Asymmetric El Niño–Southern Oscillation and tropical cyclone relationships in the Philippines during October–December

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Introduction

TC activities v.s. Large-scale conditions

Variables: sea sufrace temperatures (SSTs), relative vorticity and humidity, vertical wind shear

western Pacific subtropical high (WPSH) and monsoon trough (MT).

Seasonally, these circulations migrate northward from June to August and shift southward from September to November, so to do TC genesis locations (Chen et al., 2006, 2017).

A northwestward path toward Taiwan can be guided by anomalous southeasterly flows between an anomalous anticyclone on the northern side and an anomalous cyclone on the southern side (Chen et al., 2007, 2010).

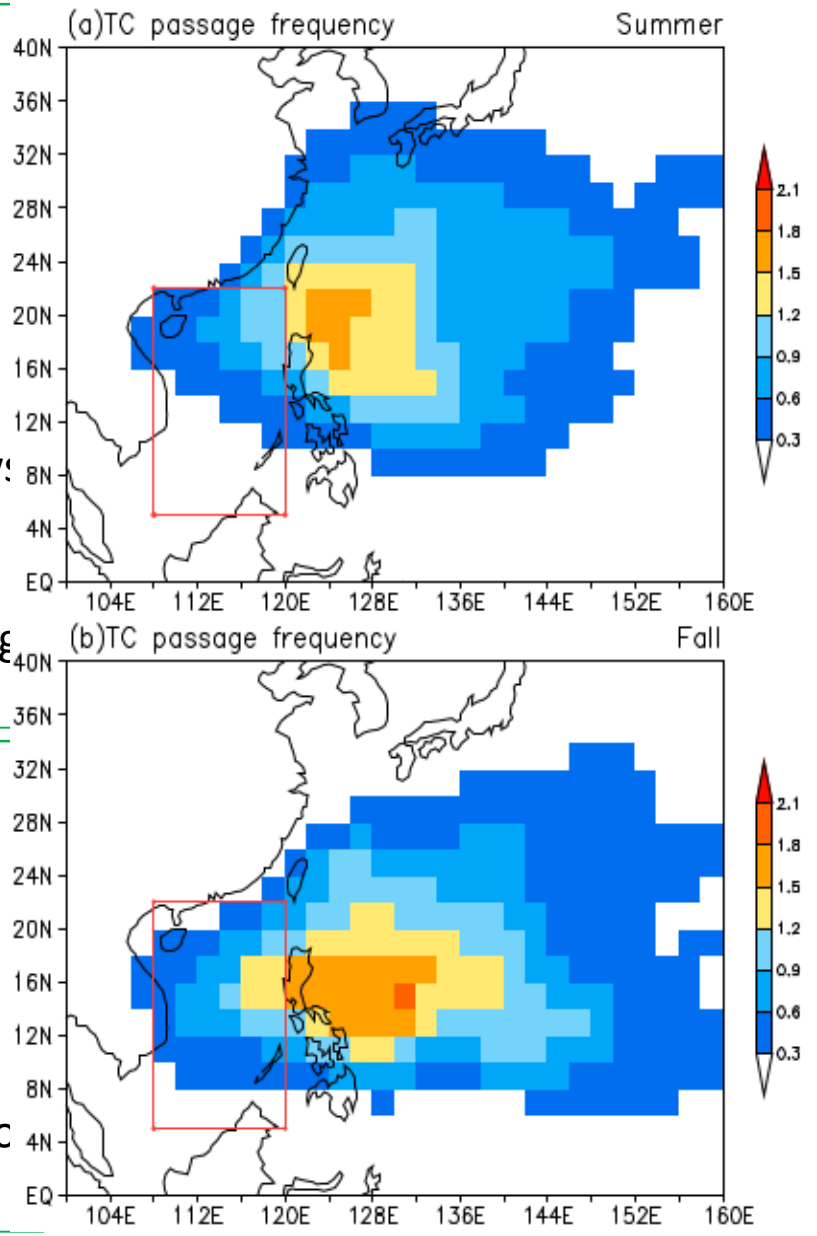
Spatially, WNP TCs forming in a more westward sector have a higher chance of moving into the SCS than those forming in a more eastward sector (Chen et al., 2017).

The Philippines:

ENSO is the major mode causing interannual TC activity over the WNP and the Philippines(Chan, 1985, 2000, 2005; Corporal-Lodangco et al., 2016; Wu et al., 2018).

The WNP TCs move toward the Philippines mainly passing through regions north of 14°N during summer, but north of 10 ° N during fall

Kubota and Chan (2009) and Corporal-Lodangco and Leslie (2017) demonstrated that landfall TCs over the Philippines tend to increase in La Niña years and reduce in El Niño years.

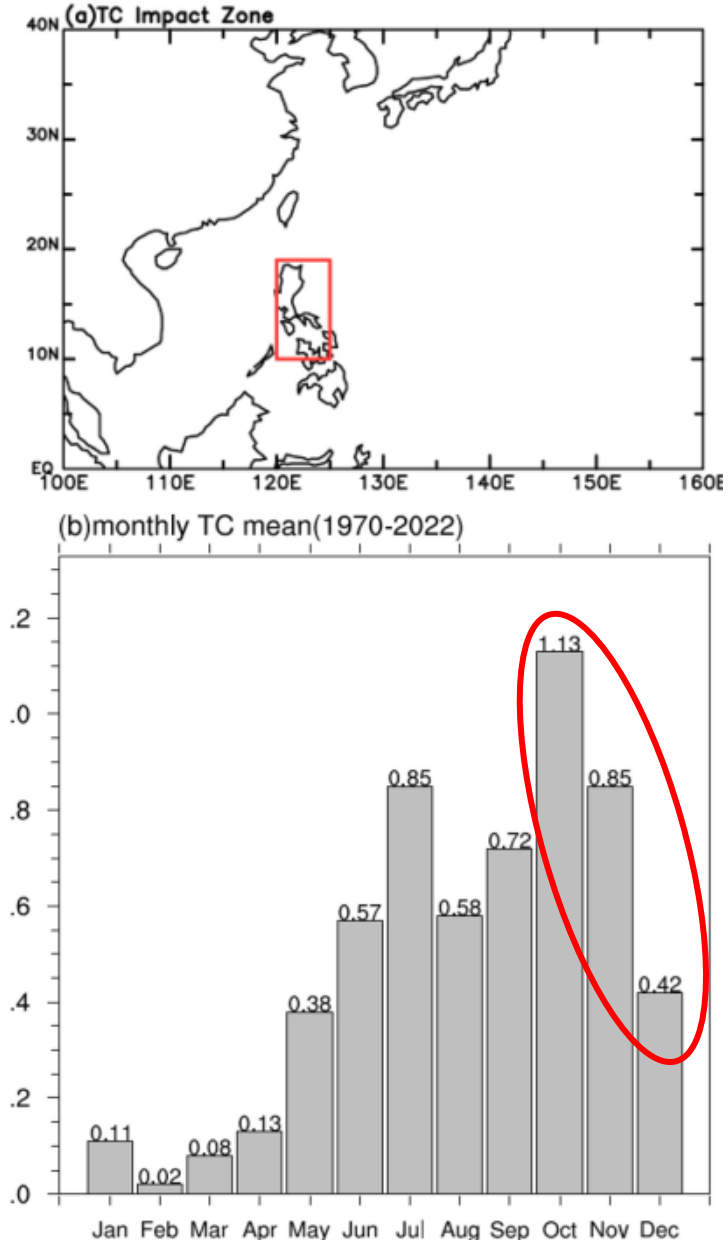


Motivation

- How do ENSO-related climatic factors modulate TC activity affecting the Philippines in different ENSO–TC relationships?

