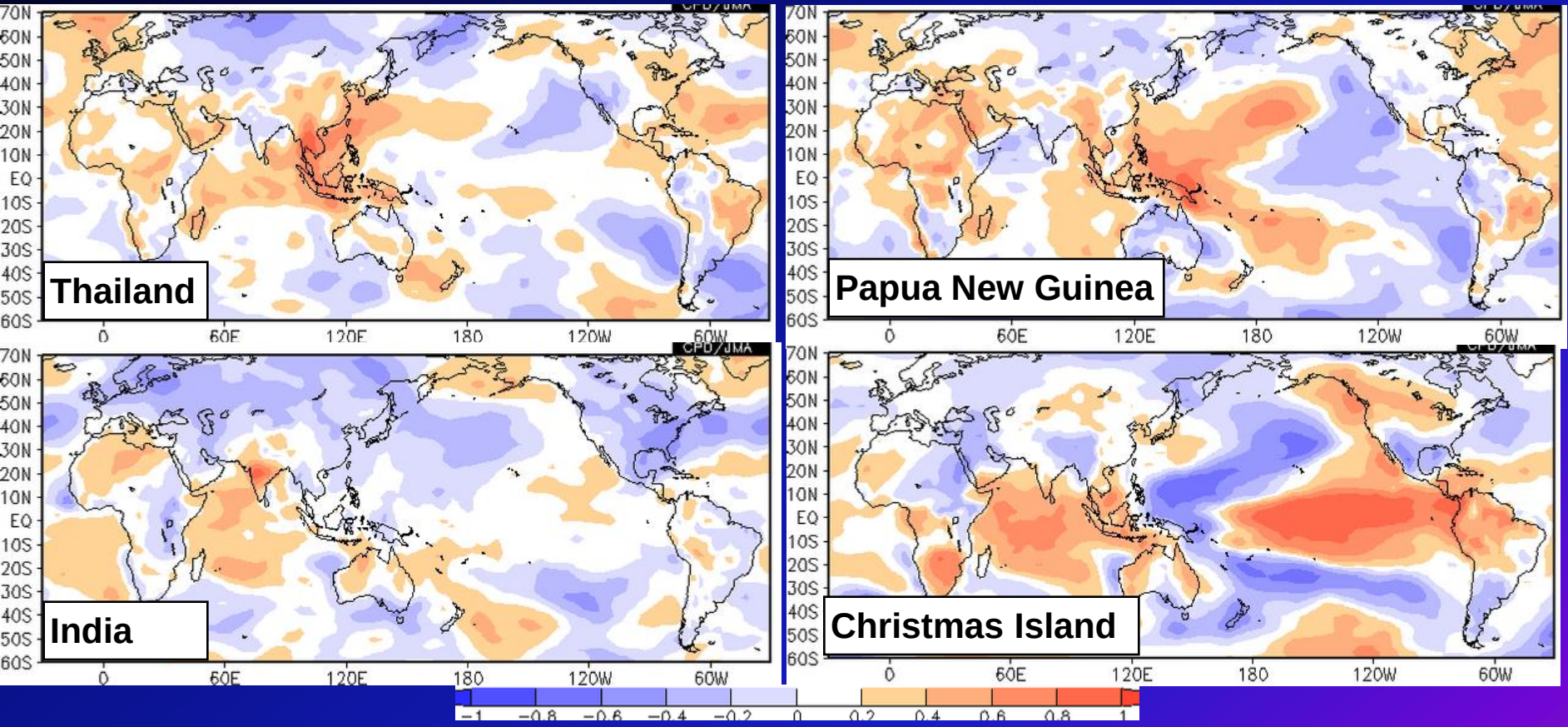


CHART 8.—S.O. of J-A with contemporary pressure.

(Walker, 1932)

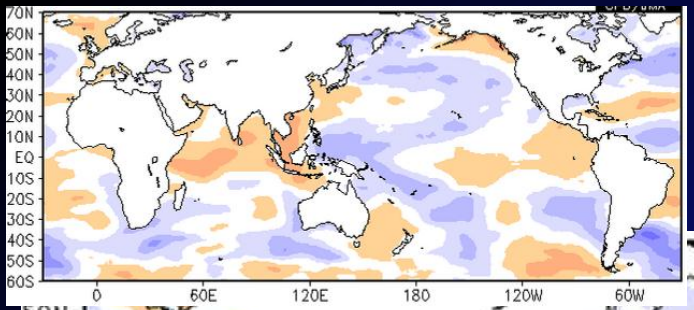
Comparison of Spatial Spread of Interannual Variability related to the variation at the key grid

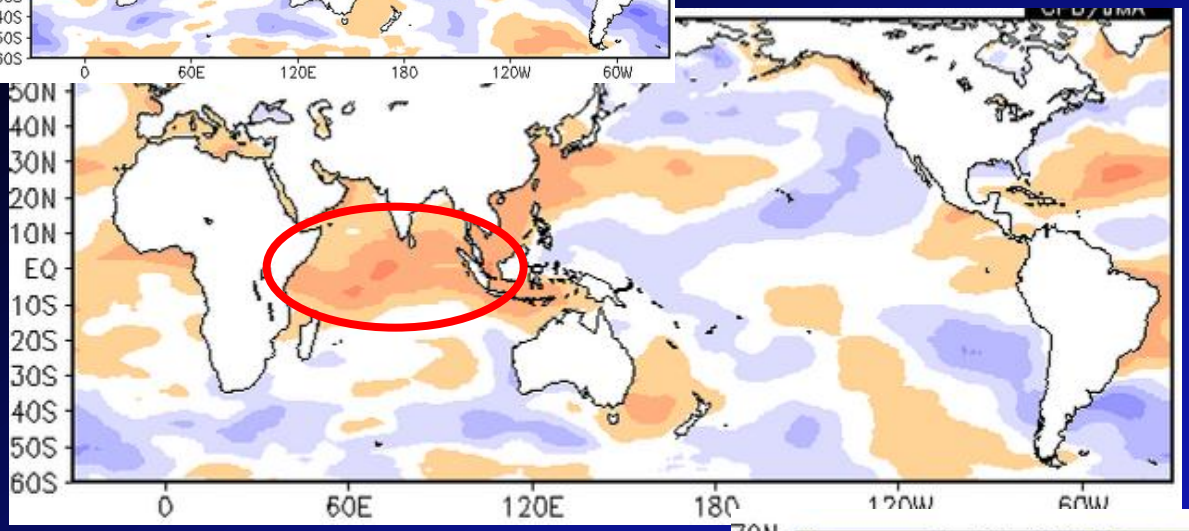
Correlation coefficient of world wide to the key grid for seasonal mean (DJF) 2m-temperature



Spatial spread is quite different for each grid

What is related to the Interannual Variability at the key grid?

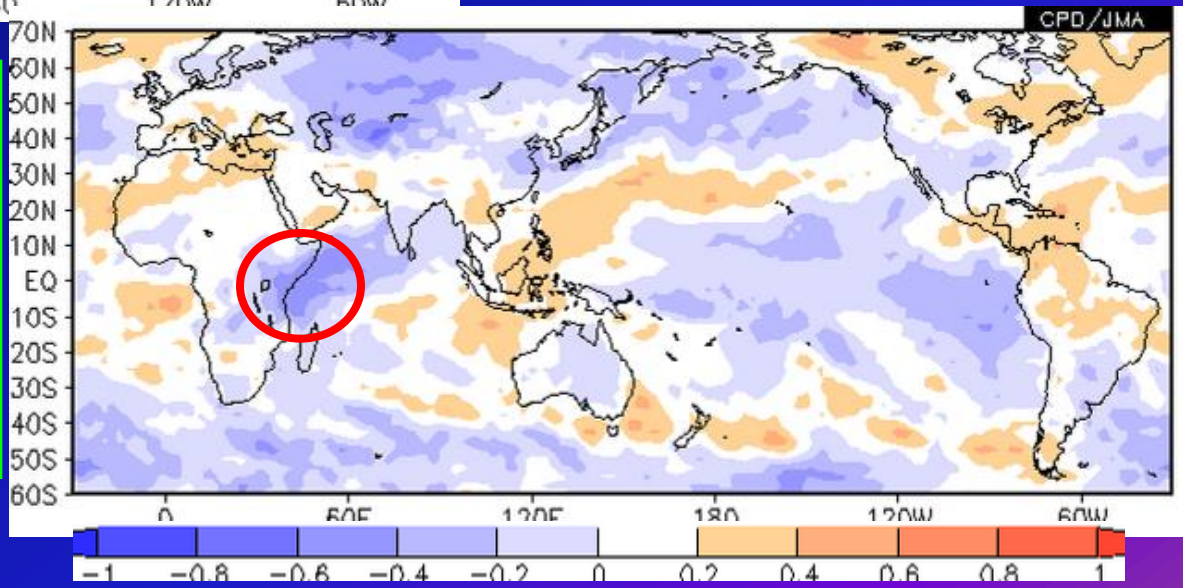




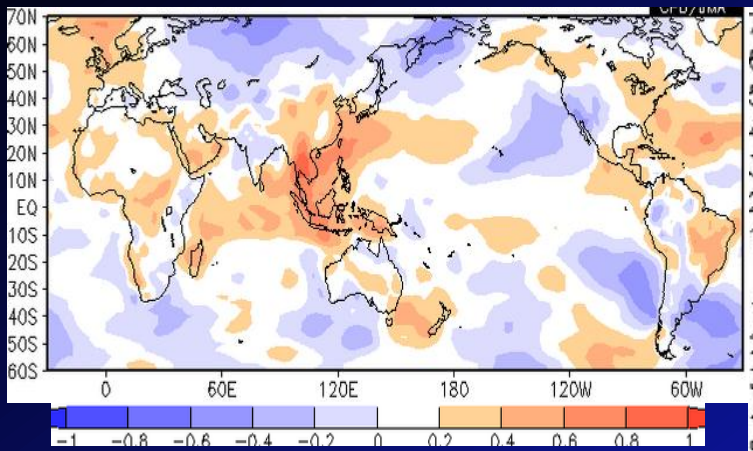
Correlation coefficient of SST (left) and OLR (below) to 2m-temperature at the key grid for seasonal mean

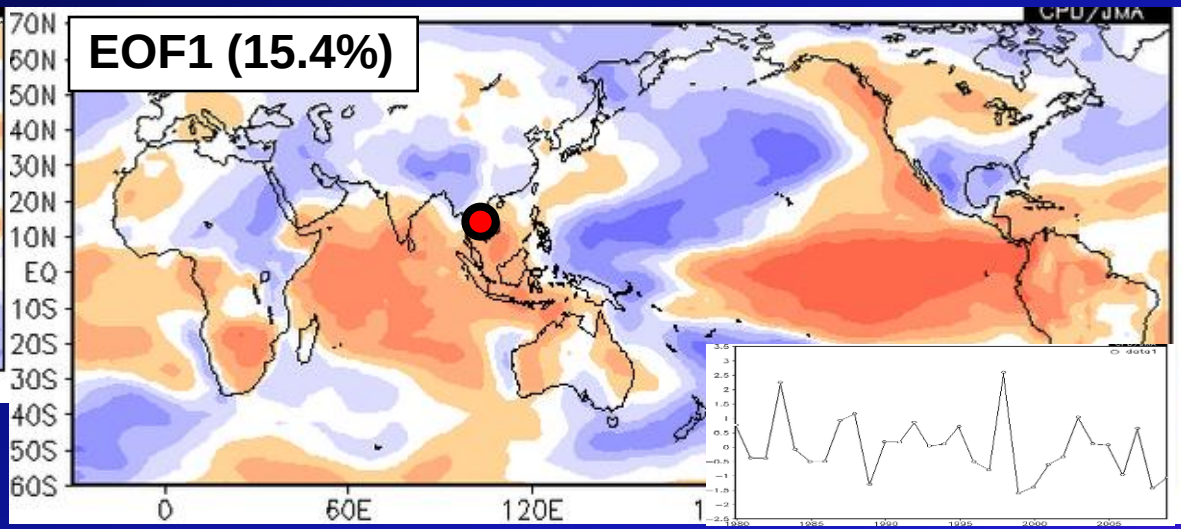
(upper one is same except for SST to trend removed 2m-temperature)

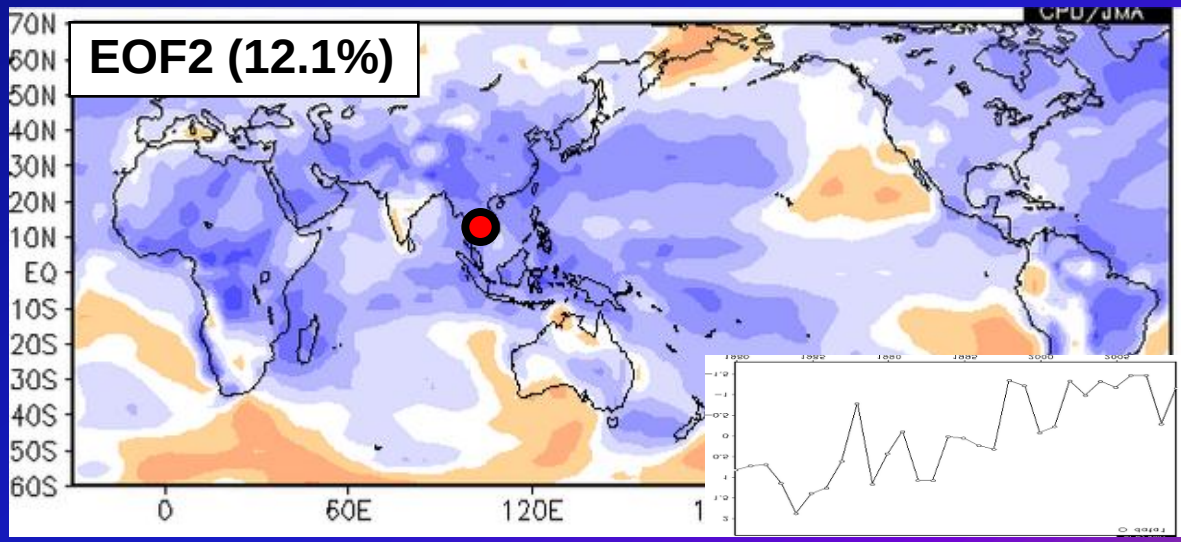
SST in the tropical Indian Ocean and convection over the western Indian Ocean are well related to 2m-temperature variability at the key grid.



