Increasing influence of NPMM SST on the East Asian climate since the 2000s

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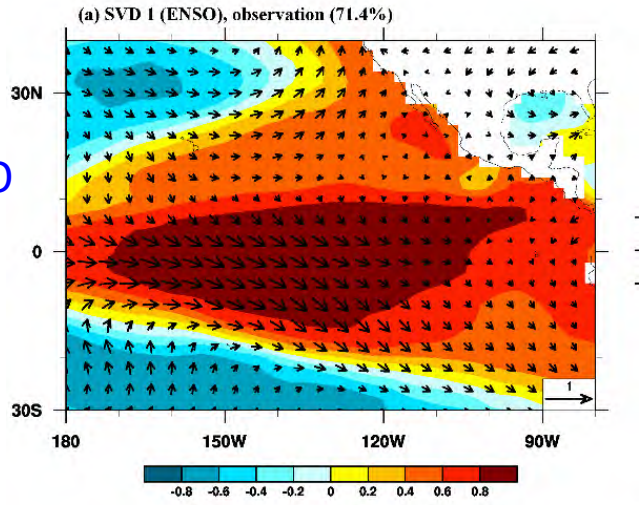
Lee et al. (2016)
Hong et al. (2016) JGR
Wu et al. (2017) Climate Dynamic
Hong et al. (2018)
Kao et al. (2018)

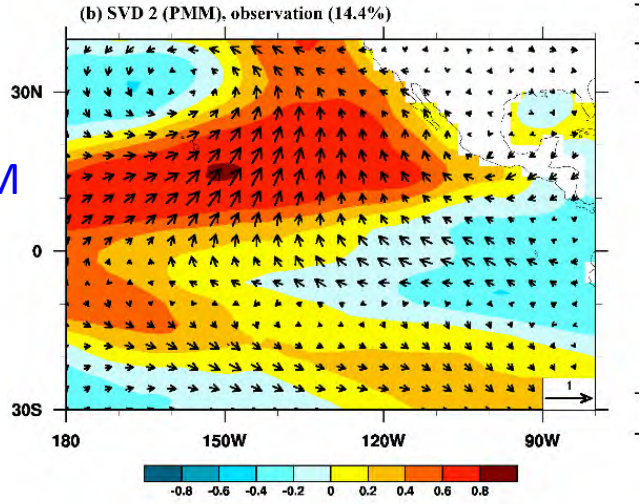
@ CWB

OCT 4 2018, Taipei, Taiwan

SVD1: ENSO MODE



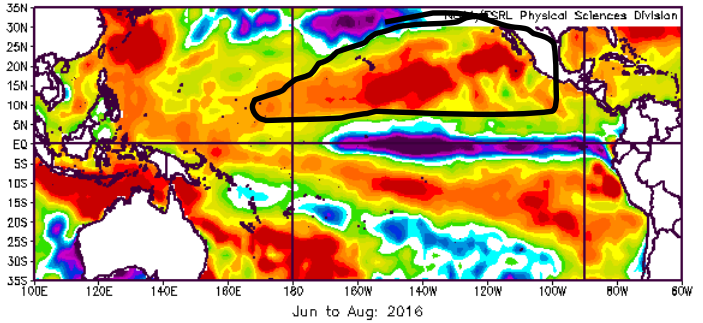
SVD2: PMM MODE



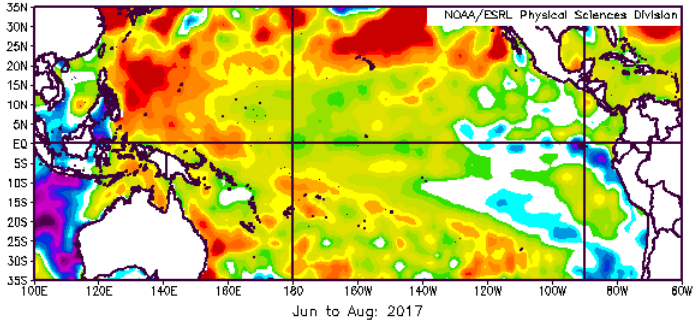
Chiang, & Vimont (2004).

NPMM

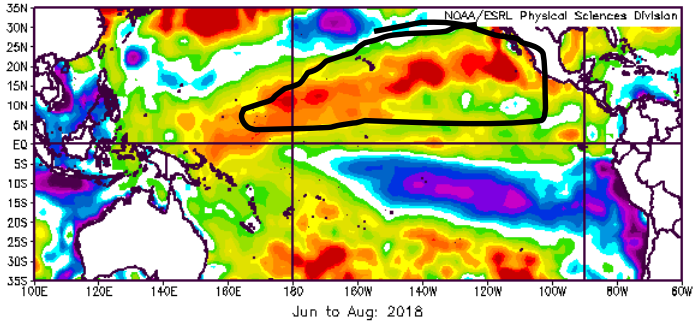
2016



2017



2018

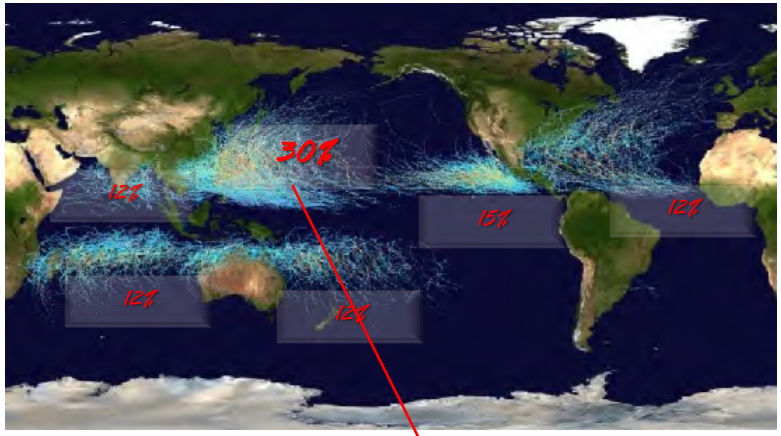


NPM

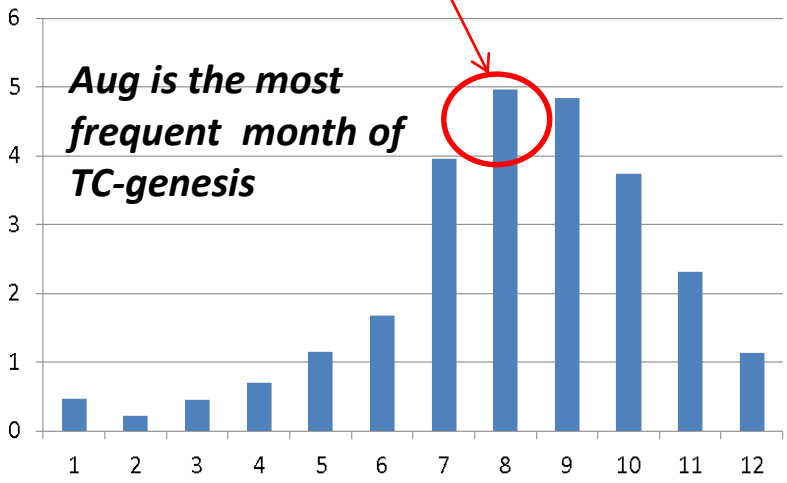
Refereed as: North Pacific meridional mode (NPMM), or subtropical Eastern North Pacific (SENP)

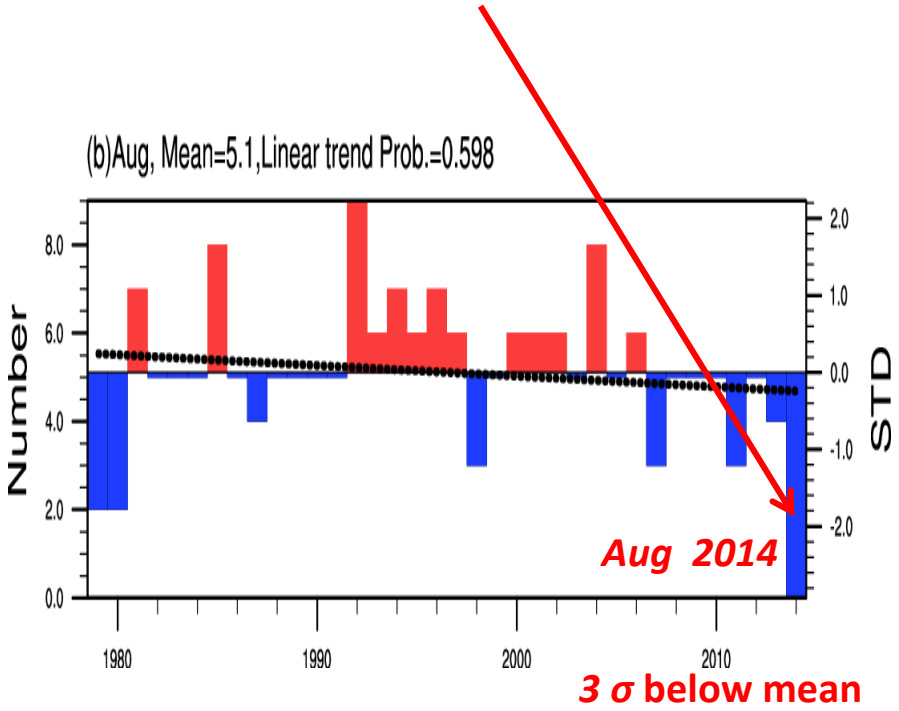
Motivation

No TCs occurred in August 2014 !



Climatological monthly TC-genesis number

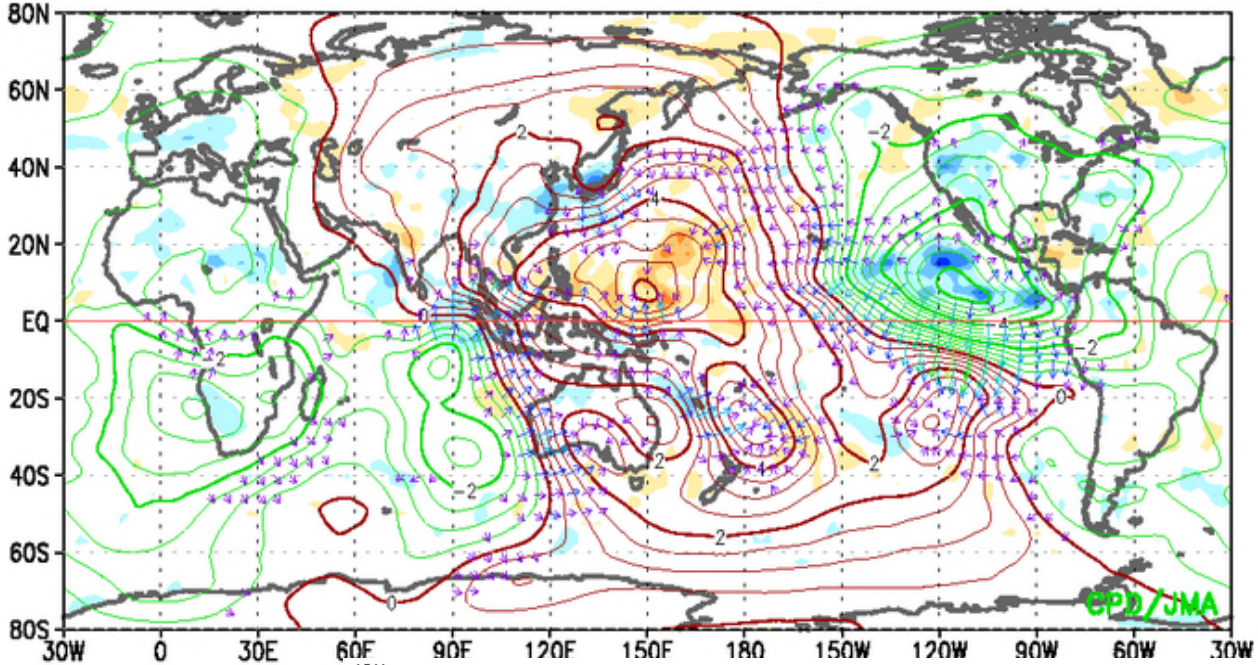




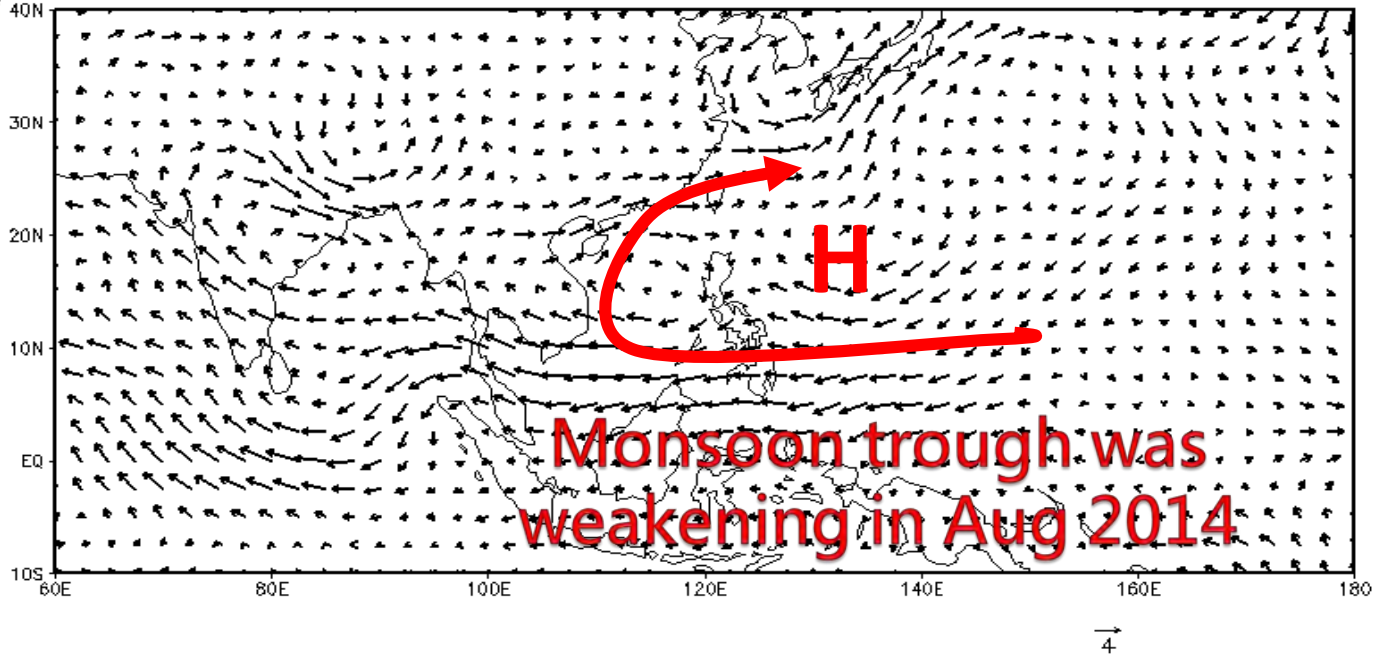
This unusual extreme was never observed since 1945

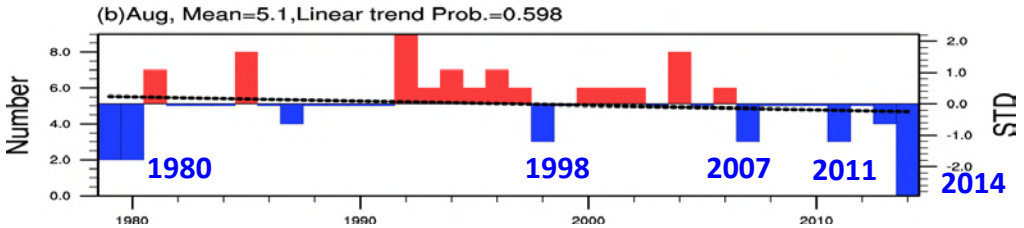
Hong et al. (2016): Compounding factors causing the unusual absence of tropical cyclones in the western North Pacific during August 2014. JGR-Atmos.

