The Abrupt Change of Tropical Cyclone Number over the Western North Pacific in the Mid-1990s

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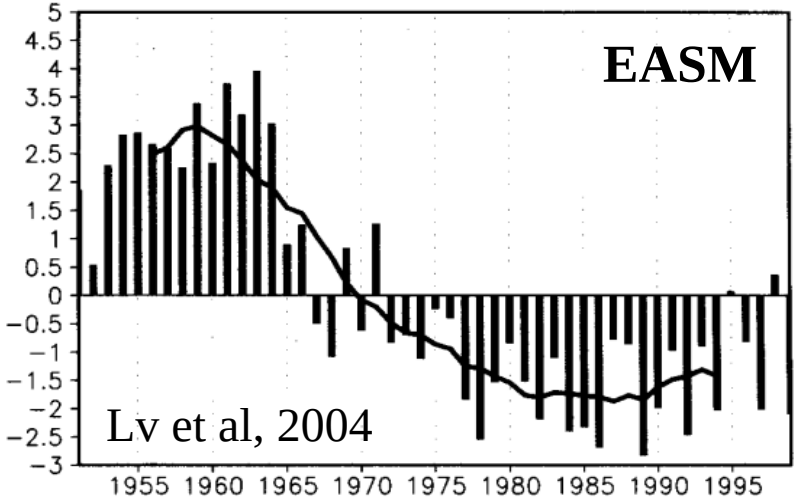
Global interdecadal abrupt climate change in the mid-to-late 1970s

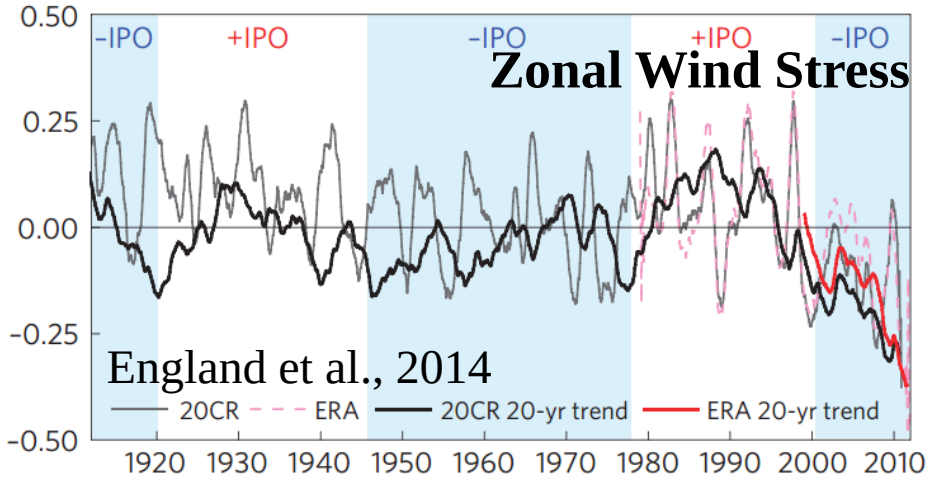
- Pacific Decadal Oscillation (PDO) altered its phase
- Aleutian Low deepened and moved southward
- Western Pacific Subtropical High (WPSH) extended westward and shifted southward
- East Asian Summer Monsoon (EASM) weakened



A series of interdecadal variations of environmental factors pushed the TC number over the western North Pacific into a relatively small period

Abrupt Change in 1990s?

- PDO phase changed suddenly around the mid-1990s
- EASM have recovered and began to strengthen around the early 1990s
- WPSH retreated eastward and shifted poleward
- The unprecedented powerful tropical Pacific easterly trade winds since the late-1990s have slowed the global warming trend

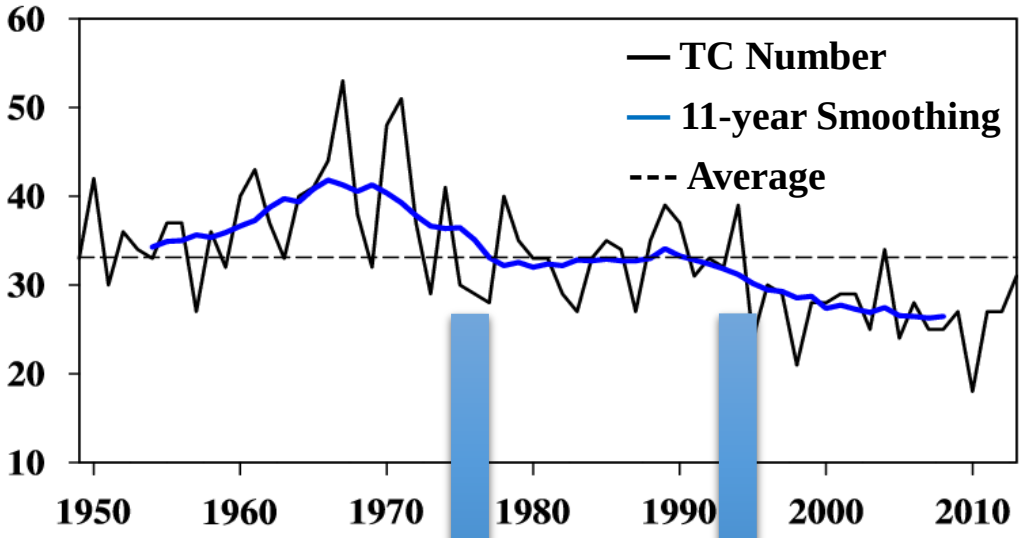


The 1990s might be a new period of interdecadal climate background over North Pacific

