# Global Warming and Tropical Cyclone Activity in the western North Pacific/ Thermodynamic Controls on Intense TCs

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# Outline

- ***Part I*** **- Actual observations and possible explanations of the variations of the following WNP TC characteristics**
  - **numbers and intensity**
  - **tracks and landfall locations**
- **Part I Summary**
- **Part II – relationship between MPI and frequency of occurrence of intense TCs**

# Part I


SRC:GUAMGSRS SAT:GMS_VS PRO:SAT REG:b_typhoon CLRMAP:UNDEFINED 97_09_09
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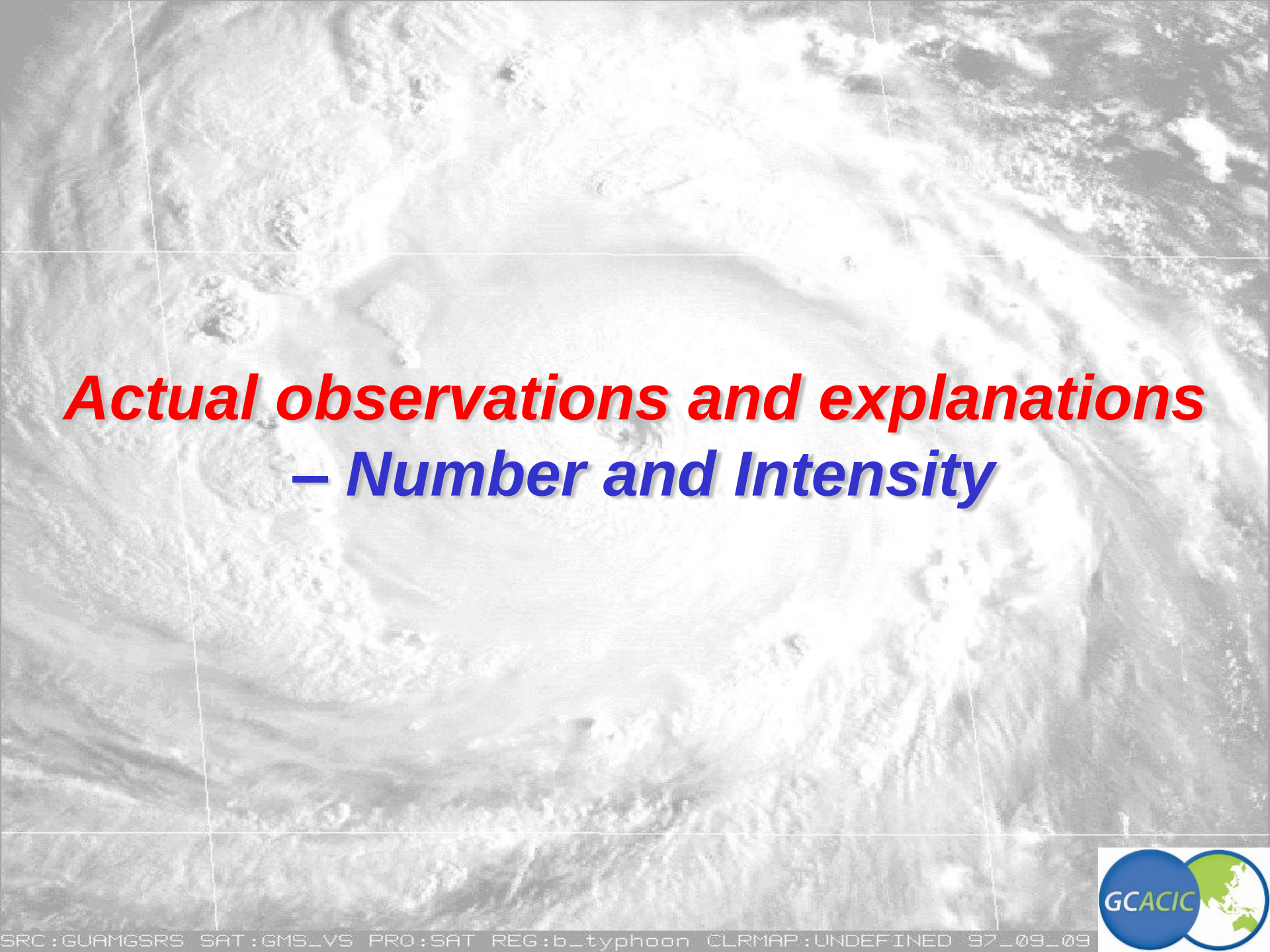
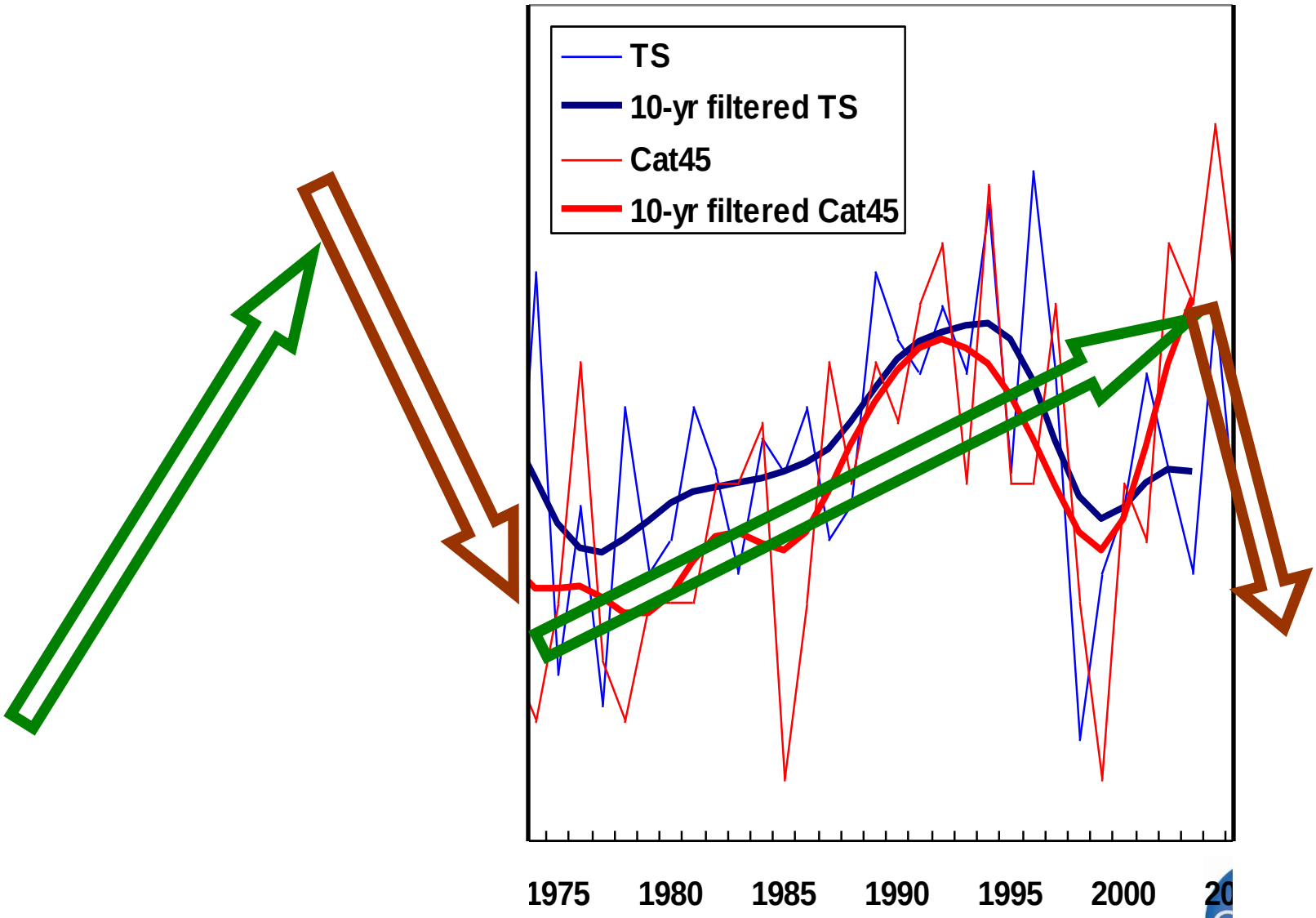
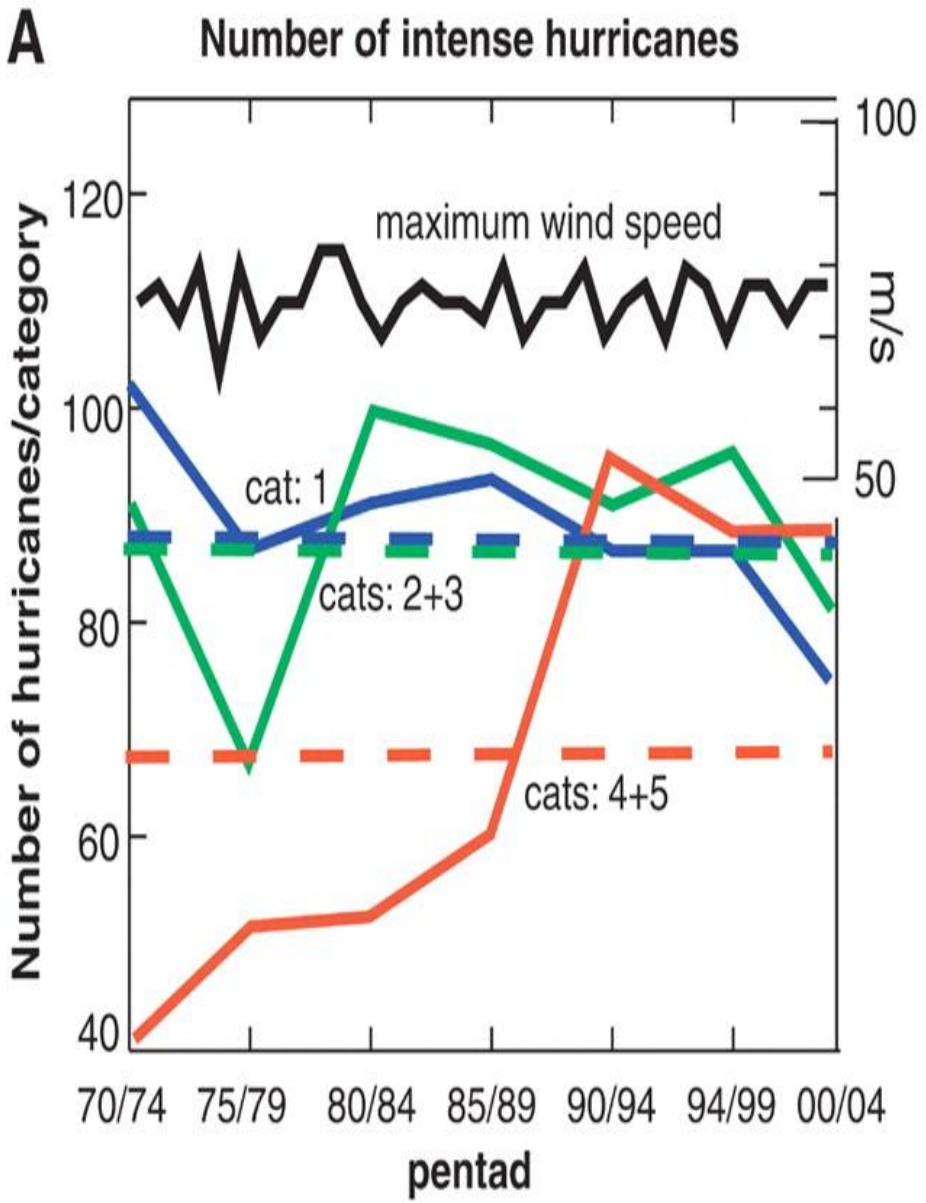
# *Actual observations and explanations – Number and Intensity*

