Intraseasonal Oscillation and the Taiwan Climate

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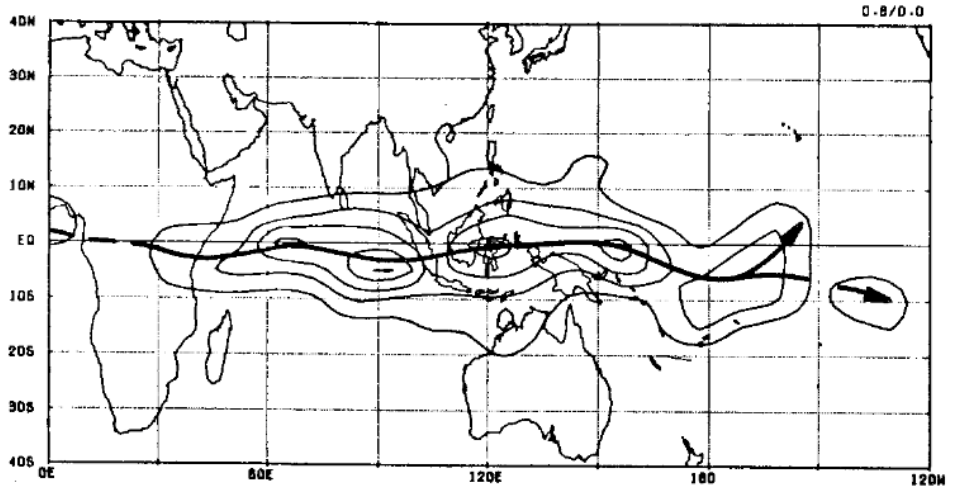
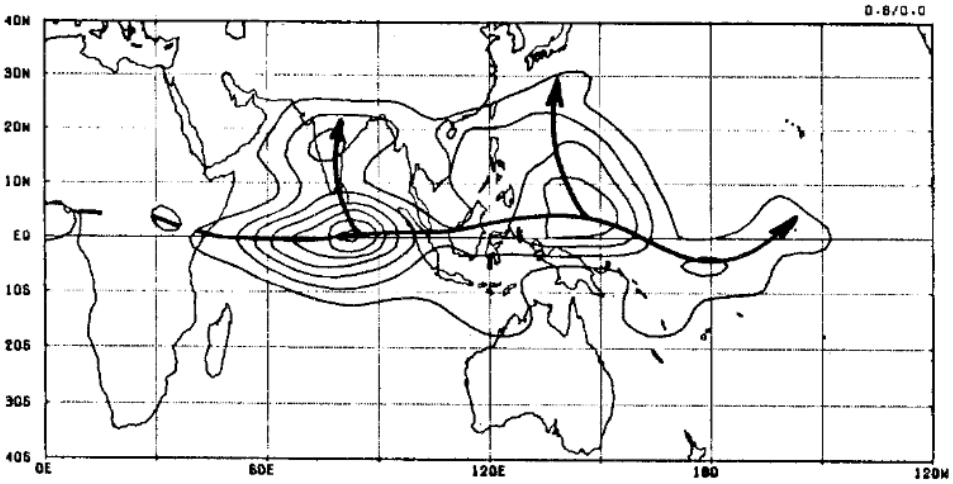


Boreal Winter
(TISO / MJO)



Boreal Summer
(BSISO)

Wang and Rui 1990

Outline

1. TISO and the Taiwan winter rainfall (NDJFMA)

Hung, C. –w., H. -J. Lin, and H. –H. Hsu, 2014: Madden–Julian Oscillation and the Winter Rainfall in Taiwan. *J. Climate,* **27**, 4521–4530, https://doi.org/10.1175/JCLI-D-13-00435.1

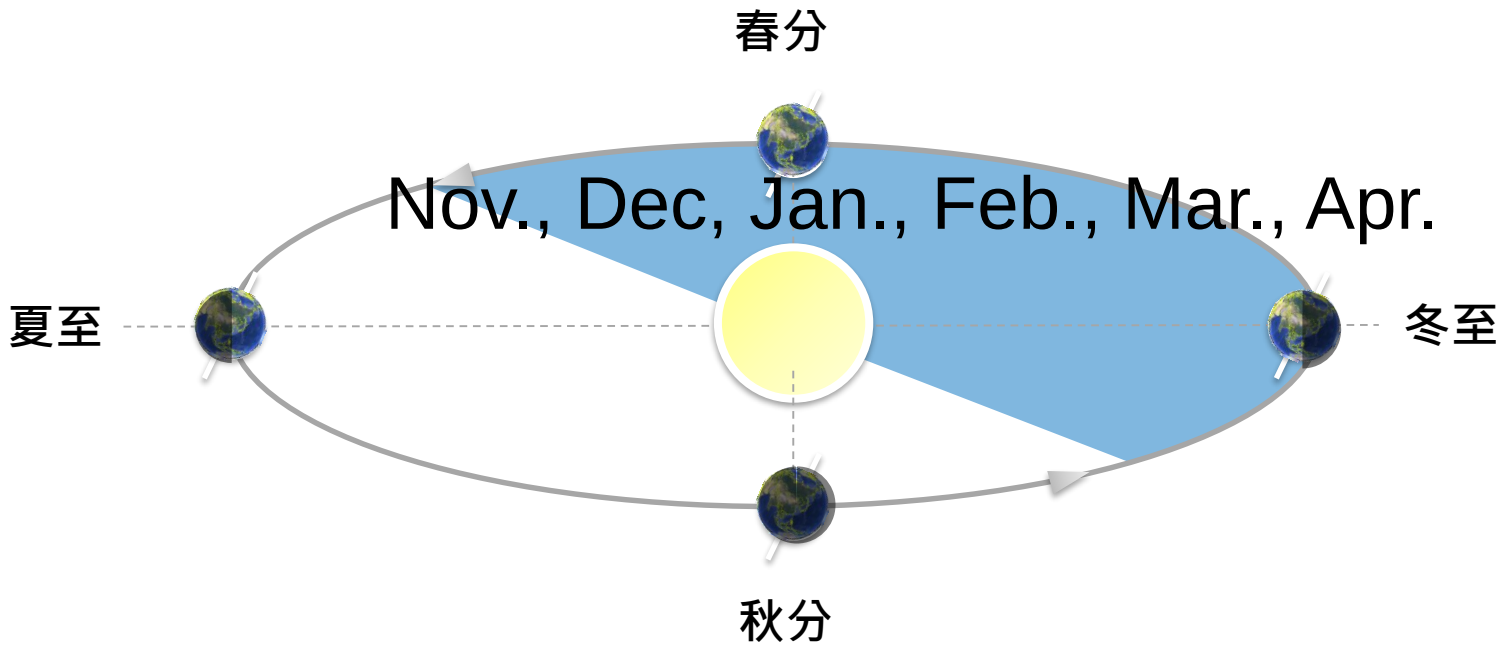
2. TISO and Taiwan Mei-yu (AMJ)

Hung, C. -w. and H. –H. Hsu, 2008: The First Transition of the Asian Summer Monsoon, Intraseasonal Oscillation, and Taiwan Mei-yu. *J. Climate,* **21**, 1552–1568, https://doi.org/10.1175/2007JCLI1457.1

3. **BSISO and Typhoon in Taiwan (JASO)**

Hung, C. -w, H. -J. Lin, P. –k. Kao, M. -F. Shih, and W. –y. Fong, 2016: Boreal Summer Intraseasonal Oscillation Impact on Western North Pacific Typhoons and Rainfall in Taiwan. *Terr. Atmos. Ocean. Sci*., 27, 893-906, https://doi.org/10.3319/TAO.2016.05.30.01(A)

TISO (MJO) and the Taiwan winter rainfall (winter-half year)



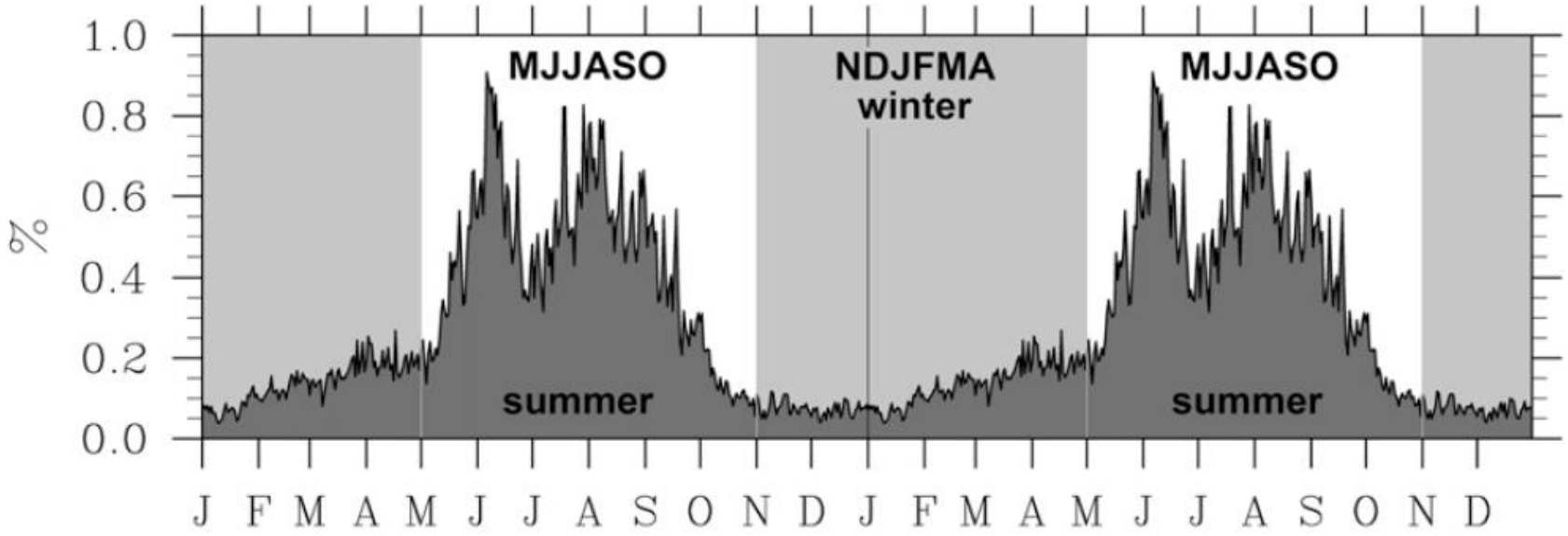


FIG. 1. The mean annual cycle of the rainfall in Taiwan represented by the 1900–2010 TRI (%). The annual cycle is repeated twice to show a completed winter season. NDJFMA and May–October (MJJASO) stand for the winter-half and summer-half, respectively.

Taiwan Rainfall and MJO phase / Front and MJO phase

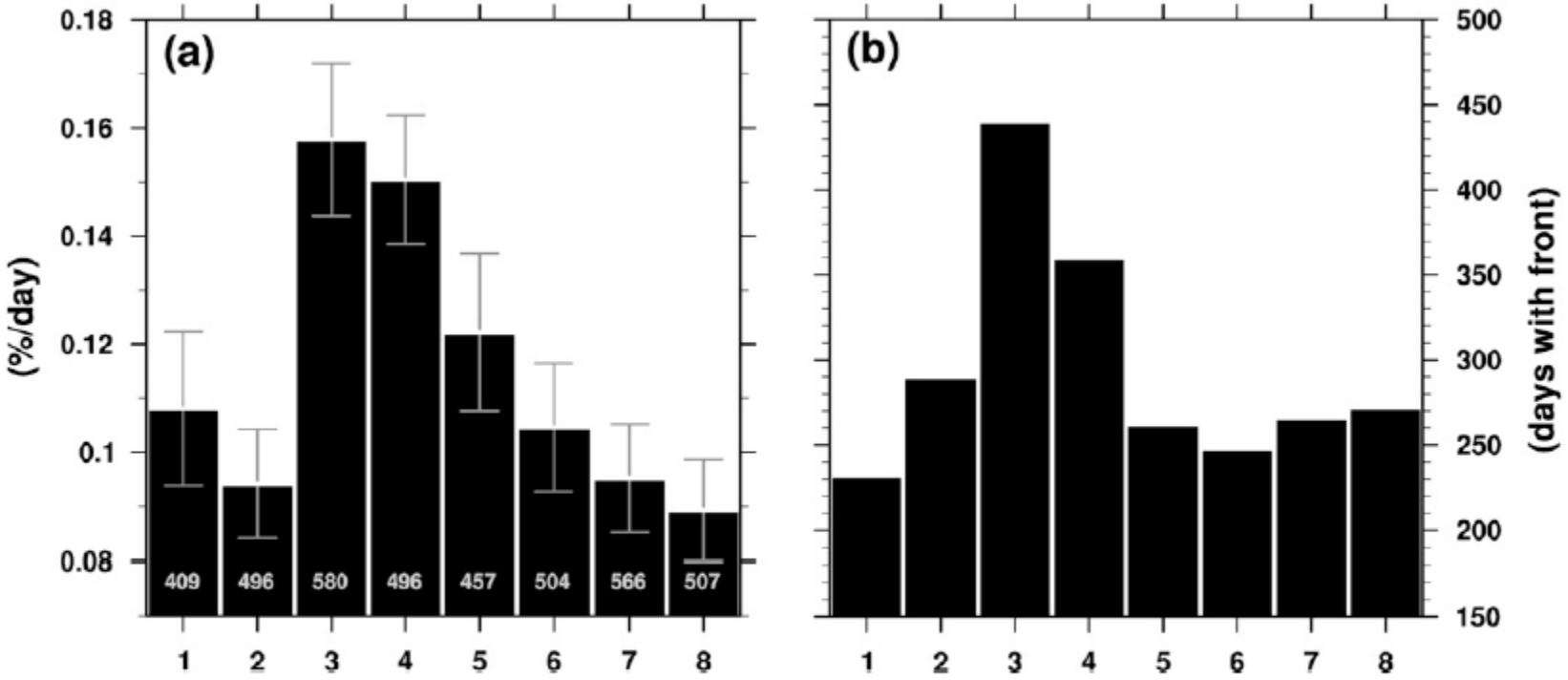
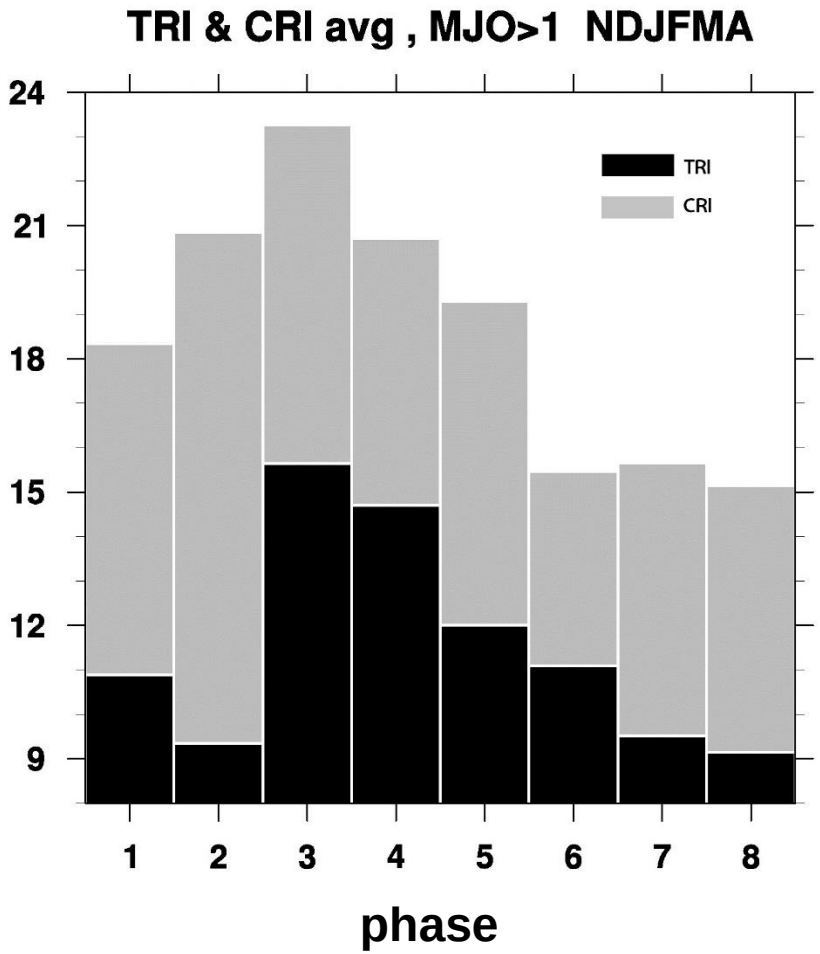
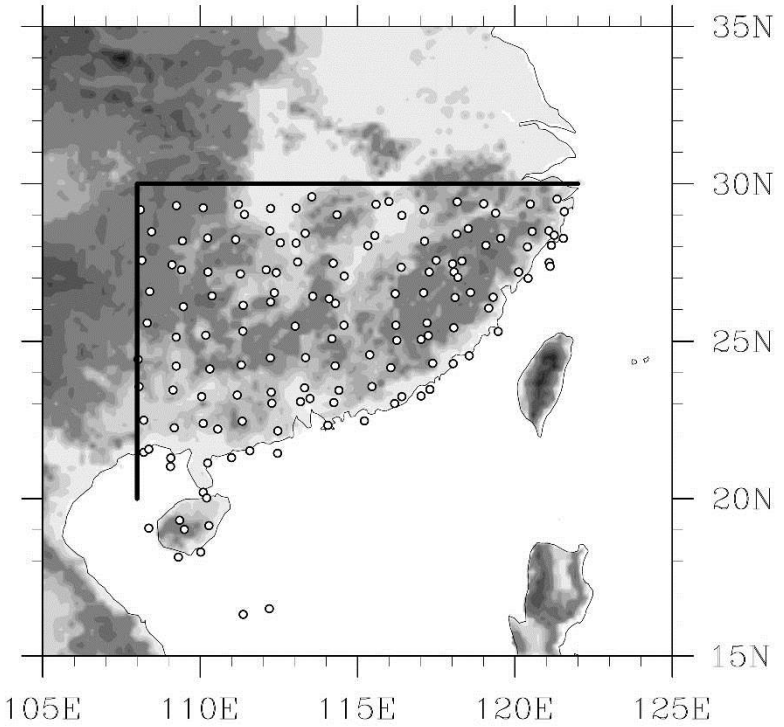


FIG. 2. (a) The mean TRI values for MJO phases 1–8 during NDJFMA from 1974 to 2009. The numbers at each bar indicate the numbers of days for each MJO phase. The standard error for each phase is plotted in the figure. (b) The number of days with fronts over the Taiwan area (20°–28°N, 118°–124°E, and excluding the continental China area) for each MJO phase from 1974 to 2009.

