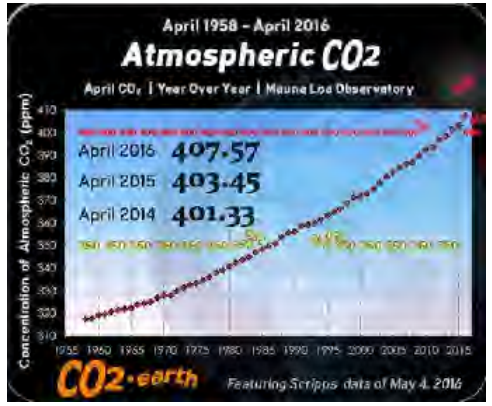
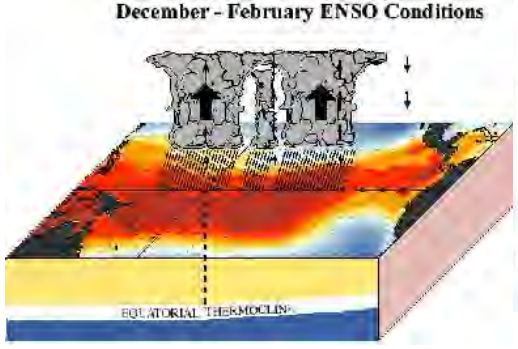
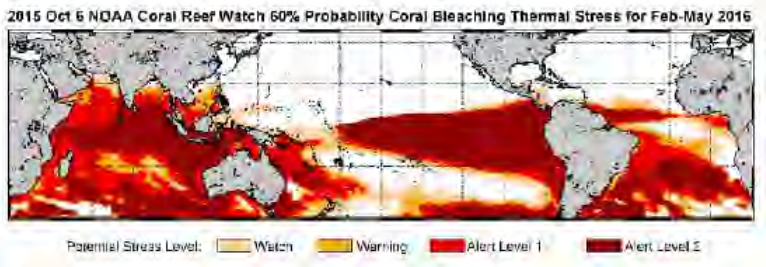
Onset of 2015-2016 El Niño and Other Unique Phenomena

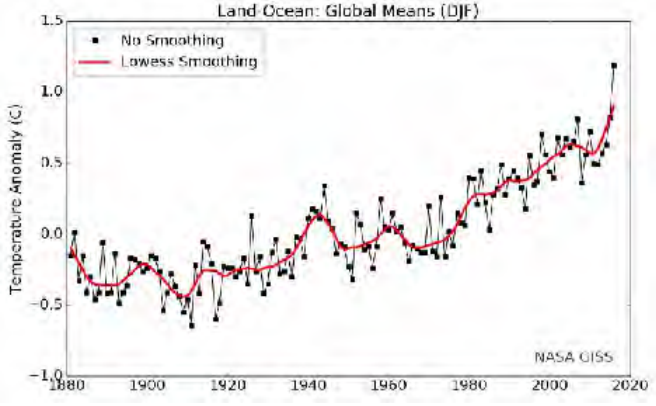
H.-H. Hsu, C.-C. Hong (洪志誠), M.-Y. Lee(李明營)

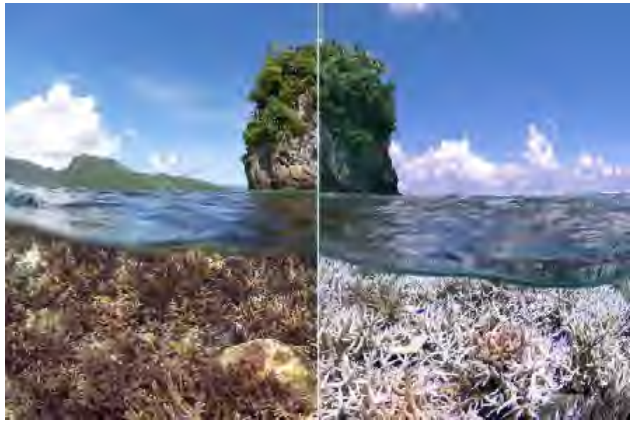
曾琬鈴、曹俊和、邱品峻、梁信謙、徐佩君





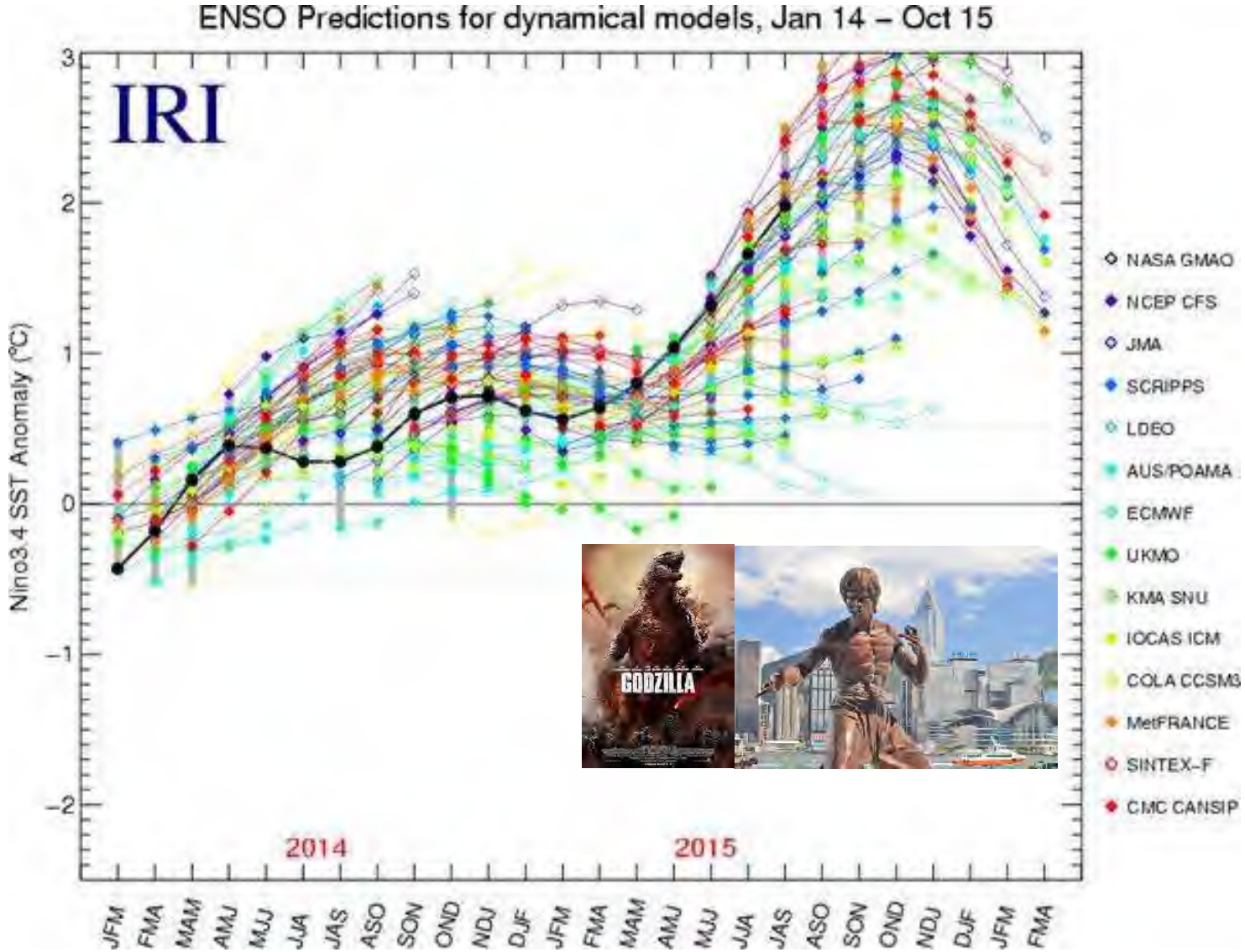




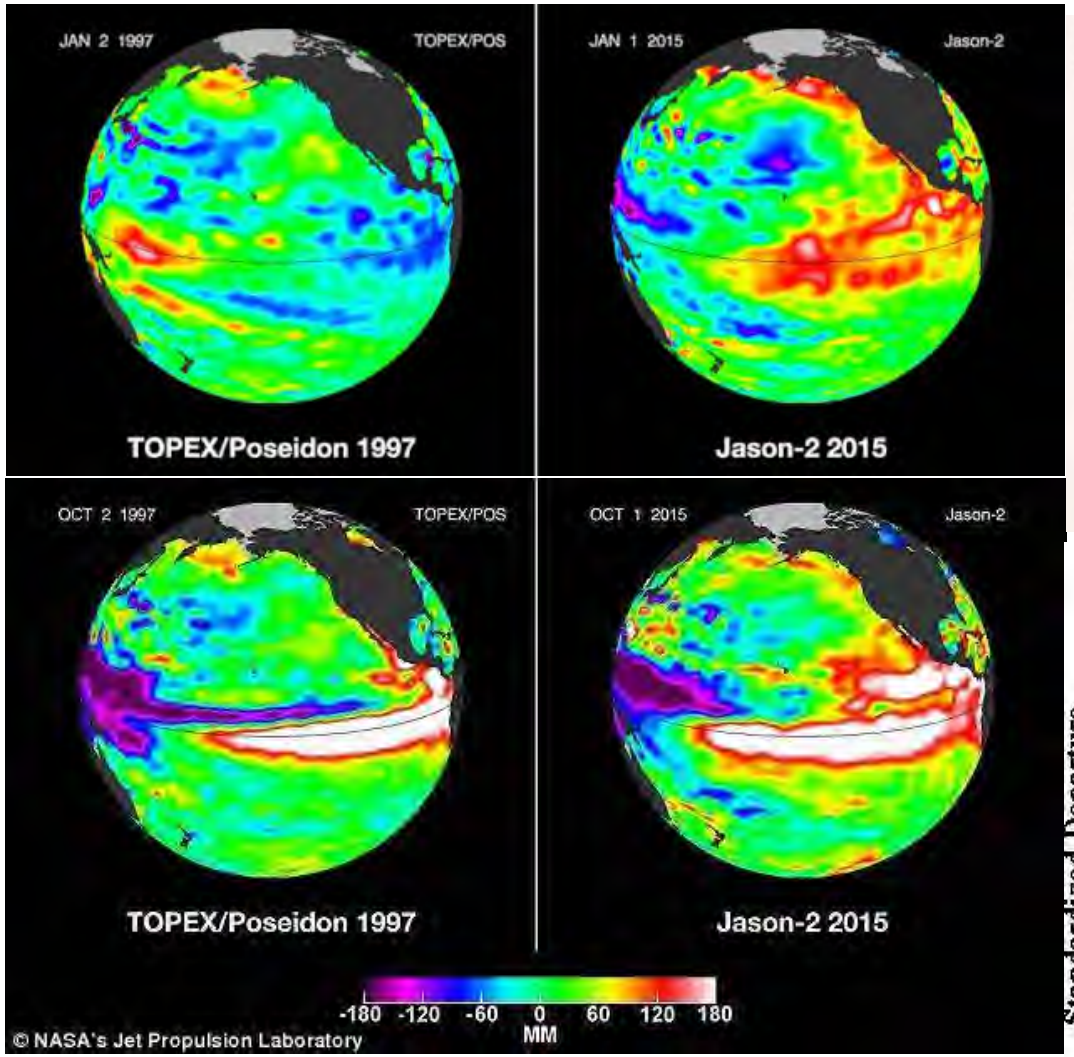


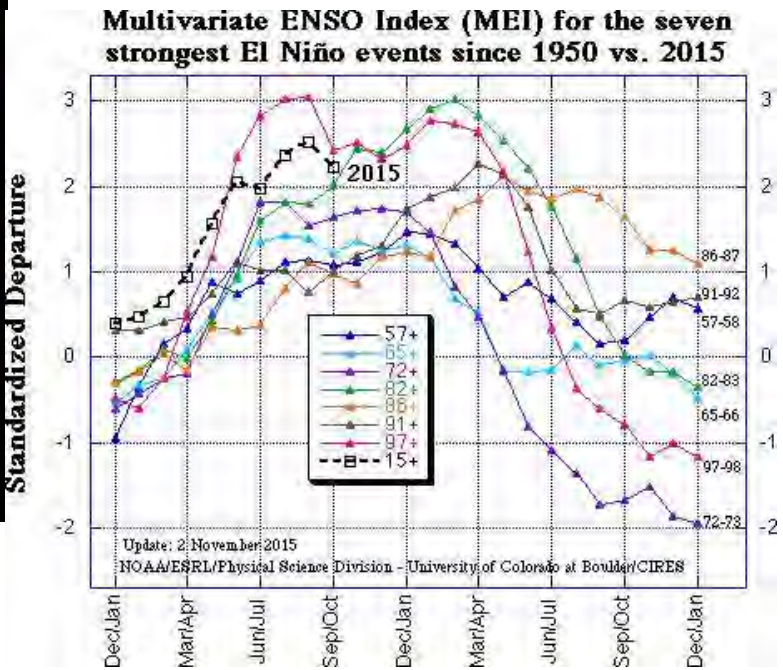
胎死腹中的2014聖嬰
– 慘敗的聖嬰預測!