30Jul.2014 – 28Aug.2014 *OLR& 200hPa velocity potential anomalies*



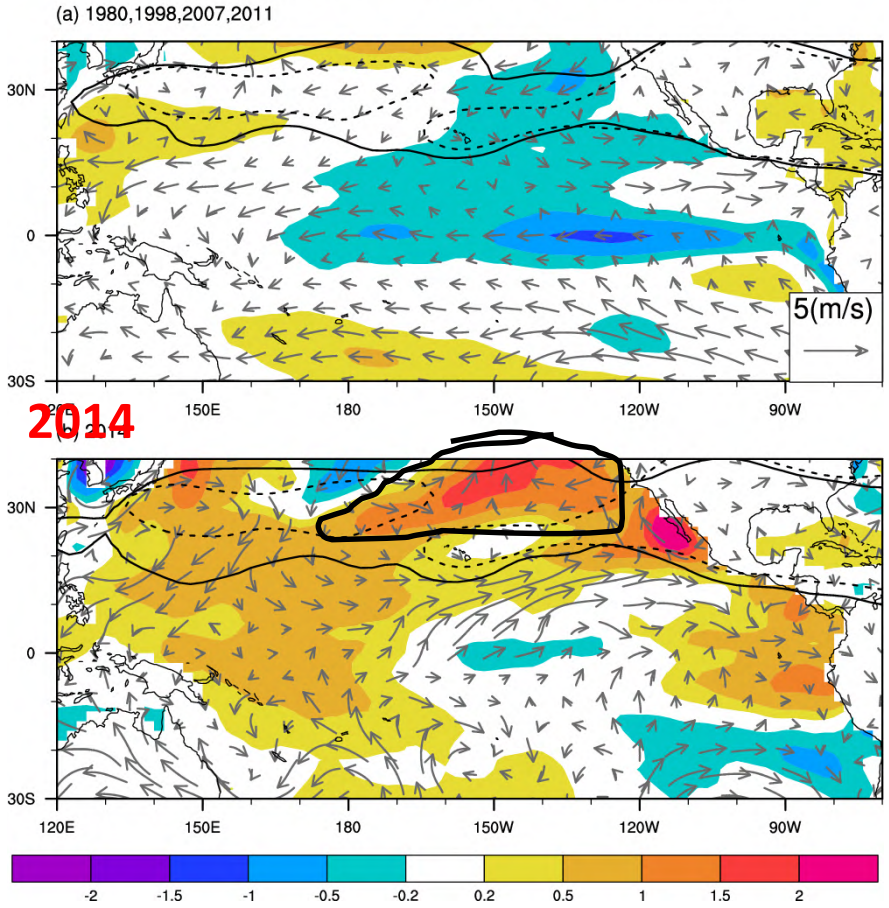
Unusual downward motion anomaly in WNP and extremely strong WNPSH



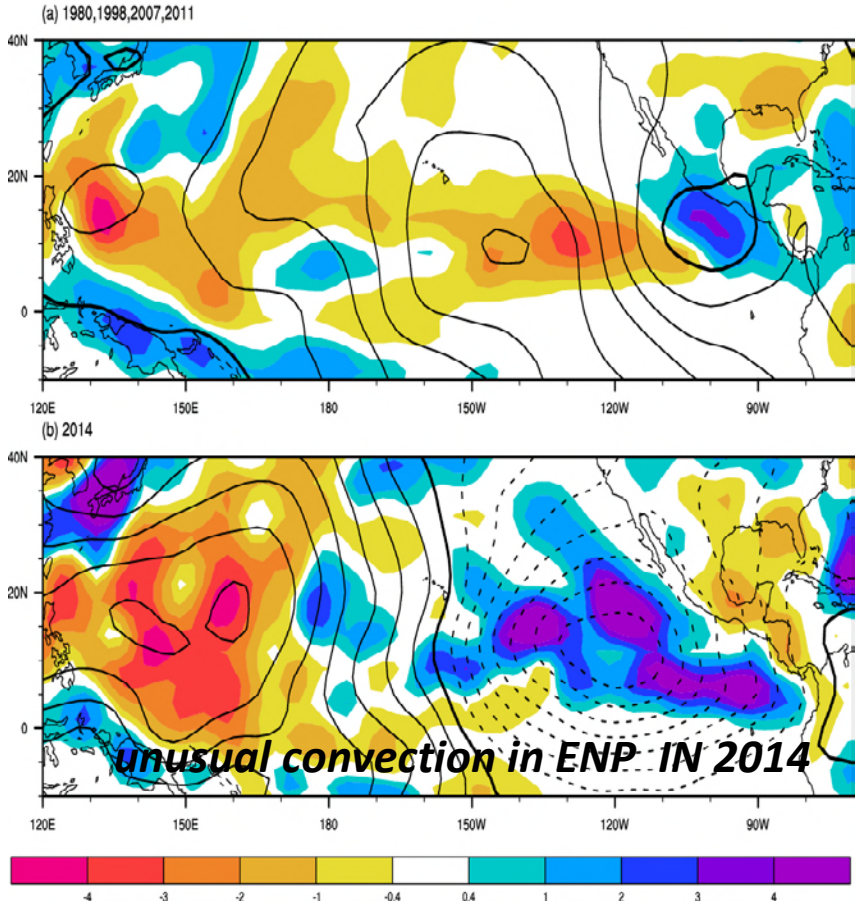


Composite

SST & Wind 925 Anom. & H500=5880 in Aug

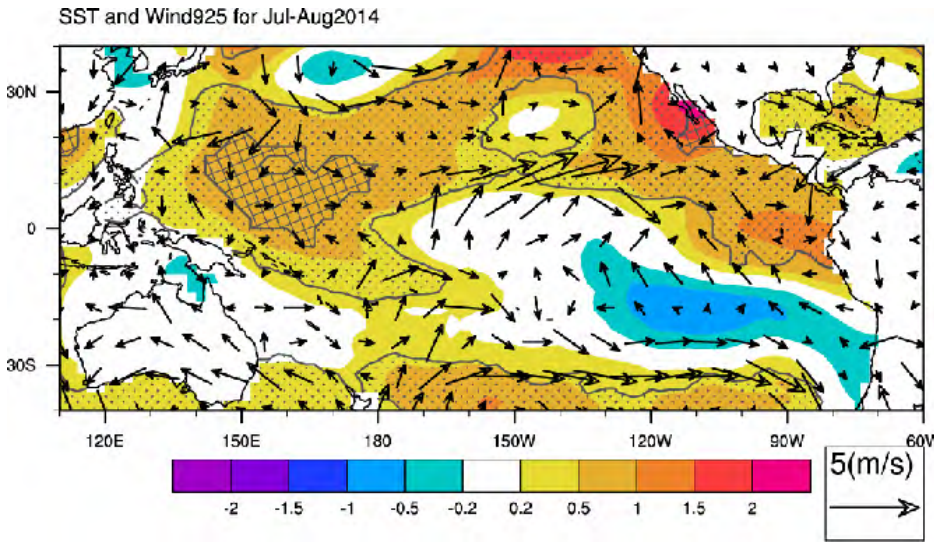


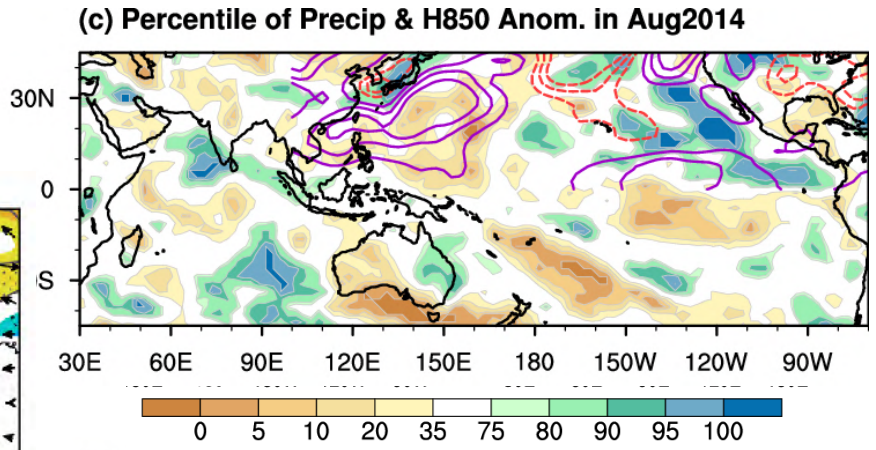
Prcip.& χ200 Anom. in Aug

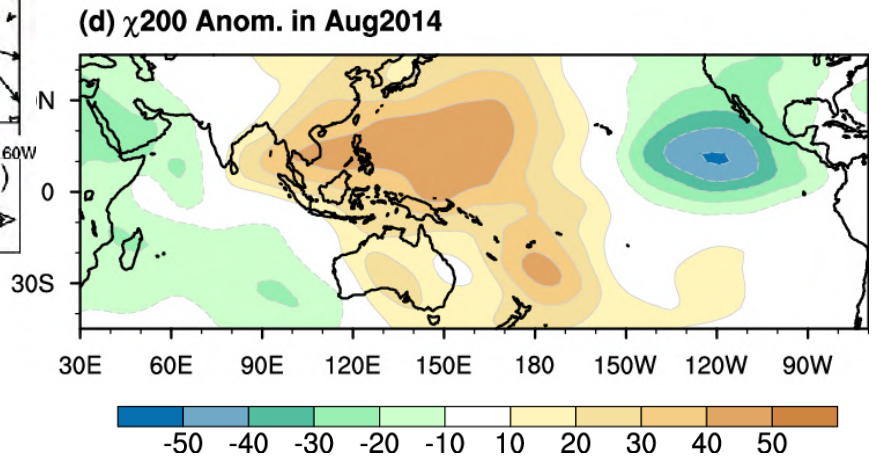


2014

Years of TC-genesis number in August over the WNP were 1.5 σ below normal during the period 1980-2014. They are, 1980, 1998, 2007,2011,and 2014







Contribution of ENP-SST associated cross equatorial flow

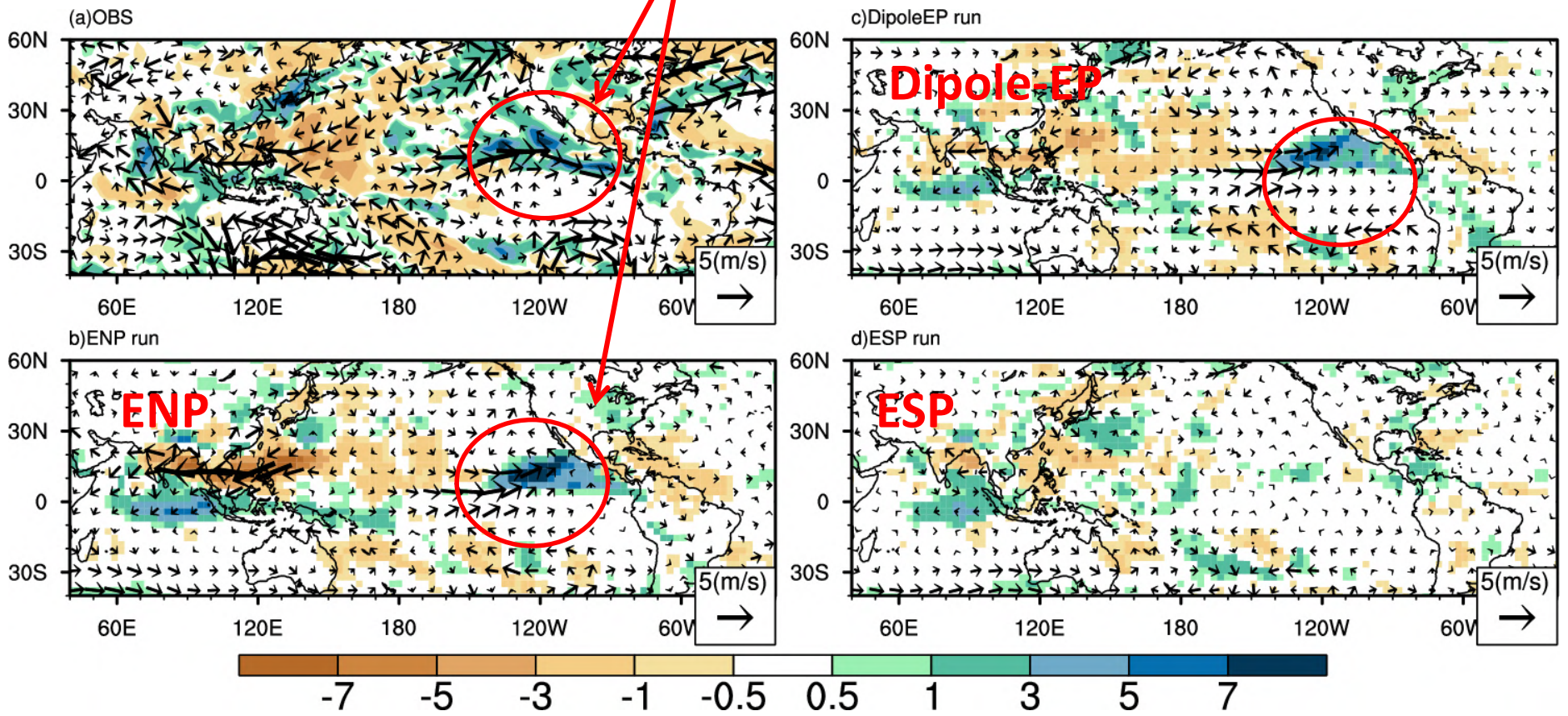
Hypothesis :

S-N dipole SSTA
→ enhanced cross equatorial flow
→ enhanced ITCZ
→ enhanced convection in ENP
→west-east overturning circulation

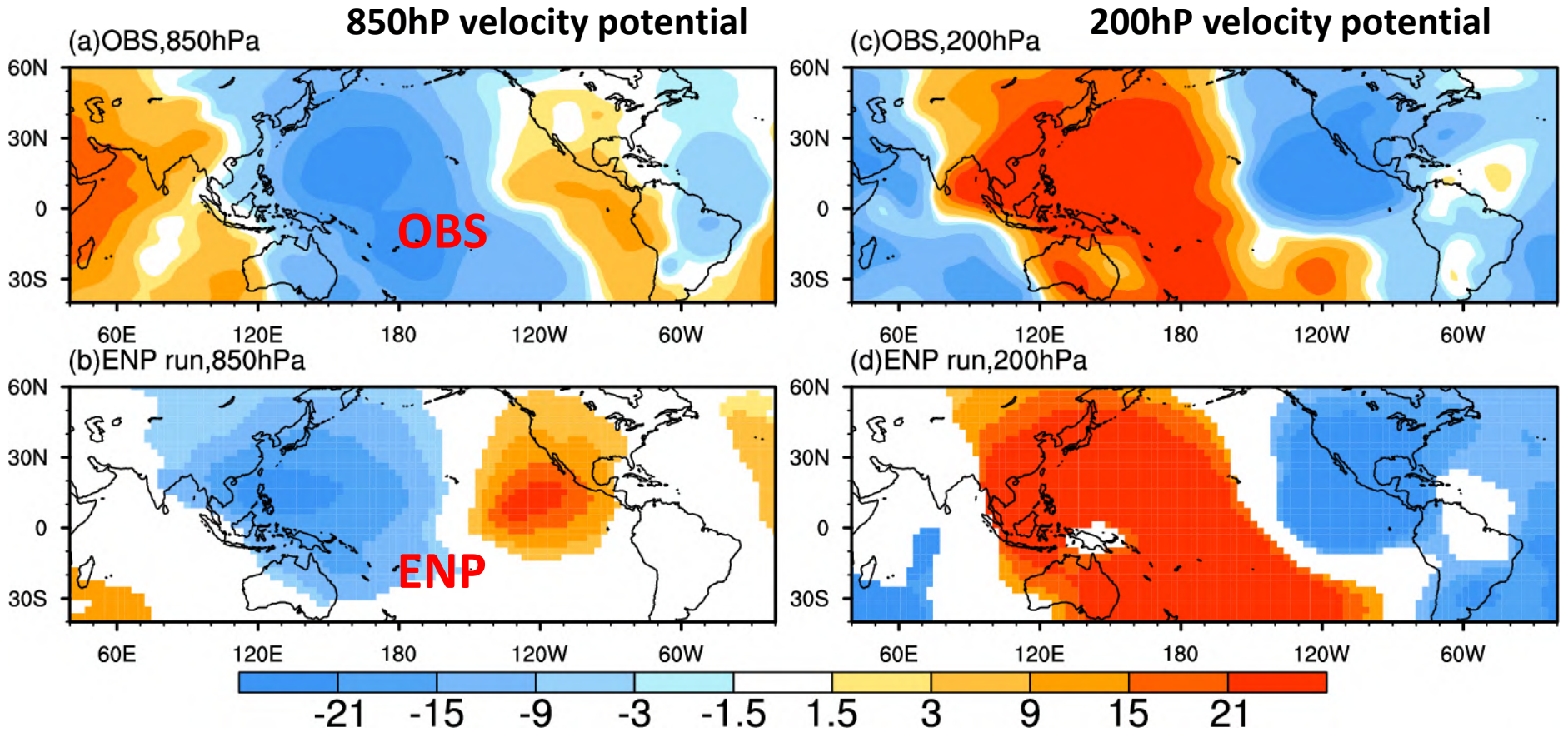
The positive ENSP-SSTA forced an anomalous cross equatorial flow in the EP, in which the associated divergence may enhance the convection in the ENP

