Does Global Warming Increase Typhoon Activity/Intensity?

Prediction/Simulation of Tropical Cyclone Climate Using a High-resolution Global Model

Johnny Chan

Laboratory for Atmospheric Research

Dept. of Physics & Mat. Sci.

City University of Hong Kong

Outline/Questions

Part I

- Evidence supporting the “yes” answer
- The skeptics
- What is really happening and why?
- Conclusion

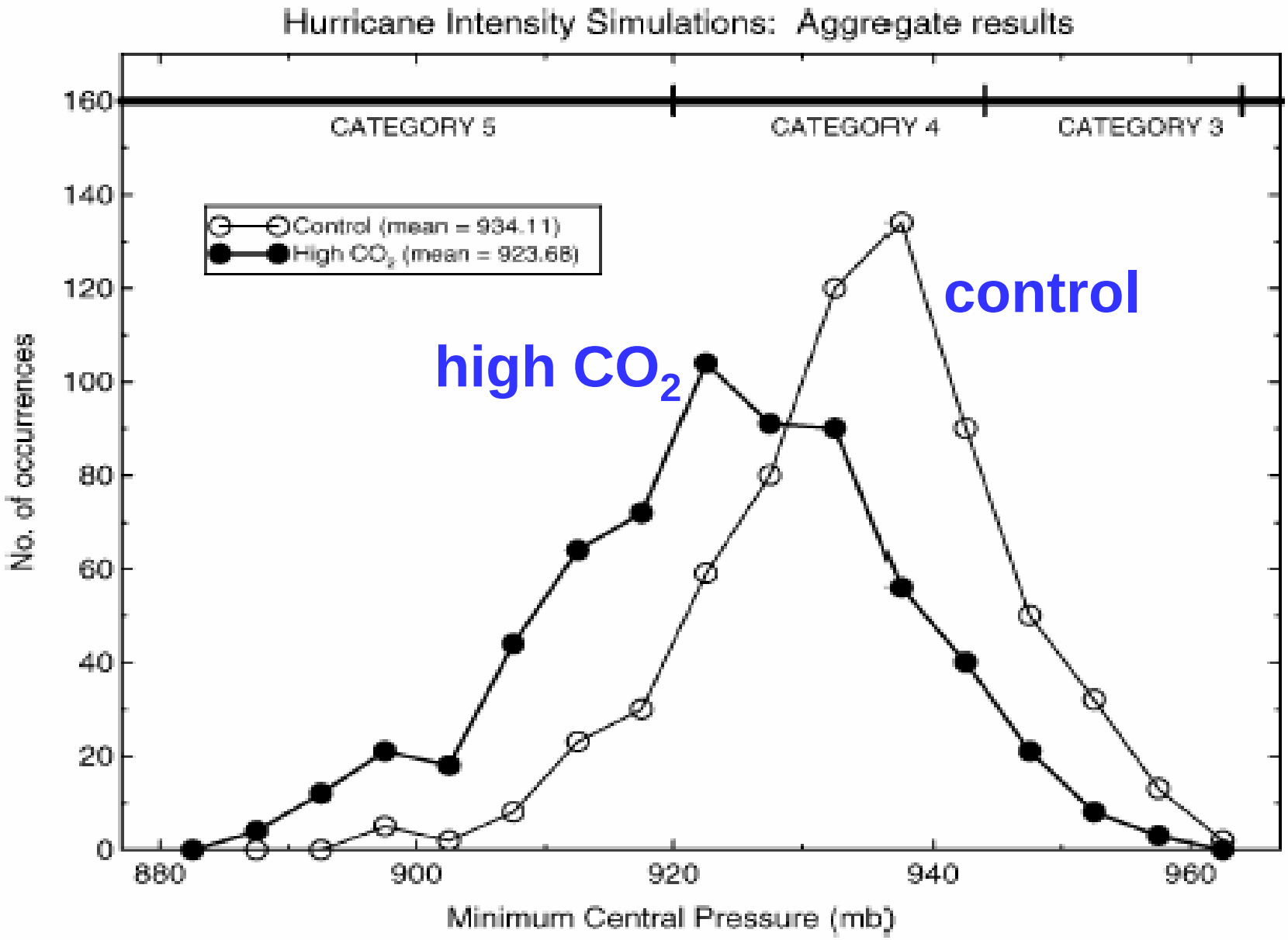
Outline/Questions

Part II *(in collaboration with Lance Leslie)*

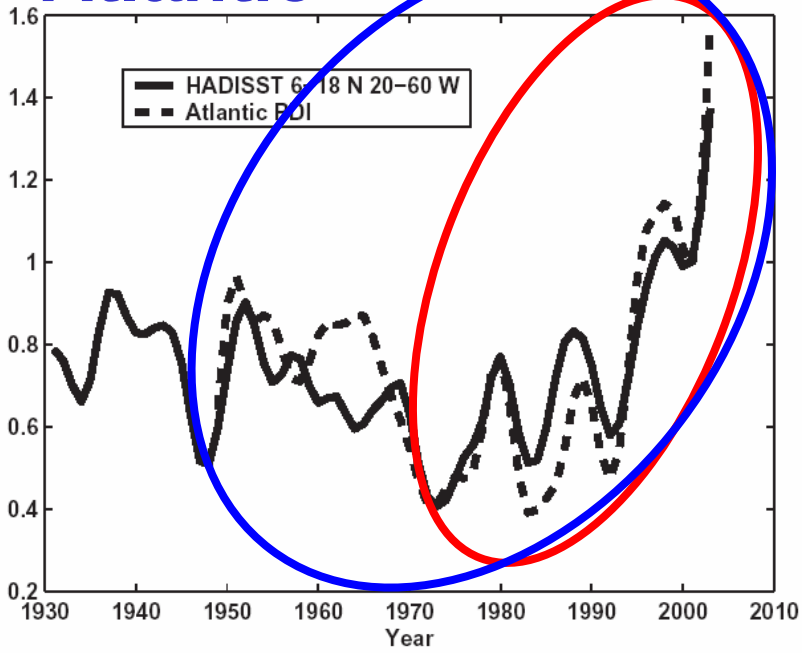
- **The University of Oklahoma model**
- **The simulated TC structure**
- **The simulated TC frequency**
- **How can we use this model to study TC climate?**


Part I
SRC:GUAMGSRS SAT:GMS_VS PRO:SAT REG:b_typhoon CLRMAP:UNDEFINED 97_09_09 20:34
05x05

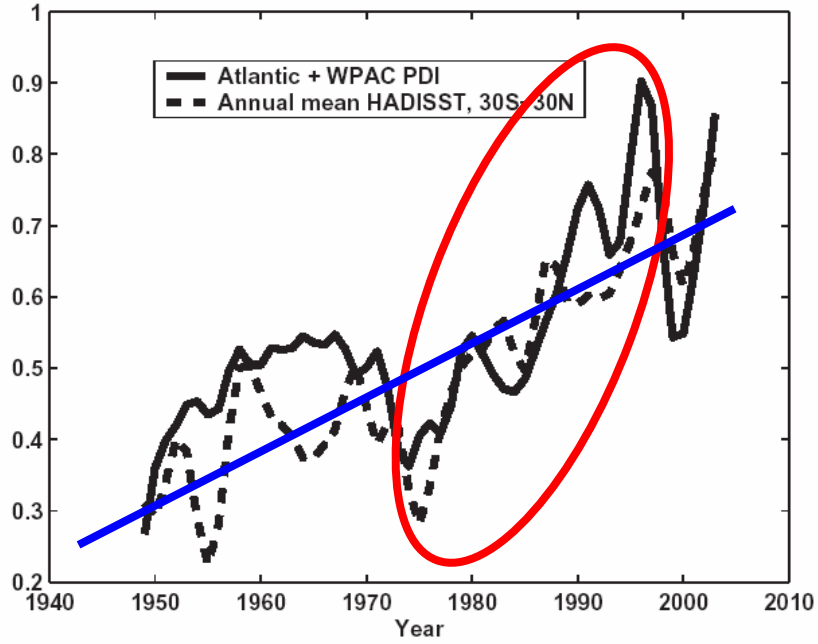
Knutson and Tuleya's (2004) *J Climate* paper