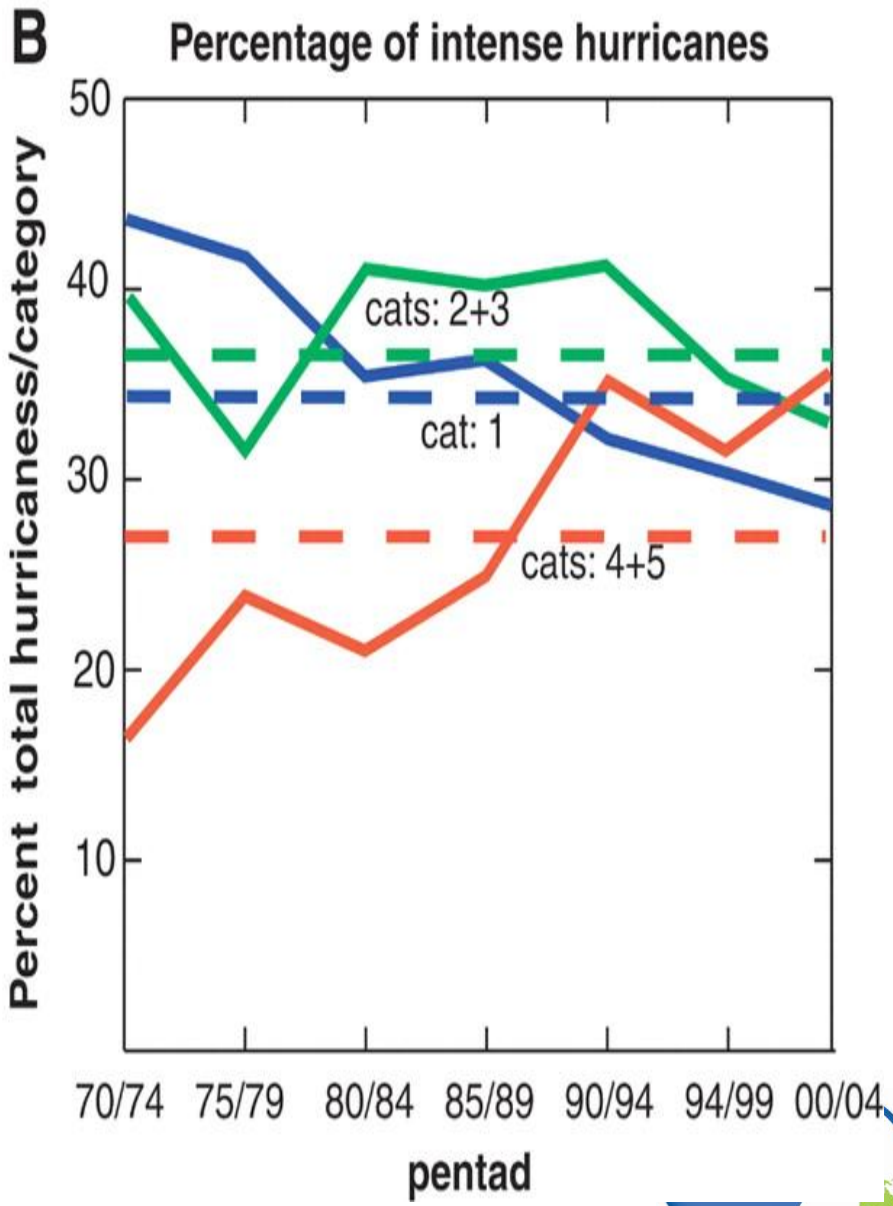


# Annual Number of TCs and intense TCs in WNP



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



# No. of Category 4 and 5 Typhoons

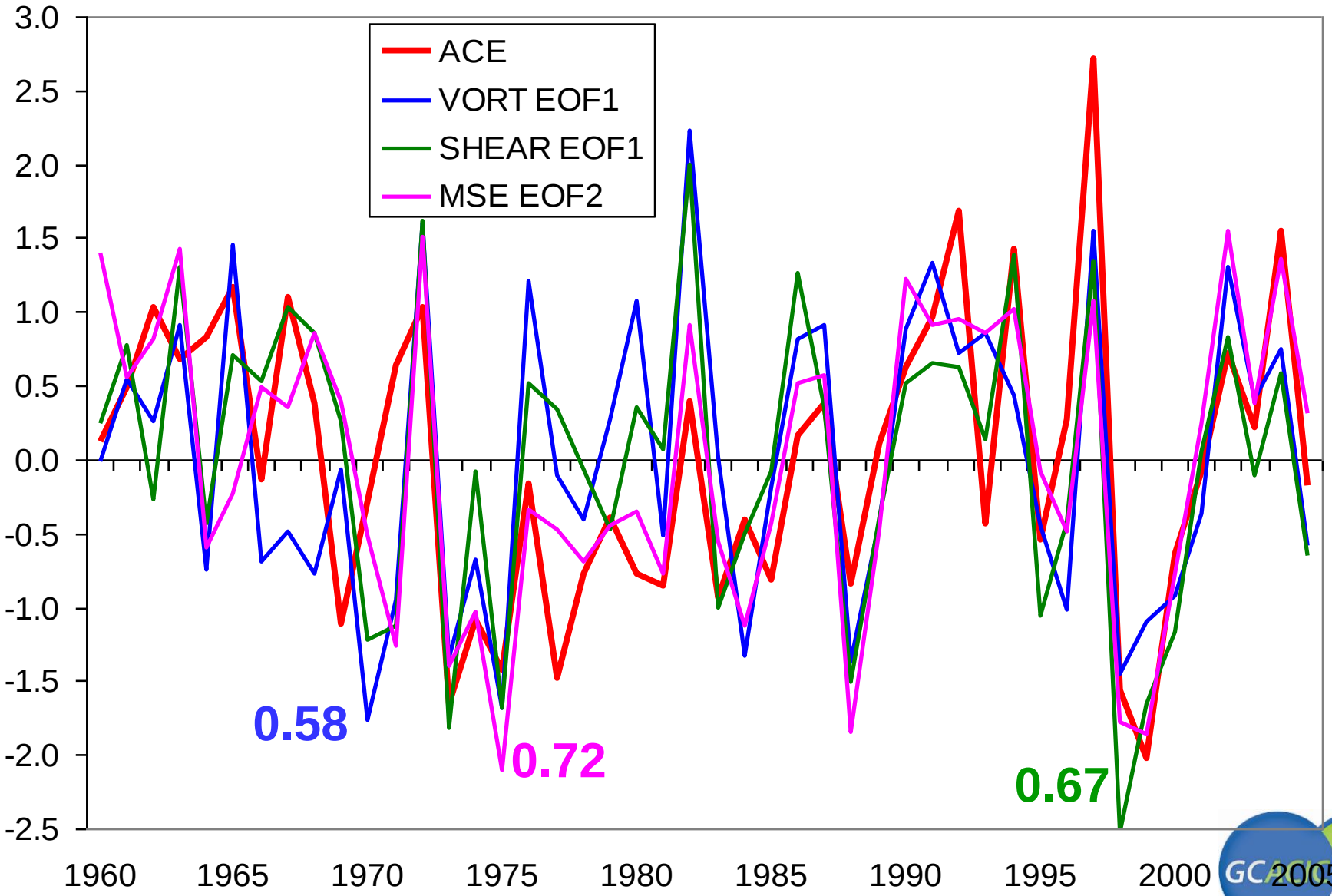
| | 1975-89 | 1990-2004 |
|---|---|---|
| Number | 75 | 115 |
| Percentage | 32 | 42 |

# No. of Category 4 and 5 Typhoons

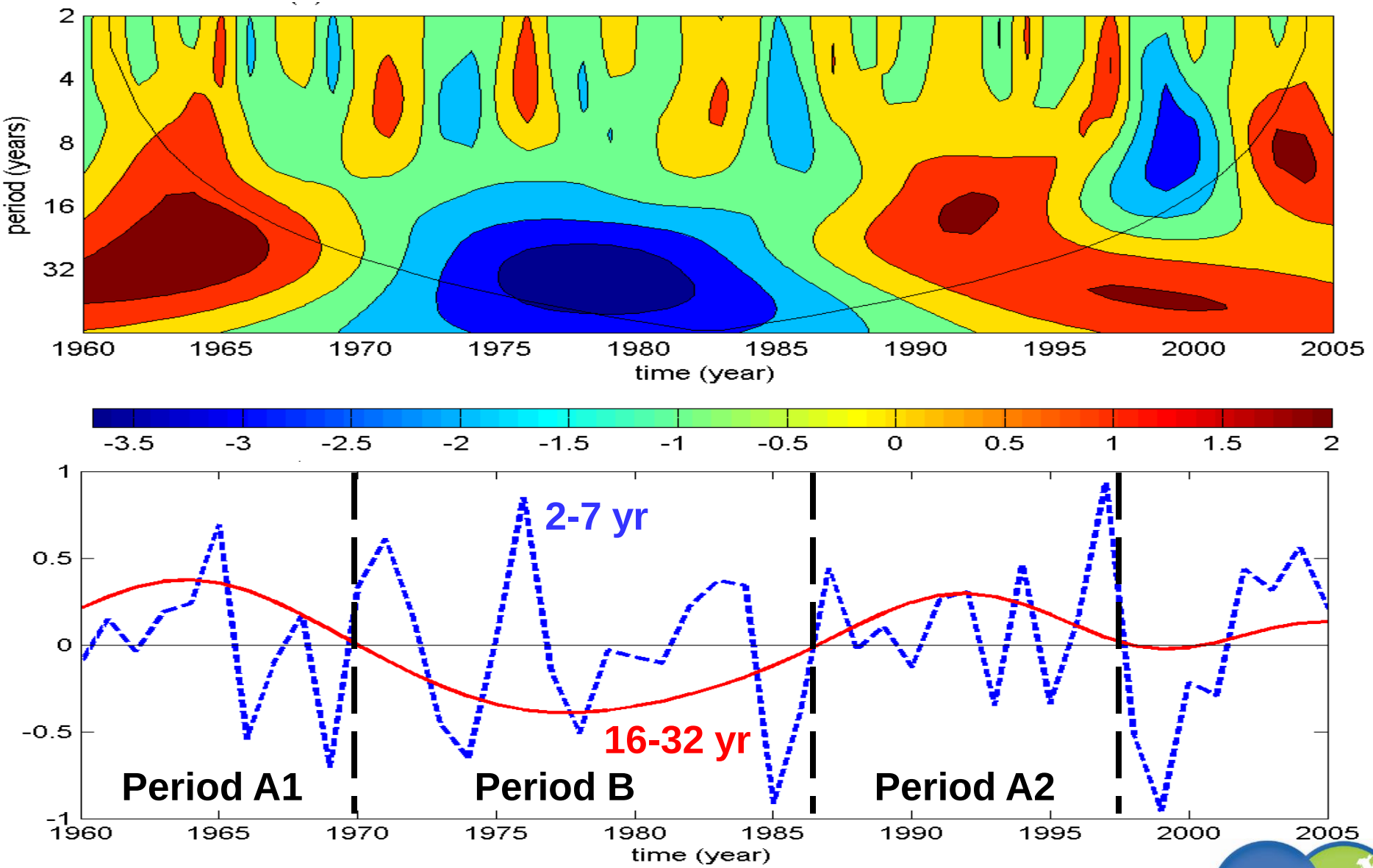
| | 1960-74 | 1975-89 | 1990-2004 |
|---|---|---|---|
| Number | 105 | 75 | 115 |
| Percentage | 37 | 32 | 42 |