Dominant mode of Interannual Variability in seasonal (DJF) mean 2m-temperature

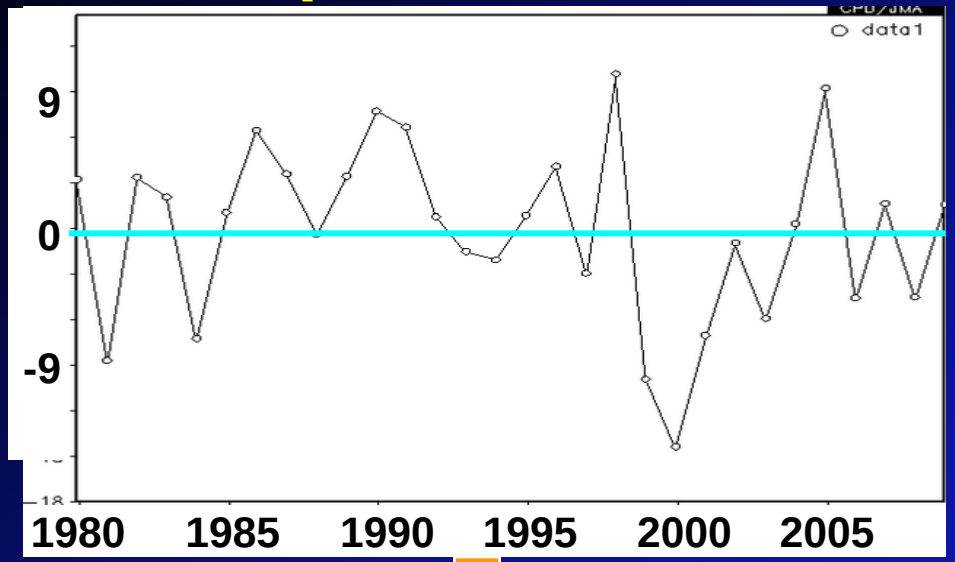






ENSO mode (EOF1) is the most dominant, but no signal at the key grid. Trend mode (EOF2) covers much area in the tropics and sub-tropics and a little similar to the one point correlation map.

Interannual Variability at one grid (OLR: substitute of precipitation)

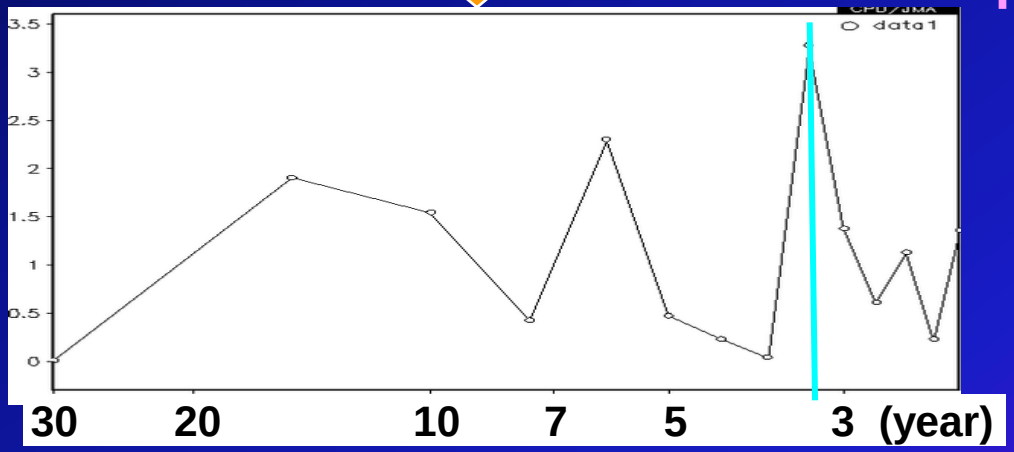


Seasonal (DJF) mean OLR anomaly at 15N, 100E (hereafter "key grid").

A warming trend with a large interannual variability is dominant.

FFT

Power spectrum

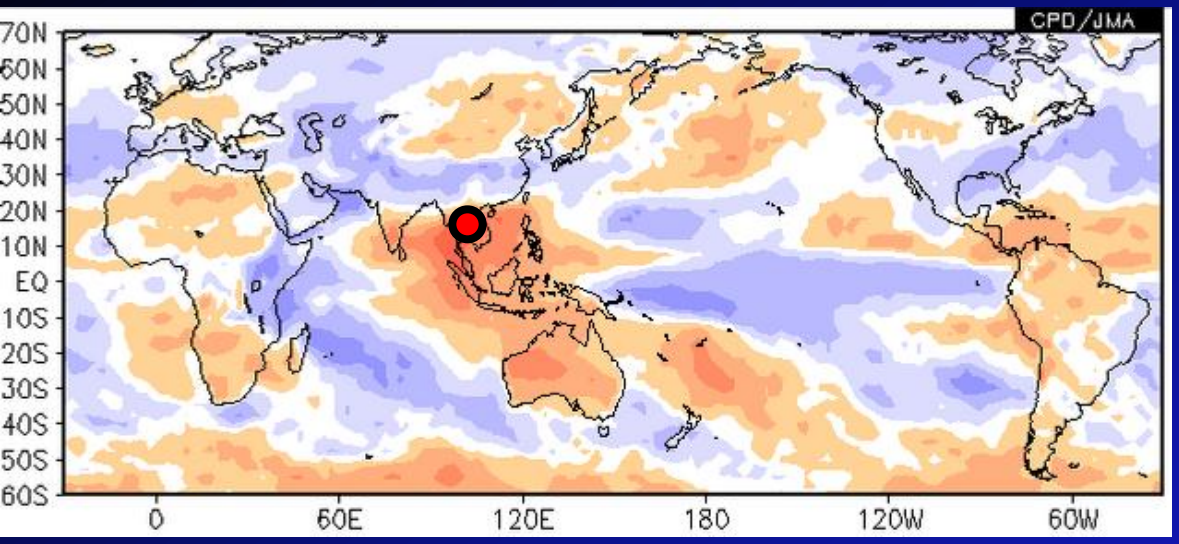


The period of peak is about 3.5 year.

Is this related to ENSO?

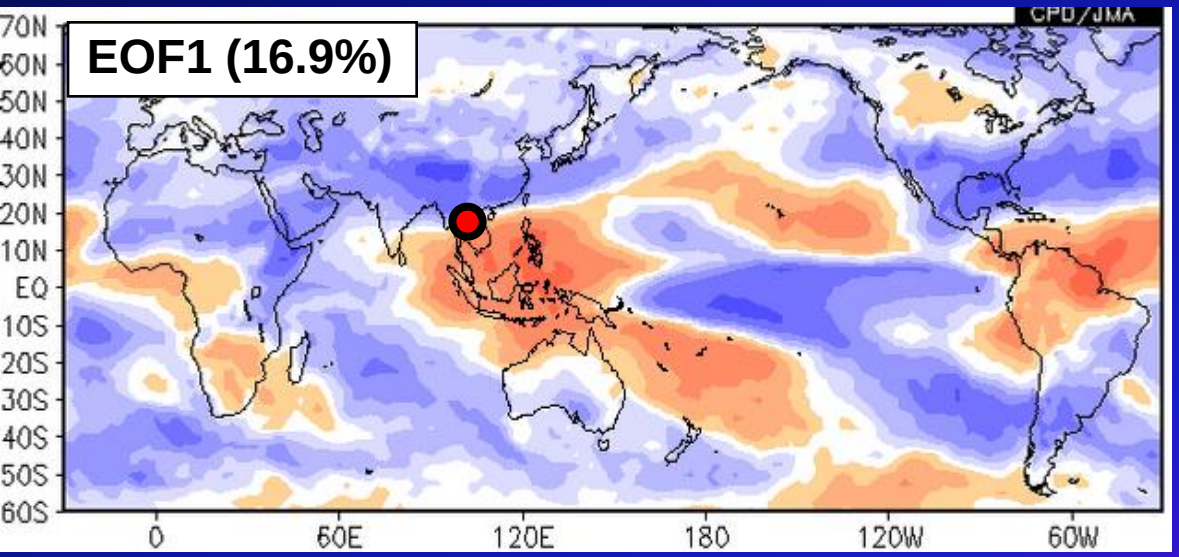
(The peak around 15-year means warming trend)

Spatial Spread of Interannual Variability related to the variation at the key grid



One point correlation map

Correlation coefficient of OLR to the key grid for seasonal (DJF) mean OLR

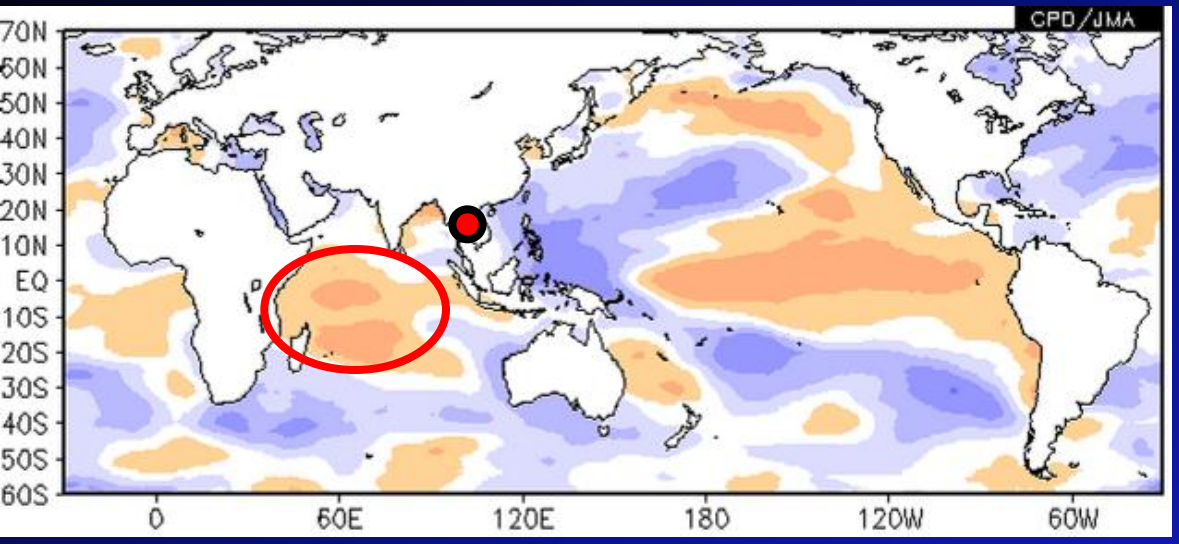


EOF1 for seasonal (DJF) mean OLR

These two figures are well resemble.

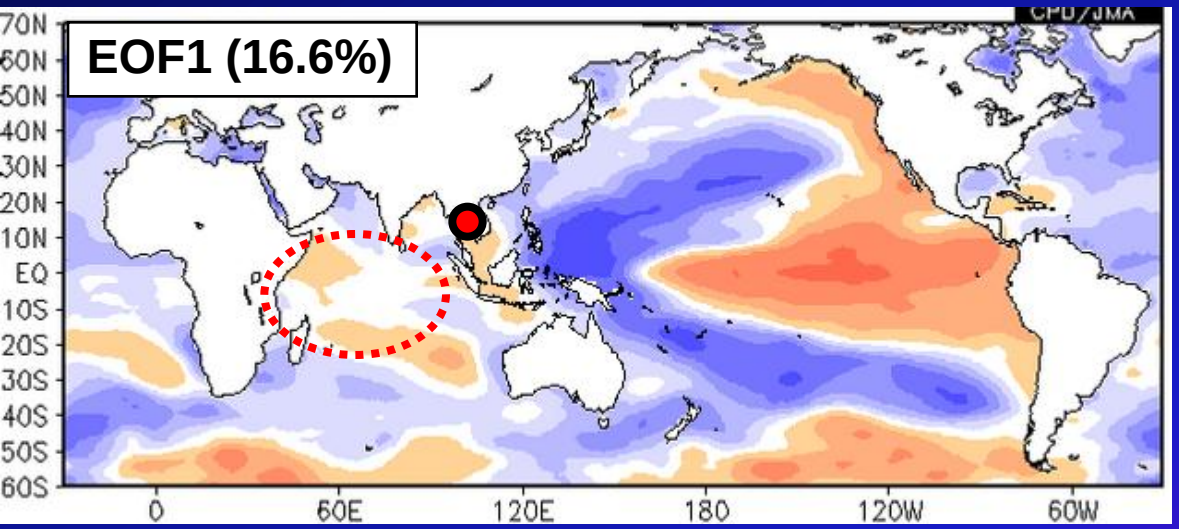
Though, the key grid is the edge of spatial spread area, it belongs to the same variation related to ENSO.

Spatial Spread of Interannual Variability related to the variation at the key grid



One point correlation map

Correlation coefficient of SST to the key grid for seasonal (DJF) mean OLR



EOF1 for seasonal (DJF) mean SST

These two figures are also well resemble.

