

Global Warming and Tropical Cyclone Activity in the western North Pacific

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Outline

- The common perception
- Actual observations and possible explanations of the variations of the following TC characteristics
 - numbers and intensity
 - tracks and landfall locations
- Summary



The “Common” Perception



Global increase in air temperature

SST increase

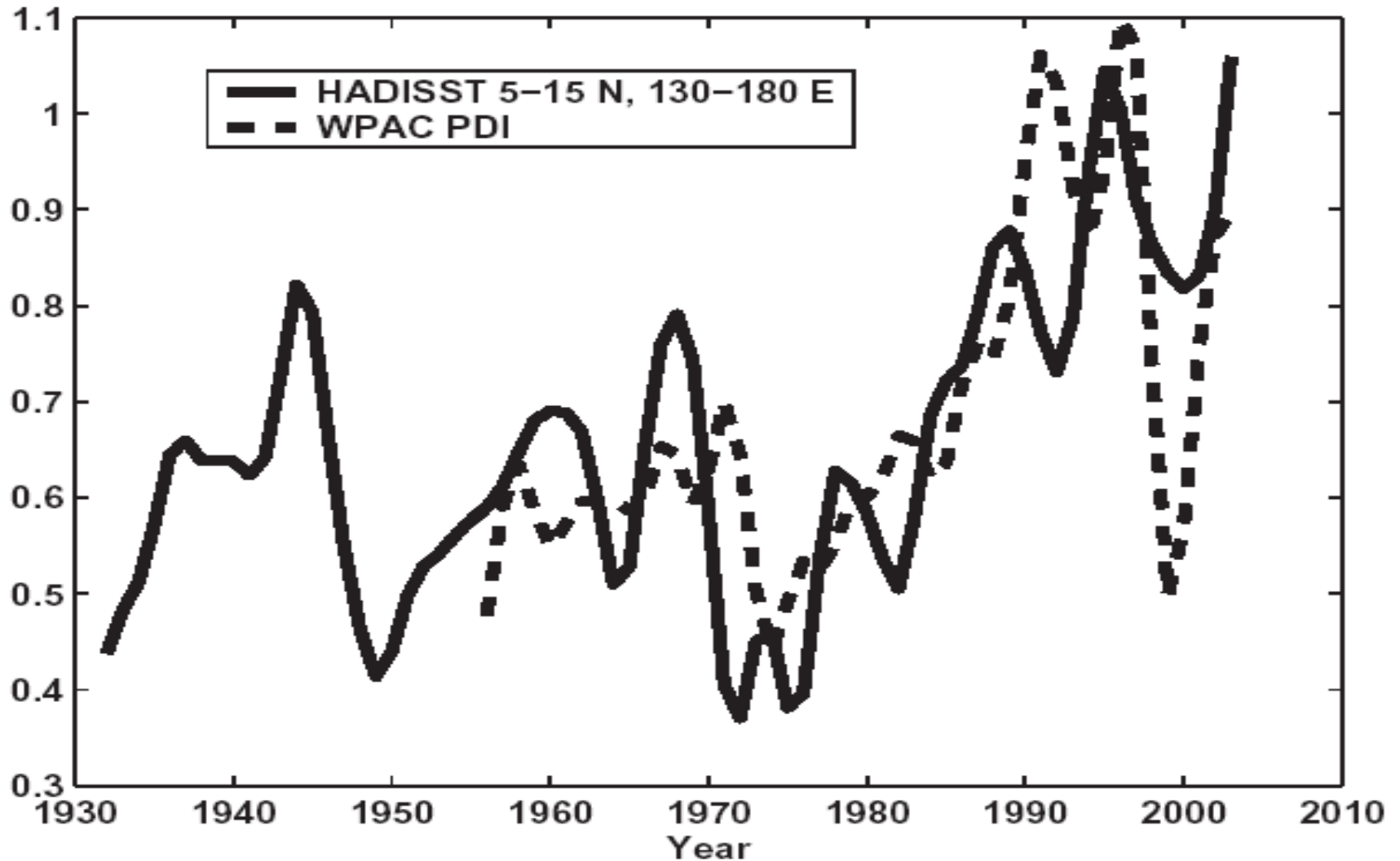
- **Provides more moisture**
- **Destabilizes the lower atmosphere**

More convection

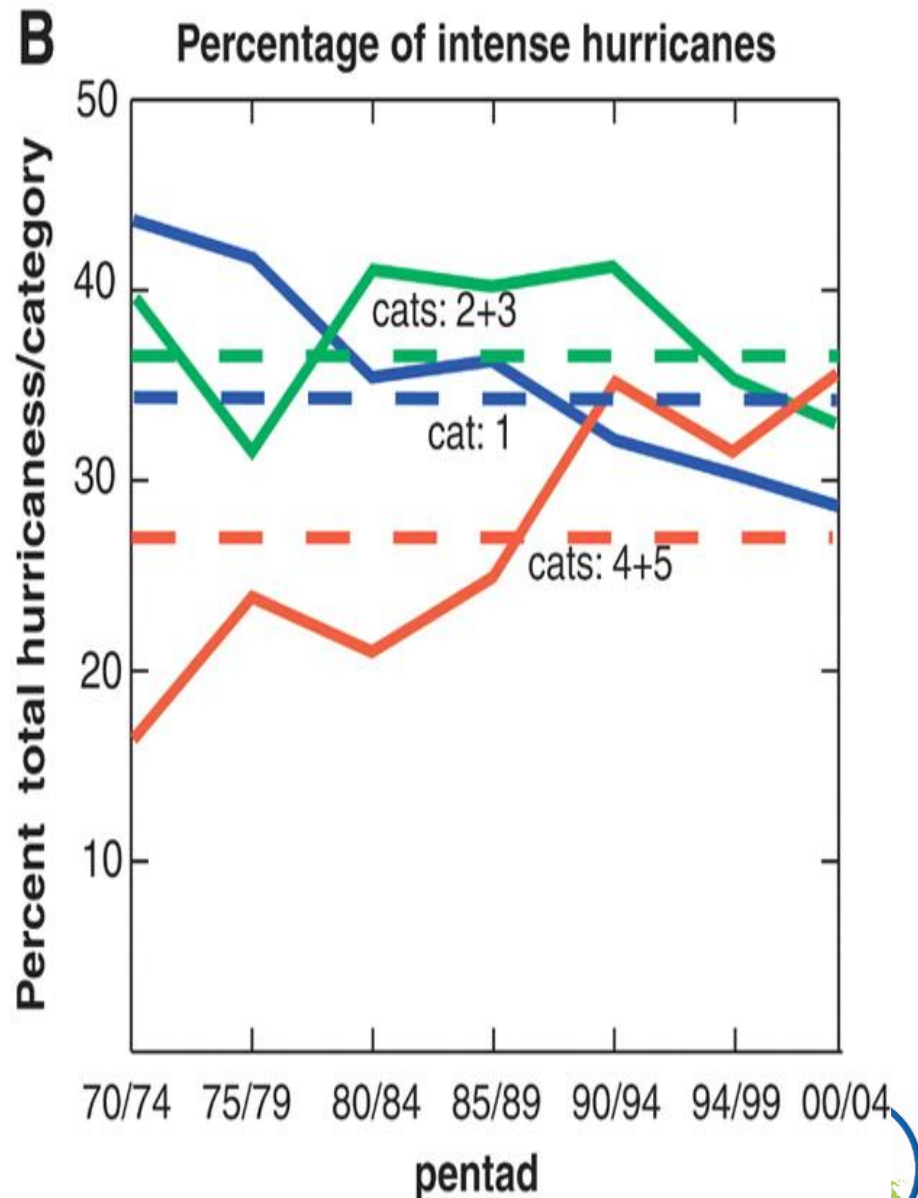
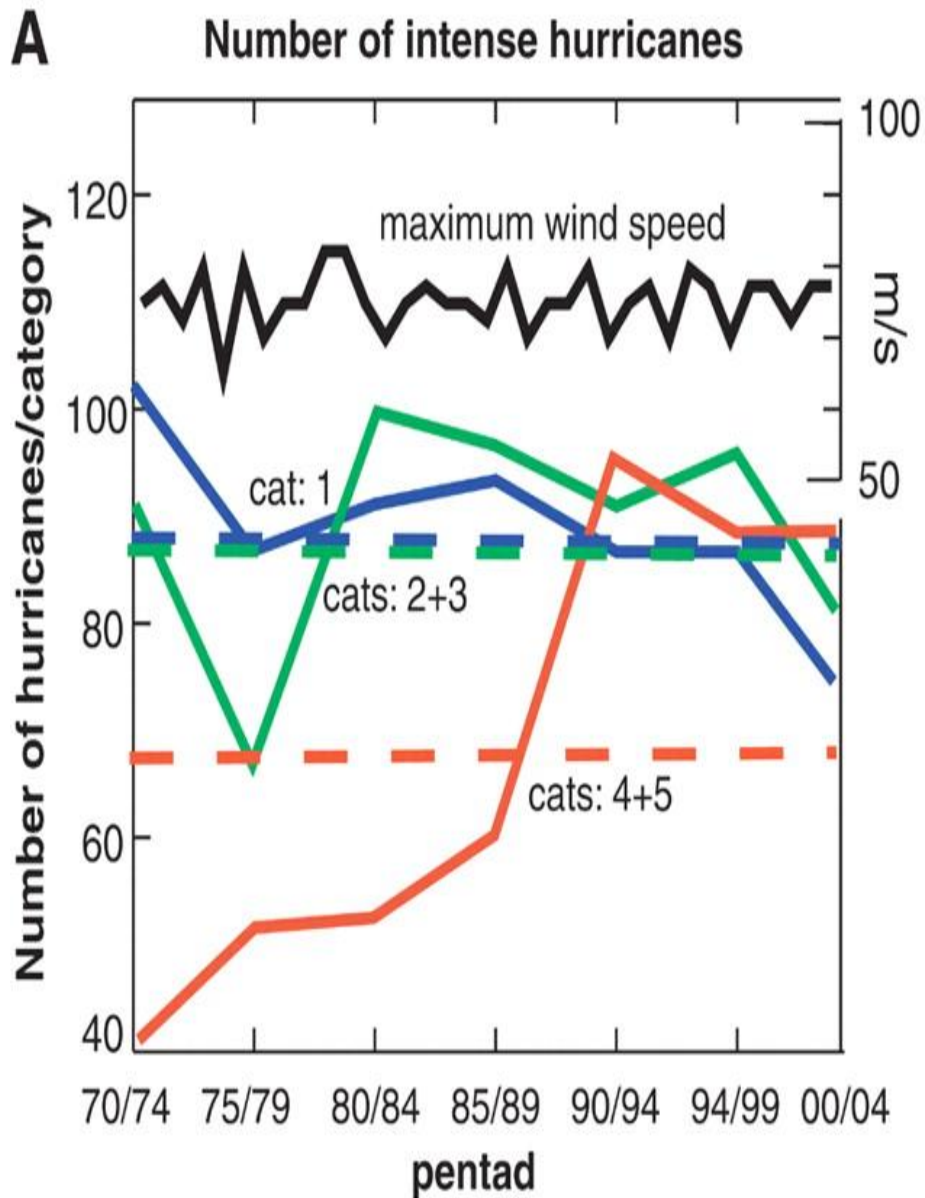
Increase in TC number and intensity