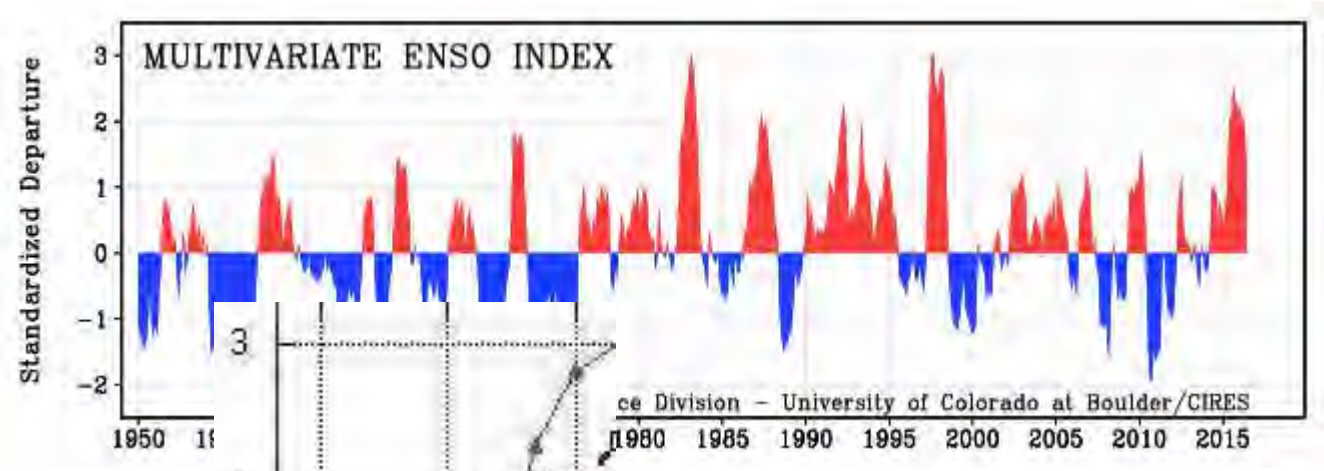
2015超級聖嬰
Bruce Lee; Godzilla

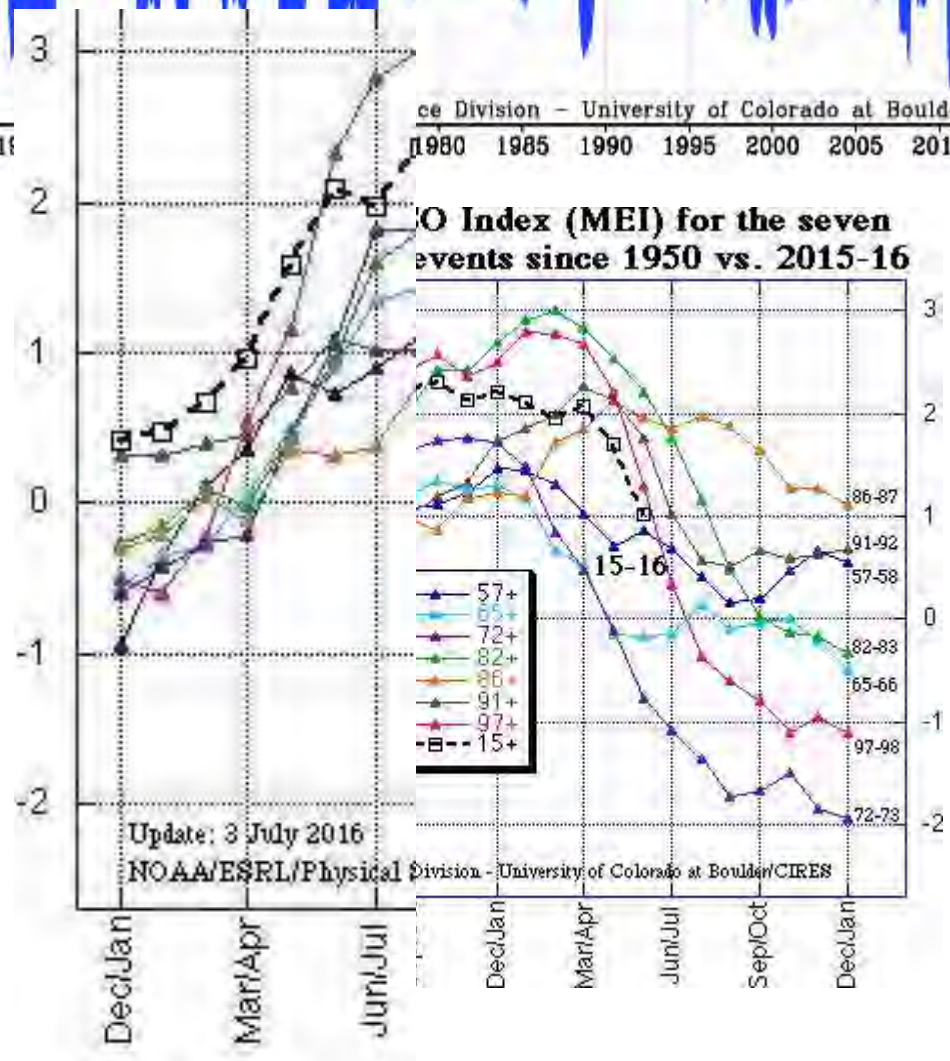


1997聖嬰　vs.　2015聖嬰







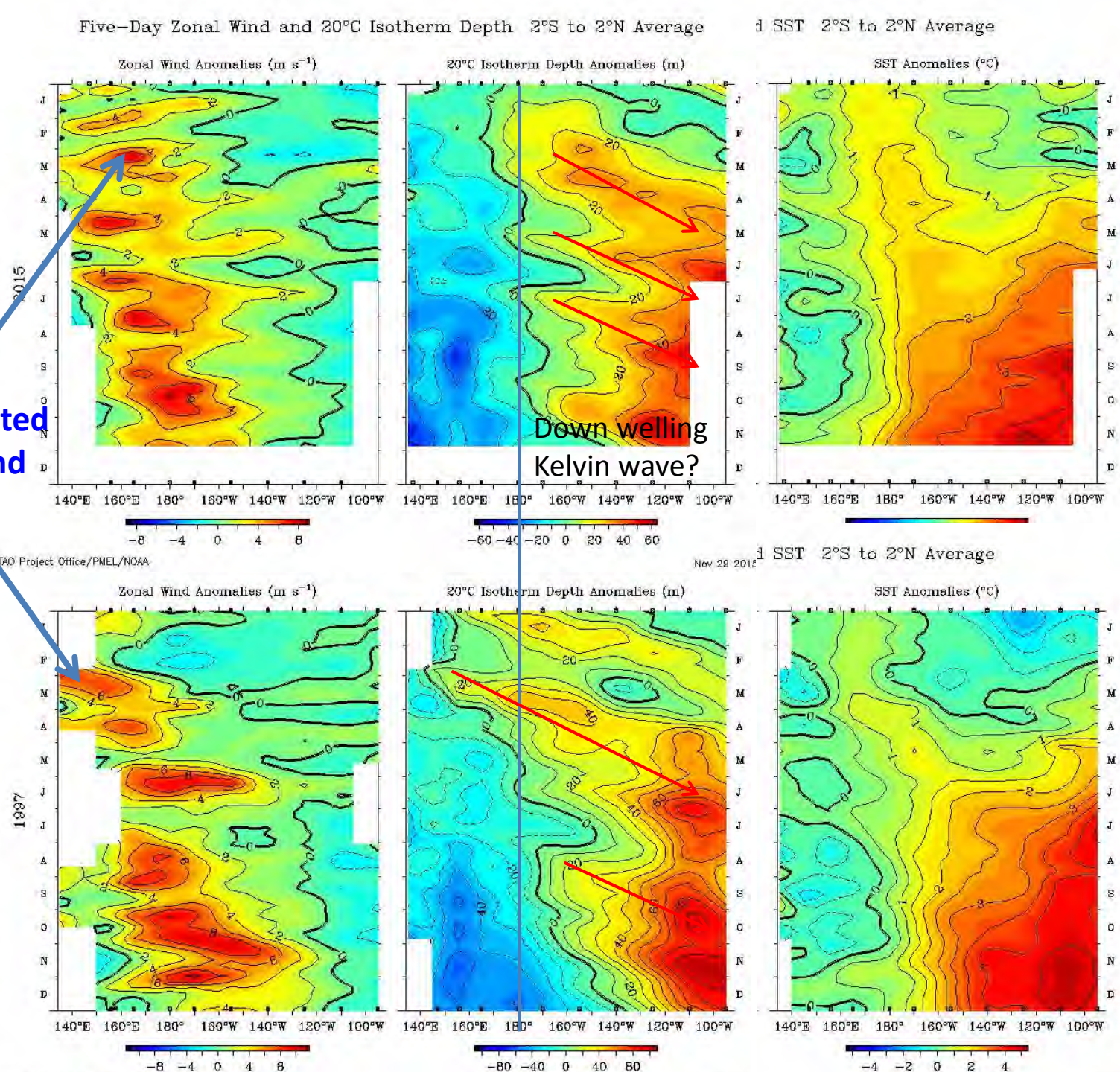


O Index (MEI) for the seven
events since 1950 vs. 2015-16

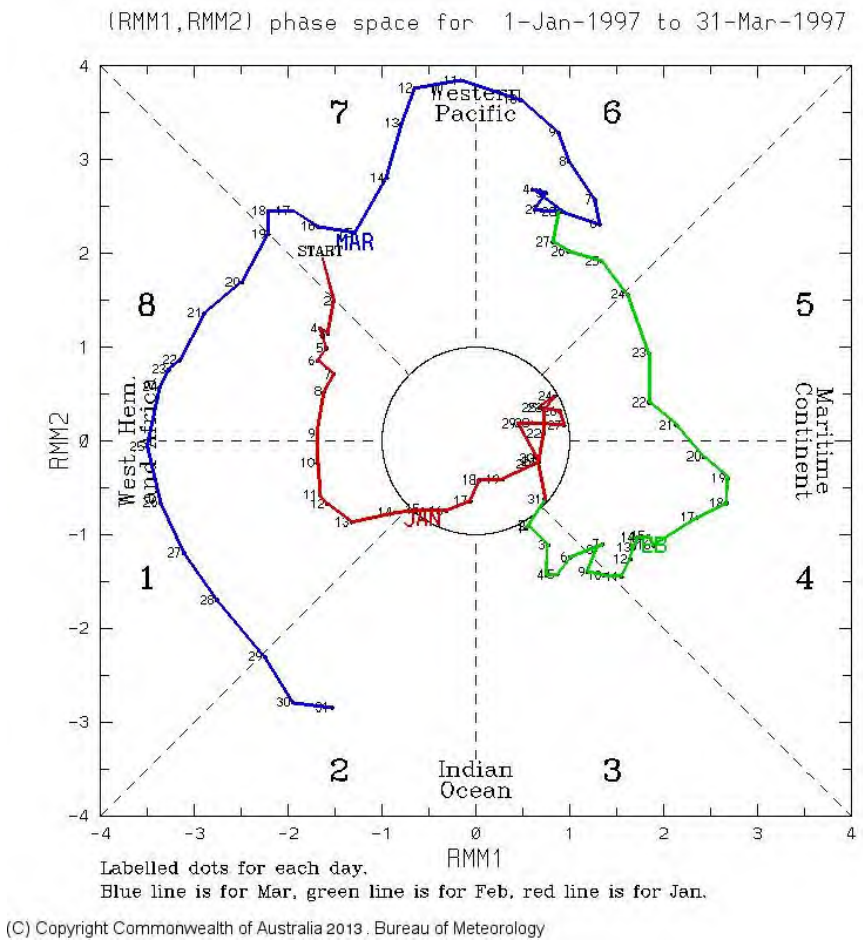
2015

MJO associated westerly wind

1997

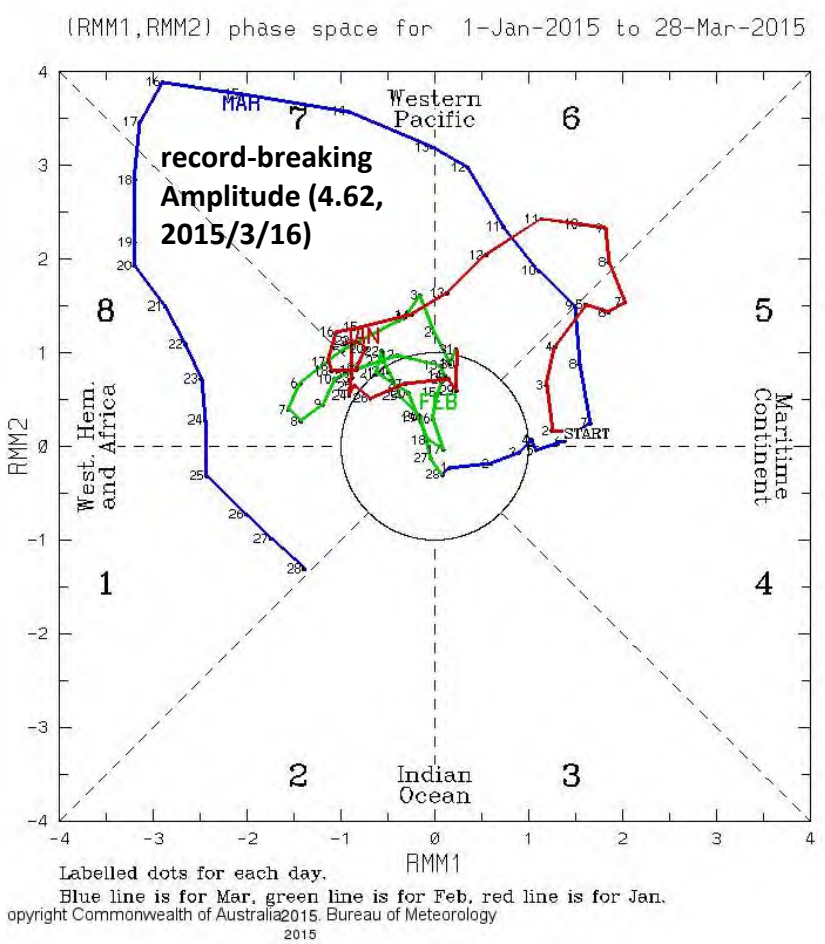


1997

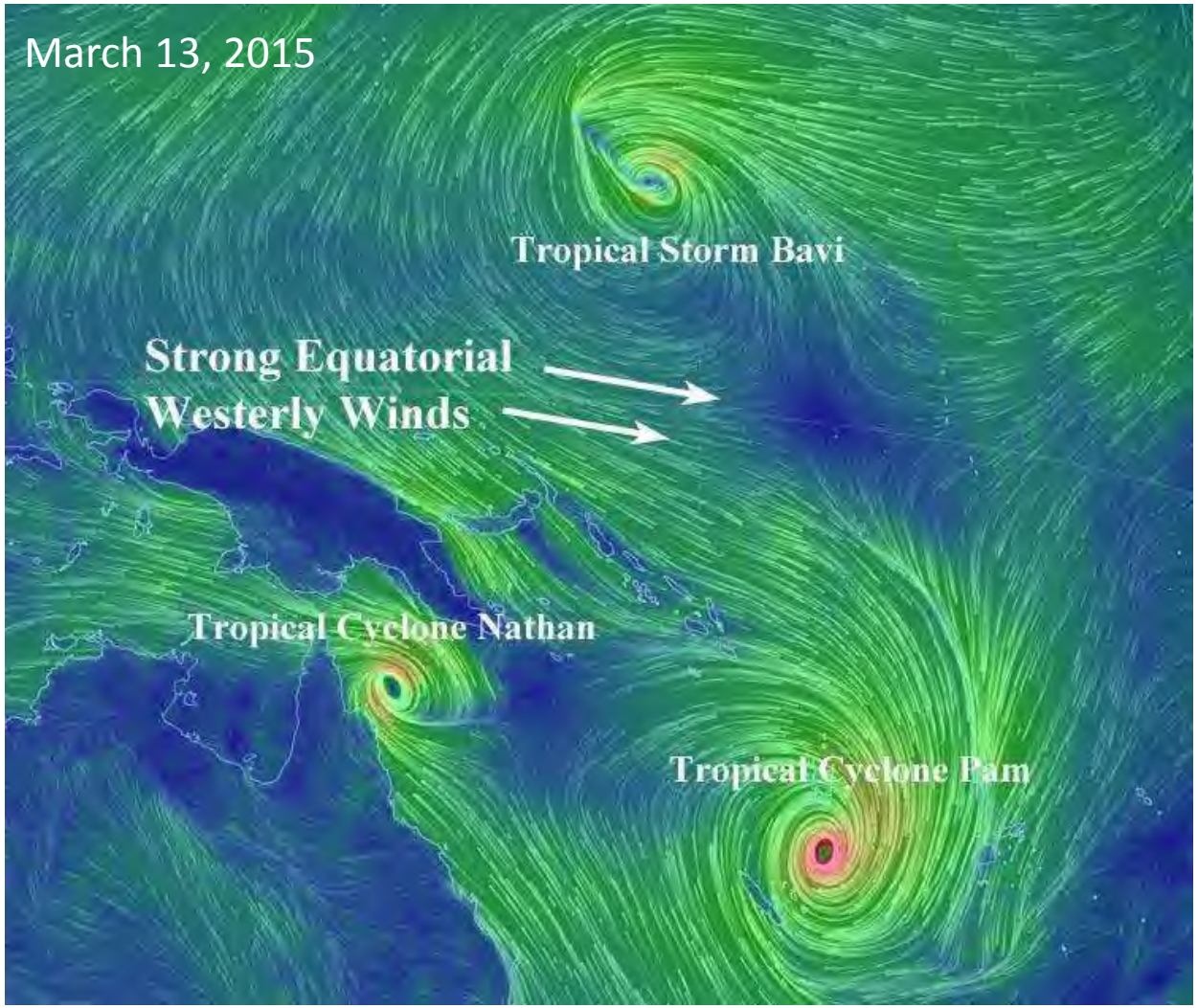


(C) Copyright Commonwealth of Australia 2013 . Bureau of Meteorology

2015

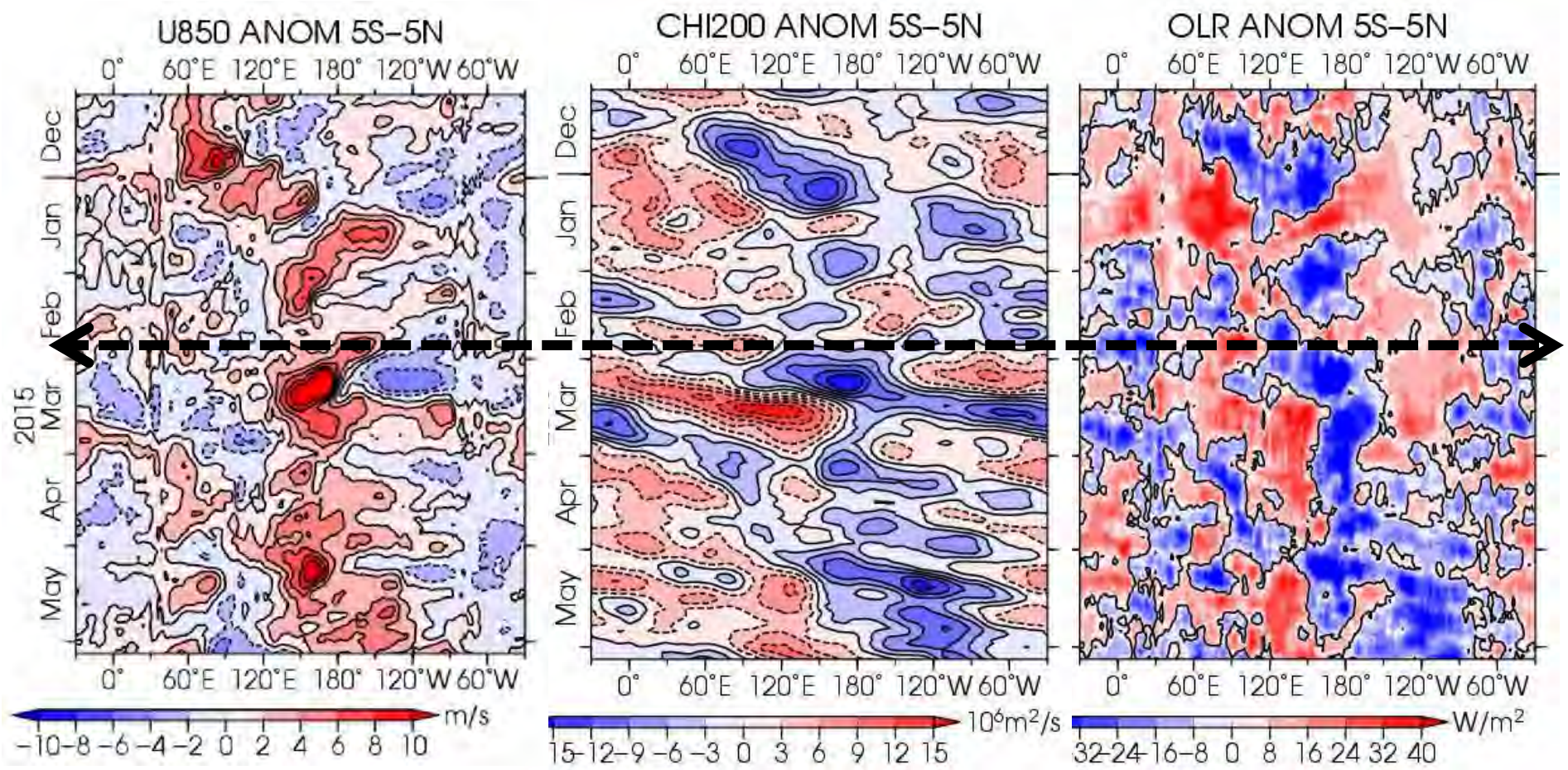


opyright Commonwealth of Australia2015. Bureau of Meteorology
2015



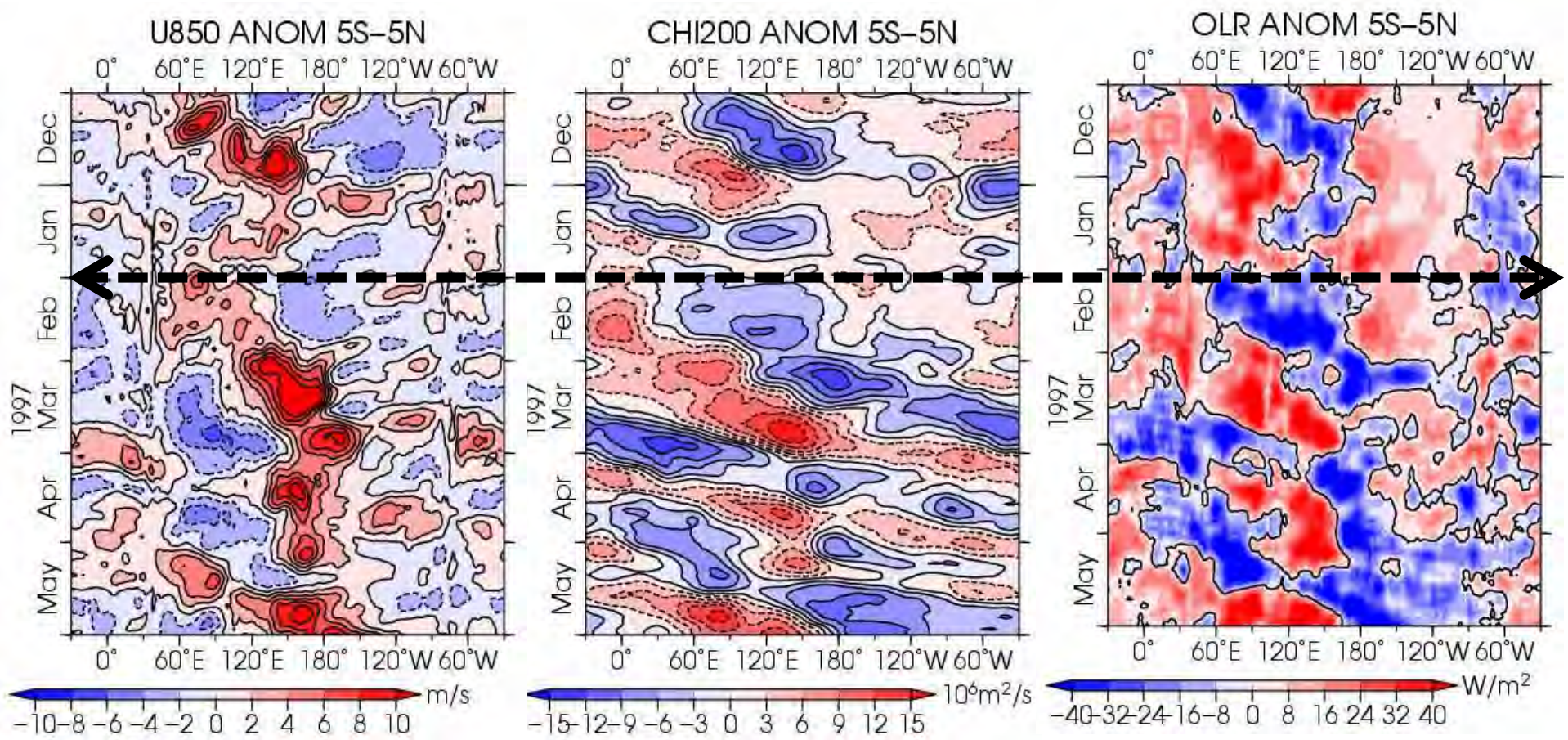
The MJO index hit 4.09 on March 15, 2015, beating the old record of 4.01 set on February 14, 1985. March 16, 2015, the MJO index set an even higher mark--4.67.

