Global Impacts of the MJO on Weather and Climate

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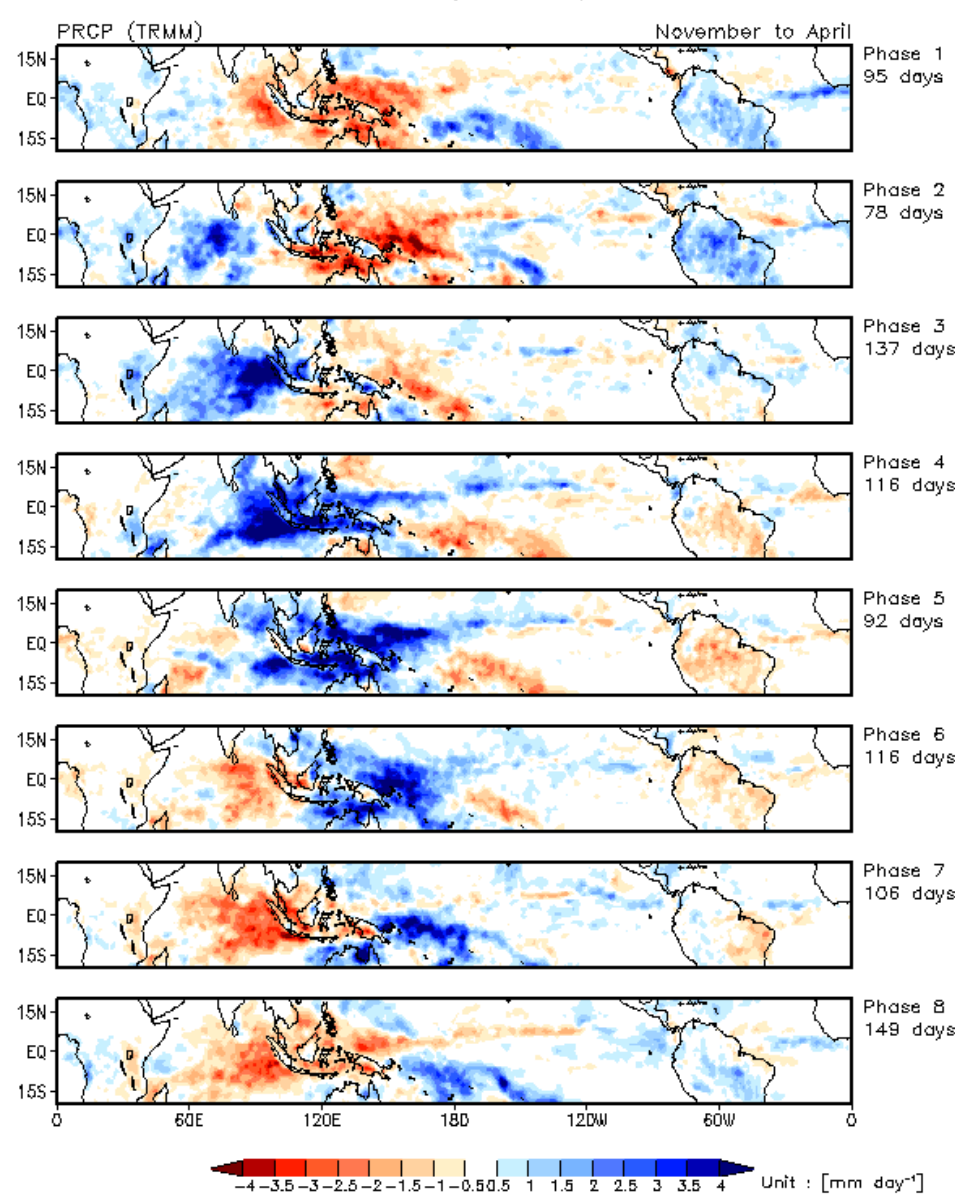
Part IIa – A Quick Review of the MJO and BSISO

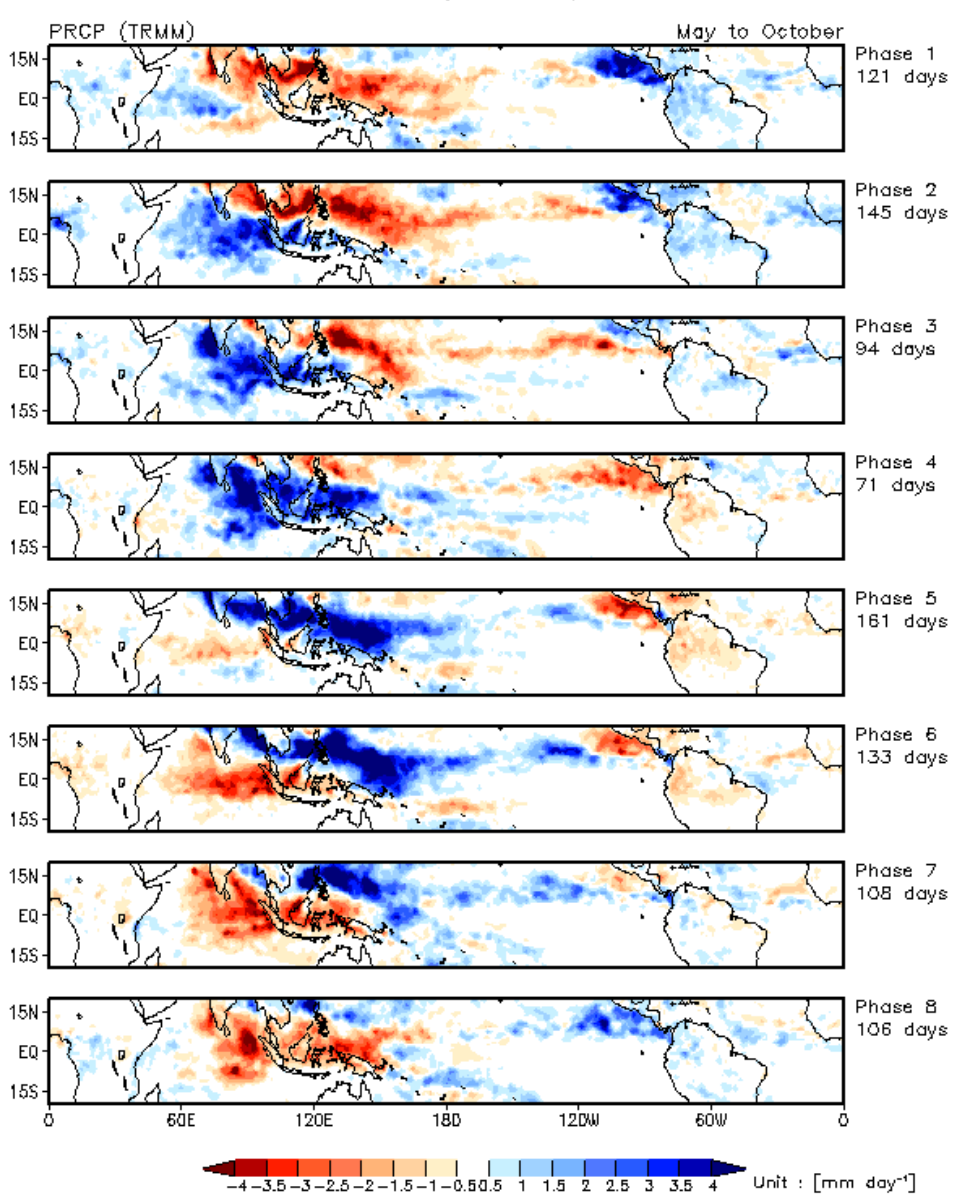
Part IIb – MJO and Global Impact

Part IIc – MJO/BSISO impact on Asia

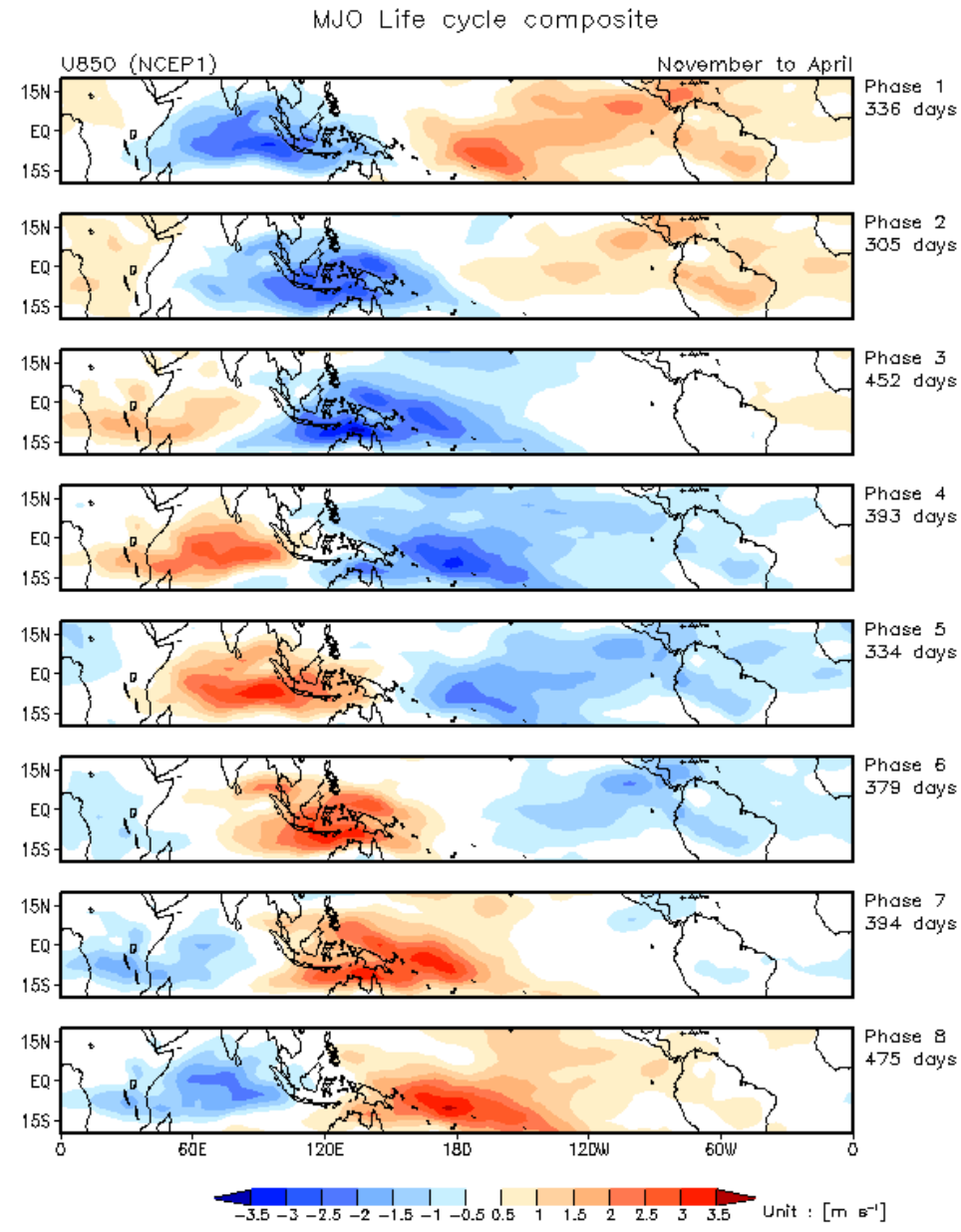
Dec-Feb Composite



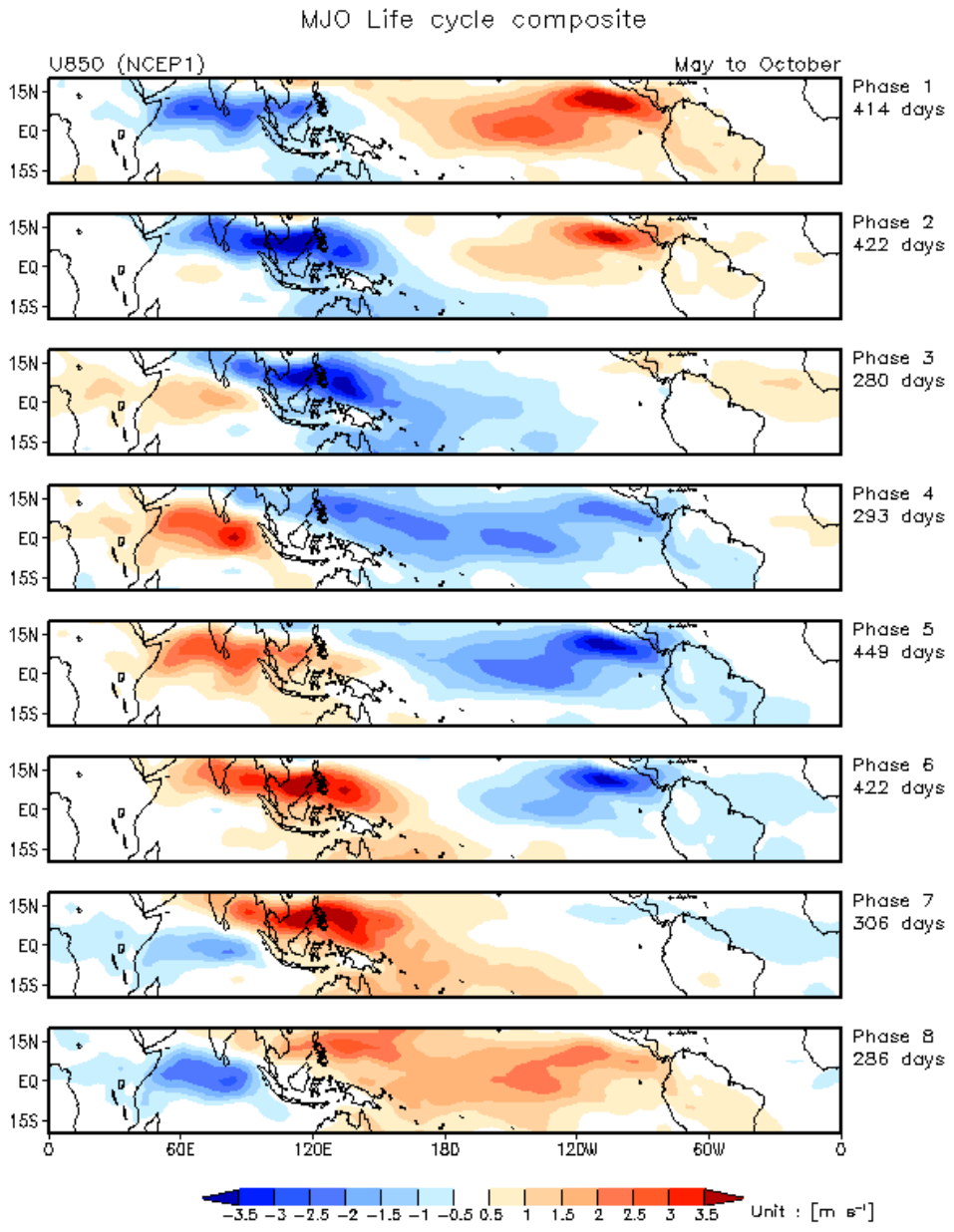
May-June Composite



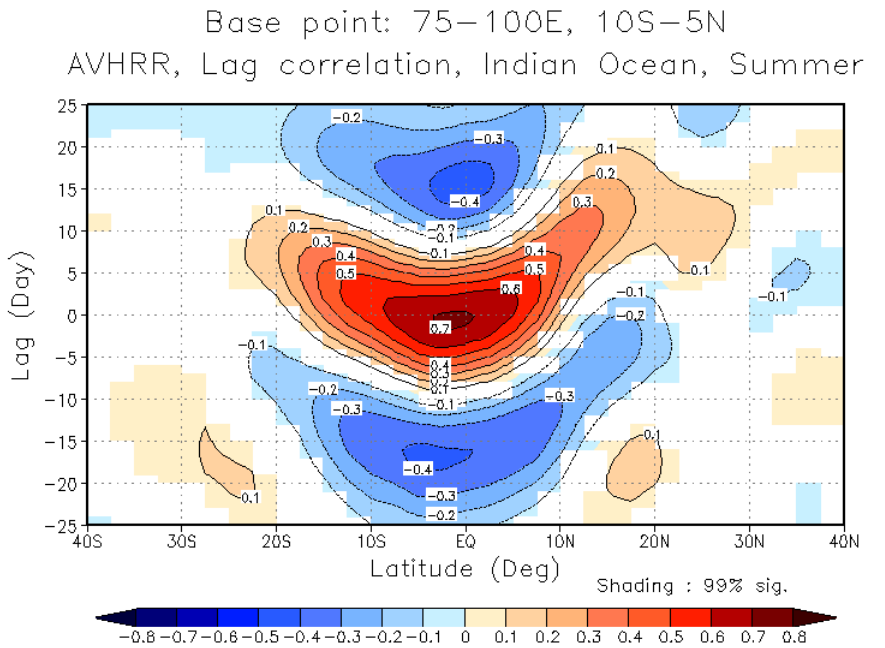
Dec-Feb Composite

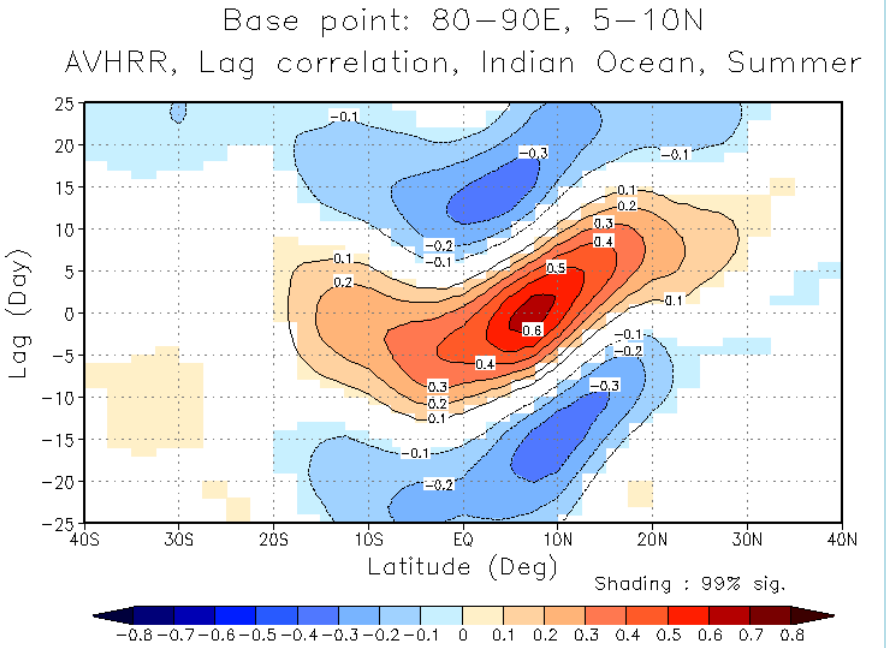


May-June Composite



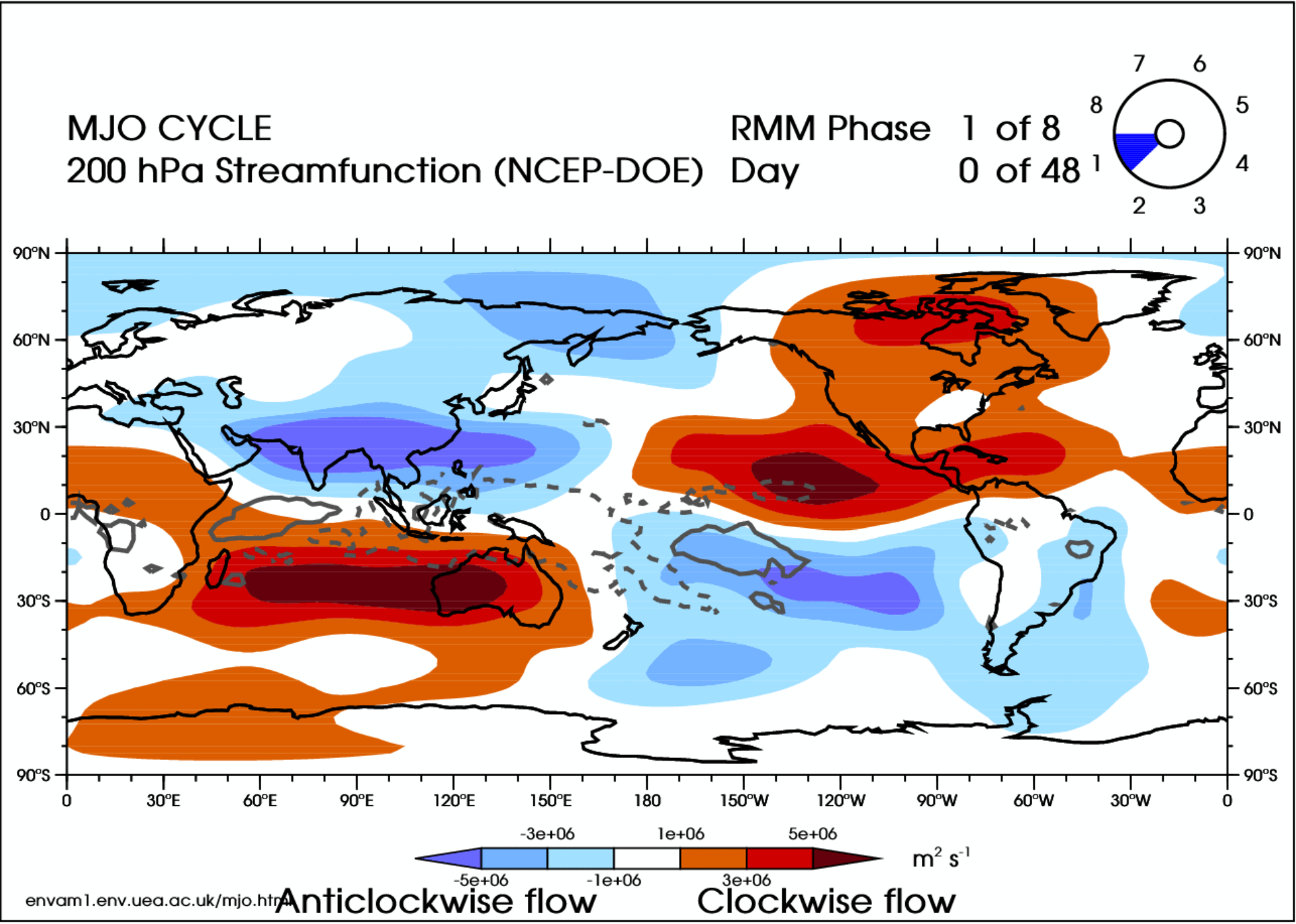
Lag-Correlation in Latitude

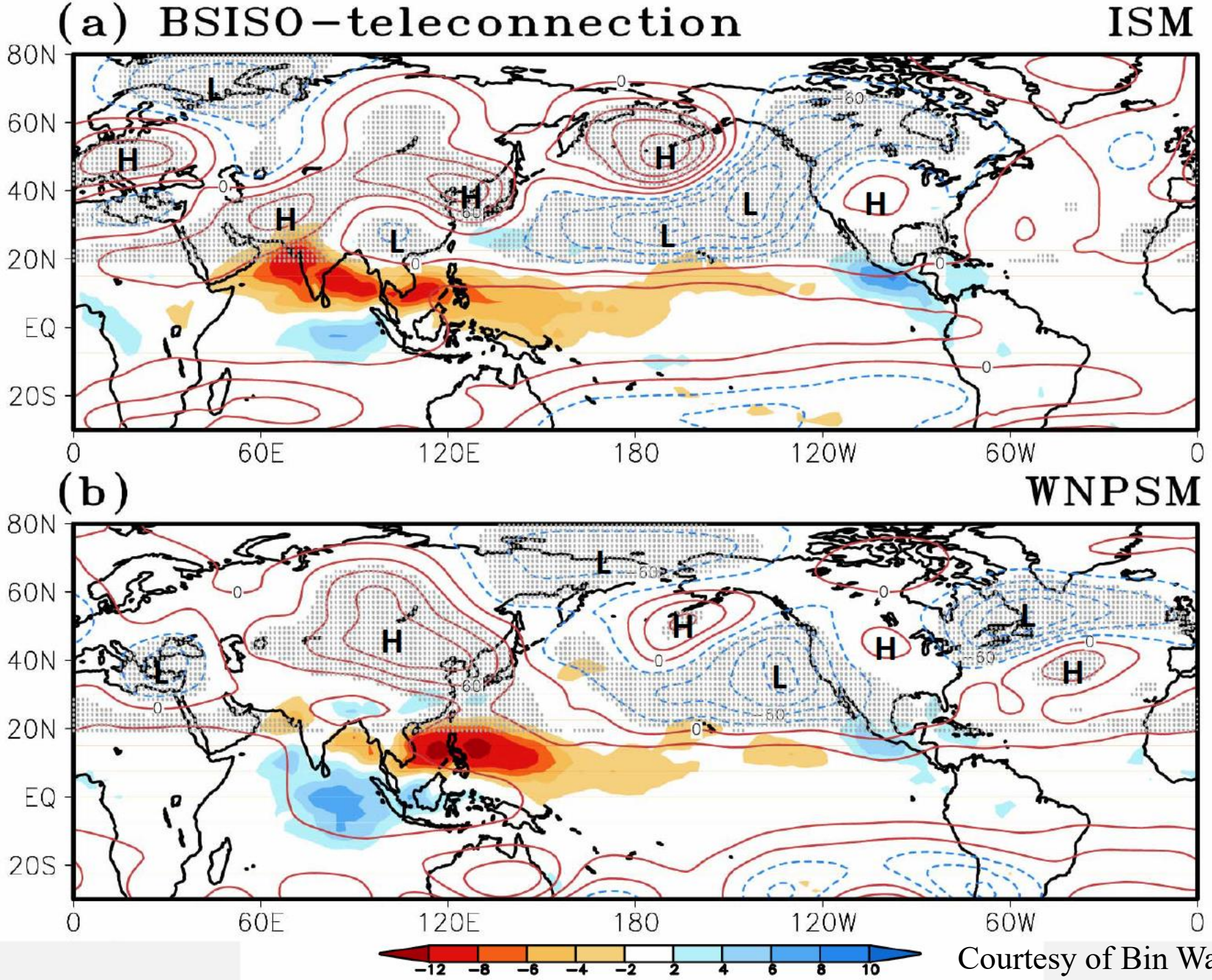




- Center of base point: Southern Hemisphere
- Center of base point: Northern Hemisphere

- 20-100day filtered, 80-100E averaged OLR is used

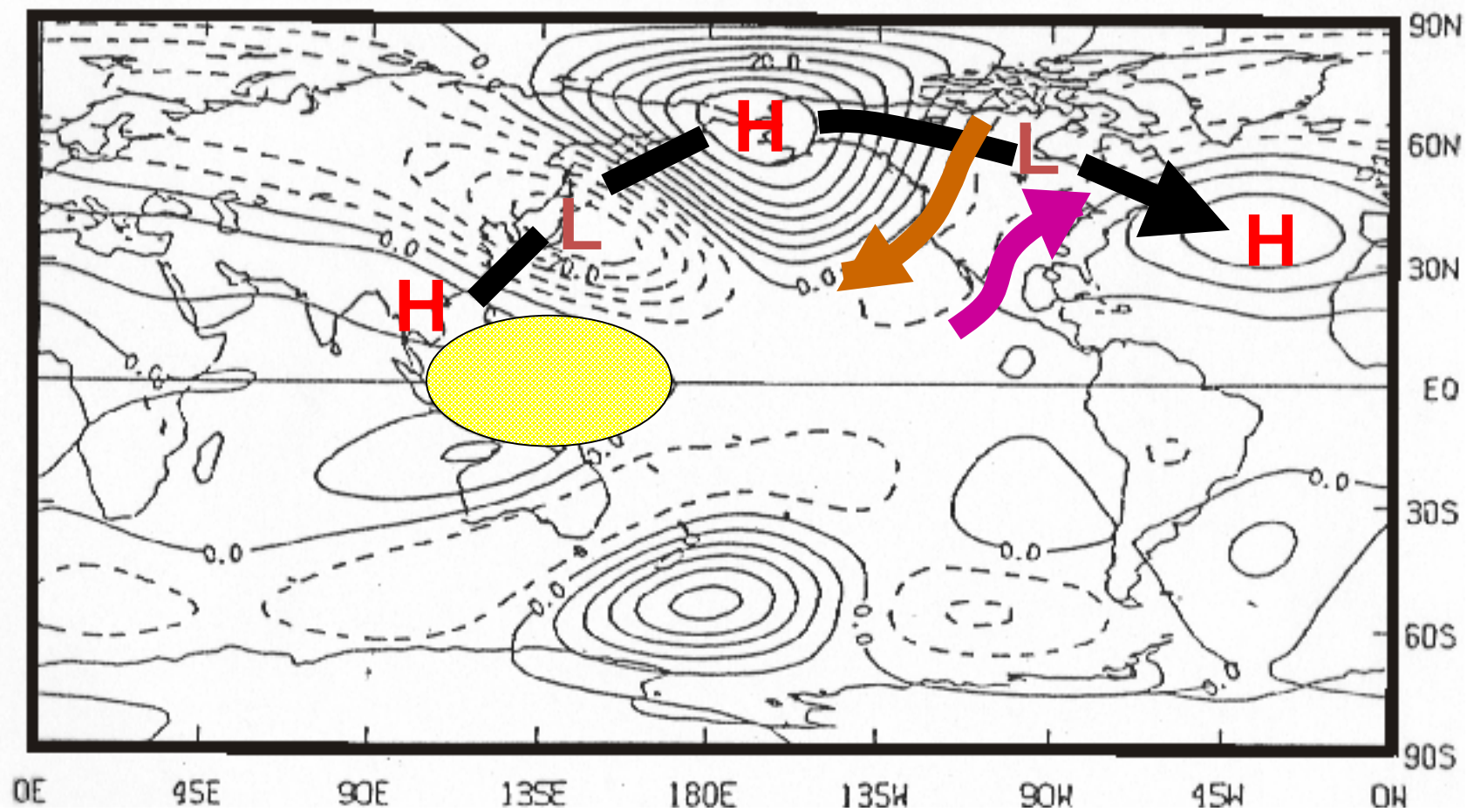

MJO CYCLE
200 hPa Streamfunction (NCEP-DOE)
RMM Phase 1 of 8
Day 0 of 48
1
2
3
4
5
6
7
8
90°N
60°N
30°N
0
30°S
60°S
90°S
0
30°E
60°E
90°E
120°E
150°E
180
150°W
120°W
90°W
60°W
30°W
0
-3e+06
1e+06
5e+06
-5e+06
-1e+06
3e+06
m² s⁻¹
envam1.env.uea.ac.uk/mjo.html
Anticlockwise flow
Clockwise flow



