Regional Climate Studies in East Asia

At Climate Dynamics Lab./ASNTU

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National Taiwan university

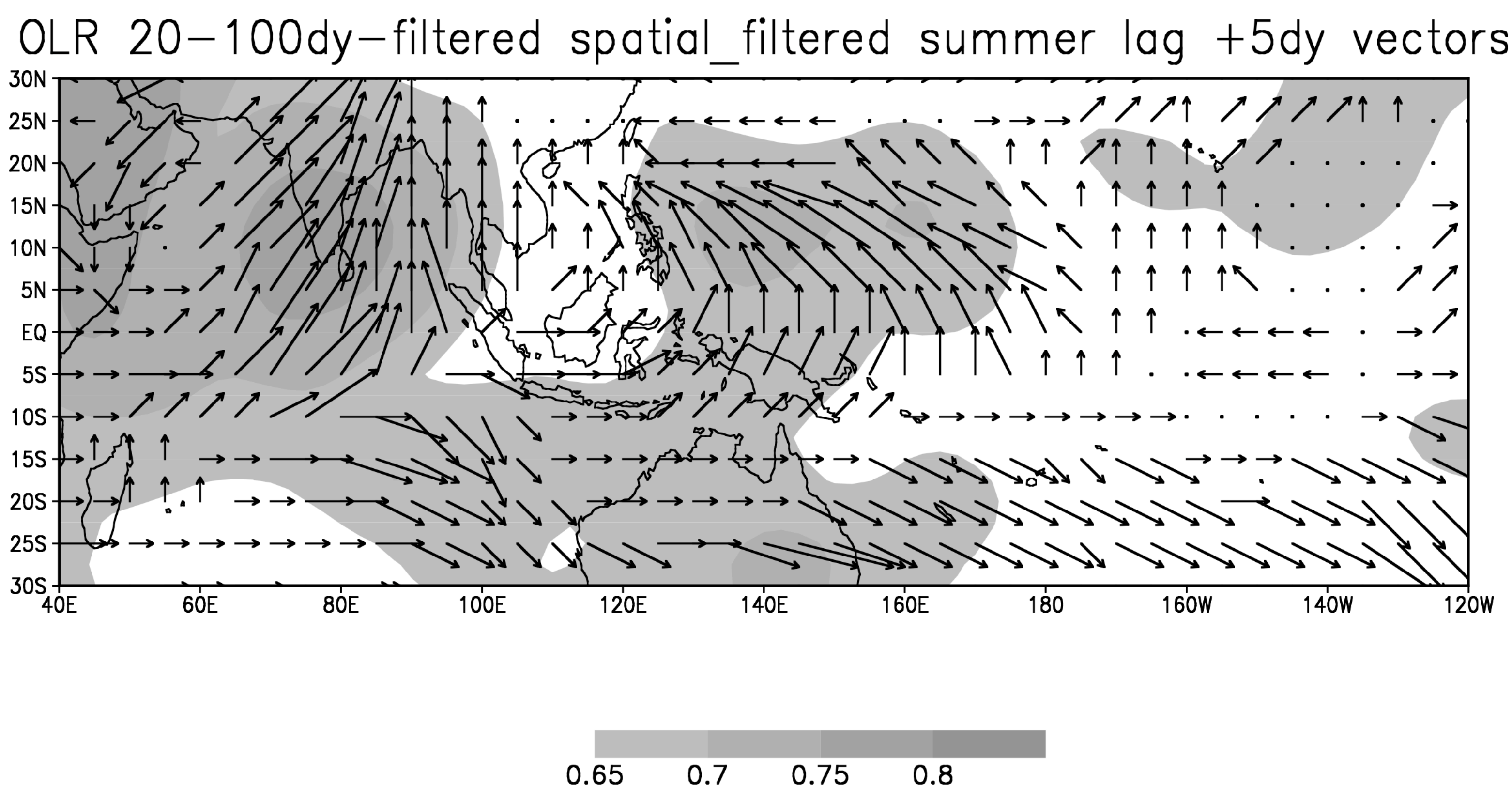
Part I: ISO vs. East Asian summer monsoon onset and TC

Part II: Interannual variability of summer rainfall

Part III: Regional Climate Simulation

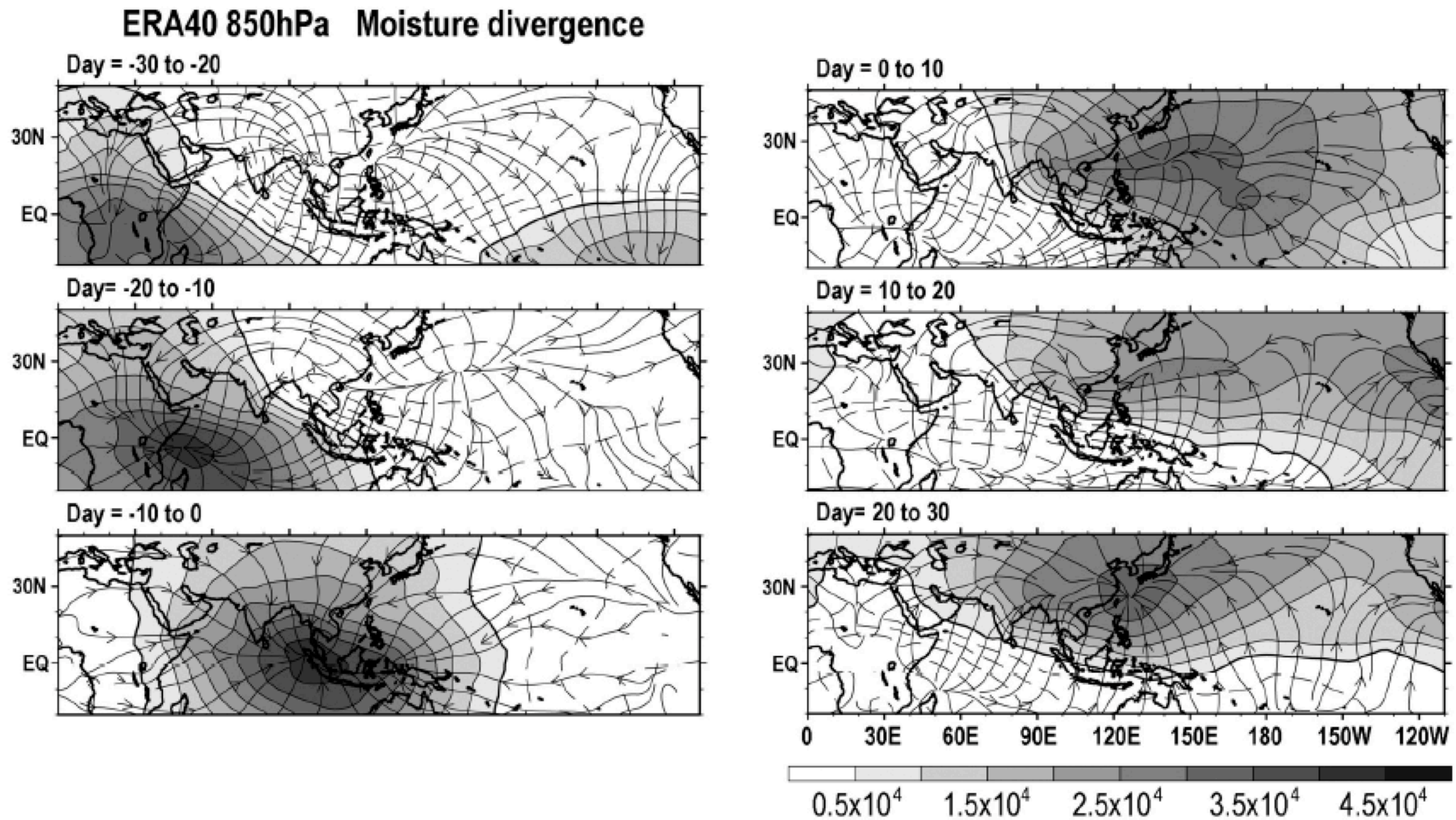
Climate Dynamics Laboratory
http://hsu.as.ntu.edu.tw

Propagation tendency of ISO (April to October)



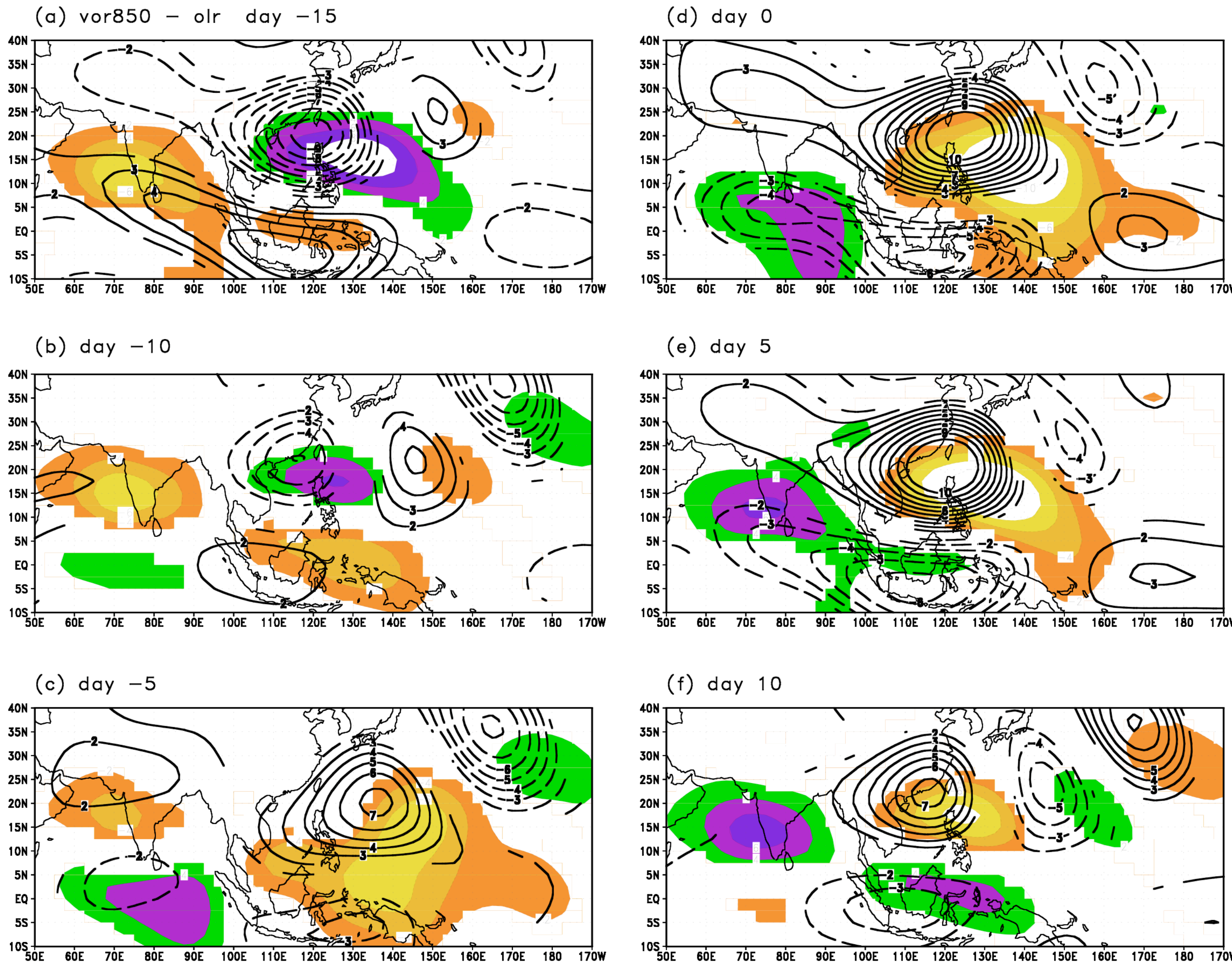
EA summer monsoon onset is strongly affected by MJO in some years

C.-W. Hung and H.-H. Hsu (2005)

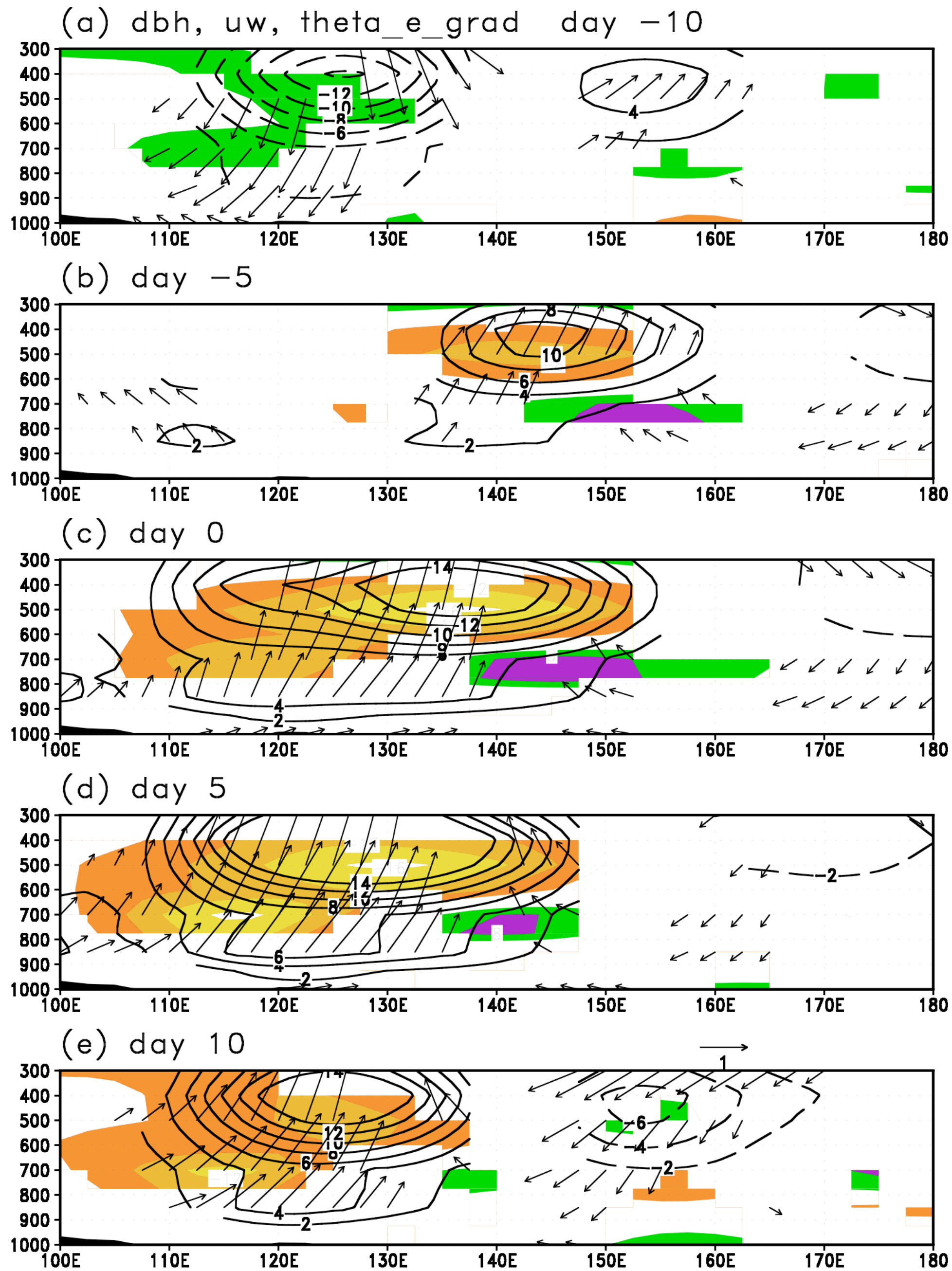


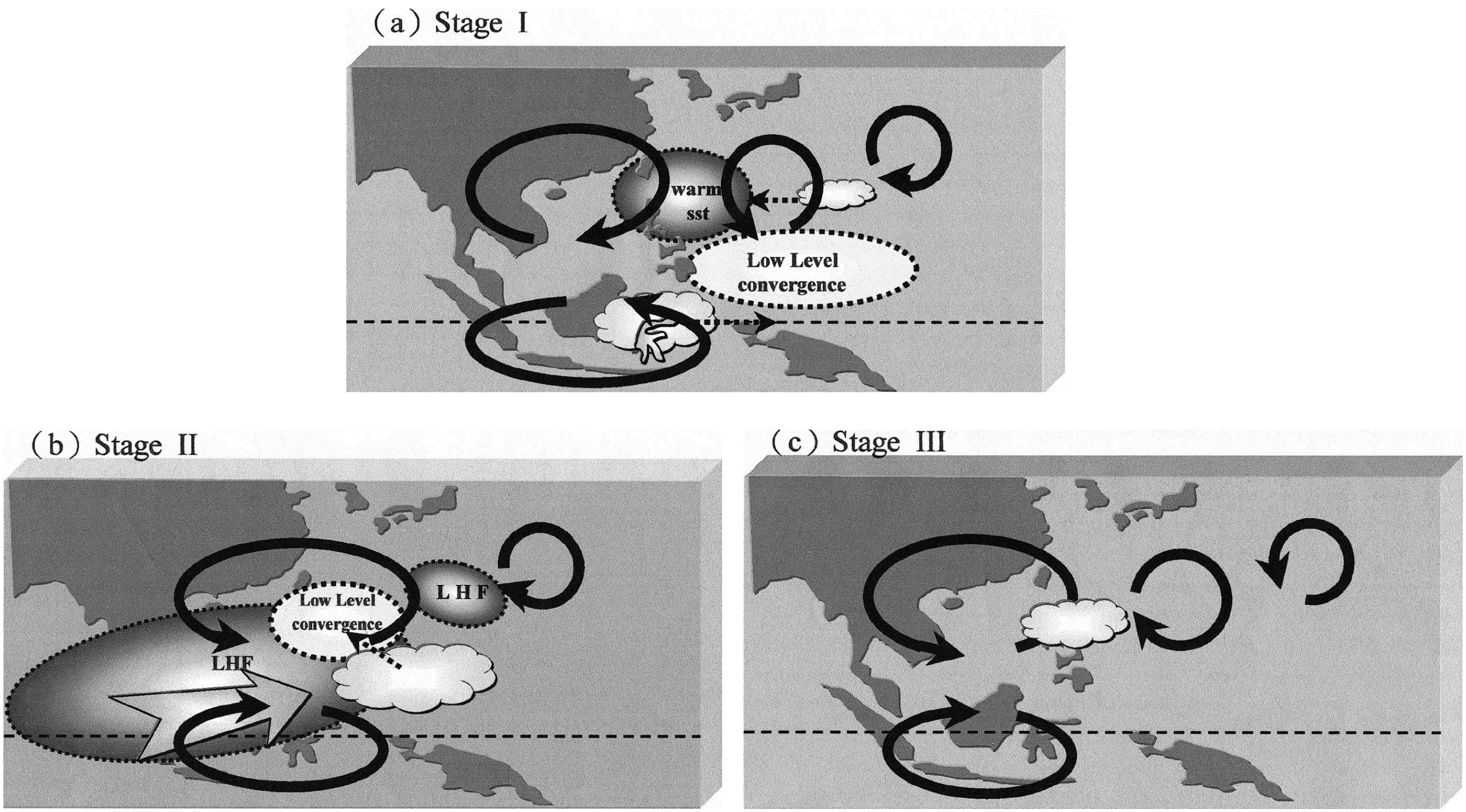
Intraseasonal Oscillation in the Western North Pacific during Northern Summer