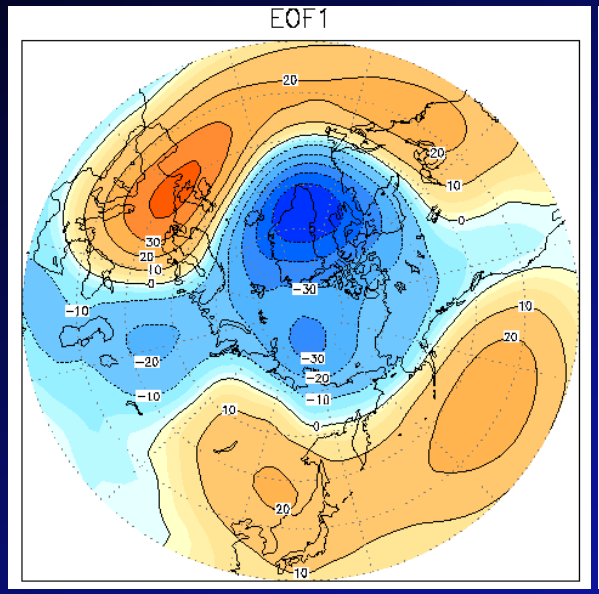
In addition to ENSO impact, SST in the Indian Ocean seems to affect the variation at the key grid.

Major Interannual Variability

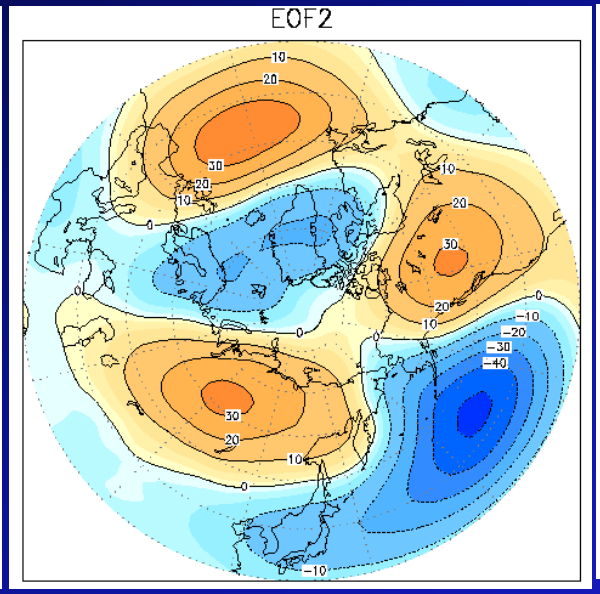
One of the simple methods to extract interannual variability is EOF for time series of the same season data.

Interannual Variability of N.H. 500hPa height in winter (DJF)

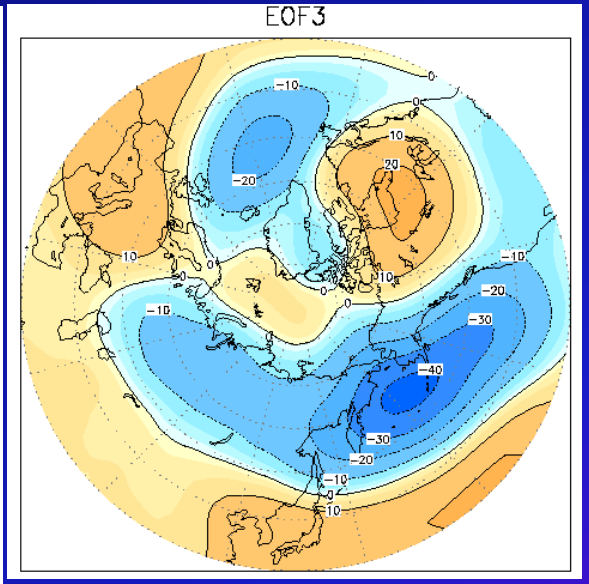
EOF1

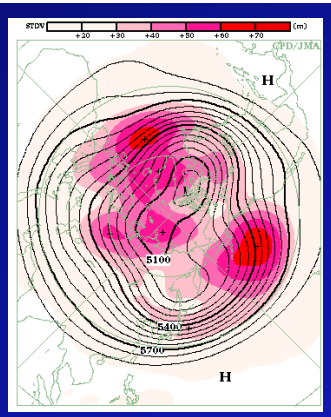


EOF2



EOF3



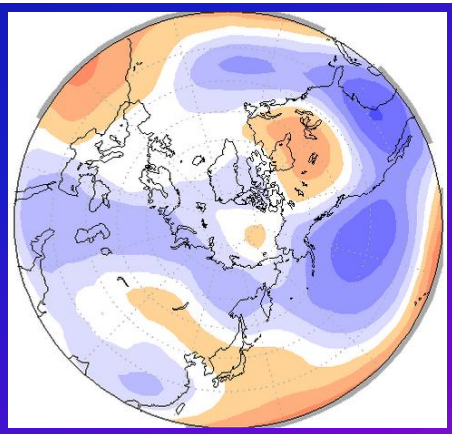


Standard deviation

EOF1: Arctic Oscillation (AO)

EOF2: PNA etc.

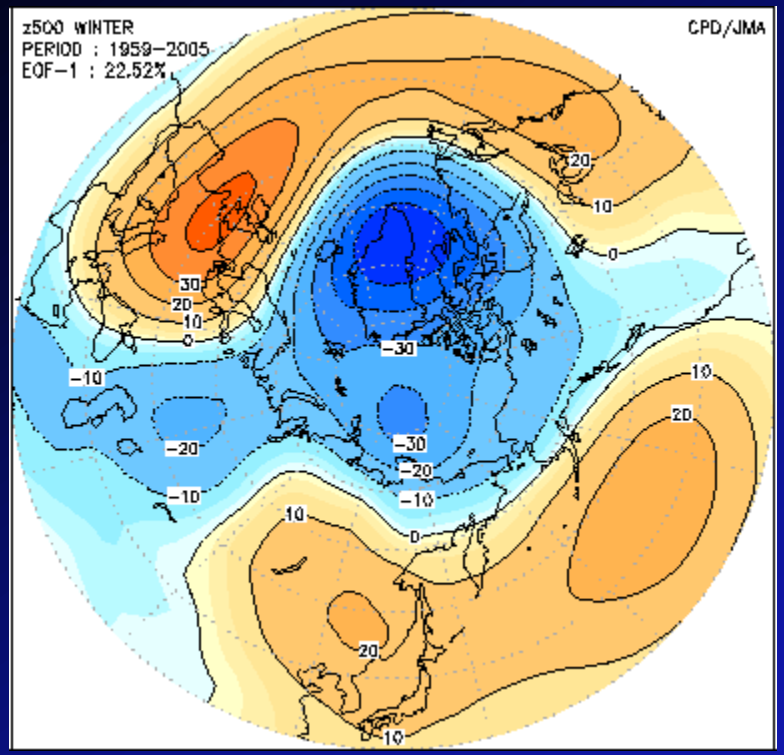
EOF3: WP and TNH (ENSO impact)



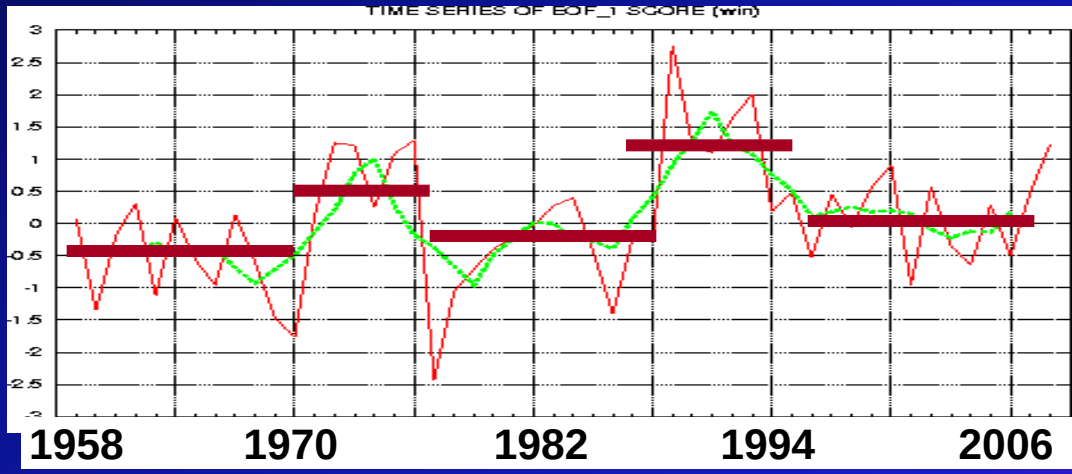
Correlation coefficient of Z500 to NINO.3

Arctic Oscillation (AO)

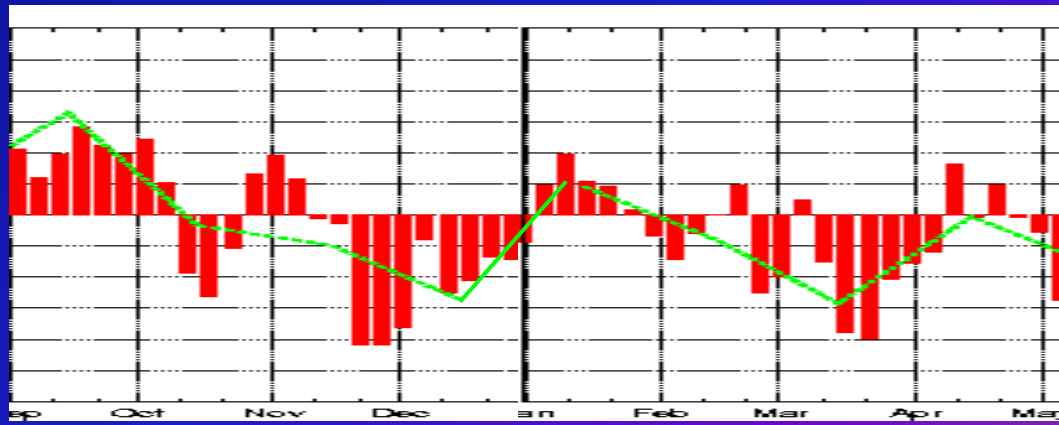
EOF1 for DJM mean 500hPa height



Time series of seasonal score of EOF1



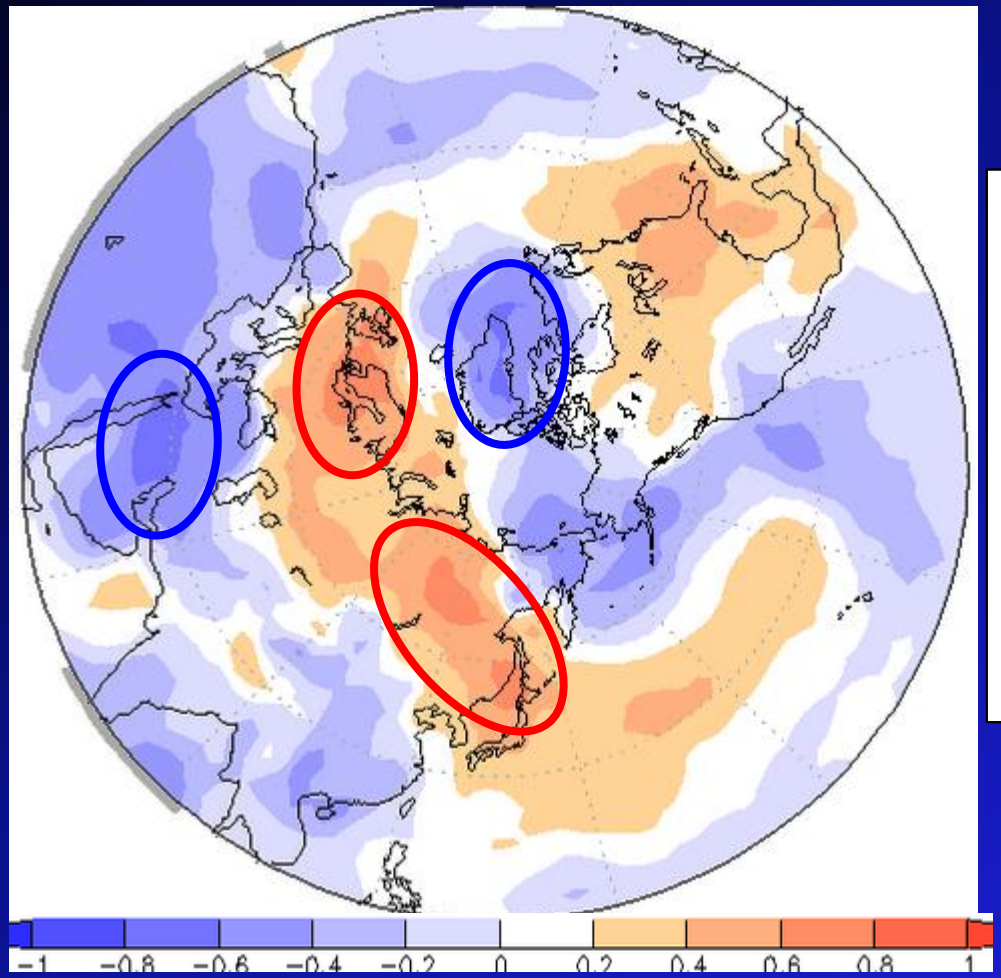
Pentad score of EOF1 in 05/06 winter



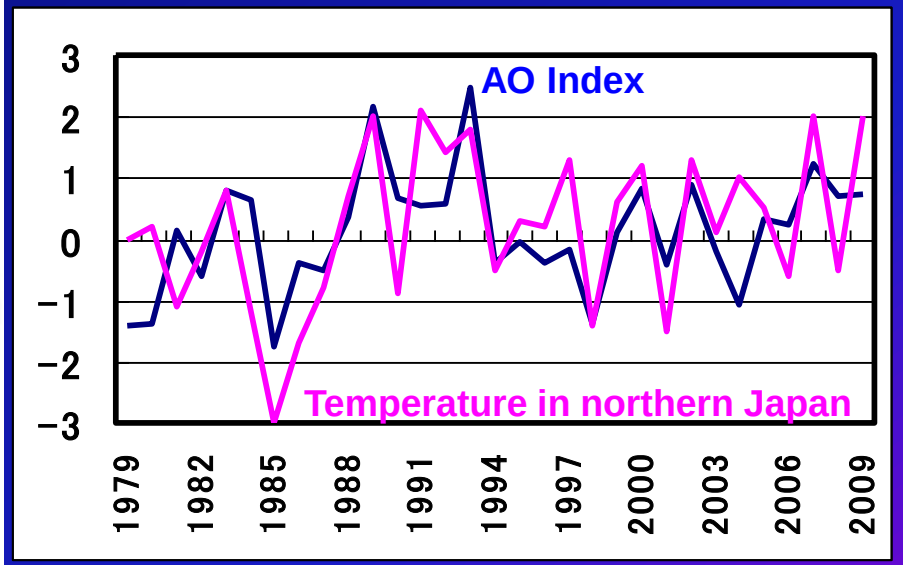
Various time scale such as decadal, interannual and intra-seasonal are dominant in the AO variabilities.