Courtesy of Bin Wang

MJOs and Teleconnections

Modeled Tropospheric Response to Western Tropical Pacific Positive Heating Anomaly in Northern Winter



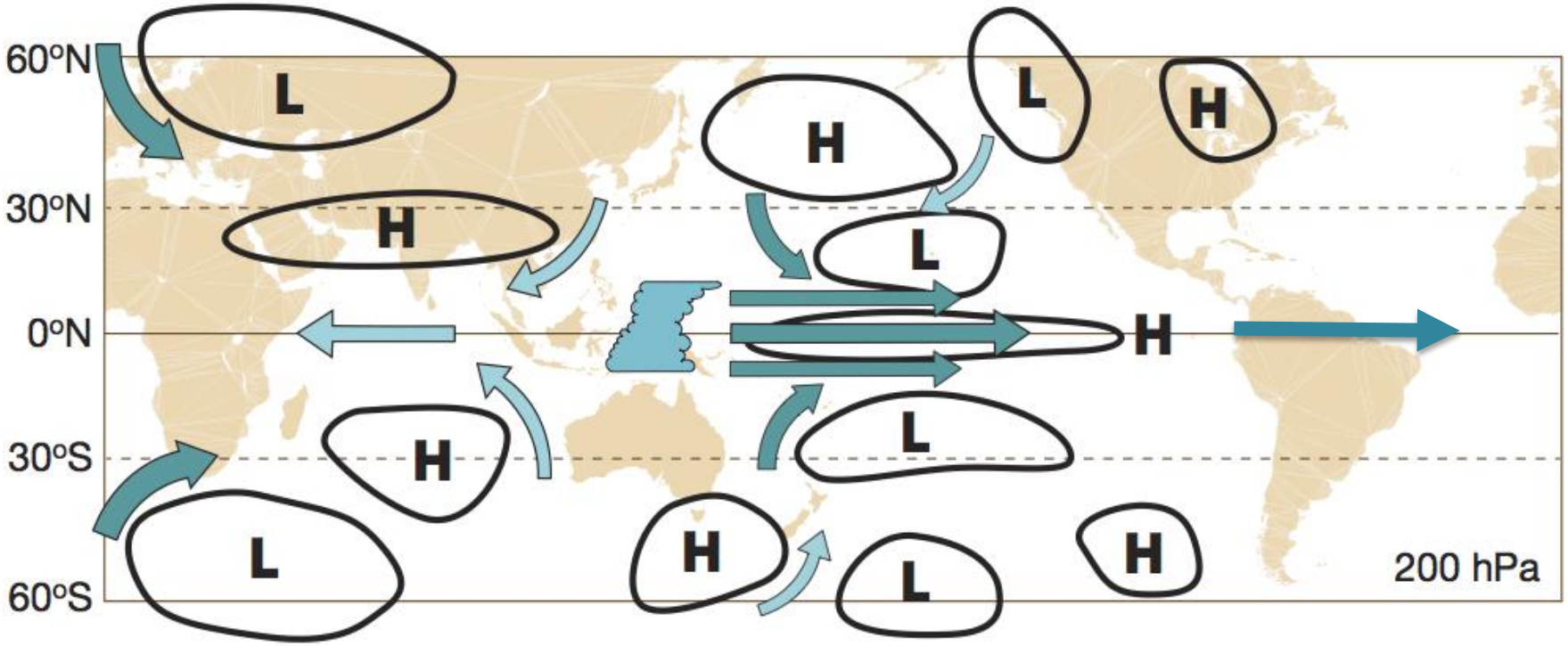
= positive heating anomaly

= energy propagation through wave train

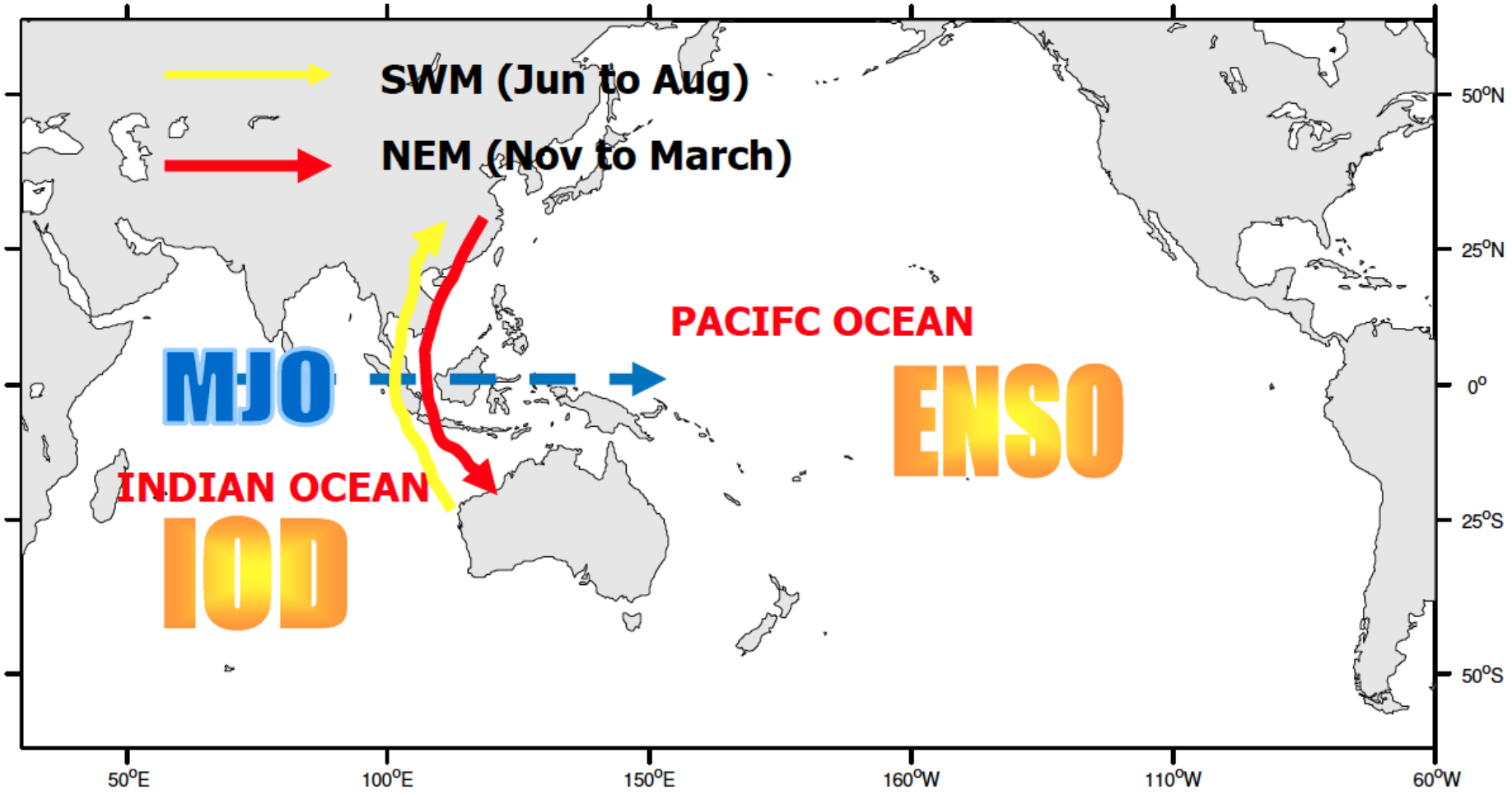
= dry air advection

= moist air advection

Illustration of MJO Remote Effects



Adames (2013)



Courtesy of Wan Azli Wan Hassan

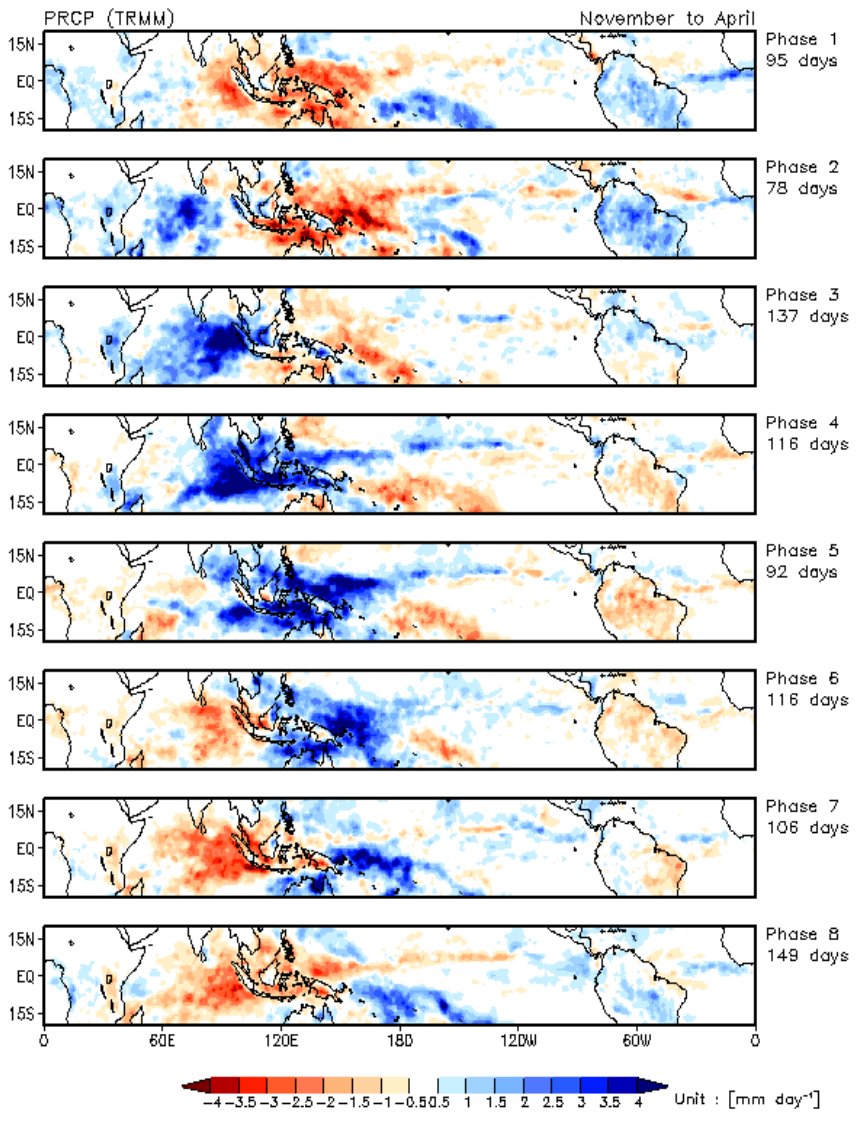
Detecting MJO Effects: Statistical Signals

Fluctuations in weather events:

- **between different phases of the MJO/BSISO**
- **between a particular MJO/BSISO phase and periods of no MJO/BSISO (phase 0)**

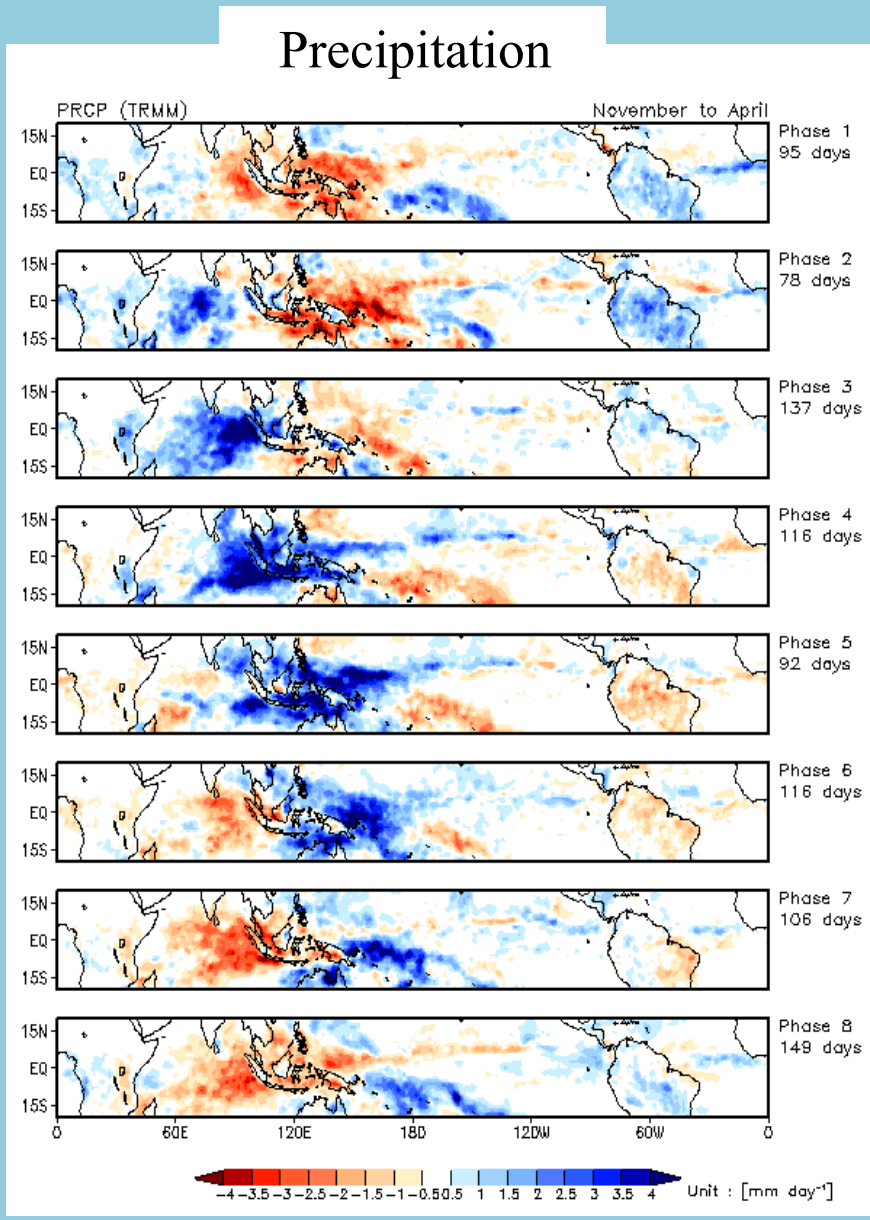
The MJO/BSISO can either enhance or reduce extreme events.

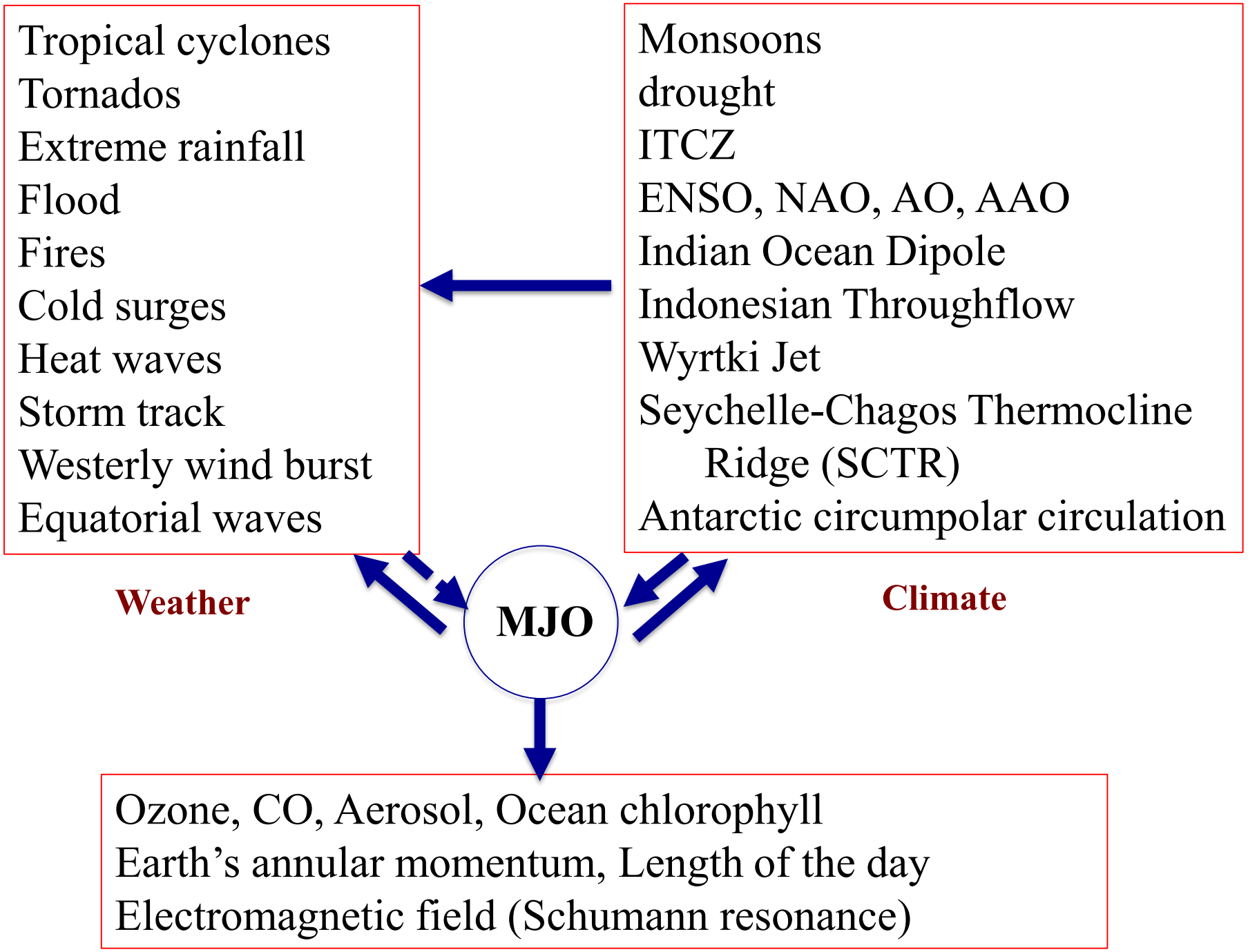
Precipitation



Effects of MJO on Extremes

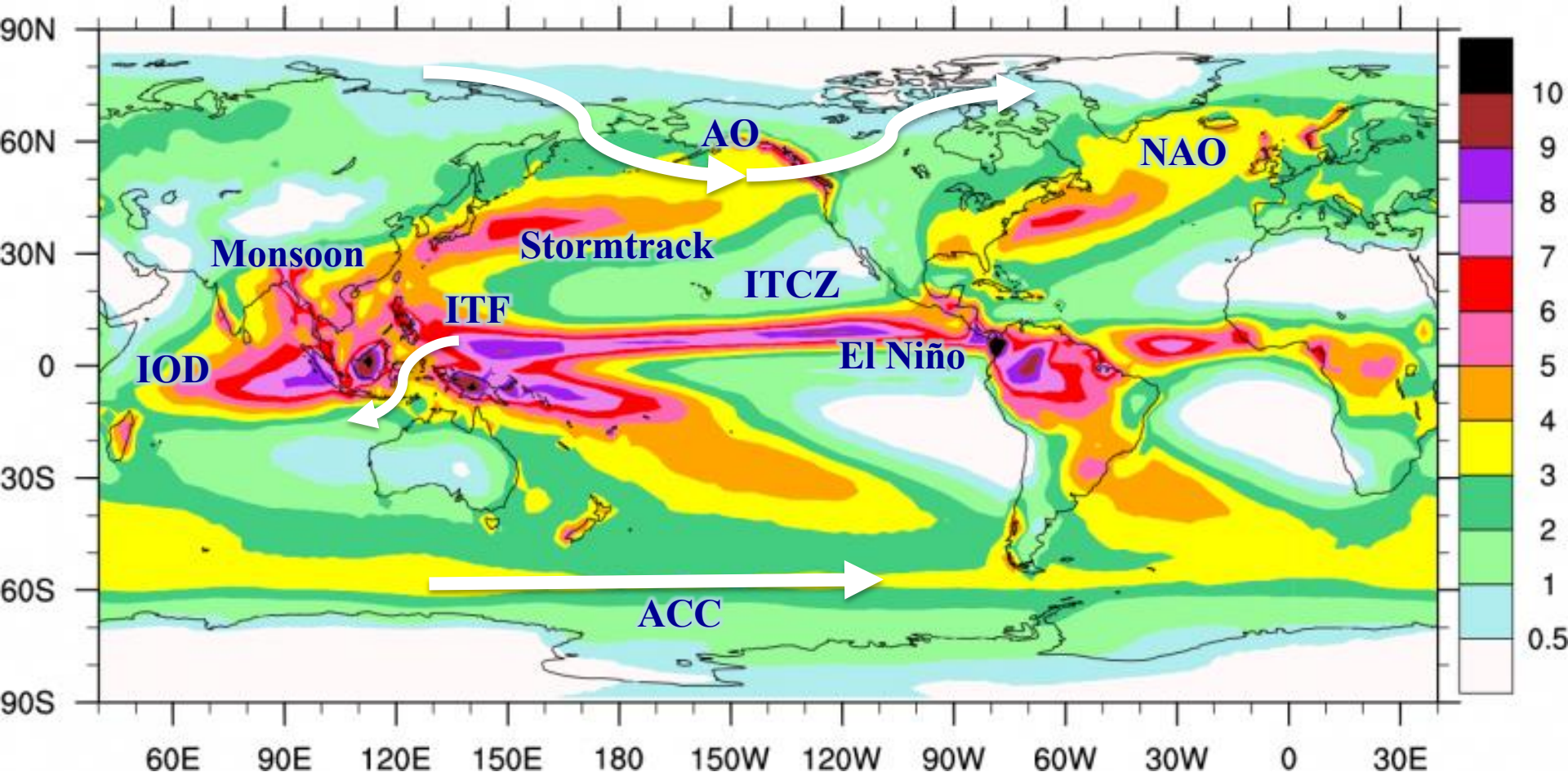
- Within the MJO convection envelope
- Through teleconnections and remote circulation patterns
- Through influencing other climate mode




Tropical cyclones
Tornados
Extreme rainfall
Flood
Fires
Cold surges
Heat waves
Storm track
Westerly wind burst
Equatorial waves
Monsoons
drought
ITCZ
ENSO, NAO, AO, AAO
Indian Ocean Dipole
Indonesian Throughflow
Wyrtki Jet
Seychelle-Chagos Thermocline Ridge (SCTR)
Antarctic circumpolar circulation
Weather
MJO
Climate
Ozone, CO, Aerosol, Ocean chlorophyll
Earth's annular momentum, Length of the day
Electromagnetic field (Schumann resonance)

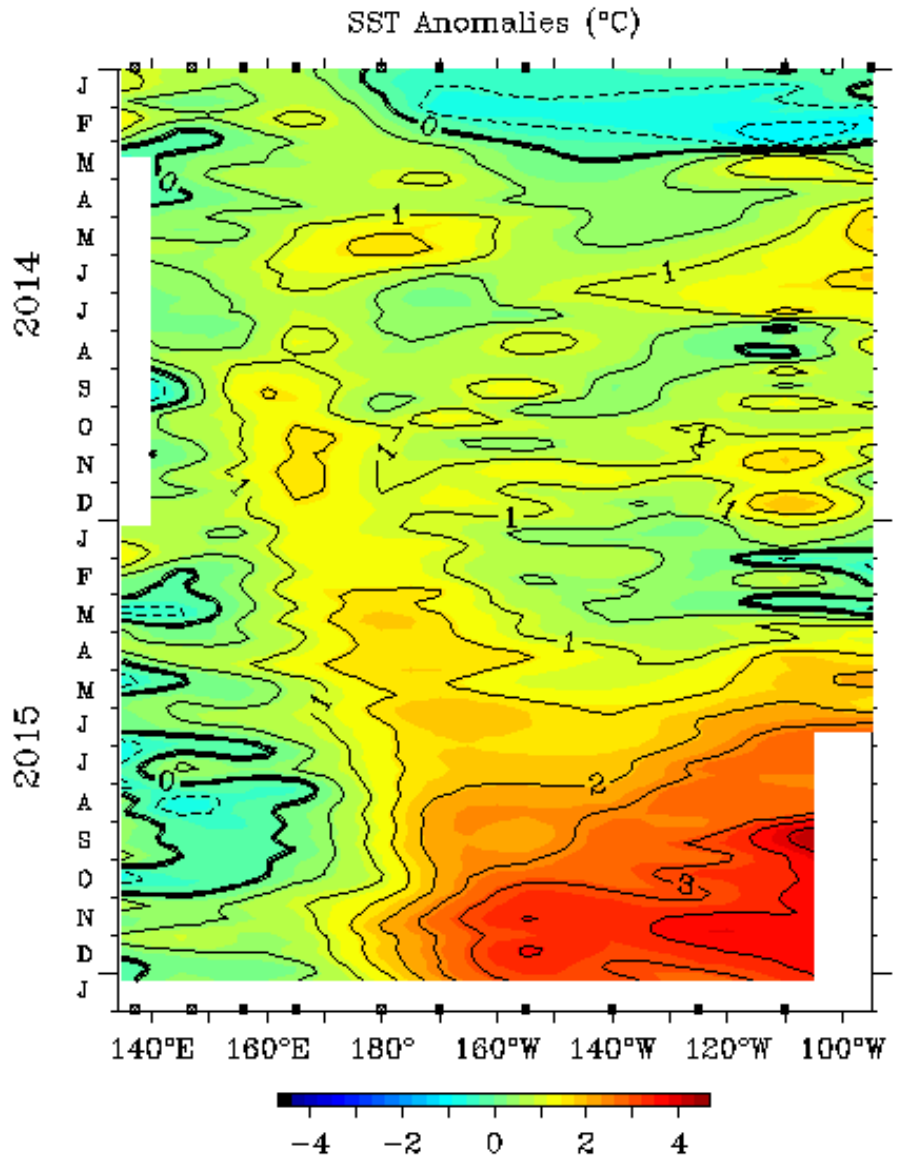
MJO Impact on Climate Modes

Zhang (2013)



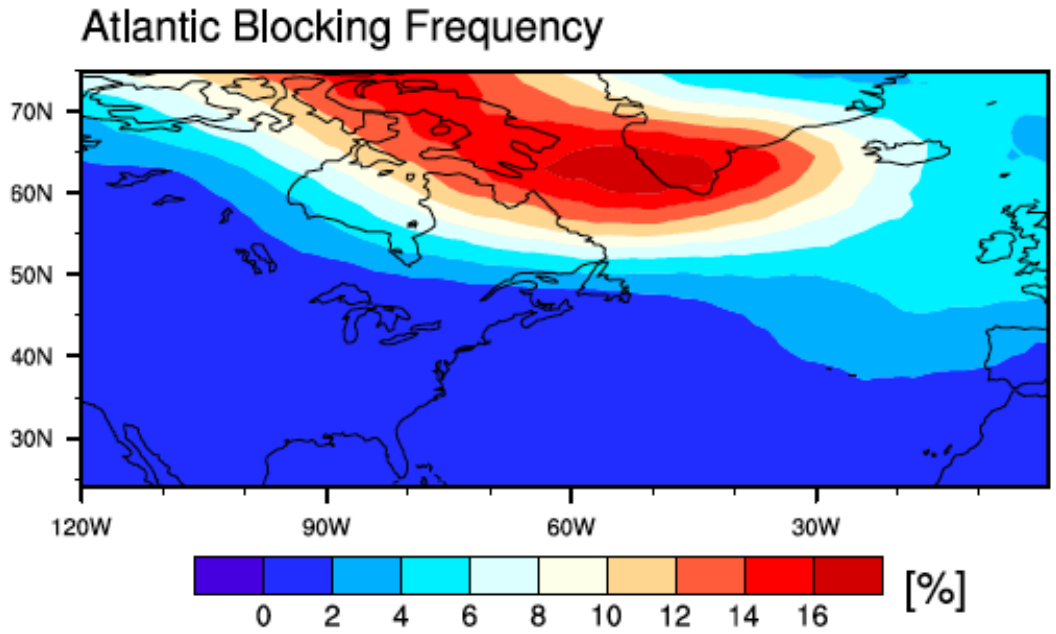
TRMM GPCP mean precipitation (mm/day) 1979-2010
Courtesy of UCAR/NCAR

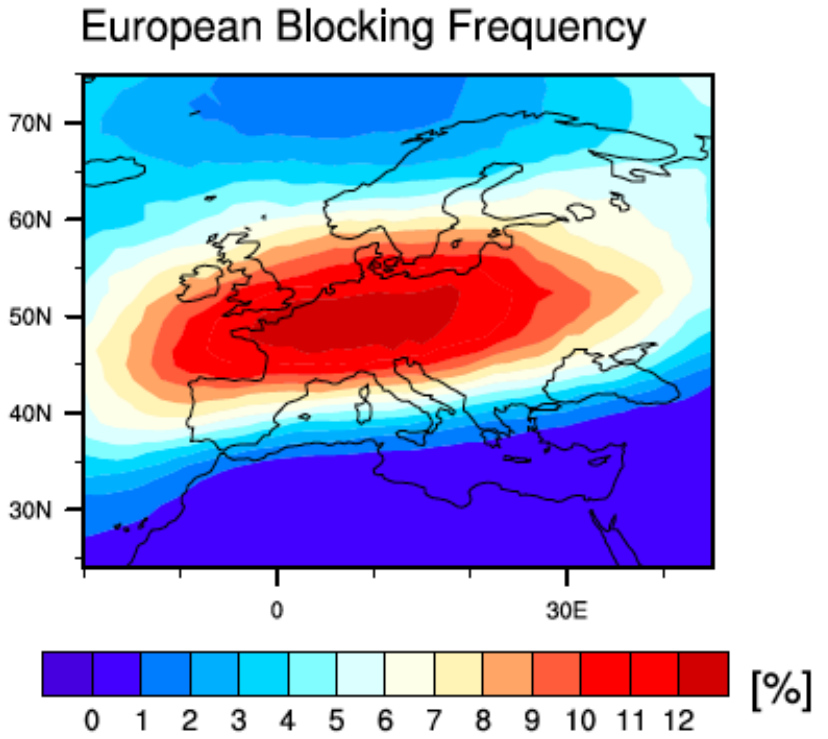
Five-Day SST and Zonal Wind 2°S to 2°N Average

