Training Seminar on Climate Information and Forecasting

Climate System Monitoring

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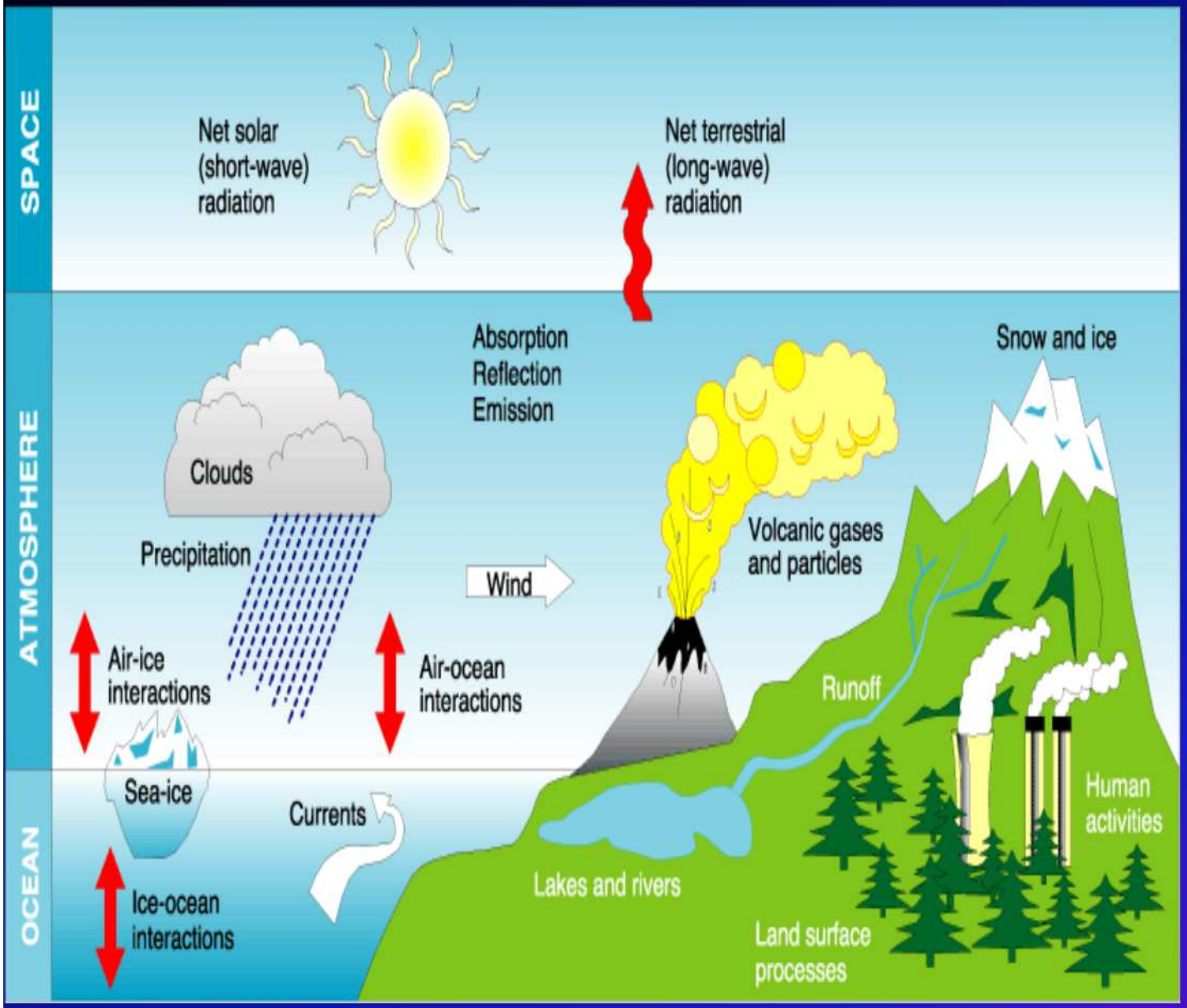
Climate Prediction Division
Japan Meteorological Agency

4th November 2008

Climate System consists of many subsystems

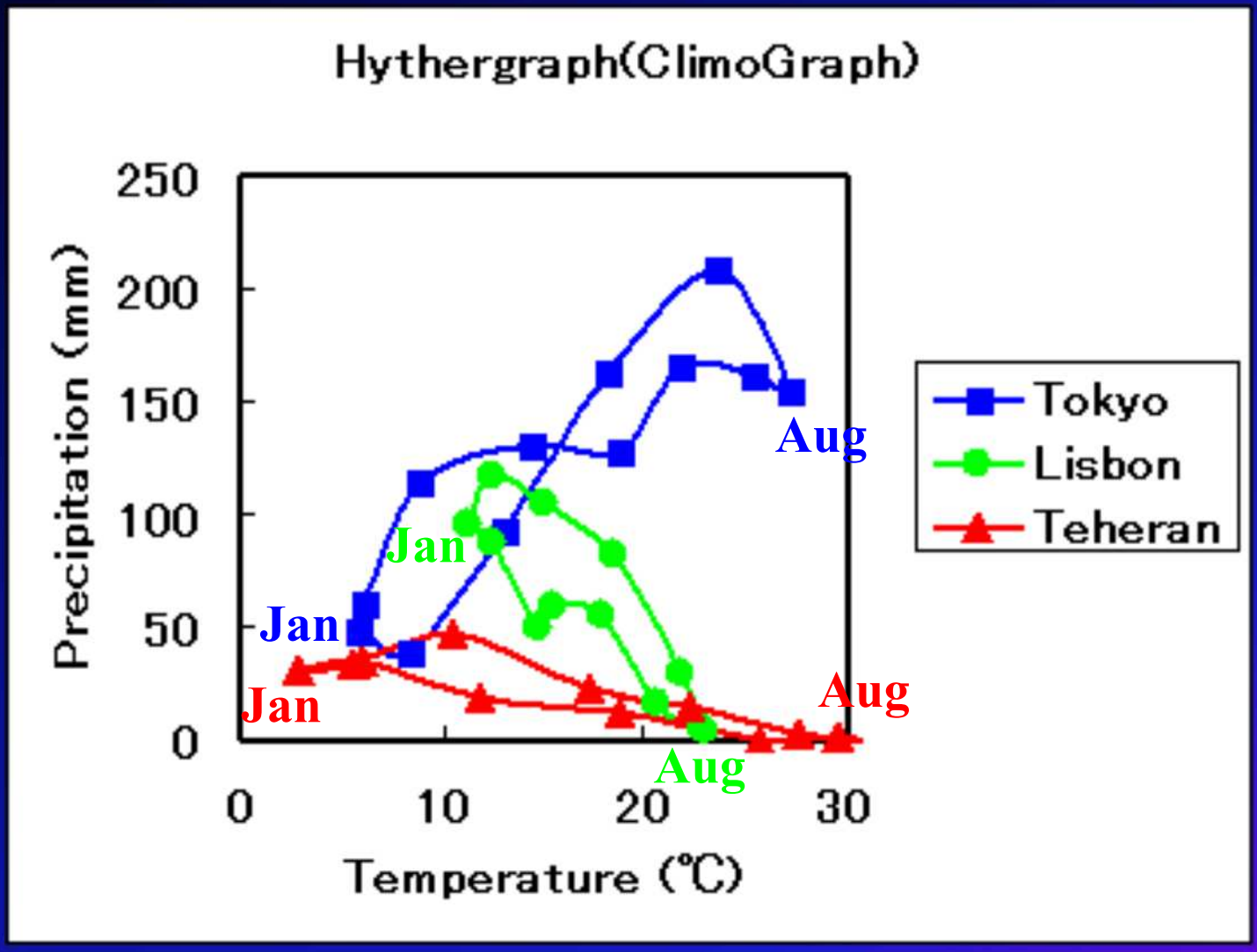


- Solar activity
- Stratosphere
- Troposphere
- Ocean
  - * SST
  - * Sea Ice
  - * Current
  - * Deep Sea current
- Land
  - * Vegetation
  - * Snow
  - * Runoff
- Aerosol
- Human Activity

Climate and Geography

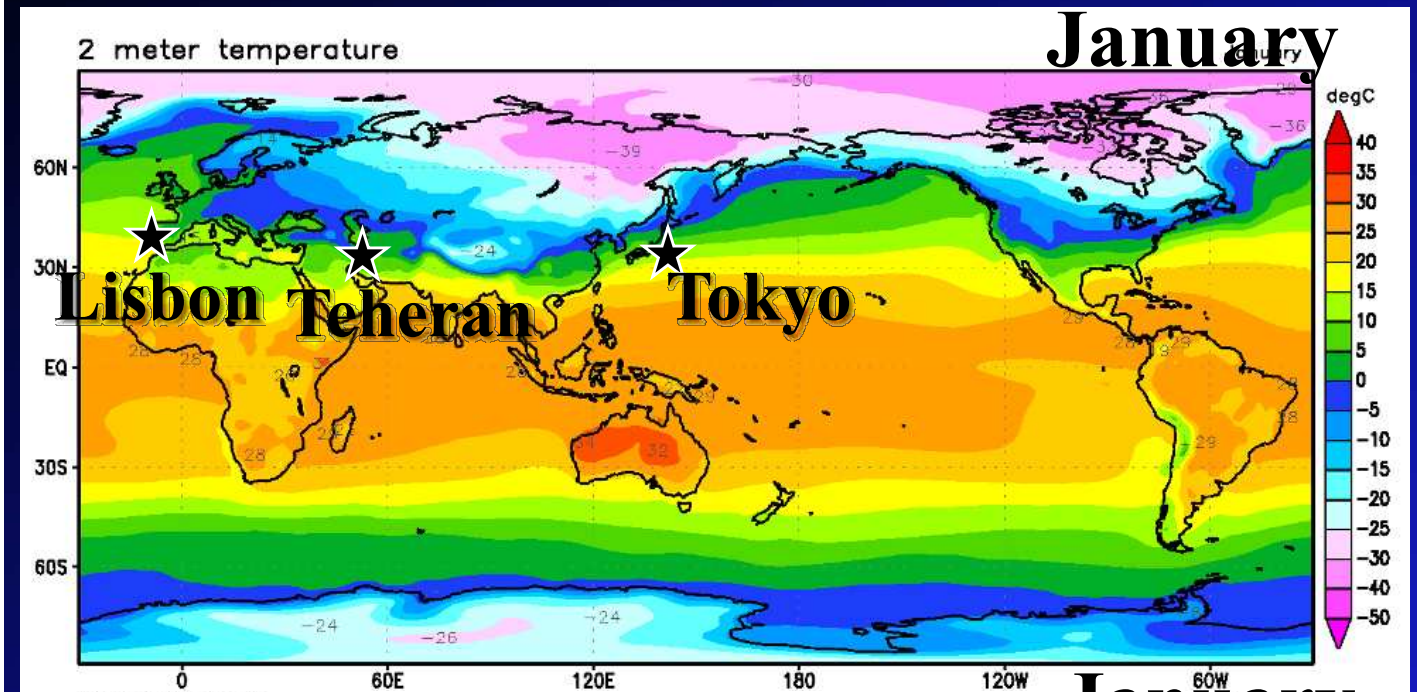
Distribution of Continents and Oceans

Do you know the climate in Japan ?

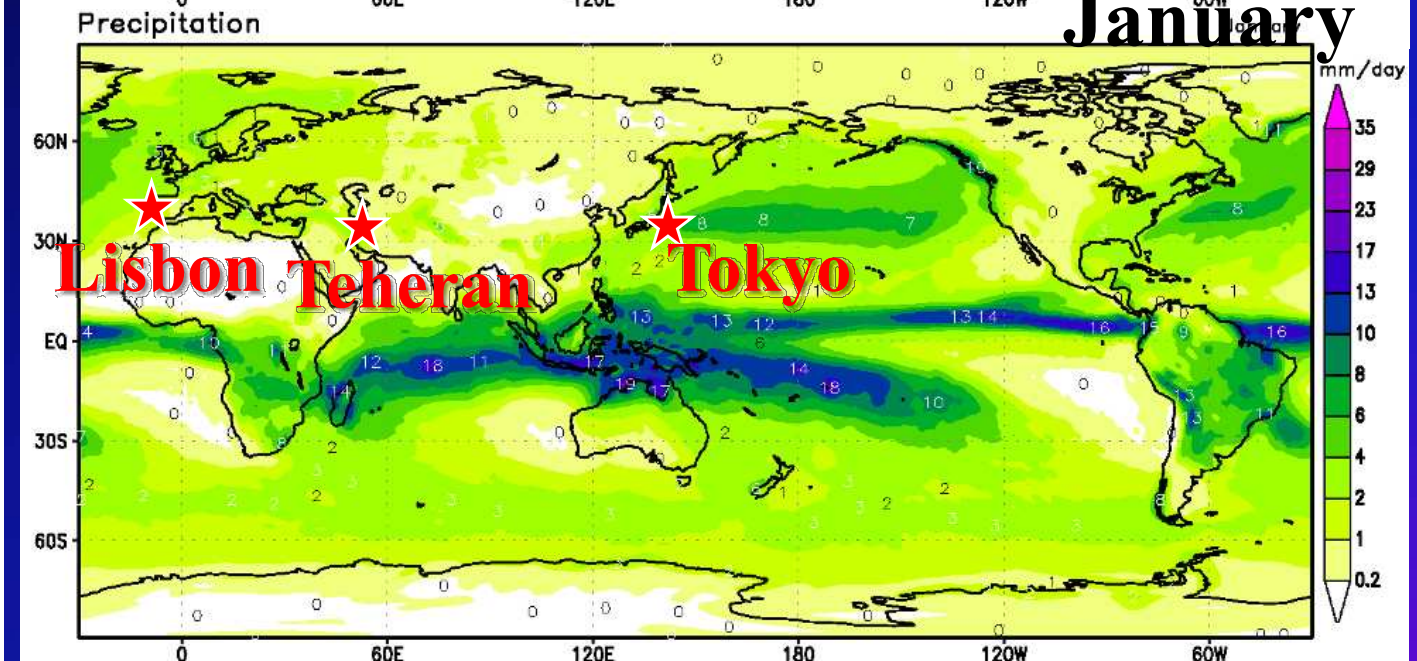


Climates are quite different among cities even if they lie at the same latitude.

Climate mainly depends on geographic distribution of Continents and Oceans



Surface Temperature

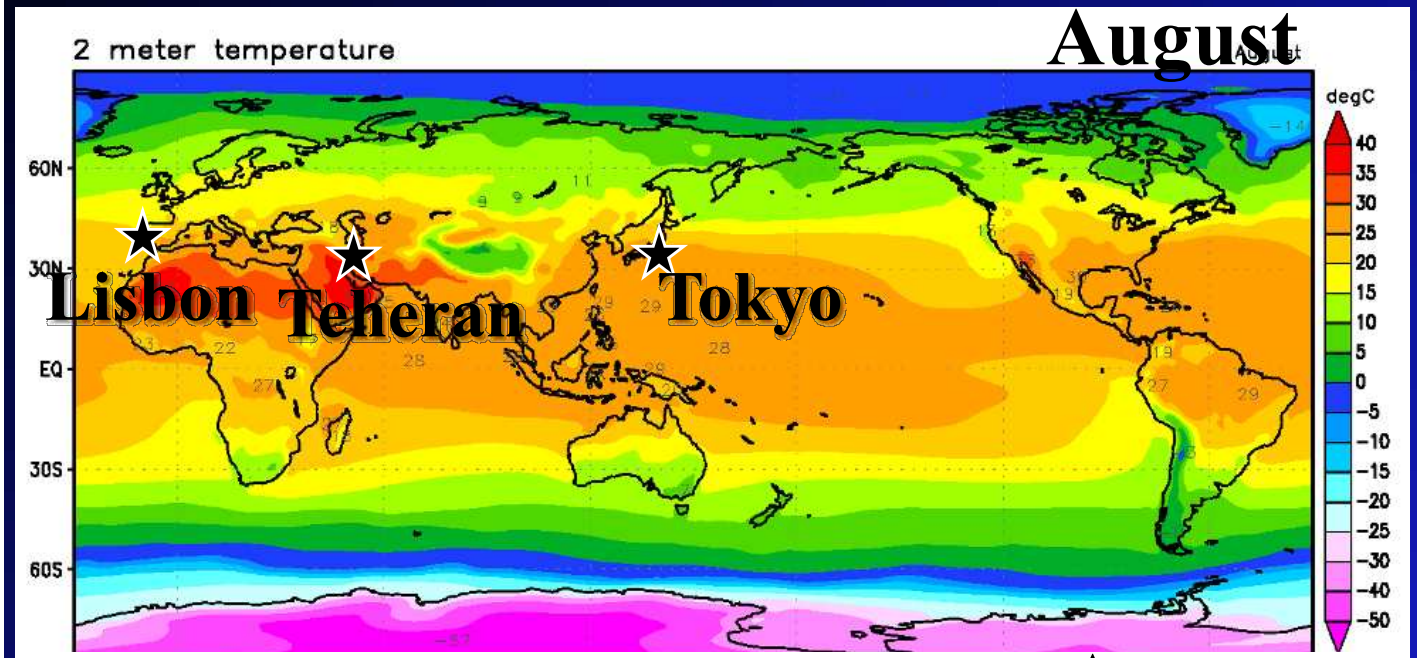


Precipitation

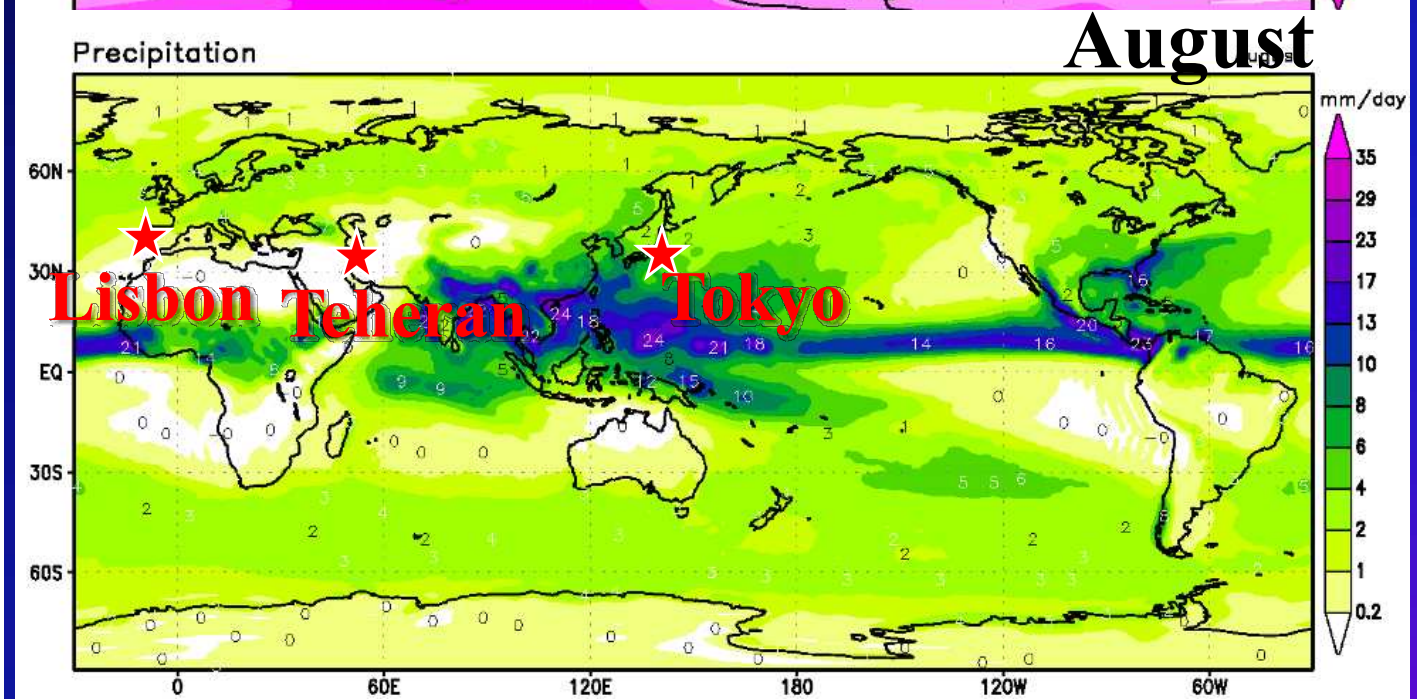
JRA-25 Atlas

http://ds.data.jma.go.jp/gmd/jra/atlas/eng/atlas-tope.htm

Climate mainly depends on geographic distribution of Continents and Oceans



Surface Temperature



Precipitation

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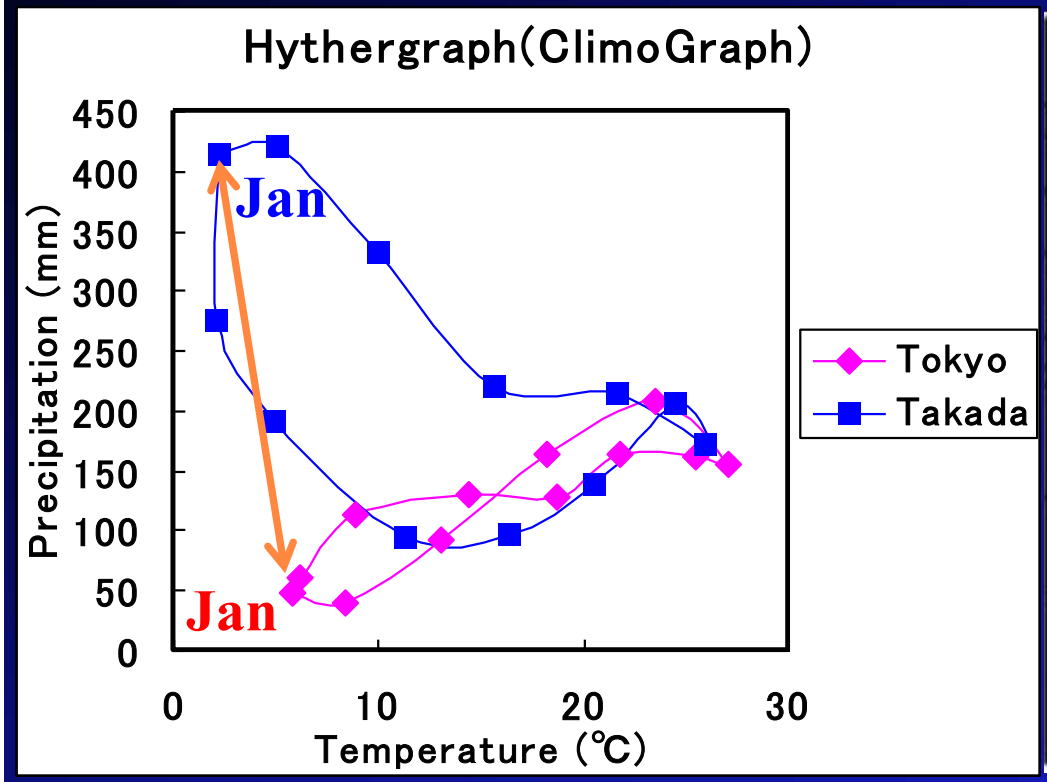
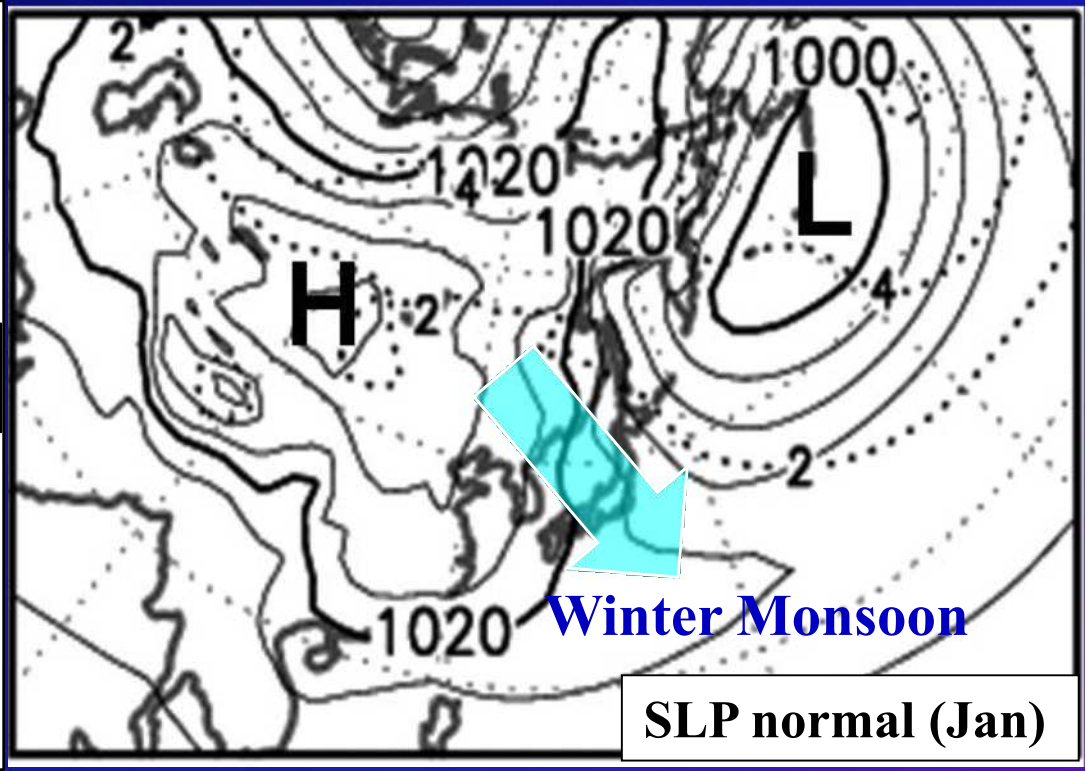
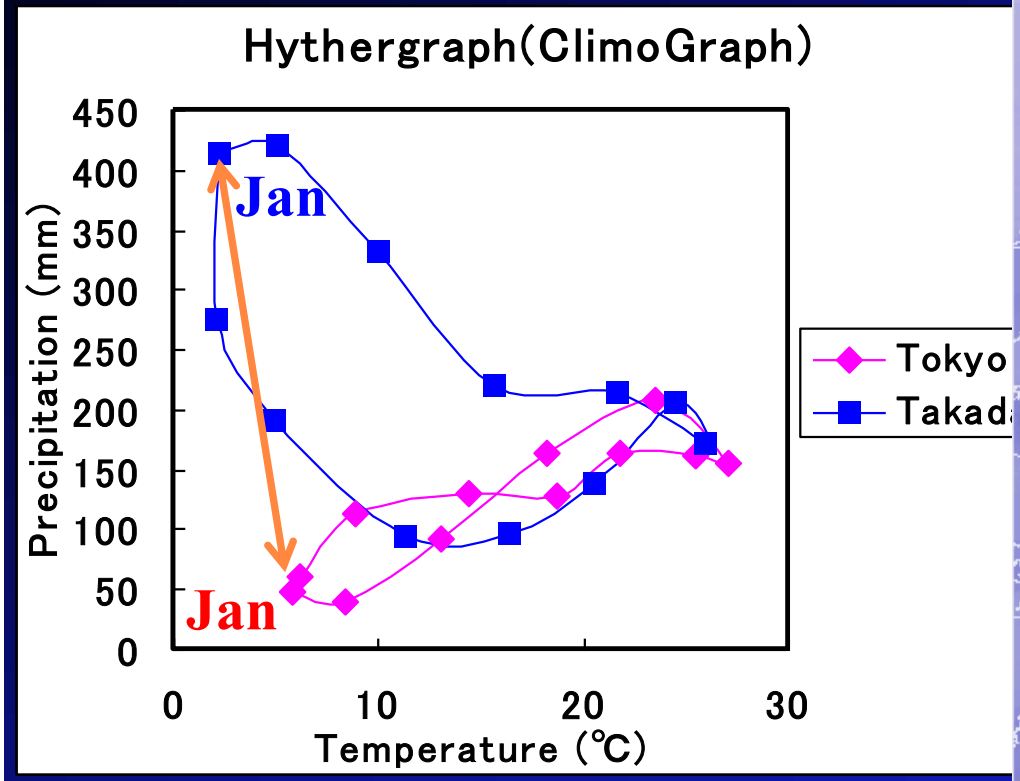
Do you exactly know the climate in Japan ?