Emanuel's (2005) *Nature* paper

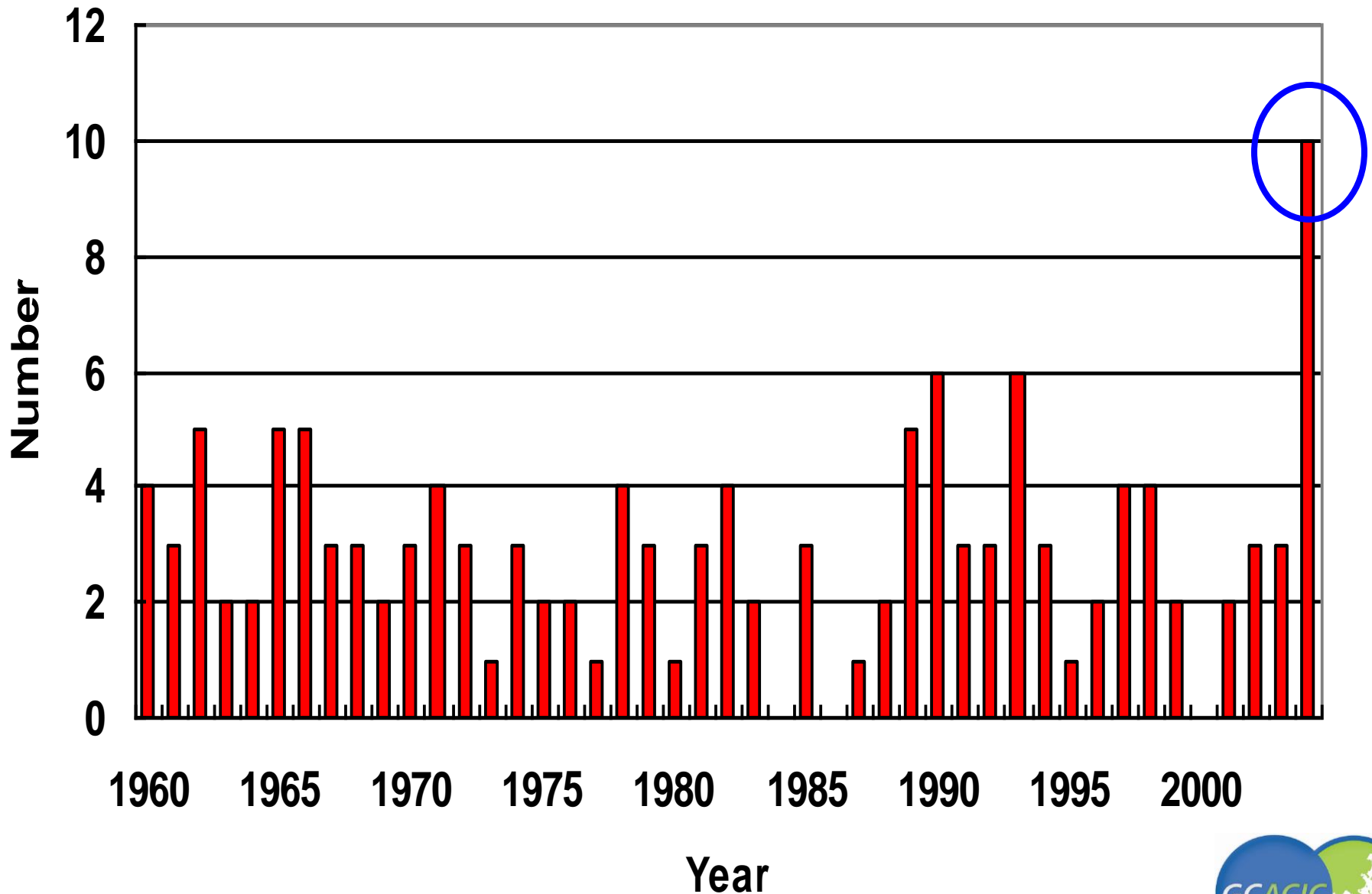
W. North Pacific PDI: (max wind)³



Webster et al.'s (2005) Science paper

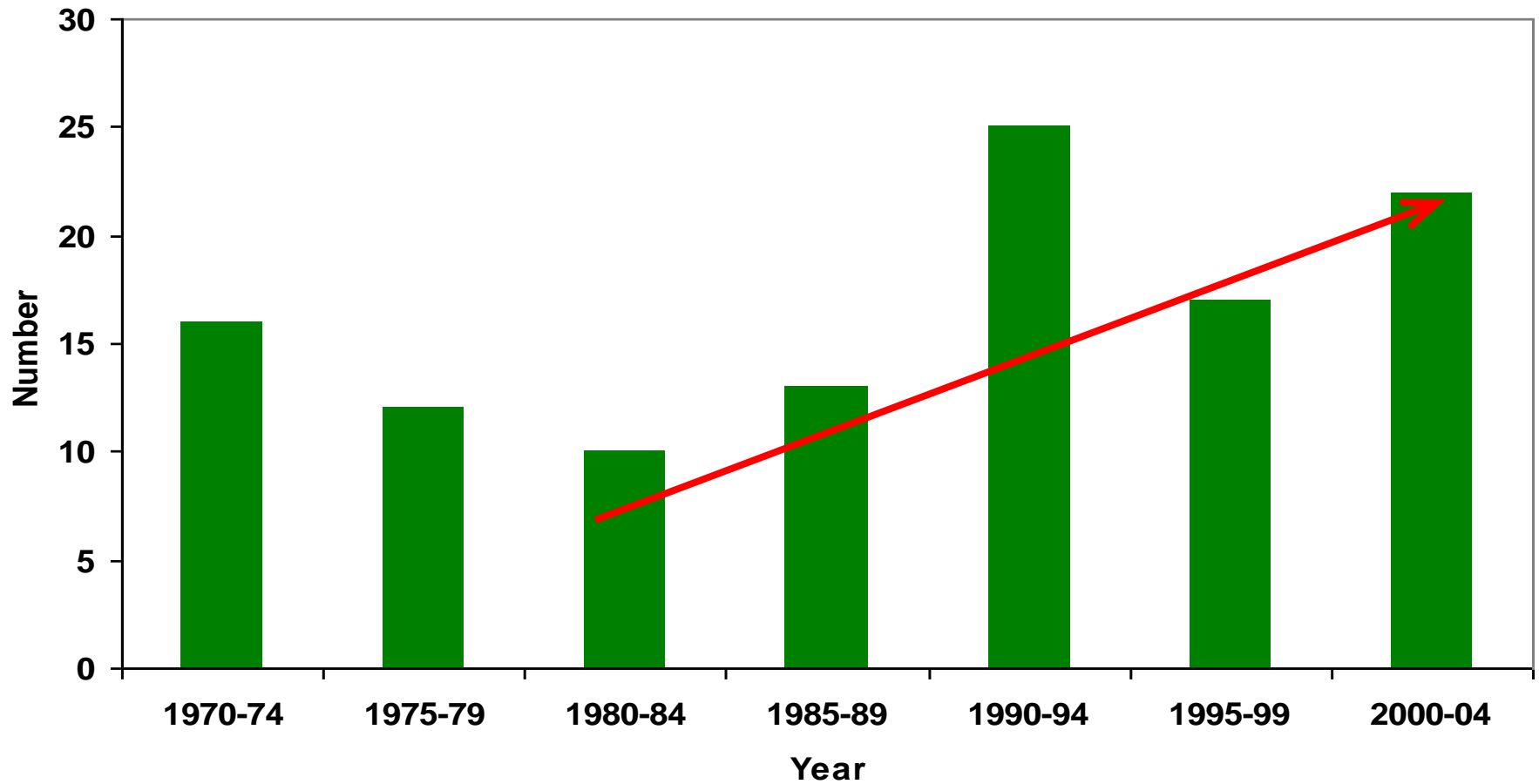


Number of Tropical Cyclones Making Landfall in Japan



Number of Tropical Cyclones Making Landfall in Japan and Korea Every 5-year period (1970-2004)

No. of Tropical Cyclones Making Landfall in Japan and Korea



The “Common” Conclusion

Tropical cyclone activity and that of intense typhoons in the western North Pacific, as well as the number of tropical cyclones making landfall along the Asian coast have been on the increase as a result of global warming.



A satellite image of a typhoon, showing a well-defined eye and a dense, swirling cloud structure. The image is in grayscale, with the clouds appearing as bright white and light gray against the darker background of the ocean and surrounding clouds.

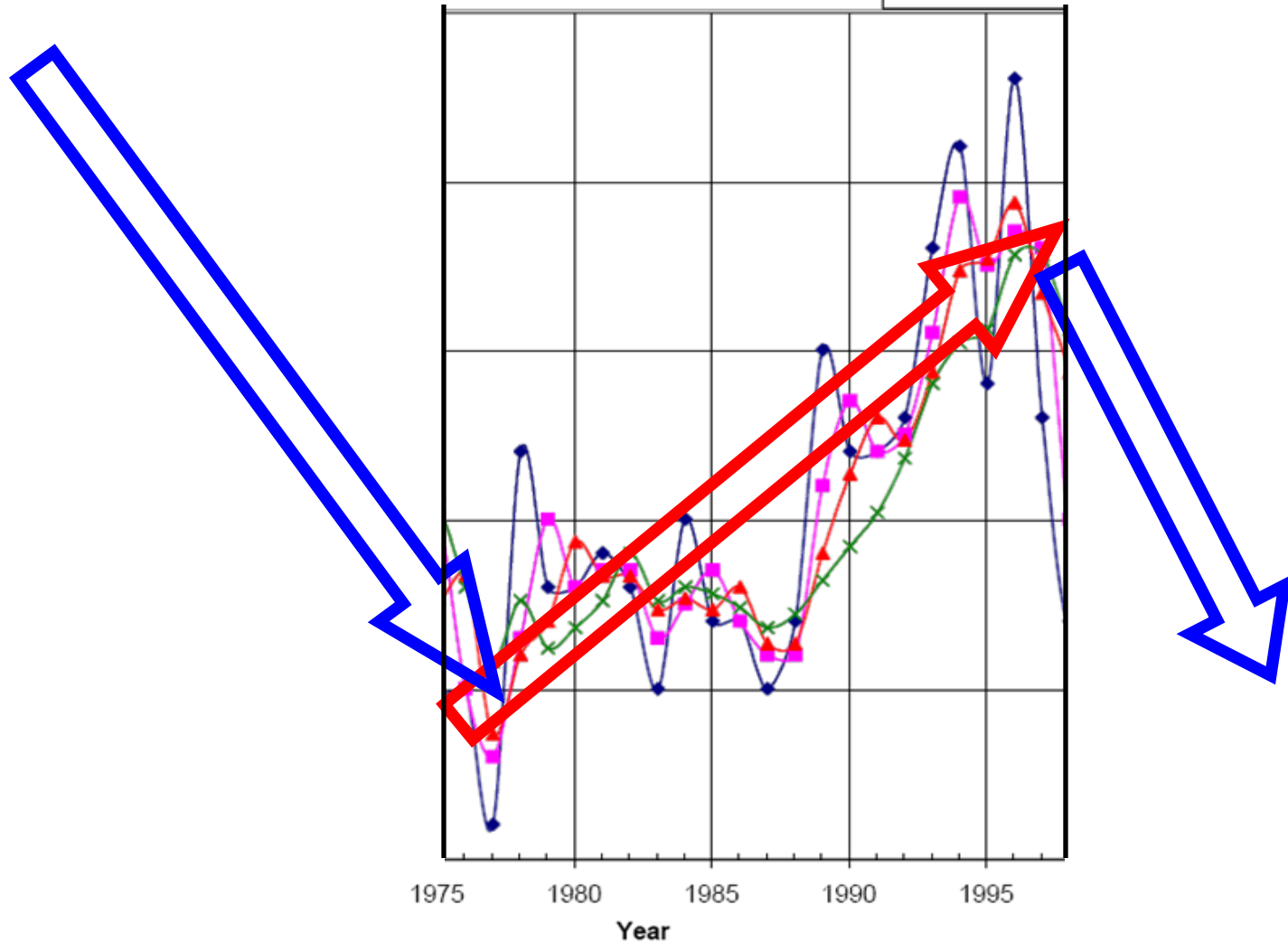
Actual observations and explanations
– Number and Intensity



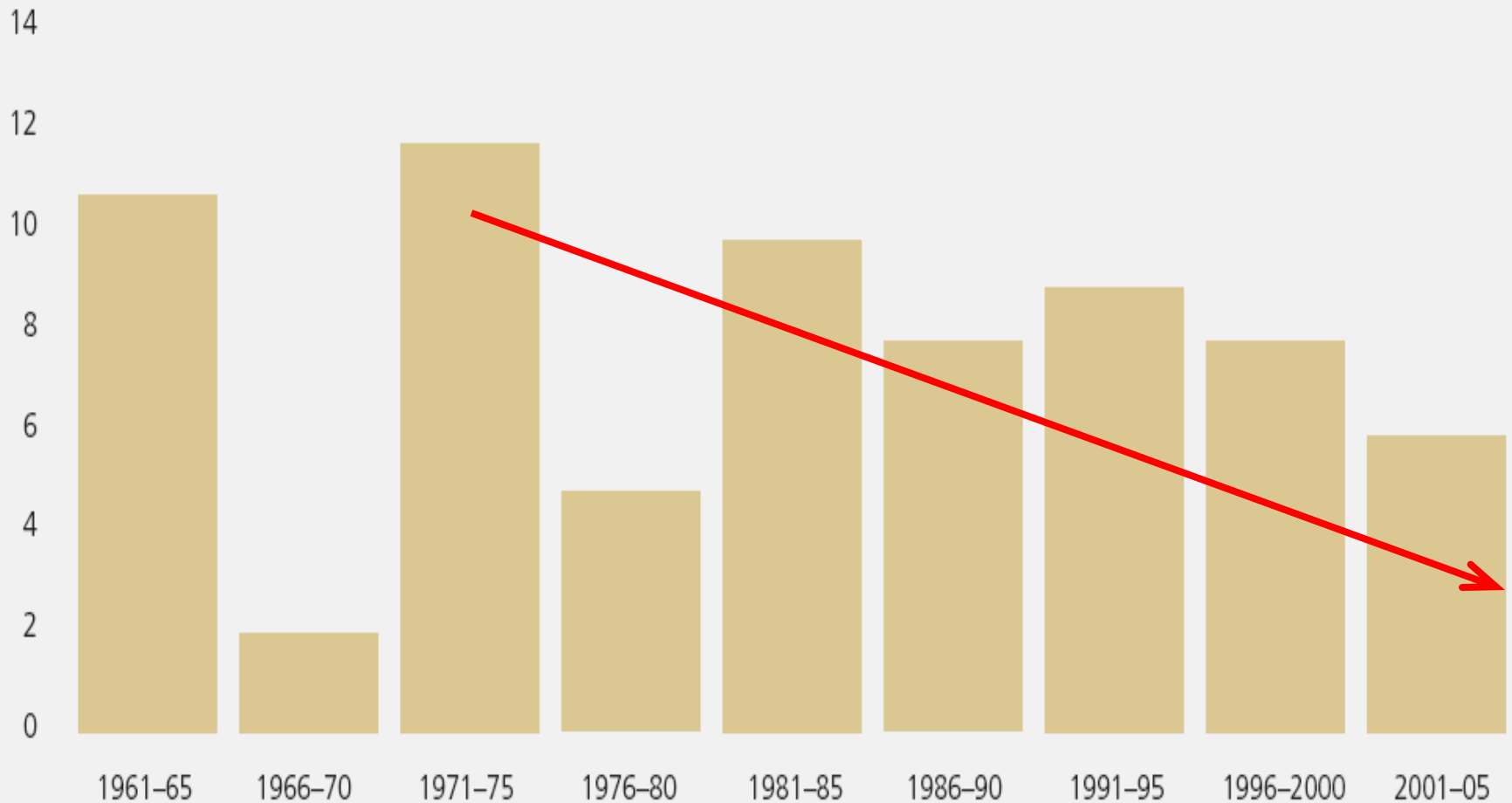
Number of TCs in WNP (from JTWC)

of all TC's in NorthWestPac

- Yearly data
- 2 year mean
- 3 year mean
- 5 year mean

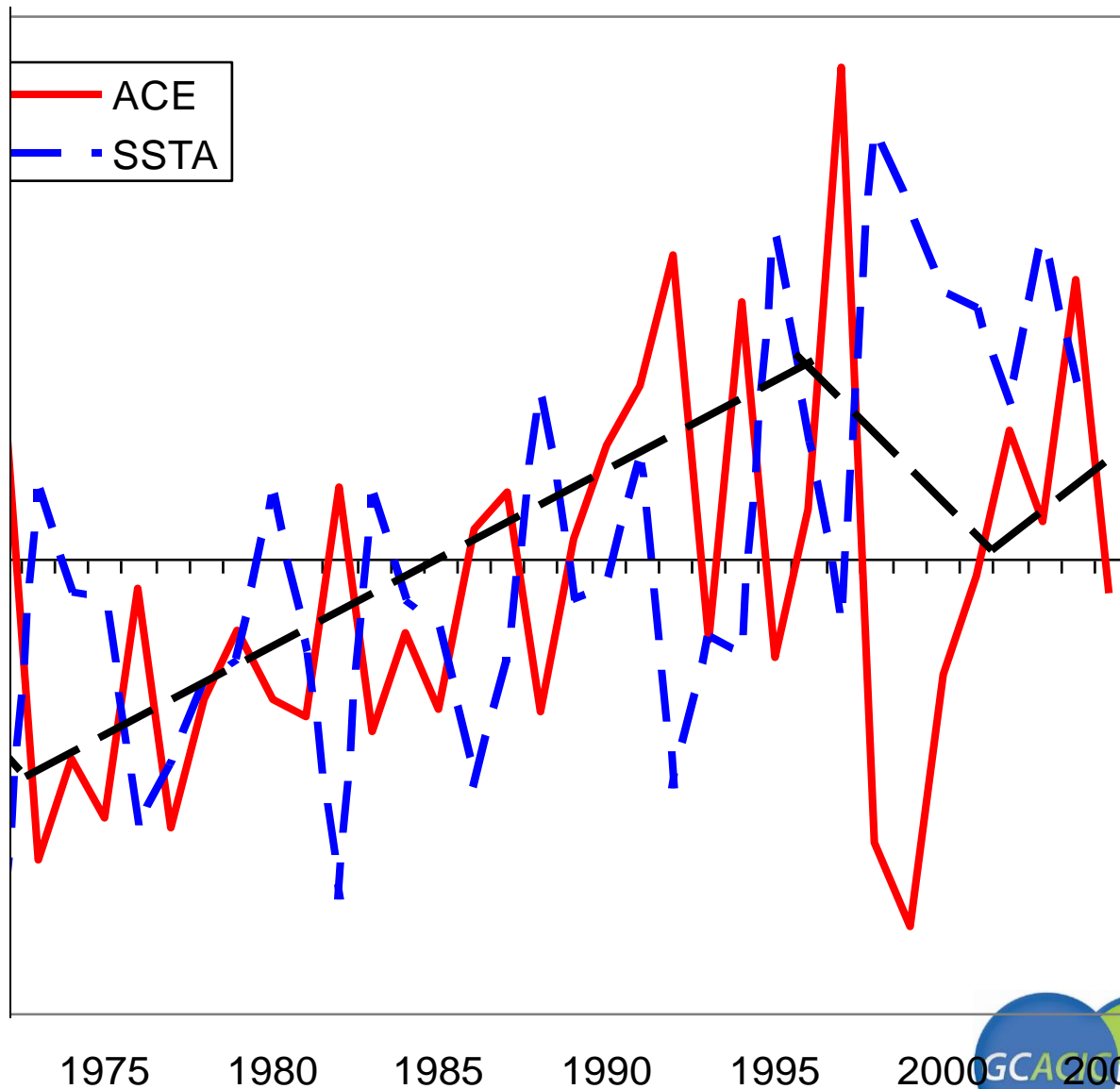


Number of Typhoons Making Landfall in Guangdong/Hainan (South China) Every 5-year period (1960-2005)