Rainfall surplus and westerly wind anomaly were realistic simulated in ENP-exp

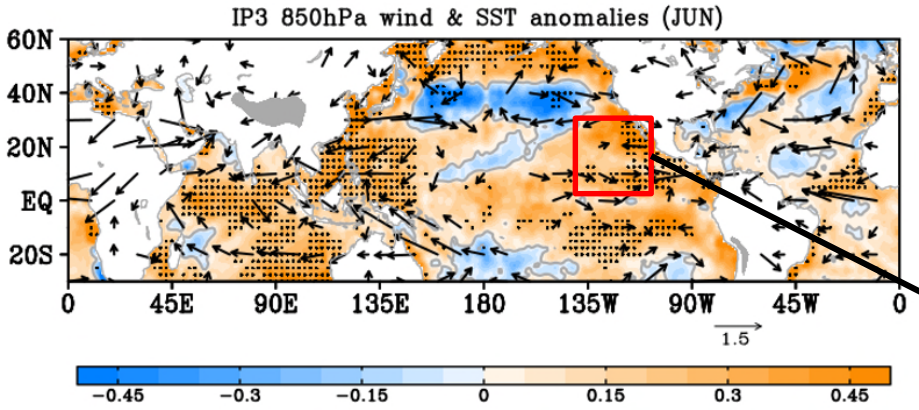
OBS

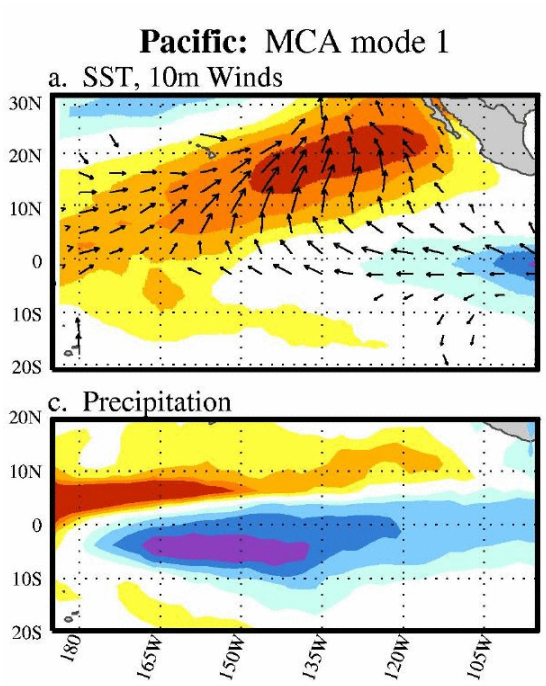


The positive ENP-SSTA generated an west-east overturning circulation anomaly, which in term the subsidence in the WNP may suppress the TC activity in the WNP

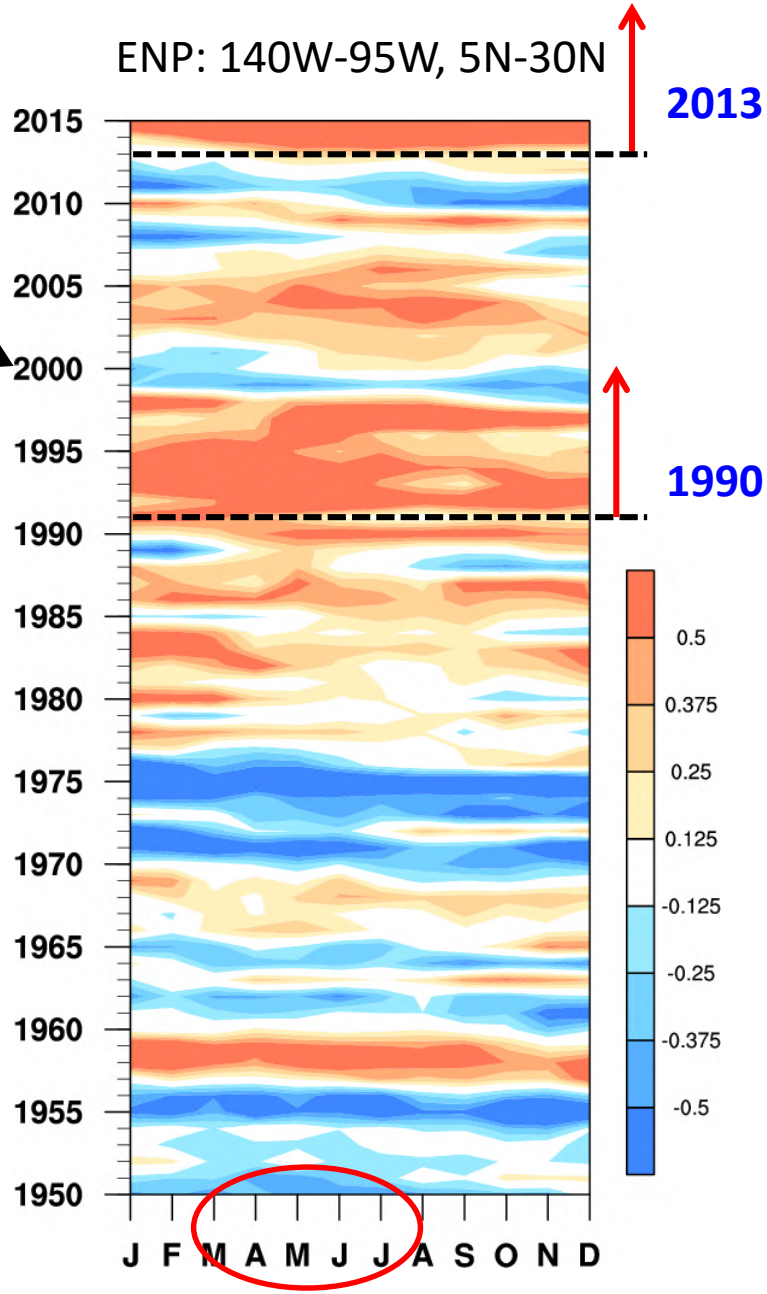


Indentify of SST warming in the ENP



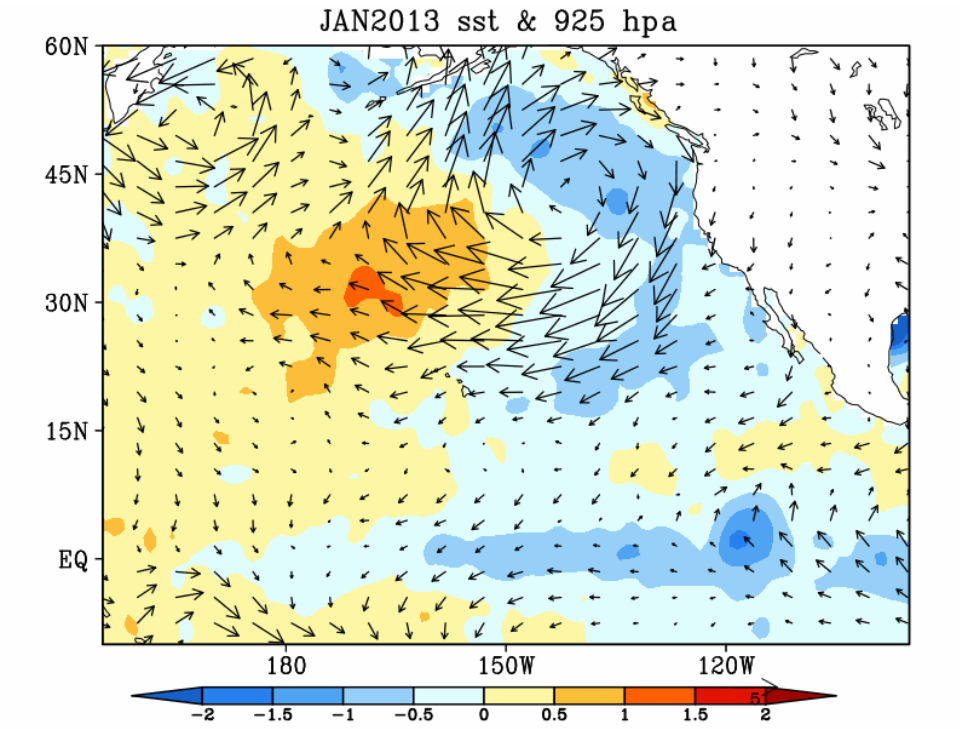


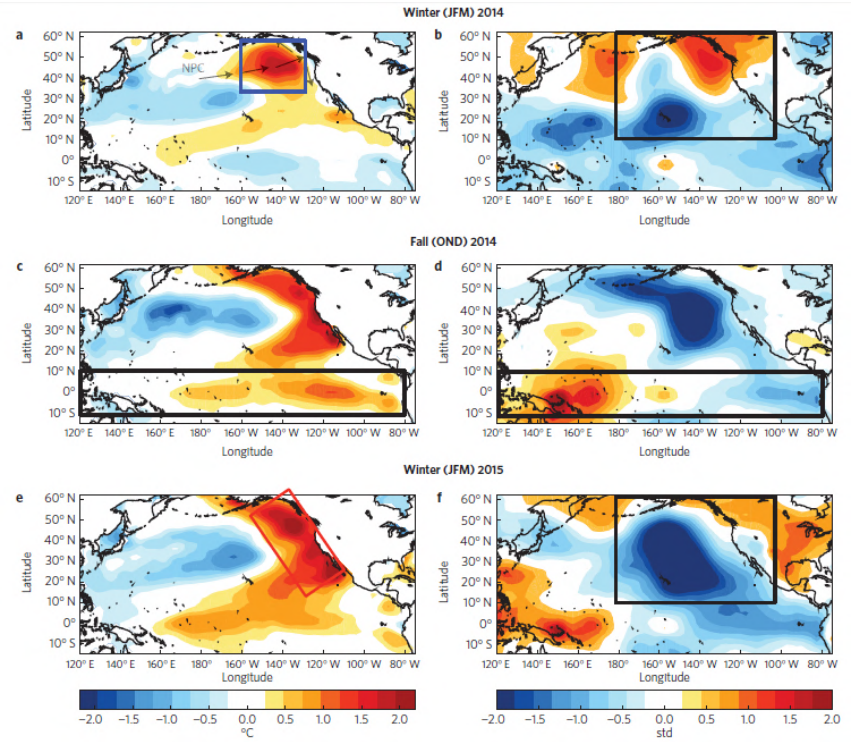
Chiang, & Vimont (2004).



Spring to early summer

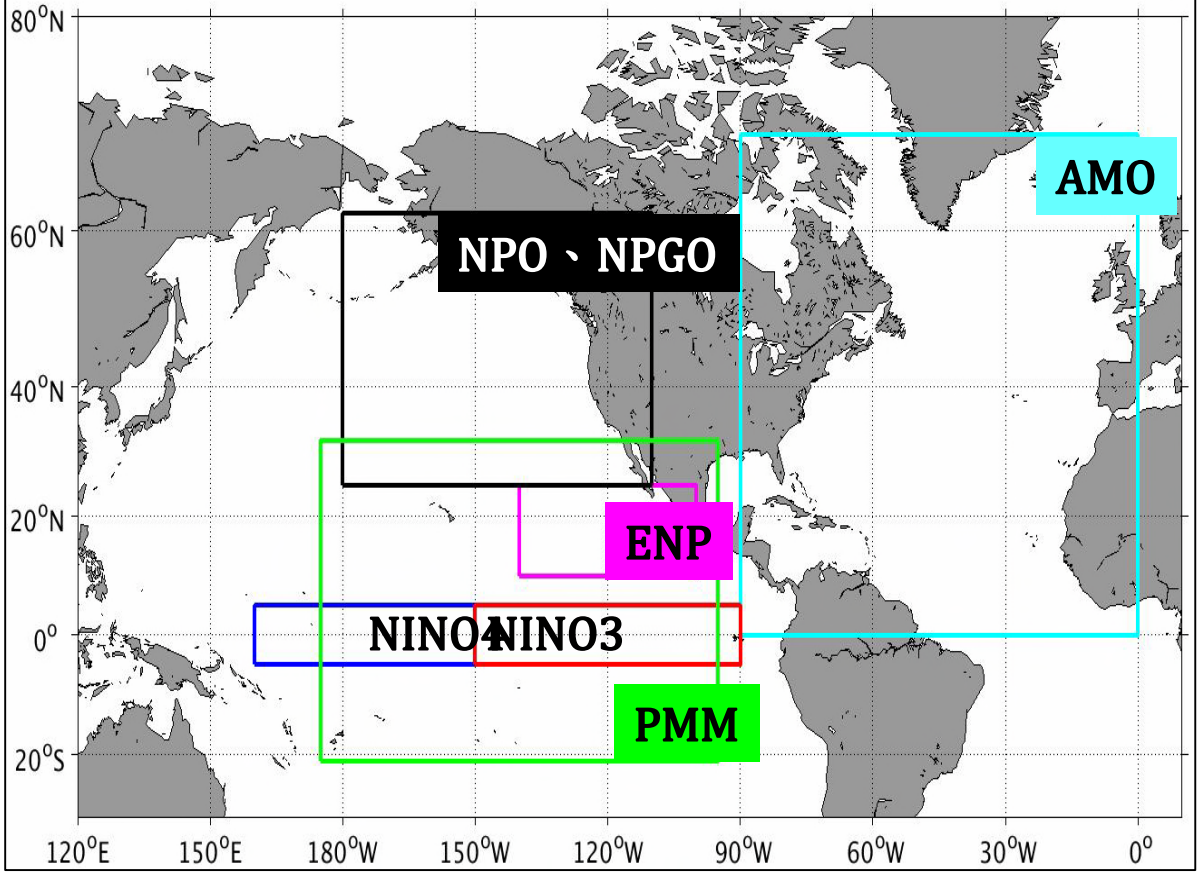
ENP-SST Warming since 2013



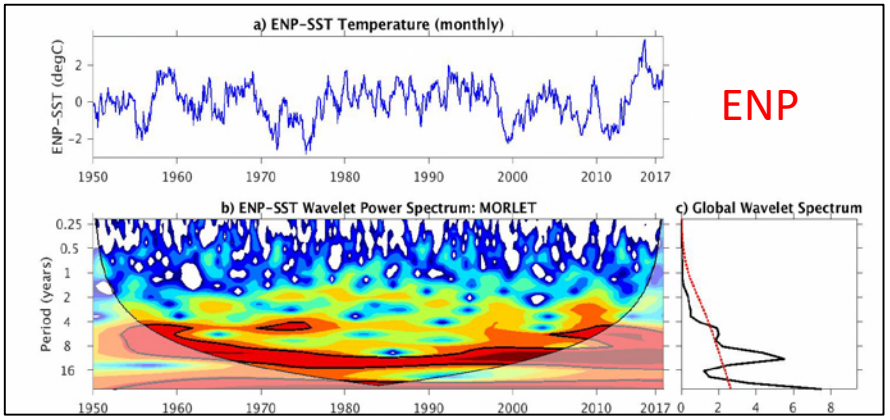


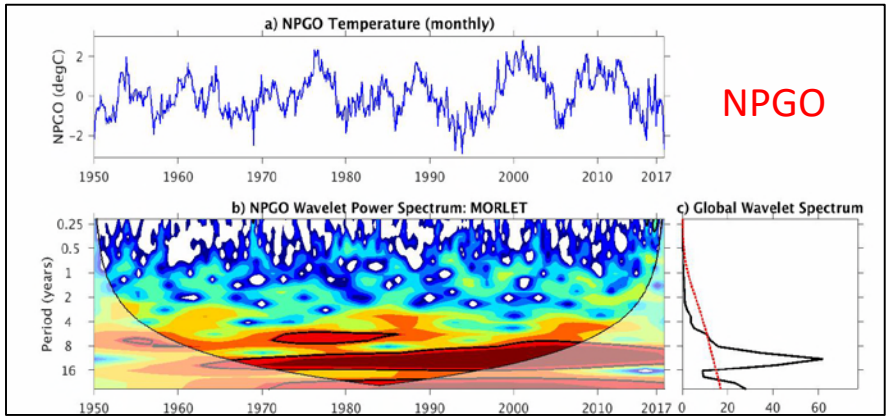
Lorenzo and Mantua (2016)

