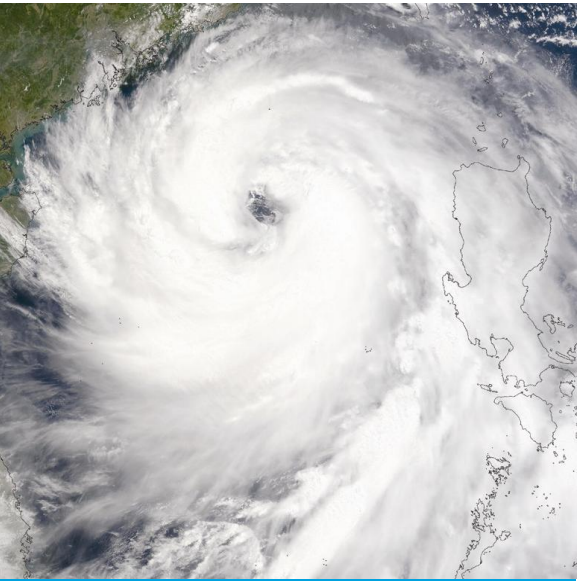


Possible Effects of Global Warming on Tropical Cyclone Activity

Johnny Chan

Guy Carpenter Asia-Pacific Climate Impact Centre
City University of Hong Kong

Outline

- Background
- Relationship between global warming and frequency of intense tropical cyclone occurrence
- Variations of tropical cyclone characteristics in the western North Pacific
- Summary

Background

- **Global warming leads to**
  - **an increase in the temperature near the earth's surface (land and ocean)**
  - **an increase in the amount of water vapour in the atmosphere due to an increase in ocean temperature and a higher atmospheric temperature capable of holding more water vapour**
- **No study has definitively demonstrated that the dynamic factors are modified by global warming (although some have suggested an increase in vertical wind shear).**

Background

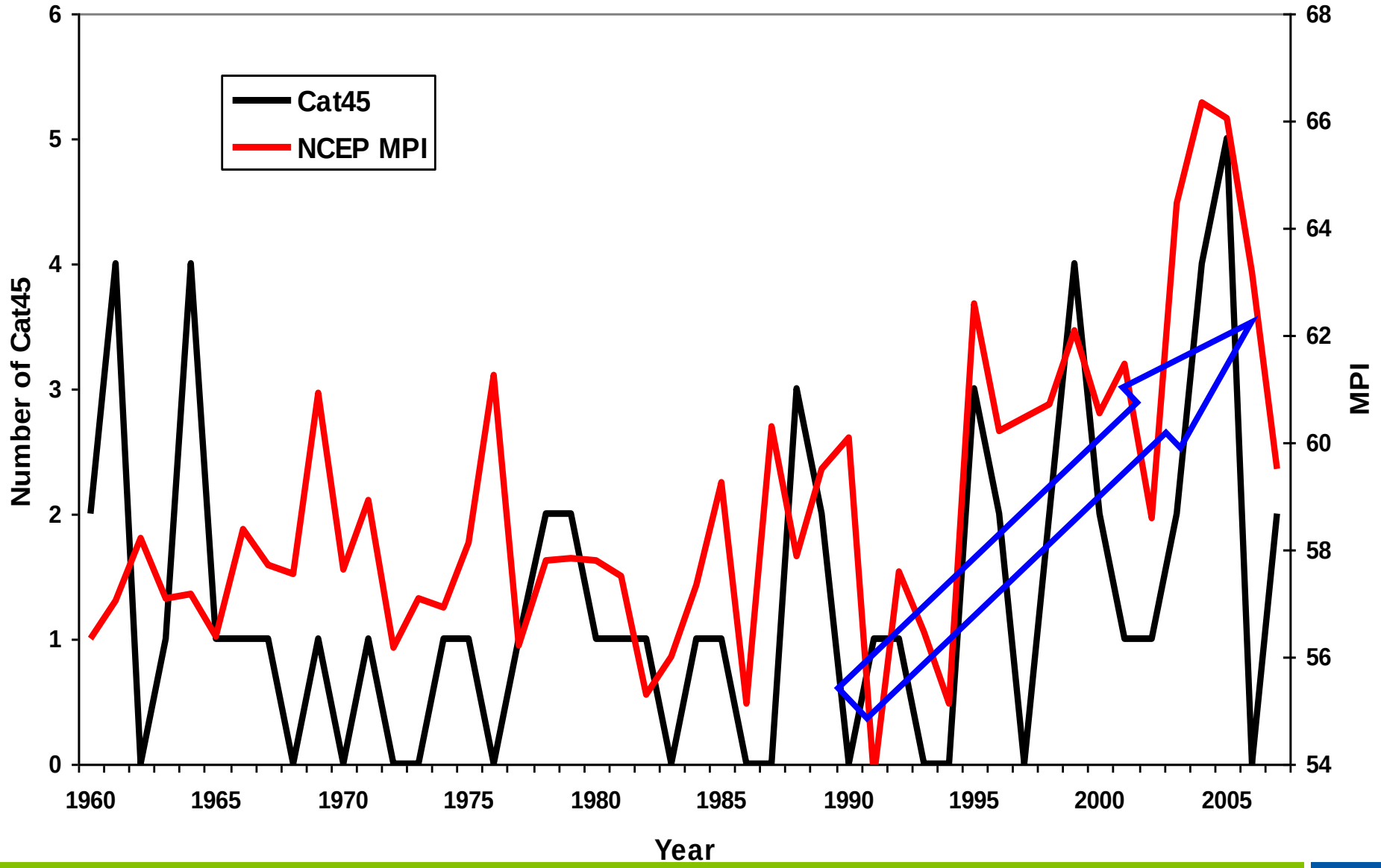
- Due to global warming, the thermodynamic factors have become more favourable for tropical cyclone formation and development.
- To determine whether global warming has an impact on the frequency of occurrence of tropical cyclones or of intense cyclones, we need to examine whether the thermodynamic factors are related to the variations on such frequencies.
- A good proxy of the thermodynamic factors is the Maximum Potential Intensity (MPI)

Background

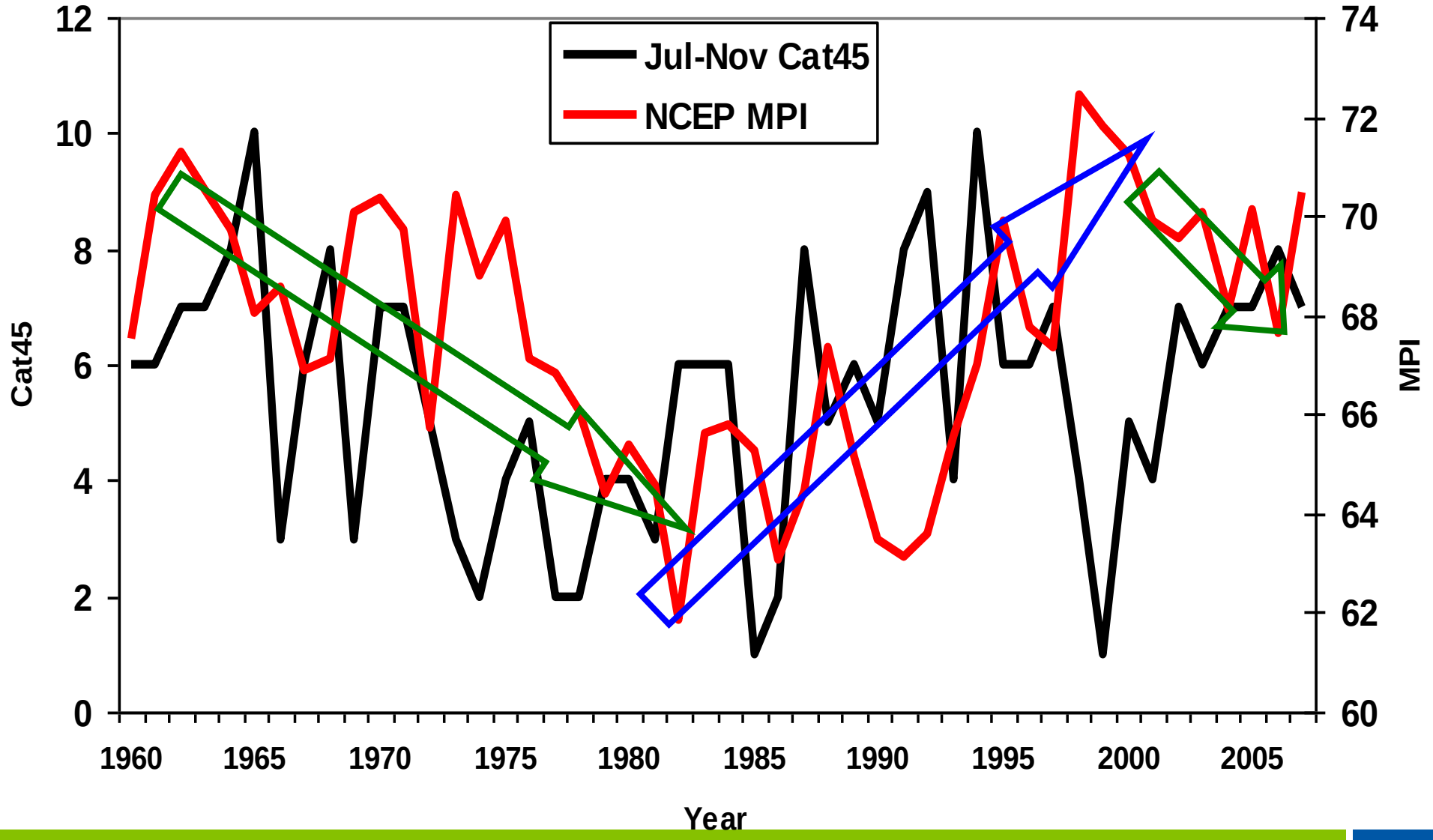
- **MPI = f(ocean temperature, outflow temperature, net amount of energy available for convection)**
- **Because MPI gives the maximum possible intensity, a higher value of MPI summed over the ocean basin and over a season should imply a more thermodynamically energetic atmosphere, and more TCs could reach higher intensities**

∴ a season with a higher value of MPI should have more intense TCs if the dominant control is thermodynamic

Atlantic


Cat45
NCEP MPI
Number of Cat45
MPI
Year
0
1
2
3
4
5
6
54
56
58
60
62
64
66
68
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005