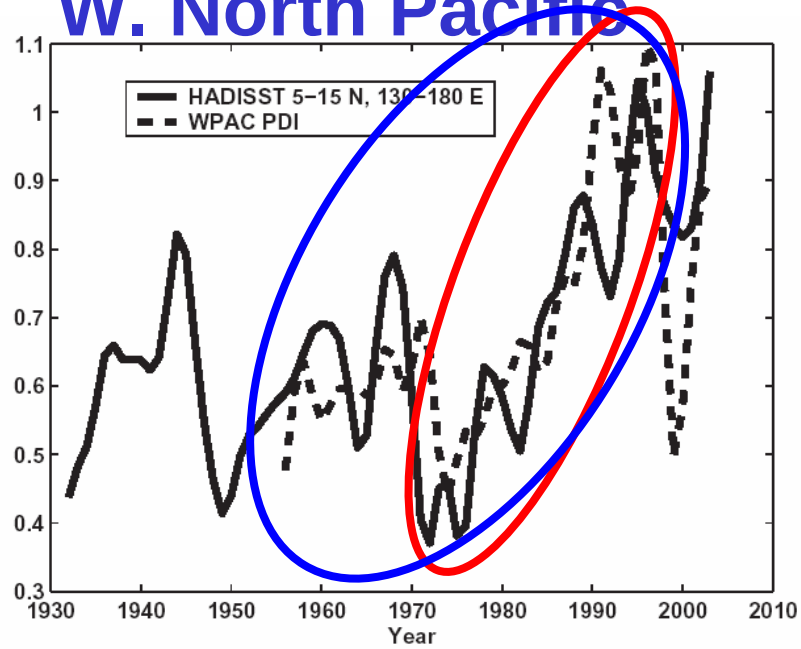
Atlantic



Atlantic + W N Pacific



W. North Pacific

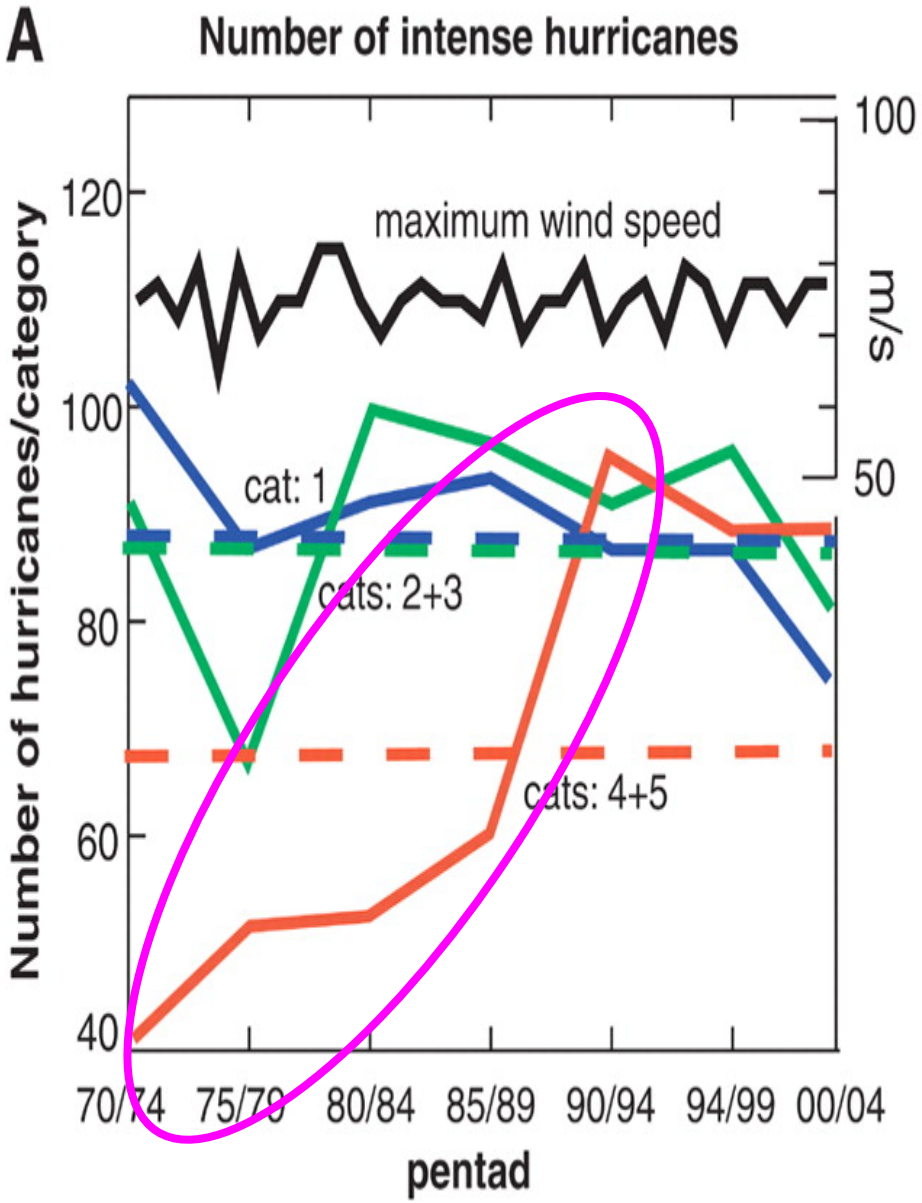


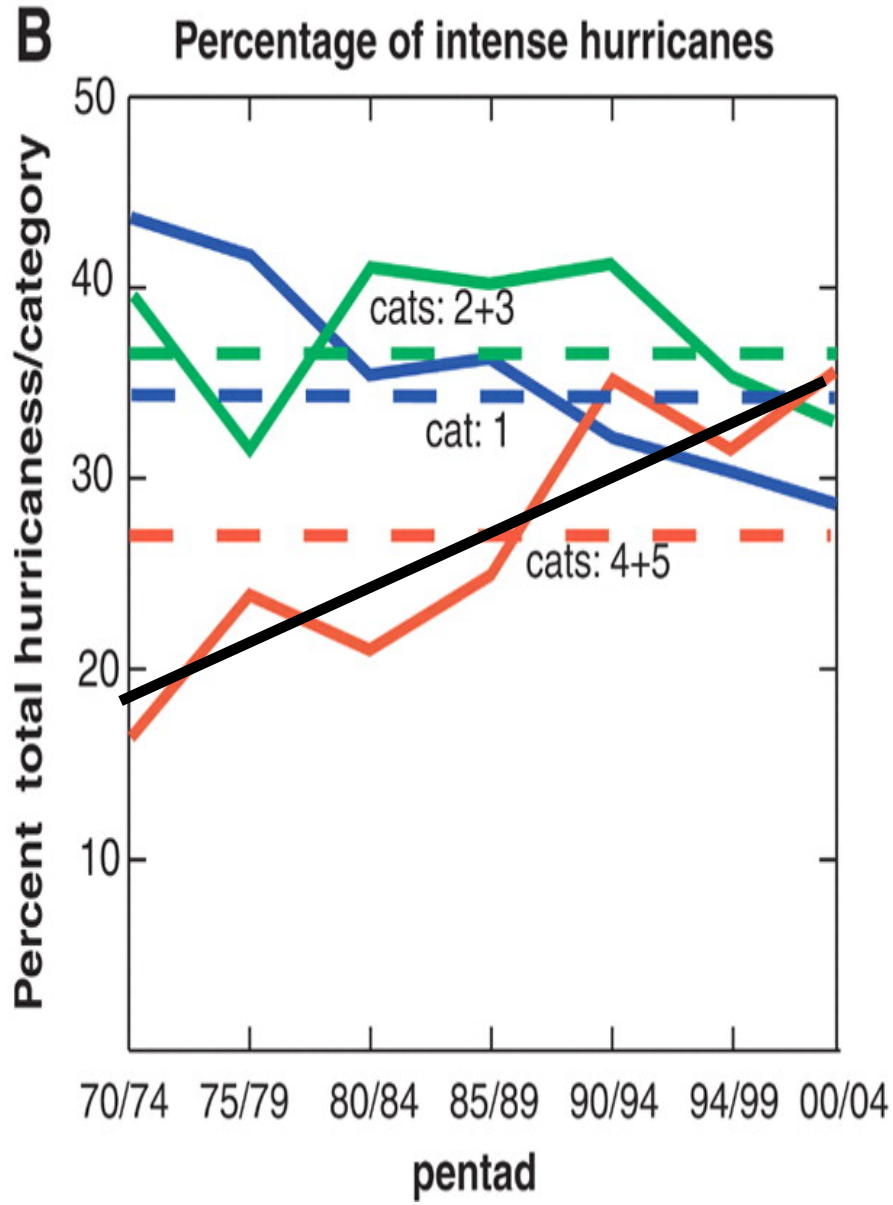
Emanuel's (2005) *Nature* paper

PDI: (max wind)^3

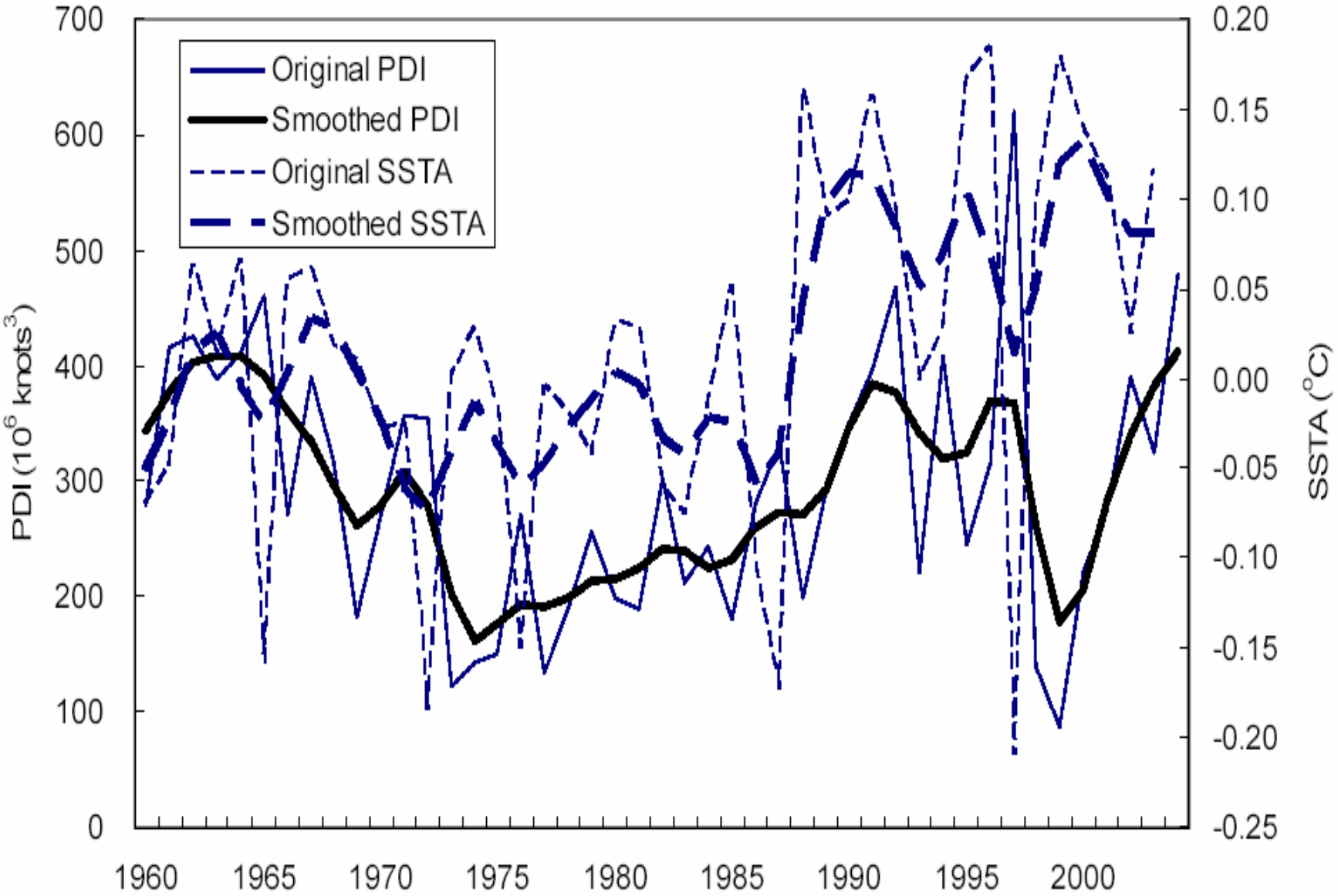
SST: sea-surface temperature

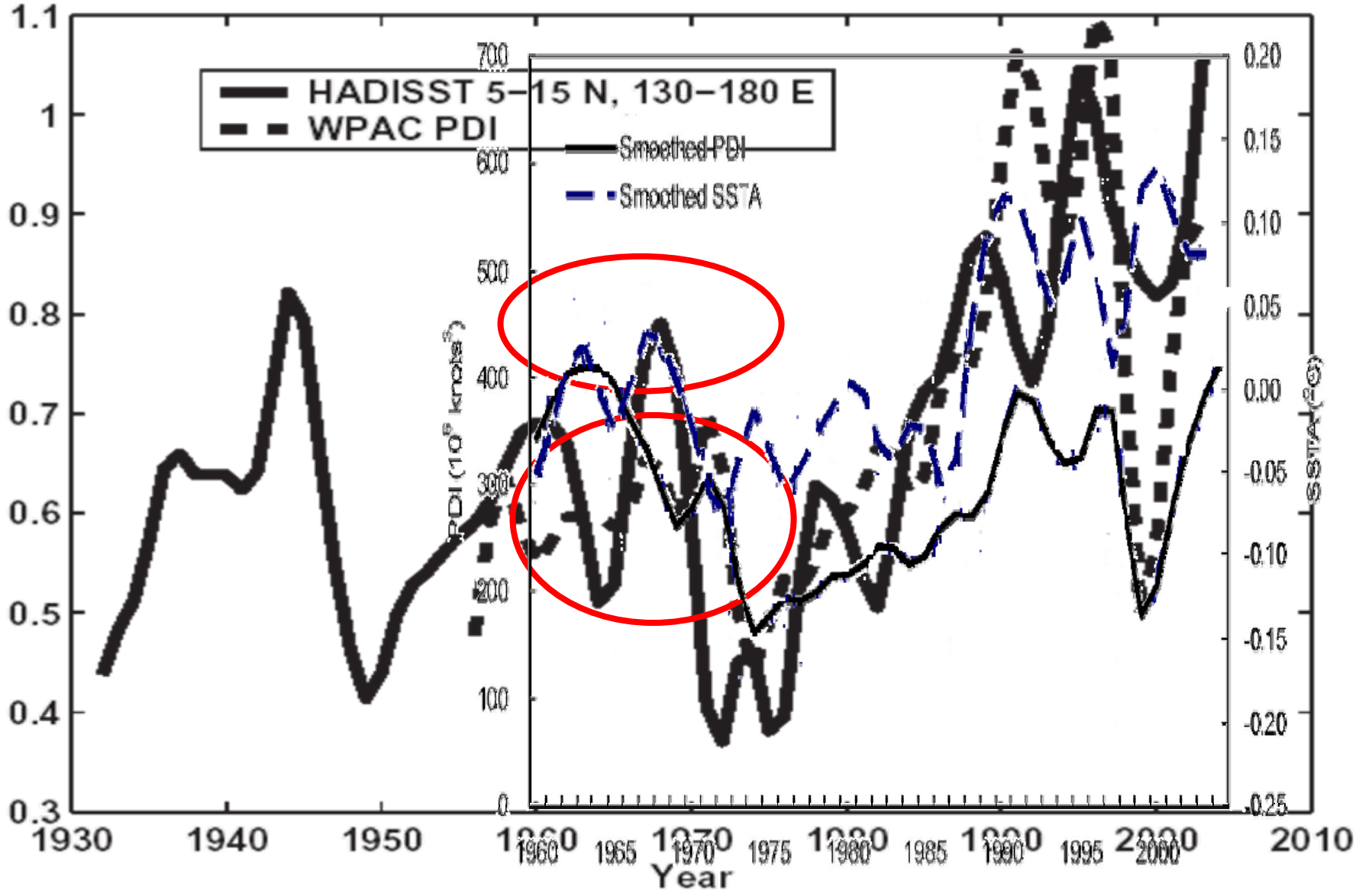
Webster et al.'s (2005) *Science* paper





Actual Data for W North Pacific

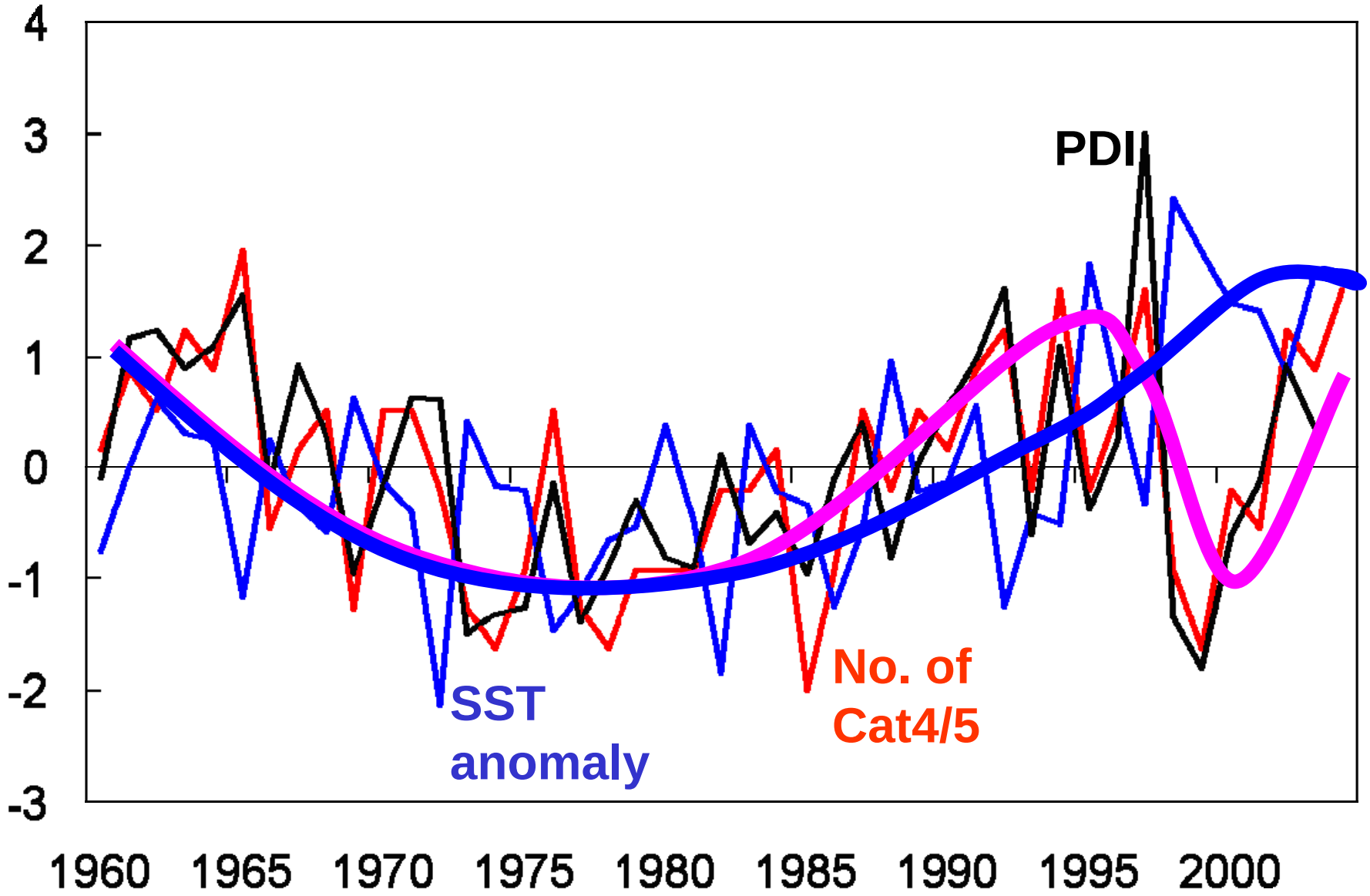



HADISST 5–15 N, 130–180 E
WPAC PDI
Smoothed PDI
Smoothed SSTA
PDI (10^6 knots^2)
SSTA (°C)
Year
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
700
600
500
400
300
200
100
0
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
-0.20
-0.25
1930
1940
1950
1960
1965
1970
1975
1980
1985
1990
1995
2000
2010