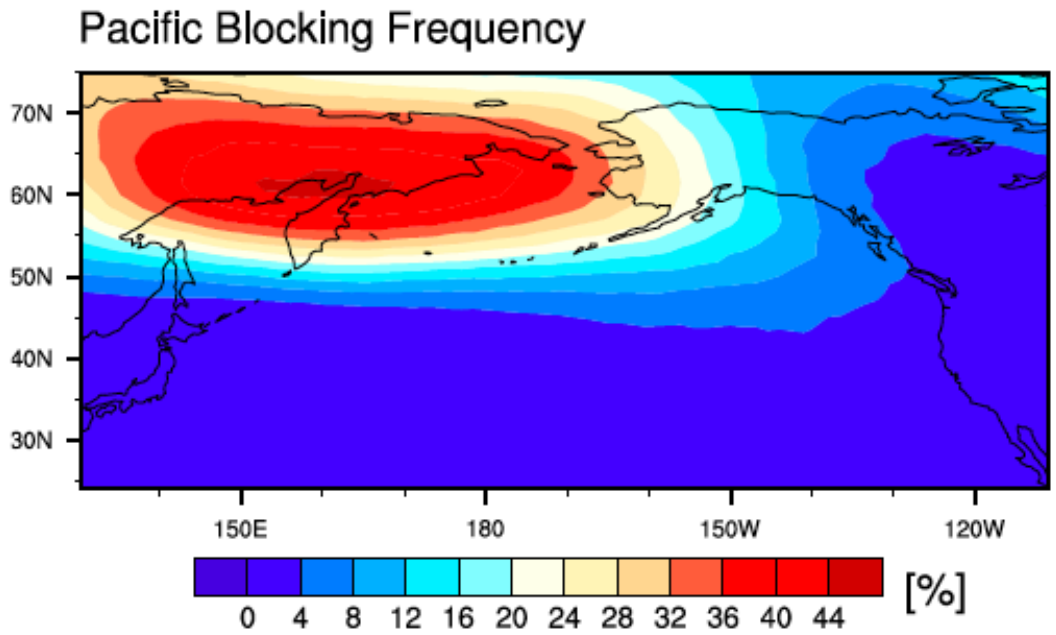


TAO Project Office/PMEL/NOAA

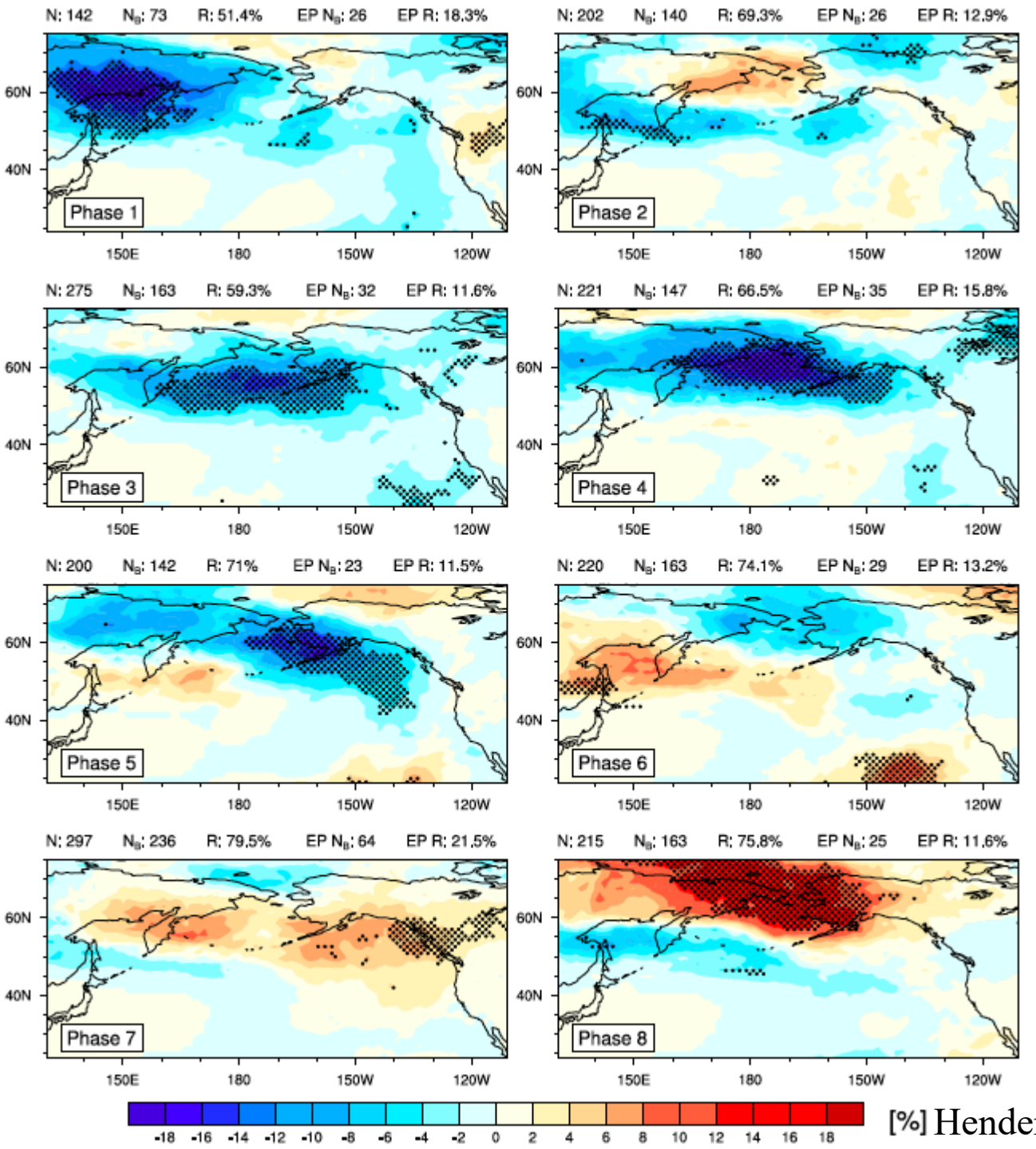
Jan 9 2016



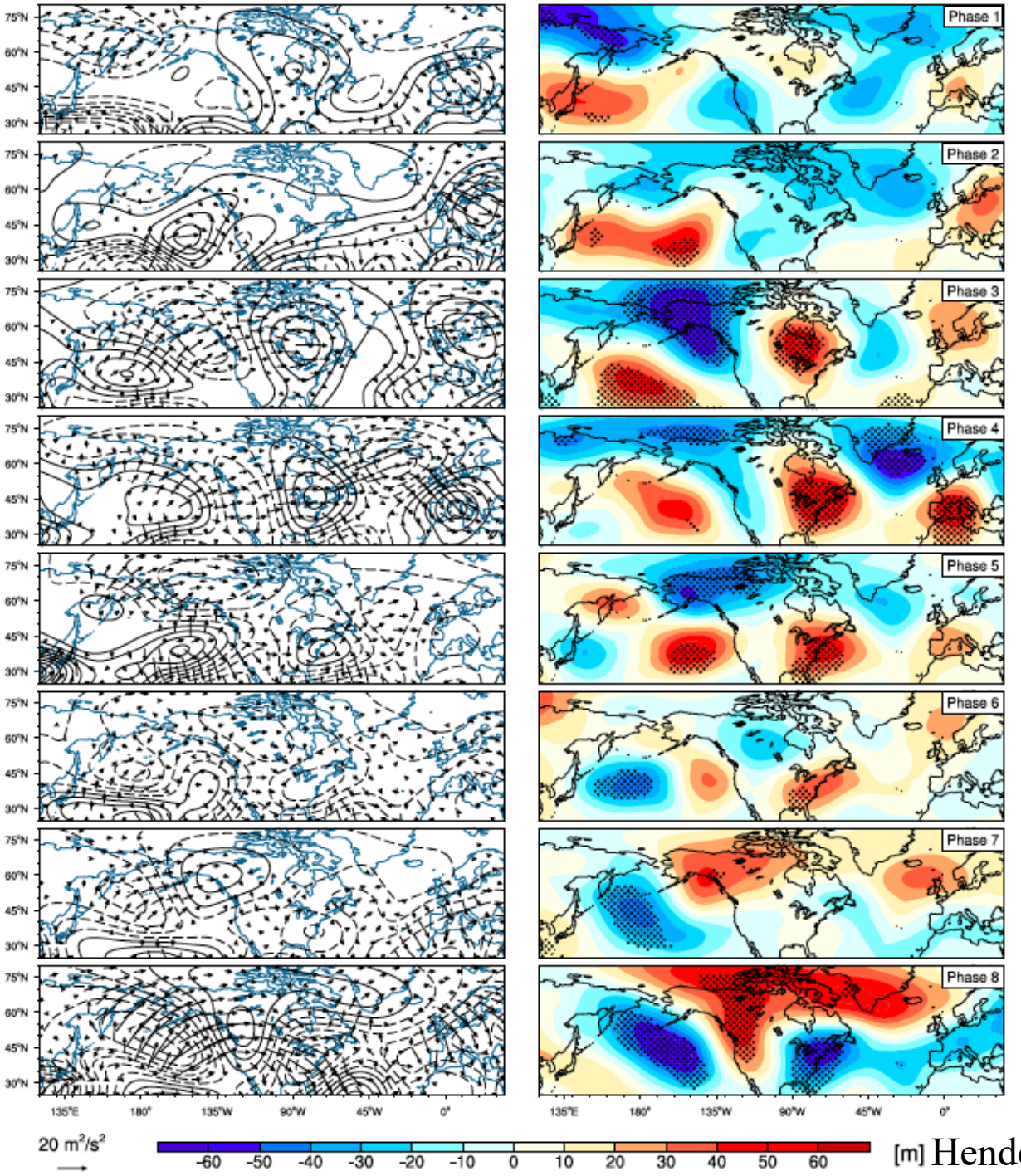




Henderson et al. (2016)

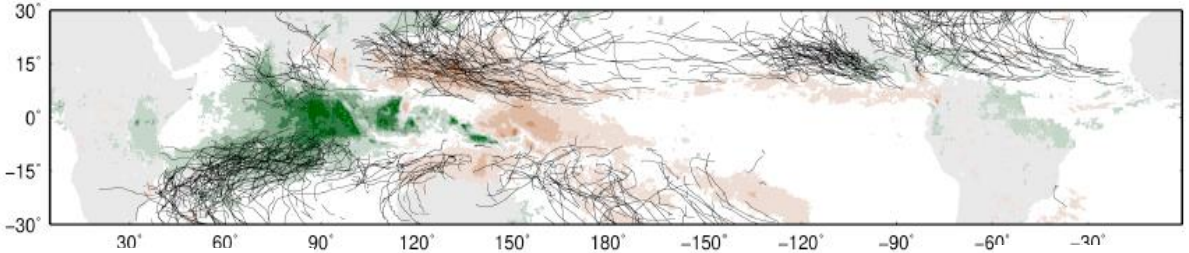


[%] Henderson et al. (2016)

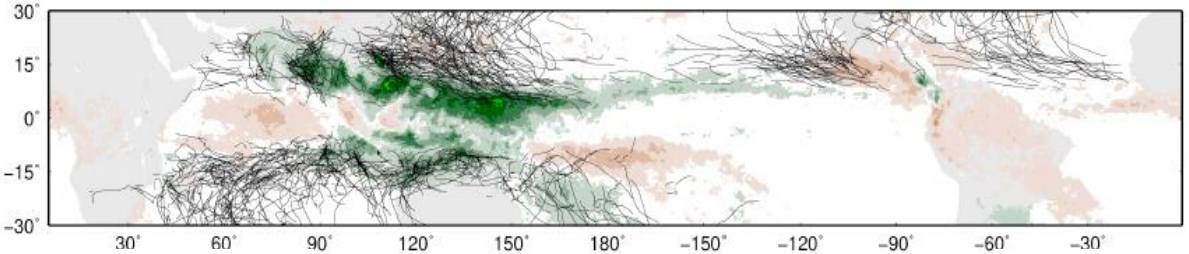


Henderson et al. (2016)

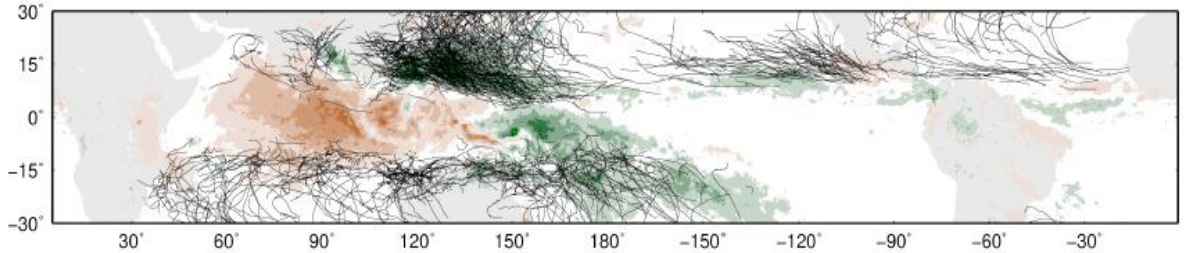
Phases 2 & 3 293 days



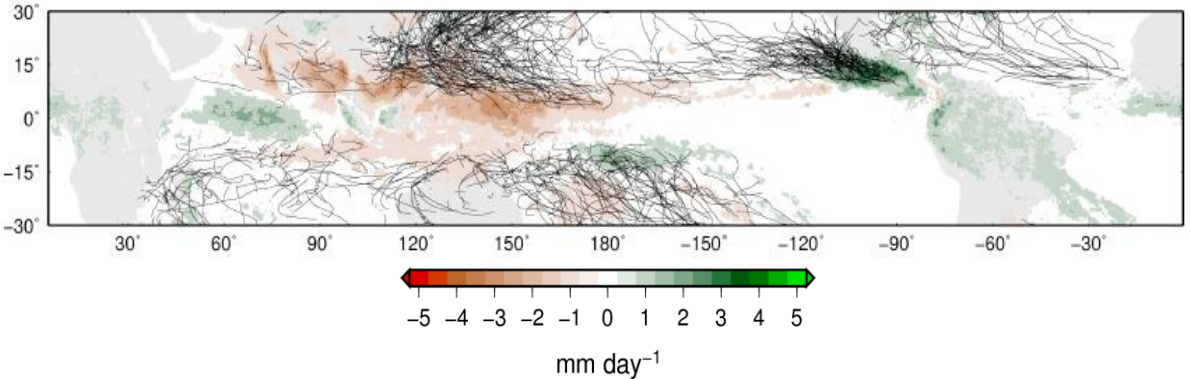
Phases 4 & 5 283 days



Phases 6 & 7 262 days



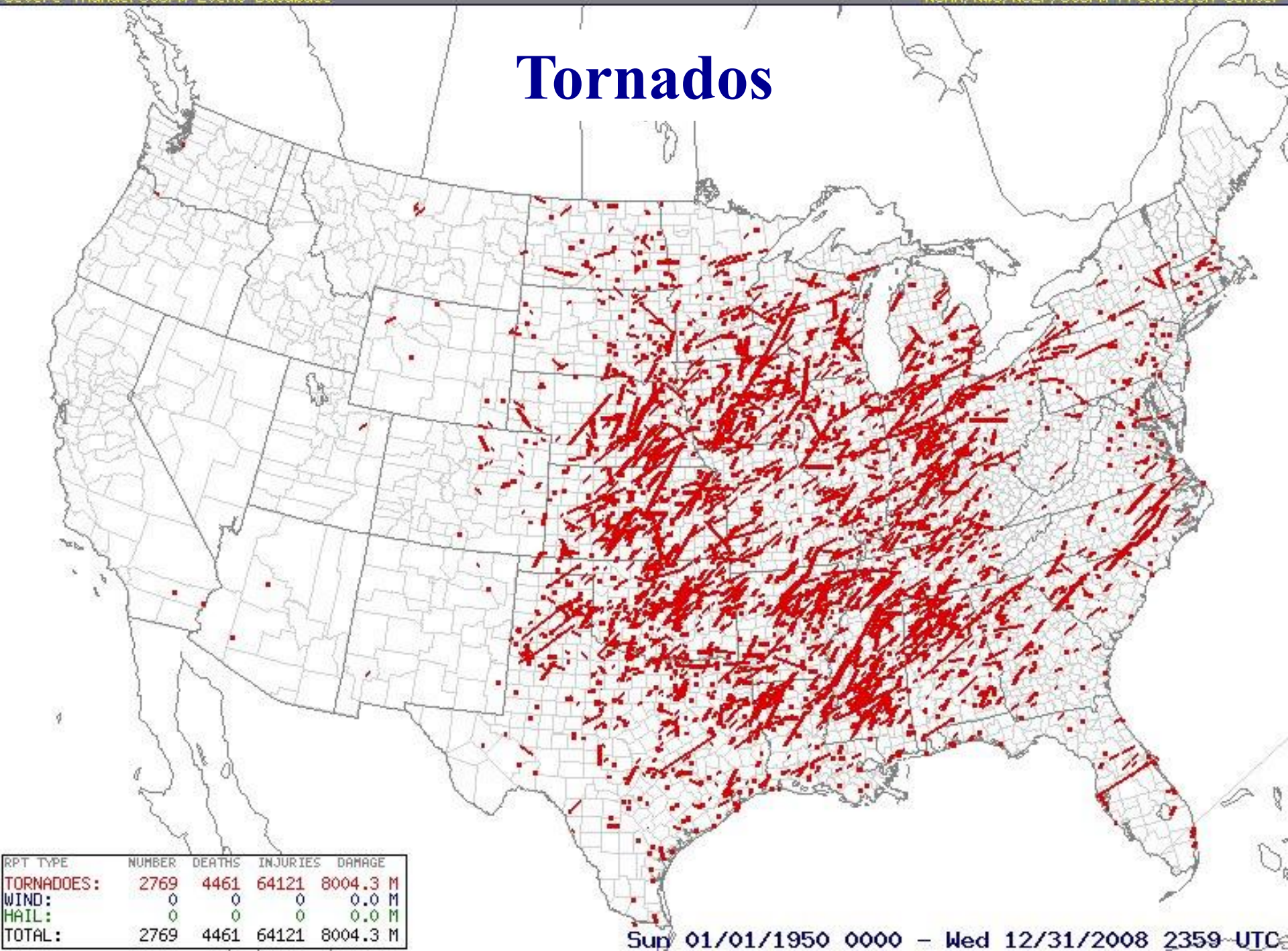
Phases 8 & 1 246 days



1 January 1975 –
31 December 2011

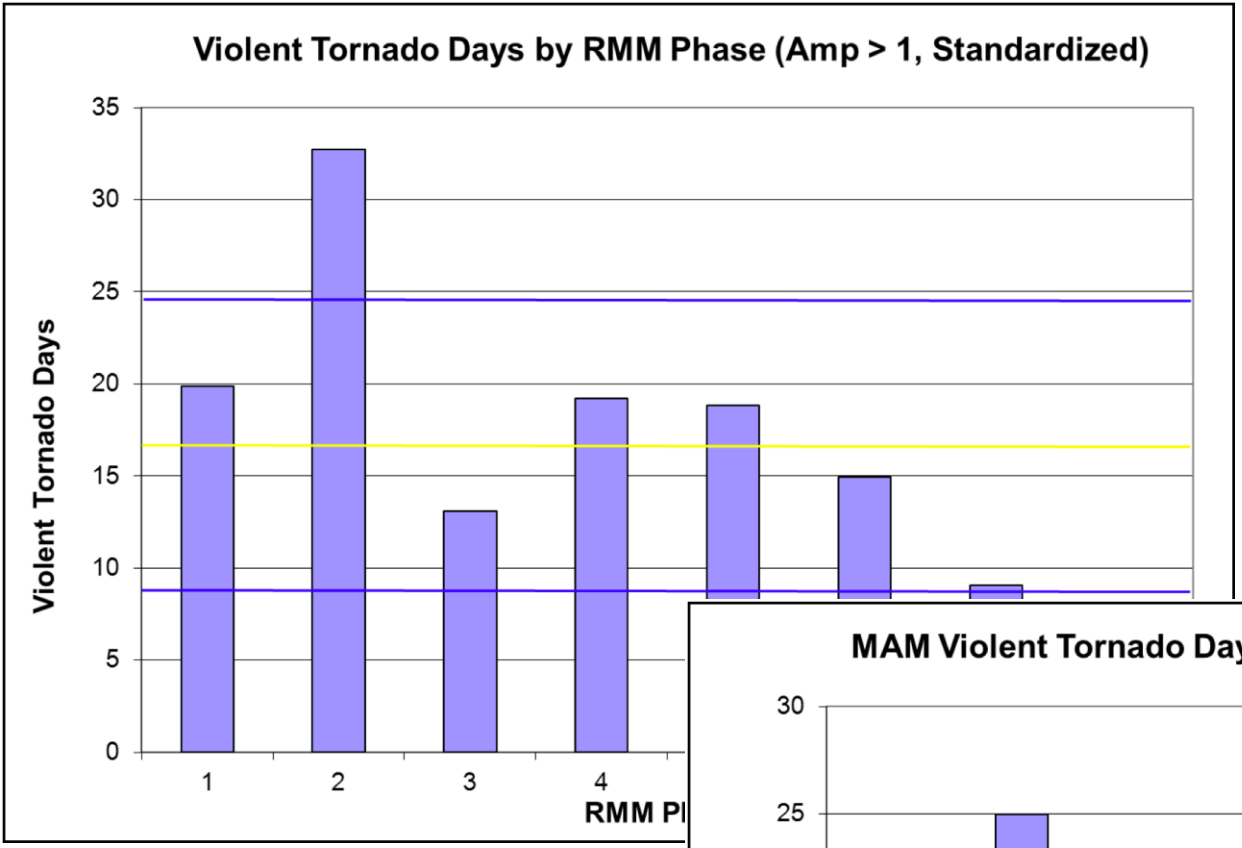
Zhang (2013)

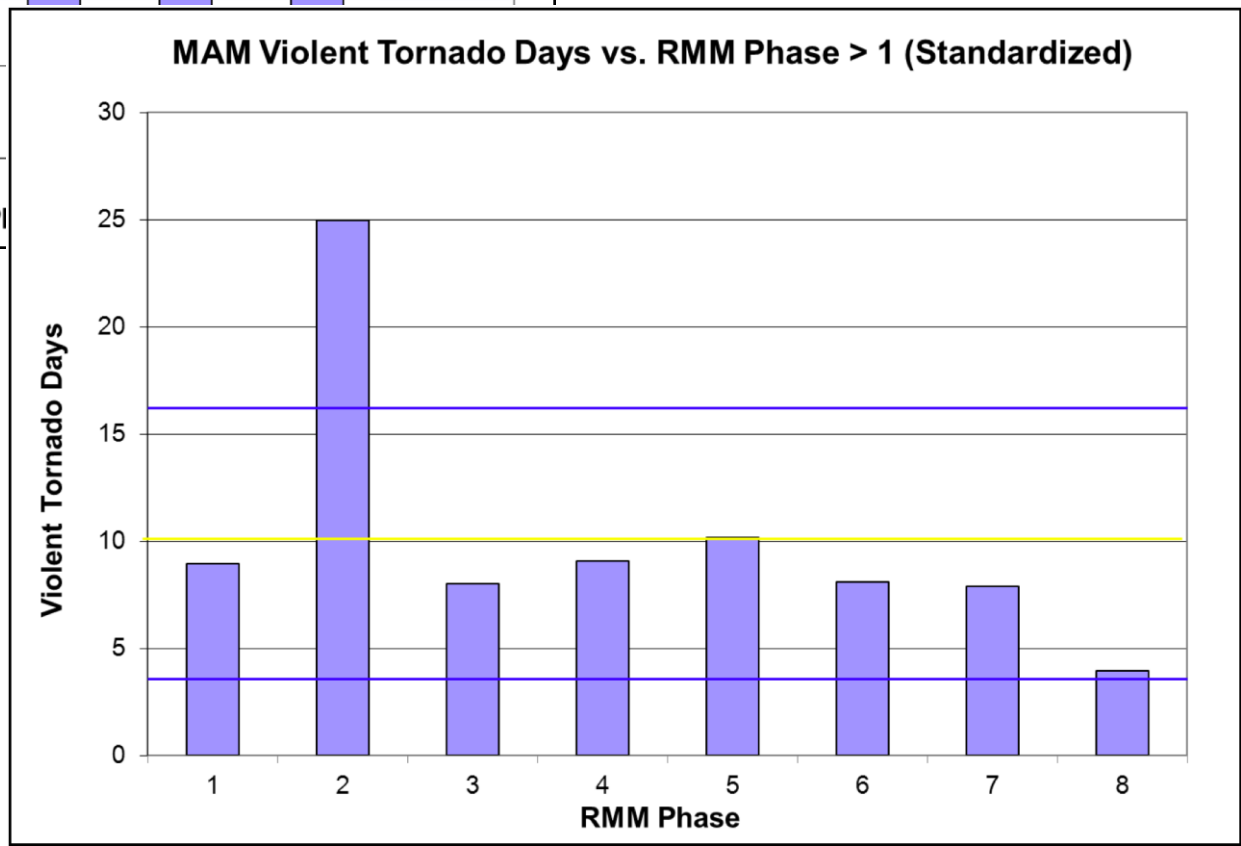
Tornados



RPT TYPE	NUMBER	DEATHS	INJURIES	DAMAGE
TORNADOES:	2769	4461	64121	8004.3 M
WIND:	0	0	0	0.0 M
HAIL:	0	0	0	0.0 M
TOTAL:	2769	4461	64121	8004.3 M

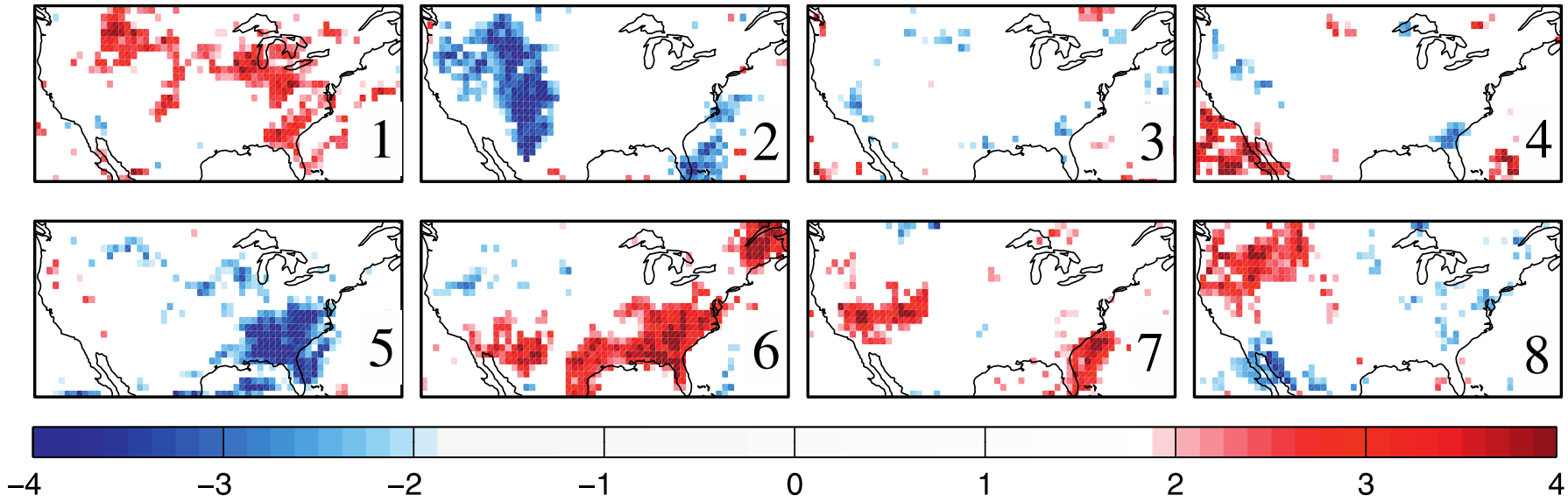
Sun 01/01/1950 0000 - Wed 12/31/2008 2359 UTC