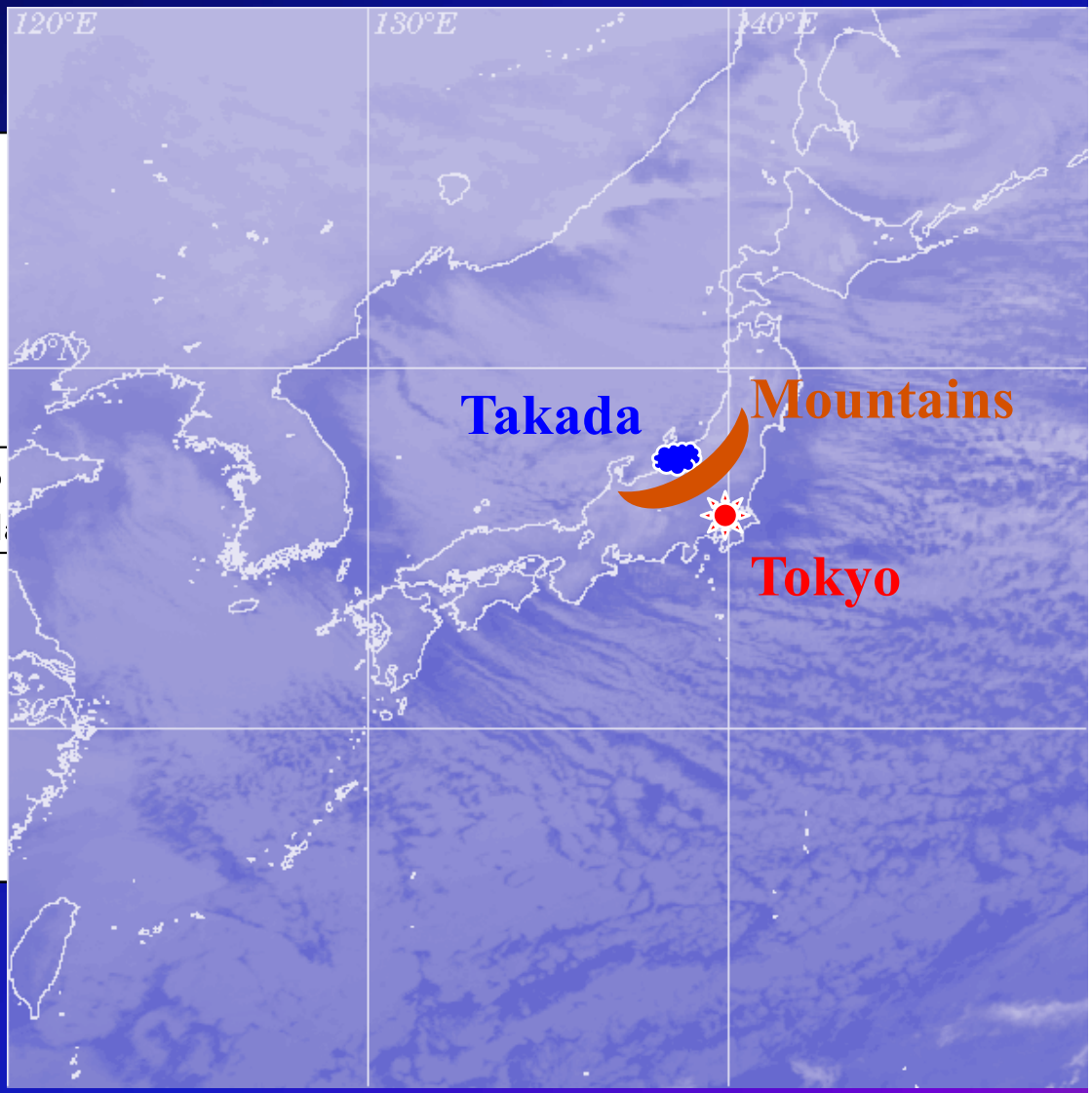




Local topography has a large influence on the local climate.

Do you exactly know the climate in Japan ?





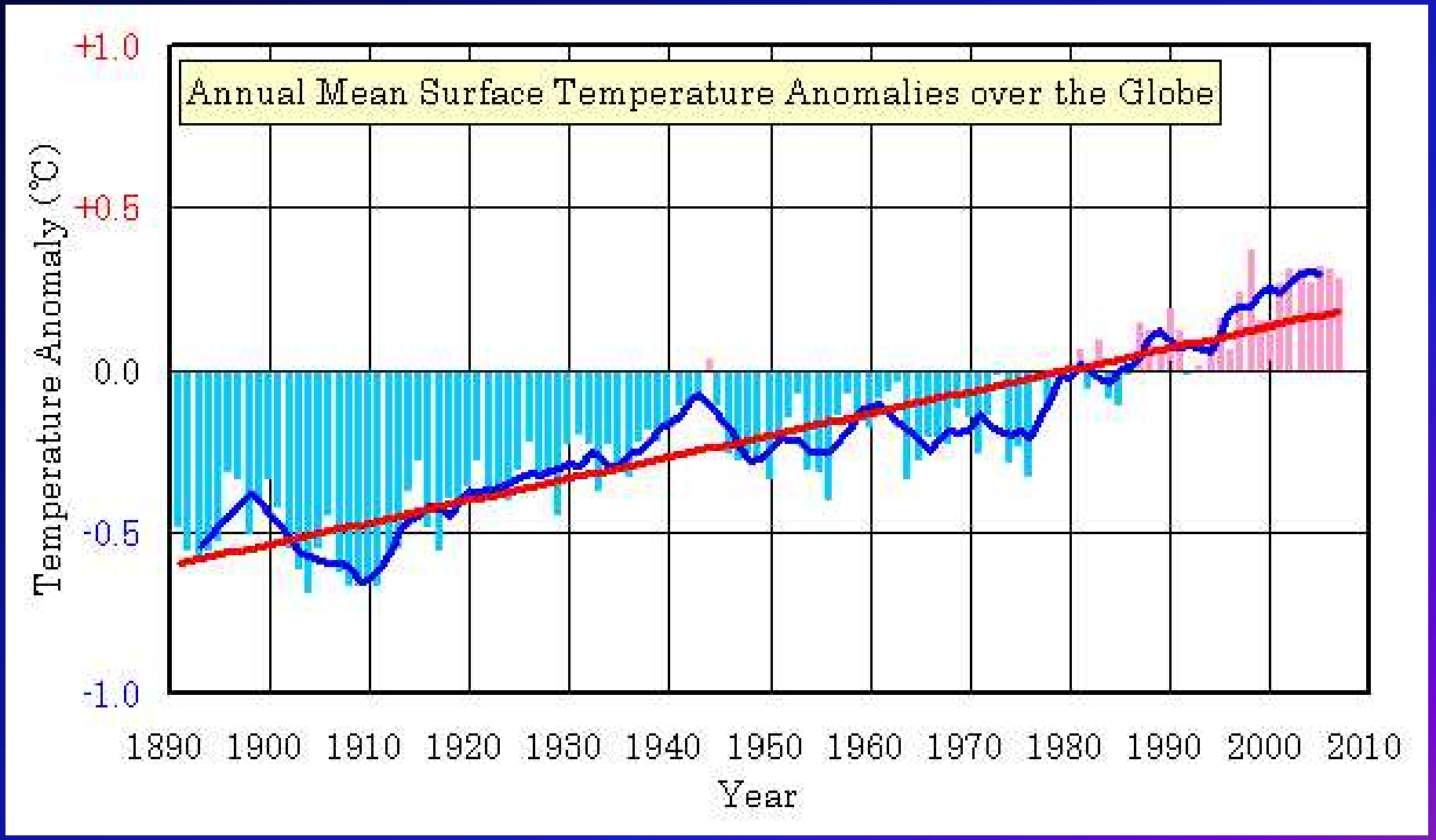
Local topography has a large influence on the local climate.

Climate variability

Various time scale phenomena

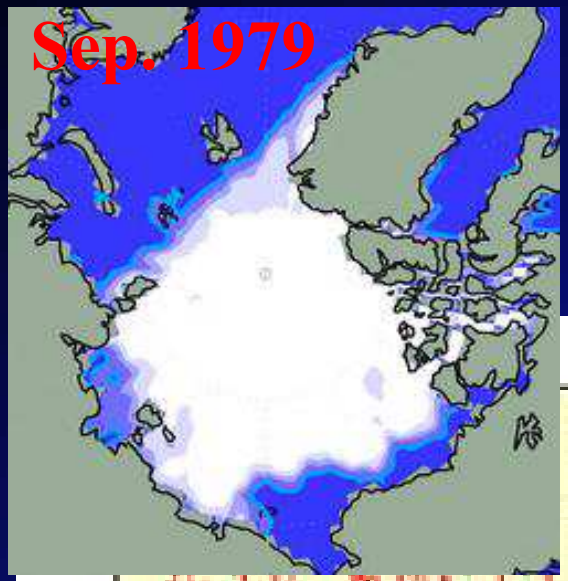
Climate variability – Long term variation -

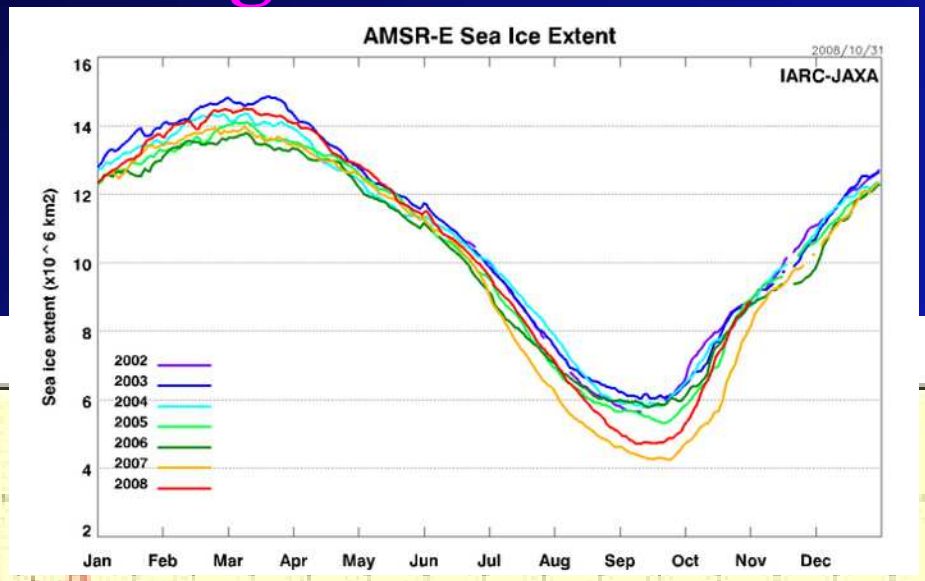
Global warming

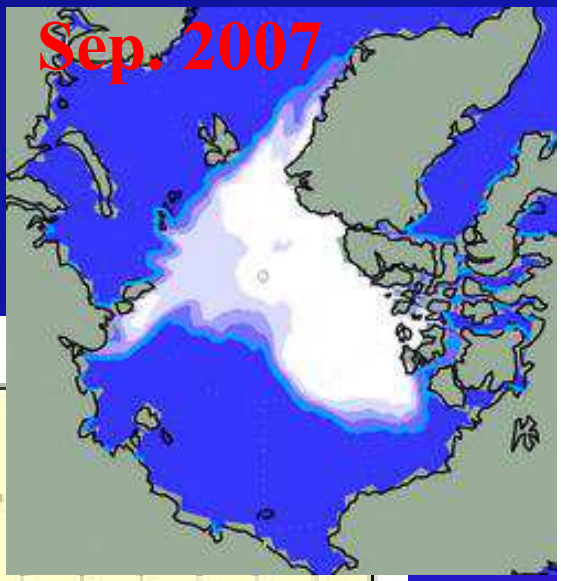


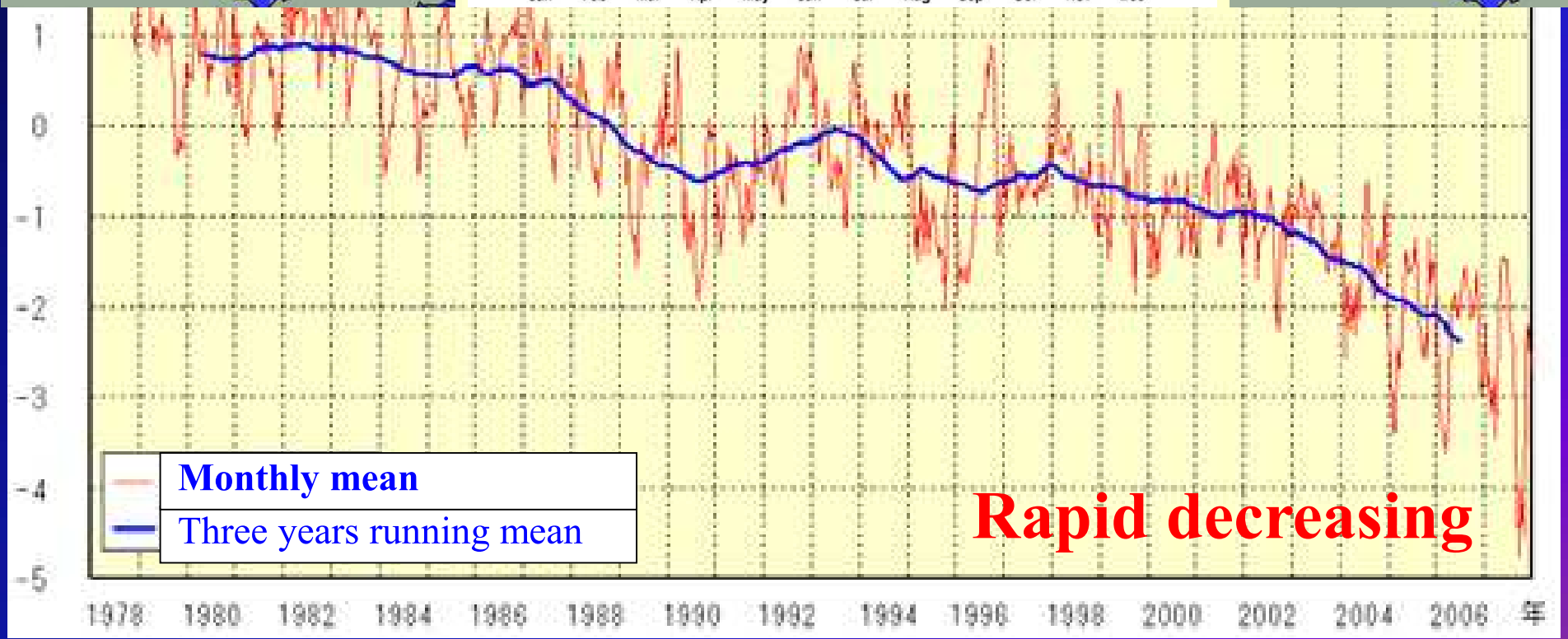
Climate variability – Long term variation -

Decreasing Arctic Sea Ice



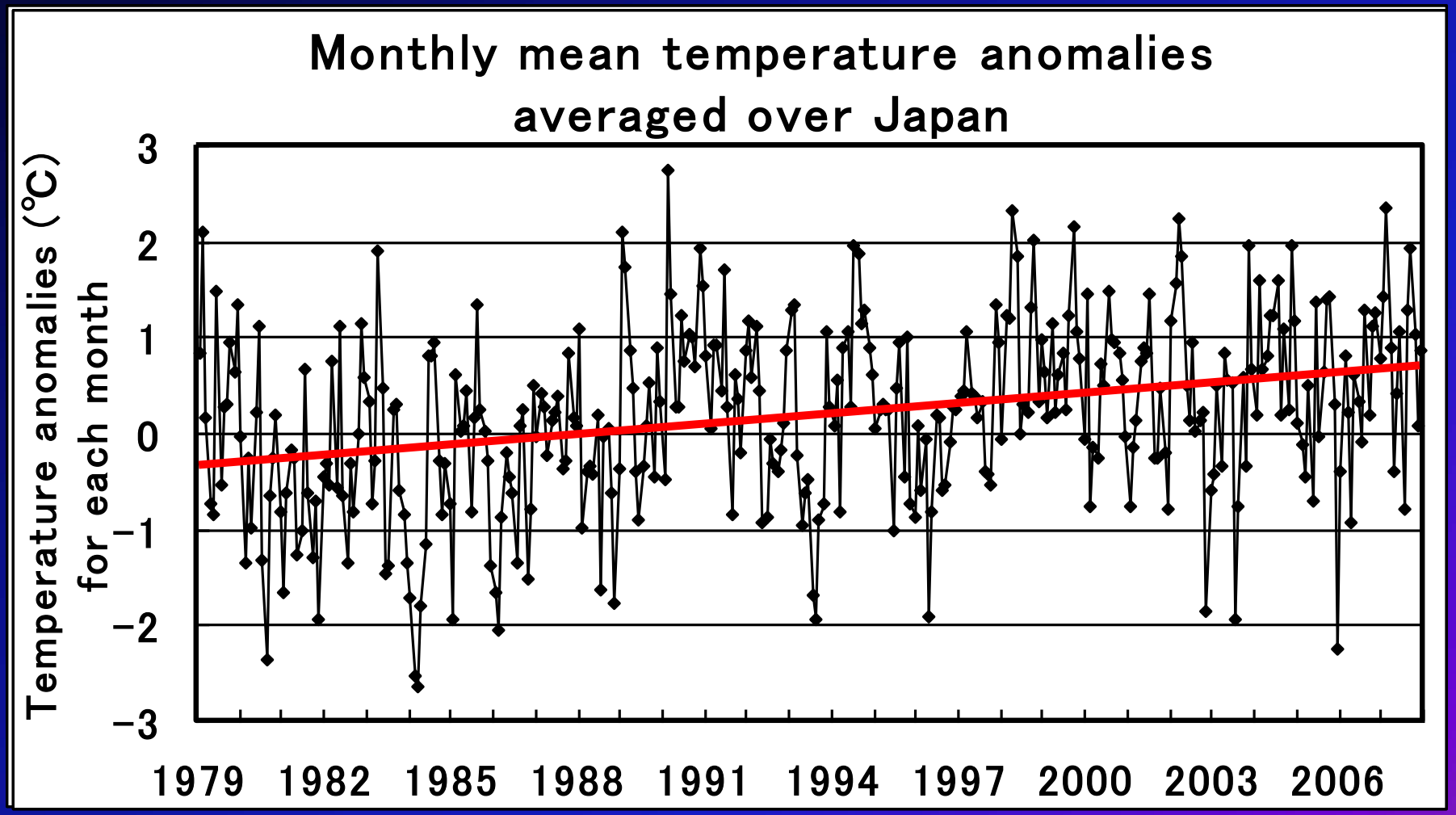






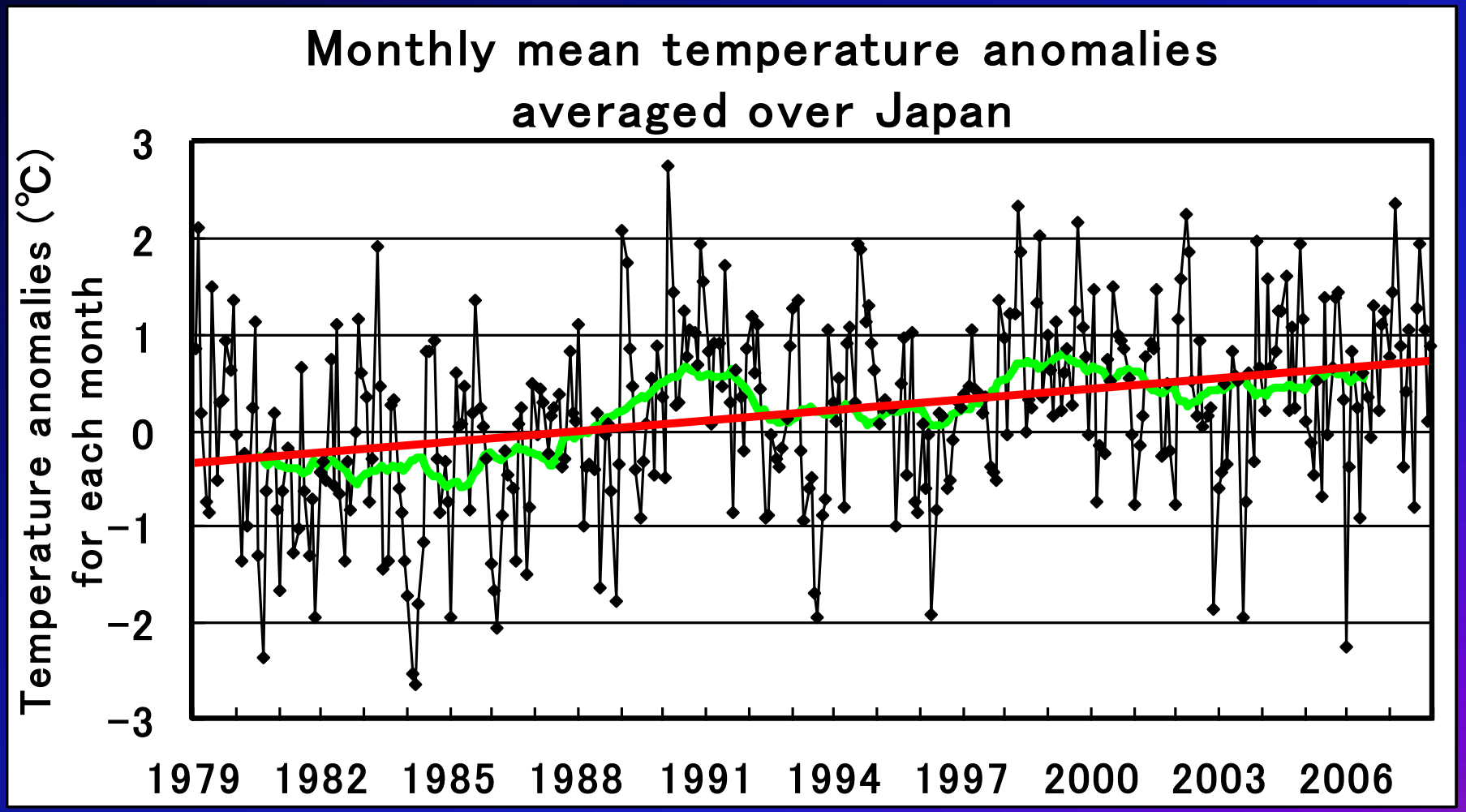
Climate variability – Long term variation -