H.-H. Hsu and C.-H. Weng (2001)



(a) vor850 – olr day –15
(b) day –10
(c) day –5
(d) day 0
(e) day 5
(f) day 10
40N
35N
30N
25N
20N
15N
10N
5N
EQ
5S
10S
50E
60E
70E
80E
90E
100E
110E
120E
130E
140E
150E
160E
170E
180
170W


(a) dbh, uw, theta_e_grad day −10
(b) day −5
(c) day 0
(d) day 5
(e) day 10
300
400
500
600
700
800
900
1000
100E
110E
120E
130E
140E
150E
160E
170E
180


(a) Stage I
warm
sst
Low Level
convergence
(b) Stage II
Low Level
convergence
L H F
LHF
(c) Stage III

Strong ISO-TC Coupling in 2004 Typhoon Season

H.-H. Hsu and Y.-L. Chen (2005)

- recruving tracks - 10 typhoon landfalls in Japan
- appearing in clusters

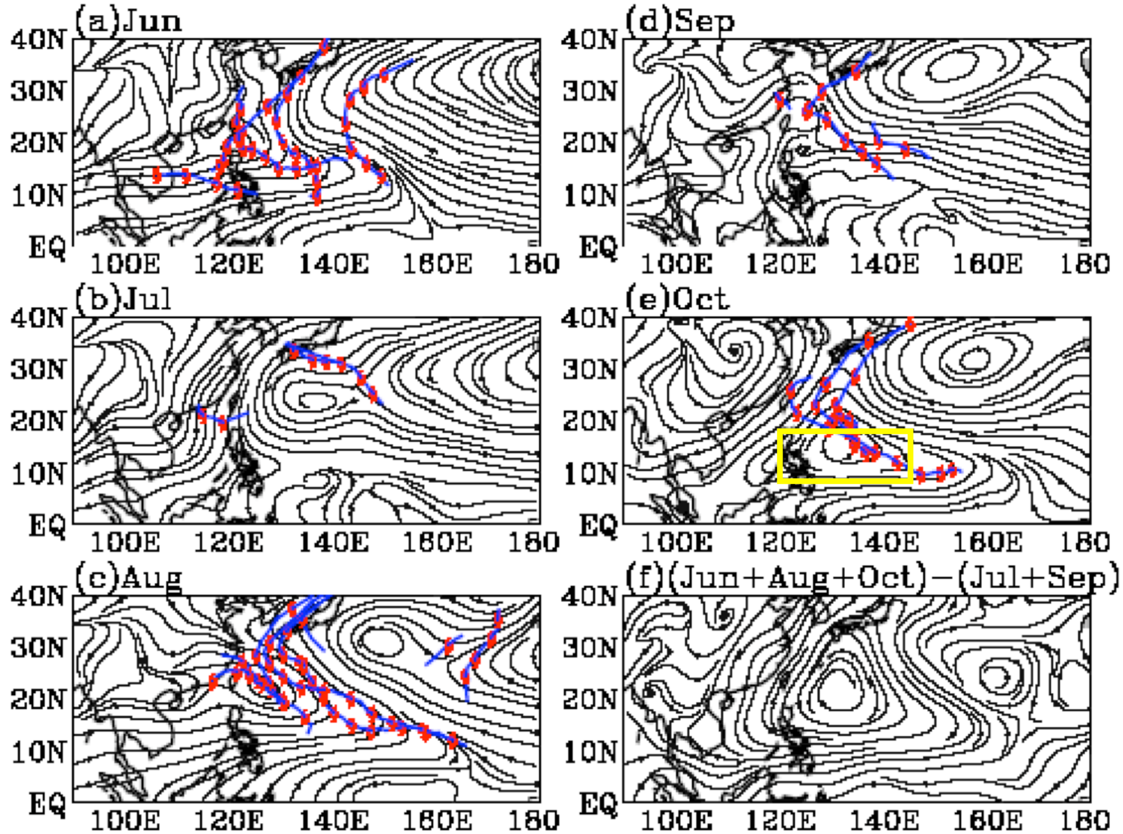
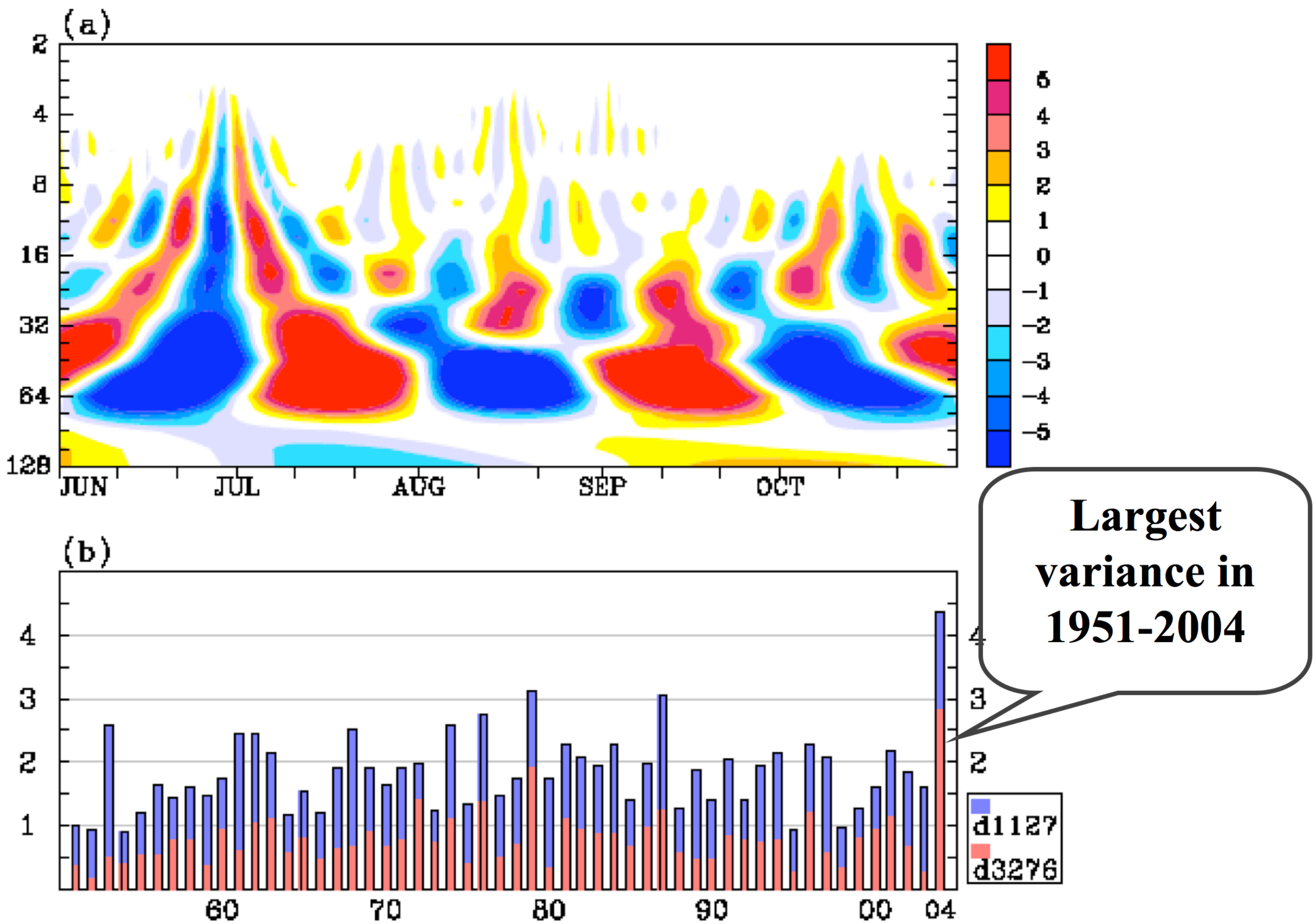


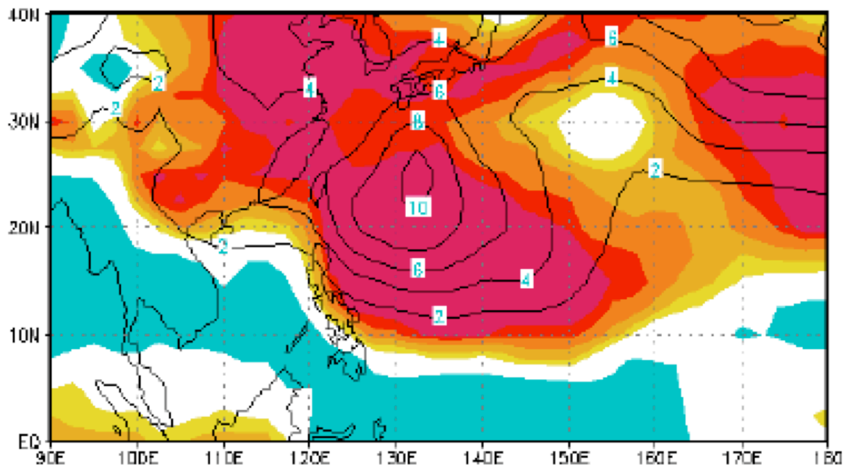
Figure 1. Monthly mean 850 hPa streamline and typhoon tracks from June to

monsoon trough index: MSLP (10N-20N, 120E-150E)

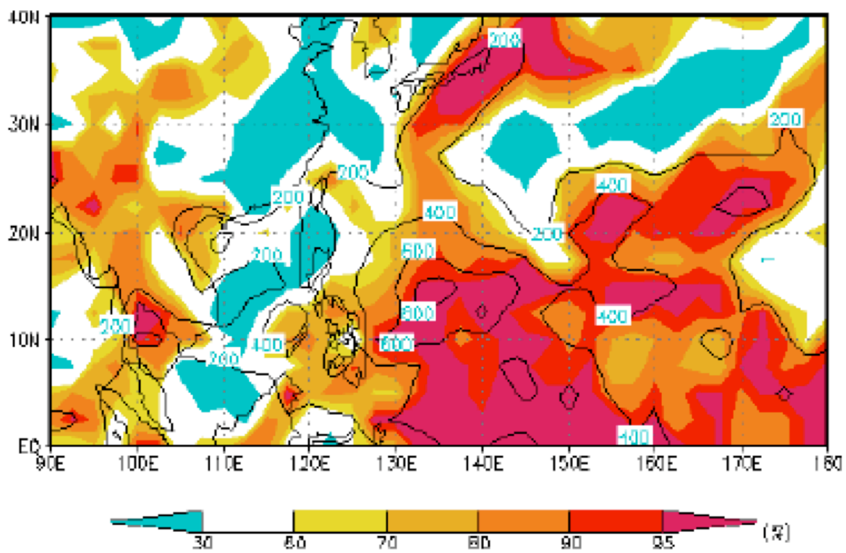


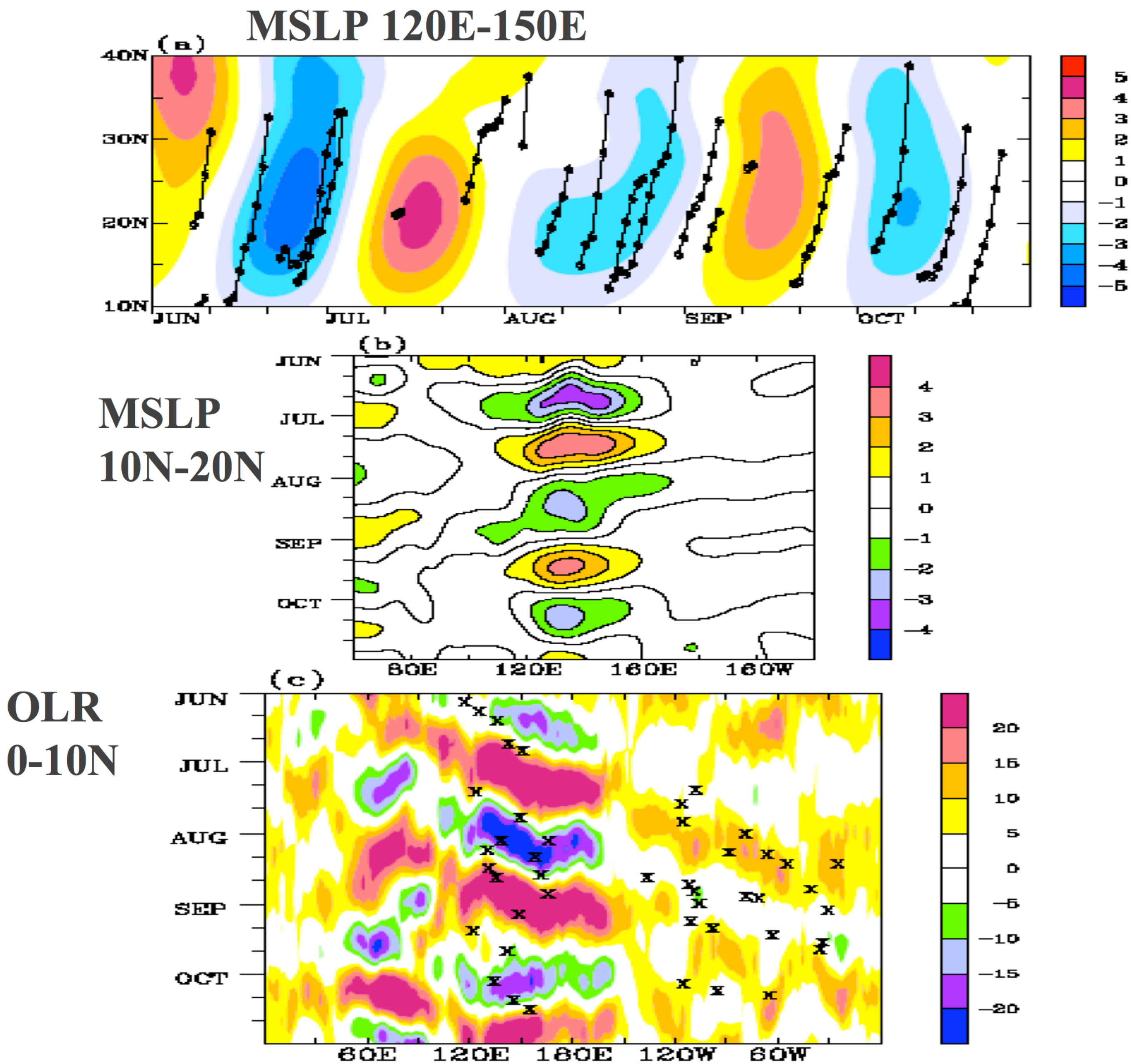
32-76-day variance and percentile in 2004

(a) MSLP



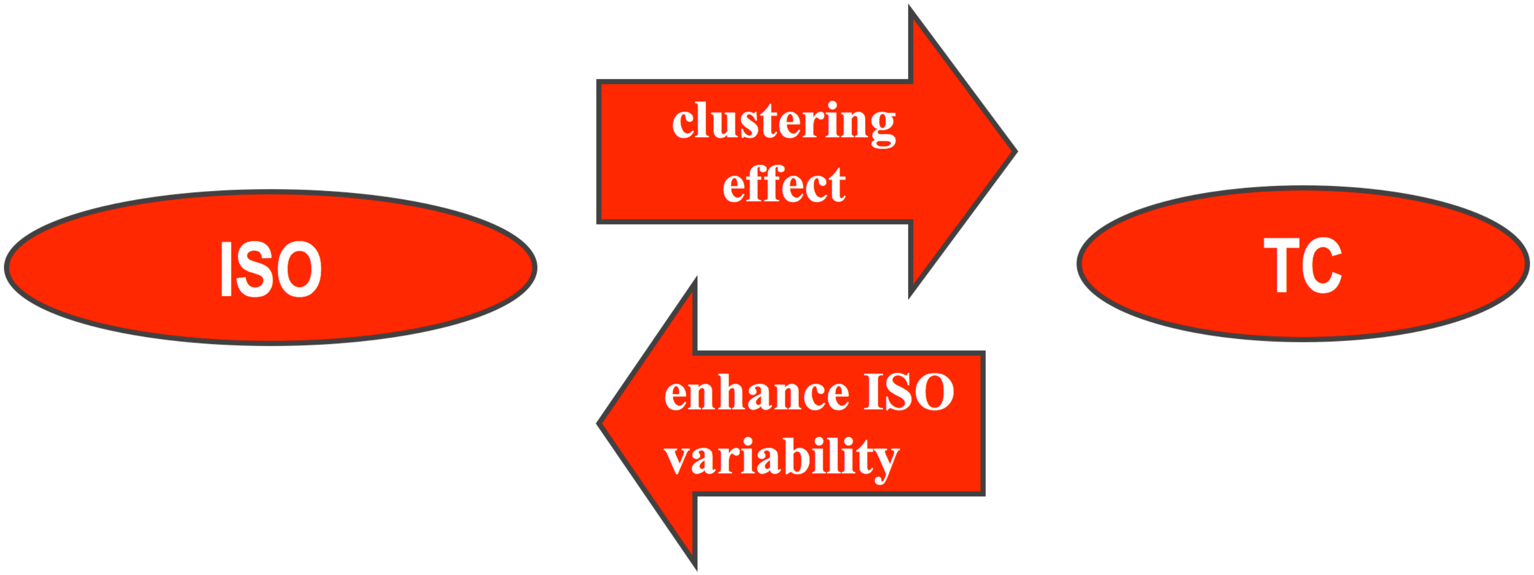
(b) OLR



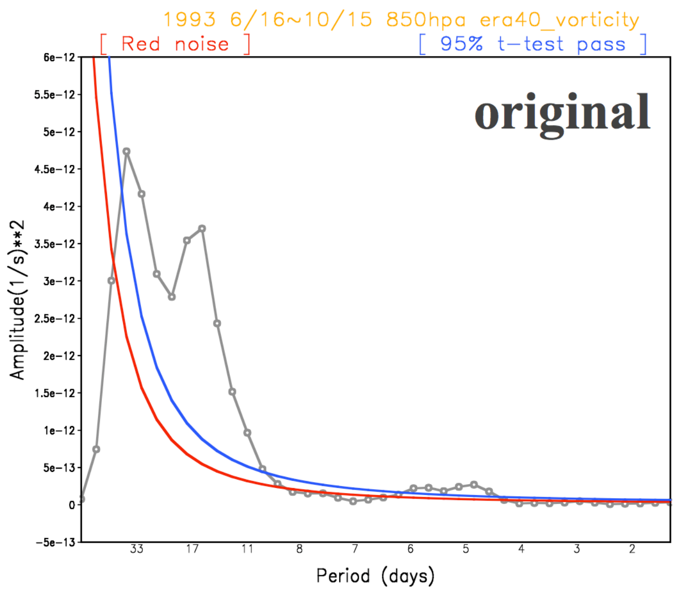

MSLP 120E-150E
(a)
40N
30N
20N
10N
JUN
JUL
AUG
SEP
OCT
5
4
3
2
1
0
−1
−2
−3
−4
−5
MSLP
10N-20N
(b)
JUN
JUL
AUG
SEP
OCT
80E
120E
160E
160W
4
3
2
1
0
−1
−2
−3
−4
OLR
0-10N
(c)
JUN
JUL
AUG
SEP
OCT
60E
120E
180E
120W
60W
20
15
10
5
0
−5
−10
−15
−20