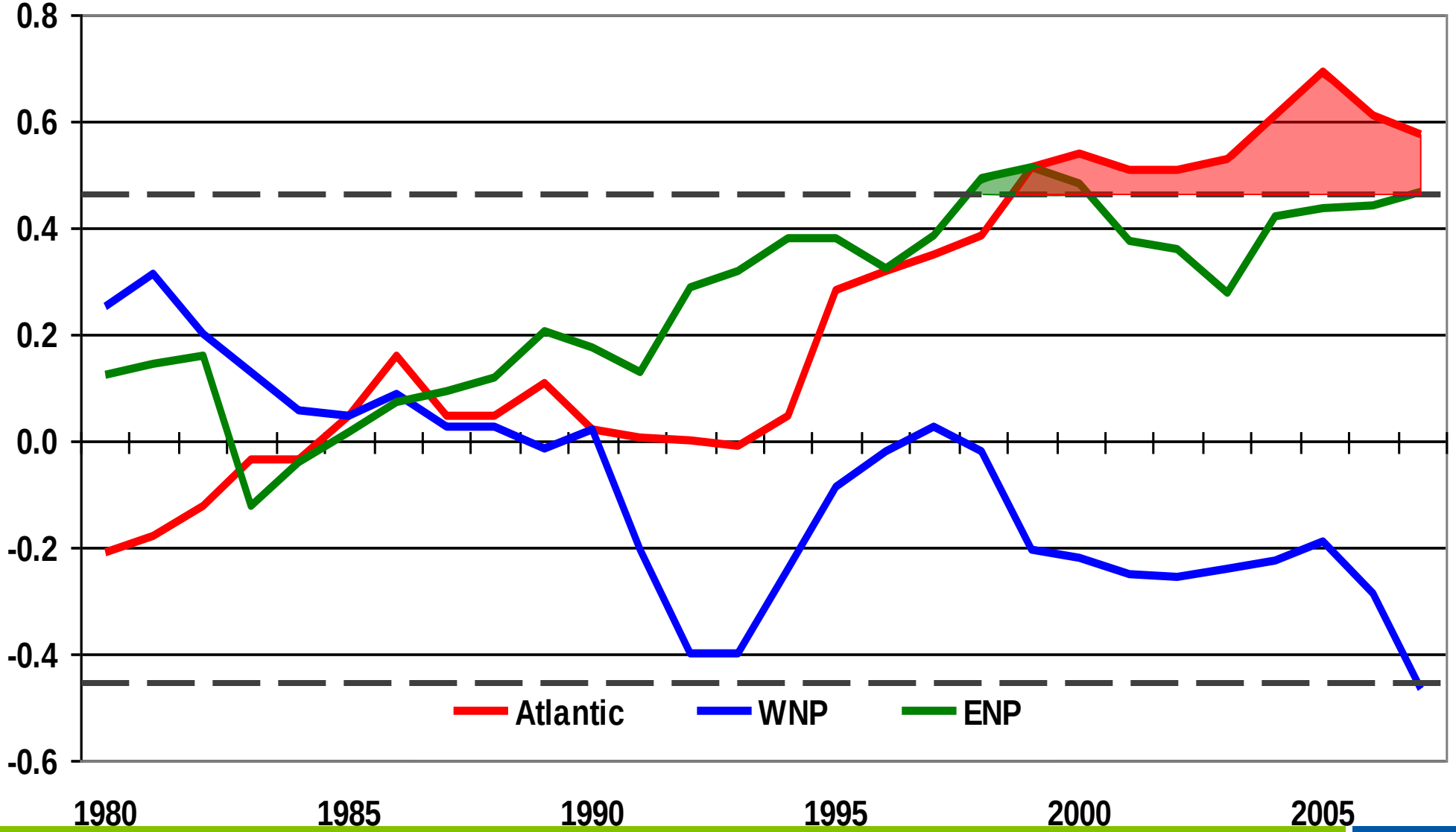
Western North Pacific



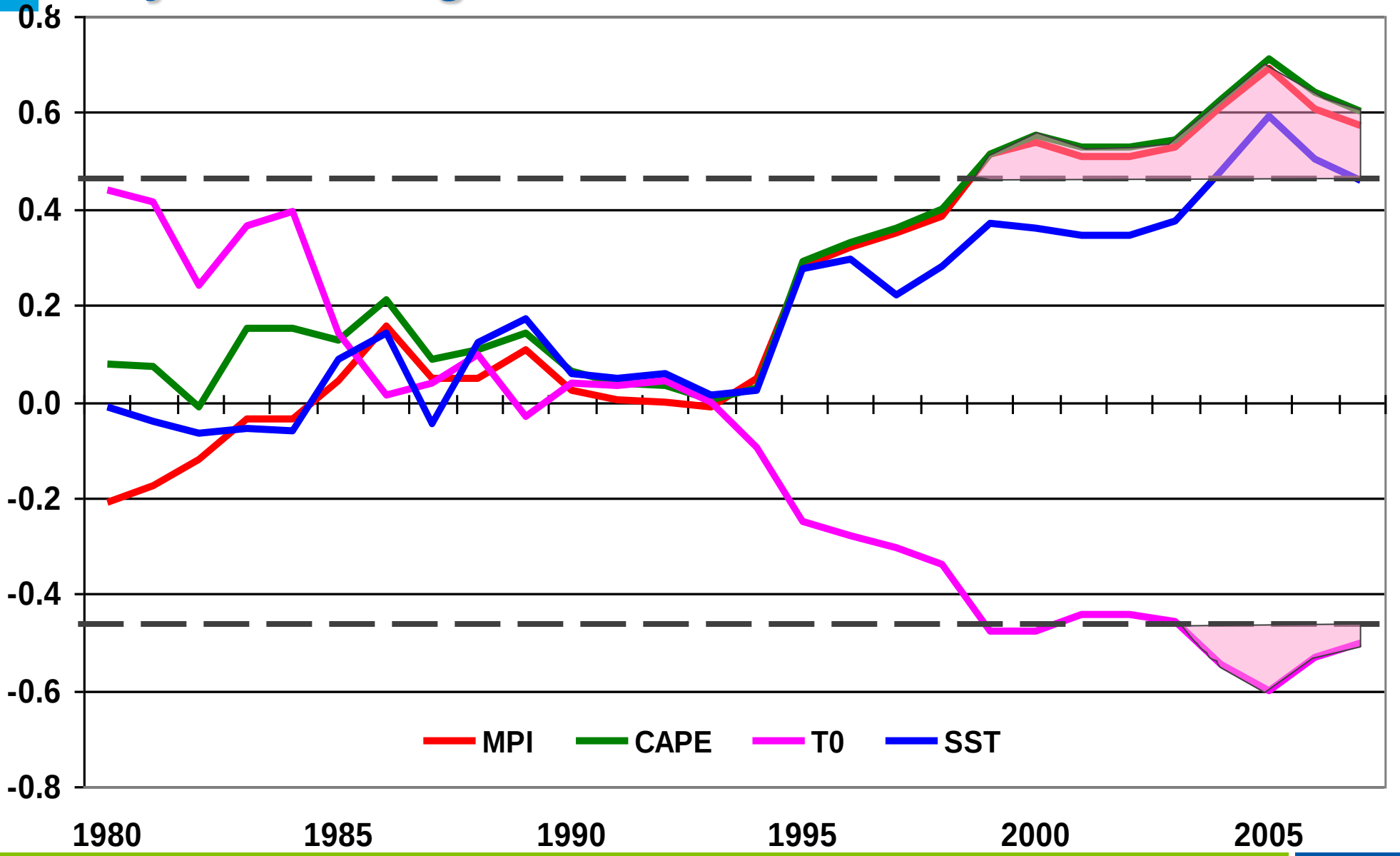
21-year running correlations with NCat45

Ocean Basin	Period	Correlation (best track)	Correlation (Kossin et al. 2007)
Atlantic	1960-2007	0.45	
	1970-2007	0.59	
	1980-2007	0.63	
	1979-2006	0.61	0.61
Western North Pacific	1960-2007	-0.01	
	1970-2007	-0.06	
	1980-2007	-0.08	
	1981-2006	-0.13	-0.36
Eastern North Pacific	1960-2007	0.29	
	1970-2007	0.35	
	1980-2007	0.34	
South Indian Ocean	1981-2007	0.35	
South Pacific	1981-2007	0.03	

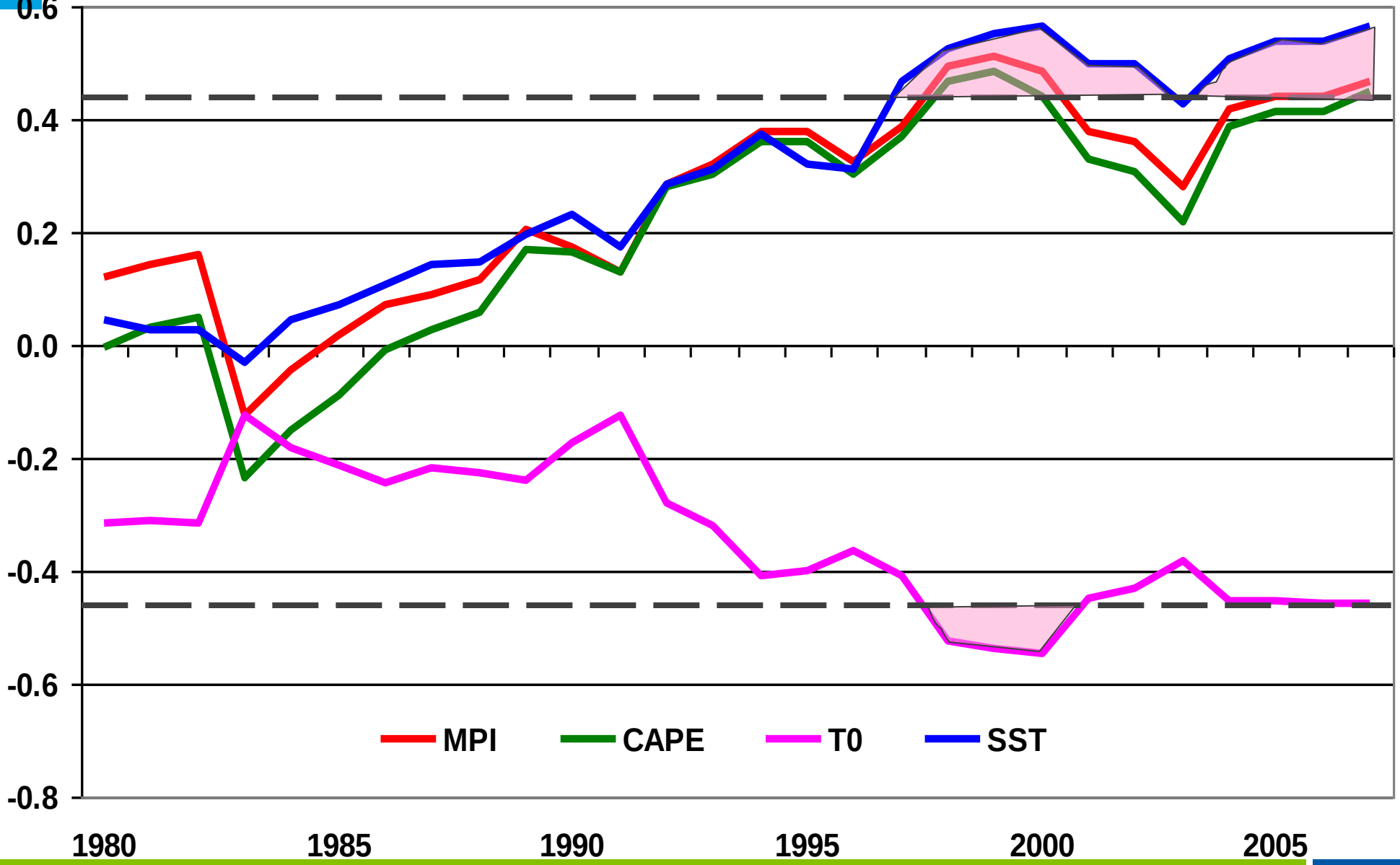
21-year running correlations with NCat45



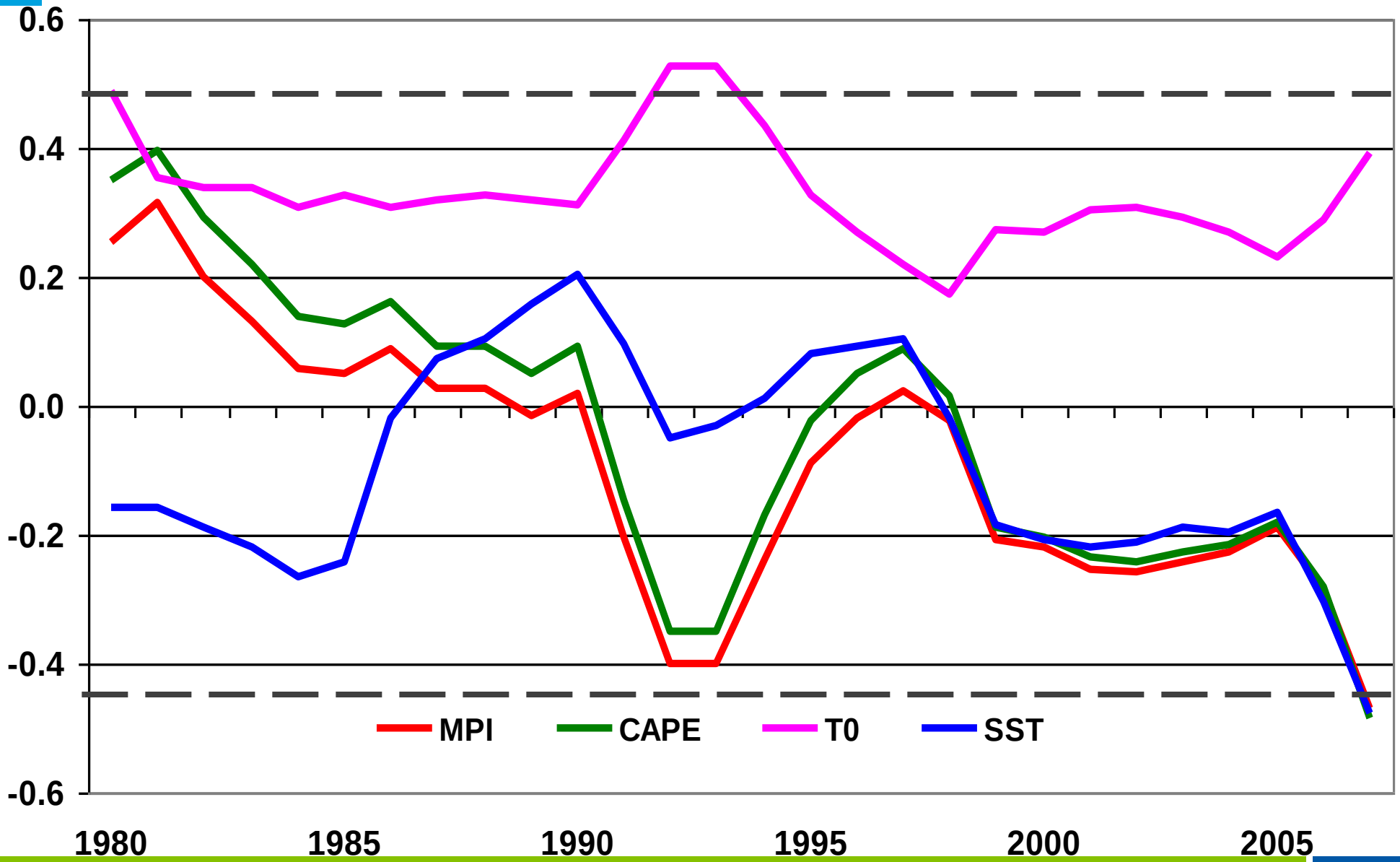
21-year running correlations with NCat45 - Atlantic