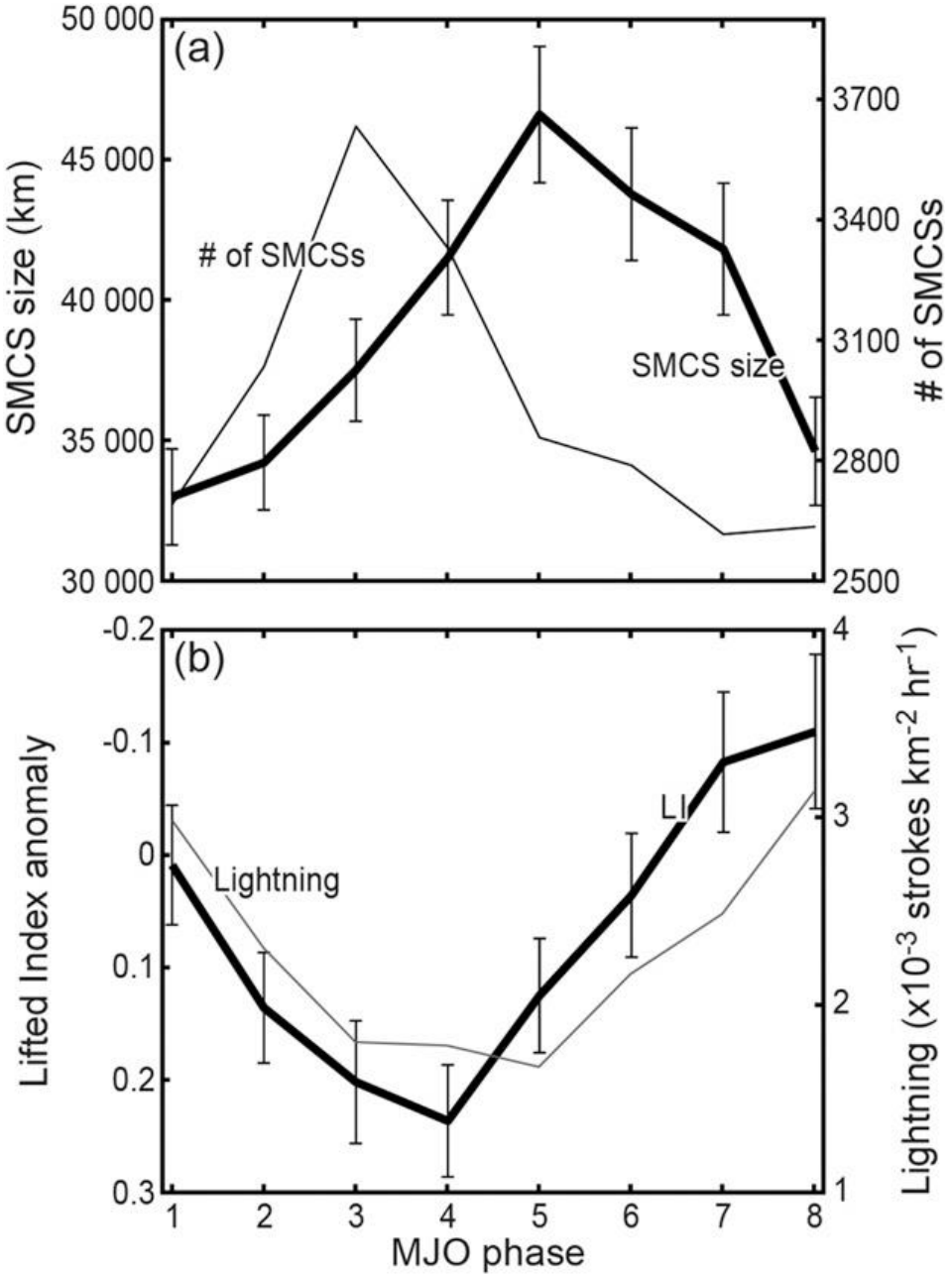
Thompson and Roundy (2013)

Lightning (June – September 1990 – 2007)



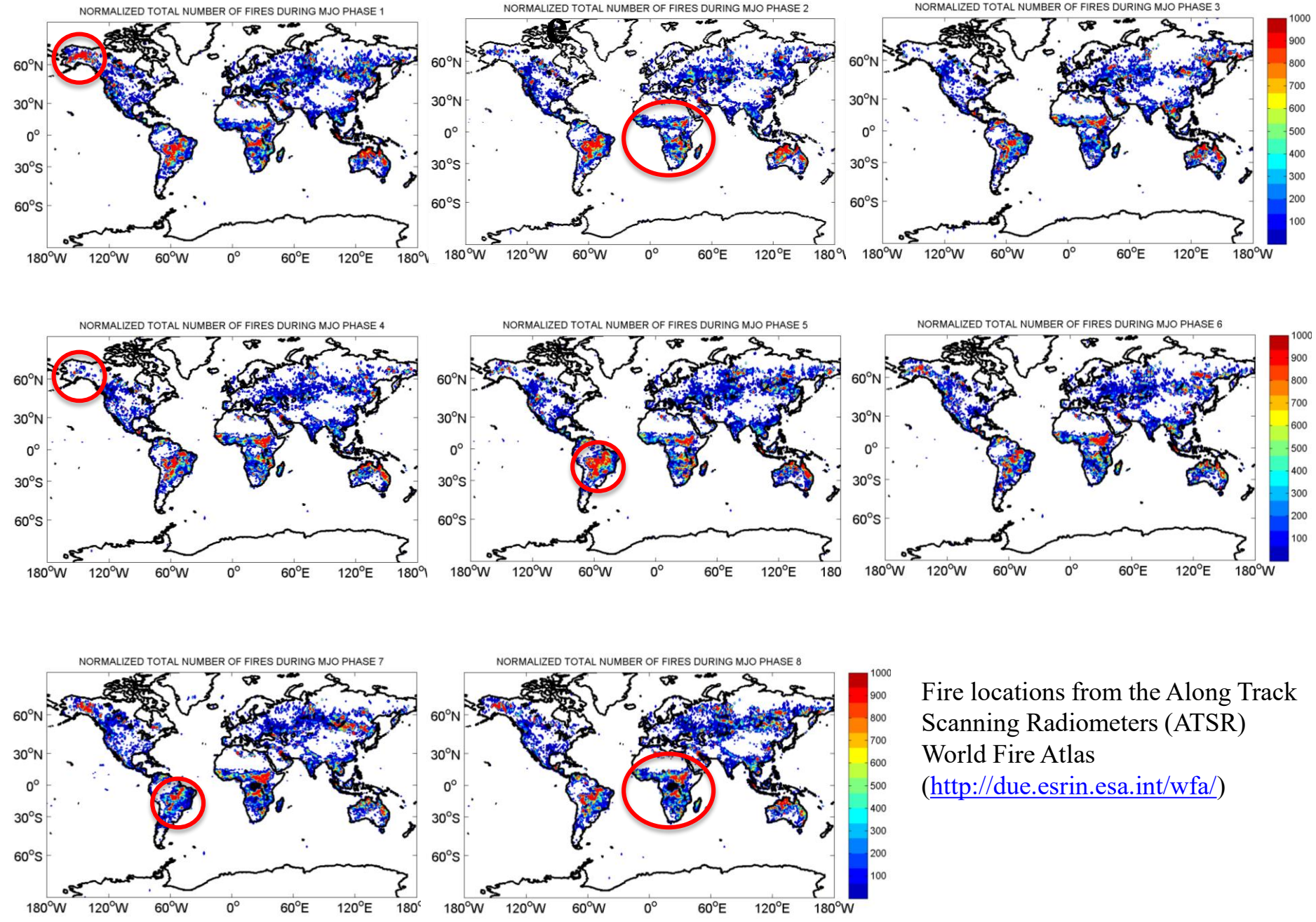
Daily cloud-to-ground lightning frequency rank-order anomalies (z scores) stratified by RMM phase (denoted in lower-right corner) during 1 June – 30 September 1990 – 2007. Red (blue) shading denotes areas of enhanced (suppressed) lighting activity for each RMM phase exceeding the 95% confidence interval. (From Abatzoglou and Brown 2009)

Lightning (Maritime Continent)

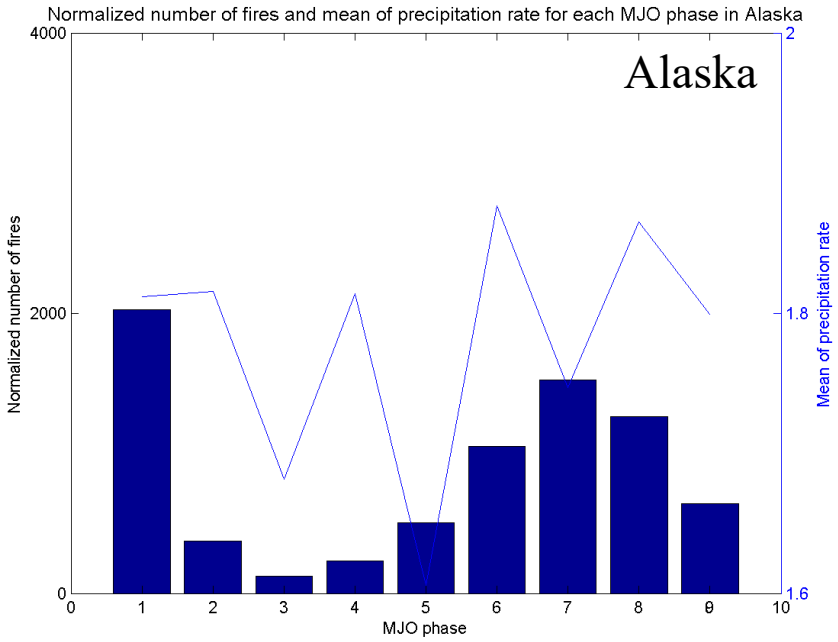


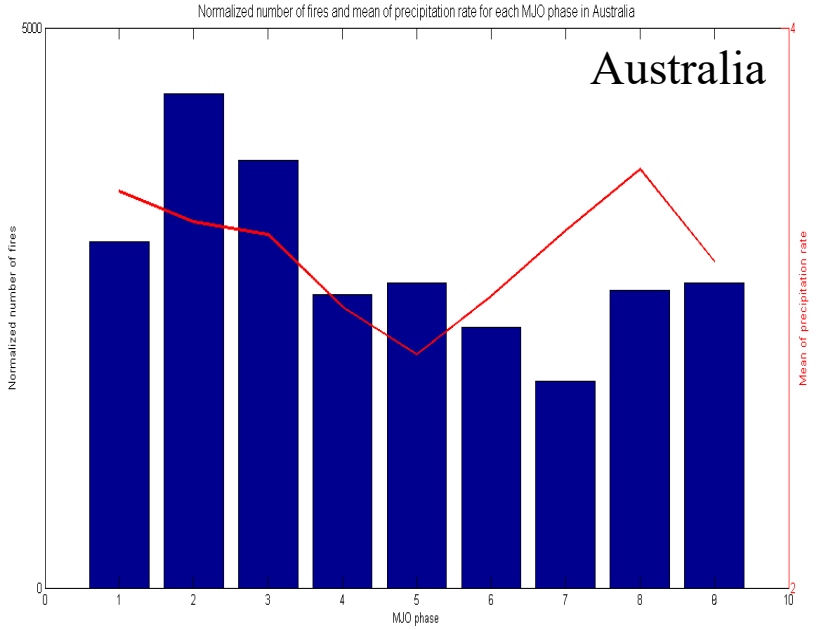
Virts and Houze (2015)

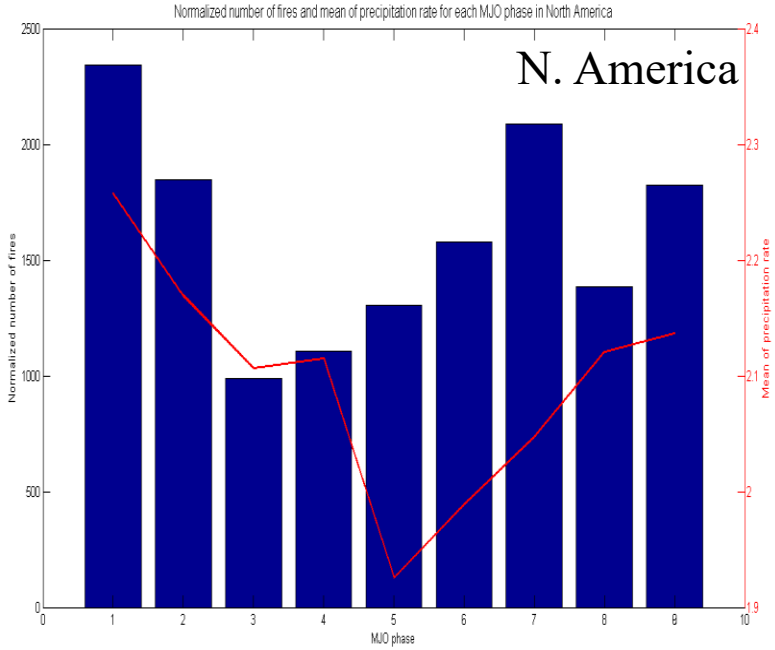
Wildfir

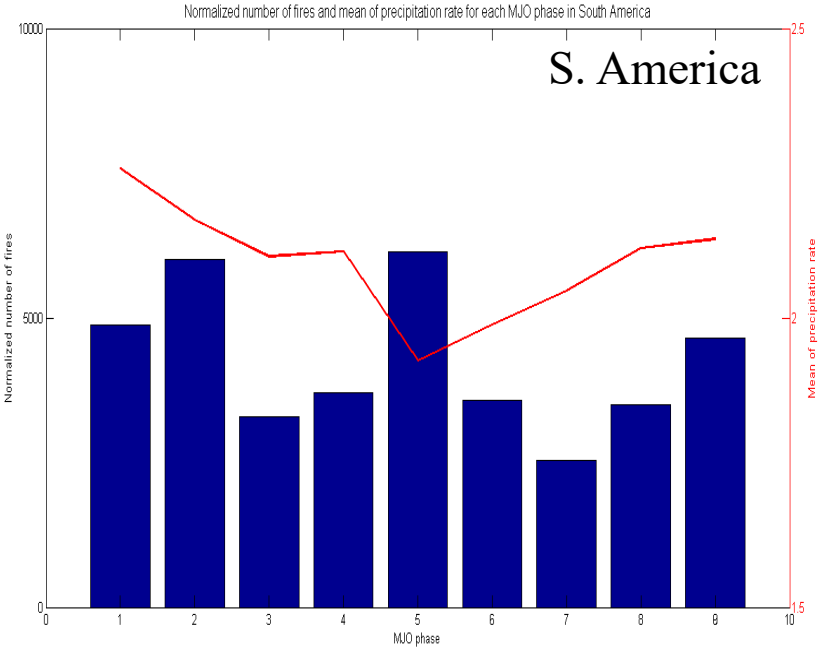


Fire locations from the Along Track Scanning Radiometers (ATSR) World Fire Atlas (http://due.esrin.esa.int/wfa/)

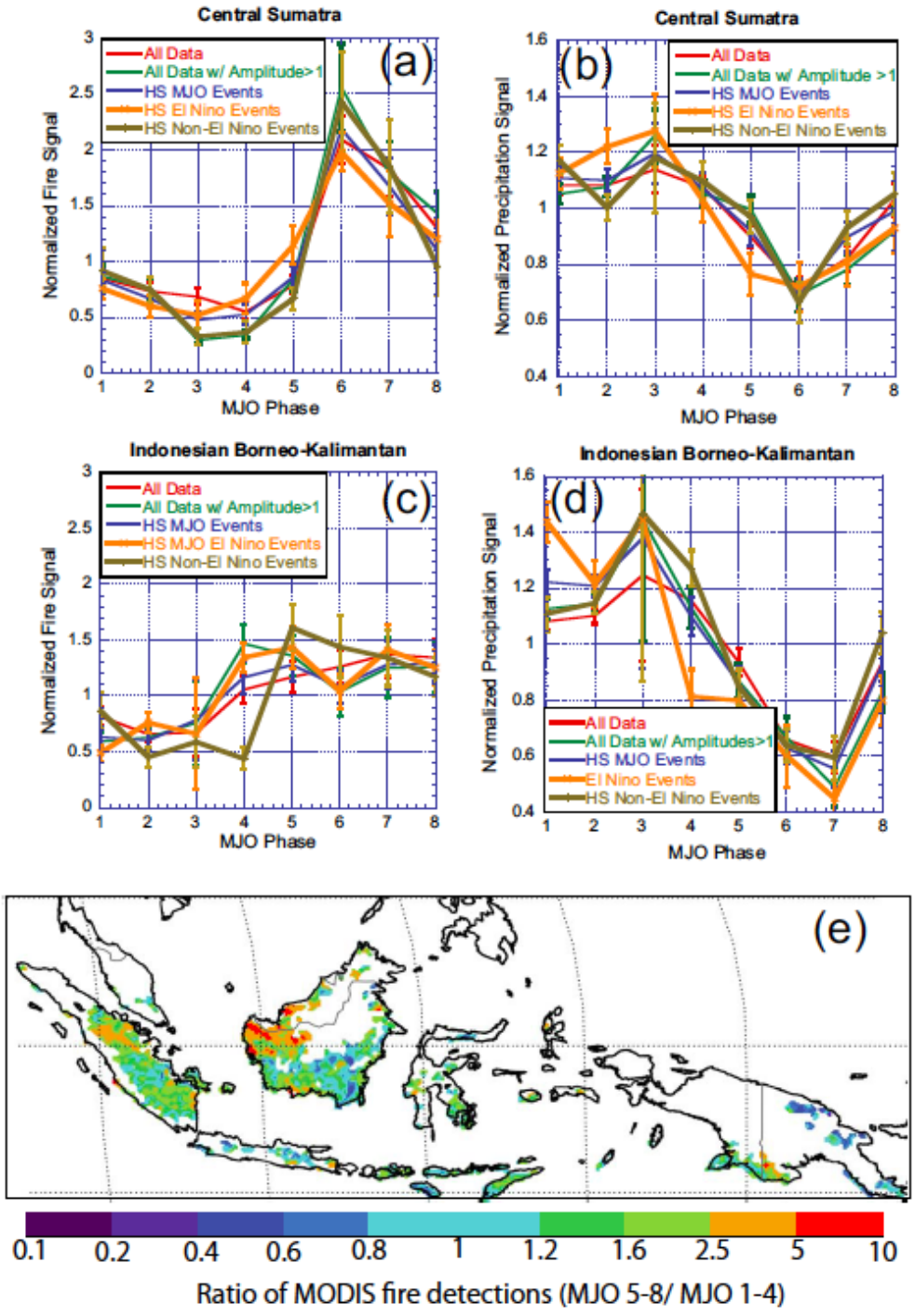

Normalized number of fires and mean of precipitation rate for each MJO phase in Alaska
Alaska
Normalized number of fires
Mean of precipitation rate
MJO phase
4000
2000
0
2
1.8
1.6
0
1
2
3
4
5
6
7
8
9
10


Normalized number of fires and mean of precipitation rate for each MJO phase in Australia
Australia
Normalized number of fires
Mean of precipitation rate
MJO phase
5000
0
4
2
0
1
2
3
4
5
6
7
8
9
10

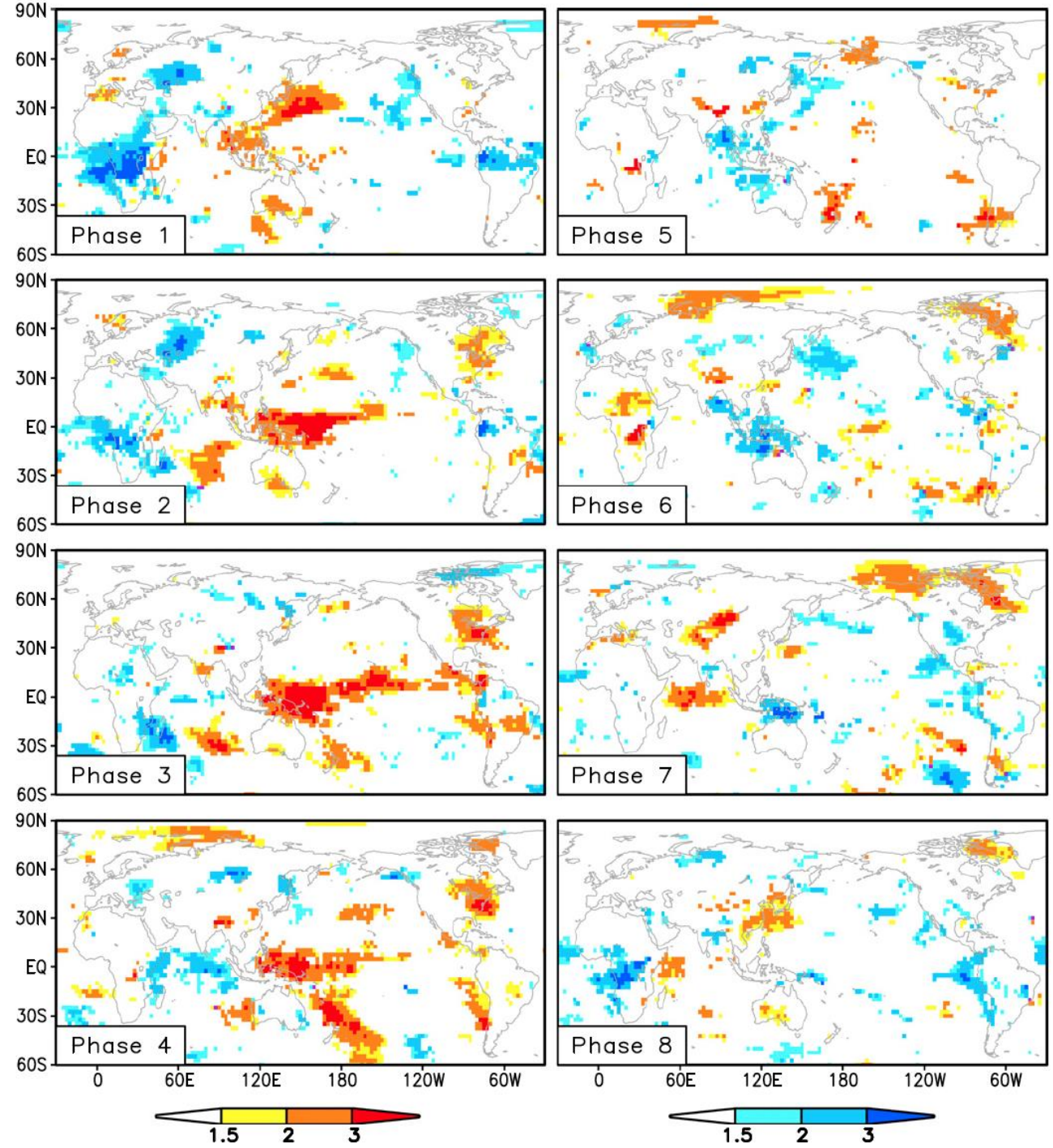

Normalized number of fires and mean of precipitation rate for each MJO phase in North America
N. America
Normalized number of fires
Mean of precipitation rate
MJO phase
2500
2000
1500
1000
500
0
2.4
2.3
2.2
2.1
2
1.9
0
1
2
3
4
5
6
7
8
9
10


Normalized number of fires and mean of precipitation rate for each MJO phase in South America
S. America
Normalized number of fires
Mean of precipitation rate
MJO phase
10000
5000
0
2.5
2
1.5
0
1
2
3
4
5
6
7
8
9
10

June-November
(2003-2009)

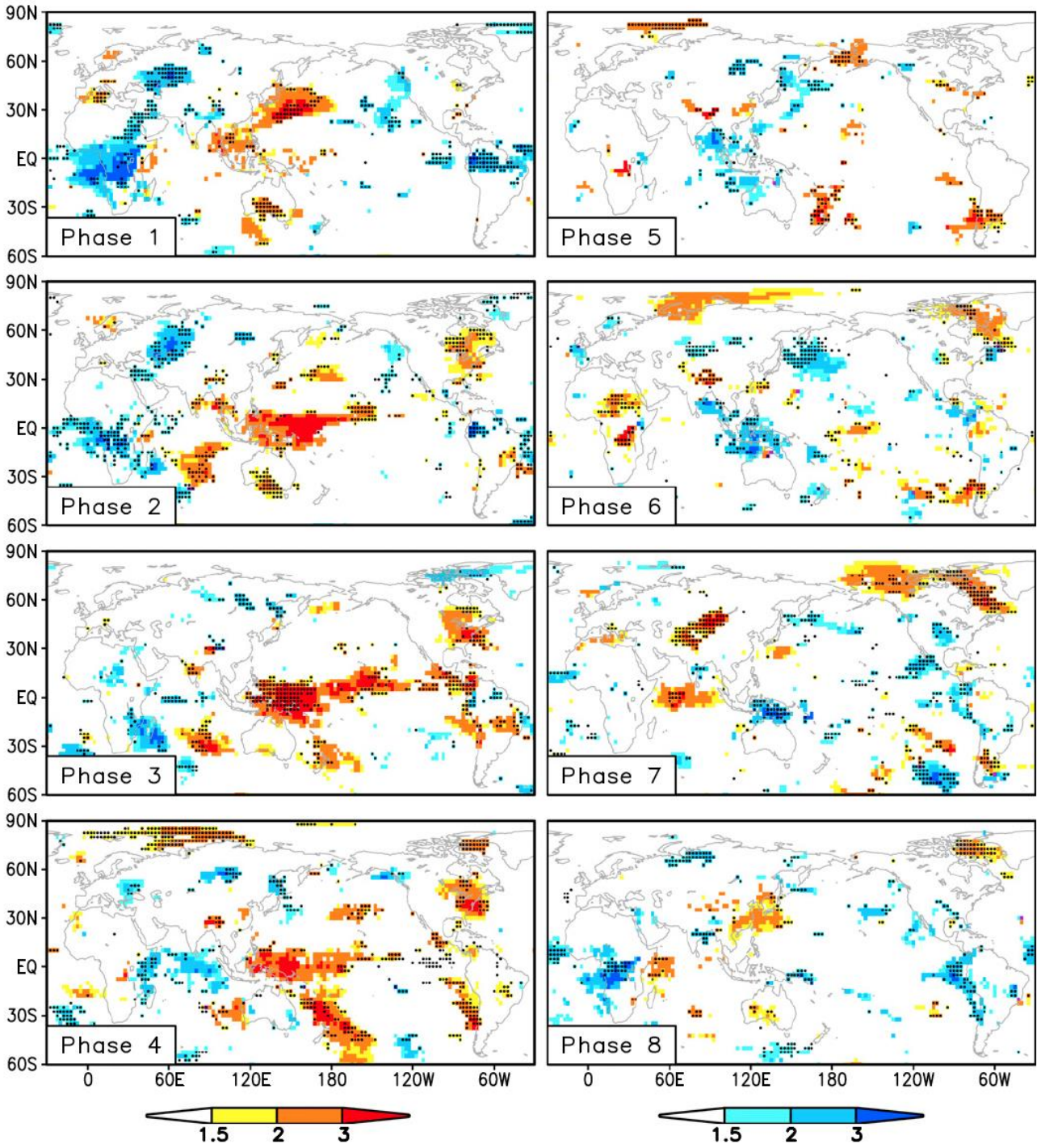


Reid et al (2012)



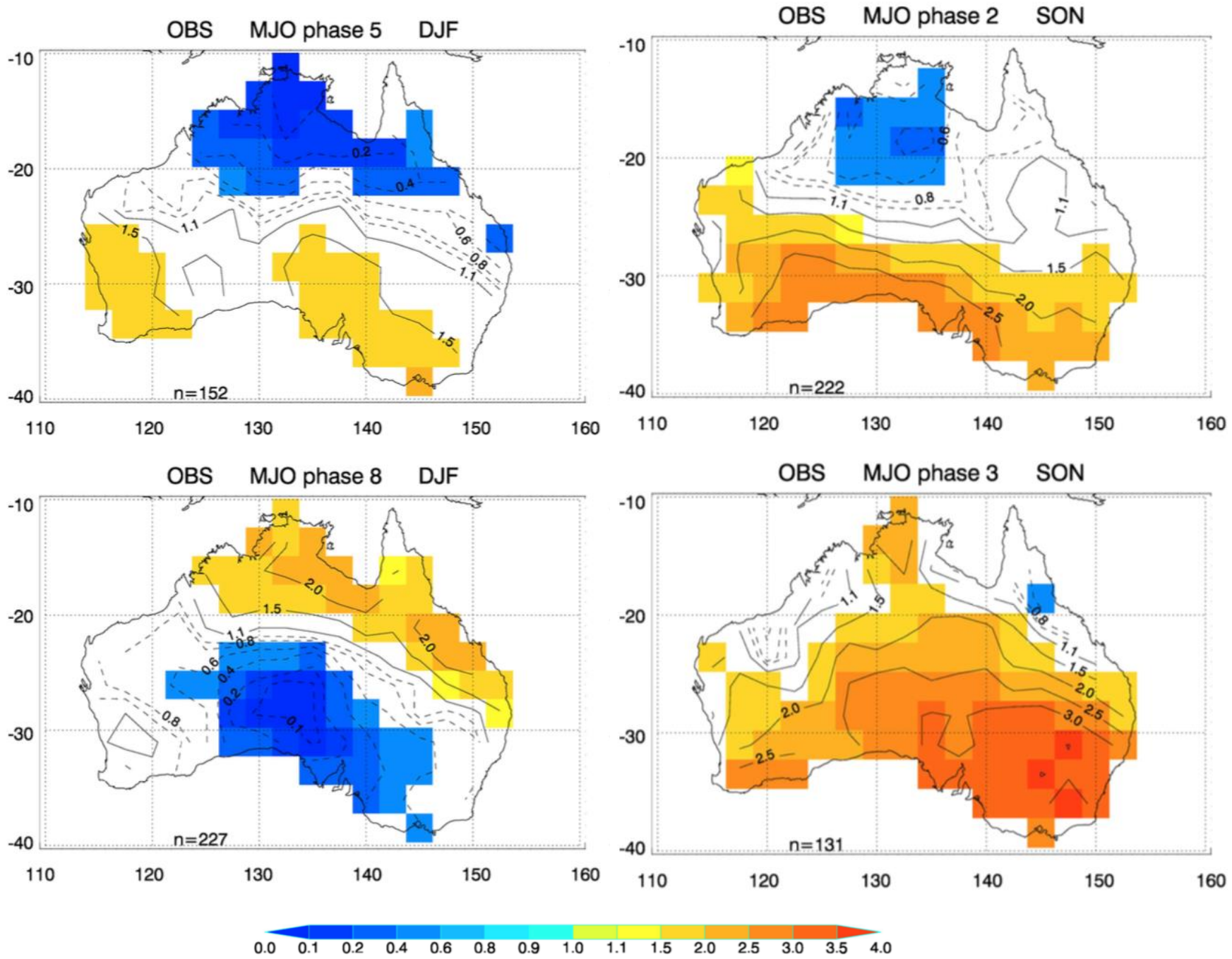
Extreme Temperature
November - April

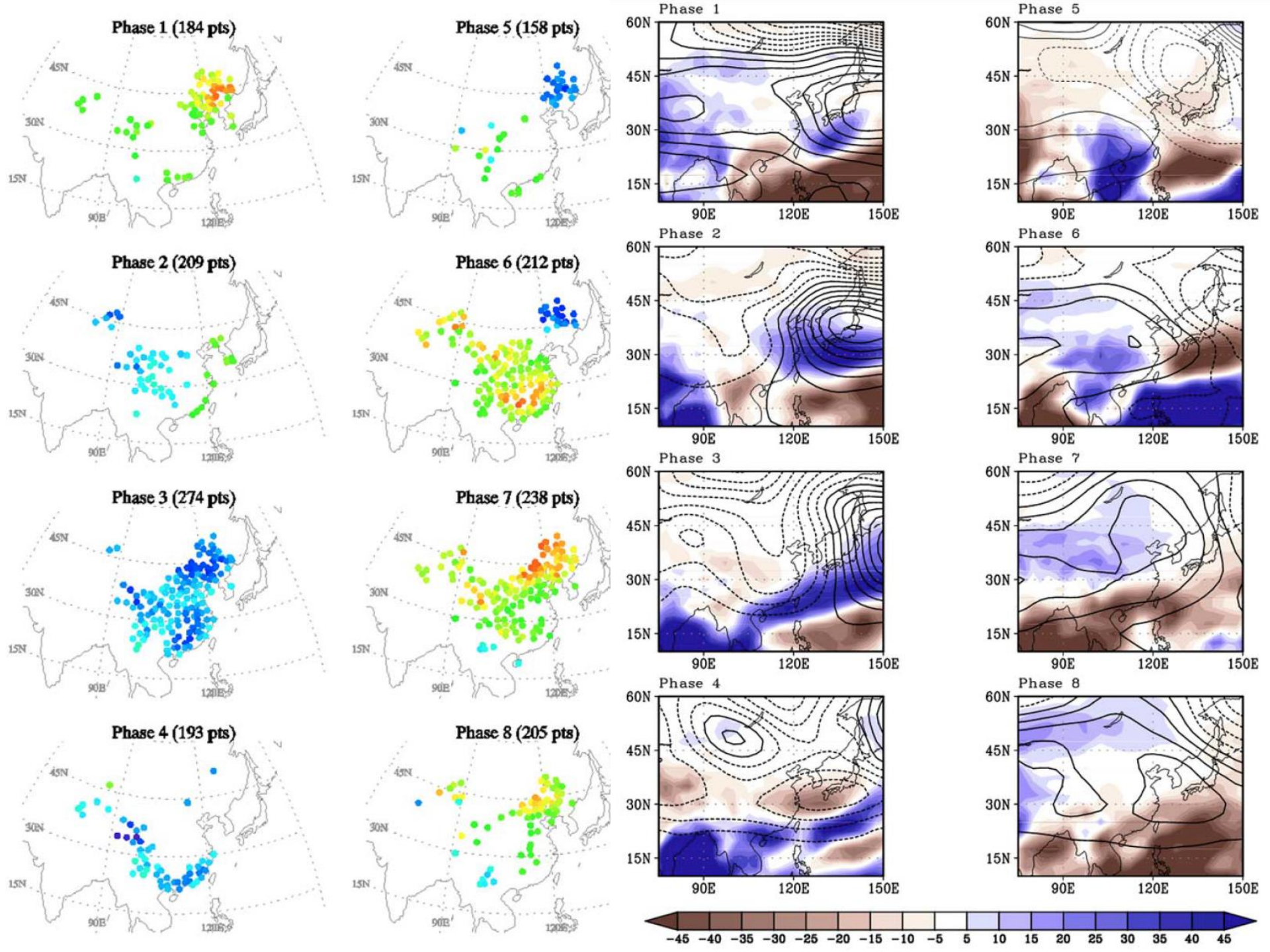
Matsueda and Takaya (2016)