- If asymmetric ENSO–TC relationships exist, what are the major variability features causing asymmetric correspondence?

- How do the ENSO–TC variability types connect to the IOD mode, PDO and various types of El Niño events?

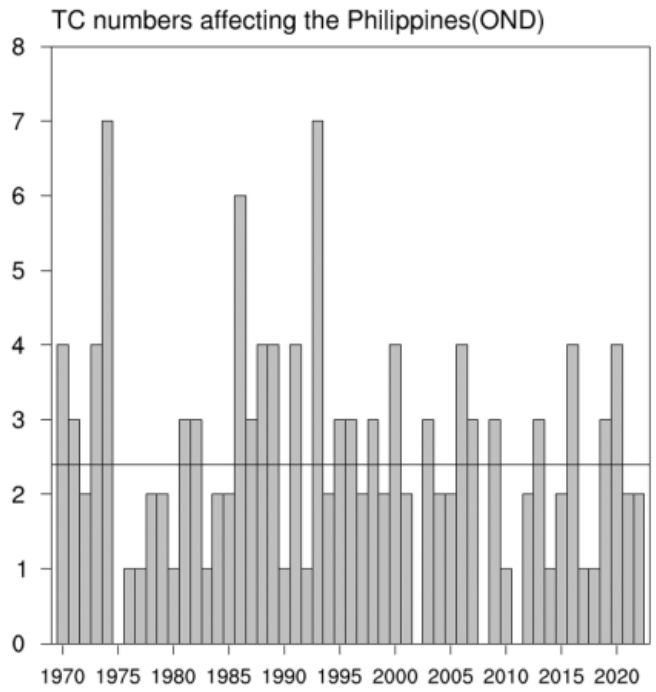


The climatological monthly means of TCs affecting the Philippines during 1970–2022.

The averaged TC numbers affecting the Philippines are larger in OND (2.4 TCs) than JAS (2.15 TCs).

Interannual TC Variability and ENSO–TC relationship types.

Interannual TC variability



long-term mean of this time series is 2.4

ENSO-TC types

Type	Year	ONI(OND)(°C)	TC numbers	Average
Active-TC(EN)	1986	1.1	6	4.7
	1991	1.2	4	
	2006	0.9	4	
Inactive-TC(LN)	1975	−1.6	0	0.5
	1983	−1	1	
	2008	−0.6	0	
	2010	−1.6	1	
	2011	−1.1	0	
	2017	−0.8	1	
Inactive-TC(EN)	1976	0.9	1	0.8
	1977	0.8	1	
	2002	1.3	0	
	2014	0.6	1	
	2018	0.9	1	
Active-TC(LN)	1970	−0.9	4	4.5
	1973	−1.9	4	
	1974	−0.8	7	
	1988	−1.8	4	
	2016	−0.7	4	
	2020	−1.3	4	

Note: El Niño years with active and inactive TC activity are denoted by Active-TC(EN) and Inactive-TC(EN), respectively. La Niña years with active and inactive TC activity are denoted by Active-TC(LN) and Inactive-TC(LN), respectively. The averaged TC numbers for each relationship type are also listed.

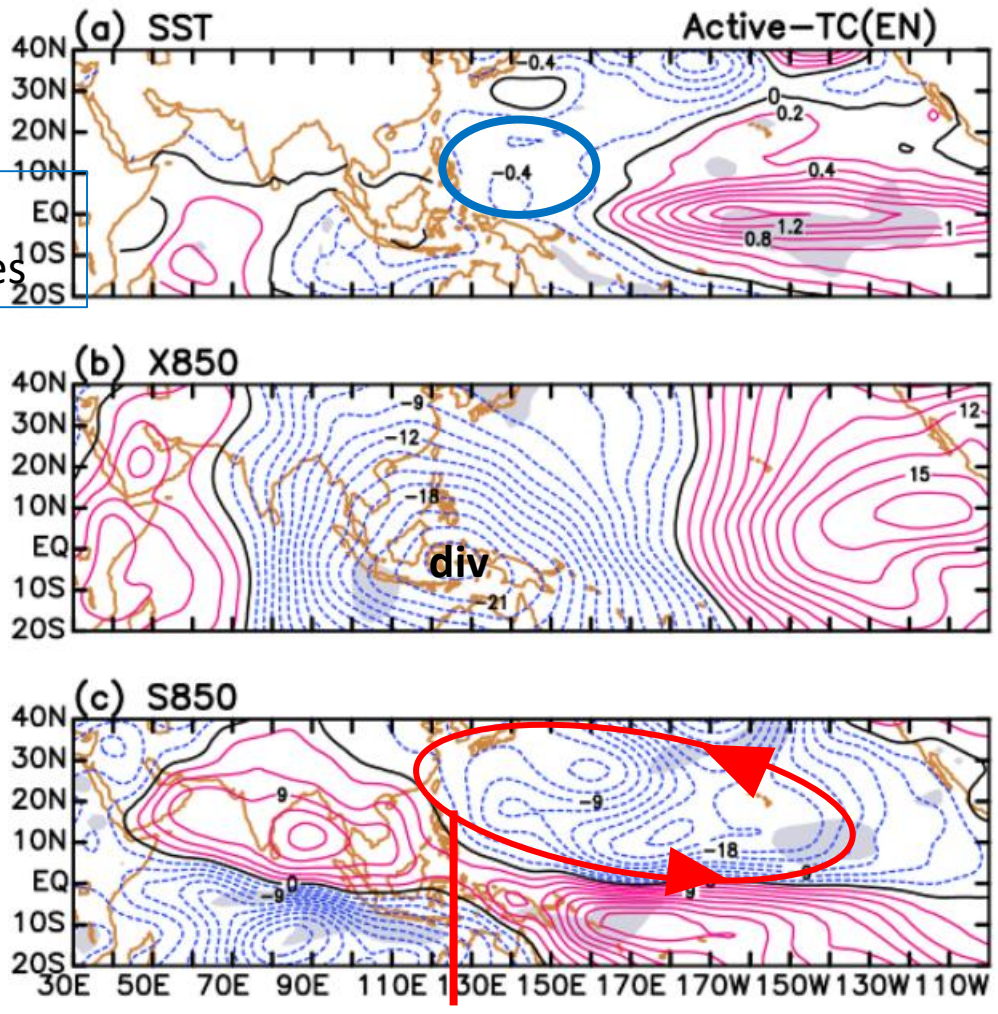
TC-active: 2.4+1.56
TC-inactive: 2.4-1.56