21-year running correlations with NCat45 - ENP



21-year running correlations with NCat45 - WNP



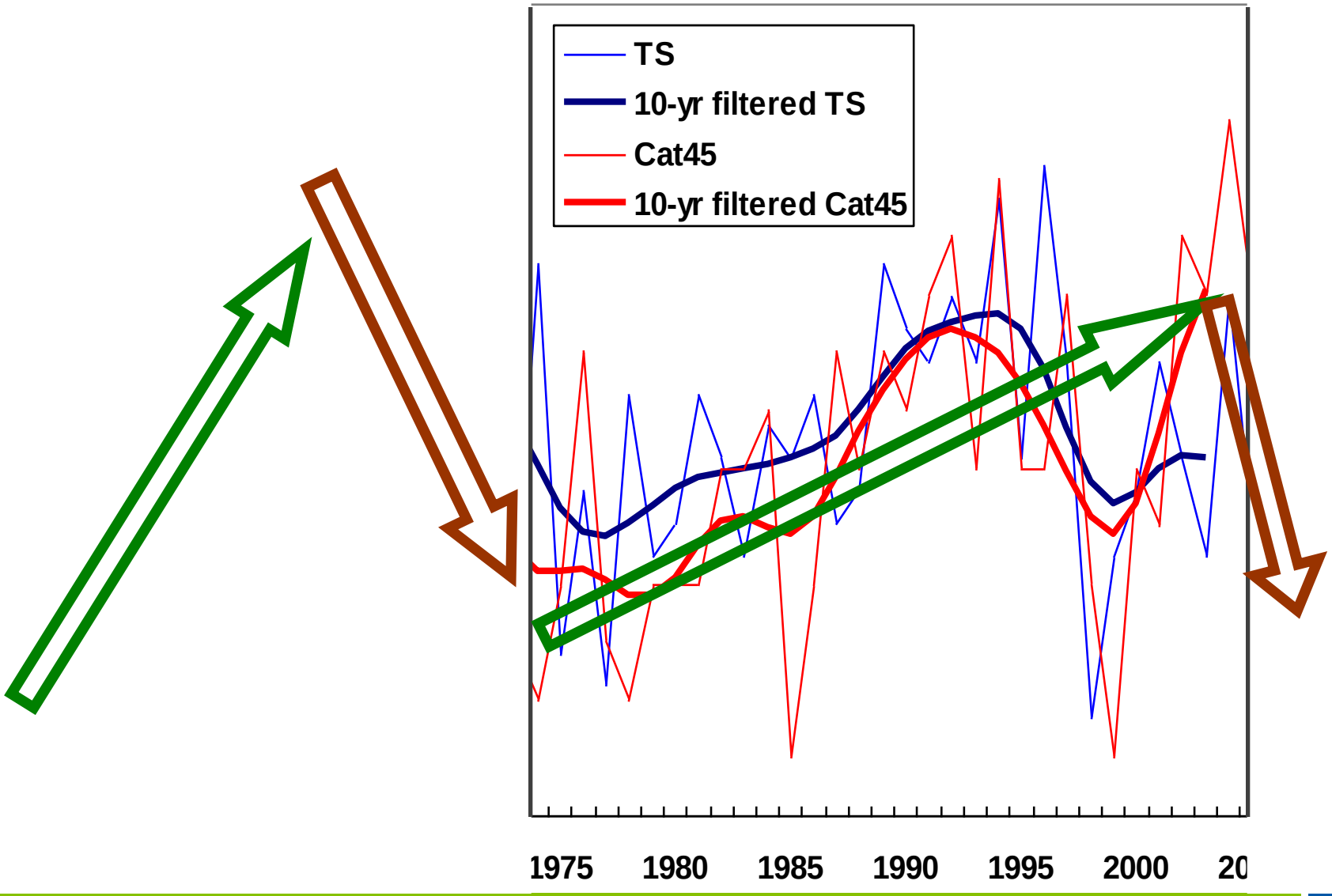
Summary

- **Thermodynamic control on the frequency of intense TCs is important *only* in the Atlantic**
- **Estimating the effect of global warming on the frequency of intense TCs therefore must also assess such an effect on the dynamic processes.**

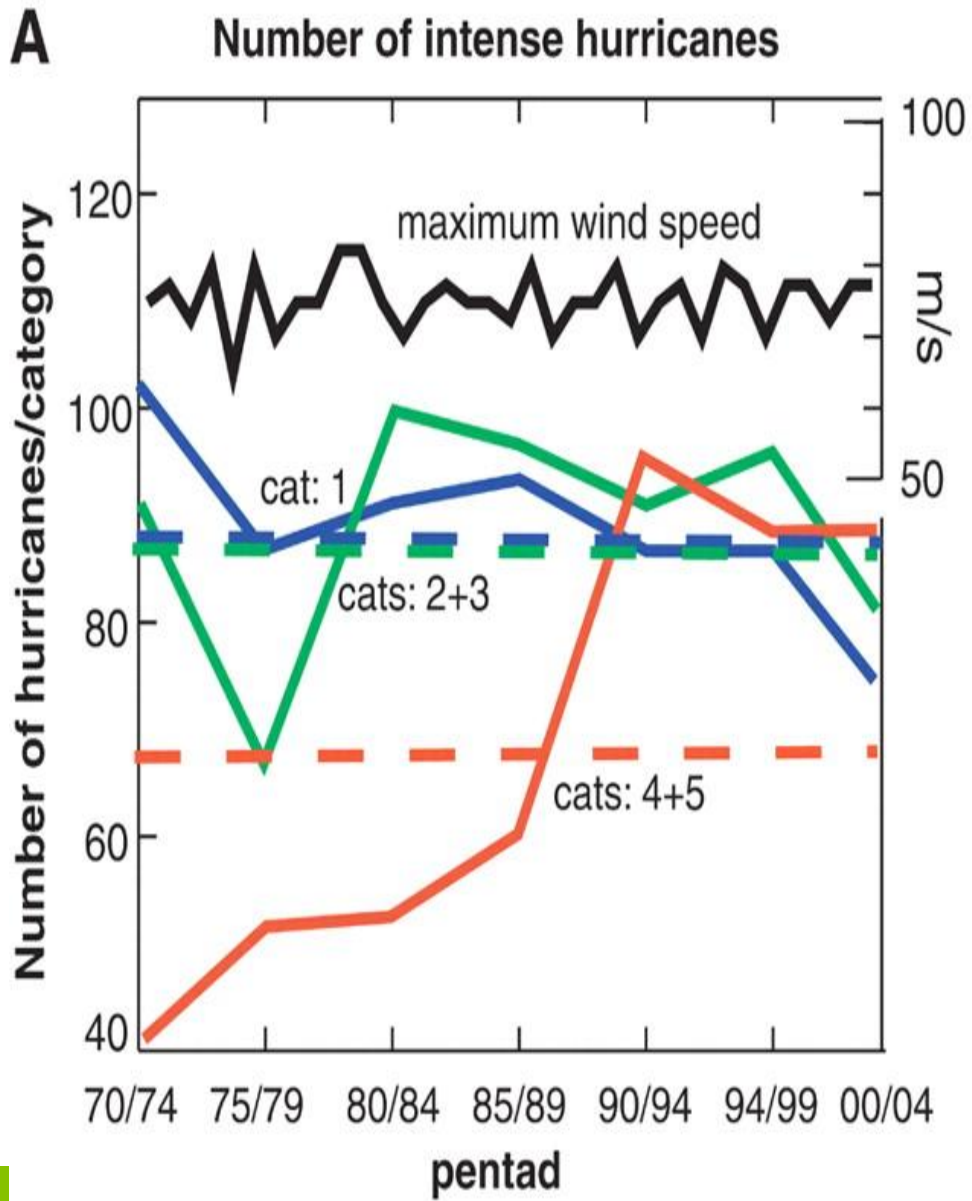
Western North Pacific Tropical Cyclones

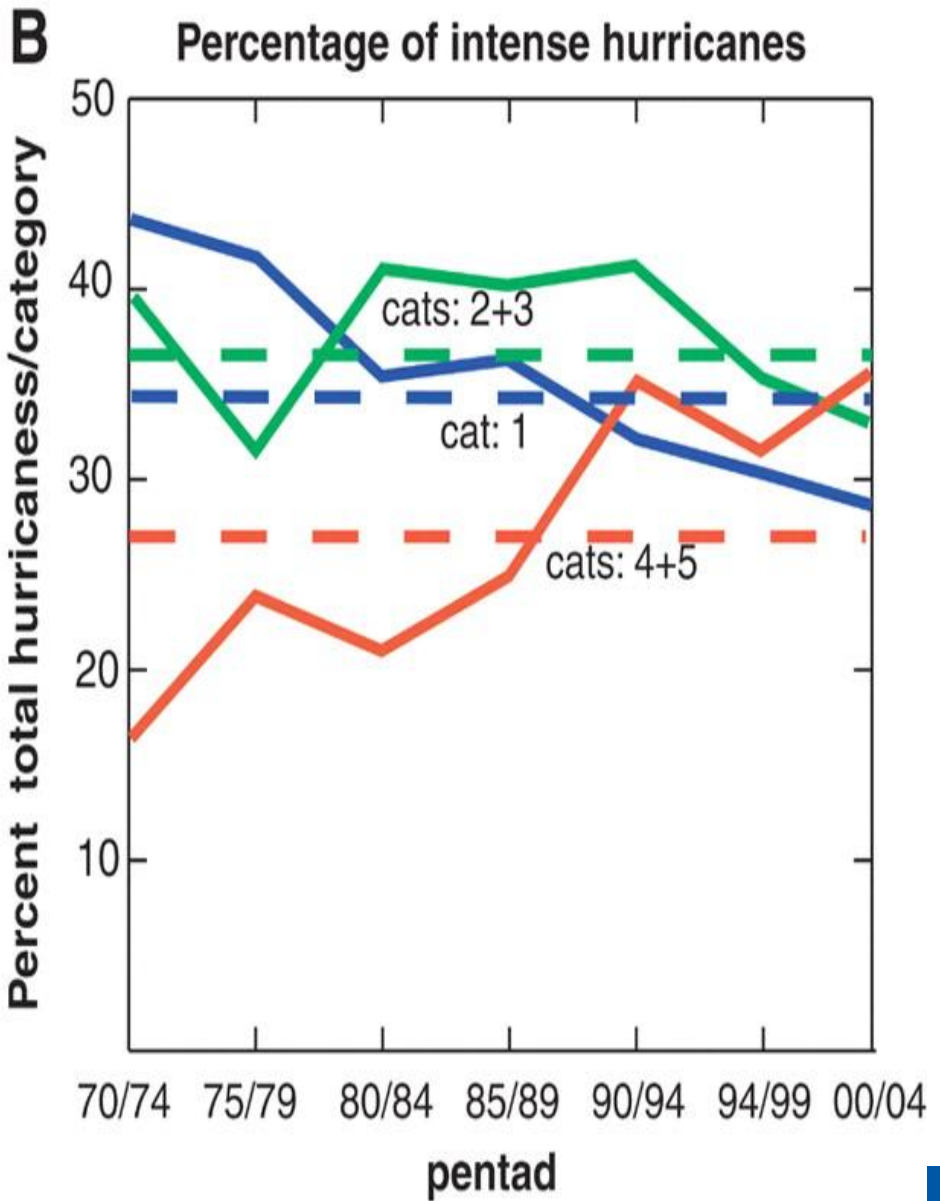
Number and Intensity

Annual Number of TCs and Intense TCs in the WNP



Webster et al.'s (2005) *Science* paper





No. of Category 4 and 5 Typhoons

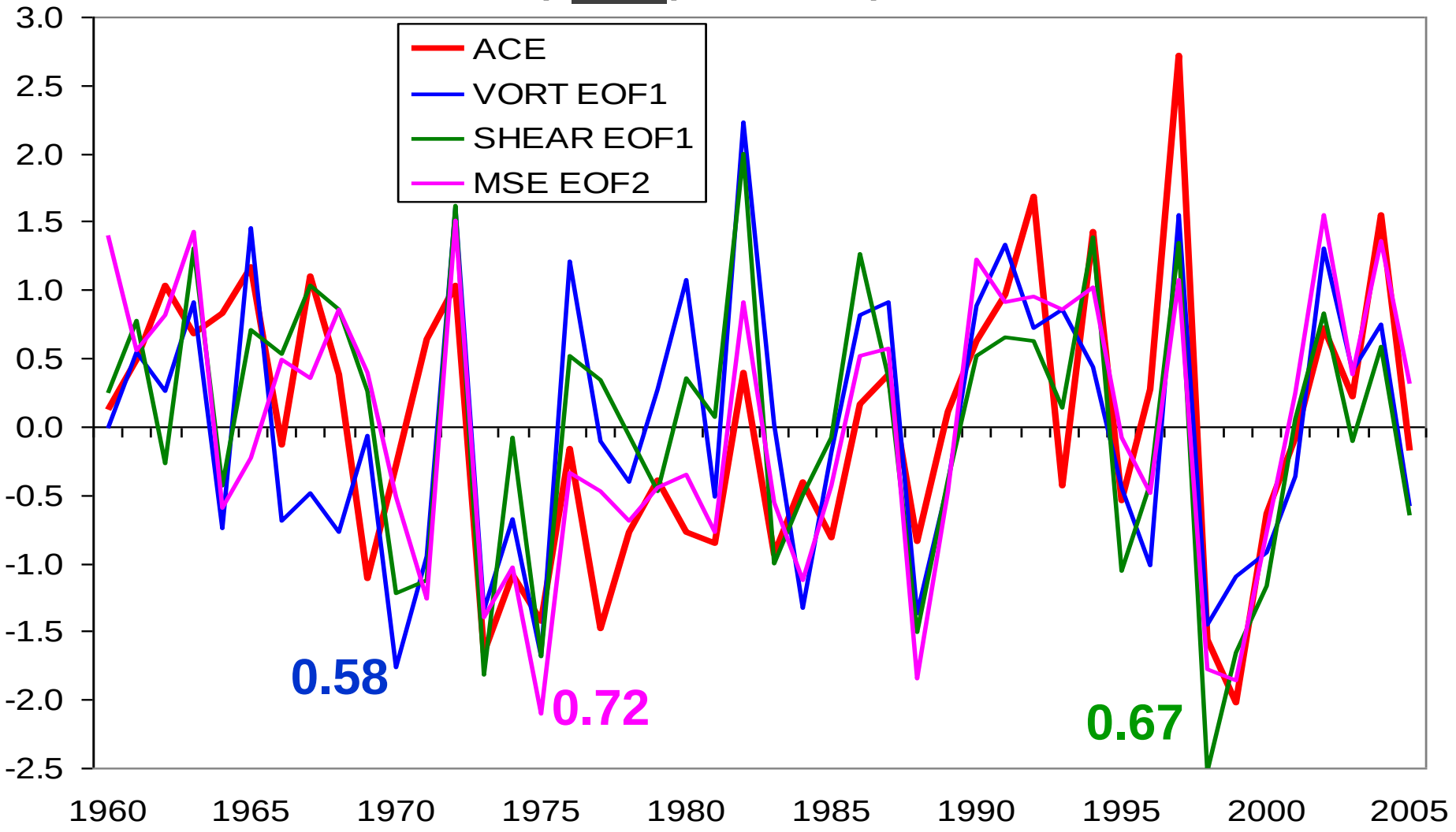
	1975-89	1990-2004
Number	75	115
Percentage	32	42