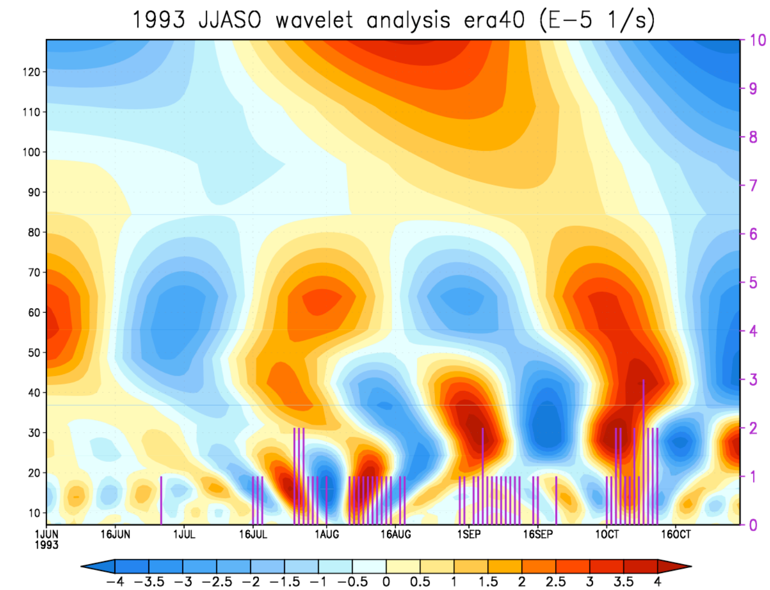
Interaction between ISO and TC

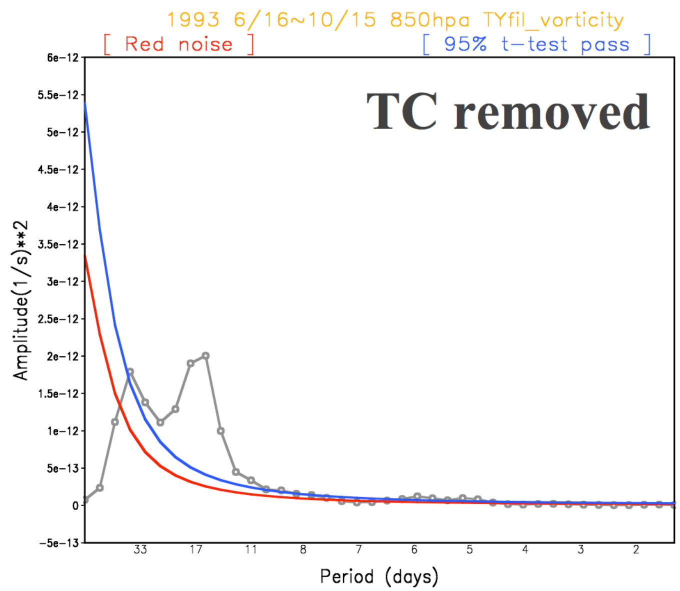
H.-H. Hsu, A.-K. Lo, and C.-C. Wu (2005)

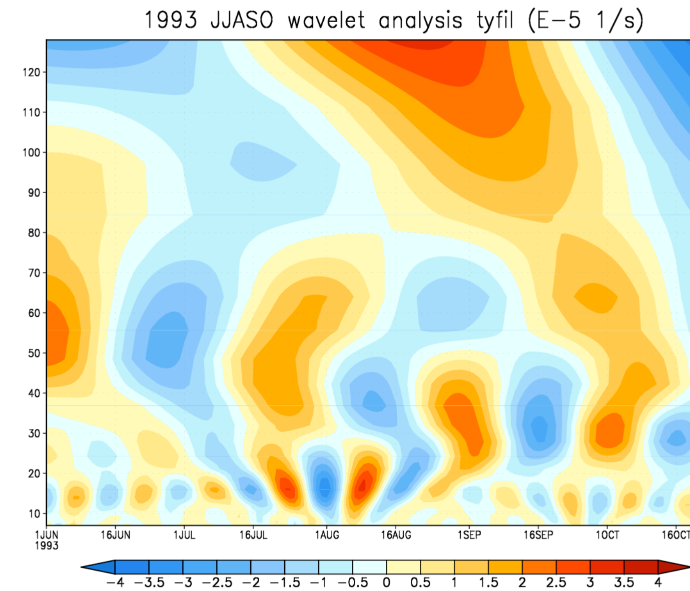


1993

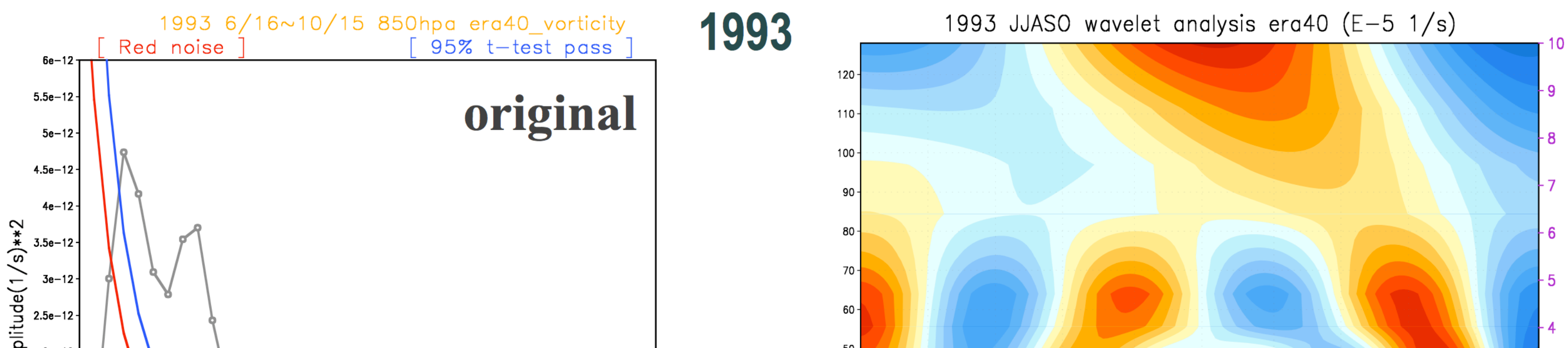




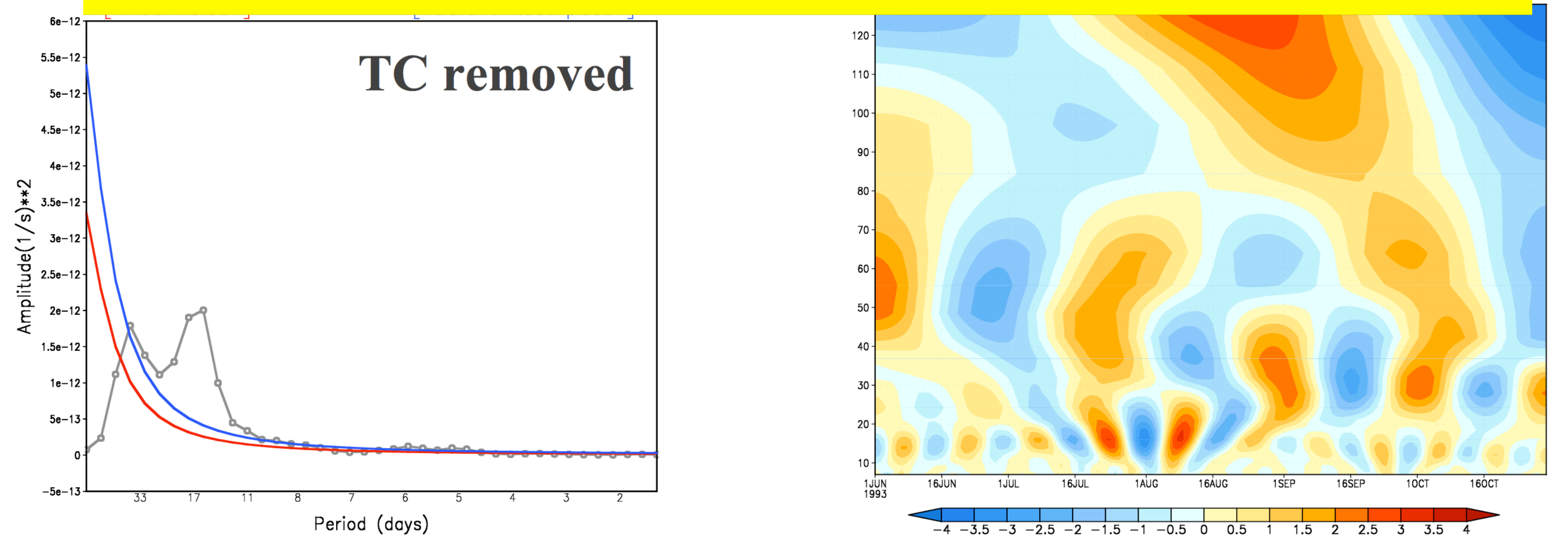




from: An-Kai Lo



TC activity contributes half of intraseasonal variance due to the clustering effect of ISO on TC.



from: An-Kai Lo

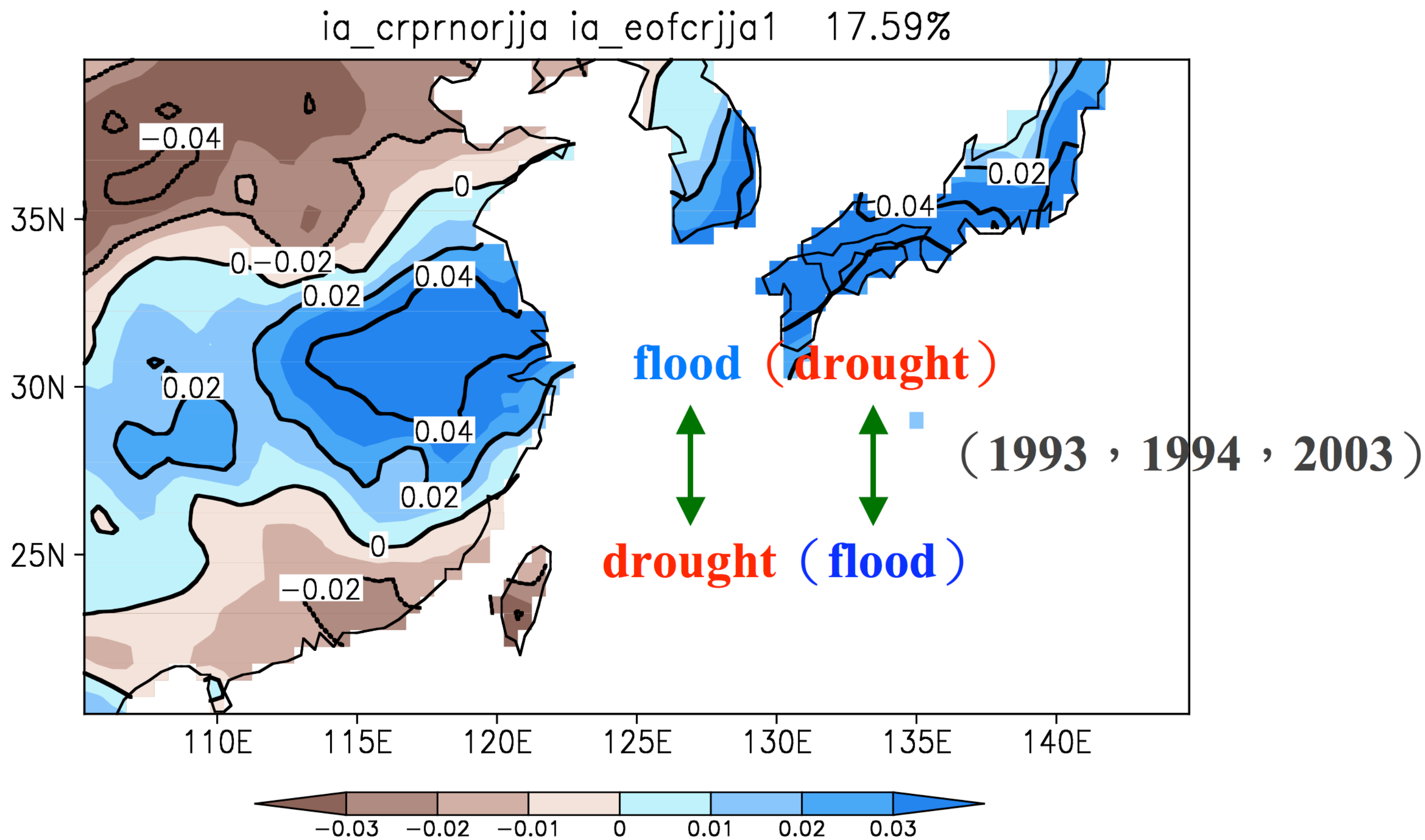
The 'Tri-pole Rainfall Pattern'

- Interannual Variability of East Asian Summer rainfall

H.-H. Hsu and S.-M. Lin (2005)

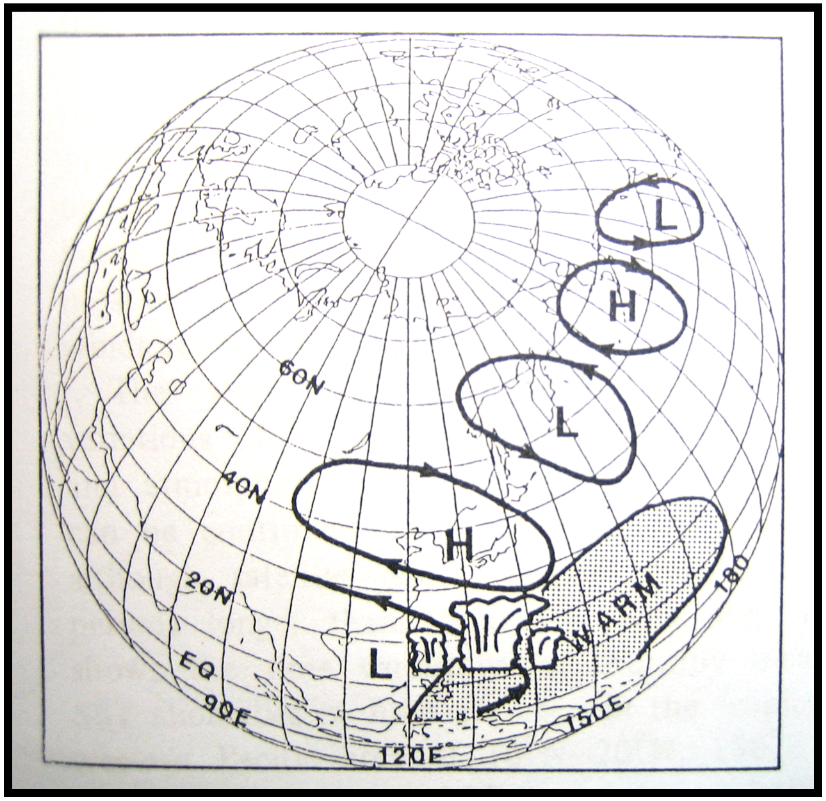
East Asia rainfall EOF1

- Explain 18% of summer rainfall variance
  Relatively wet in central China, Korea, and Japan
  dry in northern/southern China and Taiwan
- Negative phase: spatial pattern in opposite signs