Global warming



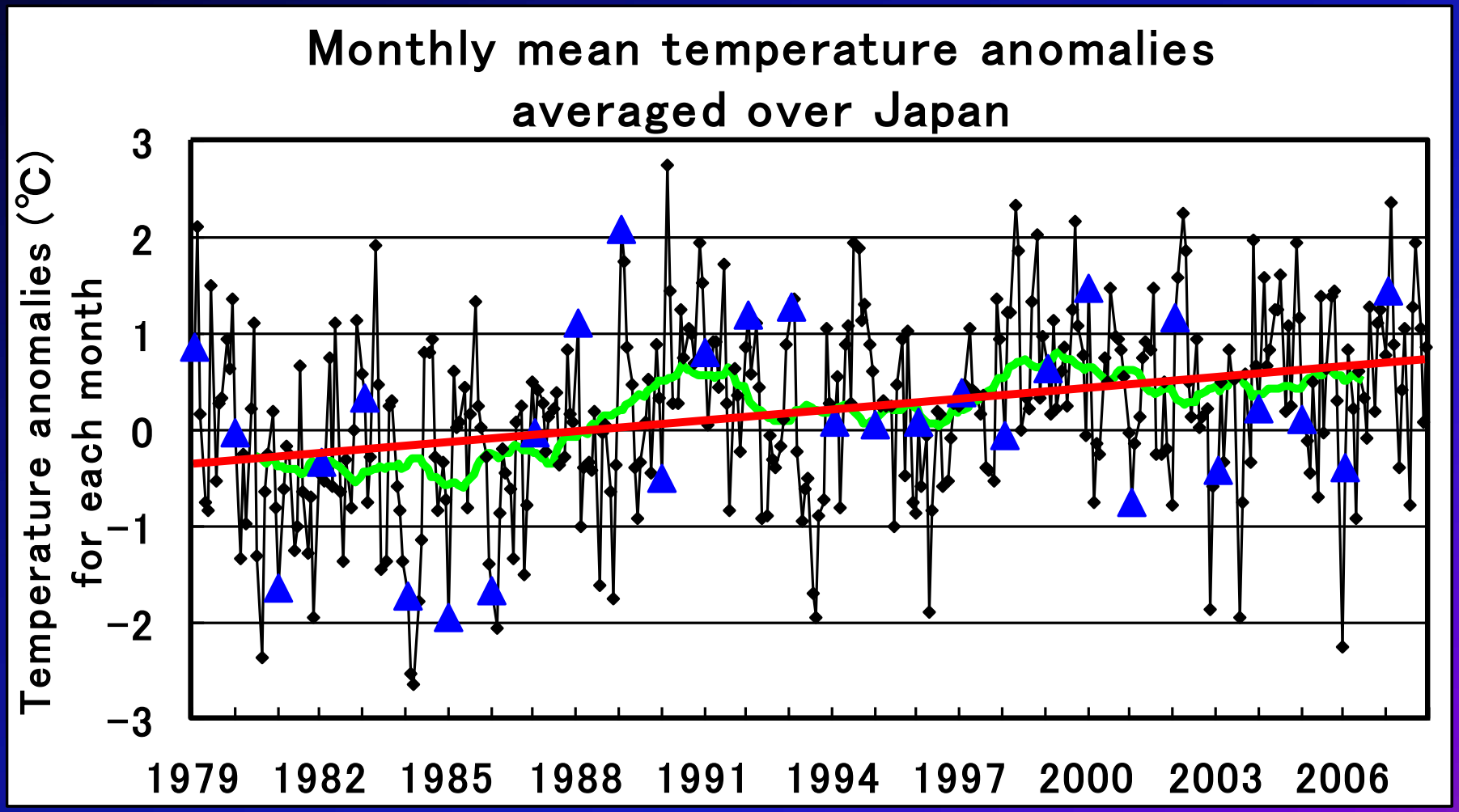
Climate variability – Long term variation -

Decadal Oscillation

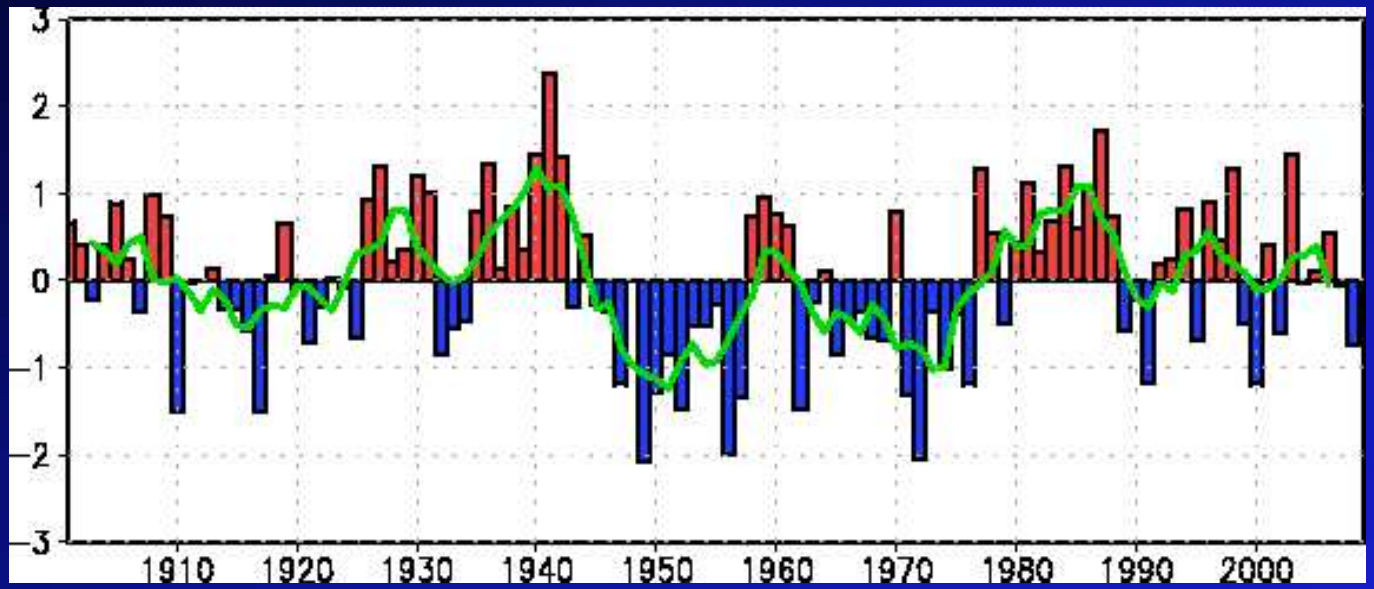


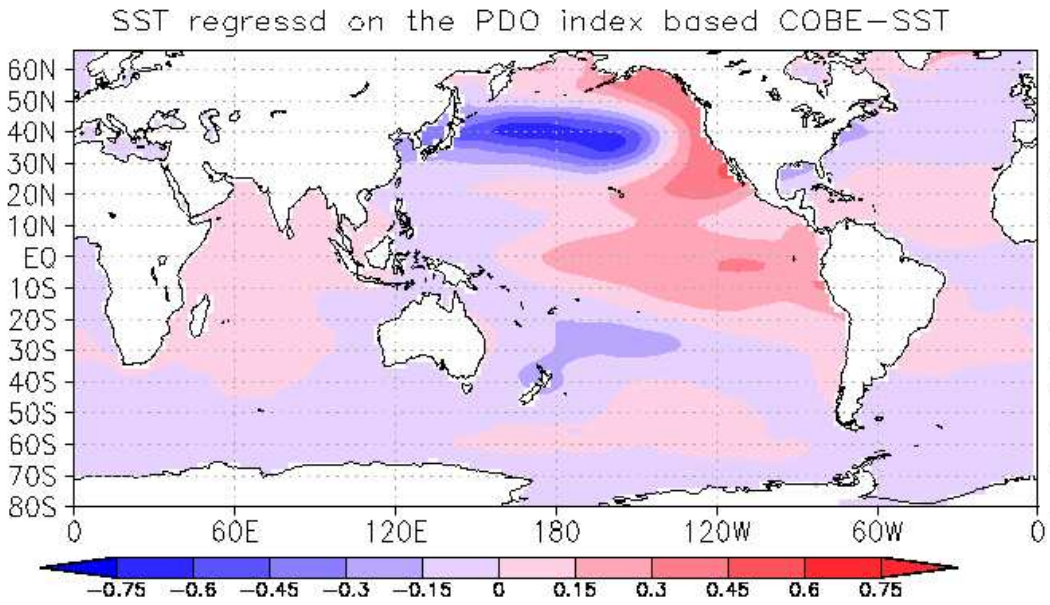
Climate variability – Long term variation -

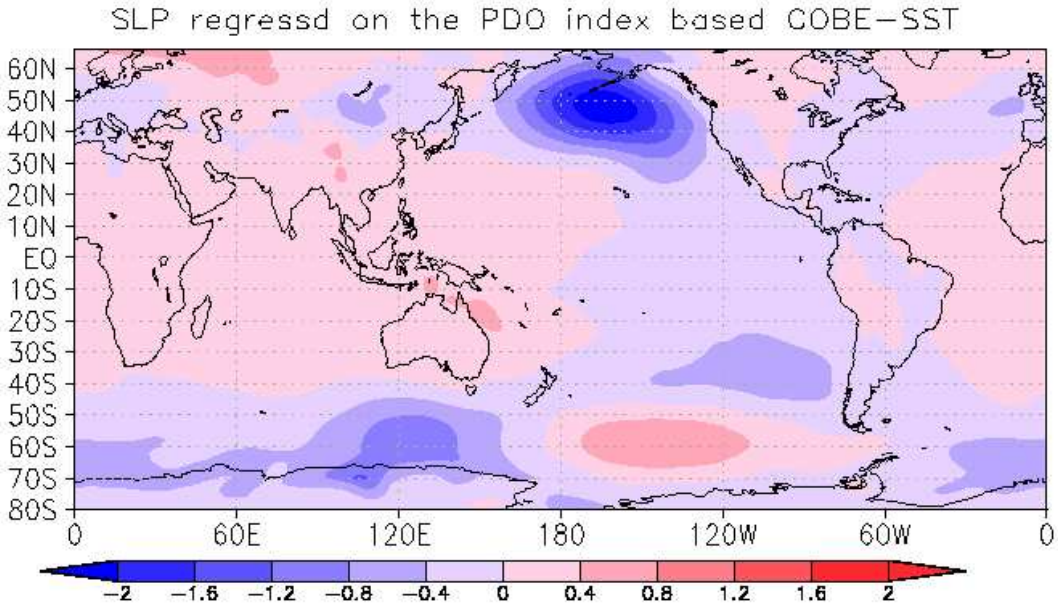
Inter-annual Variation



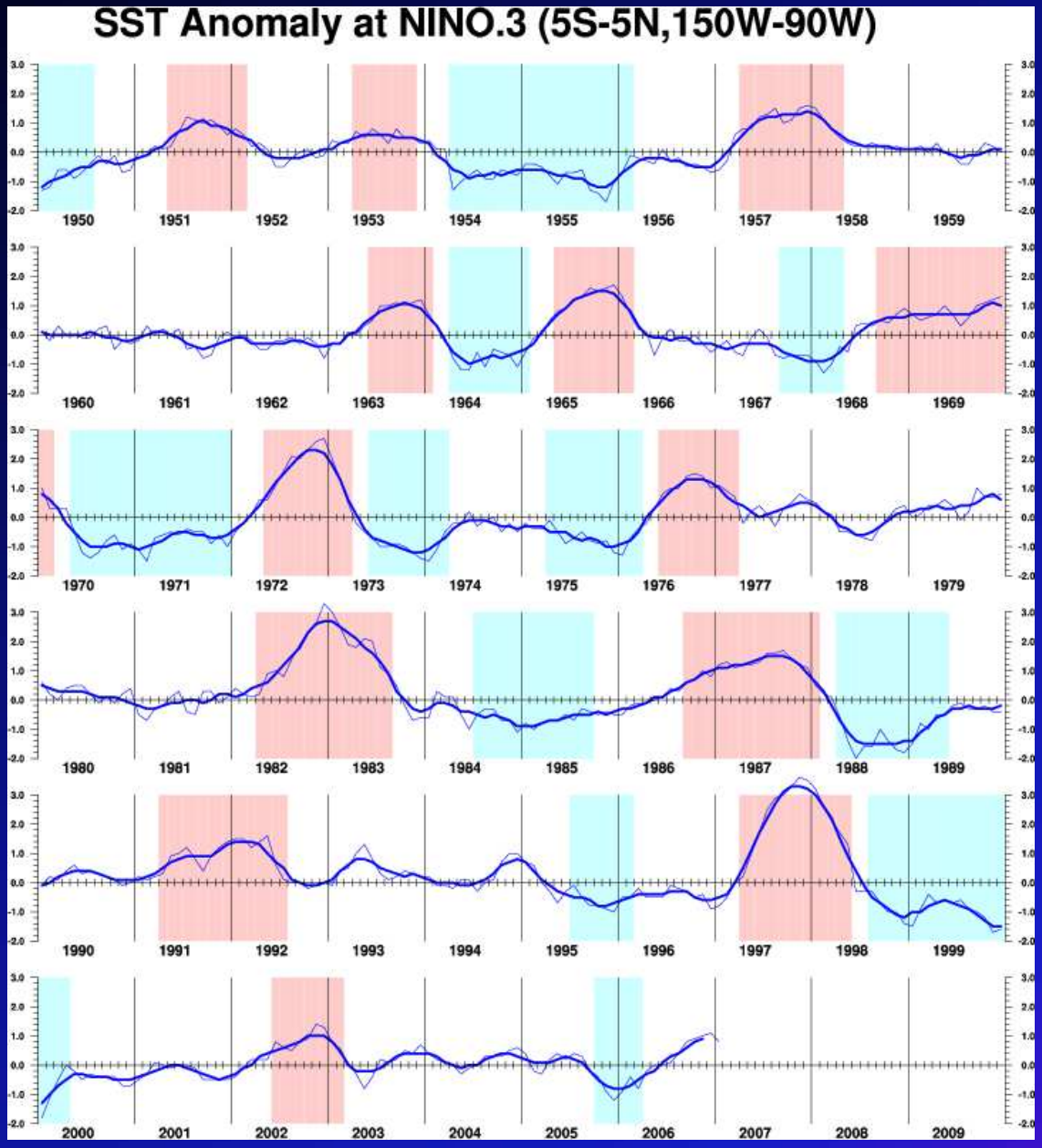
Climate variability
- Decadal variation -
Pacific Decadal Oscillation

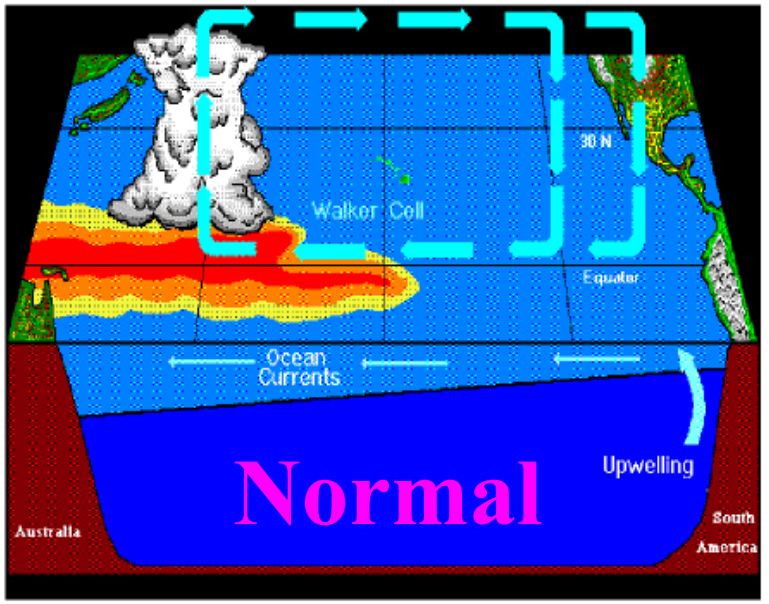


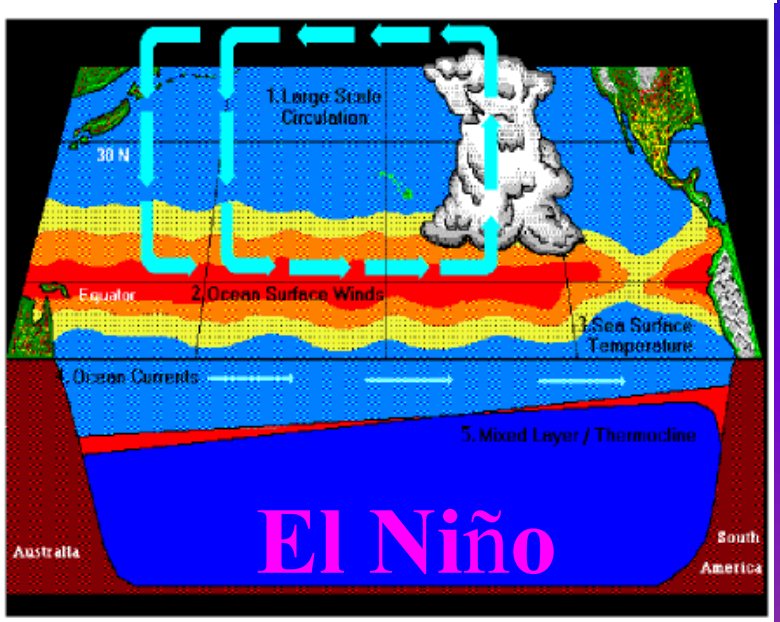




Climate variability
– Inter Annual Variation -
El Niño Southern Oscillation

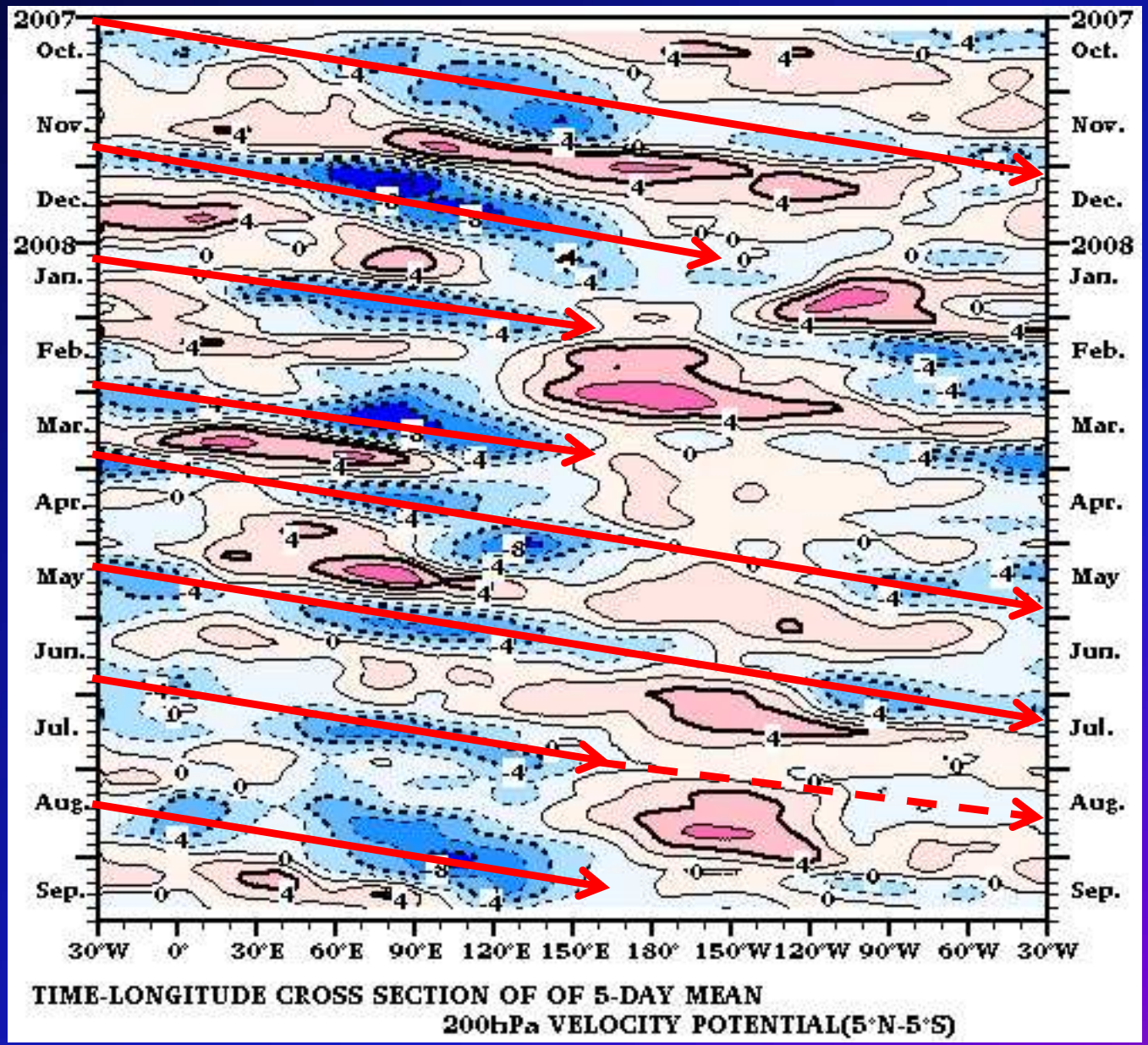




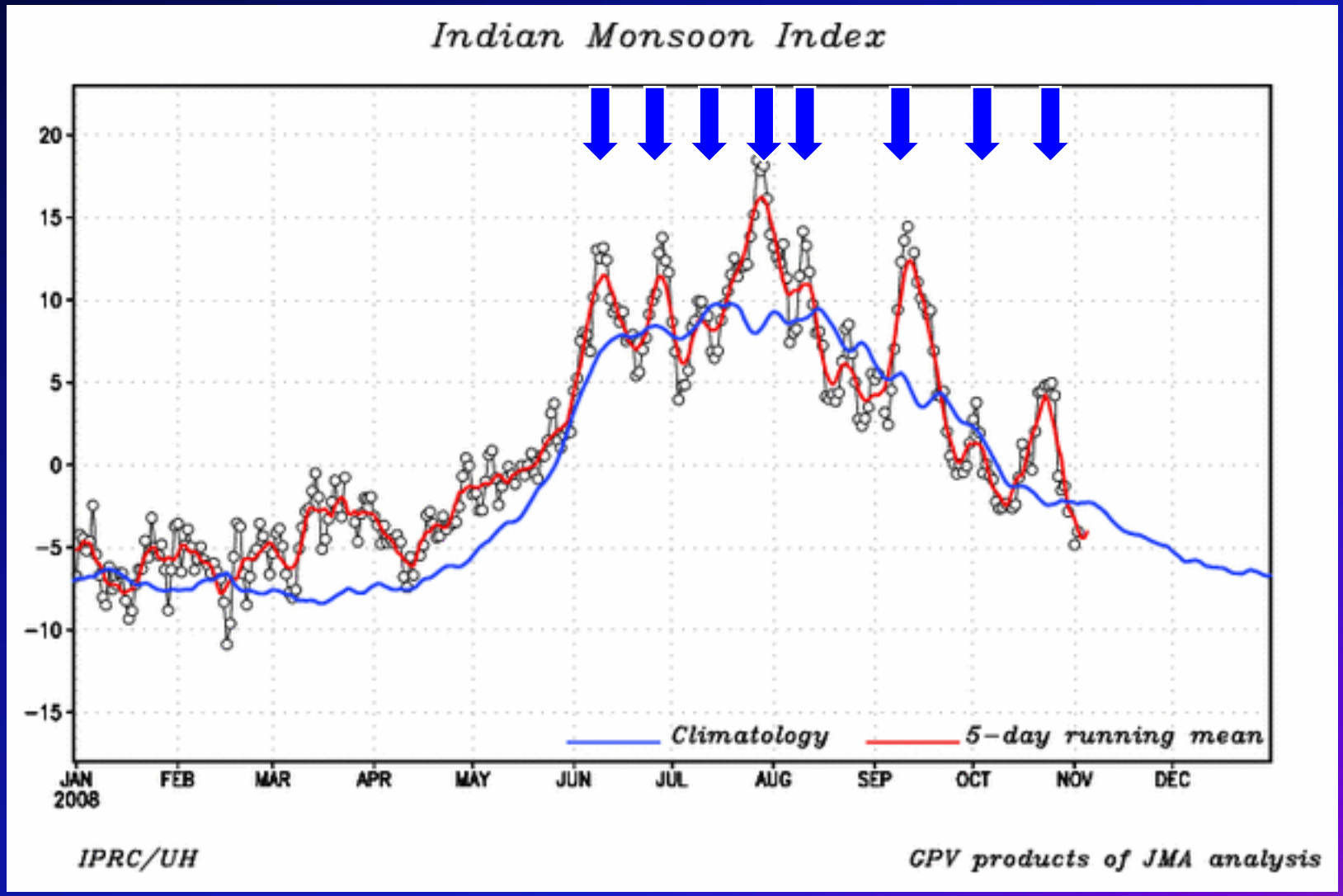


Climate variability
- Intra Seasonal Variation -

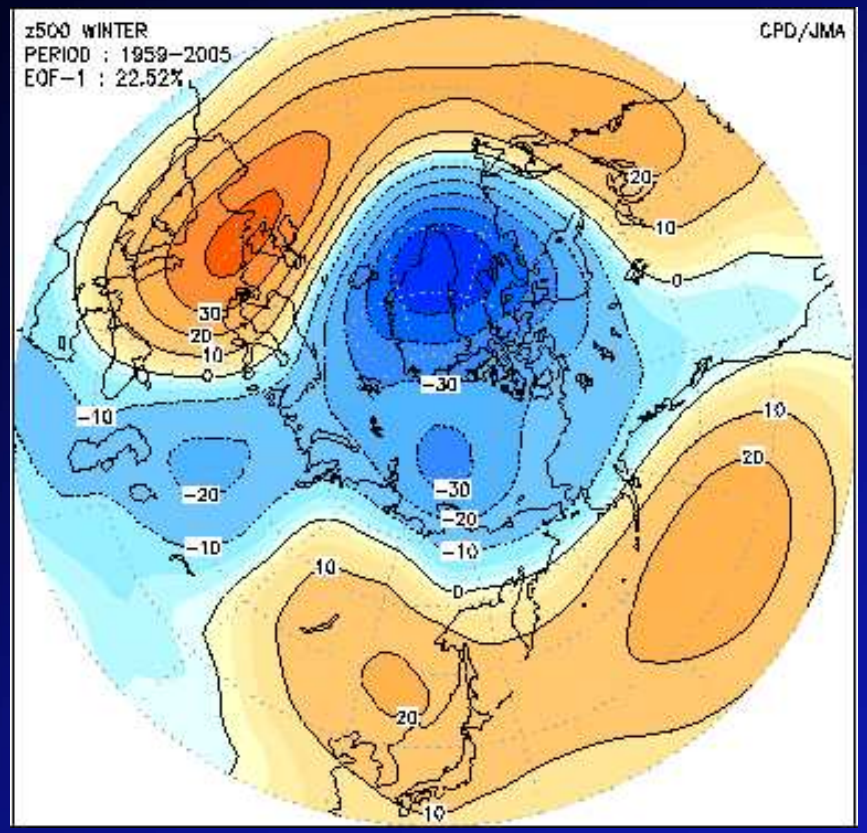
Madden Julian Oscillation (30-60days)