Taiwan Rainfall / Southern China Rainfall and MJO phase



Stations in Southern China



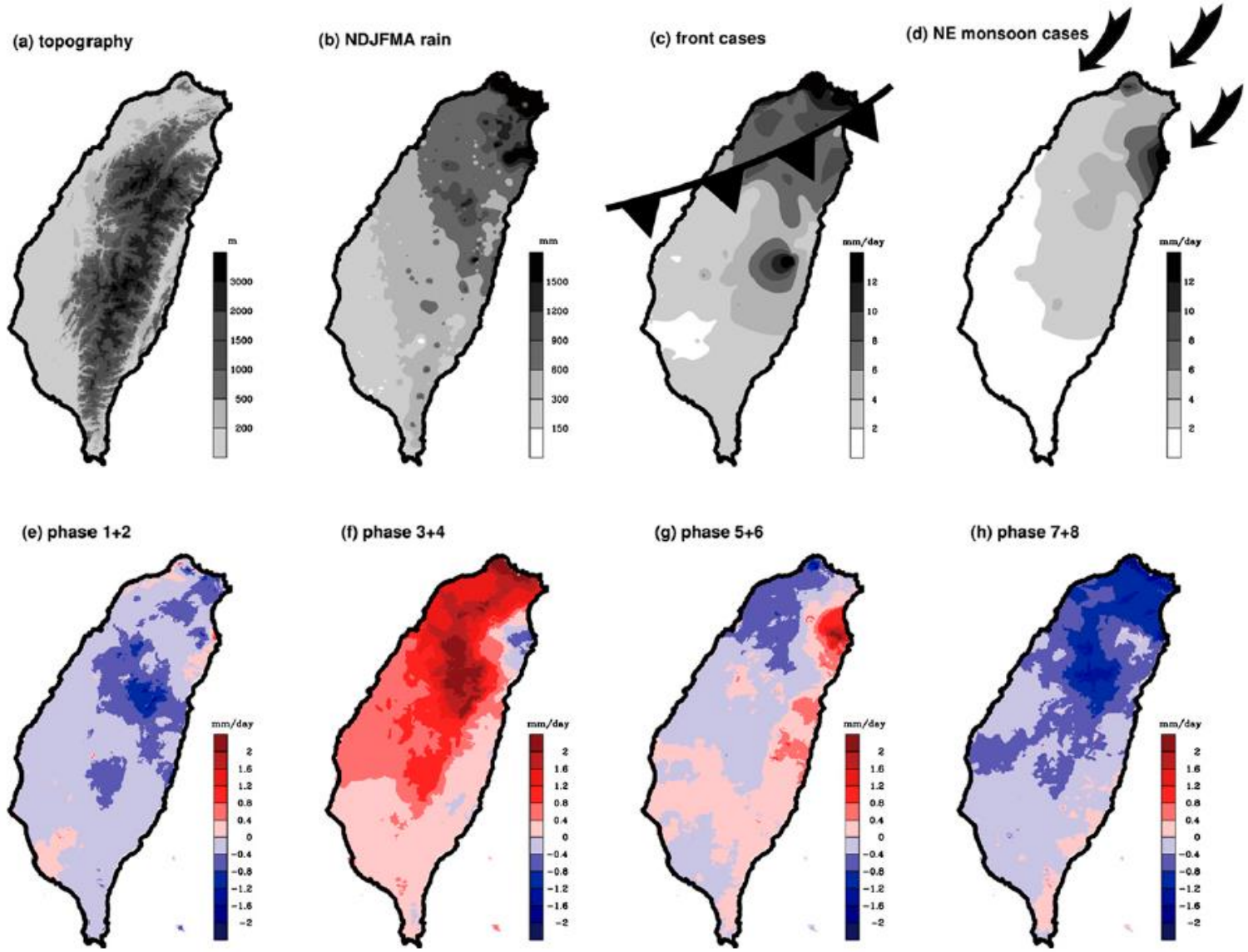


FIG. 3. (a) The topography of Taiwan (m). (b) The mean November–April rainfall for 1974–2009 (mm). (c),(d) The daily rainfall composites (mm day^{-1}) for the front cases and northeasterly monsoon cases from Fig. 3 of Hung and Kao (2010), respectively. (e),(f),(g),(h) The mean anomalous rainfall patterns (mm day^{-1}) in Taiwan for MJO phases 1 + 2, 3 + 4, 5 + 6, and 7 + 8 in 1974–2009, respectively.

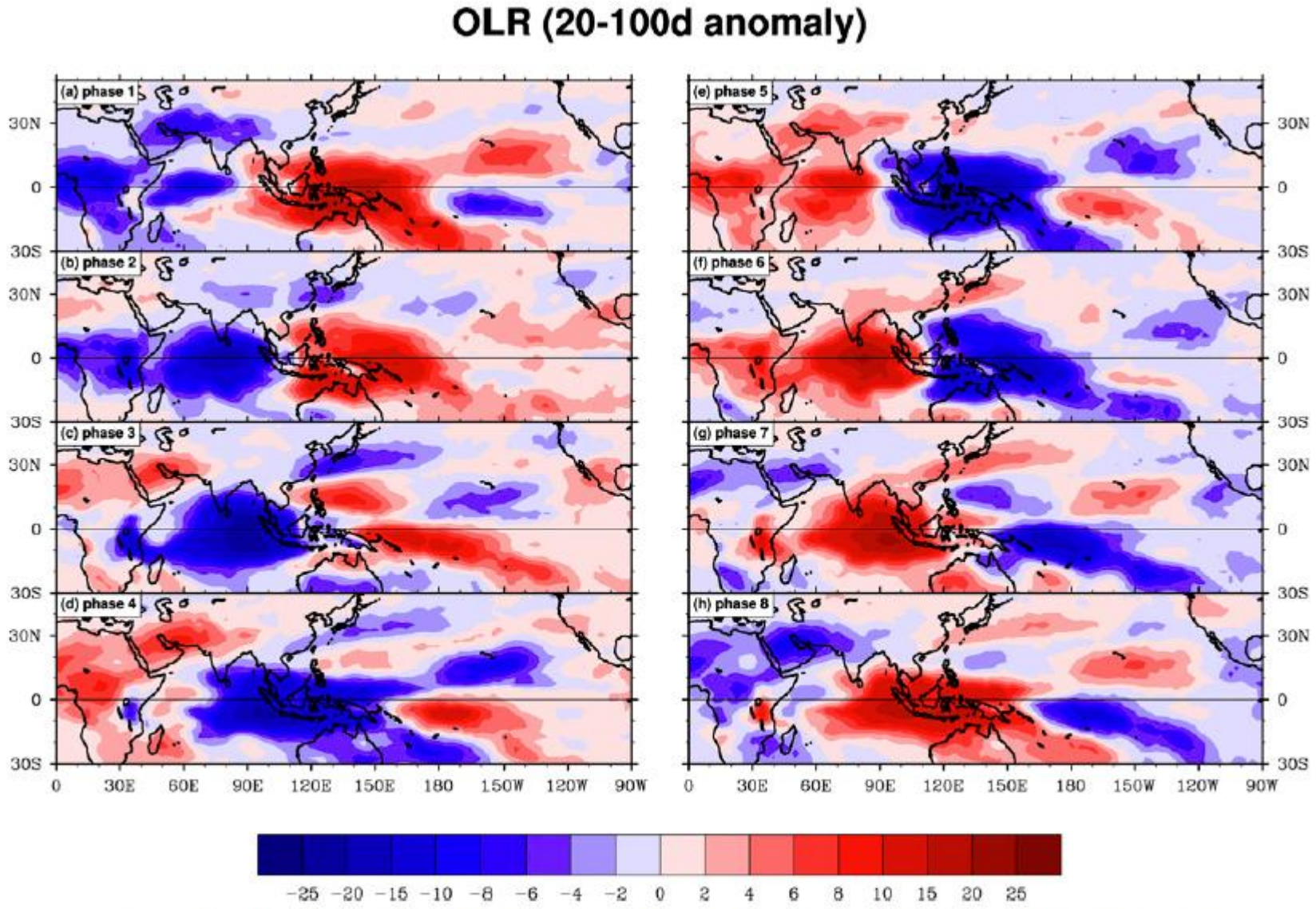
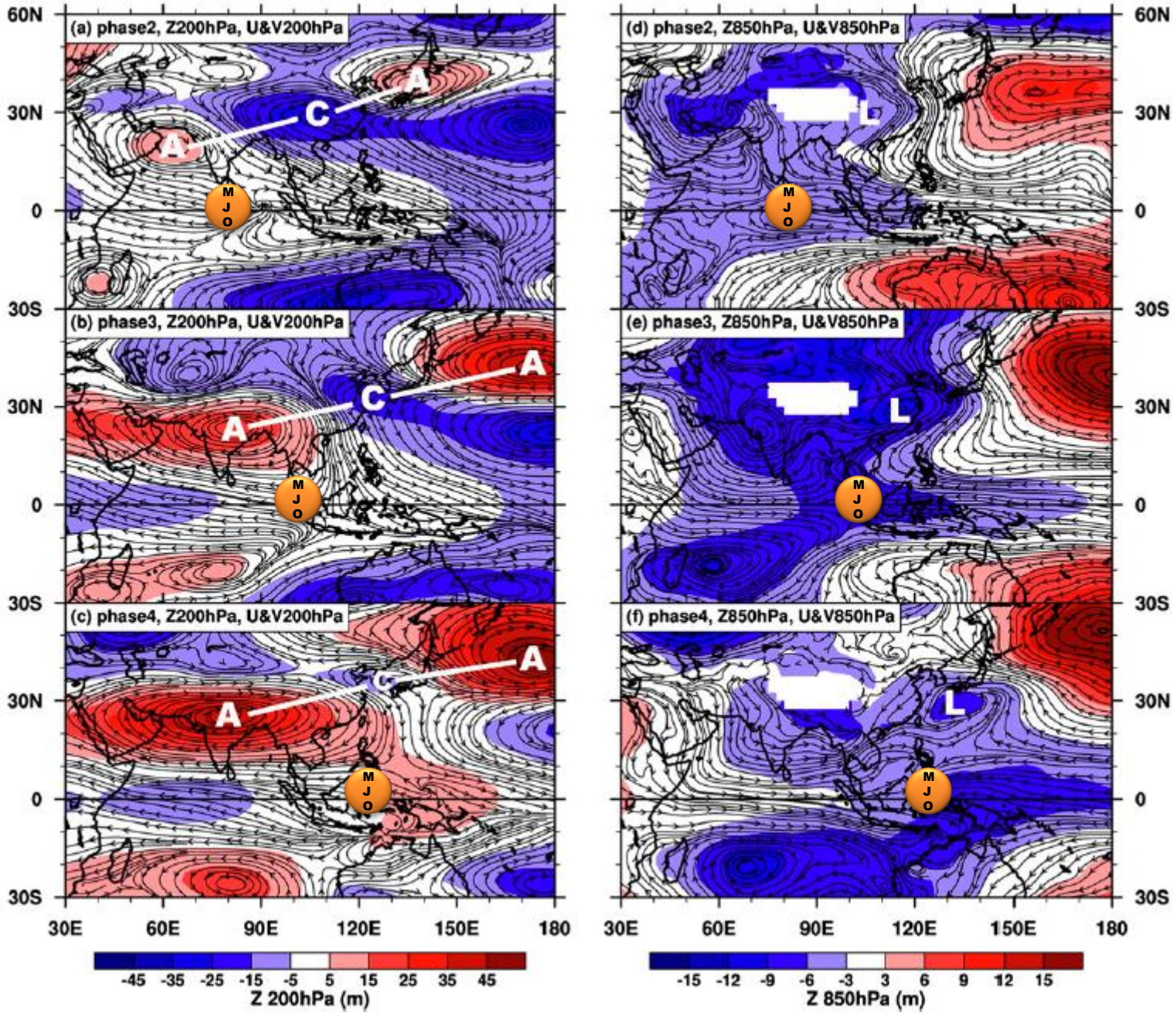
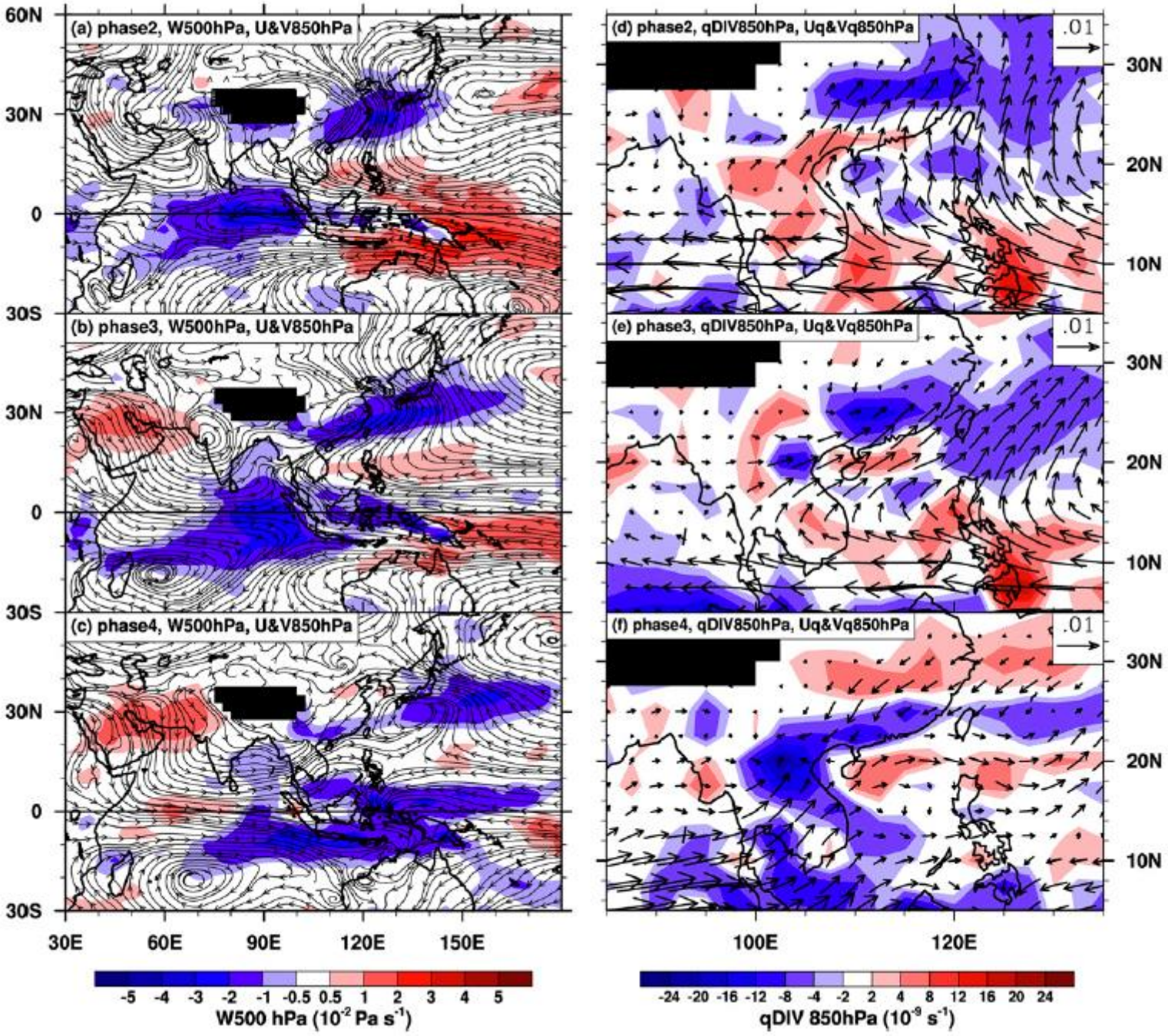
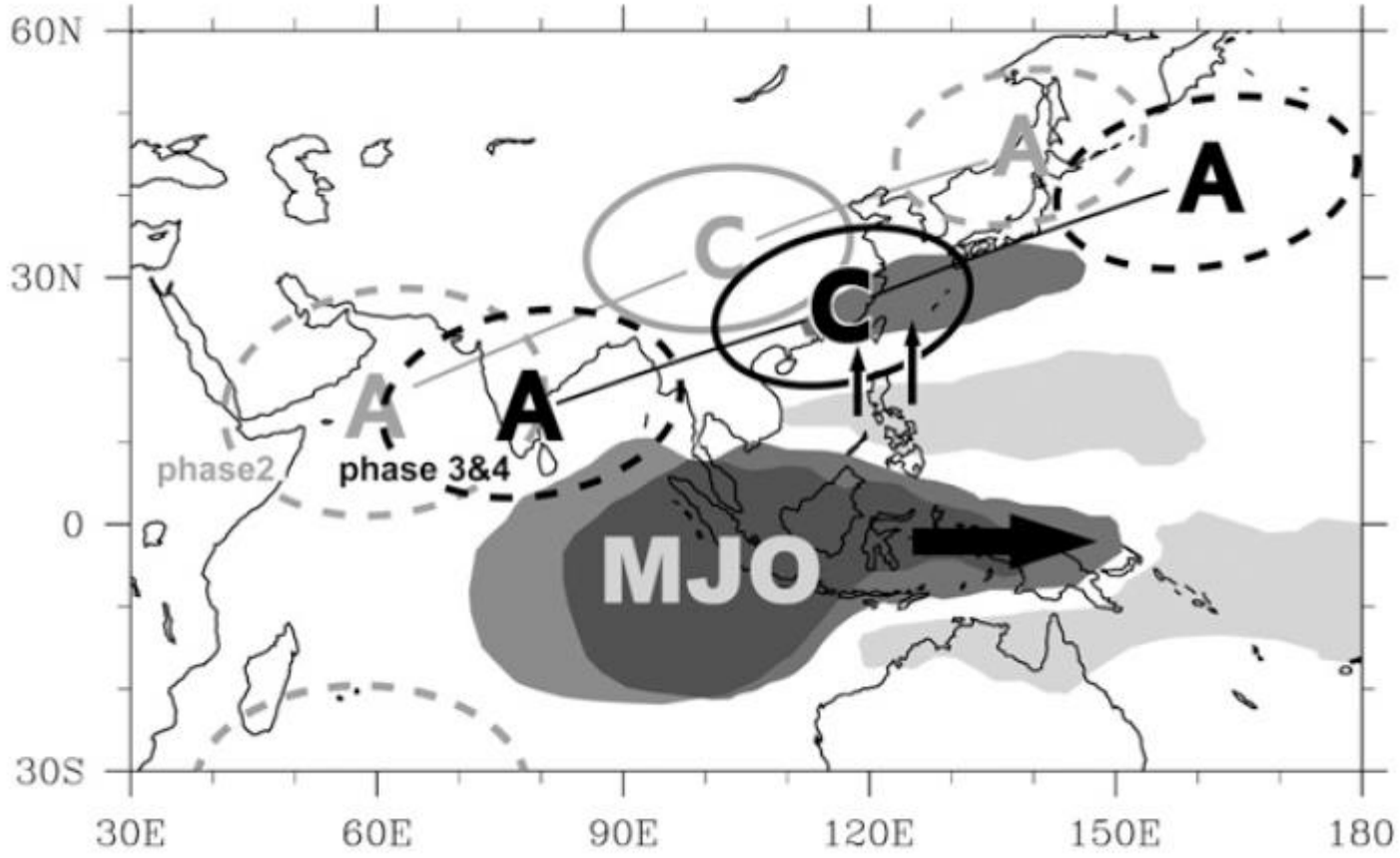