No. of Category 4 and 5 Typhoons

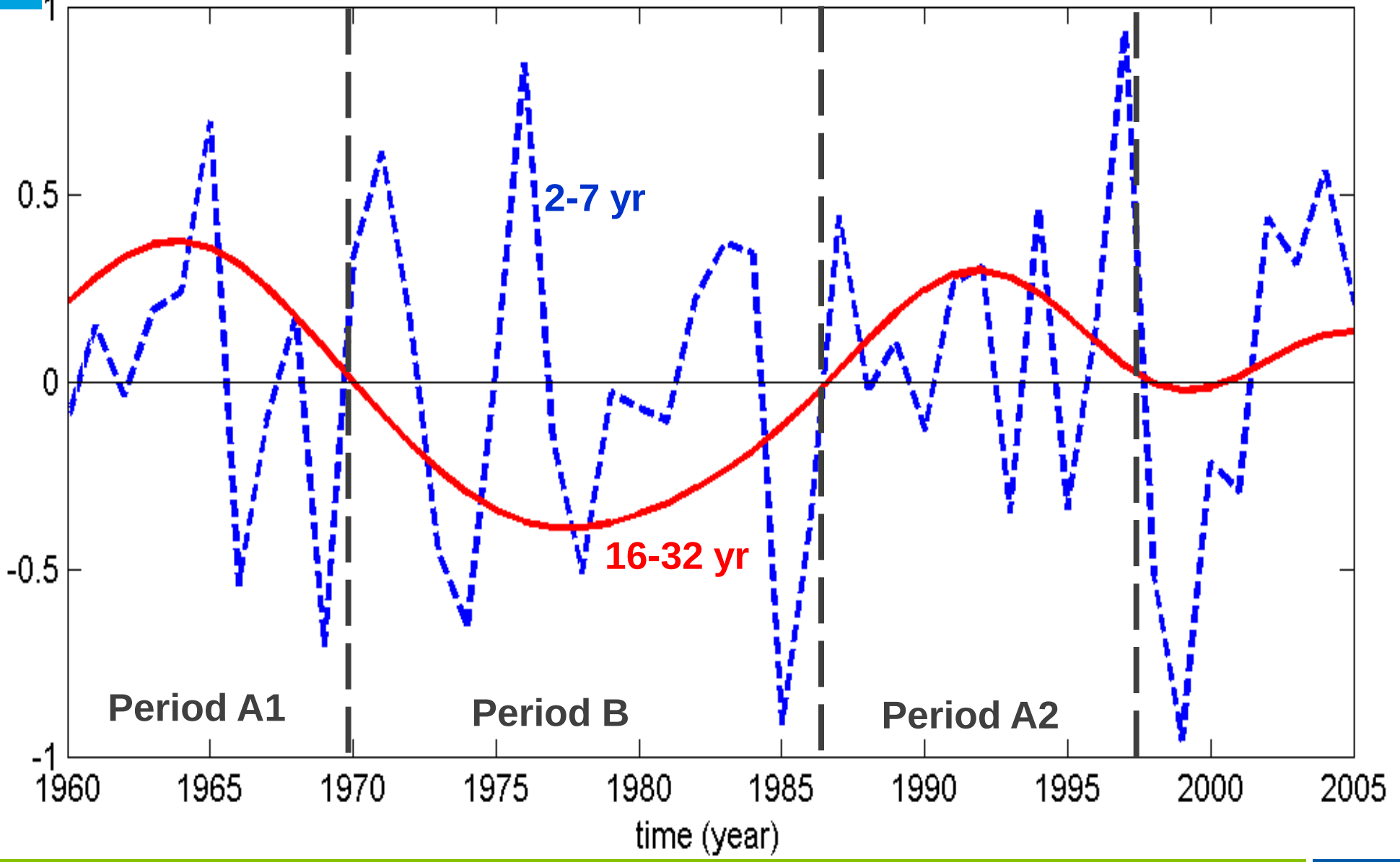
	1960-74	1975-89	1990-2004
Number	105	75	115
Percentage	37	32	42