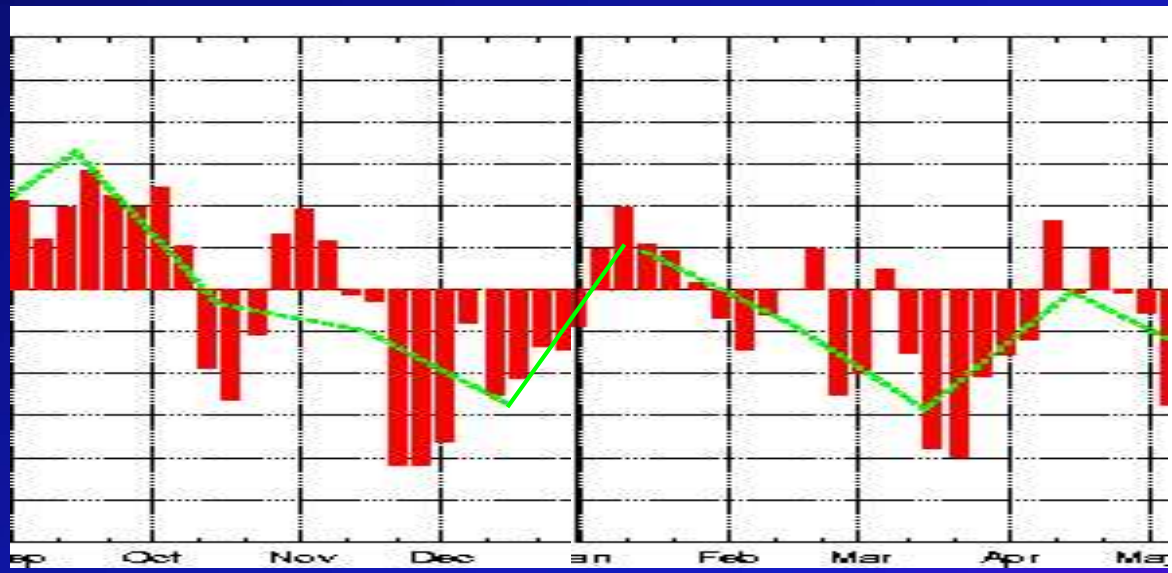
Climate variability
- Intra Seasonal Variation -
Monsoon Intra Seasonal Oscillation (15-20days)



Climate variability
- Intra Seasonal Variation -
Arctic Oscillation

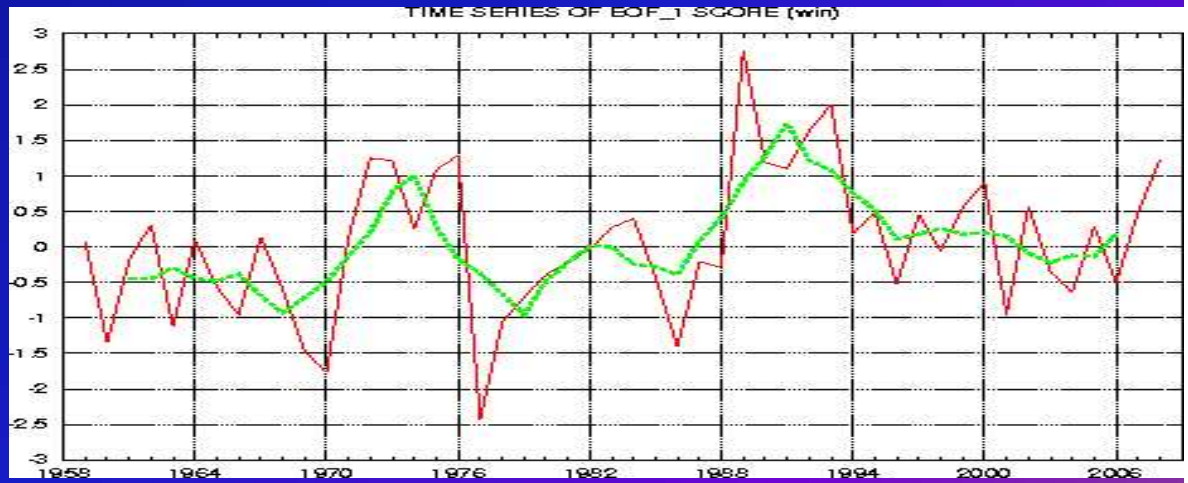


EOF1 for DJM mean 500hPa height



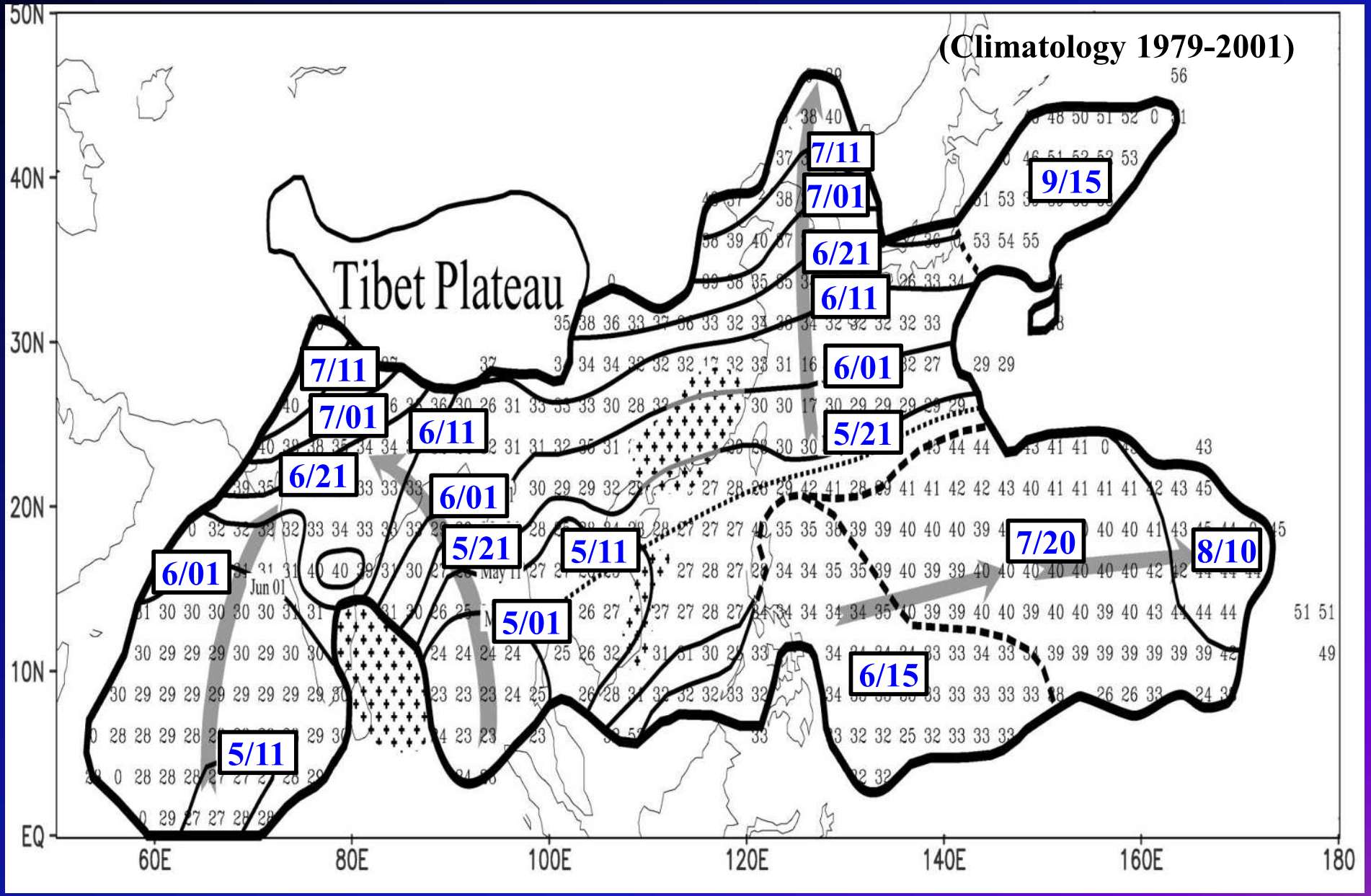
Sep Oct Nov Dec Jan Feb Mar Apr

Pentad score of EOF1 in 05/06 winter



The AO has a Decadal Variation, too.