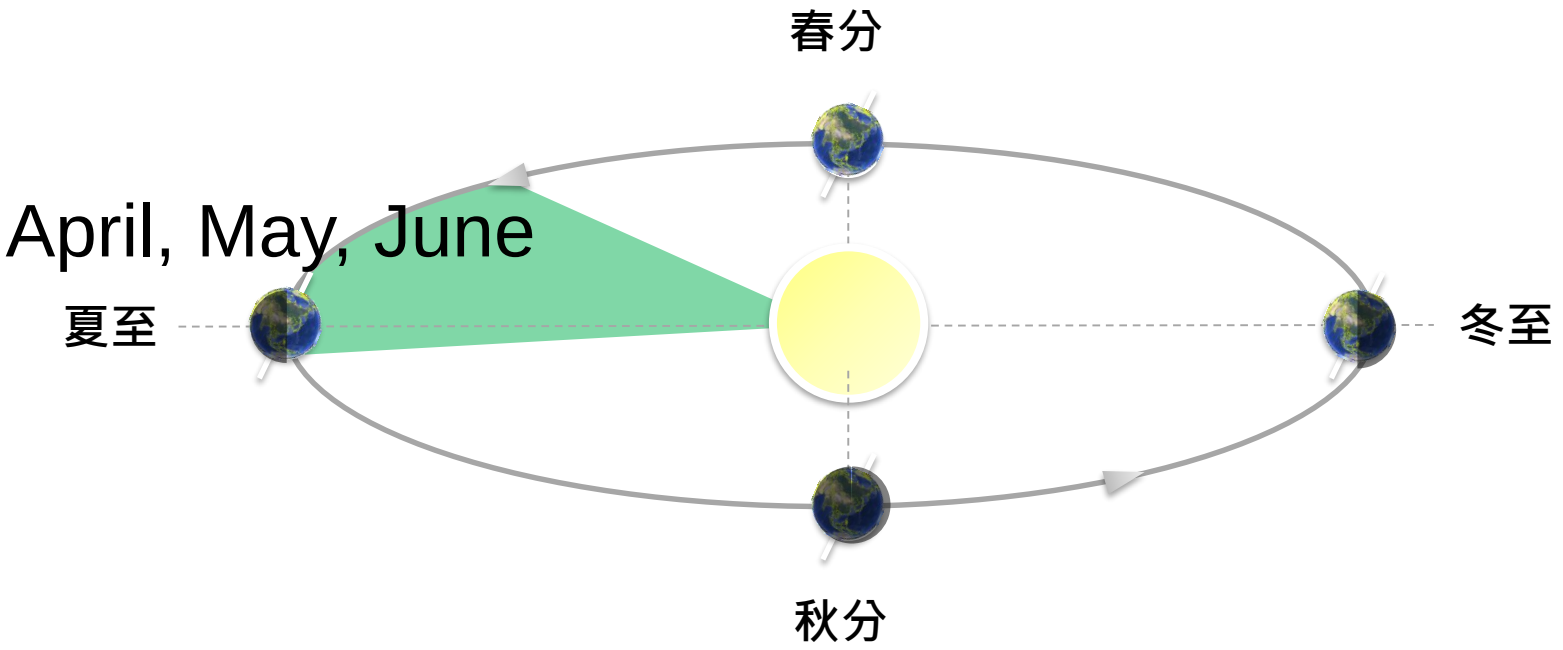
FIG. 4. The 20–100-day filtered anomalous OLR (red/blue shading; W m^{-2}) for MJO phases 1–8.


(a) phase2, Z200hPa, U&V200hPa
(b) phase3, Z200hPa, U&V200hPa
(c) phase4, Z200hPa, U&V200hPa
(d) phase2, Z850hPa, U&V850hPa
(e) phase3, Z850hPa, U&V850hPa
(f) phase4, Z850hPa, U&V850hPa
A
C
L
MJO
60N
30N
0
30S
30E
60E
90E
120E
150E
180
-45 -35 -25 -15 -5 5 15 25 35 45
Z 200hPa (m)
-15 -12 -9 -6 -3 3 6 9 12 15
Z 850hPa (m)


(a) phase2, W500hPa, U&V850hPa
(b) phase3, W500hPa, U&V850hPa
(c) phase4, W500hPa, U&V850hPa
(d) phase2, qDIV850hPa, Uq&Vq850hPa
(e) phase3, qDIV850hPa, Uq&Vq850hPa
(f) phase4, qDIV850hPa, Uq&Vq850hPa
.01
60N
30N
0
30S
30E
60E
90E
120E
150E
100E
120E
20N
10N
-5 -4 -3 -2 -1 -0.5 0.5 1 2 3 4 5
W500 hPa (10^{-2} Pa s^{-1})
-24 -20 -16 -12 -8 -4 -2 2 4 8 12 16 20 24
qDIV 850hPa (10^{-9} s^{-1})


60N
30N
0
30S
30E
60E
90E
120E
150E
180
A
A
C
C
A
A
phase2
phase 3&4
MJO

TISO and Taiwan Mei-yu
(Asia Summer Monsoon First transition)



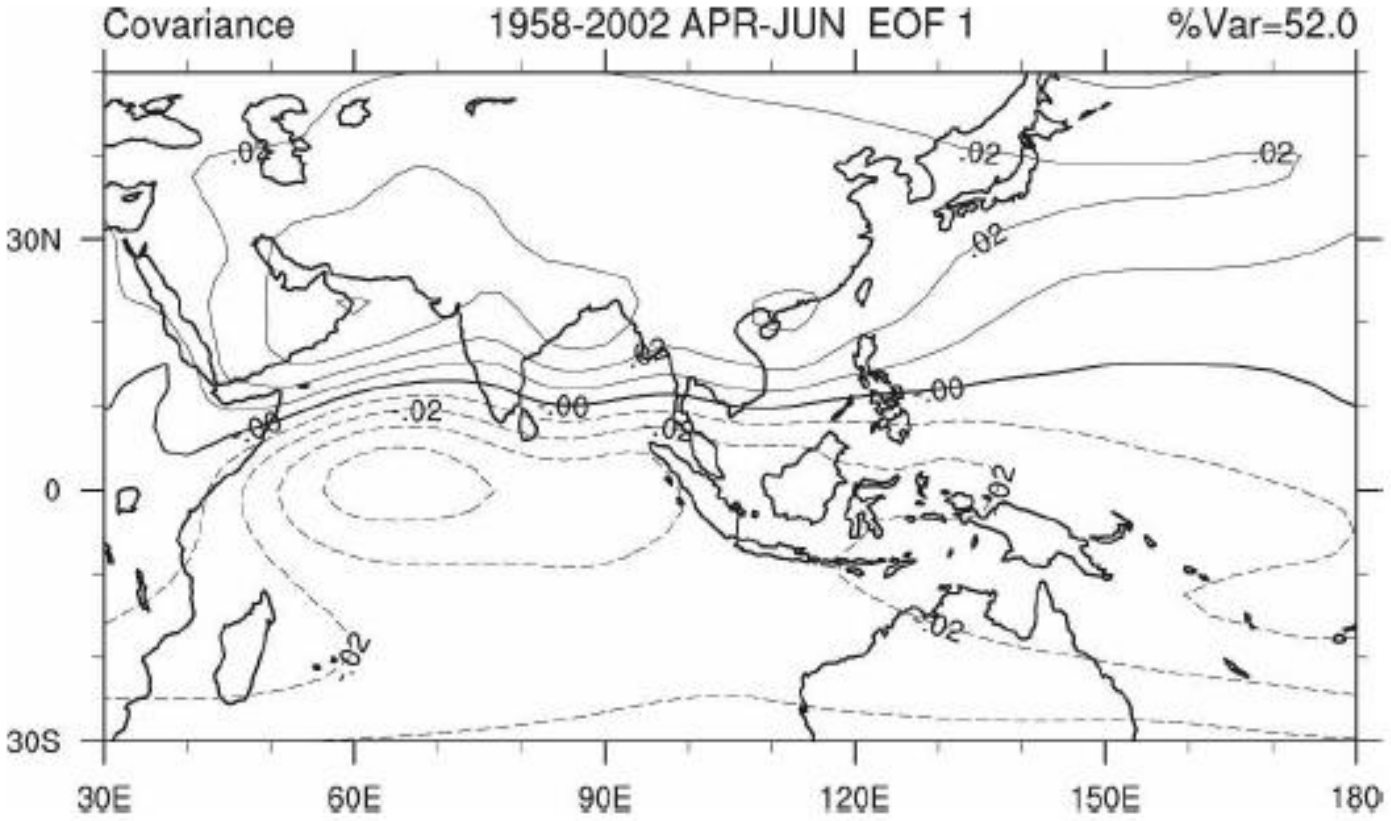


FIG. 1. The first EOF of the 850-hPa streamfunction for the period 1958–2002 based on the method described in Hsu et al. (1999) is shown.

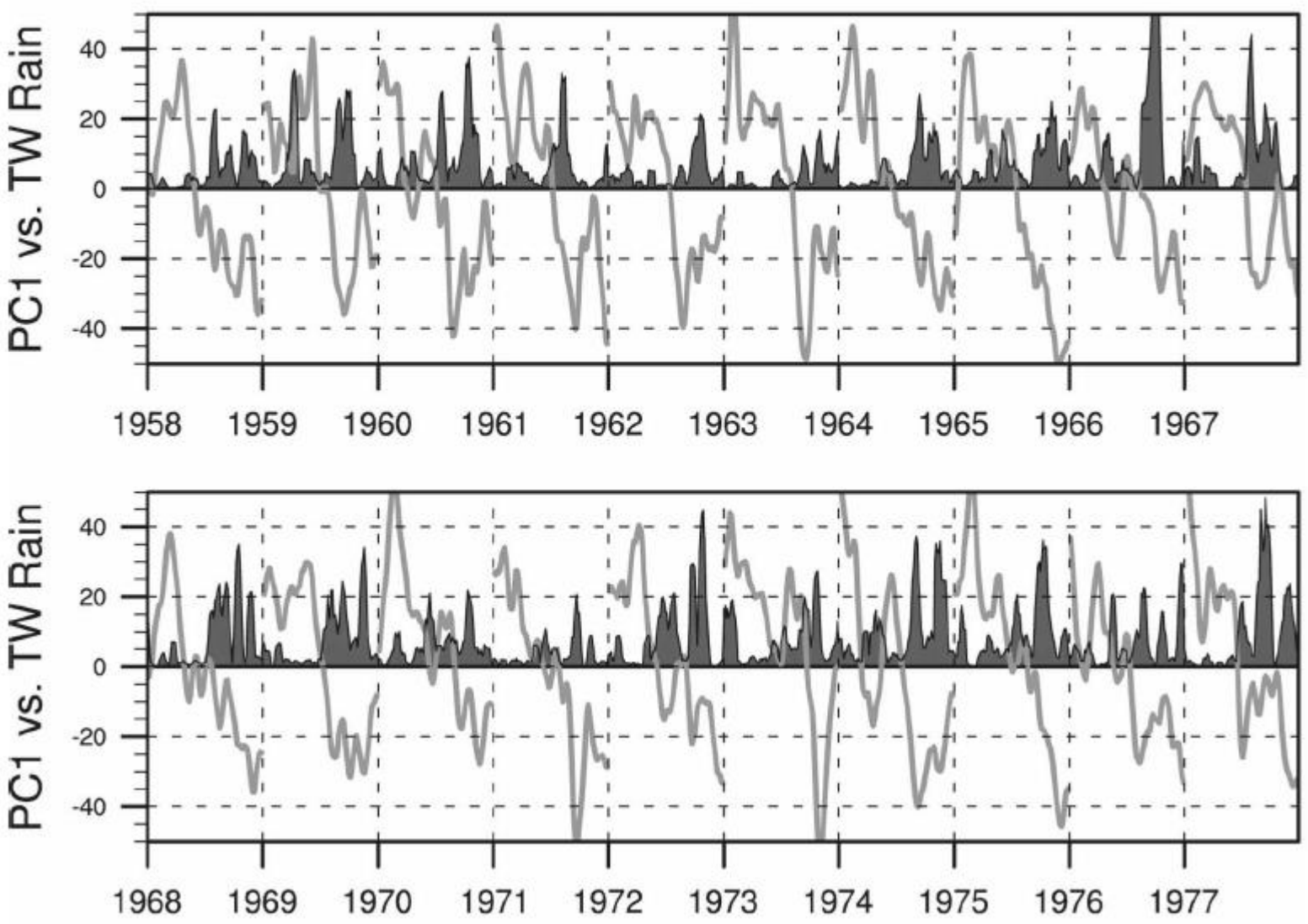


FIG. 2. Subseasonal fluctuation are shown of Taiwan rainfall (dark shading; mm day^{-1}) and PC1 (gray line; 10^{-7} is multiplied in order to be shown together with rainfall). Only data from 1 April to 30 June are displayed for each year.