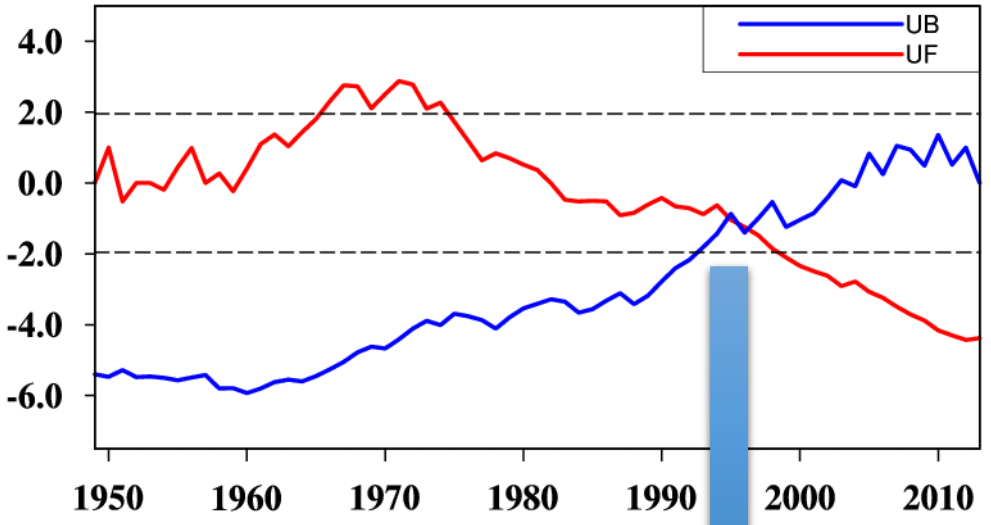
Interdecadal change in TC number around 1990s?

Variation Characteristics of Western North Pacific TC Number

1949~2013 TC Number (CMA Best-track)



Mann-Kendall



Above the average

Steady

Enter a relatively less than normal period

1995
Abrupt Change

Results

Interdecadal Characteristics of Air-Sea Background Before and After 1995

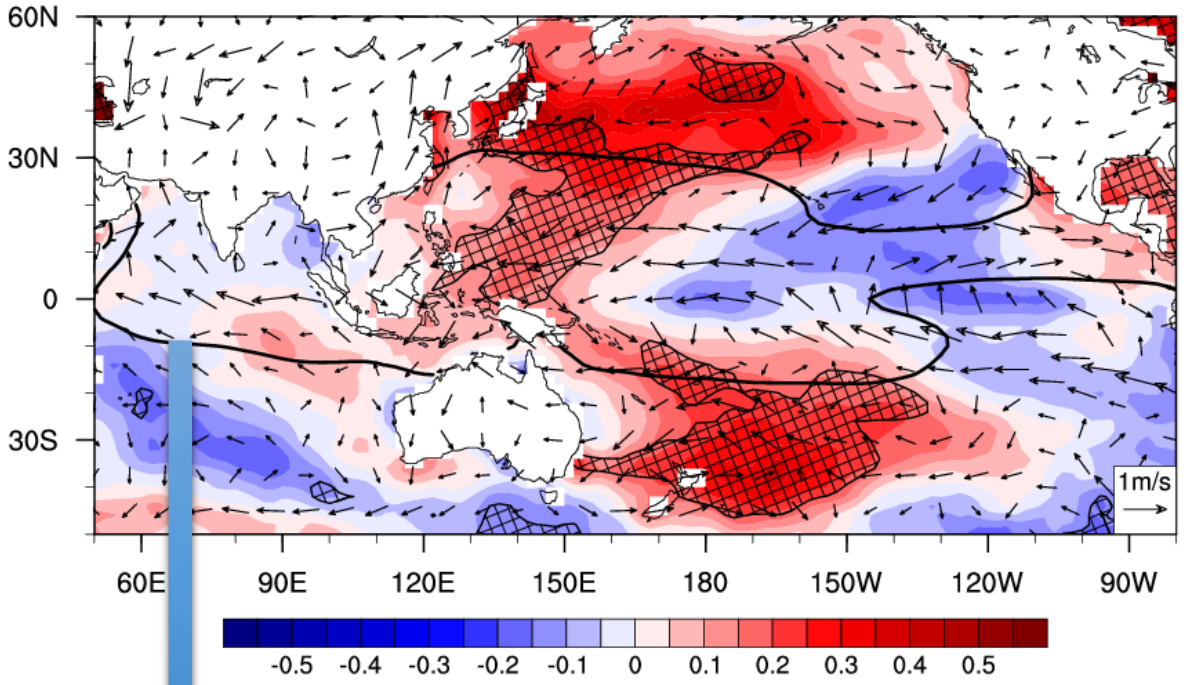
- **SST, 850hPa Wind, Omega, Vertical Uwnd Shear, SLP, Generating Location**