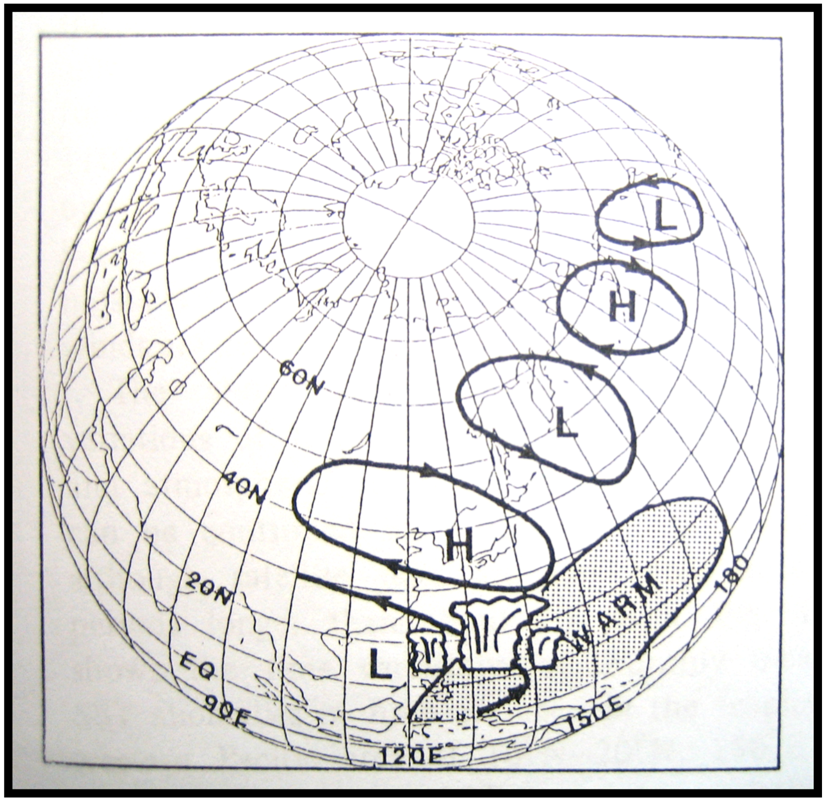
Nitta (1987) …

Pacific Japan Pattern



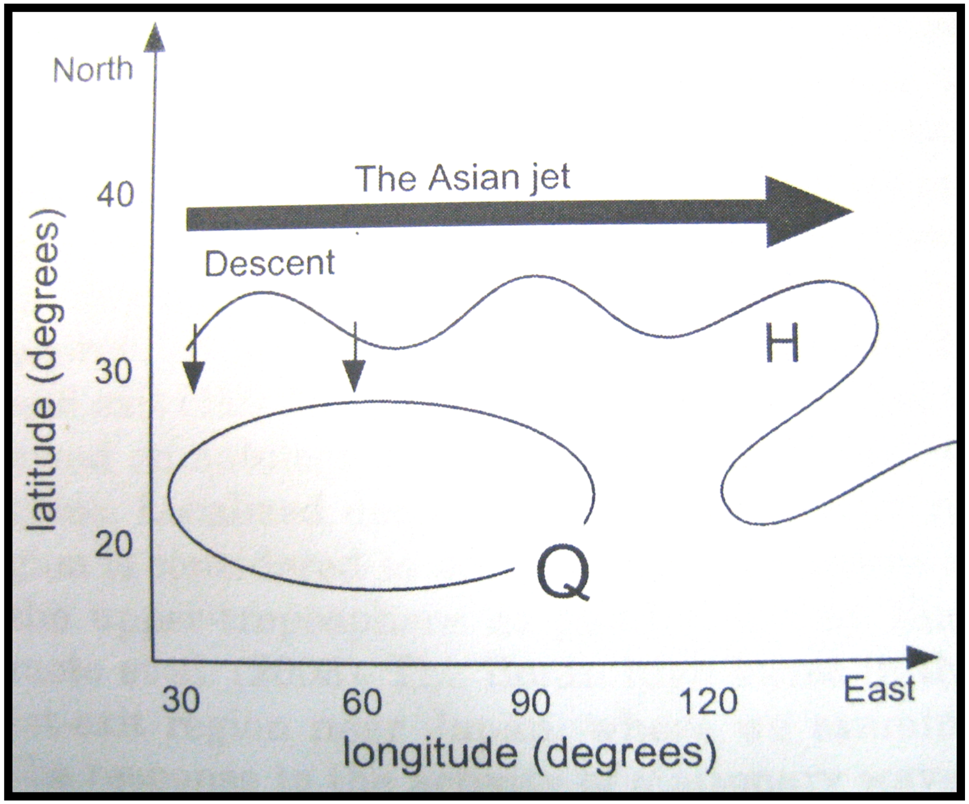
Nitta (1987) …

Pacific Japan Pattern



Enomoto et al. (2003) …

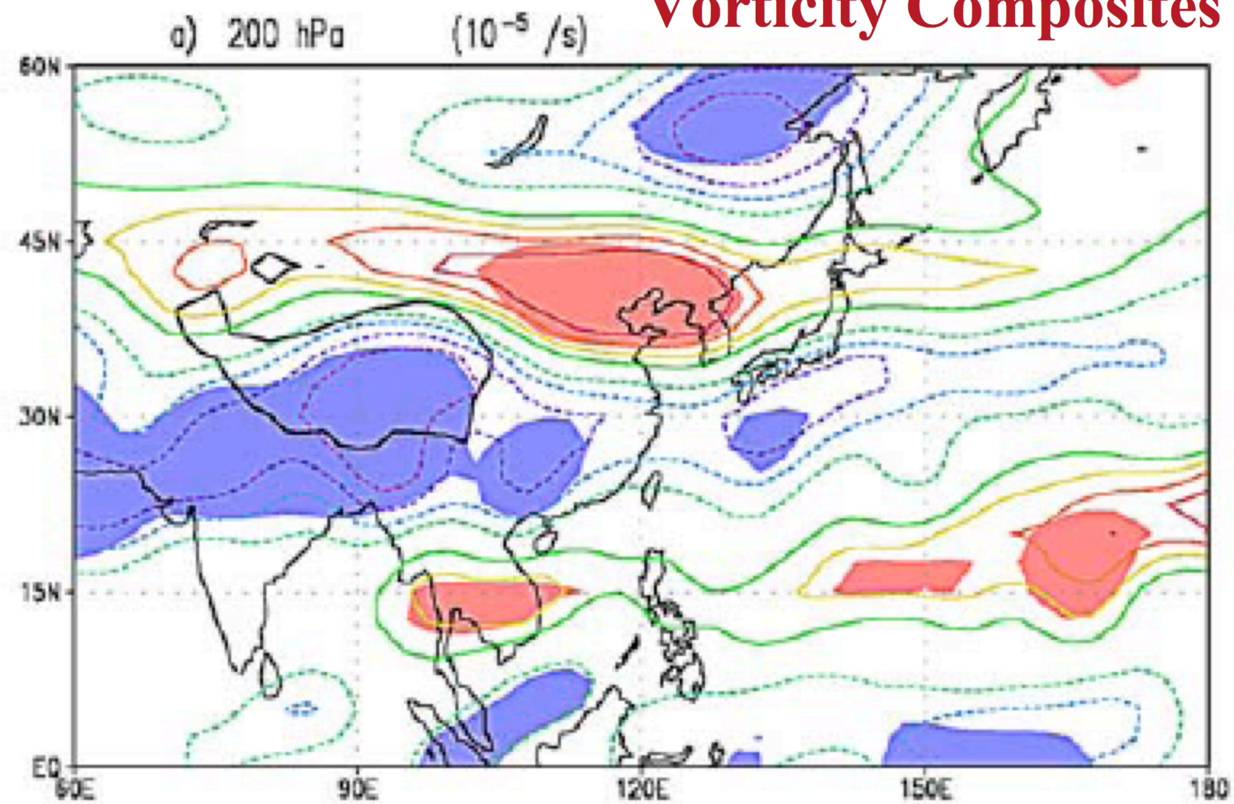
Silk Road Pattern



Wave-like perturbations forced by the Tibetan heating?

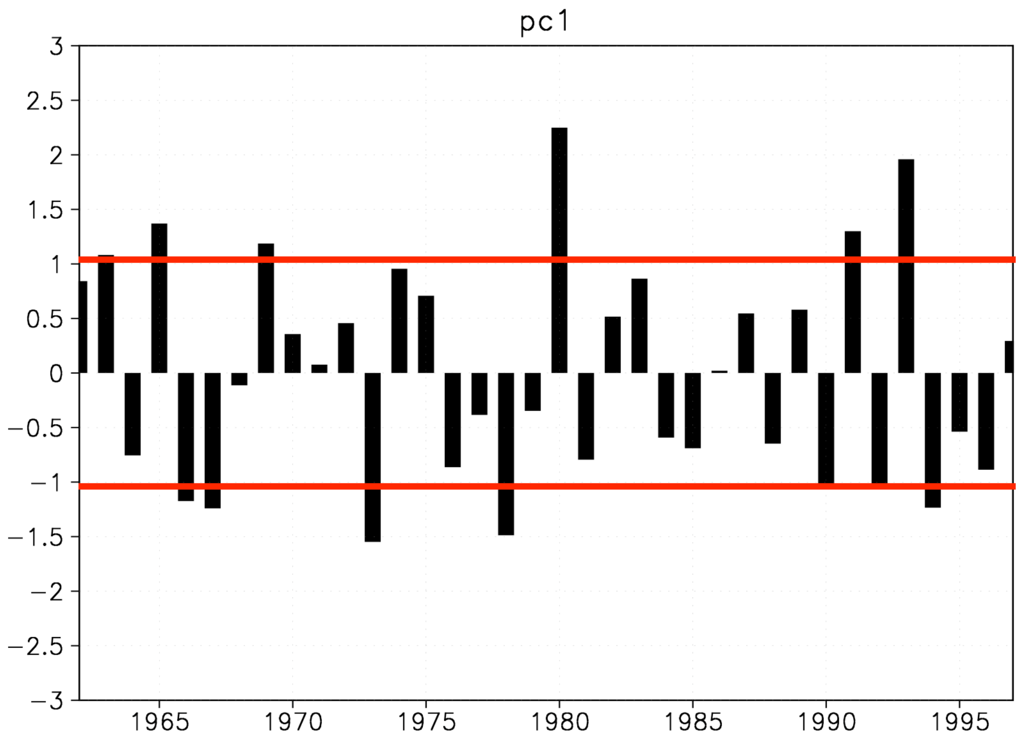
Hsu and Liu (2003)

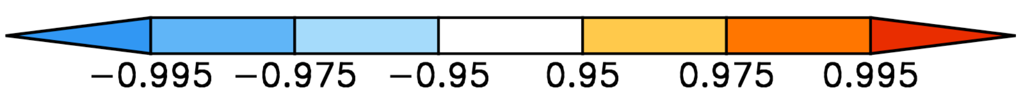
Vorticity Composites



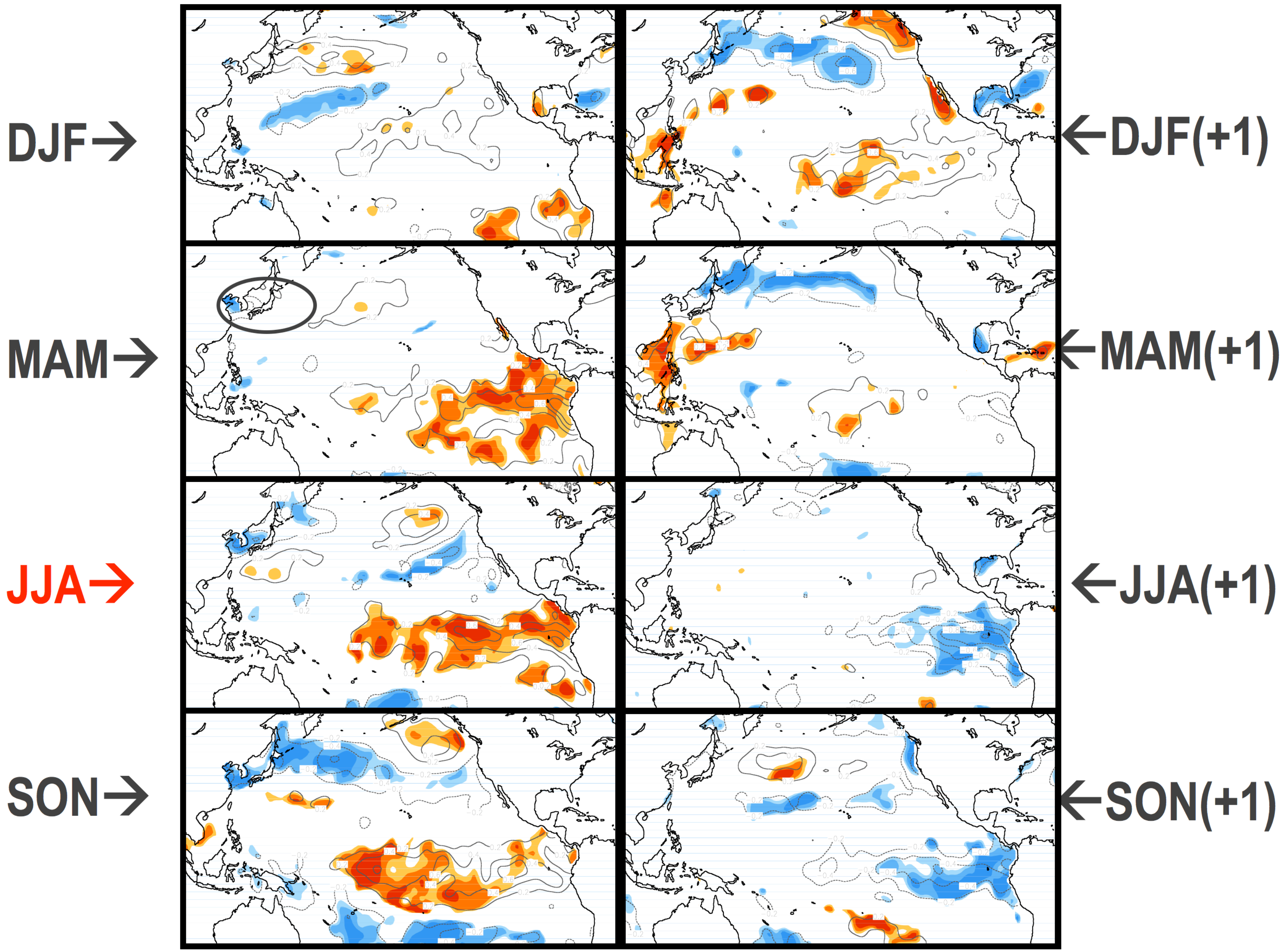
Composite Method

- Positive phase > 1 std → wet years (central China)
  Negative phase < -1 std → dry years
- Averaged anomalies for wet and dry years
  → Student's t-test

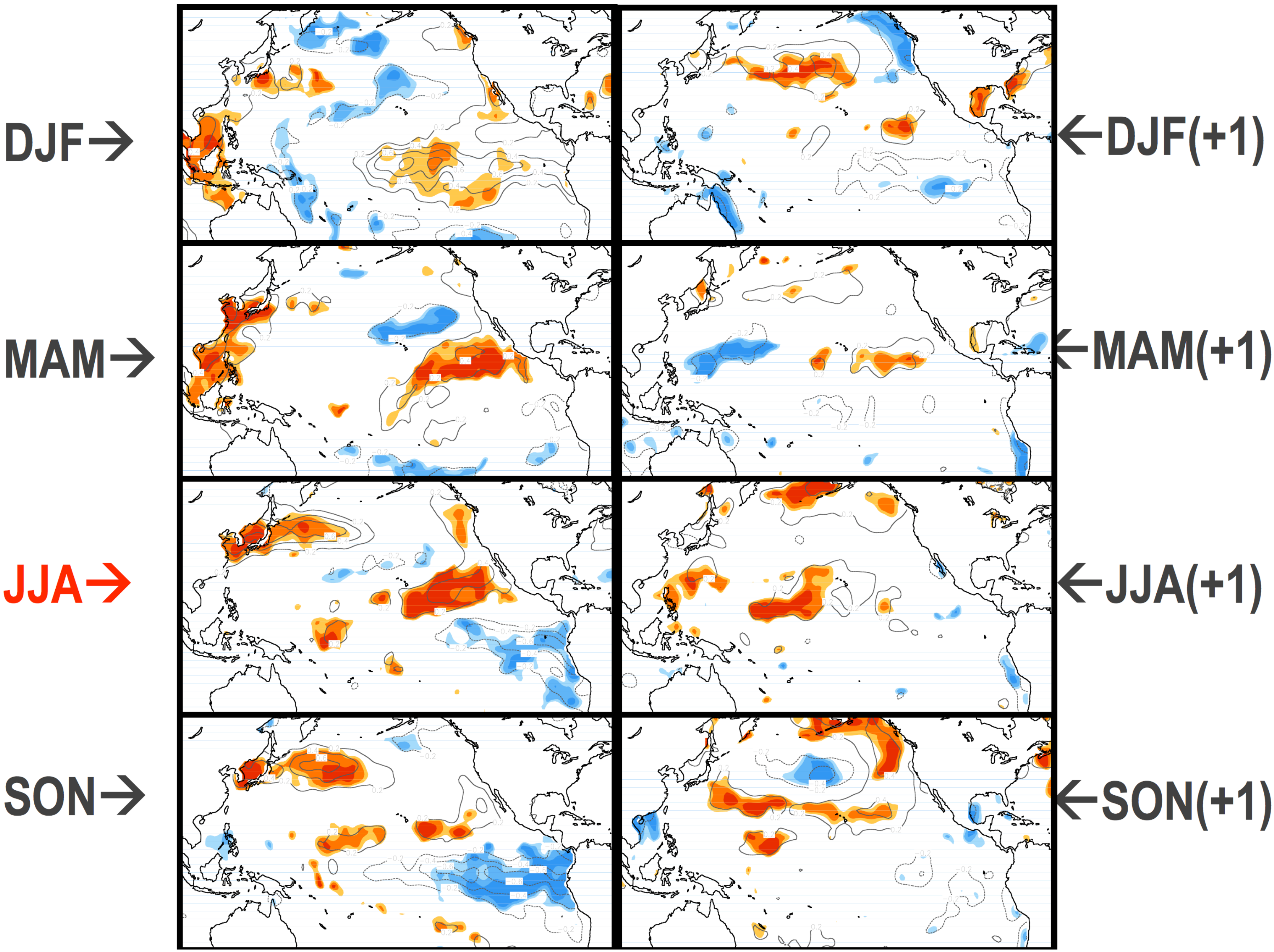




SSTA: wet year



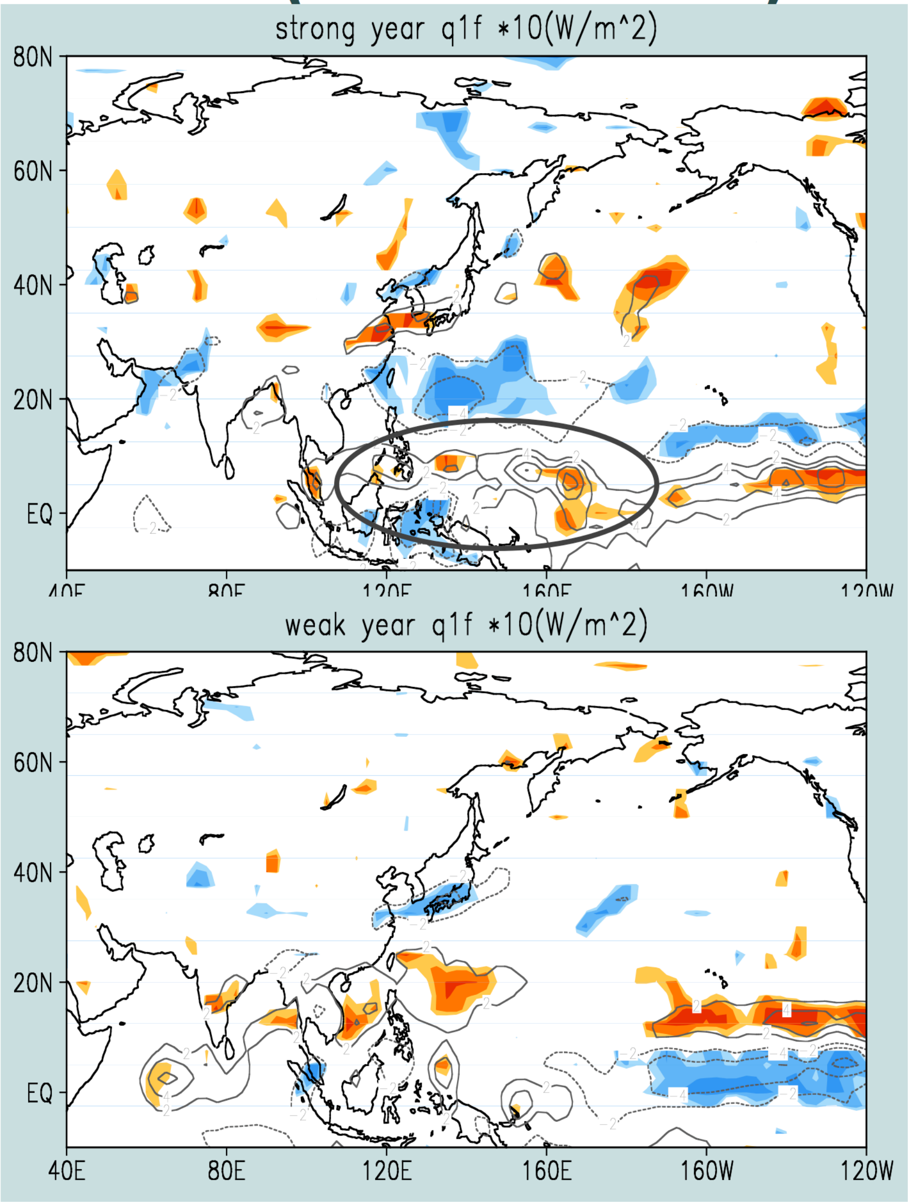
SSTA: dry year



Q1 (Heat Source)