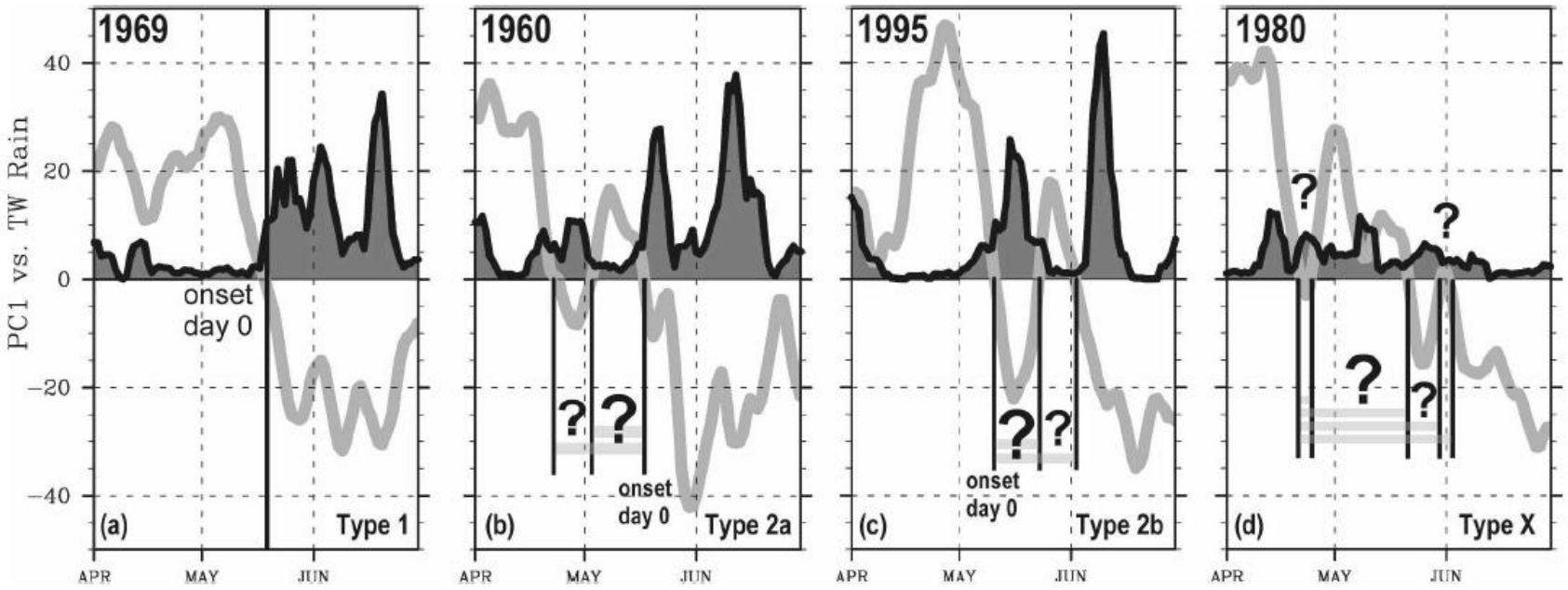


FIG. 3. Selected examples are shown for type (a) 1 (1969), (b) 2a (1960), (c) 2b (1995), and (d) X (1980) from Fig. 2. The gray line shows the PC1 (10^{-7} is multiplied) and the black line with gray shading is Taiwan rainfall (mm day^{-1}). The question marks indicate the uncertain period between two zero PC1 values.

The strong connection between the sharp onset and strong TISO is evident in this study.

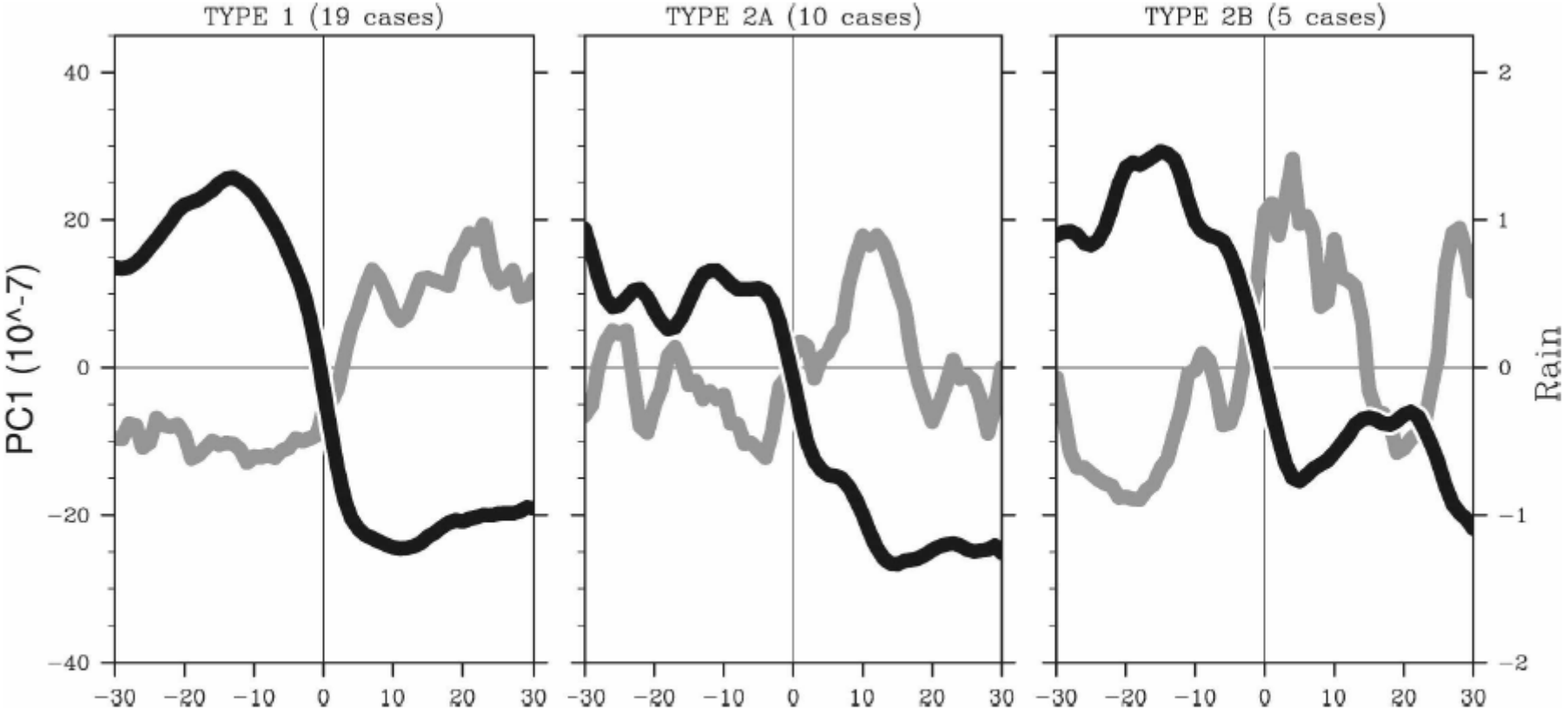


FIG. 4. (a) The composites of PC1 (thick black line; 10^{-7} is multiplied to show together with rainfalls) and standardized Taiwan rainfall (thick gray line) for the 19 abrupt-onset cases (type 1) are shown. Day 0 denotes the onset day, and negative (positive) dates represent the number of day before (after) the onset. (b), (c) Same as (a), but for type 2a and 2b, respectively.

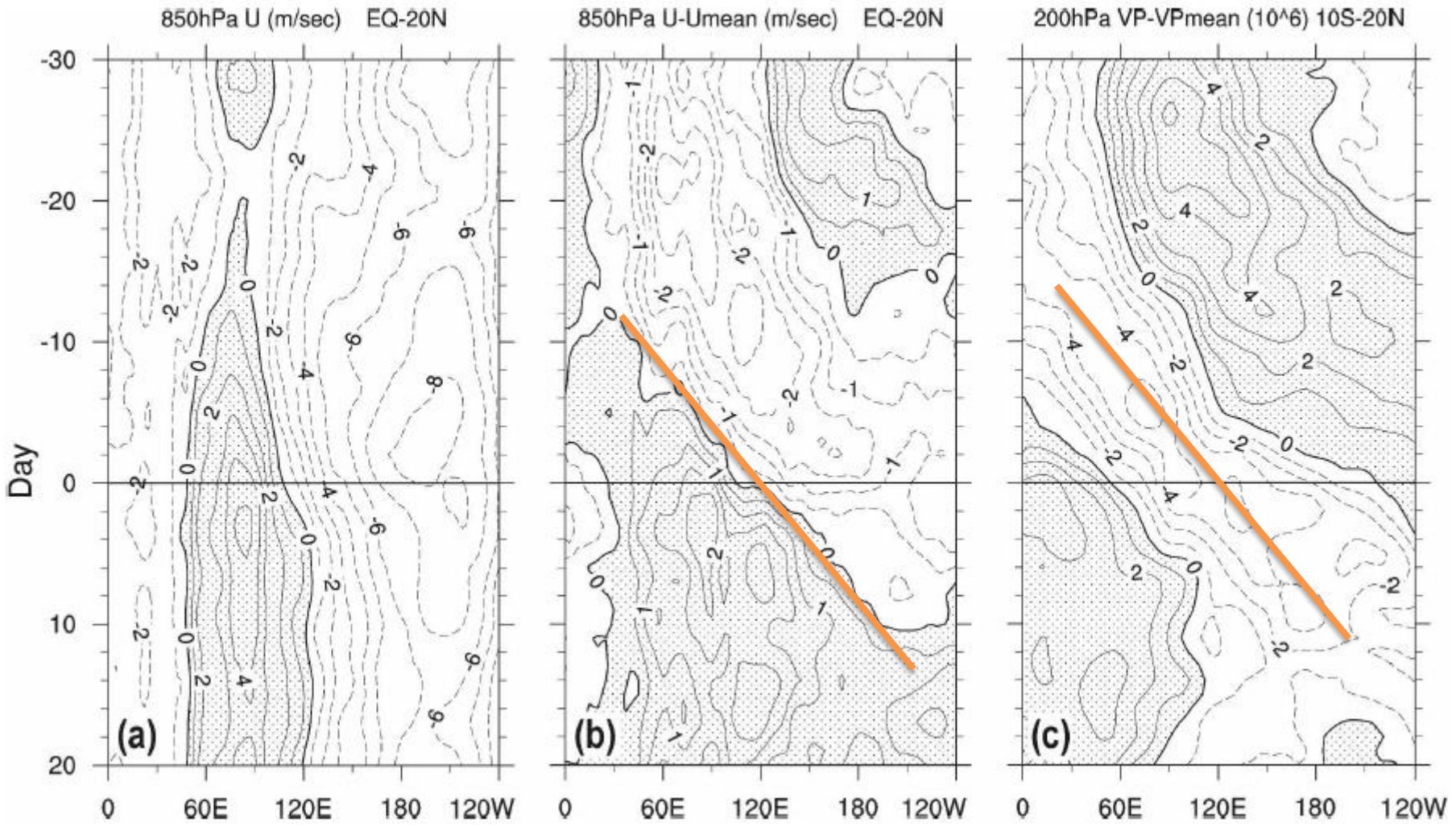


FIG. 7. **(a)** Time–longitude (averaged between the **equator and 20˚N**) composites of *u at 850 hPa for **19 abrupt-onset cases** are shown.* Dashed lines refer to the negative values, and solid lines with stippled shading are the positive values. The contour interval is 1 m s^{-1}. **(b)** Similar to (a), but the time mean between days 30 and -30 is removed. Contour interval is 0.5 m s^{-1}. **(c)** Similar to (b), but for velocity potential at 200 hPa and the longitudinal average between 10˚S and 20˚N. The contour interval is 10^6 m^2 s^{-1}.

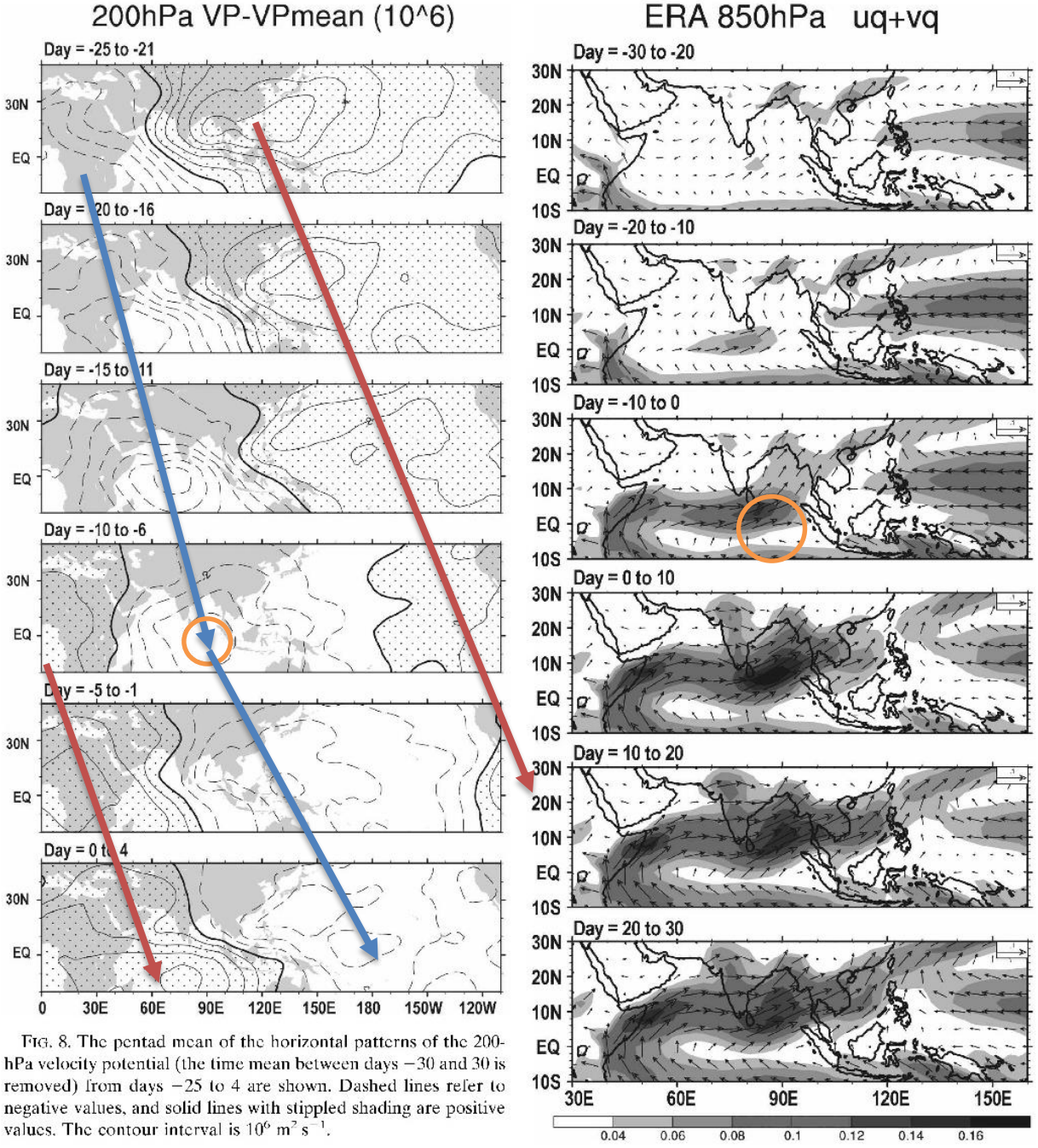


FIG. 8. The pentad mean of the horizontal patterns of the 200-hPa velocity potential (the time mean between days −30 and 30 is removed) from days −25 to 4 are shown. Dashed lines refer to negative values, and solid lines with stippled shading are positive values. The contour interval is 10^6 m^2 s^{-1}.