Interannual Characteristics of Main Impact Factors for TC Generation Before and After 1995

- **SST, 850hPa Wind, Omega, Vertical Uwnd Shear**
- **The Relative Importance of SST and Circulation on the Interannual variation of TC Number**

Interdecadal Characteristics of Air-Sea Background Before and After 1995

Composite difference (before 1995 minus after 1995) of typhoon season (JJASO) SST & 850hPa Wind



La Nina-like PDO cold phase-like

Threshold value (26.5℃) of the thermal condition for TC generation does not change in the whole period, so the **anomalous warming** of western North Pacific

SST does not contribute to the abrupt change of TC number in 1995

Interdecadal Characteristics of Air-Sea Background Before and After 1995

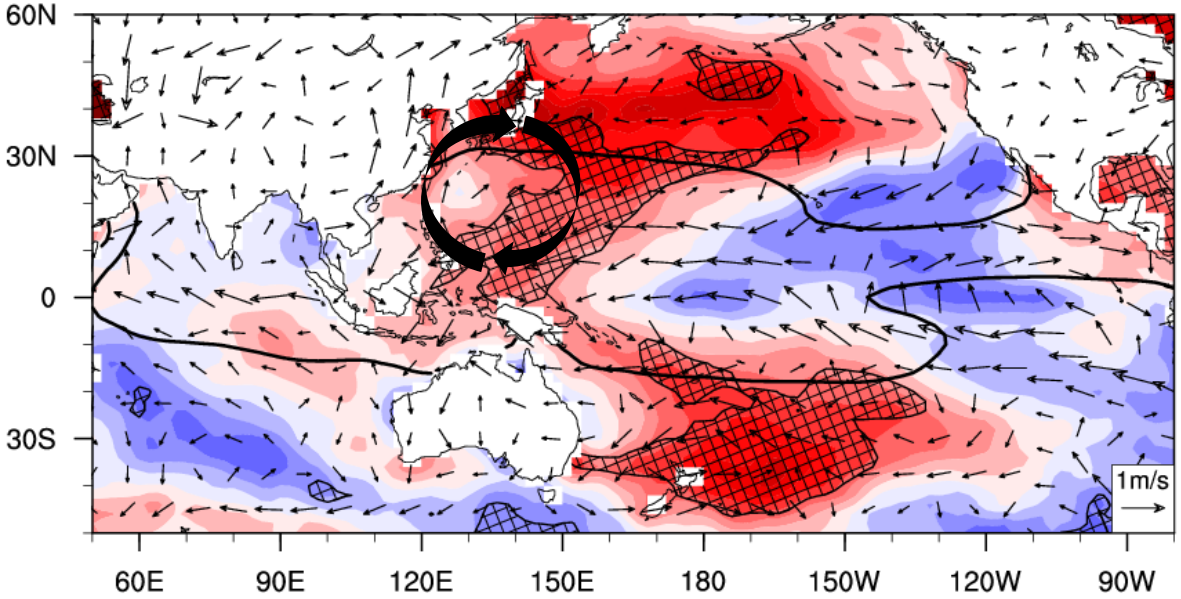
Comparison of the percentages of TC number in the average and four generating locations (divided by 15°N and 150°E)

	Average location	**NW**	**NE**	SW	SE
Before 1995	(15.5°N, 139.1°E)	40.6%	11.6%	35.8%	12.0%
After 1995	(16.1°N, 137.3°E)	**48.3%** ↑	12.3% ↑	29.7% ↓	9.7% ↓