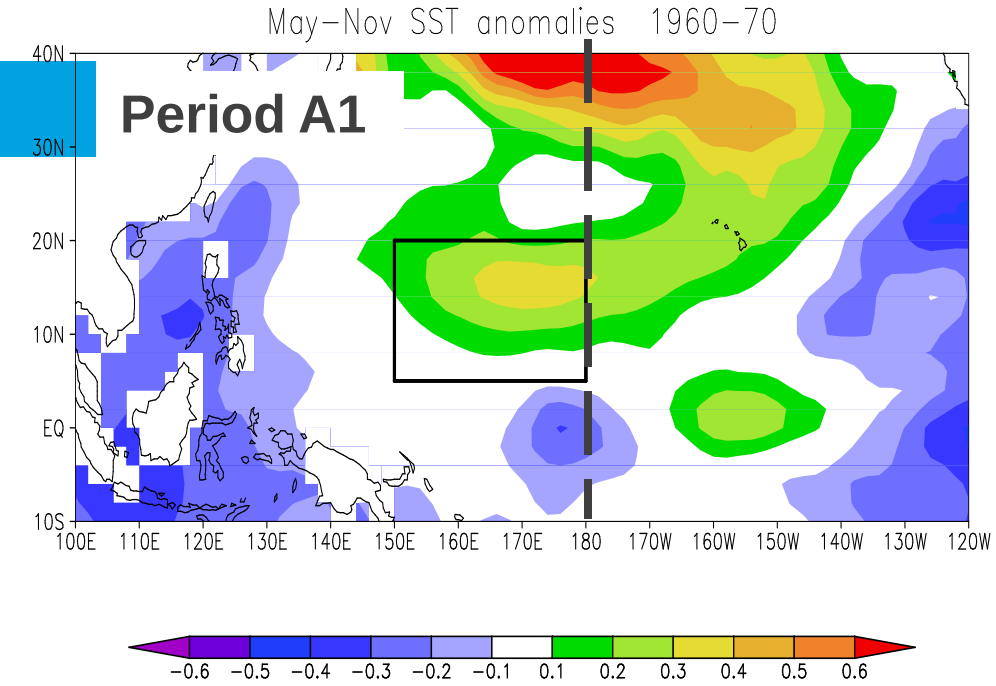
ACE vs.. VORT, SHEAR and MSE

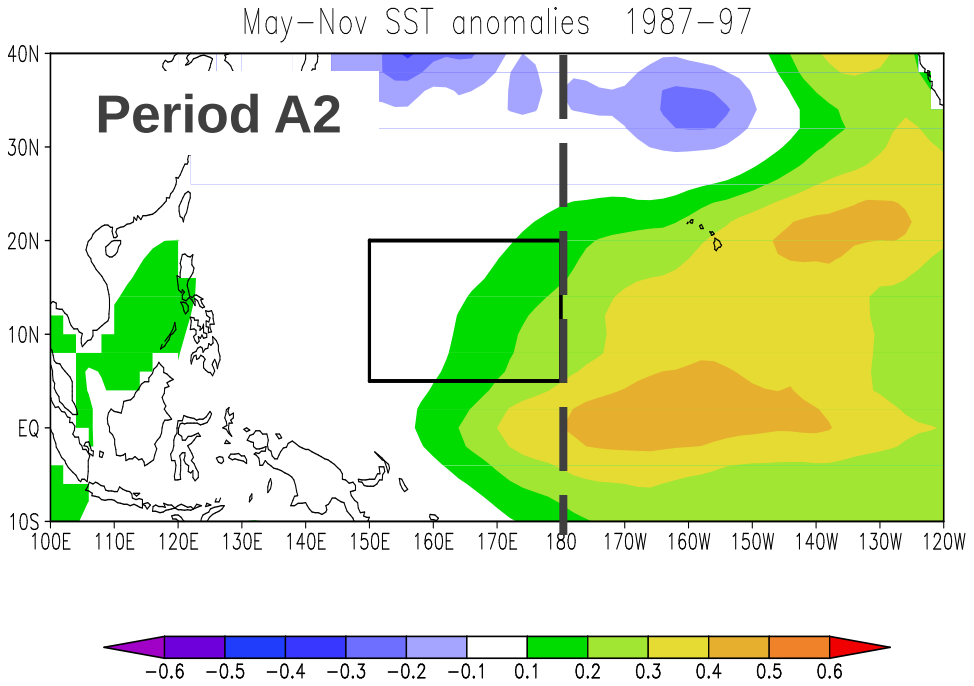
Science, 311, 1713b, *Tellus 2007*

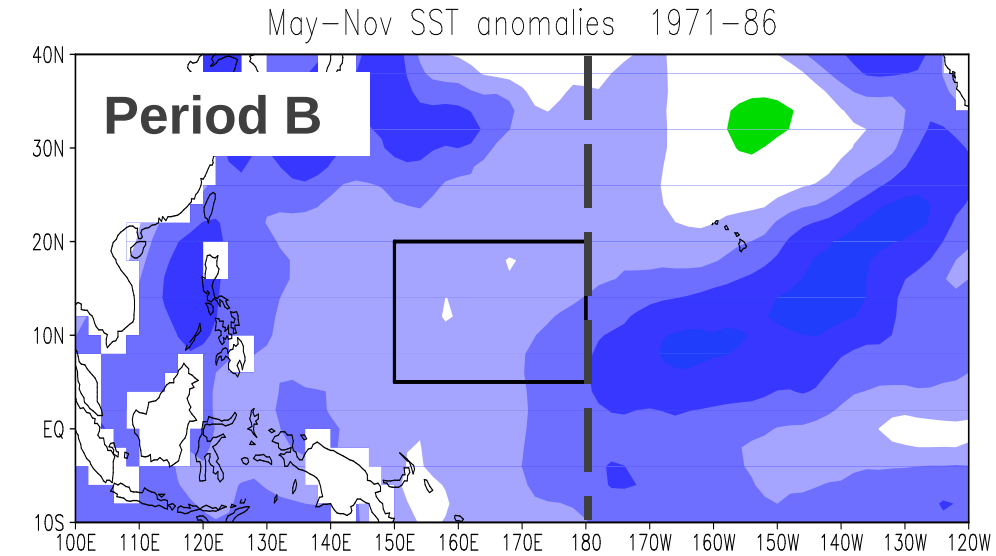


Wavelet Analysis of Intense Typhoon Occurrence Frequency

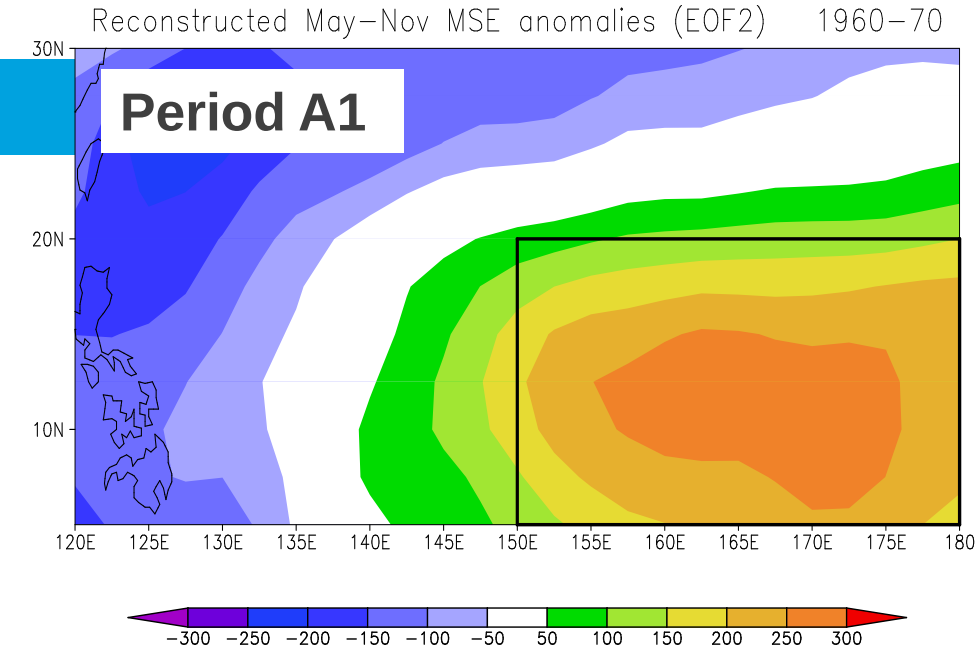


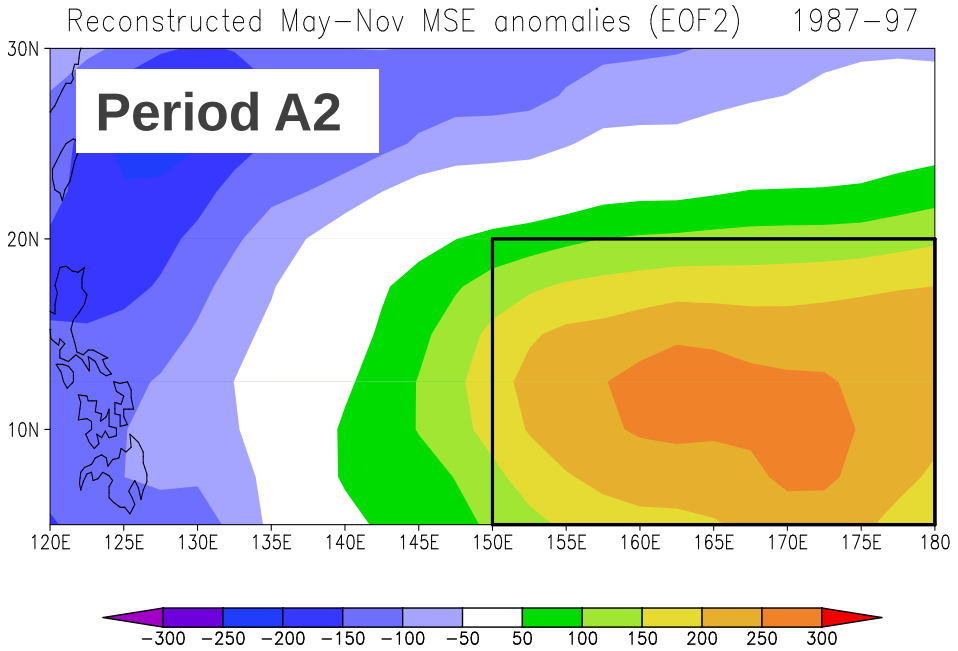


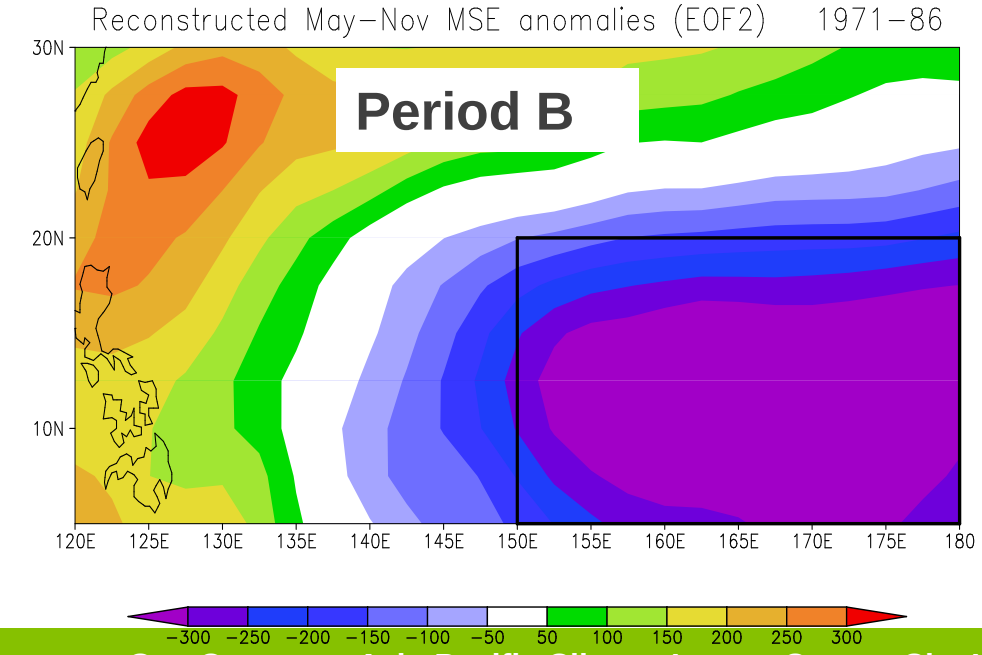




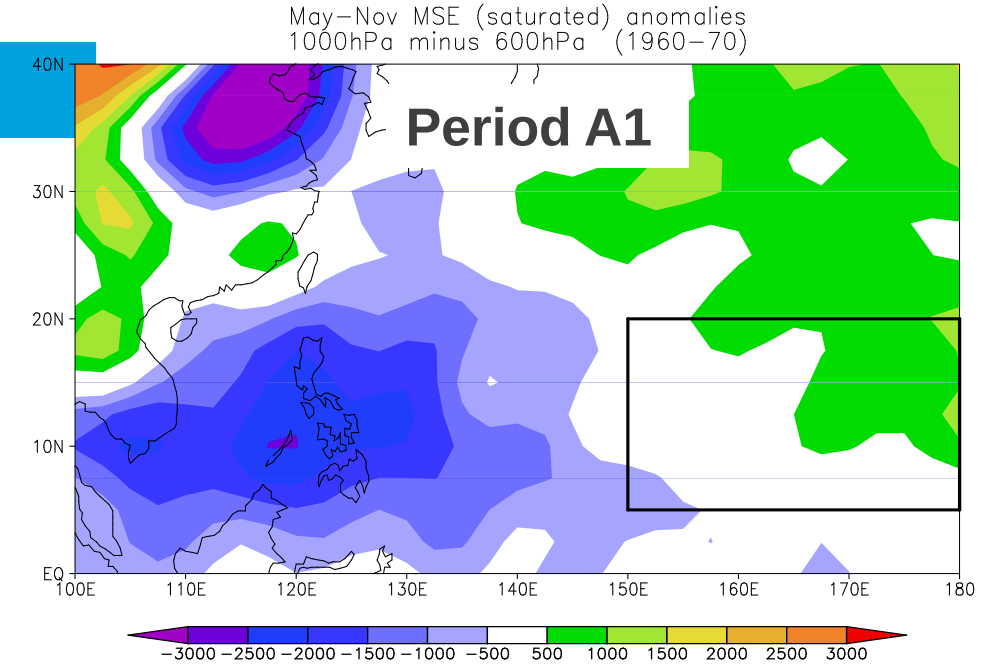
Ocean Temperature Anomalies