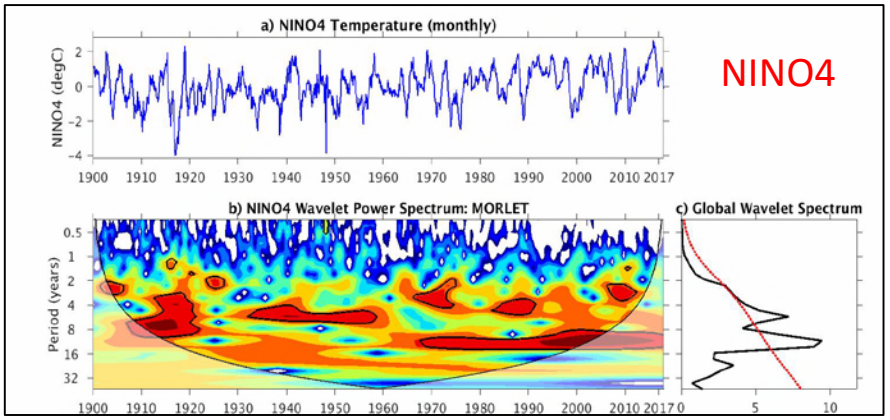
Data Information

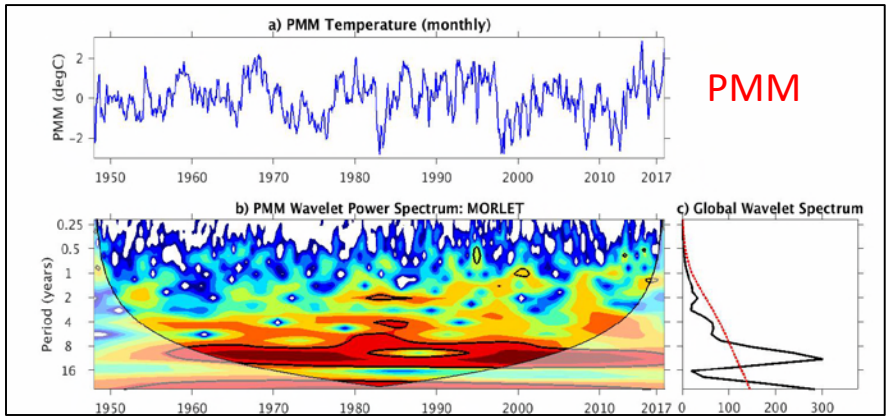


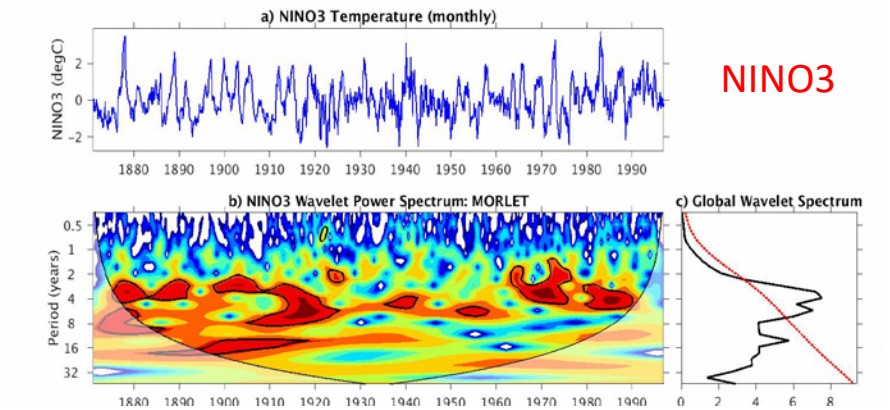
Index		Data	Time range	Interannual (yr)	Interdecadal (yr)
AMO	Atlantic Multi-Decadal Oscillation	monthly	1950/1-2017/12		7 – 12
ENP	Eastern North Pacific	monthly	1950/1-2017/12	4 – 8	8 – 16
		annually	1979-2099	2 – 6	
NPGO	North Pacific Gyre Oscillation	monthly	1950/1-2017/12	5 – 8	8 – 16
NINO3	Nino 3	monthly	1871/1-1996/12	2 – 8	12 – 16
NINO4	Nino 4	monthly	1900/1-2017/12	2 – 8	8 – 14
NPO	North Pacific Oscillation	monthly	1948/1-2017/12	0.25 – 1	
PMM	Pacific Meridional Mode	monthly	1948/1-2017/12	2 – 8	8 – 14

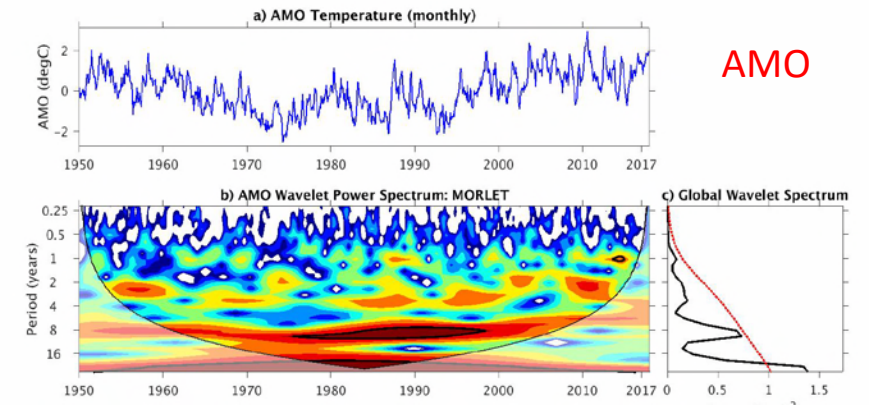

a) ENP-SST Temperature (monthly)
ENP-SST (degC)
ENP
b) ENP-SST Wavelet Power Spectrum: MORLET
c) Global Wavelet Spectrum
Period (years)


a) NPGO Temperature (monthly)
NPGO (degC)
NPGO
b) NPGO Wavelet Power Spectrum: MORLET
c) Global Wavelet Spectrum
Period (years)


a) NINO4 Temperature (monthly)
NINO4 (degC)
NINO4
b) NINO4 Wavelet Power Spectrum: MORLET
c) Global Wavelet Spectrum
Period (years)


a) PMM Temperature (monthly)
PMM (degC)
PMM
b) PMM Wavelet Power Spectrum: MORLET
c) Global Wavelet Spectrum
Period (years)


a) NINO3 Temperature (monthly)
NINO3 (degC)
NINO3
b) NINO3 Wavelet Power Spectrum: MORLET
c) Global Wavelet Spectrum
Period (years)


a) AMO Temperature (monthly)
AMO (degC)
AMO
b) AMO Wavelet Power Spectrum: MORLET
c) Global Wavelet Spectrum
Period (years)

1960: r of 1950-1970
1961: r of 1951-1971
1962: r of 1952-1972

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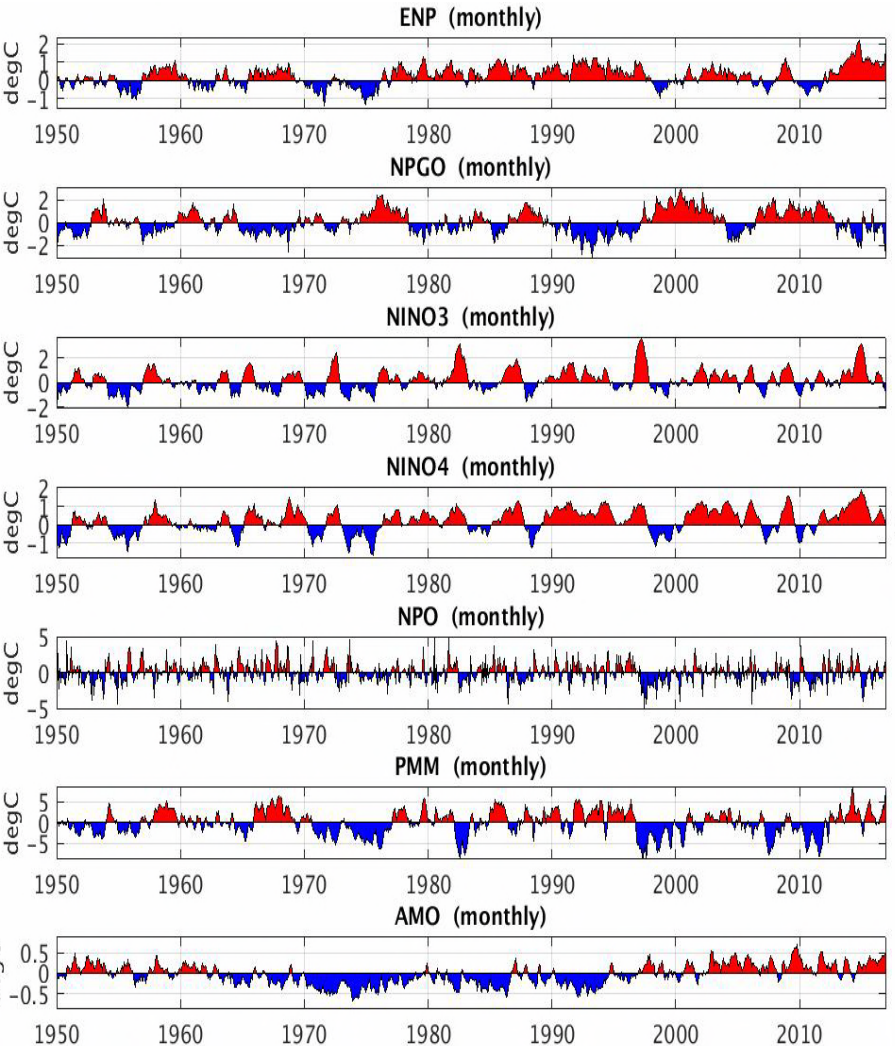
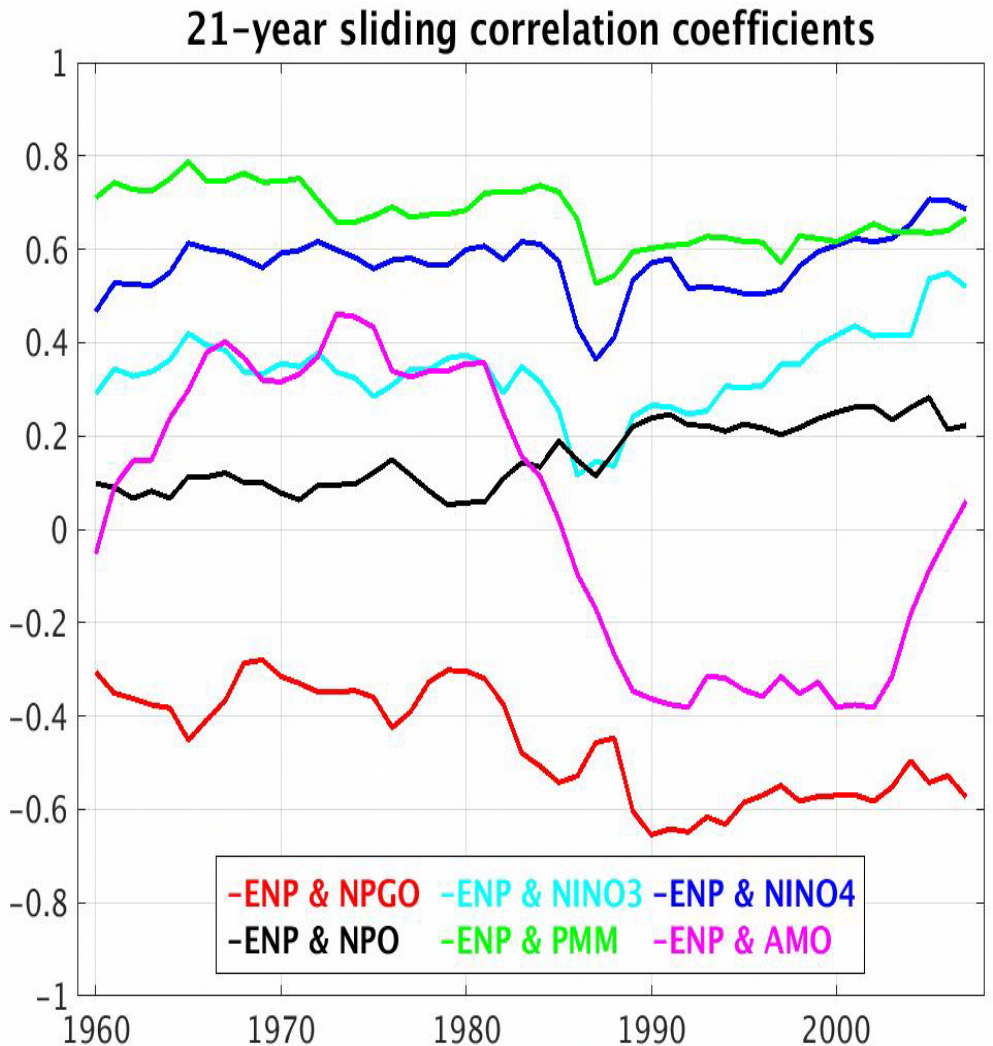
.
.

2007: r of 1997-2017

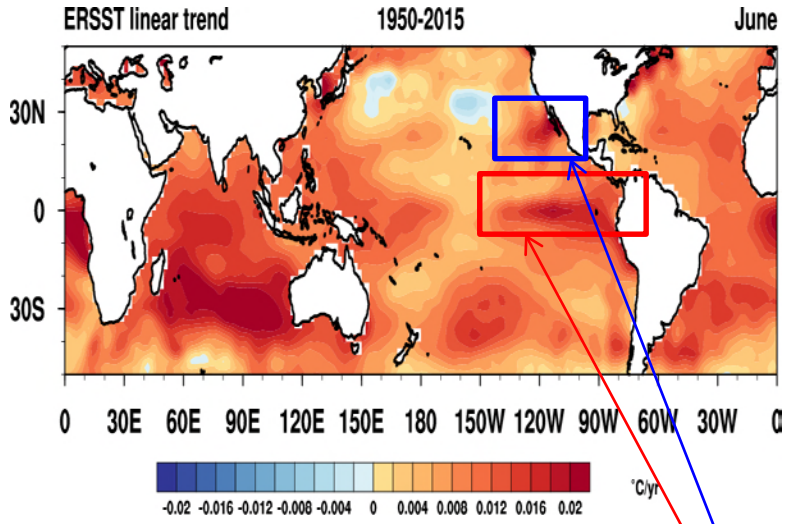
21-year sliding (1960-2007)

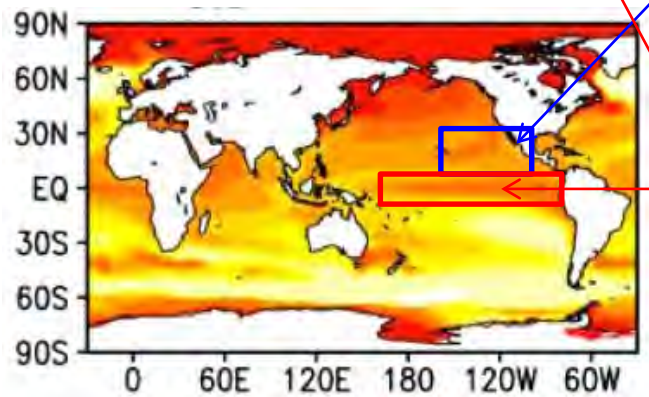
ENP





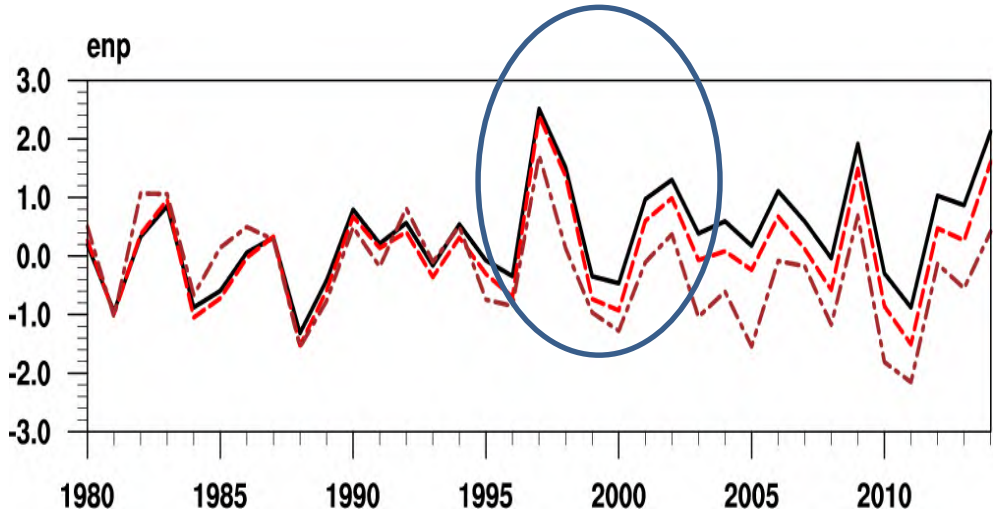
Linear warming trend





CMI5-RCP8.5 SST future Change

Warming trend contributes approximately 20-30% in ENSP-SST warming



pmm-like

enso-like

Raw data

Detrend: least square

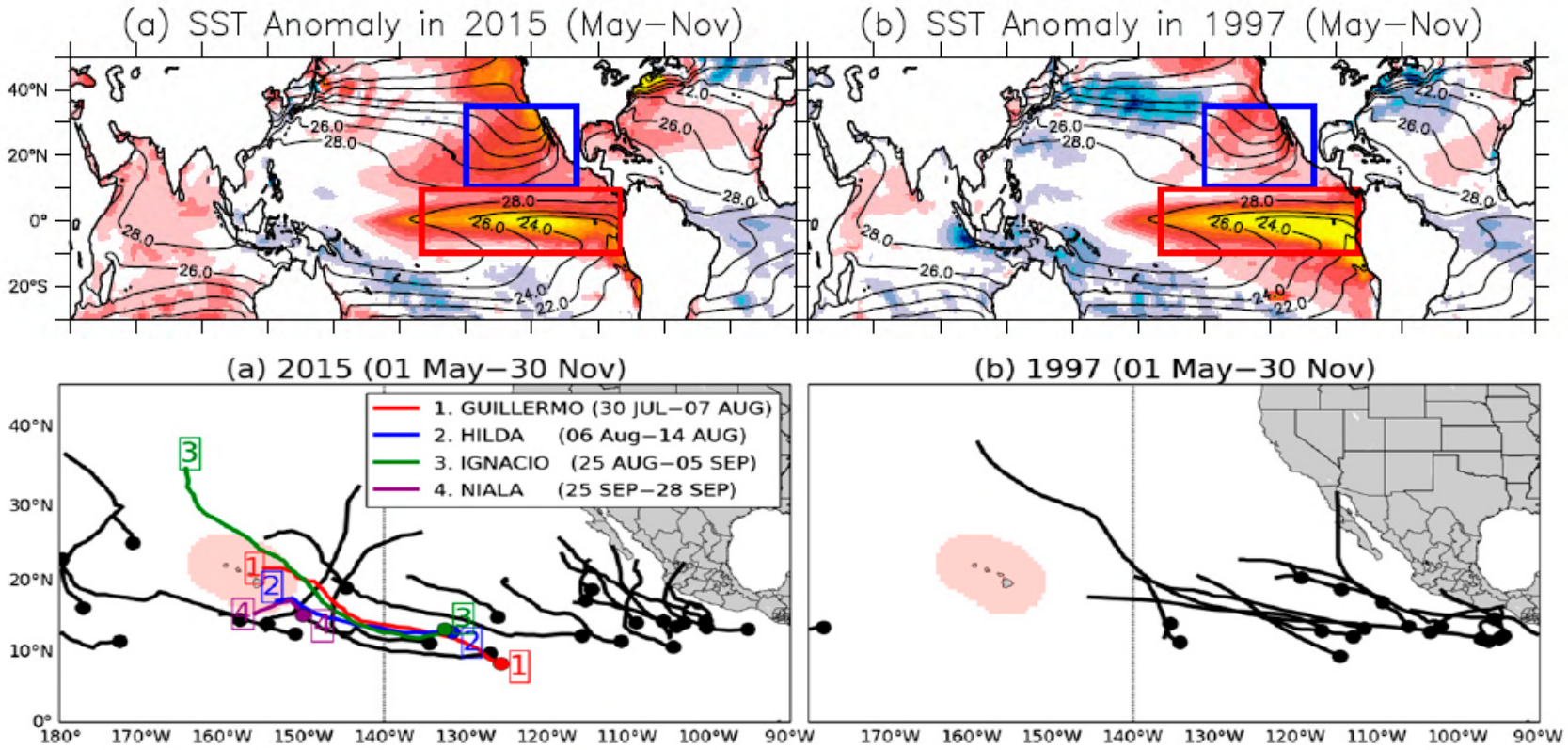
Detrend: remove global mean

Possible Impact on East Asian weather and climate

Three examples:

- **TC genesis position in the WNP**
- Distinct effects of the two strong El Niño events in 2015–2016 and 1997–1998 on the WNPSM and TC activity

Role of ENP-SST in the extreme Eastern Pacific Hurricane season in 2015



Murakami et al 2017

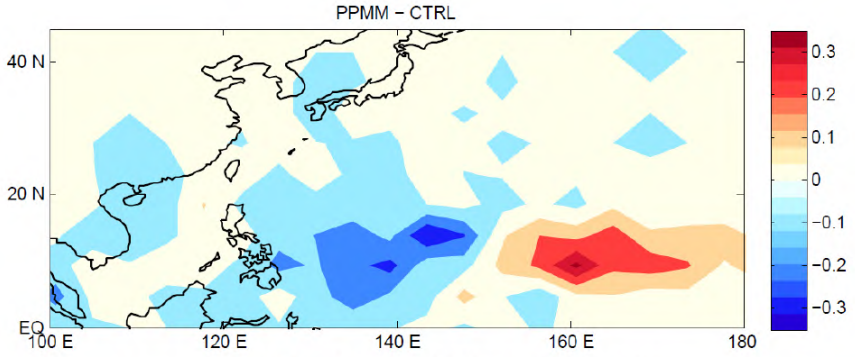
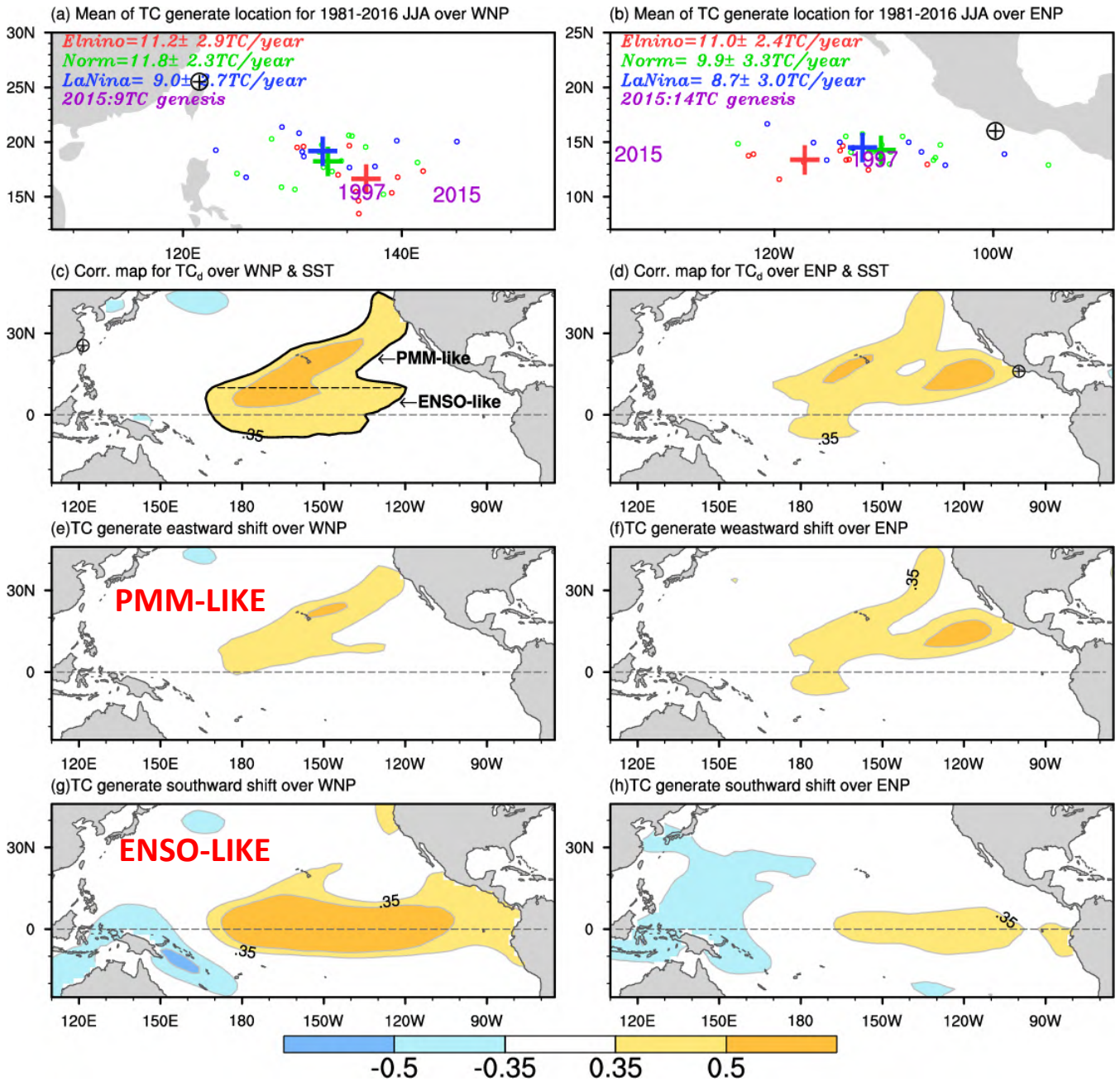


Figure 11. As in Fig.10, but for TC genesis.

PMM effect: Zhang et al. 2015

Modifies TC-genesis position to shifts eastward

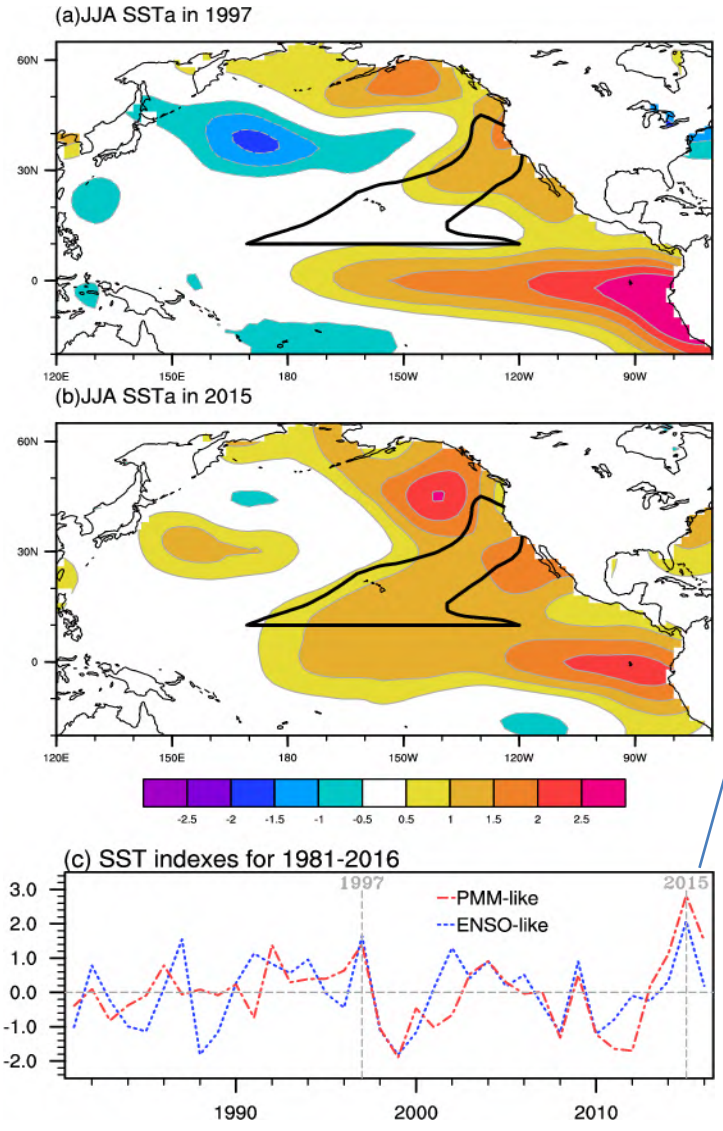


TC(Pos)

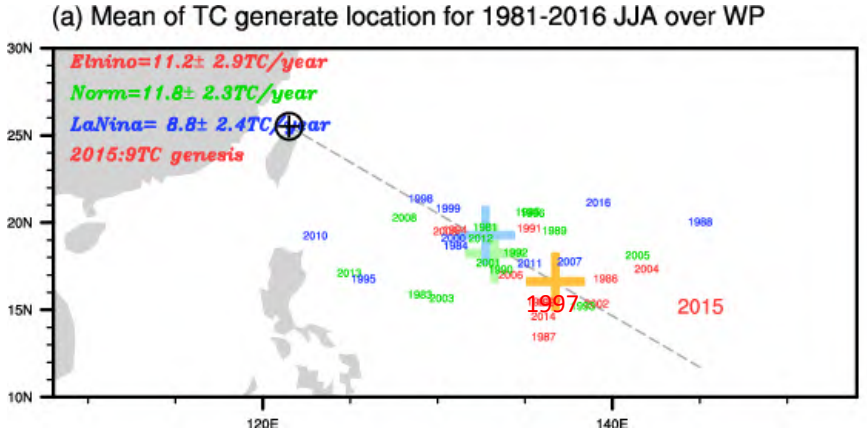
TC(Lon)

TC(Lat)

Hong et al. 2017
JCLI (in revision)

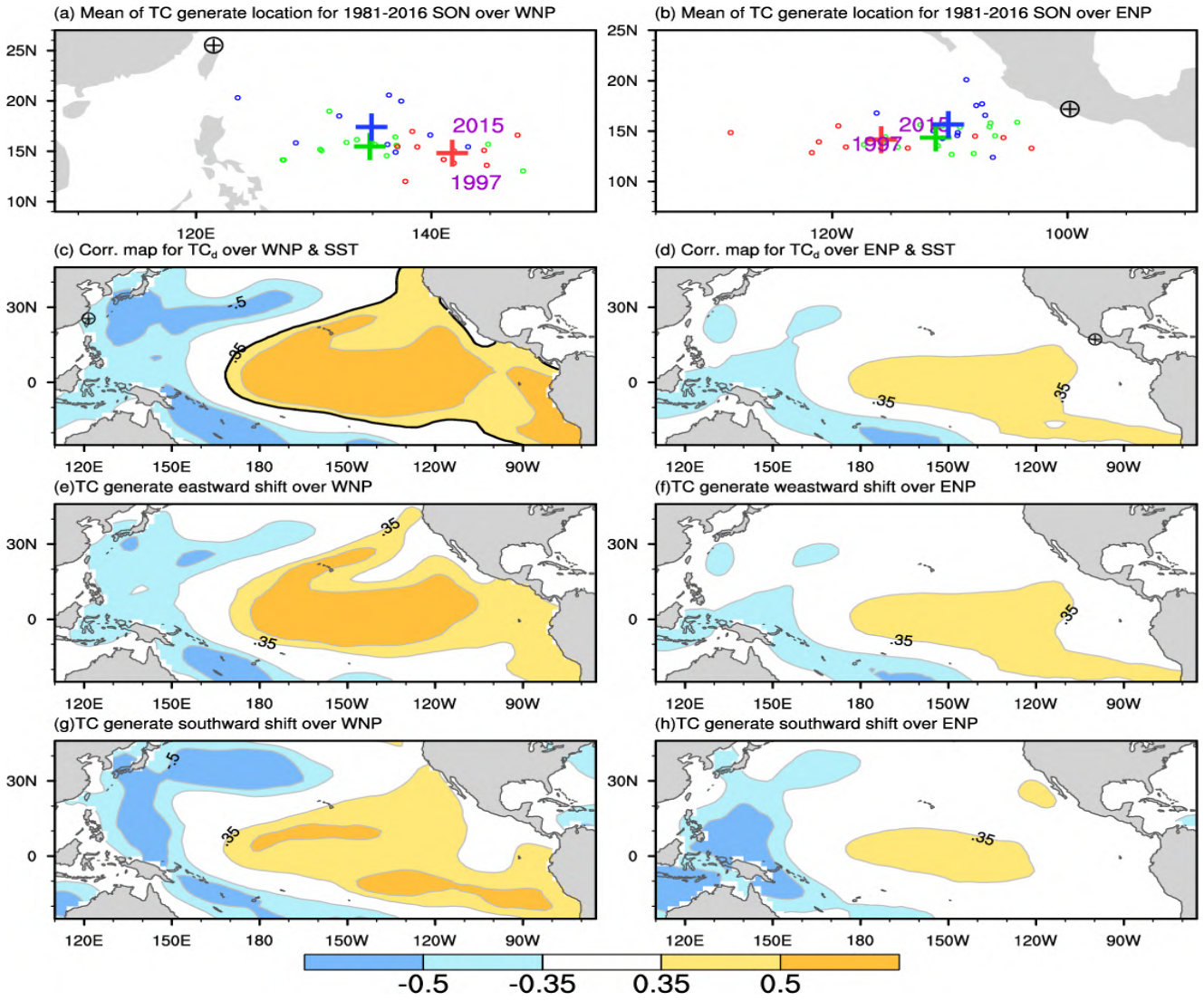


Whereas the ENSO-like SSTA in 1997 and 2015 were approximately equal, the amplitude of PMM-like SSTA in 2015 was approximately twice as large as that in 1997.