- MJO onset in early March near the Maritime Continent
- Convection and westerly prevailed in the Central/E. Pacific 2015

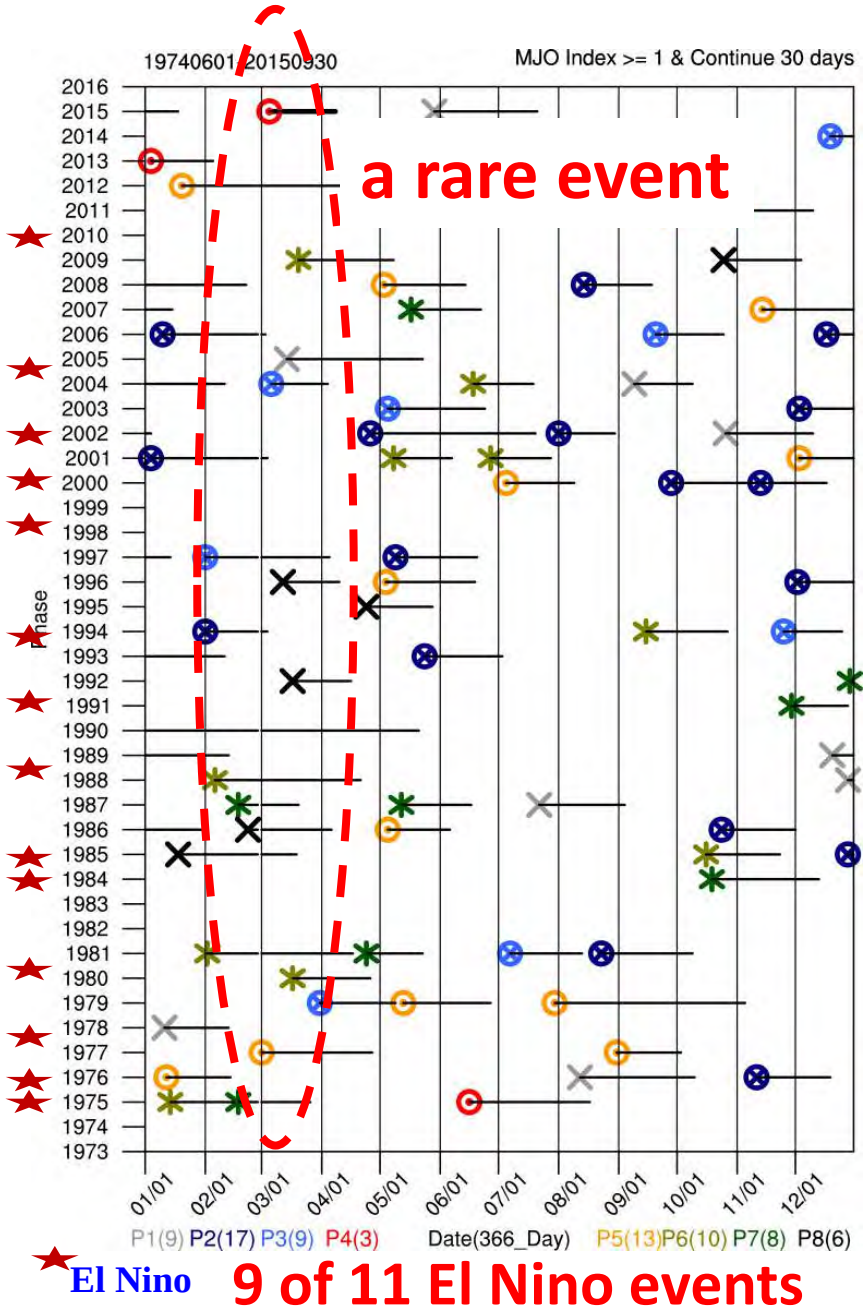


- MJO onset in early February in the Indian Ocean and propagated to the western Pacific
- Convection and westerly prevailed in the Central/E. Pacific

1997



Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ
1974	-1.7	-1.5	-1.2	-1.0	-0.9	-0.8	-0.6	-0.4	-0.4	-0.6	-0.7	-0.6
1975	-0.5	-0.5	-0.6	-0.6	-0.7	-0.8	-1.0	-1.1	-1.3	-1.4	-1.5	-1.6
1976	-1.5	-1.1	-0.7	-0.4	-0.3	-0.1	0.1	0.3	0.5	0.7	0.8	0.8
1977	0.7	0.6	0.4	0.3	0.3	0.4	0.4	0.4	0.5	0.6	0.8	0.8
1978	0.7	0.4	0.1	-0.2	-0.3	-0.3	-0.4	-0.4	-0.4	-0.3	-0.1	0
1979	0	0.1	0.2	0.3	0.3	0.1	0.1	0.2	0.3	0.5	0.5	0.6
1980	0.6	0.5	0.3	0.4	0.5	0.5	0.3	0.2	0	0.1	0.1	0
1981	-0.2	-0.4	-0.4	-0.3	-0.2	-0.3	-0.3	-0.3	-0.2	-0.1	-0.1	0
1982	0	0.1	0.2	0.5	0.6	0.7	0.8	1.0	1.5	1.9	2.1	2.1
1983	2.1	1.8	1.5	1.2	1.0	0.7	0.3	0	-0.3	-0.6	-0.8	-0.8
1984	-0.5	-0.3	-0.3	-0.4	-0.4	-0.4	-0.3	-0.2	-0.3	-0.6	-0.9	-1.1
1985	-0.9	-0.7	-0.7	-0.7	-0.7	-0.6	-0.4	-0.4	-0.4	-0.3	-0.2	-0.3
1986	-0.4	-0.4	-0.3	-0.2	-0.1	0	0.2	0.4	0.7	0.9	1.0	1.1
1987	1.1	1.2	1.1	1.0	0.9	1.1	1.4	1.6	1.6	1.4	1.2	1.1
1988	0.8	0.5	0.1	-0.3	-0.8	-1.2	-1.2	-1.1	-1.2	-1.4	-1.7	-1.8
1989	-1.6	-1.4	-1.1	-0.9	-0.6	-0.4	-0.3	-0.3	-0.3	-0.3	-0.2	-0.1
1990	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.3	0.4	0.4
1991	0.4	0.3	0.2	0.2	0.4	0.6	0.7	0.7	0.7	0.8	1.2	1.4
1992	1.6	1.5	1.4	1.2	1.0	0.8	0.5	0.2	0	-0.1	-0.1	0
1993	0.2	0.3	0.5	0.7	0.8	0.6	0.3	0.2	0.2	0.2	0.1	0.1
1994	0.1	0.1	0.2	0.3	0.4	0.4	0.4	0.4	0.4	0.6	0.9	1.0
1995	0.9	0.7	0.5	0.3	0.2	0	-0.2	-0.5	-0.7	-0.9	-1.0	-0.9
1996	-0.9	-0.7	-0.6	-0.4	-0.2	-0.2	-0.2	-0.3	-0.3	-0.4	-0.4	-0.5
1997	-0.5	-0.4	-0.2	0.1	0.6	1.0	1.4	1.7	2.0	2.2	2.3	2.3
1998	2.1	1.8	1.4	1.0	0.5	-0.1	-0.7	-1.0	-1.2	-1.2	-1.3	-1.4
1999	-1.4	-1.2	-1.0	-0.9	-0.9	-1.0	-1.0	-1.0	-1.1	-1.2	-1.4	-1.6
2000	-1.6	-1.4	-1.1	-0.9	-0.7	-0.7	-0.6	-0.5	-0.6	-0.7	-0.8	-0.8
2001	-0.7	-0.6	-0.5	-0.3	-0.2	-0.1	0	-0.1	-0.1	-0.2	-0.3	-0.3
2002	-0.2	-0.1	0.1	0.2	0.4	0.7	0.8	0.9	1.0	1.2	1.3	1.1
2003	0.9	0.6	0.4	0	-0.2	-0.1	0.1	0.2	0.3	0.4	0.4	0.4
2004	0.3	0.2	0.1	0.1	0.2	0.3	0.5	0.7	0.7	0.7	0.7	0.7
2005	0.6	0.6	0.5	0.5	0.4	0.2	0.1	0	0	-0.1	-0.4	-0.7
2006	-0.7	-0.6	-0.4	-0.2	0.0	0.1	0.2	0.3	0.5	0.8	0.9	1.0
2007	0.7	0.3	0	-0.1	-0.2	-0.2	-0.3	-0.6	-0.8	-1.1	-1.2	-1.3
2008	-1.4	-1.3	-1.1	-0.9	-0.7	-0.5	-0.3	-0.2	-0.2	-0.3	-0.5	-0.7
2009	-0.8	-0.7	-0.4	-0.1	0.2	0.4	0.5	0.6	0.7	1.0	1.2	1.3
2010	1.3	1.1	0.8	0.5	0	-0.4	-0.8	-1.1	-1.3	-1.4	-1.3	-1.4
2011	-1.3	-1.1	-0.8	-0.6	-0.3	-0.2	-0.3	-0.5	-0.7	-0.9	-0.9	-0.8
2012	-0.7	-0.6	-0.5	-0.4	-0.3	-0.1	0.1	0.3	0.4	0.4	0.2	-0.2
2013	-0.4	-0.5	-0.3	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3
2014	-0.5	-0.6	-0.4	-0.2	0	0	0	0	0.2	0.4	0.6	0.6
2015	0.5	0.4	0.5	0.7	0.9	1.0	1.2	1.5	1.8	2.0	2.3	

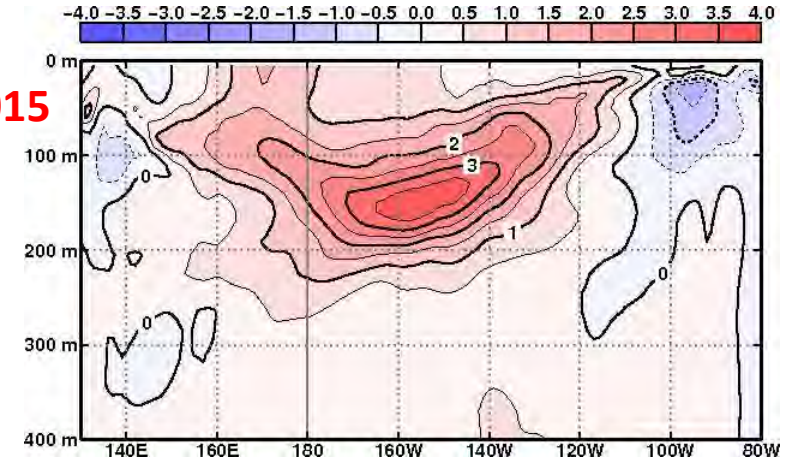


9 of 11 El Nino events followed by MJO

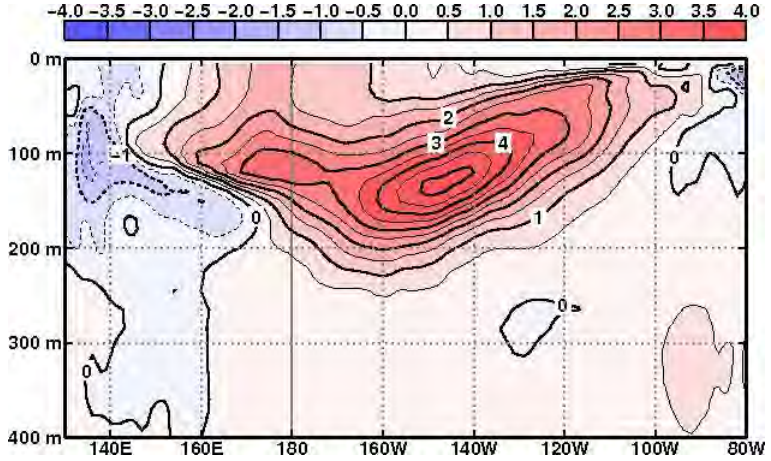
http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml

MJO triggered El Niño onset ?

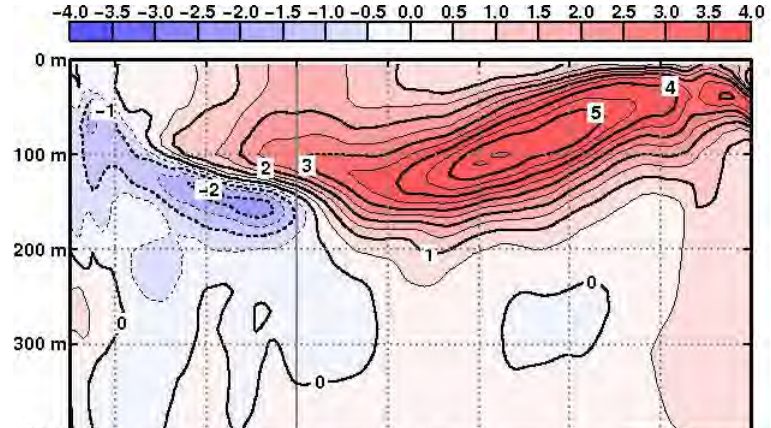
2015



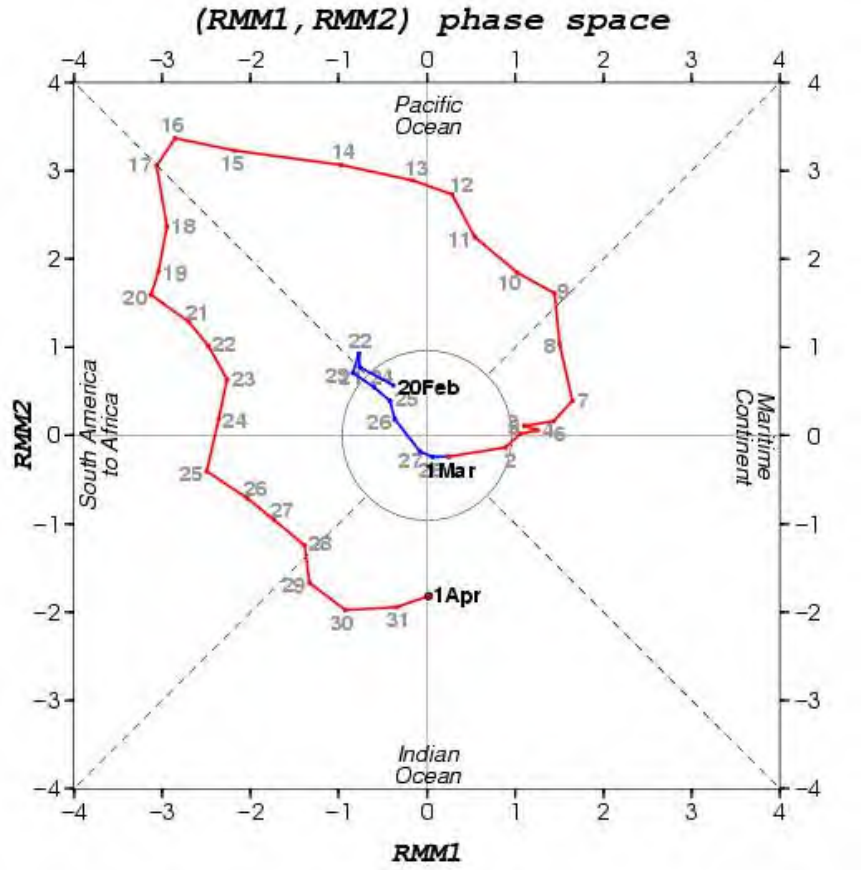
FEB



MAR



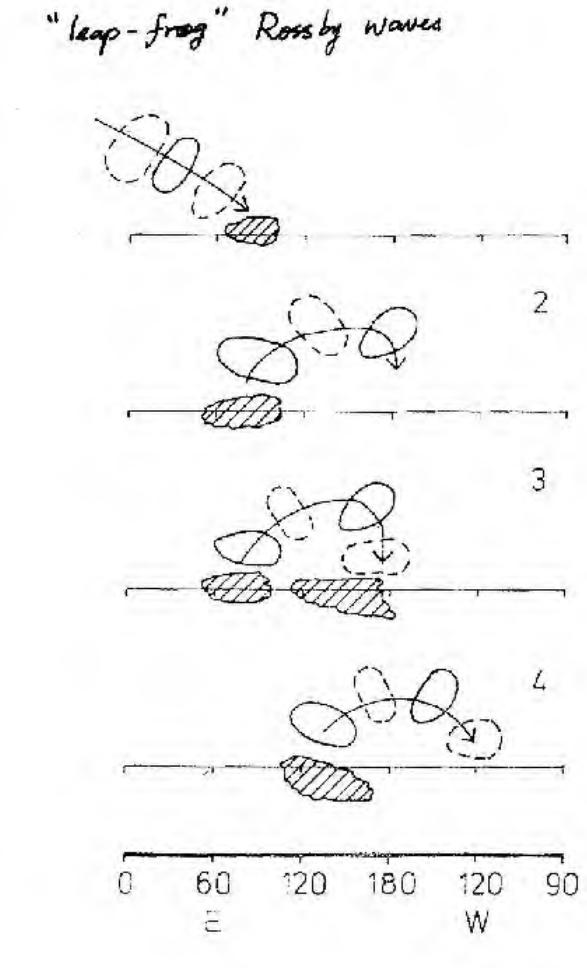
Apr



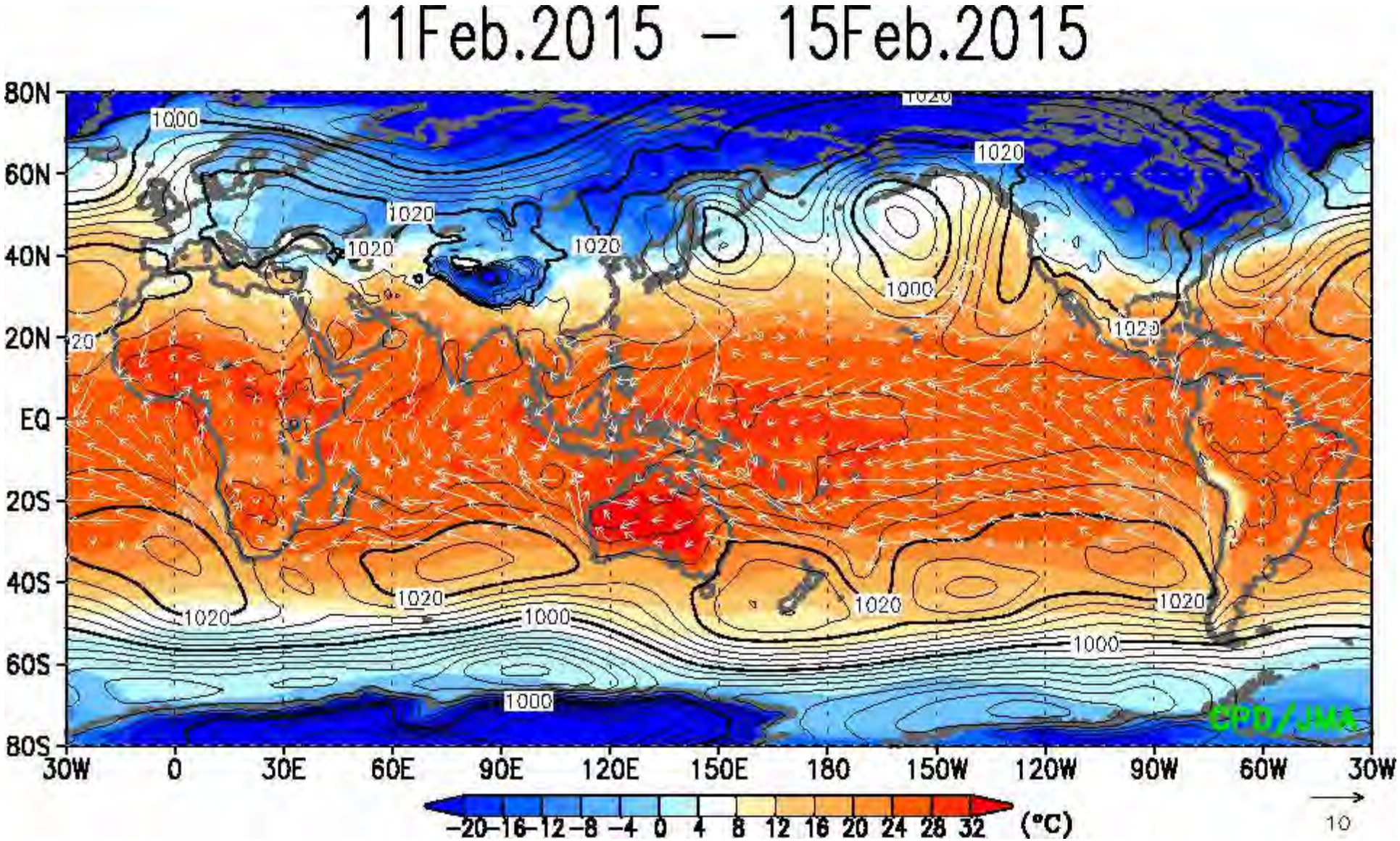
The MJO developed quickly to an extreme amplitude in middle March because of the favorable oceanic condition, a warm SST in the central-eastern Pacific remaining from the aborted 2014 El Nino

What triggered MJO?