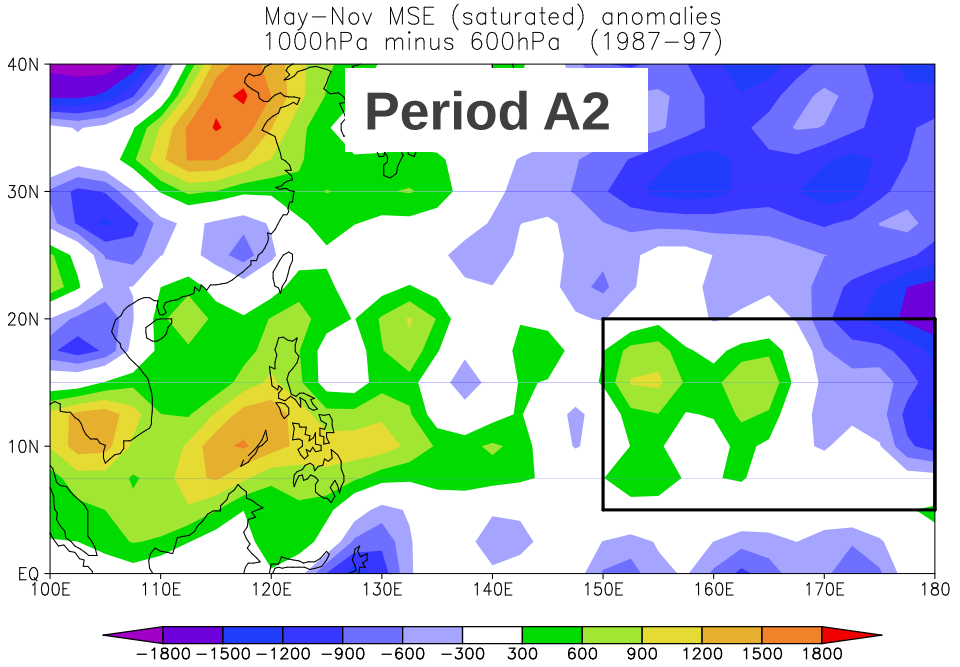


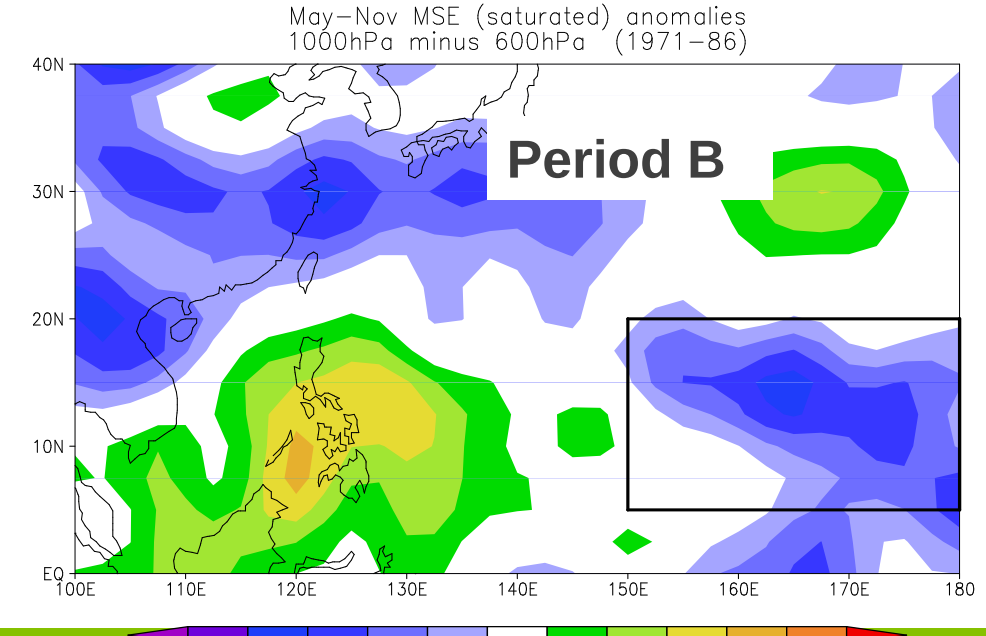




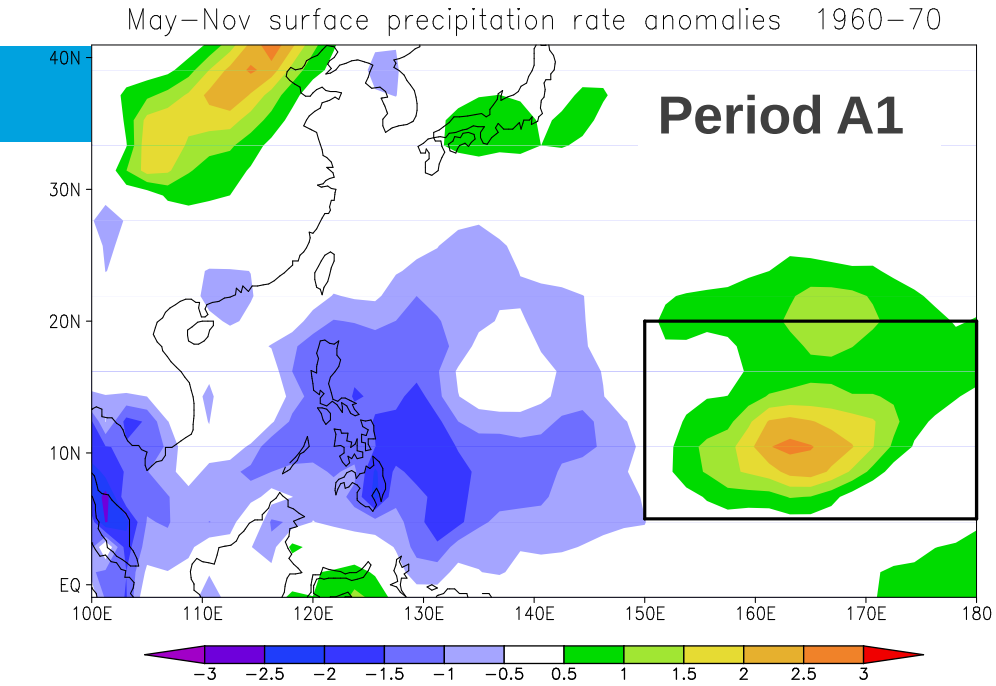
Saturated Moist Static Energy Anomalies

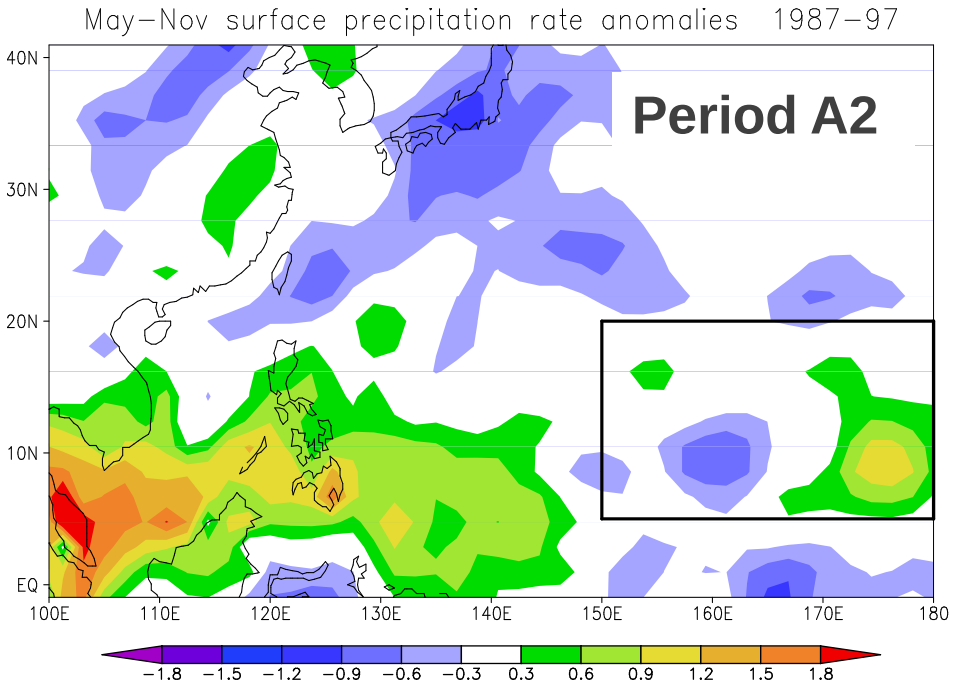


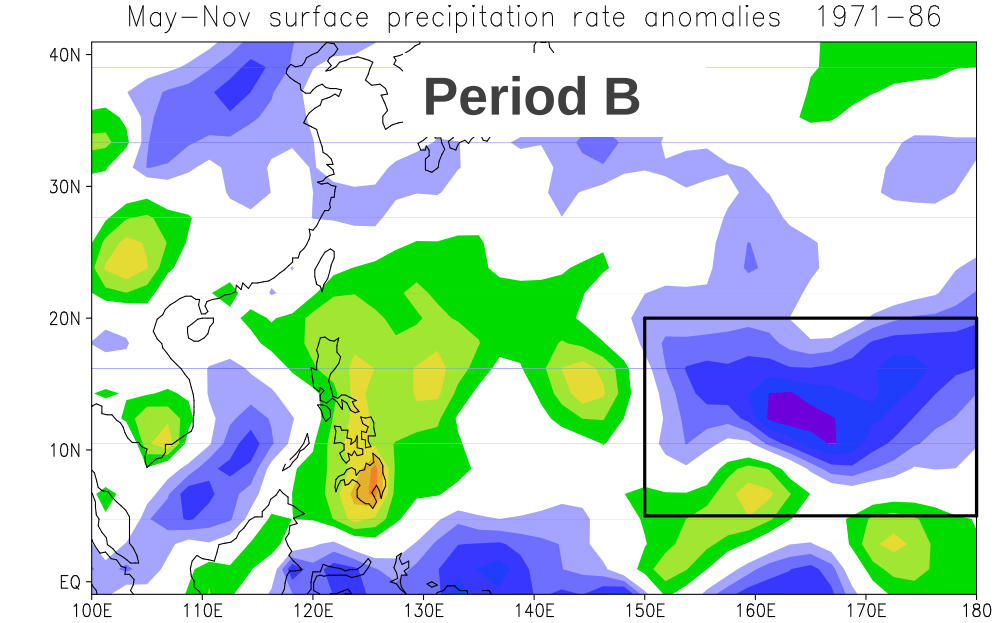




Anomalies of Vertical Gradient (1000 minus 600 hPa) of Moist Static Energy



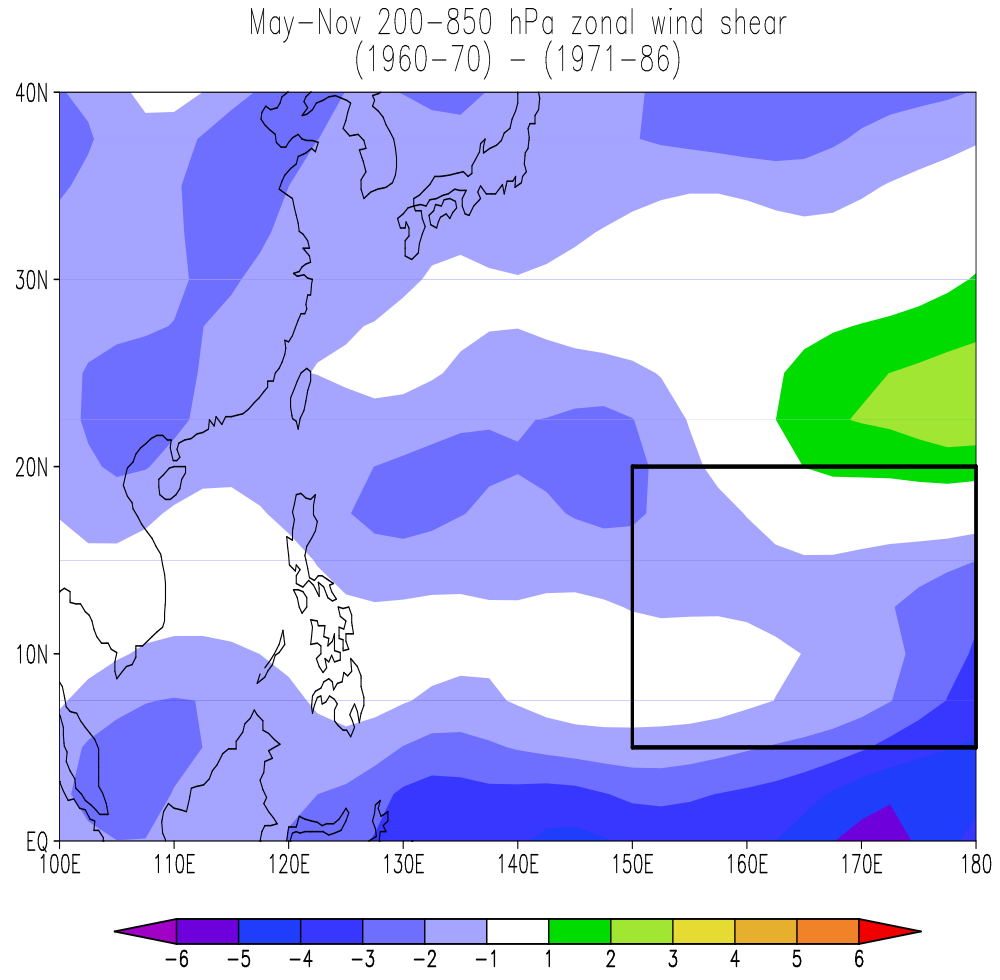




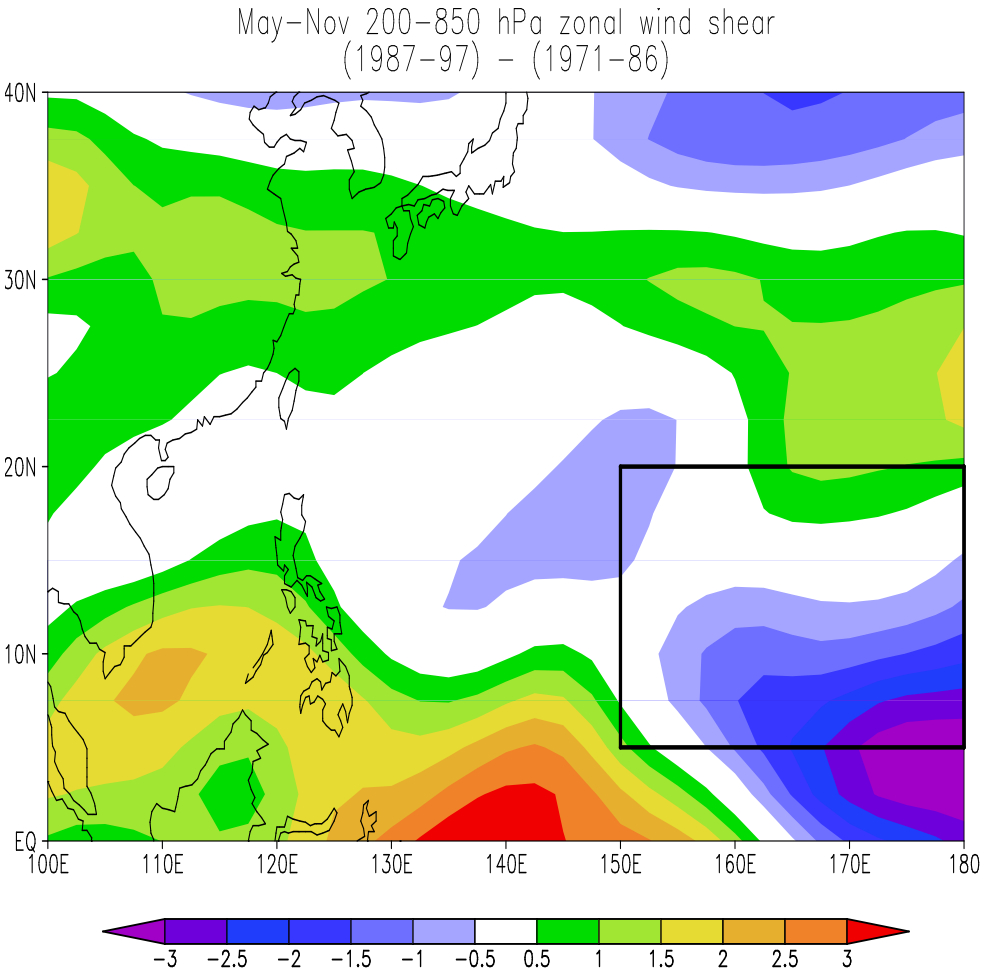
Rainfall Anomalies