WET

DRY

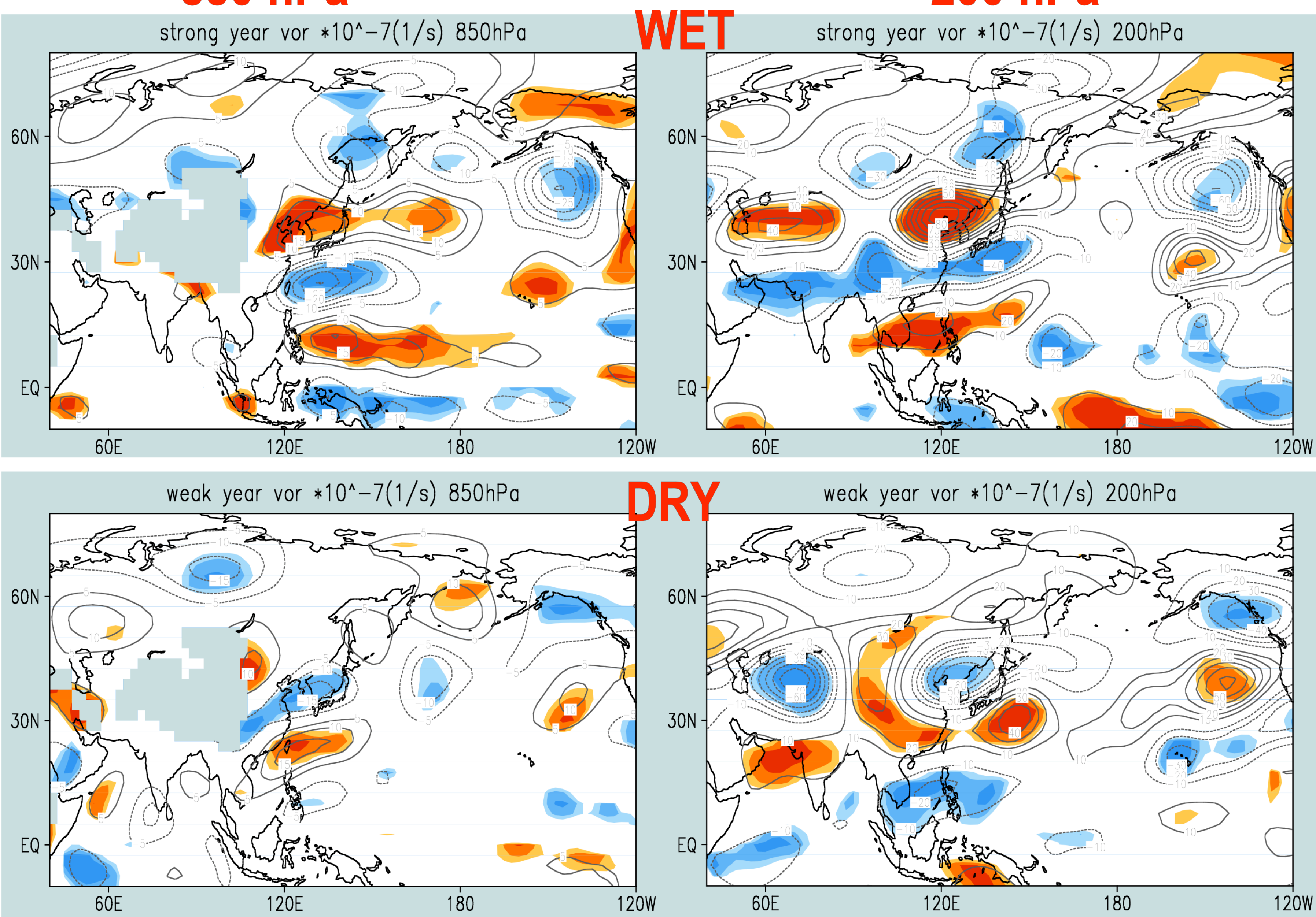


Summary

- Wet-year SSTA exhibits El Nino (year 0-1) characteristics, while dry-year SSTA exhibits only weak La Nina (year 0-1) characteristics.
- Relationship between the SST and diabatic heating anomalies:
  - Tropical Eastern Pacific:
    + (-) SSTA ←→ + (-) heating anomalies
    → SSTA affects atmosphere (heating anomalies)
  - Extratropical W. Pacific:
    + (-) SSTA ←→ - (+) heating anomalies
    → Atmosphere affects SSTA

Vorticity*

850 hPa **200 hPa**

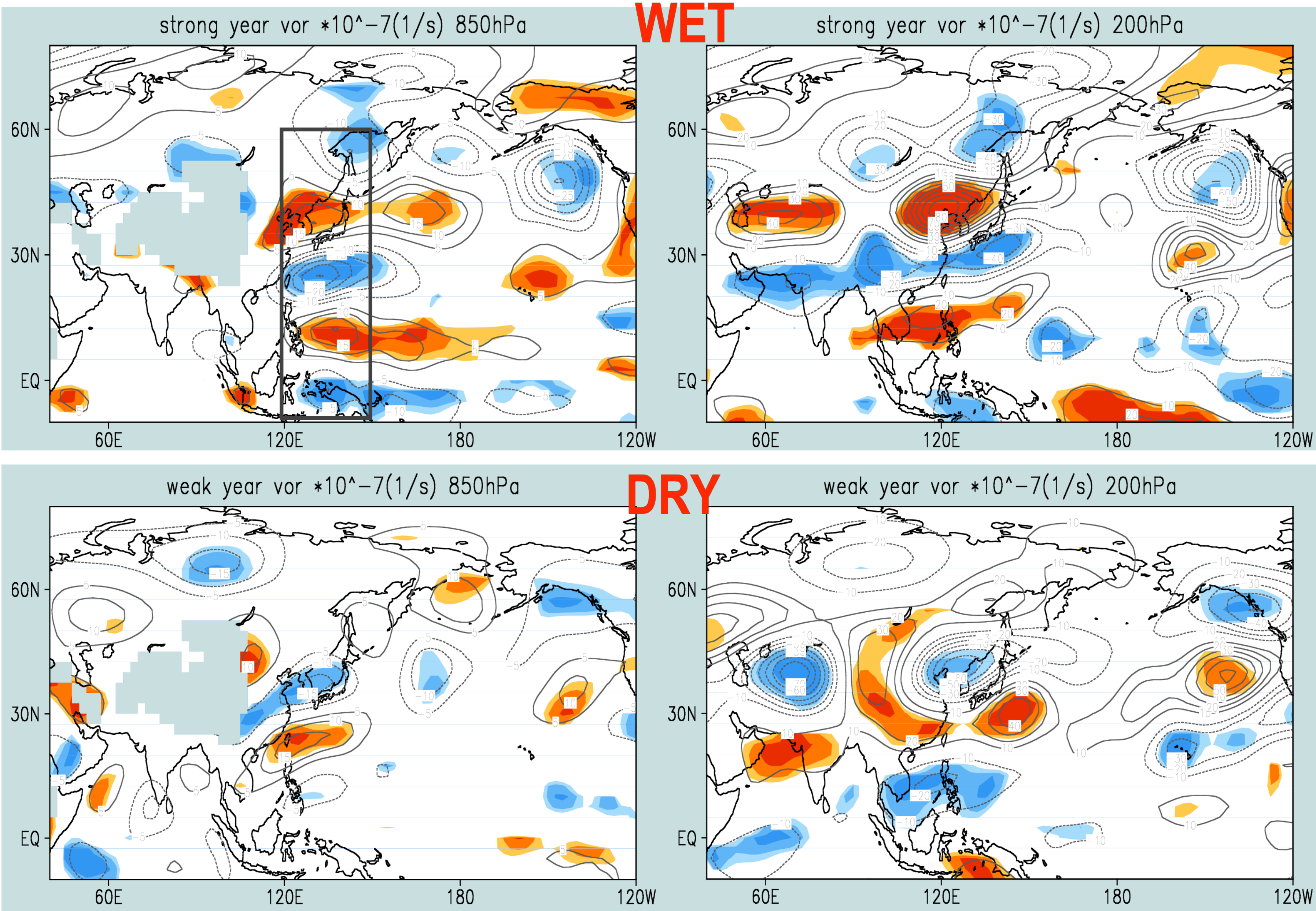


Vorticity*

850 hPa | 200 hPa

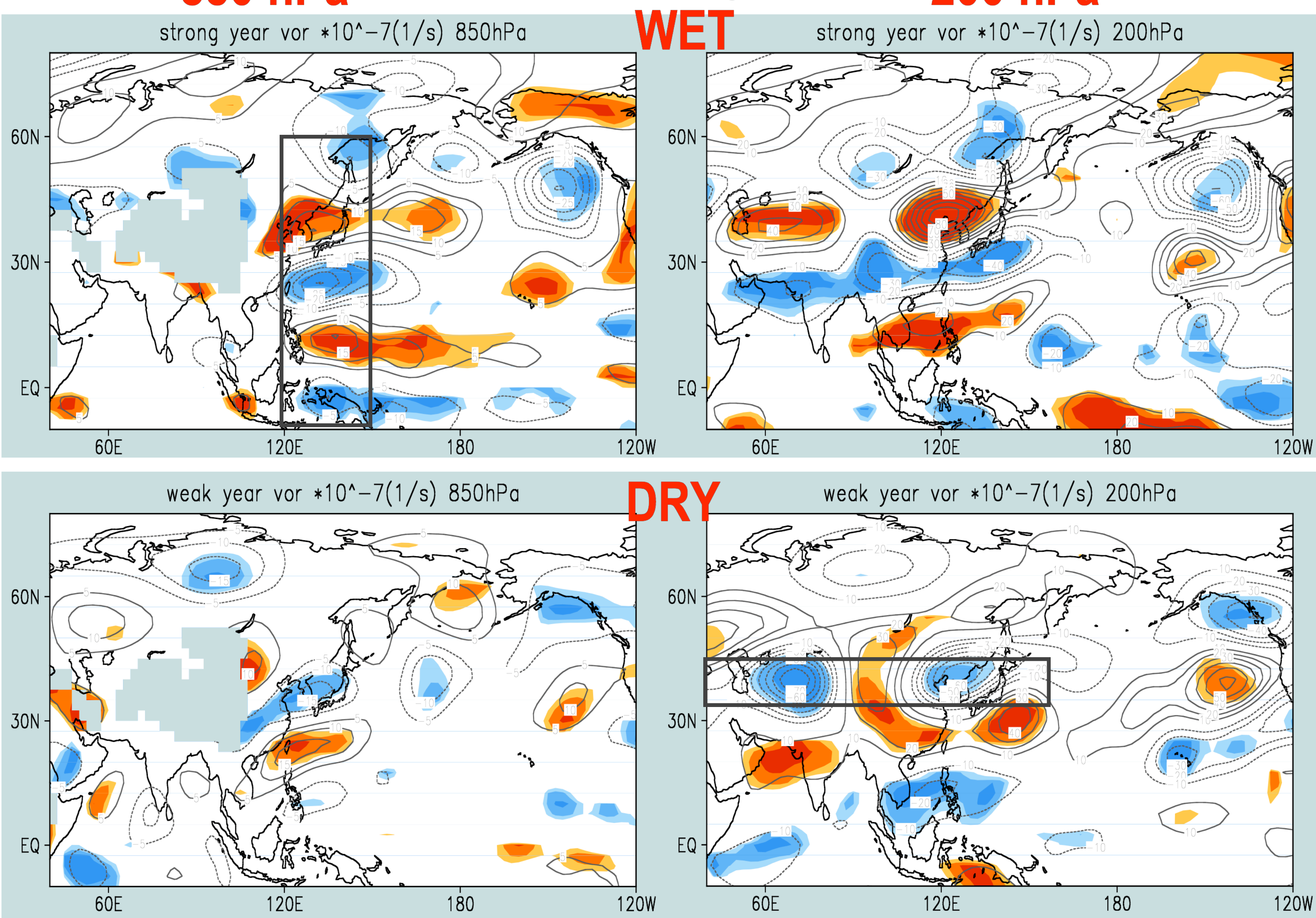
WET

DRY

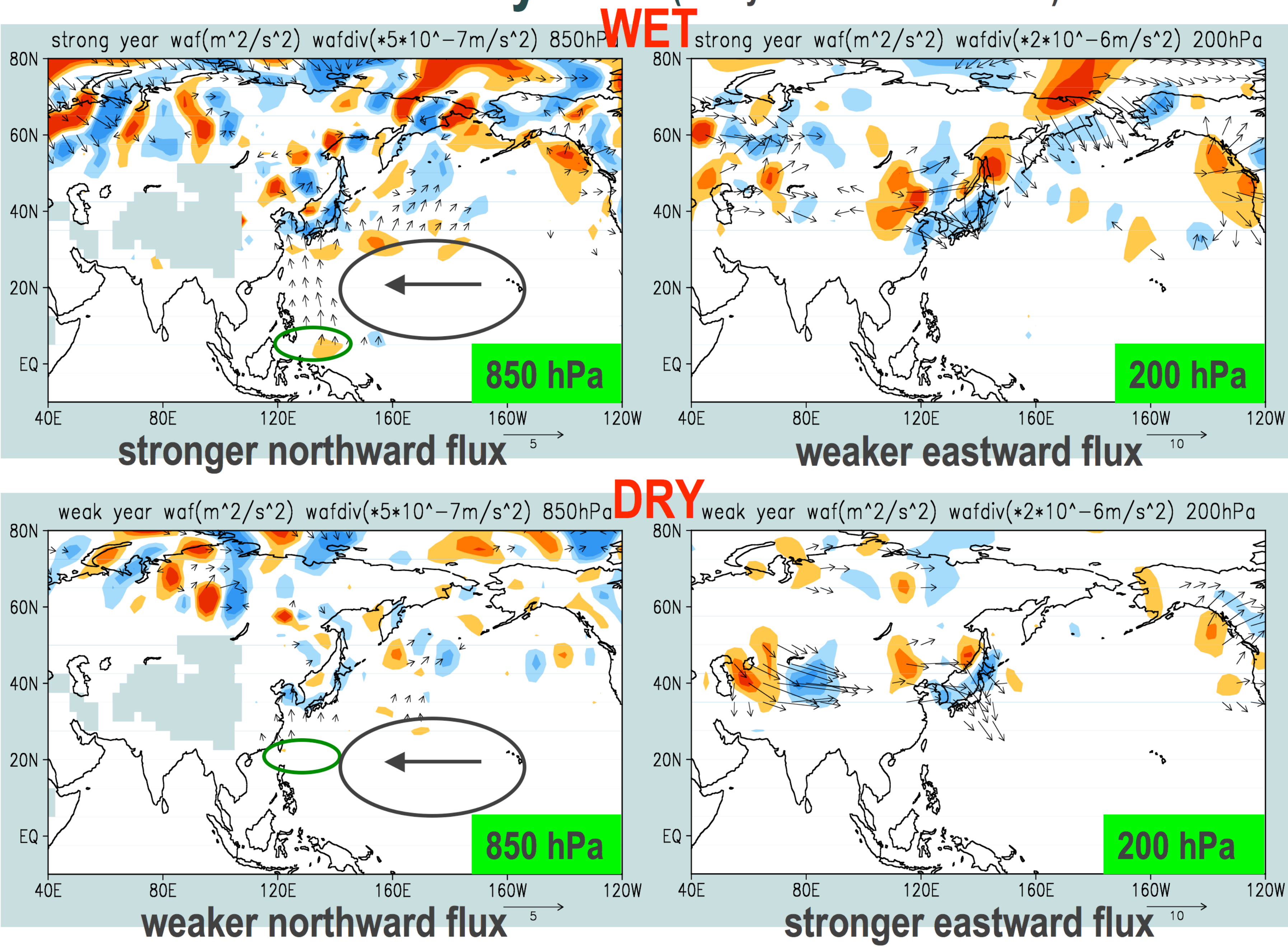


Vorticity*

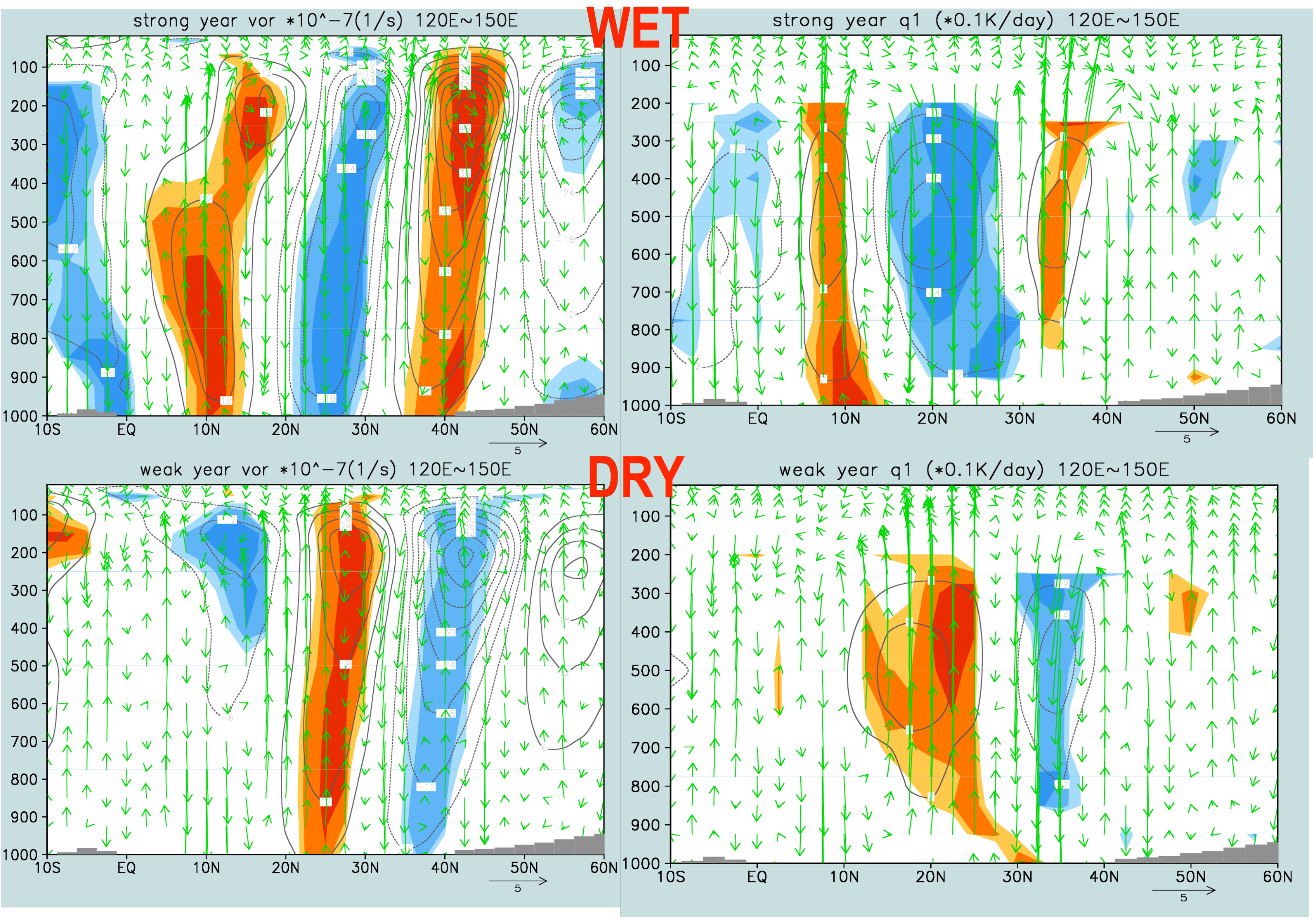
850 hPa | **200 hPa**



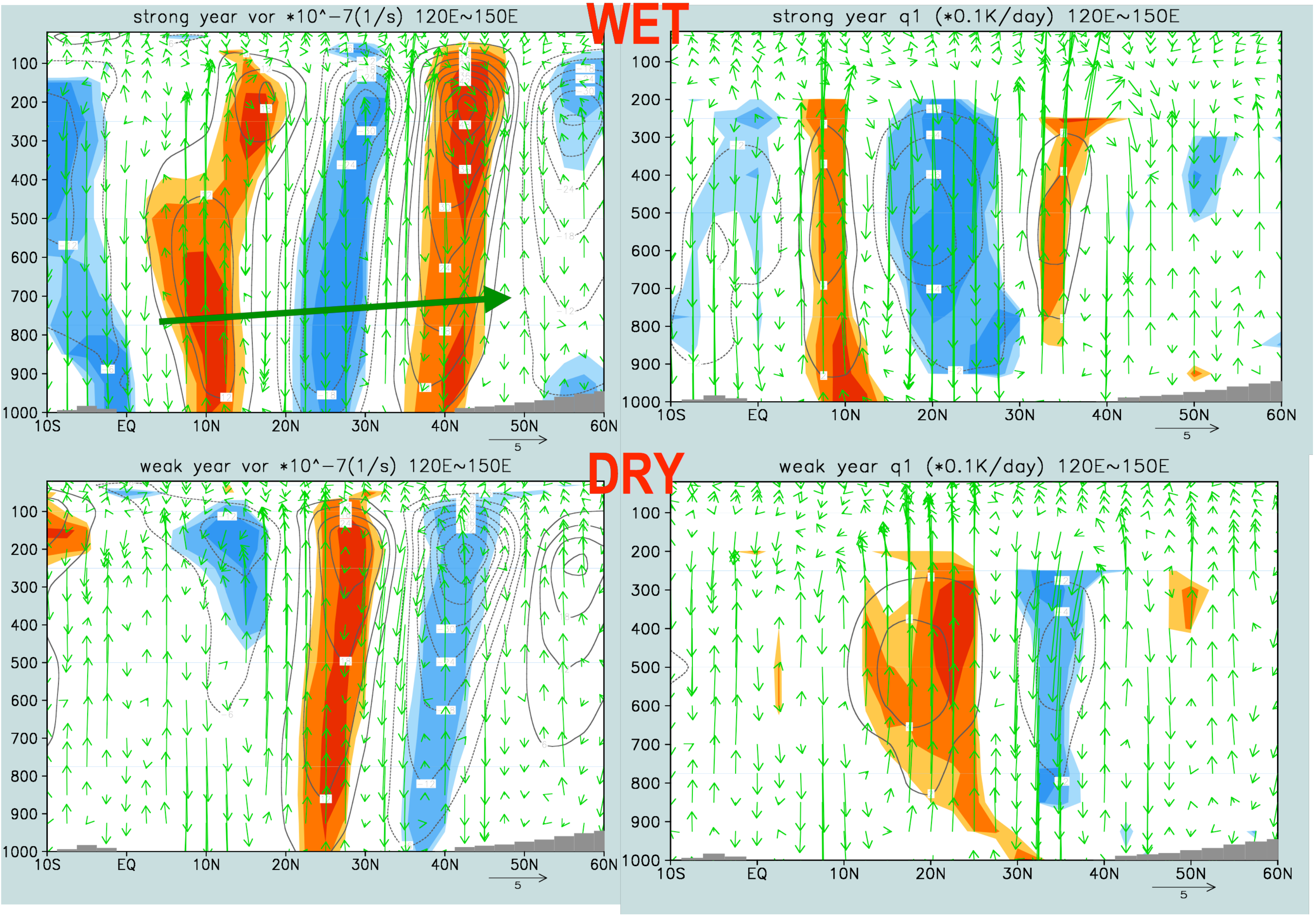
Wave Activity Flux (Takaya and Nakamura 1997)



