A Tripolar Variability of East Asian Summer Monsoon

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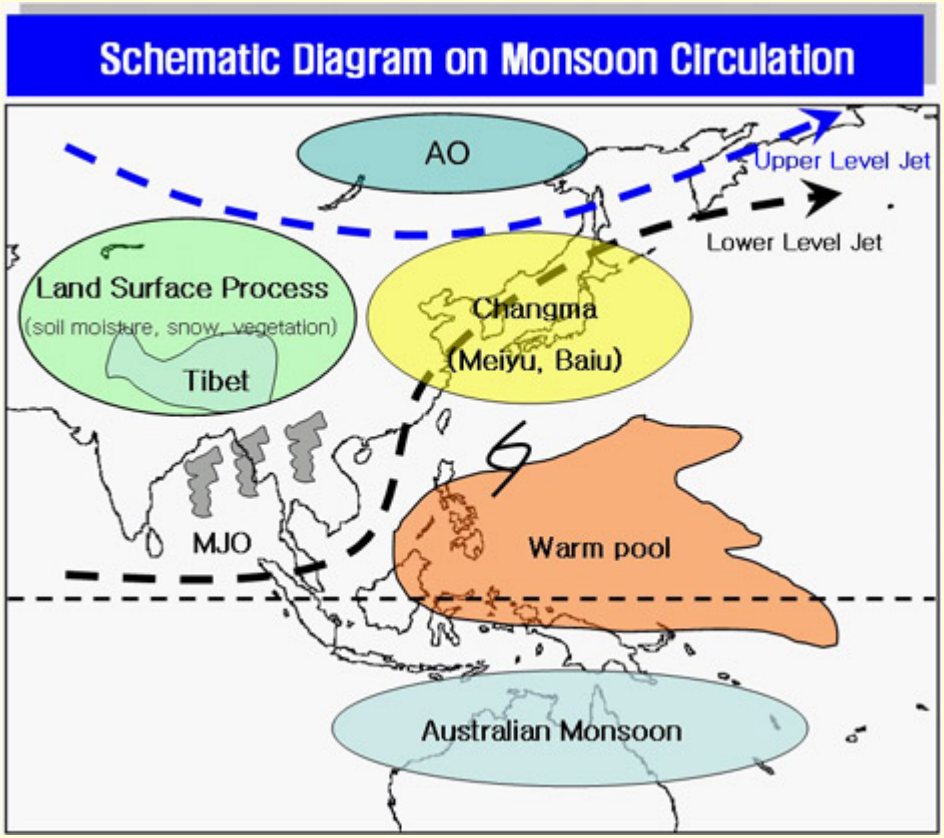
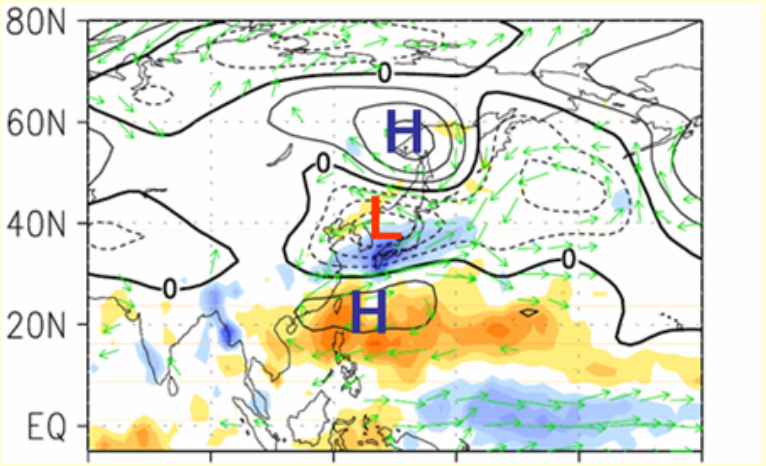
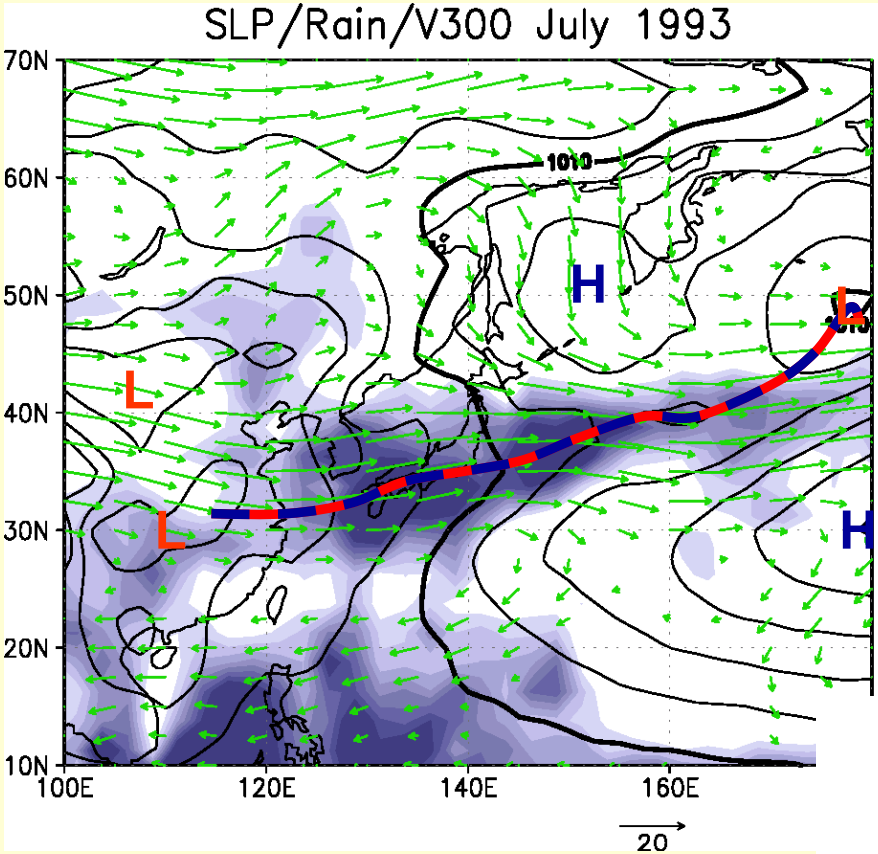
The University of Tokyo



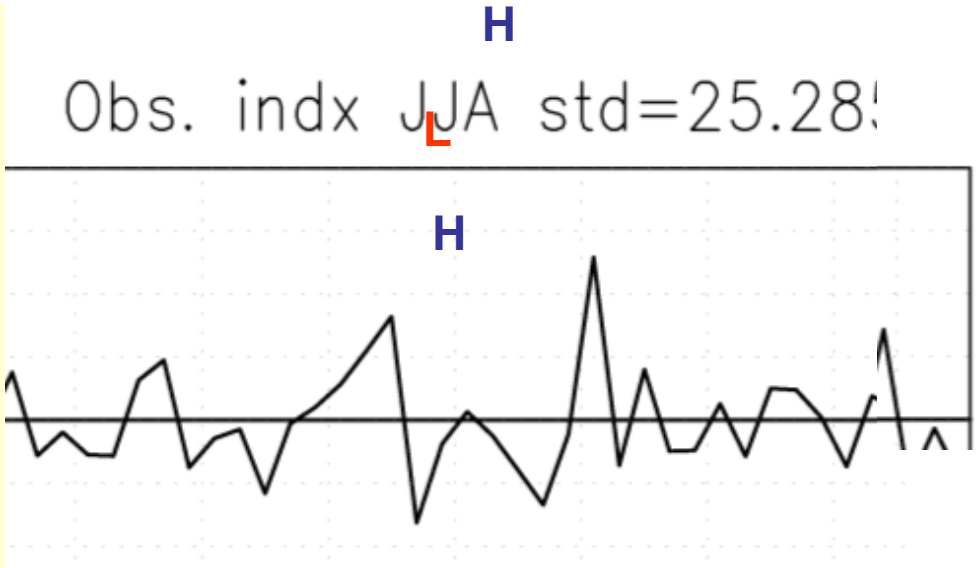




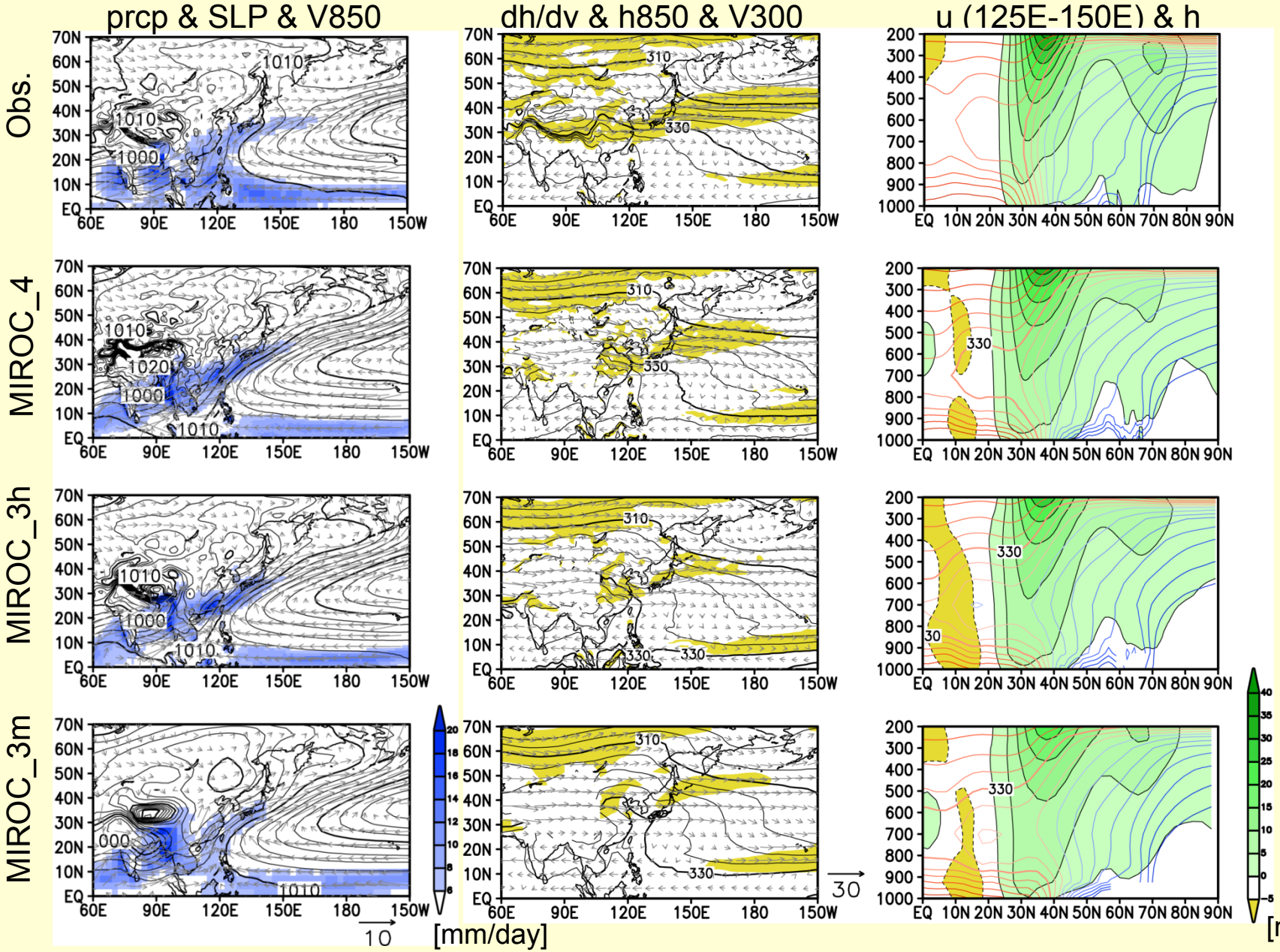
PJ teleconnection (Nitta, 1986,1987)

Rain, Z500 & V850 anomalies → regressed against western Japan percentage precipitation anomaly time series

The Tripolar Pattern



Climatology over East Asia (Jun)