The TC genesis position in 2015 shifted unprecedentedly eastward to 150°E, approximately 10 longitudinal degrees farther to the east compared with 1997

SON



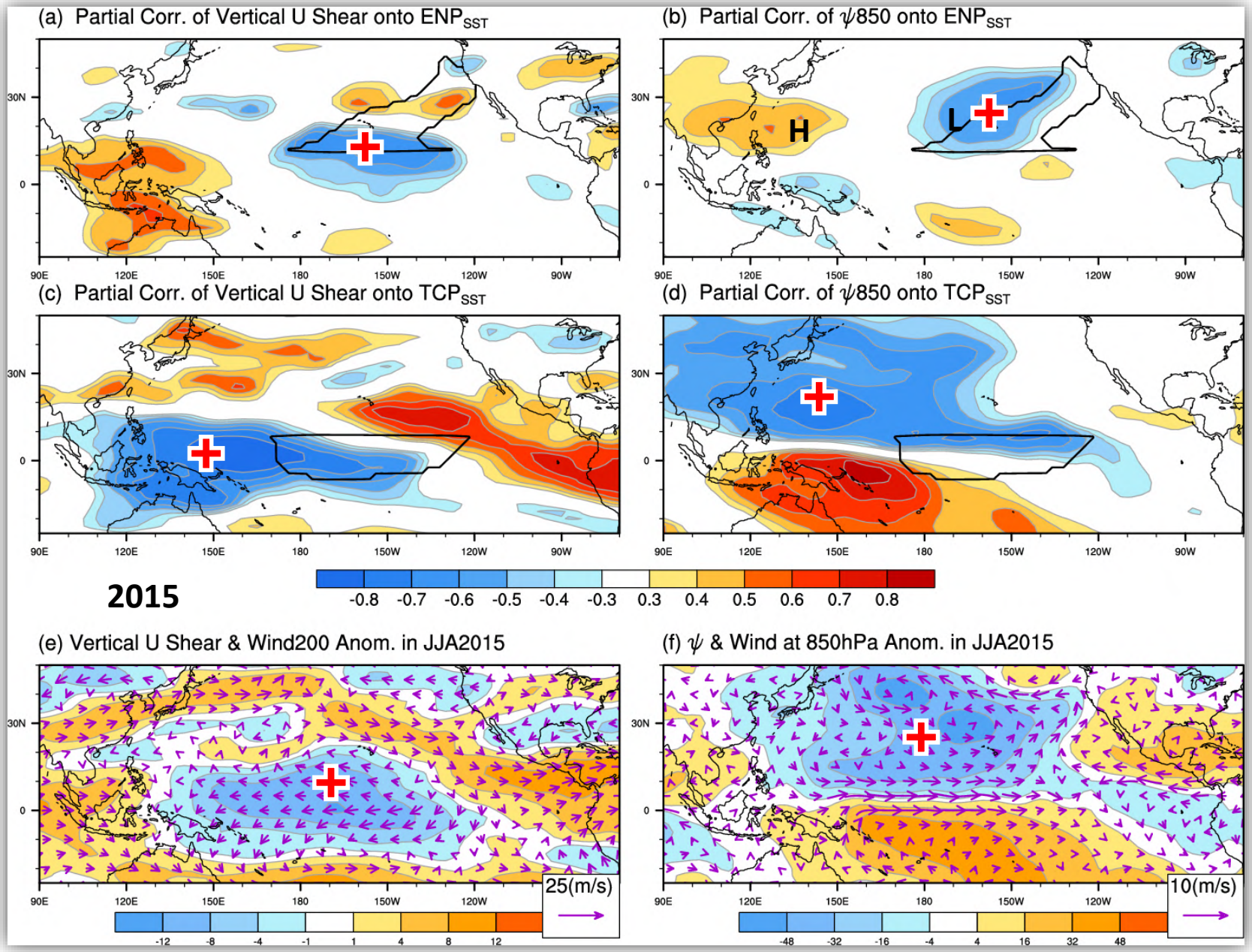
The effect OF PMM-like SST in SON is insignificant