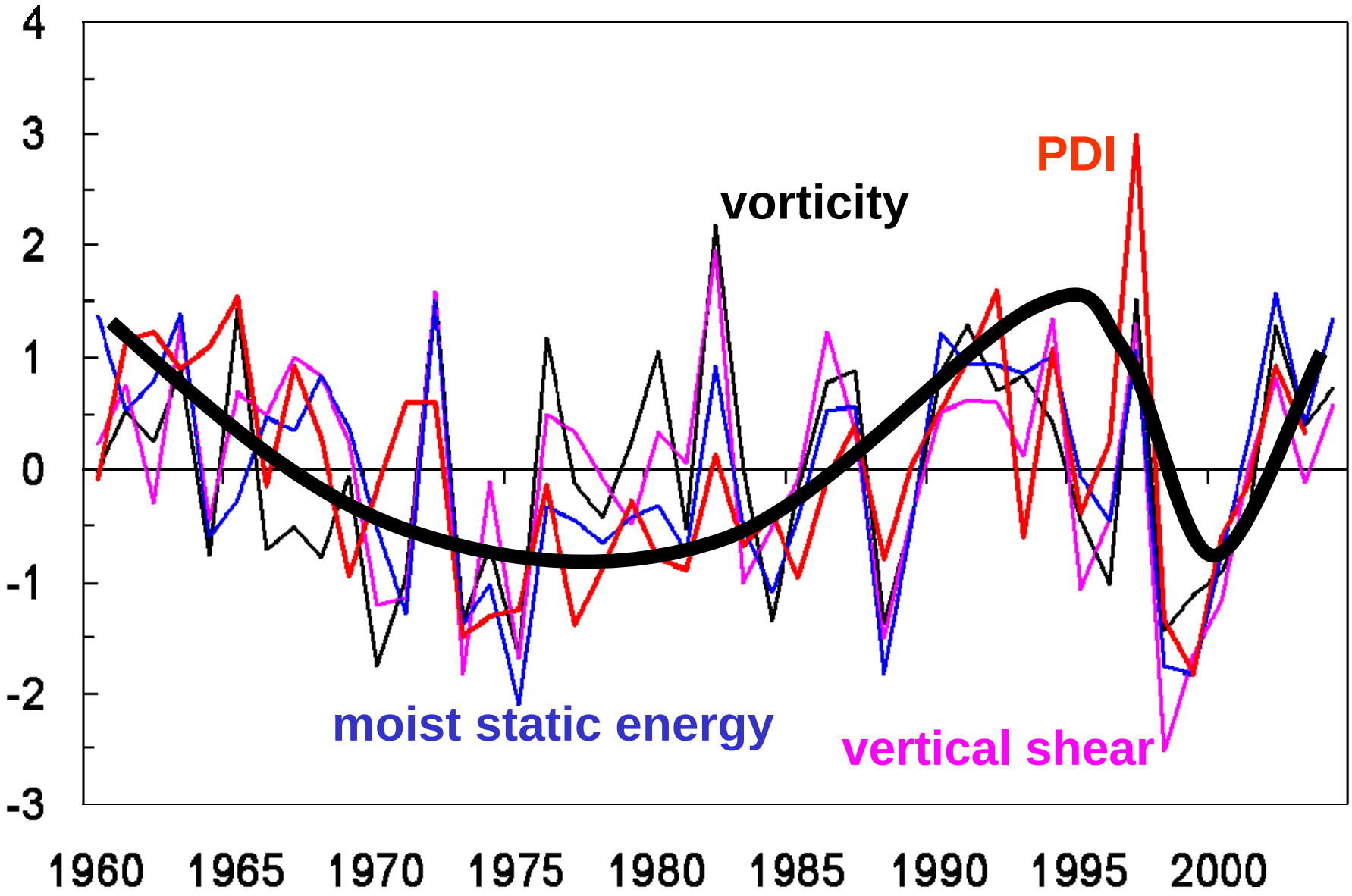
No. of Category 4 and 5 Typhoons

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

Actual Data for W North Pacific



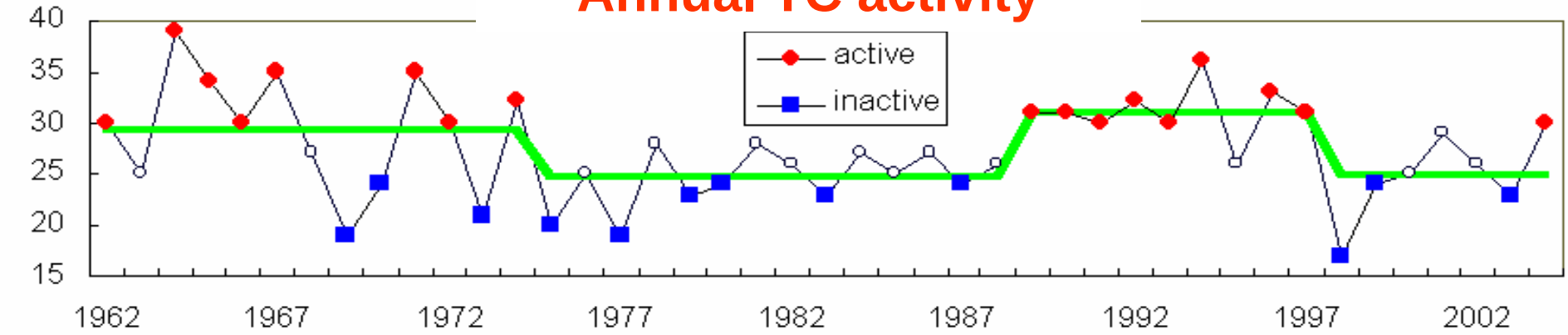
Actual Data for W North Pacific



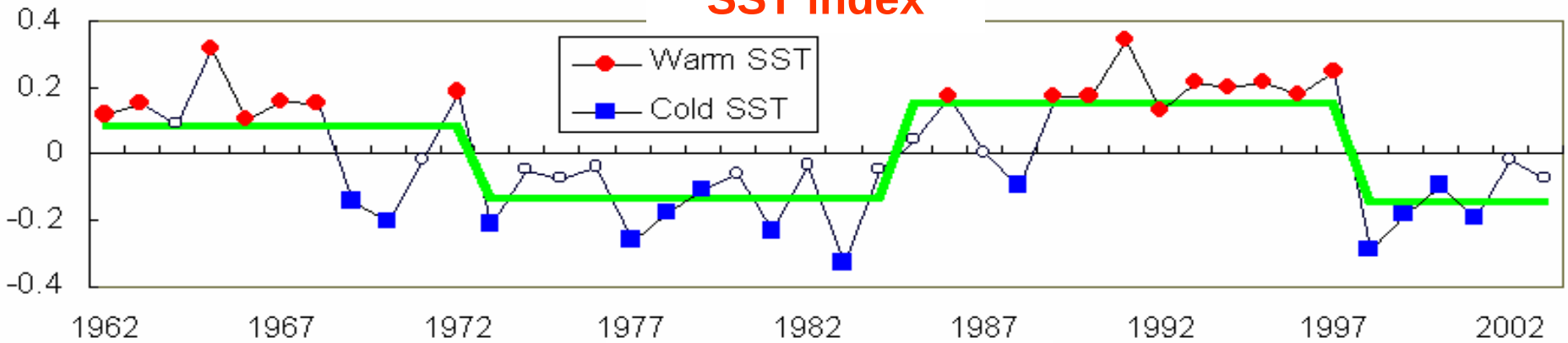
Conclusion 1

Variations of TC activity/intensity have large amplitudes in the interannual and interdecadal time scales