Resolution dependence of "heavy rain" reproducibility

of days w/ R>=30 mm/ day

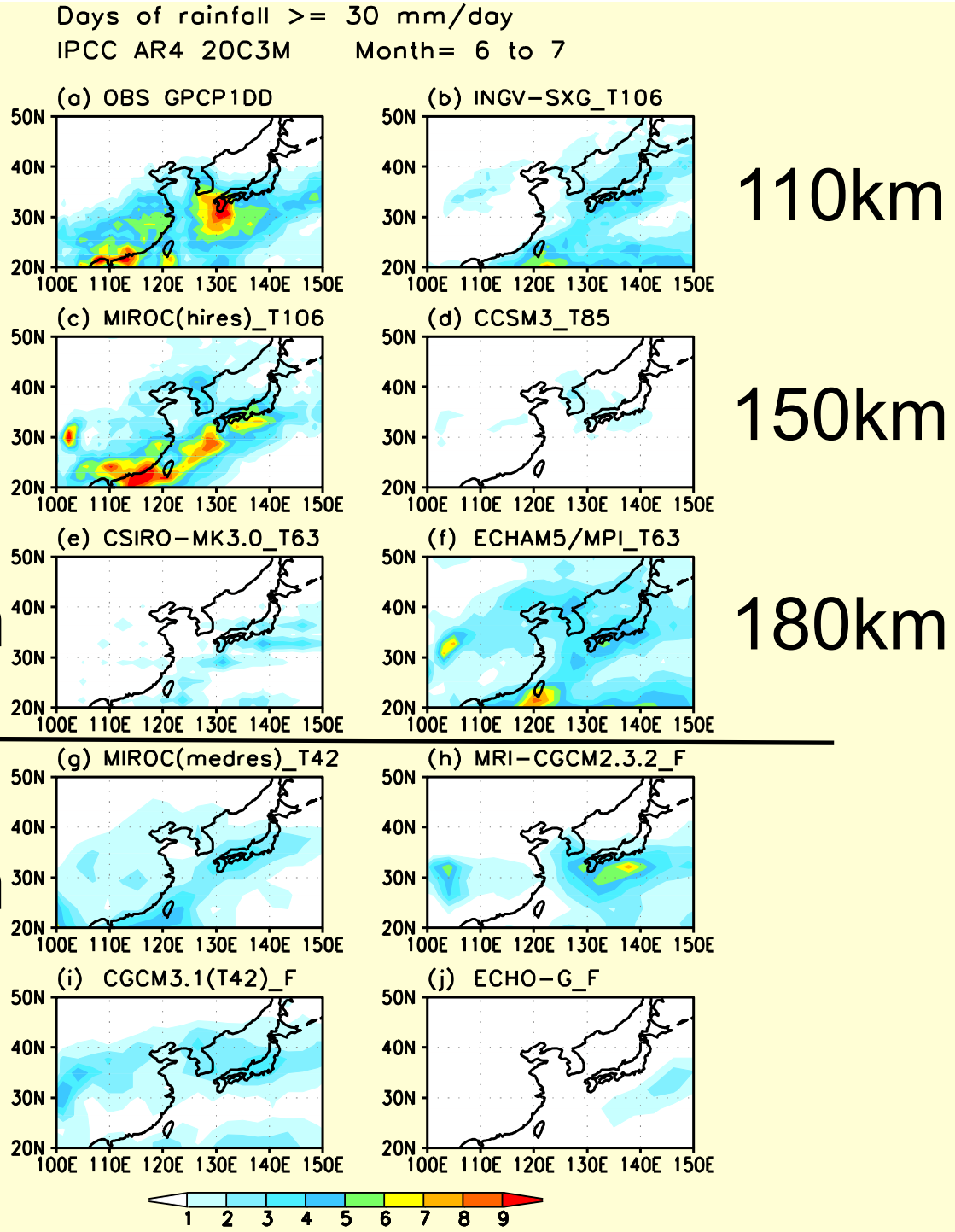
OBS

110km

180km

250km

or coarser



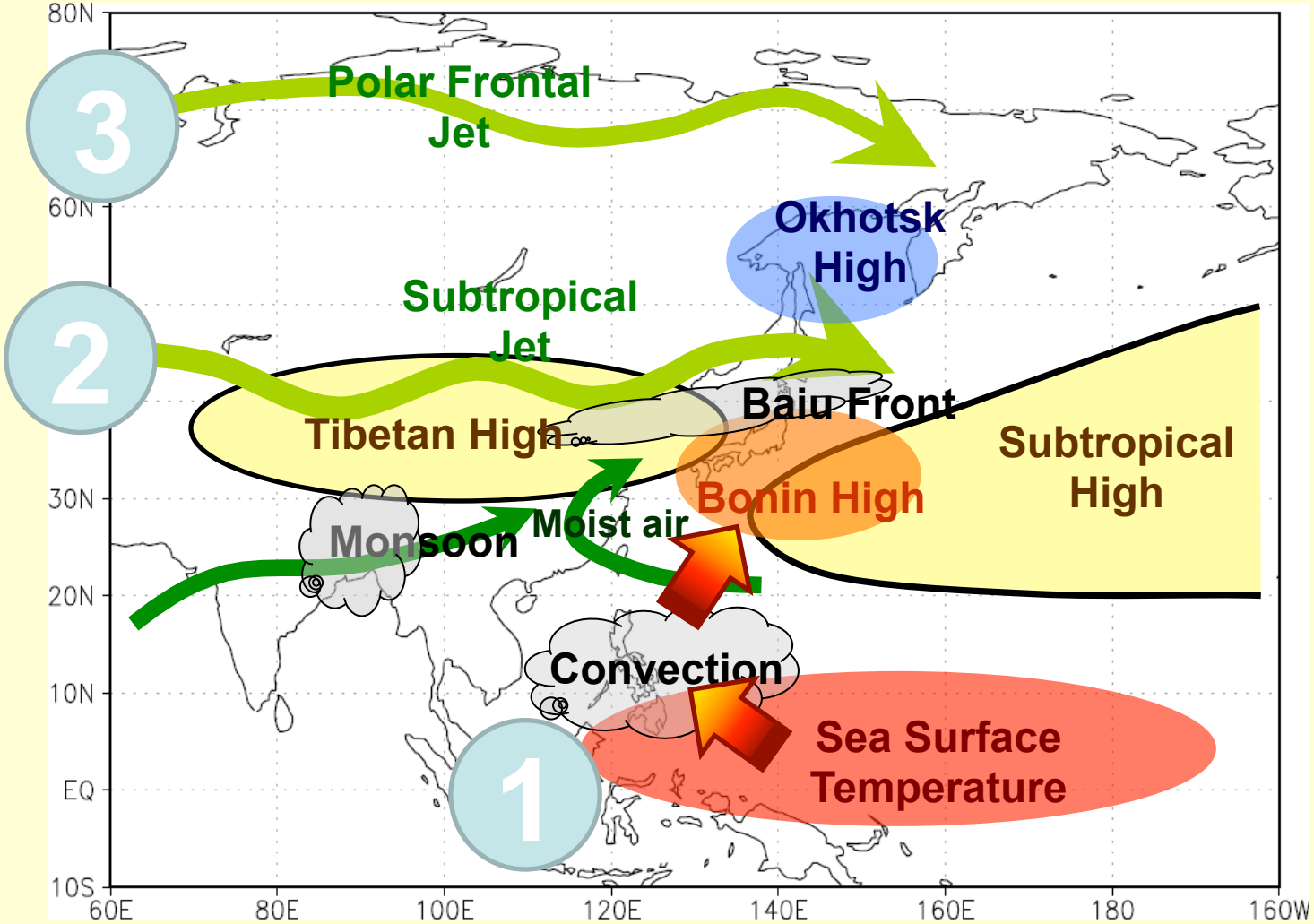
110km

150km

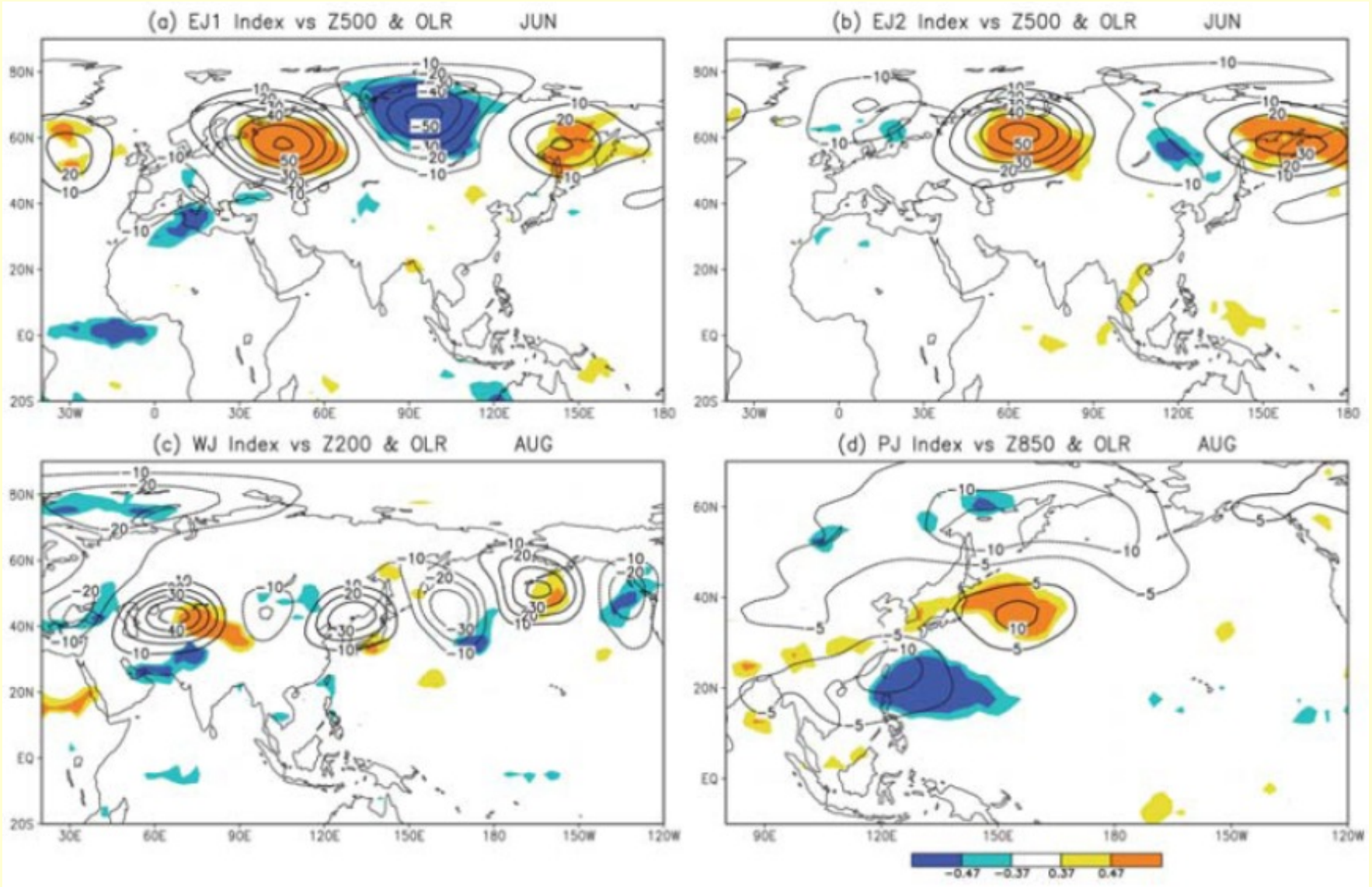
180km

Slide courtesy of Dr. Kusunoki (MRI)

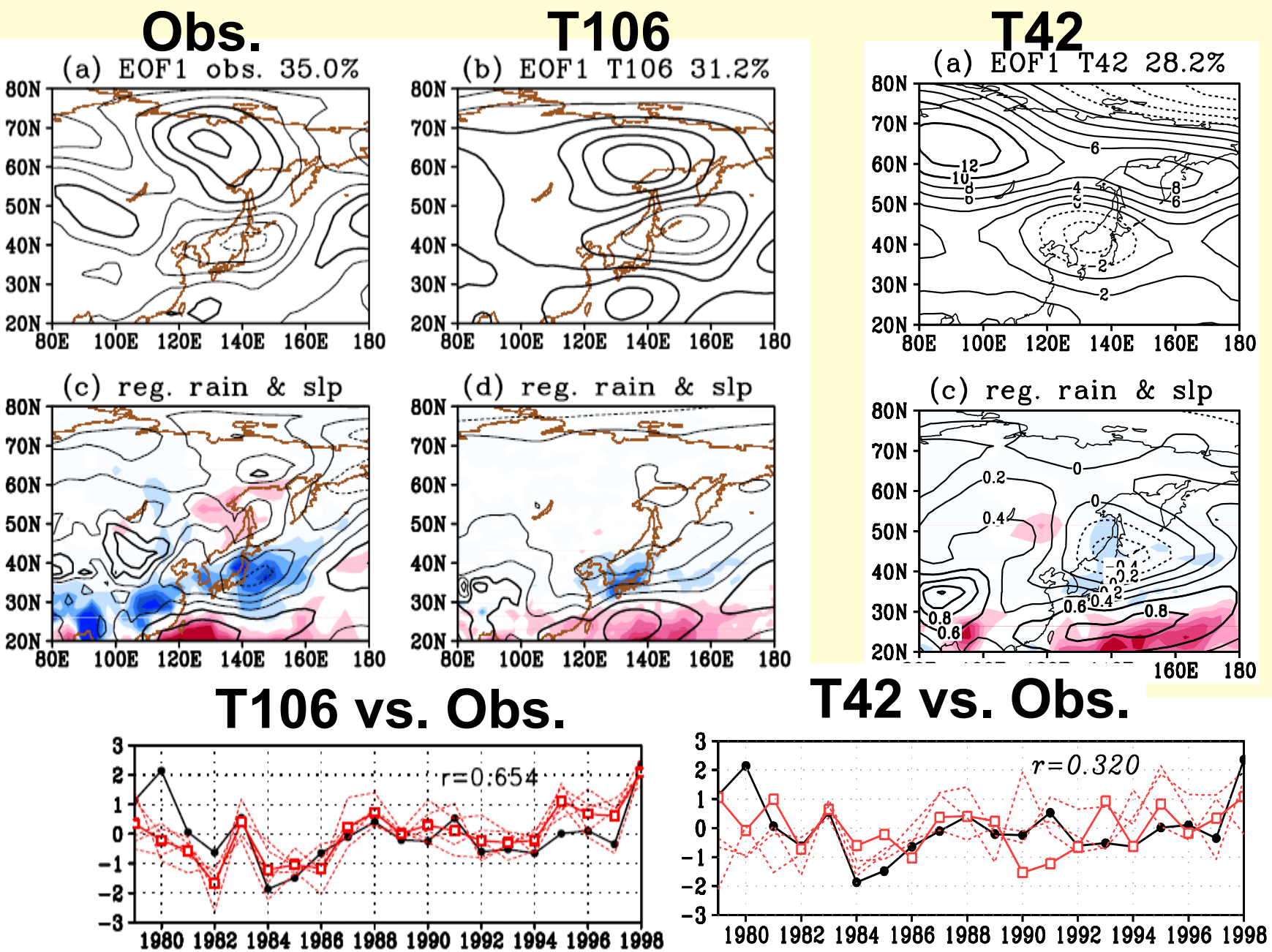
Factors affecting East Asian Summer Climate



Teleconnection pathwaysaffecting East Asia in summer

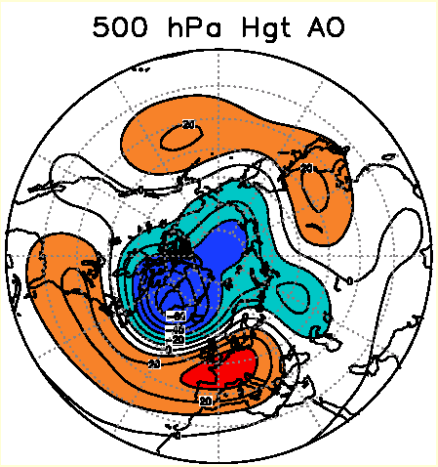


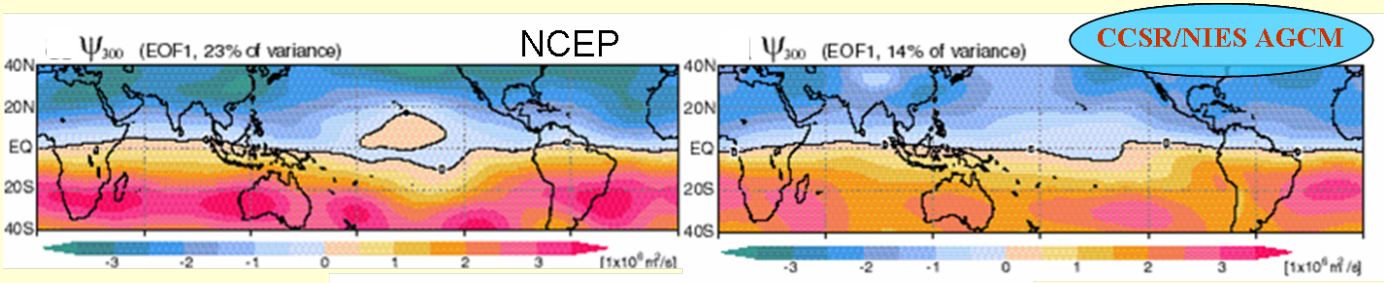
Wakabayashi and Kawamura (2004)

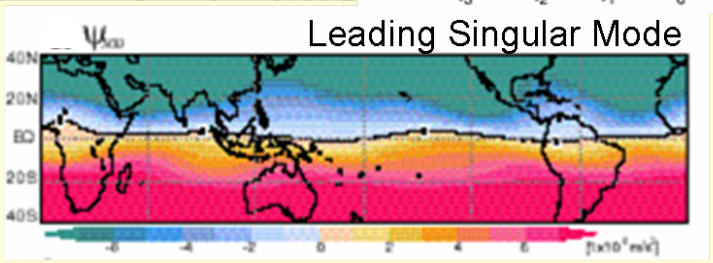


Arai and Kimoto (2007)

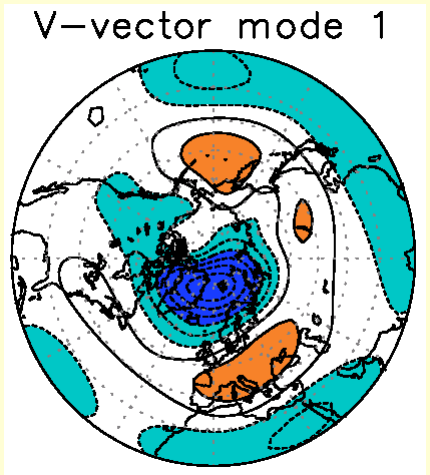
Dynamics and predictability of principal modes of climate variability

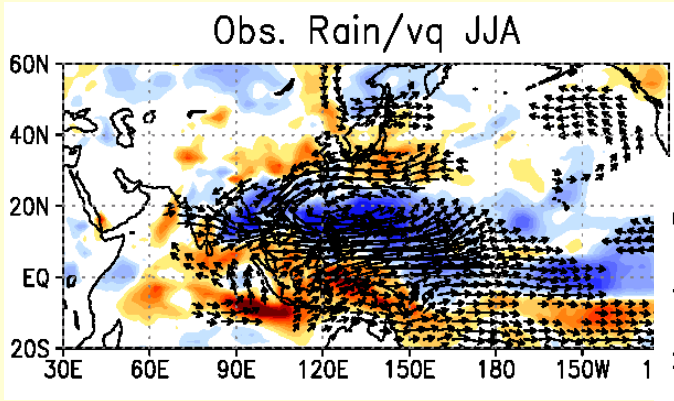


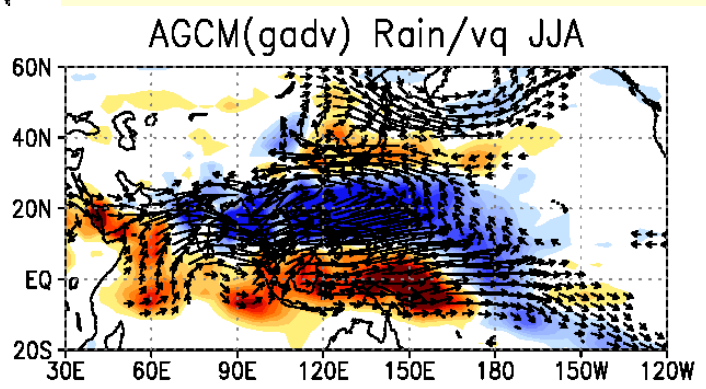




Tropical Axisymmetric Mode (TAM)
(Watanabe, Jin & Kimoto)







Pacific-Indo Dipole
(Yasutomi & Kimoto)

Zonal-eddy coupling and a neutral mode theory for the Arctic Oscillation

(Kimoto, Jin, Watanabe and Yasutomi 2001)

Neutral Modes

$$\frac{d\mathbf{x}}{dt} = \mathbf{A}\mathbf{x} + \mathbf{f} \approx \mathbf{0}$$

$$\mathbf{A} = \mathbf{U}\,\mathbf{\Sigma}\,\mathbf{V}^{\mathrm{T}}$$

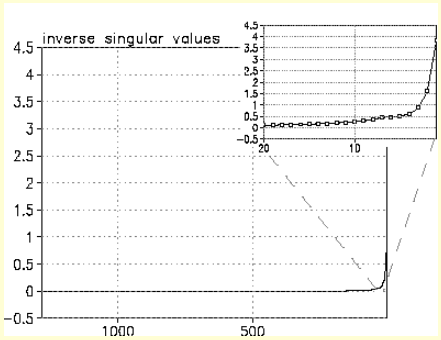
$$\mathbf{x} = \sum_i \mathbf{v}_i \frac{\mathbf{u}^{\mathrm{T}}\mathbf{f}}{\sigma_i}$$