Arctic Oscillation (AO)

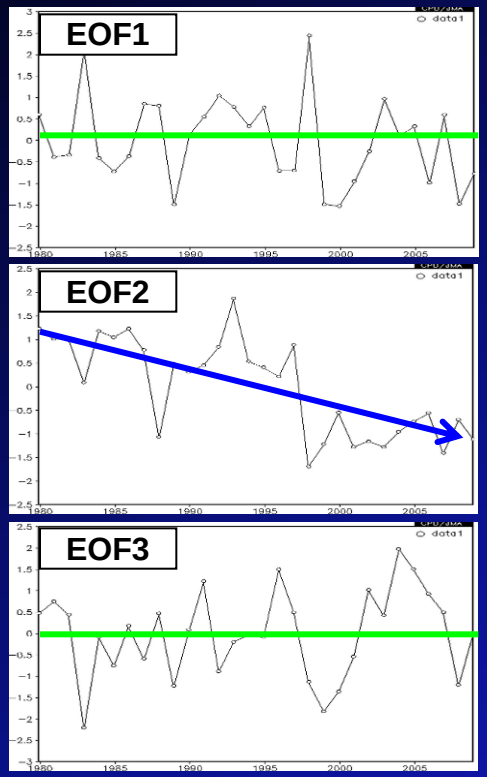
Correlation coefficient of 2m-temperature to score of EOF1 (January)

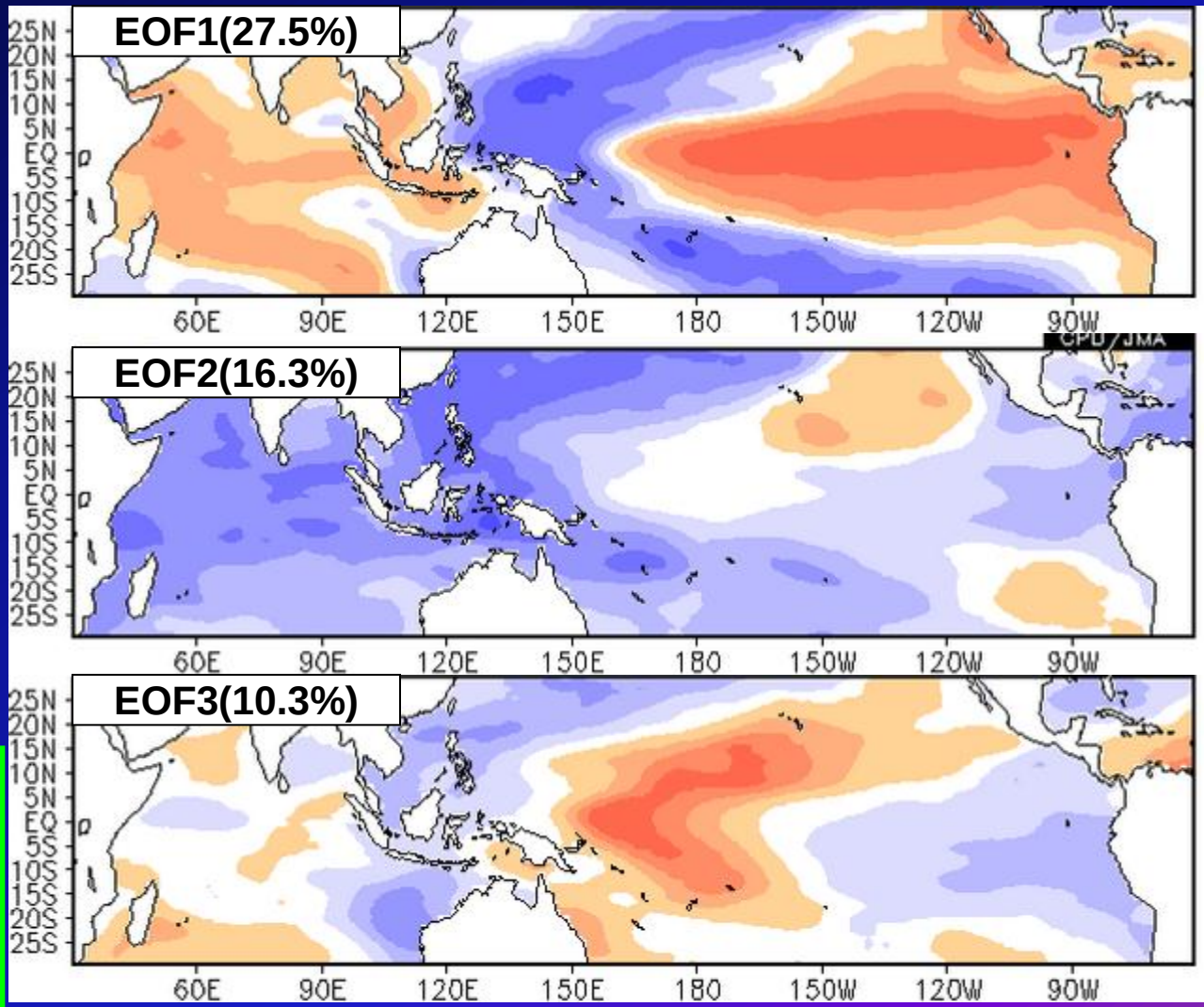


Relationship between AO index and temperature in northern Japan (January)



Interannual Variability in the tropical Pacific and Indian Ocean (DJF)



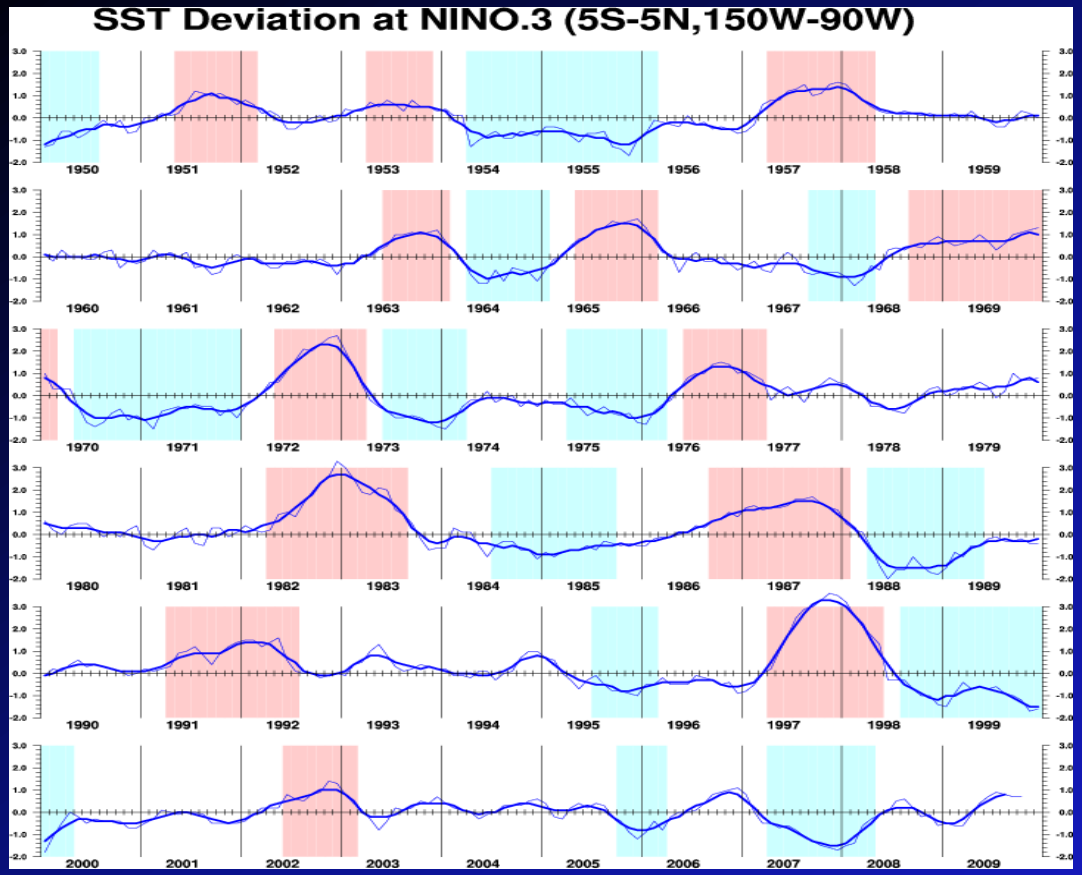


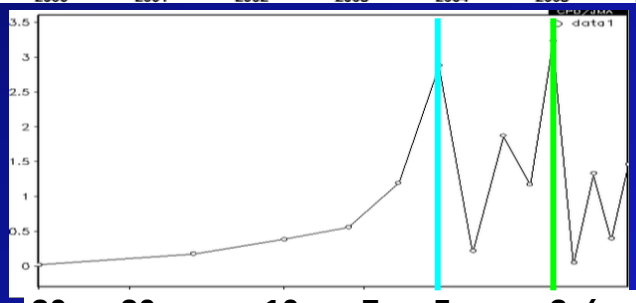
EOF1: ENSO

EOF2: Warming Trend

EOF3: ?

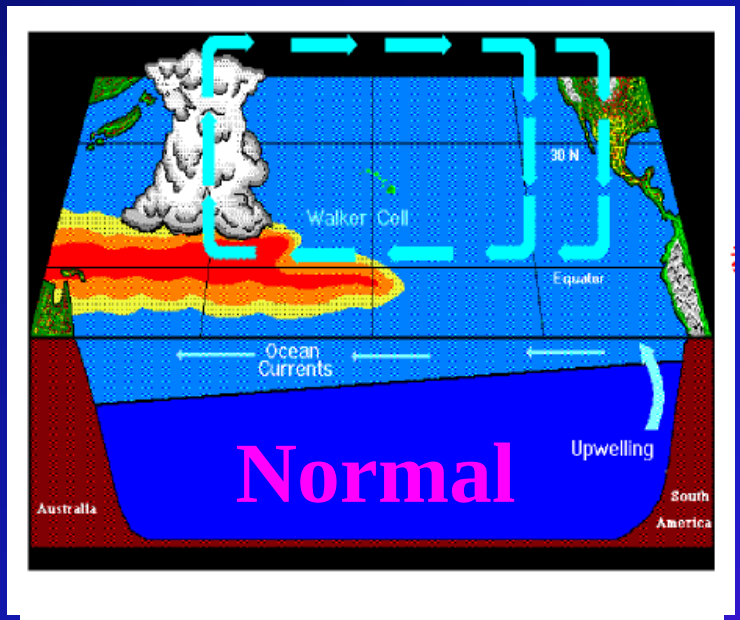
El Niño Southern Oscillation (ENSO)

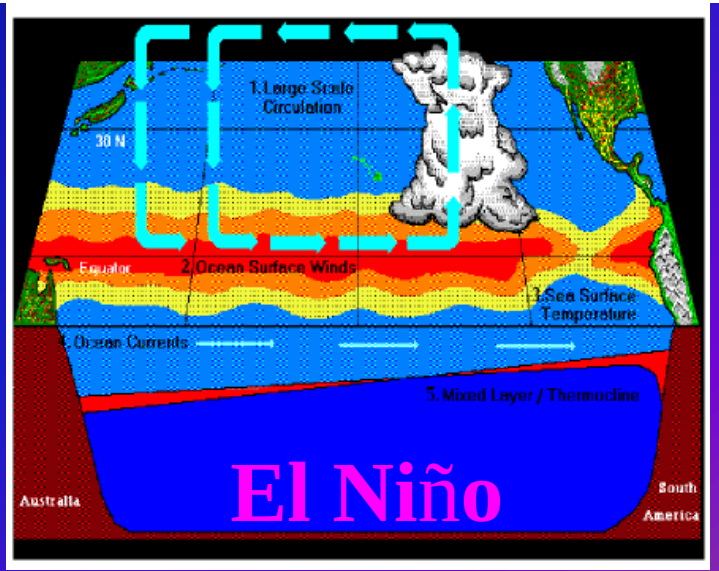




Power spectrum for DJF mean NINO.3

Dominant period is 3-year and 5-year

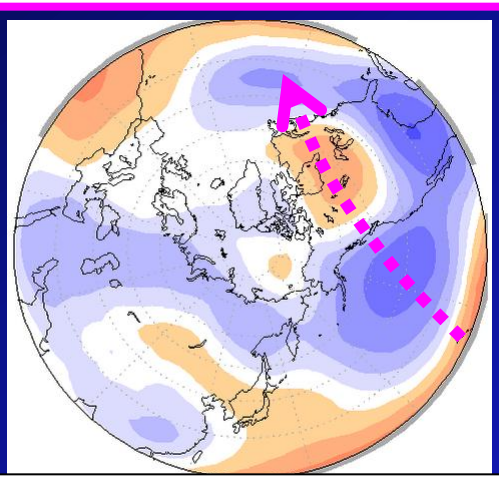




Atmospheric Features in ENSO (Boreal winter)