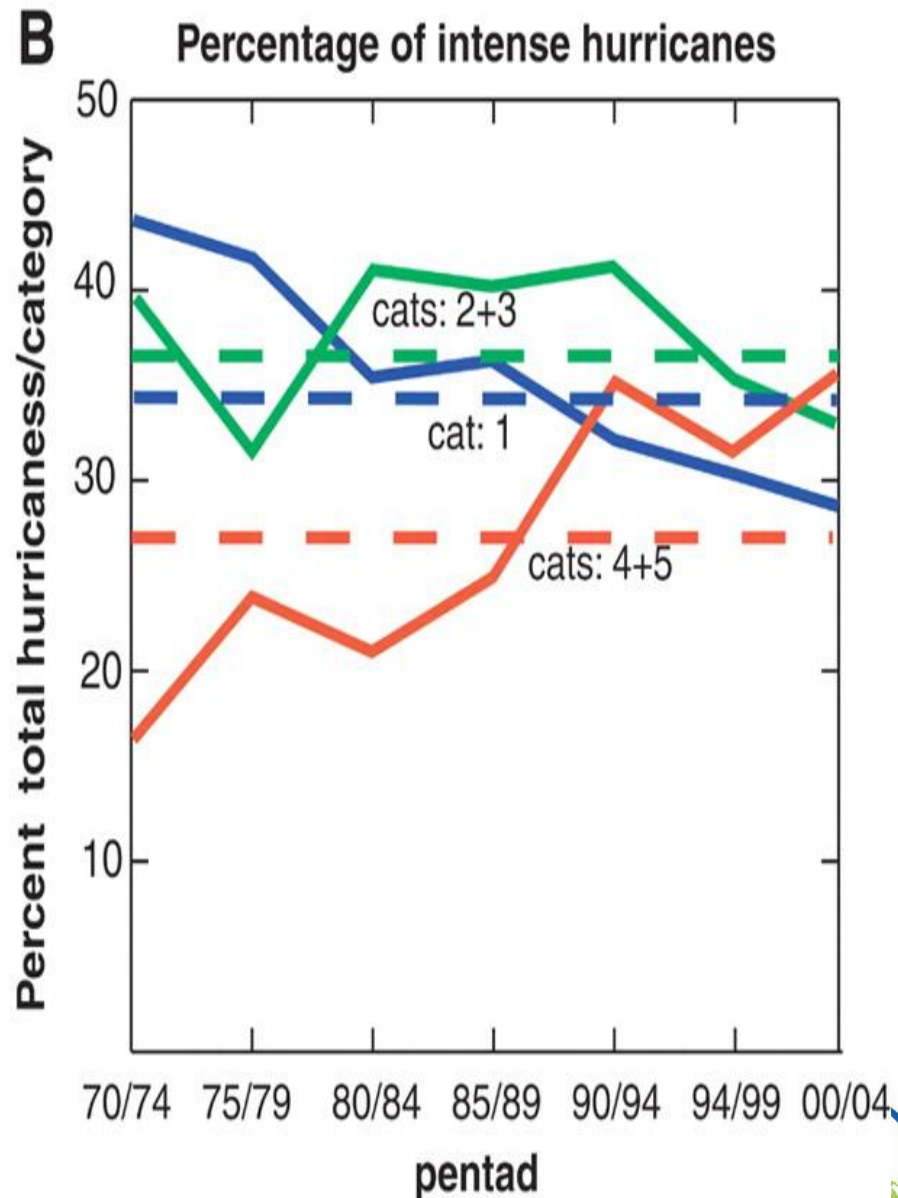
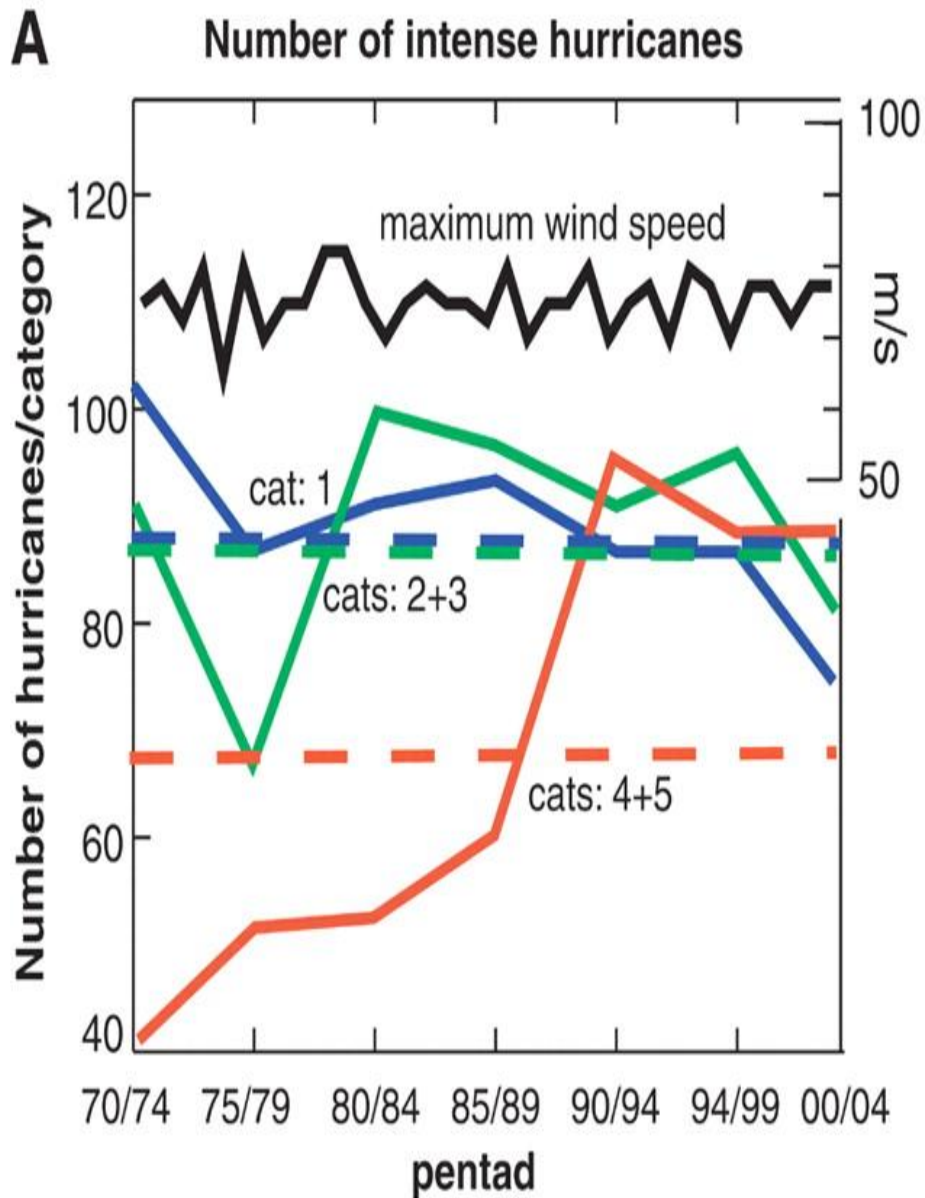


ACE vs. May-Nov SSTA (5-30°N, 120-180°E)

[standardized = (raw-mean)/S.D.]

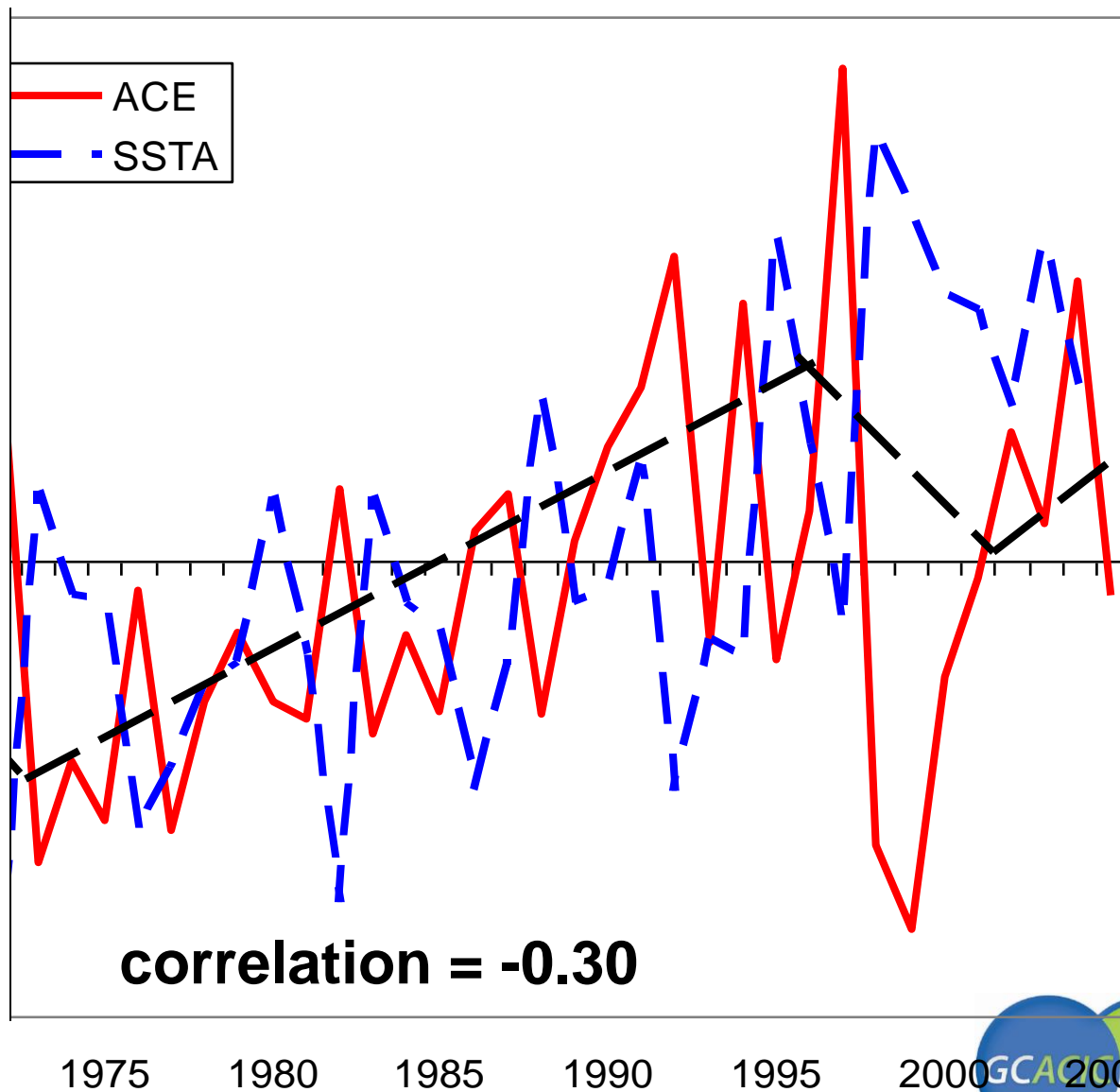


Webster et al.'s (2005) Science paper



ACE vs. May-Nov SSTA (5-30°N, 120-180°E)

[standardized = (raw-mean)/S.D.]



No. of Category 4 and 5 Typhoons

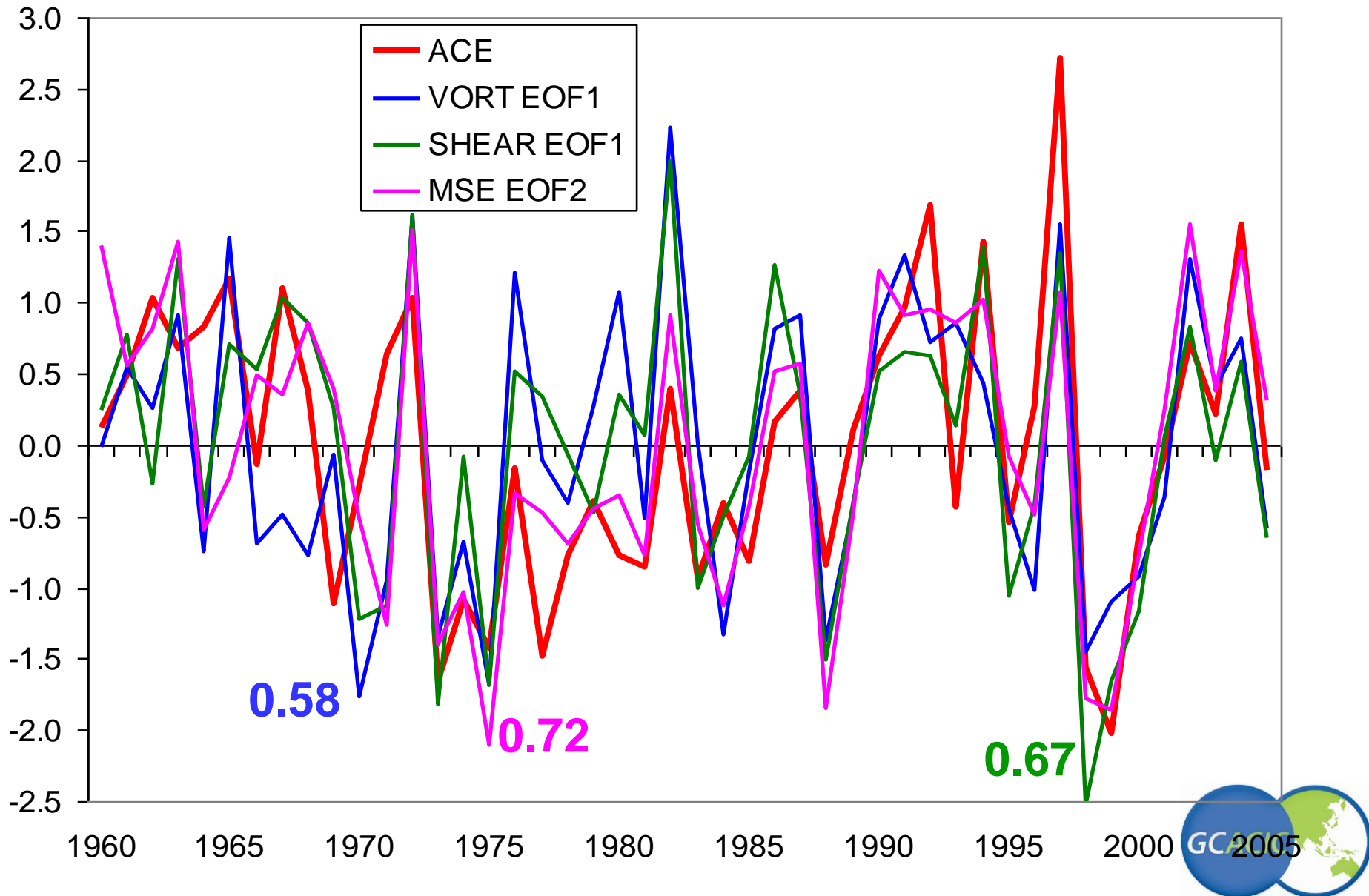
	1975-89	1990-2004
Number	75	115
Percentage	32	42