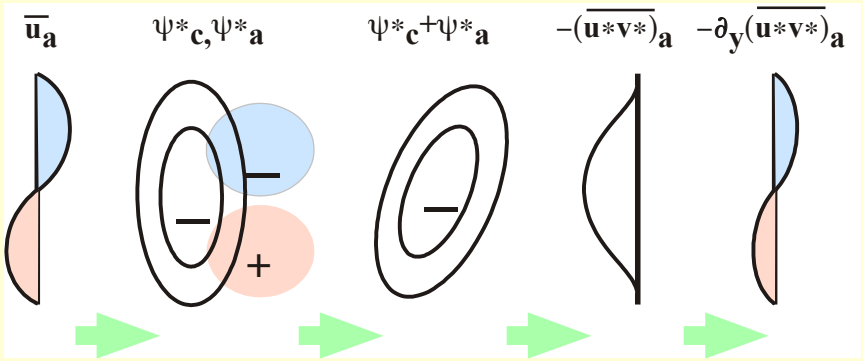
Navarra (1993)
Itoh & Kimoto (1999)

$$\frac{\partial q}{\partial t} + \mathbf{v}.\nabla q = 0$$

$$q = \bar{q} + q_L + q_H$$

$$\frac{\partial q_L}{\partial t} + \bar{\mathbf{v}}\cdot\nabla q_L + \mathbf{v}_L\cdot\nabla\bar{q} + \mathbf{v}_L\cdot\nabla q_L = -\nabla\cdot\left(\mathbf{v}_H q_H\right)_L + f_L$$

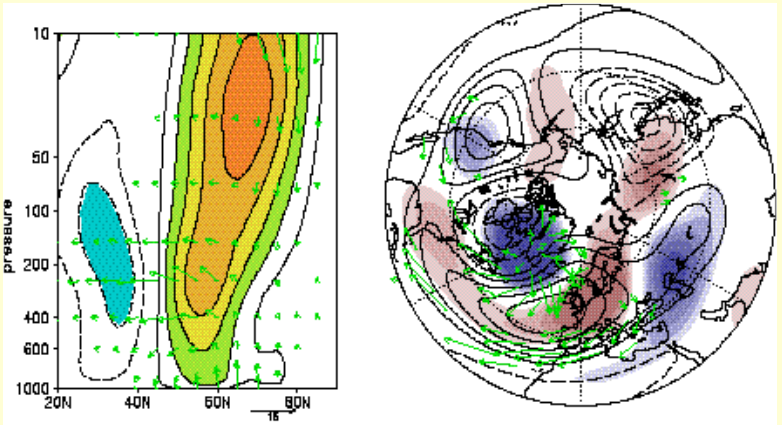




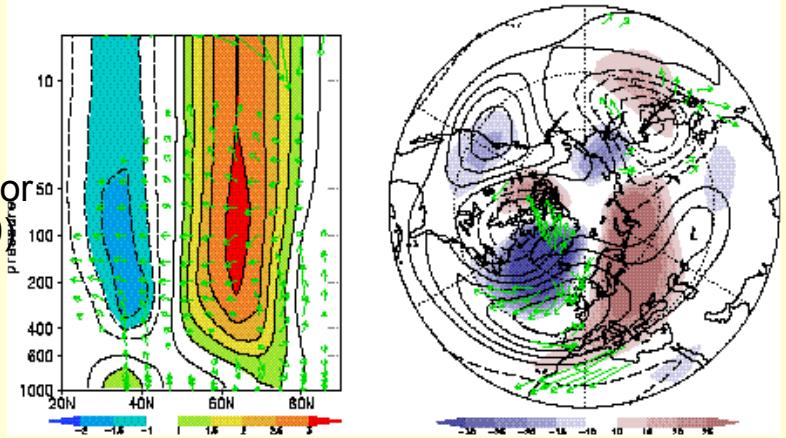
Ubar & EP-flux

300hPa Height & E-vector

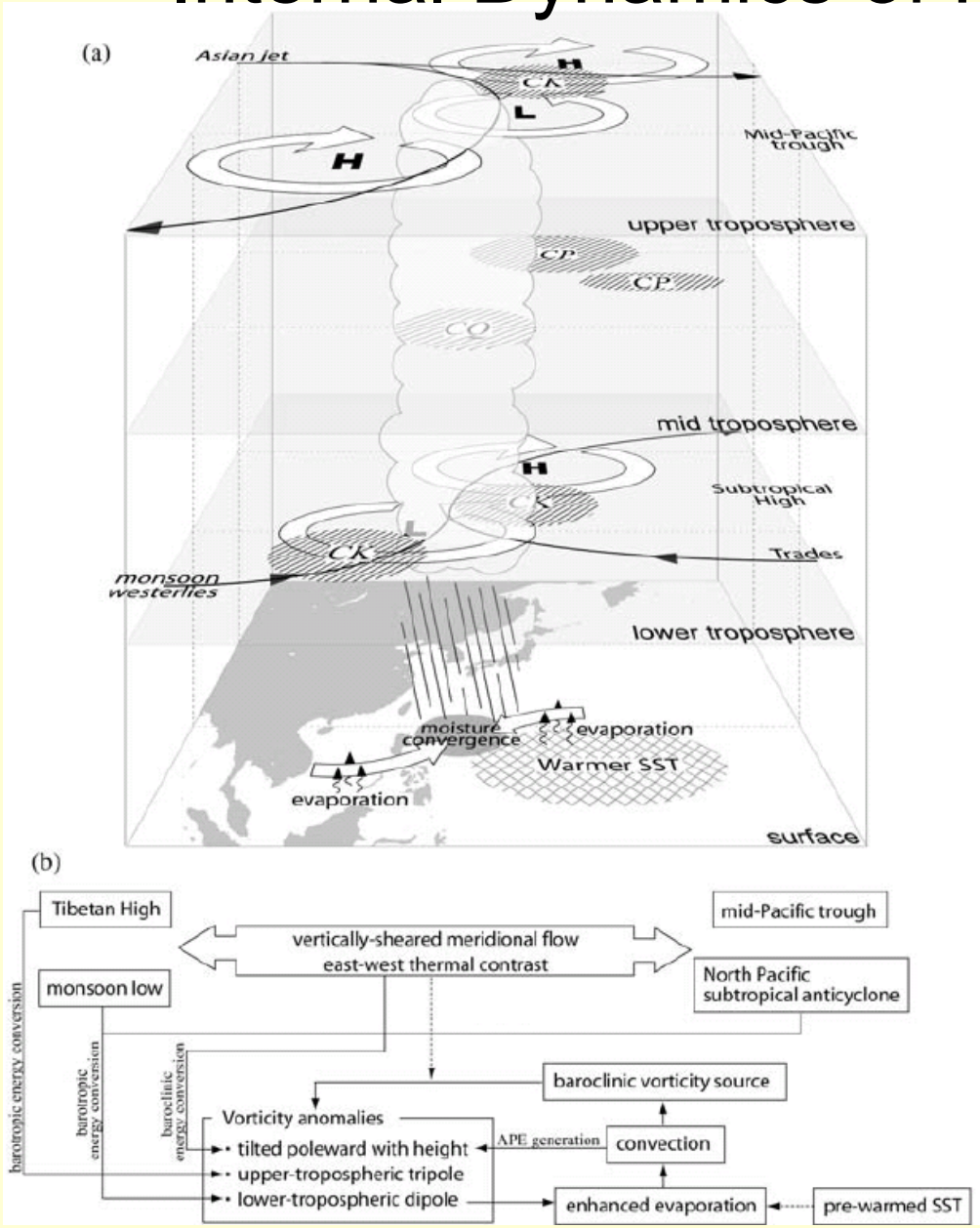
Obs.



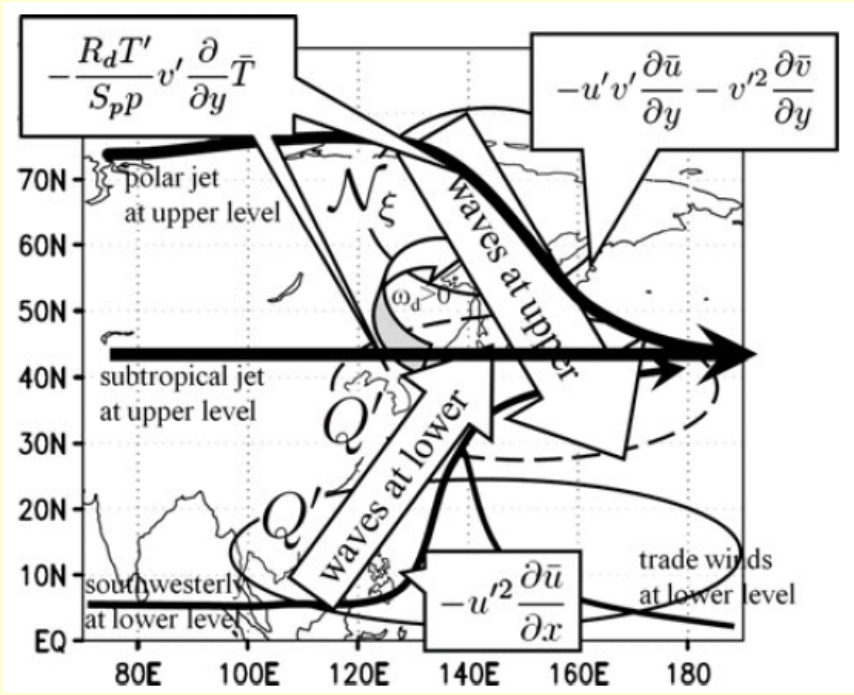
1st V-vector (T10L20)



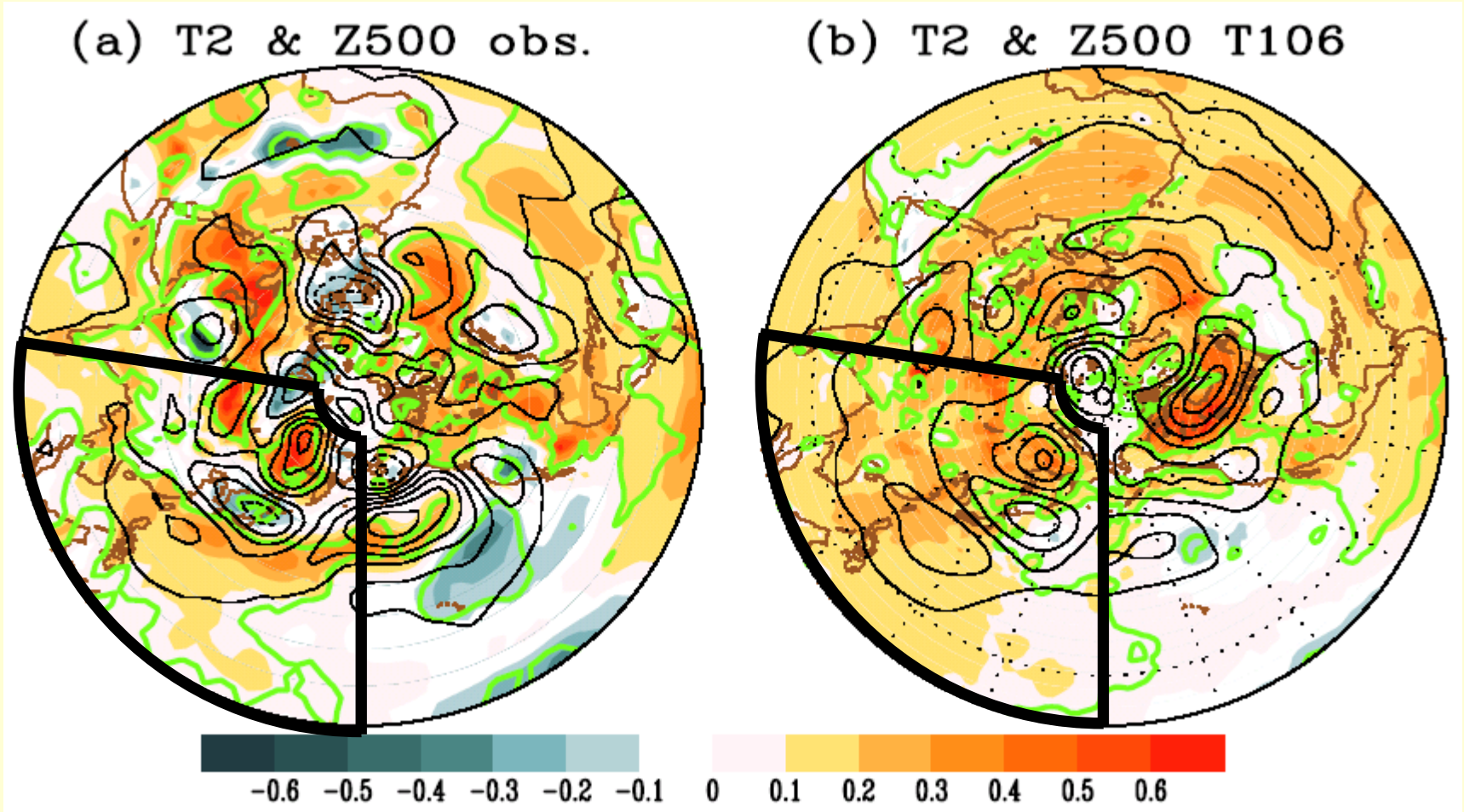
Internal Dynamics of PJ/Tripolar Pattern

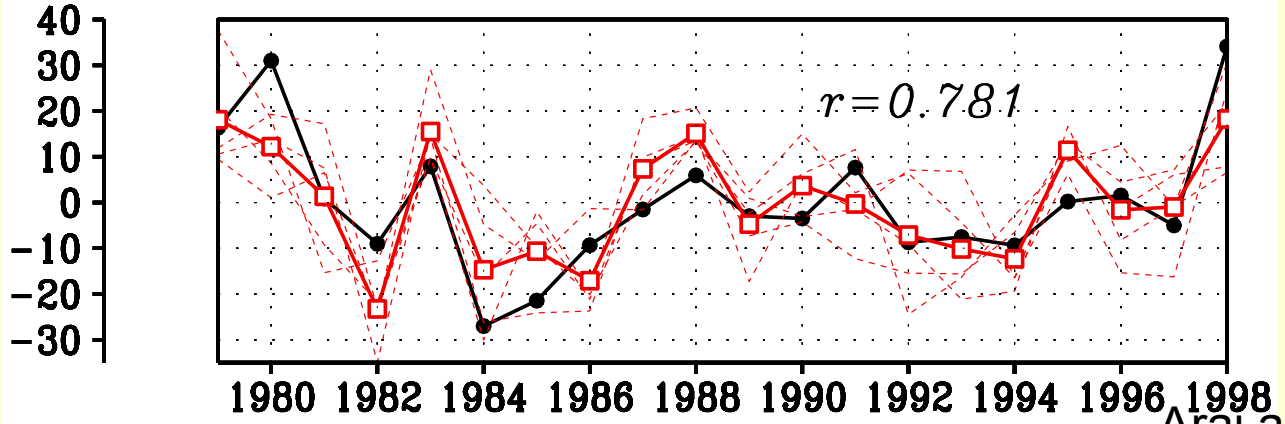


Kosaka and Nakamura (2006)



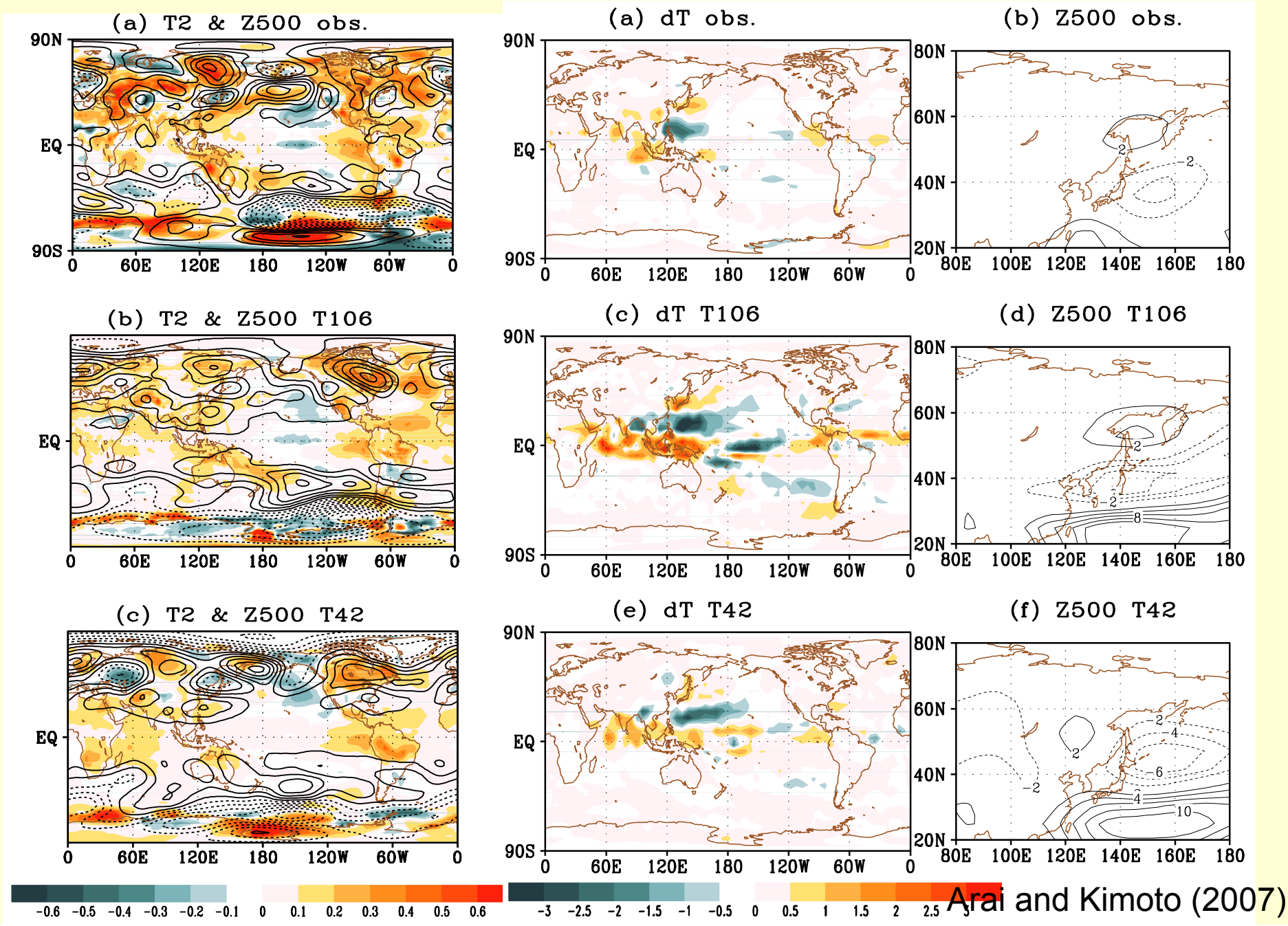
Hirota and Takahashi (2012)