El Niño: $\geq 0.5^{o}C$
La Niña: $\leq 0.5^{o}C$

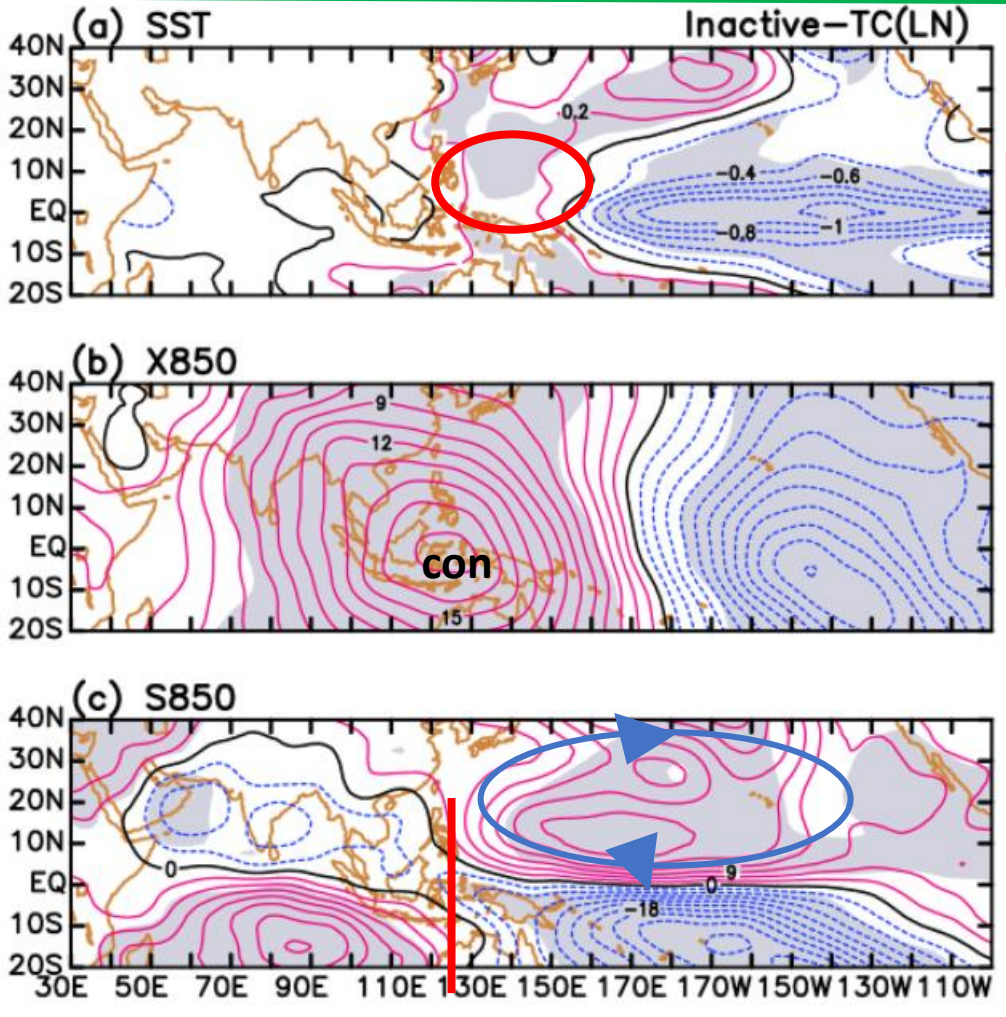
LARGE-SCALE MODULATIONS IN VARIOUS ENSO–TC TYPES