Moisture Convergence

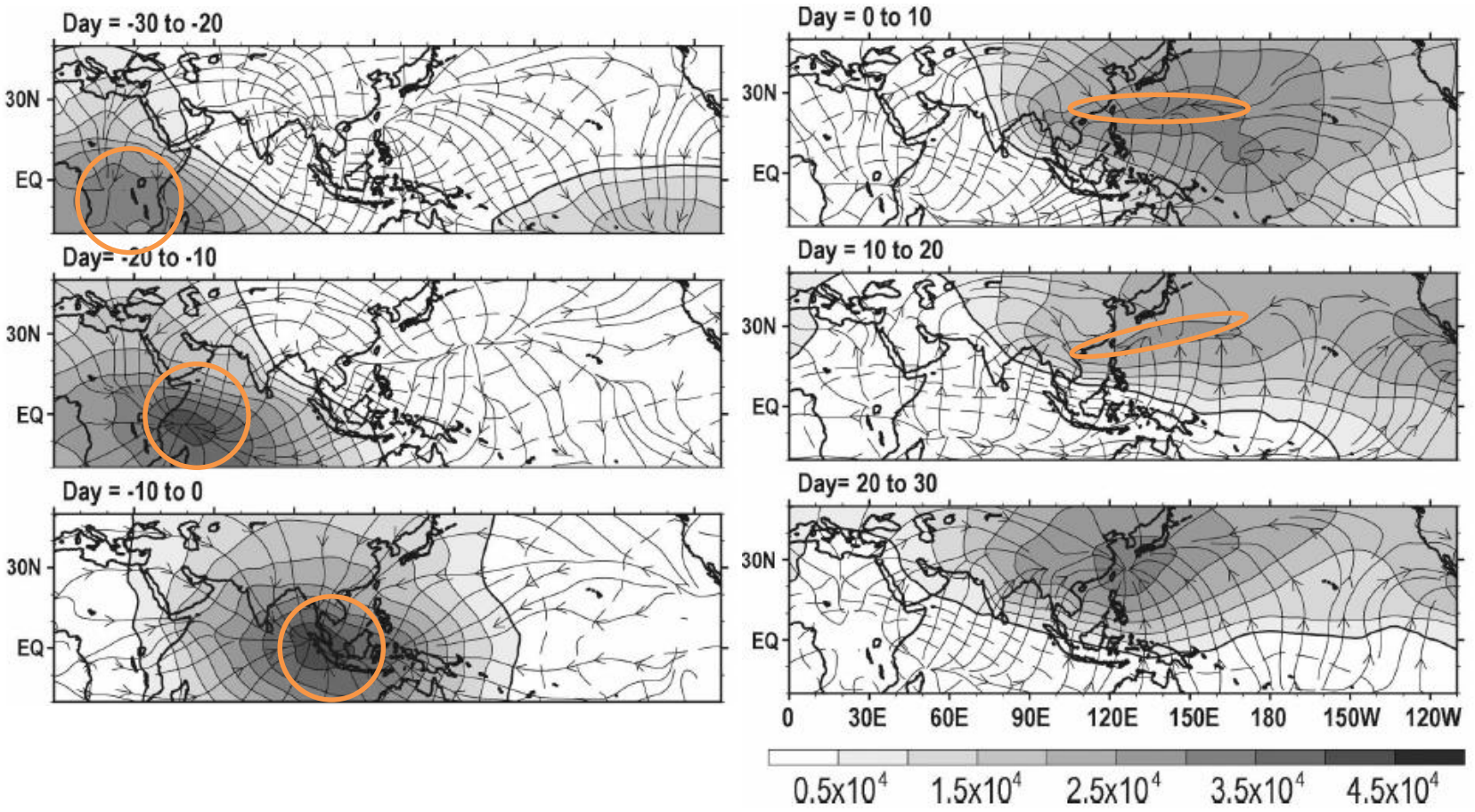
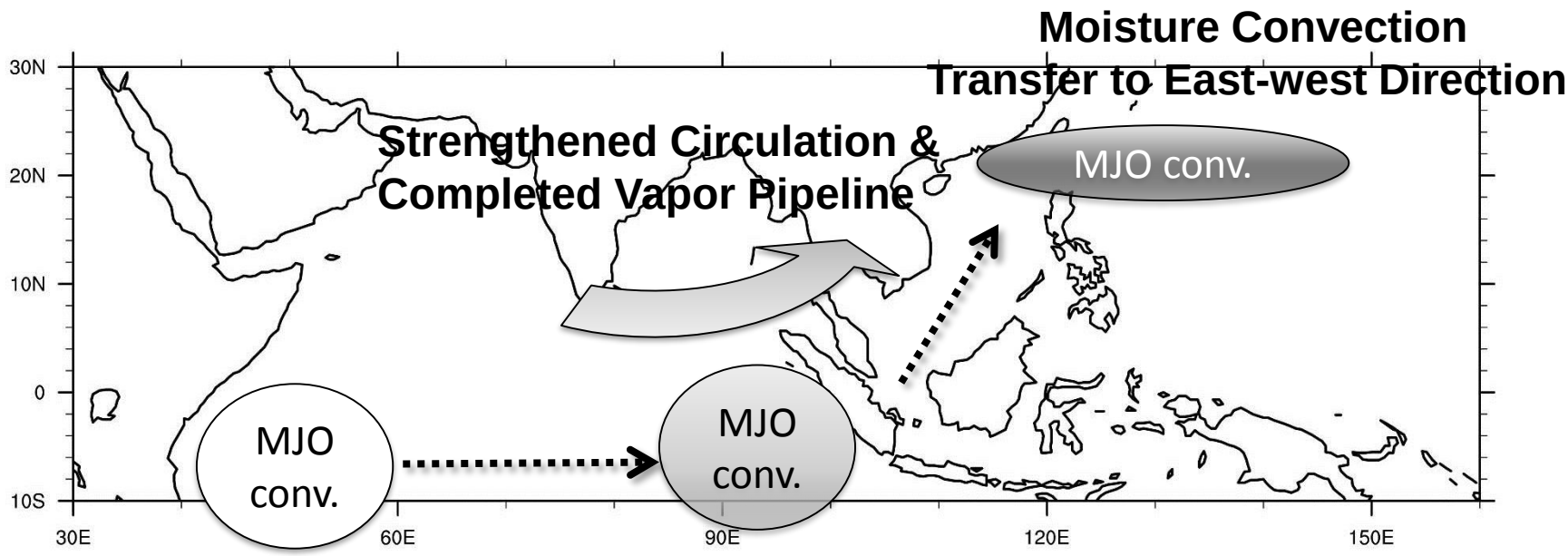
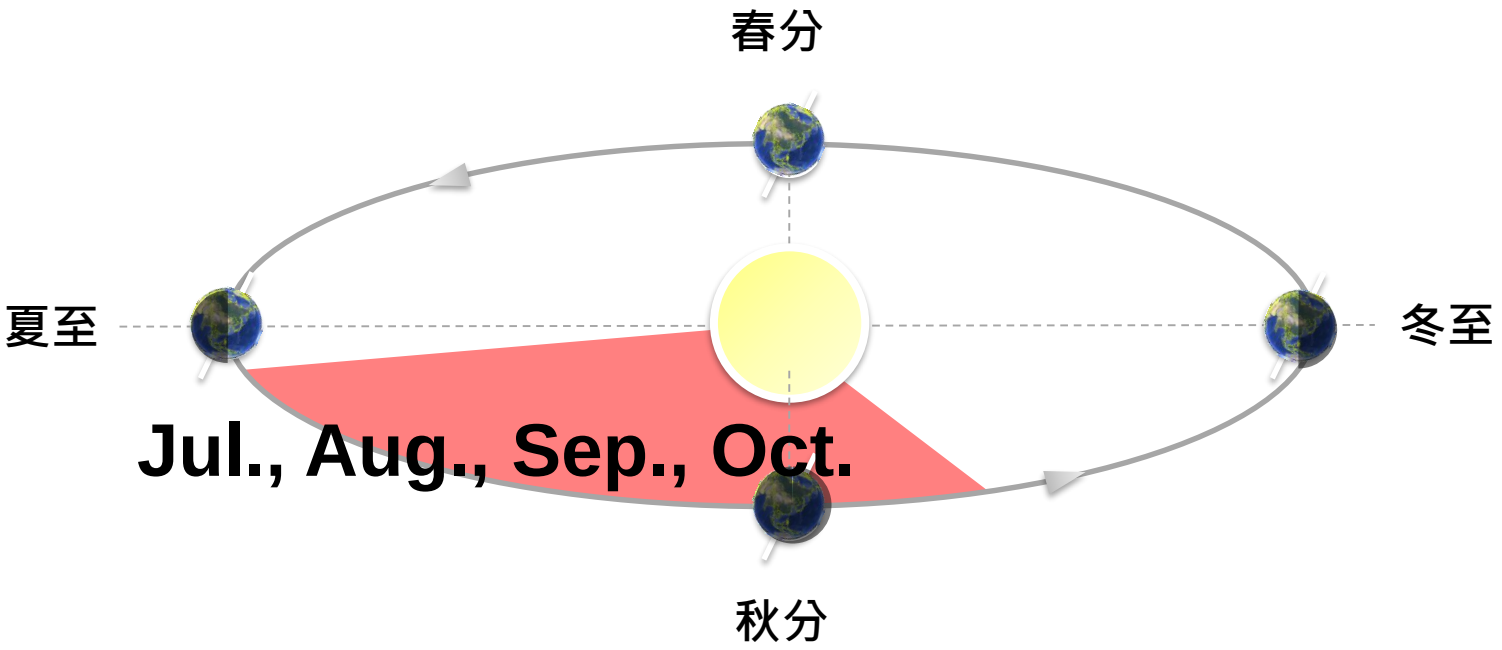


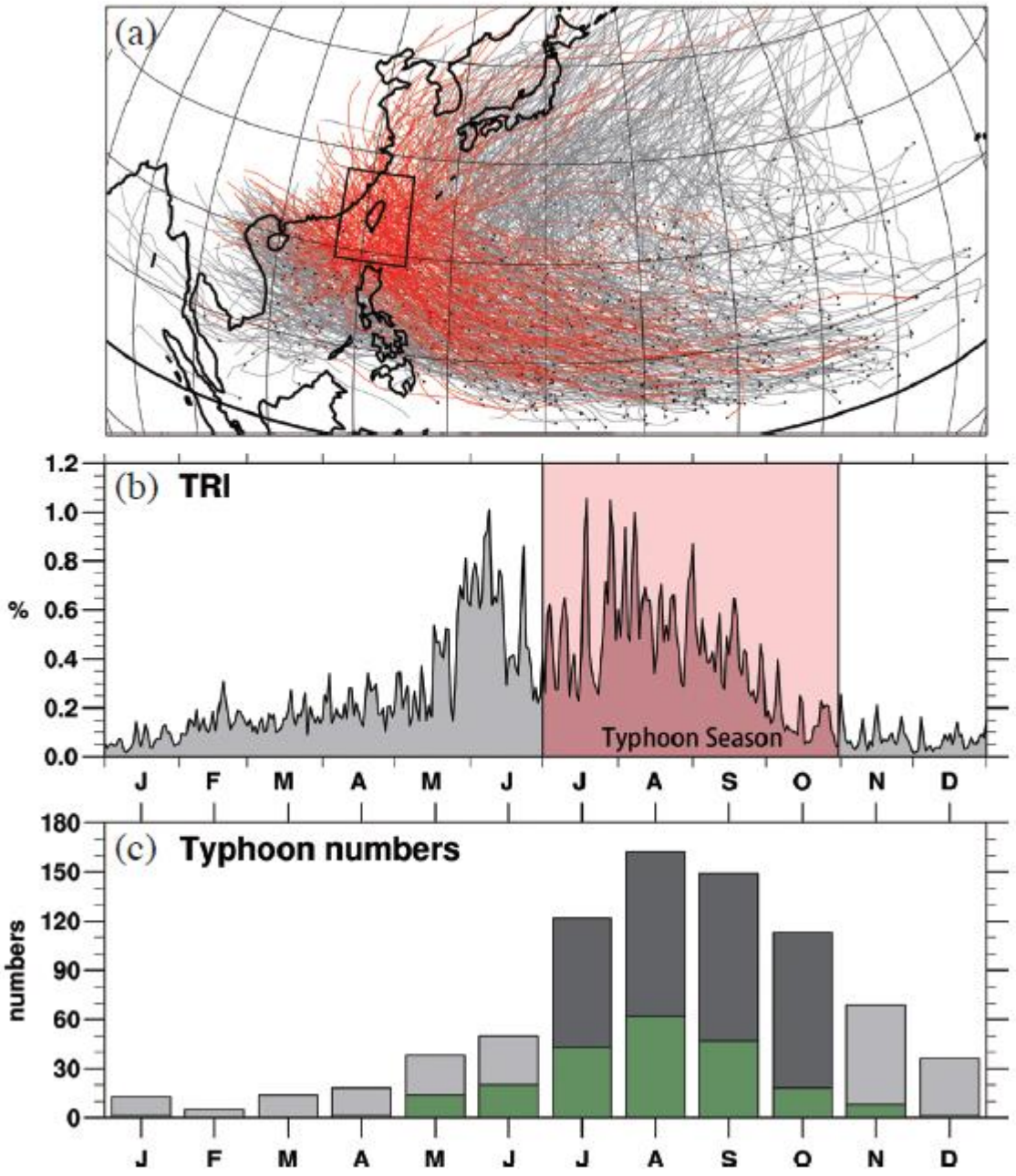
FIG. 10. Composites of 11-day mean moisture divergence at 850 hPa for the 19 abrupt-onset cases are shown. The moisture divergence is displayed in streamlines of moisture flux and potential (in gray shading for positive values). The contour interval is 0.5 10^4 m^2 s^{-1}.

Concept Chart --
Sharp Onset of Taiwan Mei-yu



BSISO and Typhoon Rainfall in Taiwan




(a)
(b) TRI
%
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Typhoon Season
J F M A M J J A S O N D
(c) Typhoon numbers
numbers
180
150
120
90
60
30
0
J F M A M J J A S O N D

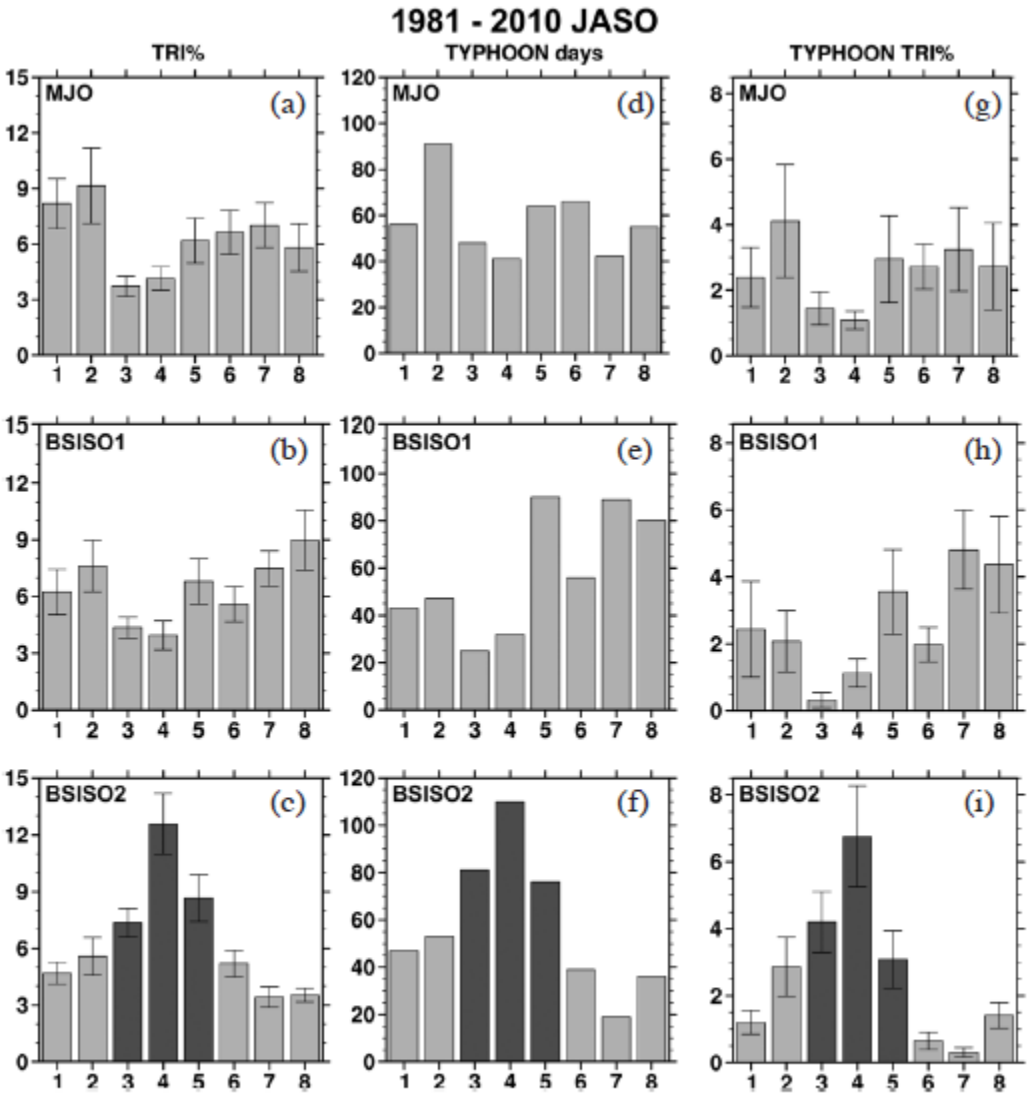


Fig. 2. The mean TRI values (unit: %) for (a) MJO, (b) BSISO1, and (c)BSISO2 phases 1 - 8 during JASO from 1981 to 2010. The dark gray bars indicate the phases 3, 4, and 5 for BSISO2 (details in the text). (d), (e), and (f) are similar to (a), (b), and (c), but for the numbers of days with typhoons in the Taiwan area. (g), (h), and (i) are similar to (a), (b), and (c), but for the TRI values during the typhoon days in Taiwan. In (a), (b), (c), (g), (h), and (i), the standard errors are plotted for references.