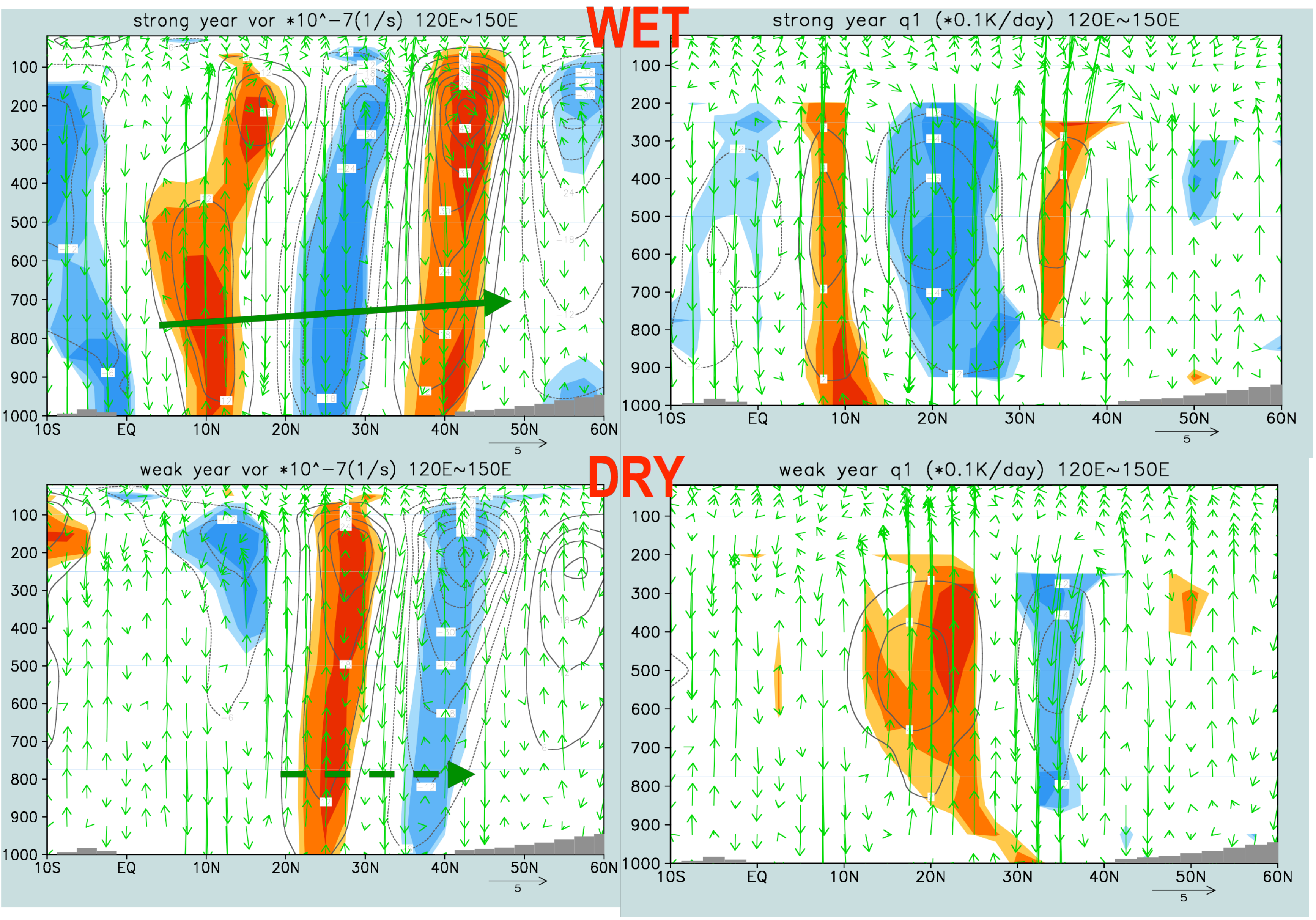
vorticity 120E-150E Q1



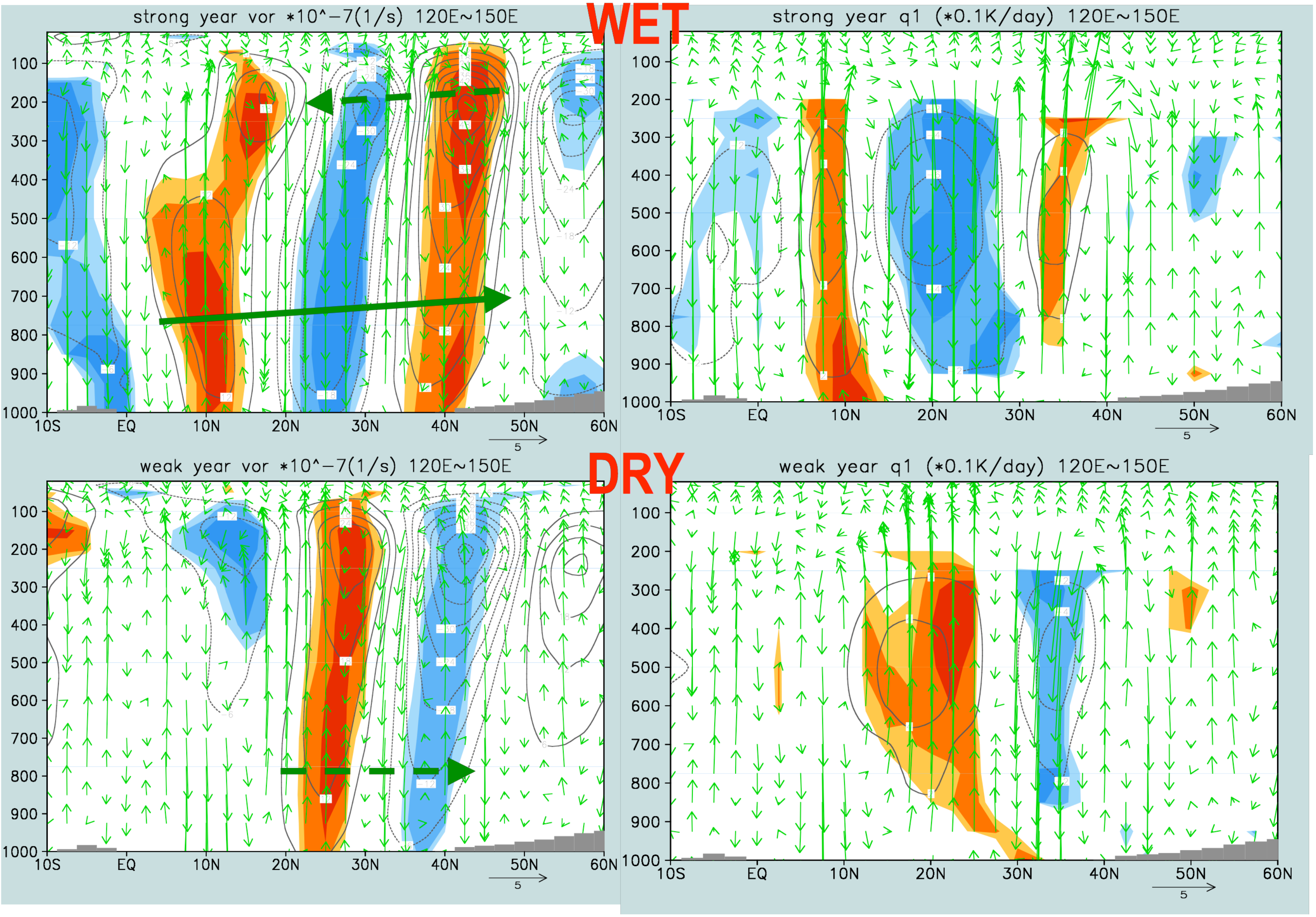
vorticity **120E-150E** **Q1**



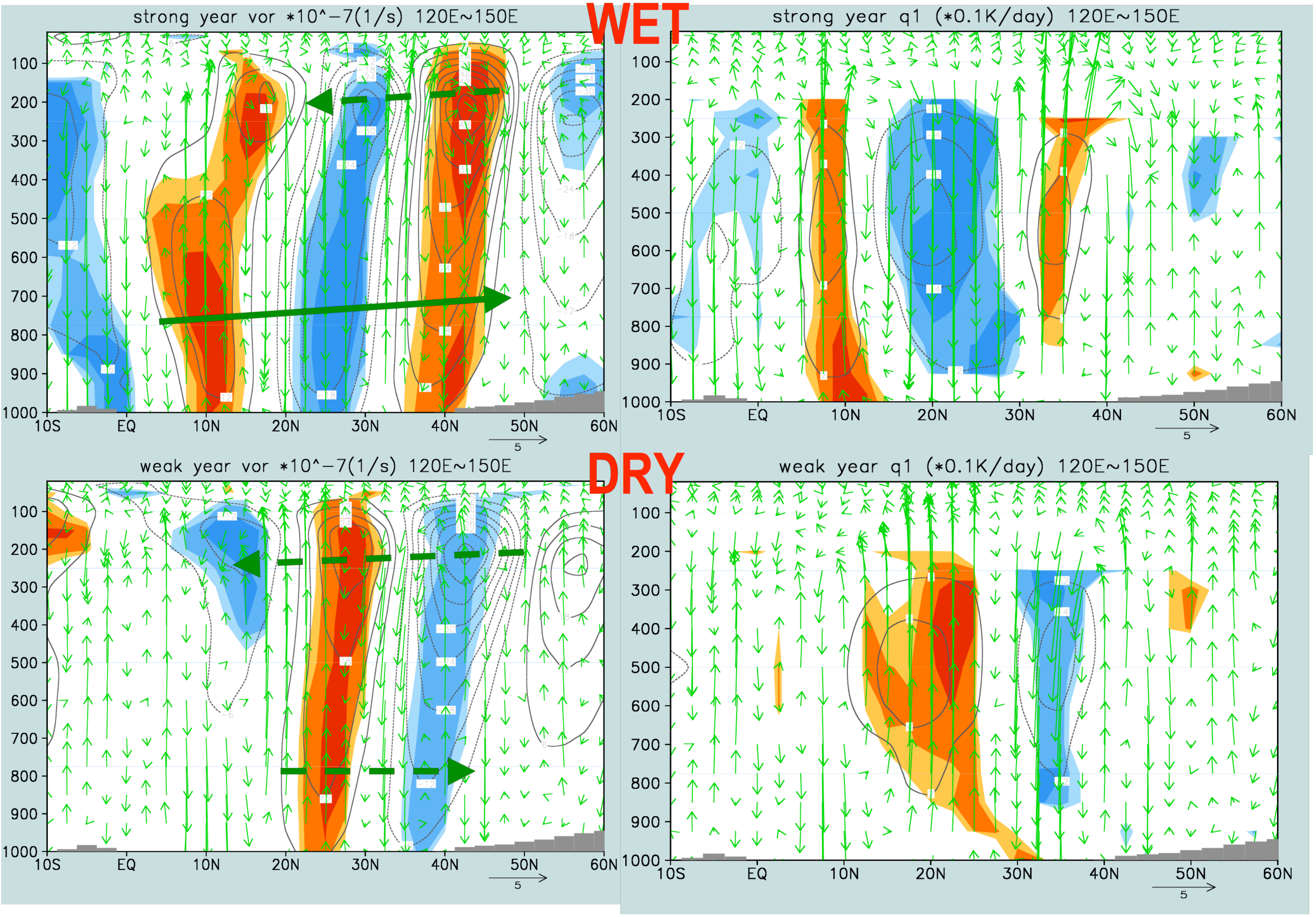
vorticity 120E-150E Q1



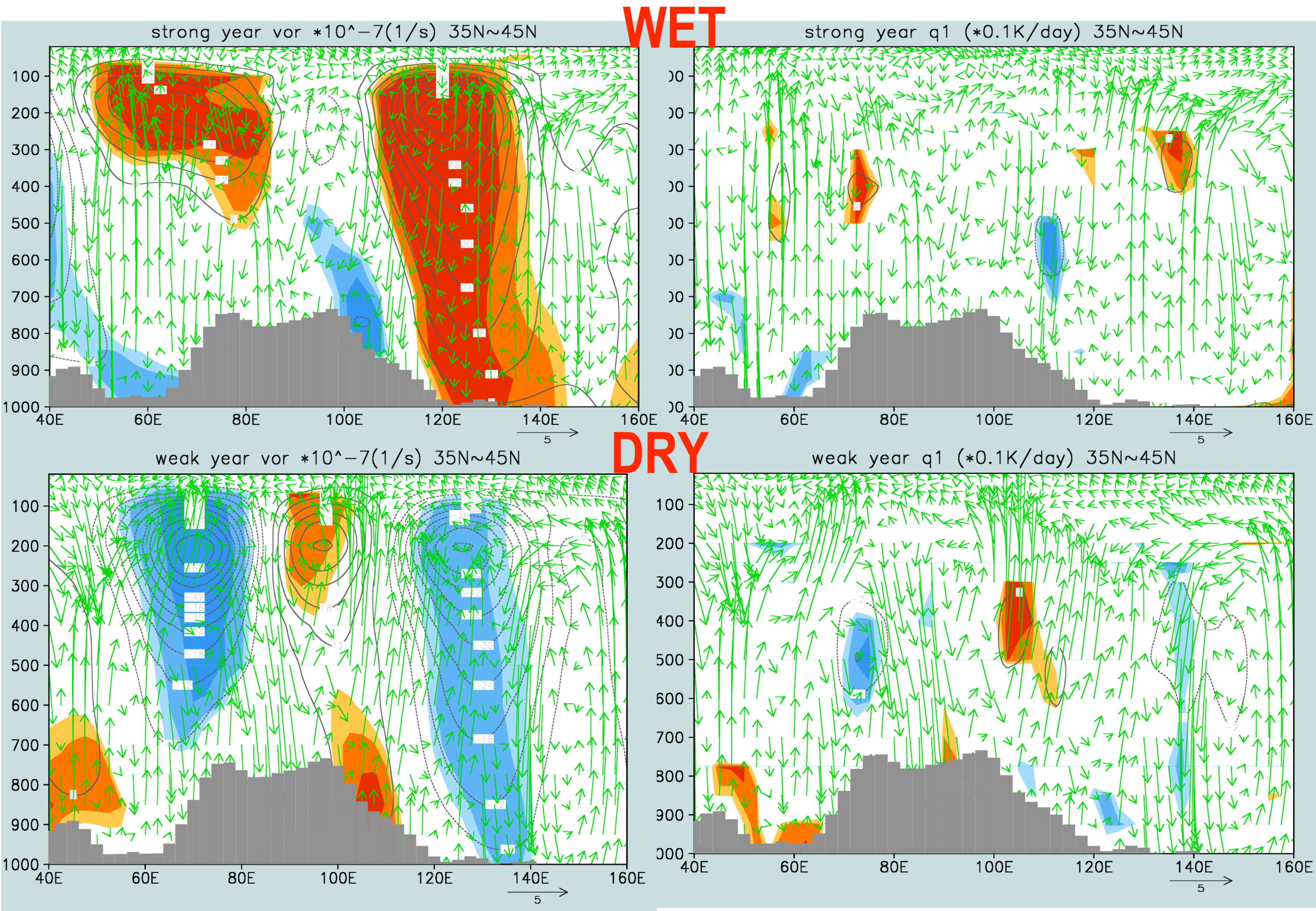
vorticity 120E-150E Q1



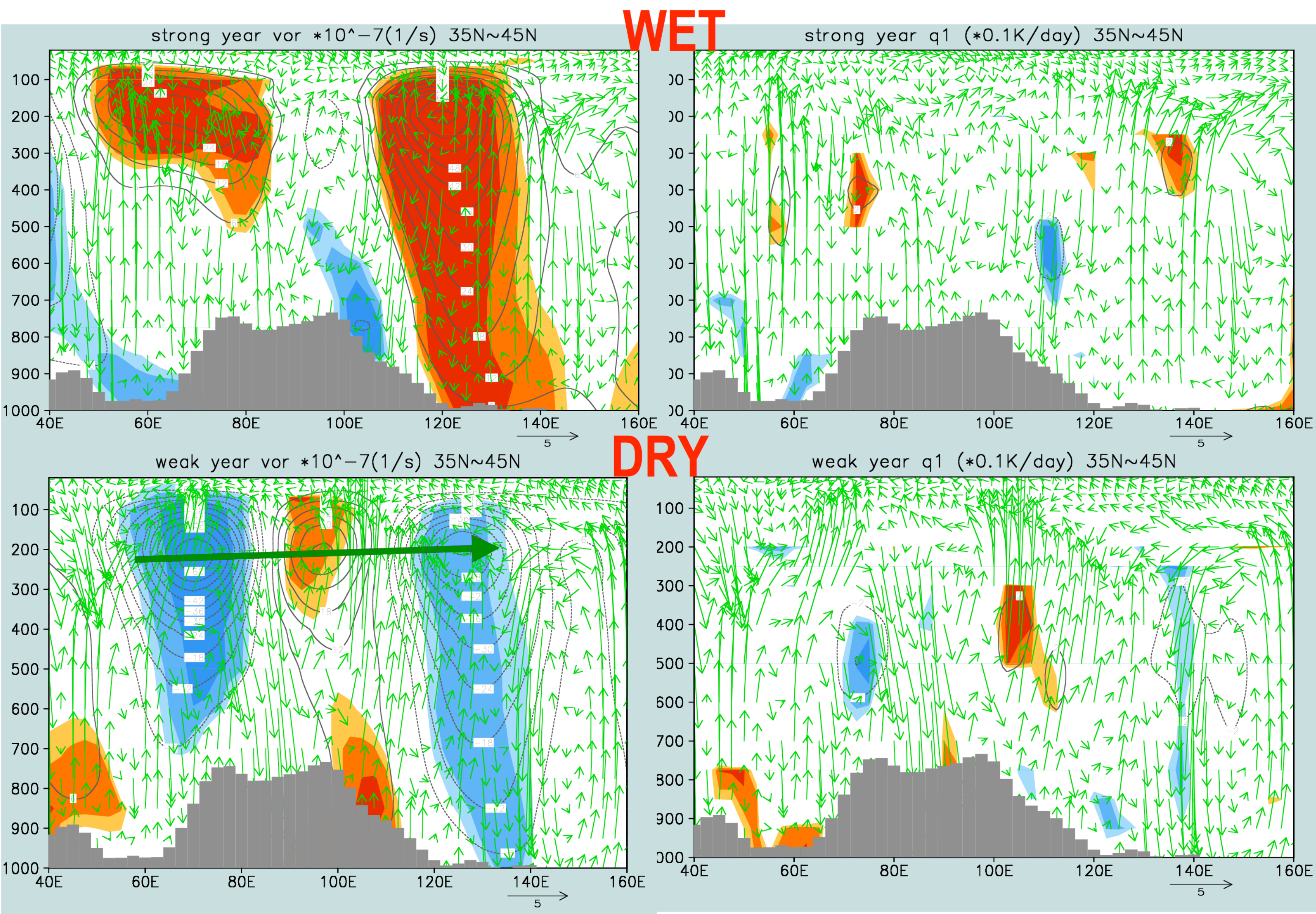
vorticity 120E-150E Q1



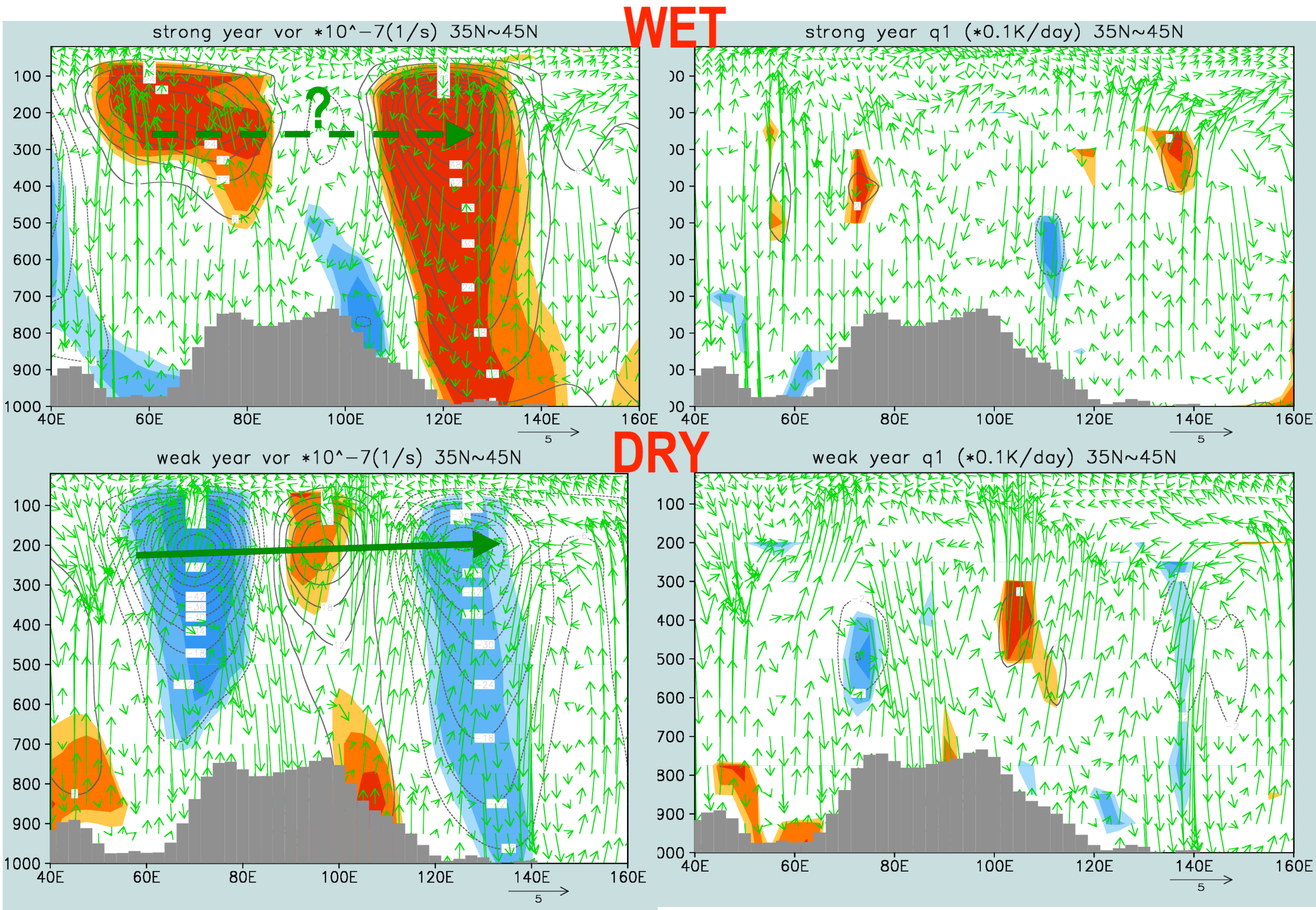
vorticity 35N-45N Q1



vorticity 35N-45N Q1



vorticity 35N-45N Q1



Summary

- Two dominant wave-like patterns:
  1. North-south wave train along the E. Asian coast.
  2. East-west wave train over the extratropical Eurasian continent in the 30N-50N latitudinal band.
- Both wave trains exhibit slightly tilting vertical structure.

Summary (cont.)

North-South wave train

- Similar to the Pacific Japan pattern, but not necessarily forced by tropical heating
- Energy propagation: northward in the lower troposphere and southward tendency in the upper troposphere
- Northward propagation forced by tropical heating is confined in a narrow westerly zone along the East Asian coast.