No. of Category 4 and 5 Typhoons

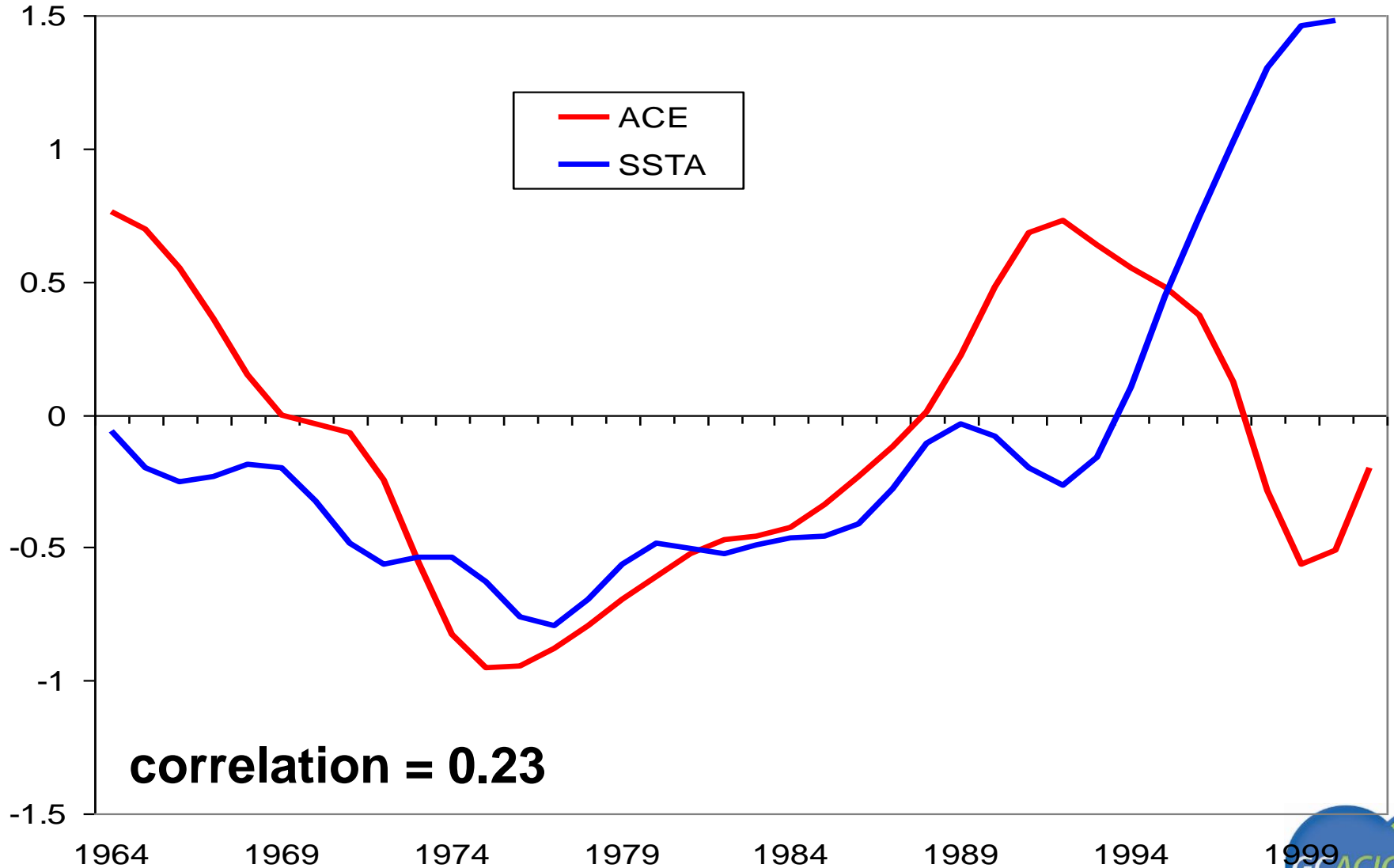
	1960-74	1975-89	1990-2004
Number	105	75	115
Percentage	37	32	42

ACE vs.. VORT, SHEAR and MSE

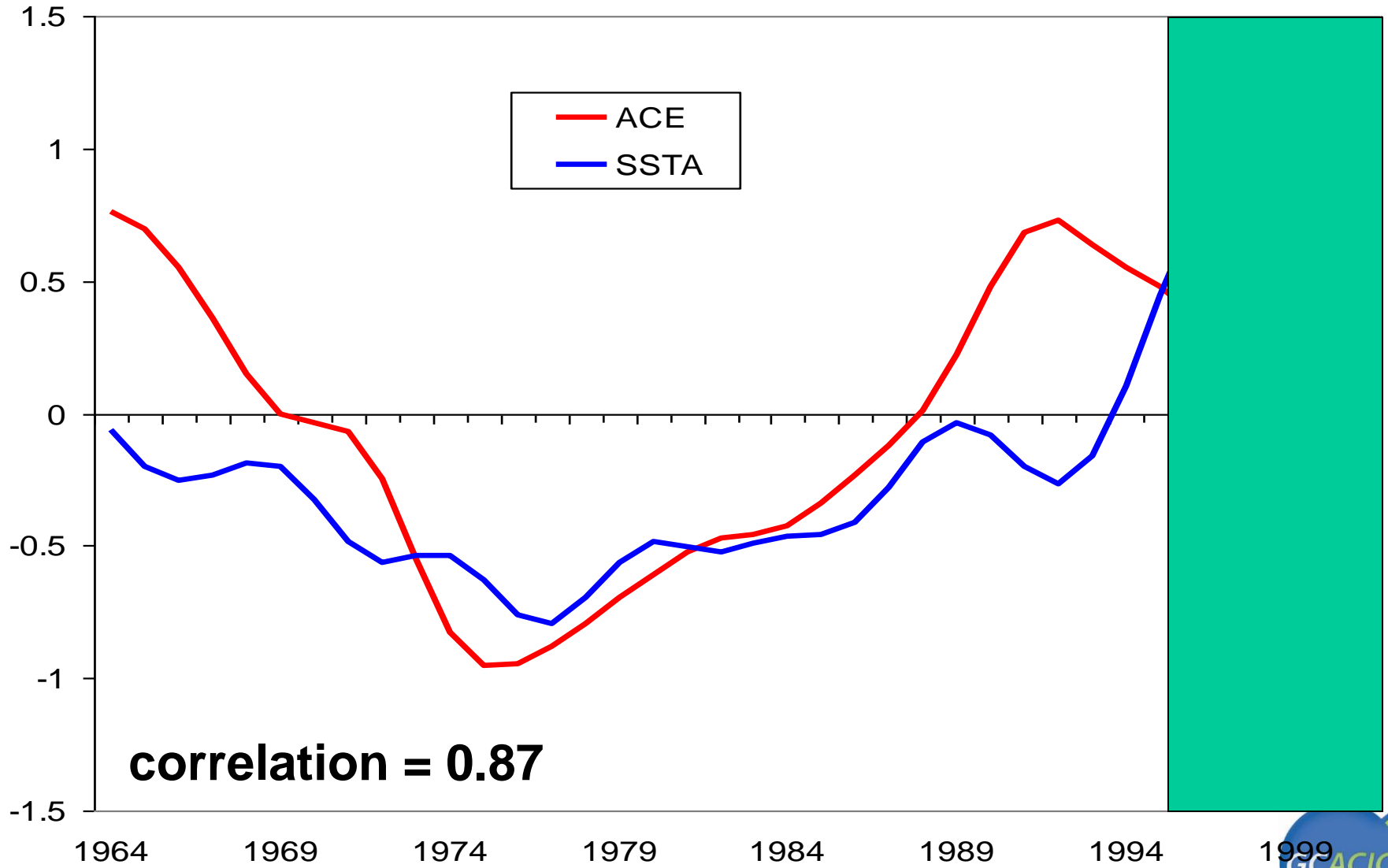
Science, 311, 1713b, *Tellus 2007*



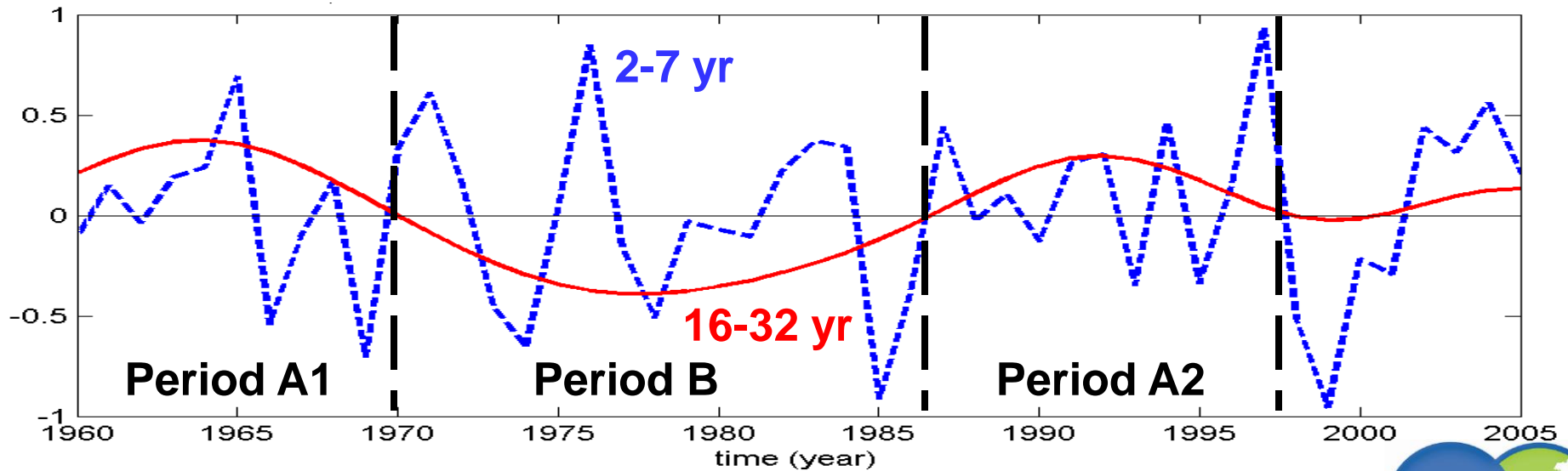
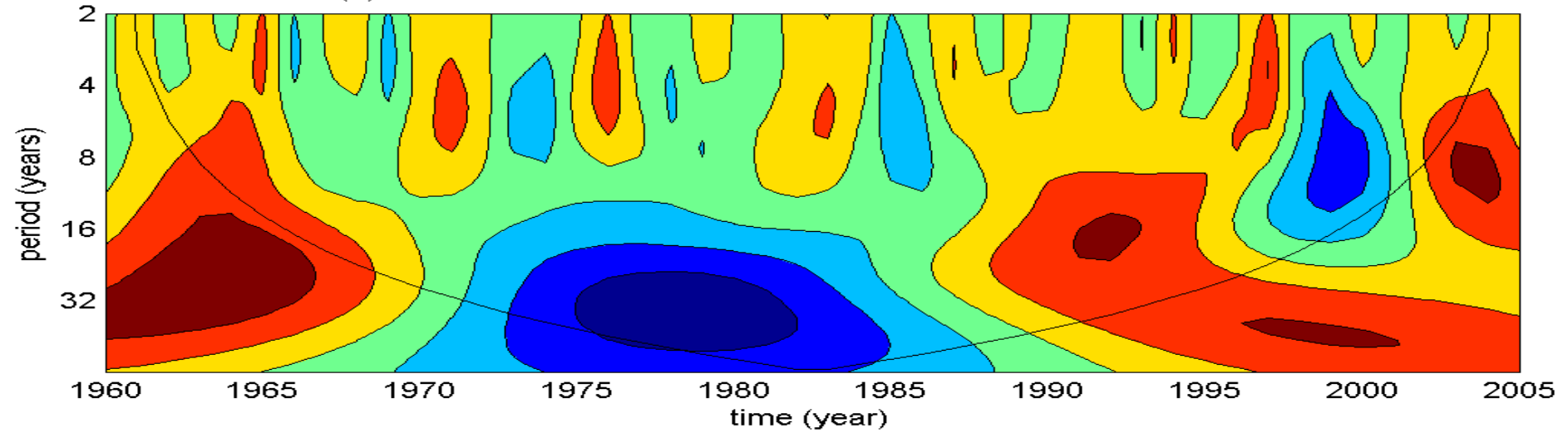
ACE vs. May-Nov SSTA (5-30°N, 120-180°E) [10-year Gaussian-filtered; standardized]



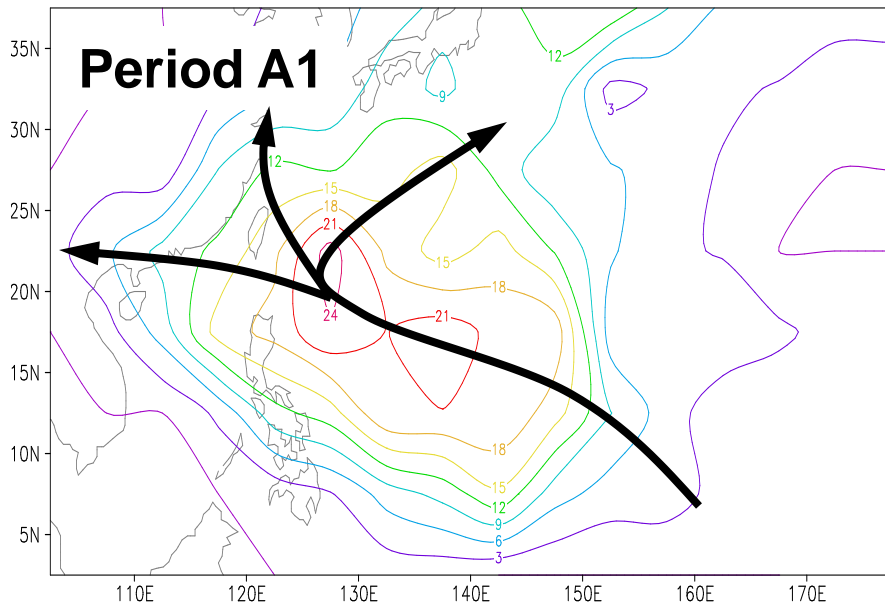
ACE vs. May-Nov SSTA (5-30°N, 120-180°E) [10-year Gaussian-filtered; standardized]