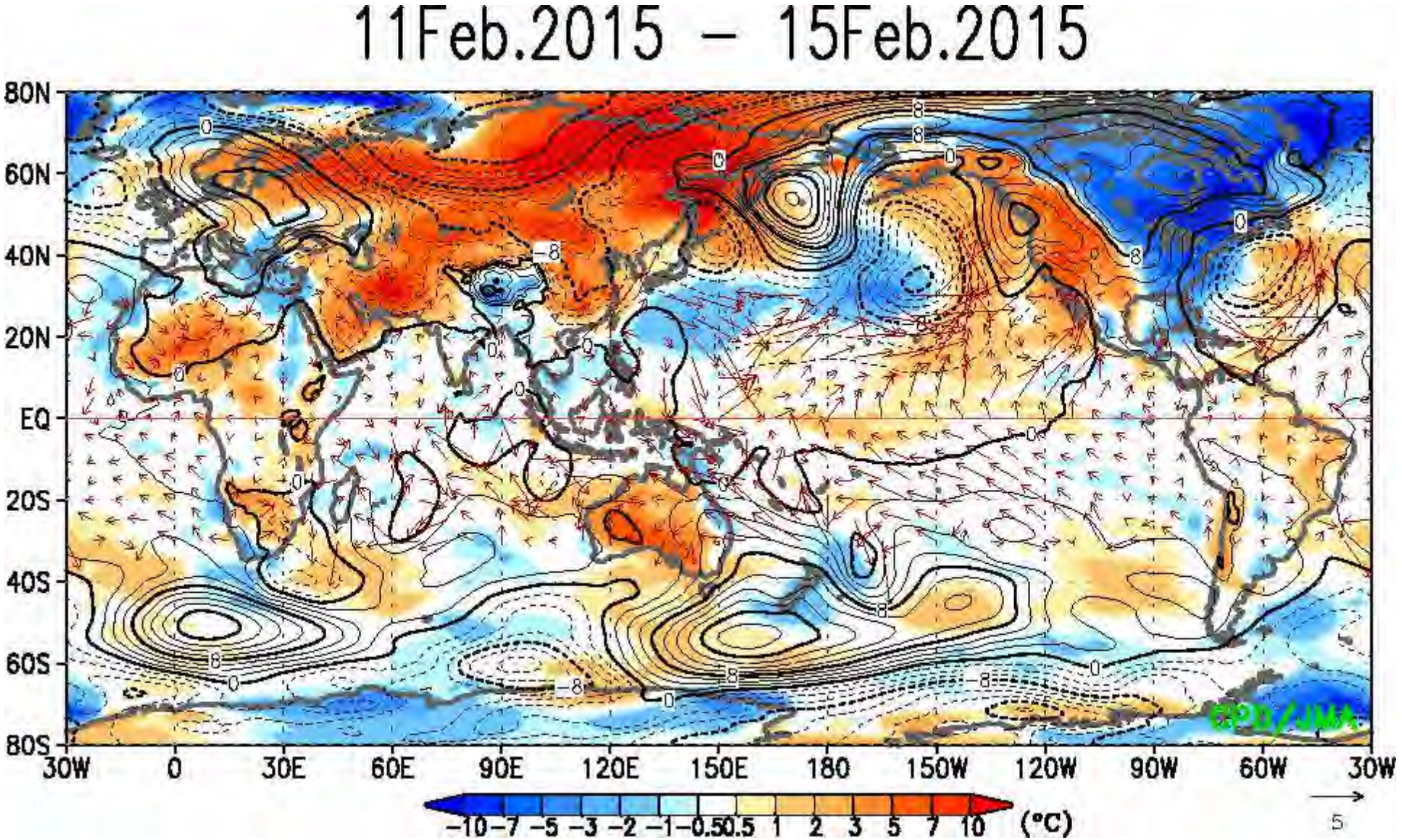
Extratropical forcing?



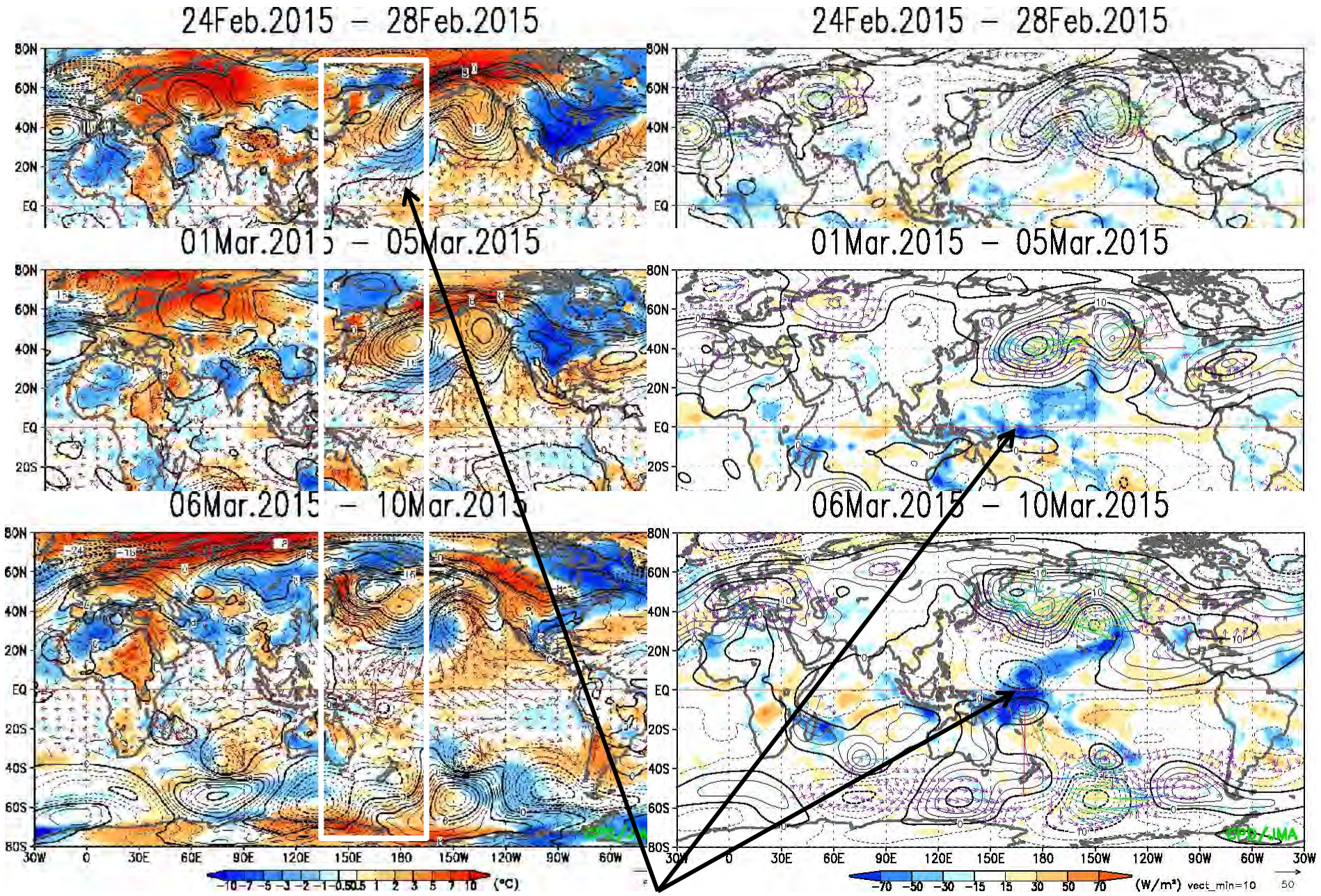
Hsu et al. 1990, JAS



The shading indicates 2-m temperatures (˚C). The contours show sea level pressure at intervals of 4 hPa. The vectors denote 10-m wind (m/s) in the tropical region (30˚N-30˚S).

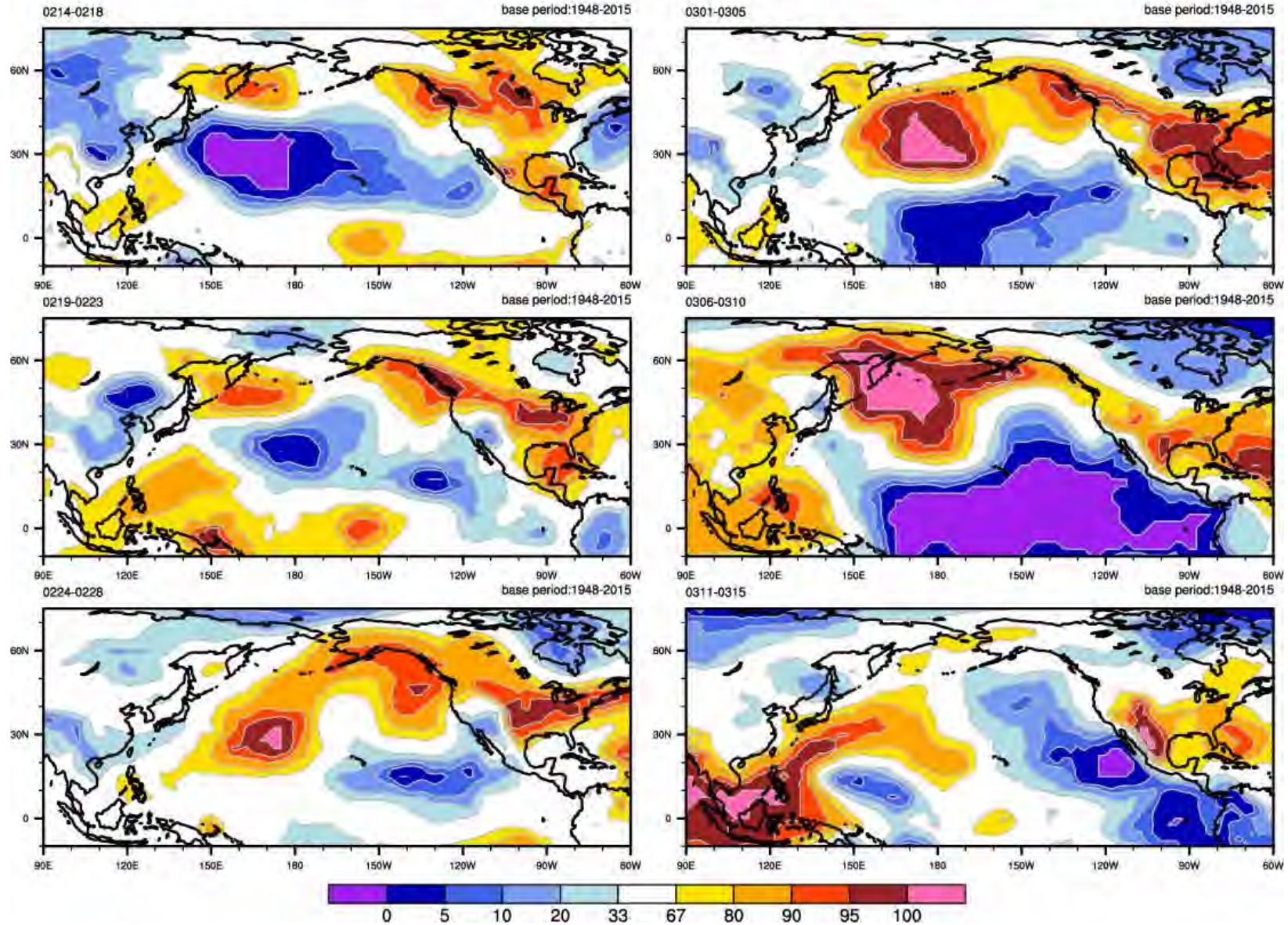


The shading indicates 2-m temperature anomalies (˚C). The contours show normal sea level pressure anomalies at intervals of 2 hPa (1-hPa for 30-day mean). The vectors denote 10-m wind anomalies (m/s) in the tropical region (30˚N-30˚S).



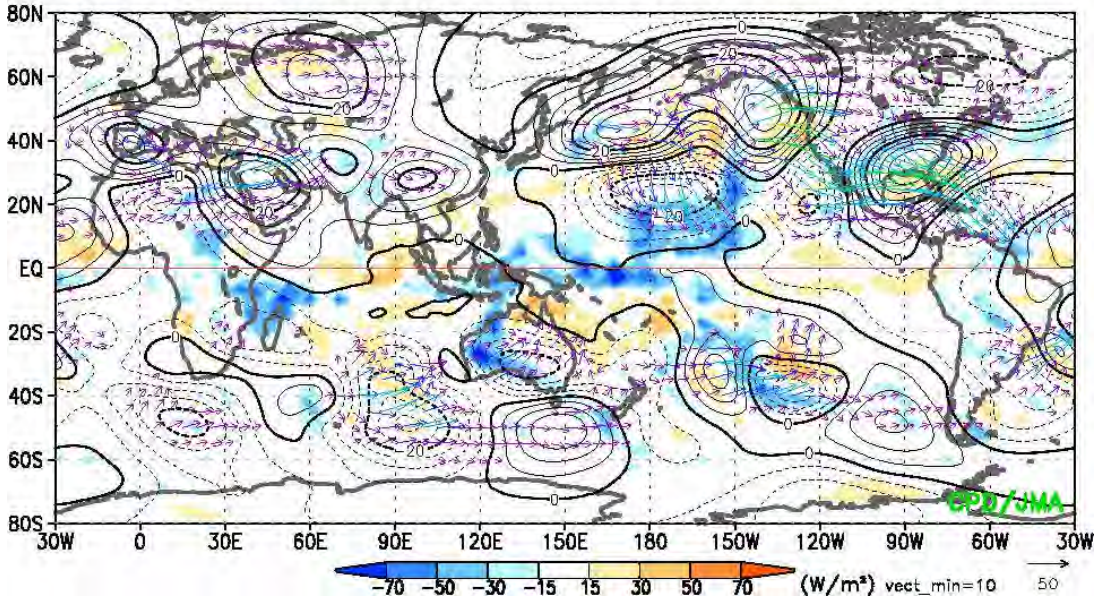
North Pacific blocking associated northerly wind penetrated dry and cold air southward over warm and moist ocean that triggers the convective instability and MJO initiation