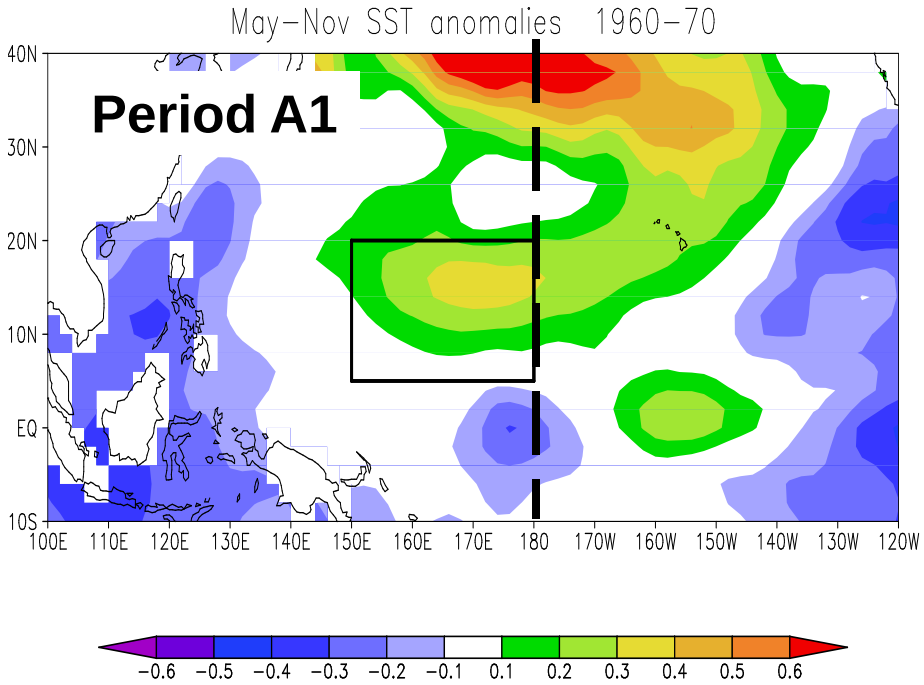
# ACE vs.. VORT, SHEAR and MSE

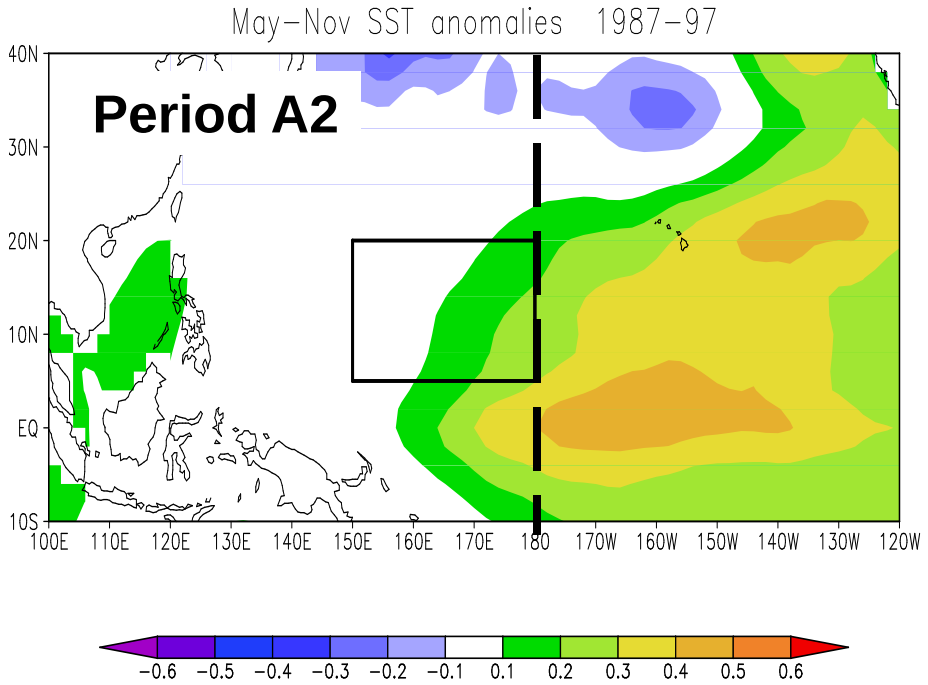
## *Science*, 311, 1713b, *Tellus 2007*

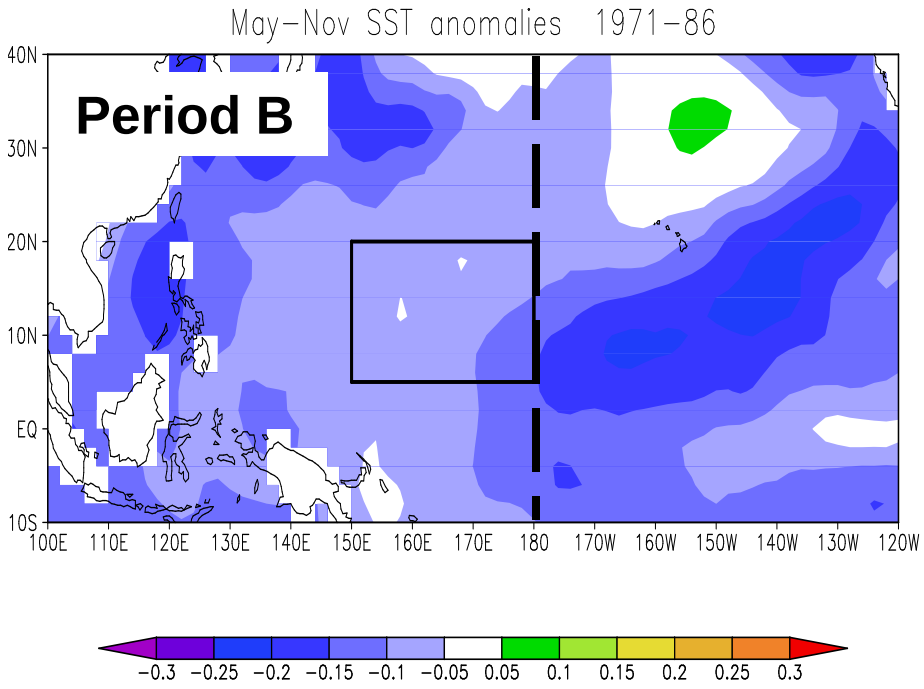


# Wavelet Analysis of Intense Typhoon Occurrence Frequency






# Sea-surface Temperature Anomalies

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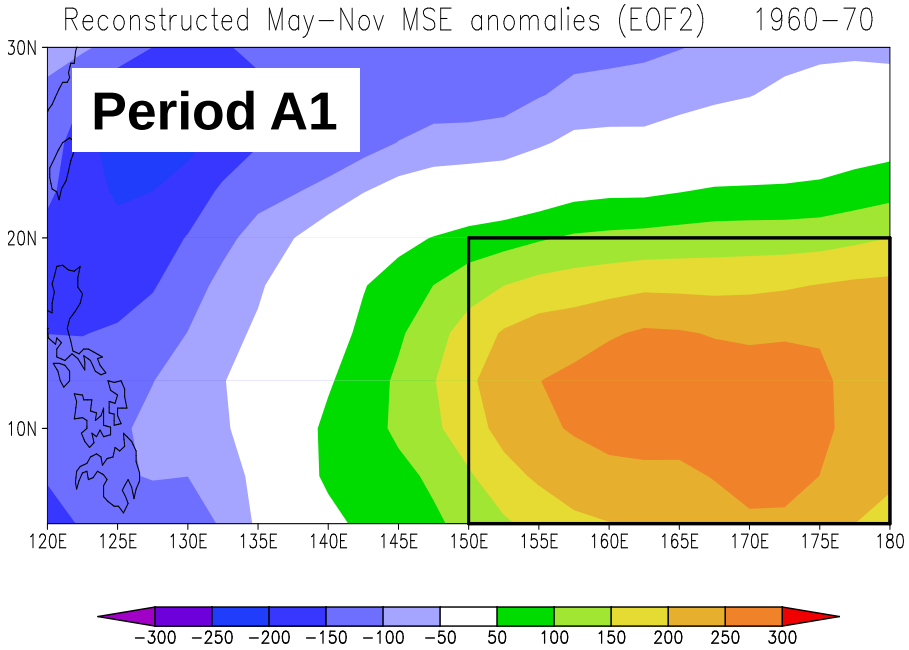


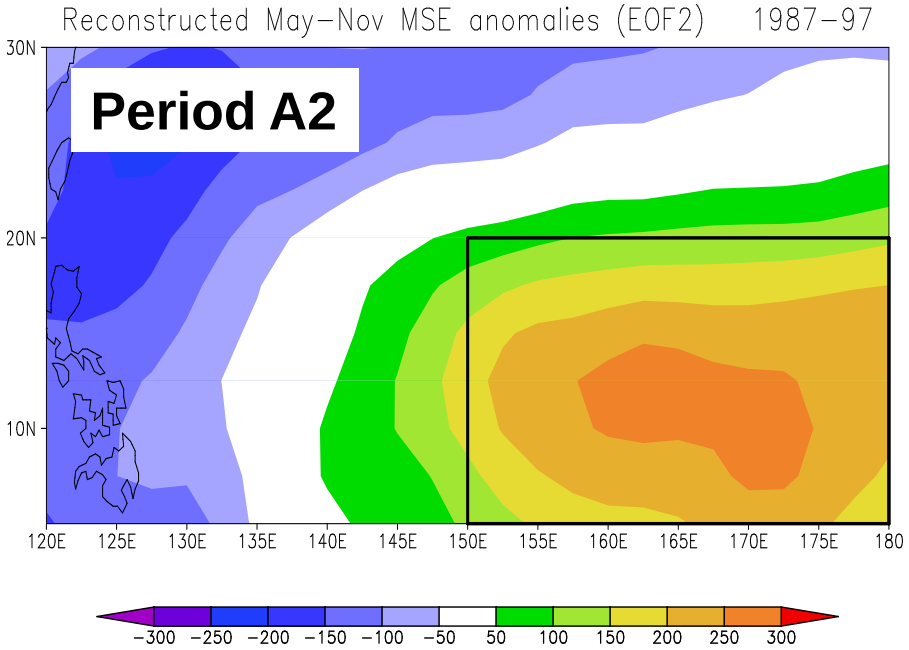


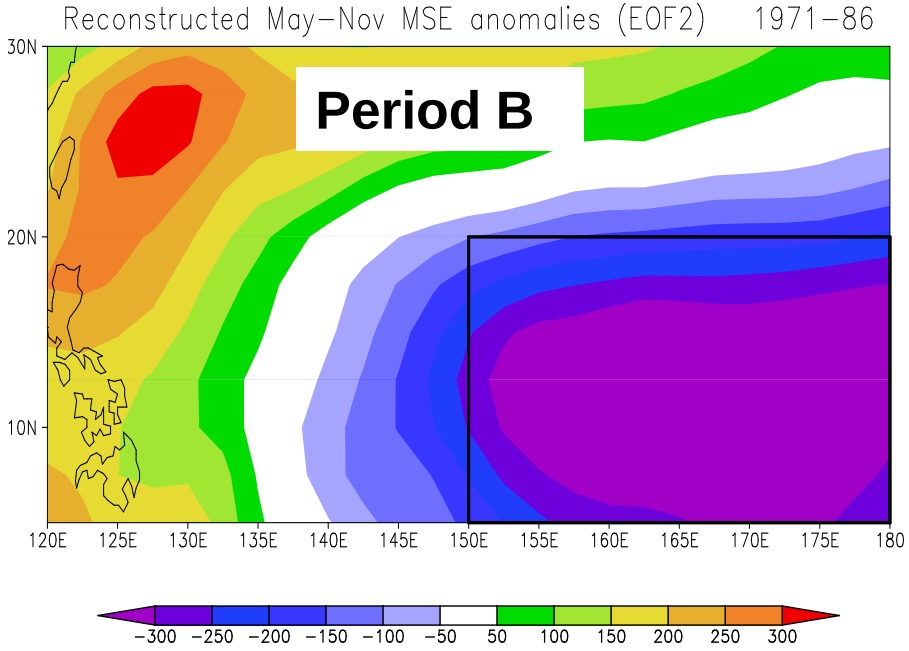


# Reconstructed Moist Static Energy (EOF2)

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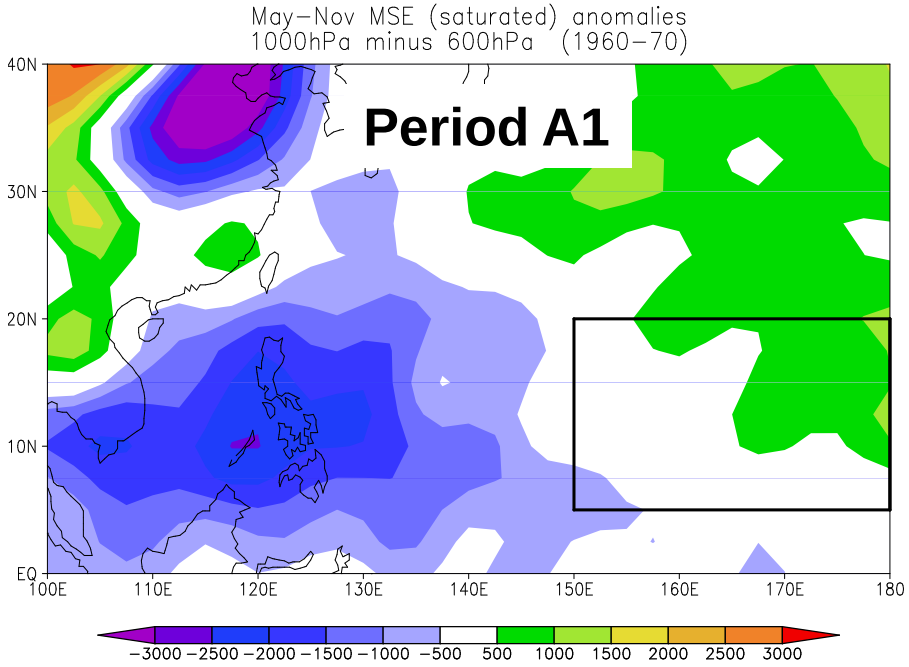