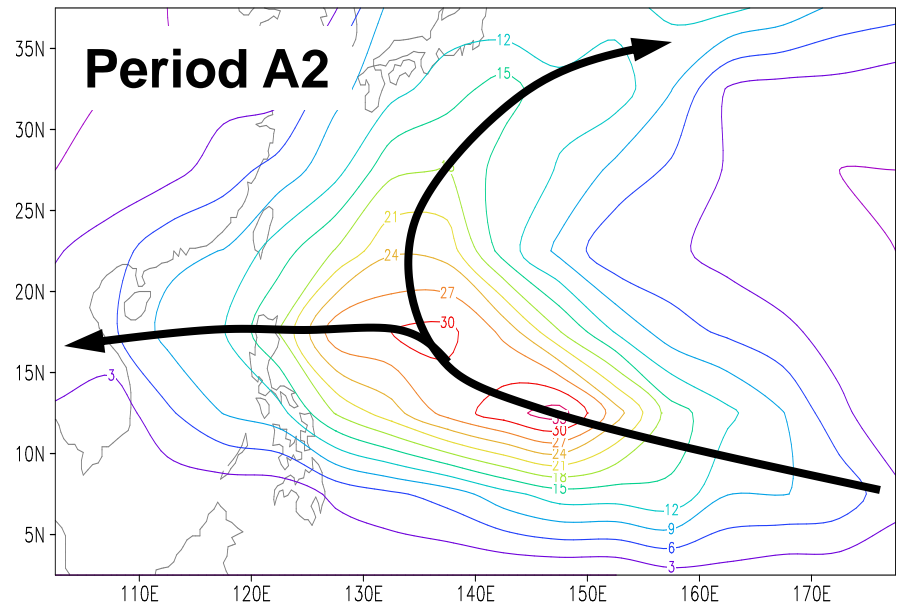
Wavelet Analysis of Intense Typhoon Occurrence Frequency



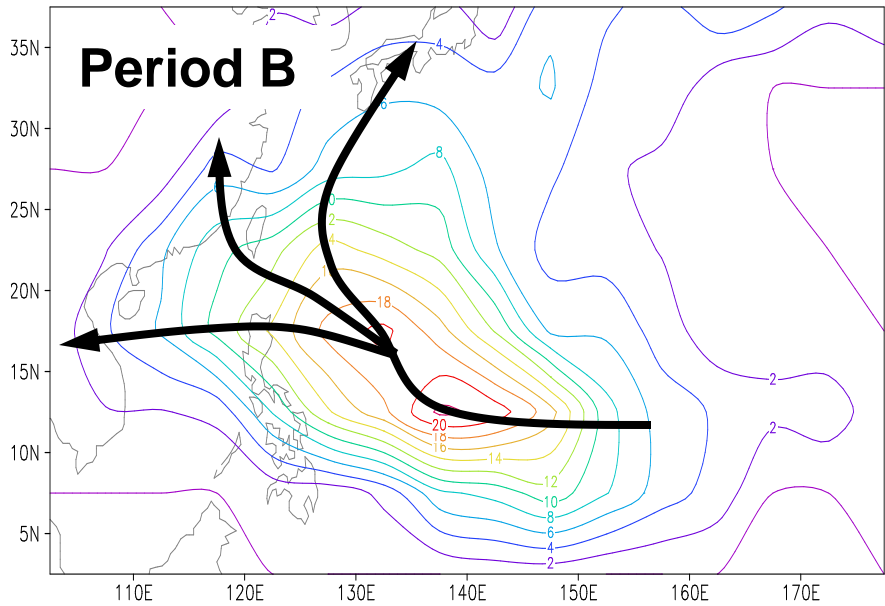
Frequency of occurrence of intense TY (x10) (1960–70)



Frequency of occurrence of intense TY (x10) (1987–97)



Frequency of occurrence of intense TY (x10) (1971–86)



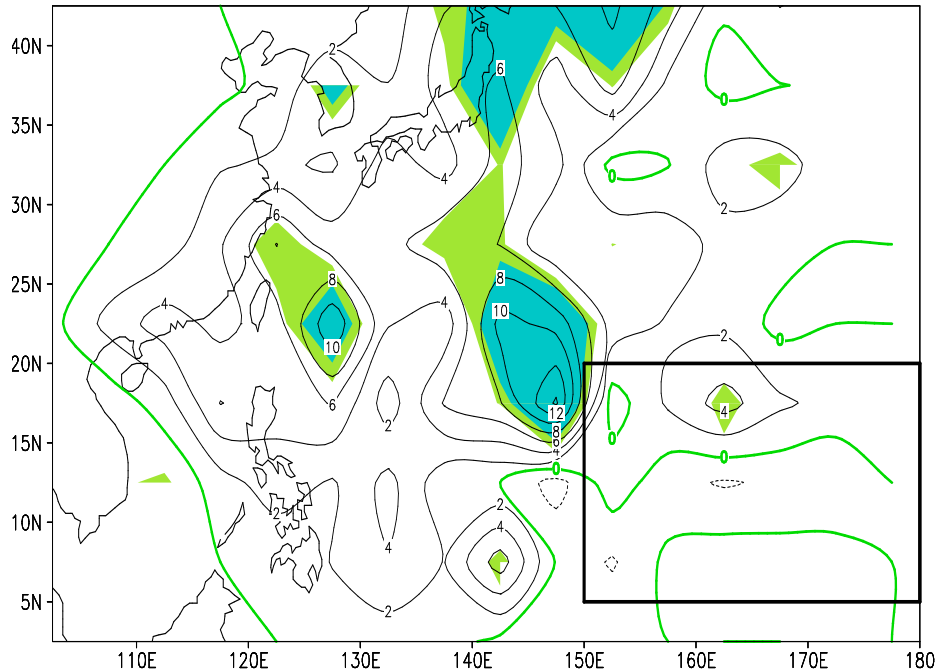
Frequency of Occurrence of Intense Typhoons

Difference in the Frequency of Occurrence of Intense Typhoons

Proceedings, Royal Society A (2008)

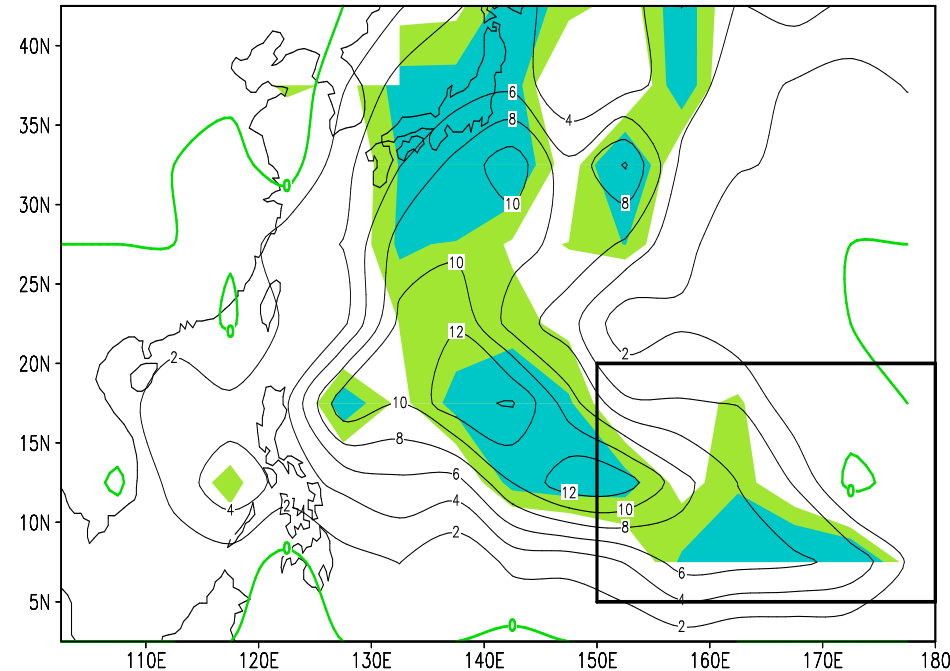
Period A1 minus Period B

Frequency of occurrence of intense TY (x10)
(1960-70) minus (1971-86)



Period A2 minus Period B

Frequency of occurrence of intense TY (x10)
(1987-97) minus (1971-86)



Blue shading: 95%

Green shading: 90%

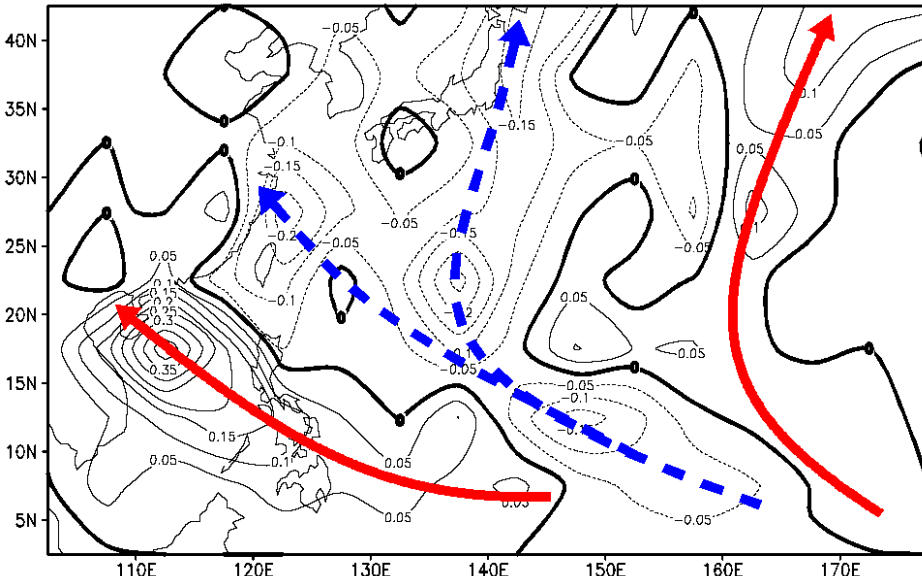


Actual observations and explanations
– Track and Landfall Variations



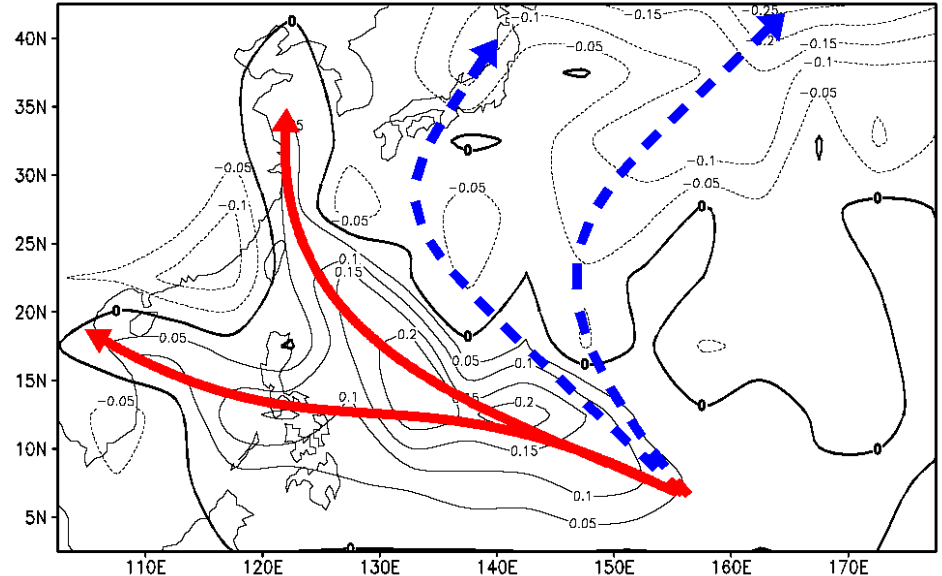
1964-76

TS occurrence EOF2 (18.0%)



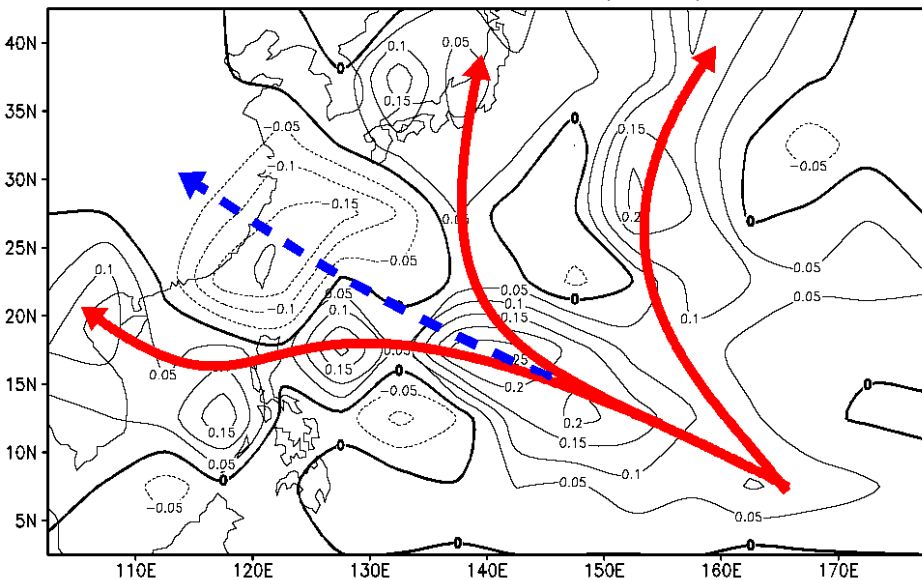
1977-88

TS occurrence EOF1 (25.8%)



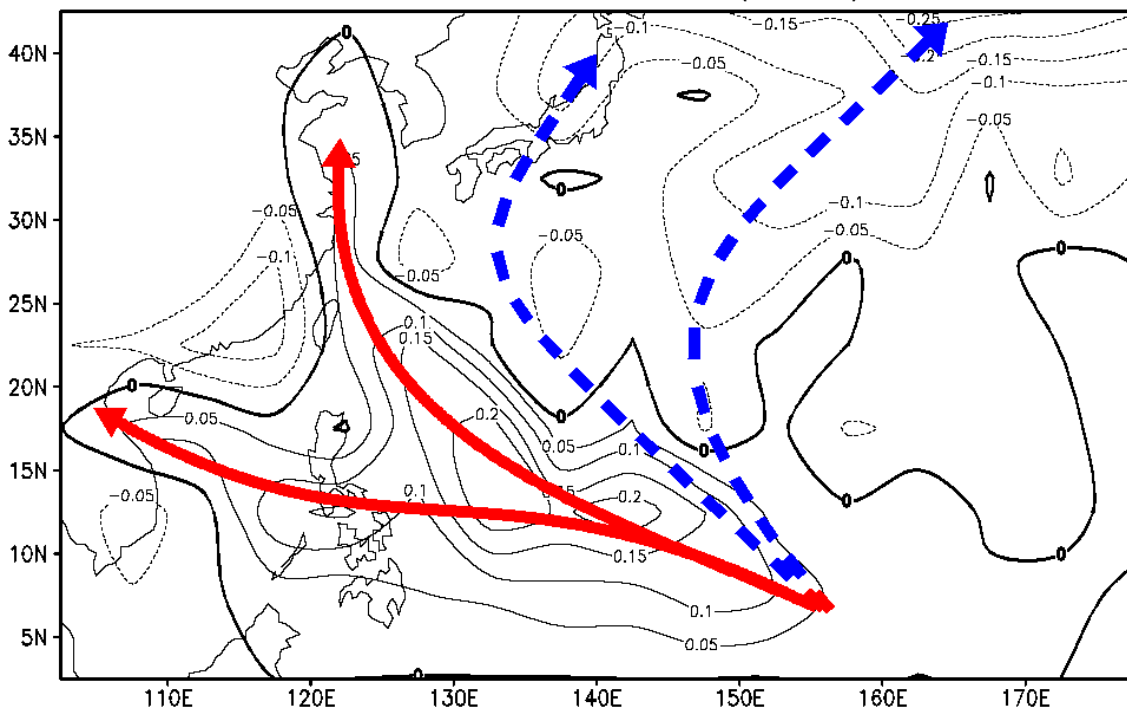
1989-97

TS occurrence EOF3 (15.2%)