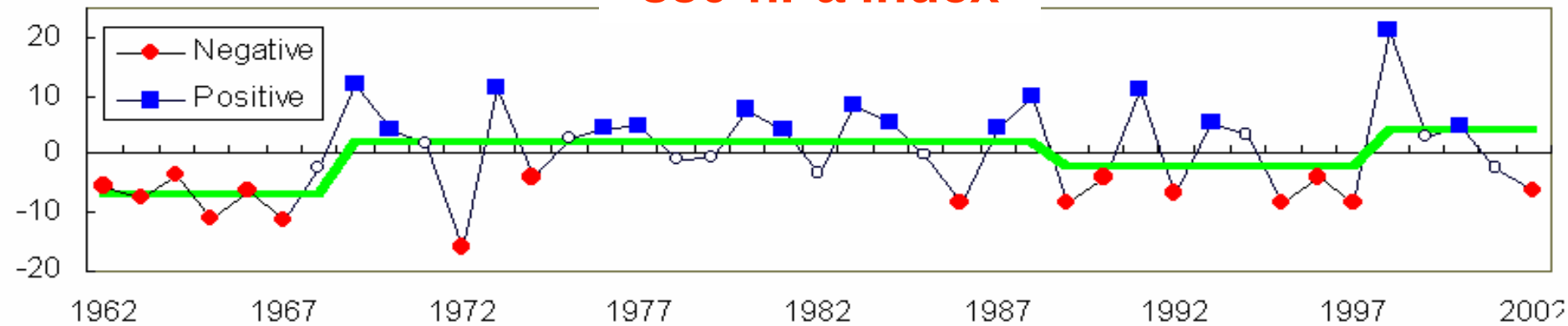
Annual TC activity



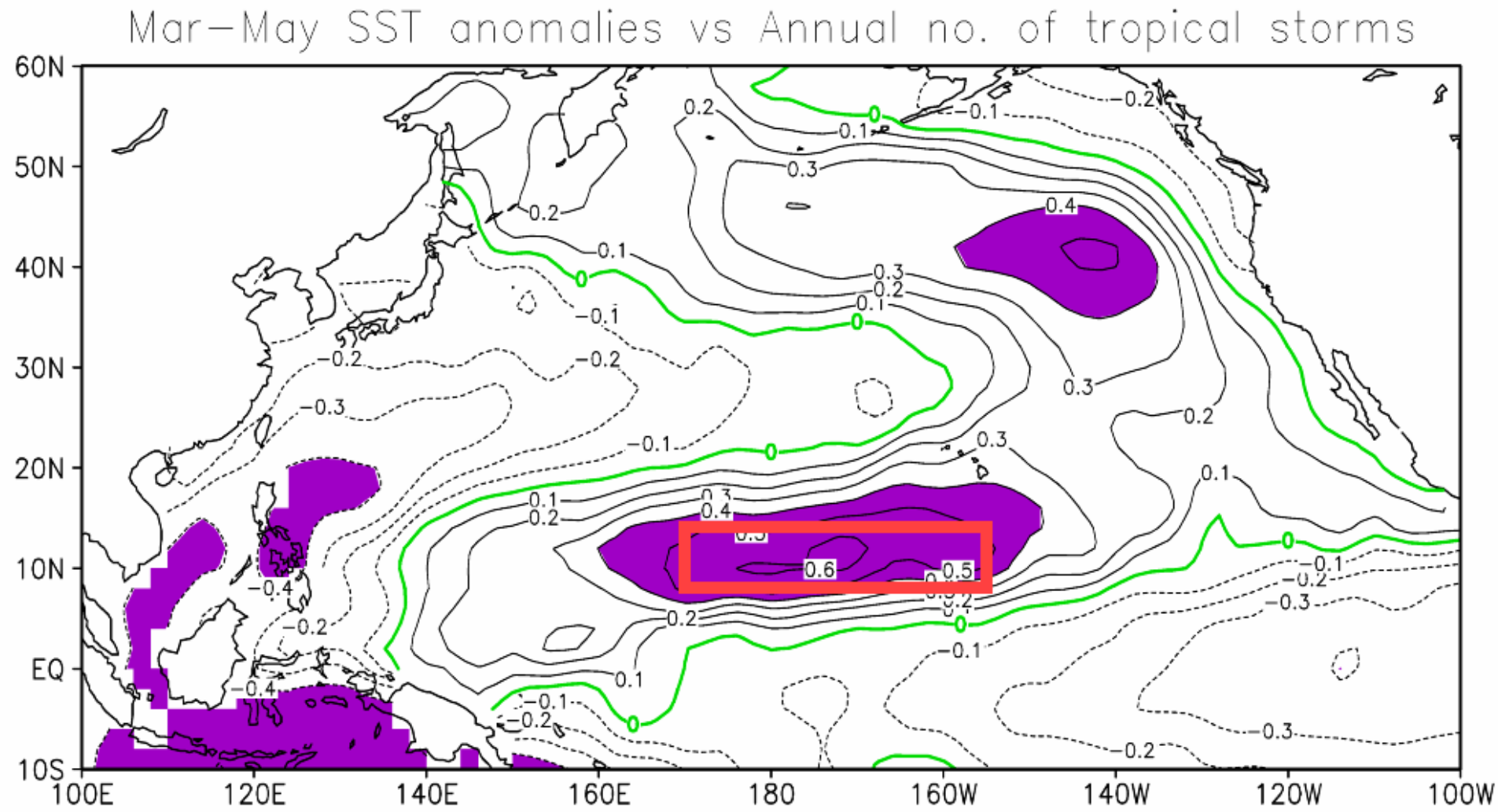
SST index



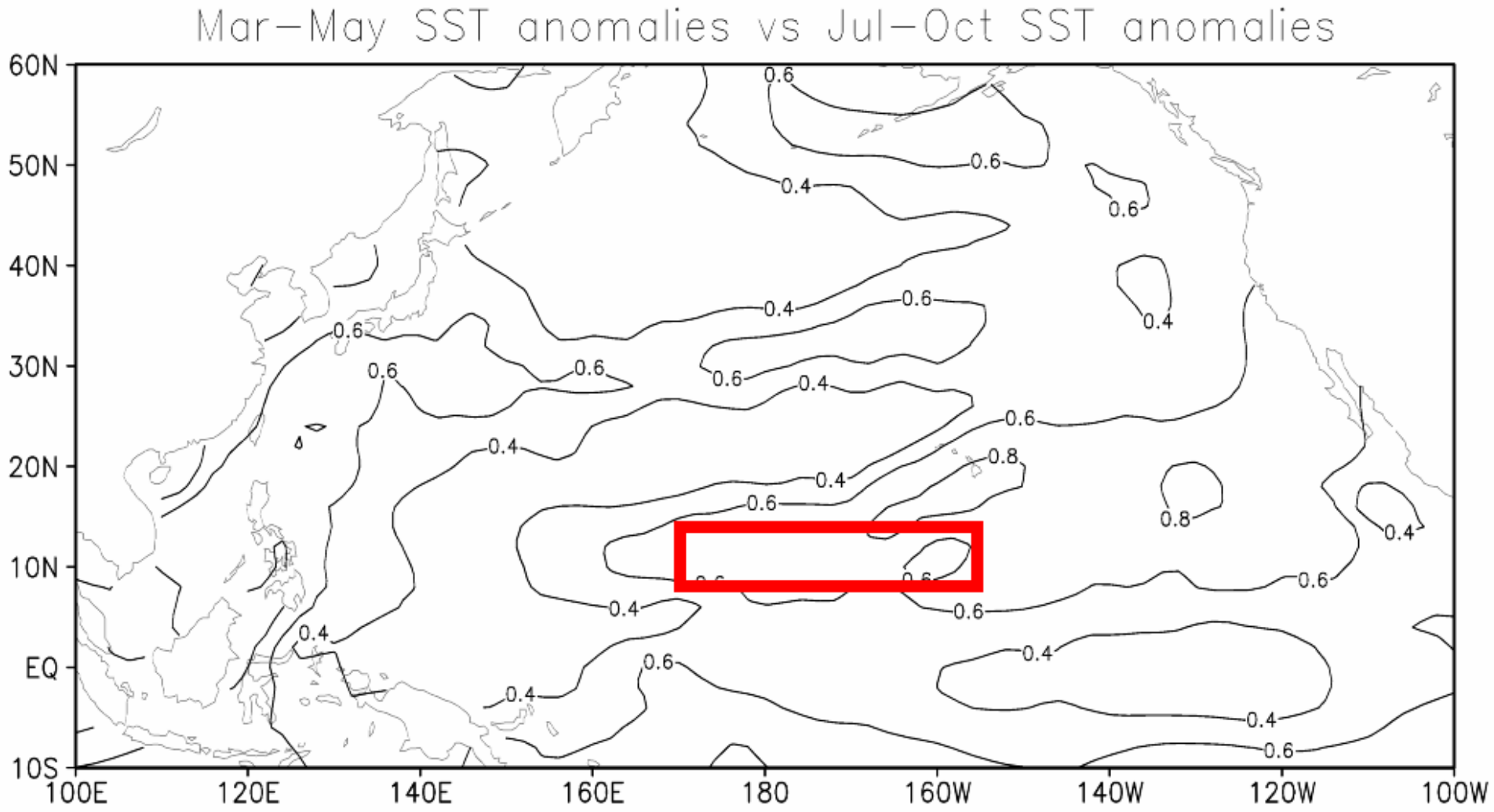
850-hPa index



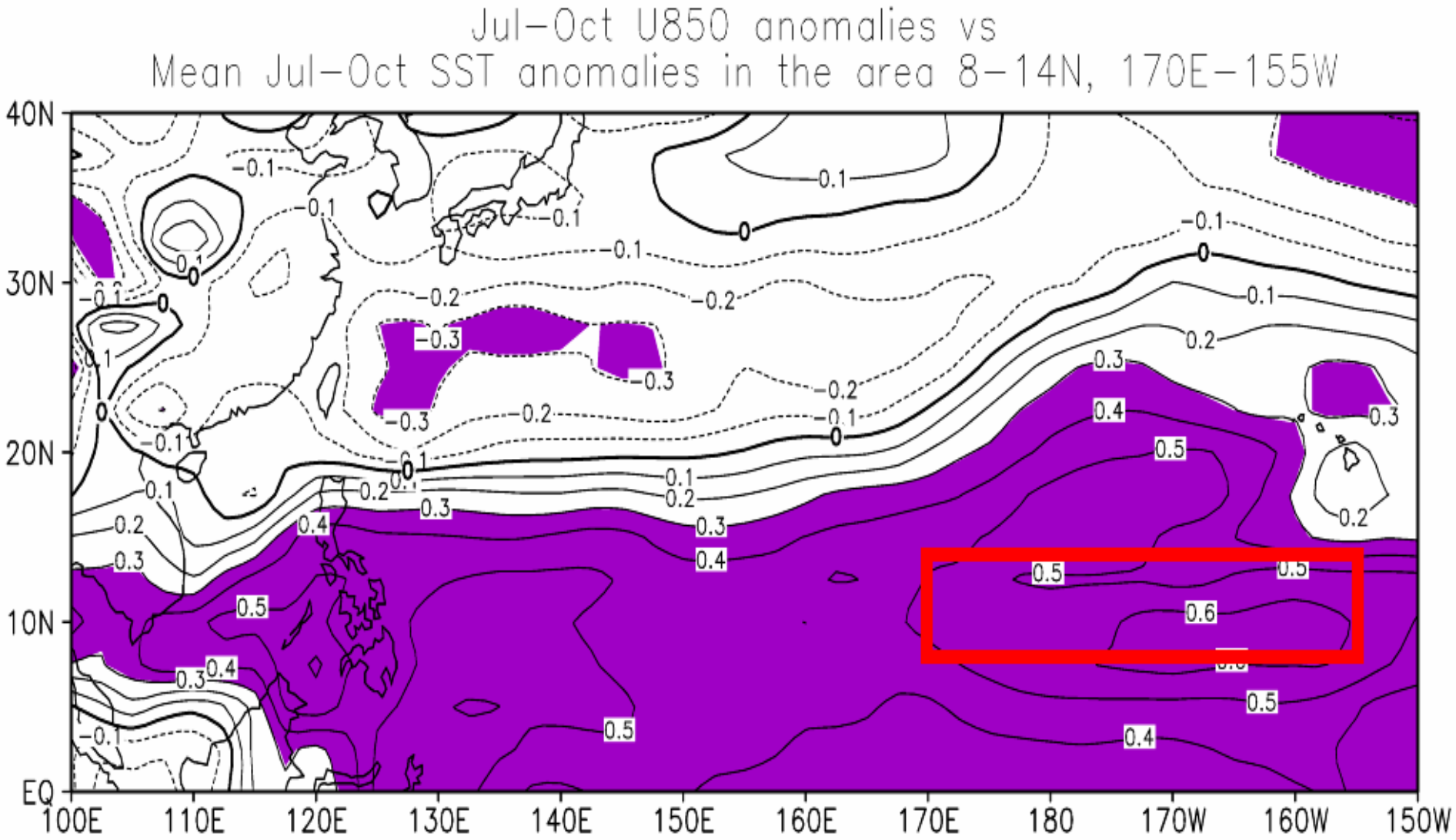
Correlation between MAM SST and Annual TC Activity

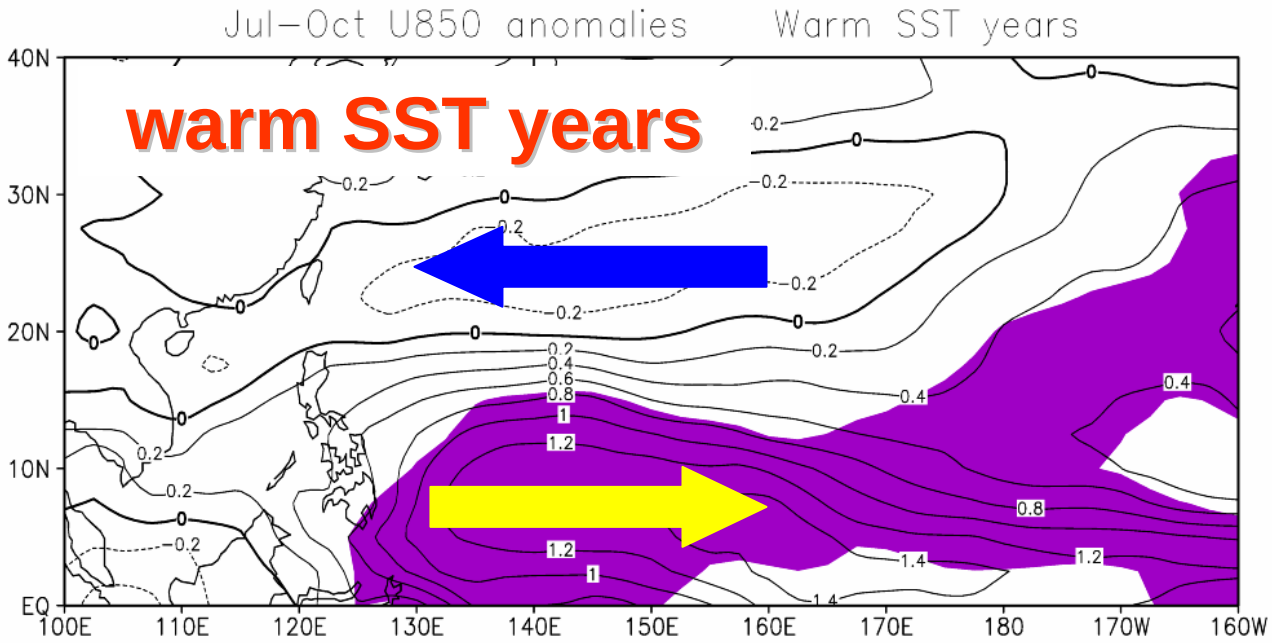


Correlation between MAM and JASO SST



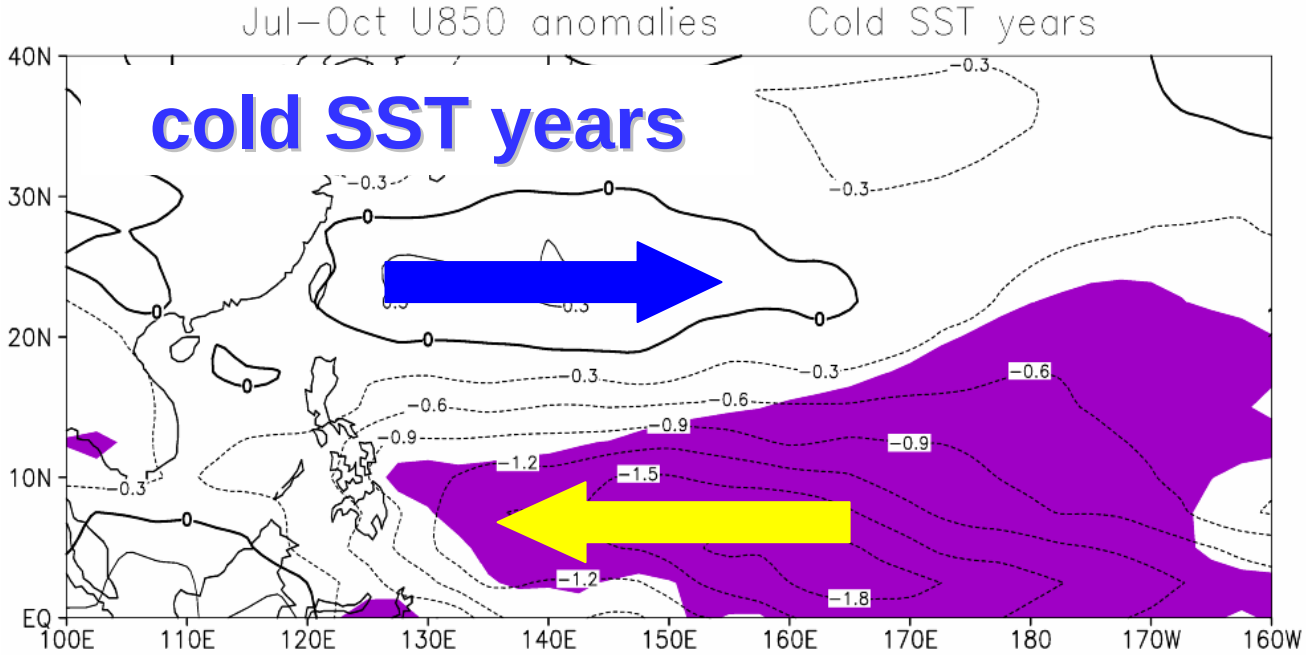
Correlation between 850-hPa winds and SST (JASO)