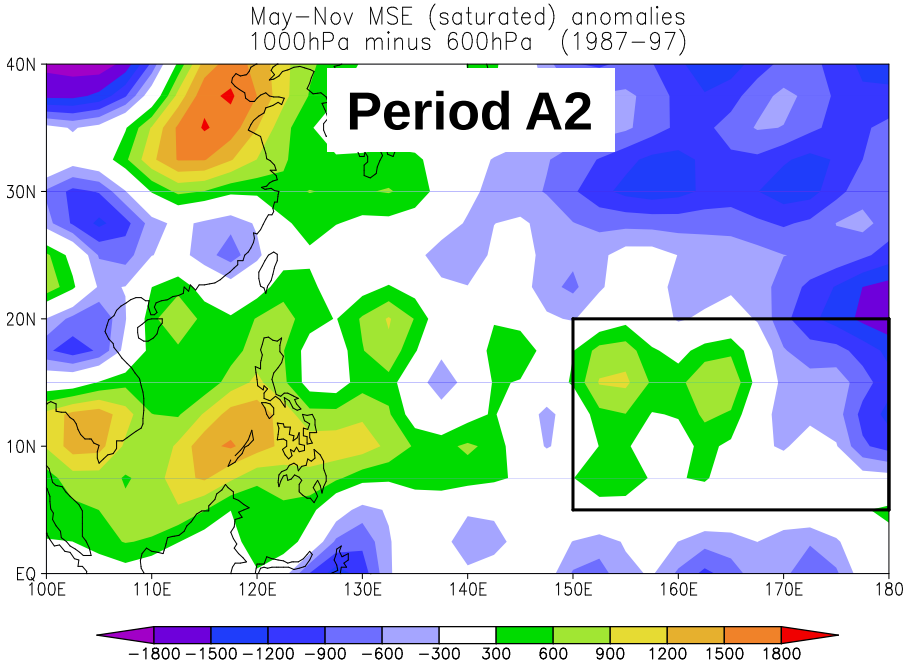


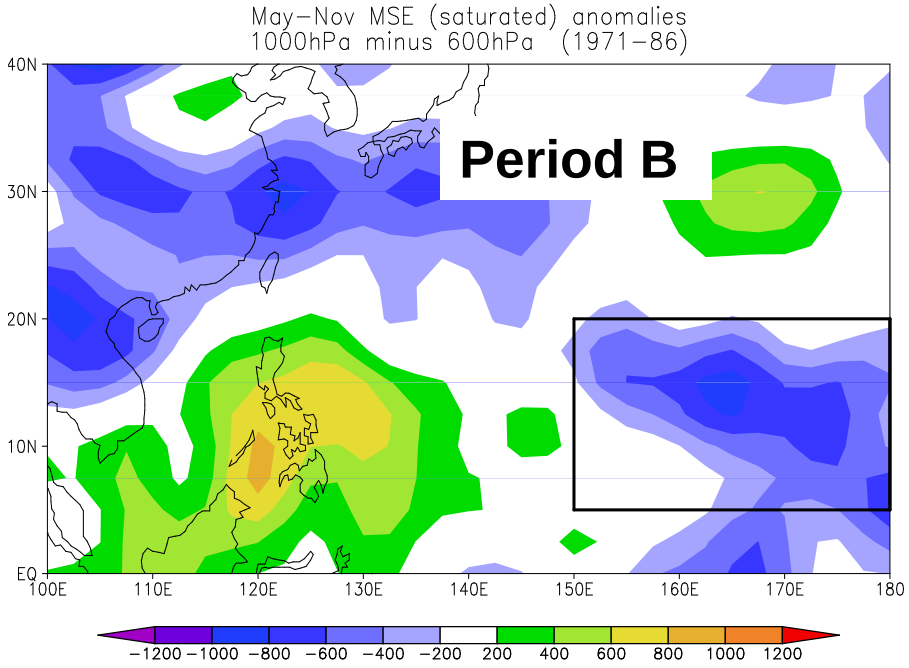


# Vertical Gradient of Saturated Moist Static Energy

# (1000 minus 600 hPa)

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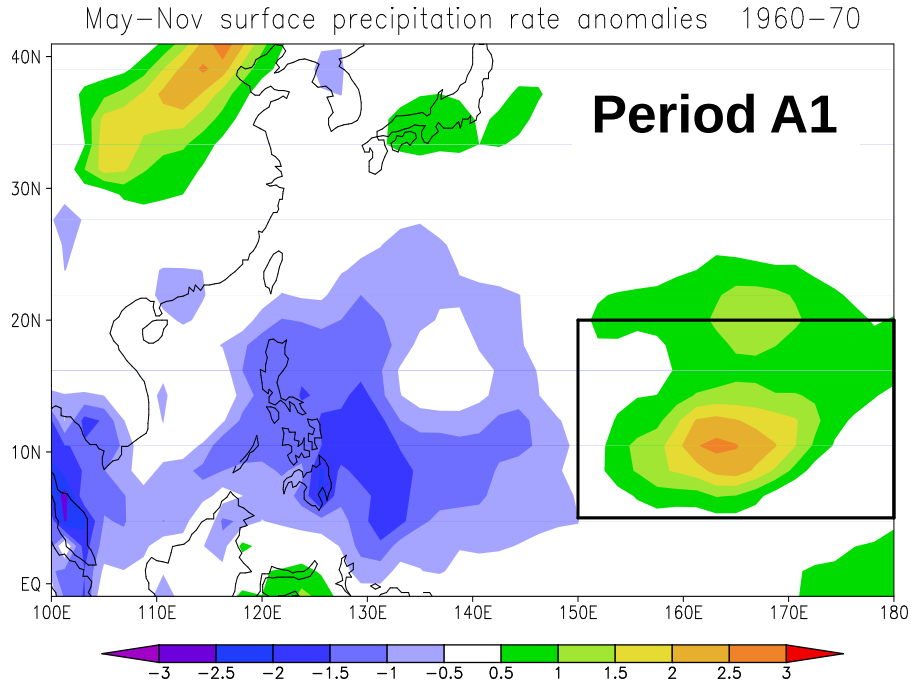


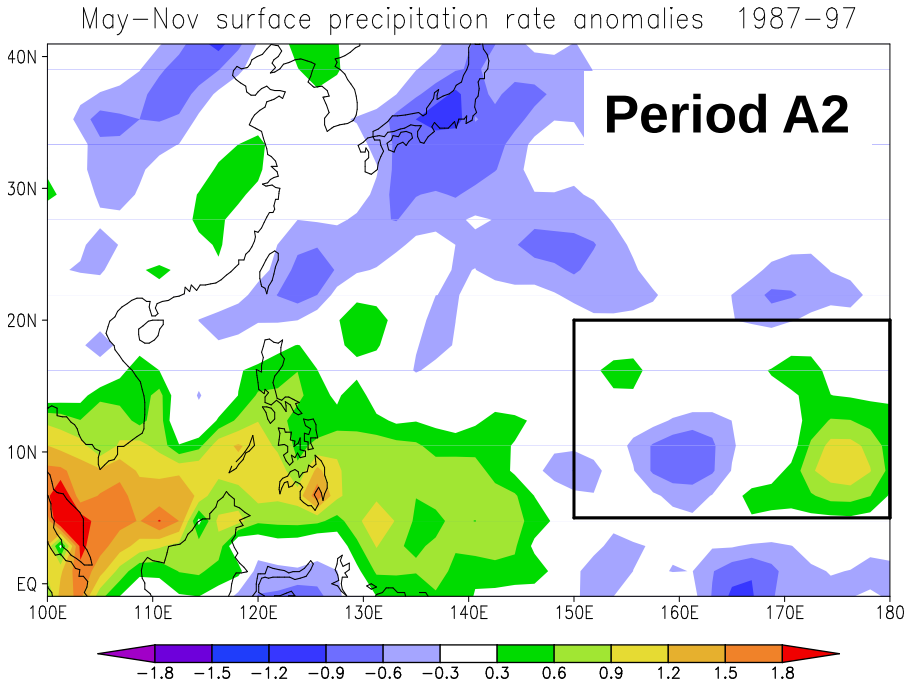


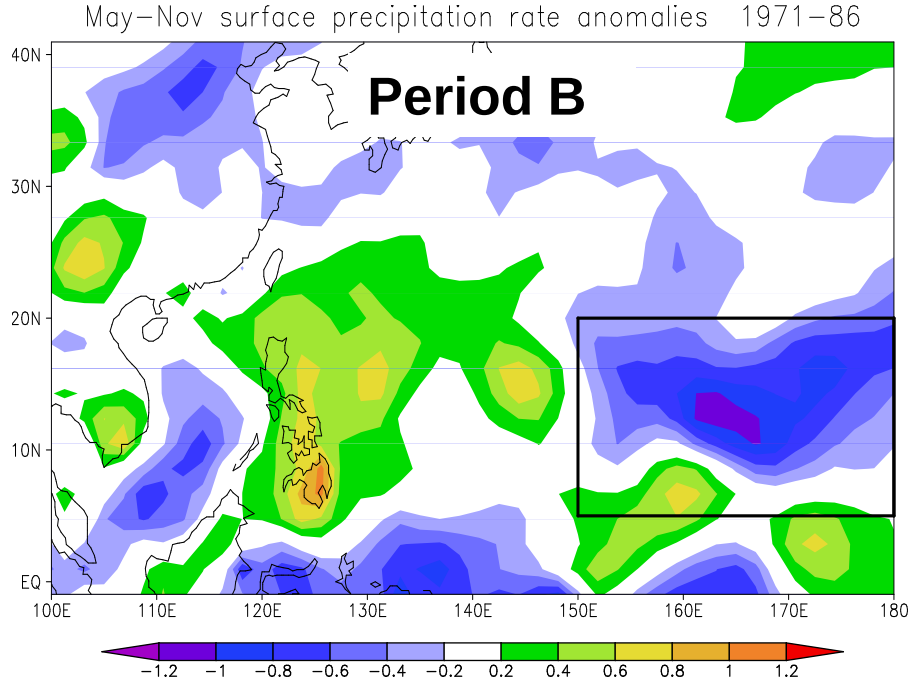


# Precipitation Rate Anomalies

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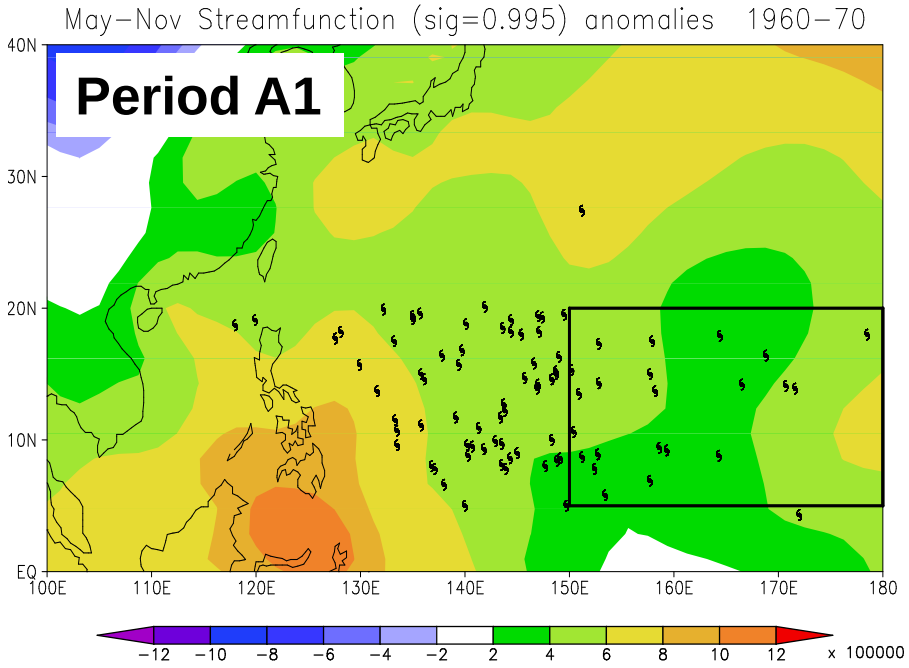