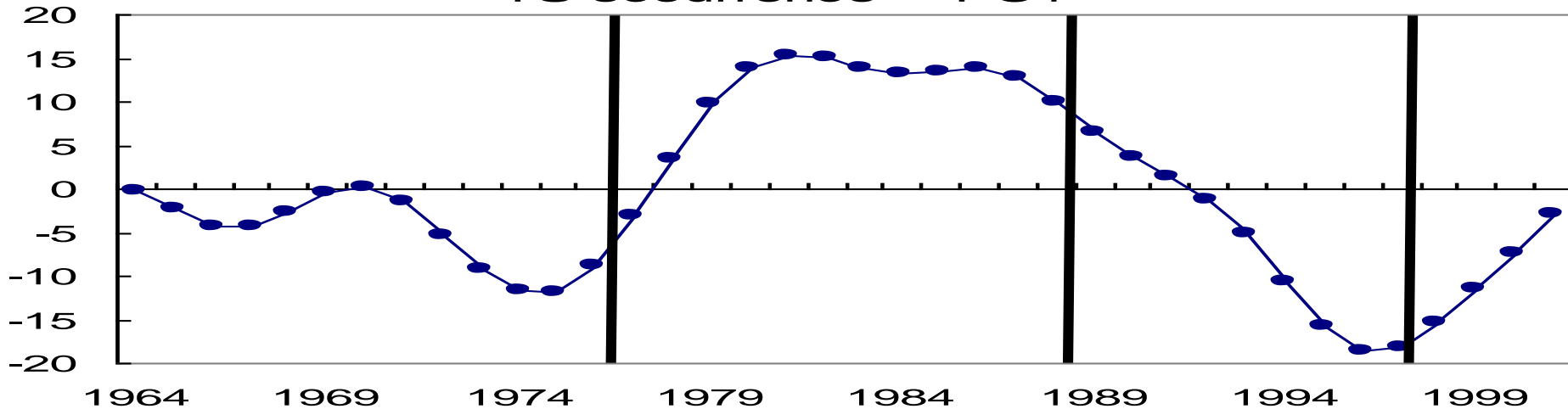
Anomalies of Frequency of TC Occurrence

TS occurrence EOF1 (25.8%)

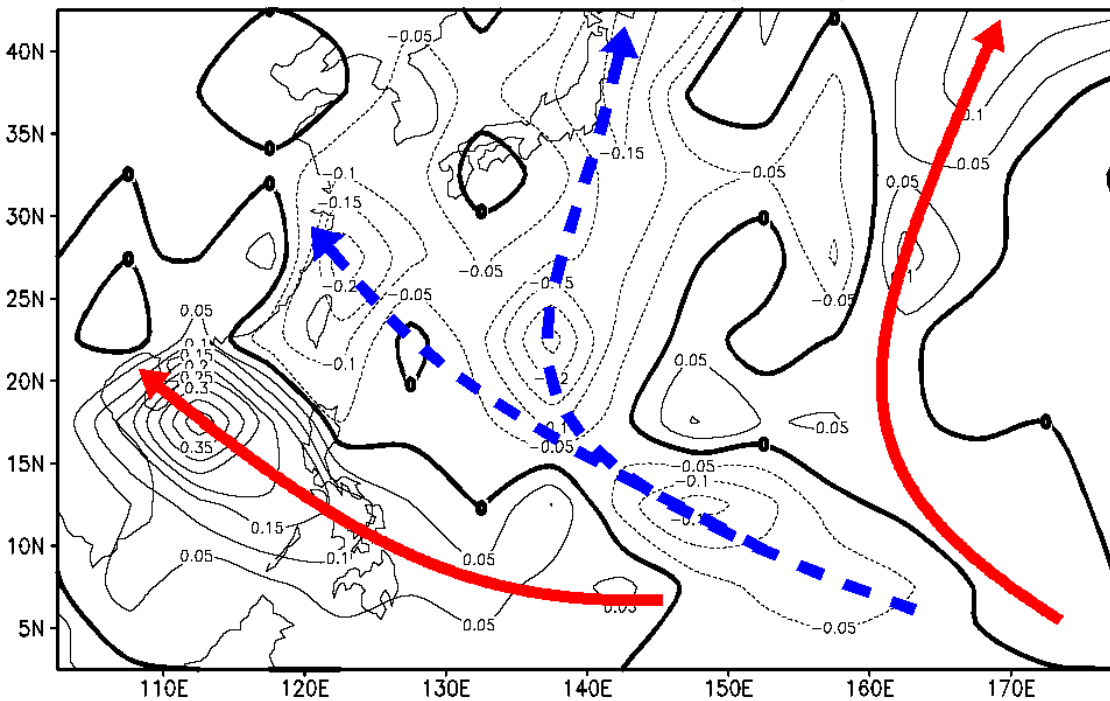


**EOF1 of
10-year-filtered
TC occurrence**

TS occurrence PC1

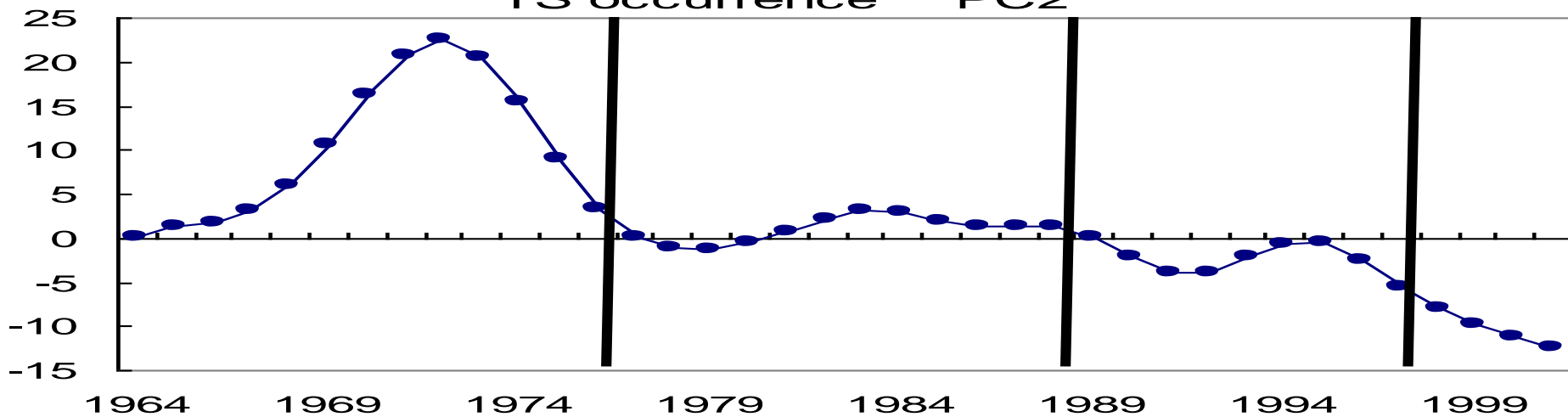


TS occurrence EOF2 (18.0%)

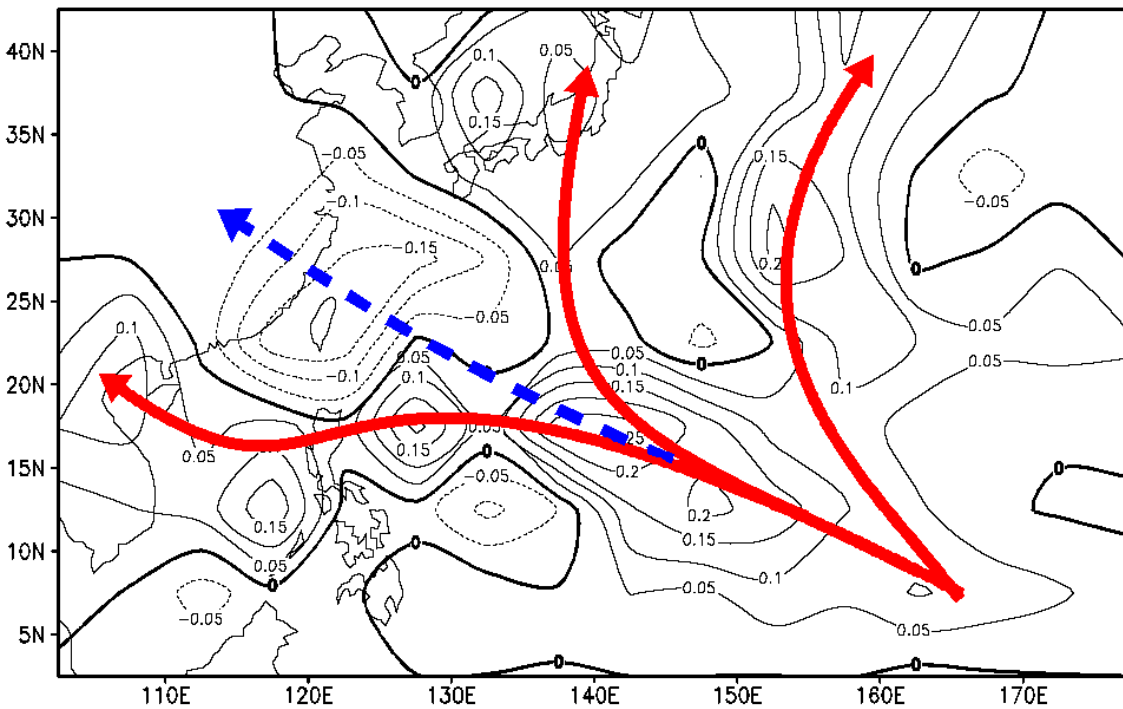


**EOF2 of
10-year-filtered
TC occurrence**

TS occurrence PC2

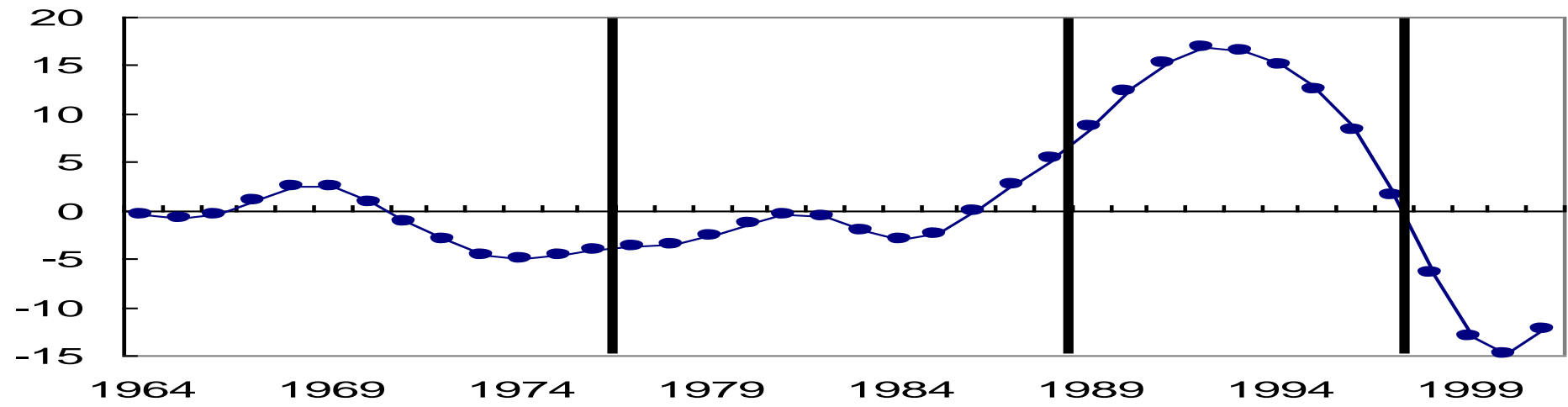


TS occurrence EOF3 (15.2%)