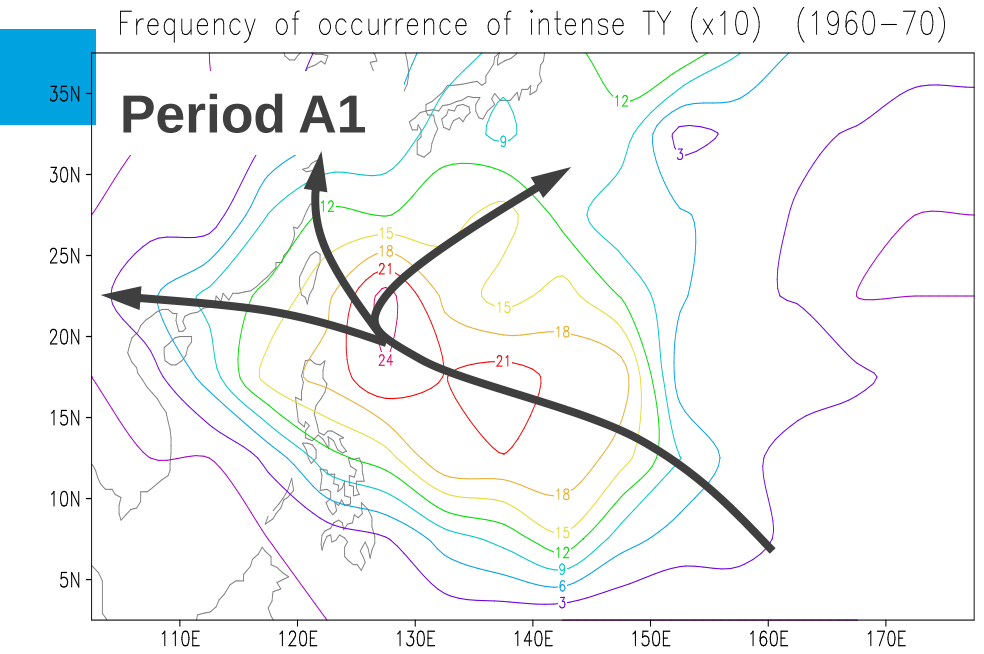
Vertical Wind Shear

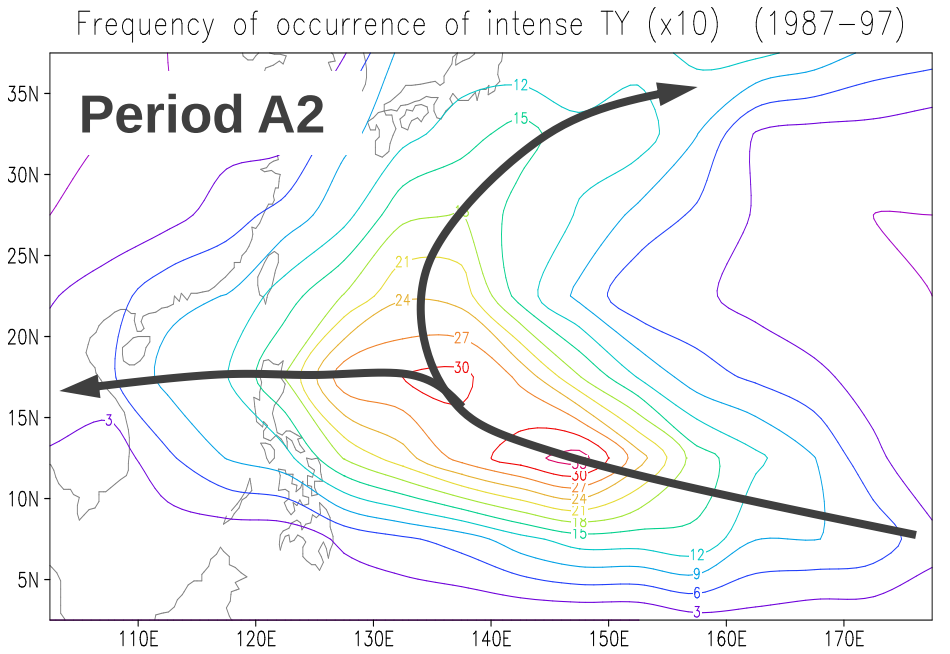
Period A1 minus Period B

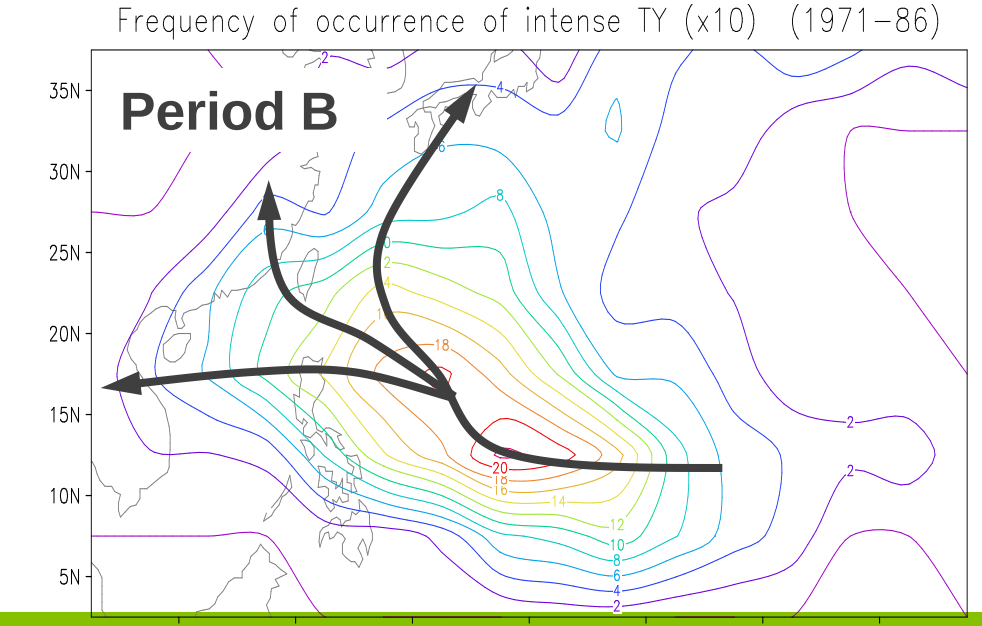


Period A2 minus Period B







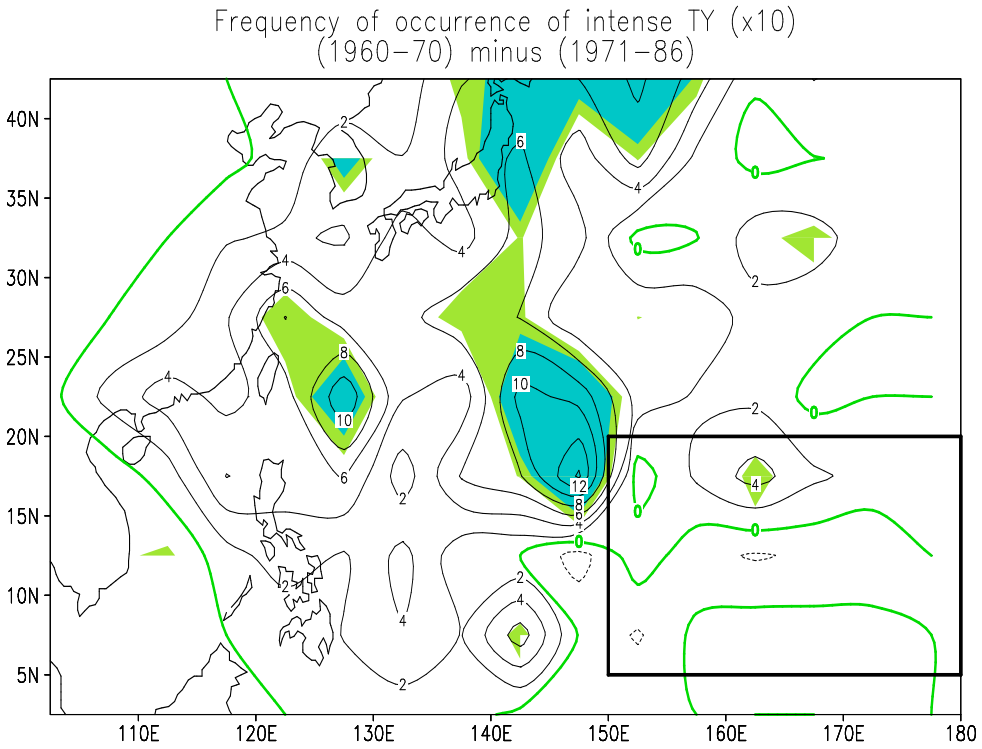


Frequency of Occurrence of Intense Typhoons

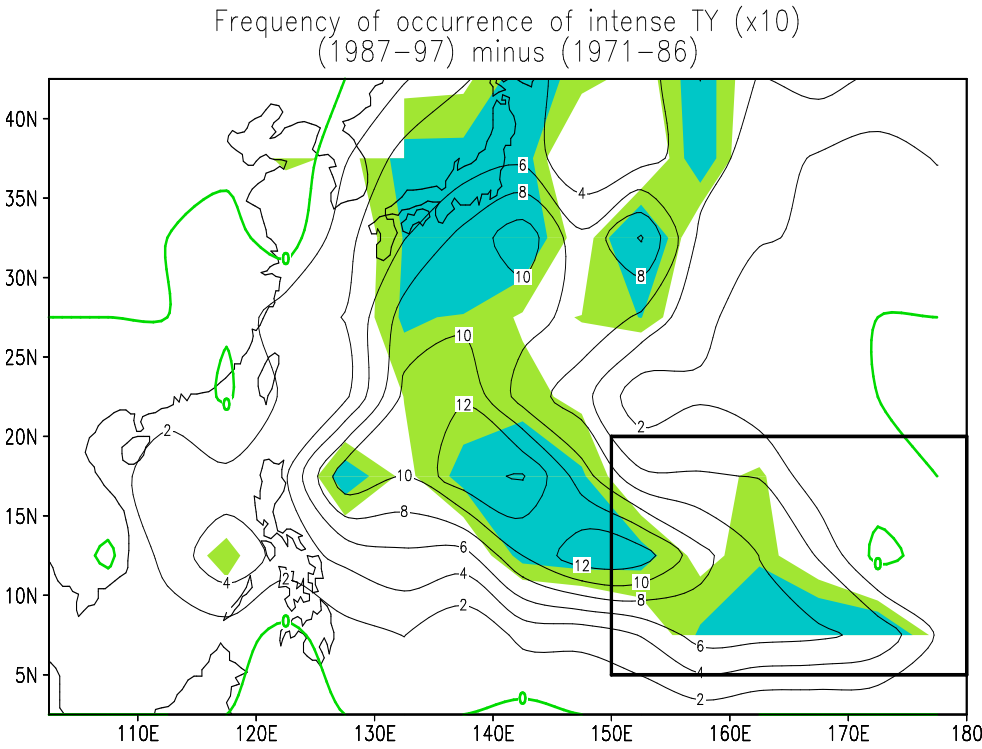
Difference in the Frequency of Occurrence of Intense Typhoons

Proceedings, Royal Society A (2008)