ENSO-like SST dominates in SON

Possible path PMM-like SST affects the TC genesis position

Vertical wind shear

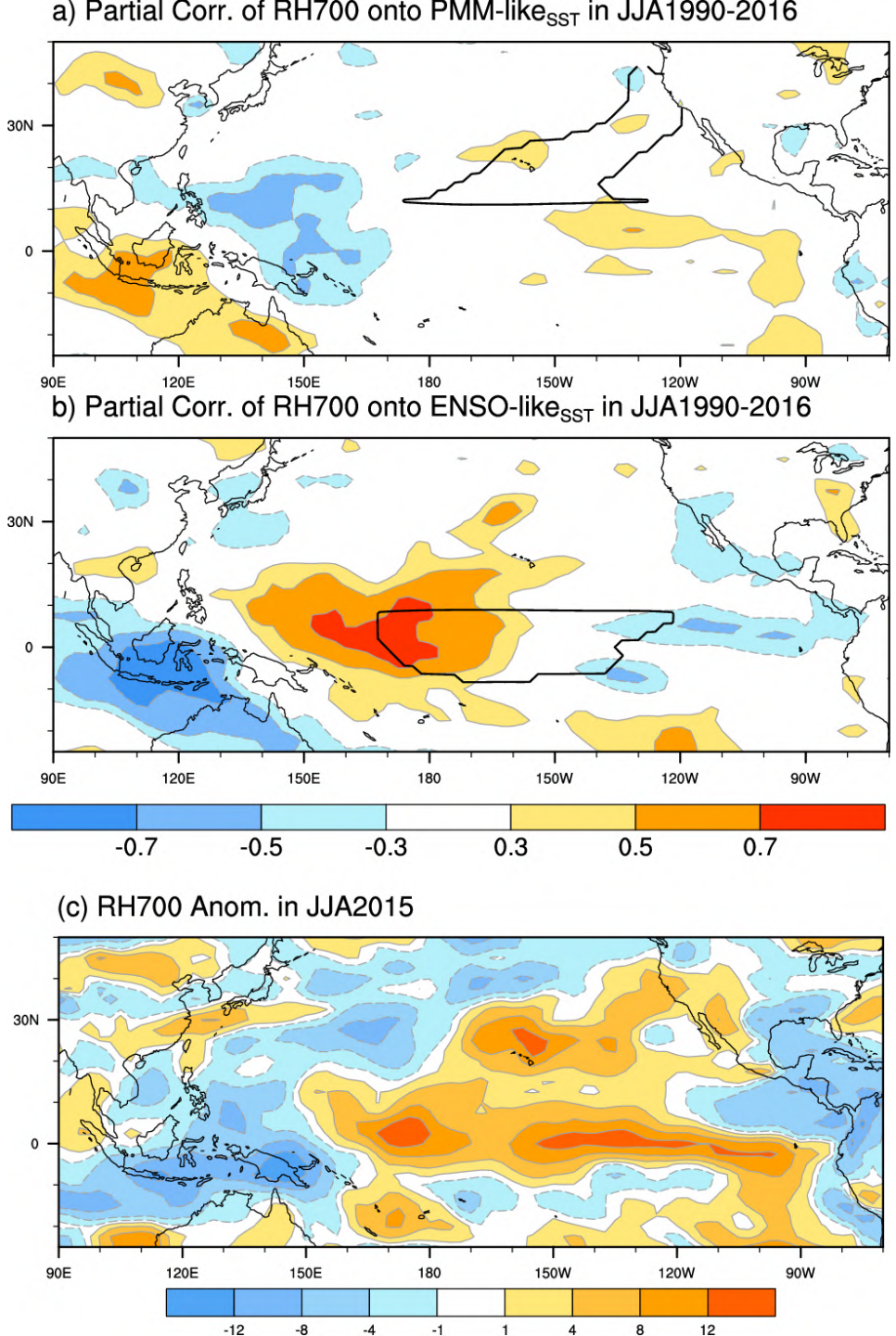
850hPa sreamfunction

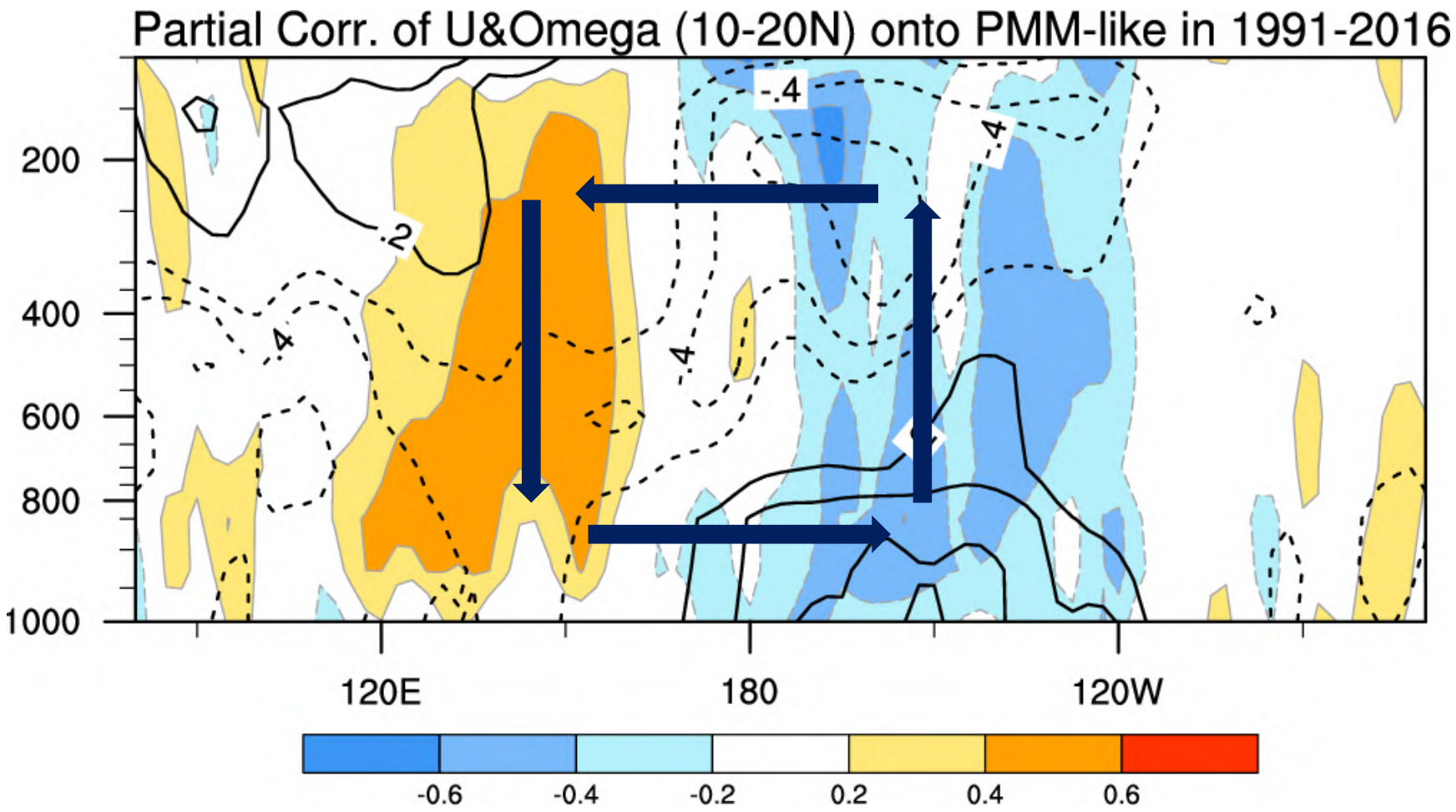


PMM-like SST

ENSO-like SST

OBS

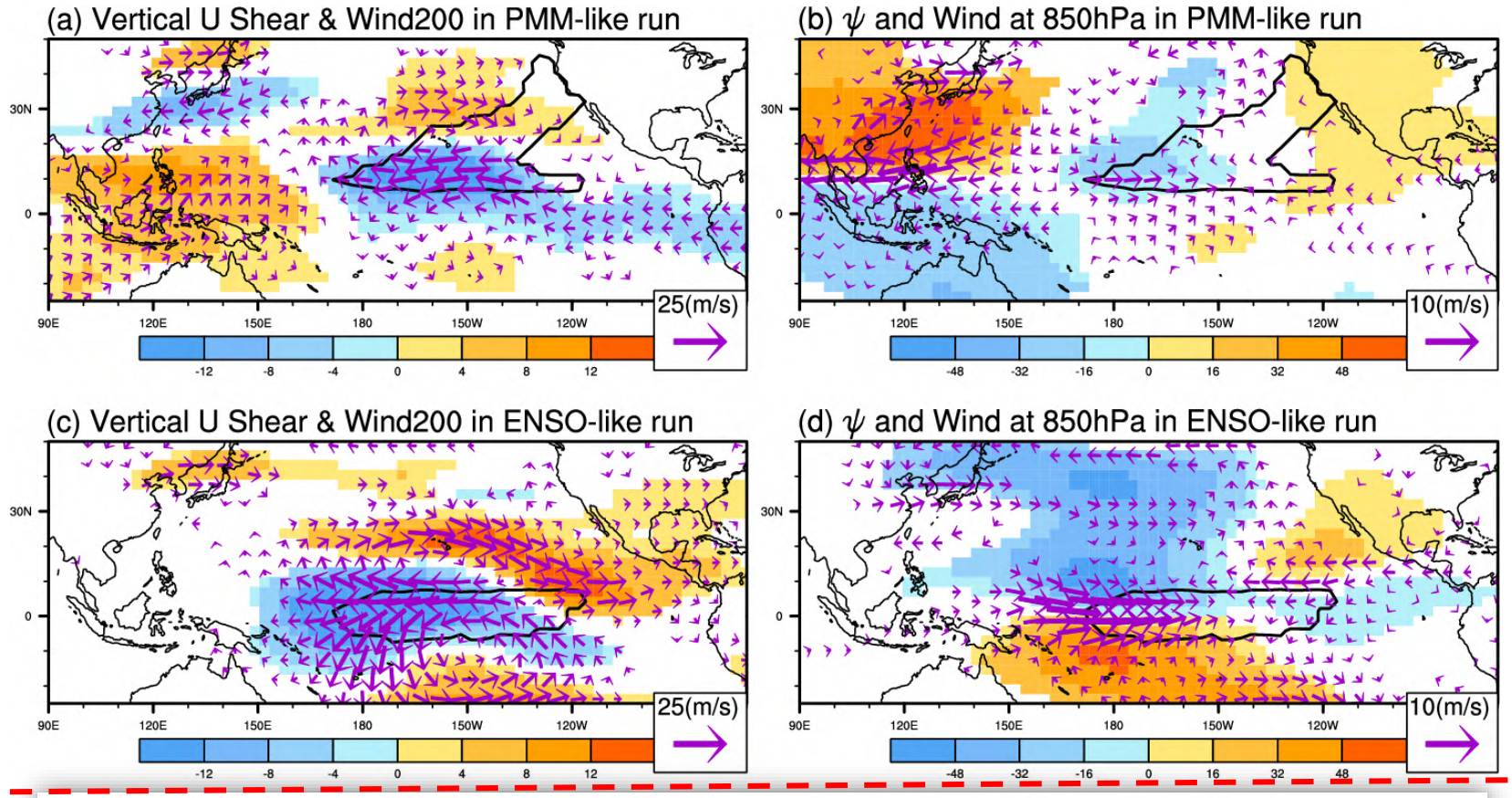




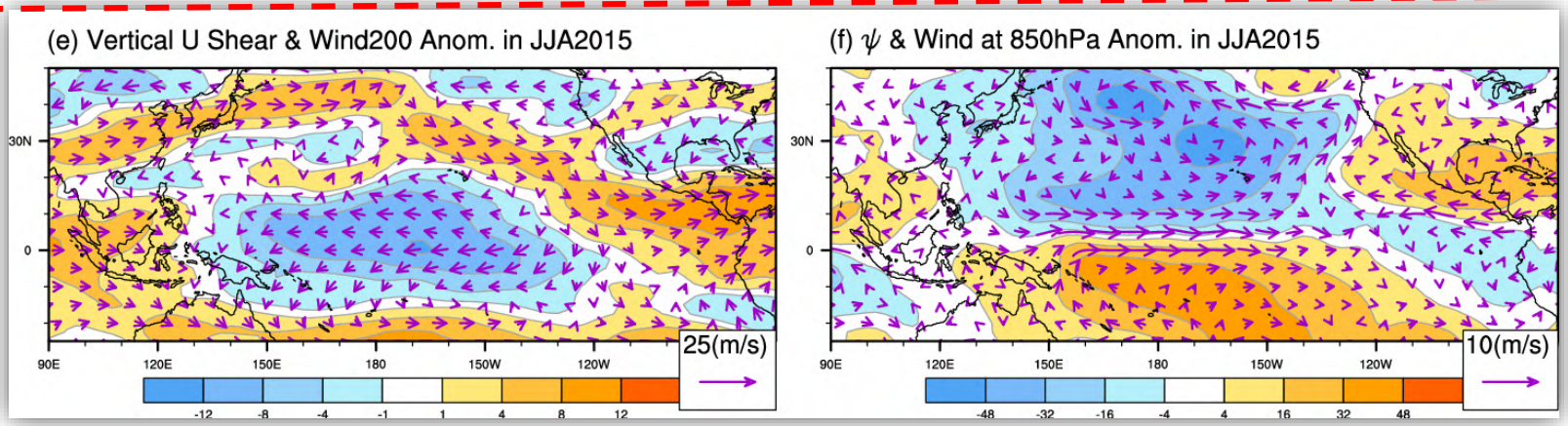
Shading: omega

Contour: zonal wind

Numerical Experiment



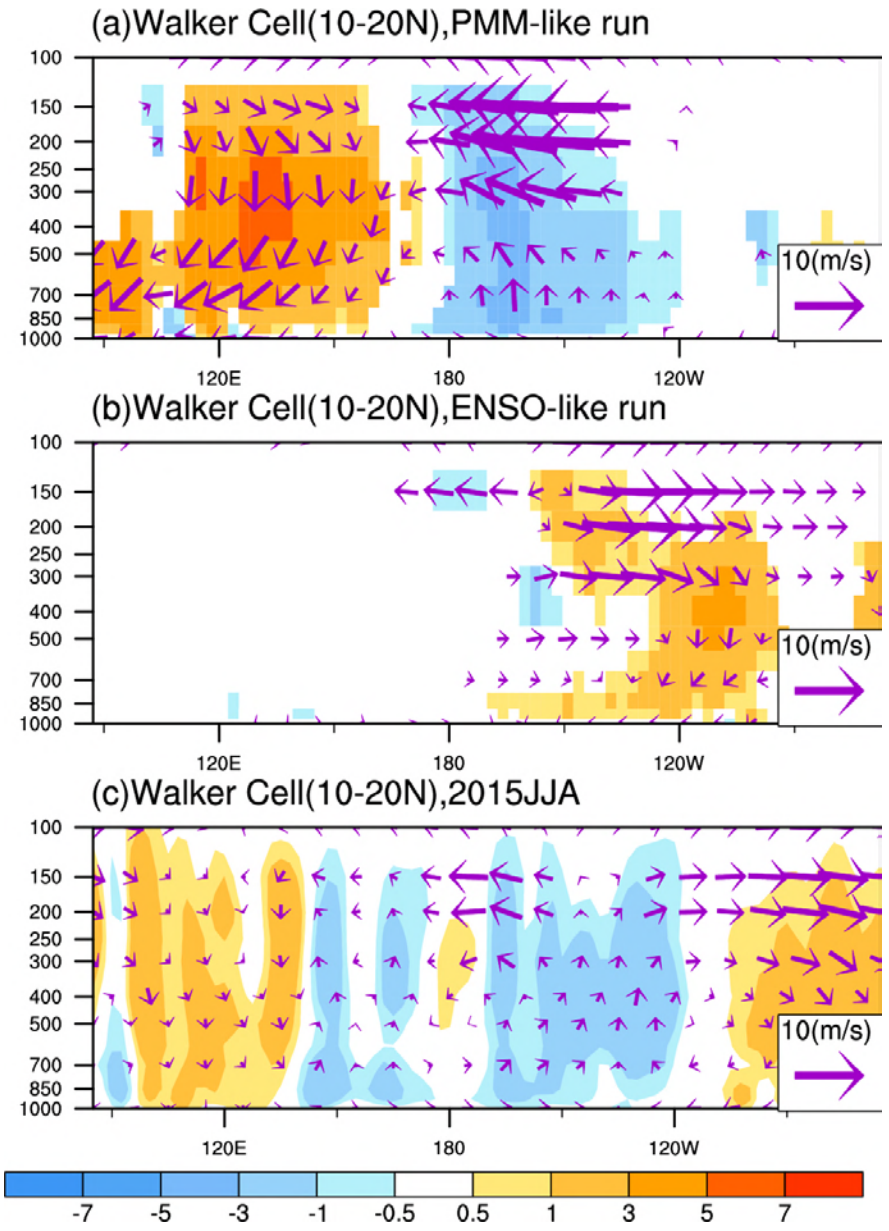
obs



PMM-like SST

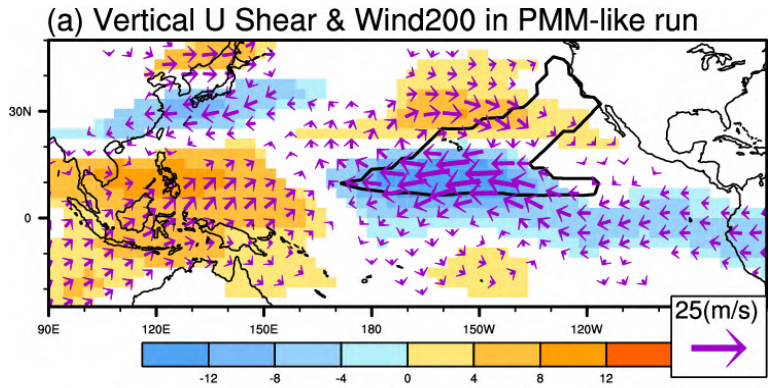
ENSO-like SST

OBSERVATION

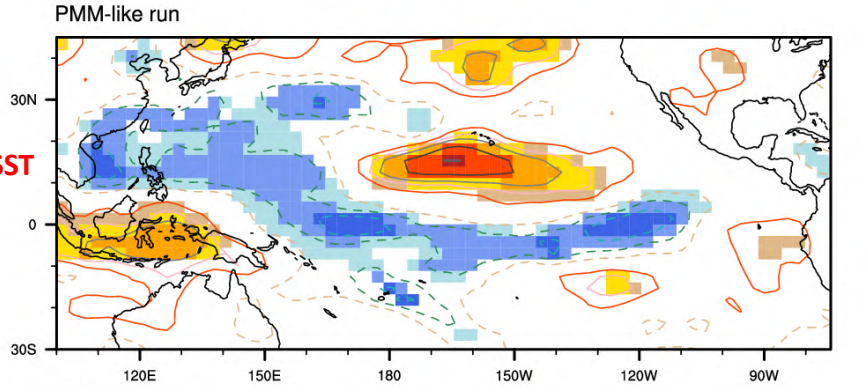


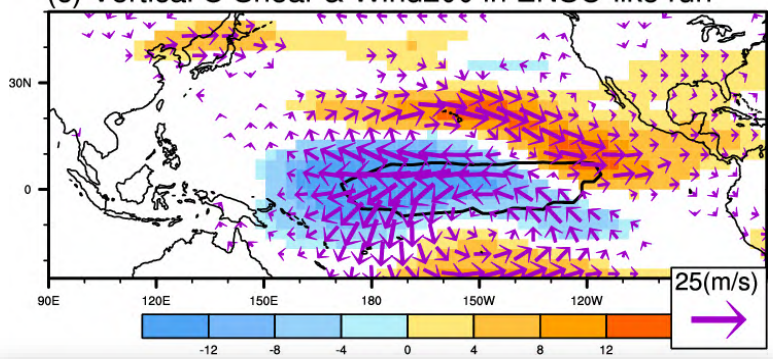
Vertical wind shear

700hPa relative humidity

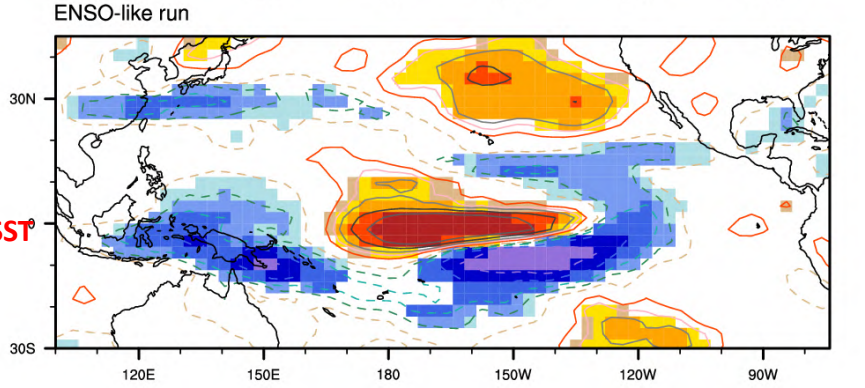


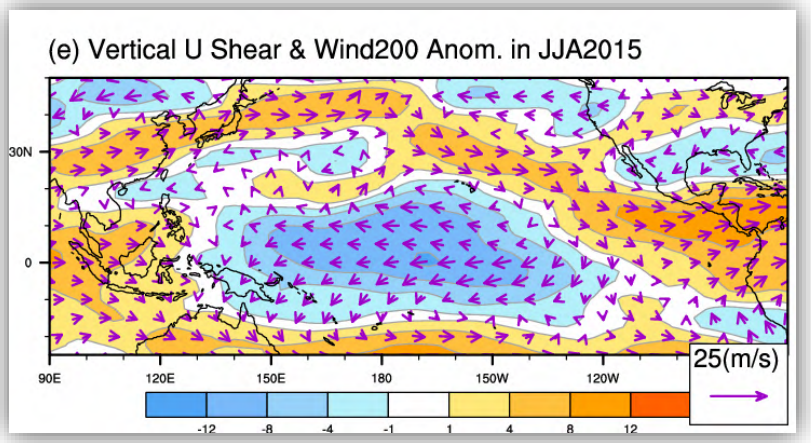
PMM-like SST



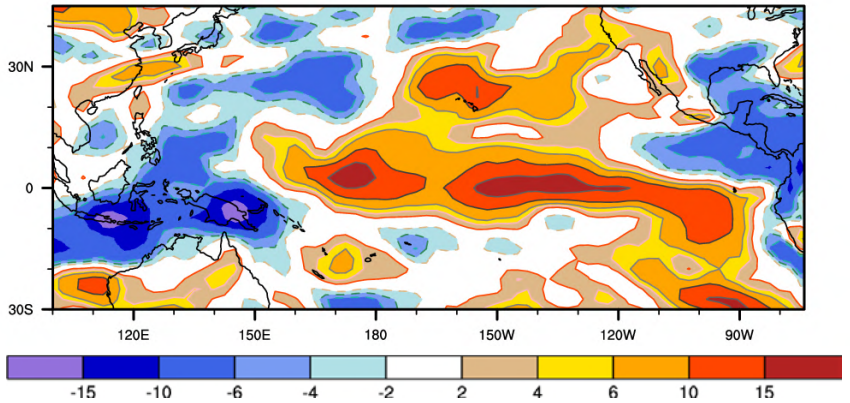


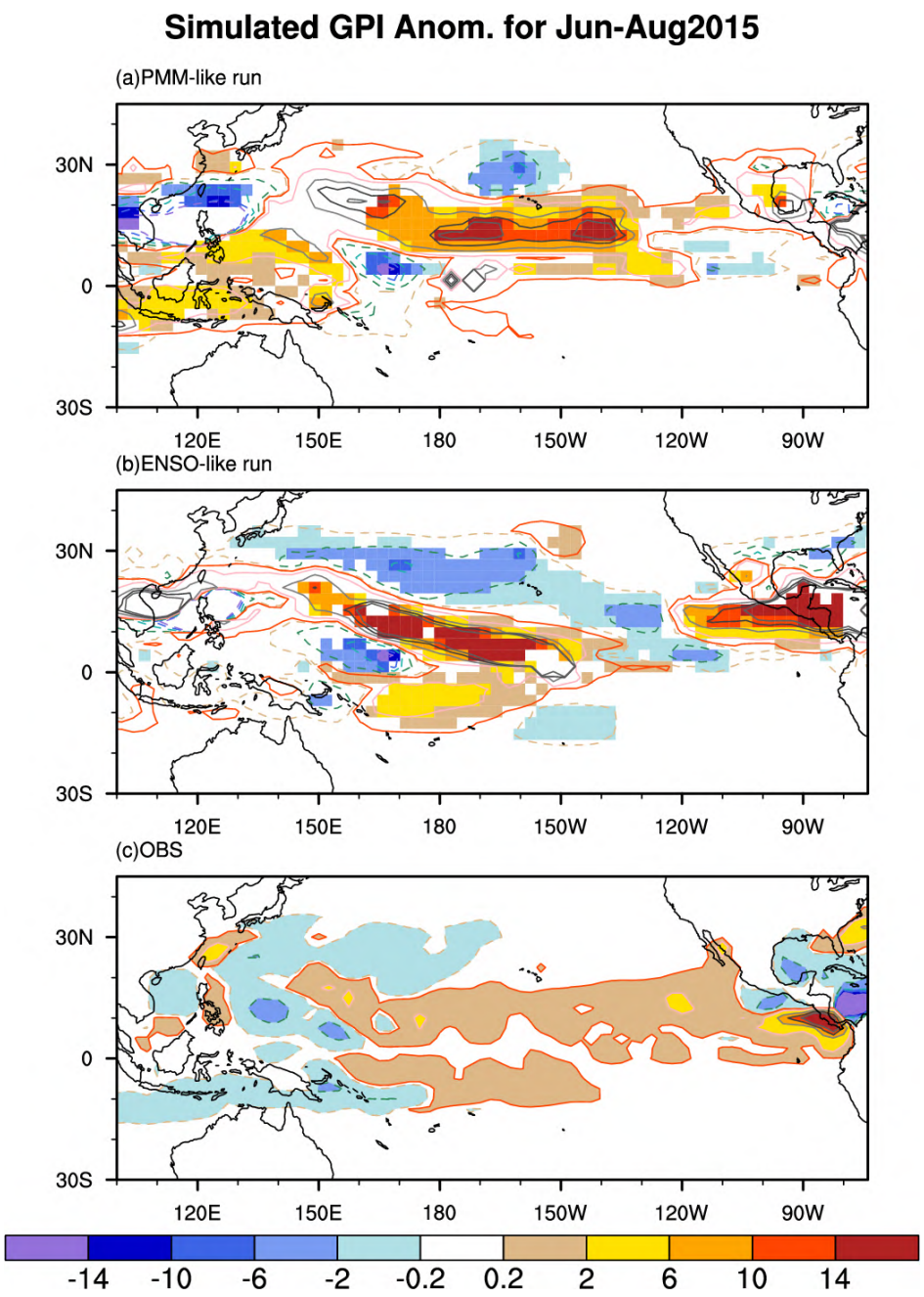
ENSO-like SST





OBS





$$GPI = |10^5 \eta|^{3/2} (H/50)^3 (V_{pot}/70)^3 (1+0.1V_{shear})^{-2}$$

Emanuel and Nolan 2004

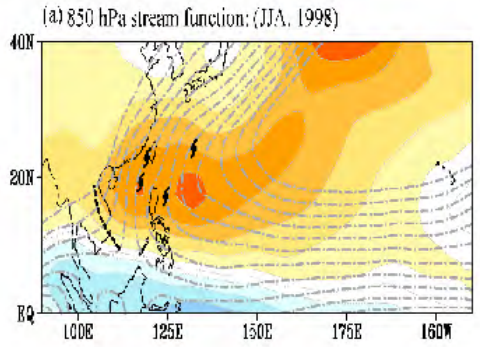
η : 850 hpa absolute vorticity

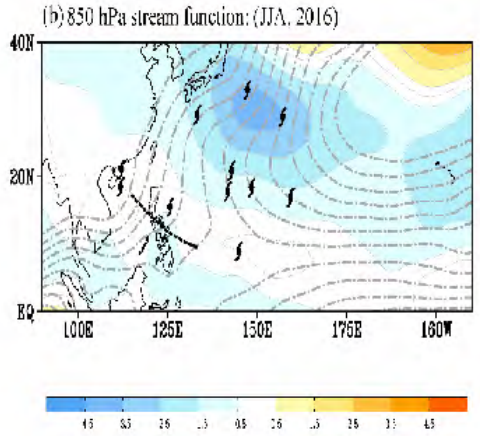
H : 700 hpa relative humidity

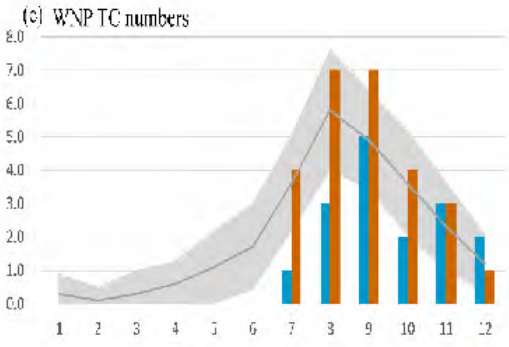
V_{pot} : potential intensity

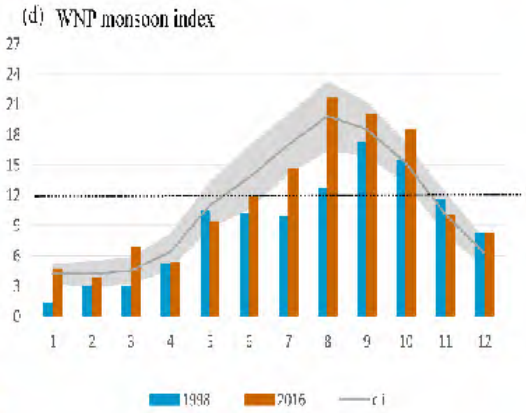
V_{shear} : wind shear

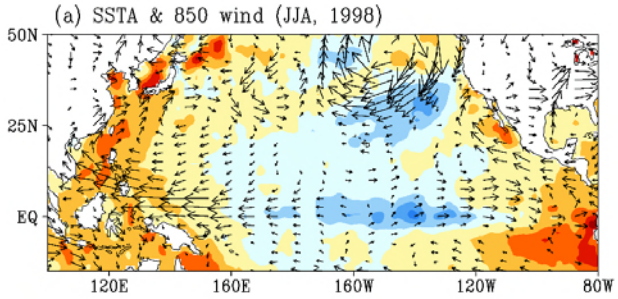
Distinct effects of the two strong El Niño events in 2015–2016 & 1997–1998 on the WNPSM and TC activity