- Tropical heating in the tropical western Pacific is an important factor affecting rainfall in central China and Japan in wet years.

Summary (cont.)

East-west extratropical wave train

- Similar to Silk Road pattern
- Eastward energy propagation
- Stronger in dry years

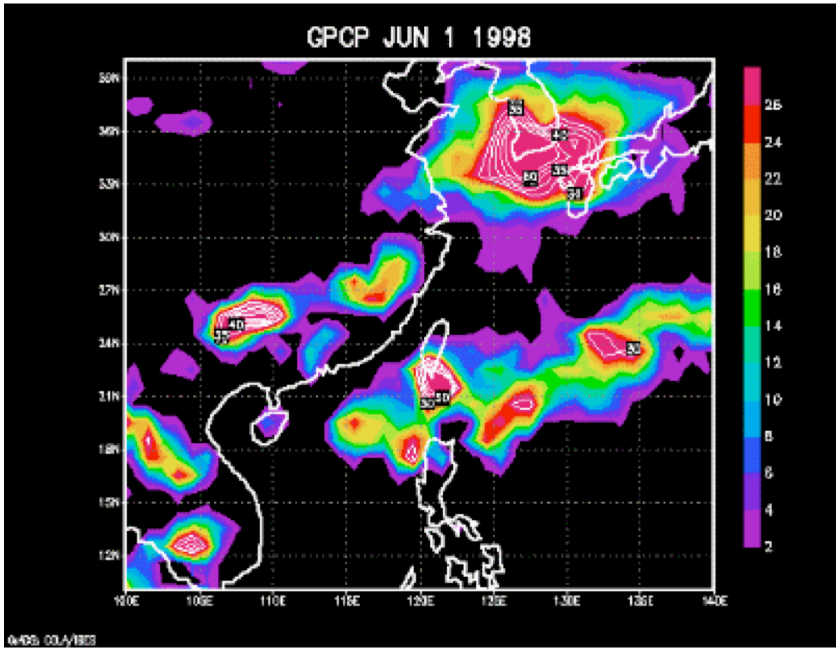
Can not be explained by a simple mechanism:

- Nitta, Enomoto, Hsu and Liu revealed only one part of the whole picture.

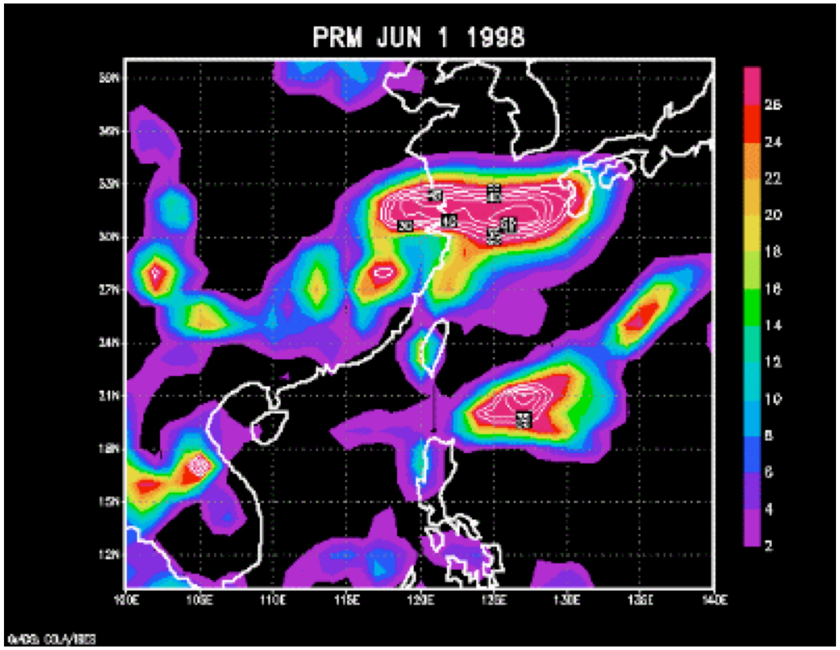
Regional Climate Simulation using Purdue Regional Model

June 1998

observed precip.



simulated precip.



Hsu H.-H., W.-S. Kau, W.-R. Hsu, W.-Y. Sun, Y.-C. Yu, Y.-S. Tong, C.-F. Shi, W.-N. Yu

10 summer simulation

CMAP 1991
0.83
PRM 1991

CMAP 1992
0.72
PRM 1992

CMAP 1993
0.64
PRM 1993

CMAP 1994
0.68
PRM 1994

CMAP 1995
0.73
PRM 1995

CMAP 1996
0.81
PRM 1996

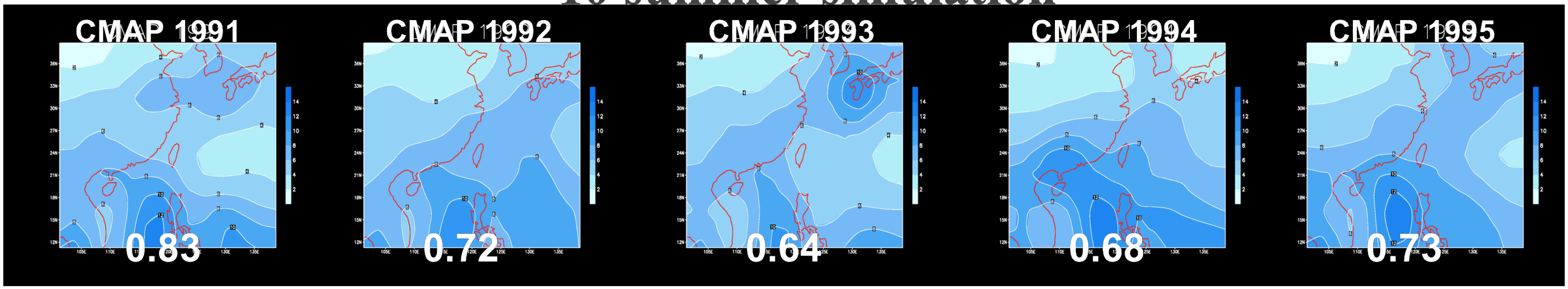
CMAP 1997
0.74
PRM 1997

CMAP 1998
0.66
PRM 1998

CMAP 1999
0.88
PRM 1999

CMAP 2000
0.80
PRM 2000

10 summer simulation



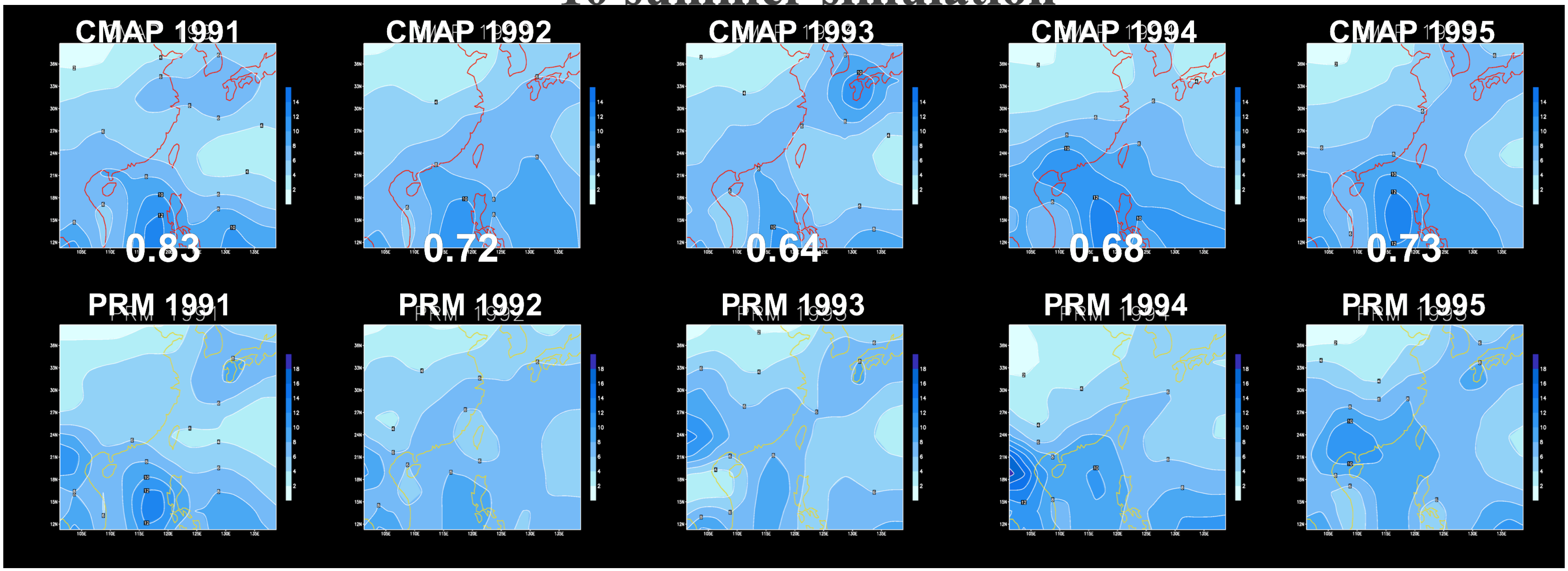
PRM 1991 PRM 1992 PRM 1993 PRM 1994 PRM 1995