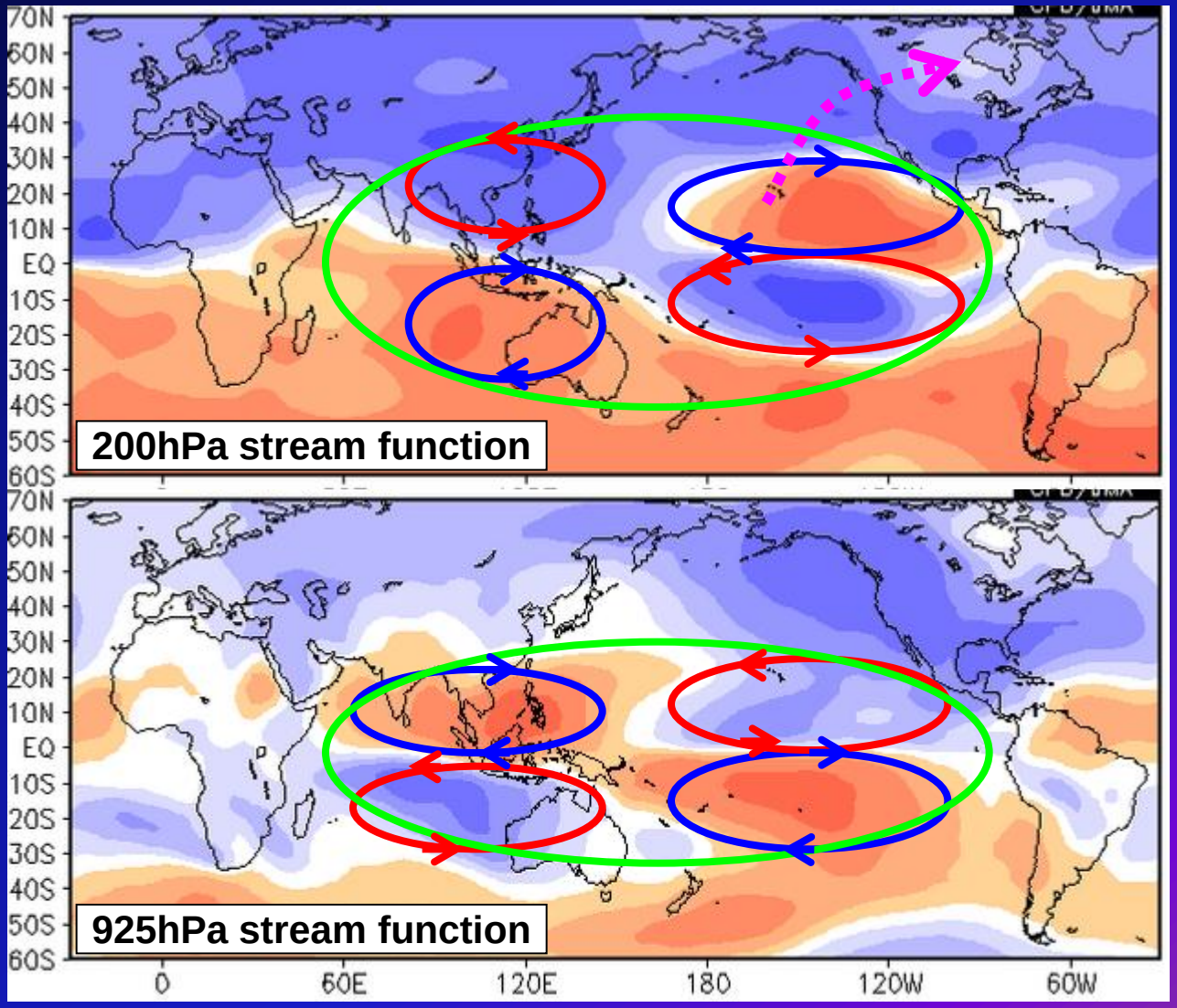
Direct response to anomalous convection (Matsuno-Gill pattern) -> coupled system

Teleconnection by a propagation of Rossby wave packet -> ENSO impact



500hPa height

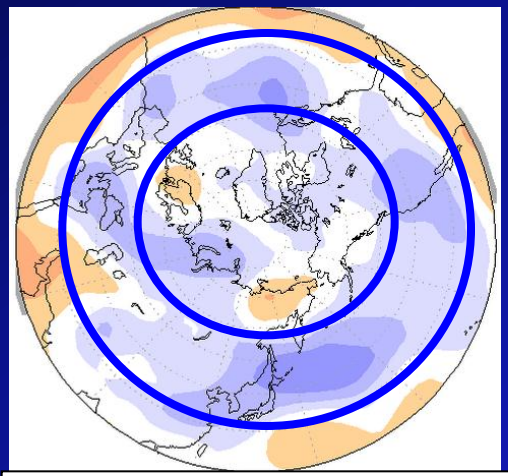
Correlation coefficient to NINO.3



Atmospheric Features in ENSO (Boreal summer)

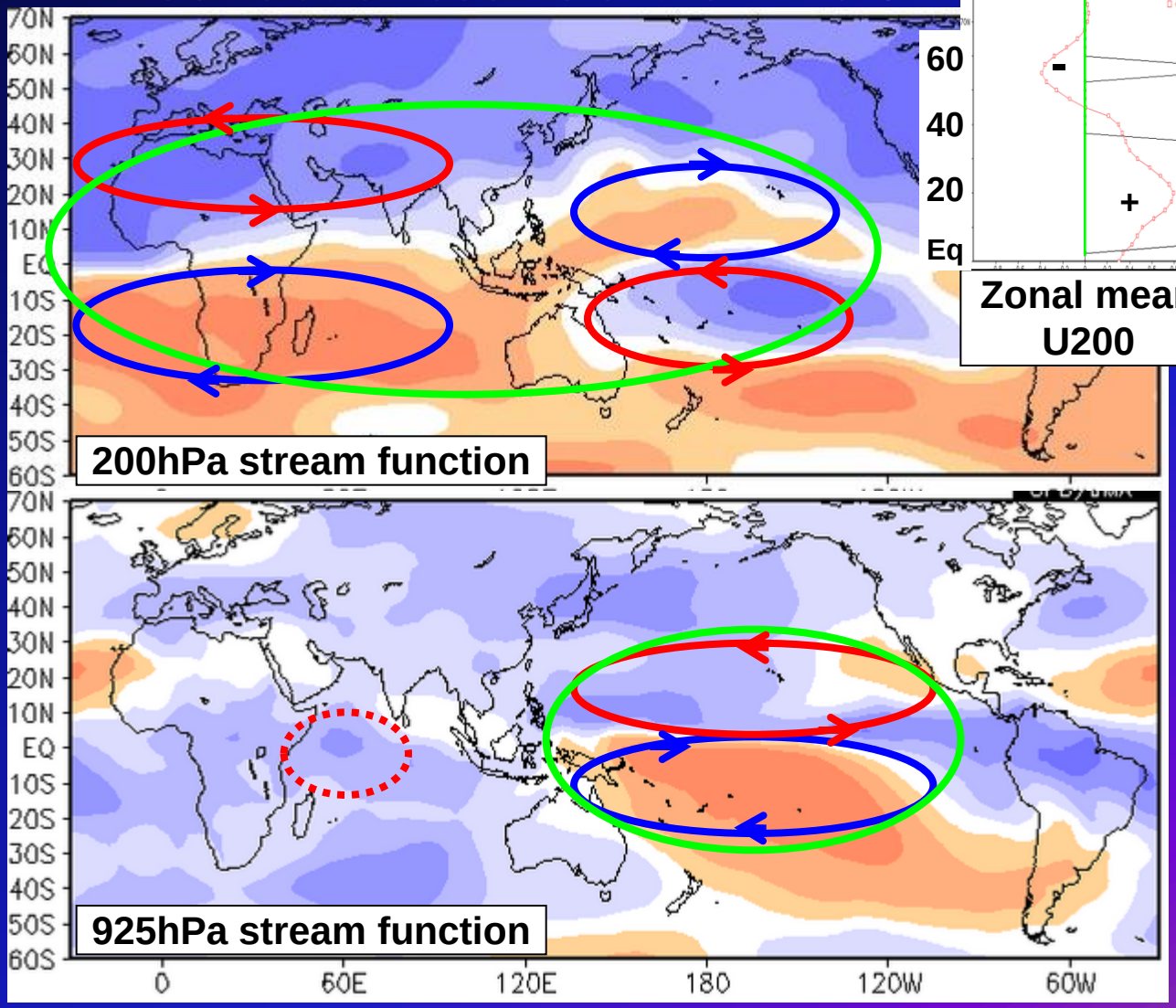
Direct response to anomalous convection (Matsuno-Gill pattern, is not dominant in the low level circulation.

Accompanied with the southward shift of sub-tropical jet stream, negative 500hPa height anomalies are zonally dominant in the mid-latitude.