Active-TC(EN) type versus Inactive-TC(LN) type

cold SST anomalies



125°E

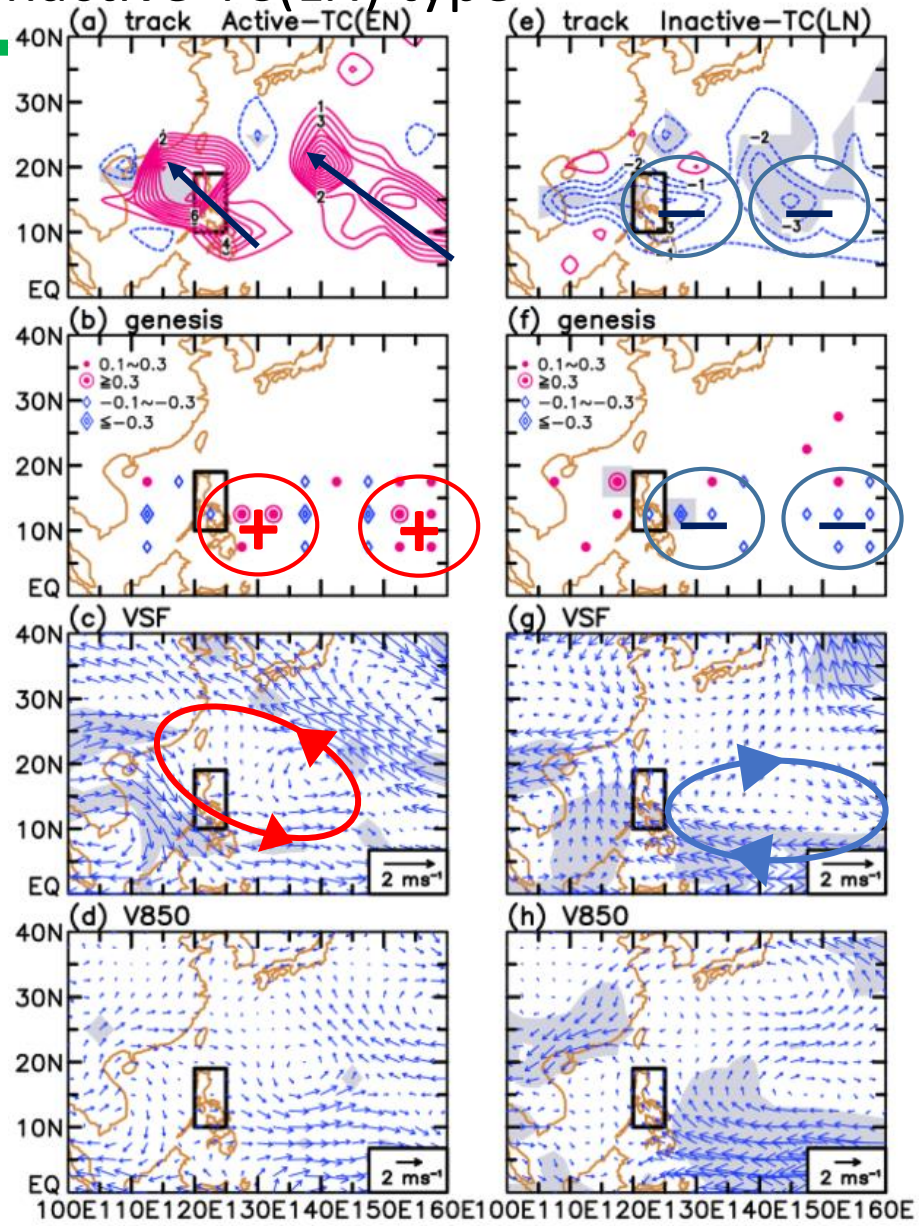


125°E

warm SST anomalies

LARGE-SCALE MODULATIONS IN VARIOUS ENSO–TC TYPES

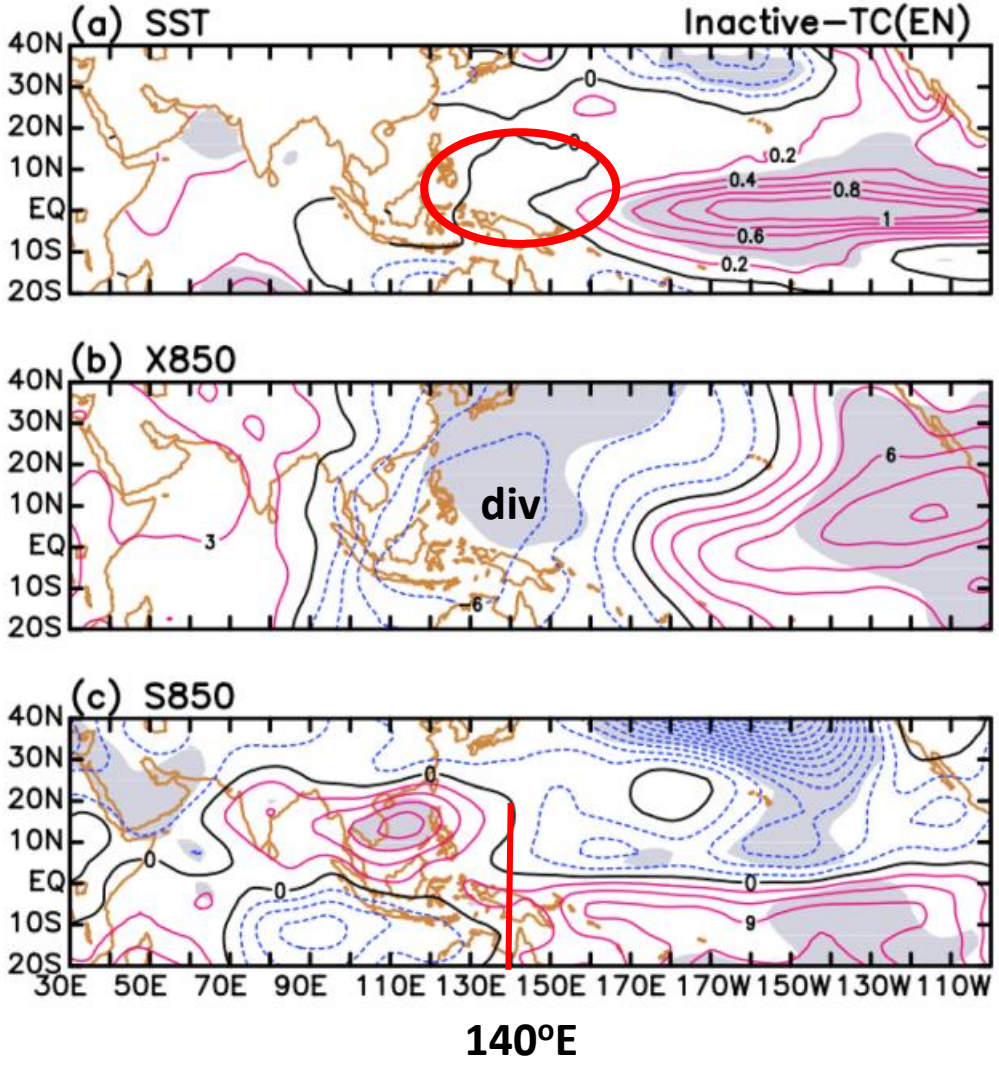
- Active-TC(EN) type versus Inactive-TC(LN) type