CMAP 1996 CMAP 1997 CMAP 1998 CMAP 1999 CMAP 2000

0.81 0.74 0.66 0.88 0.80

PRM 1996 PRM 1997 PRM 1998 PRM 1999 PRM 2000

10 summer simulation

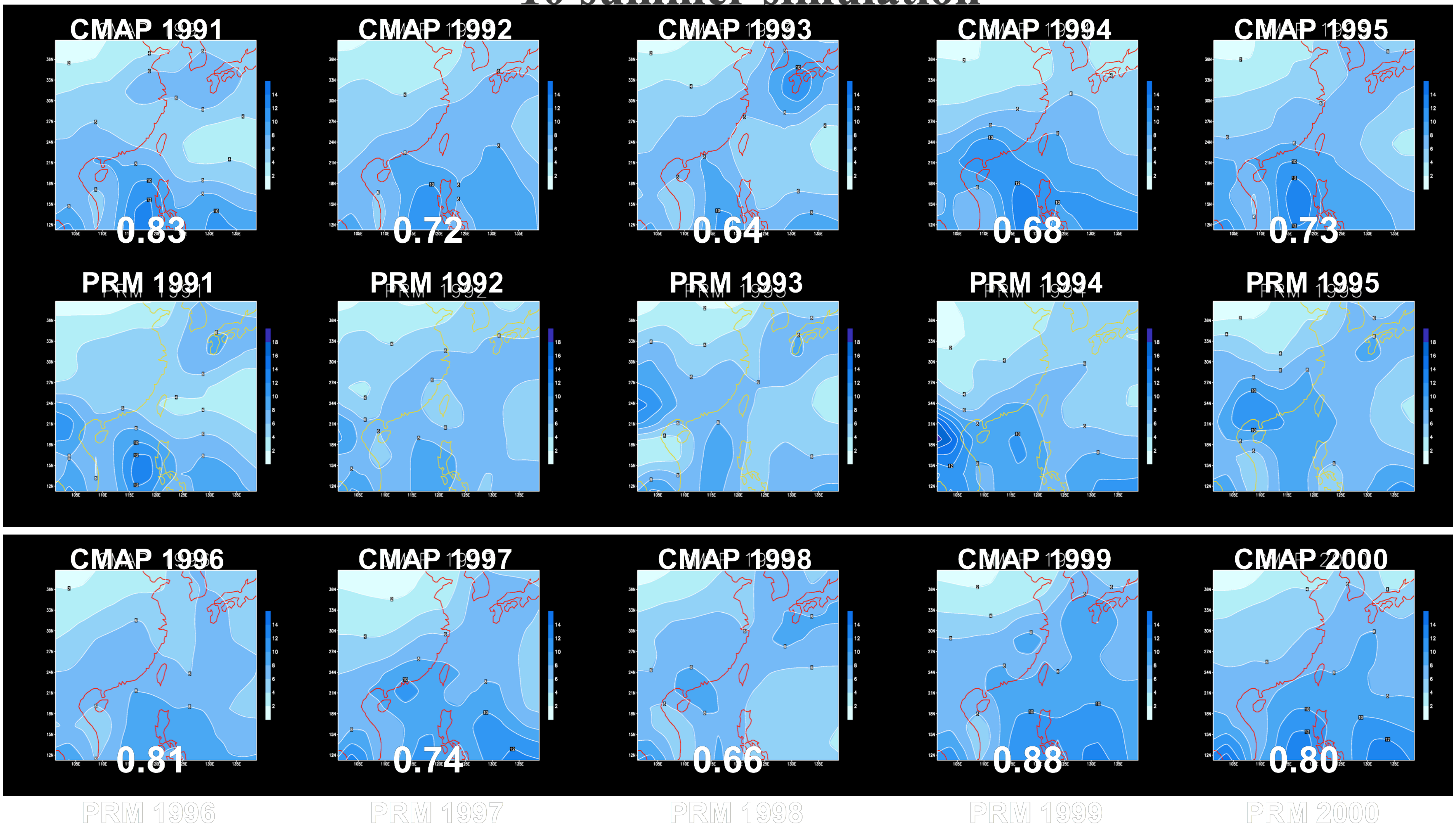


CMAP 1996 CMAP 1997 CMAP 1998 CMAP 1999 CMAP 2000

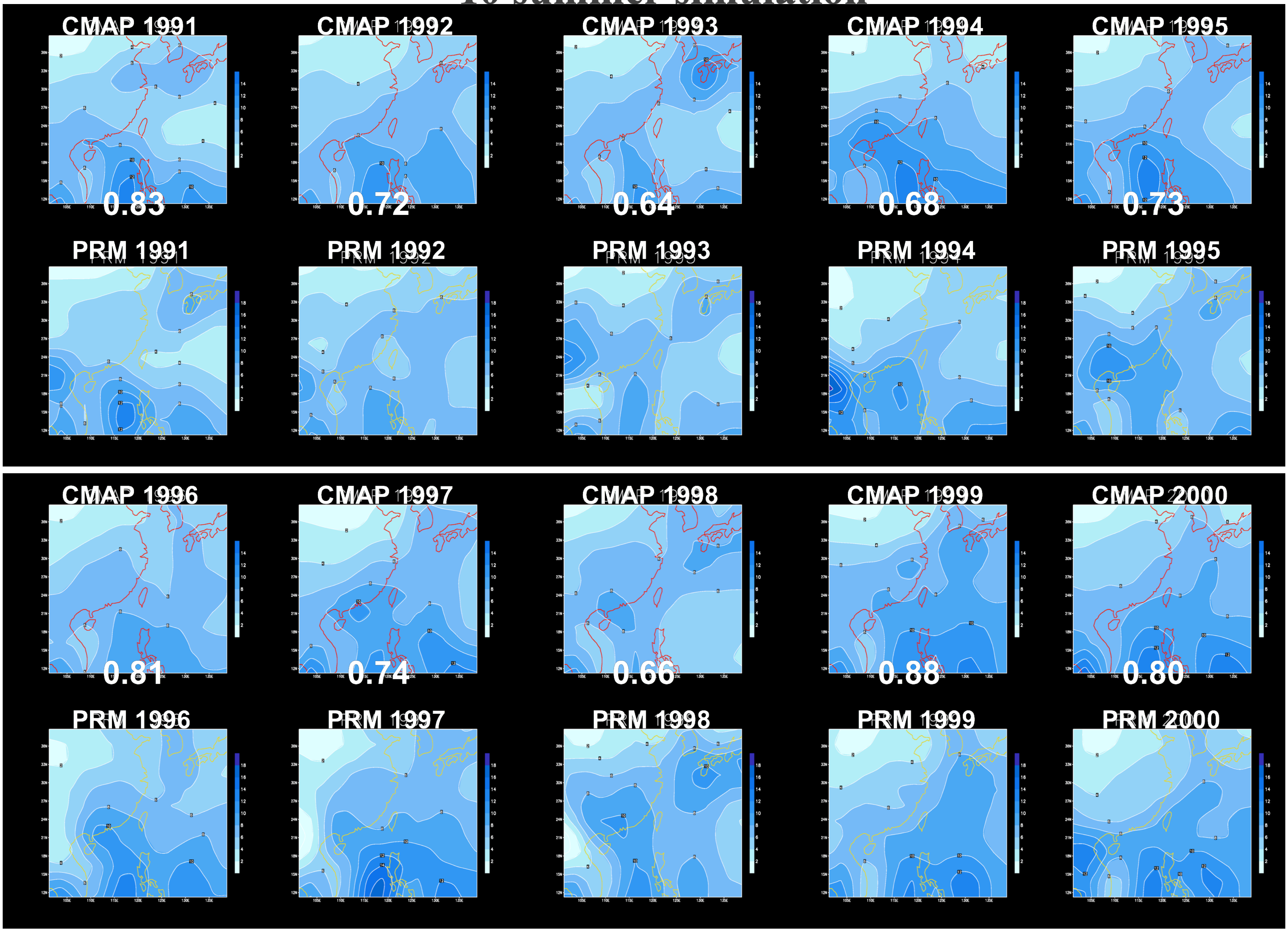
0.81 0.74 0.66 0.88 0.80

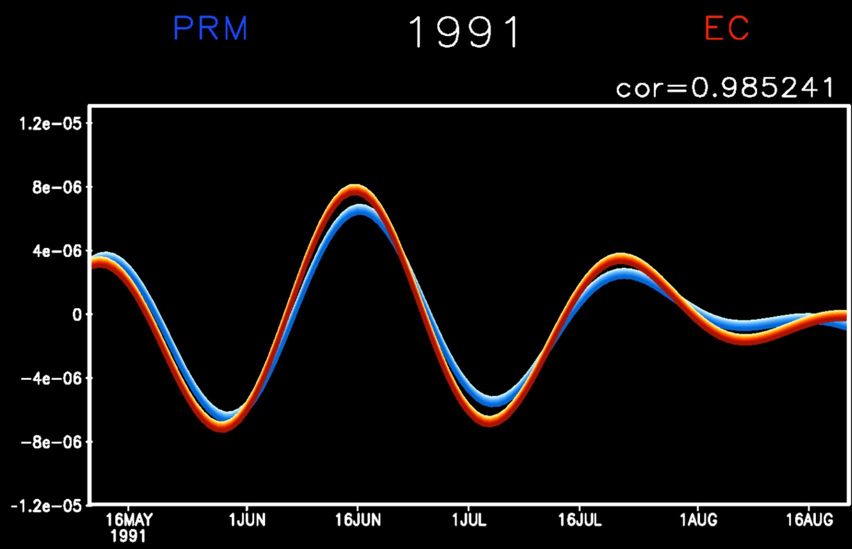
PRM 1996 PRM 1997 PRM 1998 PRM 1999 PRM 2000

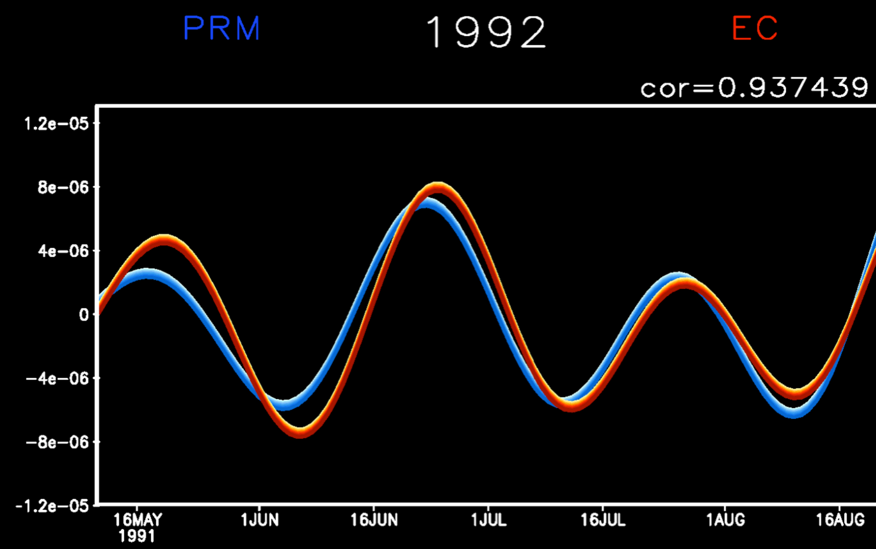
10 summer simulation



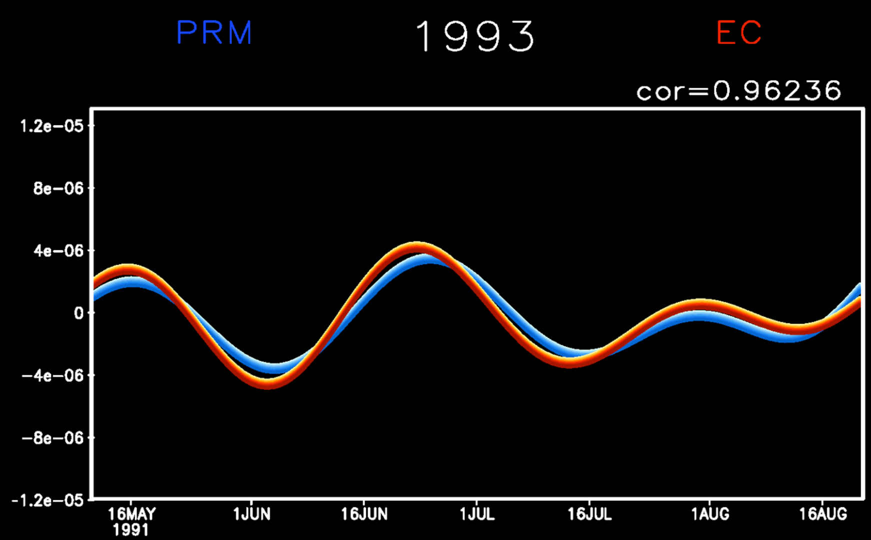
10 summer simulation

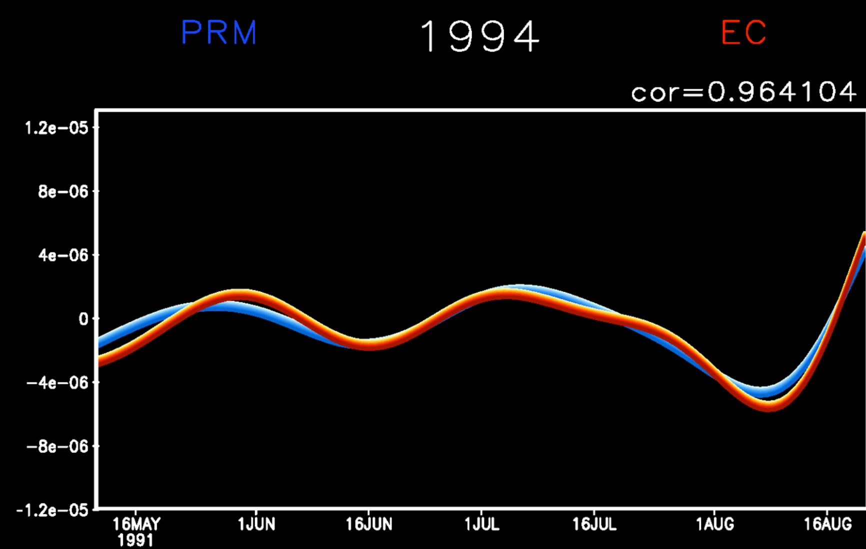


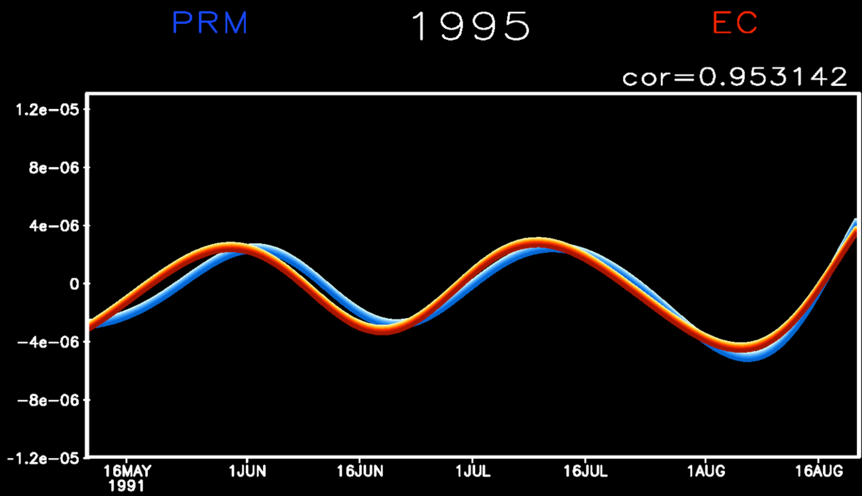


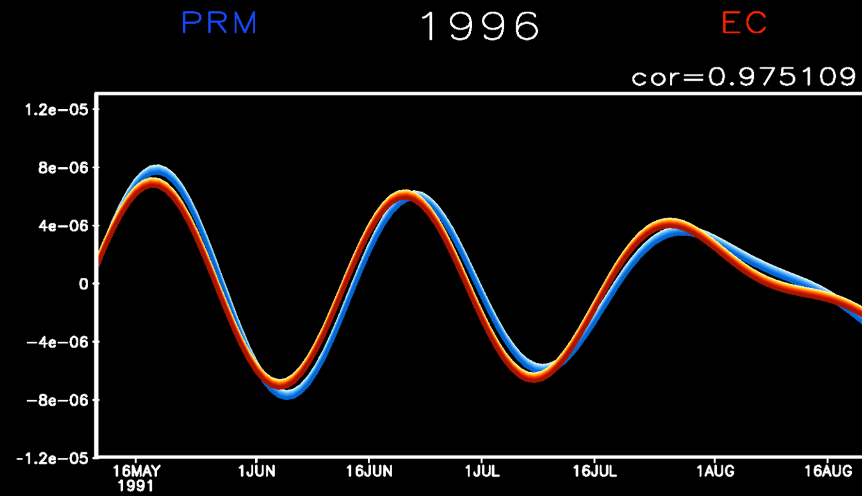


Intraseasonal oscillation in 15~20N, 110~120E

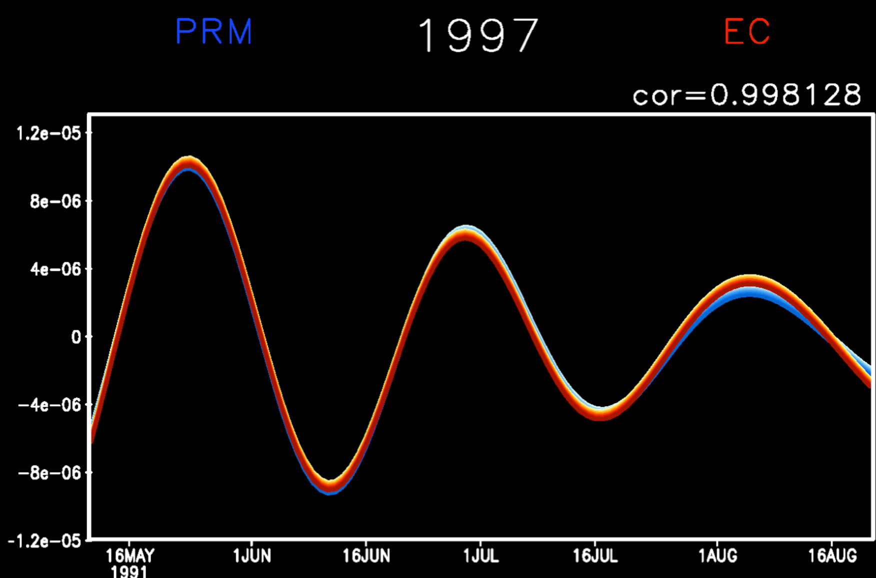


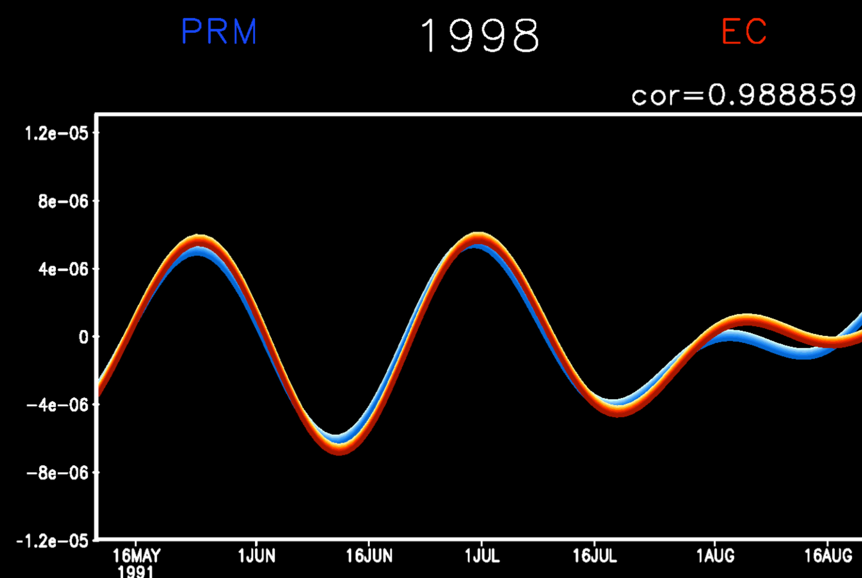


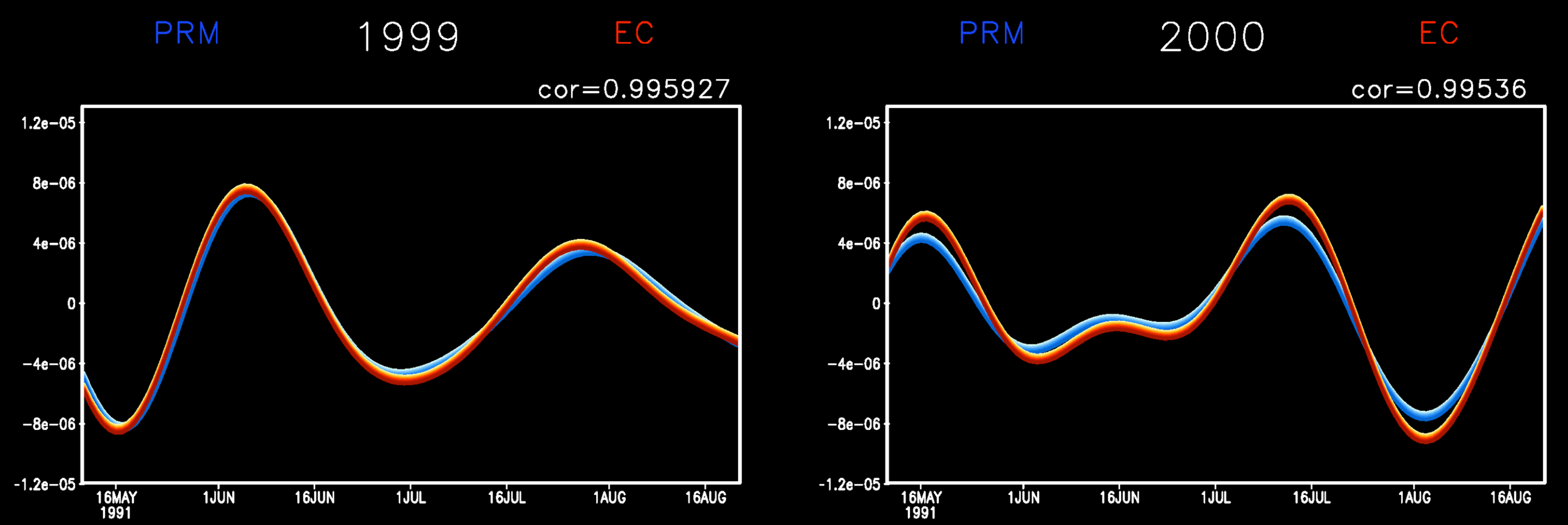




Intraseasonal oscillation in 15~20N, 110~120E







Intraseasonal oscillation in 15~20N, 110~120E

Thank You for Your Attention!