500hPa height

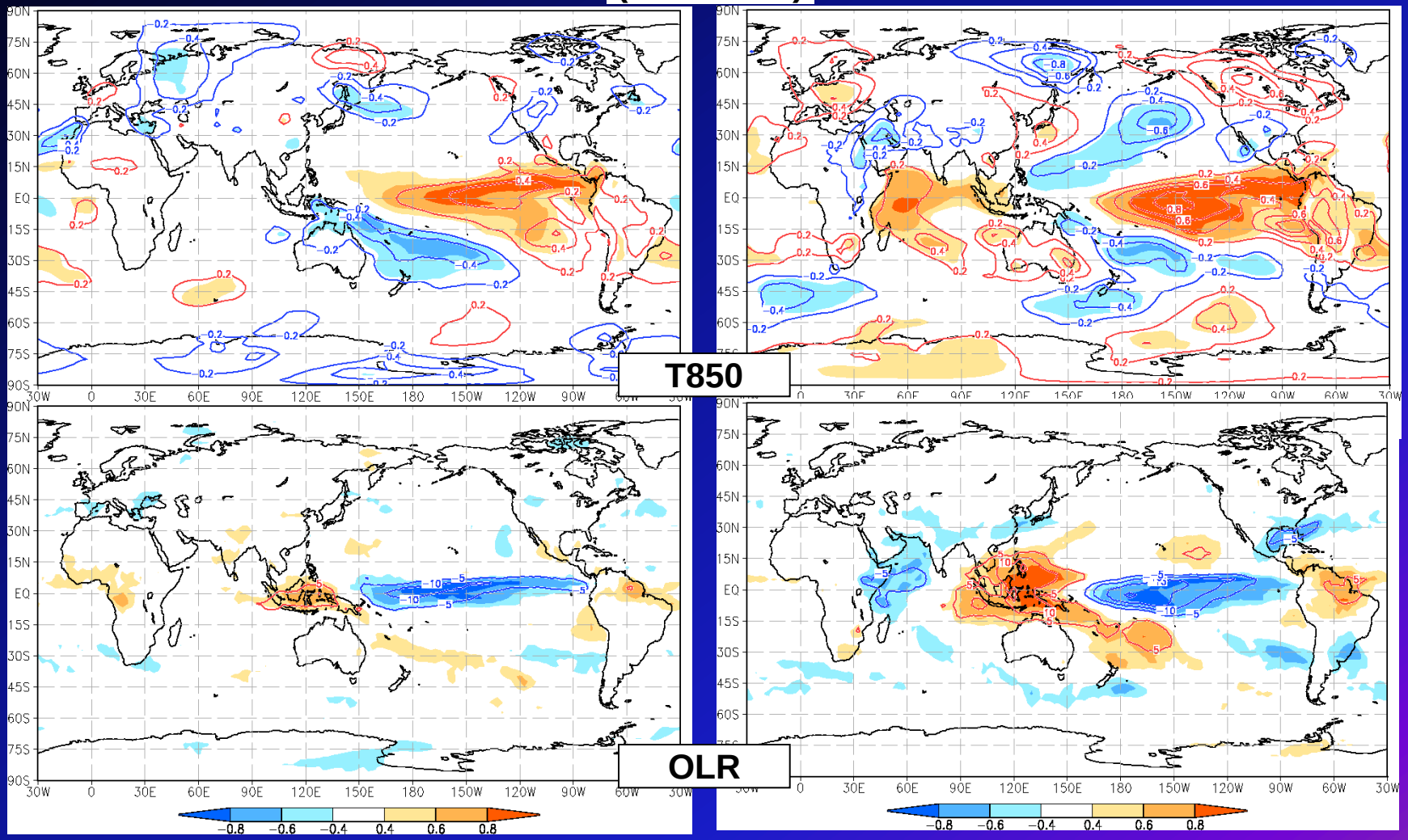
Correlation coefficient to NINO.3



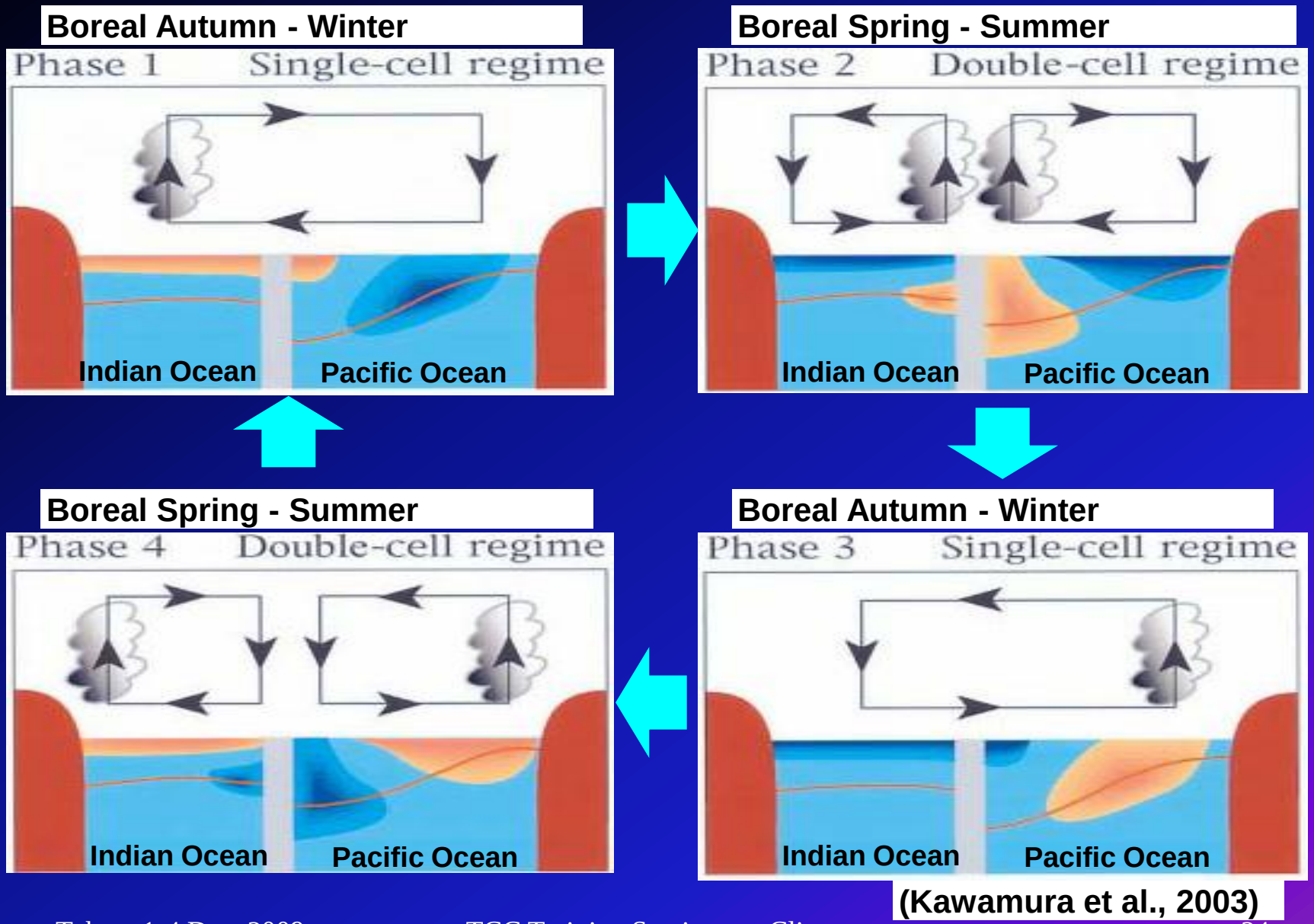
Zonal mean U200

Global Impact of ENSO
Regression & Correlation map to NINO.3

Boreal summer (JJA) **(1979-2008)** **Boreal winter (DJF)**

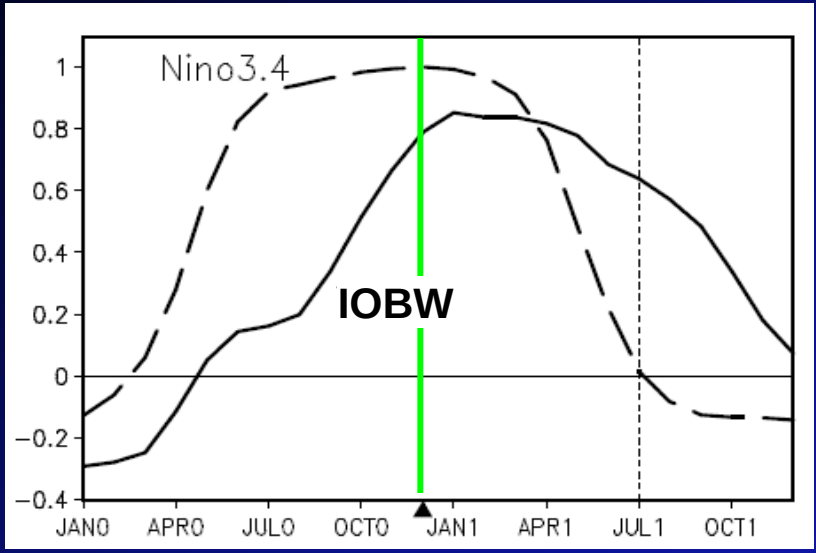


Tropospheric Biennial Oscillation



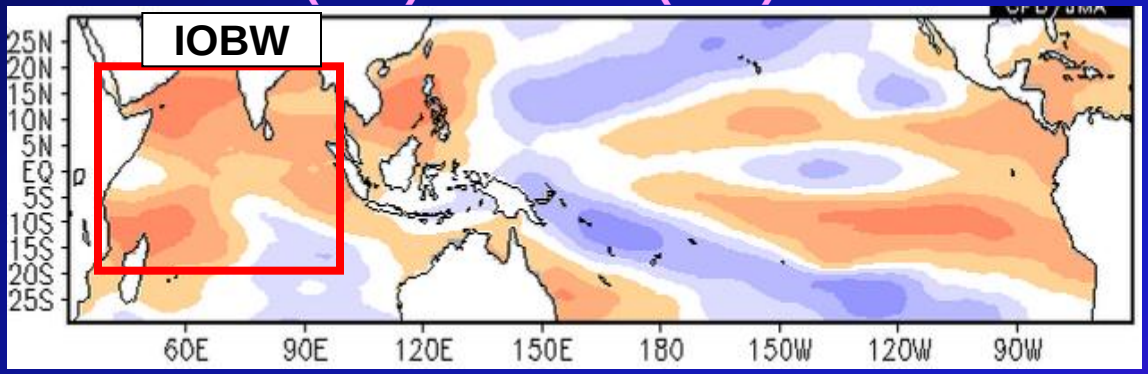
(Kawamura et al., 2003)

Lagged Influence of ENSO

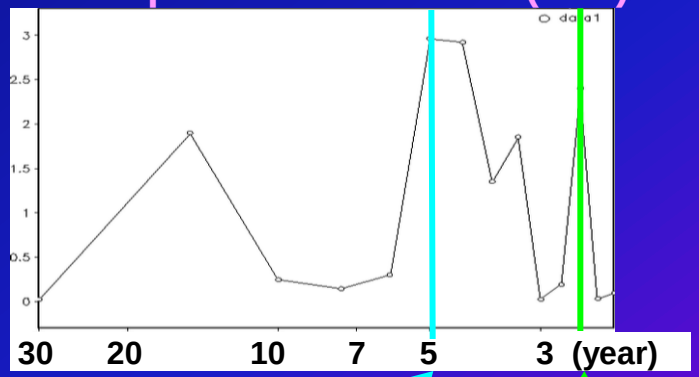


Time evolution of correlation coefficient to NINO3.4 in December

6-month lag correlation coefficient of SST (JJA) to NINO3 (DJF)



Power spectrum for IOBW (JJA)

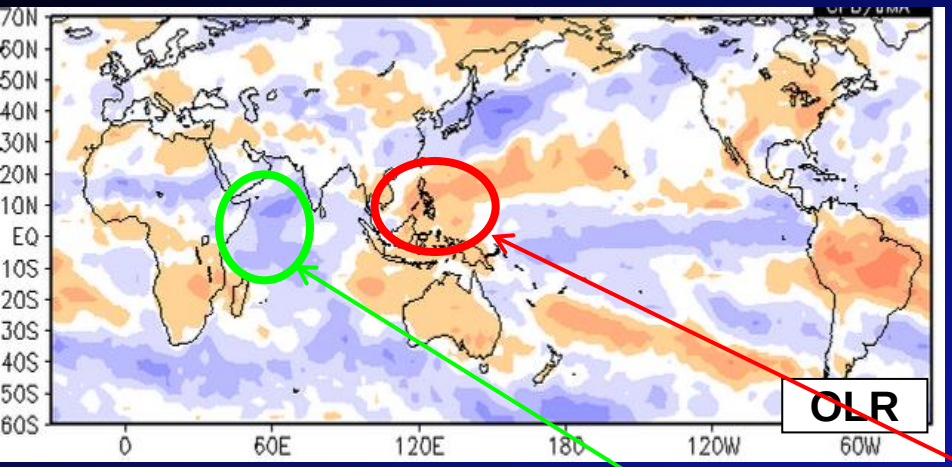


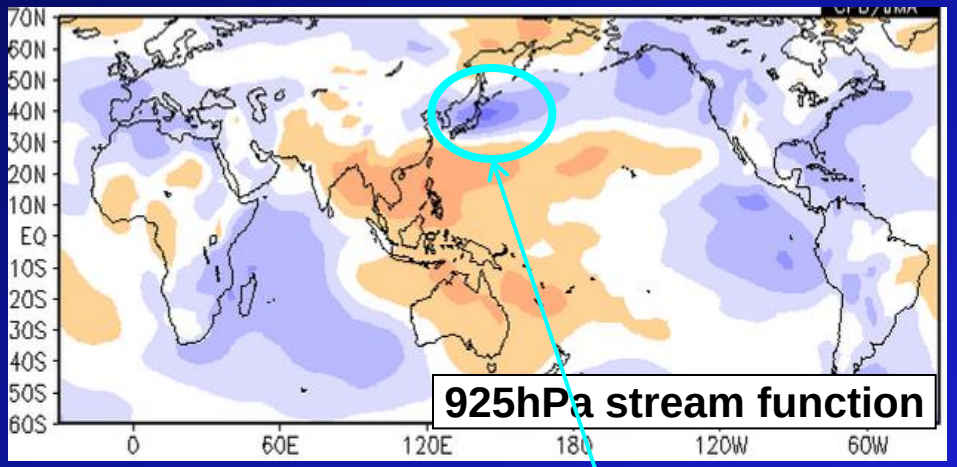
Synchronize with ENSO?

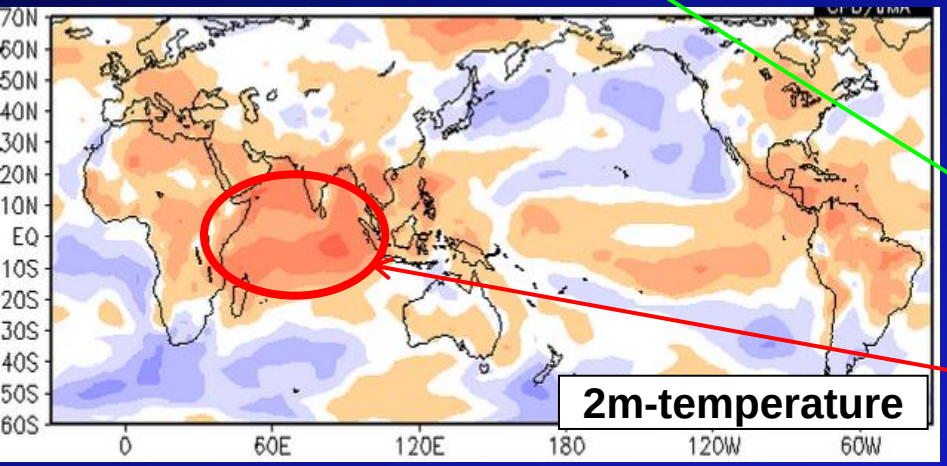
Synchronize with TBO?