Arai and Kimoto (2007)

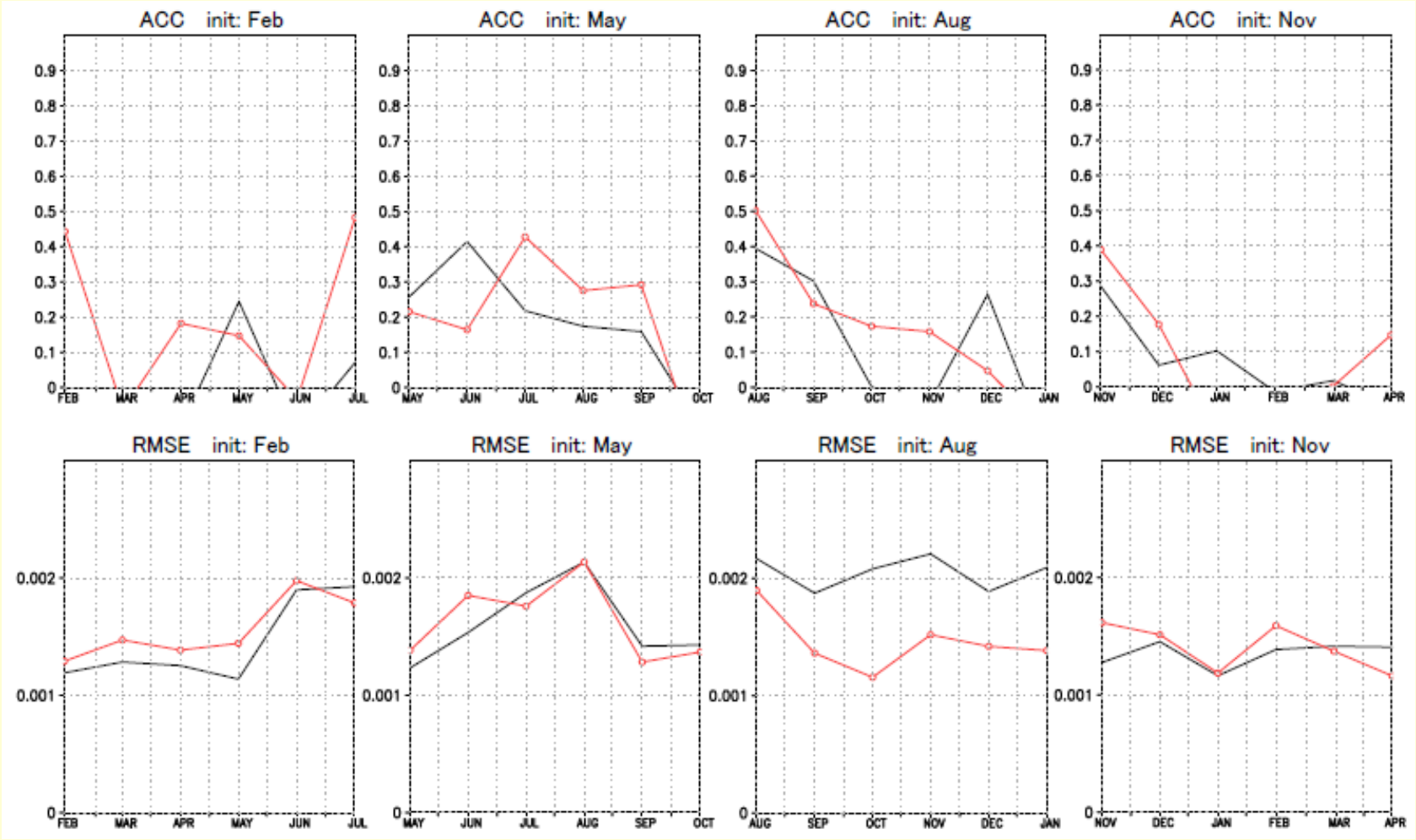
A linear model experiment



Arai and Kimoto (2007)

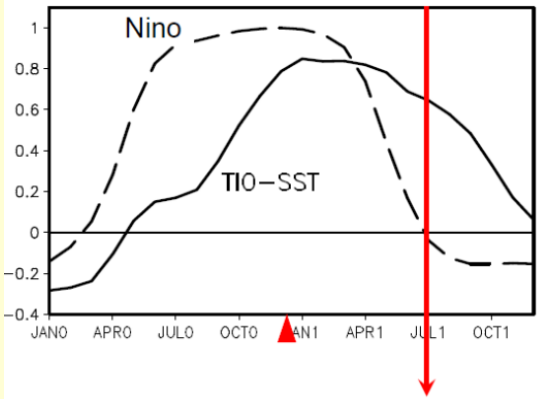
Initial-value predictability of the Tripolar Pattern (tentative)

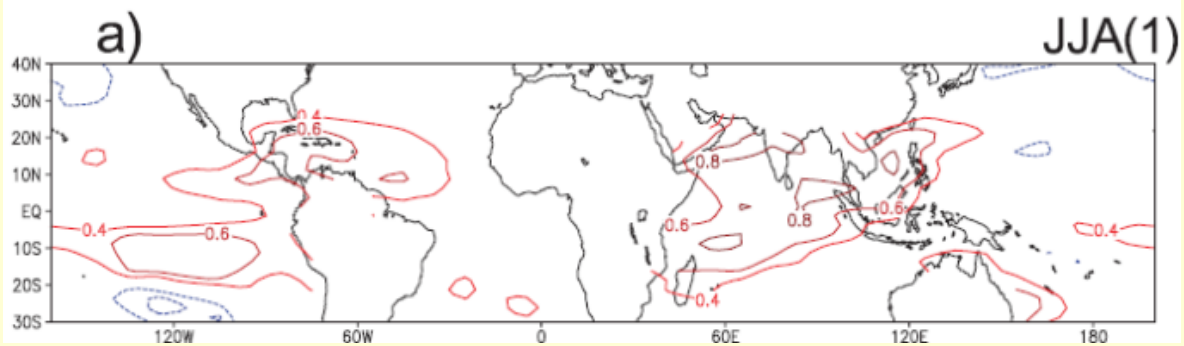
prediction — persistence

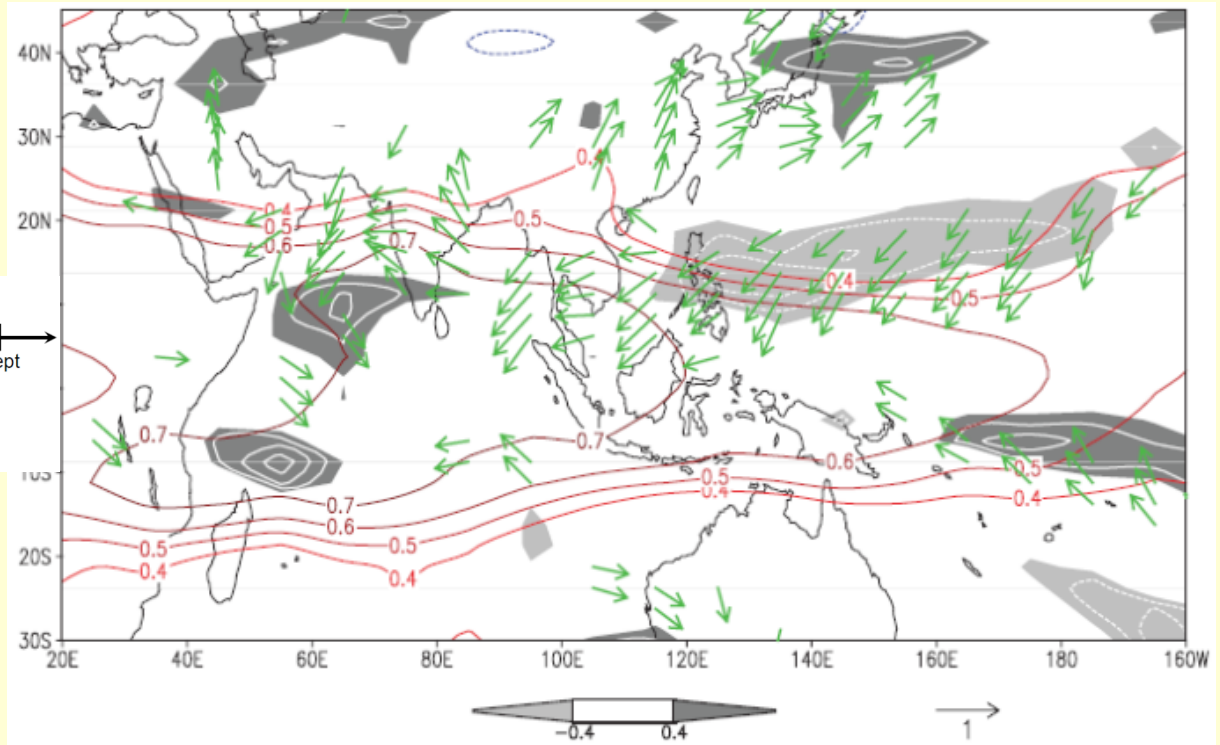


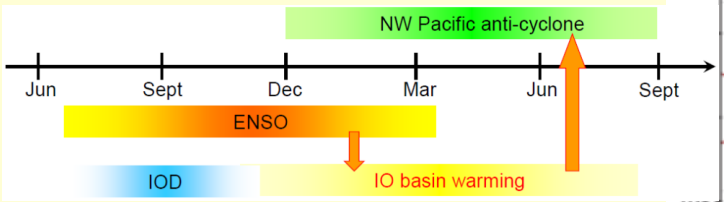
Preliminary results of SPAMseasons (Imada, 2012)

Indian Ocean Capacitor Effect





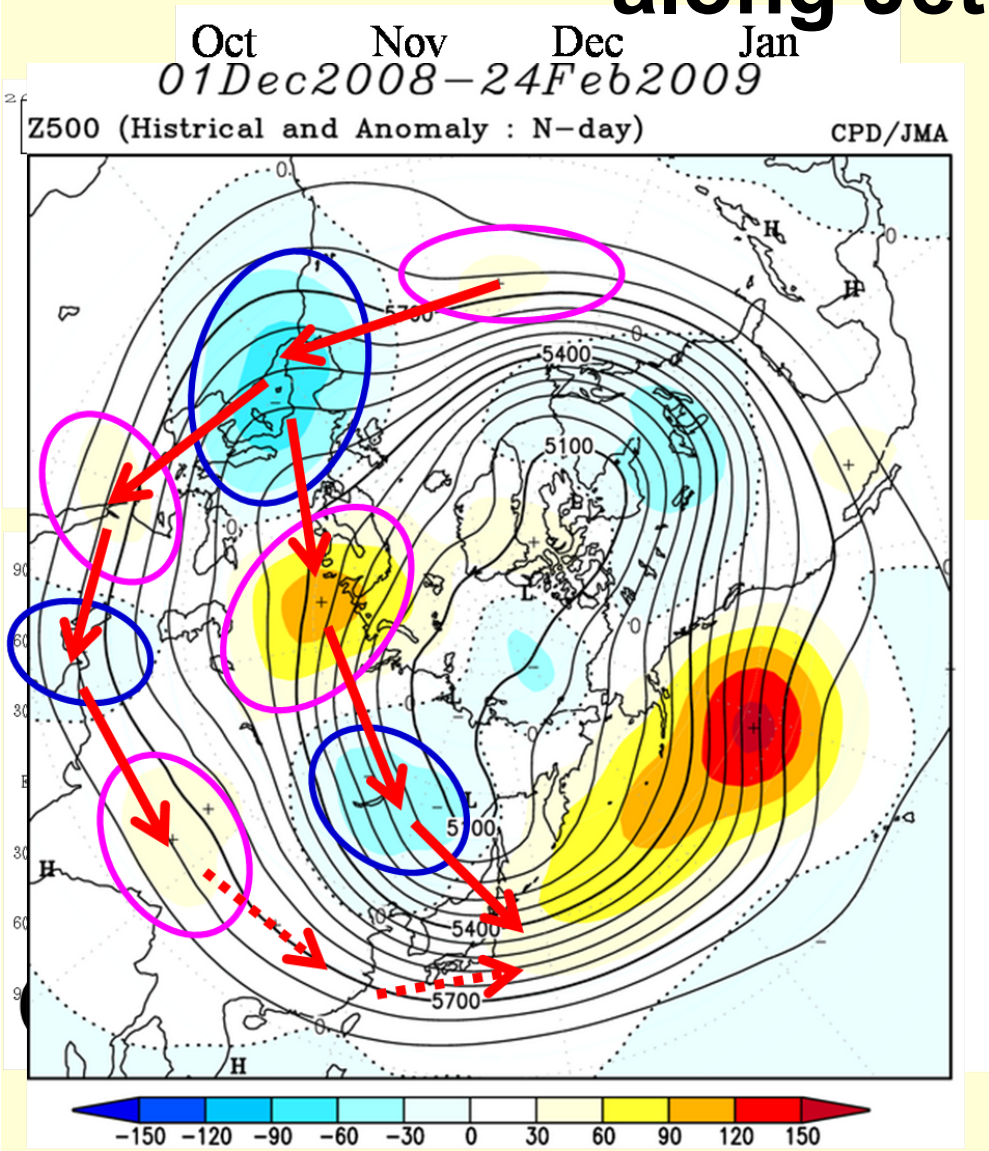




→
JJA(1) correlation with the NDJ(0) Nino3.4 SST index:
850–250hPa temperature (contours), precipitation (shades) and surface wind velocity

Xie et al. (2009)

Quasi-stationary Rossby Wave propagation along Jet streams



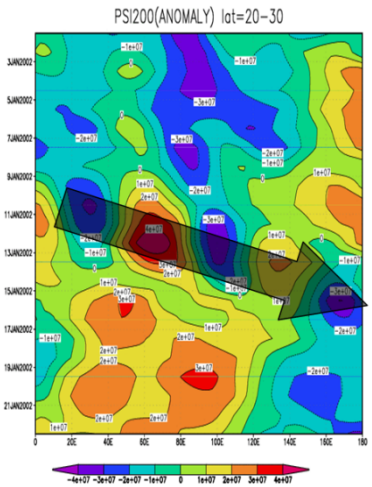
JRA-25 Japanese 25-year Reanalysis Project