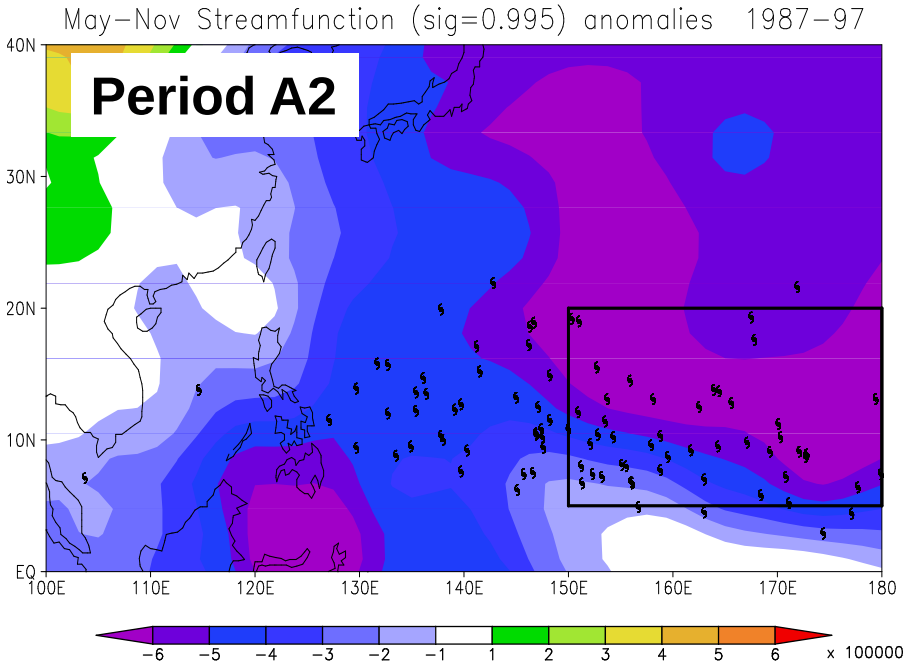


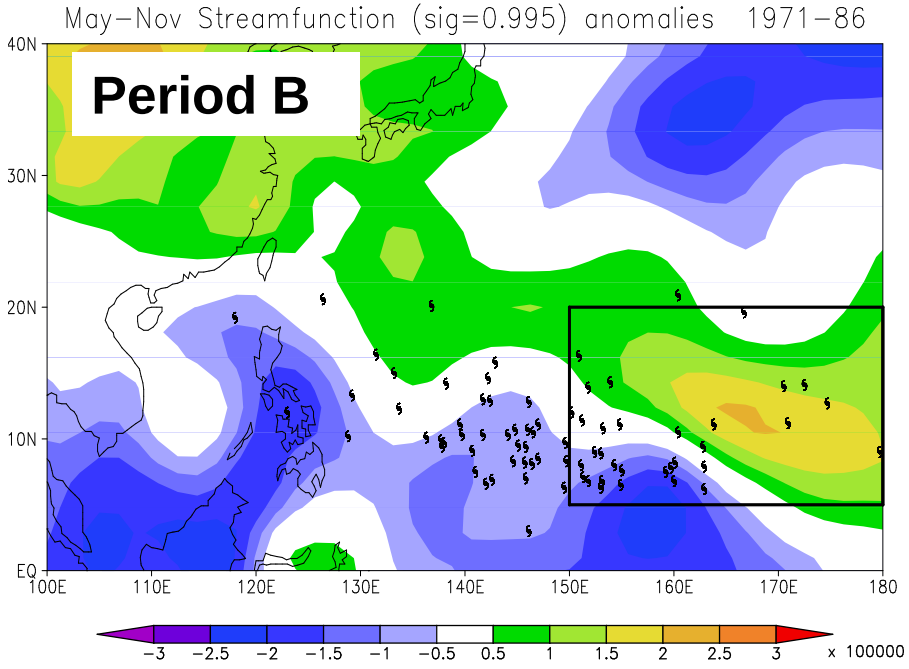


# Lower Tropospheric Streamfunction Anomalies

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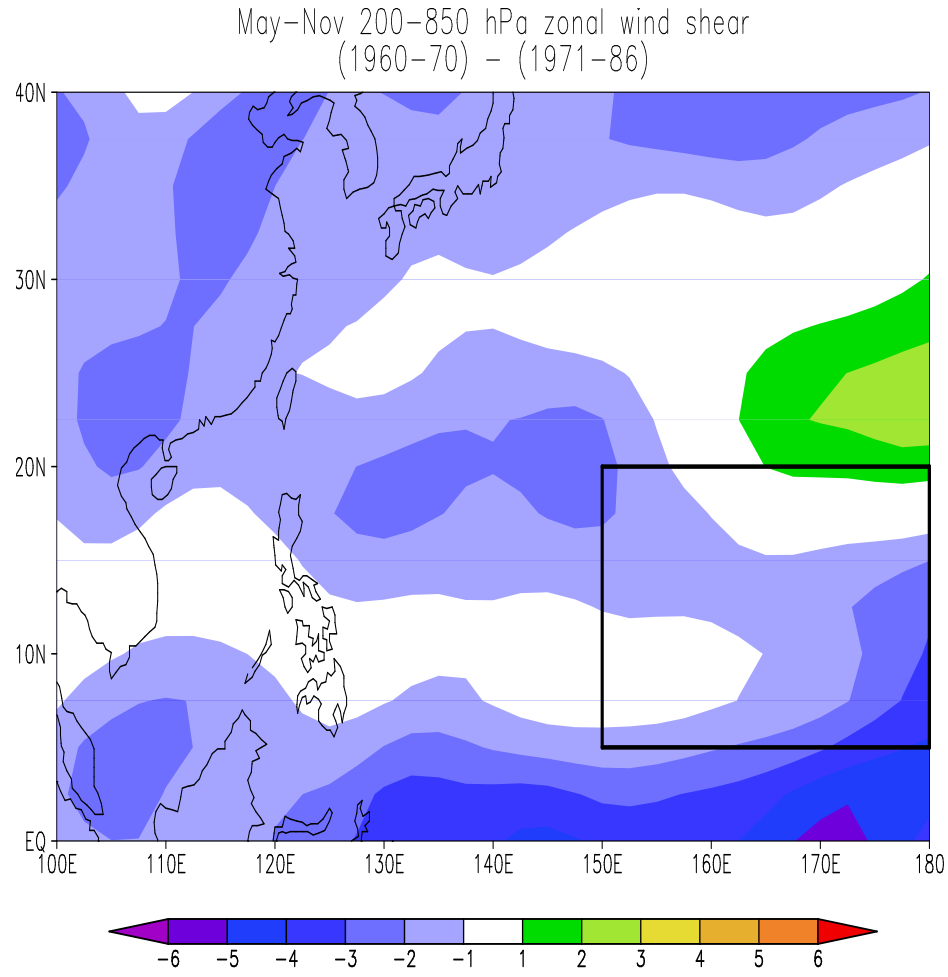
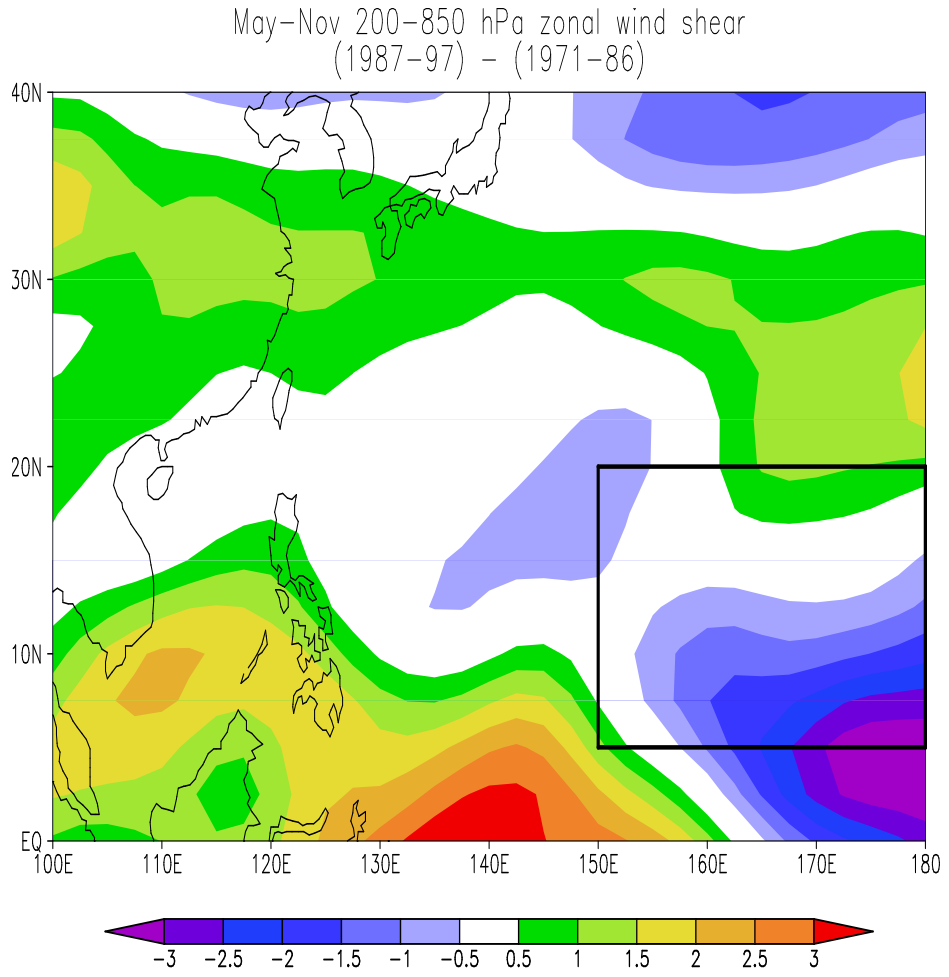
# 200-hPa minus 850-hPa Zonal Wind Shear

## Period A1 minus Period B




## Period A2 minus Period B

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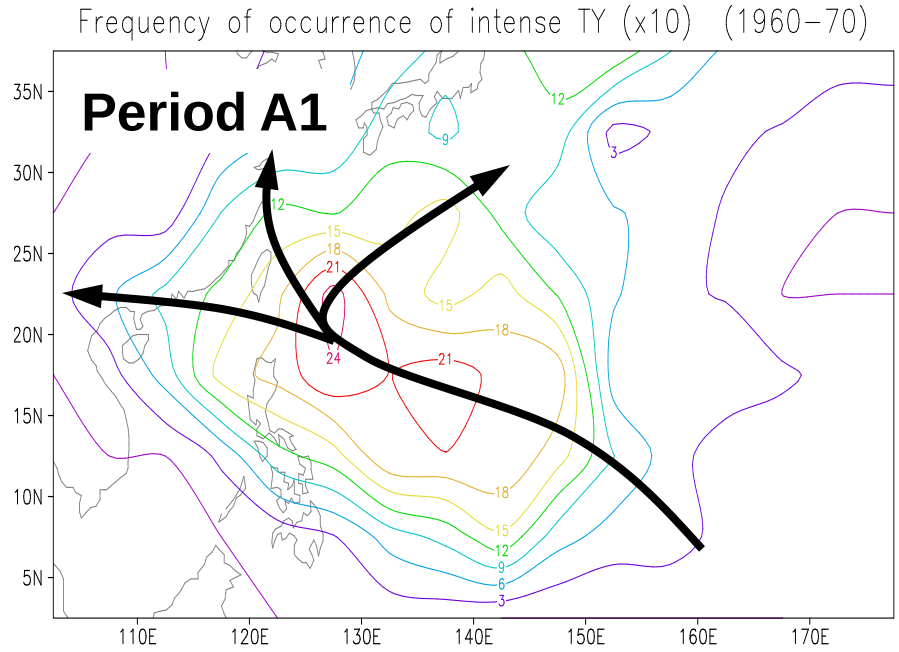


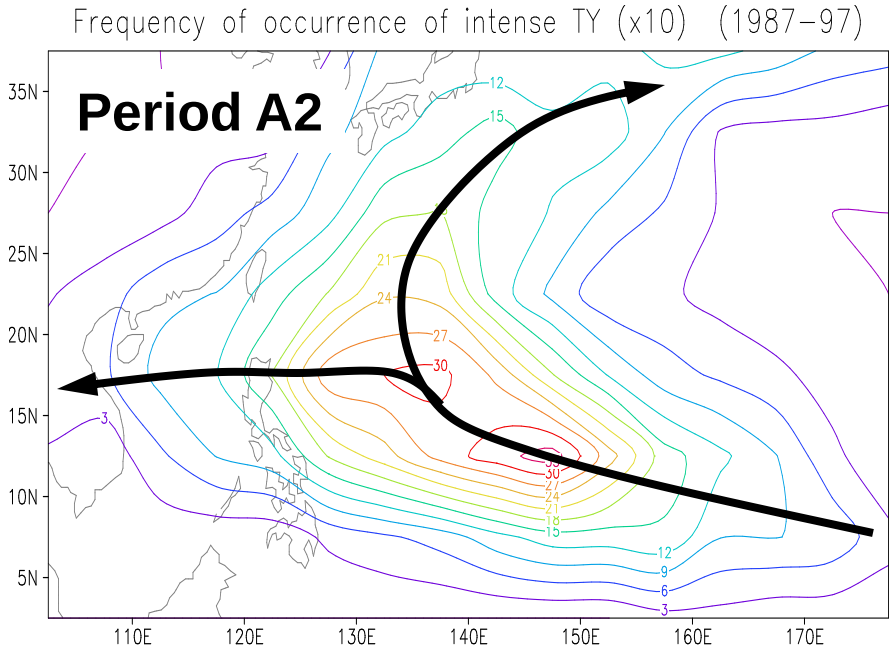


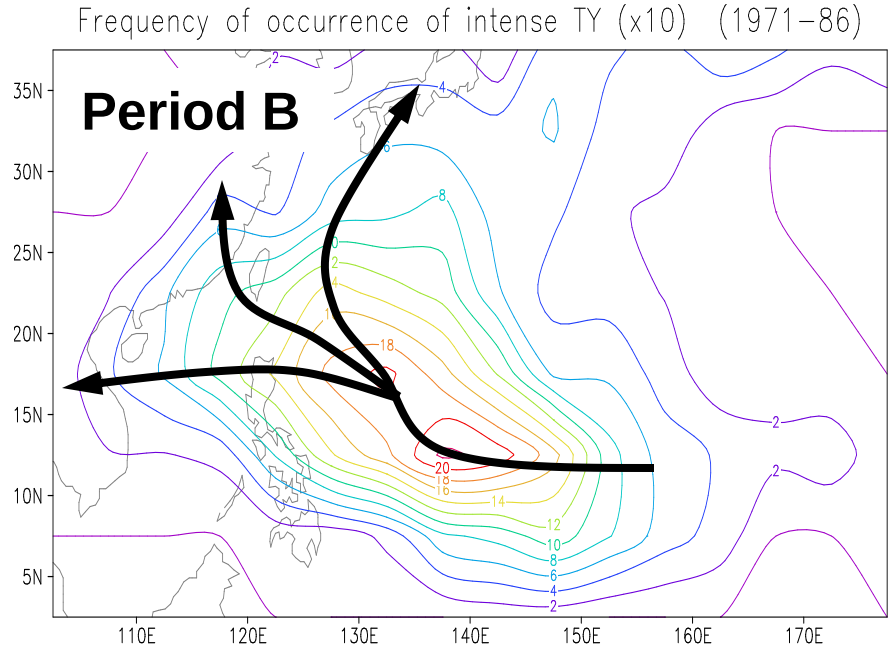


# Frequency of Occurrence of Intense Typhoons

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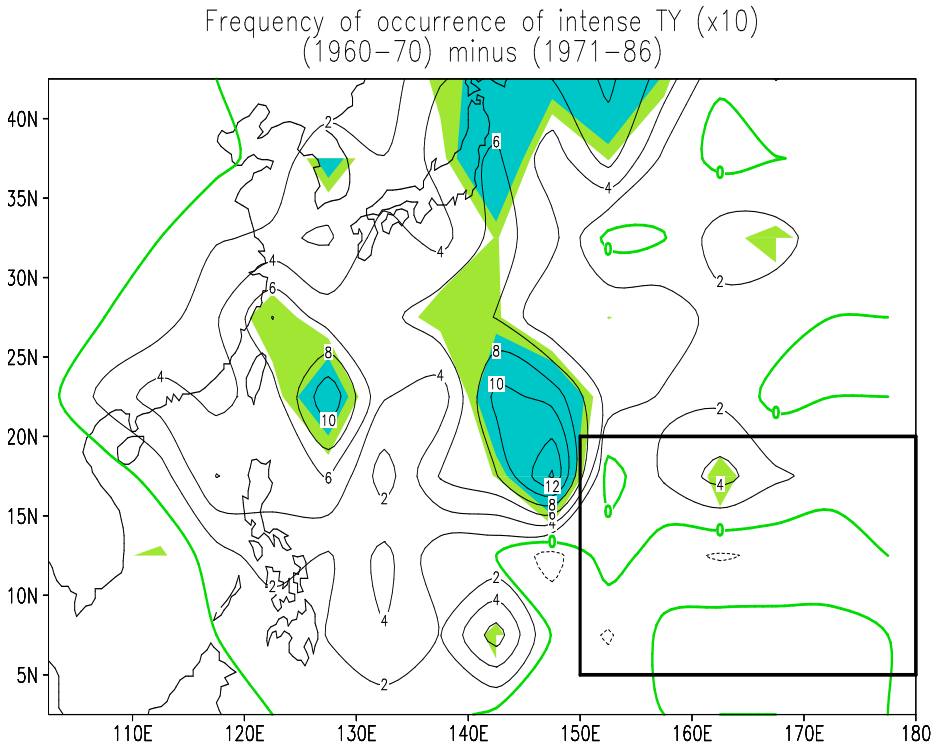
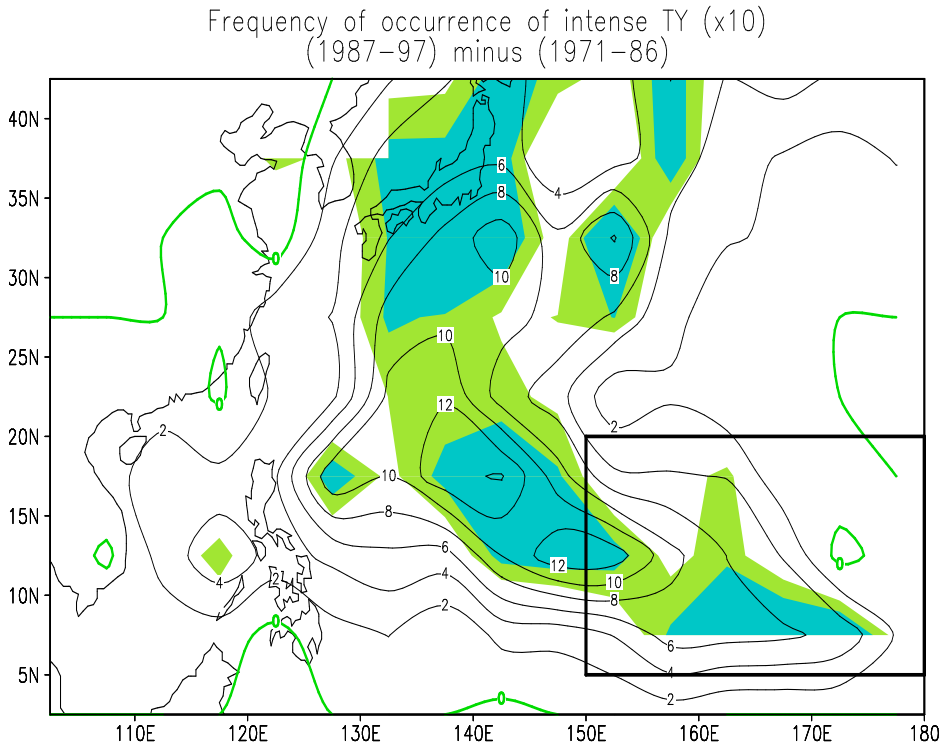
# Difference in the Frequency of Occurrence of Intense Typhoons