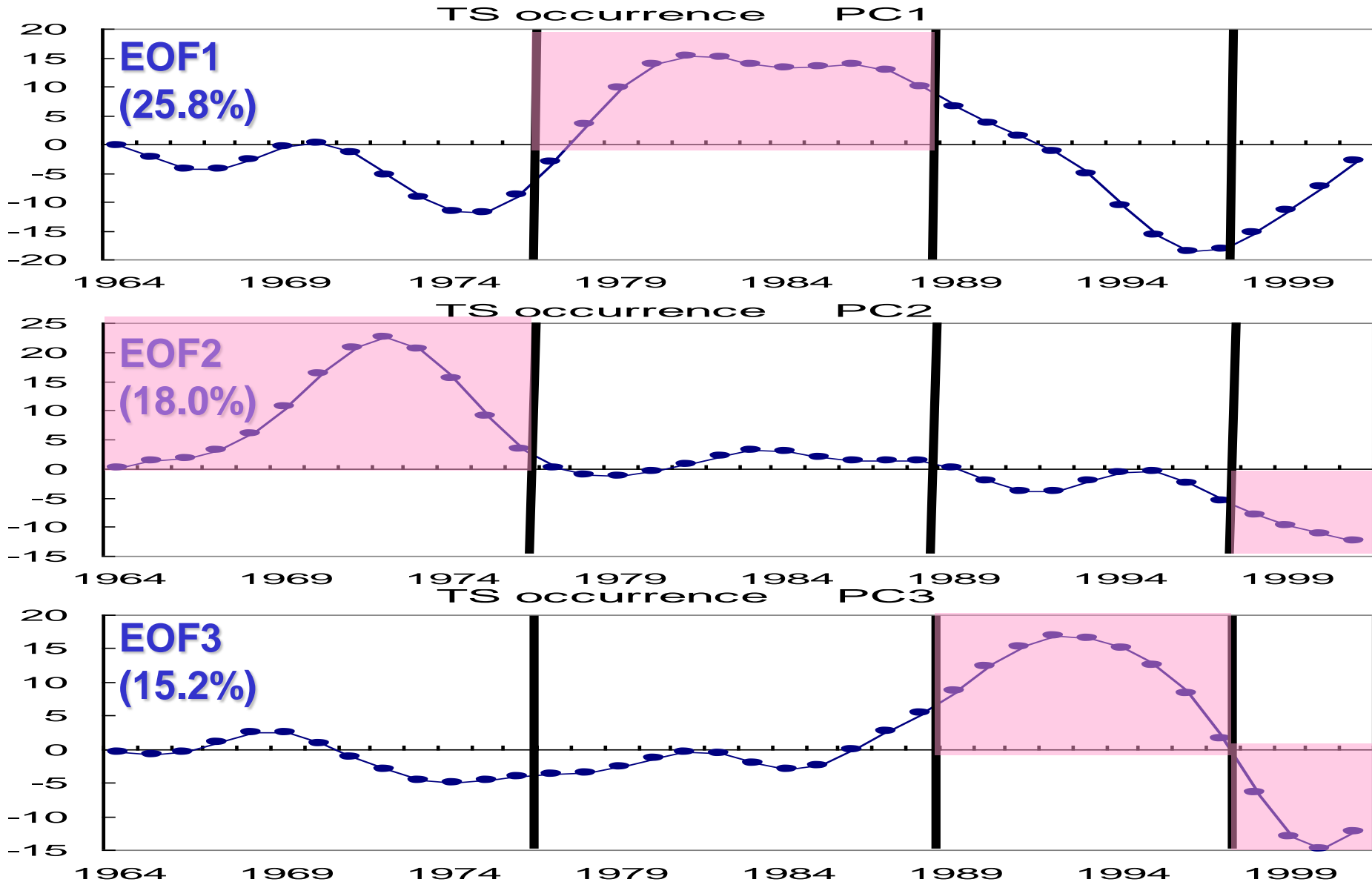


**EOF3 of
10-year-filtered
TC occurrence**

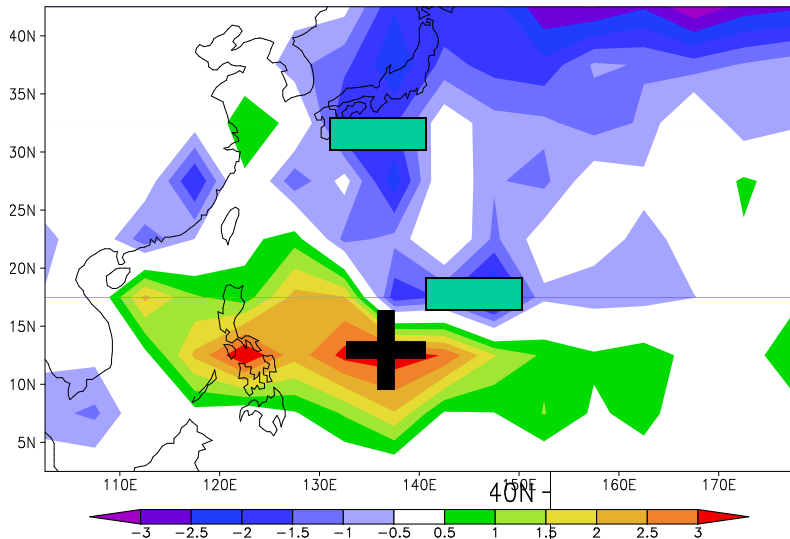
TS occurrence PC3



Time series of EOFs of 10-year-filtered TC occurrence

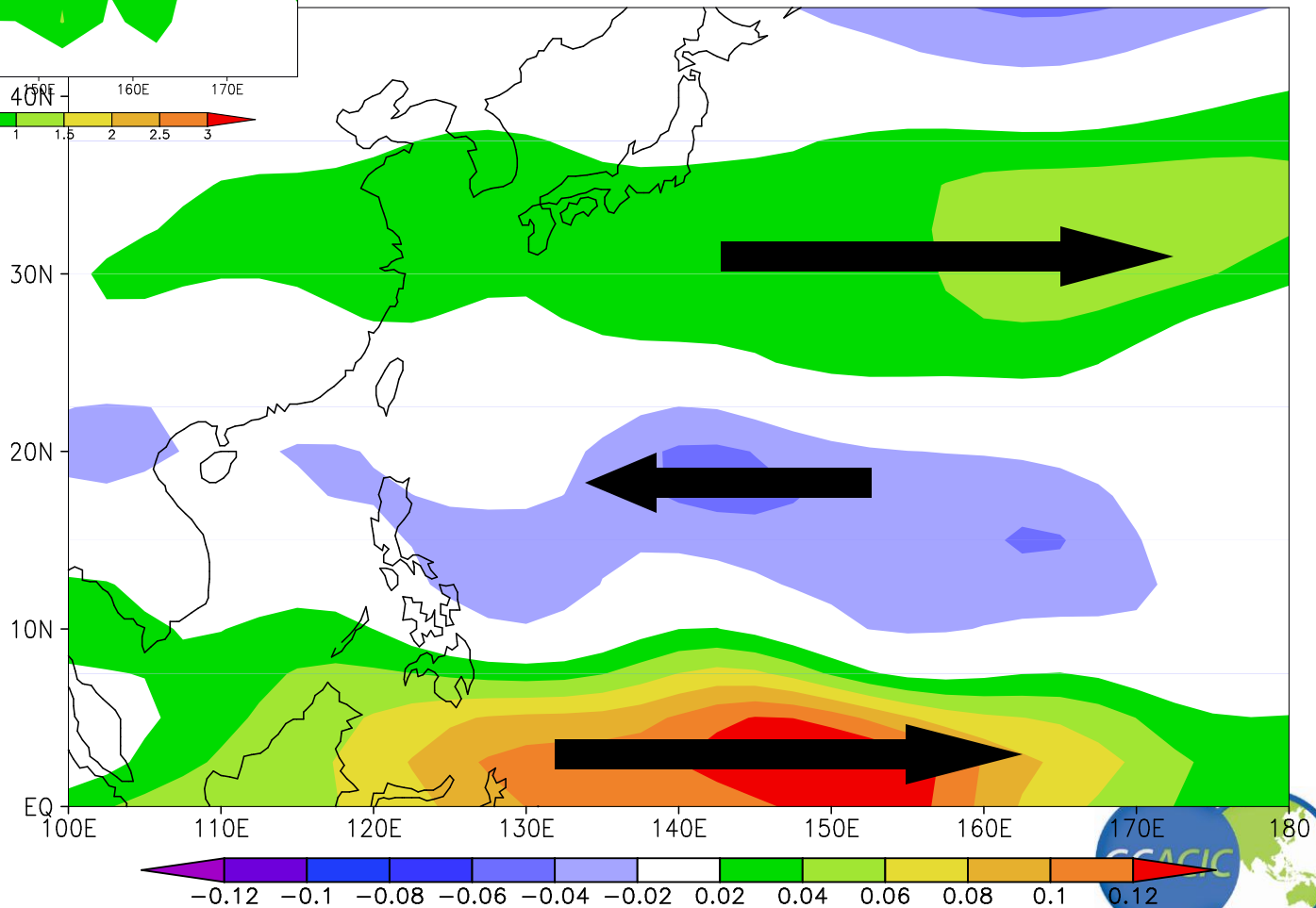


Anomalous TS occurrence (1977-88)

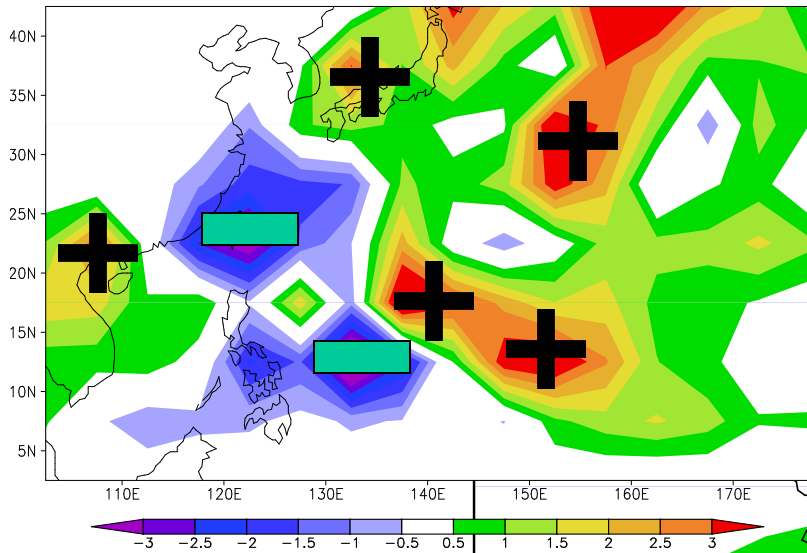


500-hPa zonal flow pattern (1977-88)

1st 500-hPa zonal wind EOF1 (Patte. 1)



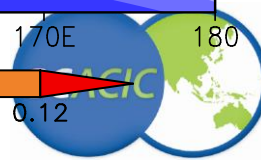
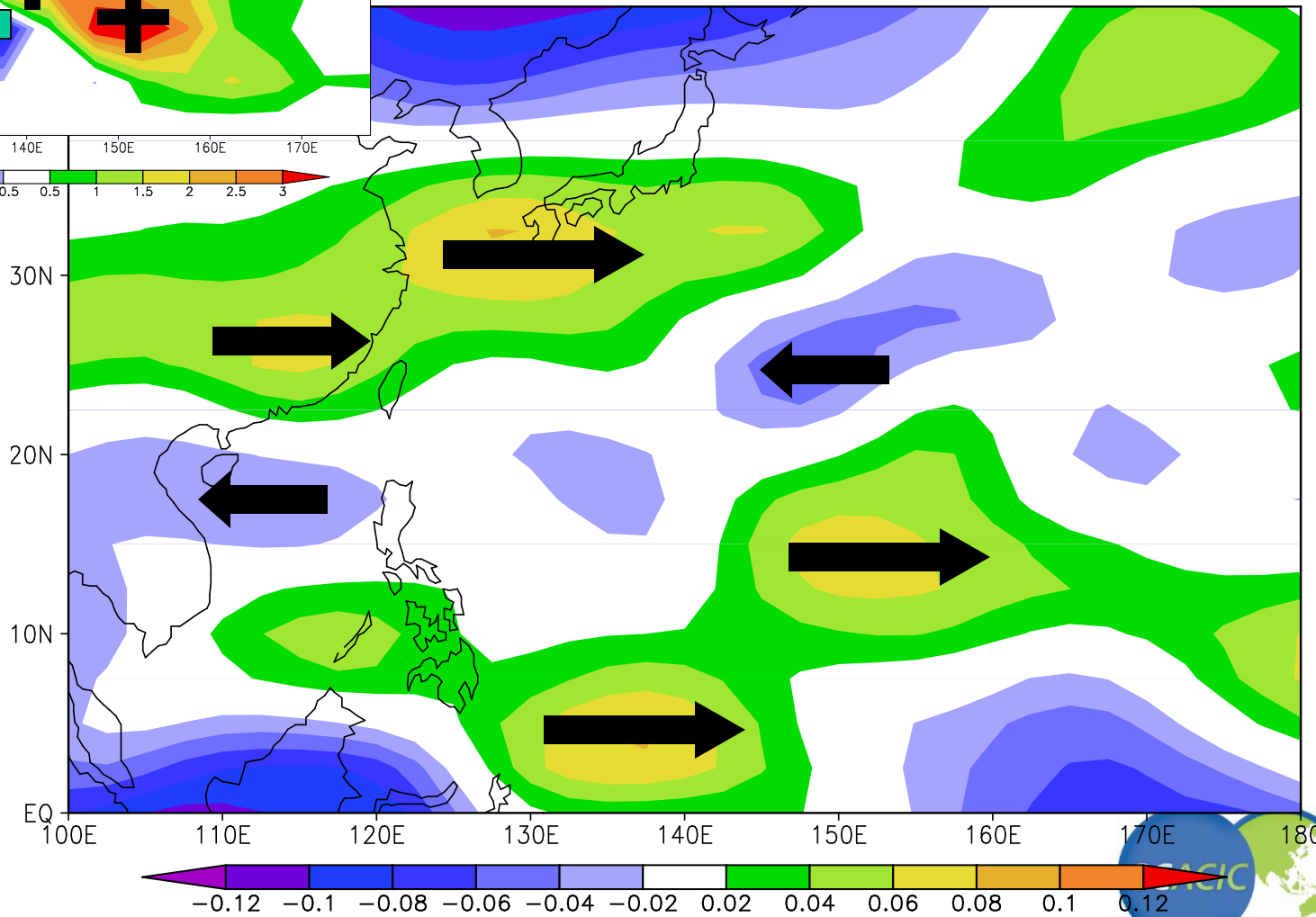
Anomalous TS occurrence (1989-97)



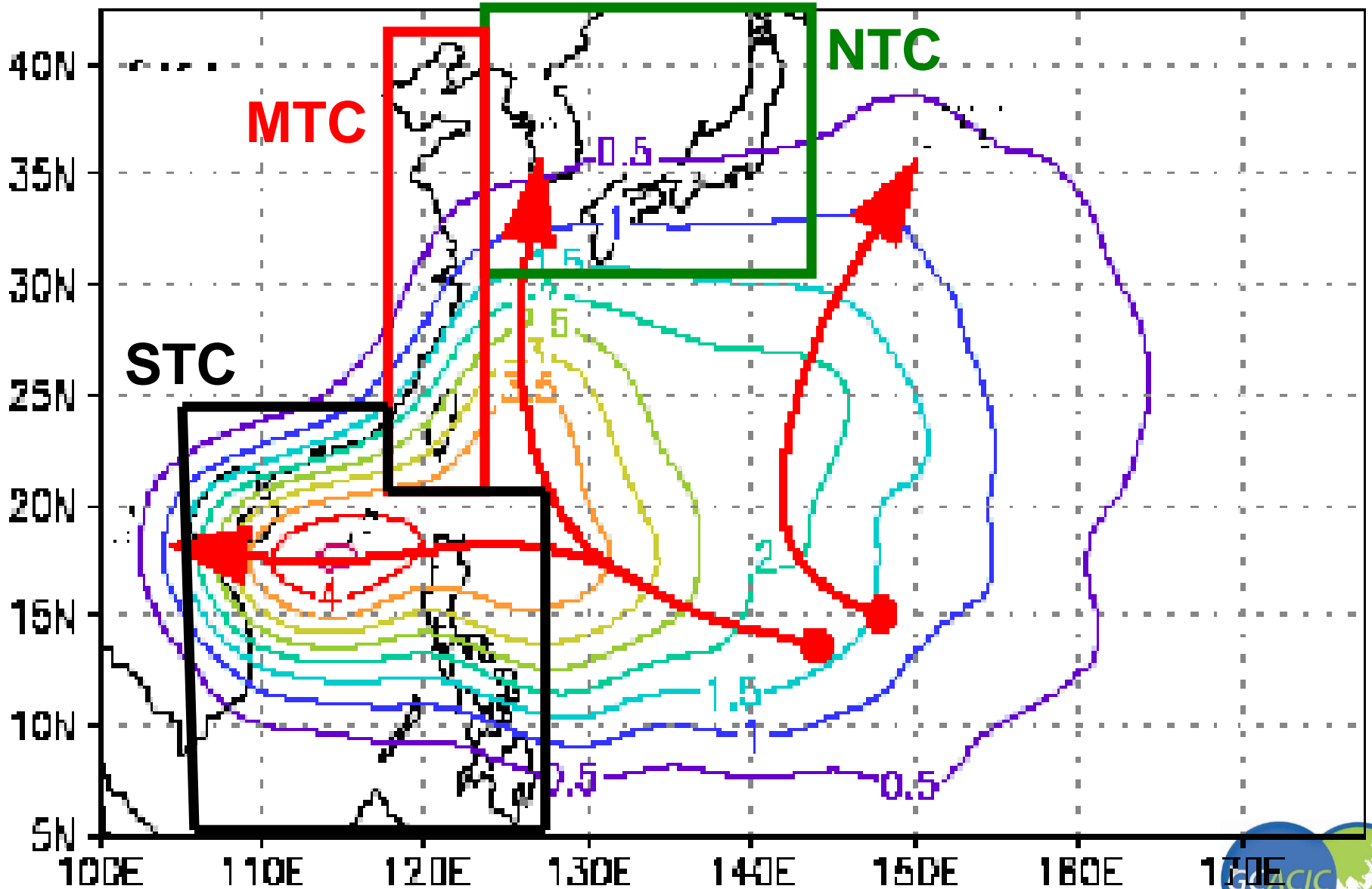
500-hPa zonal flow pattern (1989-97)