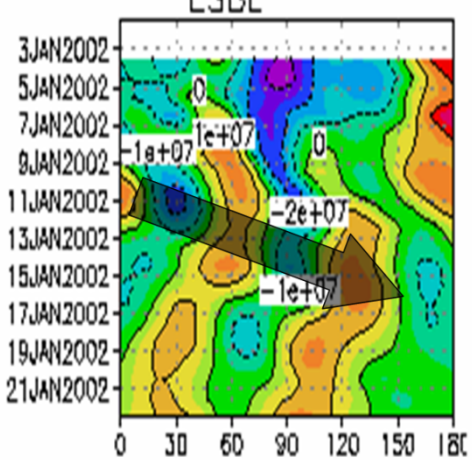
気象庁

気象研究コンソーシアム

気象庁、(社)日本気象学会

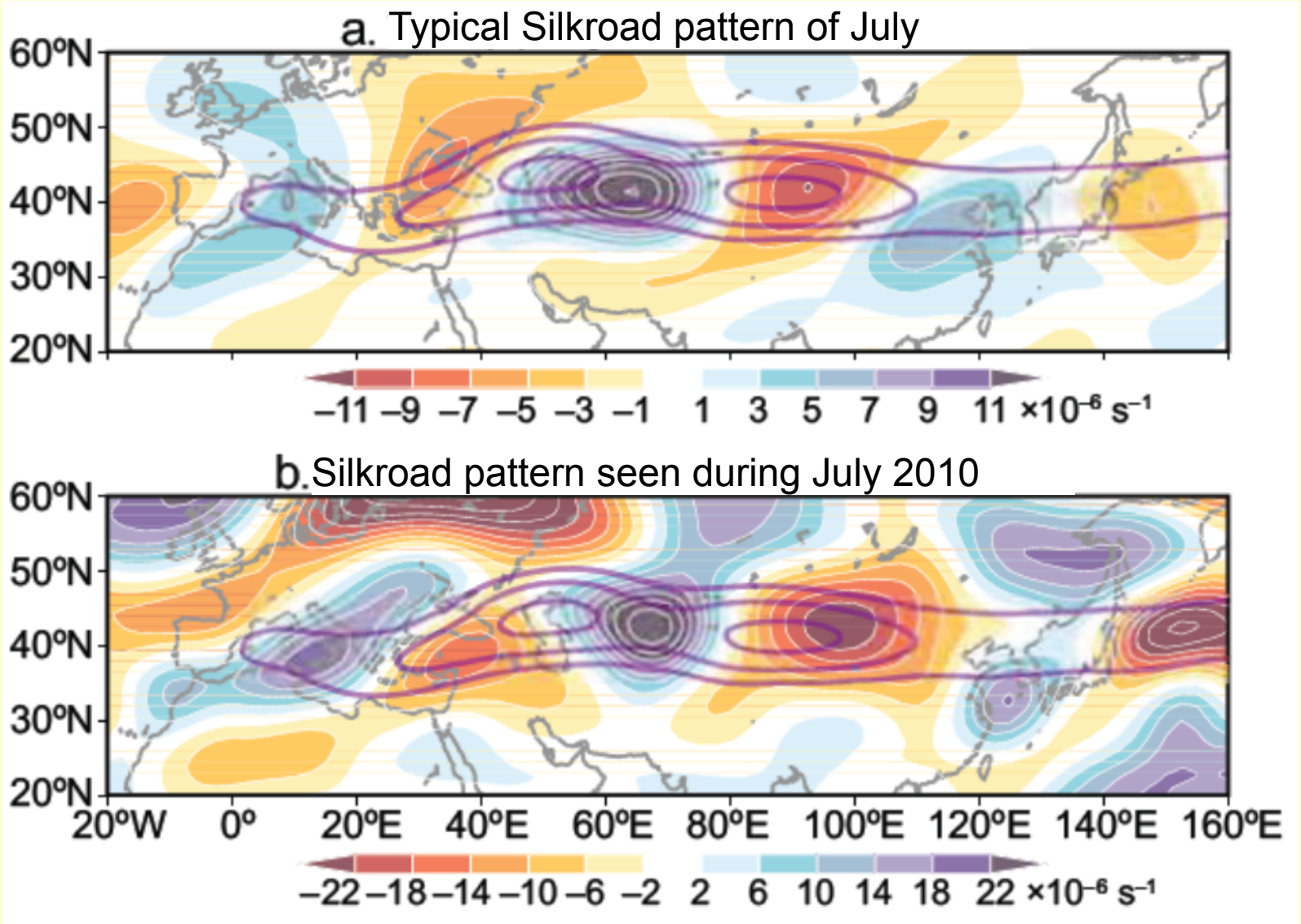
METEOROLOGICAL SOCIETY OF JAPAN 日本気象学会



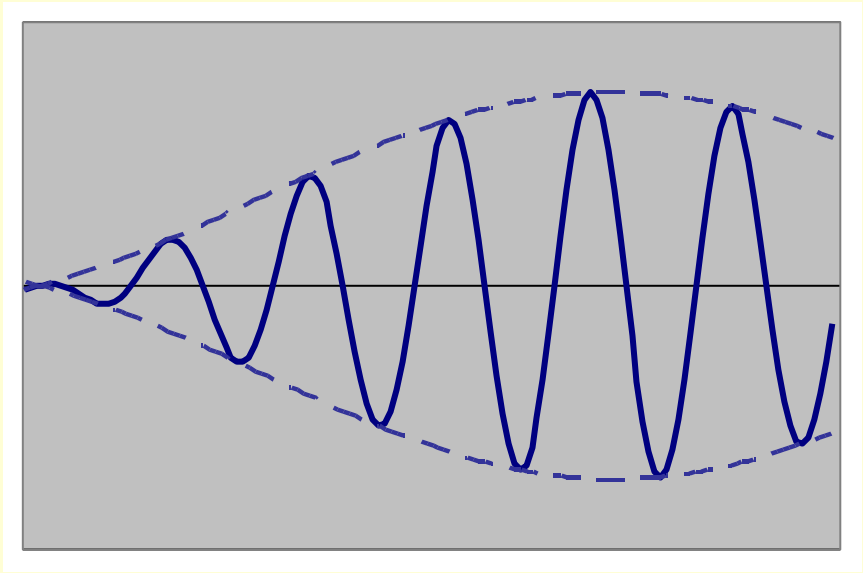


S. Maeda

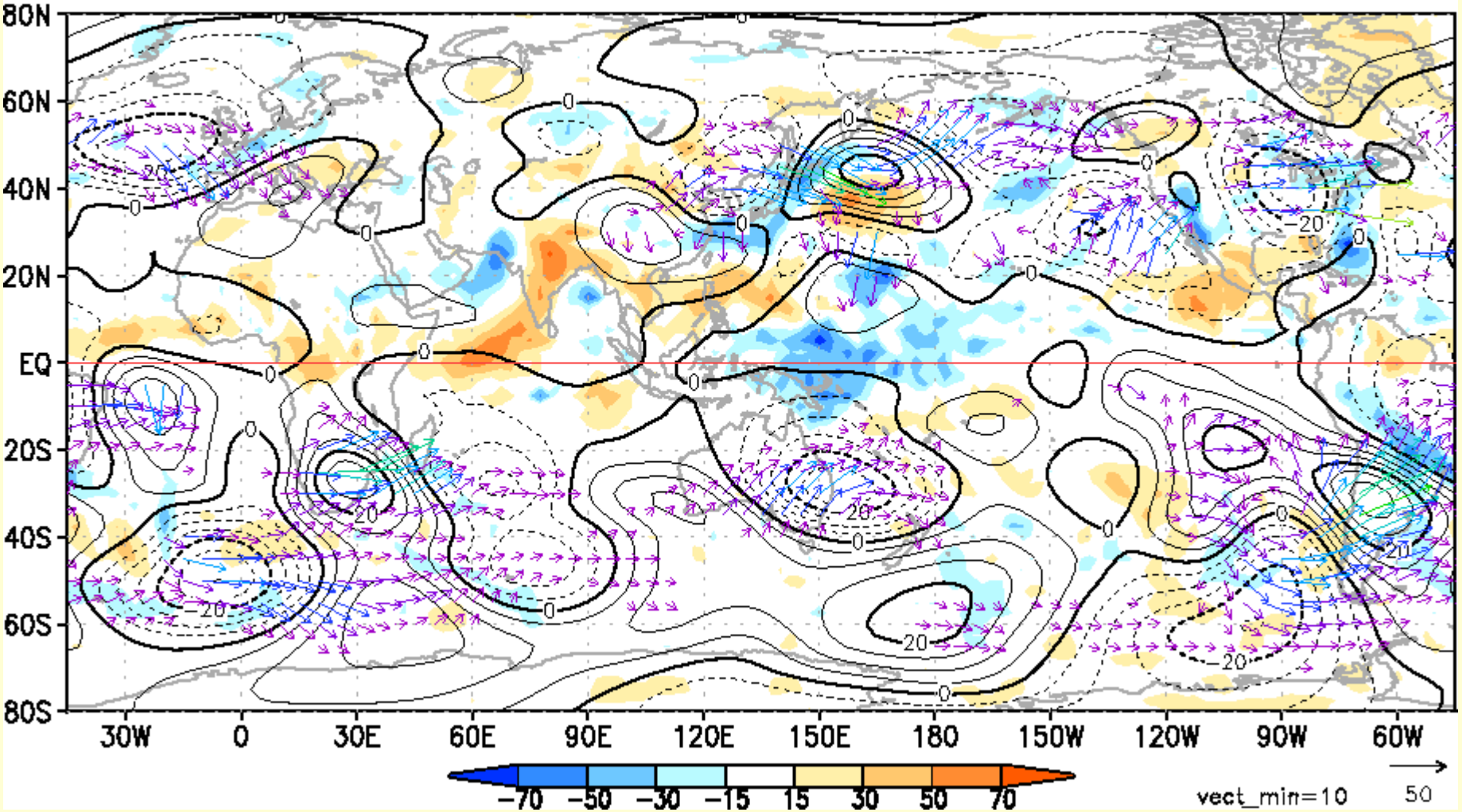
The Silkroad Teleconnection



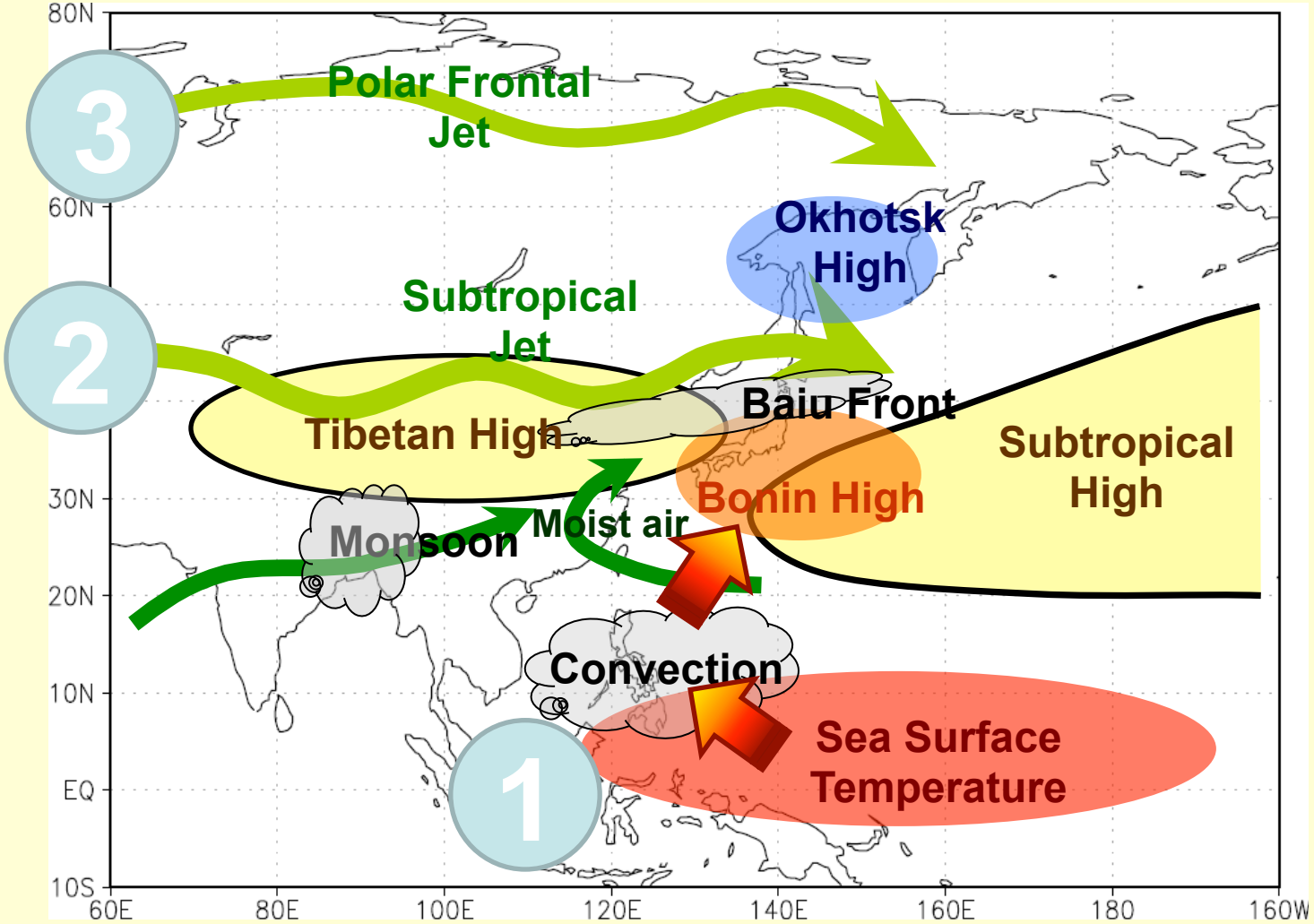
Enomoto et al. (2003), Enomoto (2004), Sato and Takahashi (2006), Kosaka et al. (2009)
cf. Circumglobal teleconnection; Branstator (2002), Ding and Wang (2005), Watanabe (2009)