Skill of Forecasting Extreme Temperature November - April

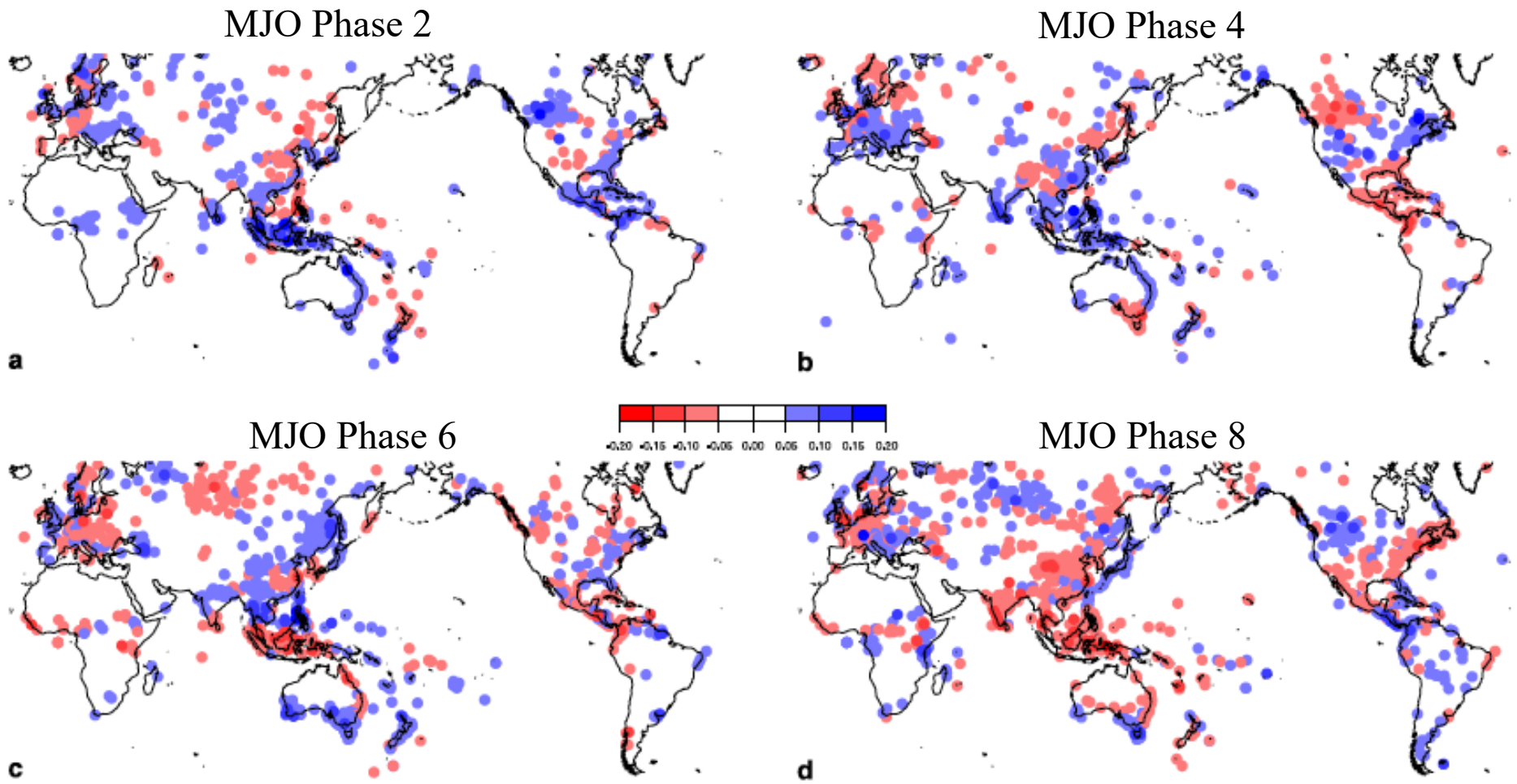
Matsueda and Takaya (2016)


OBS MJO phase 5 DJF
n=152
OBS MJO phase 2 SON
n=222
OBS MJO phase 8 DJF
n=227
OBS MJO phase 3 SON
n=131
-10
-20
-30
-40
110
120
130
140
150
160
0.0 0.1 0.2 0.4 0.6 0.8 0.9 1.0 1.1 1.5 2.0 2.5 3.0 3.5 4.0


Phase 1 (184 pts)
Phase 5 (158 pts)
Phase 2 (209 pts)
Phase 6 (212 pts)
Phase 3 (274 pts)
Phase 7 (238 pts)
Phase 4 (193 pts)
Phase 8 (205 pts)
45N
30N
15N
90E
120E
Phase 1
Phase 5
Phase 2
Phase 6
Phase 3
Phase 7
Phase 4
Phase 8
60N
45N
30N
15N
90E
120E
150E
−45 −40 −35 −30 −25 −20 −15 −10 −5 5 10 15 20 25 30 35 40 45


车场出口
Parking Lot Exit
进车场
Parking Lot Entrance
车场出口
Parking Lot Exit

Global Rainfall Anomalies (austral winter)

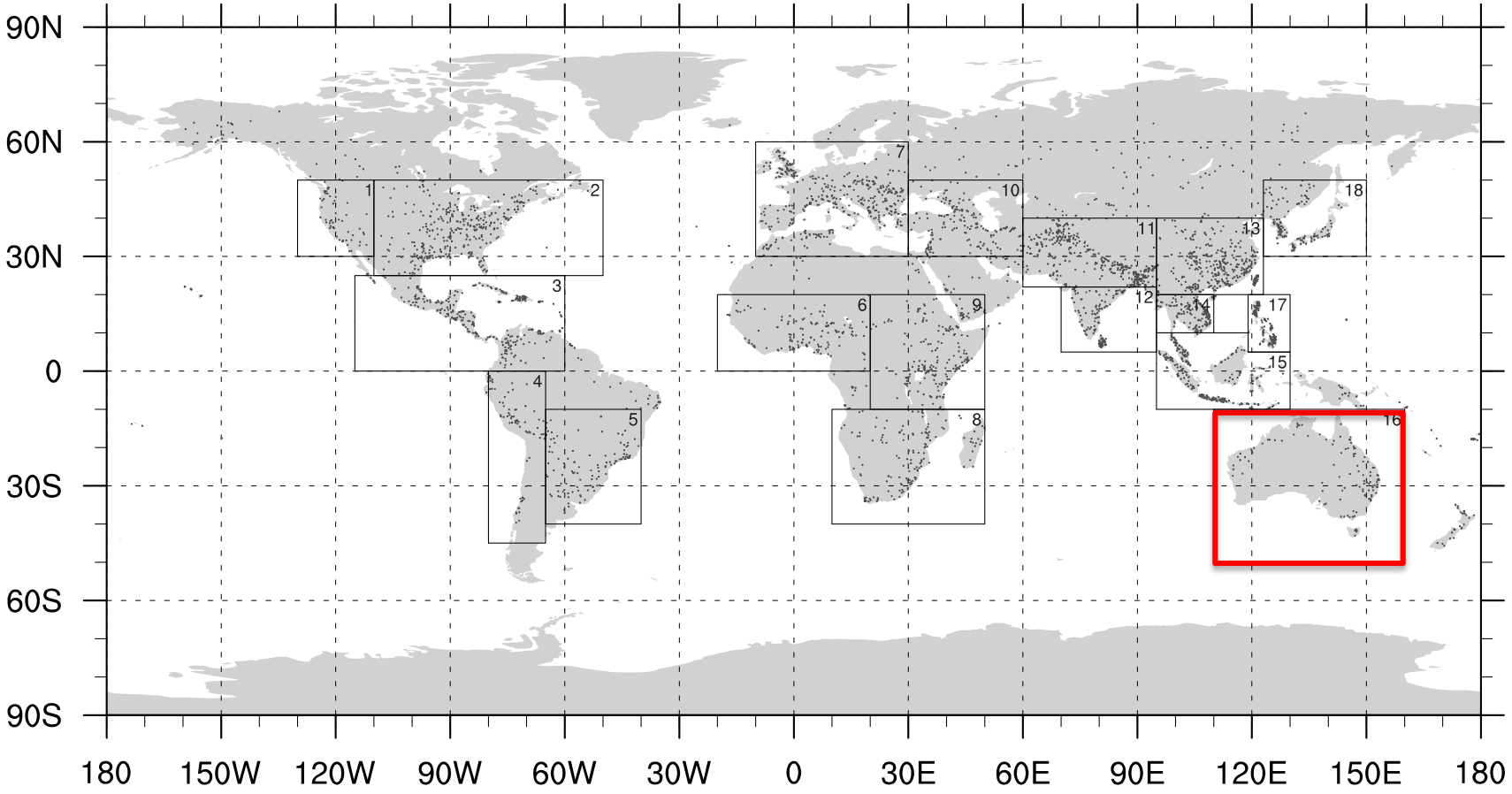


Donald et al. (2006)

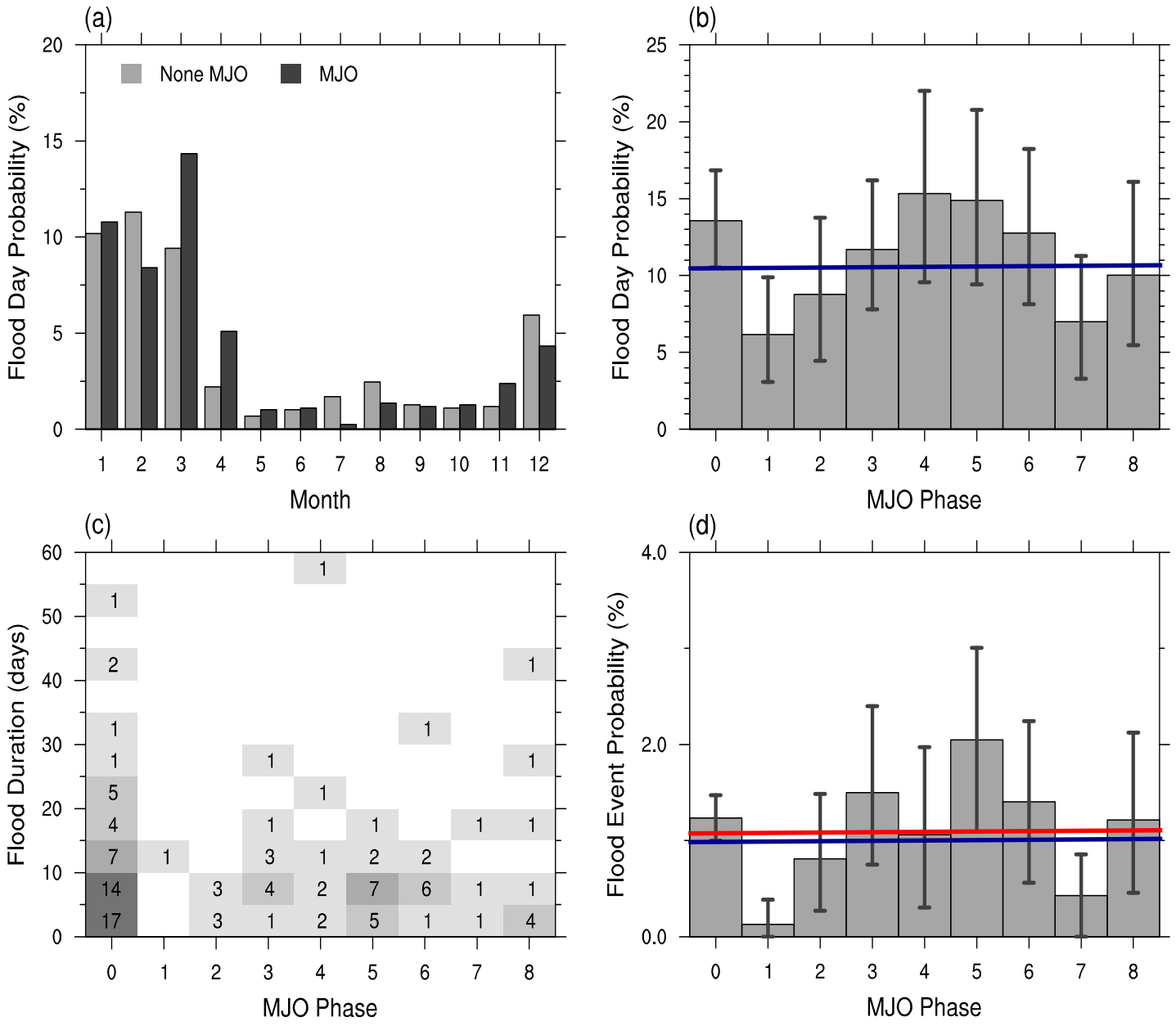
Decadal Flood Events

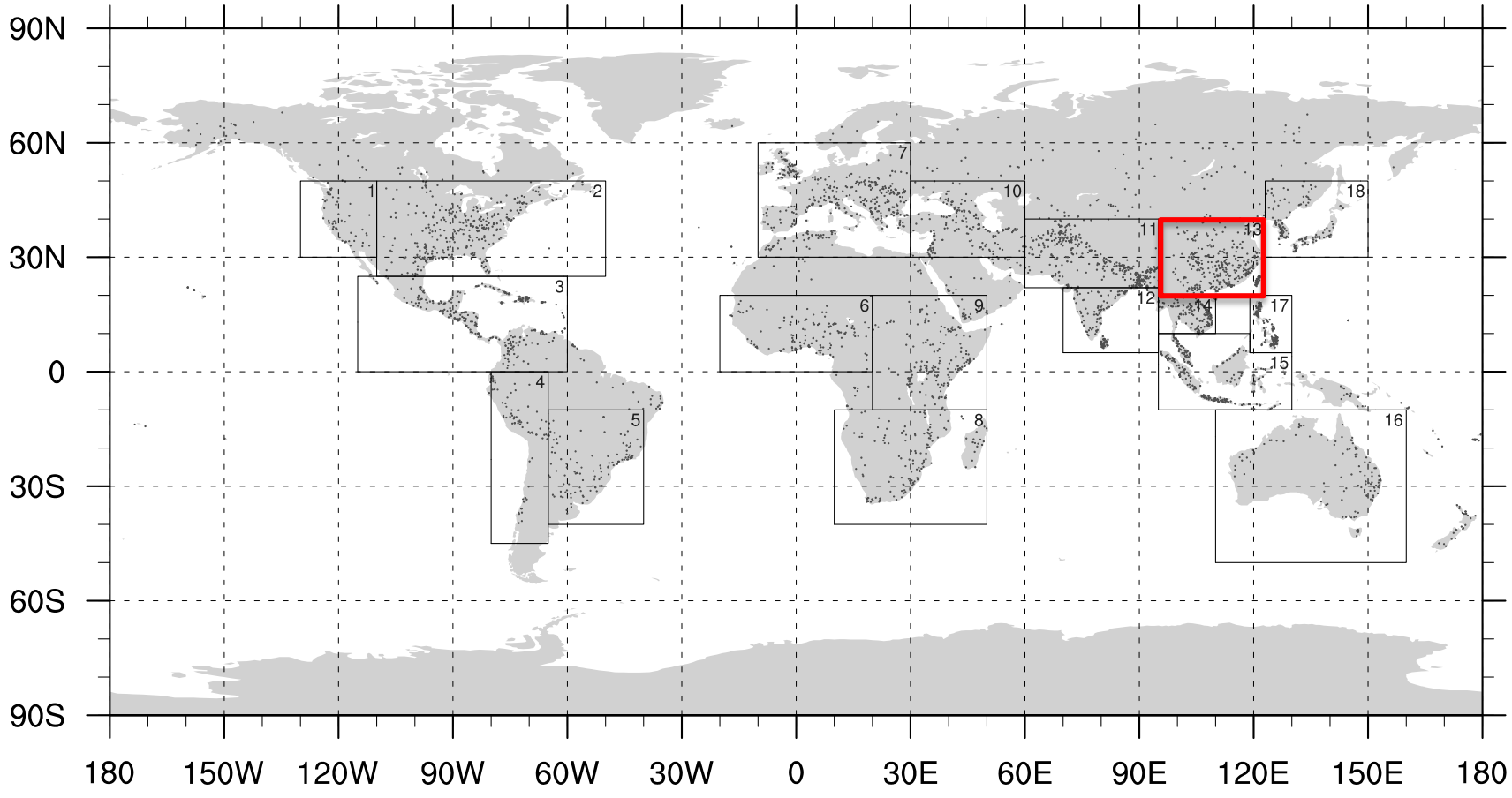
Data: Dartmouth Flood Observatory Archive 1985-2010 (http://floodobservatory.colorado.edu/)

Flood Parameters: *flood days; number of events*; magnitude (duration, areal coverage, water volume, fatalities)

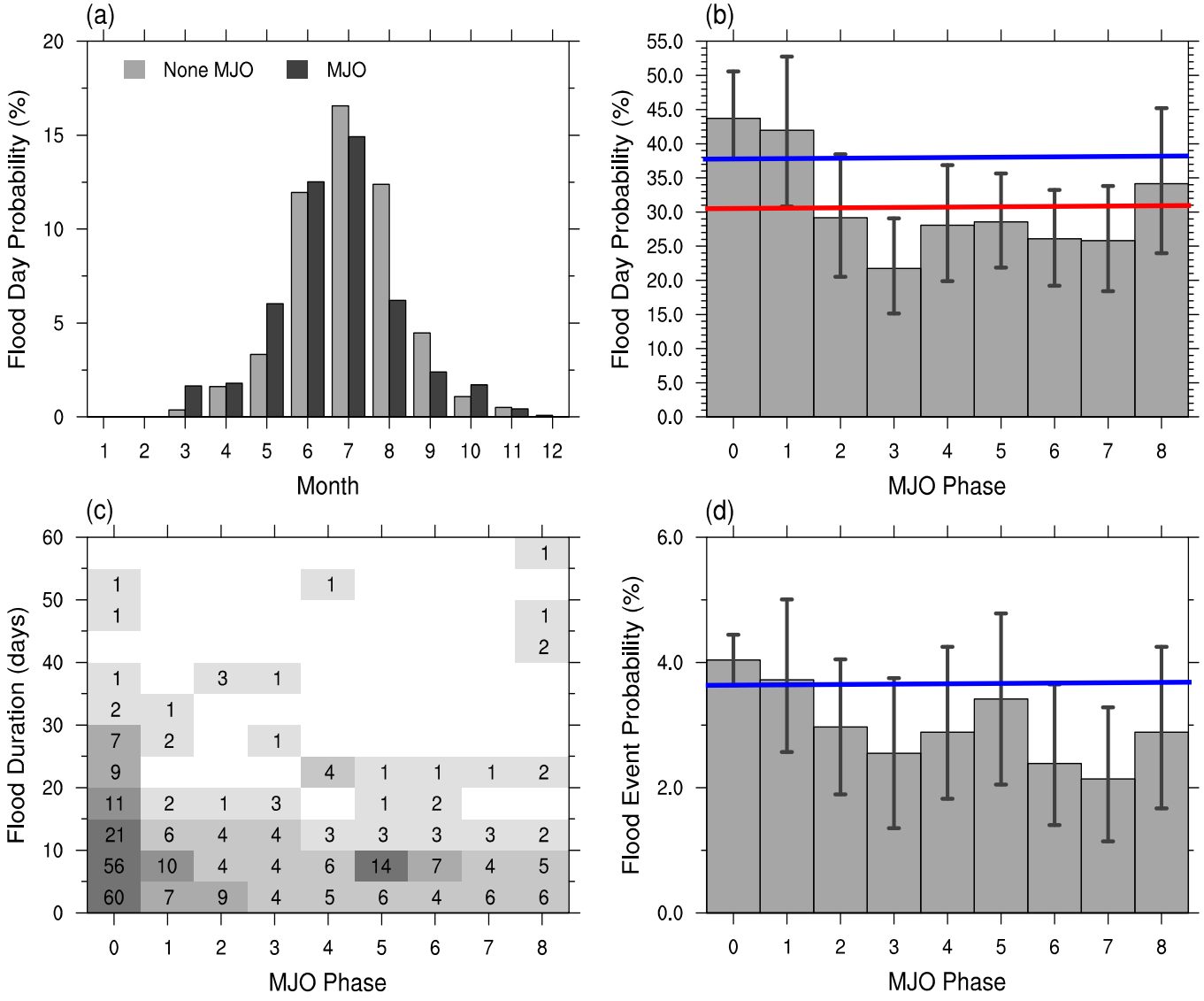


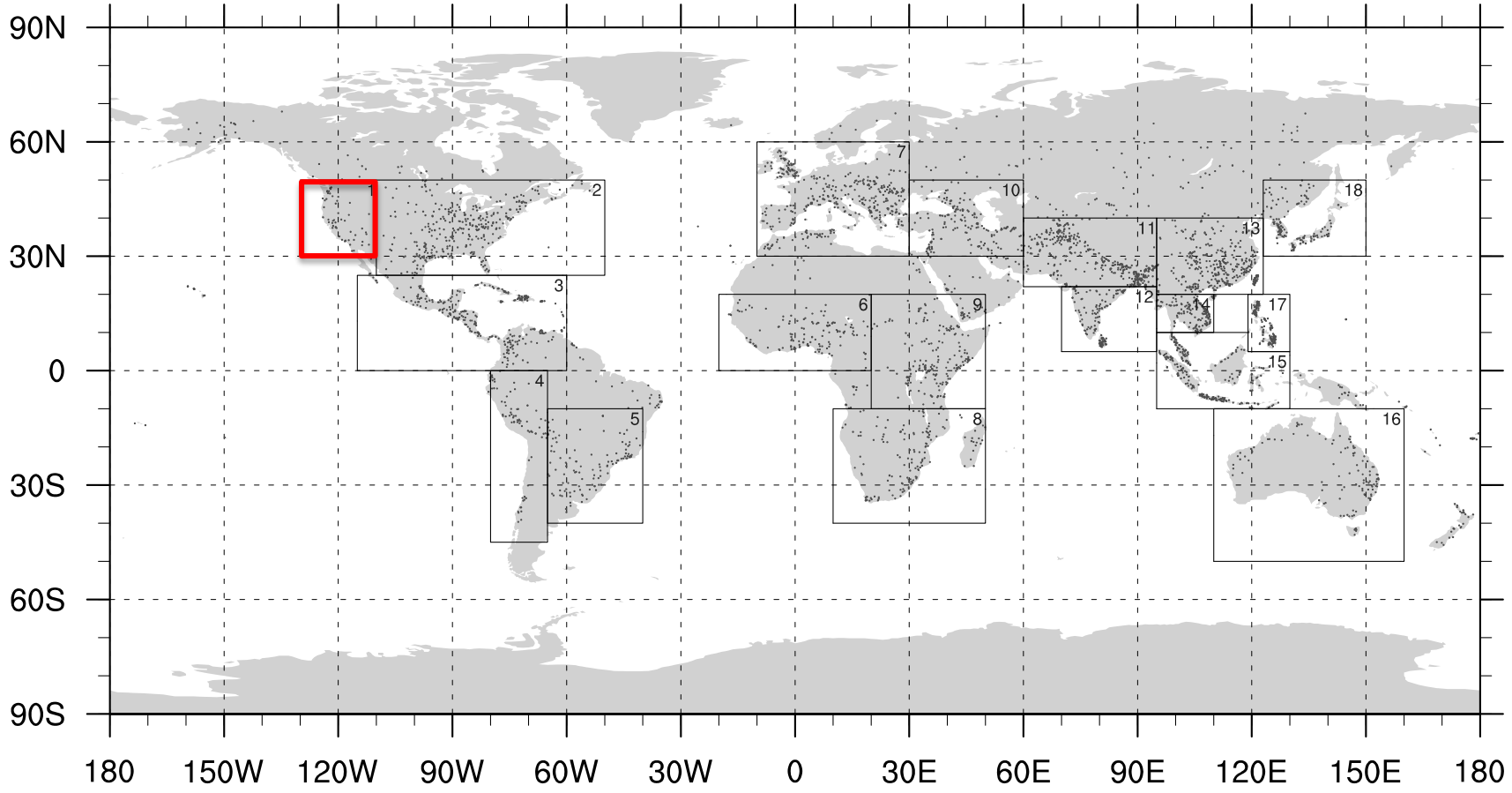
Location 16: Australia



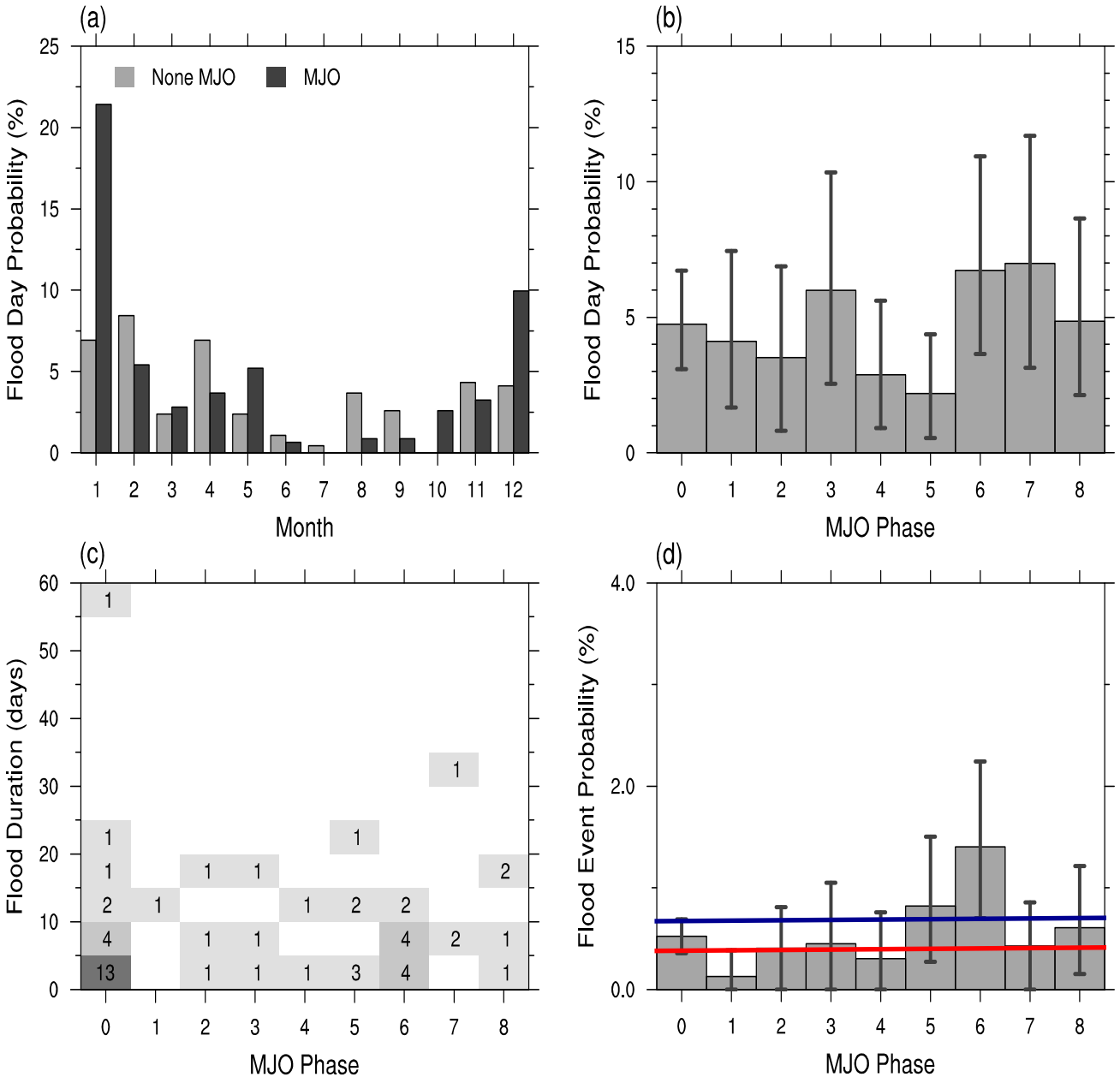

90N
60N
30N
0
30S
60S
90S
180
150W
120W
90W
60W
30W
0
30E
60E
90E
120E
150E
180
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18