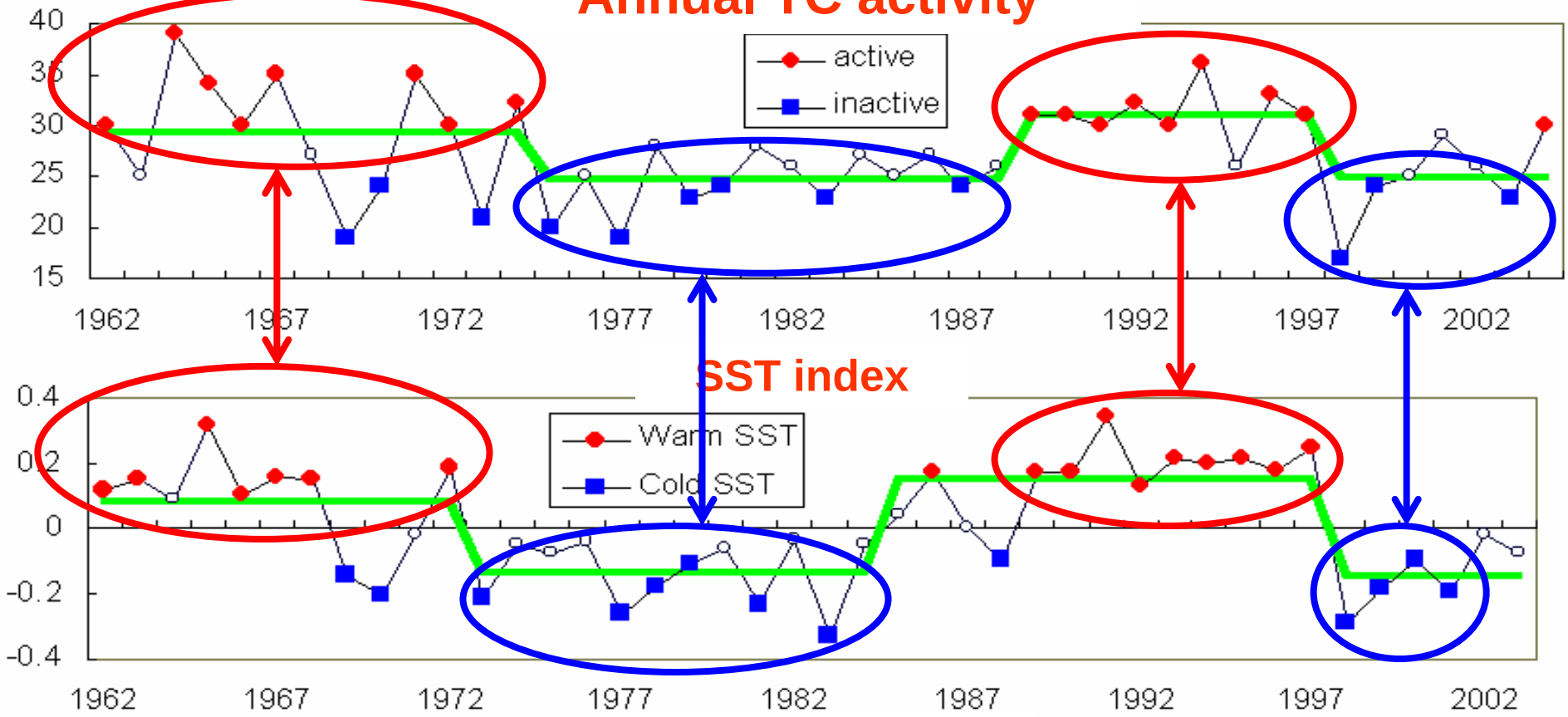


JASO

850-hPa winds

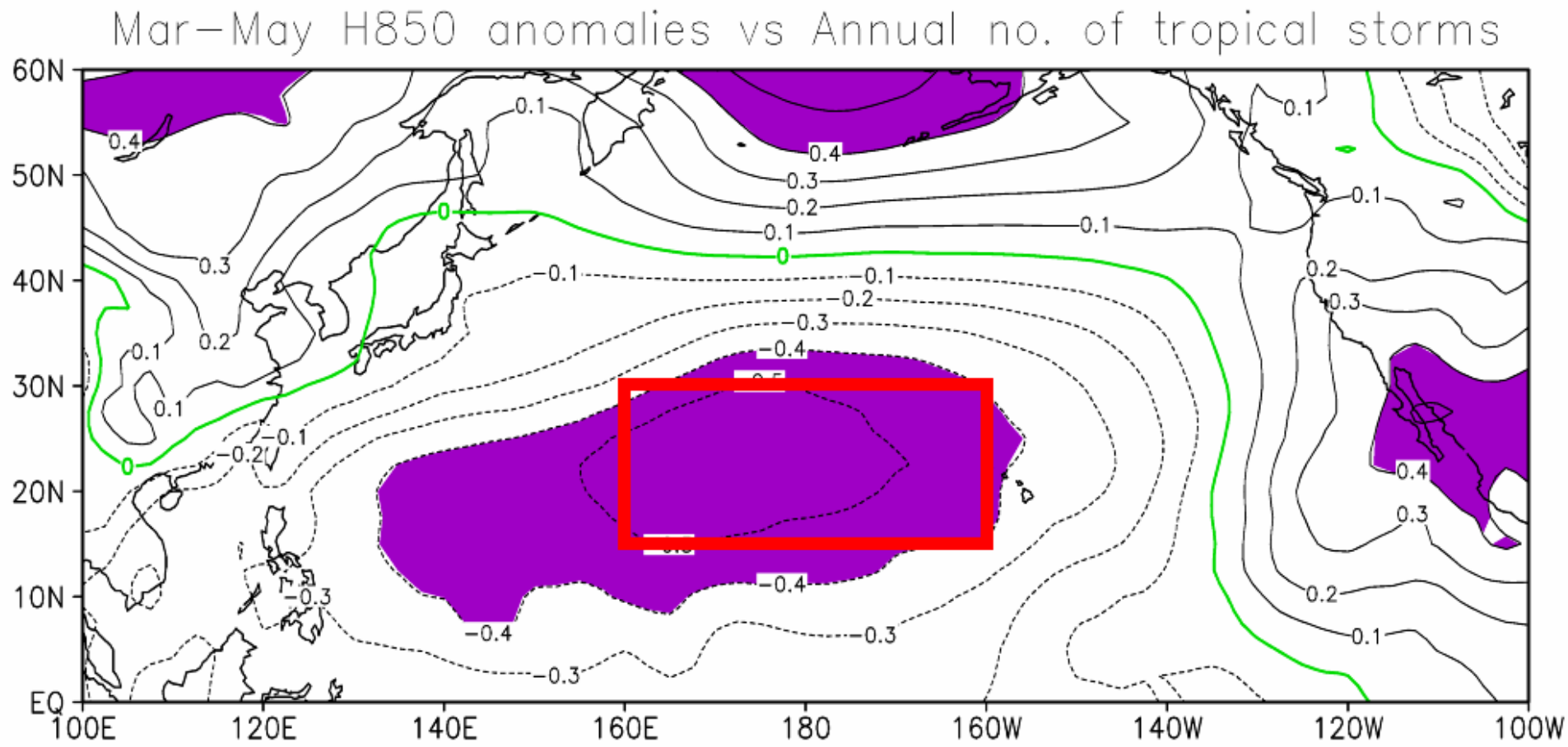


Annual TC activity

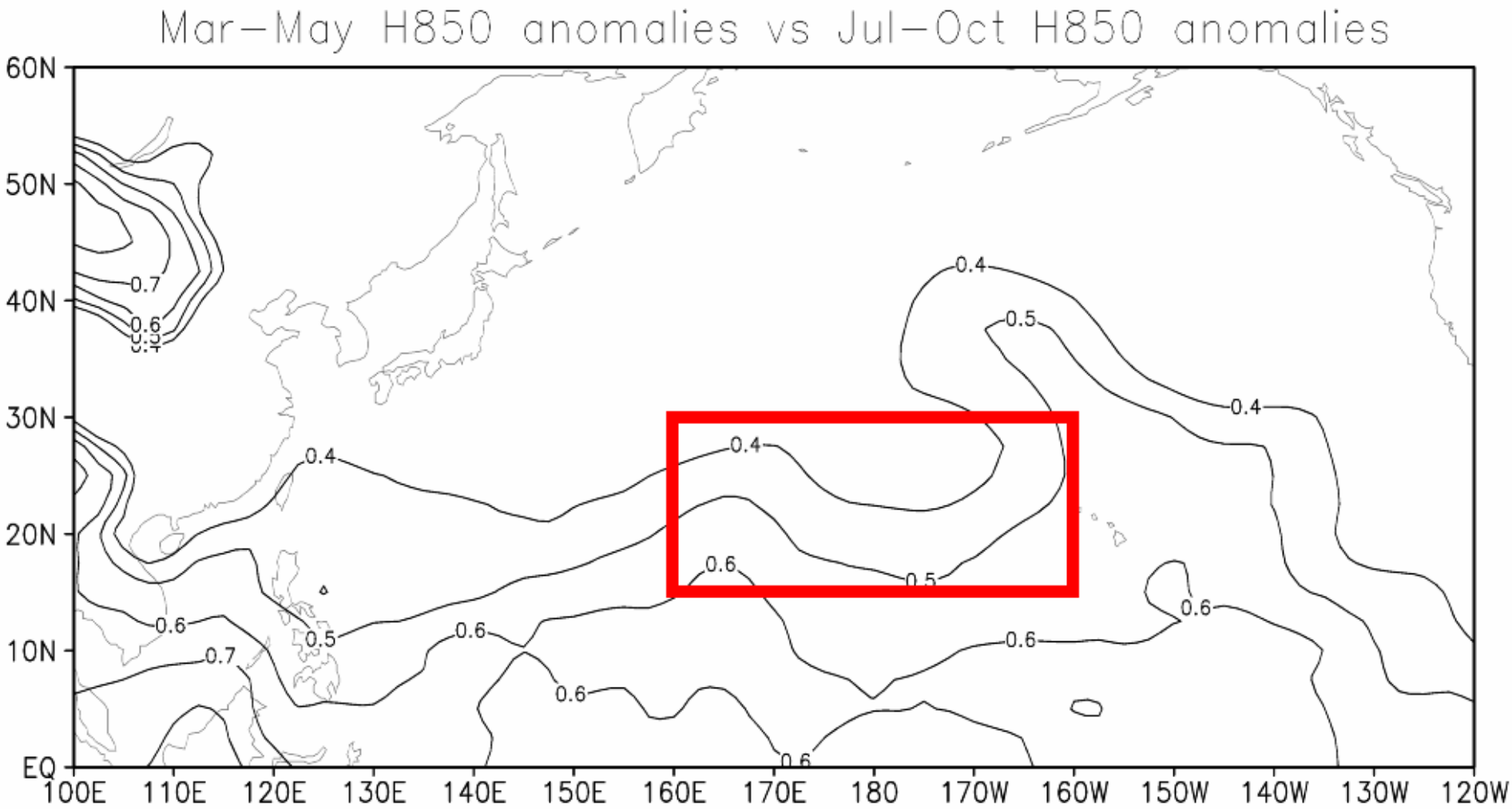


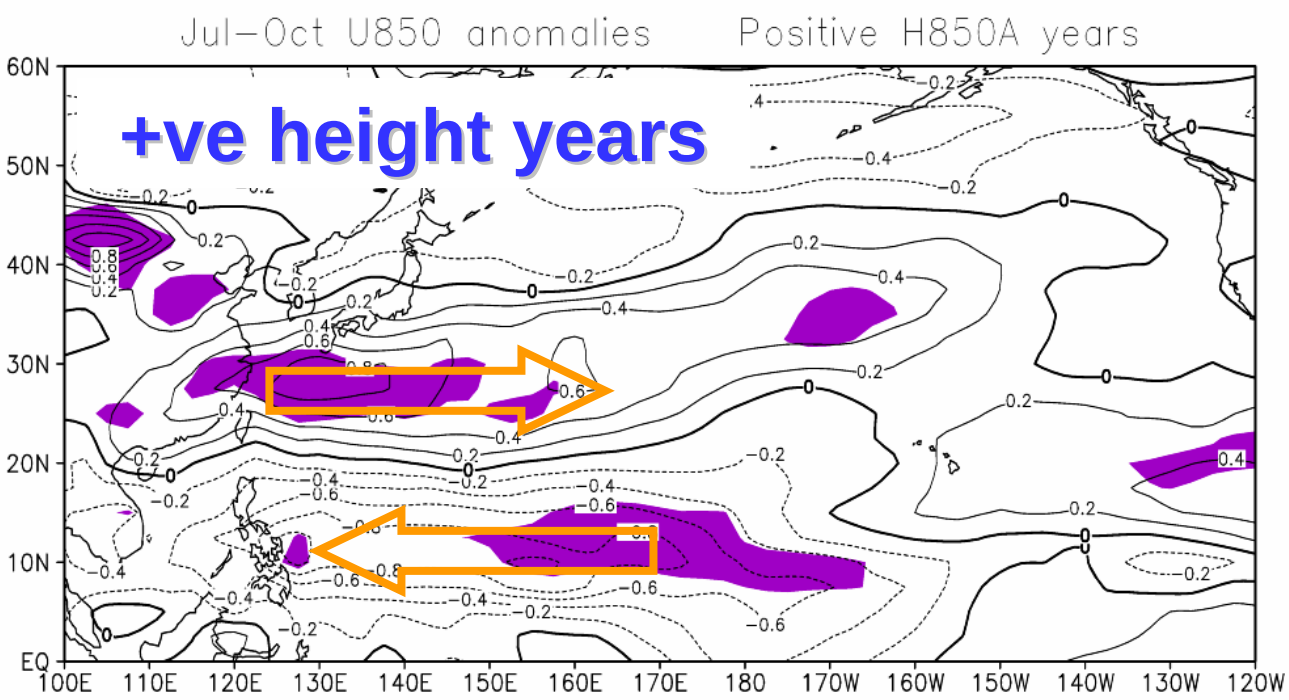
SST index

Correlation between MAM 850-hPa geopotential heights and Annual TC Activity



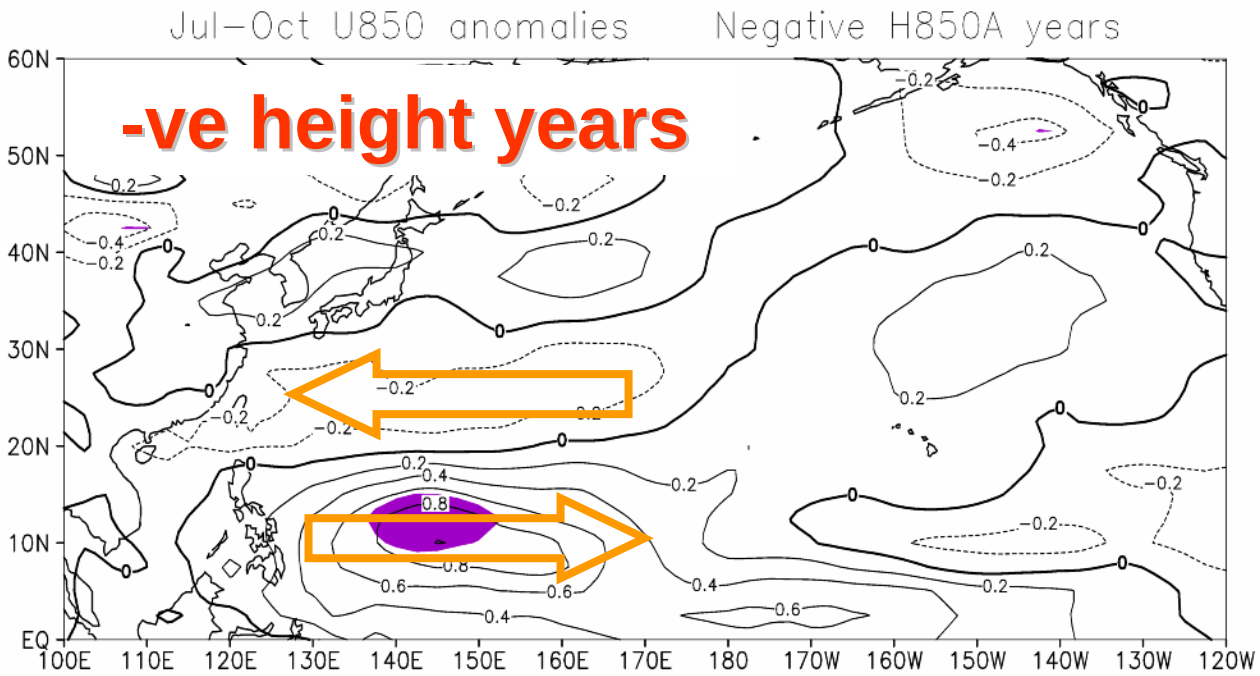
Correlation between MAM and JASO 850-hPa geopotential heights



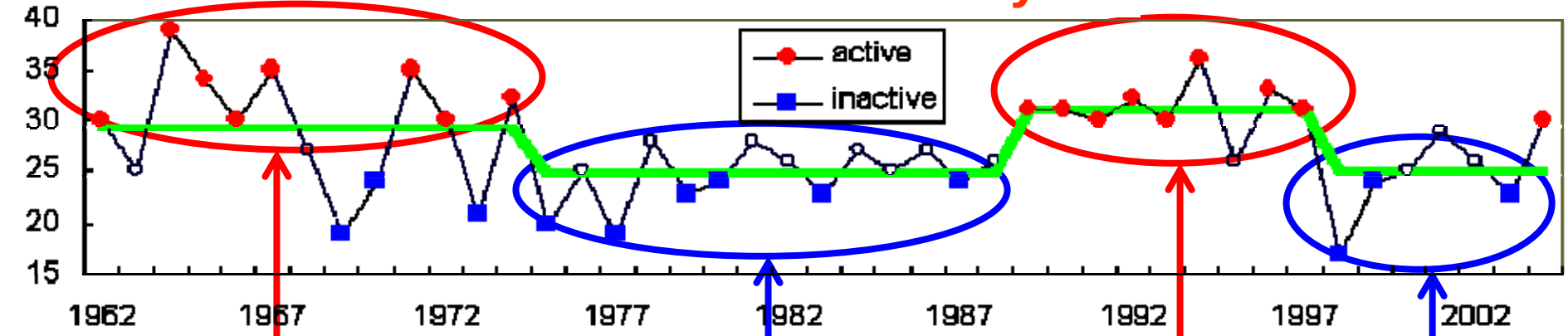


JASO

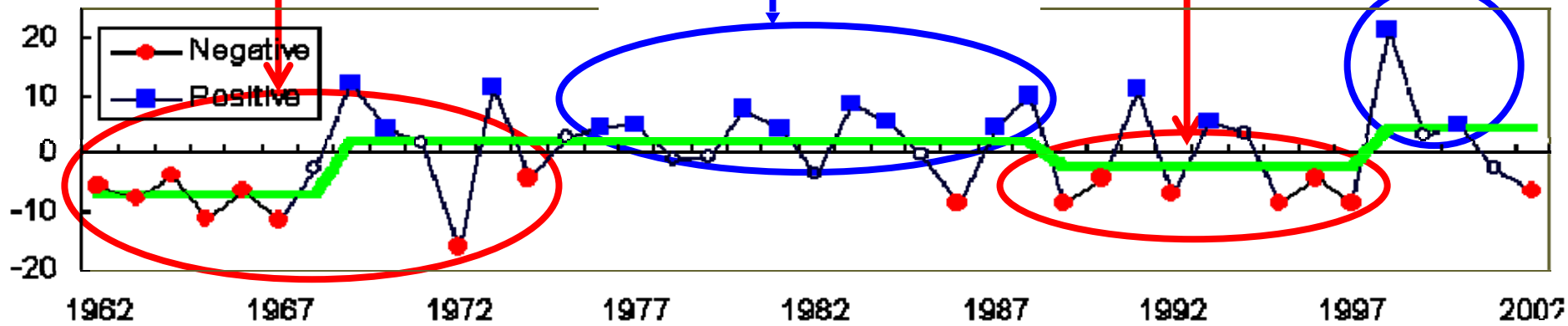
850-hPa winds

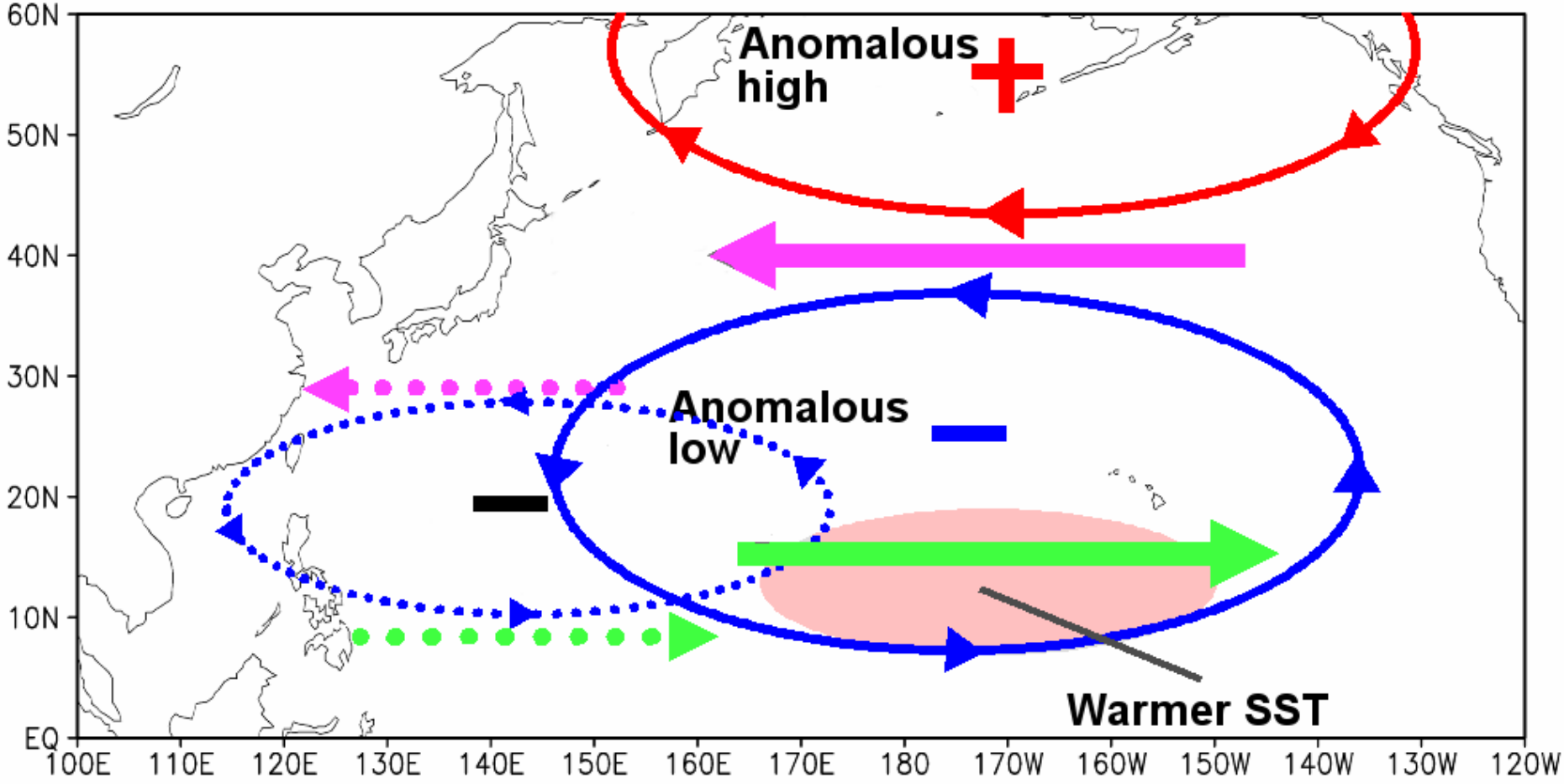


Annual TC activity



850-hPa index




Anomalous high
Anomalous low
Warmer SST
60N
50N
40N
30N
20N
10N
EQ
100E
110E
120E
130E
140E
150E
160E
170E
180
170W
160W
150W
140W
130W
120W

Conclusion 2

Interdecadal variations in TC activity are mainly determined by the atmospheric environment related to variations of similar time scales in the atmospheric and oceanographic conditions in the tropical and extratropical Pacific, and not related to local sea-surface temperature.

Main Conclusion

If global warming does increase TC activity/intensity, it is <u>not</u> because of the rise in local sea-surface temperature, but because global warming leads to changes in the atmospheric and oceanographic environment on a planetary scale.