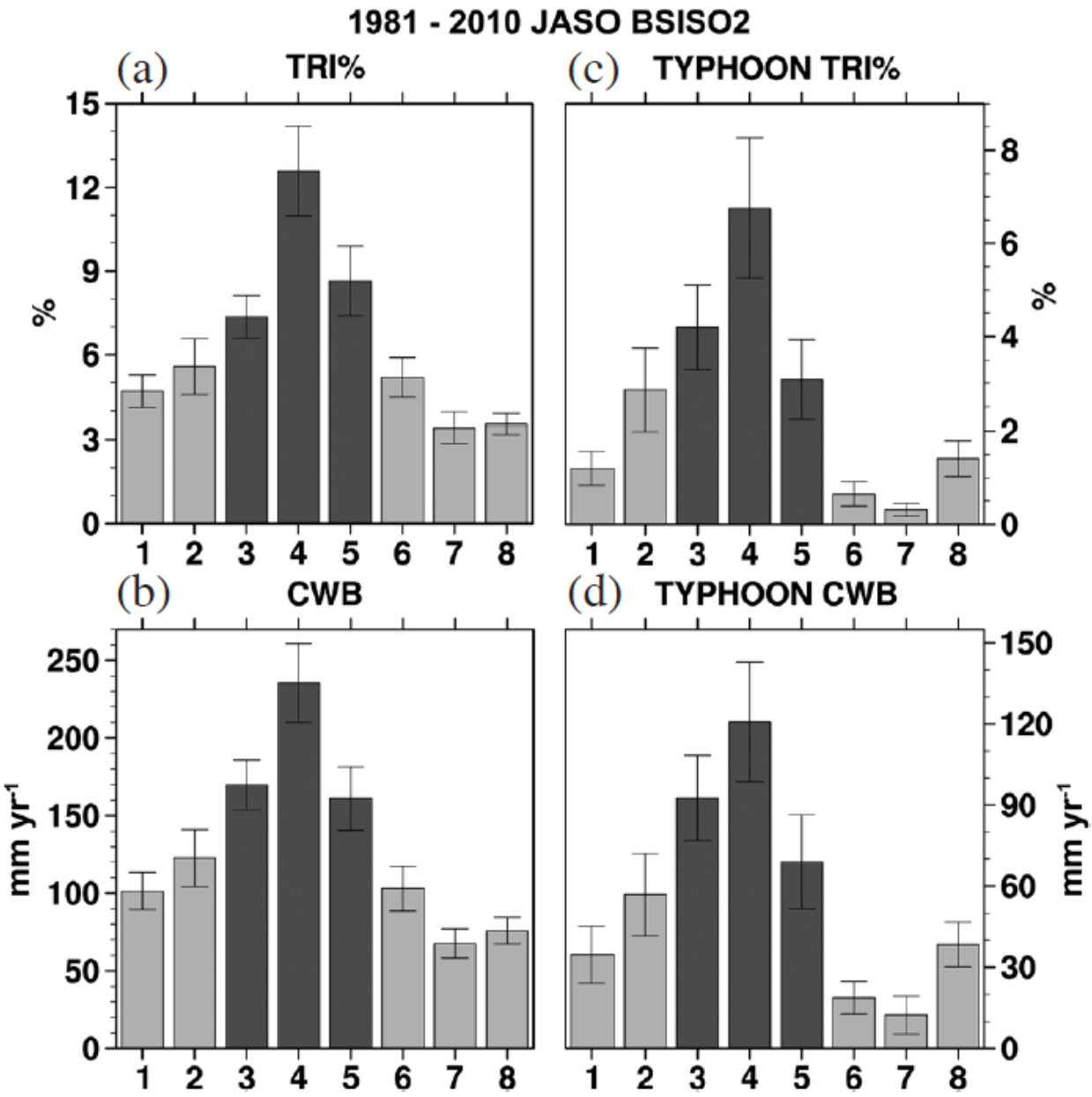
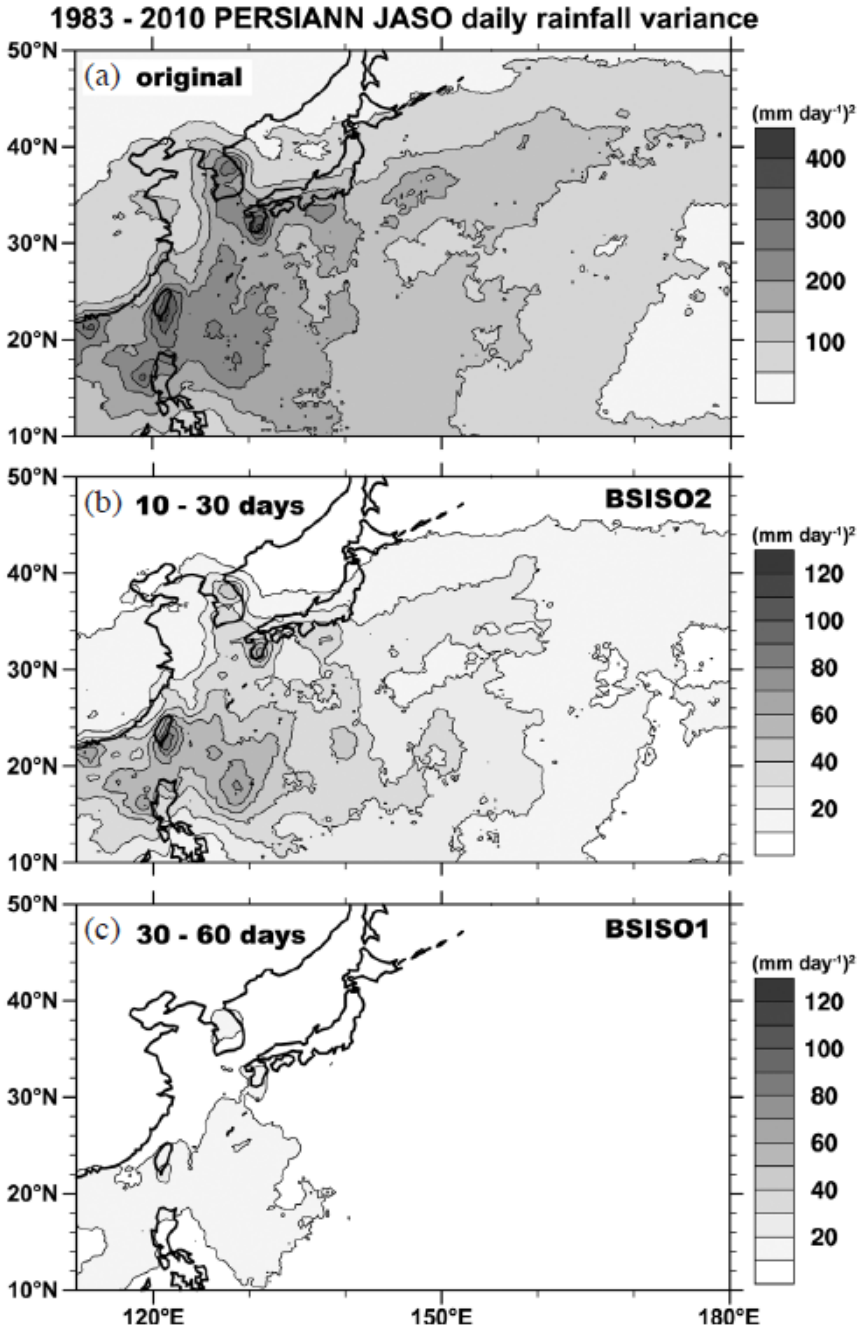


Fig. 3. The JASO (a) mean TRI values (unit: %) and (b) averaged CWB rainfall values (unit: mm) from 15 conventional weather stations in 1981 - 2010 for each BSISO2 phase. The standard errors are plotted for references. (c) and (d) are similar to (a) and (b), but for the values during typhoon days in Taiwan.



The variances of the JASO daily rainfall

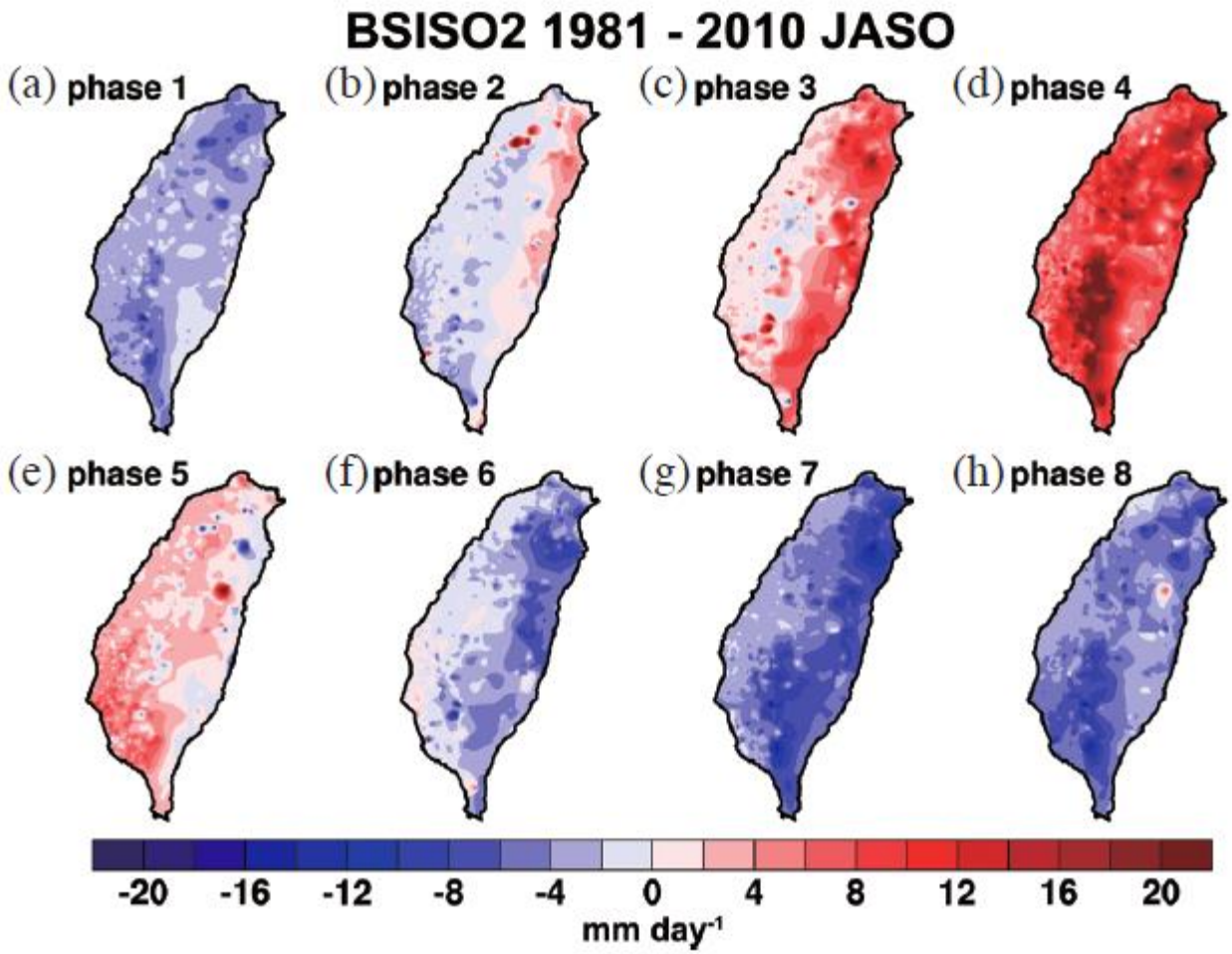


Fig. 5. The anomalous Taiwan rainfall (red/blue shading; mm day-1) for BSISO2 phases 1 - 8 [(a) to (h), respectively] in JASO. (Color online only)

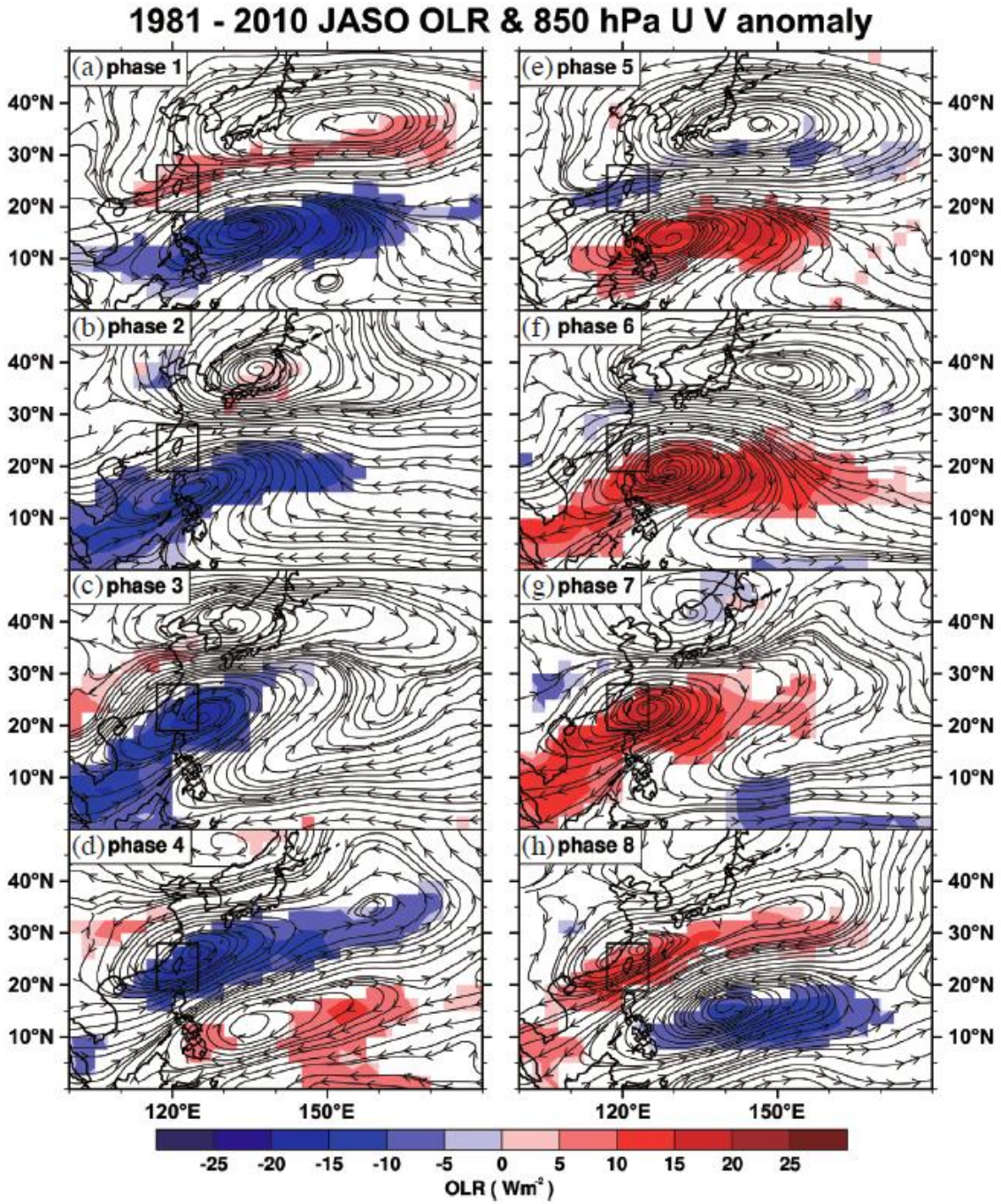


Fig. 6. The anomalous OLR (red/blue shading; W m-2) and 850-hPa streamline for BSISO2 phases 1 - 8 [(a) to (h), respectively] in JASO. The black box indicates the Taiwan area (19 - 28°N, 117 - 125°E). Only OLR anomalies exceed 95% confidence level are shown here. (Color online only)