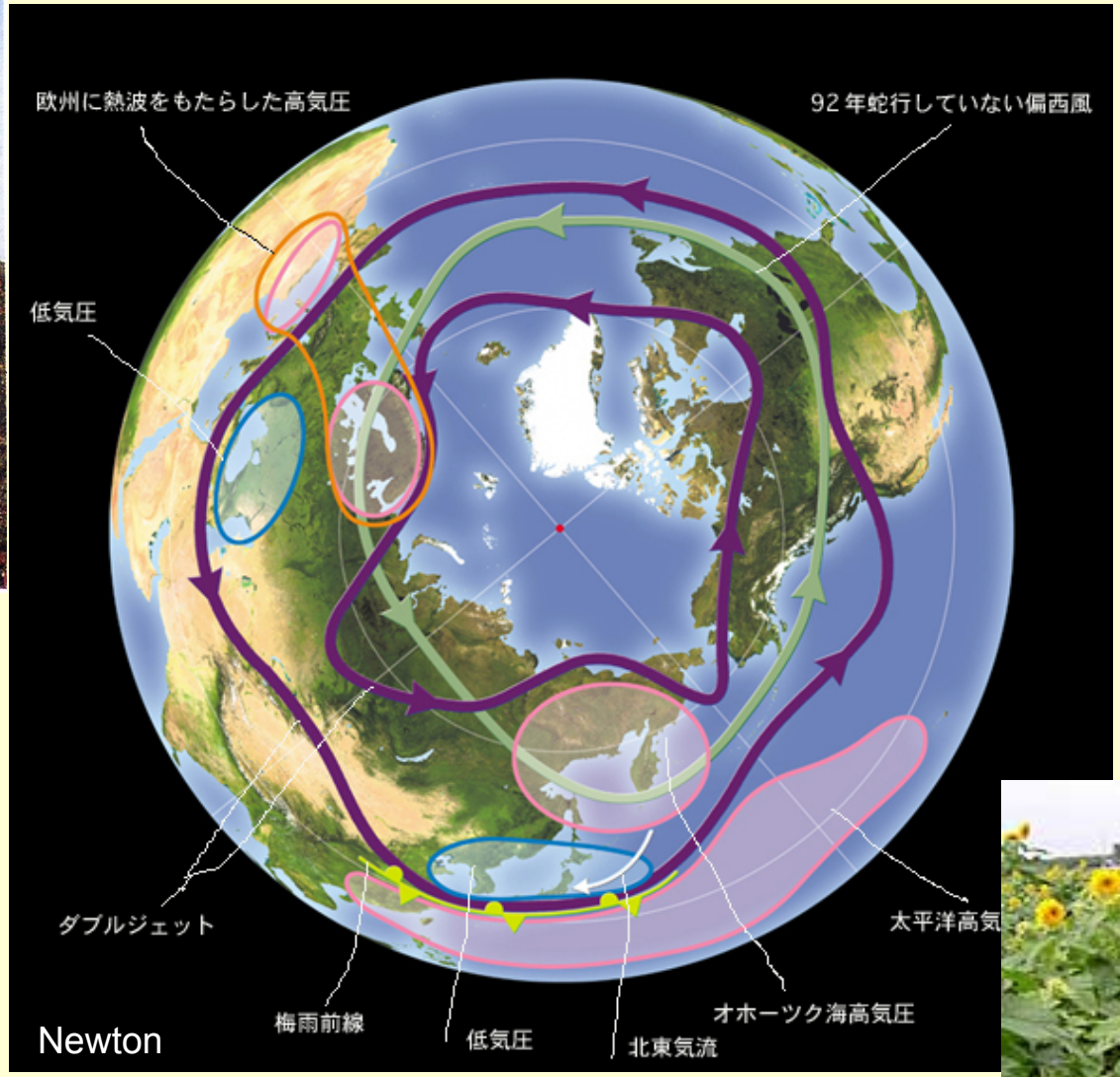
7.21 – 7.25

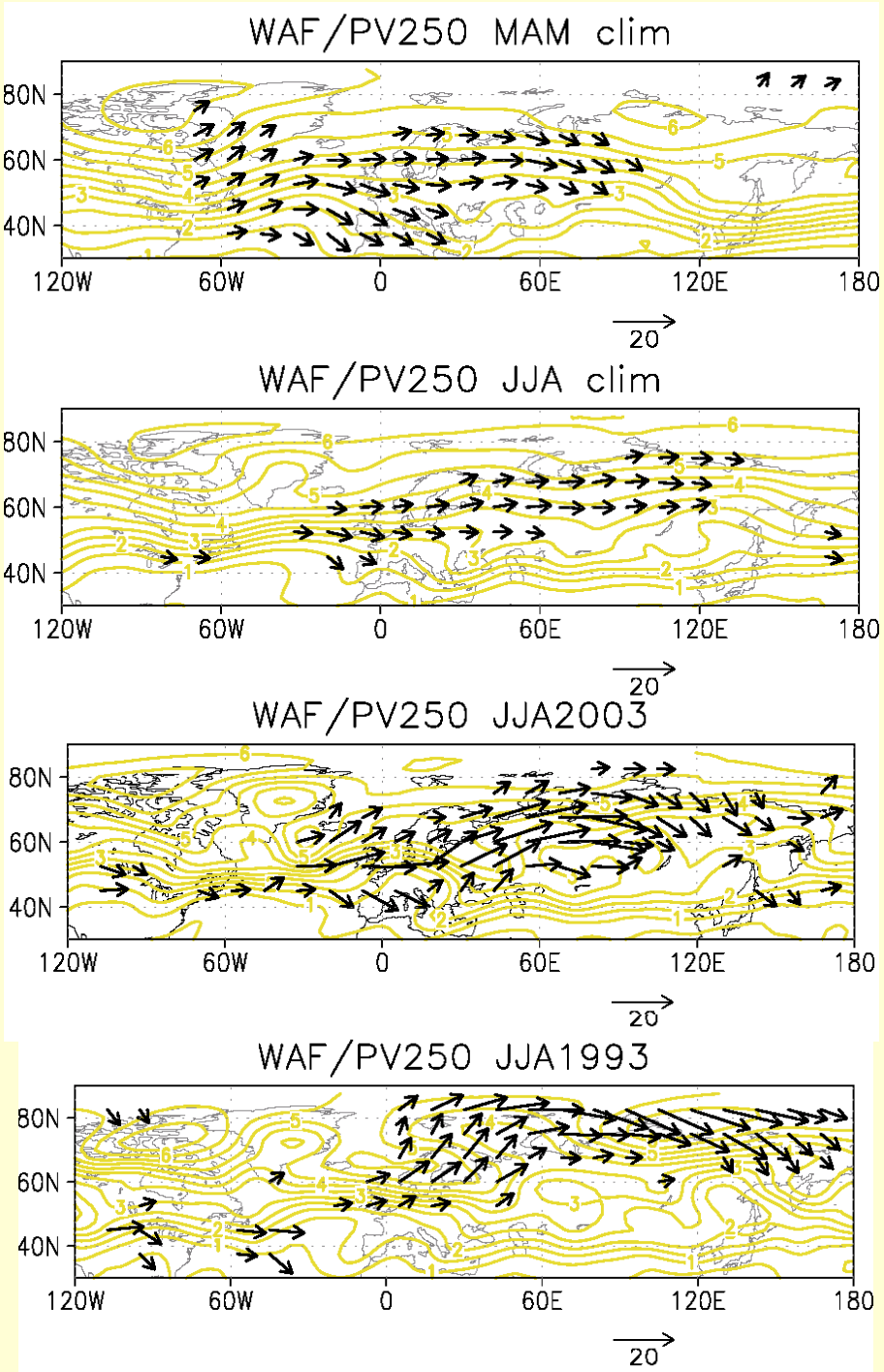

80N
60N
40N
20N
EQ
20S
40S
60S
80S
30W
0
30E
60E
90E
120E
150E
180
150W
120W
90W
60W
−70 −50 −30 −15 15 30 50 70
vect_min=10
50

Factors affecting East Asian Summer Climate



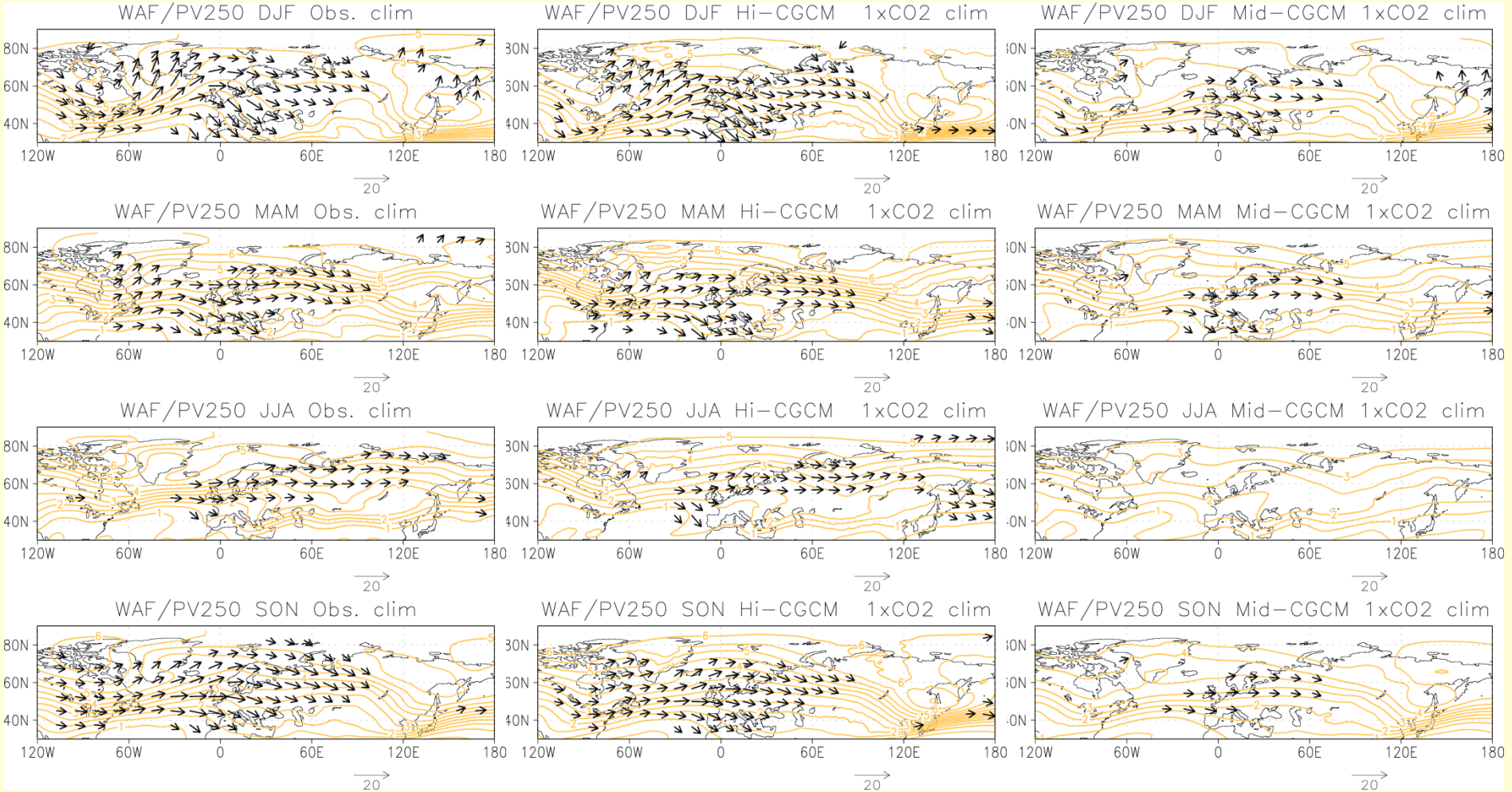
European Heat Wave and Japanese Cold Summer 2003




WAF/PV250 MAM clim
80N
60N
40N
120W
60W
0
60E
120E
180
20
WAF/PV250 JJA clim
80N
60N
40N
120W
60W
0
60E
120E
180
20
WAF/PV250 JJA2003
80N
60N
40N
120W
60W
0
60E
120E
180
20
WAF/PV250 JJA1993
80N
60N
40N
120W
60W
0
60E
120E
180
20

Seasonal Cycle of
PV & Monthly-Eddy Wave Activity Flux at 250hPa

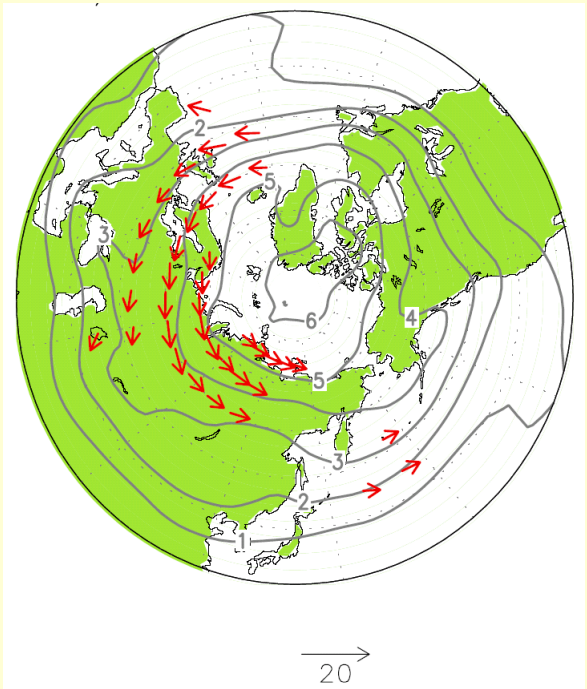
ERA40 | Hi-CGCM | Mid-CGCM

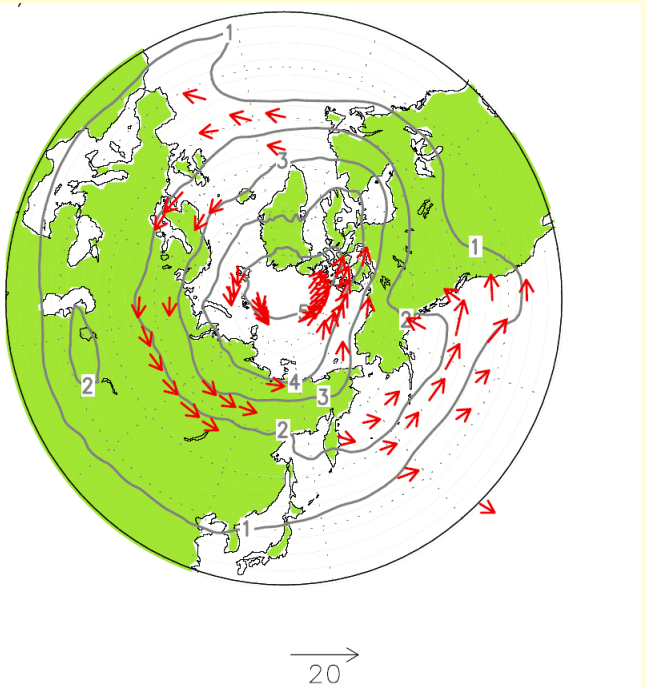


Obs.

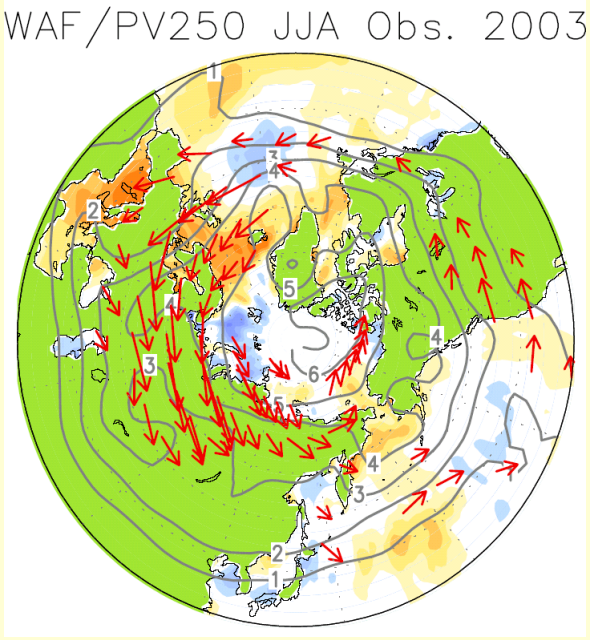
AGCM

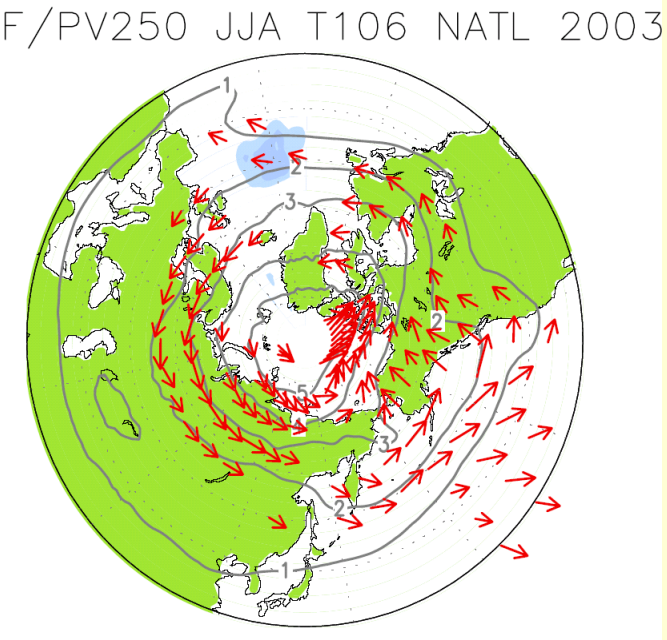
Clim.