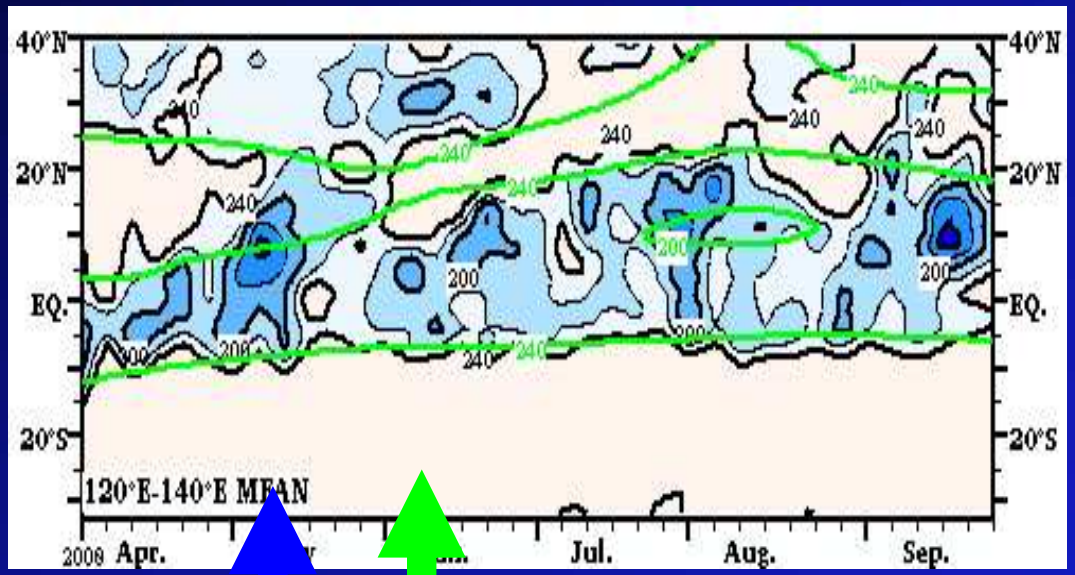
Seasonal March
Summer Monsoon Onset

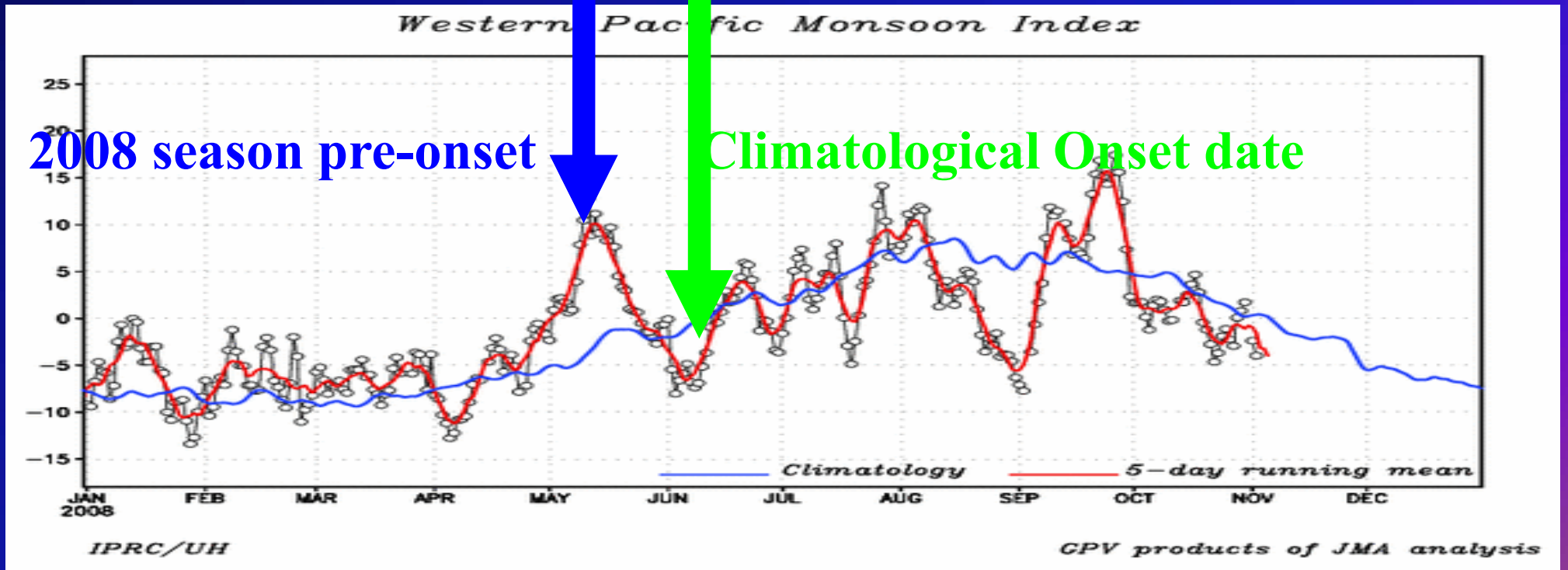


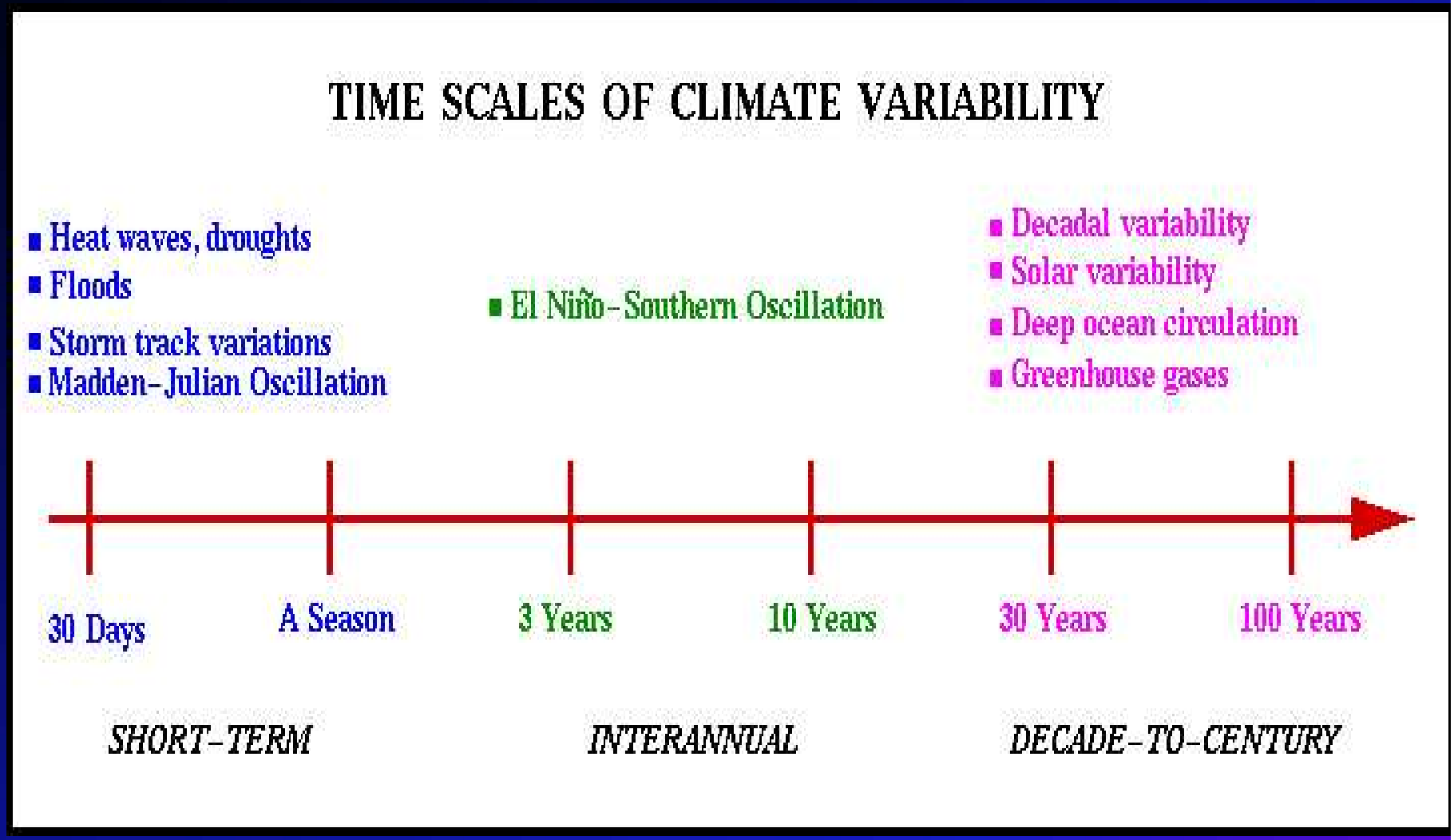
Wang and LinHo, 2002

Seasonal March

WNPM Onset







Severe Weather Forecast

Monthly Forecast

Seasonal Prediction

Annual Prediction

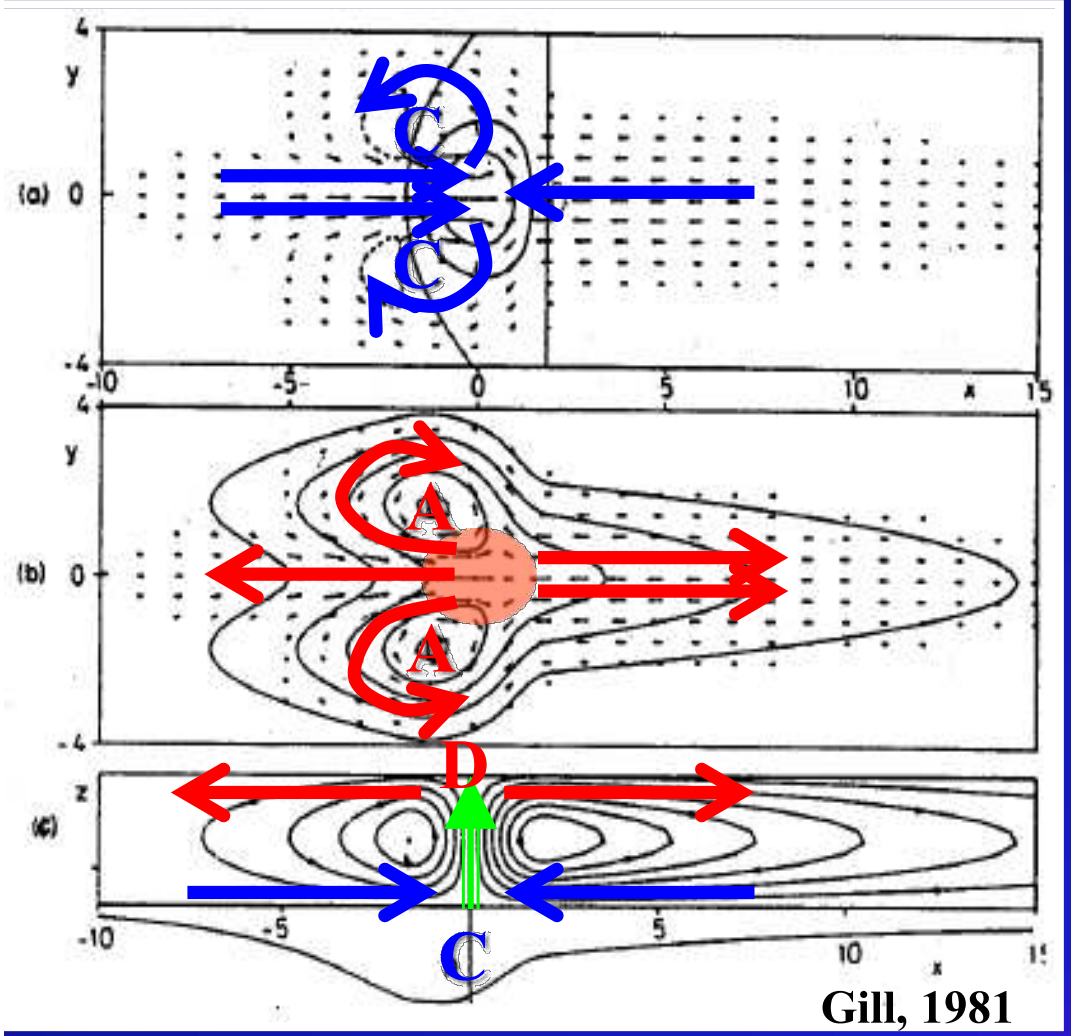
Near future Prediction

Global warming Prediction

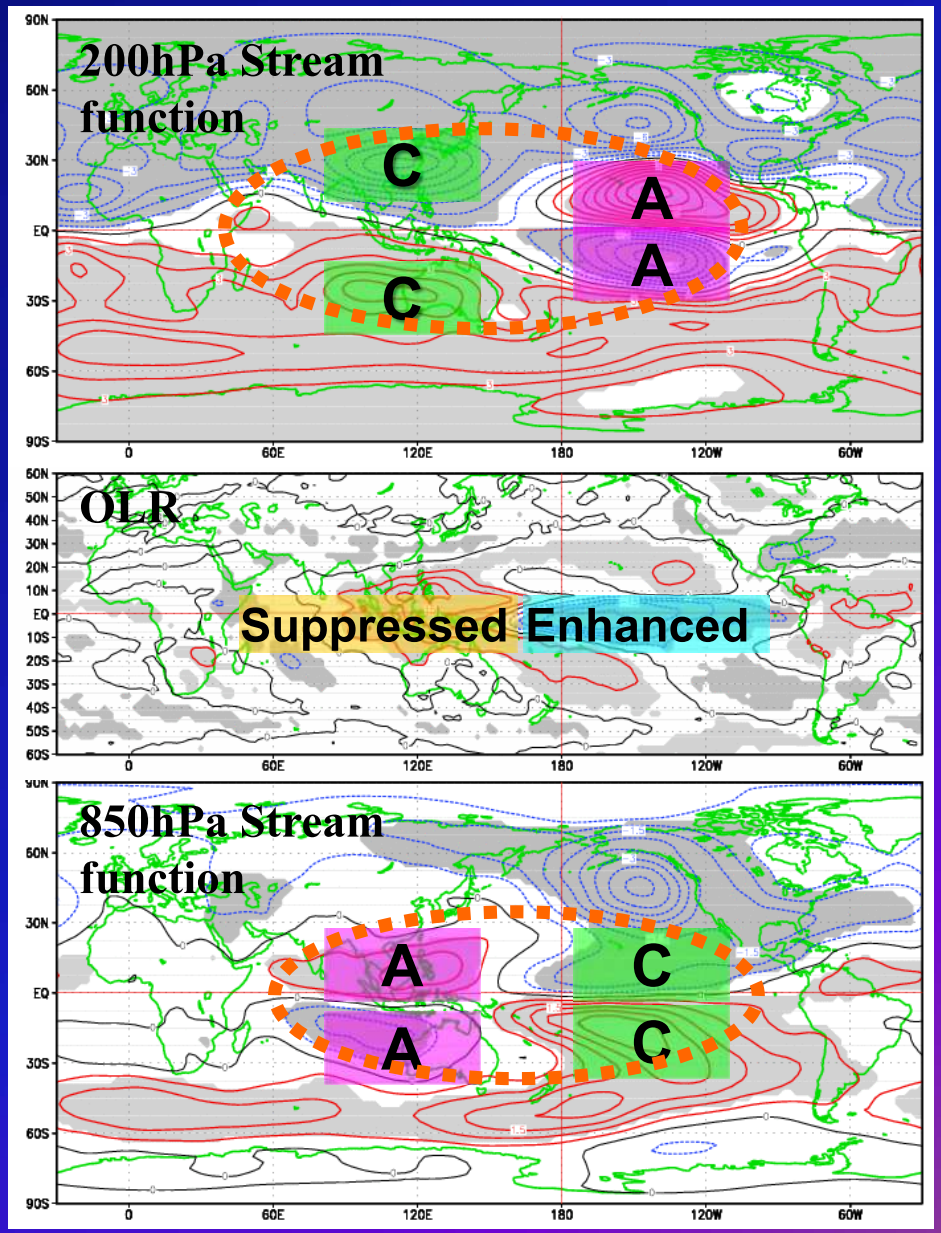
Tele-connection

Direct response to the displacement of convection in the tropics

Matsuno-Gill pattern

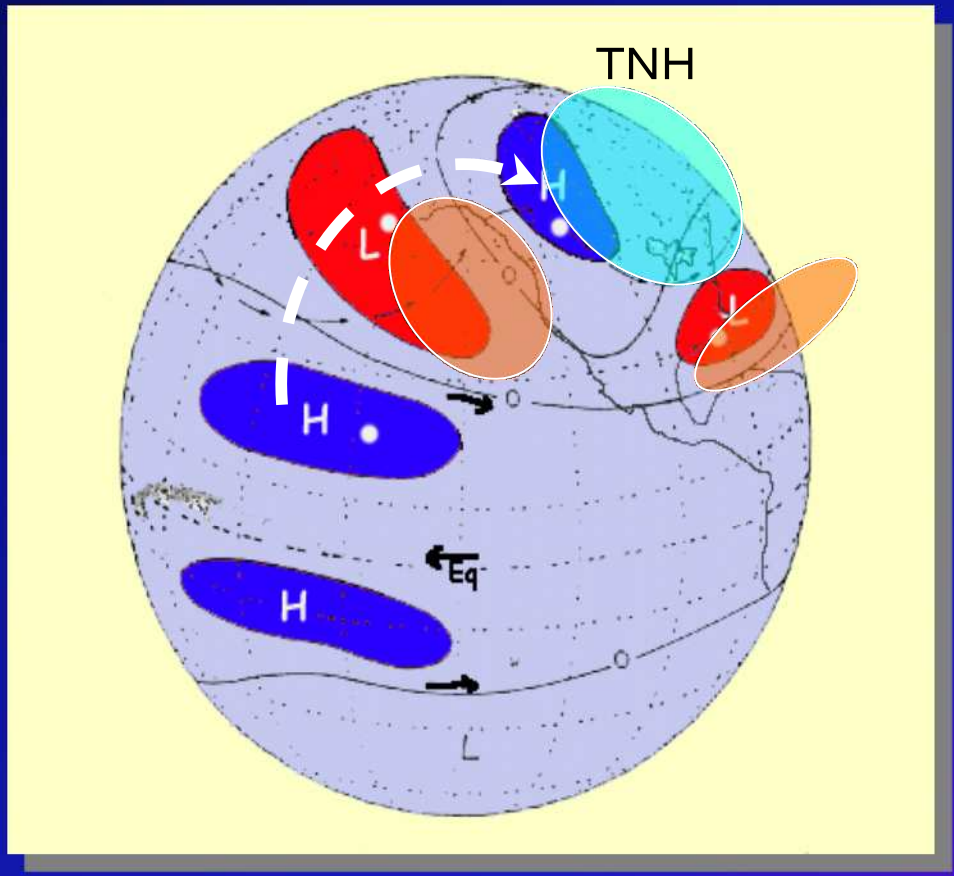


Direct response to El Niño (Regression map to NINO.3)



Tele-connection
by a stationary Rossby wave propagation

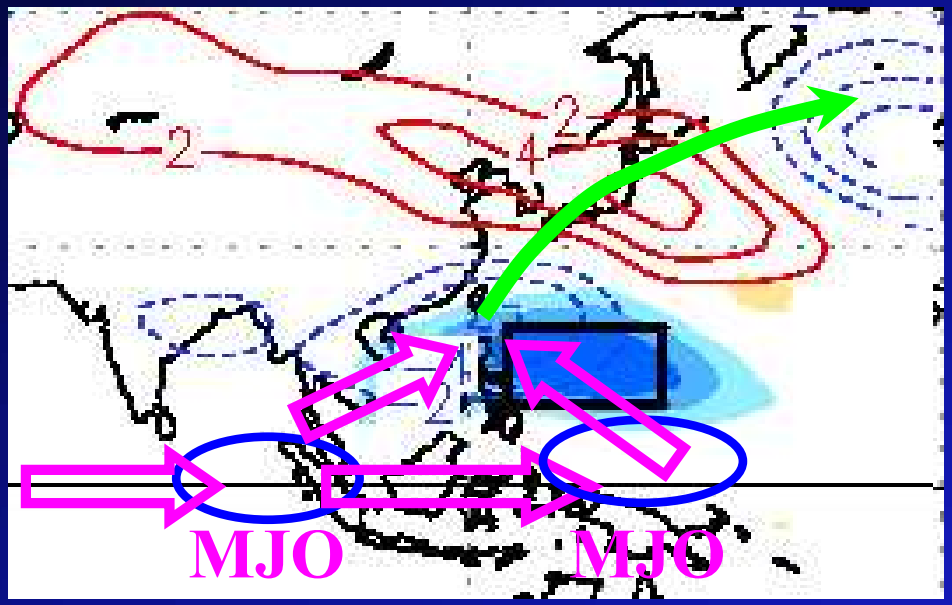
The PNA or TNH pattern excited by ENSO



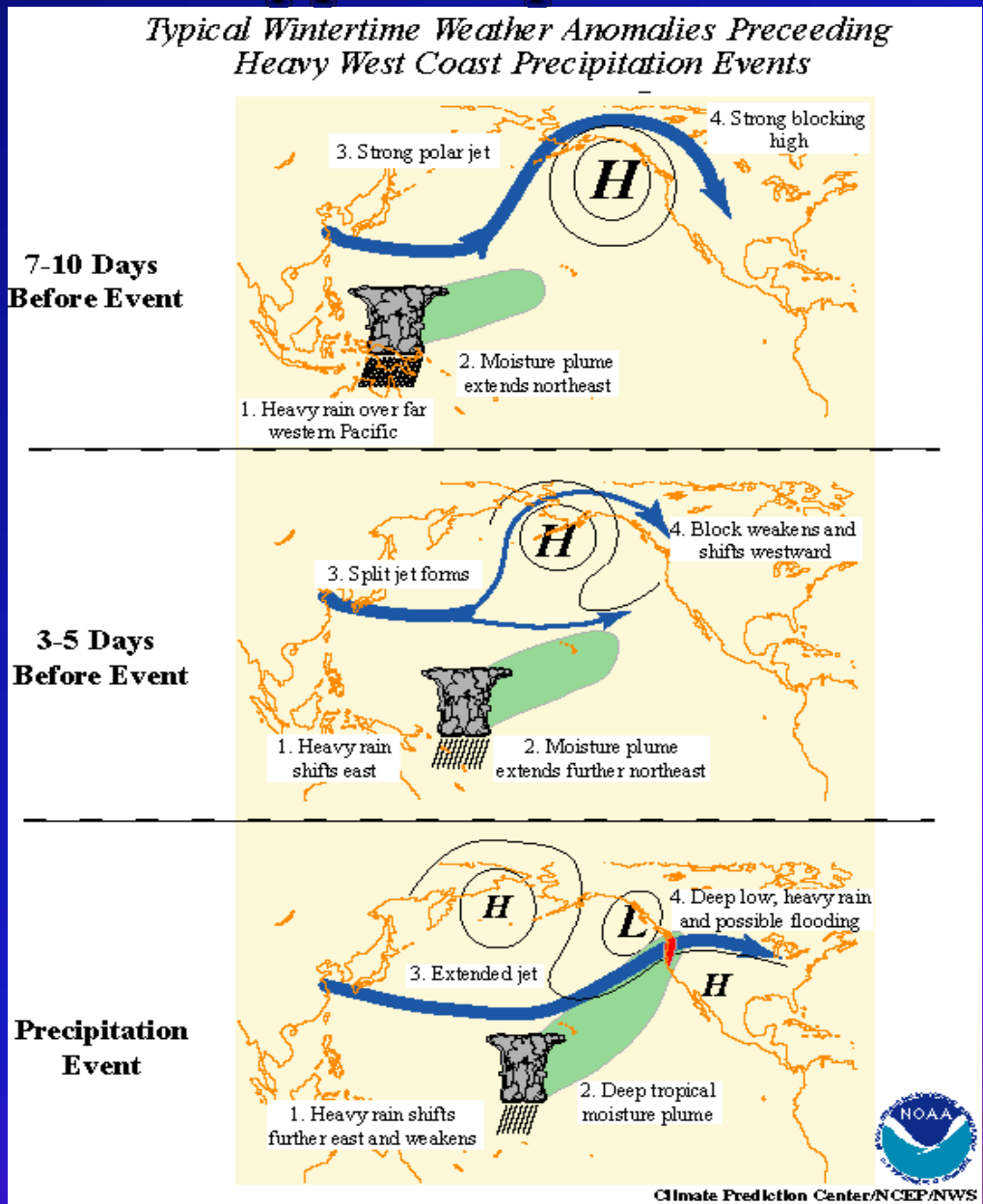
The PNA pattern is excited not only by ENSO, but also a Rossby wave propagating in the mid-latitude. In the case of the mature phase of strong El Niño, the TNH pattern which is the distorted PNA pattern is often observed.

Tele-connection
by a combination of MJO and Rossby wave

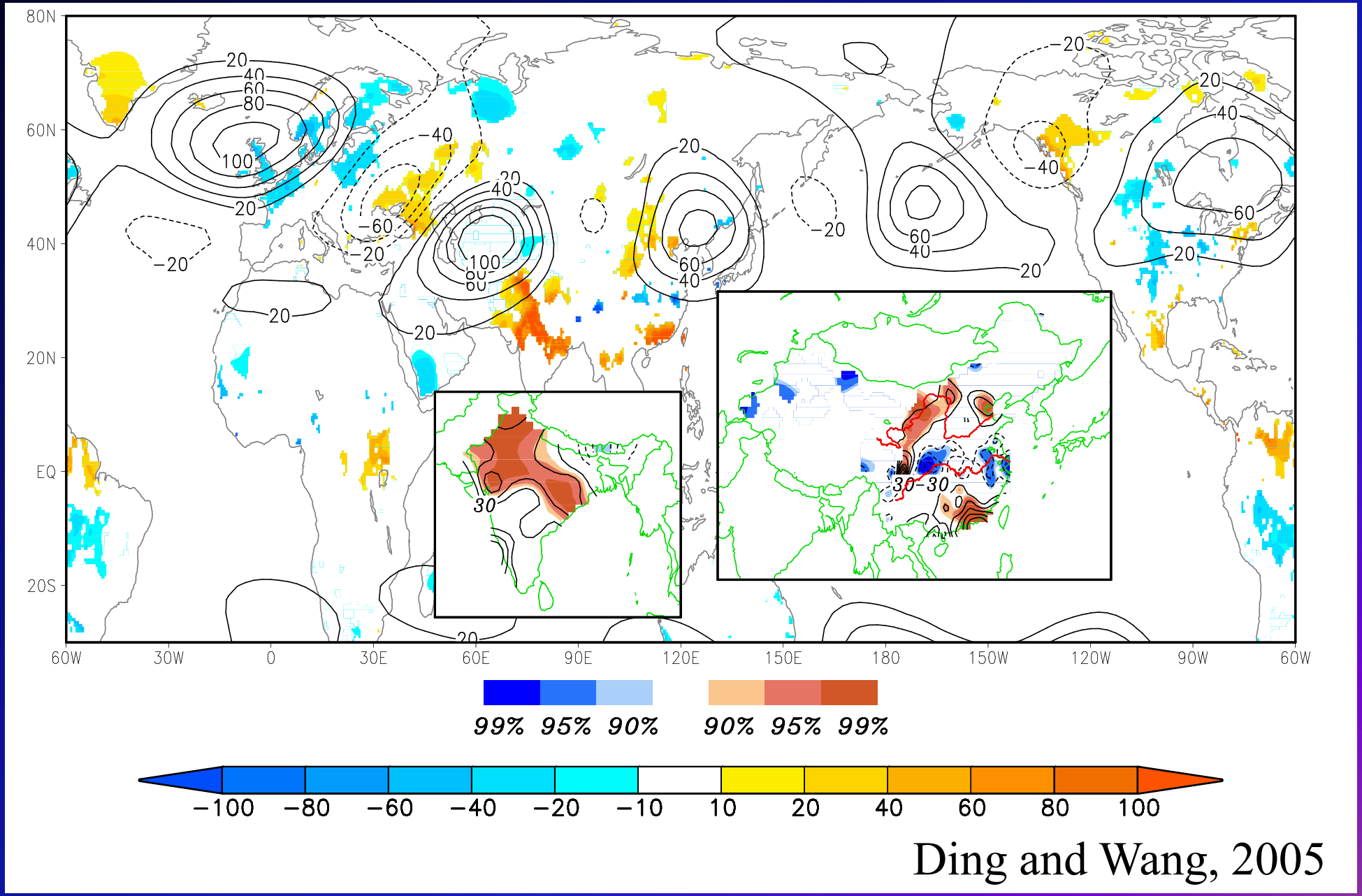
Eastward migration and northward propagation of MJO and the PJ pattern



Pineapple Express Event



Tropical-Extratropical linkage
Summer Circumglobal Tele-connection (CGT)



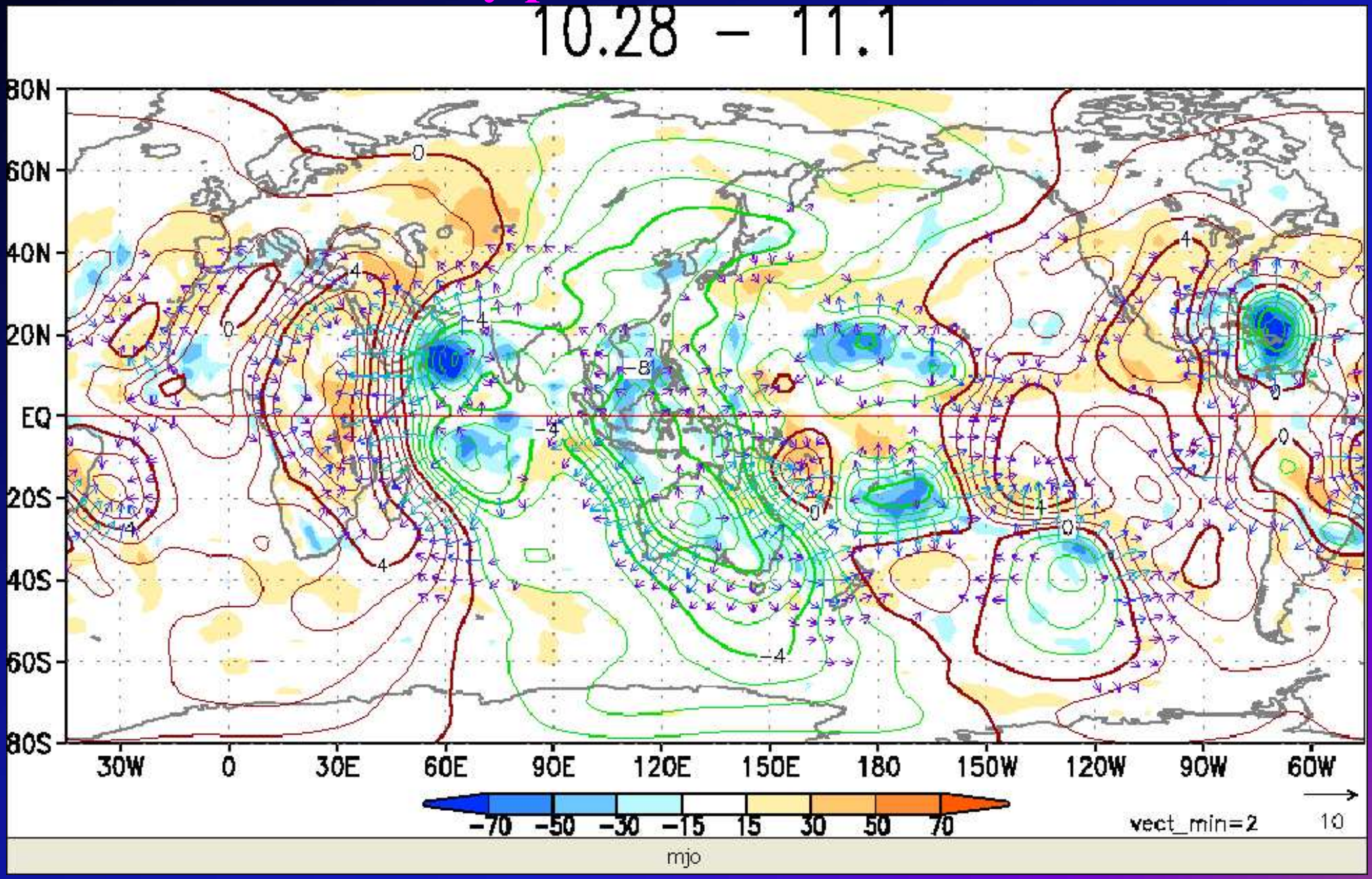
Ding and Wang, 2005

Madden Julian Oscillation

(Equatorial Intra Seasonal Variation)

Example for MJO

200hPa velocity potential and OLR anomalies



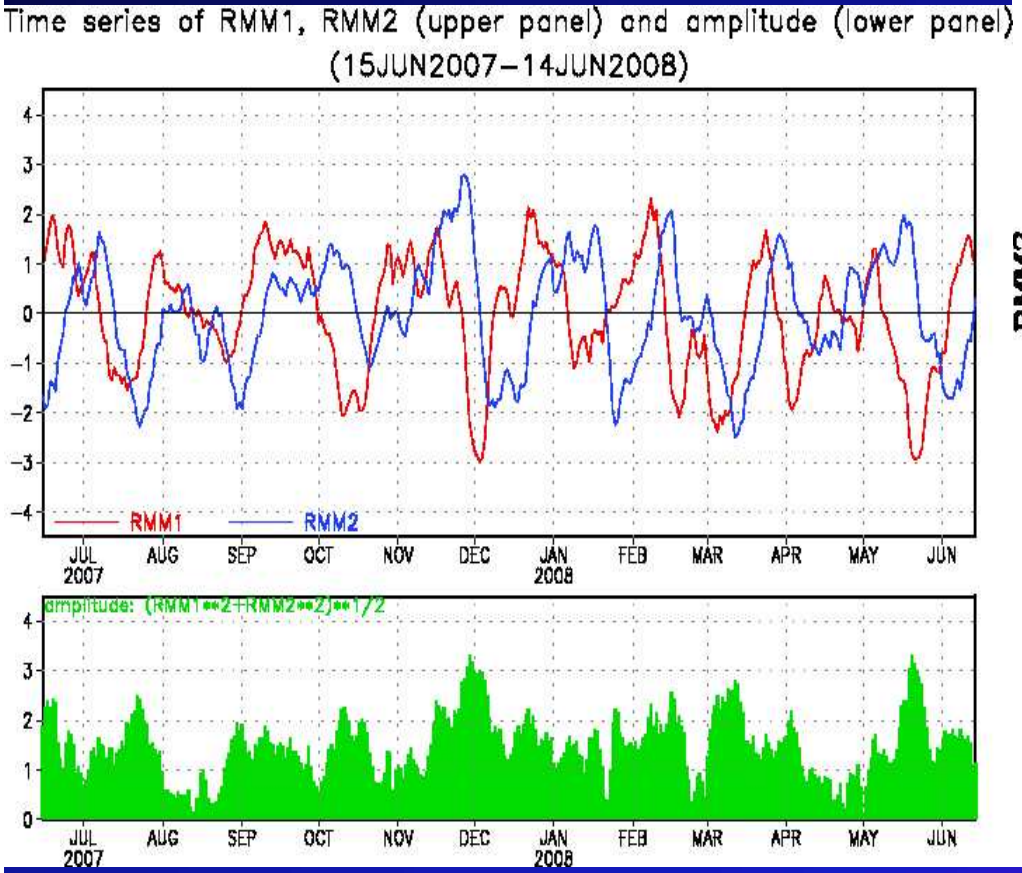
MJO detection

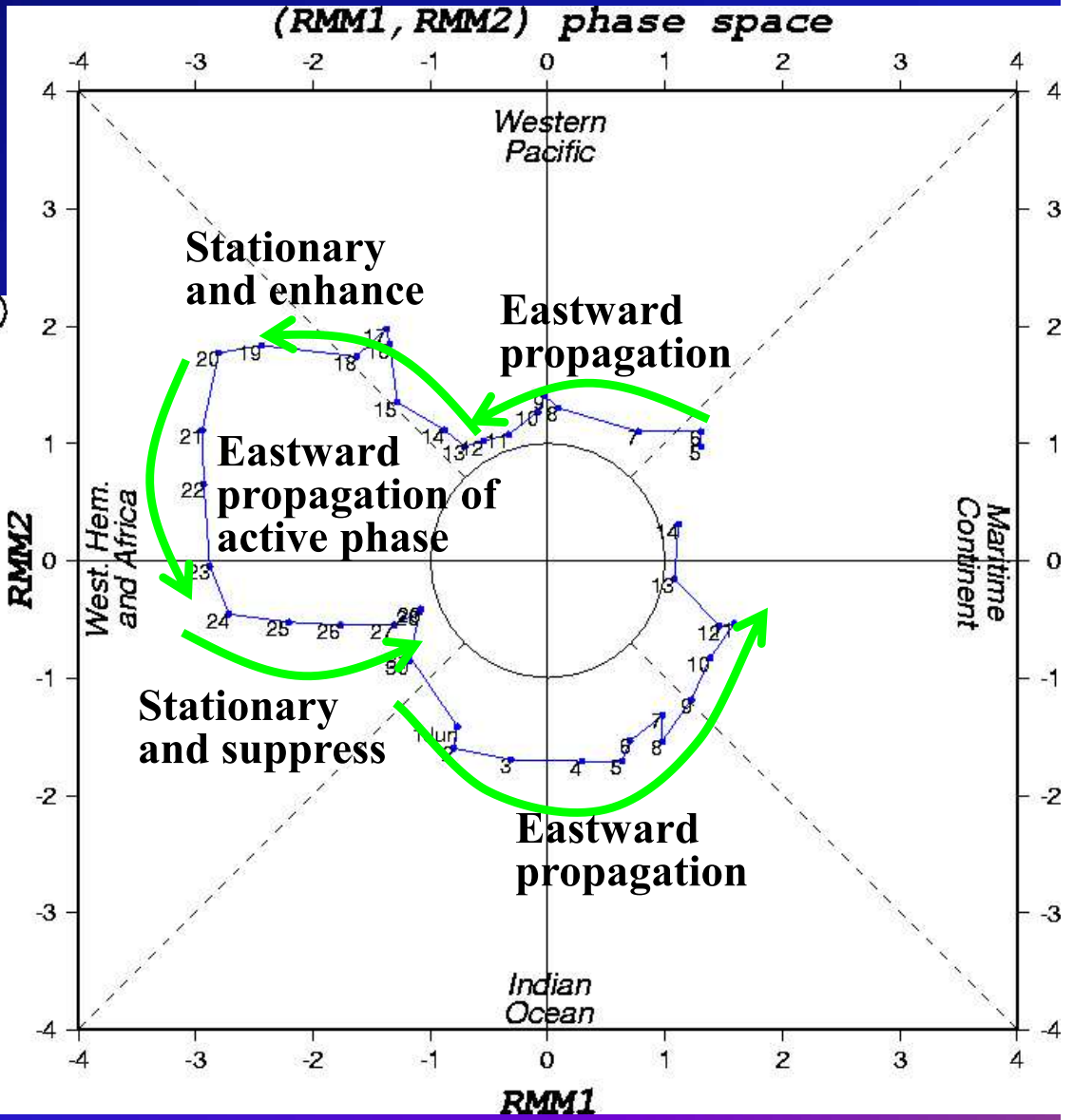
MJO index

Phase space chart (right)