Percentile of MSLP for Mid-Feb to Mid-Mar in 2015

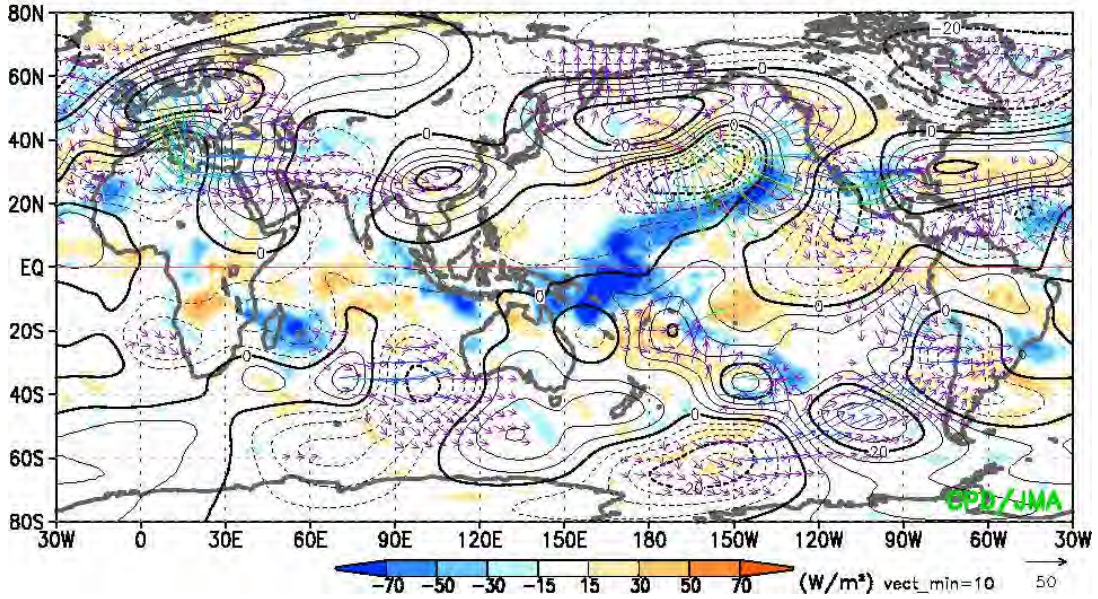


200 hPa

01Mar.2015 – 05Mar.2015

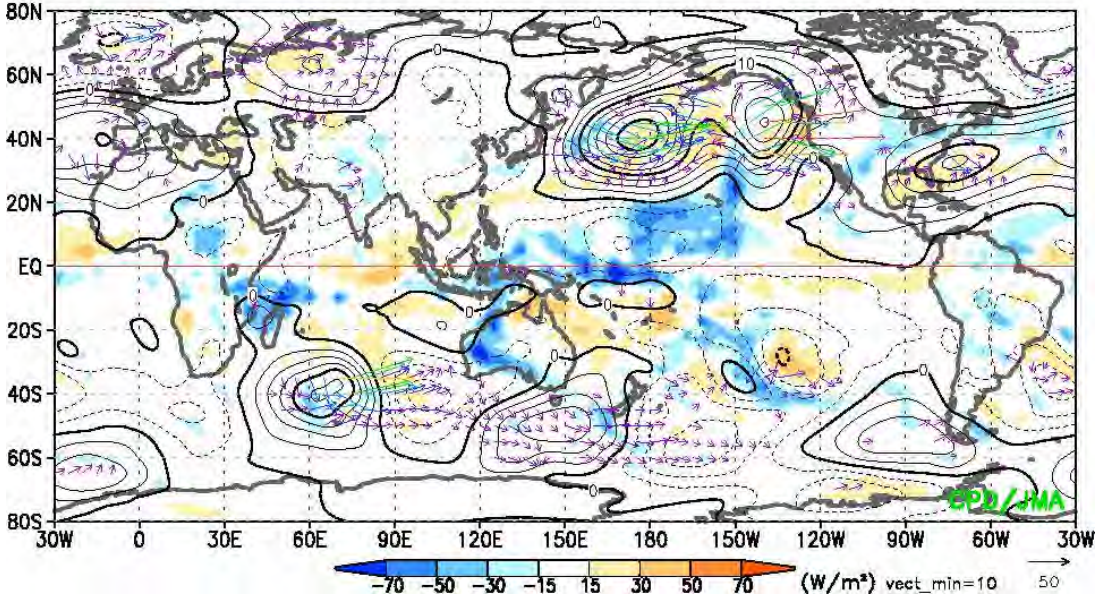


06Mar.2015 – 10Mar.2015

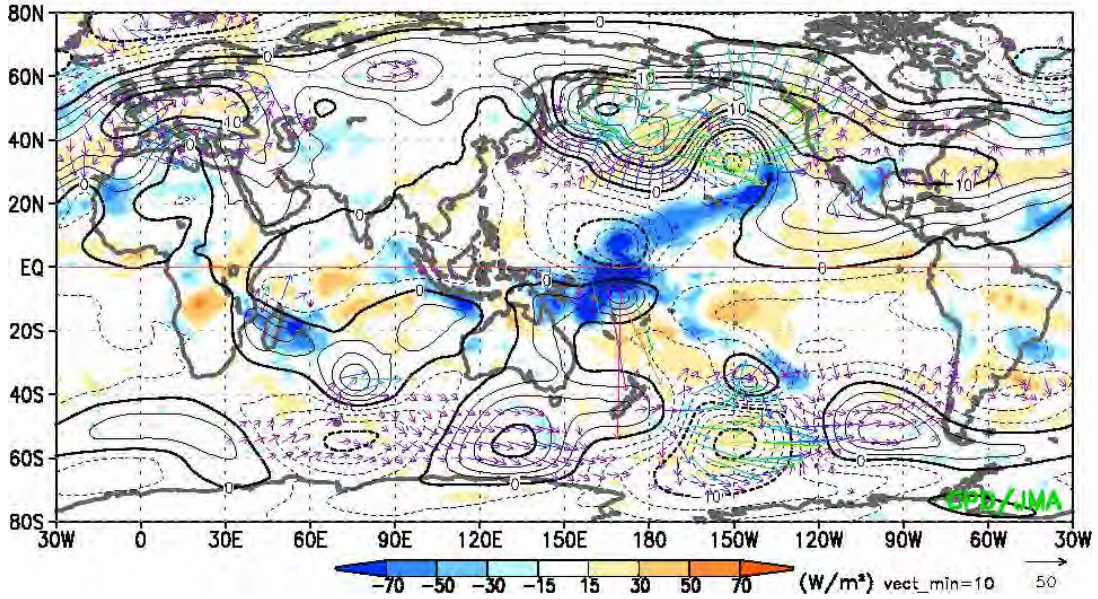


850 hPa

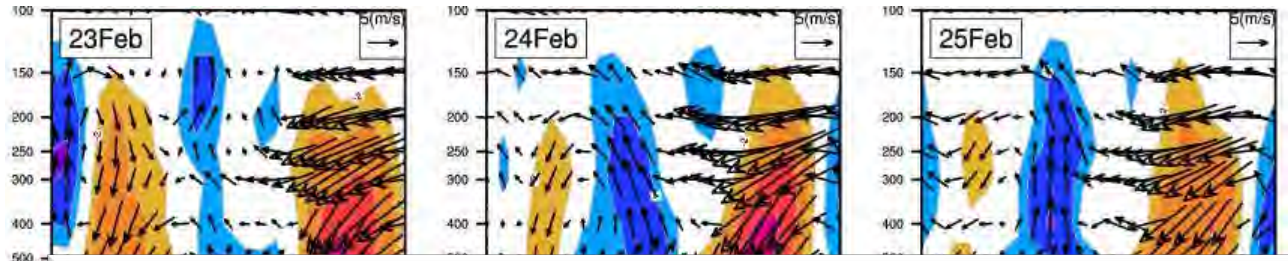
01Mar.2015 – 05Mar.2015

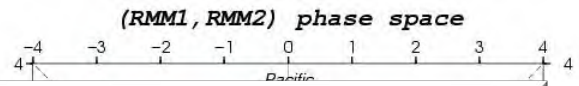


06Mar.2015 – 10Mar.2015



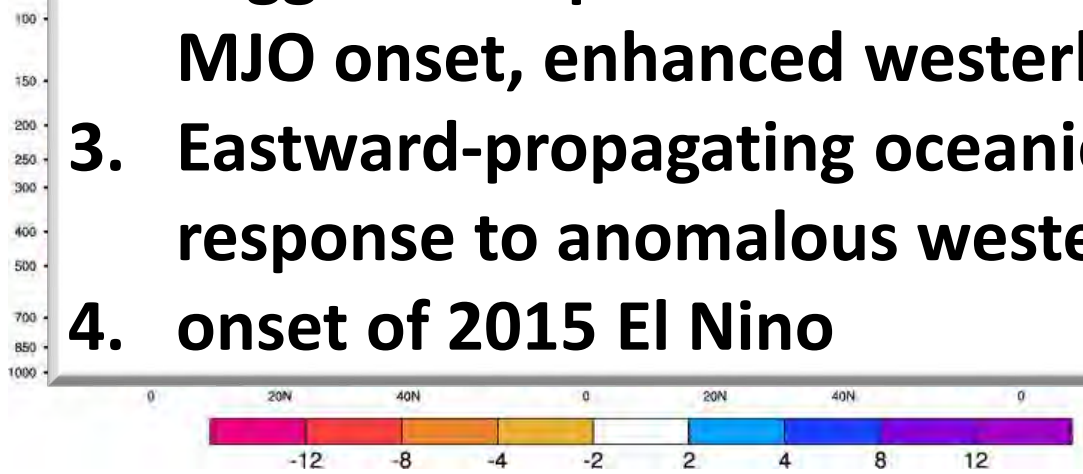
V and Omega averaged over150-180E





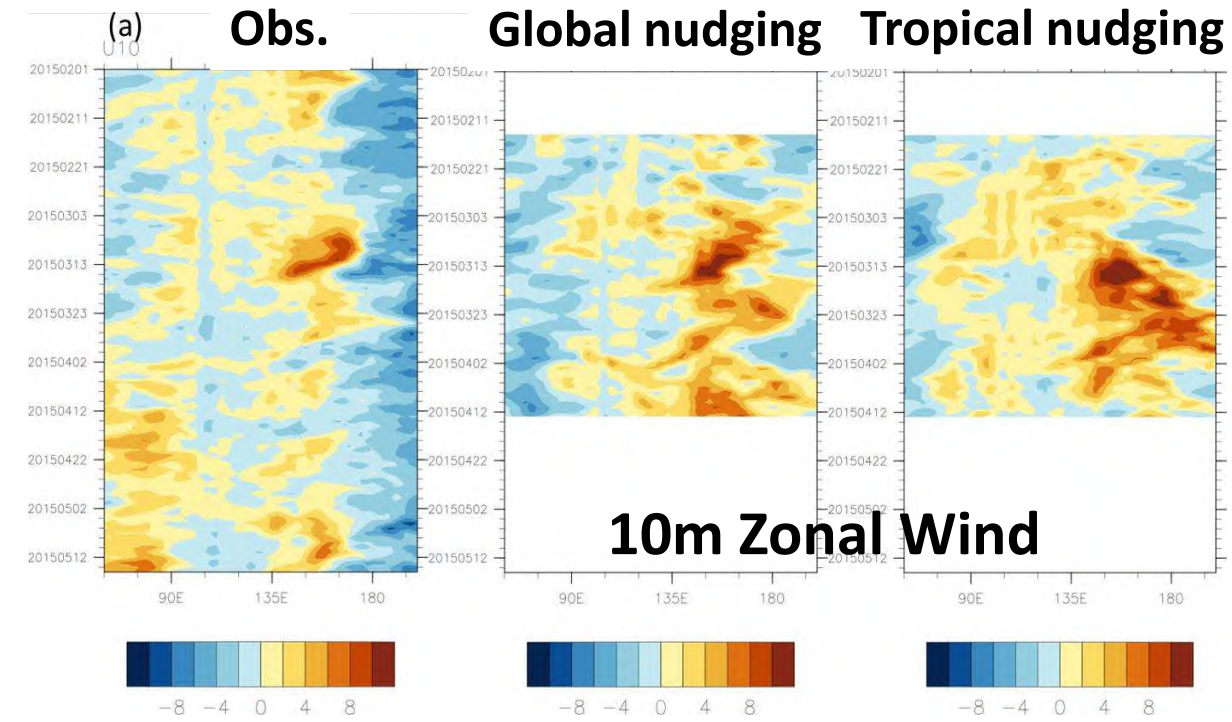
Hypothesis

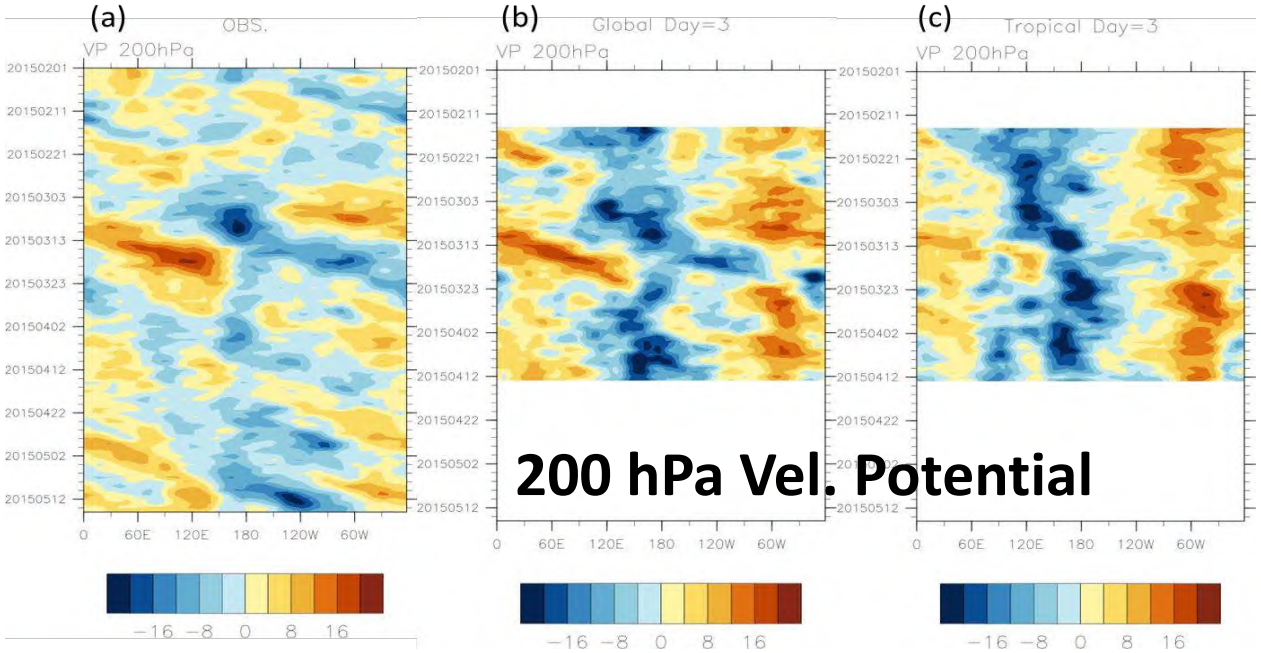
1. dry and cold northerly wind penetrated southward over warm and moist ocean;
2. triggered tropical convection over warm water → MJO onset, enhanced westerly and O-A interaction;
3. Eastward-propagating oceanic perturbation in response to anomalous westerly;
4. onset of 2015 El Nino



MJO initiated on 5 March

The convective instability further develop to MJO





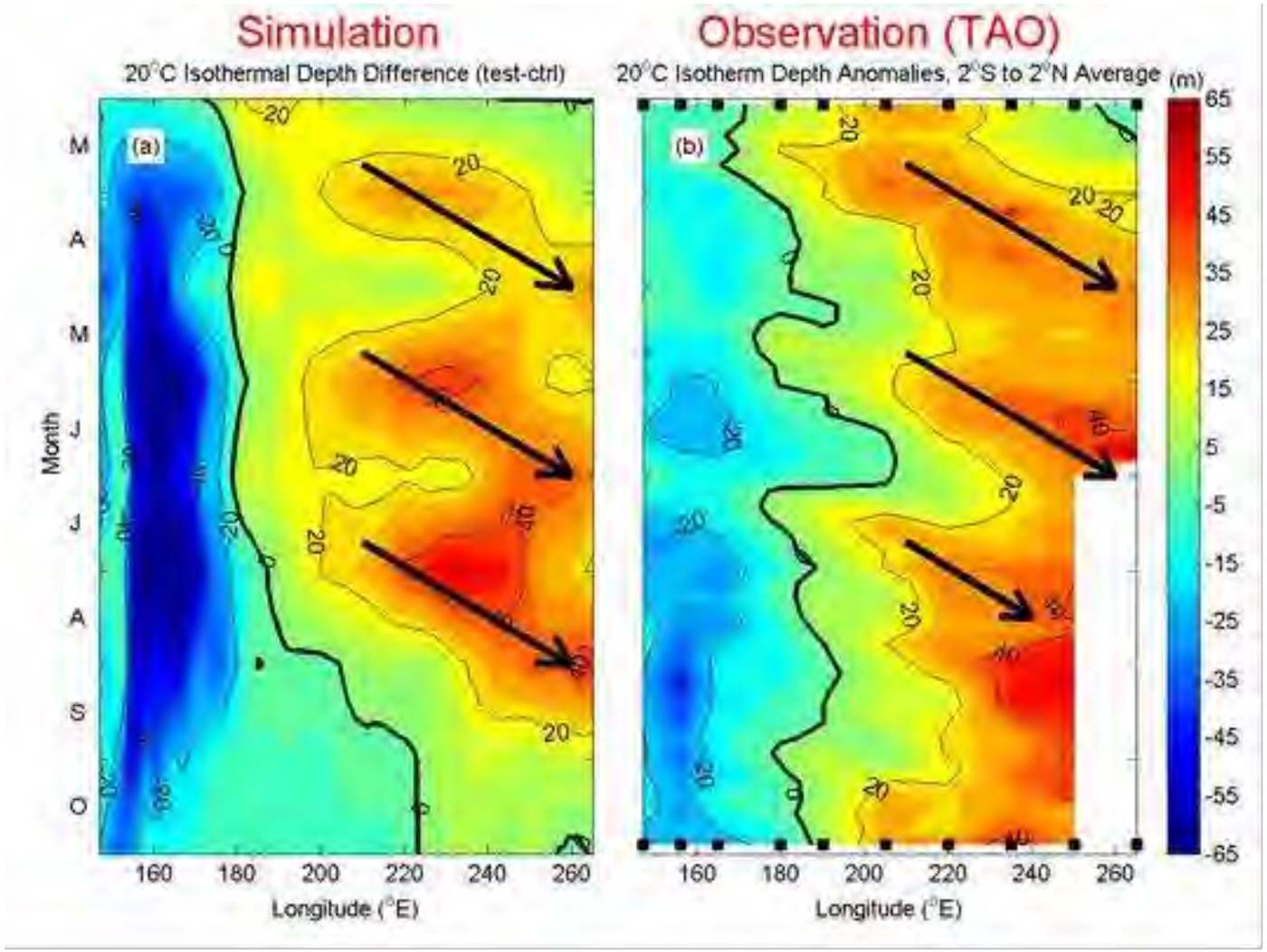
Effect of extratropical Perturbation: Numerical experiment ECHAM5-SiT

1. Twice daily in first 5 days
2. Once daily in 6-10 days
Left: observation
Middle: global nudging
Right: tropical nudging

Results:

1. Including extratropical nudging (middle), MJO onset time is properly simulated.
2. Tropical nudging only: MJO onset is delayed.
3. Implication: extratropical forcing is critical.
3. Extratropical forcing helps simulate more realistic MJO after onset.

Eastward-moving warm water was realistically simulated by forcing POP with observed westerly wind stress over 140-180E, 3S-3N



Simulated propagation speed 1.7m/s

Observed propagation speed 2~3m/s

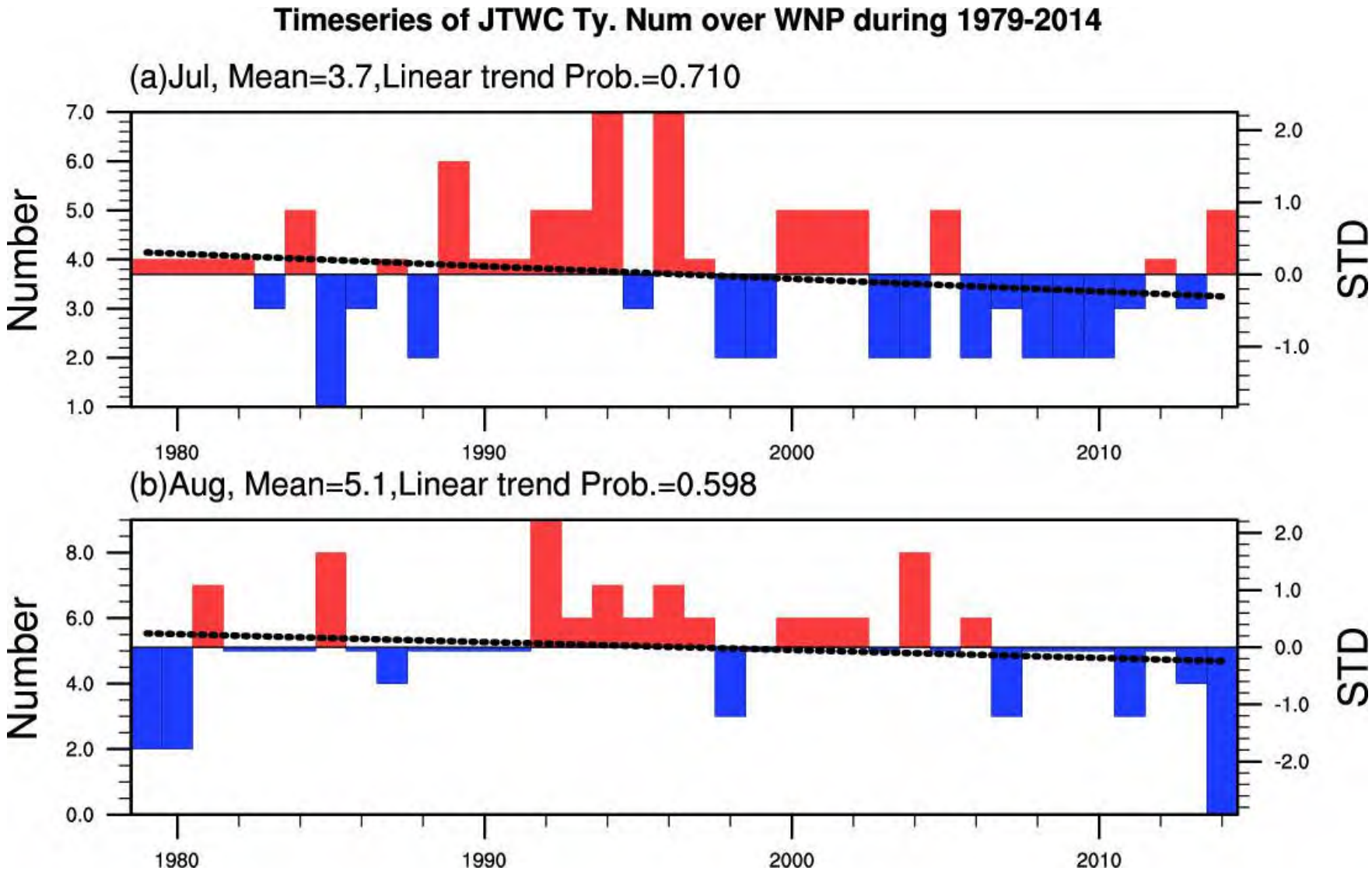
No TC in the WNP
August 2014

Ming-Ying Lee, C.-C. Hong, and H.-H. Hsu

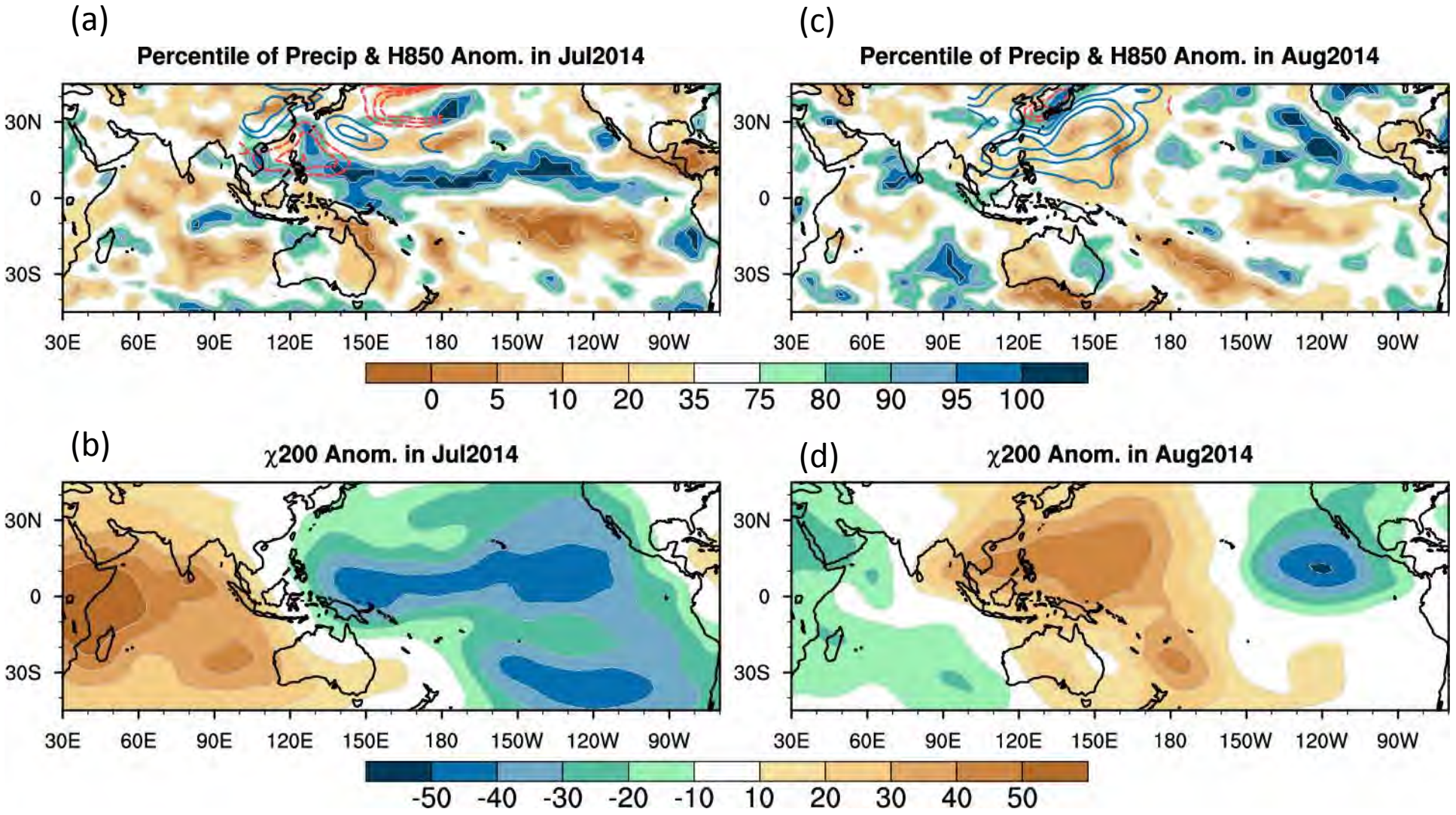
Climate Forensics Study (CFS) Team

氣候鑑識

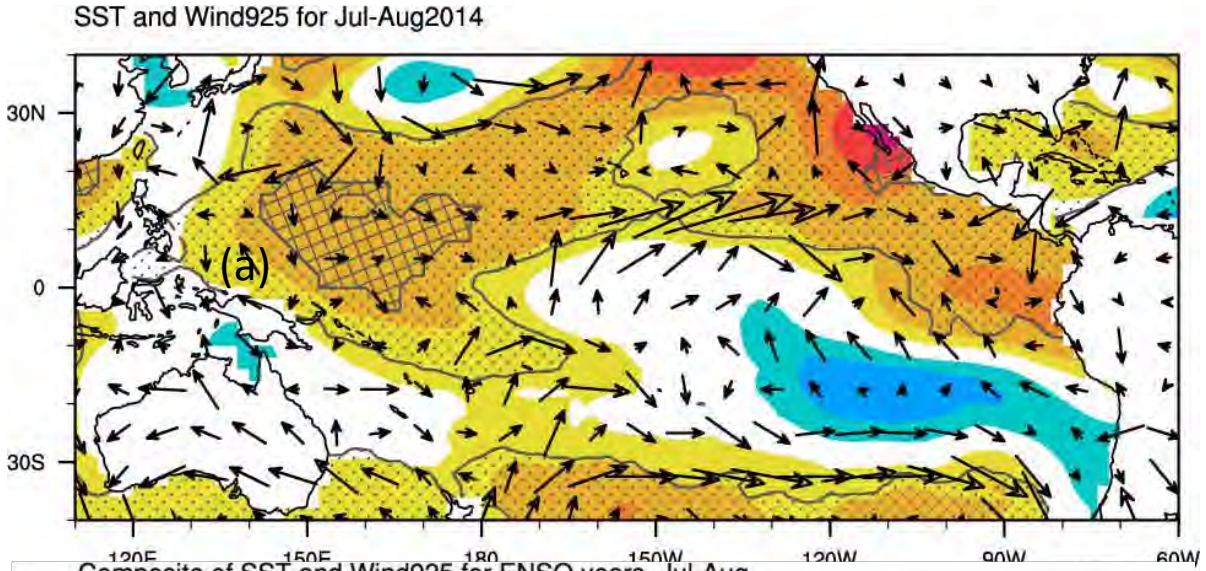
Hong, Lee, and Hsu (2016, JGR)