2003

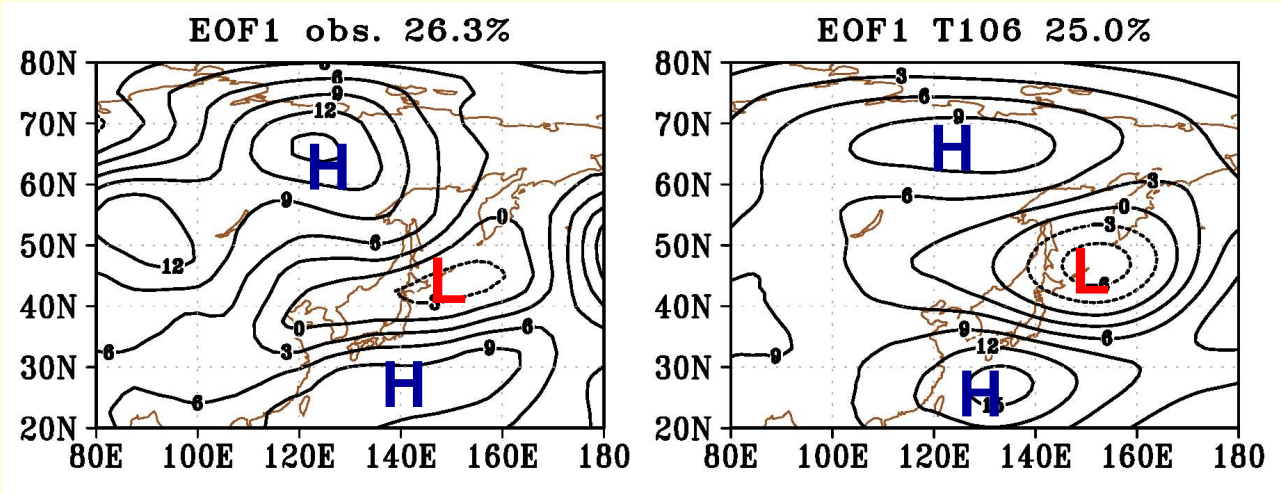


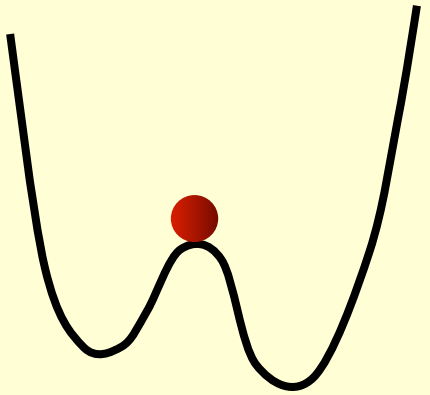


Natural variability

Observed

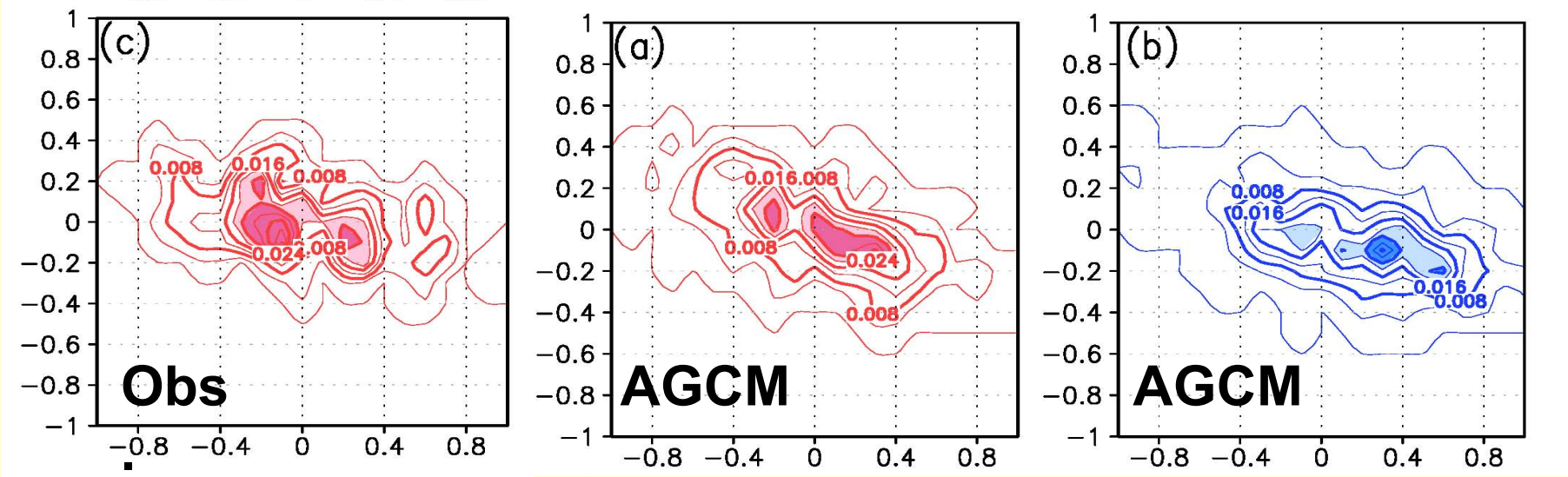
Simulated





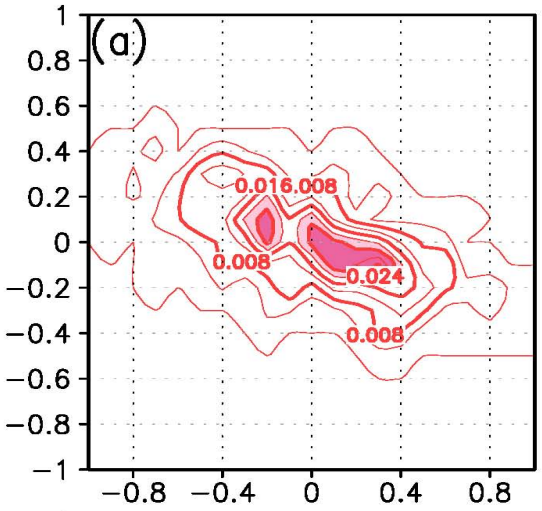
Present Climate

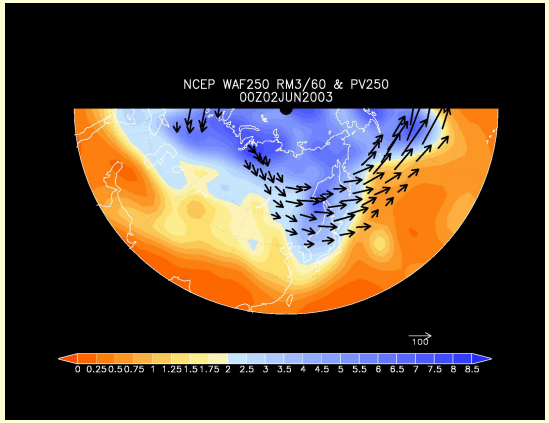
2xCO2

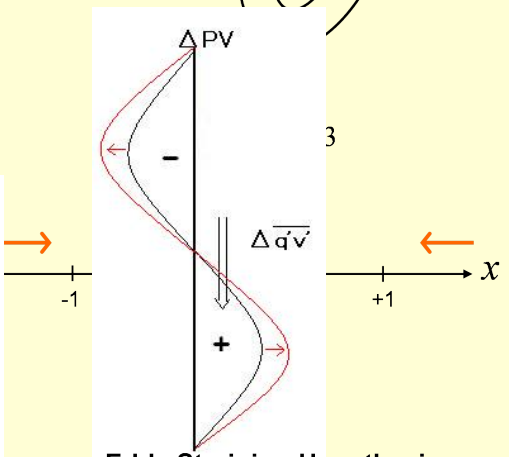


Arai and Kimoto (2007)

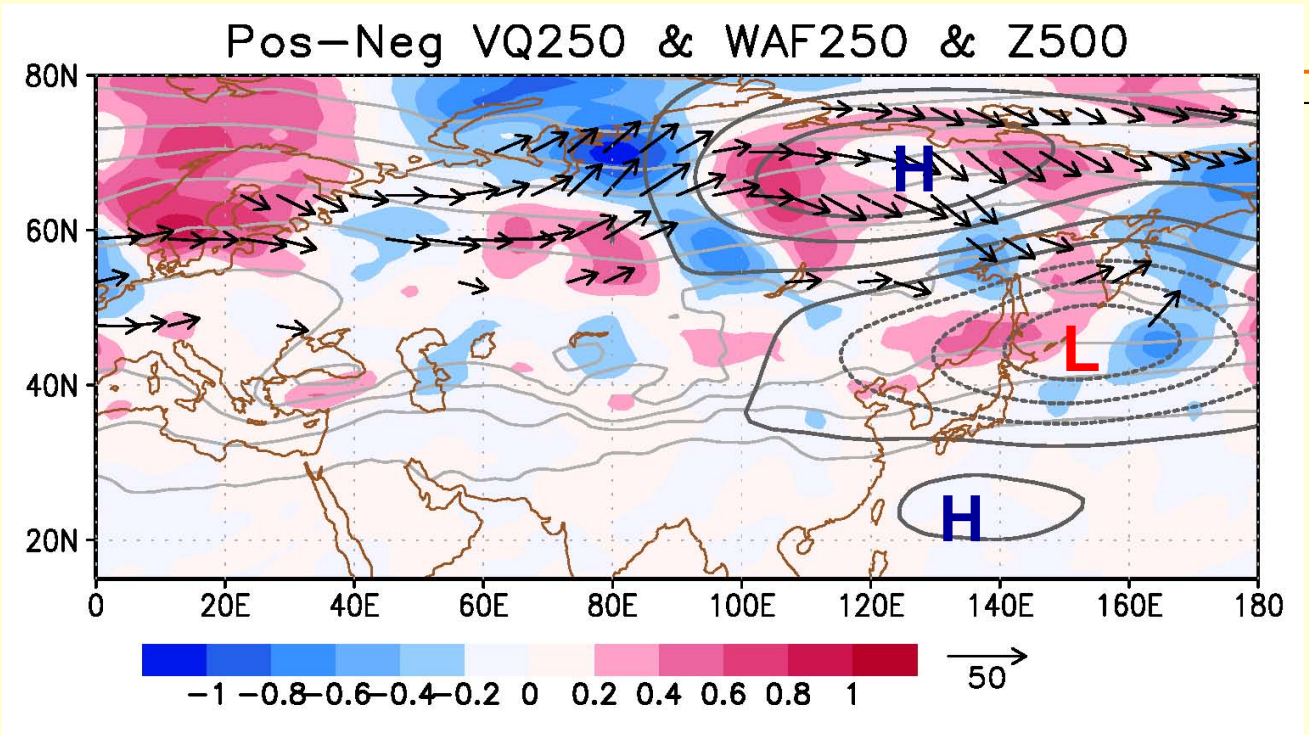
A Rossby-Eddy Straining Hypothesis

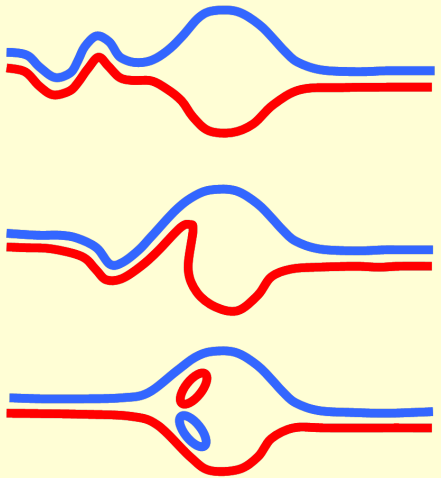






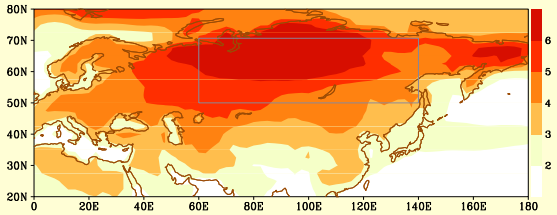
Eddy Straining Hypothesis

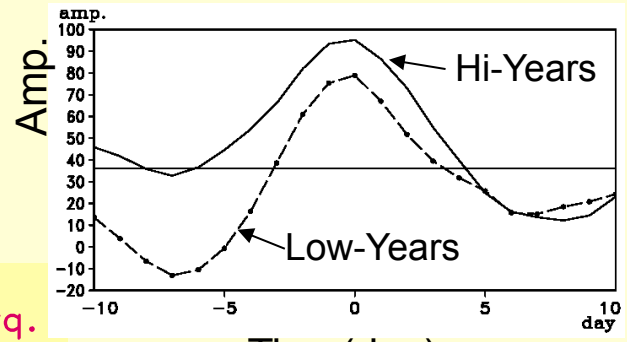




Arai and Kimoto (2008)

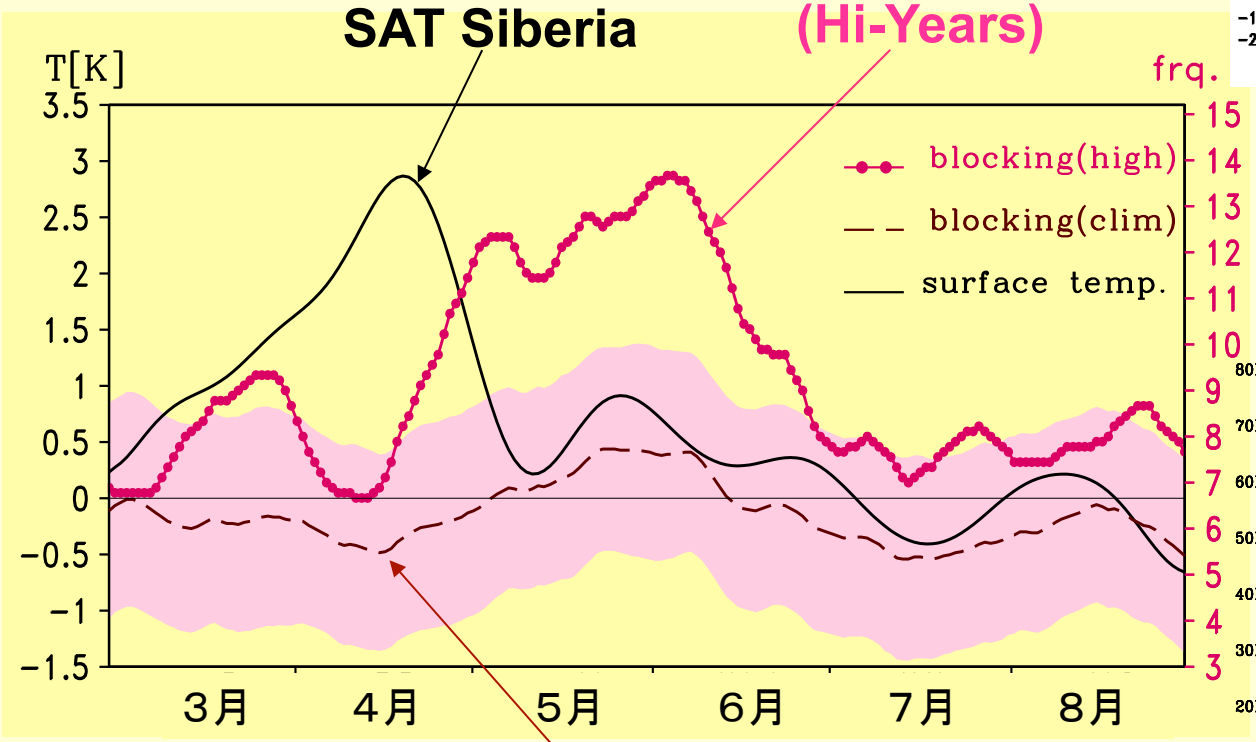
Apr. SAT affecting early summer blocking activity over East Siberia

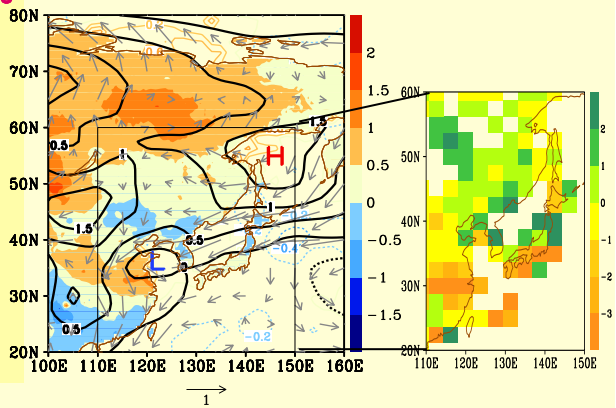




SAT Siberia

Blocking Freq. (Hi-Years)

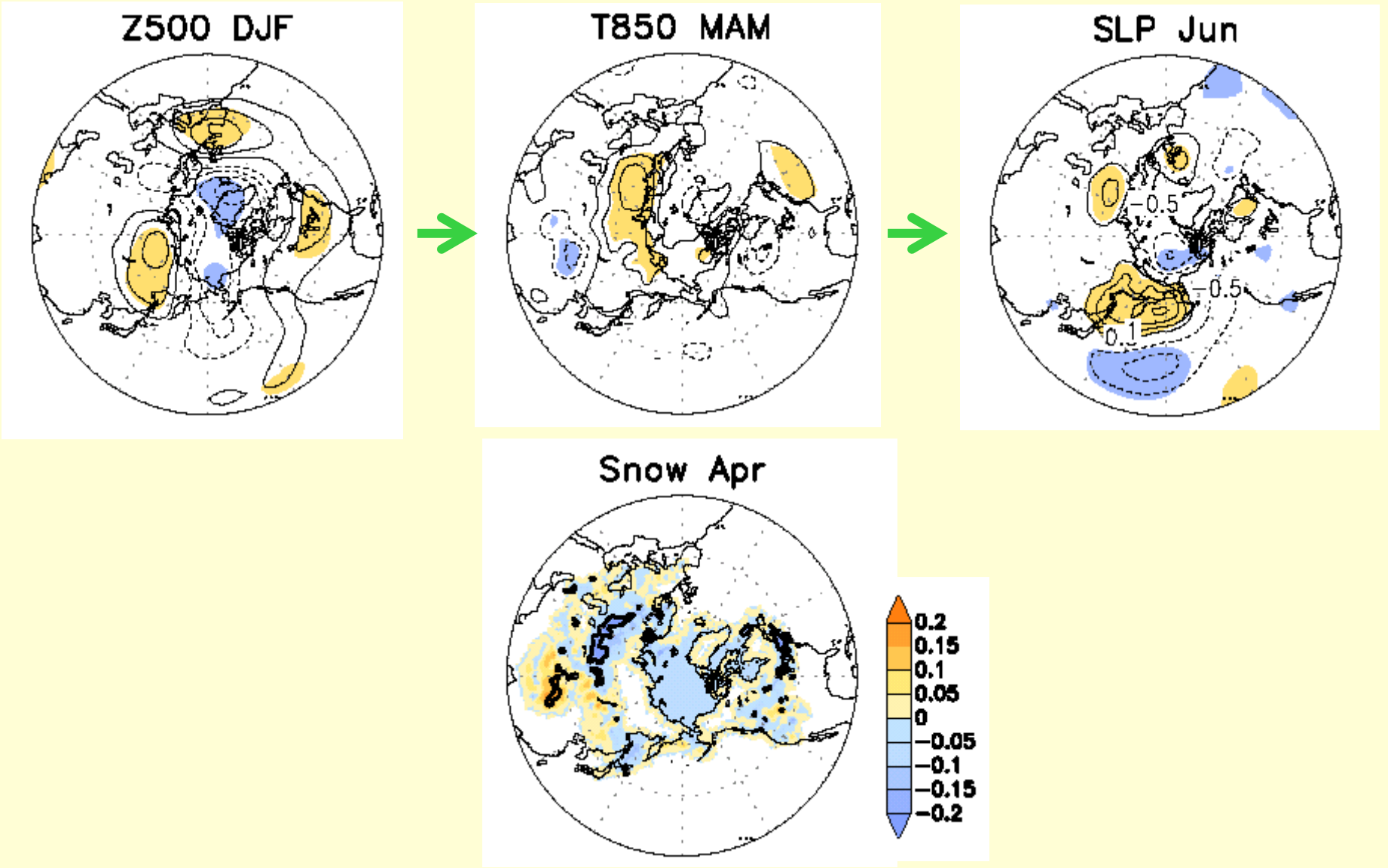




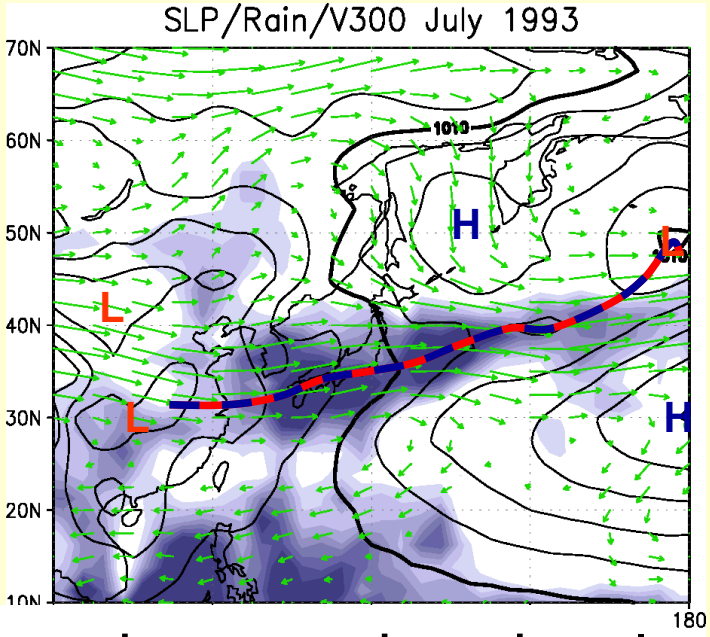
Blocking Freq. (Climatology)