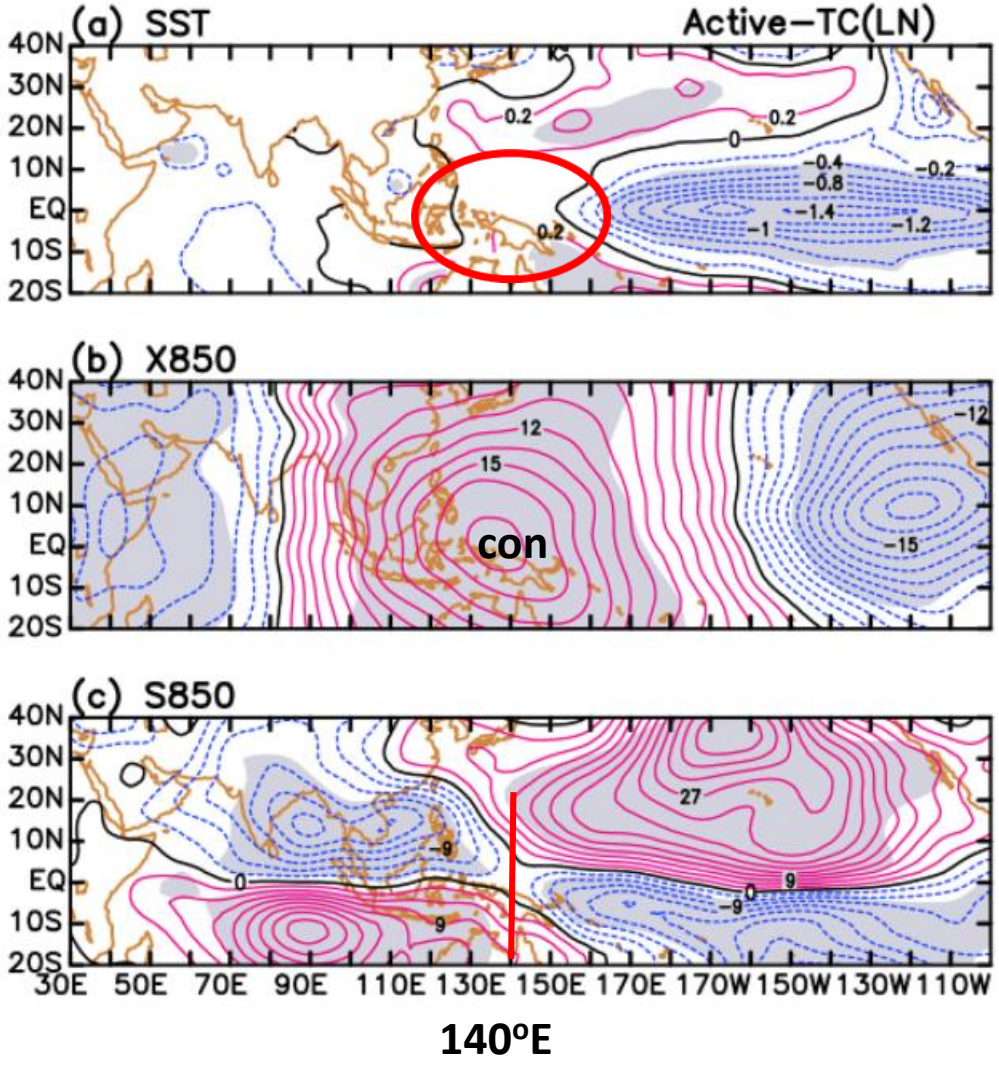


LARGE-SCALE MODULATIONS IN VARIOUS ENSO–TC TYPES

Inactive-TC(EN) type versus Active-TC(LN) type

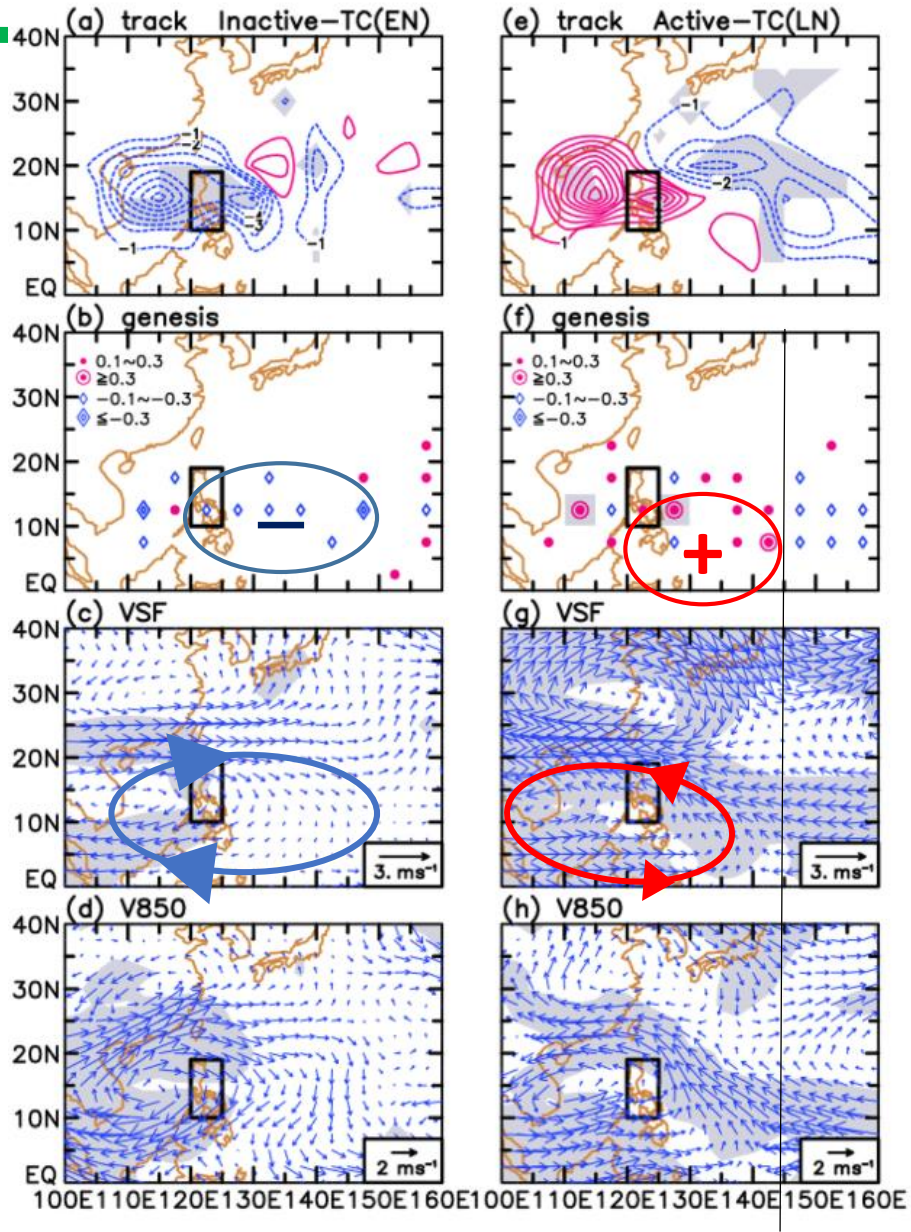
Very weak SSTA





LARGE-SCALE MODULATIONS IN VARIOUS ENSO–TC TYPES

Inactive-TC(EN) type versus Active-TC(LN) type



OTHER CLIMATIC VARIABILITY FACTORS:

Type	Year	PDO index (°C)	DMI (°C)	El Niño type
Active-TC(EN)	1986	1.33	−0.56	Mixed
	1991	0.23	0.09	Mixed
	2006	−0.51	1.23	CP
Inactive-TC(LN)	1975	−1.46	−1.52	
	1983	1.09	−0.72	
	2008	−1.46	−0.15	
	2010	−1.58	−1.12	
	2011	−2.21	0.55	
	2017	−0.39	0.41	
Inactive-TC(EN)	1976	1.11	−0.38	EP
	1977	−0.41	0.10	CP
	2002	0.74	0.34	CP
	2014	1.41	0.19	CP
	2018	−0.45	1.47	CP
Active-TC(LN)	1970	−0.92	−1.16	
	1973	−1.11	−0.55	
	1974	0.32	−1.72	
	1988	−0.17	−0.54	
	2016	0.35	−1.04	
	2020	−0.97	0.12	

Note: El Niño years are categorized into three types: central-Pacific (CP), eastern-Pacific (EP) and mixed types.

Type	Year	TC numbers	DMI (°C)	ONI (°C)
CP(EN)-IODp	1977	1	0.10	0.80
	1994	2	1.23	1.00
	2002	0	0.34	1.30
	2006	4	1.23	0.90
	2009	3	0.08	1.40
	2014	1	0.19	0.60
	2018	1	1.47	0.90
	Avg	1.7	0.66	0.99
LN-IODn	1970	4	−1.16	−0.90
	1971	3	−0.39	−1.00
	1973	4	−0.55	−1.90
	1974	7	−1.72	−0.80
	1975	0	−1.52	−1.60
	1983	1	−0.72	−1.00
	1984	2	−1.32	−0.90
	1988	4	−0.54	−1.80
	1995	3	−0.56	−1.00
	1998	3	−1.70	−1.50
	1999	2	−0.45	−1.50
	2000	4	−0.68	−0.70
	2005	2	−0.99	−0.60
	2007	3	−0.18	−1.50
	2008	0	−0.15	−0.60
	2010	1	−1.12	−1.60
	2016	4	−1.04	−0.70
	2021	2	−0.14	−1.00
	2022	2	−1.03	−0.90
	Avg	2.7	−0.84	−1.13

Note: The averages of the above variables in each type are also shown.

- The IO Dipole Mode Index (DMI; Saji & Yamagata, 2003):a tropical SST gradient between the western IO (50–70E, 10S–10N) and the southeastern IO (90–110E, 10S–0).
- A positive DMI represents a positive IOD mode with tropical SSTs warmer in the eastern IO and colder in the southeastern IO.
- CP El Nino has major warm SST anomalies centering in the Niño4 (160E–150W, 5S–5N) region.
- EP El Nino has a major SST center in the Niño3 (150–90W, 5S–5N) region

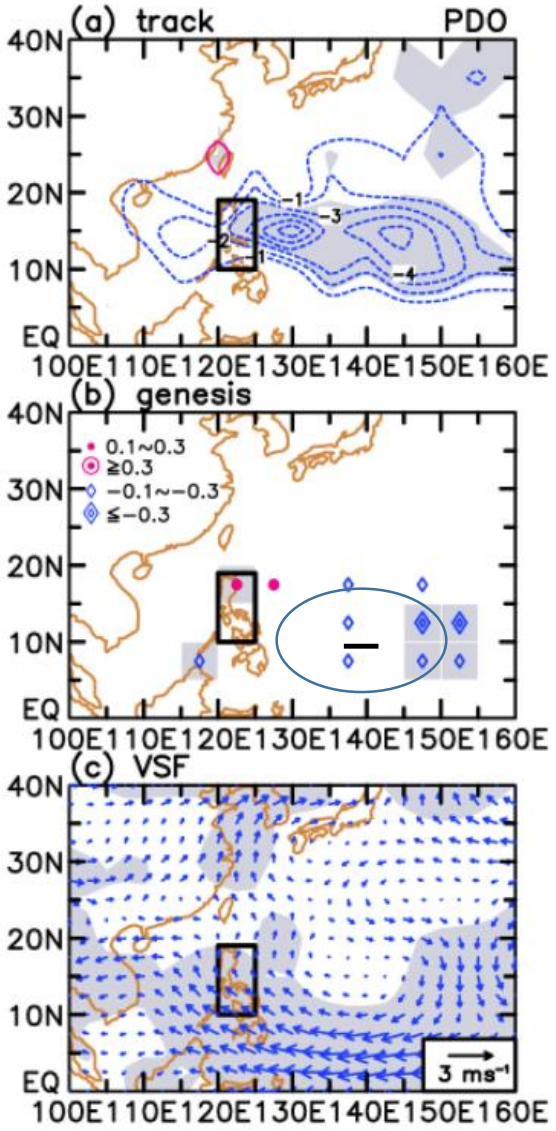
OTHER CLIMATIC VARIABILITY FACTORS:

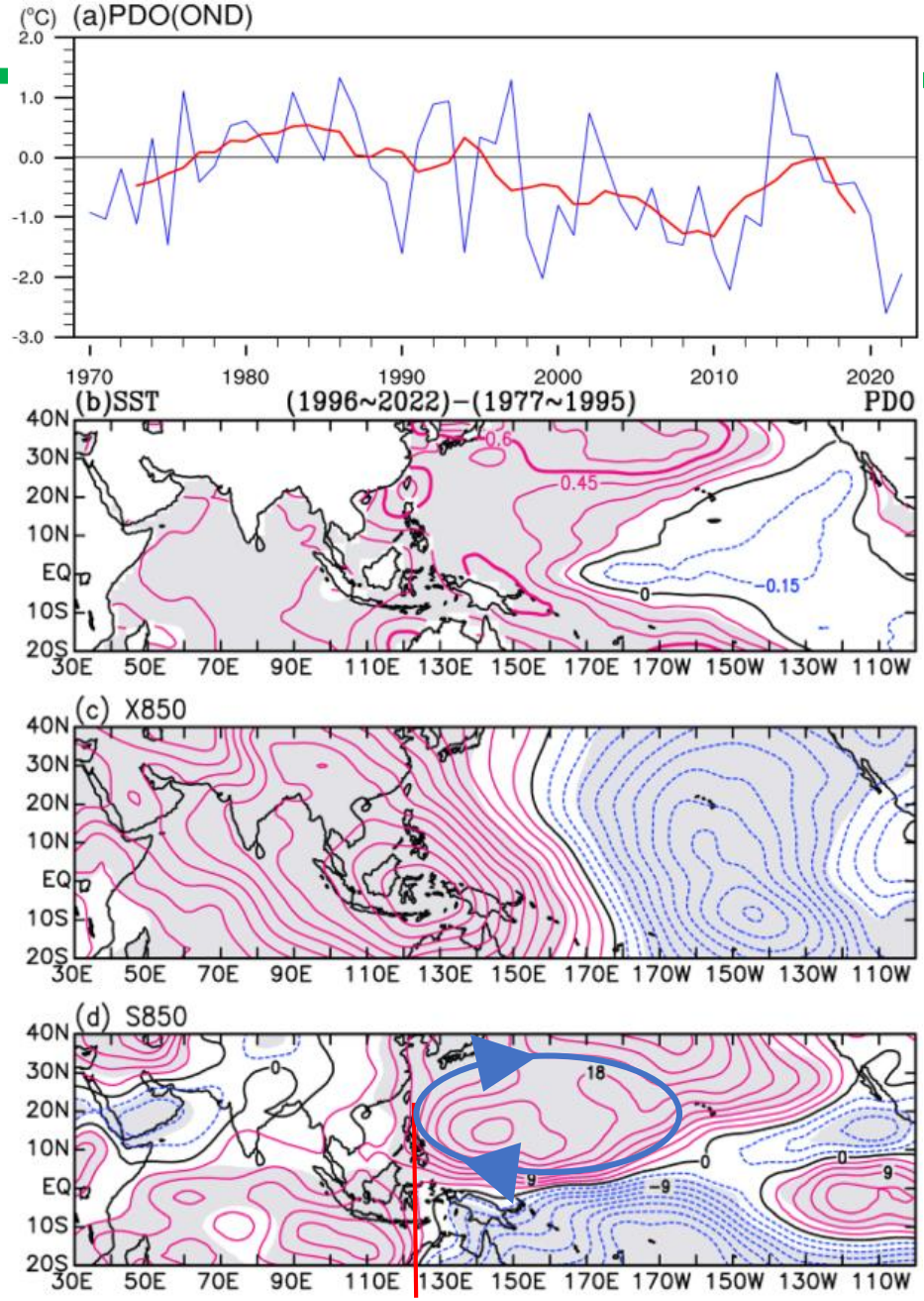
----- Effects of the PDO variability

positive phase (1977 – 1995)
negative phase (1996 – 2022)

Negative PDO (after the late 1990s) effectively reduce OND TC activity over the Philippines during the La Niña events.

positive PDO (before the late 1990s) should exert effects to intensify TC activity over the Philippines during the El Niño events