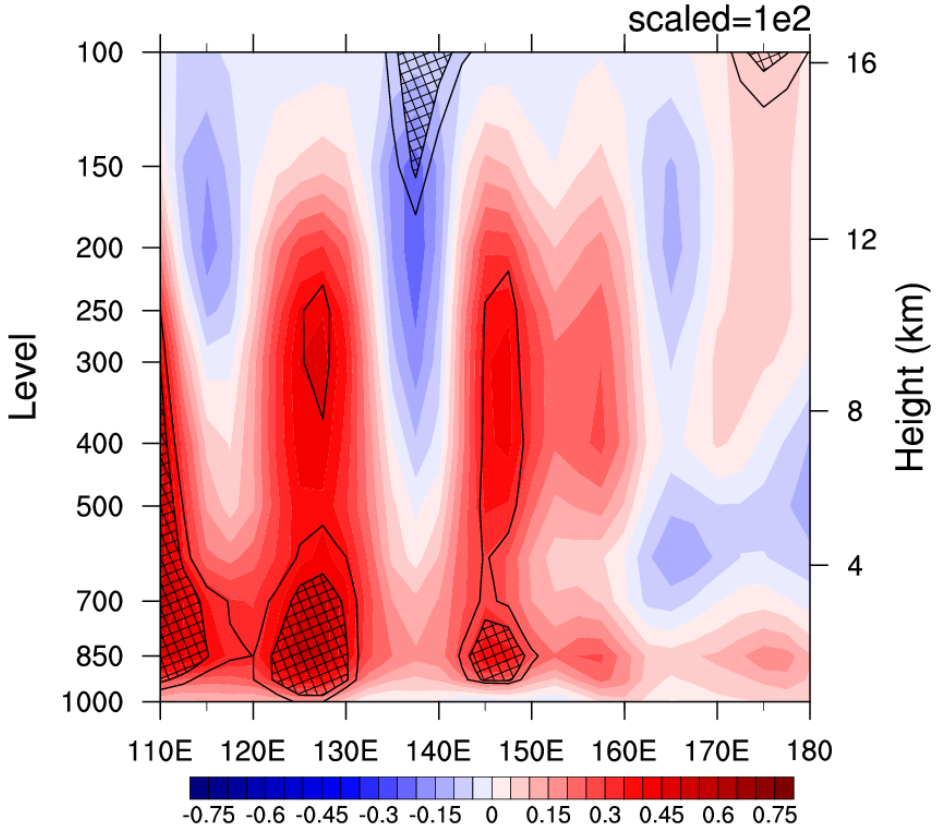
The location of TC generation shifts **northward and westward** when the PDO and ENSO are both in cold phase

TC生成数发生突变前后环流背景场特征

SST & 850hPa Wind



Composite difference of 5-25°N meridional mean omega

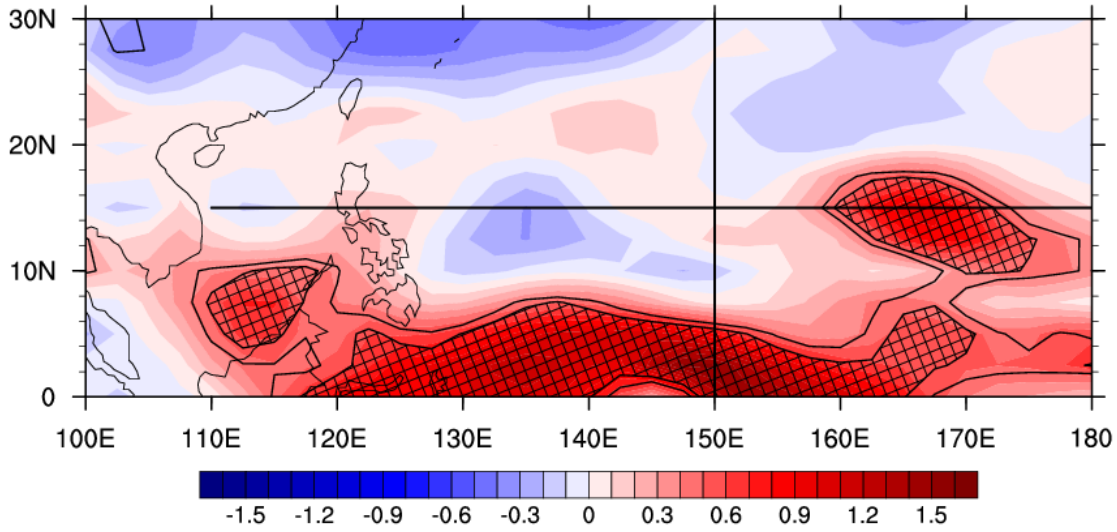


The **SSTA+** over Warm Pool **dose not** stimulate stronger vertical upward movement

While, the significant **weakened vertical upward movement** is associated with the **anomalous anticyclone** on 850hPa