Period A1 minus Period B



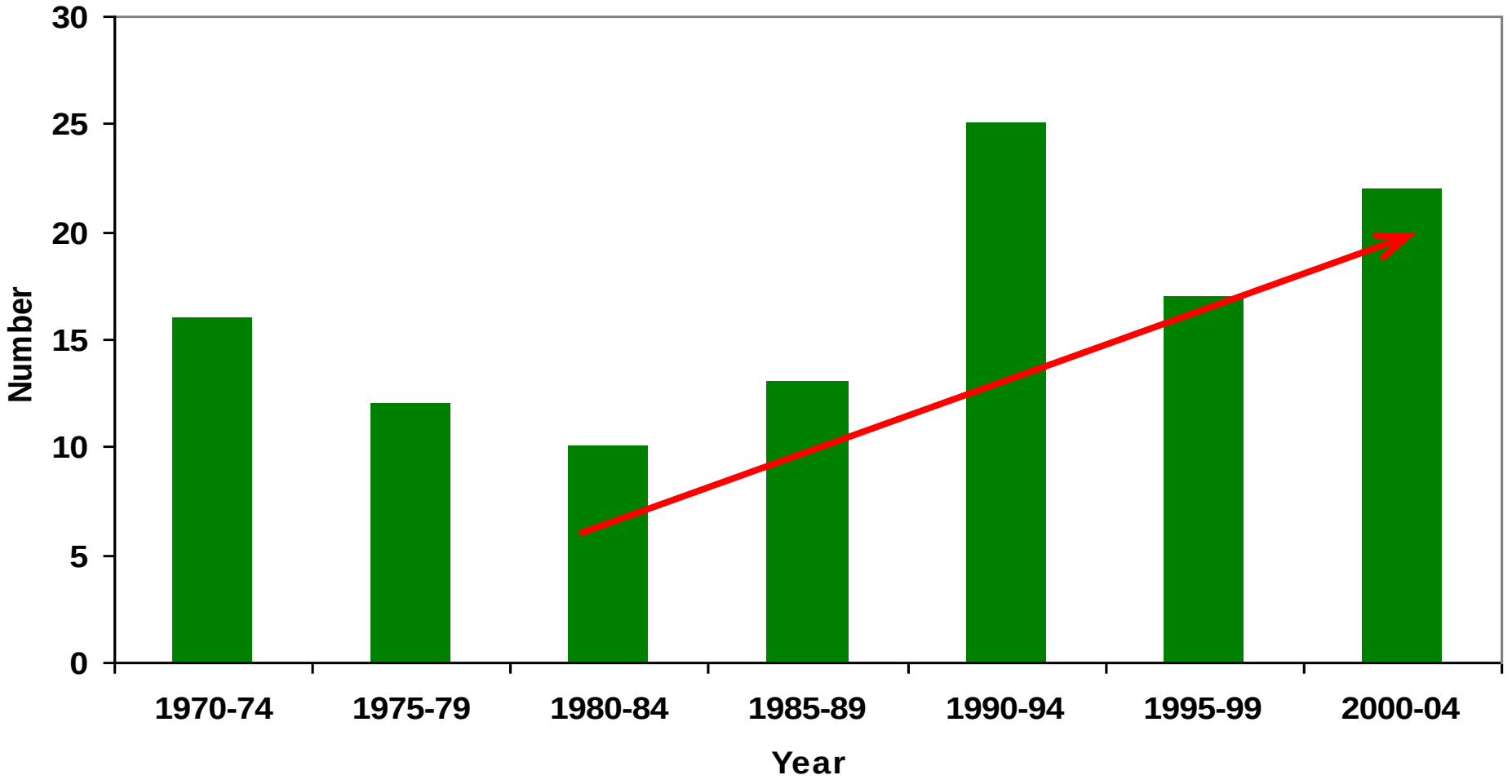
Period A2 minus Period B



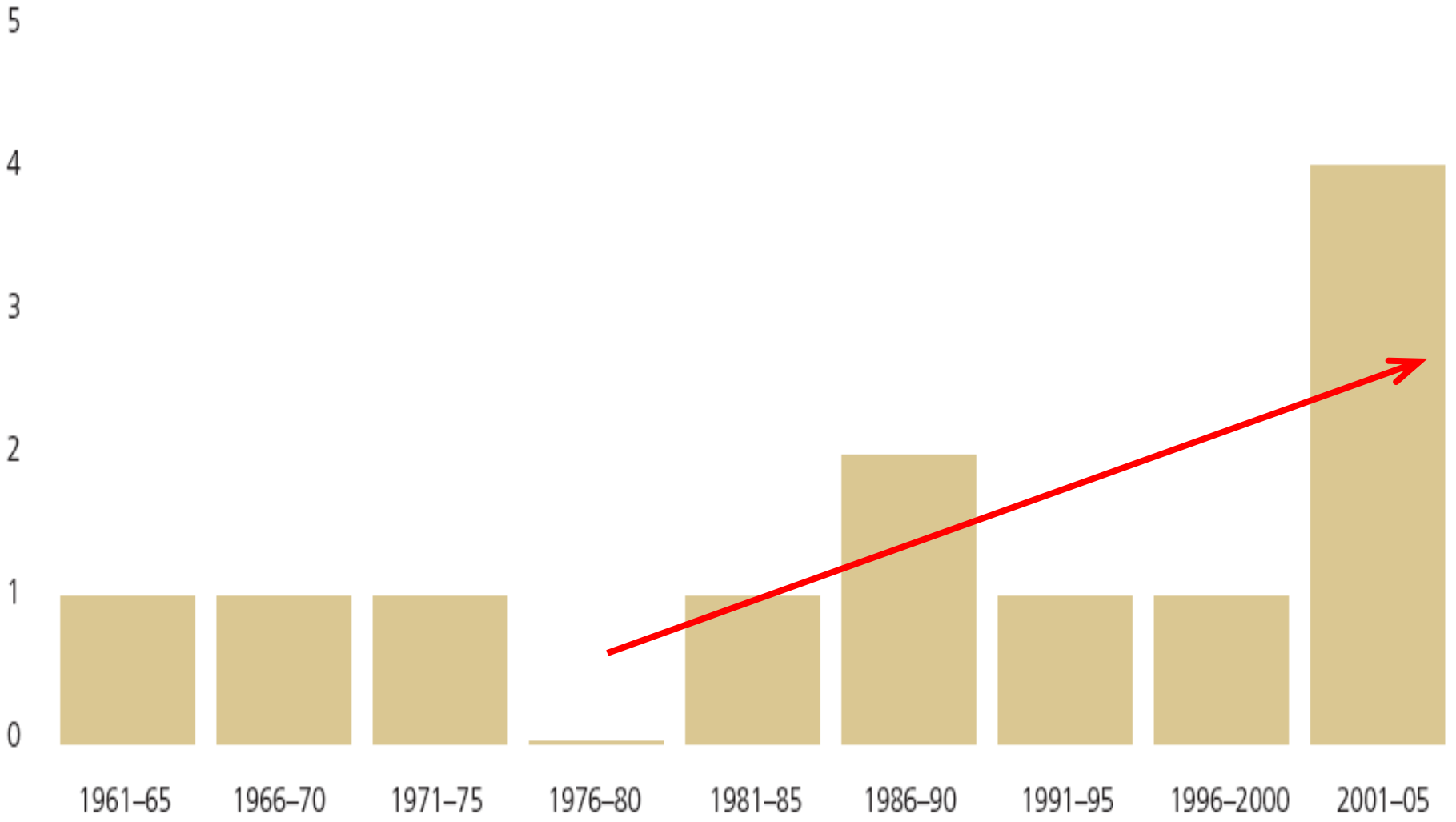
Blue shading: 95% Green shading: 90%

Track and Landfall Variations

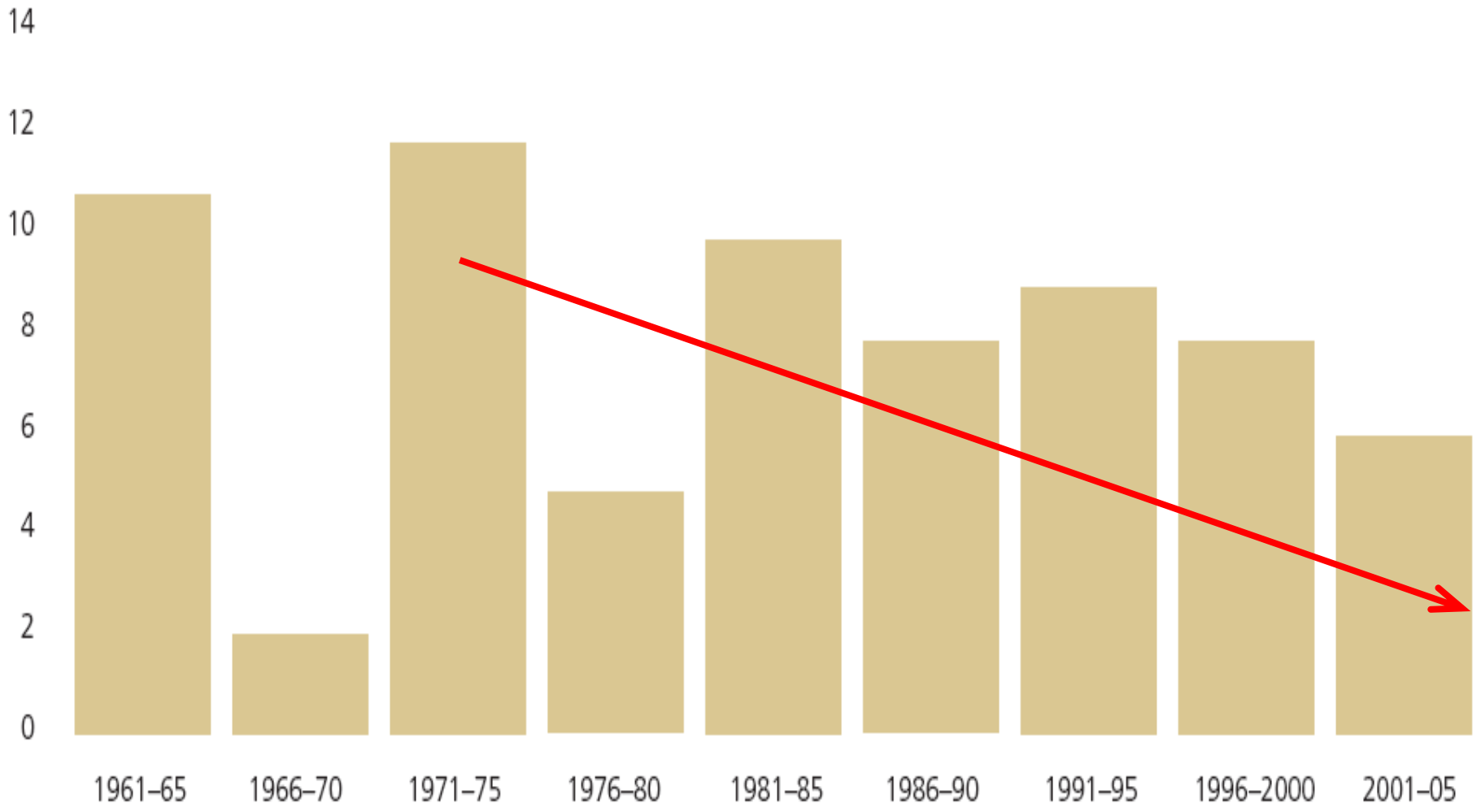
No. of TCs Making Landfall in Japan and Korea Every 5-year period (1970-2004)



No. of Typhoons Making Landfall in East China Every 5-year period (1960-2005)

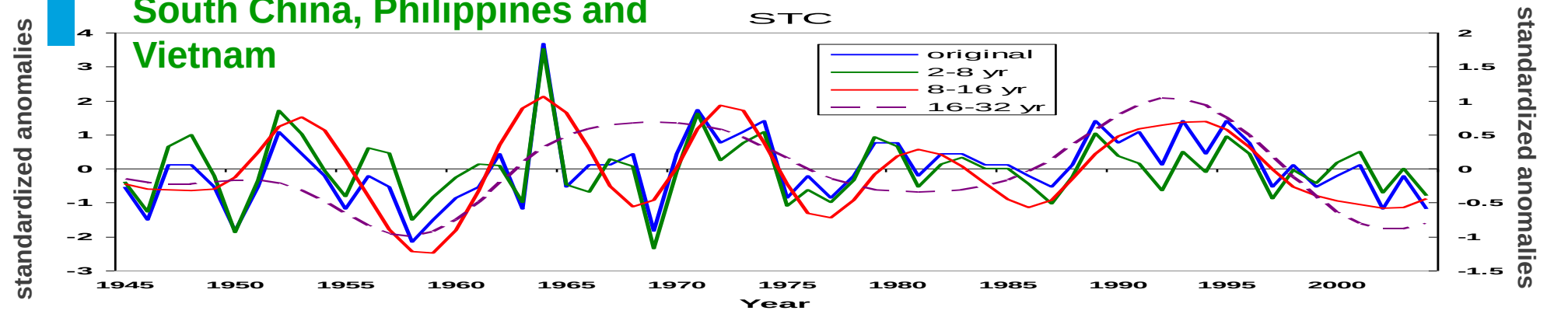


No. of Typhoons Making Landfall in South China Every 5-year period (1960-2005)

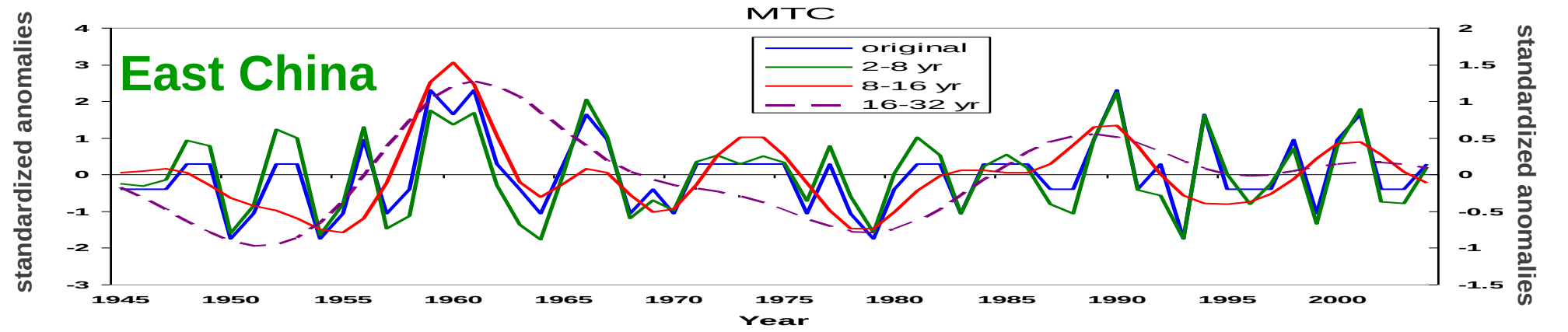


Variations of Landfall in Each Area at Various Oscillation Periods

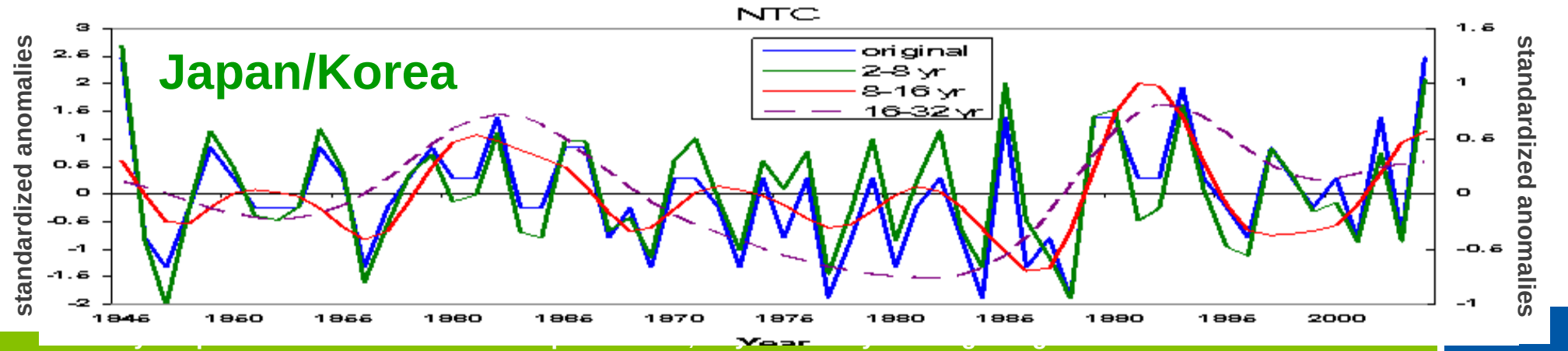
South China, Philippines and Vietnam



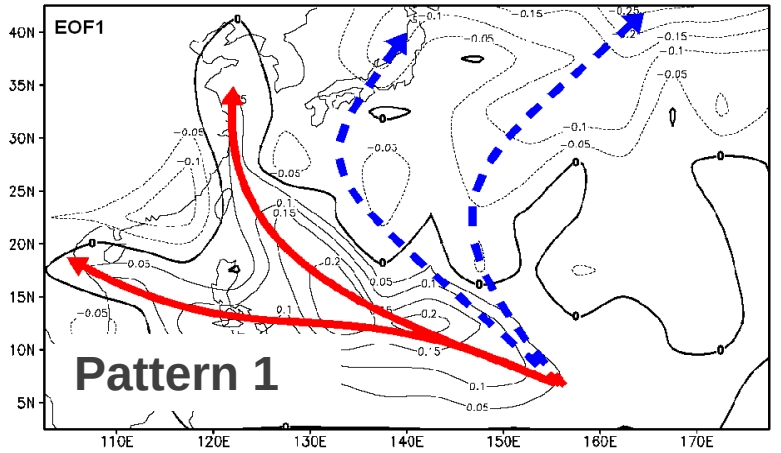
East China

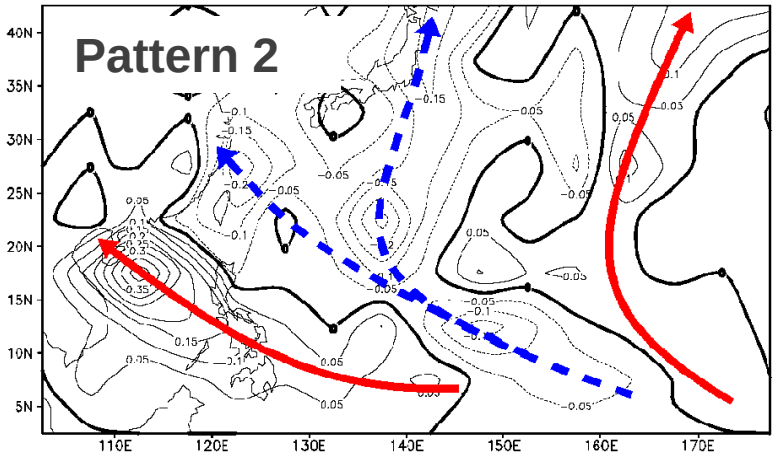


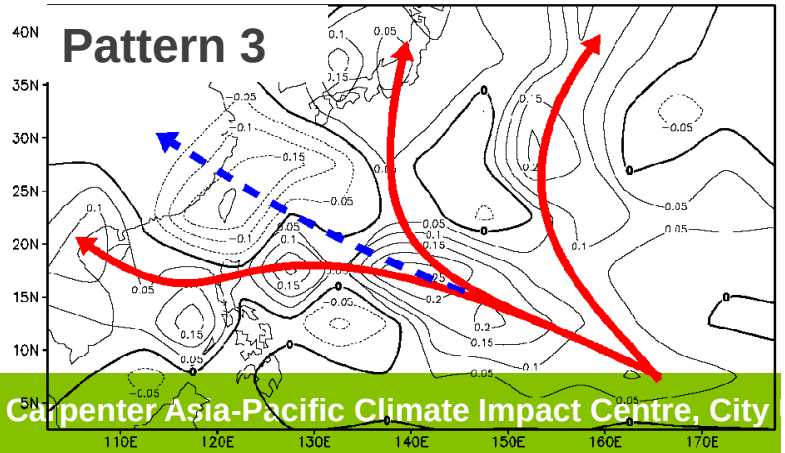
Japan/Korea



Patterns of TC occurrence anomalies







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.**