Time series of RMM1, RMM2 and amplitude (left)

（Original Wheeler and Hendon 2004 ）





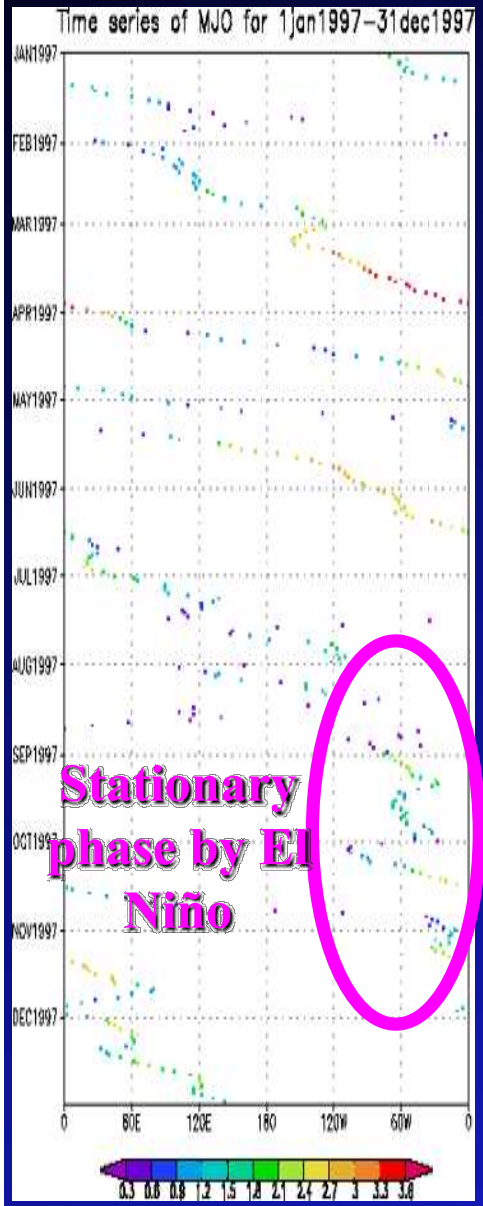
Migration and stationary of MJO

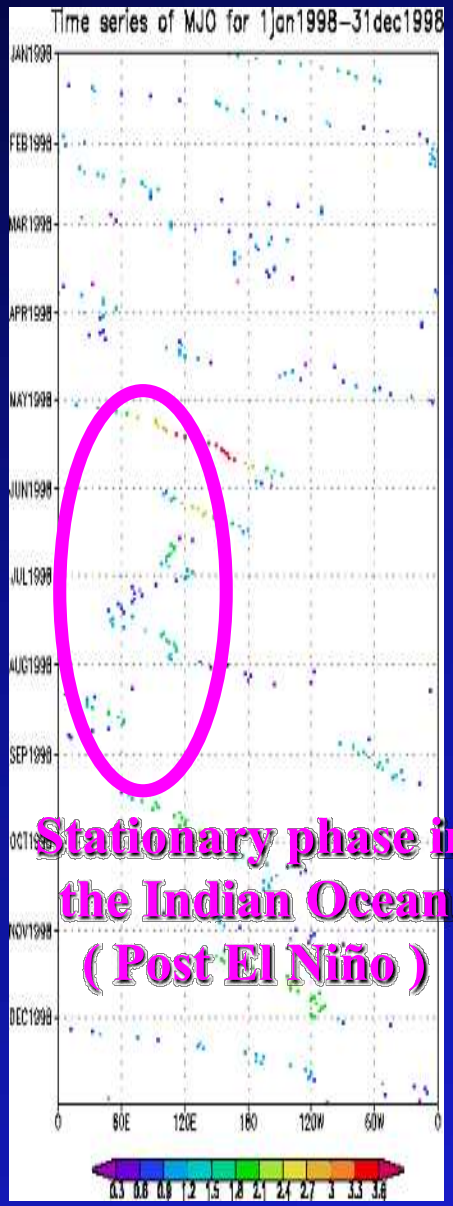
1997

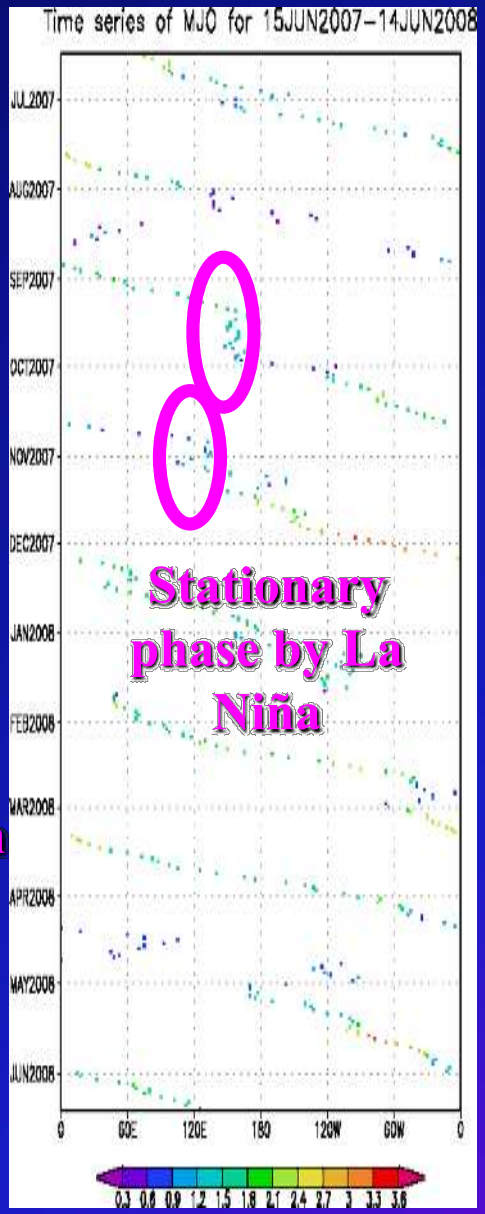
1998

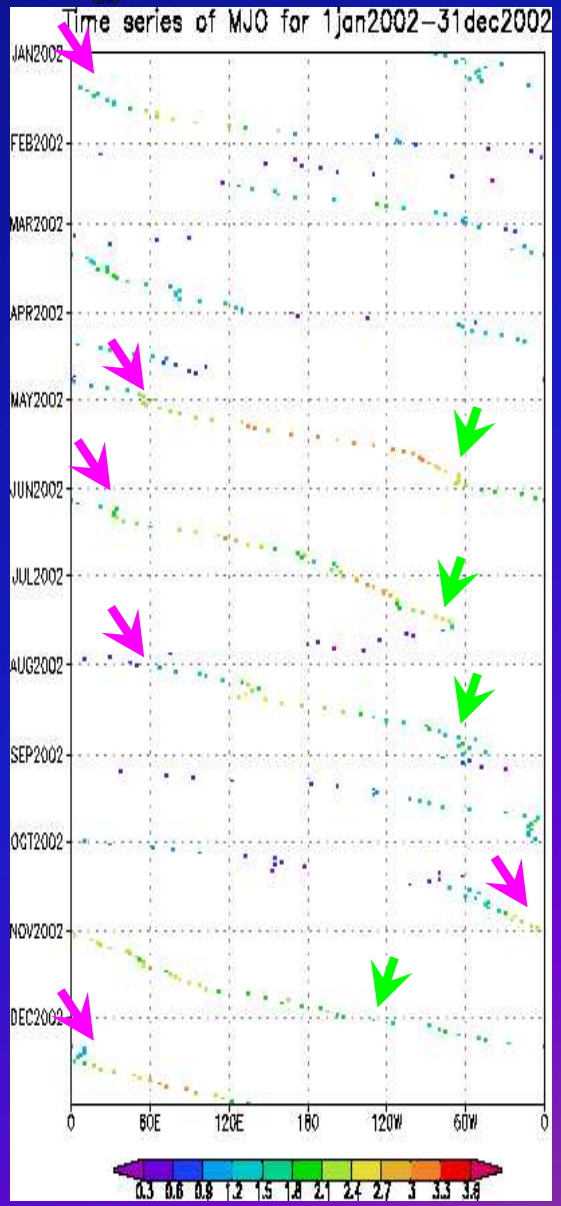
2007/2008

Onset in the Indian Ocean
Calming in the eastern Pacific



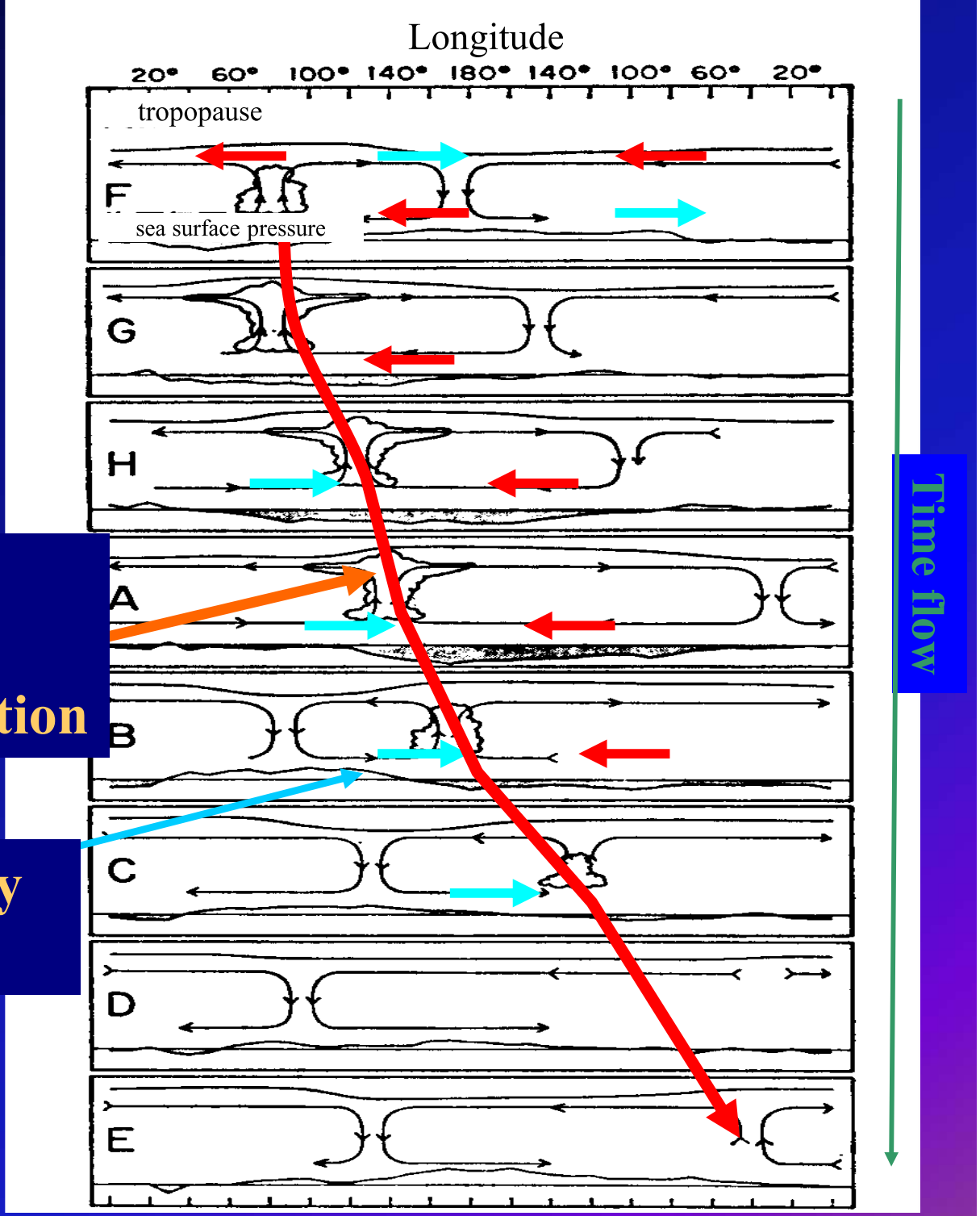






2002

Schematic diagram for a migration of MJO



Eastward migration of active convection

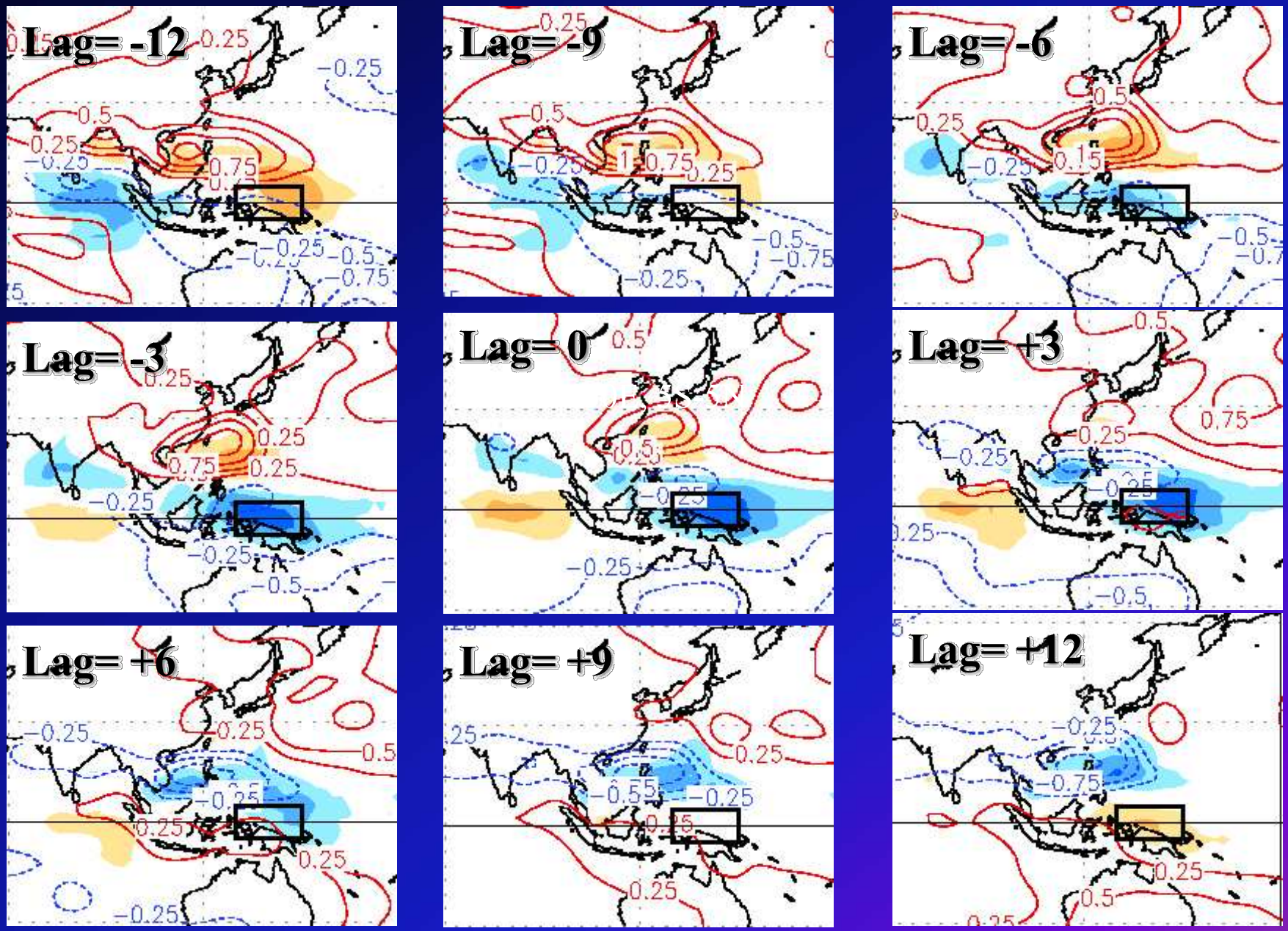
Westerly Burst

Madden and Julian, 1972

Africa Indonesia South America

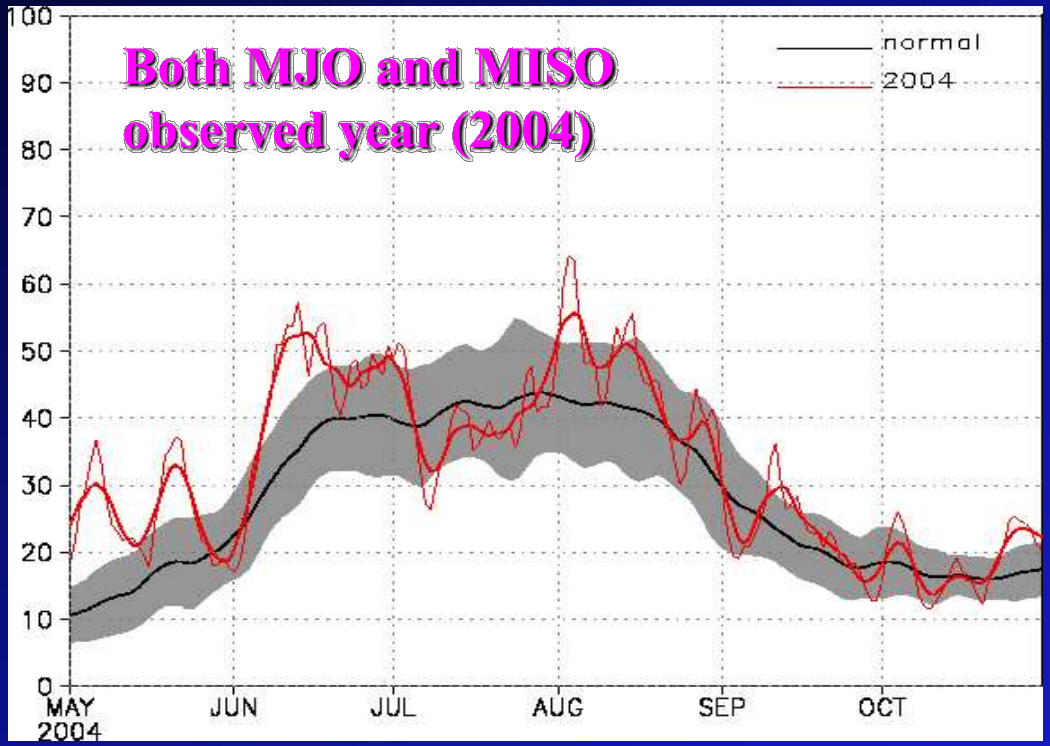
Northward propagation of MJO

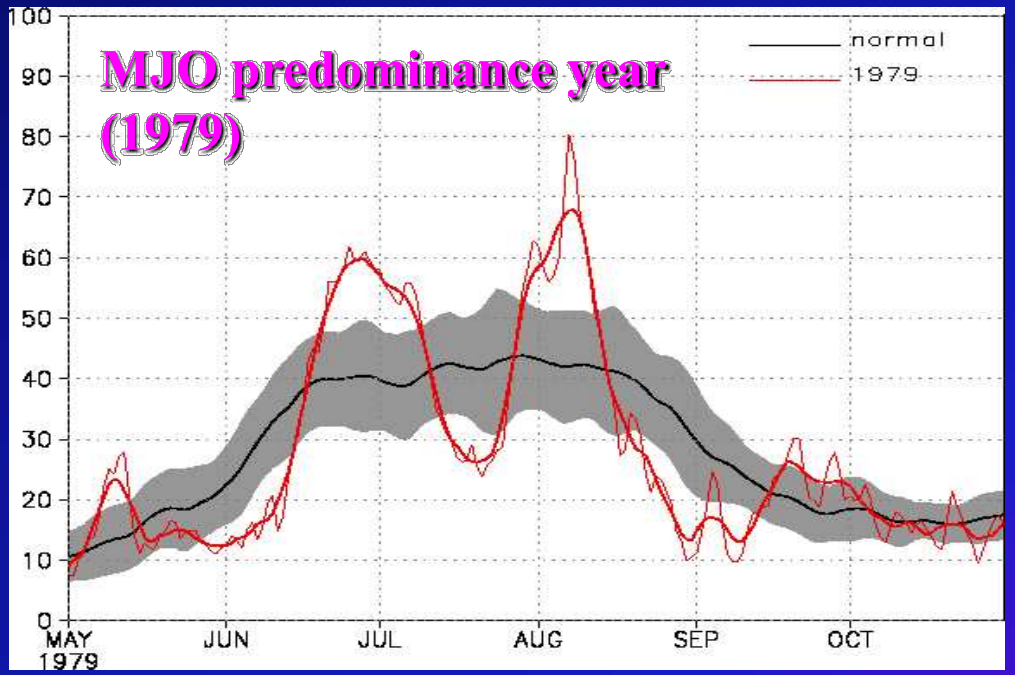
Lag regression to the area mean OLR (130-150E, 5S-5N)

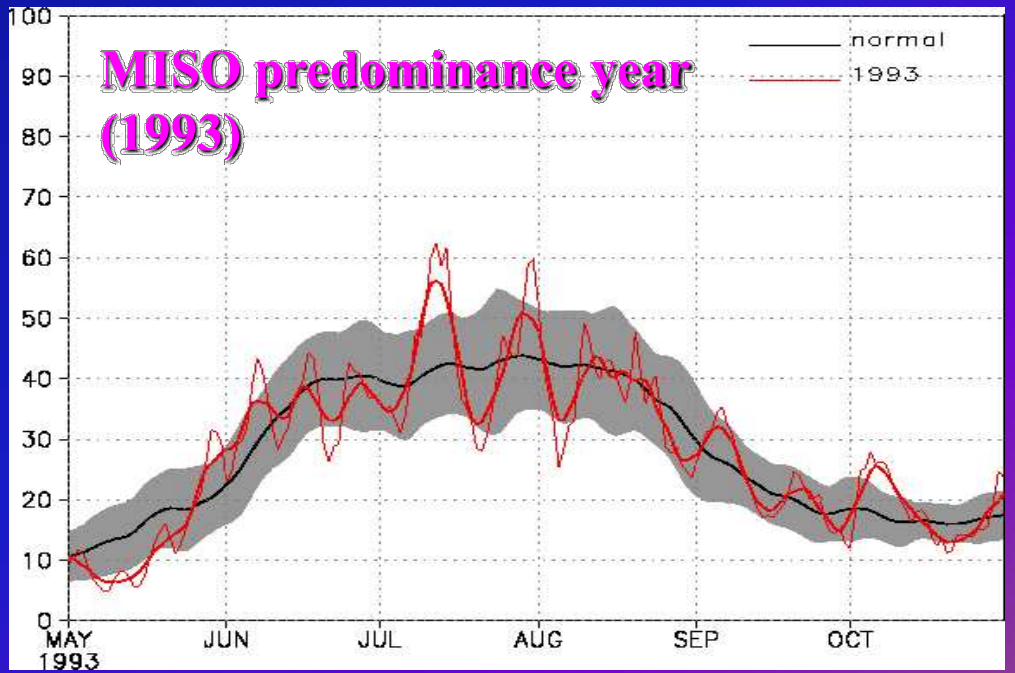


Endo and Harada, 2007

MJO and MISO in the Indian Monsoon







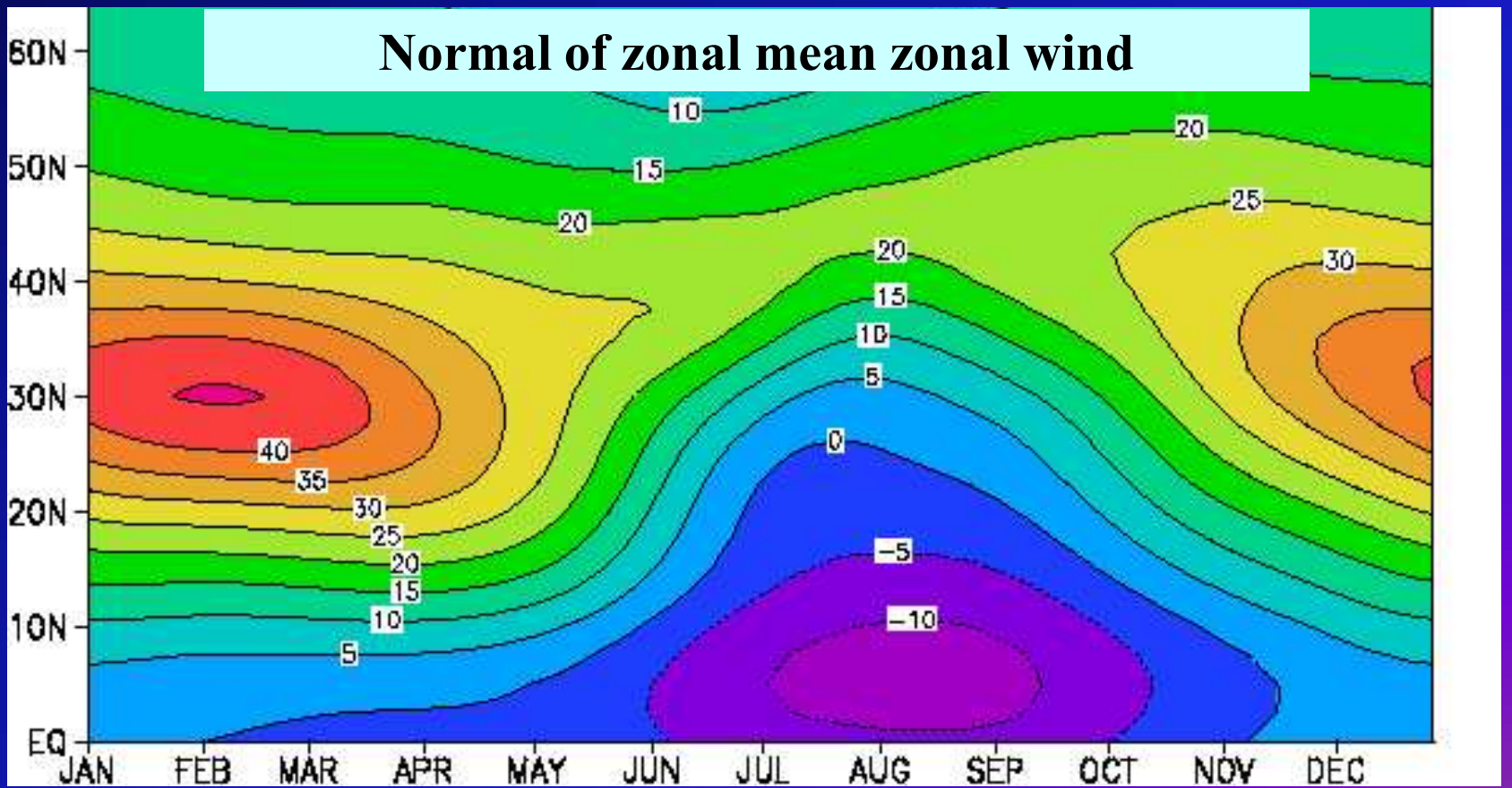
(Quasi) Stationary Rossby wave

Stationary Rossby wave

- In the case of 30N, the relations between stationary Rosby wave number (k) and zonal wind are,