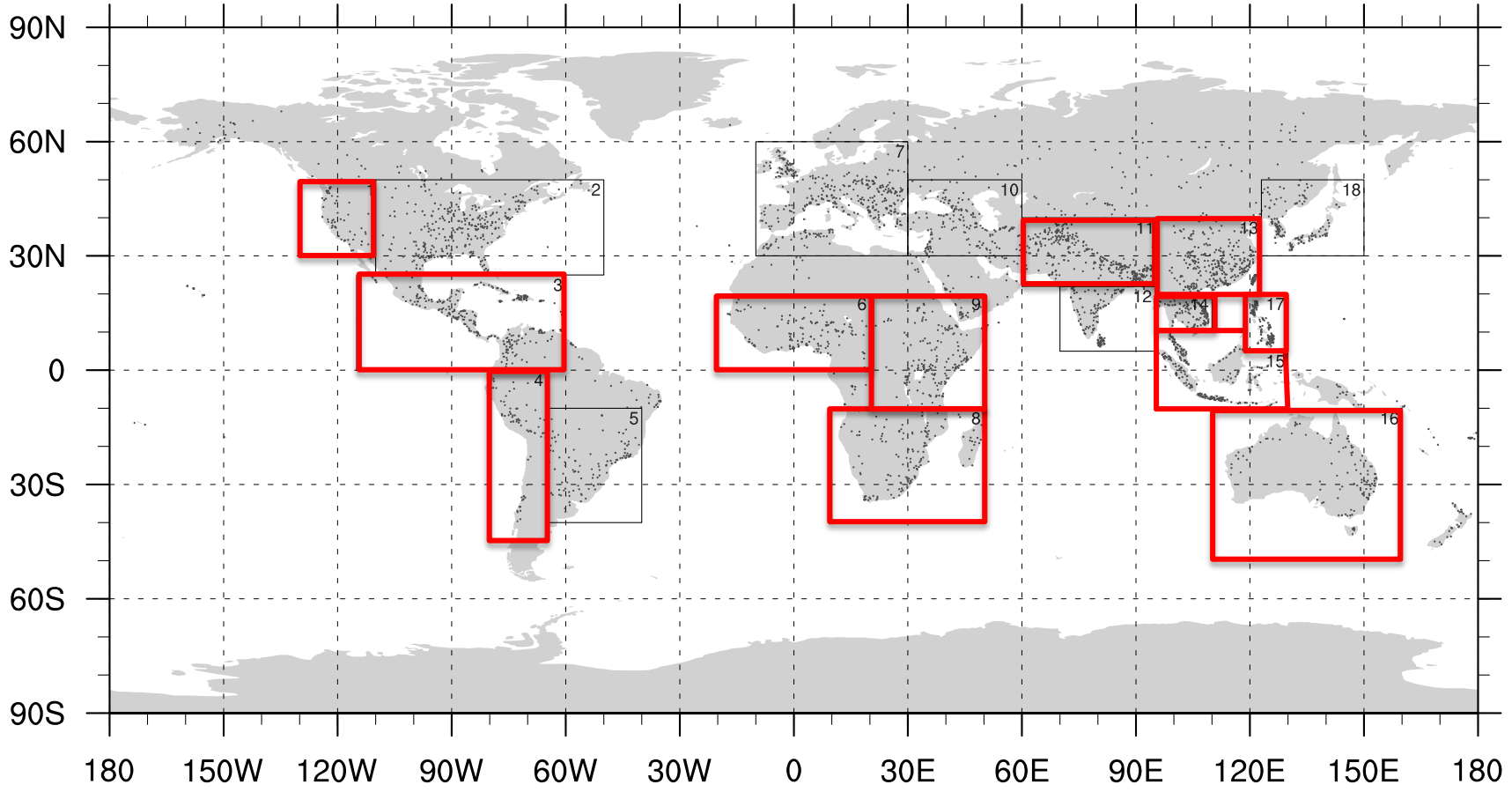
Location 13: East Asia

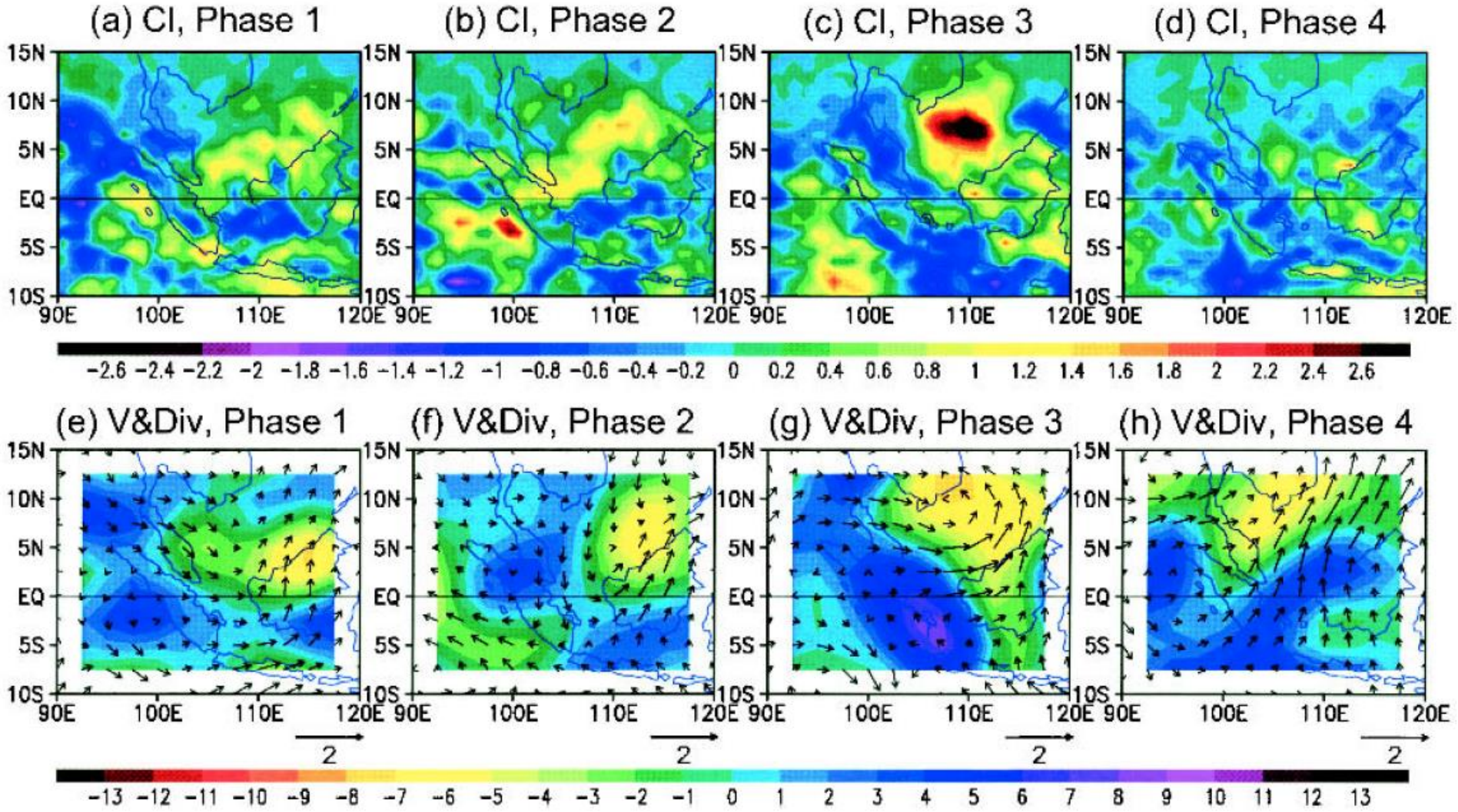



90N
60N
30N
0
30S
60S
90S
180
150W
120W
90W
60W
30W
0
30E
60E
90E
120E
150E
180
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18

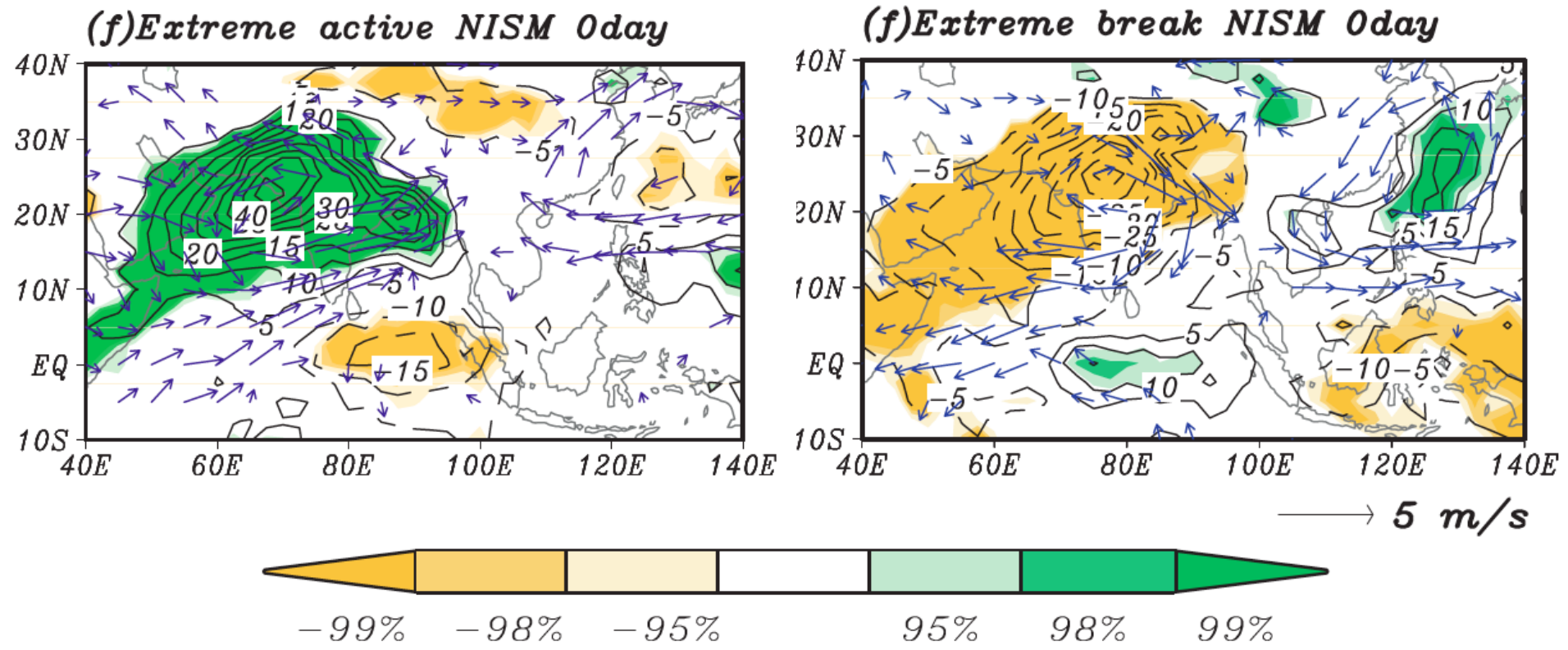
Location 1: West N. America




90N
60N
30N
0
30S
60S
90S
180
150W
120W
90W
60W
30W
0
30E
60E
90E
120E
150E
180
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18

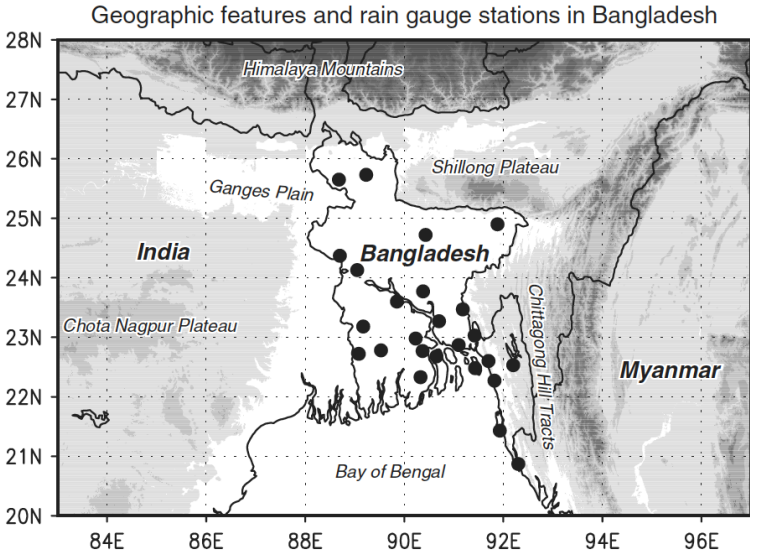


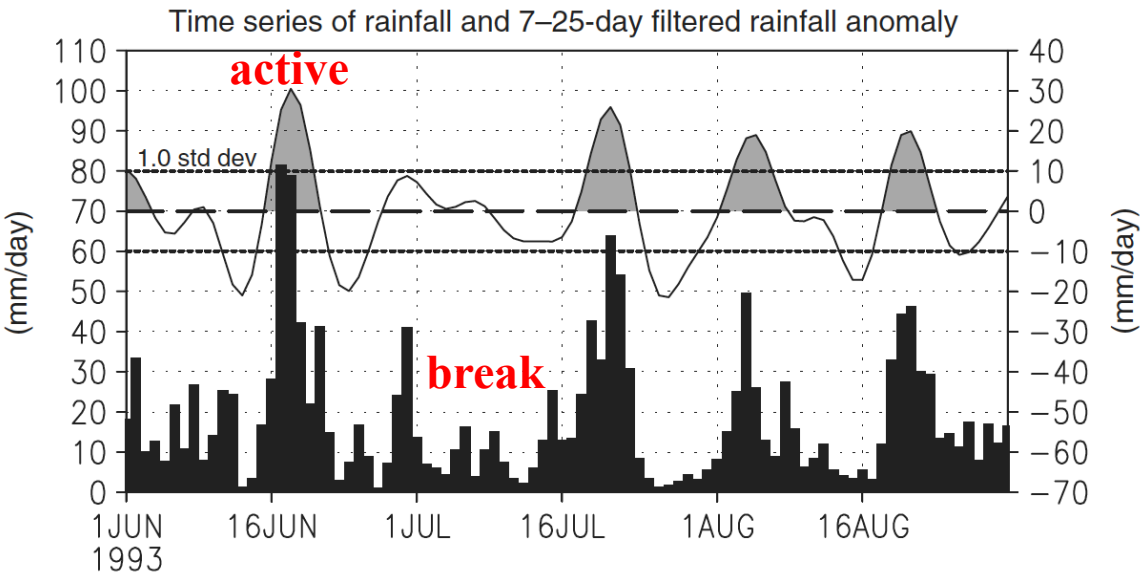
Chang et al (2005)

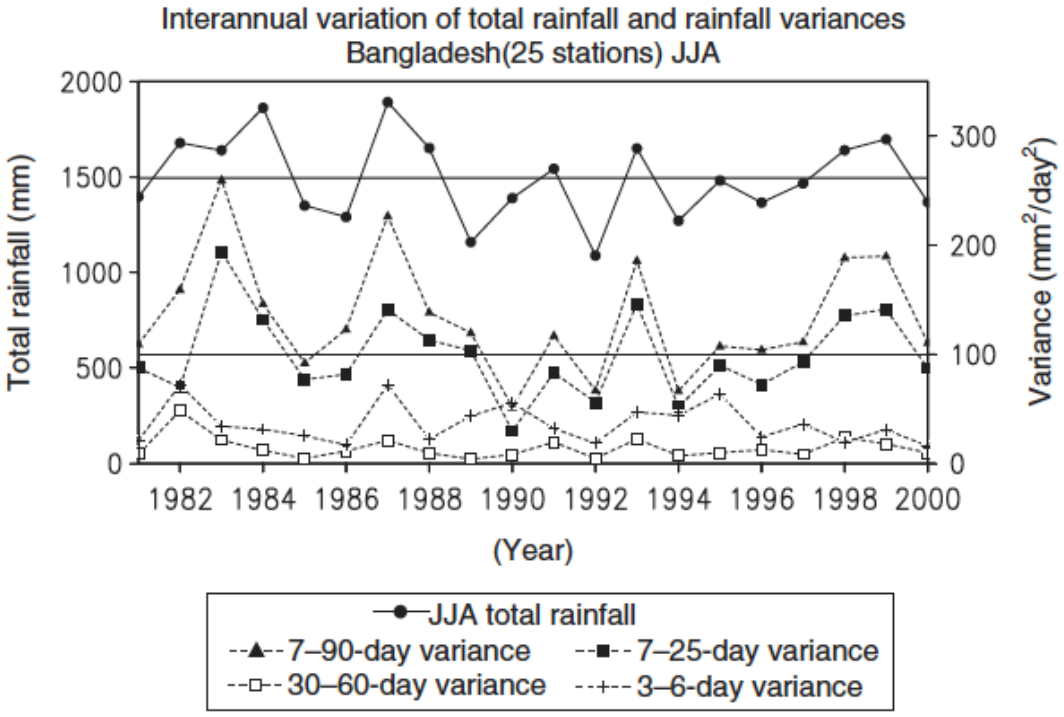


Ding and Wang (2009)

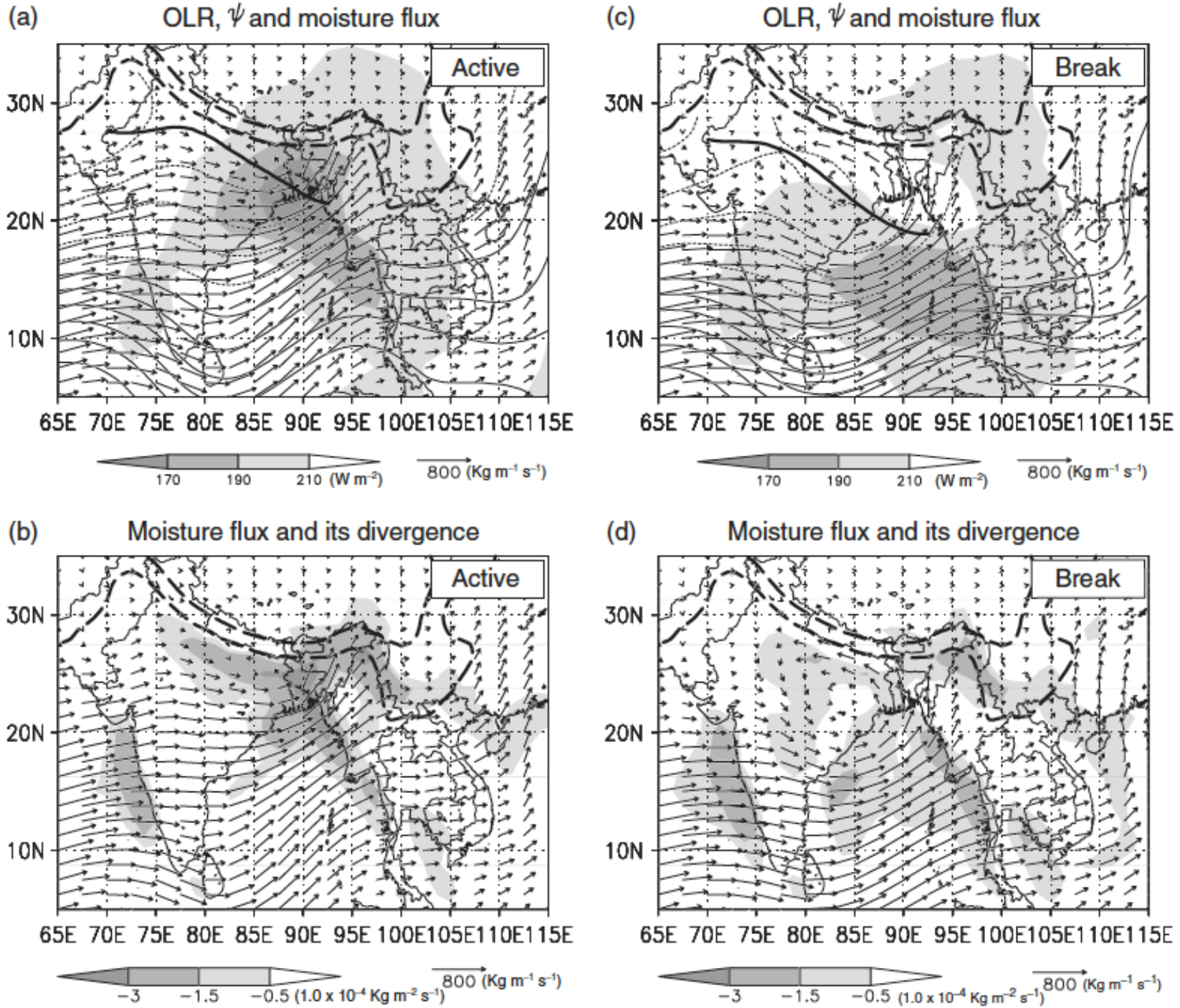
Several Cases

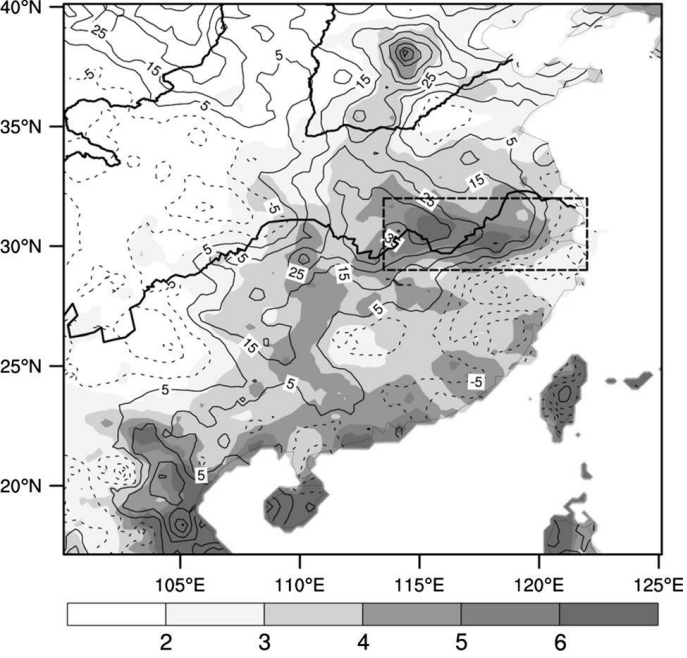


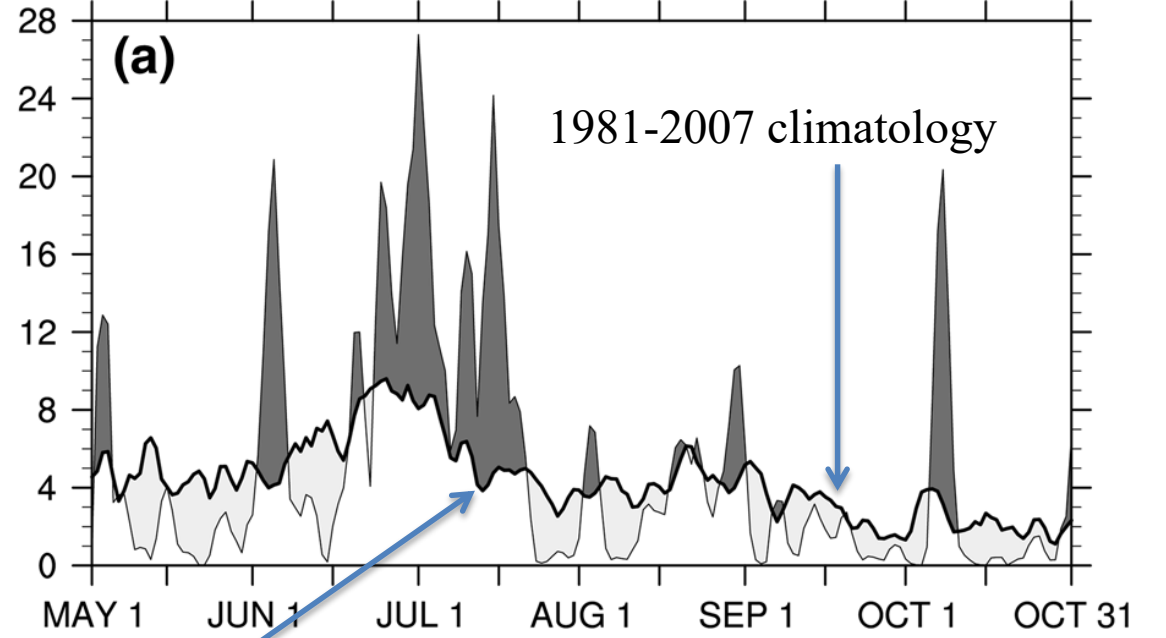


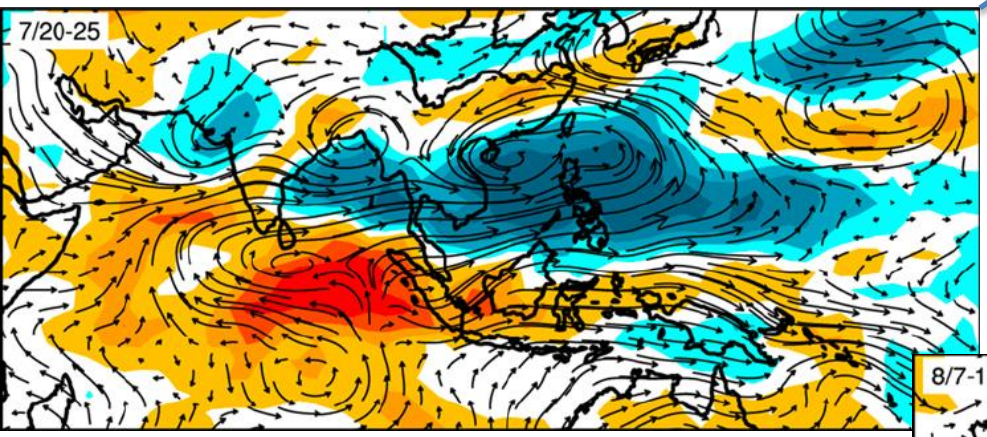


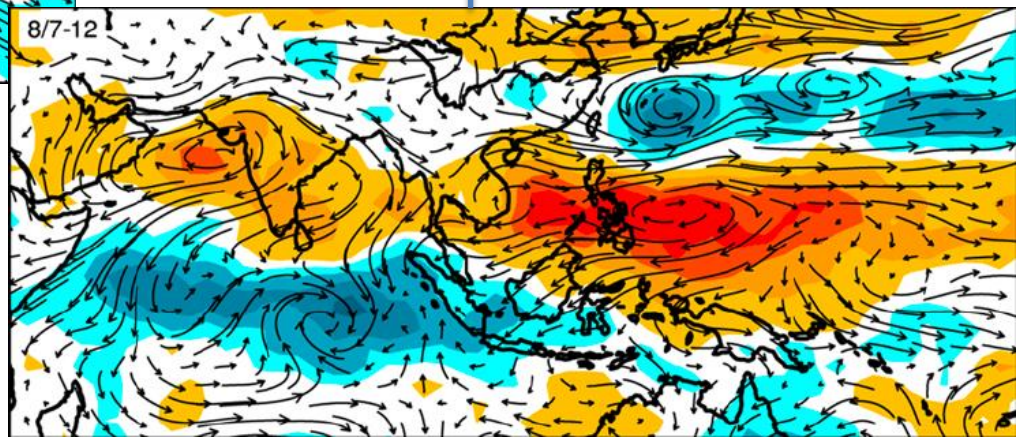
Fujinami et al (2011)


(a)
OLR, ψ and moisture flux
Active
30N
20N
10N
65E 70E 75E 80E 85E 90E 95E 100E 105E 110E 115E
170 190 210 (W m-2)
800 (Kg m-1 s-1)
(c)
OLR, ψ and moisture flux
Break
30N
20N
10N
65E 70E 75E 80E 85E 90E 95E 100E 105E 110E 115E
170 190 210 (W m-2)
800 (Kg m-1 s-1)
(b)
Moisture flux and its divergence
Active
30N
20N
10N
65E 70E 75E 80E 85E 90E 95E 100E 105E 110E 115E
−3 −1.5 −0.5 (1.0 x 10-4 Kg m-2 s-1)
800 (Kg m-1 s-1)
(d)
Moisture flux and its divergence
Break
30N
20N
10N
65E 70E 75E 80E 85E 90E 95E 100E 105E 110E 115E
−3 −1.5 −0.5 (1.0 x 10-4 Kg m-2 s-1)
800 (Kg m-1 s-1)