Main Conclusion (cont'd)

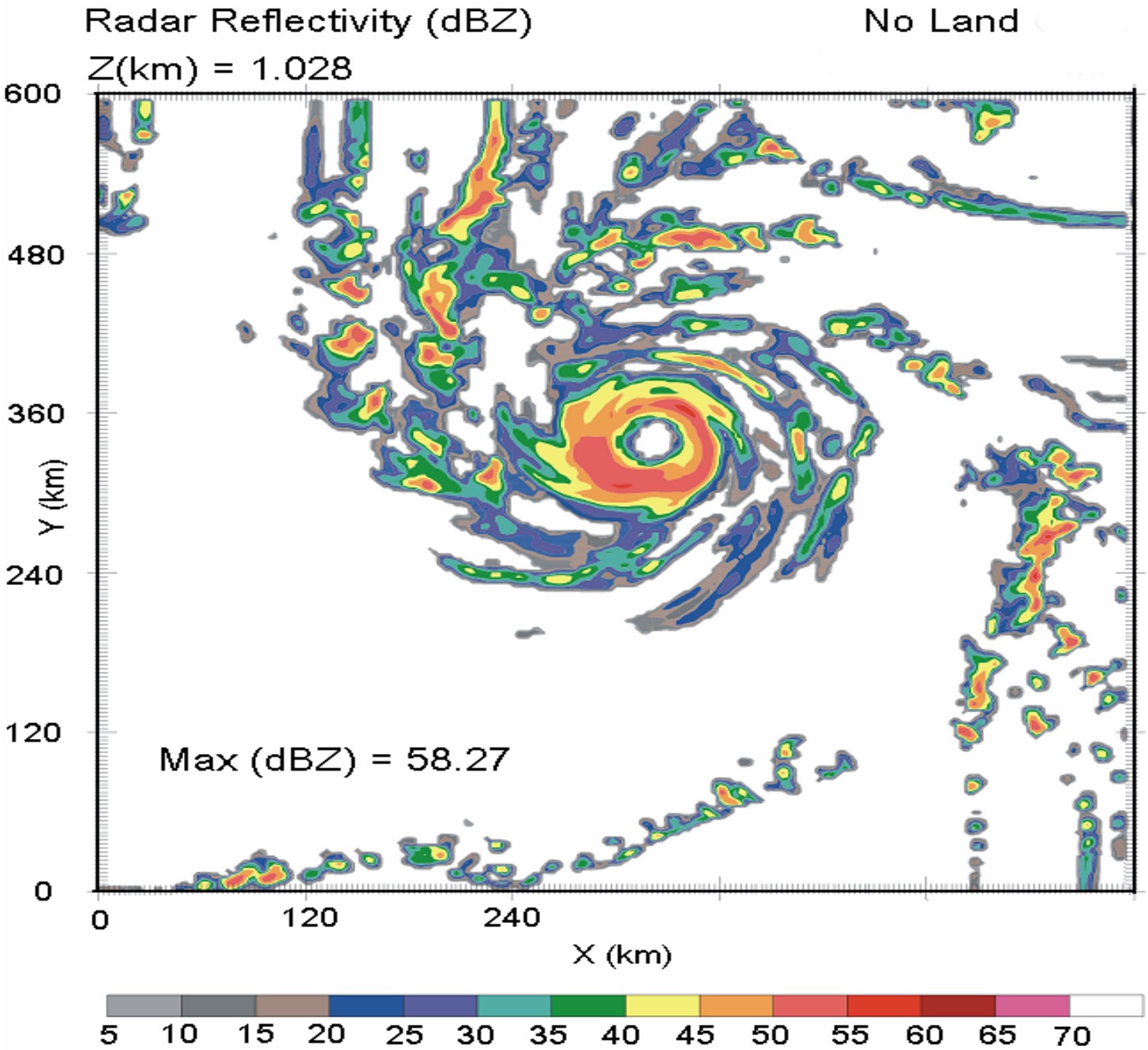
BUT this causality has yet to be established.


Part II
SRC:GUAMGSRS SAT:GMS_VS PRO:SAT REG:b_typhoon CLRMAP:UNDEFINED 97_09_09 20:34
05x05

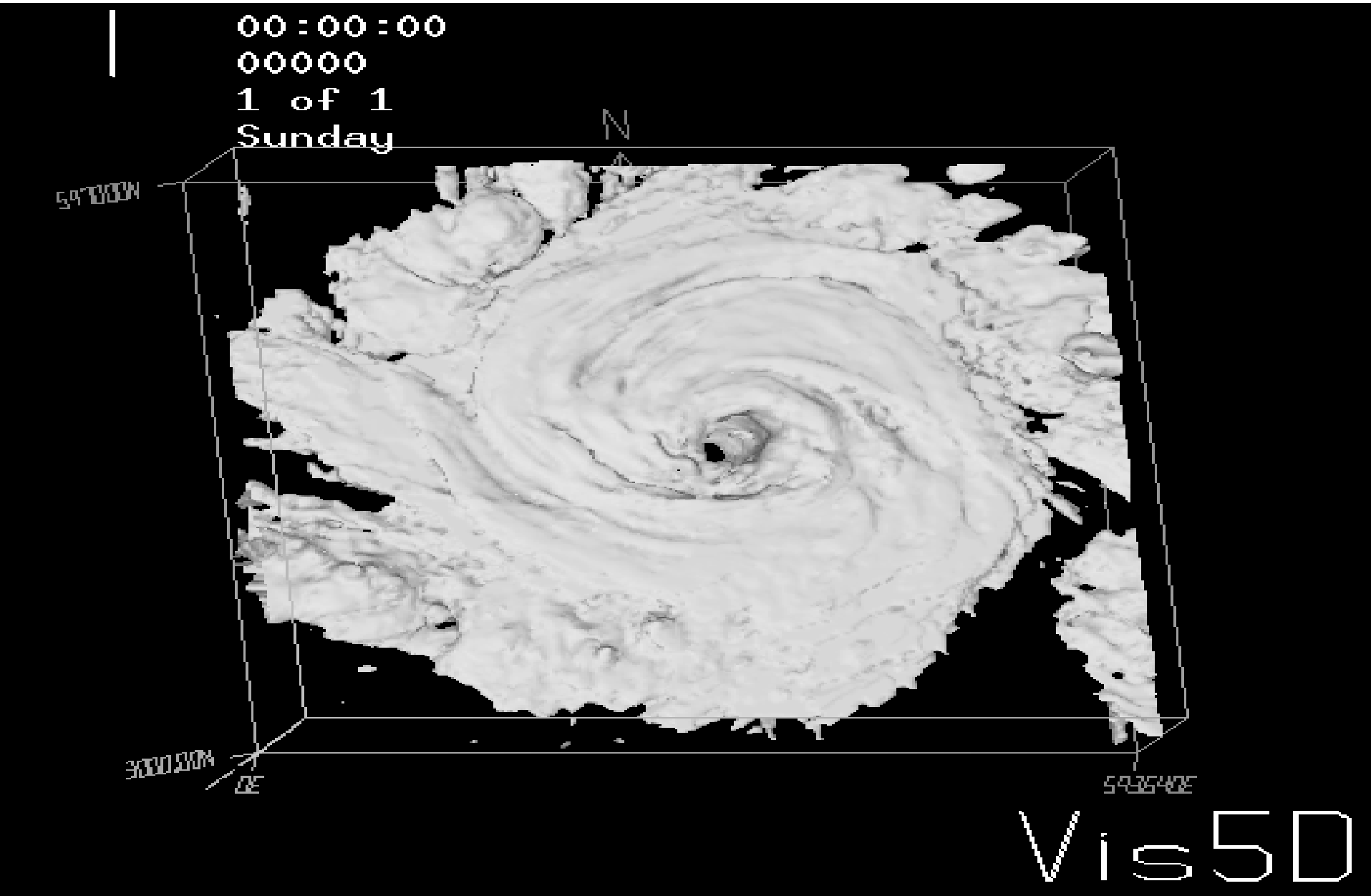
Overview of OU-CGCM

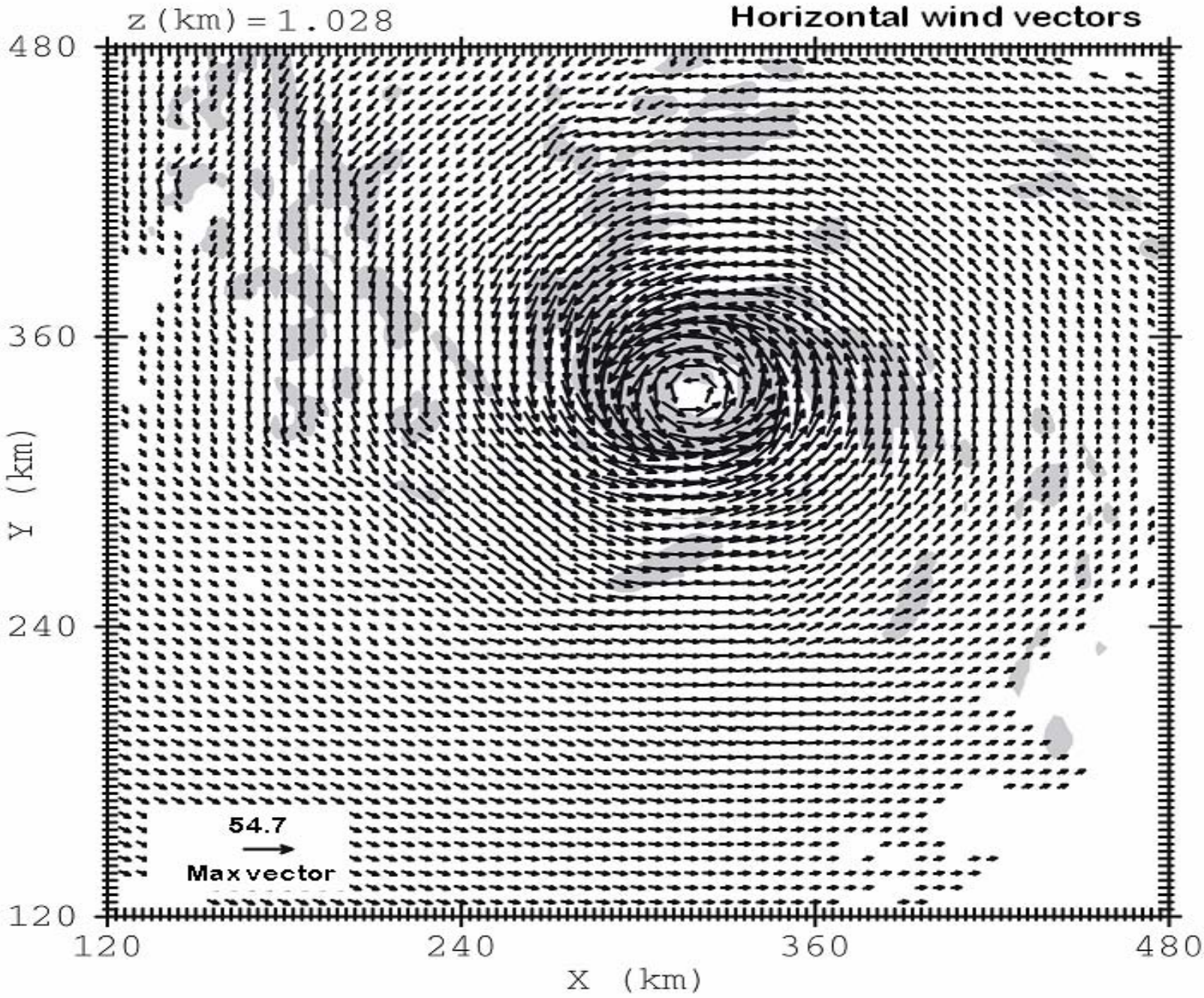
- coupled atmosphere-ocean GCM developed at OU, based on the atmospheric GCM developed at UNSW of Leslie and Fraedrich (1997)
- Atmospheric model uses finite differencing, resolution of 1.8°× 1.8°, 21 levels in vertical
- Ocean model uses MOM, 1°× 1° resolution, increasing to 0.5° at the equator, 20 levels
- *The atmospheric model has an optional high resolution window over a selected area, using a standard graded mesh approach, using two-way nesting*

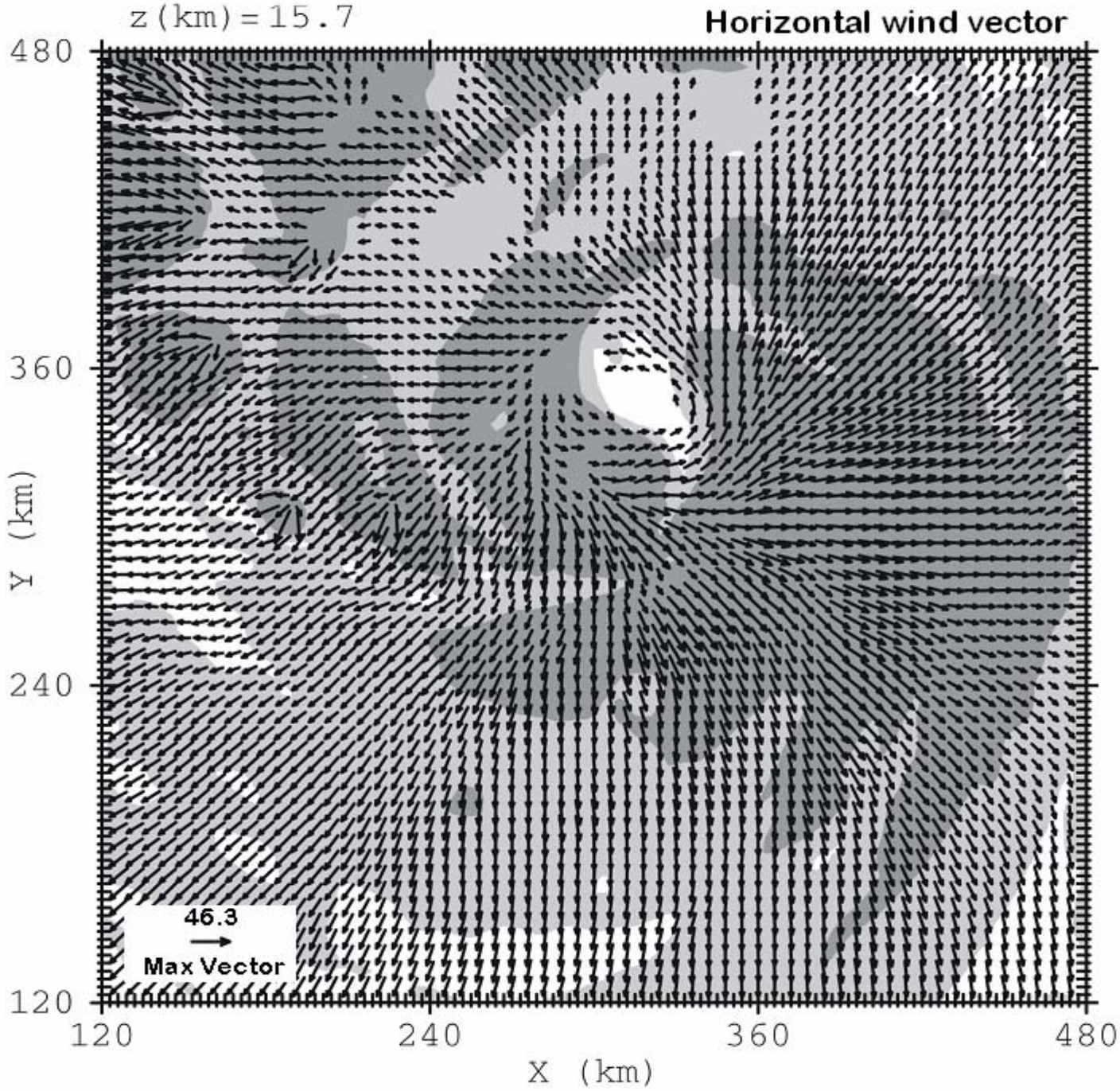
- **The ocean model is spun-up from a static state. Annual mean temperatures and salinity are based on Levitus**
- **The coupled model spin-up is 25 years**