  k=3 ⇒ U=67m/s　k=4 ⇒ U=38m/s

  k=5 ⇒ U=24m/s　k=6 ⇒ U=17m/s

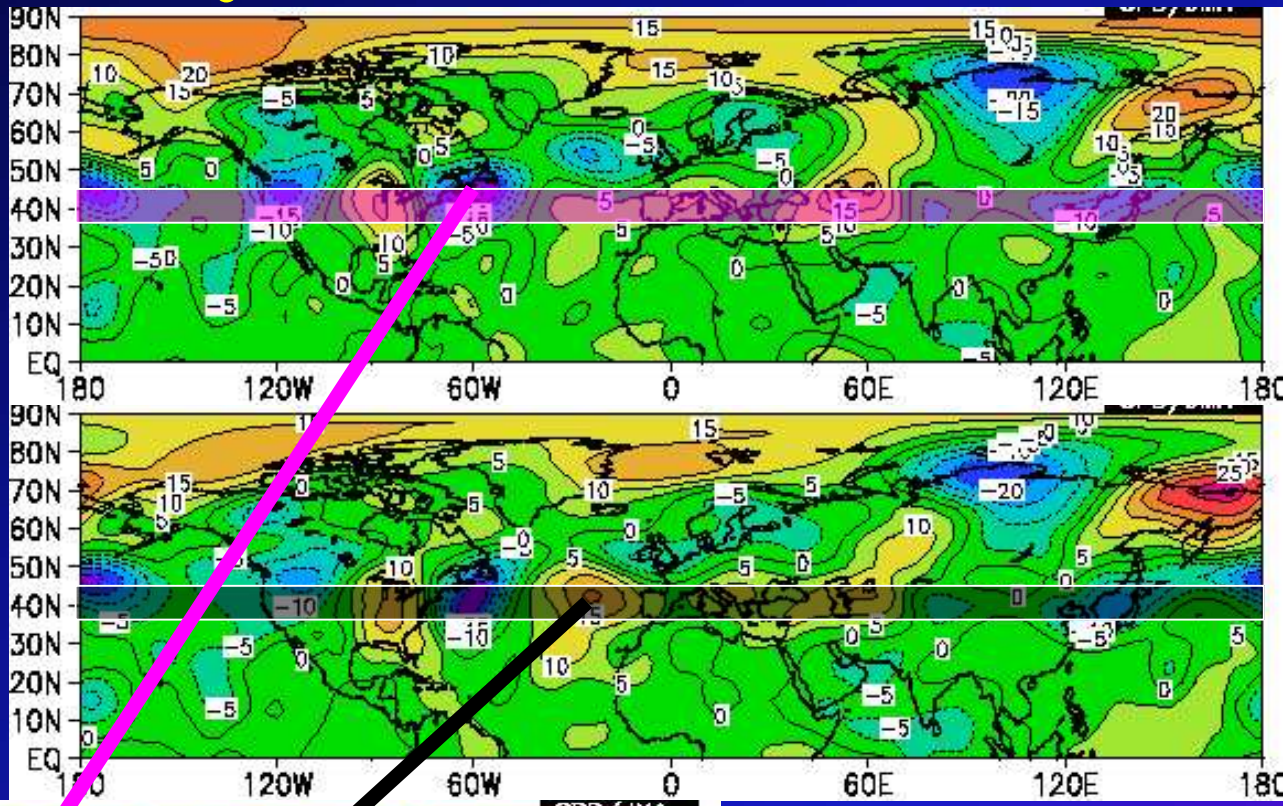


Stationary Rossby wave detection

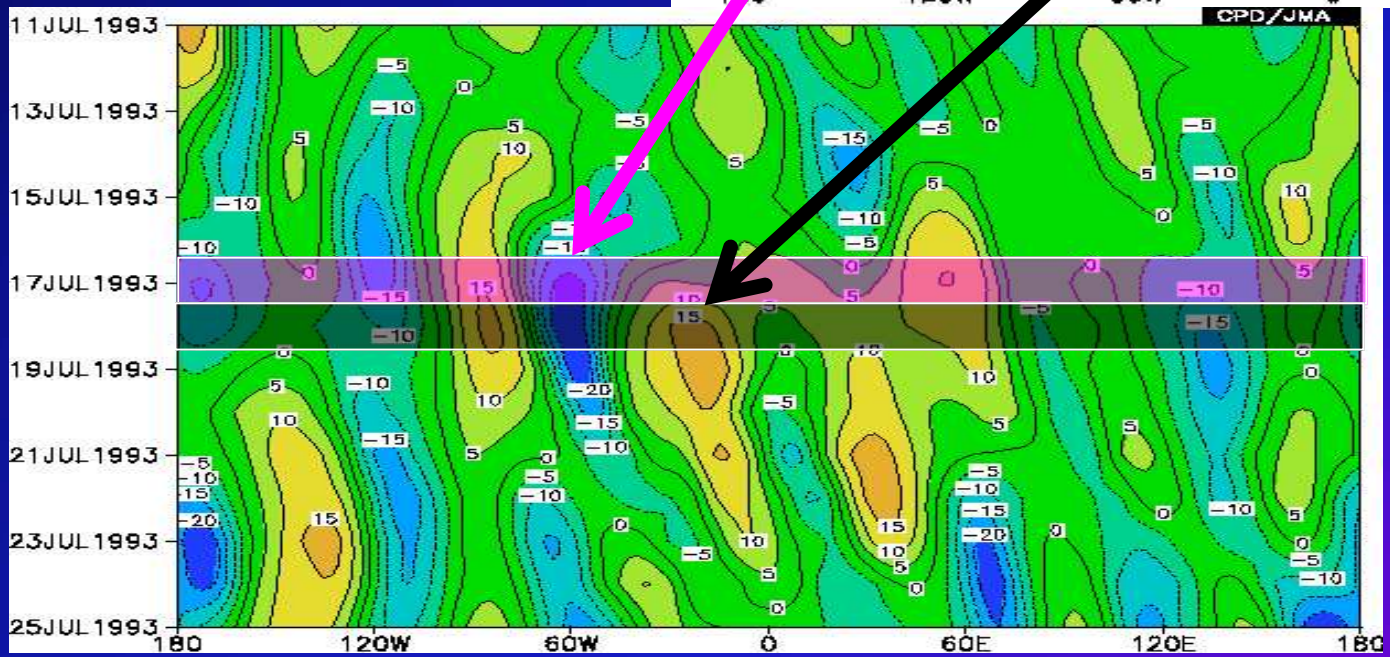
17th Jul. 1993

300hPa stream function anomalies

18th Jul. 1993



time



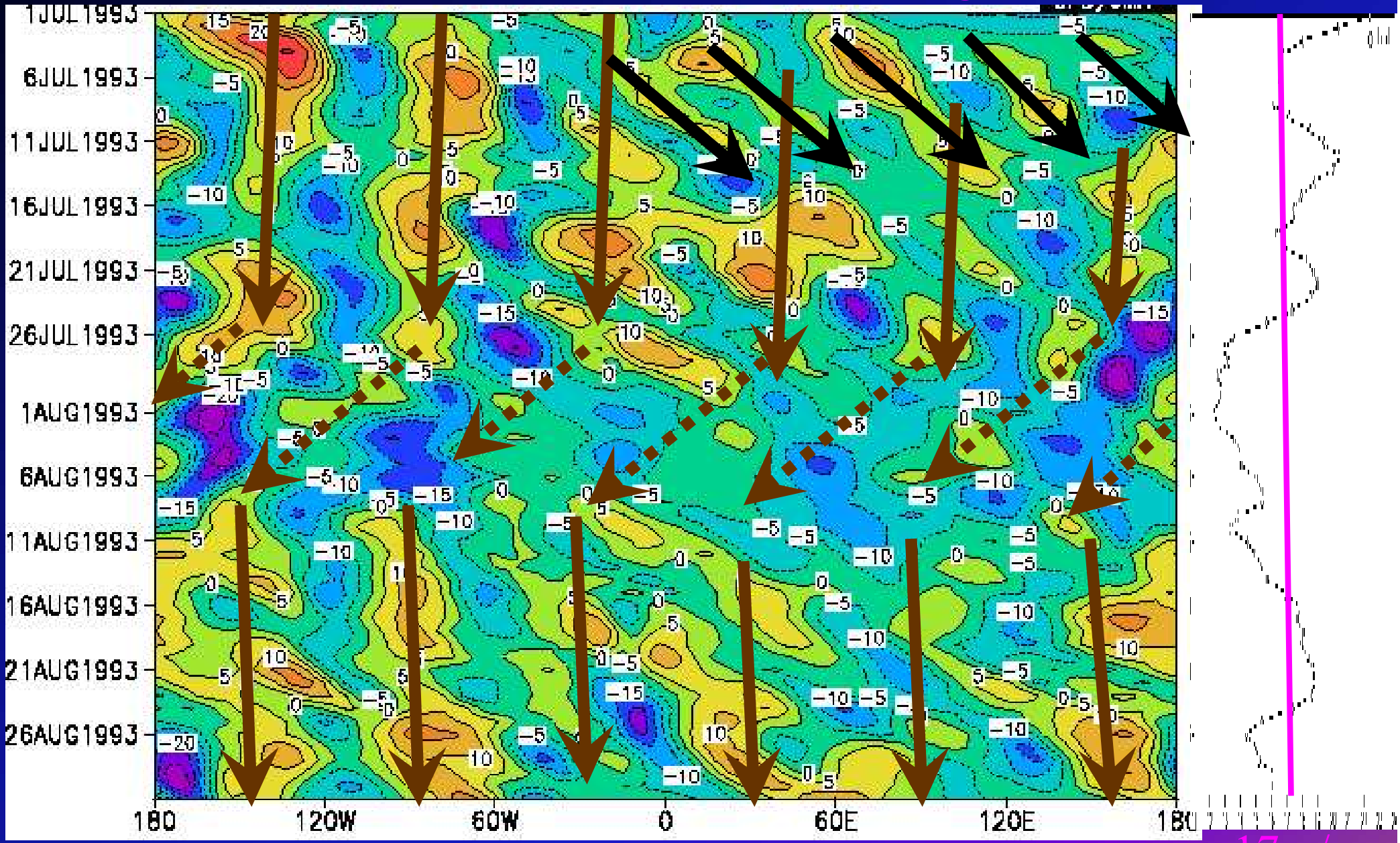
Time-Longitude cross section along 35N～45N

Example for stationary Rossby wave

Wave number = 6 (stationary)

Wave number = 8～9 (8˚/day)

TL cross section of 300hPa stream function anomalies along 35-45N. Zonal mean U



Example for propagation of stationary Rossby wave

Wave number = 6 (stationary) → Wave (number=6) packet (25°/day)

TL cross section of 300hPa stream function anomalies along 35-45N. Zonal mean U

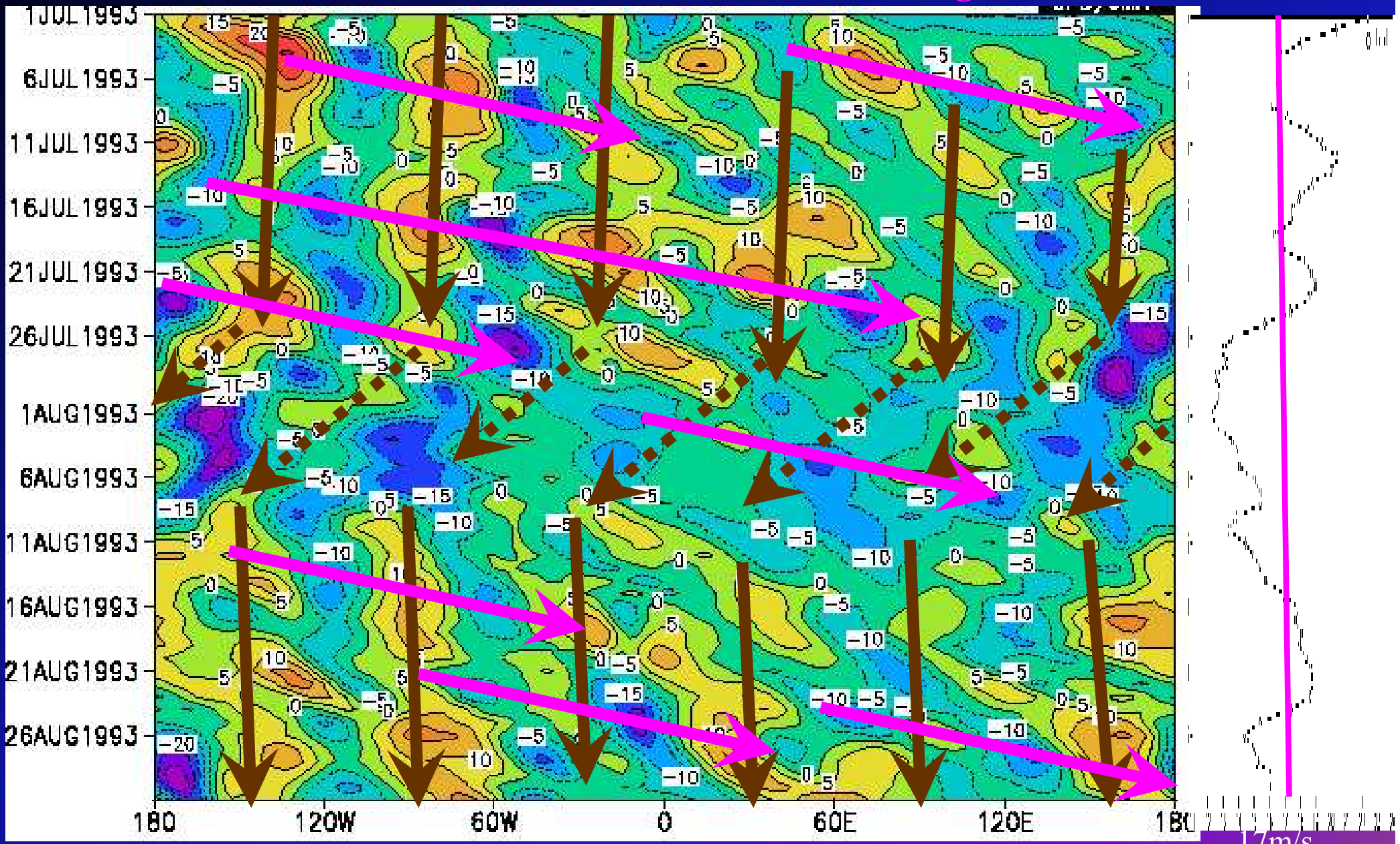
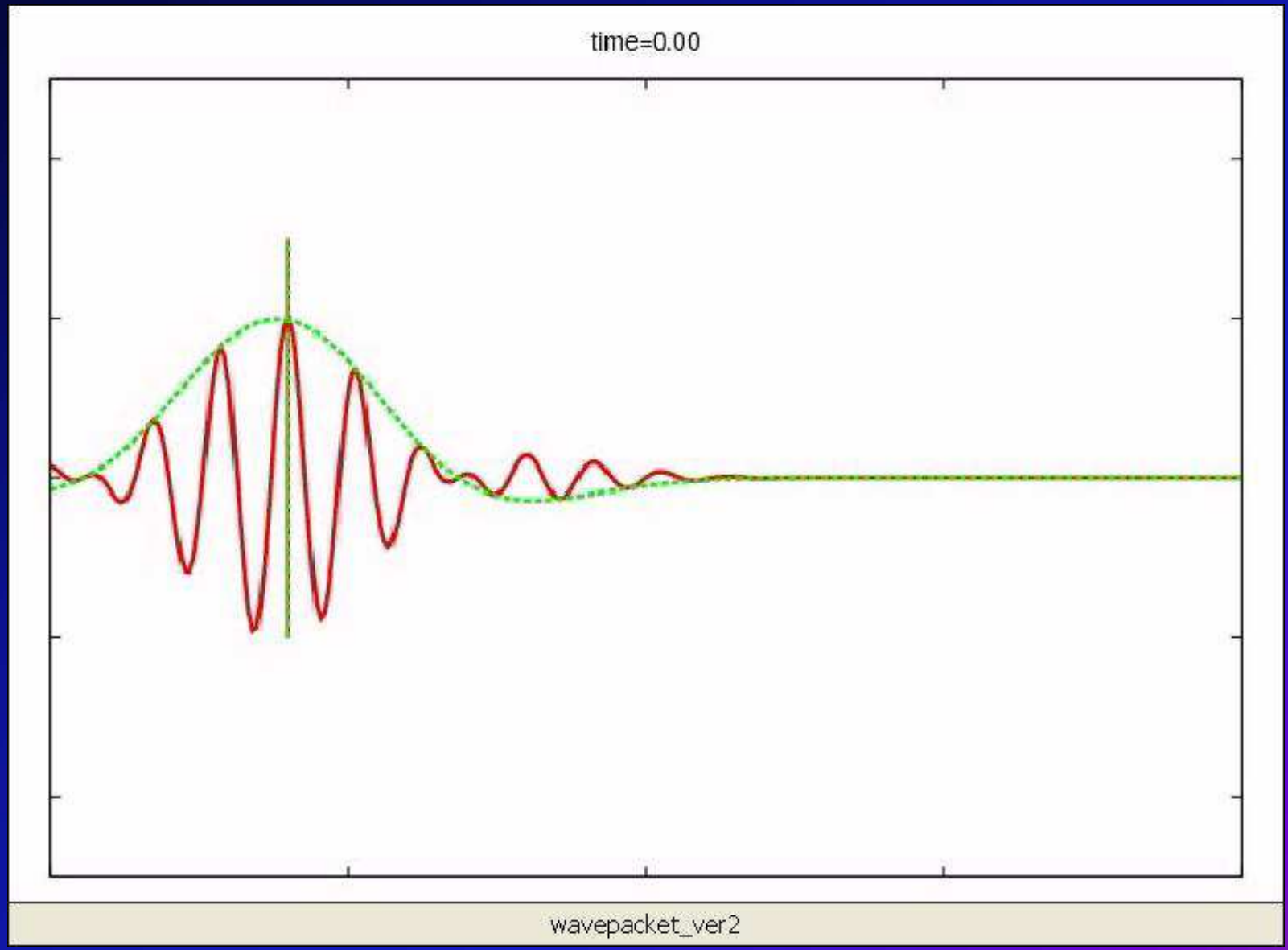