Interdecadal Characteristics of Air-Sea Background Before and After 1995

Composite difference of vertical zonal wind shear



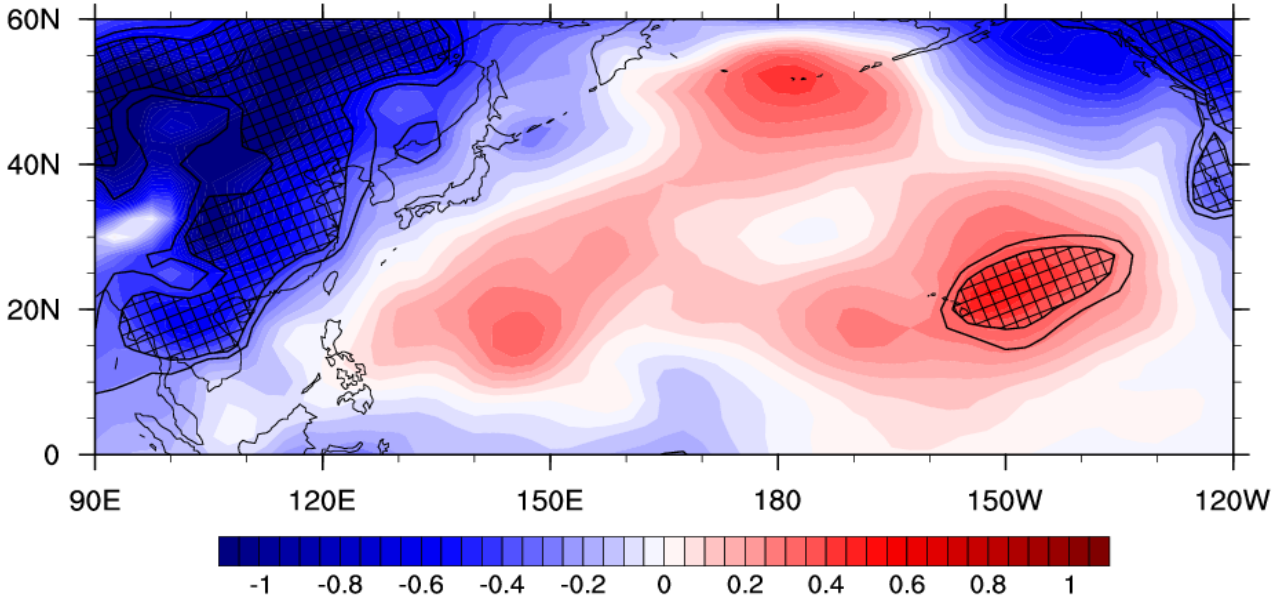
Regional averages of the difference between averaged vertical uwnd shear after 1995 and before 1995

	The whole	NW	NE	SW	SE
Vertical uwnd shear	**0.20** ↑	-0.10	-0.03	0.40	0.47

The interdecadal increase in vertical zonal wind shear is one of the main factors that make the TC number decrease after 1995

Interdecadal Characteristics of Air-Sea Background Before and After 1995

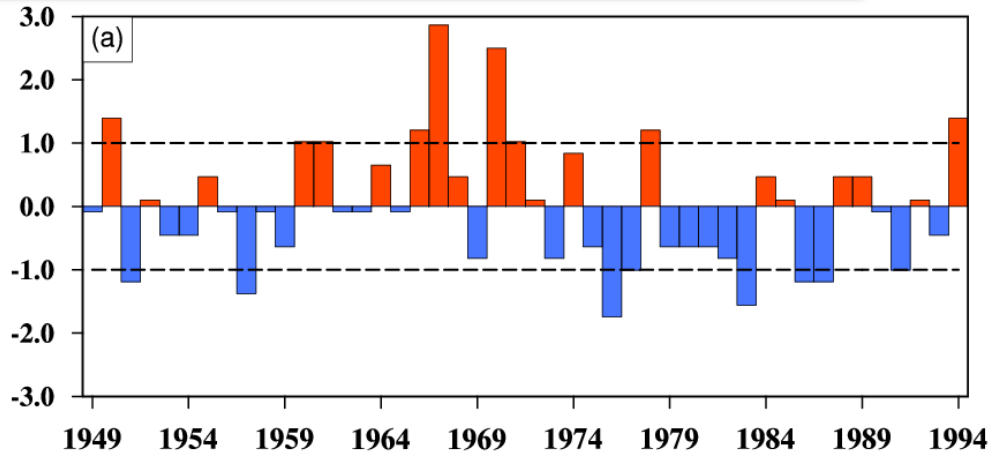
Composite difference of SLP

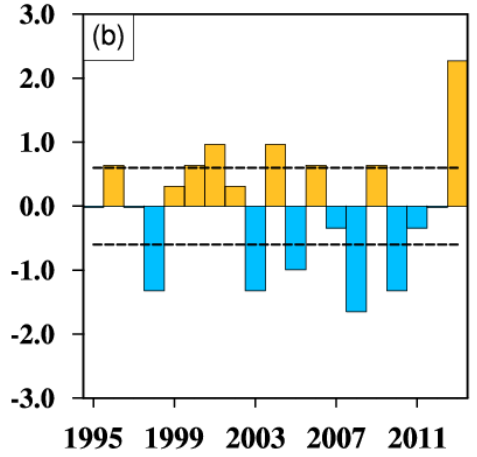


Higher SLP contributes to **suppress the formation of initial low pressure disturbance**,