Timeseries of JTWC Ty. Num over WNP during 1979-2014
(a)Jul, Mean=3.7,Linear trend Prob.=0.710
Number
STD
7.0
6.0
5.0
4.0
3.0
2.0
1.0
2.0
1.0
0.0
-1.0
1980
1990
2000
2010
(b)Aug, Mean=5.1,Linear trend Prob.=0.598
Number
STD
8.0
6.0
4.0
2.0
0.0
2.0
1.0
0.0
-1.0
-2.0
1980
1990
2000
2010

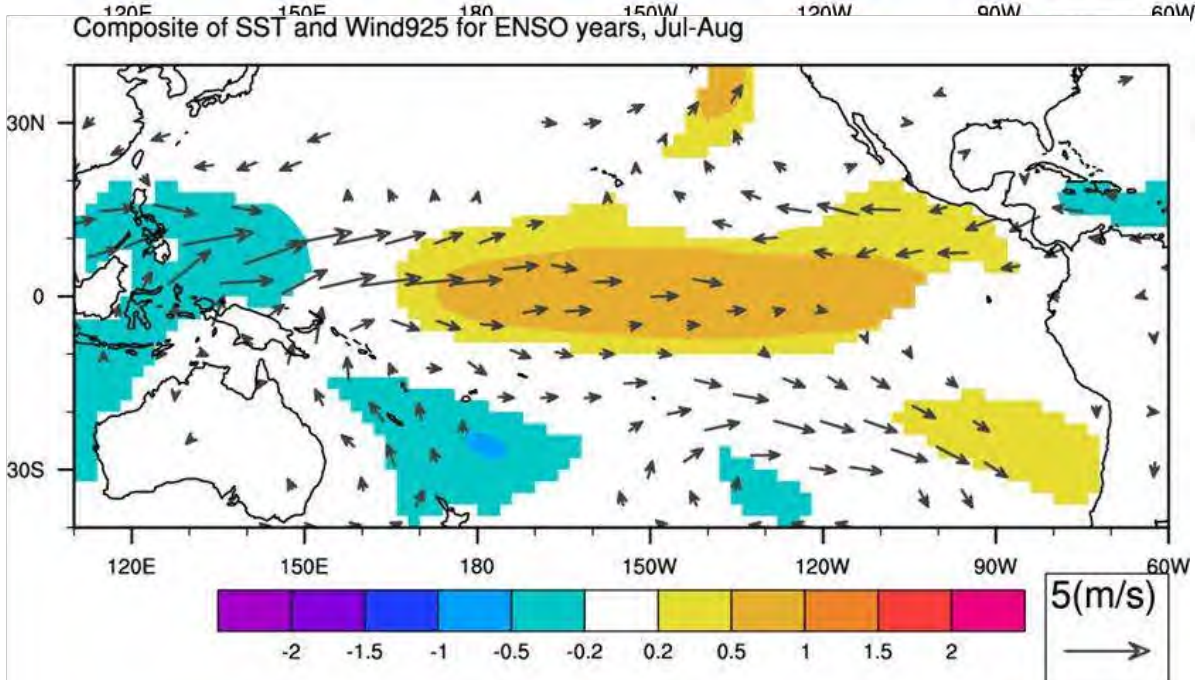
Different in WNP, Similar in eastern Pacific

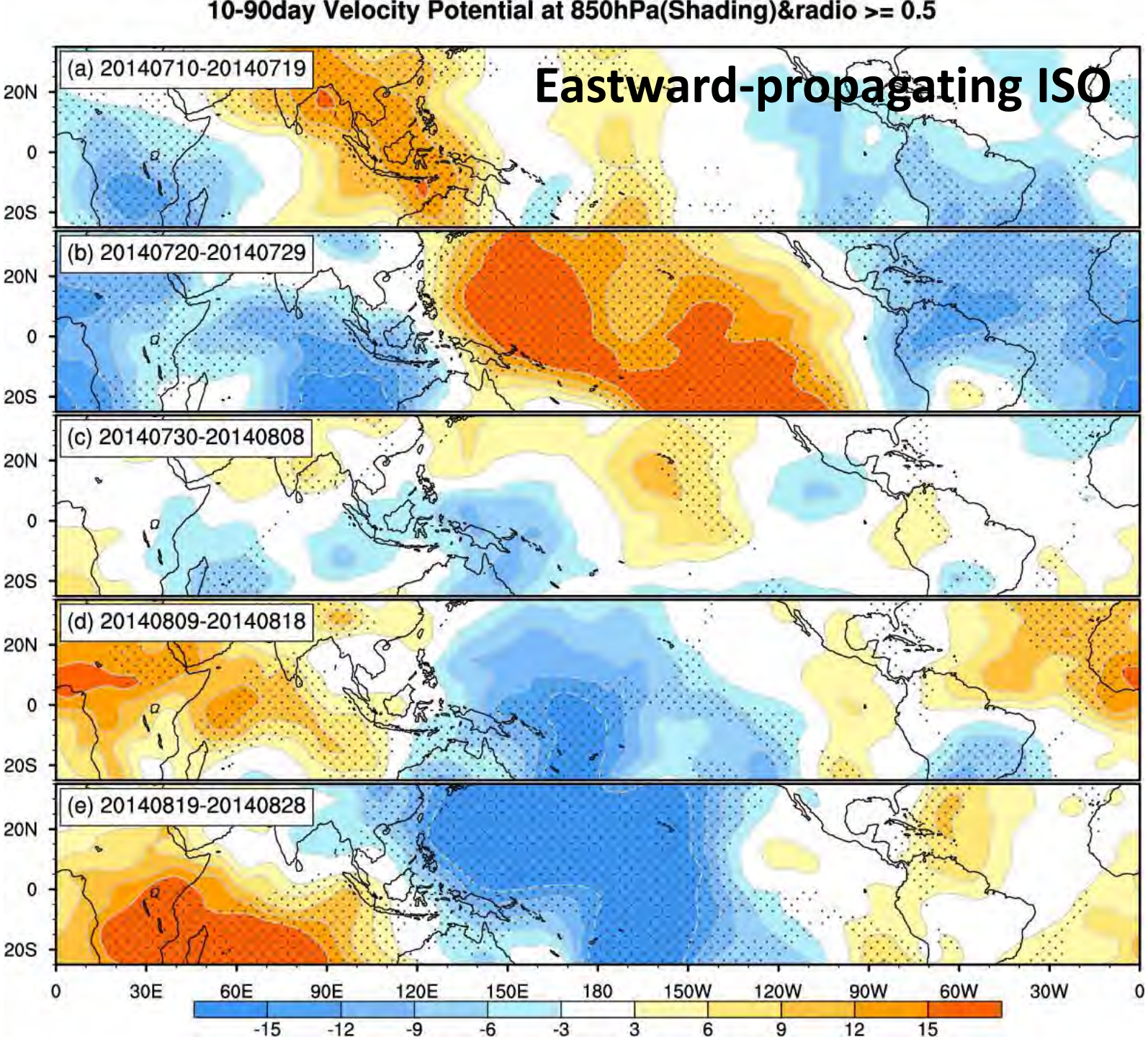


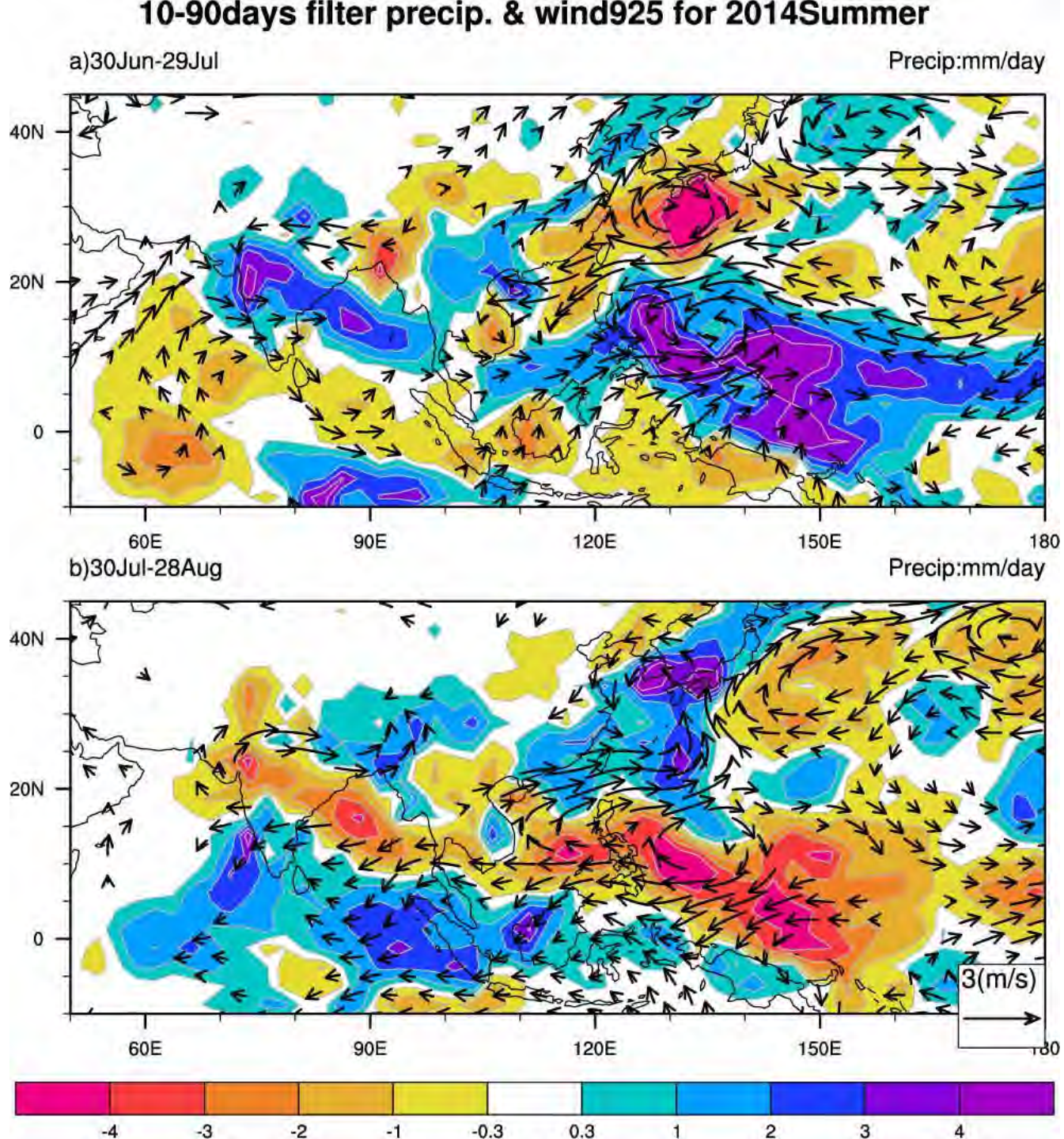
SST and wind anomalies distinctively different from canonical El Nino



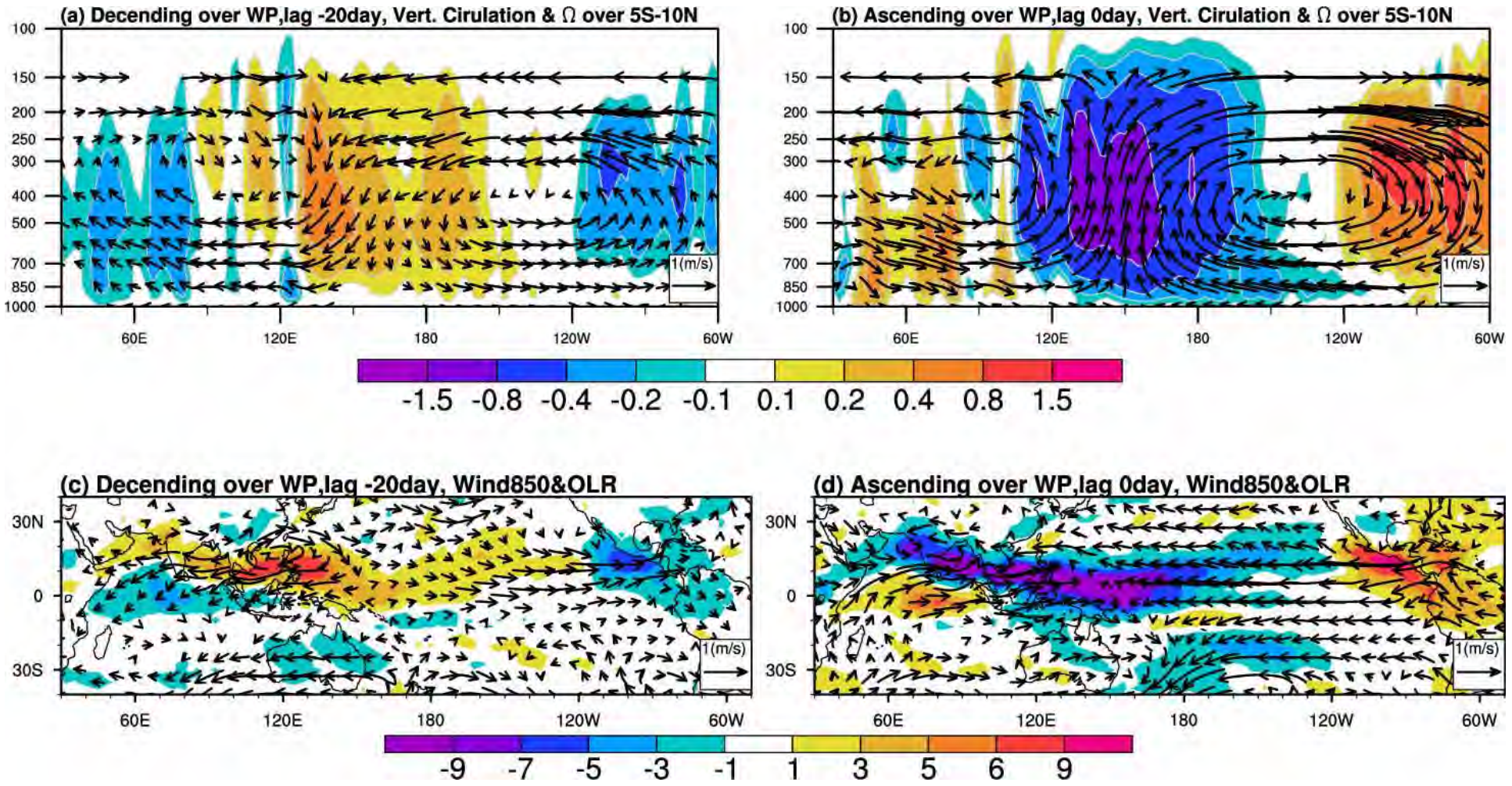
(b)



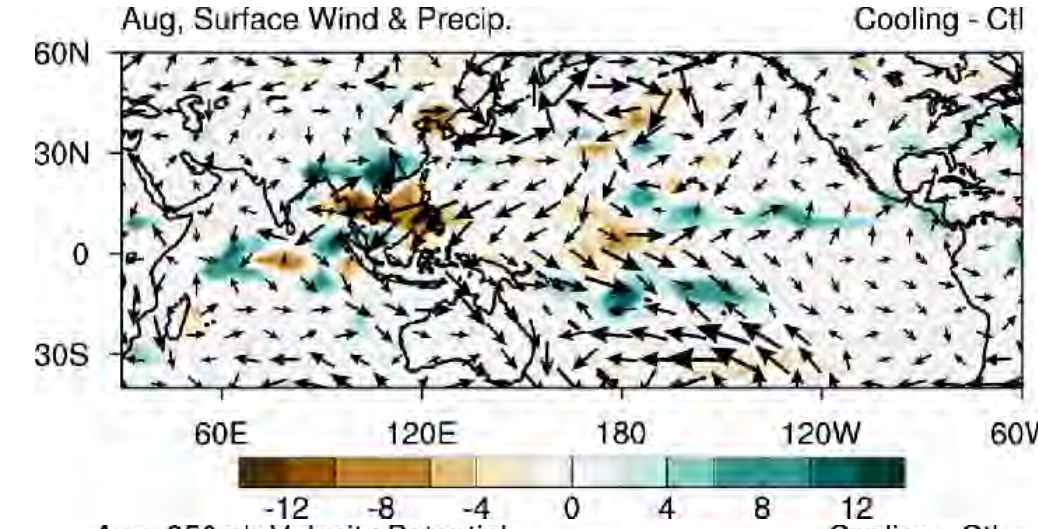

10-90day Velocity Potential at 850hPa(Shading)&radio >= 0.5
(a) 20140710-20140719
(b) 20140720-20140729
(c) 20140730-20140808
(d) 20140809-20140818
(e) 20140819-20140828
Eastward-propagating ISO
20N
0
20S
0
30E
60E
90E
120E
150E
180
150W
120W
90W
60W
30W
0
-15
-12
-9
-6
-3
3
6
9
12
15


10-90days filter precip. & wind925 for 2014Summer
a)30Jun-29Jul
Precip:mm/day
40N
20N
0
60E
90E
120E
150E
180
b)30Jul-28Aug
Precip:mm/day
40N
20N
0
60E
90E
120E
150E
3(m/s)
-4
-3
-2
-1
-0.3
0.3
1
2
3
4

Circulations during Canonical ISO

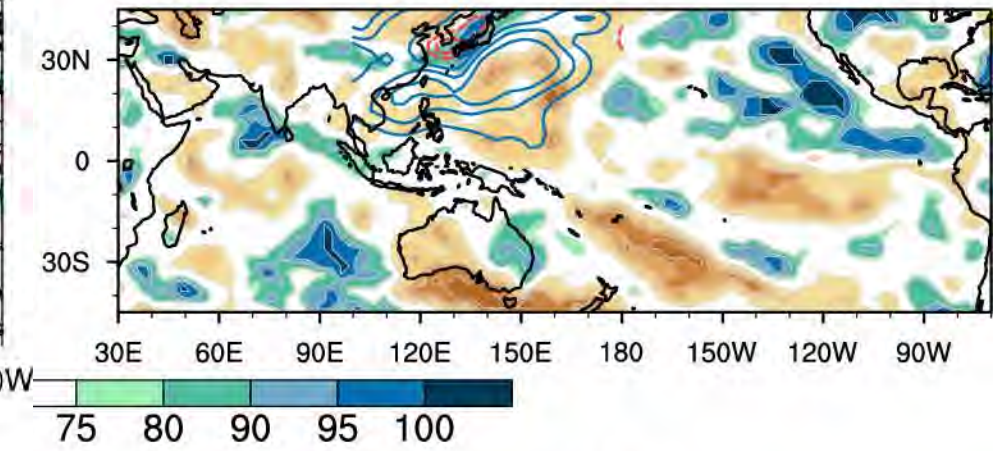


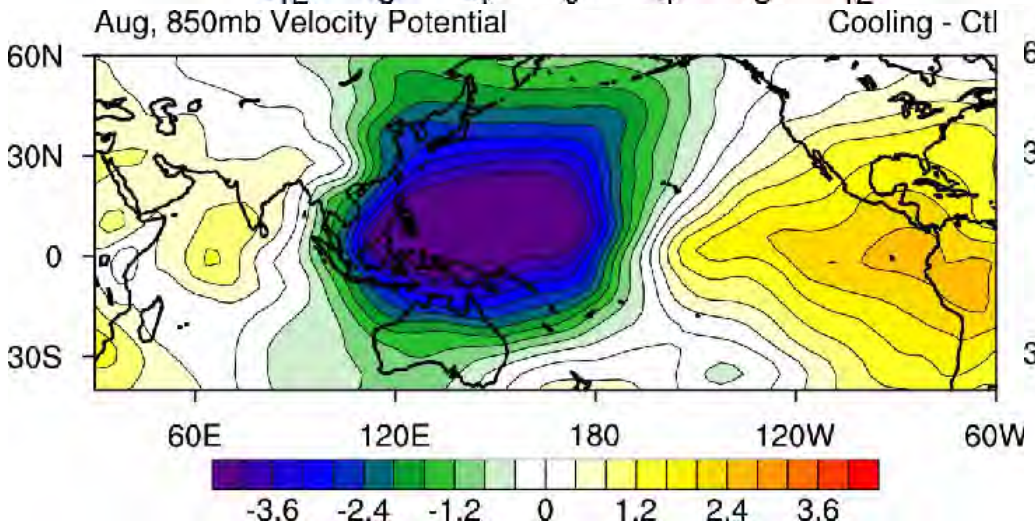
ISO in convection-inactive phase in WNP enhanced convection in the tropical eastern Pacific while suppressing convection and enhancing anticyclone in WNP? – “SPEEDY” cooling simulation