Lagged Influence of ENSO

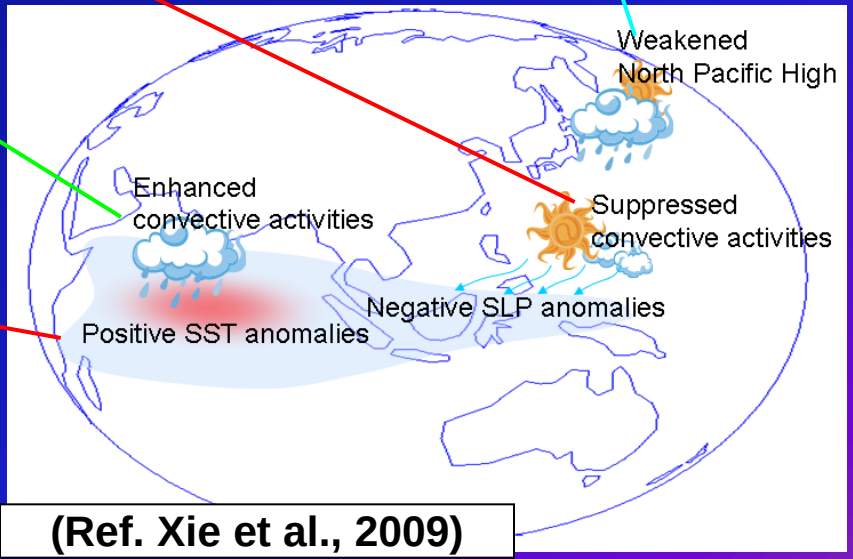
Correlation coefficient to IOBW





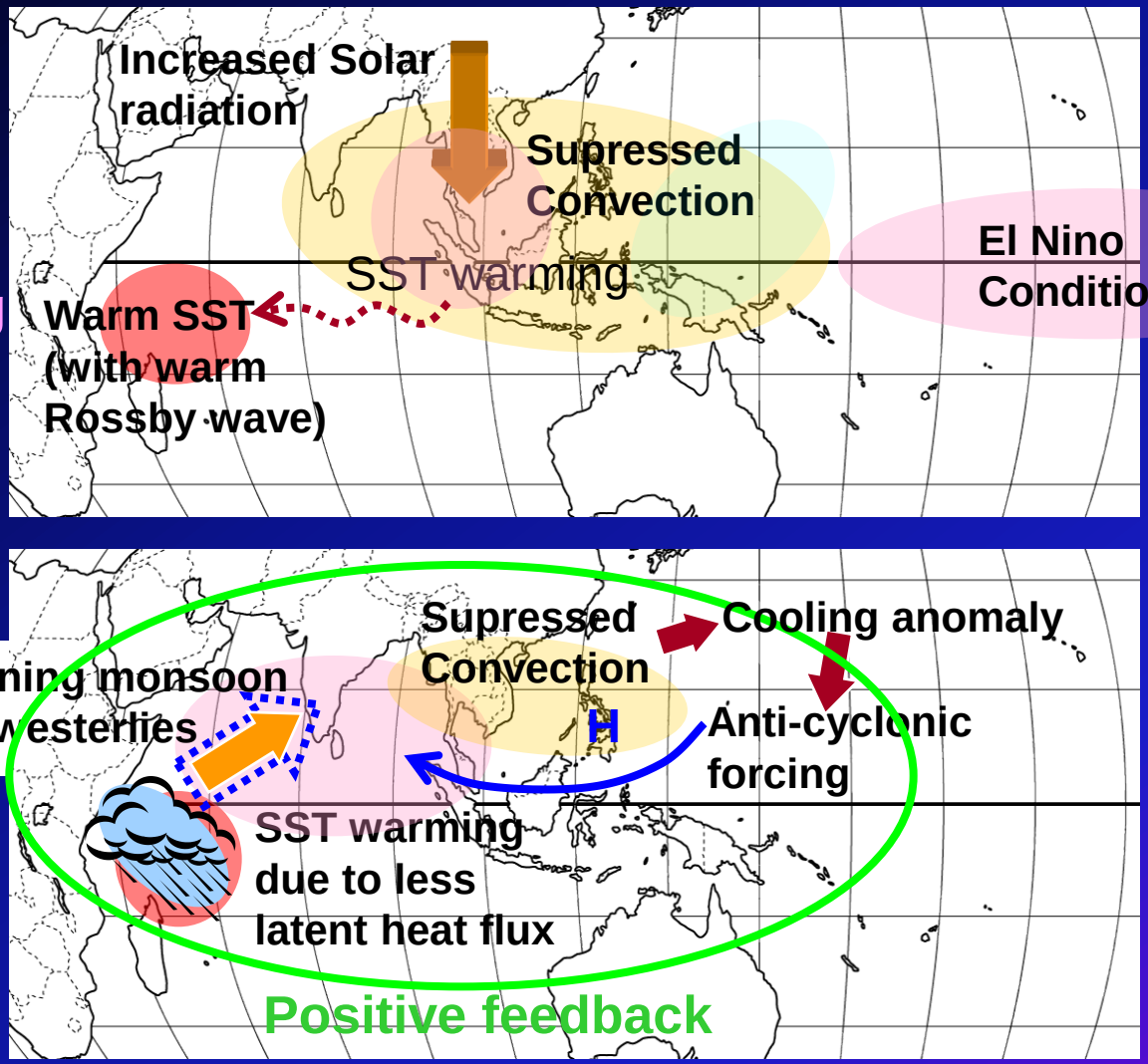


Schematic chart for the impact of the tropical Indian Ocean warming after El Nino in boreal summer



(Ref. Xie et al., 2009)

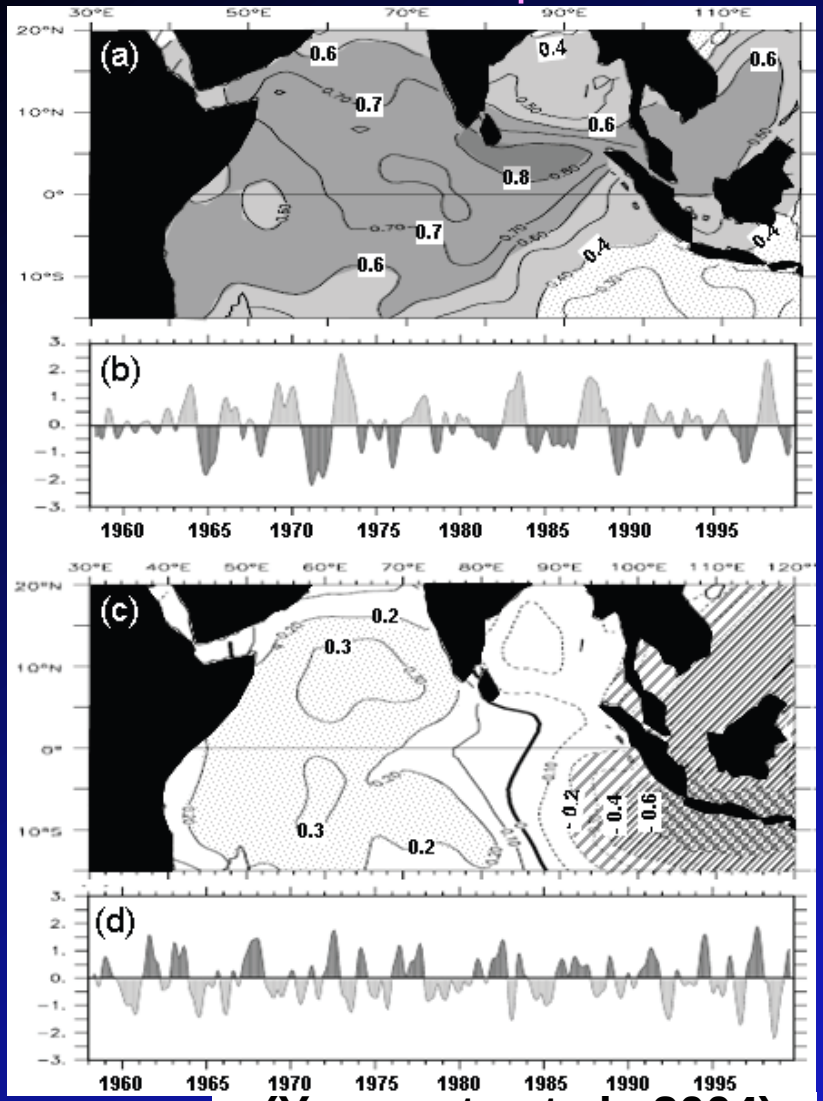
Mechanism of Lagged Influence of ENSO



(Ref. Xie et al, 2009, Du et al.(2009))

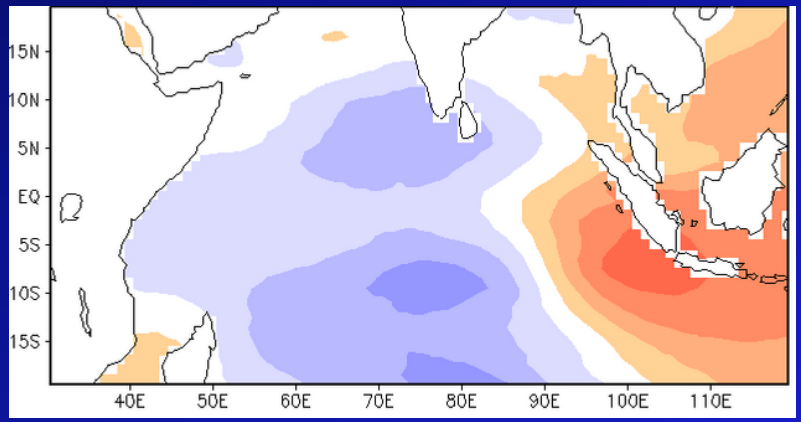
Indian Ocean Dipole

EOF for SST in the tropical Indian Ocean

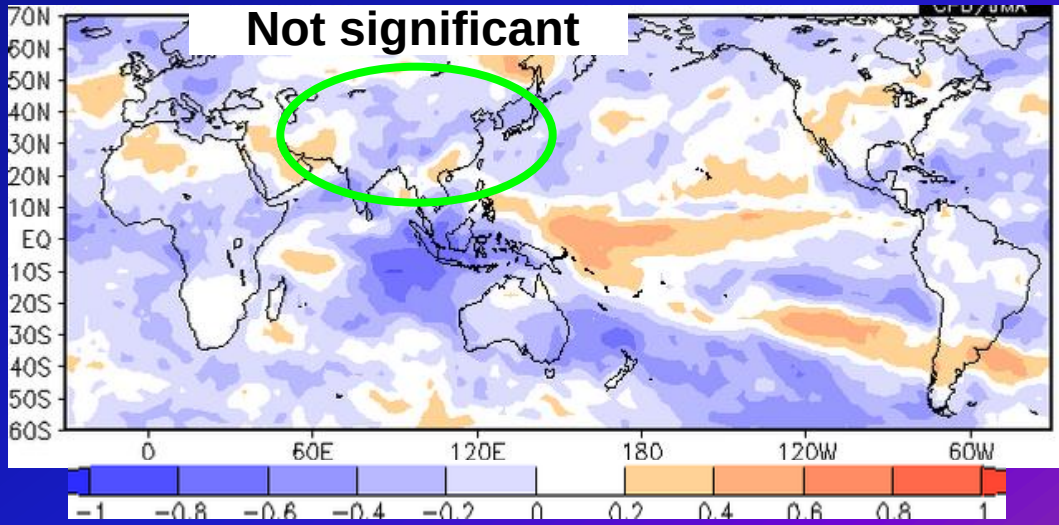


(Yamagata et al., 2004)

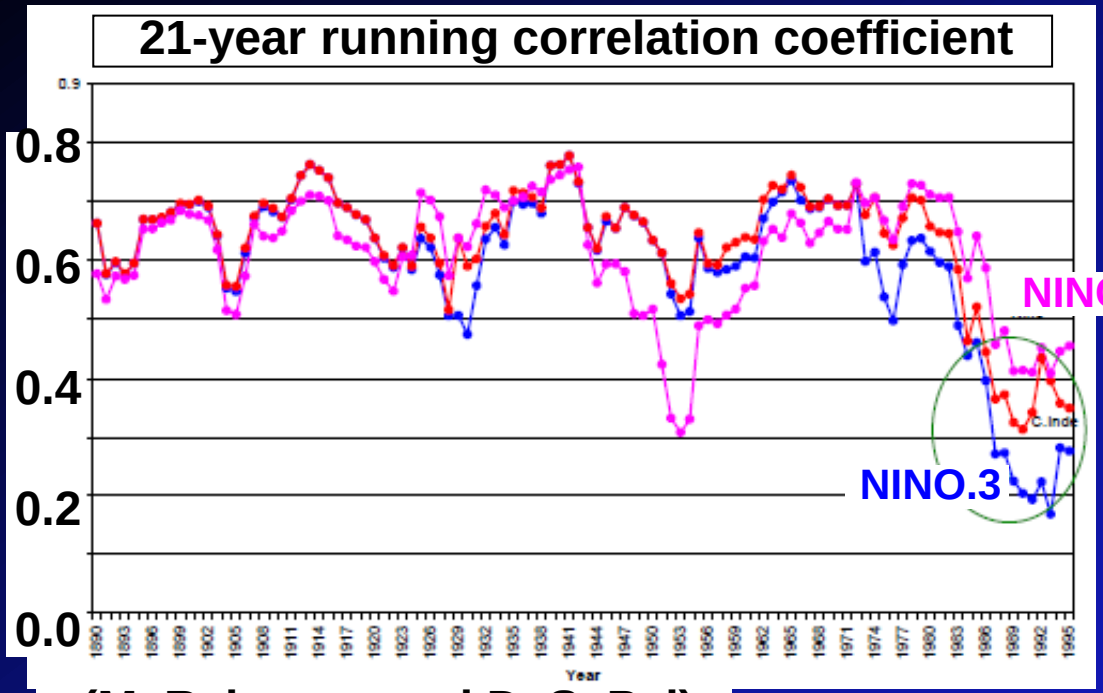
EOF2 for SST in JAS



Correlation coefficient of OLR to EOF2 in JAS

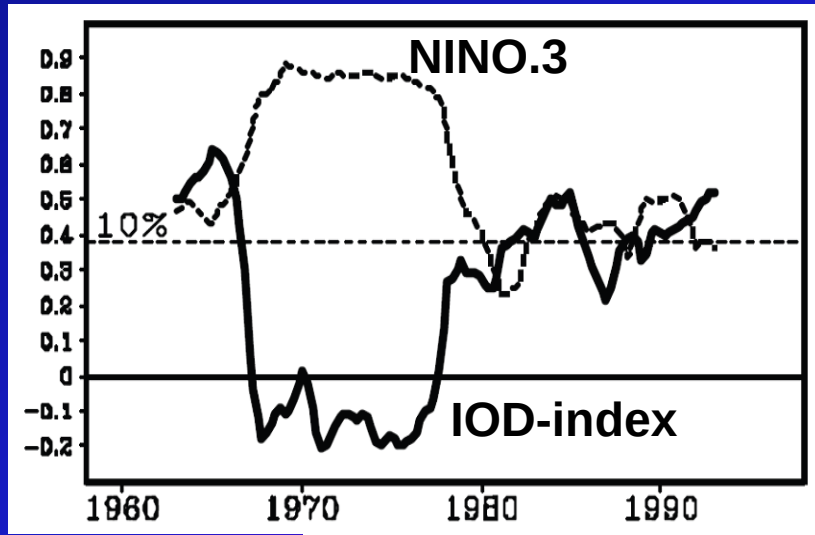


Recent change of relationship between ISMR and NINO.3



(M. Rajeevan and D. S. Pai)