which is one of the main reasons that cause less TCs generate after 1995

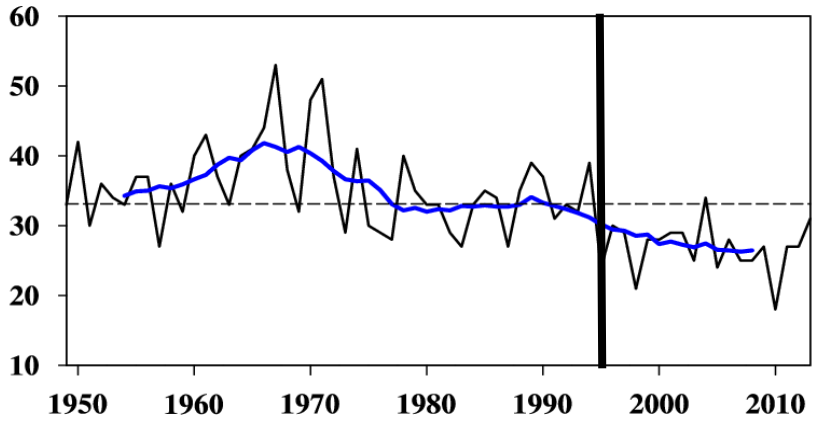
Interannual Characteristics of Main Impact Factors for TC Generation Before and After 1995





1949~1994

1995~2013



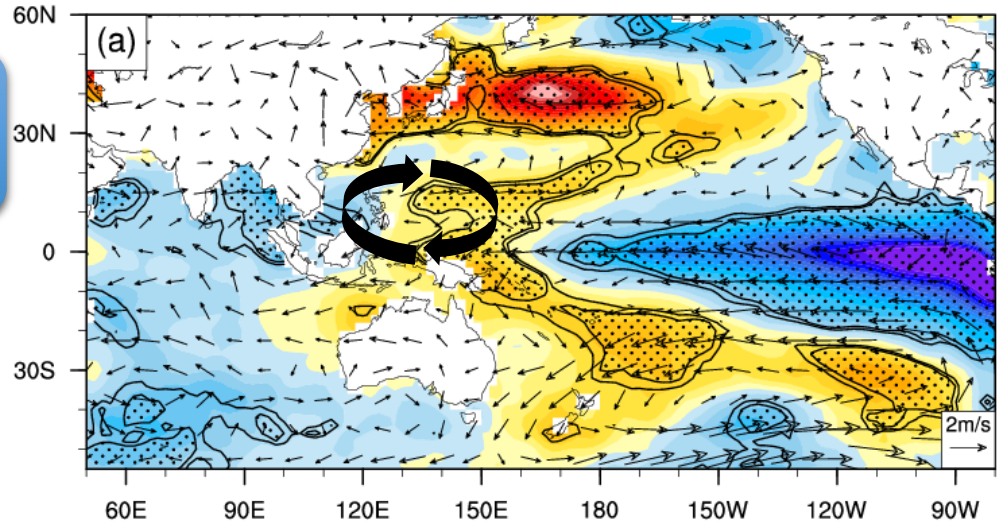
Typical years with more and less TCs

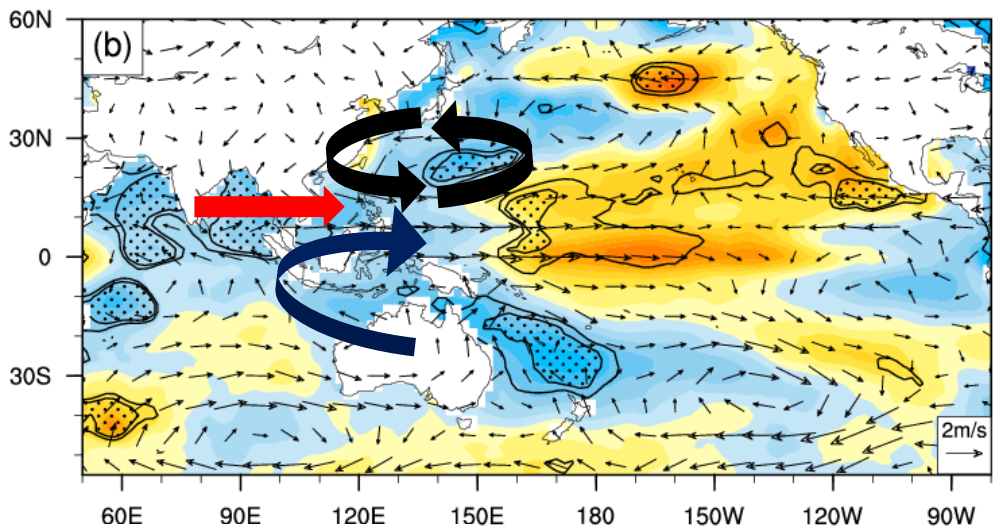
	Before 1995	After 1995
More	1950 1960 1961 1966 1967 1970 1971 1978 1994	1996 2000 2001 2004 2006 2009 2013
Less	1951 1957 1976 1977 1983 1986 1987 1991	1998 2003 2005 2008 2010