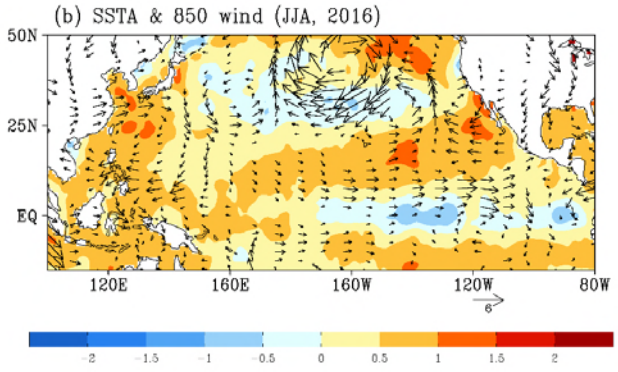


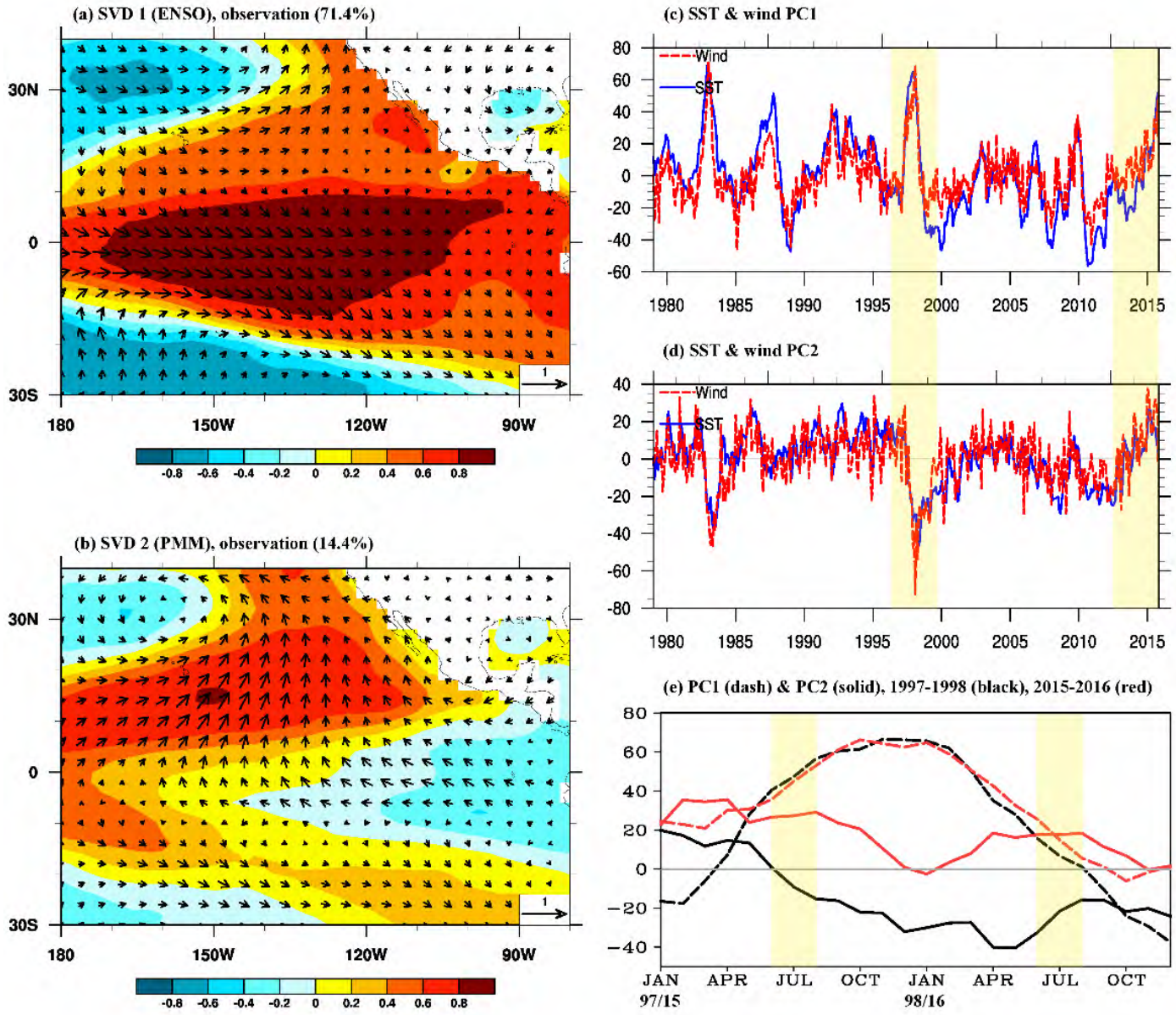


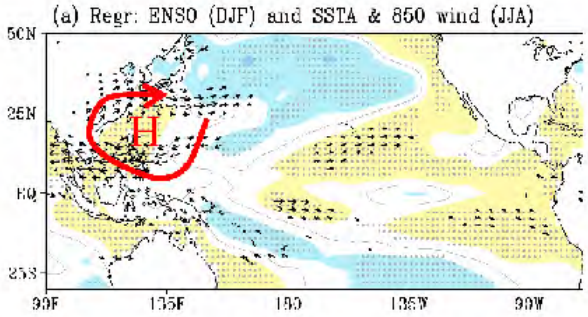


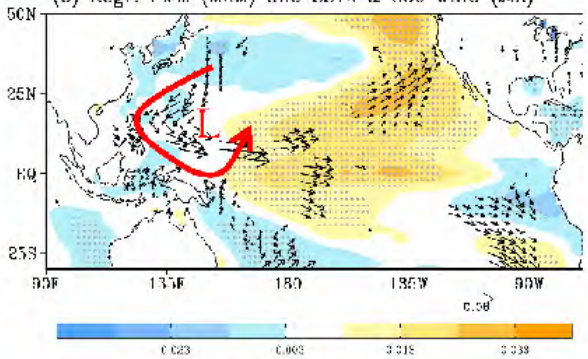


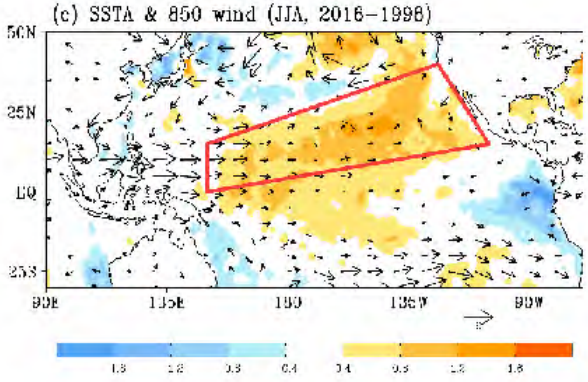


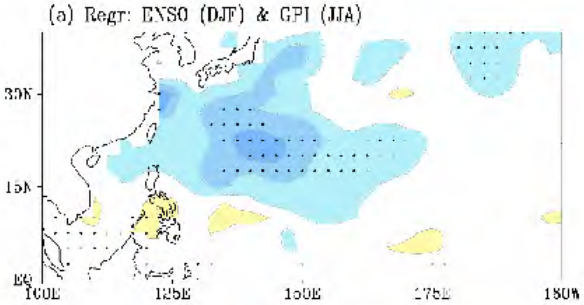


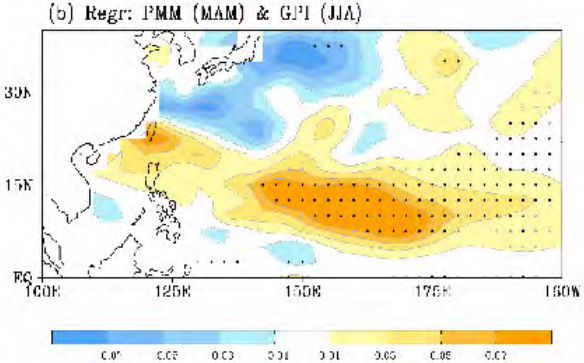

(a) SVD 1 (ENSO), observation (71.4%)
30N
0
30S
180
150W
120W
90W
-0.8 -0.6 -0.4 -0.2 0 0.2 0.4 0.6 0.8
(b) SVD 2 (PMM), observation (14.4%)
(c) SST & wind PC1
Wind
SST
(d) SST & wind PC2
(e) PC1 (dash) & PC2 (solid), 1997-1998 (black), 2015-2016 (red)
JAN APR JUL OCT JAN APR JUL OCT
97/15
98/16

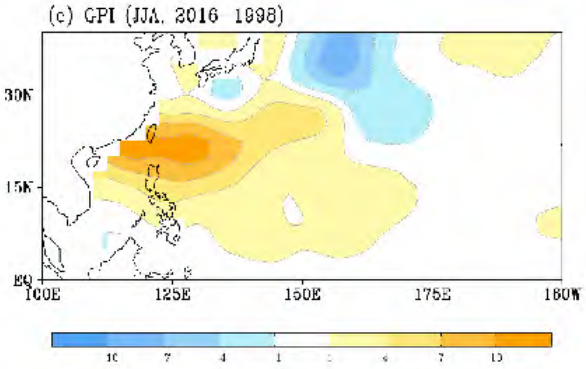

(a) Regr: ENSO (DJF) and SSTA & 850 wind (JJA)
50N
25N
EQ
25S
90E
135E
180
135W
90W
H

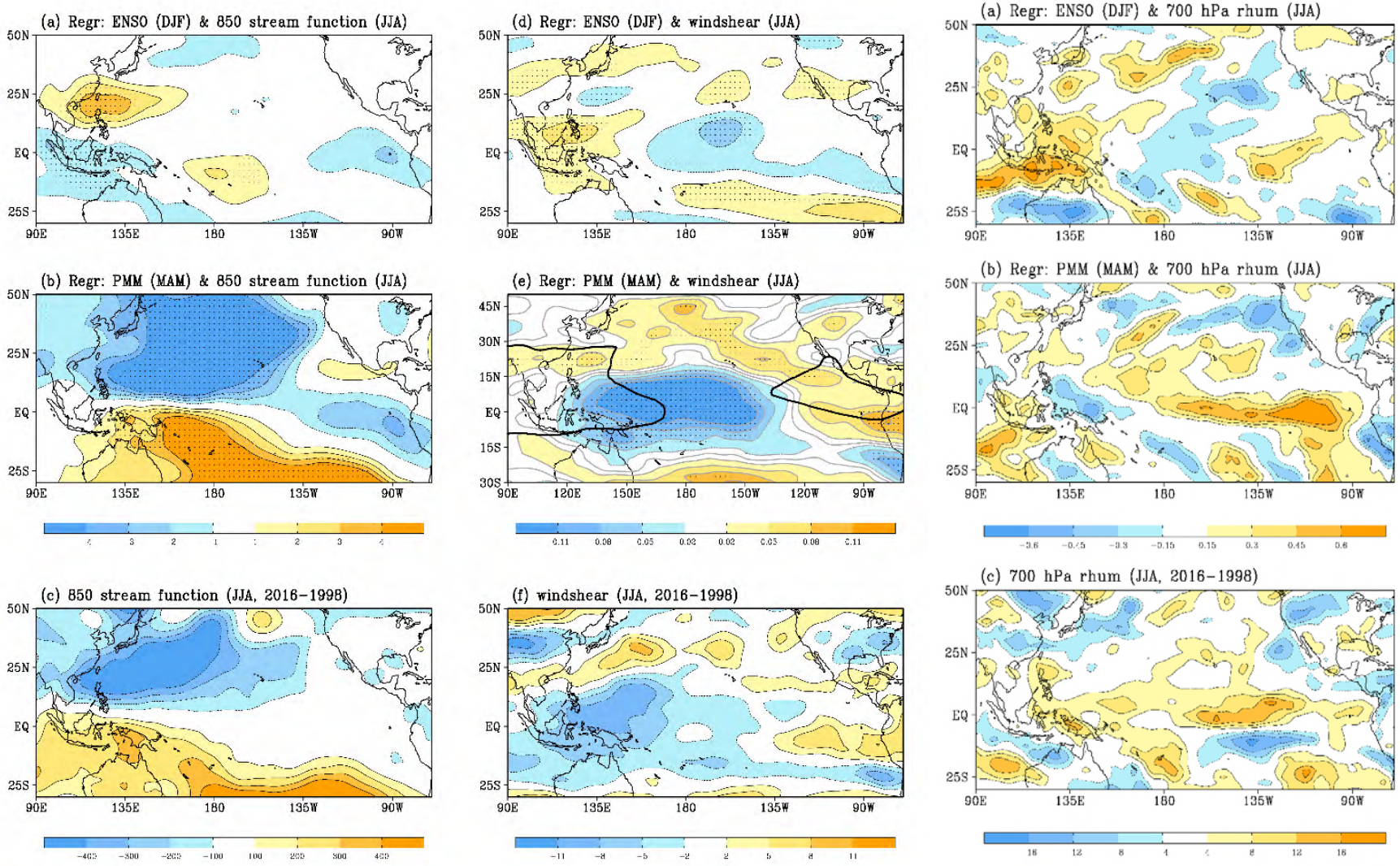

(b) Regr: PMM (MAM) and SSTA & 850 wind (JJA)
50N
25N
EQ
25S
90E
135E
180
135W
90W
L
0.5


(c) SSTA & 850 wind (JJA, 2016−1998)
50N
25N
EQ
25S
90E
135E
180
135W
90W

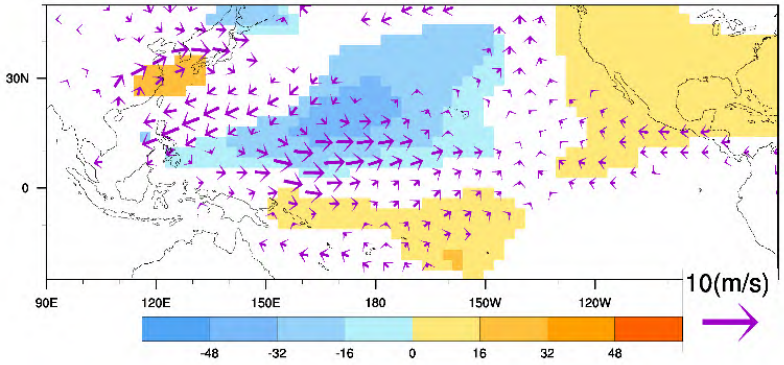

(a) Regr: ENSO (DJF) & GPI (JJA)
30N
15N
EQ
160E
125E
150E
175E
180W


(b) Regr: PMM (MAM) & GPI (JJA)
30N
15N
EQ
160E
125E
150E
175E
180W

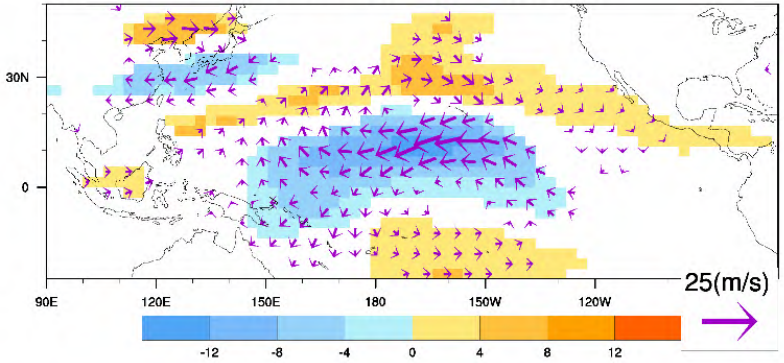

(c) GPI (JJA, 2016−1998)
30N
15N
EQ
160E
125E
150E
175E
180W


(a) Regr: ENSO (DJF) & 850 stream function (JJA)
(b) Regr: PMM (MAM) & 850 stream function (JJA)
(c) 850 stream function (JJA, 2016-1998)
(d) Regr: ENSO (DJF) & windshear (JJA)
(e) Regr: PMM (MAM) & windshear (JJA)
(f) windshear (JJA, 2016-1998)
(a) Regr: ENSO (DJF) & 700 hPa rhum (JJA)
(b) Regr: PMM (MAM) & 700 hPa rhum (JJA)
(c) 700 hPa rhum (JJA, 2016-1998)
50N
25N
EQ
25S
30S
45N
30N
15N
15S
90E
120E
150E
180
150W
135W
120W
90W
135E

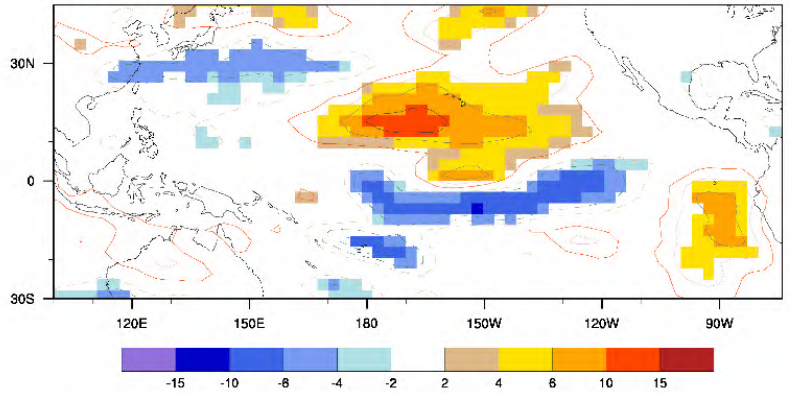
(a) 850 hPa stream function & wind



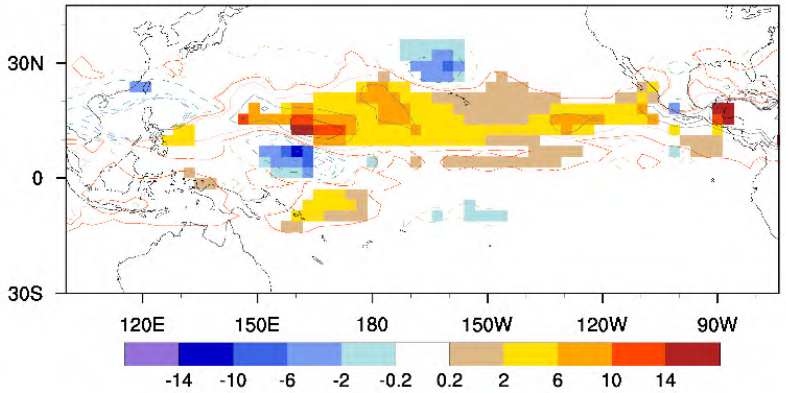
(b) vertical u shear and 200 hPa wind



(c) 700 hPa relative humidity



(d) GPI



Conclusions

Observation revealed that the NPMM-SST experienced an interdecadal warming in the early 1990s and 2010s. The warming since 2010 was especially prounced.

Significant impact of NENP-SST on the TC activity in the WNP and WNPSM was identified by the observation and was further supported by the numerical experiments.

The NPMM-SST continuously warms was enhanced by the global warming trend. It is expected that the effect of warm NPMM-SST on the East Asian should be increased in the future. The effect of NPMM-SST on East Asia climate variability deserves us further attendion.

The END

Thanks