## *Proceedings, Royal Society A (2008)*

### Period A1 minus Period B

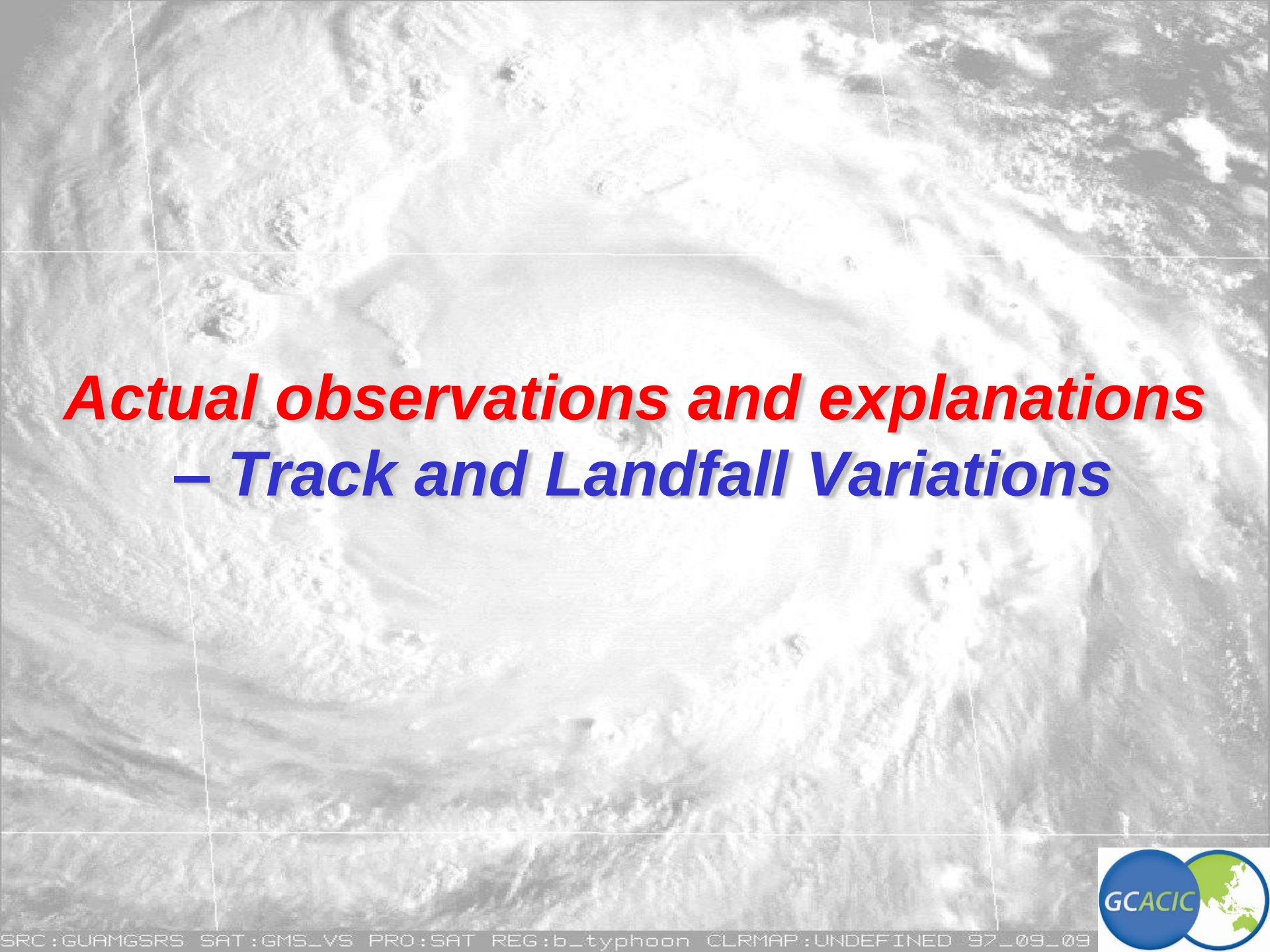



### Period A2 minus Period B

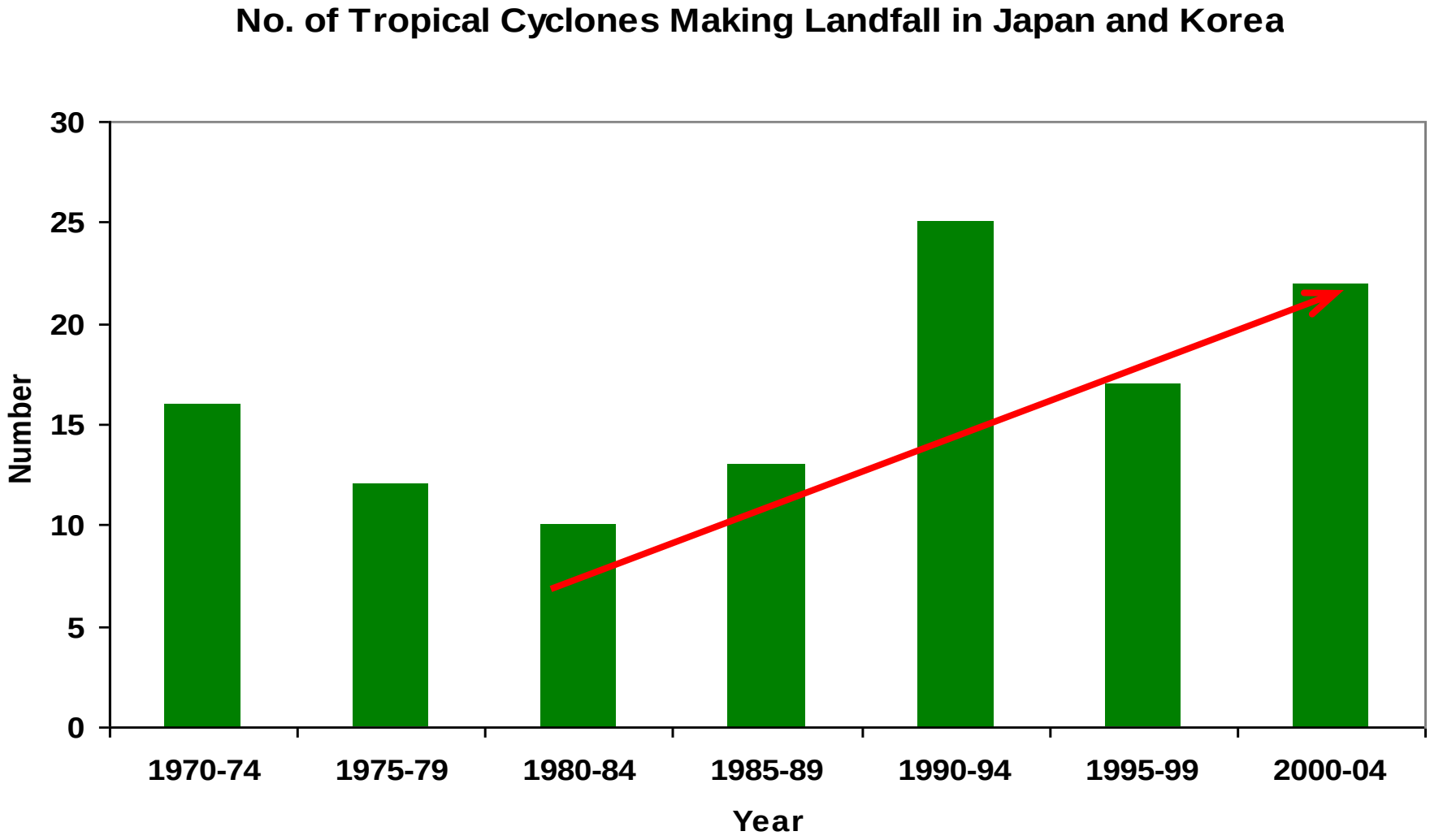



Blue shading: 95%  Green shading: 90%

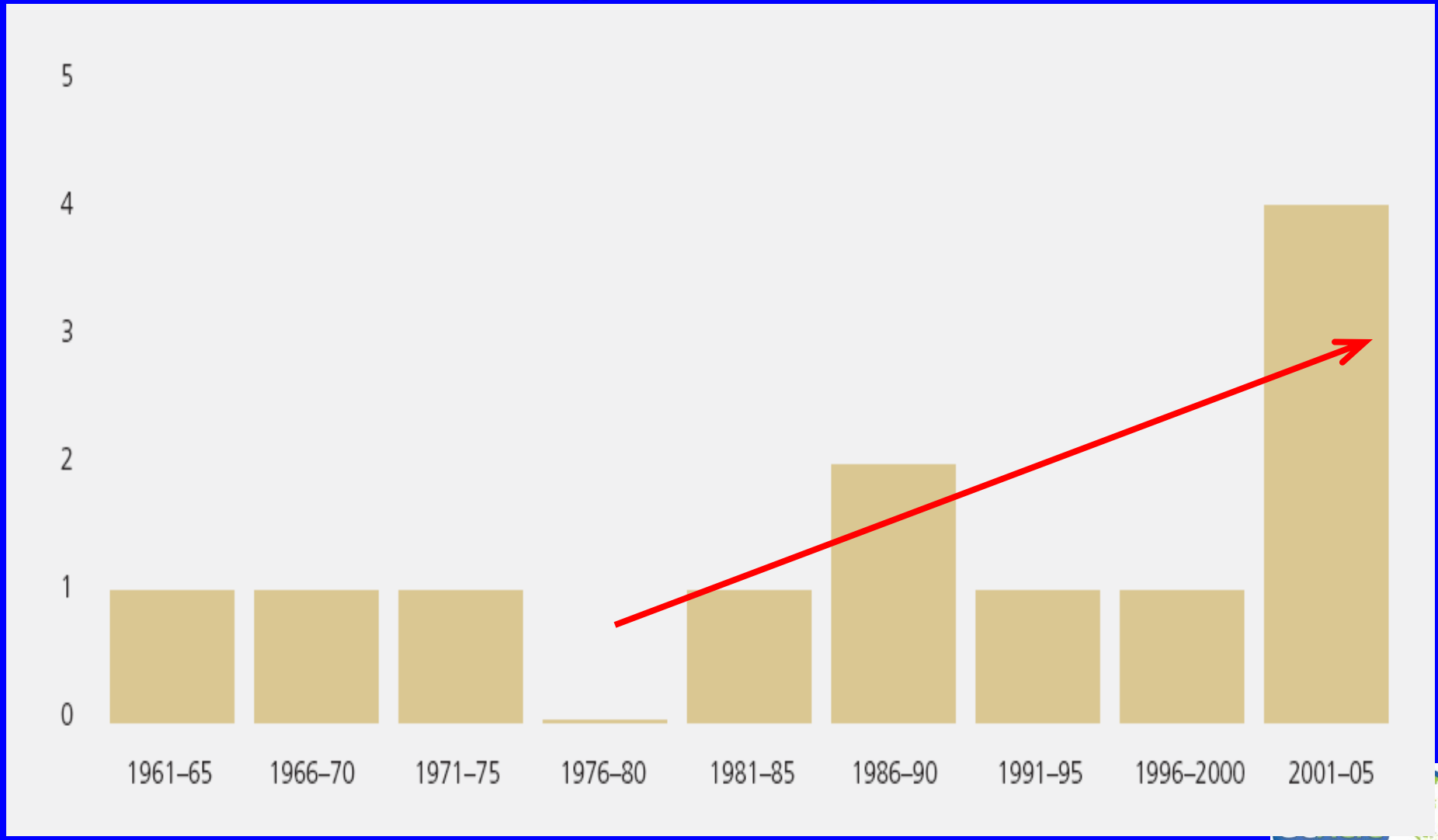
# *Actual observations and explanations – Track and Landfall Variations*