Arai and Kimoto (2005)

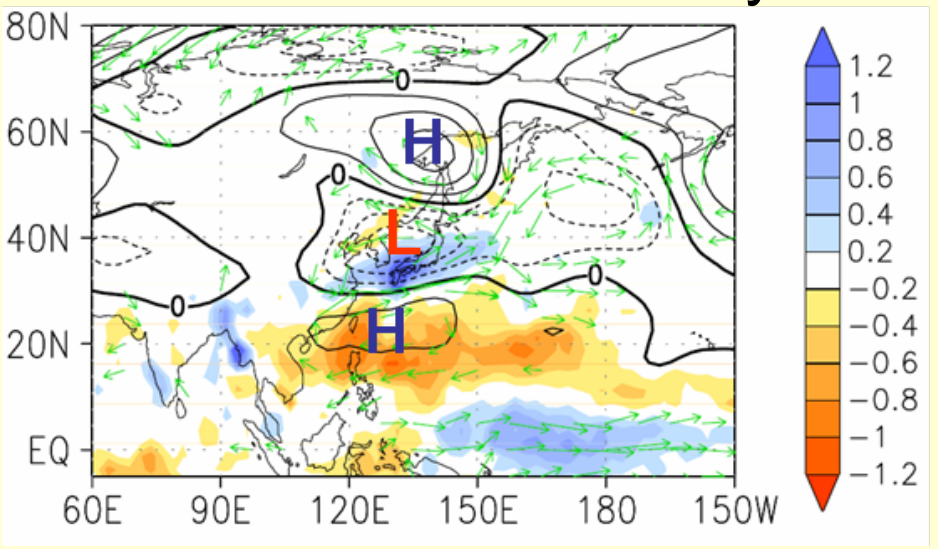
From Winter NAO to Early Summer Okhotsk High



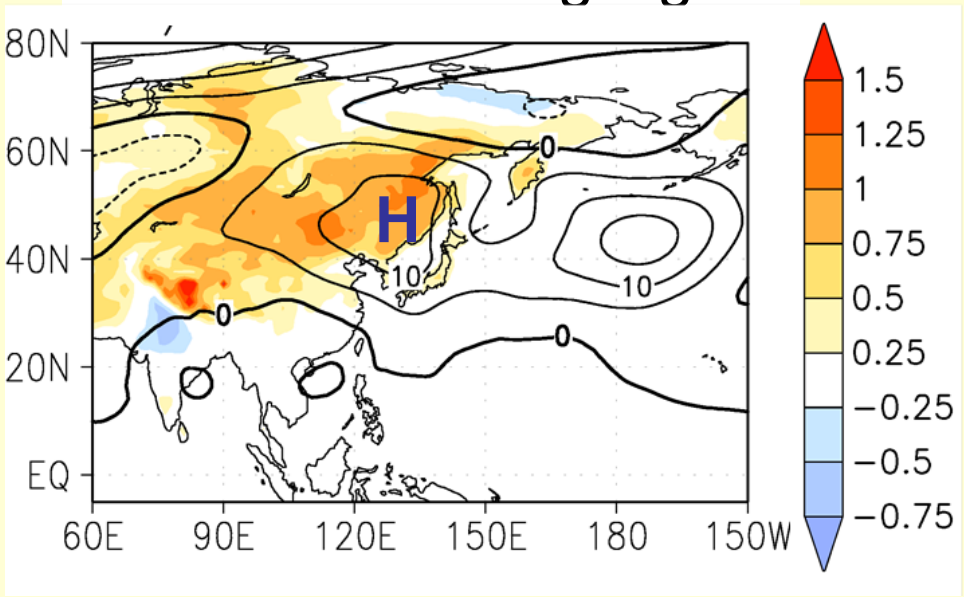
Tripolar pattern of E-Asian summer



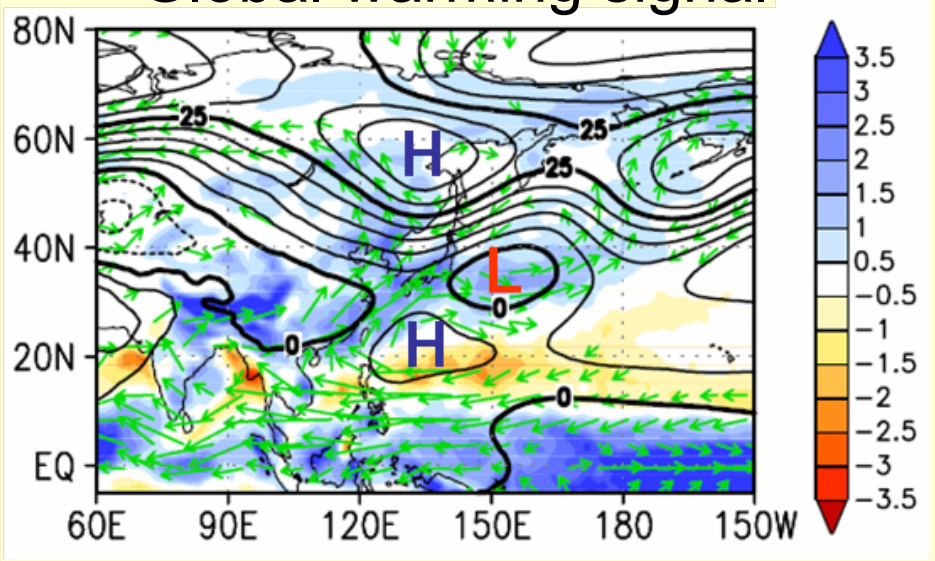
Interannual variability



Eurasian warming signal



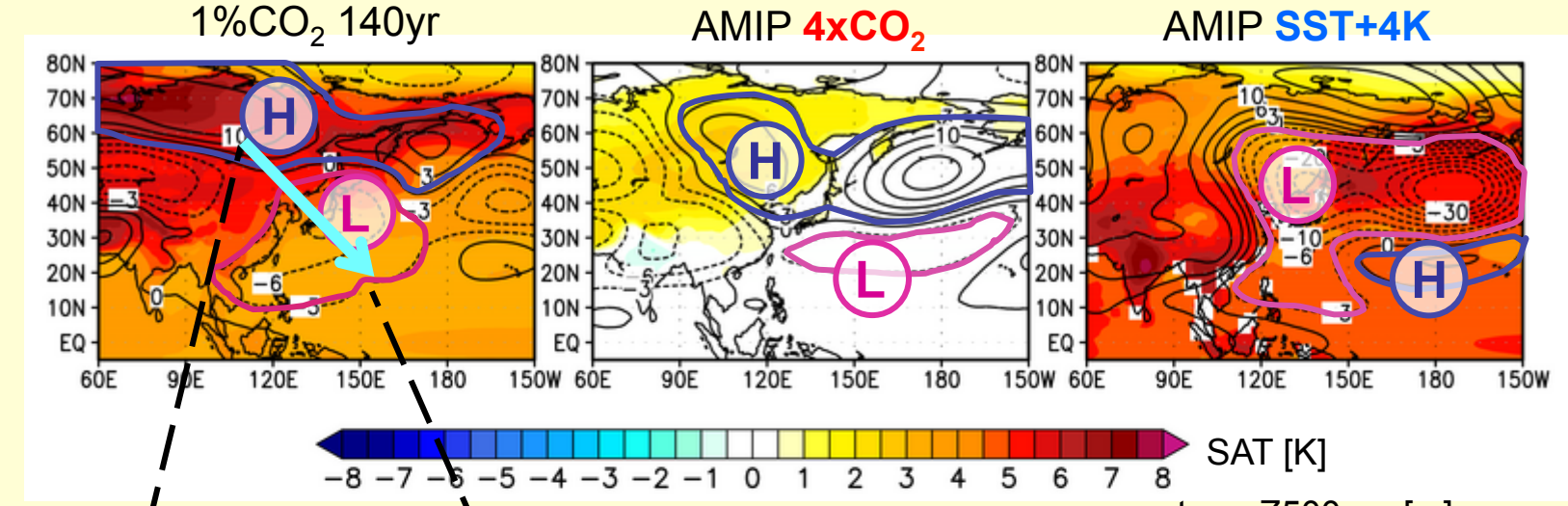
Global warming signal



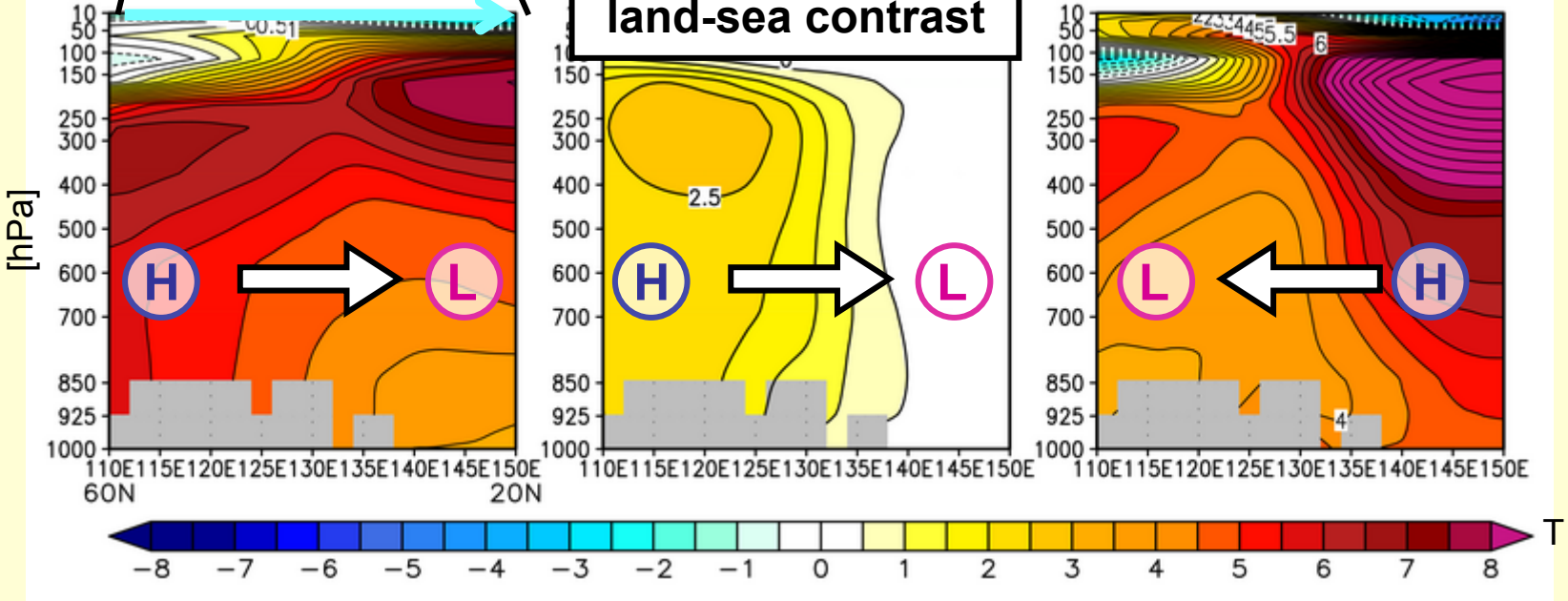
Kimoto (2005)

East Asian Summer

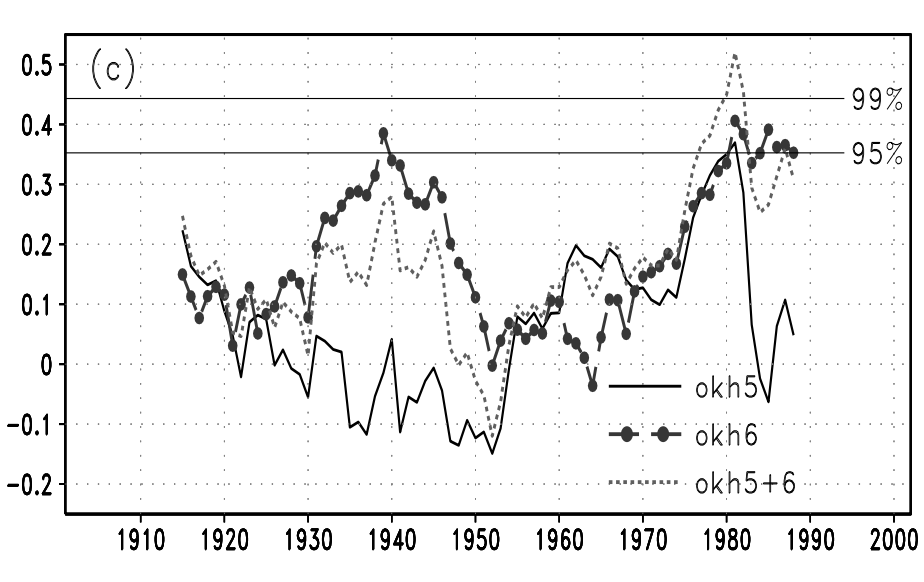
CMIP5 MME (9 models)



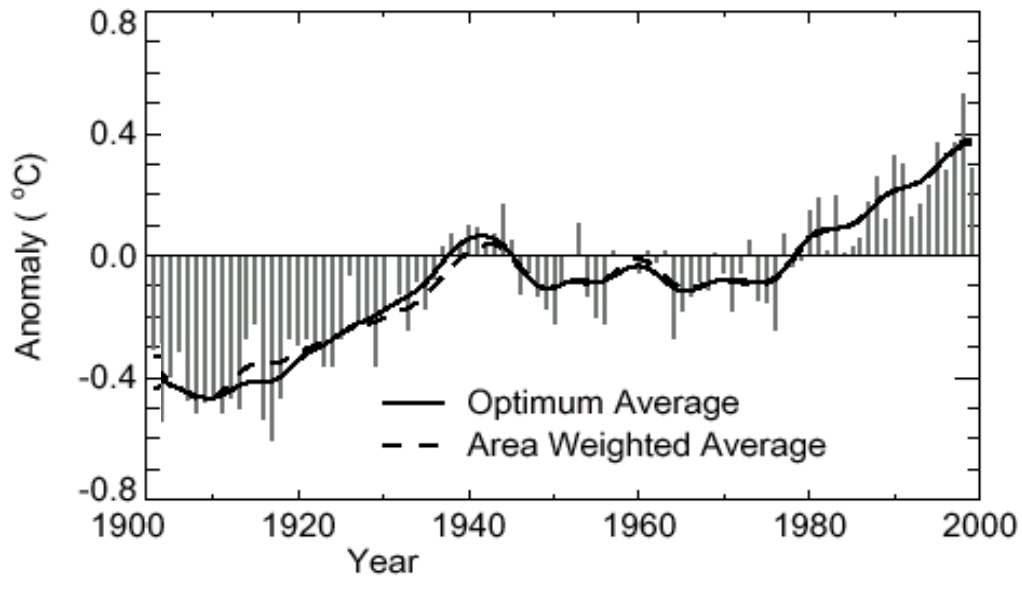
CO_2-induced land-sea contrast



Correlation between springtime surface temperature anomaly over northern Siberia and Okhotsk High in May/June



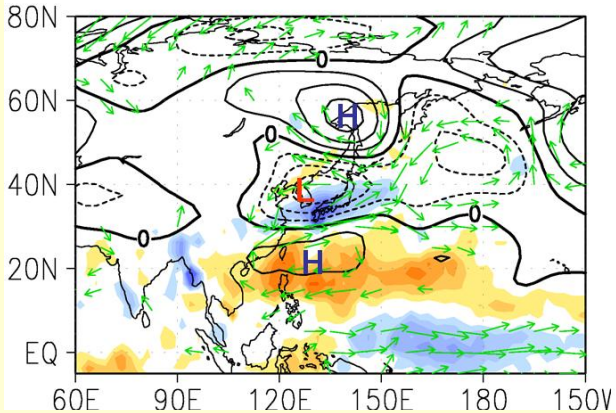
Global annual mean surface air temperature



Arai and Kimoto (2007)

Summary

- A tripolar pattern of East Asian summer monsoon variability
  - Subtropical high/Baiu rainband/
  - Okhotsk high
  - Moist neutral mode (?)



- Excitation/triggering
  - Tropical SST/subtropical convection
  - Rossby waves through subtropical jet
  - Rossby waves through polar-frontal jet/Siberian land surface influence
  - Global warming signal as shifted PDF of natural variability (?)