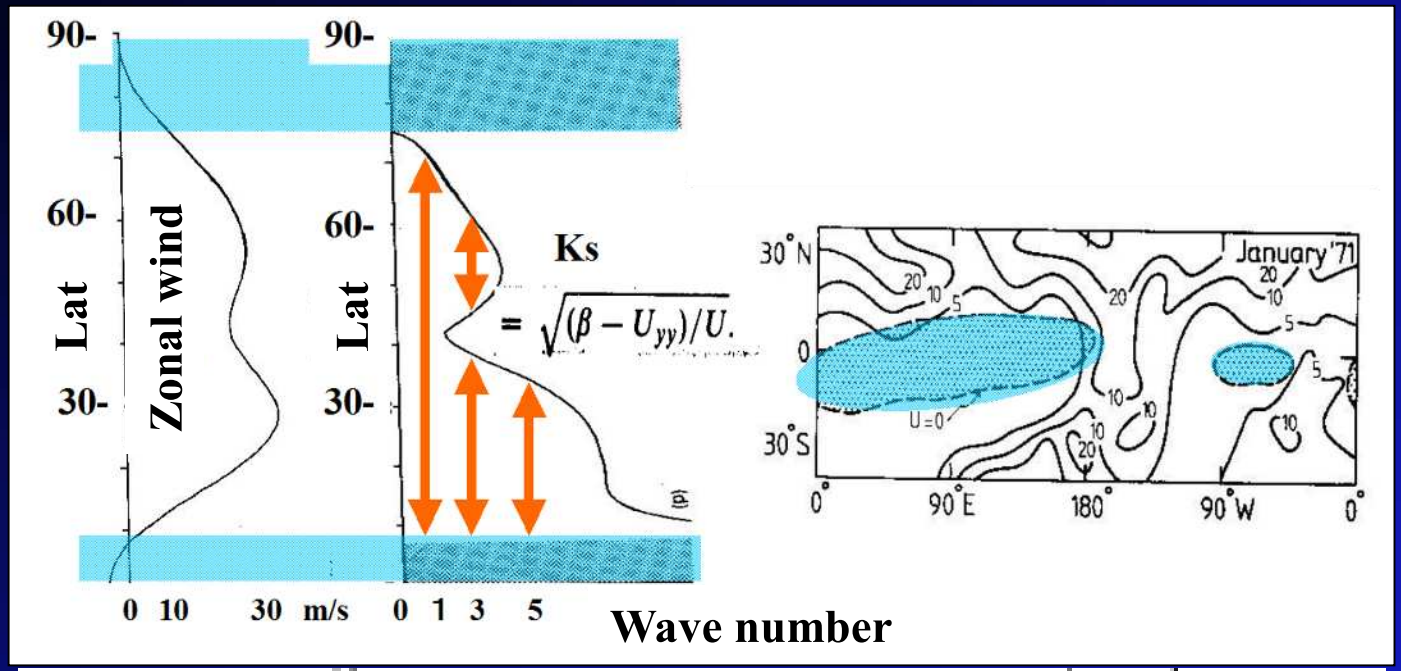
Image of Rossby wave and wave packet

Red line : Rossby wave

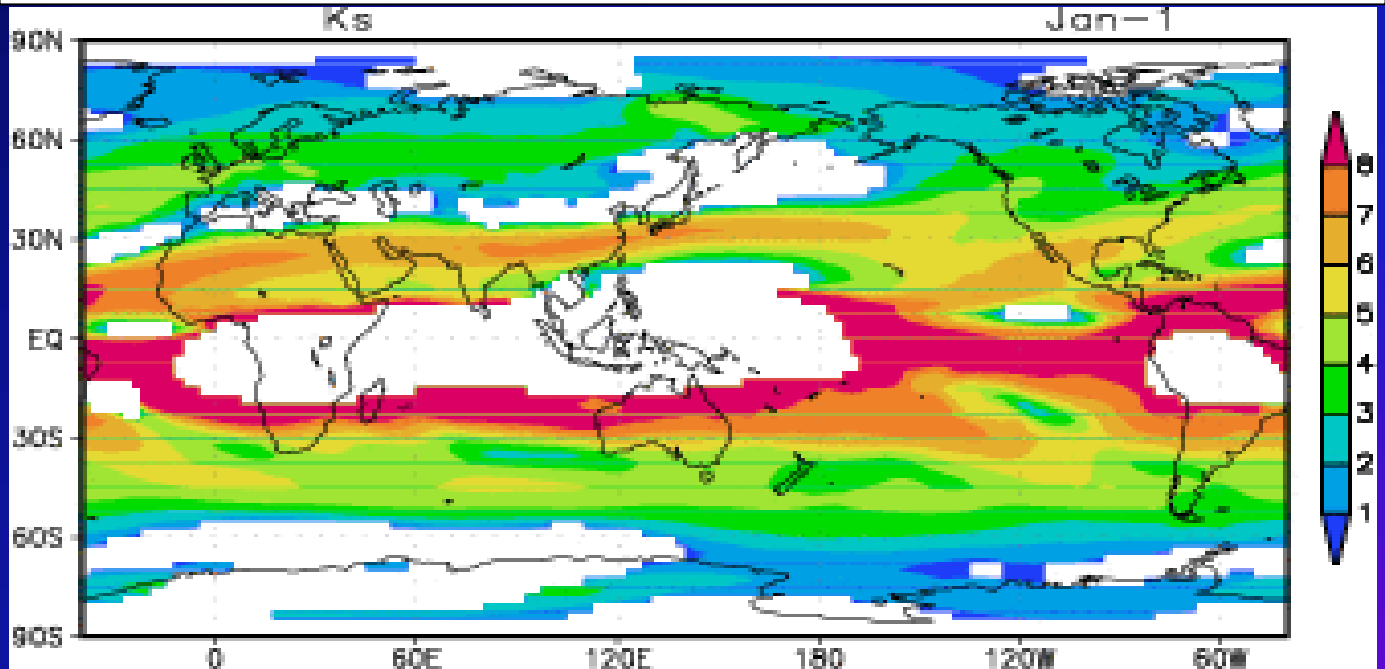
Green line : Rossby wave packet



Propagation route of stationary Rossby wave packet



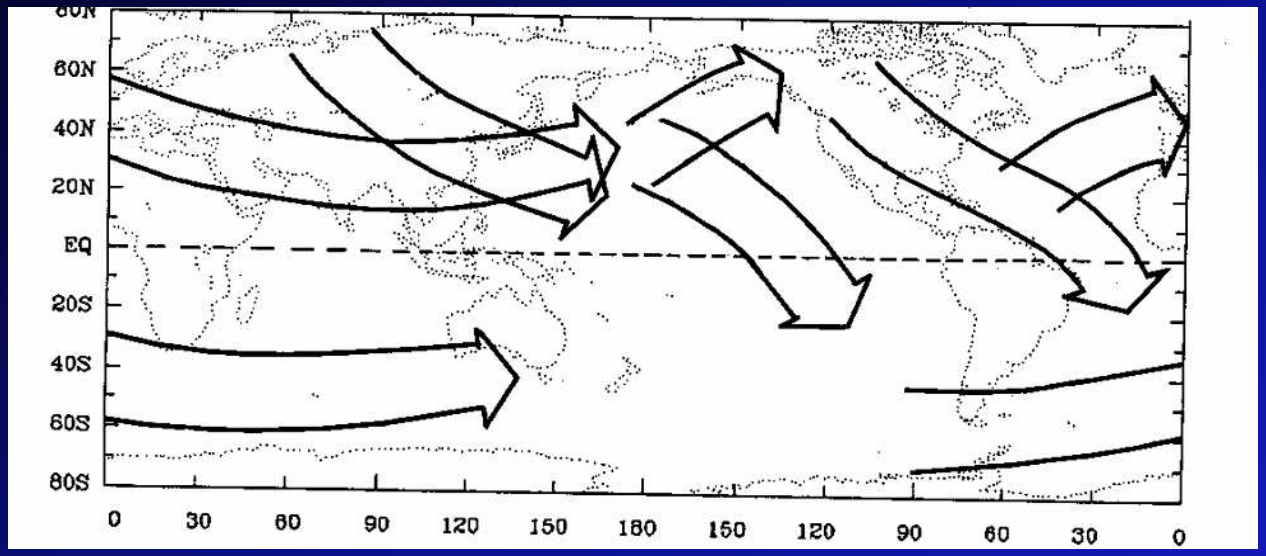
Concept for wave guide



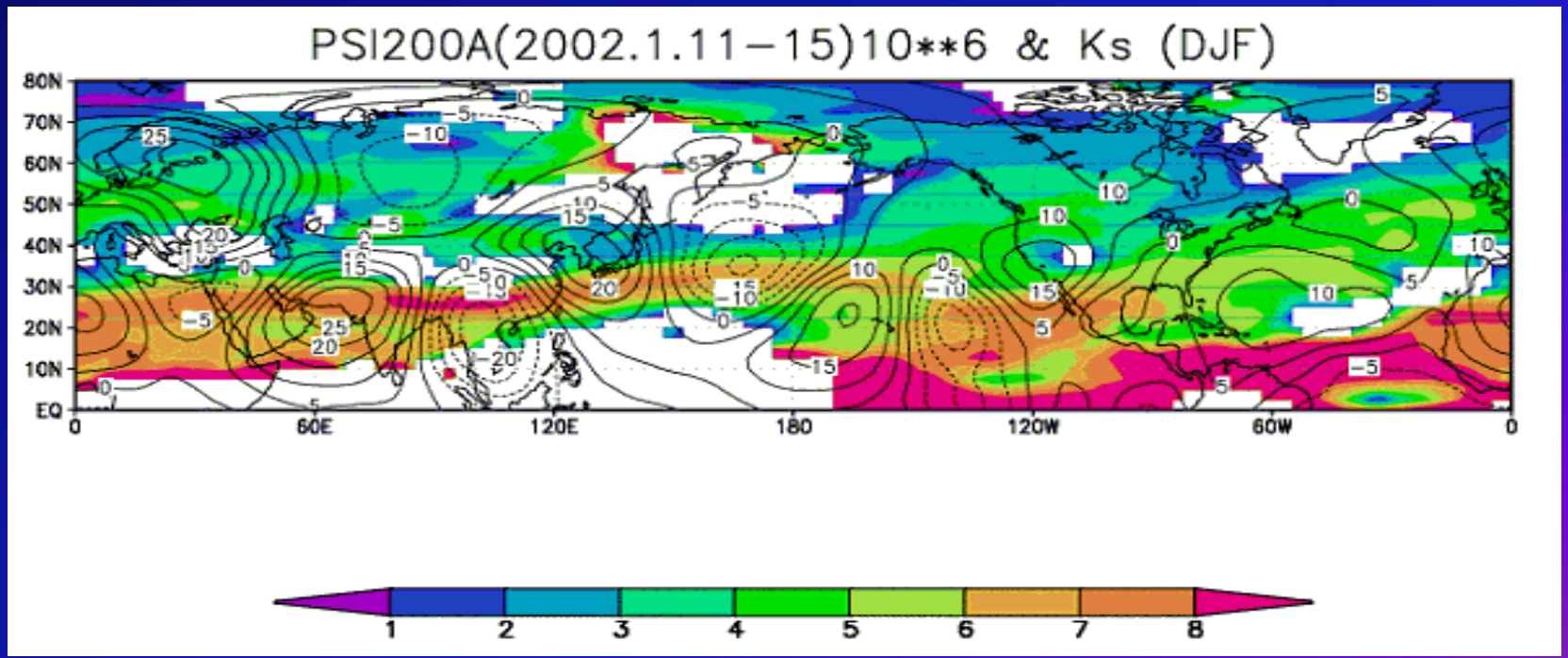
Climatological distribution of wave guide (Ks) for January 1st ten days

Sato et al. , 2004

Propagation route of stationary Rossby wave packet



Hsu and Lin, 1992



Rossby wave packet detection

$\partial A / \partial t + \nabla \cdot \mathbf{F} = 0$

A : wave activity

F : wave activity flux

$\mathbf{F} = \mathbf{V}_g A$

$\mathbf{V}_g$: Rossby group velocity vector

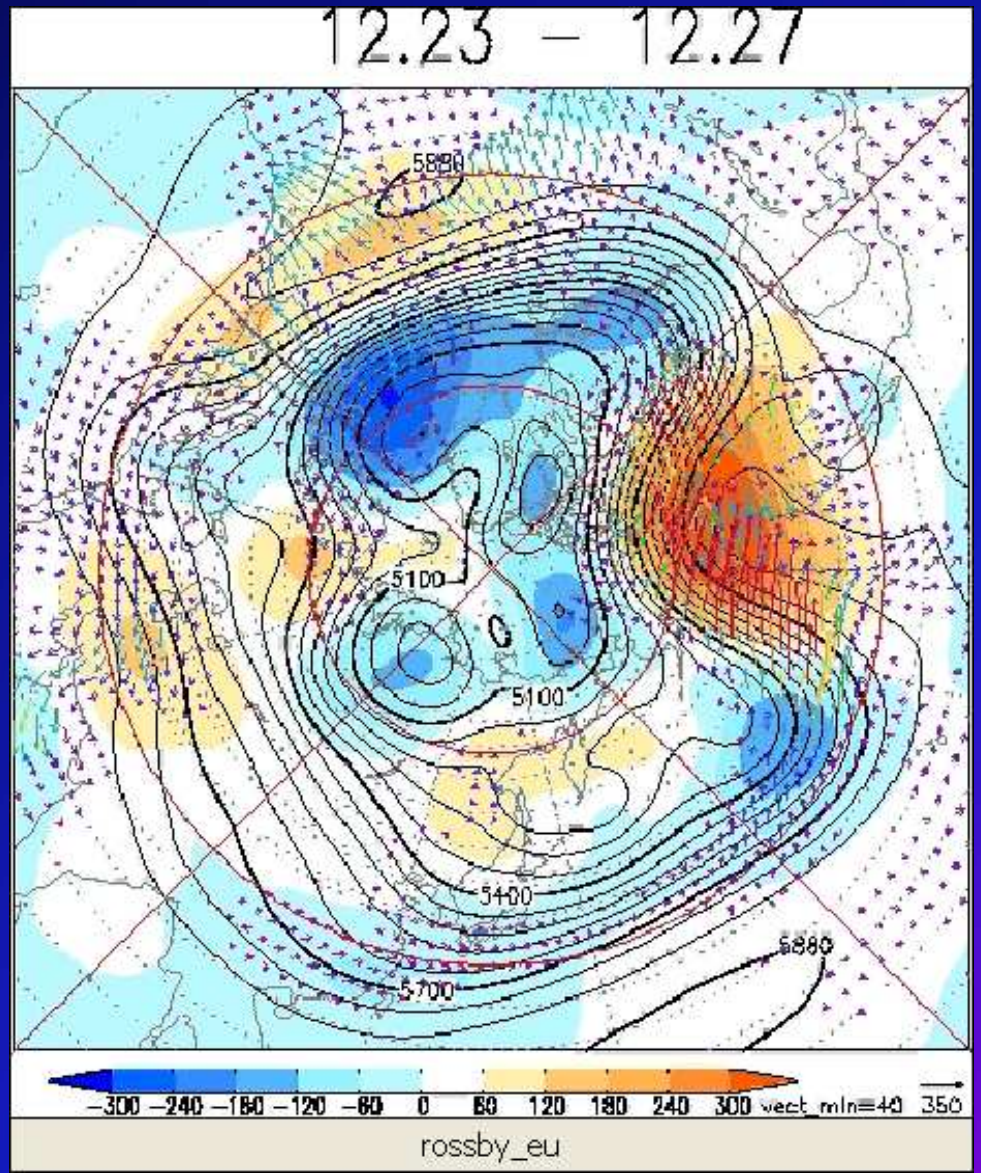
JMA has been using F

proposed by Takaya and Nakamura (2001)

Example for Rossby wave packet propagation

Quasi-stationary Rossby wave packet propagation along the polar front jet (EU pattern)

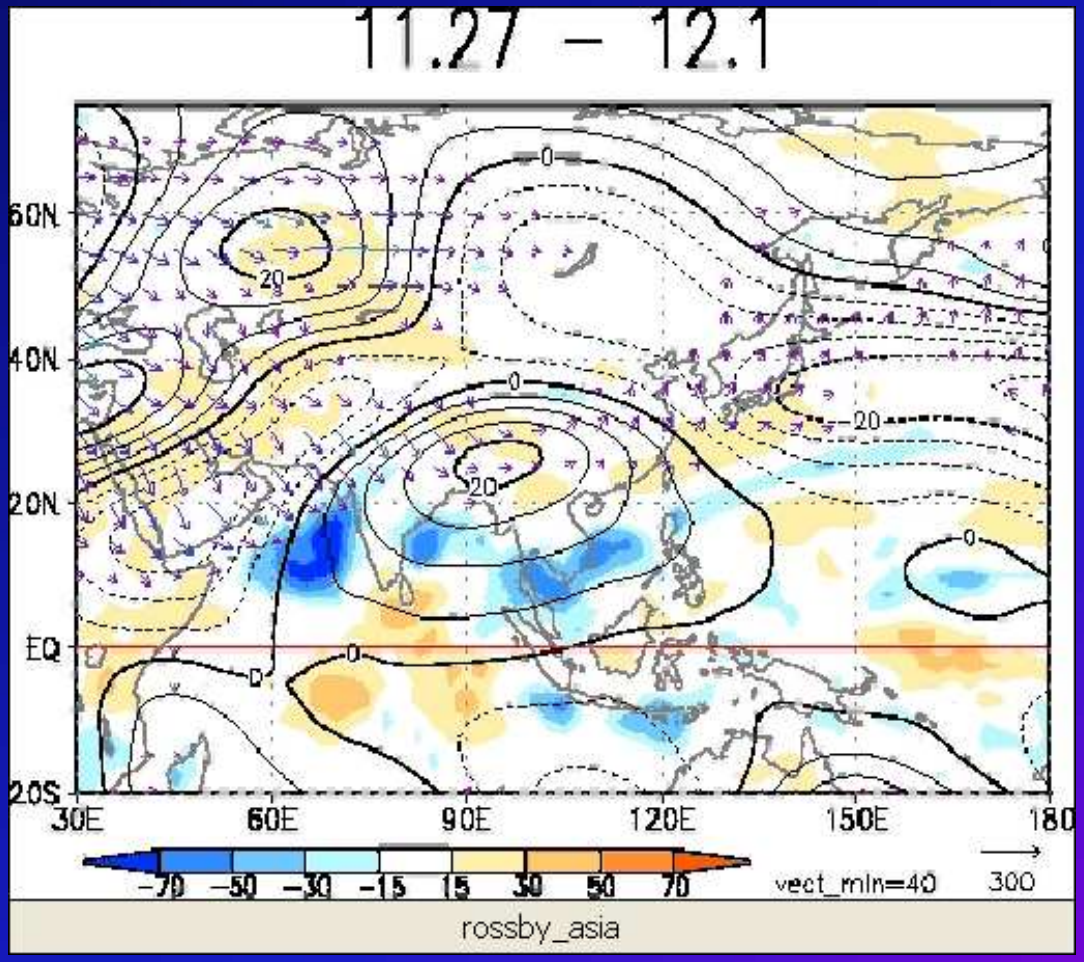
500hPa height and anomalies and wave activity flux



Example for Rossby wave packet propagation

Quasi-stationary Rossby wave packet propagation along the subtropical jet (Cold surge in East Asia)

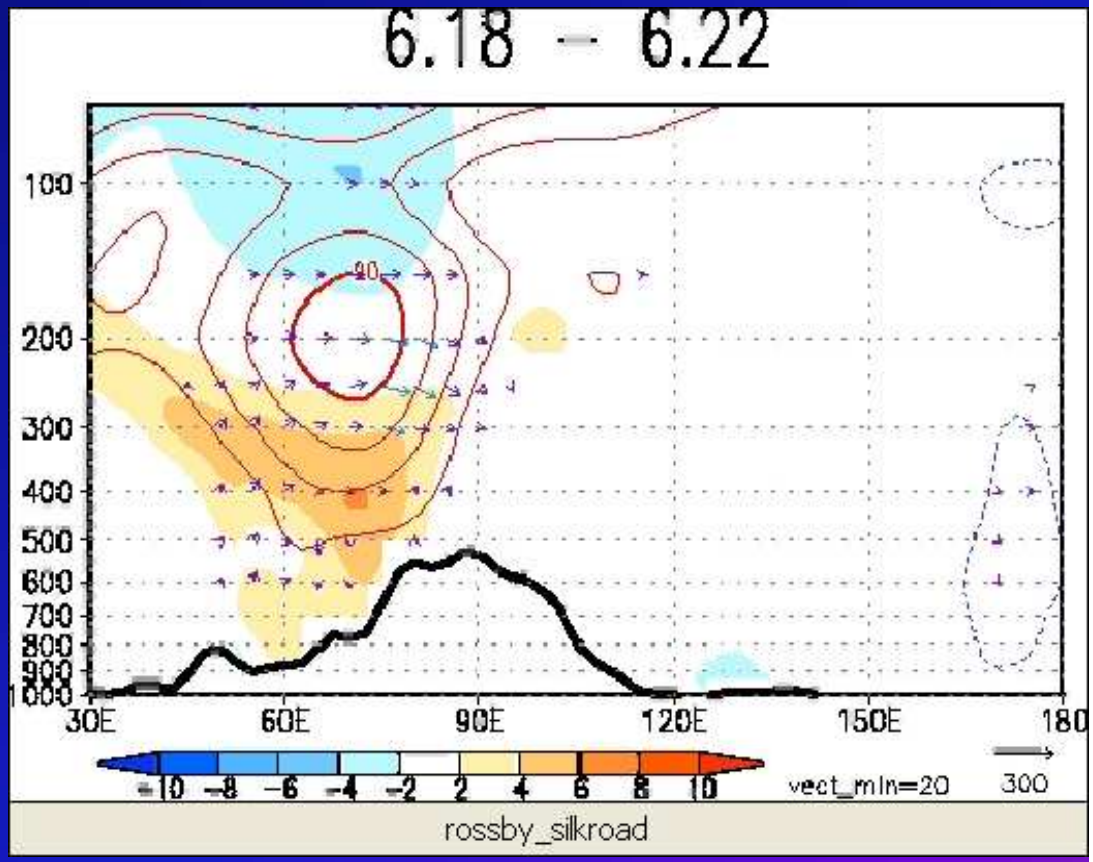
200hPa stream function anomalies ,OLR anomalies and wave activity flux

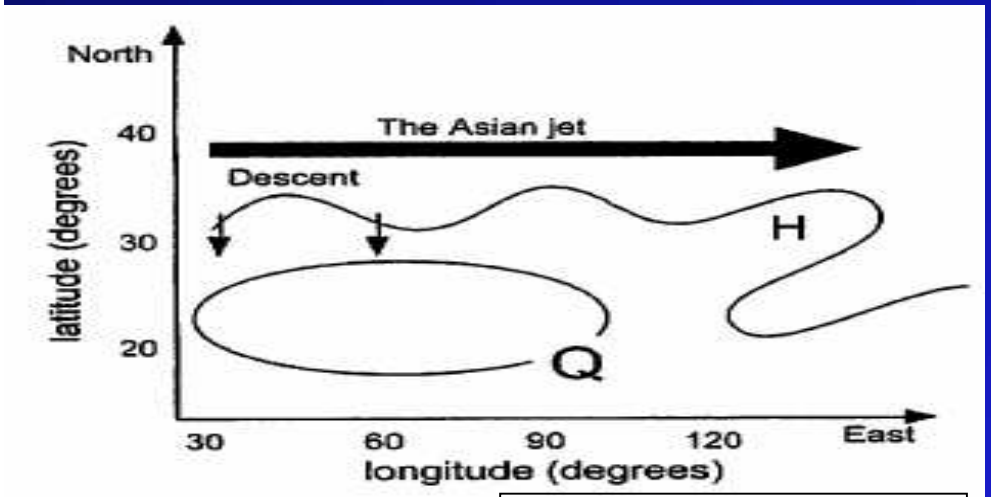


Example for Rossby wave packet propagation

Quasi-stationary Rossby wave packet propagation along the subtropical jet (Silk road pattern)

Height –Longitude cross section along 35N for 200hPa stream function Anomalies, temperature anomalies and wave activity flux



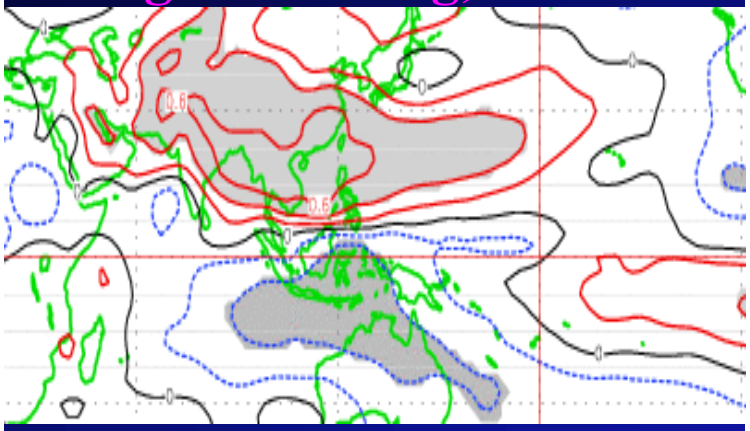


Enomoto, 2004

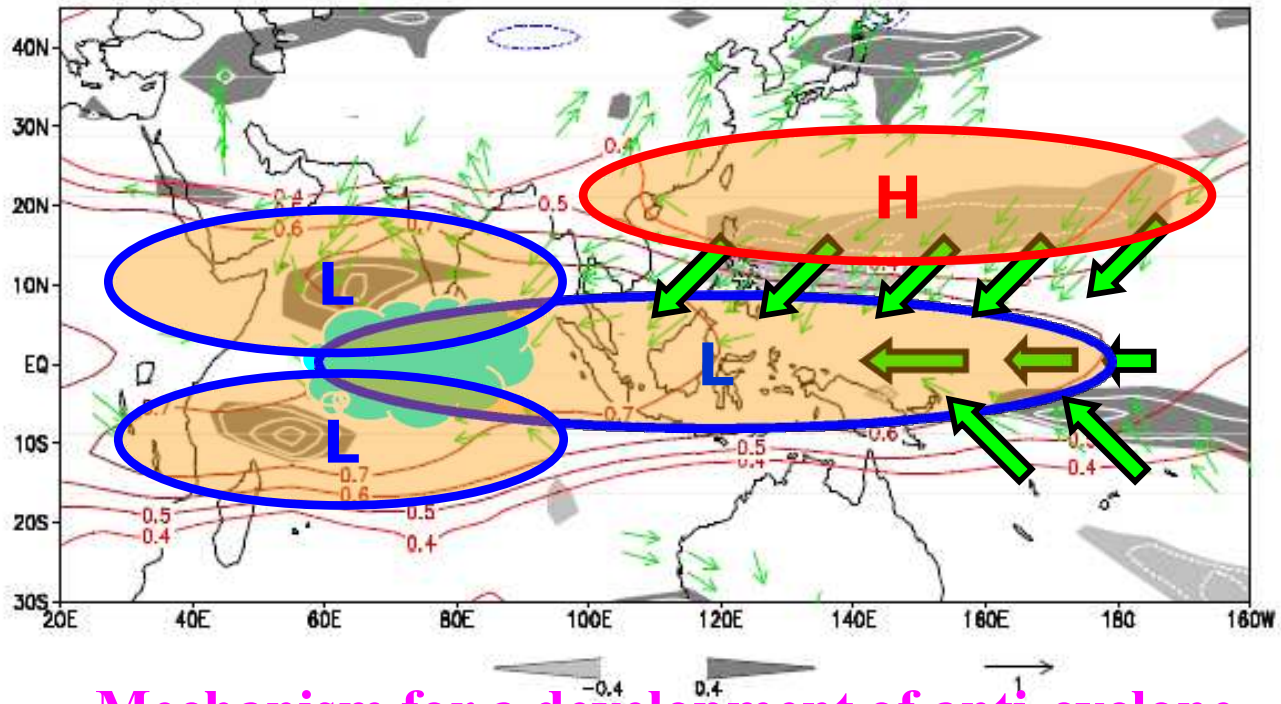
Topic form the latest research

A Lower toroposphere anti-cyclone around the Philippines in boreal summer after the peak of ENSO

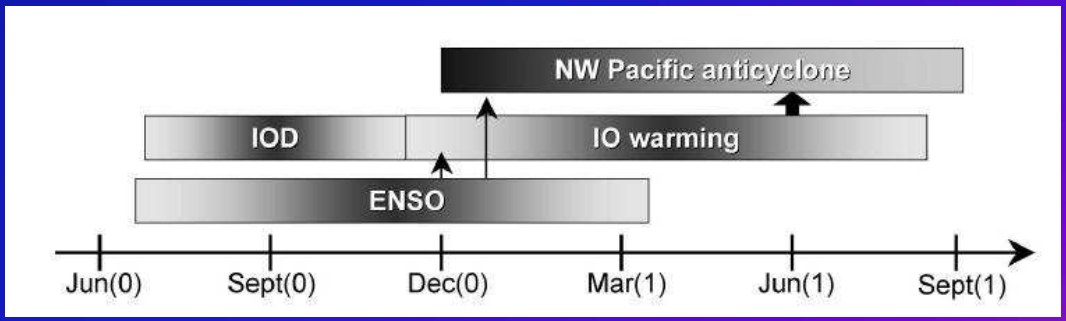
Post El Nino feature
Wang and Zhang, 2002



Lag correlation coefficient of 850hPa stream function to previous DJF NINO.3



Mechanism for a development of anti-cyclone



Xie, in press

Data for monitoring in JMA

Atmospheric Circulation :

Objective Analysis Data (JRA-25/JCDAS)

Tropical Convection :

Outgoing longwave radiation (OLR) from NOAA

Sea Surface Temperature (SST) :

Analysis Data produced in JMA (COBE-SST)

Oceanic sub-surface condition :

Ocean Data Assimilation System (MOVE-G)

Snow cover and Sea Ice :

Observations with SSM/I onboard the DMSP polar orbiting satellites from NOAA

Station data :

CLIMAT and SYNOP via GTS

Thank you!