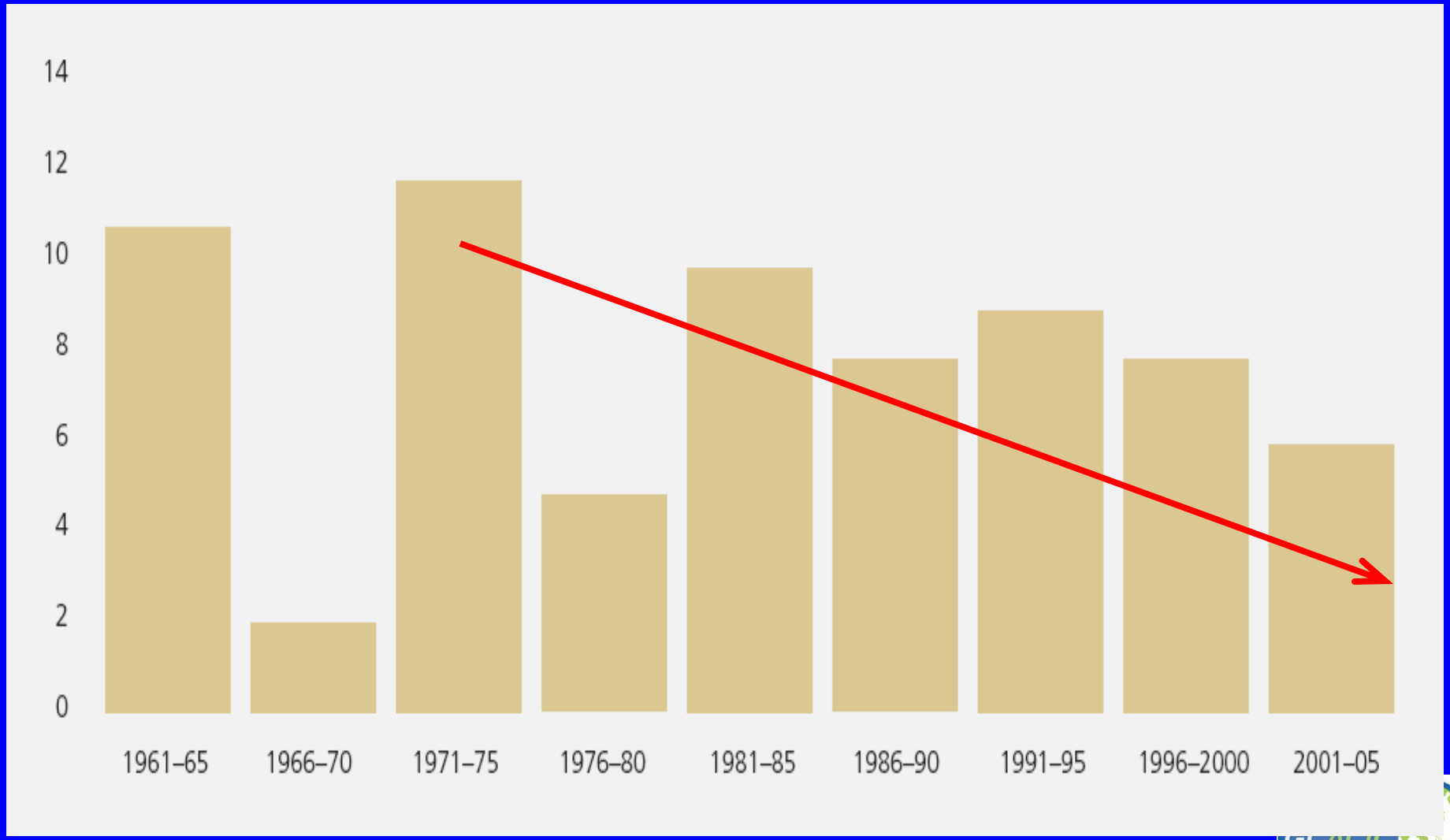
# Number of Tropical Cyclones Making Landfall in Japan and Korea Every 5-year period (1970-2004)



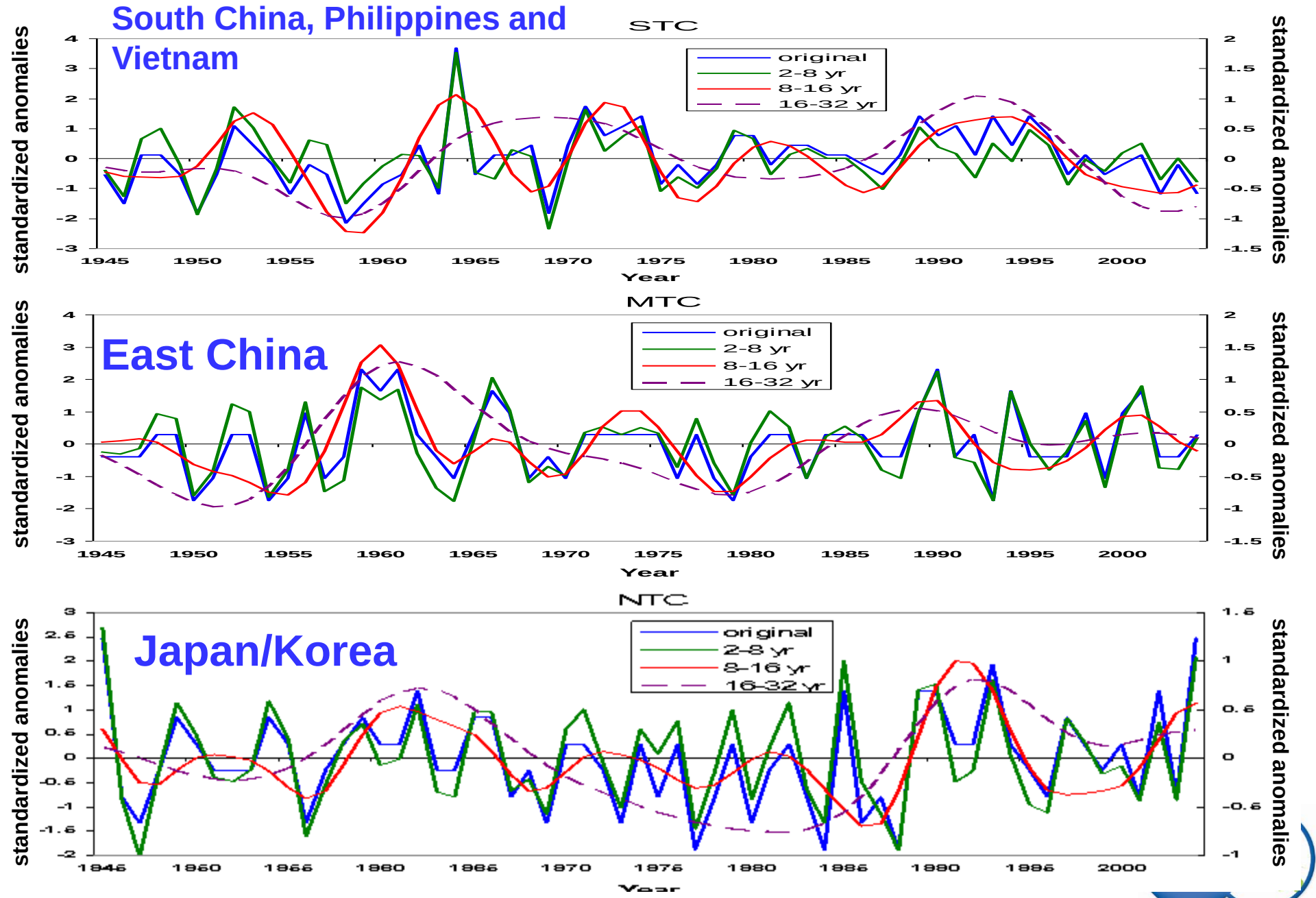
# Number of Typhoons Making Landfall in Zhejiang Province of China (East China) Every 5-year period (1960-2005)



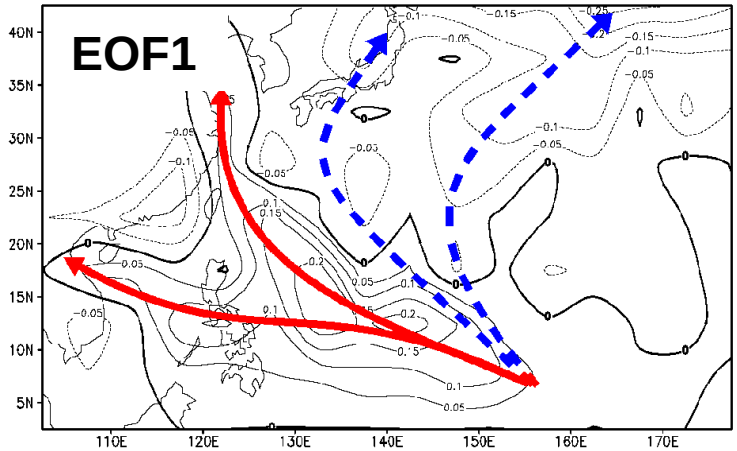
# Number of Typhoons Making Landfall in Guangdong/Hainan (South China) Every 5-year period (1960-2005)

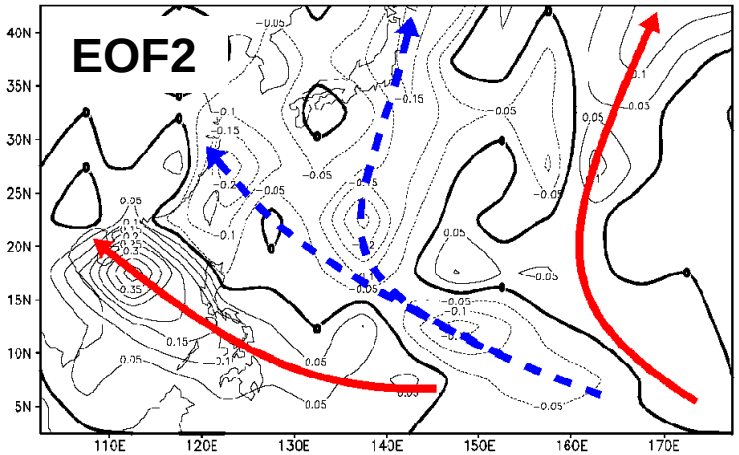


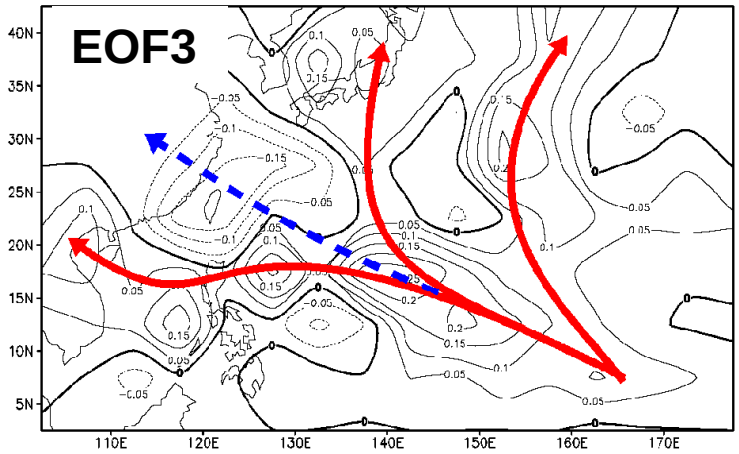
# Variations of Landfall in Each Area at Various Oscillation Periods



# EOFs 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.

# Part II


SRC:GUAMGSRS SAT:GMS_VS PRO:SAT REG:b_typhoon CLRMAP:UNDEFINED 97_09_09
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# Background

- MPI = f(SST, outflow temperature, net tropospheric CAPE)
- 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*

# Objective

**Identify the extent to which the frequency of occurrence of intense TCs is controlled by thermodynamic (versus dynamic) factors by examining the relationship between MPI and such a frequency**