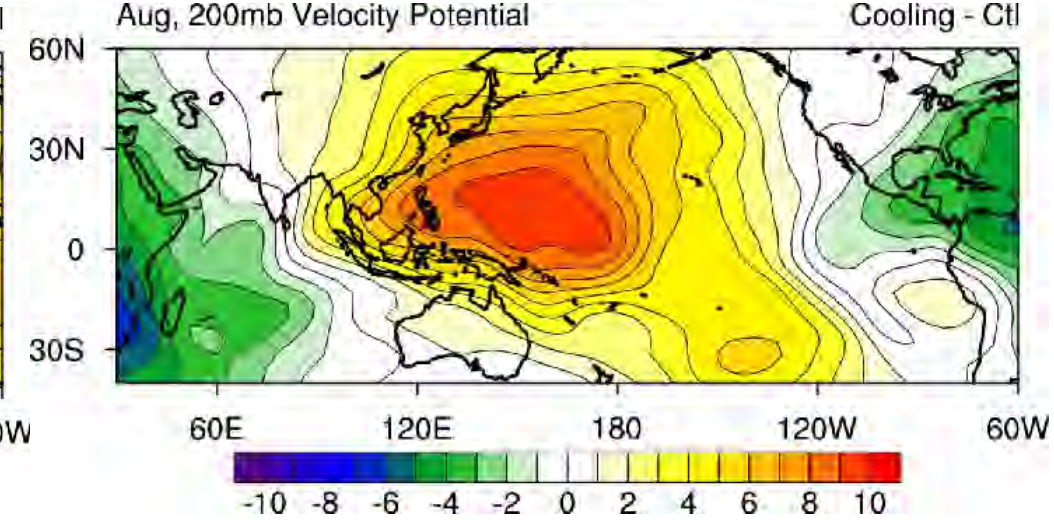


Observation

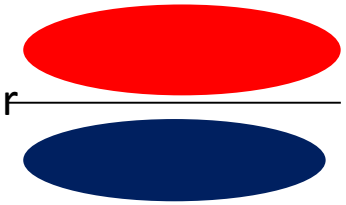
Percentile of Precip & H850 Anom. in Aug2014



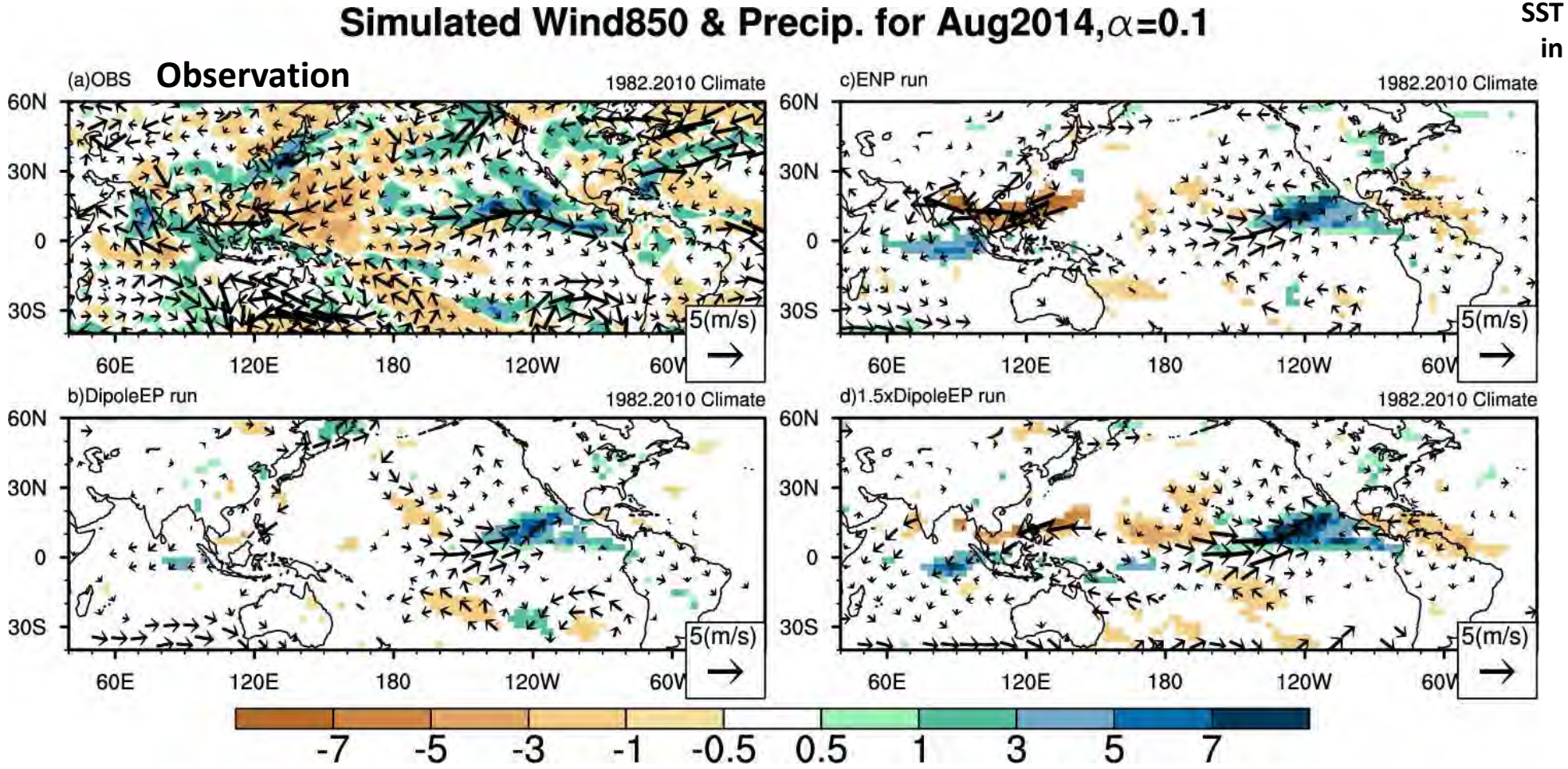




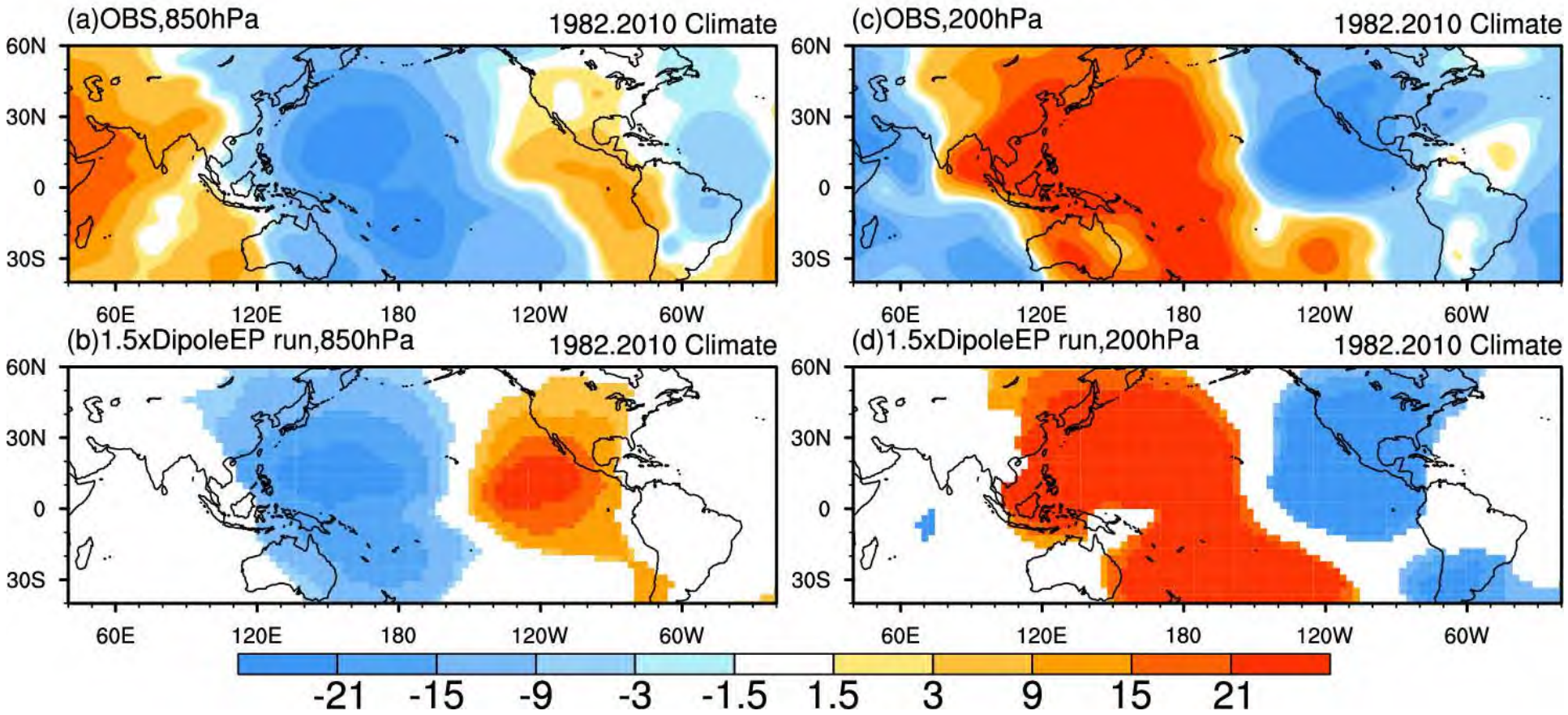
Effect SST gradient on the convection in the tropical eastern Pacific - ECHAM5 forced by SST anomaly in the eastern Pacific



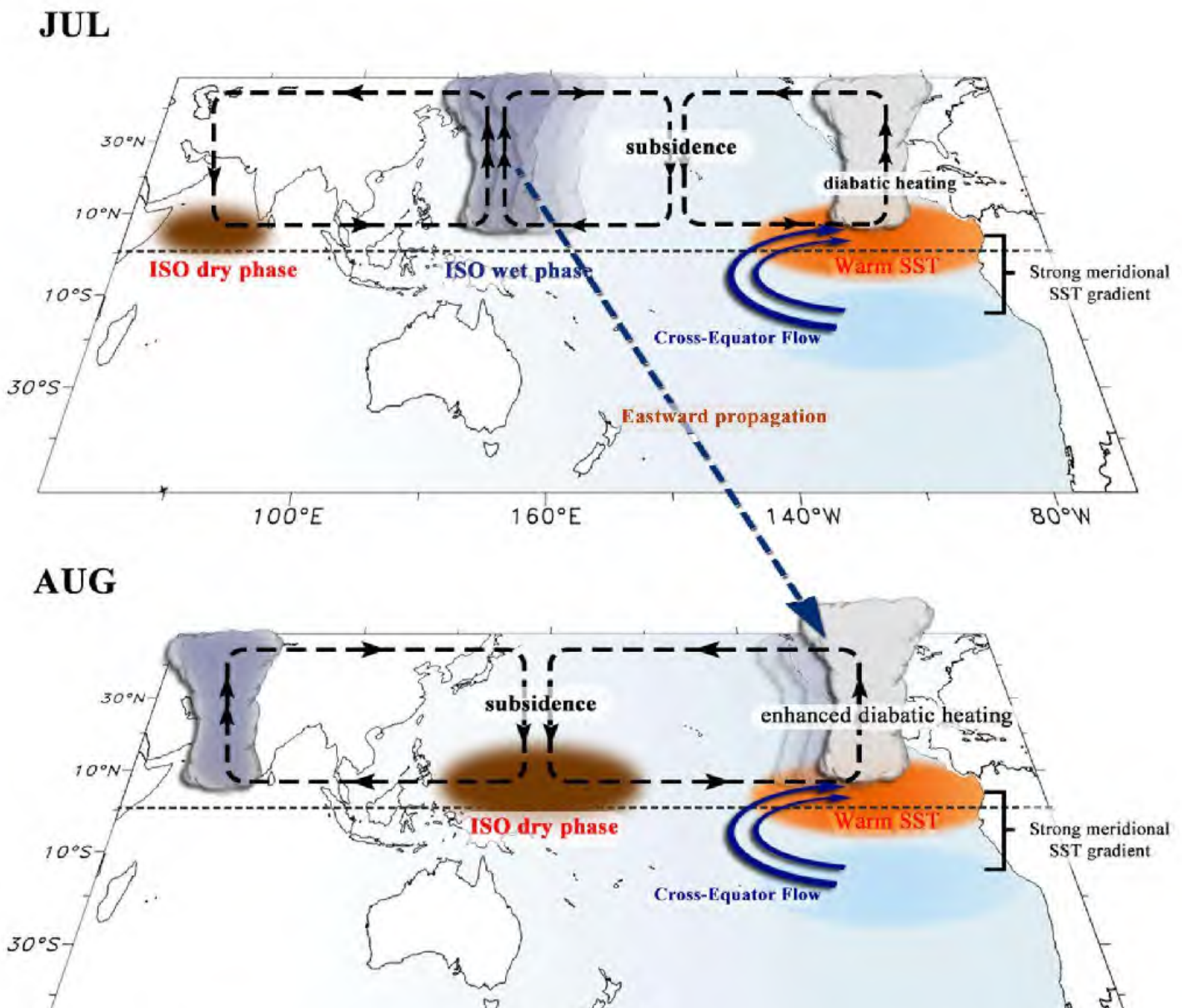
SST anomaly dipole in eastern Pacific



Simulated Velocity potential for Aug2014

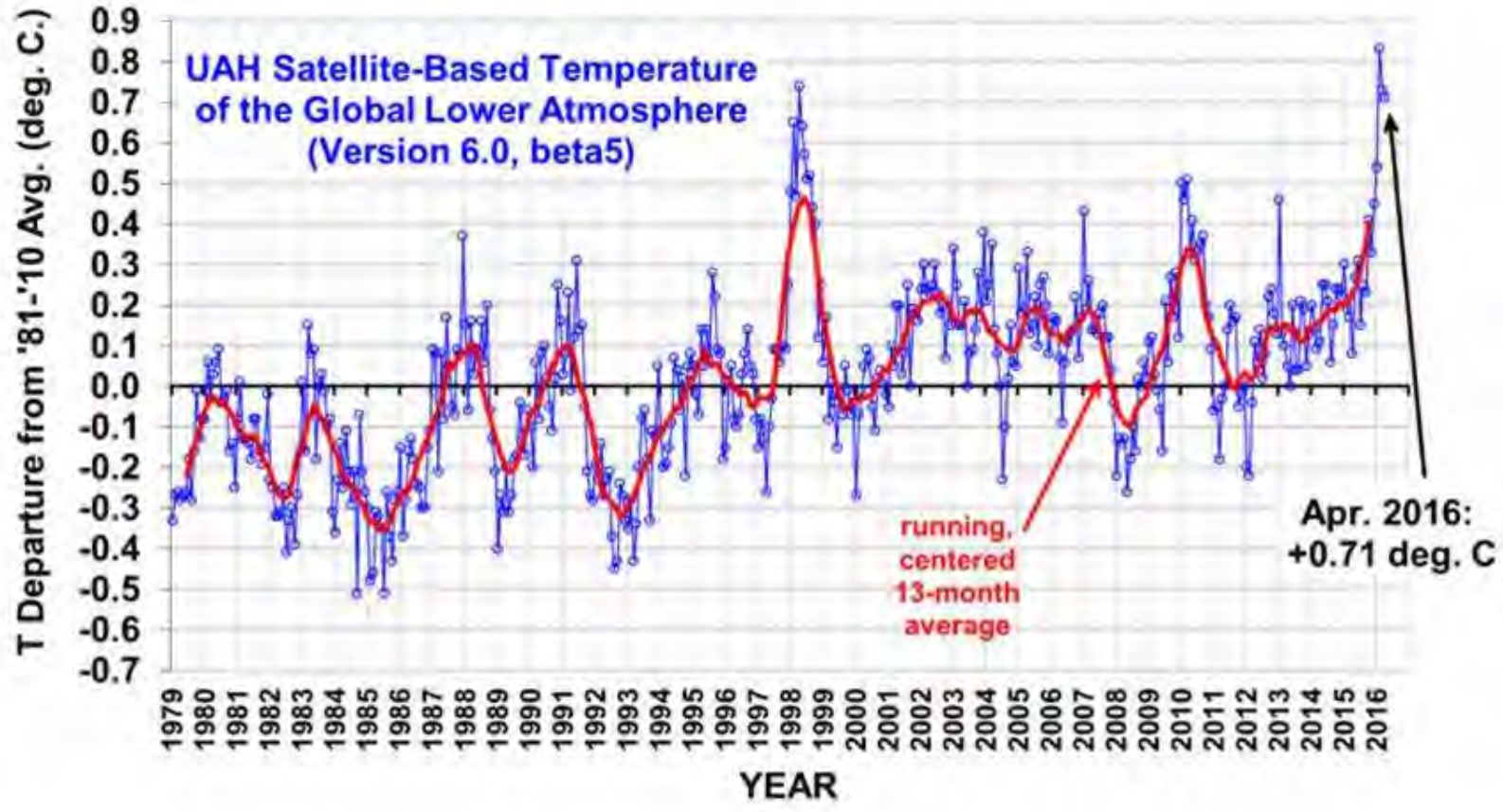


Compounding effect of ISO and El Nino led to the unusual no-TC event



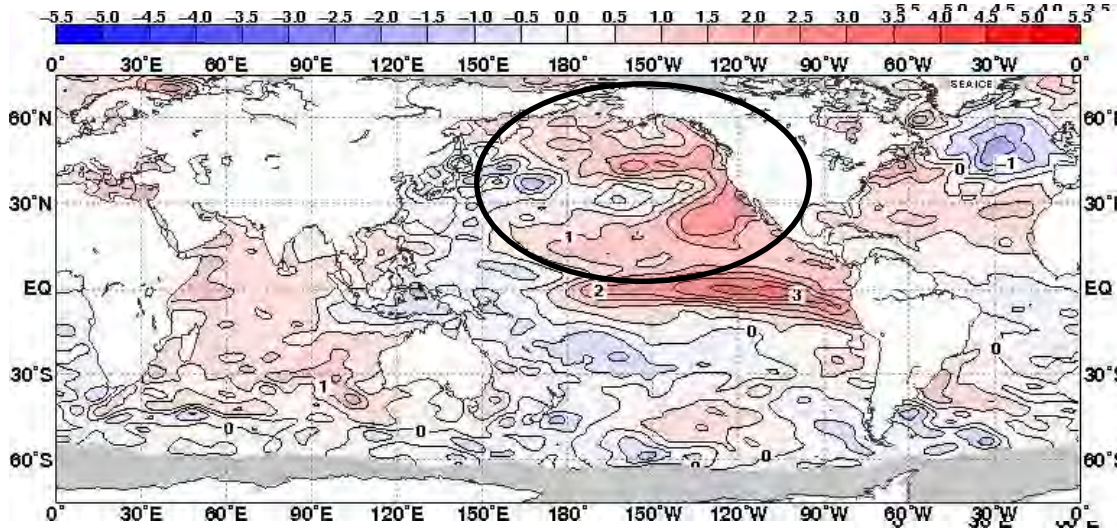
Emergence of Mutant El Niño?