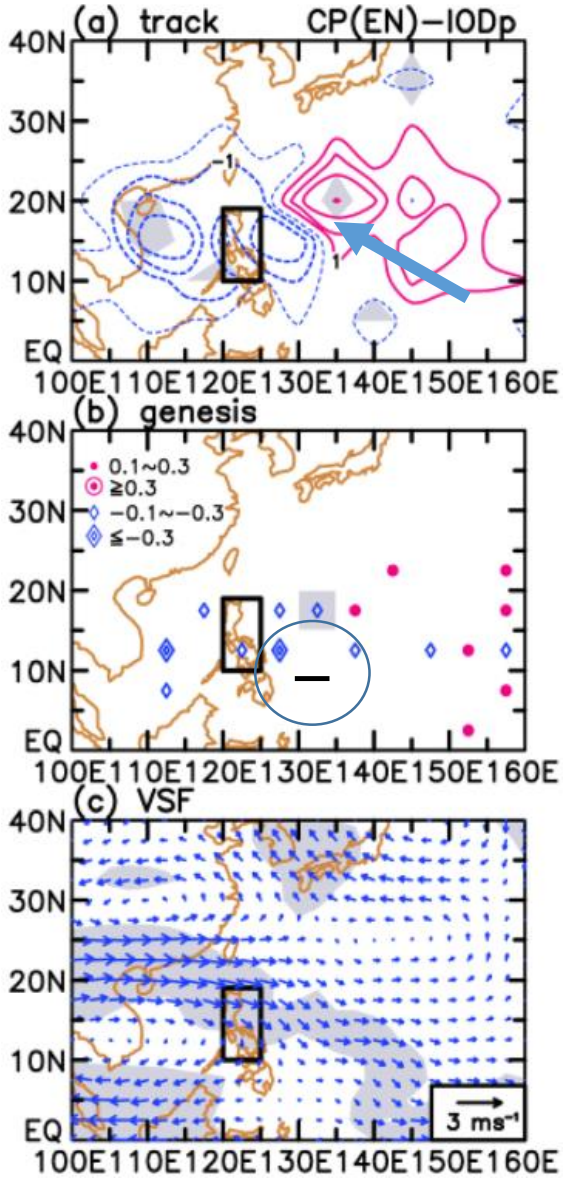


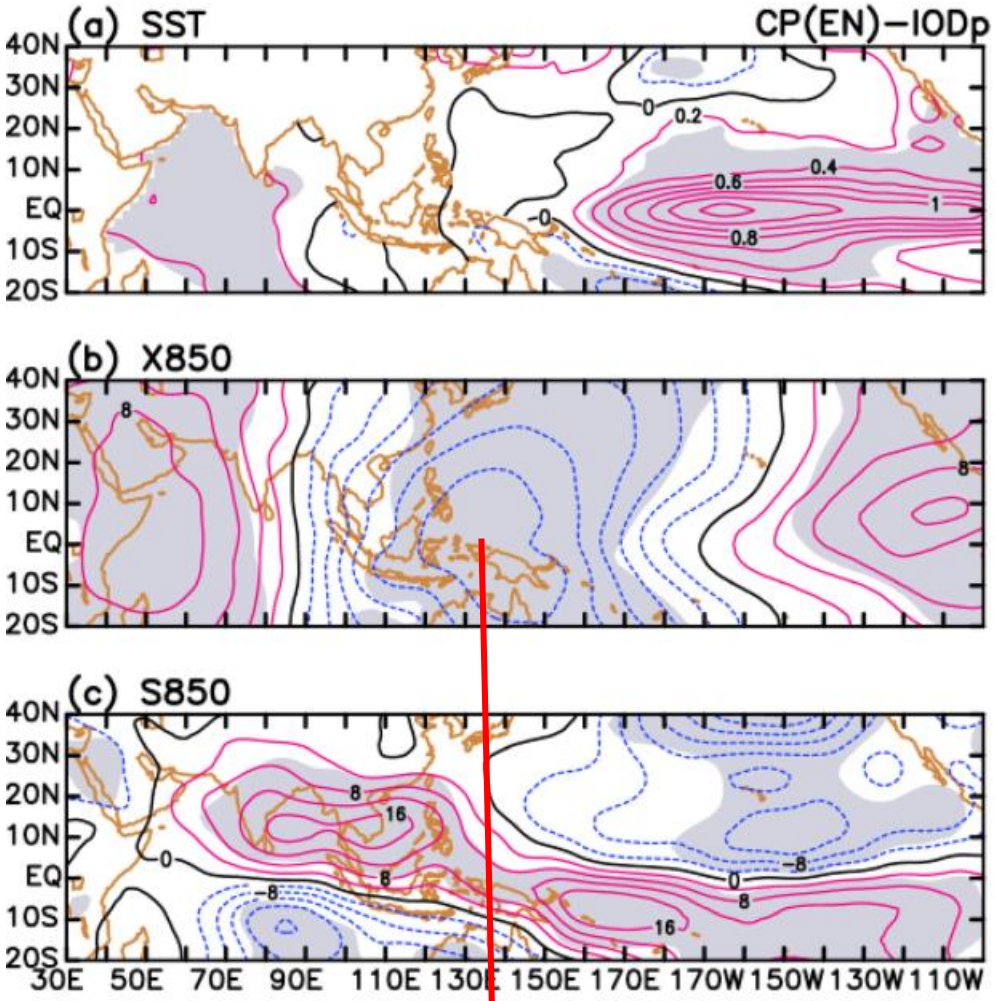
OTHER CLIMATIC VARIABILITY FACTORS:

----- Effects of the central-Pacific El Niño event

these patterns are coherent with the major features of large-scale anomalies in the **Inactive-TC(EN)** type

The joint effects of the CP El Niño event and the positive IOD mode are able to weaken TC activity over the Philippines in the Inactive-TC(EN) type