# Data

## *Track data*

**1. Operational datasets**

- **HURDAT for Atlantic and eastern North Pacific TCs**
- **JTWC for the rest**

**2. Homogeneous dataset from Kossin et al. (2007)**

## *Data for calculating MPI*

**NCEP reanalyses**

# 21-year running correlations with NCat45 - Atlantic

| 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 | |

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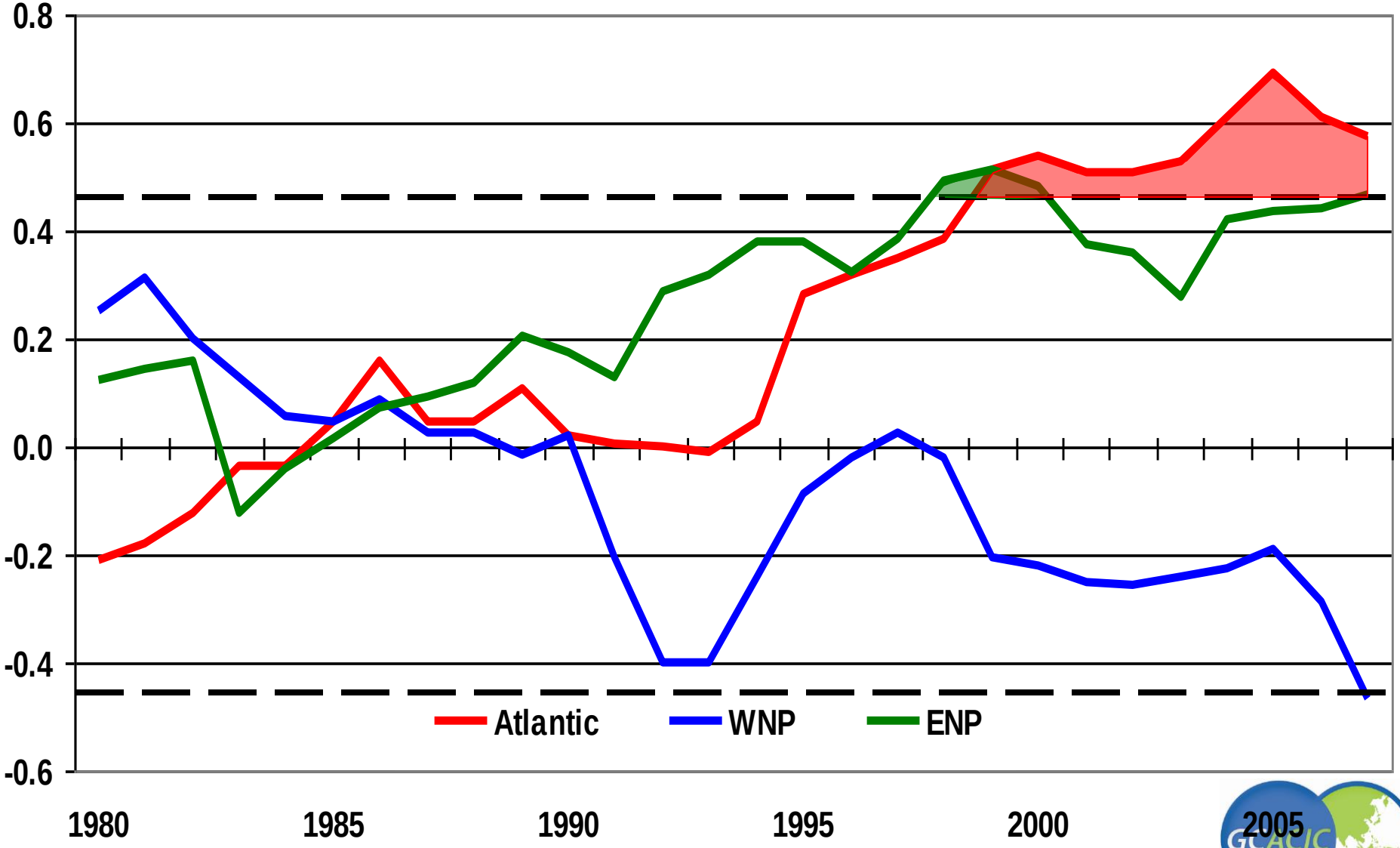
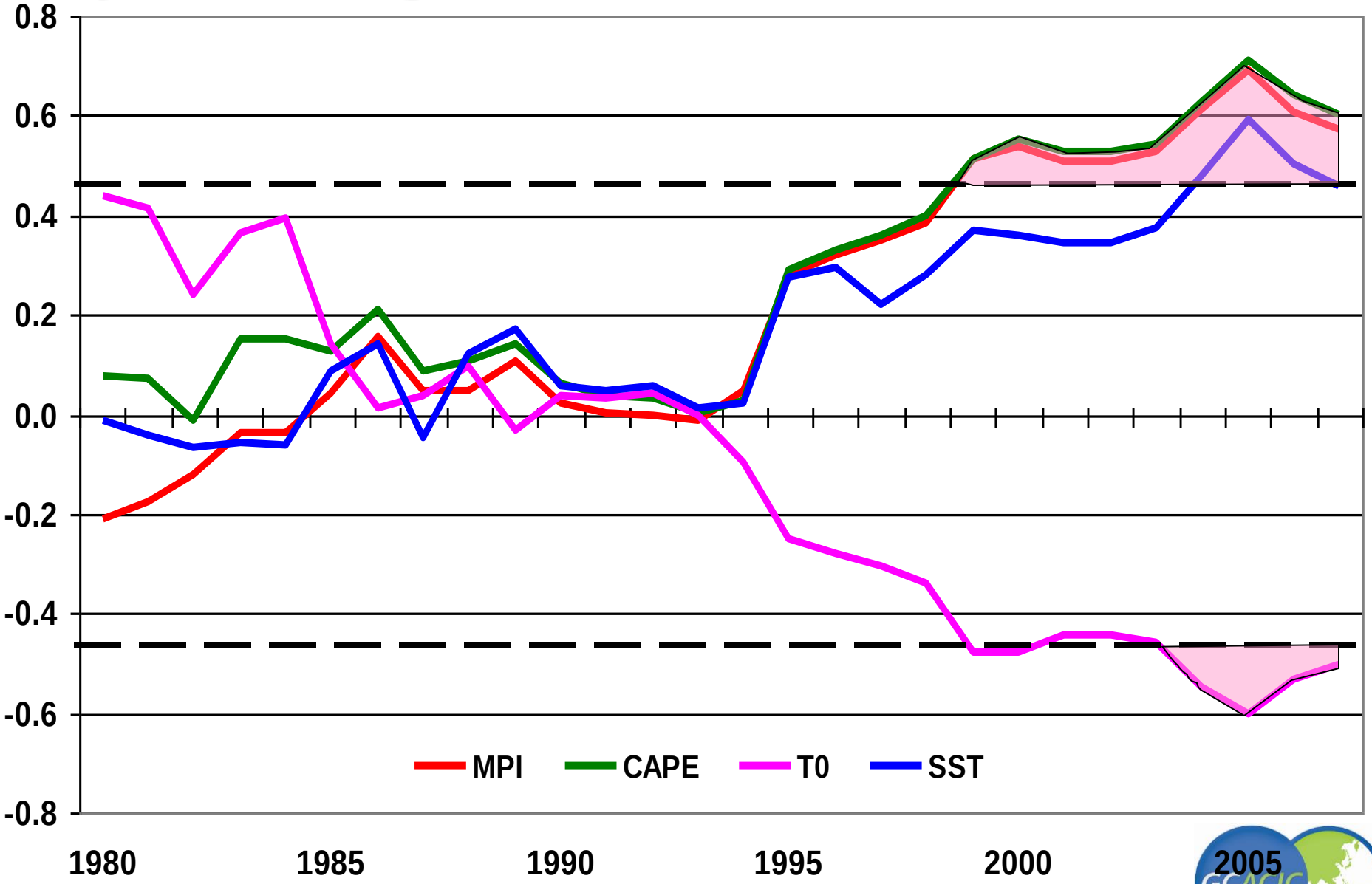
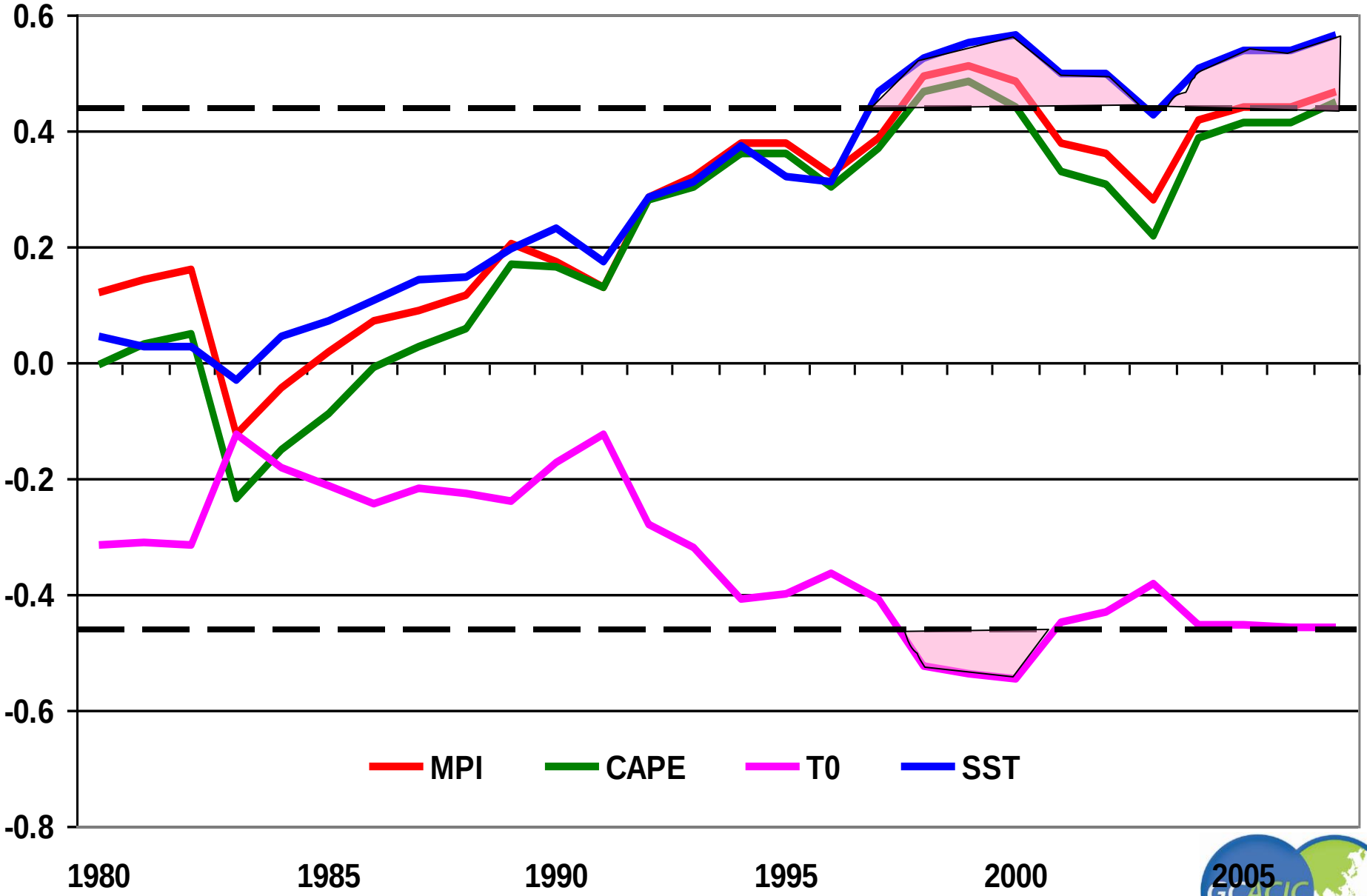
# 21-year running correlations with NCat45



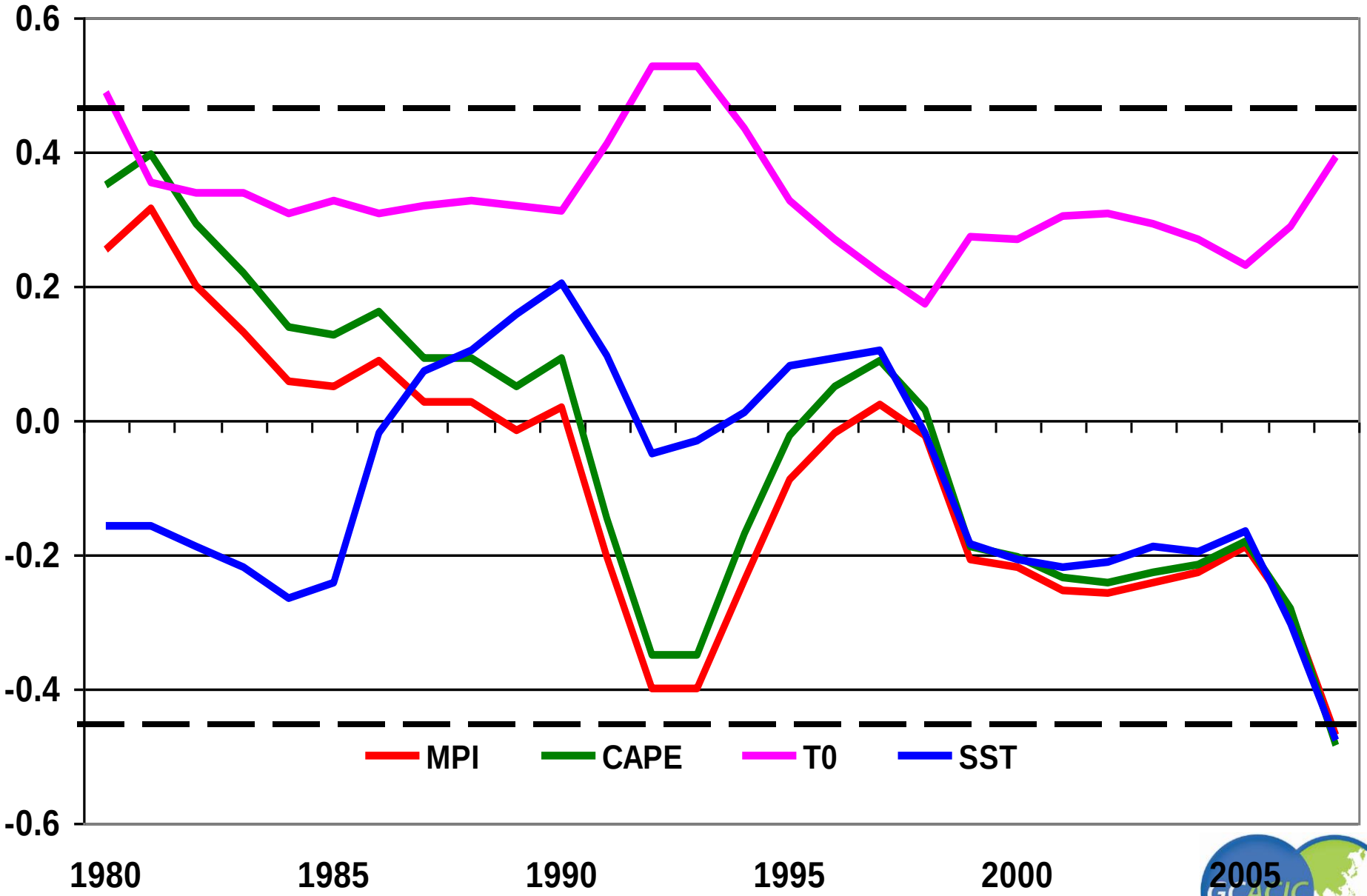
# 21-year running correlations with NCat45 - Atlantic



# 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.**