Causes of 2015-2016 Warming?
Relative contribution of El Nino and global warming?

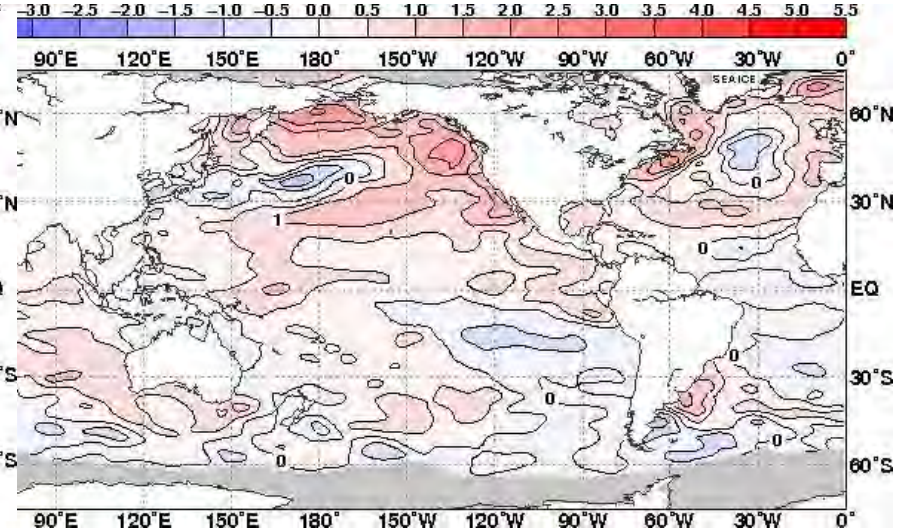


2015、1997聖嬰有何不同?

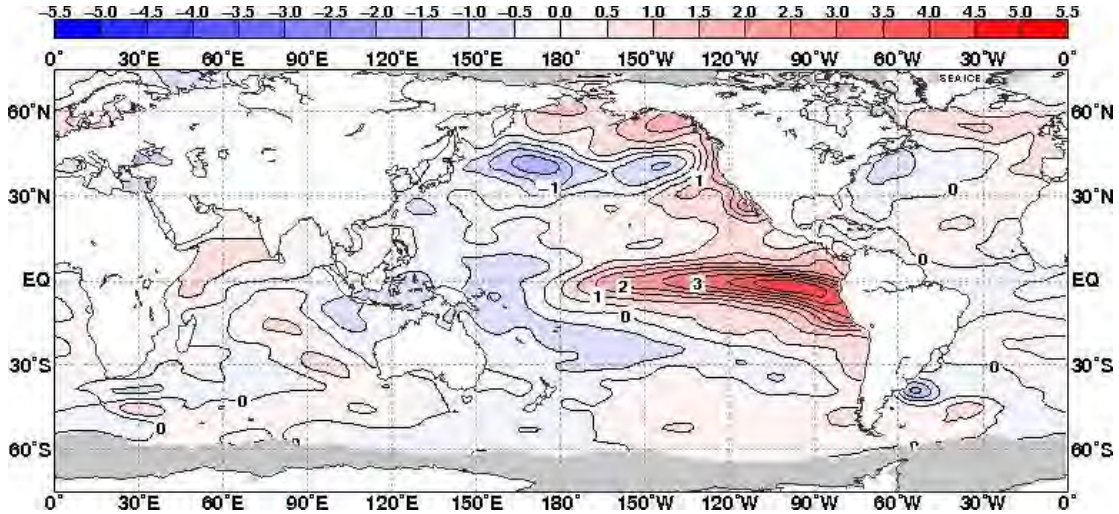
海溫距平 **August-October 2015**



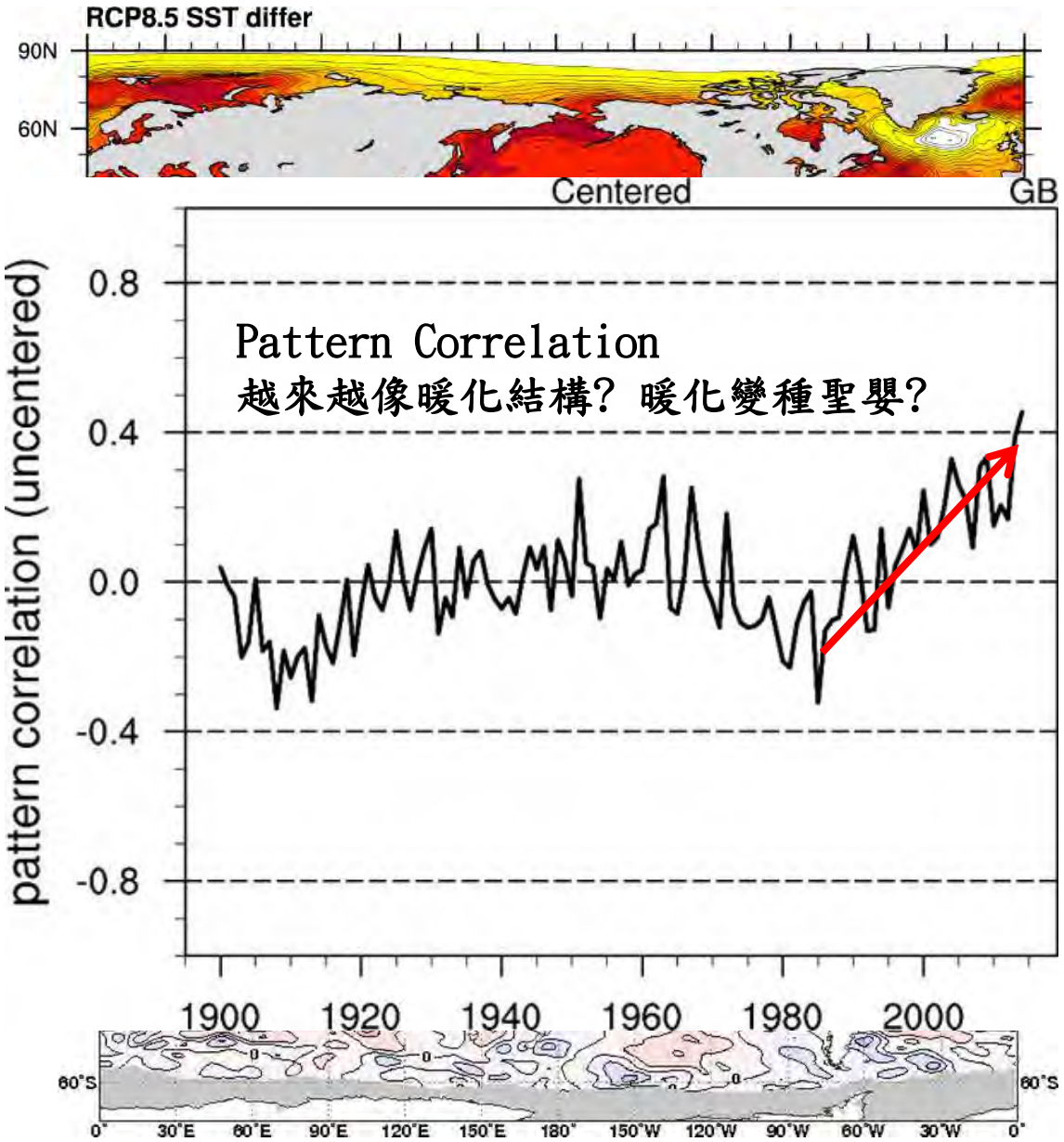
August-October 2014

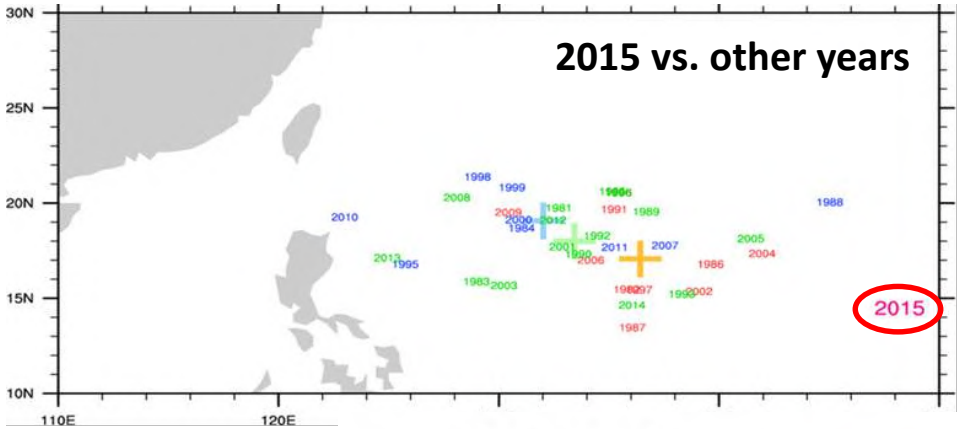


海溫距平 **August-October 1997**

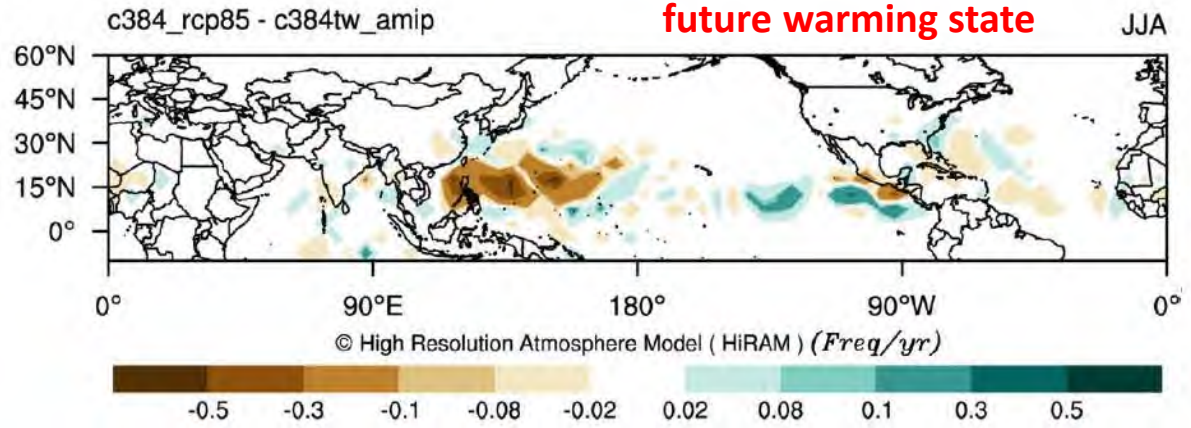


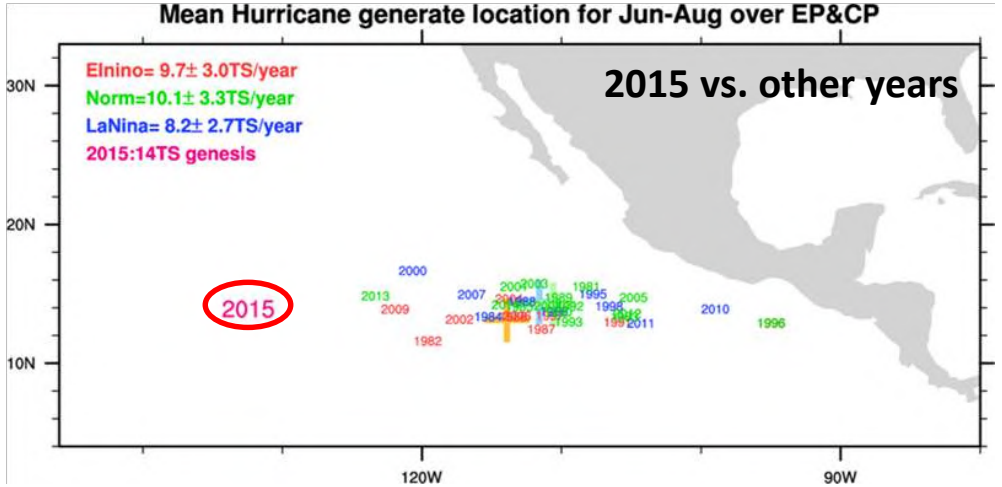
21世紀末暖化情境下，海溫變遷結構





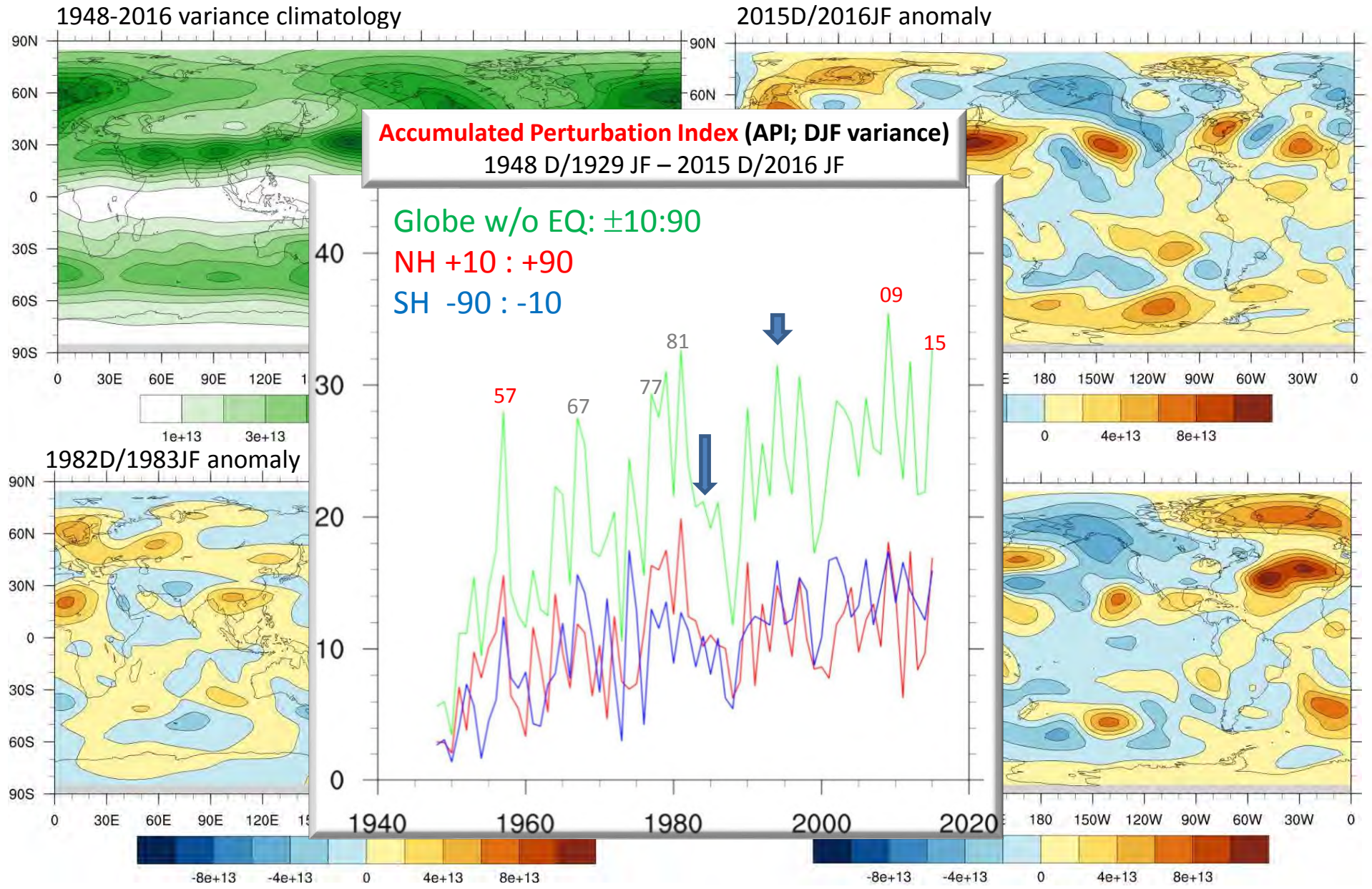
TC genesis shifting toward the central Pacific in both El Nino 2015 and warming scenario
- Can be explained physically
- tendency or coincidence?



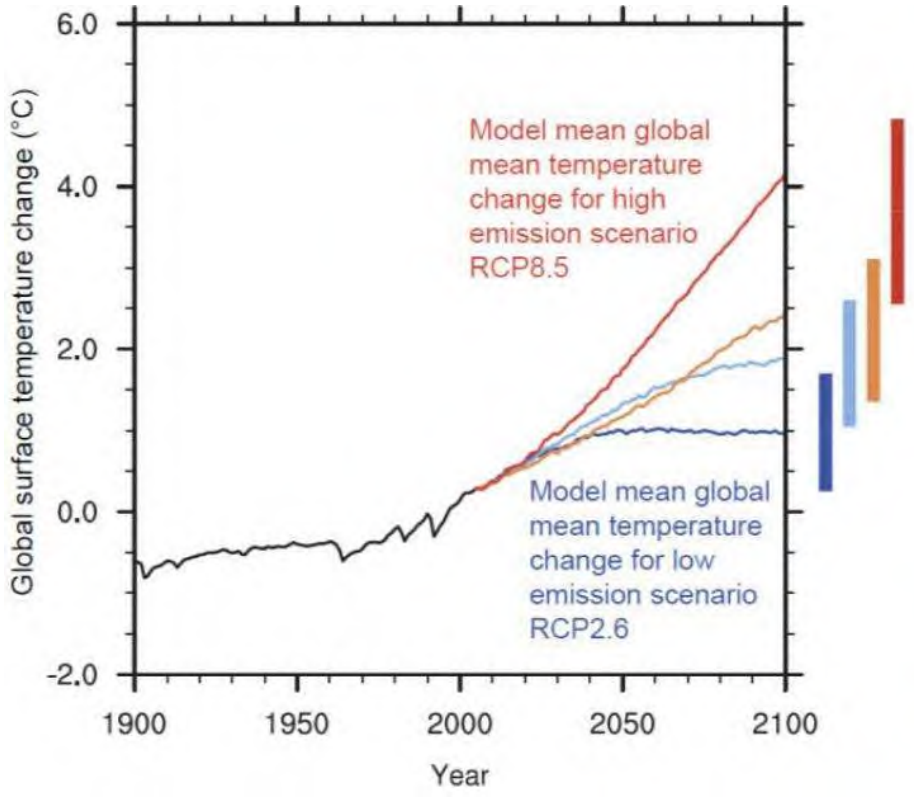


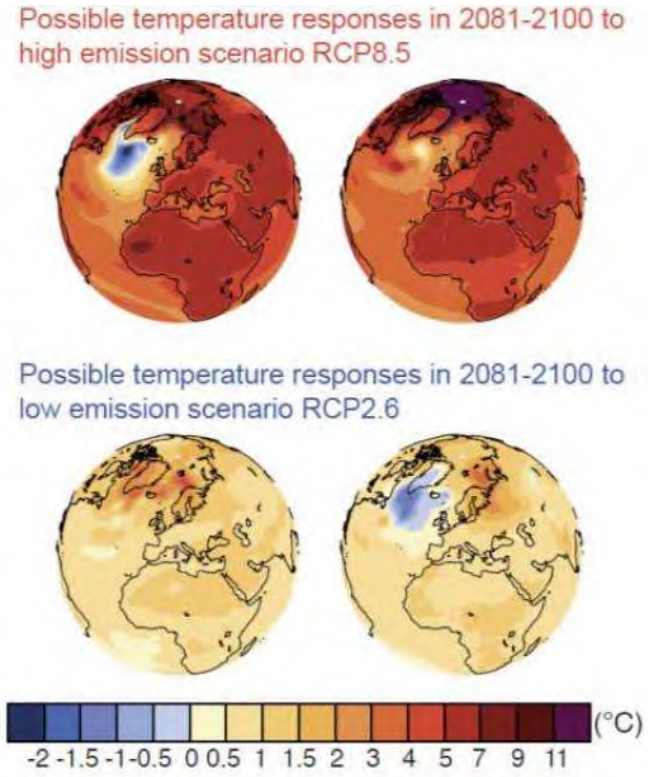
DJF **Variance** of stream function anomaly

bandpass Lanczos filter: 10-30 day number of weights:61



全球暖化:聖嬰變種?變強?
全球暖化與聖嬰有加乘效果?






That's all Folks!