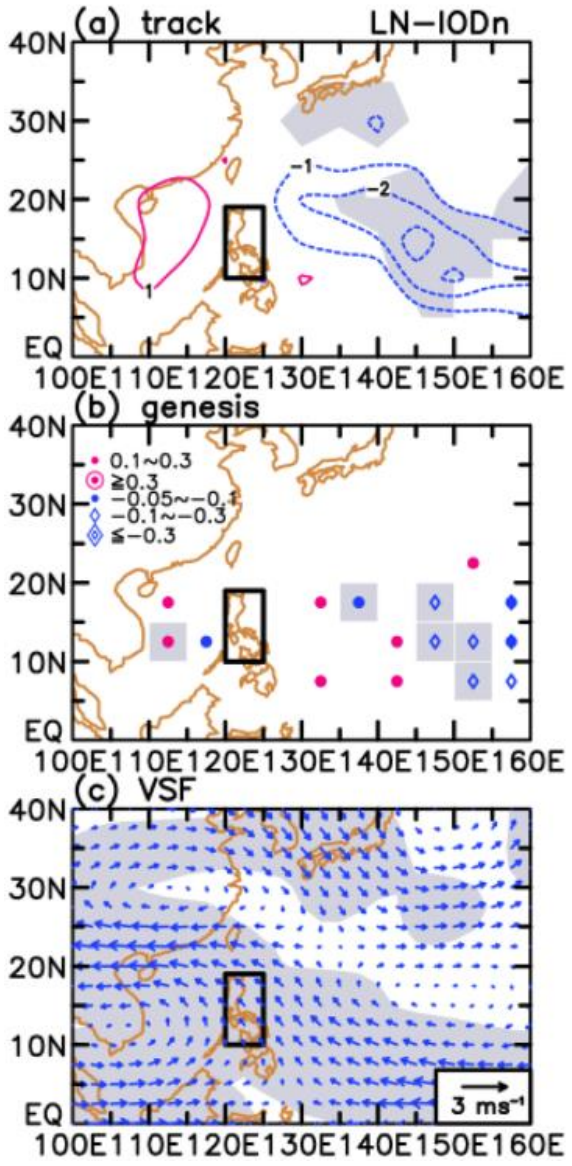


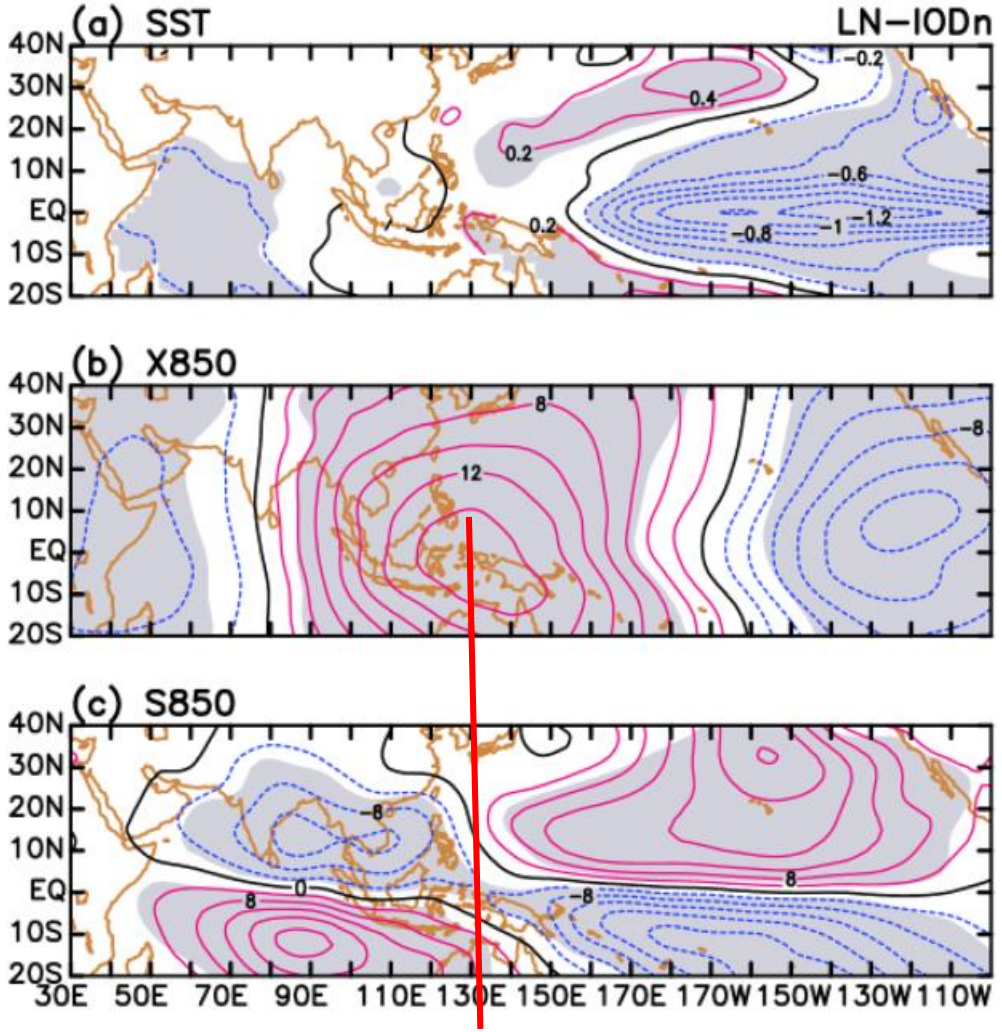
OTHER CLIMATIC VARIABILITY FACTORS:

----- Effects of the negative IOD mode

western anomalous cyclone extends more eastward up to 140°E in the Active-TC(LN) type,but only up to 130 ° E in the LN-IODn type.

This indicates that a more eastward extended anomalous cyclone over the WNP is more effective to facilitate TC genesis over the WNP and consequent TC movement toward the west, causing enhanced TC activity over the Philippines.





SUMMARY

ENSO :

- more TCs are formed and guided northwestward toward the SCS via the interior of the anomalous cyclone

- this circulation pair weakens TC genesis and westward TC movement in the tropical WNP

- SST: cold SSTanomalies in the TWP are too weak to be recognized.

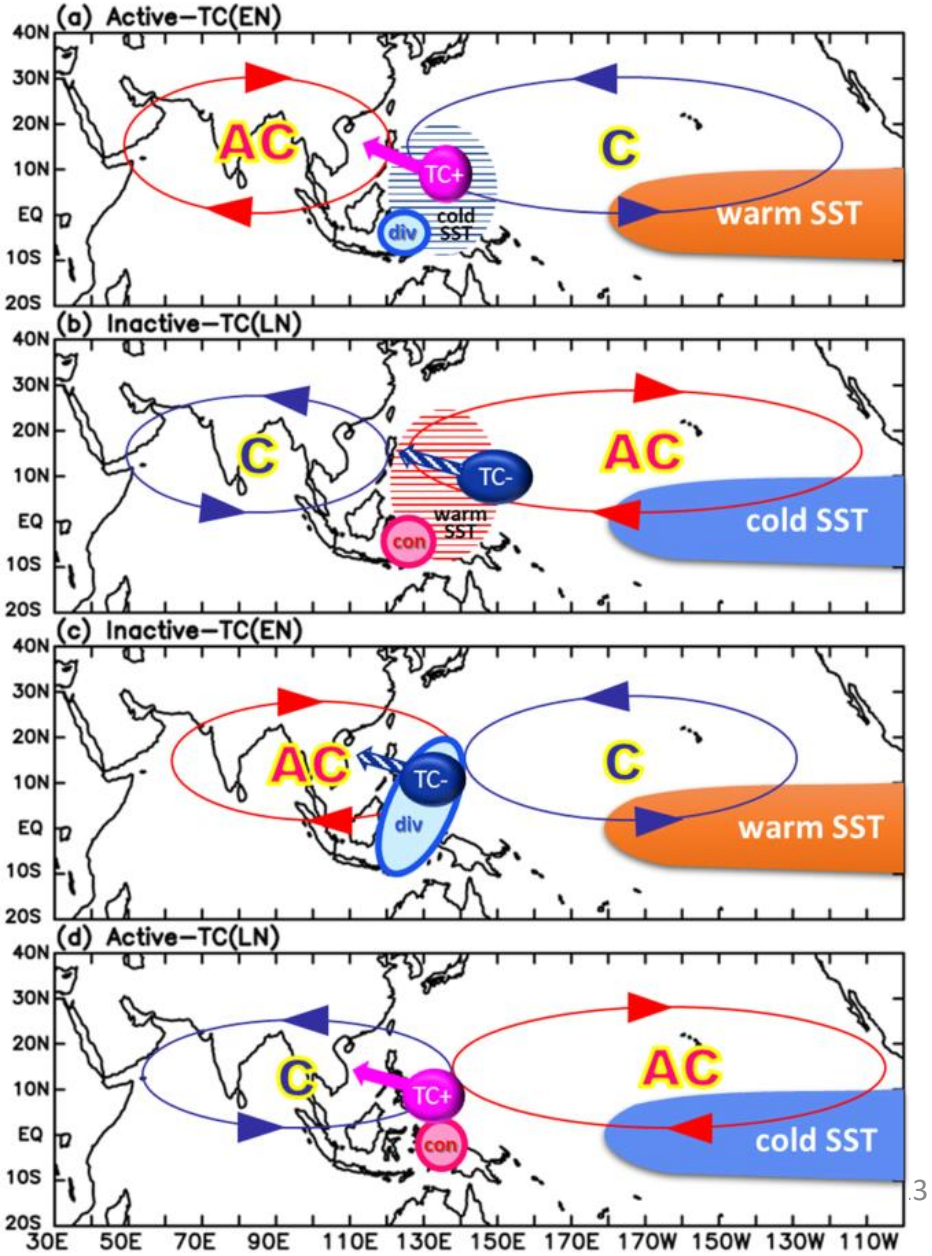
X850: weak and northeastward-extended divergent centre over the 130°E–140°E

S850: eastward displacement. Philippine Sea and western WNP are underneath an anomalous anticyclone.

- SST: weak warm SST in the TWP

X850: convergent centre over the 130°E–140°E

S850: eastward displacement. Philippine Sea and western WNP are underneath an anomalous cyclone.



SUMMARY

Other factors:

PDO

The group with the Active-TC(EN) and Inactive-TC(LN) types is affected by interdecadal variability of the PDO.
Negative PDO (after the late 1990s) effectively reduce OND TC activity over the Philippines during the La Niña events.

IOD, CP

The Inactive-TC(EN) type is jointly influenced by interannual variability of the positive IOD mode and CP El Niño events.
The joint effects of the CP El Niño and the positive IOD mode are responsible for the weakened TC activity over the Philippines in the Inactive-TC(EN) type.

Thanks for Your Attentions!