Interannual Characteristics of Main Impact Factors for TC Generation Before and After 1995

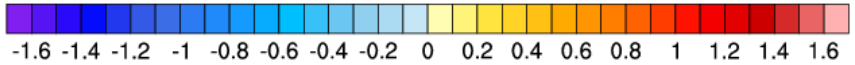
Composite difference of SST & 850hPa wind between typical more and less TC years

Before 1995





After 1995



La Nina-like → TC ↑

Anomalous anticyclone → TC ↓

SSTA or ENSO is more important before 1995

El Nino **Modoki**-like

Anomalous cyclone → TC ↑

Cross-equatorial flow from Australia

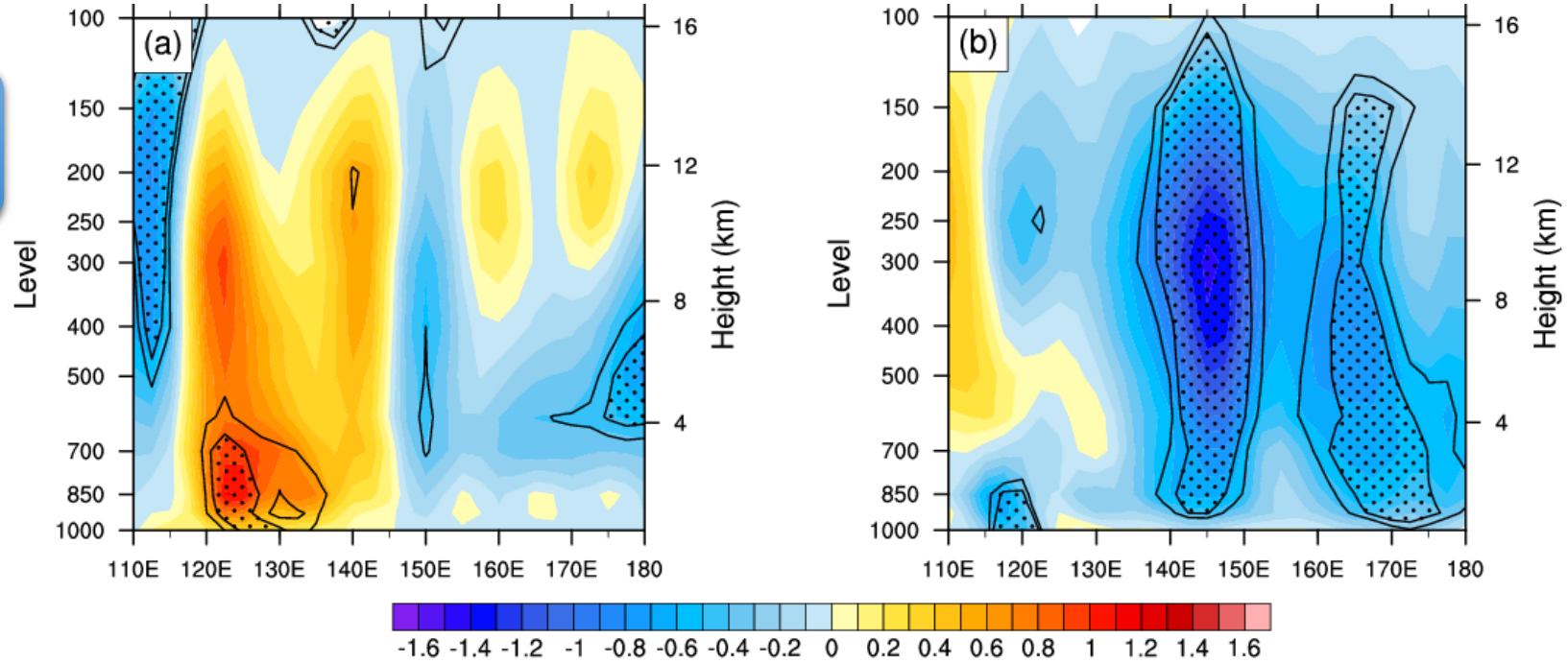
Westerlies convergence → TC ↑

Circulation is more important after 1995

Interannual Characteristics of Main Impact Factors for TC Generation Before and After 1995

Composite difference of 5-25°N meridional mean omega between typical more and less TC years

Before 1995



After 1995

Anomalous upward movement matches the positon of warm center of SSTA

SSTA is more important before 1995

Enhanced upward movement matches the anomalous cyclonical circulation and westerlies convergence on 850hPa