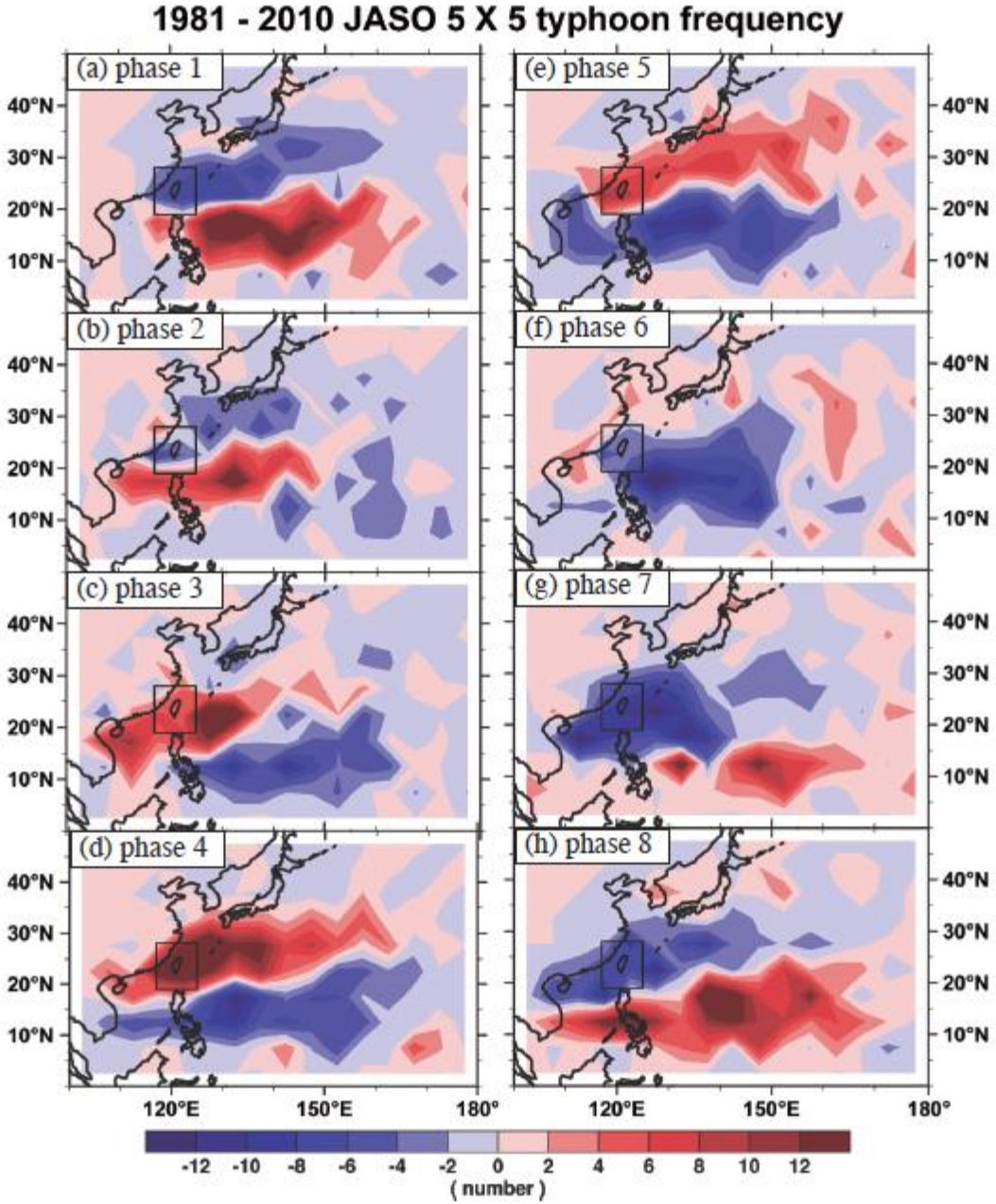
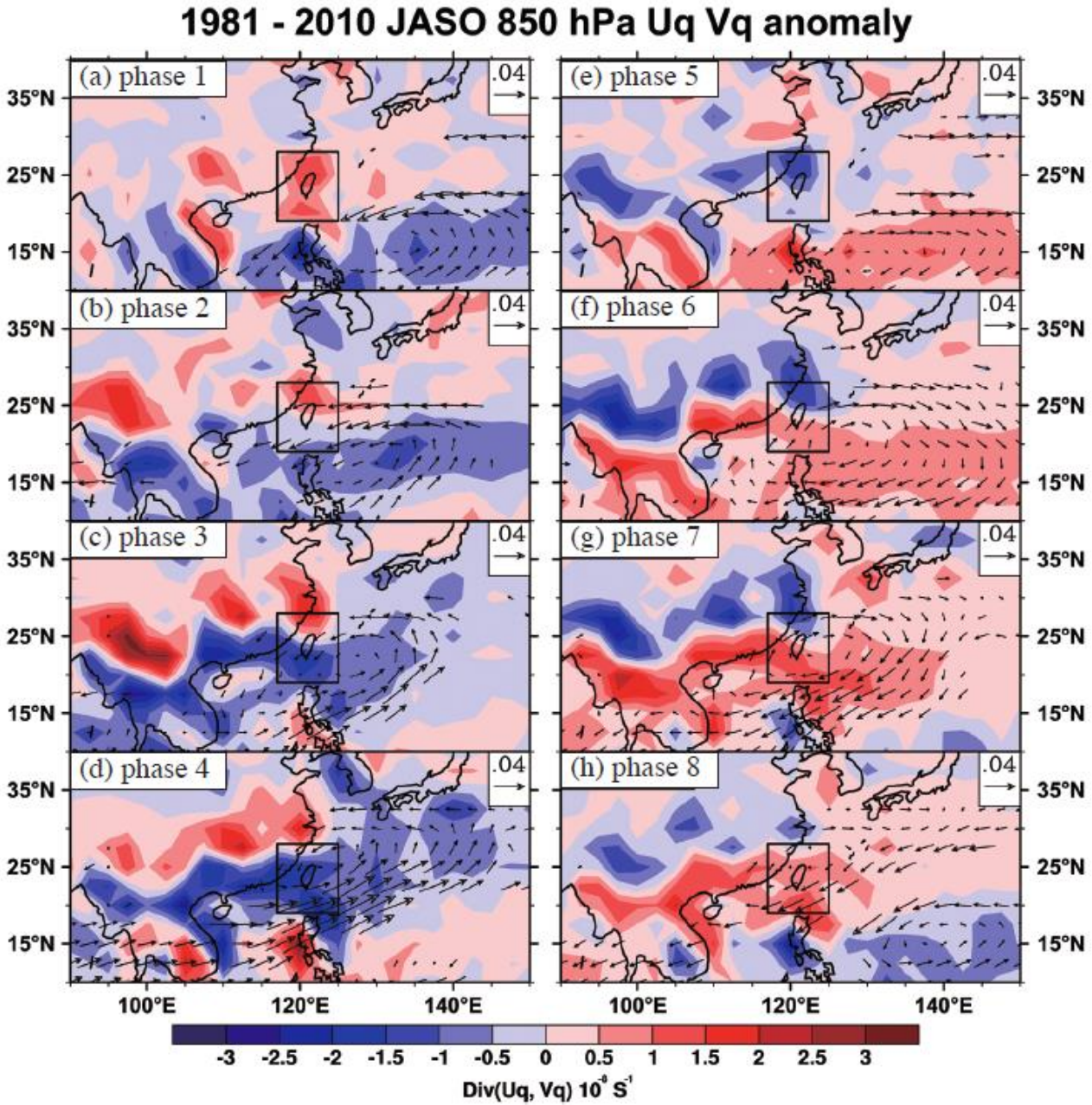
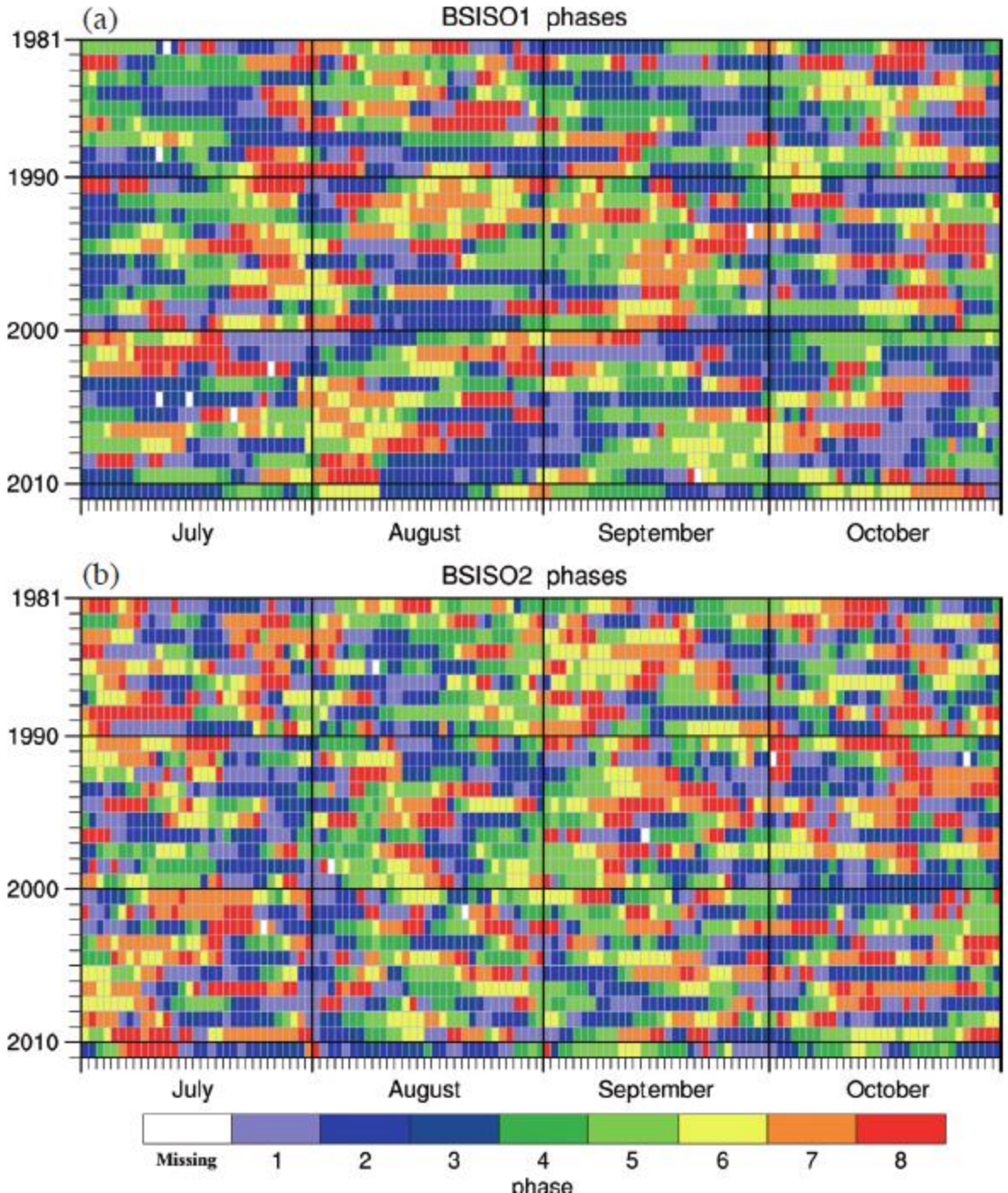


Fig. 7. Similar to Fig. 6, but for the 5° × 5° counts of the typhoon frequencies based on the JTWC data in 1981 - 2010. (Color online only)


1981 - 2010 JASO 850 hPa Uq Vq anomaly
(a) phase 1
(b) phase 2
(c) phase 3
(d) phase 4
(e) phase 5
(f) phase 6
(g) phase 7
(h) phase 8
.04
35°N
25°N
15°N
100°E
120°E
140°E
-3 -2.5 -2 -1.5 -1 -0.5 0 0.5 1 1.5 2 2.5 3
Div(Uq, Vq) 10⁻⁶ S⁻¹


(a)
BSISO1 phases
1981
1990
2000
2010
July
August
September
October
(b)
BSISO2 phases
1981
1990
2000
2010
July
August
September
October
Missing
1
2
3
4
5
6
7
8
phase

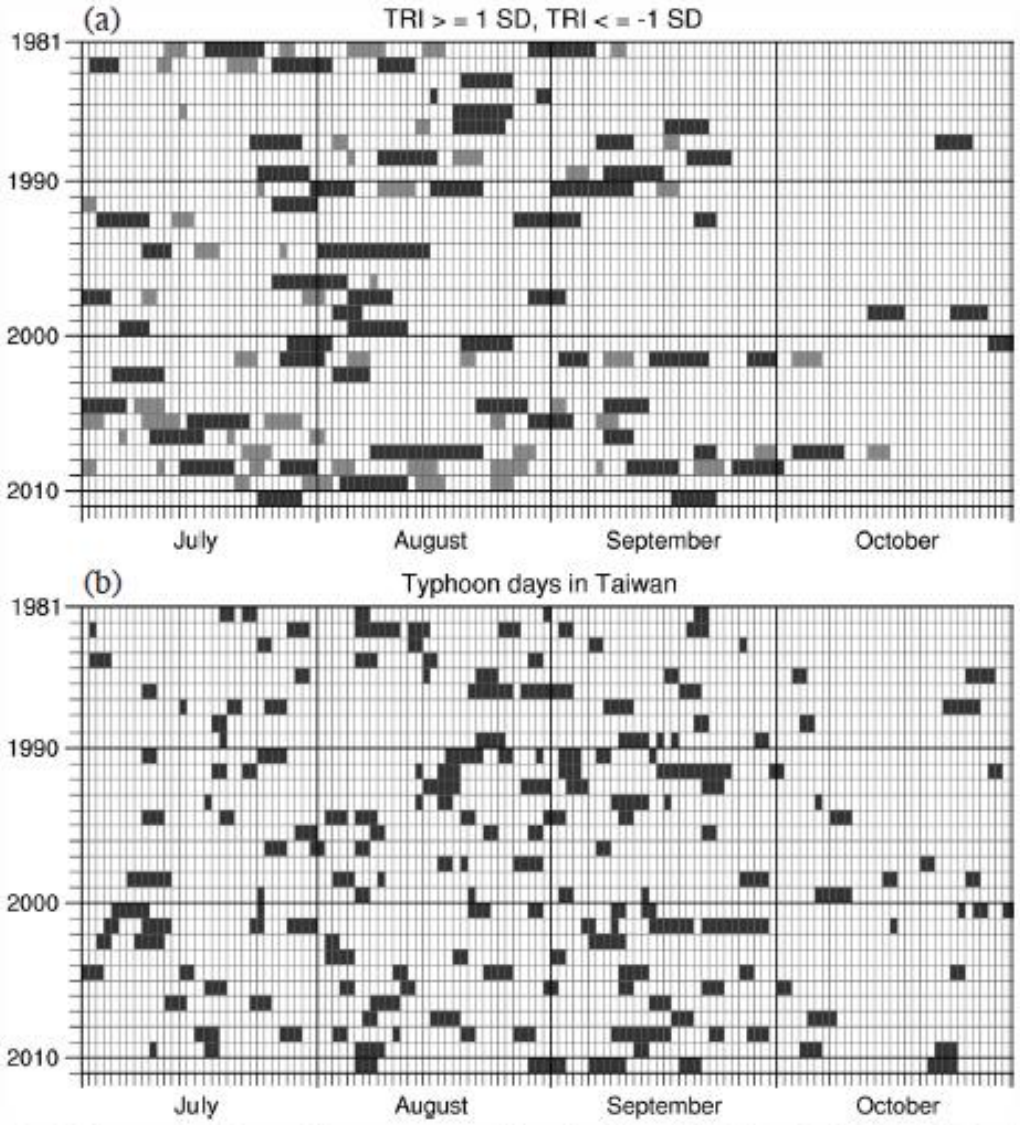


Fig. 10. (a) The JASO day-to-day Taiwan rainfall conditions represented by the filtered TRI data (> 10 days). The dark (light) gray indicate days with TRI value ≥ (≤) one standard deviation. (b) The days defined as "typhoon days" in Taiwan during JASO in 1981 - 2010.