J Climate (Sept 2008)

500-hPa zonal wind EOF4 (Pattern 3)



Frequency of Tropical Cyclone Occurrence



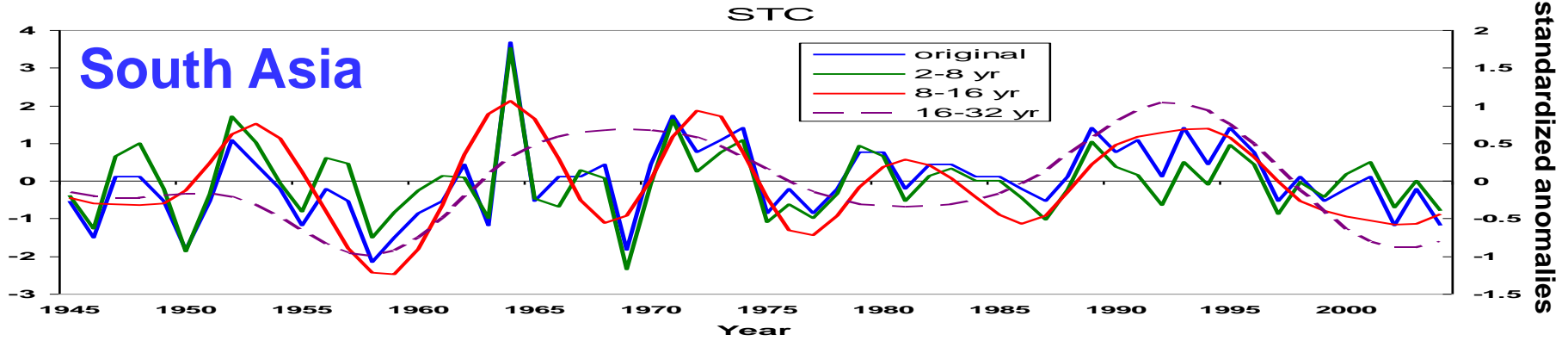
Landfall Groupings [all tropical cyclones (TCs) with maximum winds at landfall $> 17 \text{ m s}^{-1}$]

south Asia TCs (STC)	TCs making landfall in south China, Vietnam and the Philippines
middle Asia TCs (MTC)	TCs making landfall in East China (Taiwan, Fujian, Zhejiang and Jiangsu provinces, and City of Shanghai)
north Asia TCs (NTC)	TCs making landfall in the Korean Peninsula and Japan
Asian TCs (ATC)	All TCs making landfall anywhere in East Asia



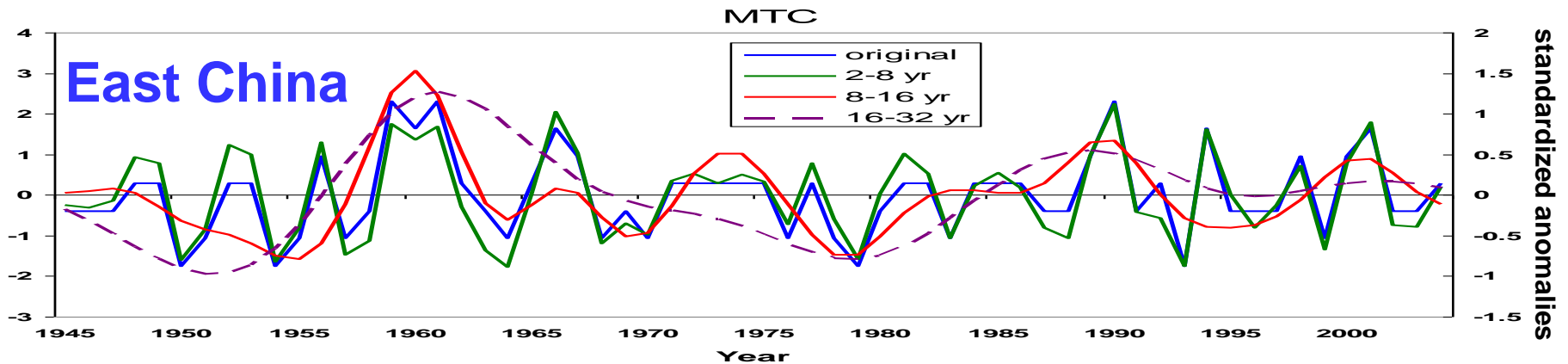
Variations of Landfall in Each Area at Various Oscillation Periods

standardized anomalies



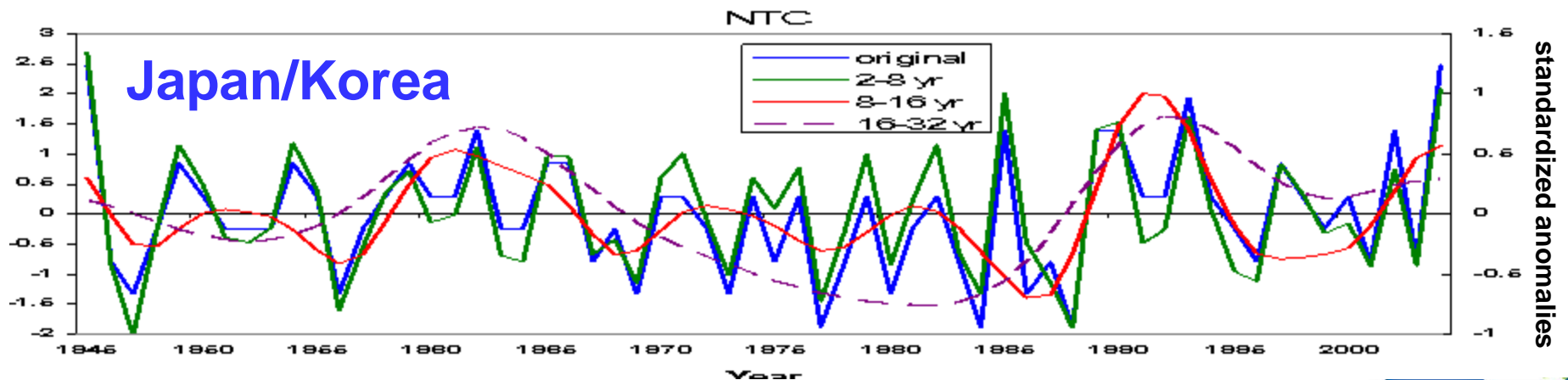
standardized anomalies

standardized anomalies



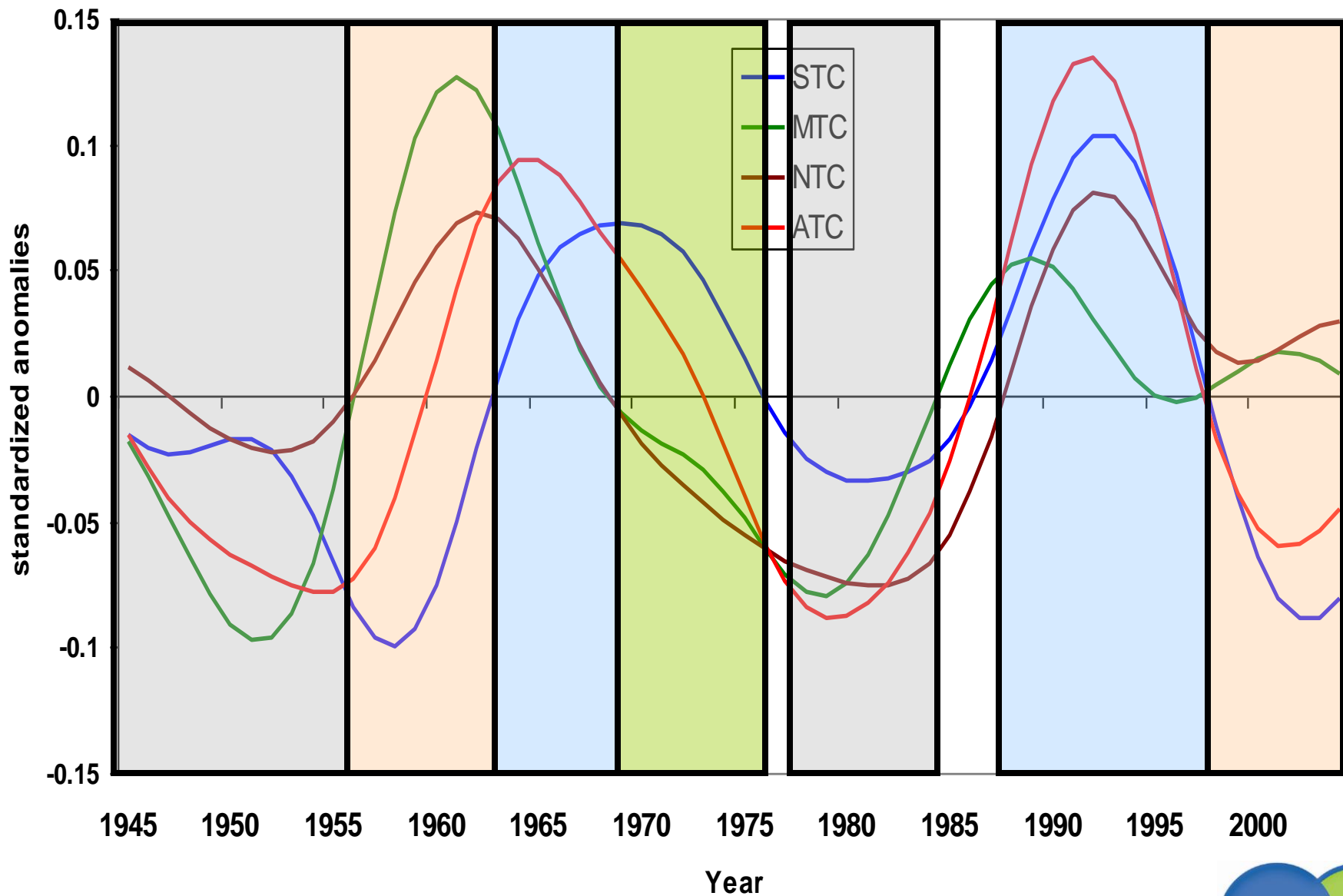
standardized anomalies

standardized anomalies

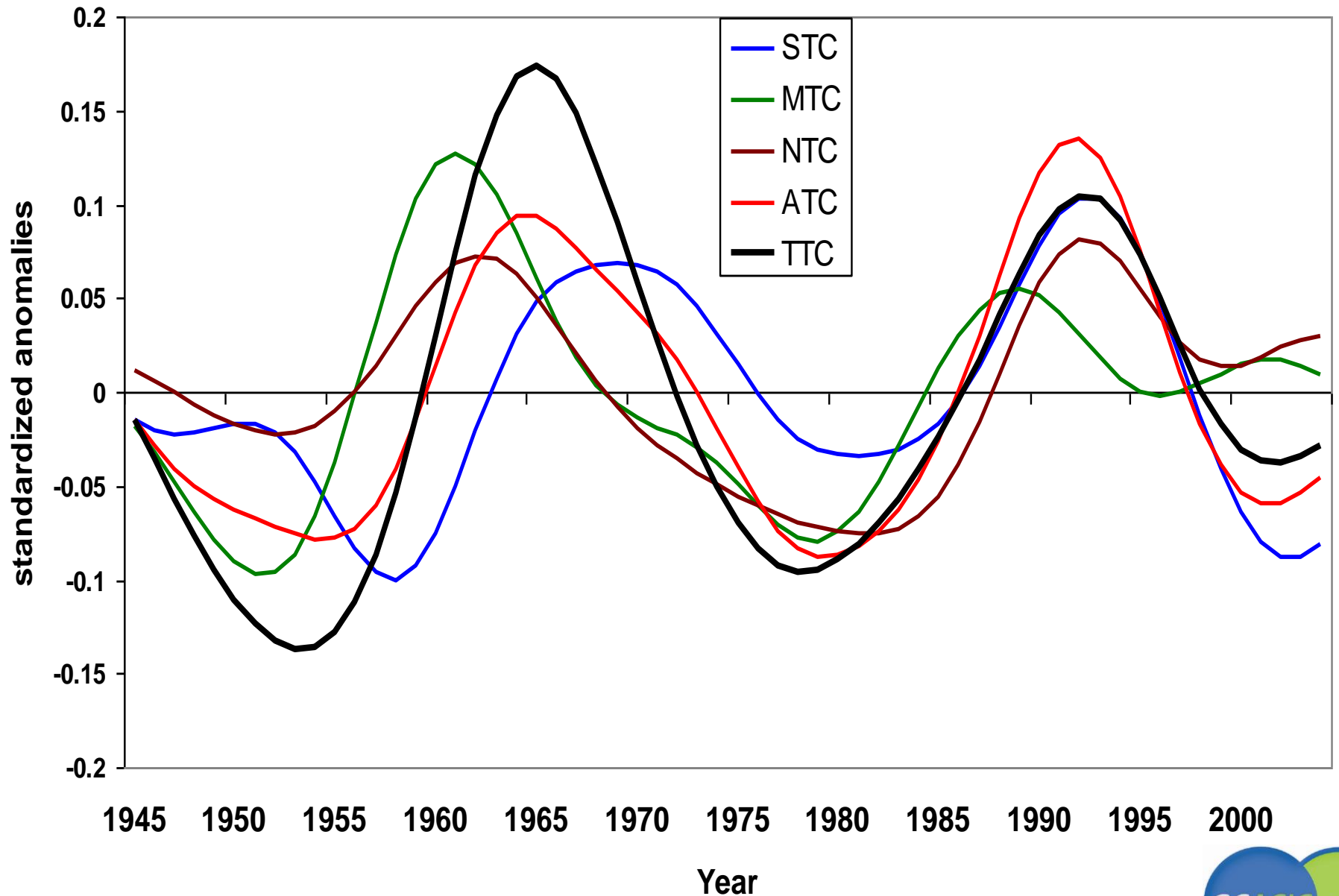


standardized anomalies

TC Landfalling Frequency (16-32 year period)



Landfall in East Asia vs. TC Activity over the Western North Pacific at the 16-32-year Oscillation Period



Summary

- No significant trend in any of the TC characteristics (number, intensity, track types, landfall locations) can be identified. In other words, TC activity in the western North Pacific **does not** follow the trend in the global increase in atmospheric or sea-surface temperature.
- Instead, all such characteristics go through large interannual and interdecadal variations.



Summary

- Such variations are very much related and apparently caused by similar variations in the planetary-scale atmospheric and oceanographic features that also **do not** have the same trend as the global increase in air temperature
- Unless the temporal variations of such features become linear, these TC characteristics are not expected to vary linearly with time.



Summary

- **Even if the observed global warming has an effect, it is probably in the noise level relative to the large interdecadal variations and therefore is not detectable.**