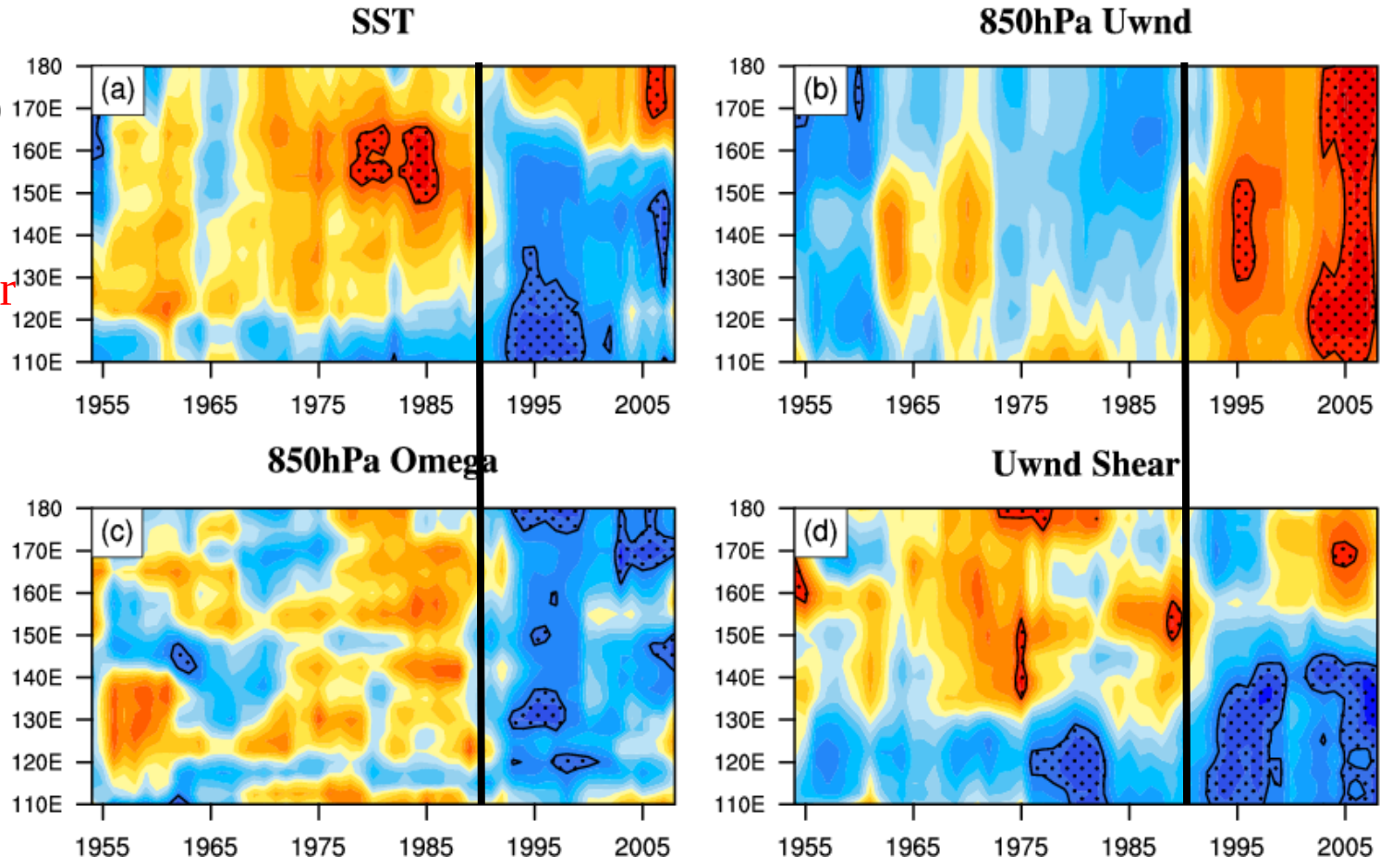
Circulation is more important after 1995

The Relative Importance of SST and Circulation on the Interannual variation of TC Number

The interannual zonal distributions of 11-year running correlation between TC number and 0-30°N meridional-mean SST, 850hPa zonal wind, 850hPa omega, and vertical uwnd shear

Positive correlation moves eastward by 30 longitudes **abruptly around 1990**.

After 1990, TC number **negatively** correlates with tropical SST.



Range of **positive correlation** region **expands suddenly around 1990.**

Negative correlation areas **expand obviously near 1990**

Negative correlation areas **shift eastward** and **expand around 1990**.

The primary impact factor for the interannual variation of TC generation changes is the SST environment before 1995 but the atmospheric circulation after 1995

Conclusion

Mann-Kendall test shows a significant abrupt change of TC number from more to less around 1995

Interdecadal

After 1995 minus Before 1995

- **Anomalous anticyclone**
- **Upward movement↓**
- **Vertical uwnd shear↑**
- **SLP↑**

Circulation Factors

TC number reduced abruptly in mid-1990s

The role of SSTA is not primary after 1995, but the La Nina-like related with the northwestward shift in TC generating location

Interannual

Typical More years minus Less Years

Before 1995

SSTA stimulated the upward movement

SSTA or ENSO is the main factor for the interannual variation of TC number

After 1995

Anomalous circulation matches the Enhanced upward movement

Circulation is the primary impact factor of TC number interannual variation


Thank You
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