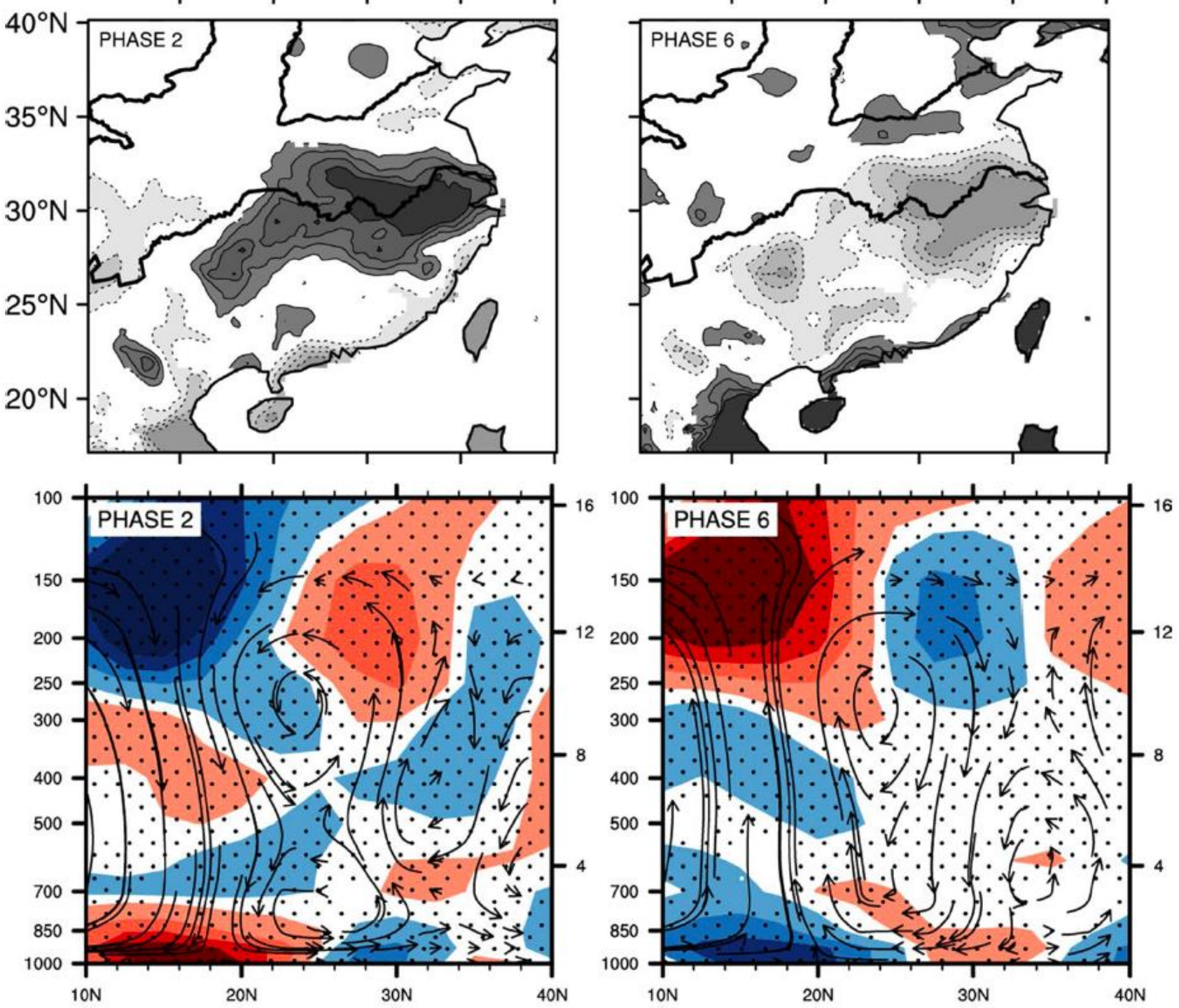

40°N
35°N
30°N
25°N
20°N
105°E
110°E
115°E
120°E
125°E
2
3
4
5
6


(a)
1981-2007 climatology
28
24
20
16
12
8
4
0
MAY 1
JUN 1
JUL 1
AUG 1
SEP 1
OCT 1
OCT 31


7/20-25


8/7-12

Li et al (2015)


PHASE 2
PHASE 6
40°N
35°N
30°N
25°N
20°N
PHASE 2
PHASE 6
100
150
200
250
300
400
500
700
850
1000
16
12
8
4
10N
20N
30N
40N

An Example of Extreme Rainfall Events as Results of Interaction Between an MJO Event and cold surges Despite an Ongoing El Niño Event

Peninsular Malaysia
December 2006 – January 2007

Tangang et al (2008)

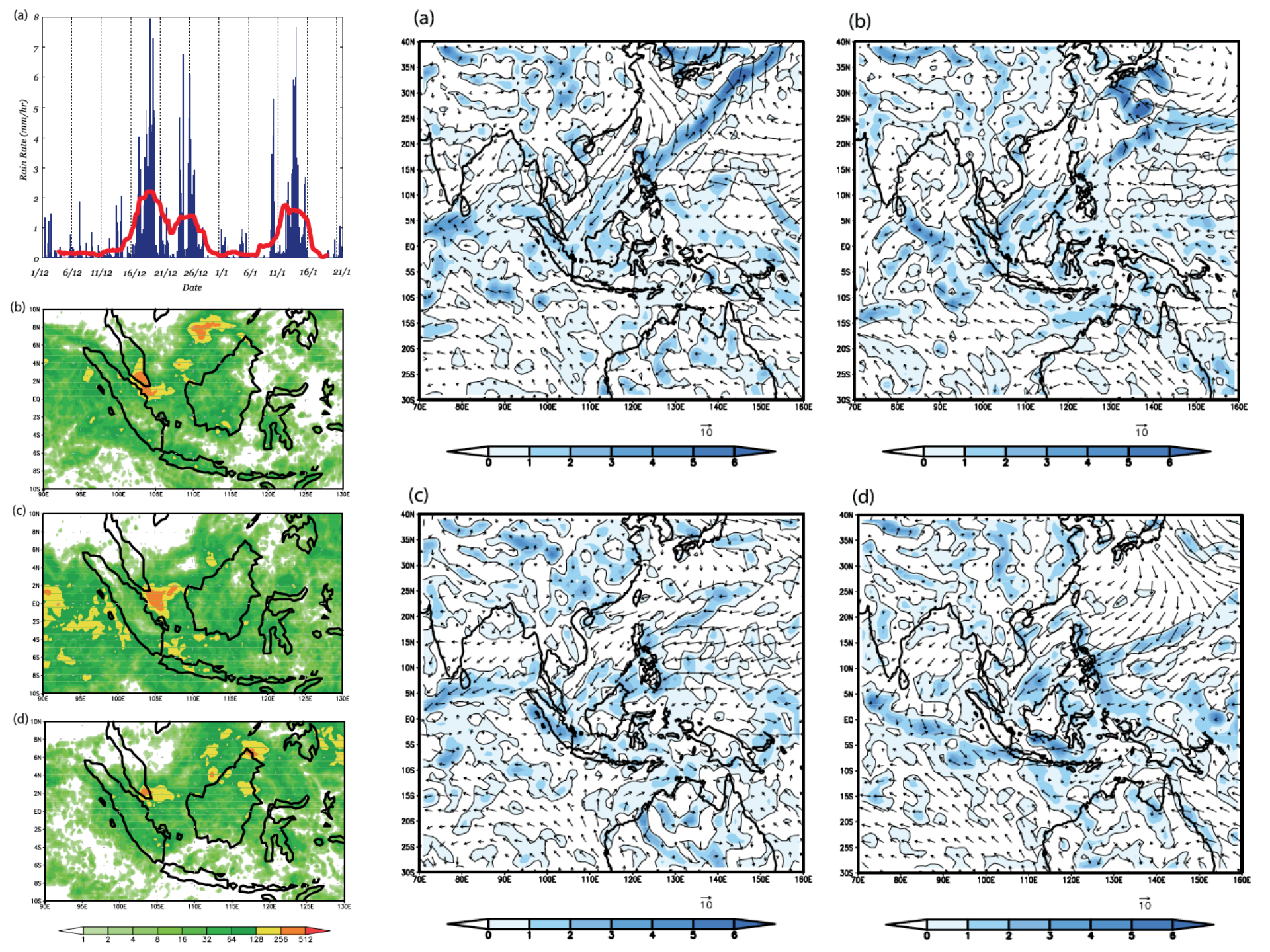
JOHOR: The overflowing Sungai Kesang in M

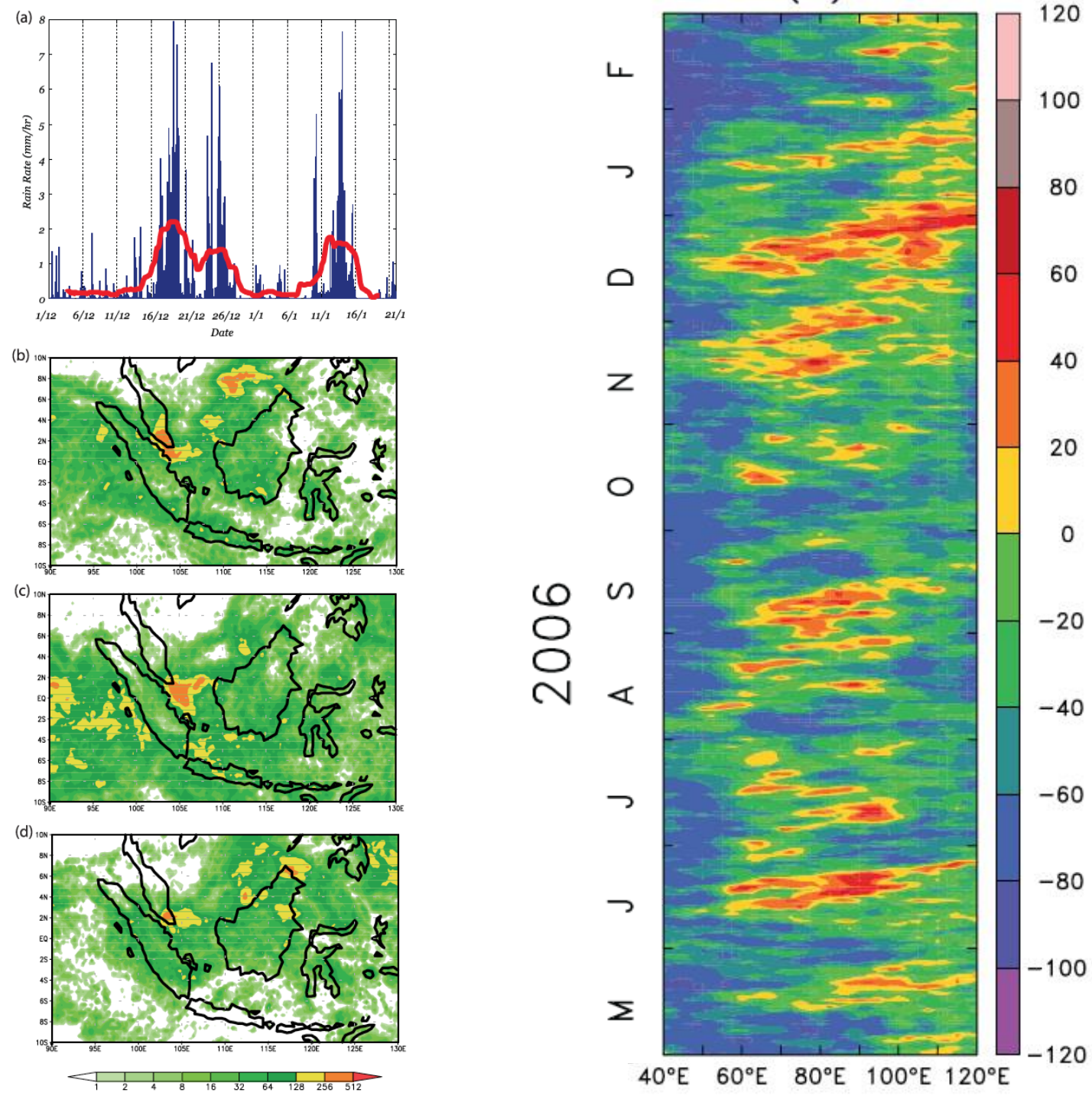
OR: Submerged vehicles were everywhere in

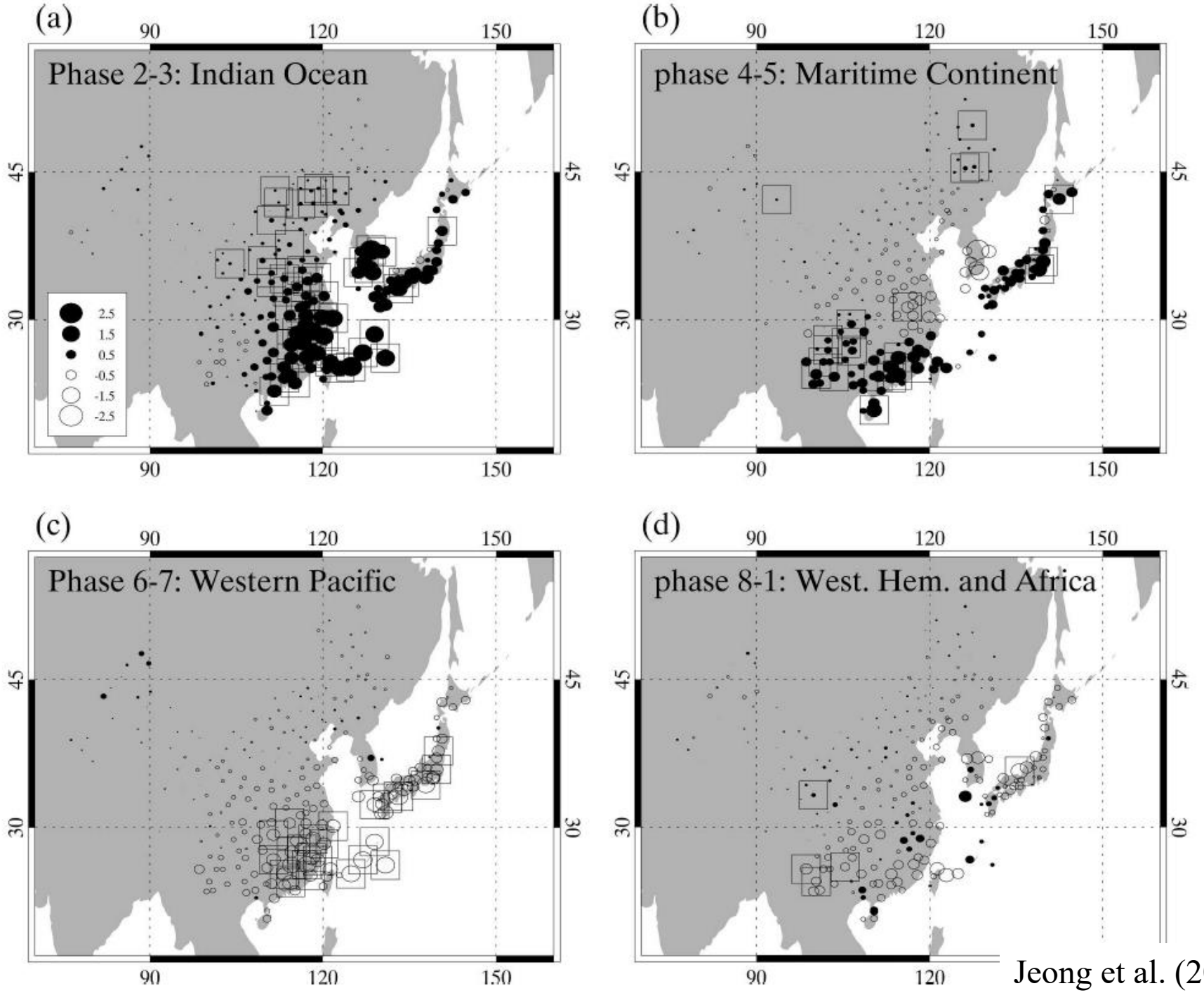
JOHOR: Railmen checking out the damage ca
the floods in Segamat. NST Pix

JOHOR: Newlyweds Haw Zhen Yap and Choo H
proceeding with their marriage during the flo
Muar, Johor

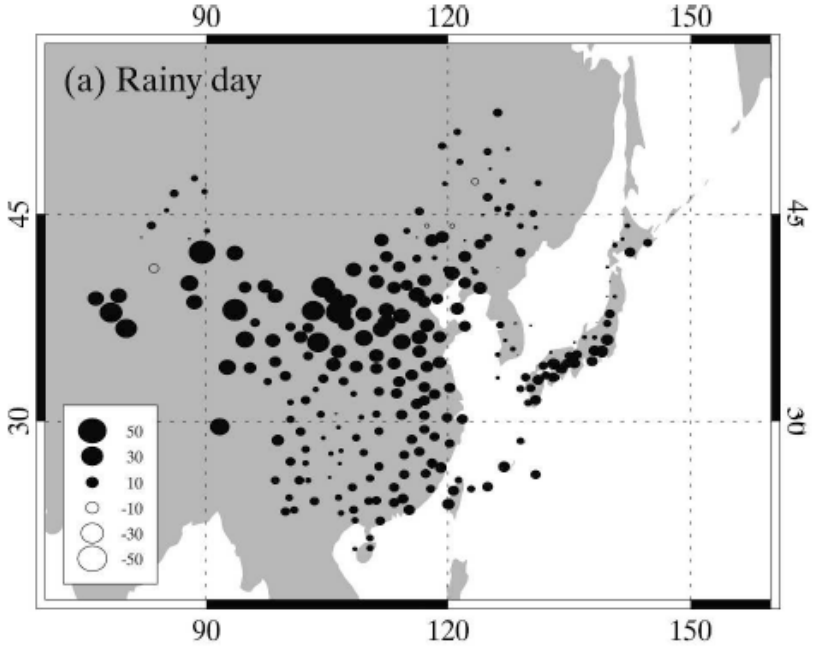
JOHOR: The Kota Tinggi bus terminal flooded.

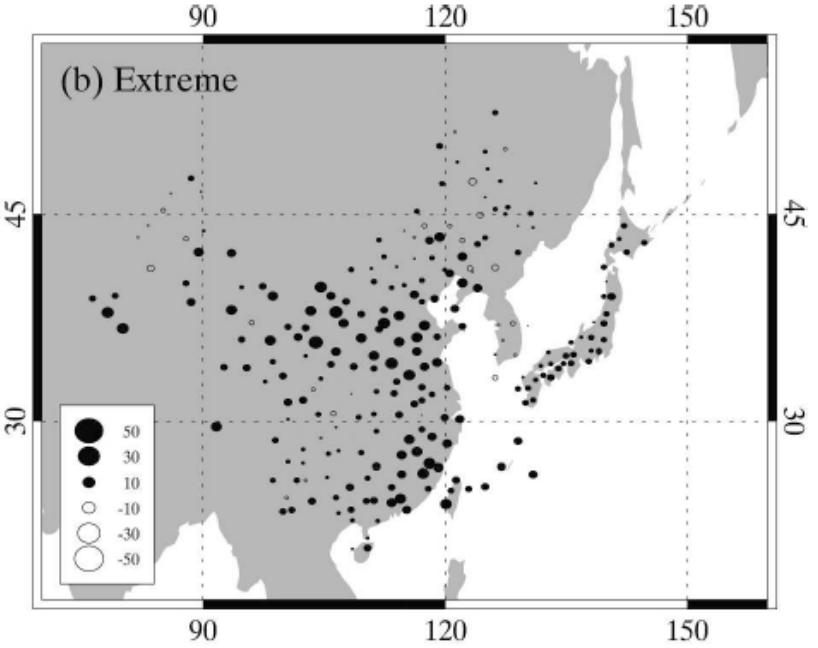

(a)
Rain Rate (mm/hr)
Date
1/12
6/12
11/12
16/12
21/12
26/12
1/1
6/1
11/1
16/1
21/1
(b)
(c)
(d)
1
2
4
8
16
32
64
128
256
512
(a)
(b)
(c)
(d)
0
1
2
3
4
5
6

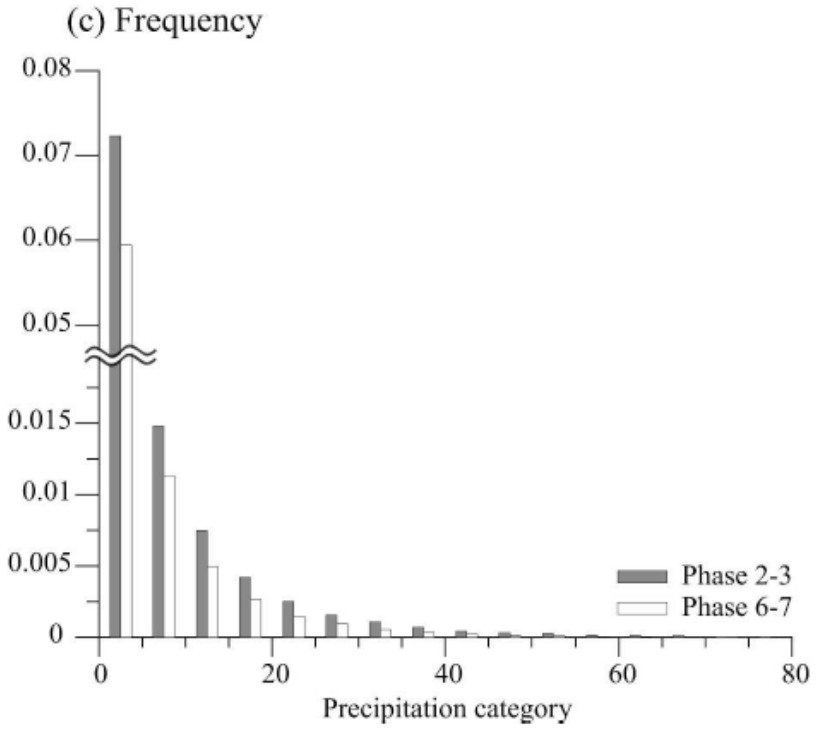

(a)
Rain Rate (mm/hr)
Date
1/12
6/12
11/12
16/12
21/12
26/12
1/1
6/1
11/1
16/1
21/1
(b)
(c)
(d)
2006
M J J A S O N D J F
40°E
60°E
80°E
100°E
120°E
120
100
80
60
40
20
0
−20
−40
−60
−80
−100
−120
1
2
4
8
16
32
64
128
256
512

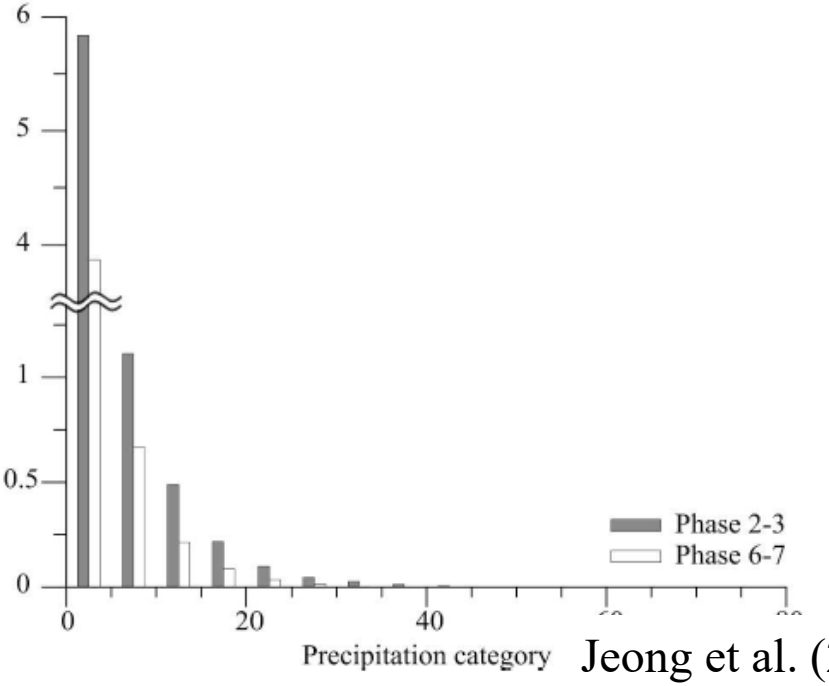


Jeong et al. (2008)



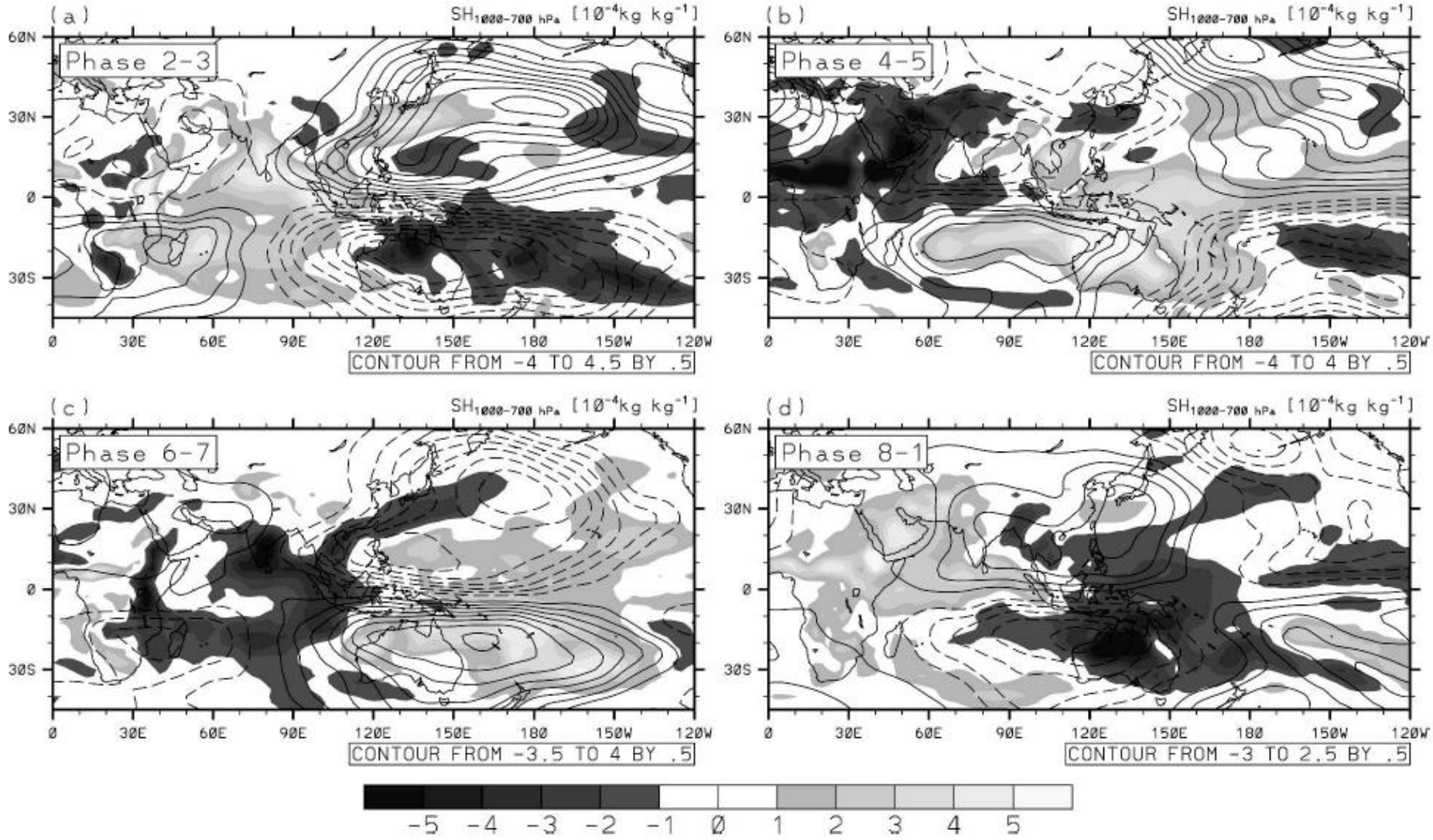






Jeong et al. (2008)