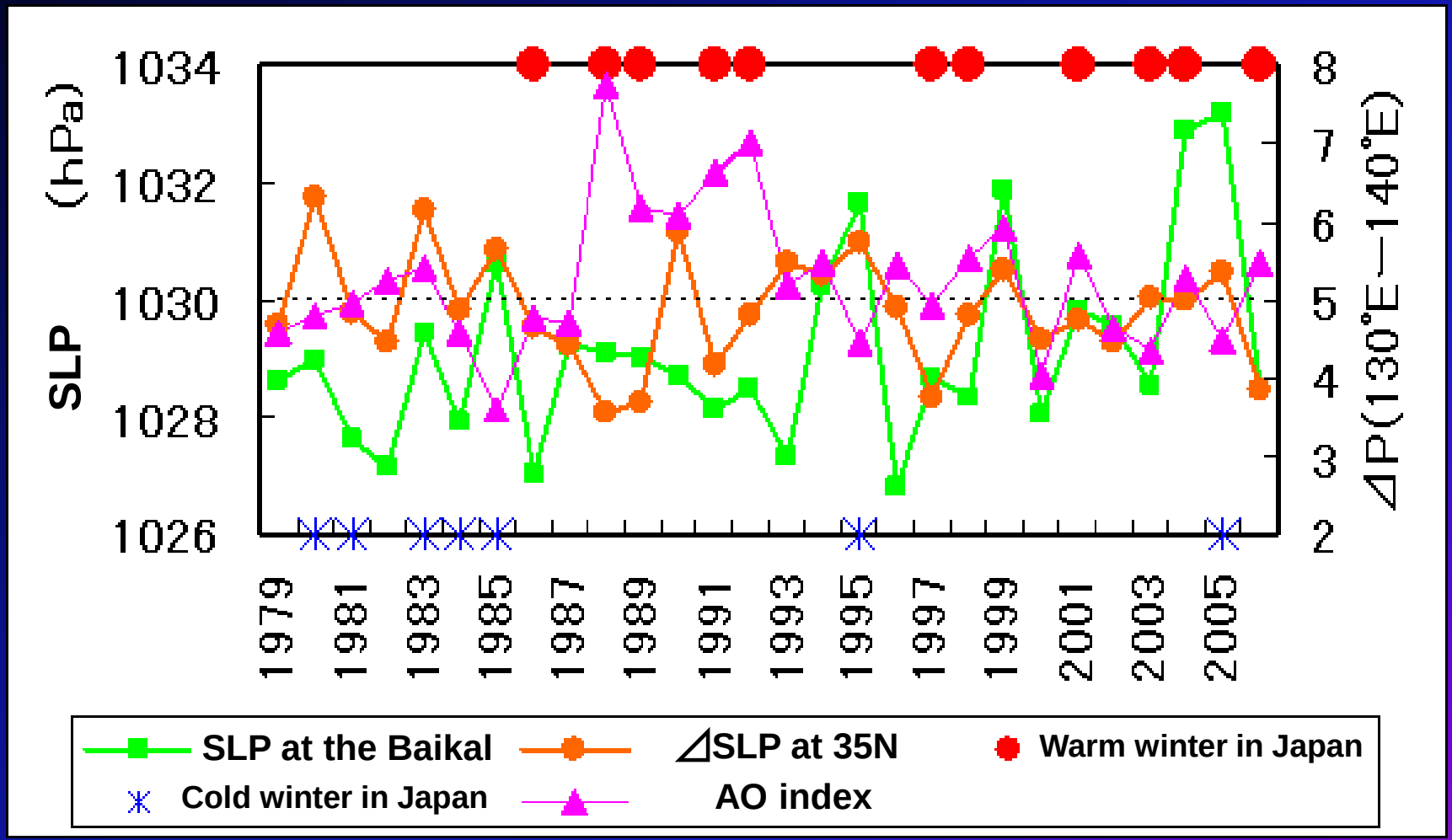
Relationship between ISMR and IOD



(Ashok et al., 2001)

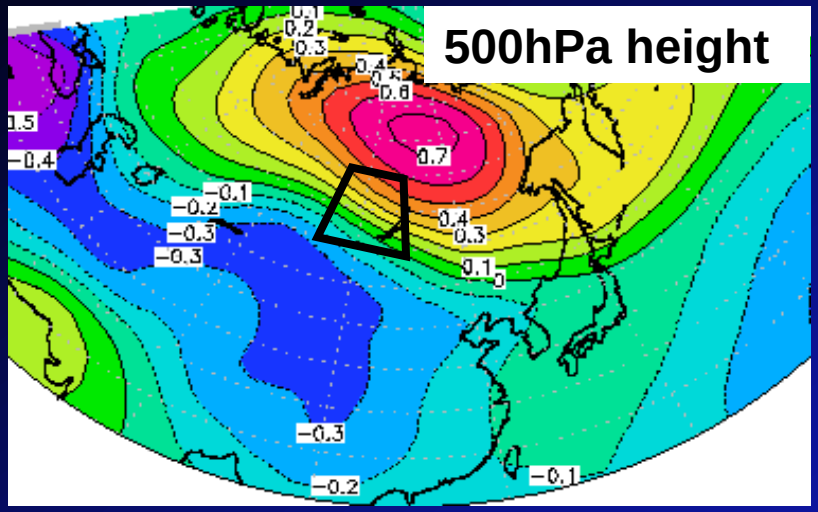
Other Interannual Variability

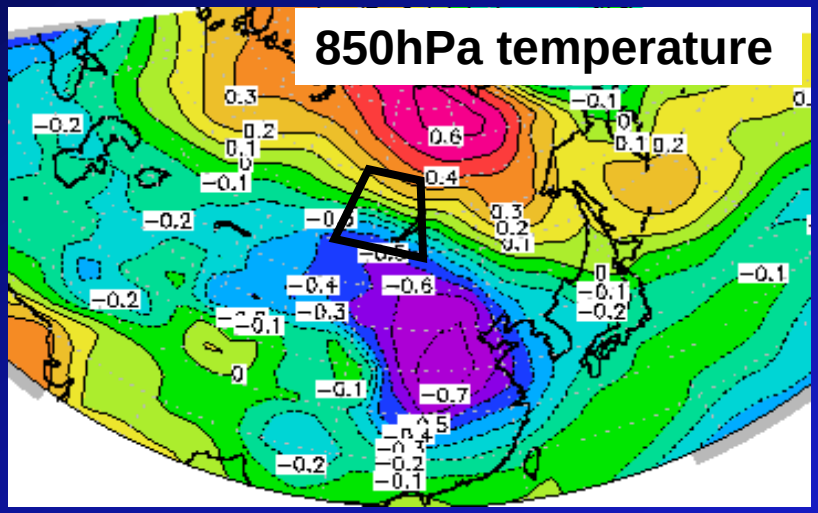
Interannual Variability of Siberian High

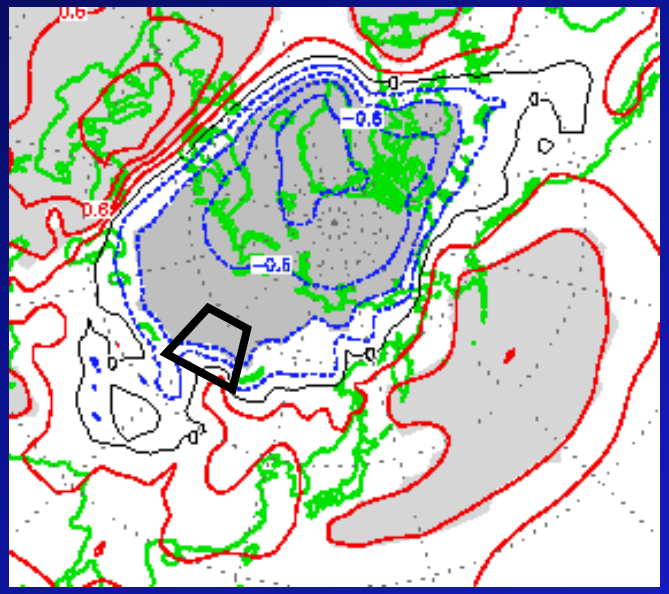


Interannual Variability of Siberian High

Correlation coefficient to the SLP of Siberian high (Jan.)







Correlation coefficient of SLP to AO index (DJF)

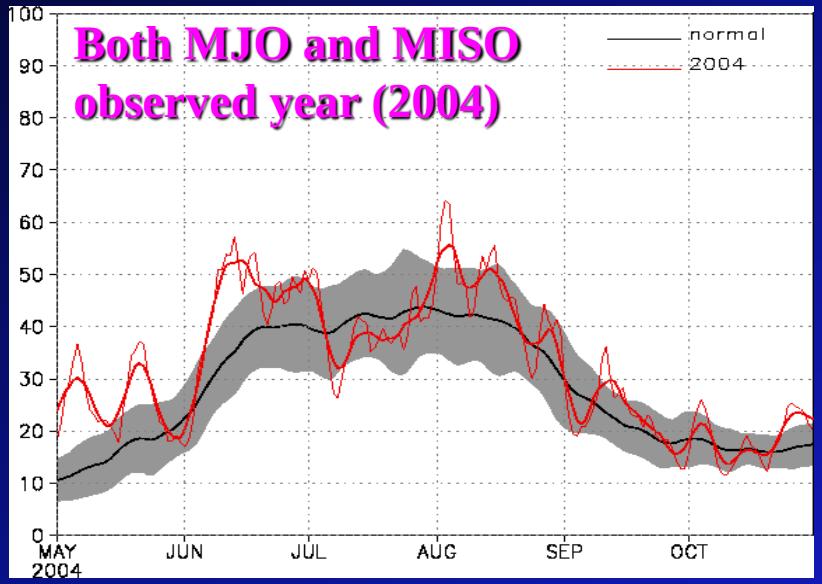
The development of Siberian high has a little relationship with AO.

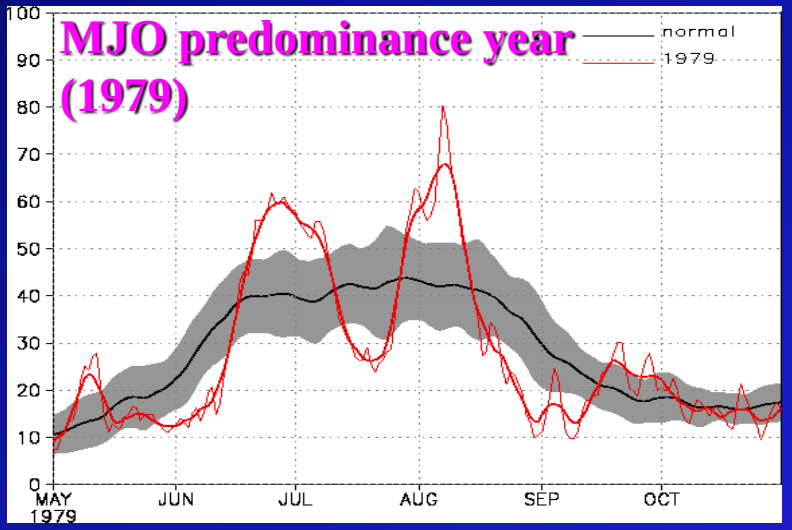
Siberian high develops accompanied with the development of upper level ridge and it bring cold spell to China.

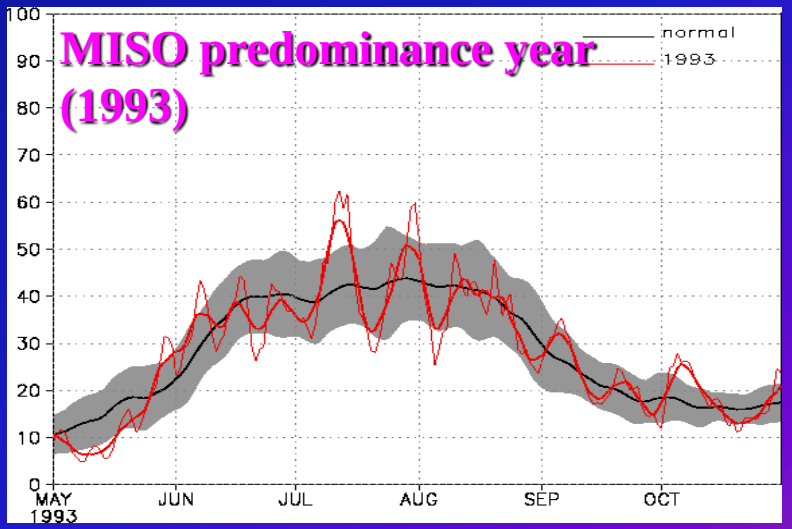
North-west monsoon around Japan depends on not only Siberian high but also the development of Aleutian low

Each Interannual Variability consists of some intra seasonal variabilities

Indian monsoon circulation index







Summary

- **Long term variation can be divided into global warming trend, decadal oscillation and interannual variability.**
- **Interannual variability is closely related to daily lives and anomalous variation causes a hazard or disaster.**
- **Before the discussion of interannl variabilities, it is important to understand the nature of it.**
- **The understanding and prediction skill of ENSO which is the most influential interannual variability, has been grown for these days.**
- **However, the relationship with ENSO has changed recently. A relationship between two interannual variabilities does not seem to be universal.**
- **It is reported that the variability of Indian Ocean may possibly affect the relationship. This makes the Indian Ocean draw researcher's attention.**

Thank you