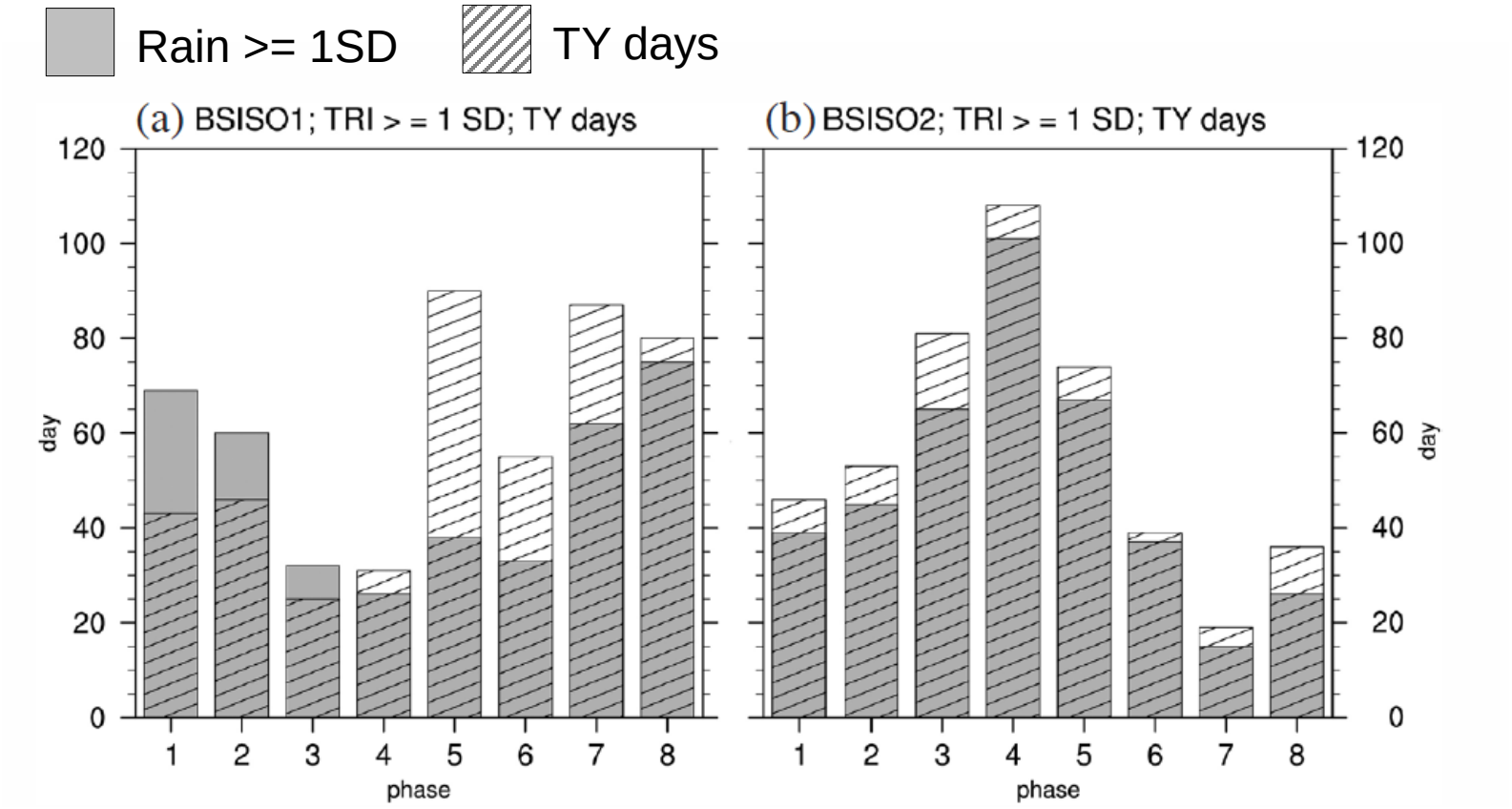
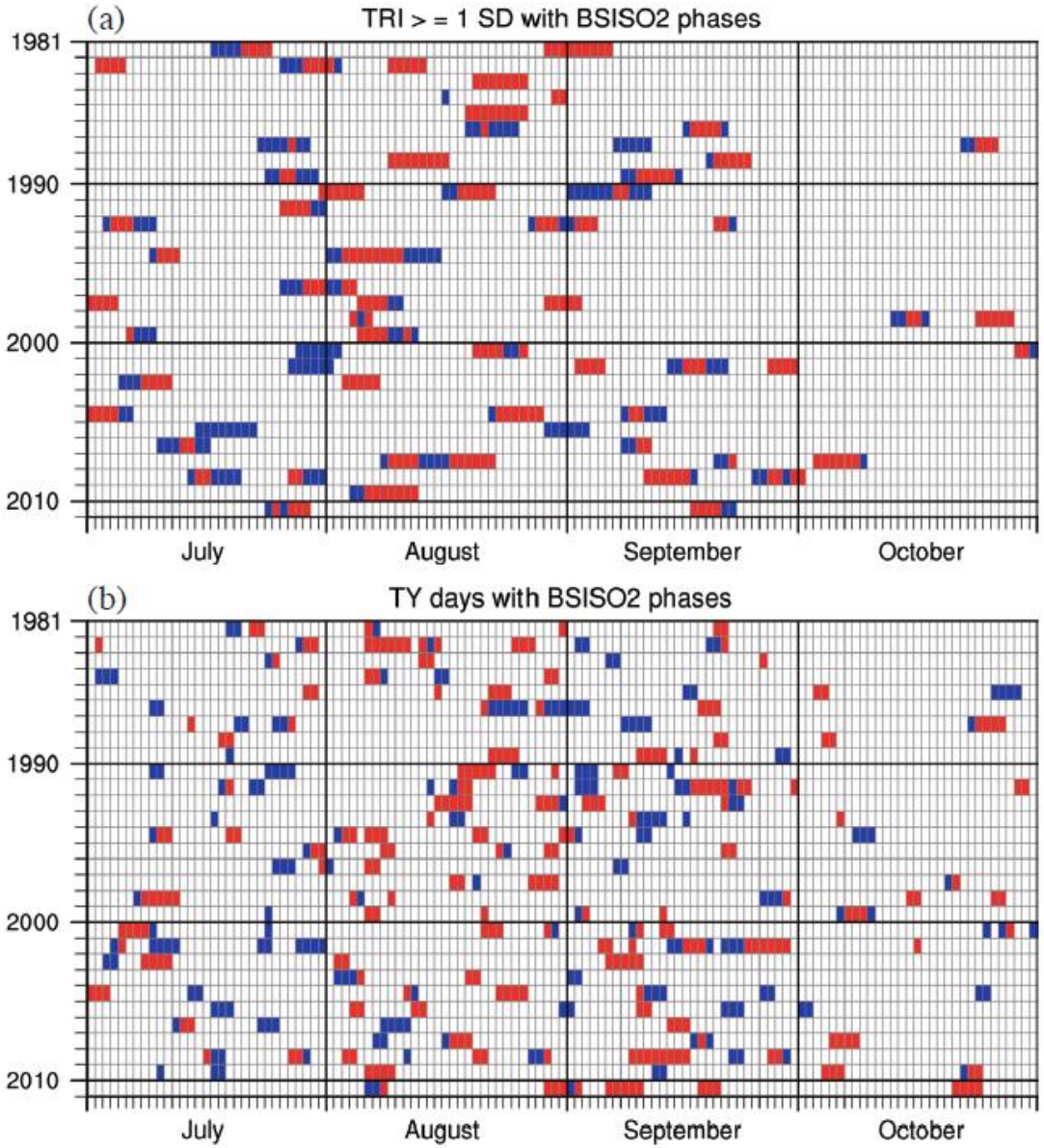


Fig. 11. (a) The total counts for the days with filtered (> 10 days) TRI values ≥ one standard deviation in 1981 - 2010 (in gray bars) and the typhoon days in Taiwan (in slash bars) for each BSISO1 phase. (b) is similar to (a) but for BSISO2.



Red：
BSISO 3,4,5

Fig. 12. Similar to Fig. 10, but the color in red indicates that the phases of BSISO2 are 3, 4, and 5. Otherwise, the color is in blue. (Color online only)

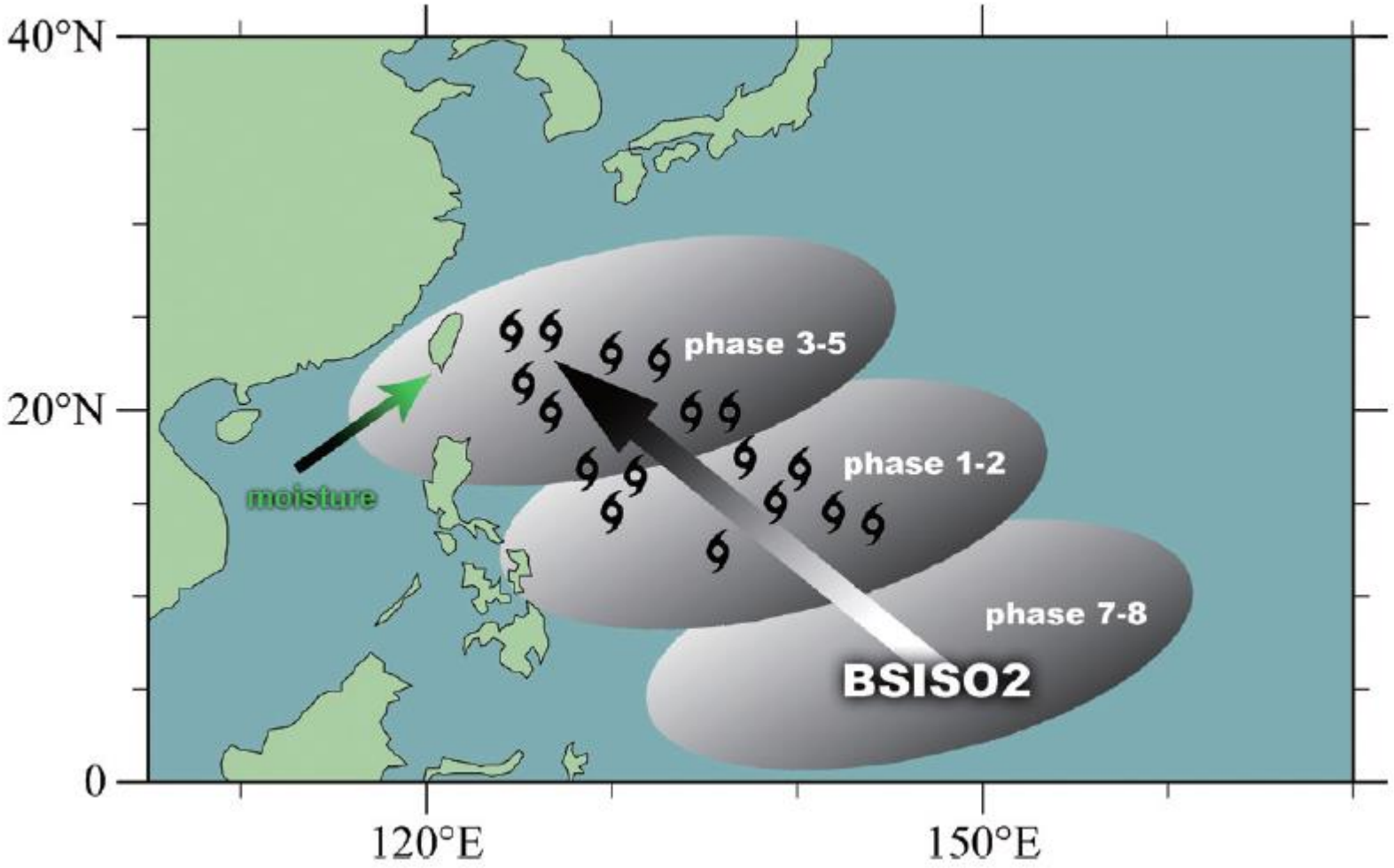
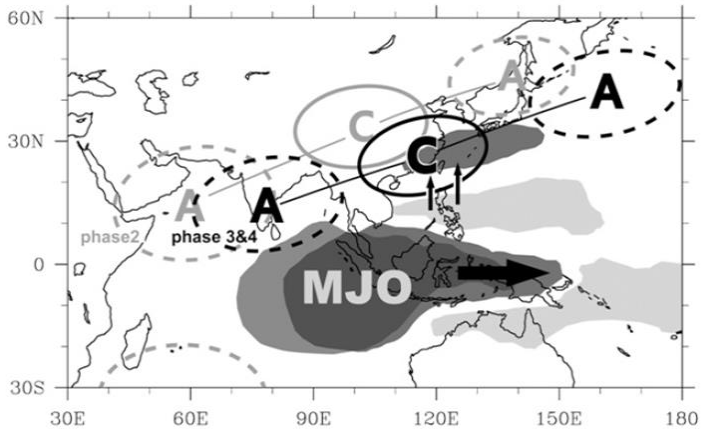
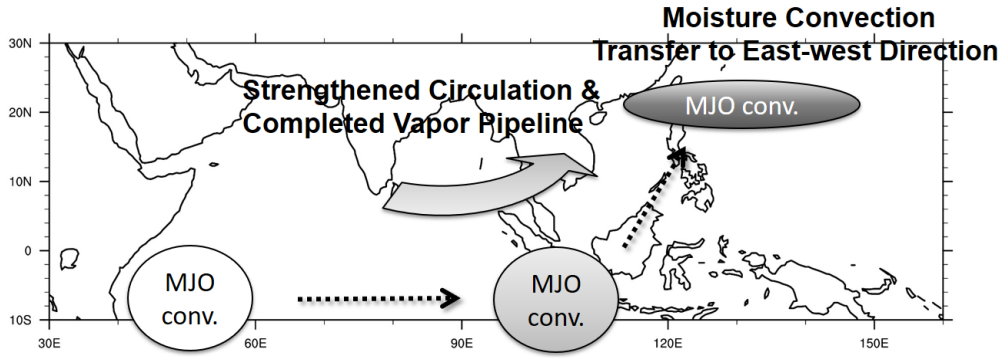


Fig. 13. The conceptual model for explaining the BSISO2 mechanism impacts on JASO rainfalls in Taiwan and the WNP typhoons. The gray shaded circles represent the major BSISO2 convection with the phases indicated. The big arrow and the small green arrow refer to the movement direction of the BSISO2 mode and moisture supply, respectively. In addition, the small typhoon symbols indicate the major typhoons occurring in the area. (Color online only)

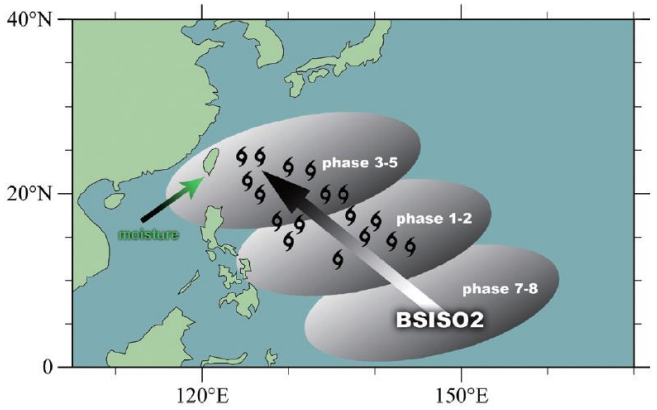
Intraseasonal Oscillation and the Taiwan Climate



Winter (NDJFMA)



Mei-yu (MJ)



Summer (JASO)

Thanks!

10.37N, 114.36E

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