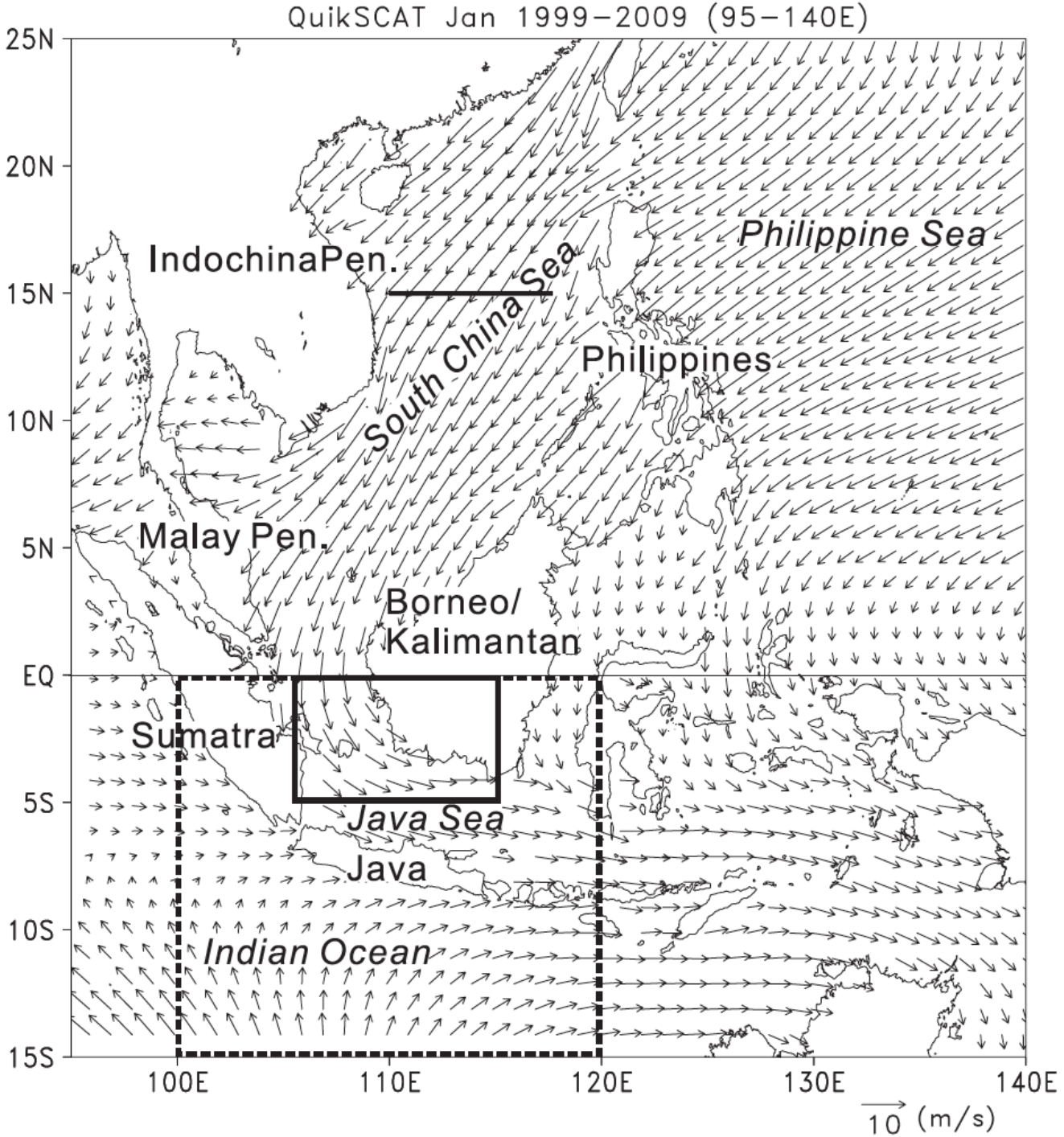
Stream Fuction at 700 hPa

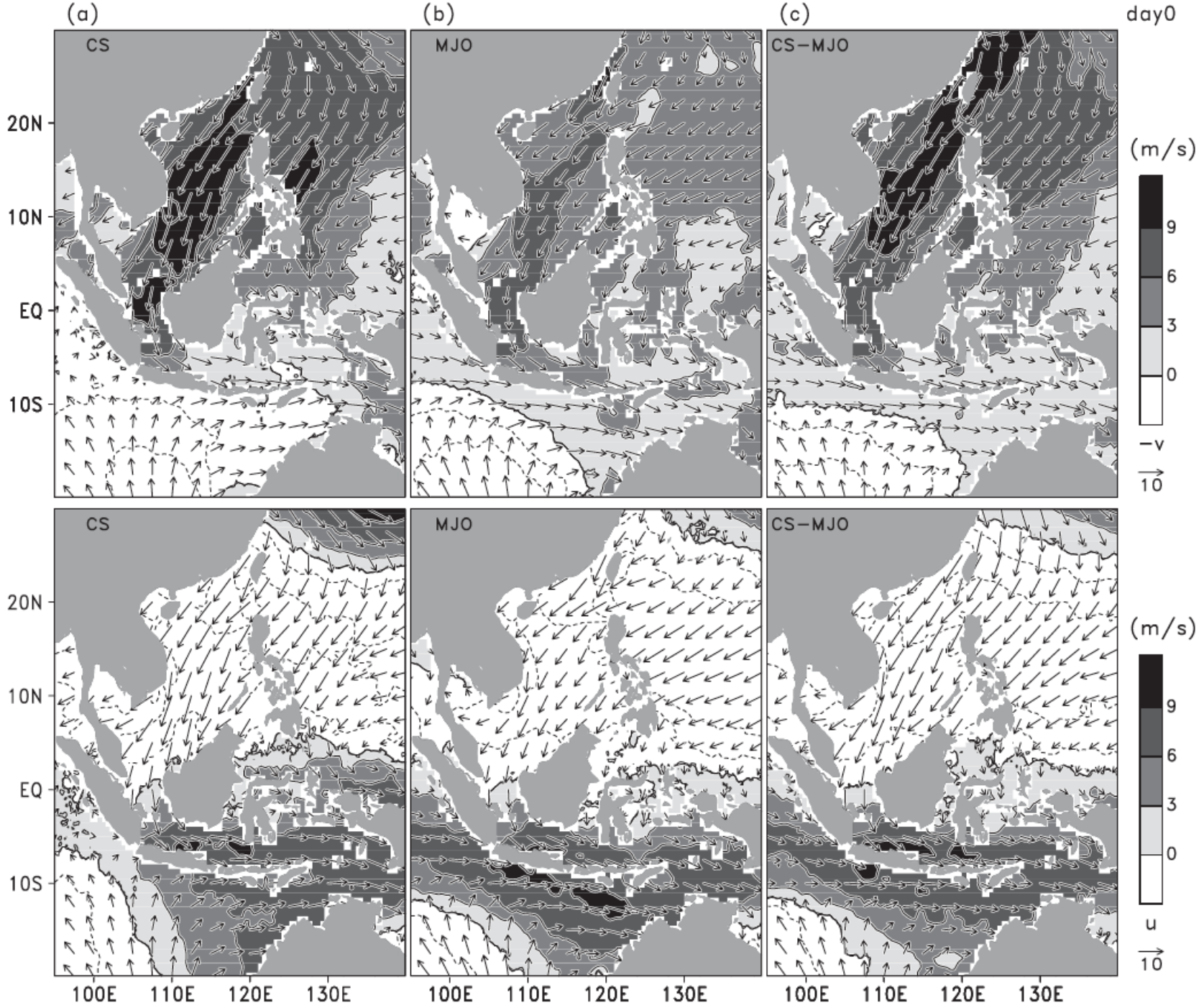


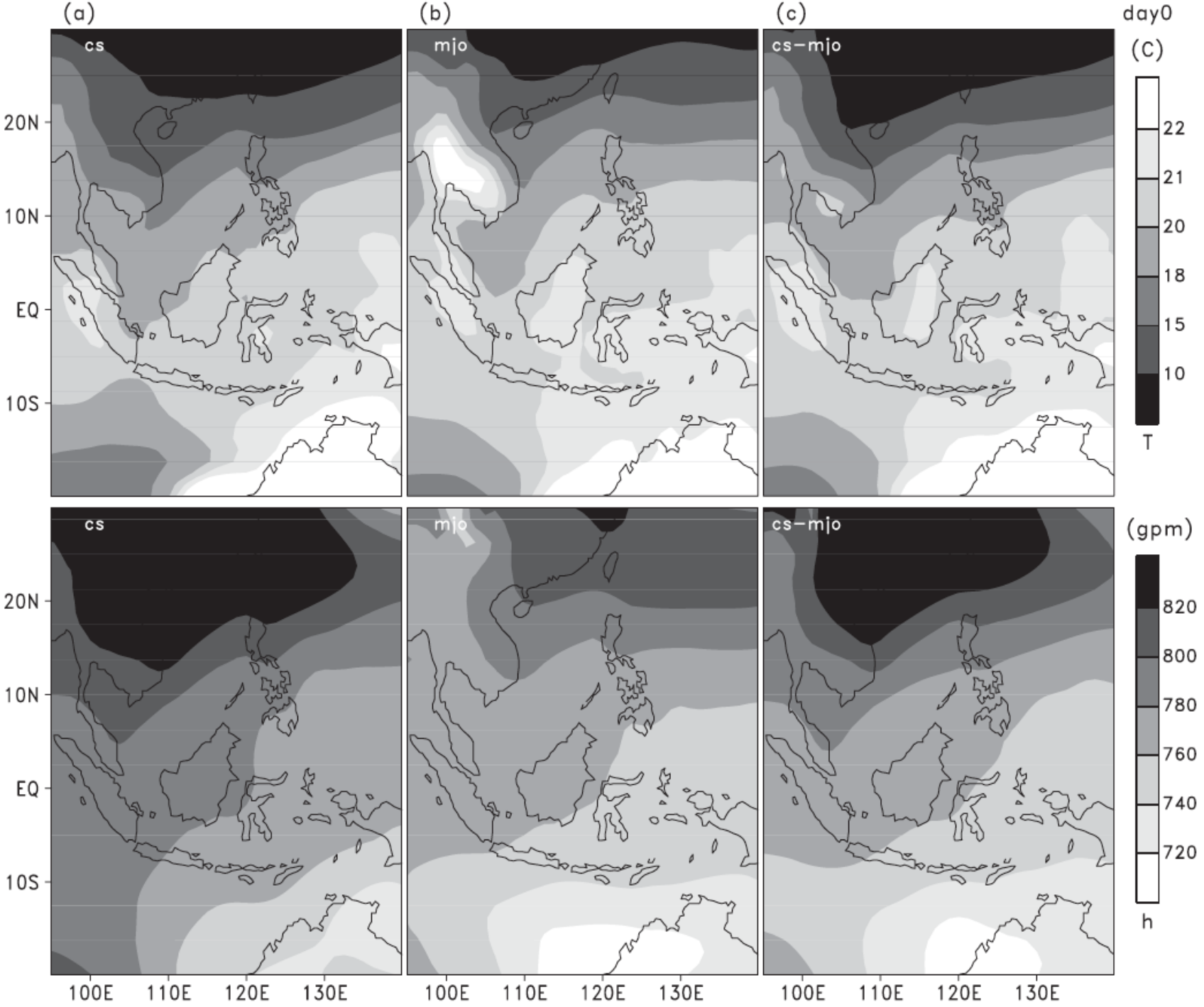
Jeong et al. (2008)

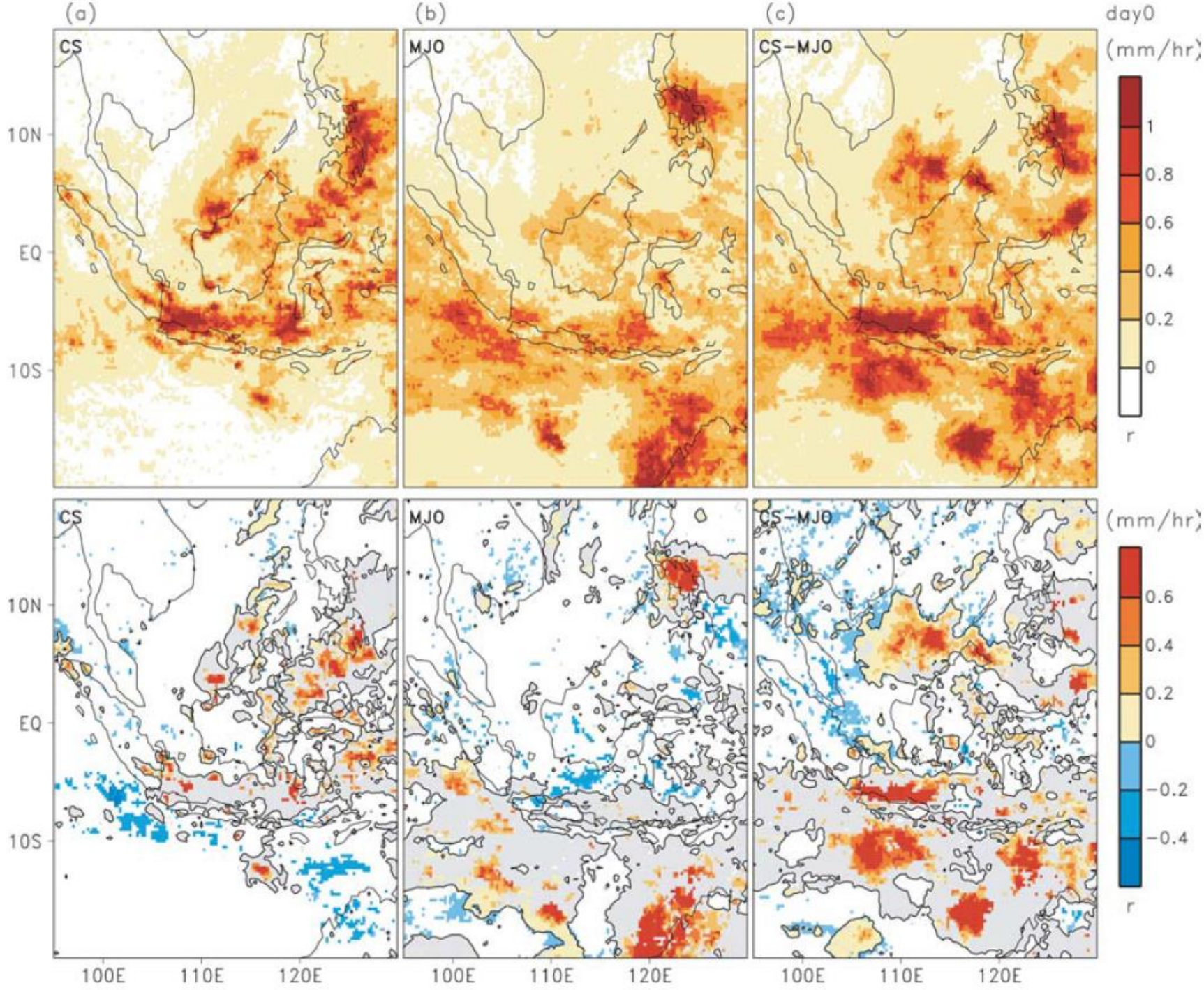
Effects of Cold Surges and the MJO On Rainfall over the Maritime Continent

Chen et al (2011)


QuikSCAT Jan 1999–2009 (95–140E)
25N
20N
15N
10N
5N
EQ
5S
10S
15S
100E
110E
120E
130E
140E
IndochinaPen.
South China Sea
Philippine Sea
Philippines
Malay Pen.
Borneo/
Kalimantan
Sumatra
Java Sea
Java
Indian Ocean
10 (m/s)

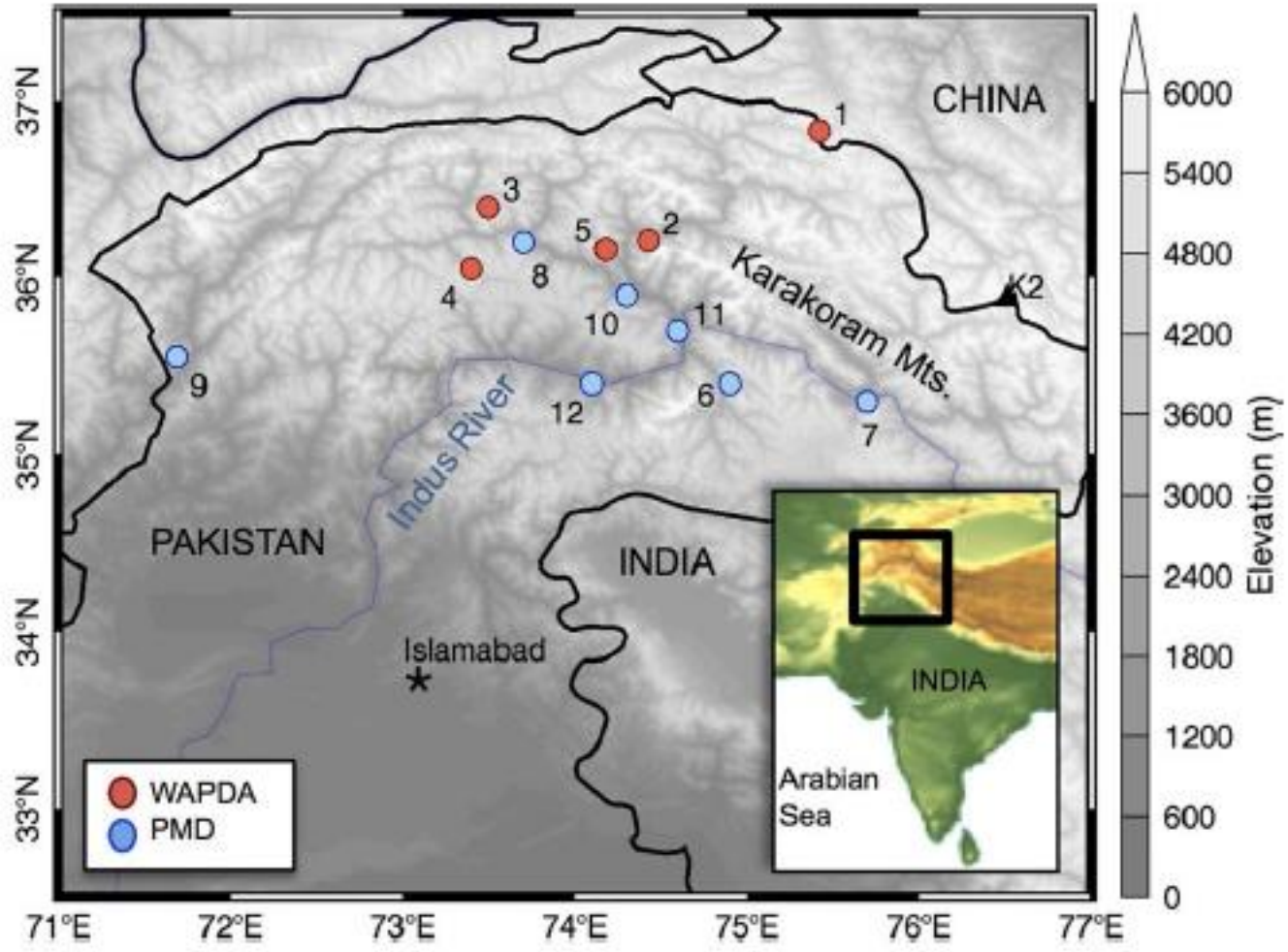

(a)
(b)
(c)
day0
CS
MJO
CS−MJO
20N
10N
EQ
10S
(m/s)
9
6
3
0
−v
10
CS
MJO
CS−MJO
20N
10N
EQ
10S
(m/s)
9
6
3
0
u
10
100E
110E
120E
130E

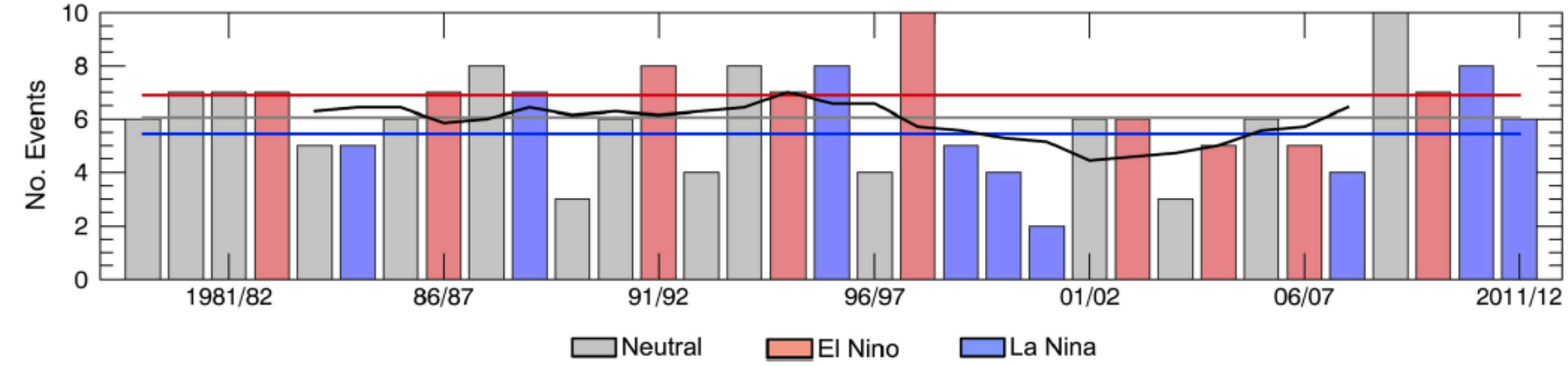

(a)
(b)
(c)
day0
(C)
cs
mjo
cs−mjo
22
21
20
18
15
10
T
20N
10N
EQ
10S
cs
mjo
cs−mjo
(gpm)
820
800
780
760
740
720
h
20N
10N
EQ
10S
100E
110E
120E
130E
100E
110E
120E
130E
100E
110E
120E
130E

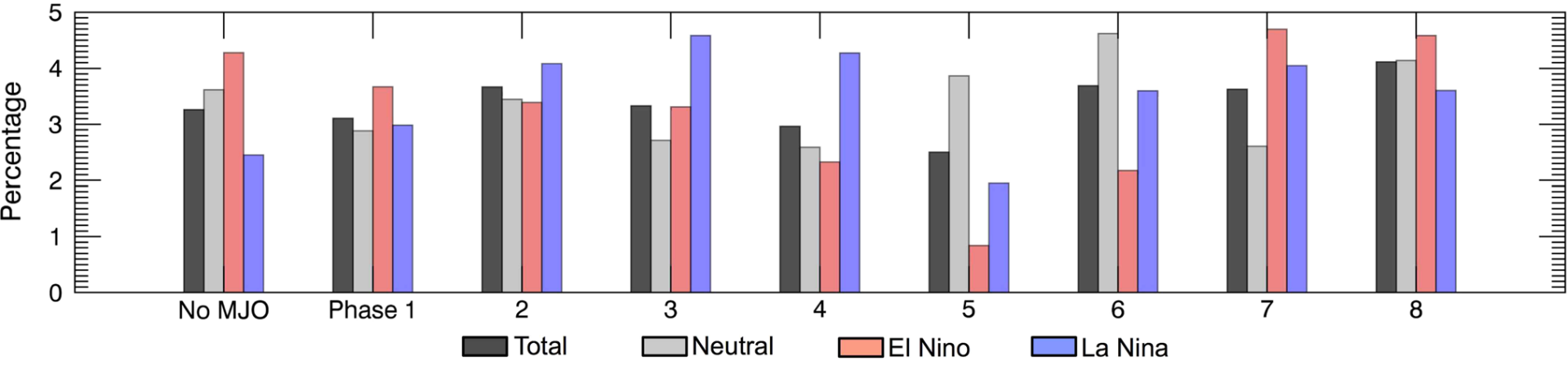

(a)
(b)
(c)
day0
(mm/hr)
CS
MJO
CS−MJO
10N
EQ
10S
1
0.8
0.6
0.4
0.2
0
r
(mm/hr)
CS
MJO
CS−MJO
10N
EQ
10S
0.6
0.4
0.2
0
−0.2
−0.4
r
100E
110E
120E
100E
110E
120E
100E
110E
120E

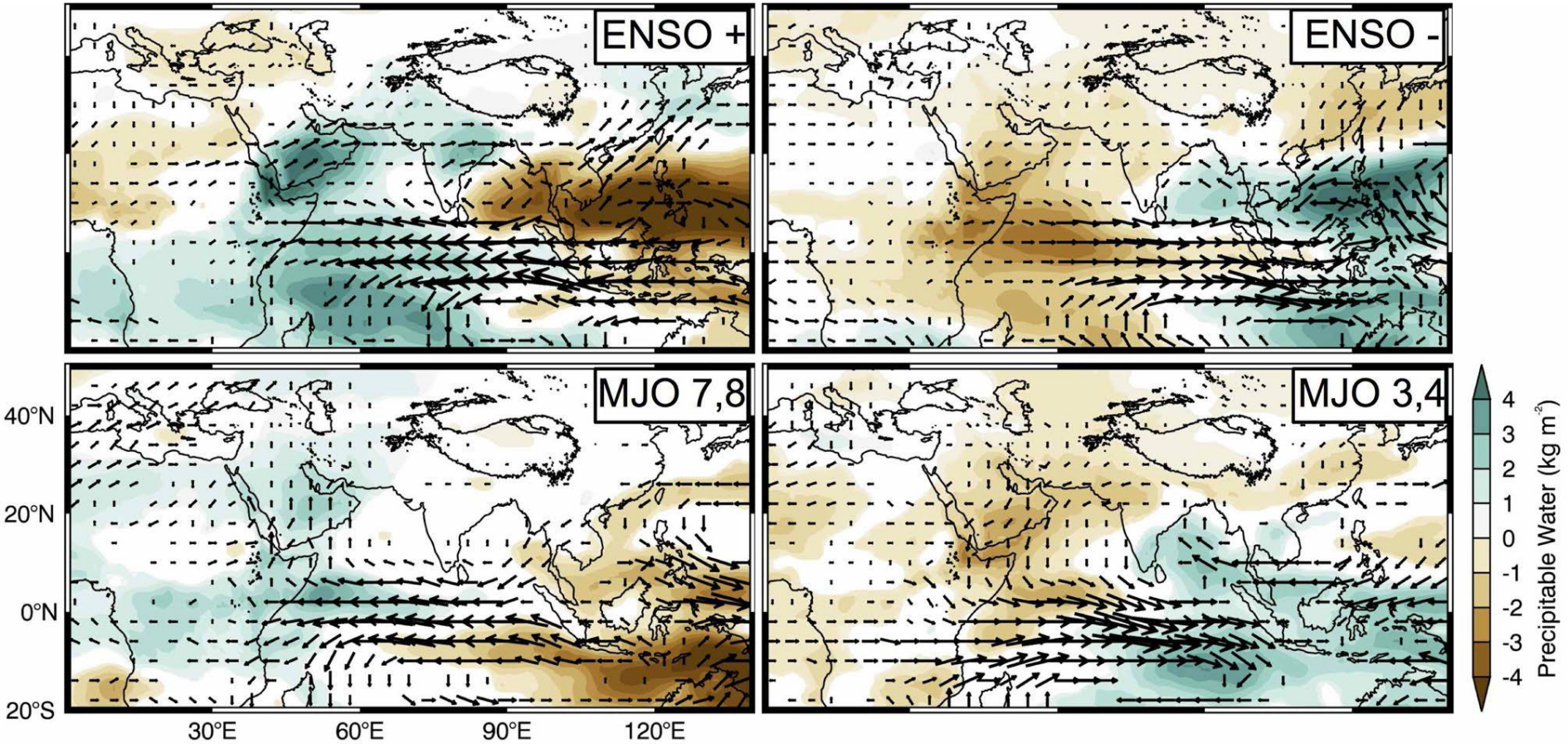
Influence of the MJO and ENSO on extreme winter precipitation in the western Himalaya

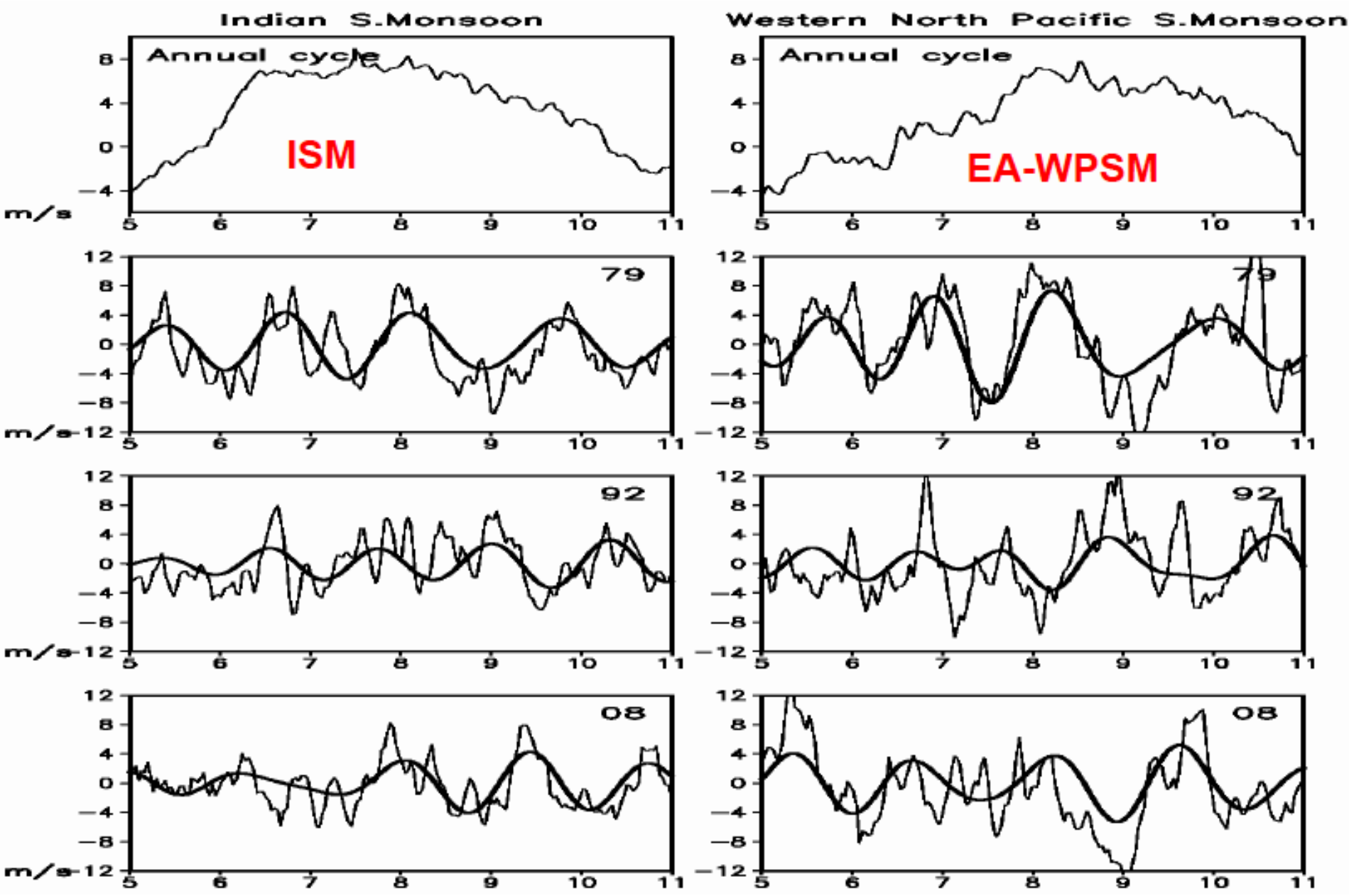
Cannon et al (2016)




No. Events
10
8
6
4
2
0
1981/82
86/87
91/92
96/97
01/02
06/07
2011/12
Neutral
El Nino
La Nina


Percentage
5
4
3
2
1
0
No MJO
Phase 1
2
3
4
5
6
7
8
Total
Neutral
El Nino
La Nina


ENSO +
ENSO -
MJO 7,8
MJO 3,4
40°N
20°N
0°N
20°S
30°E
60°E
90°E
120°E
4
3
2
1
0
-1
-2
-3
-4
Precipitable Water (kg m-2)


Indian S.Monsoon
Western North Pacific S.Monsoon
Annual cycle
Annual cycle
ISM
EA-WPSM
79
79
92
92
08
08
m/s
m/s
m/s
m/s
8
4
0
−4
12
−8
−12
5
6
7
8
9
10
11