Radar Reflectivity (dBZ)
No Land
Z(km) = 1.028
600
480
360
240
120
0
Y (km)
Max (dBZ) = 58.27
0
120
240
X (km)
5
10
15
20
25
30
35
40
45
50
55
60
65
70

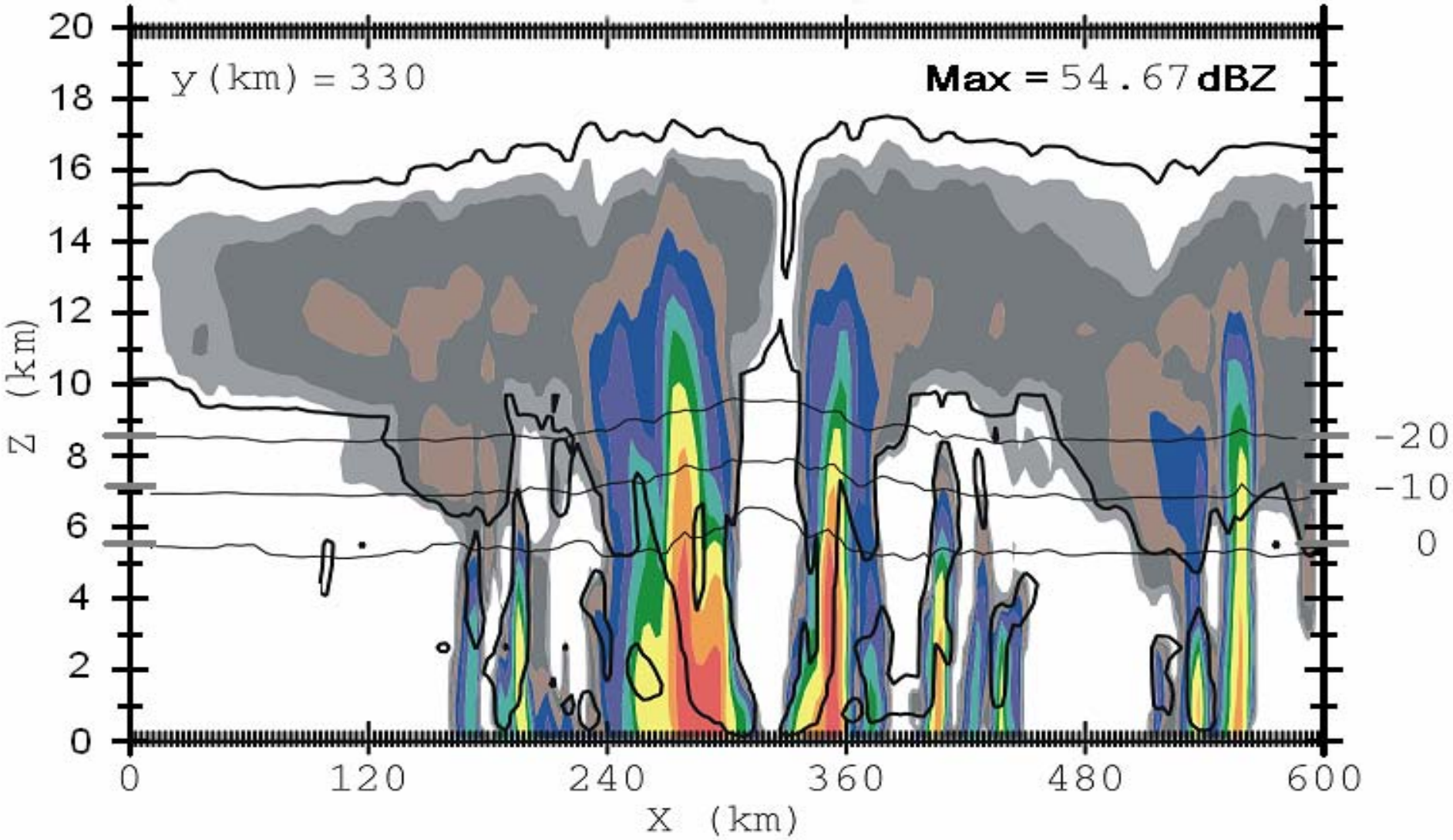
Model TC (1988) – All Cloud Water

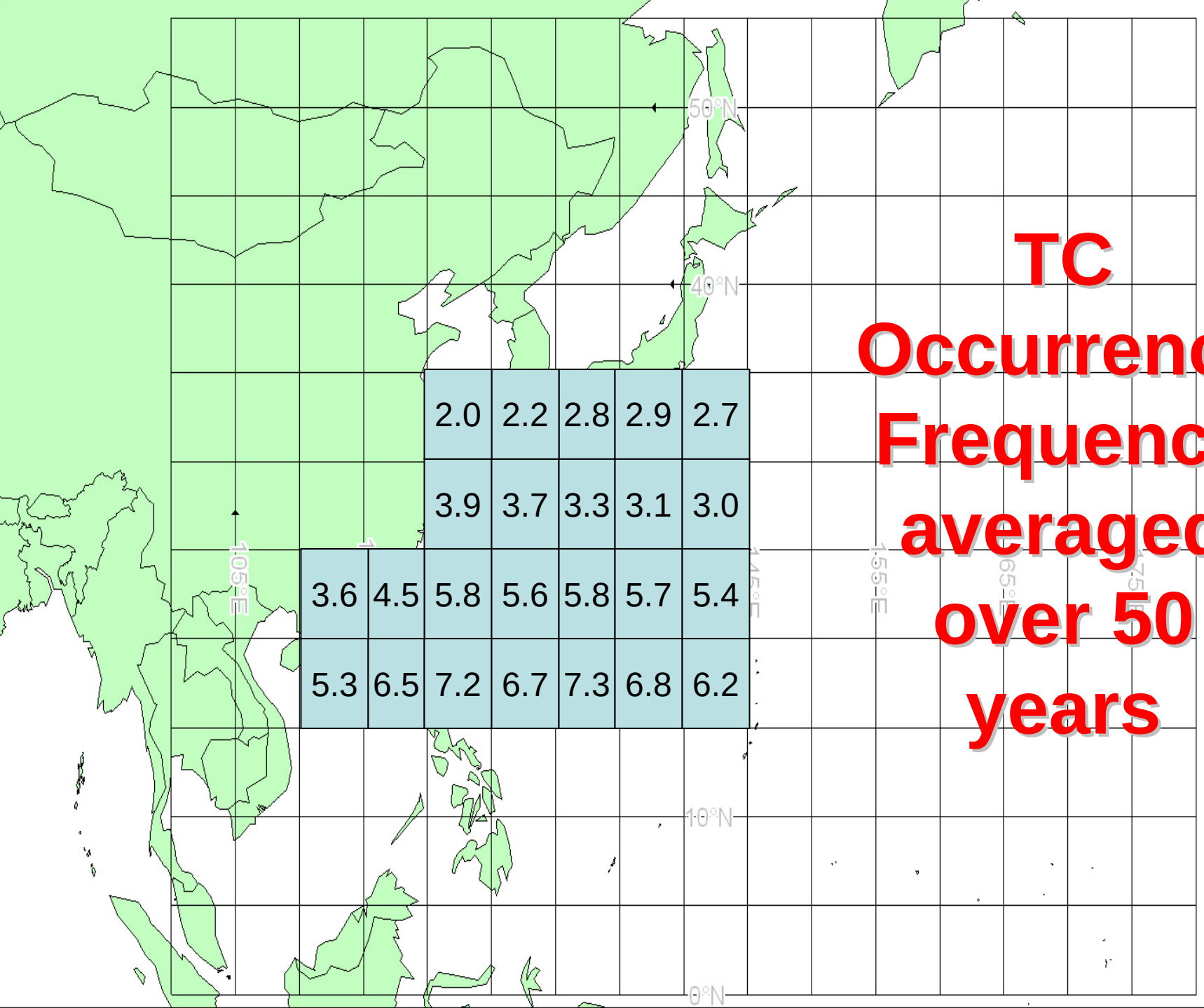



z (km) = 1.028
Horizontal wind vectors
480
360
240
120
Y (km)
120
240
360
480
X (km)
54.7
Max vector

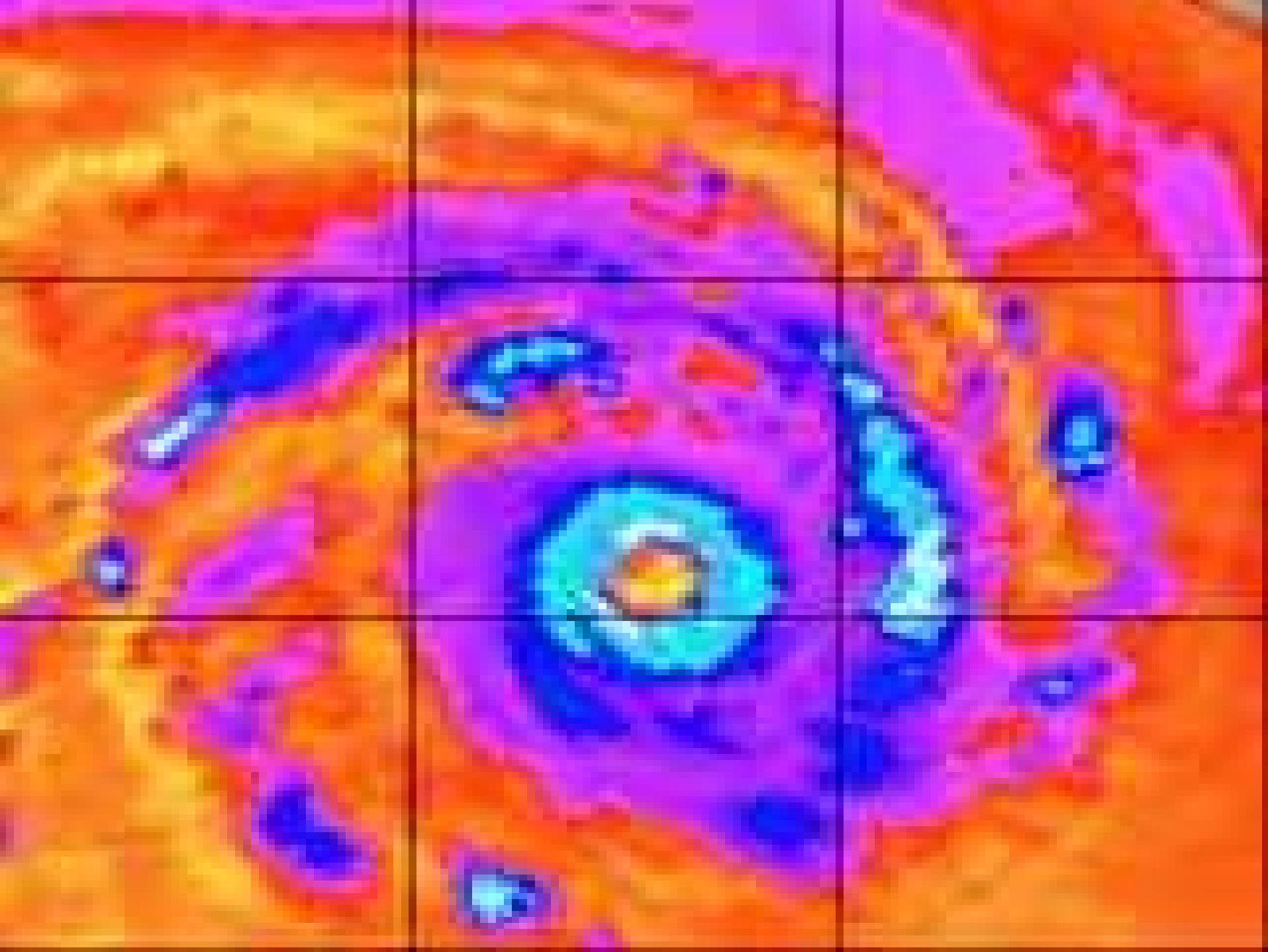

z (km) = 15.7
Horizontal wind vector
480
360
240
120
Y (km)
120
240
360
480
X (km)
46.3
Max Vector

Cross-section through a Category 4 Model TC - August 1988

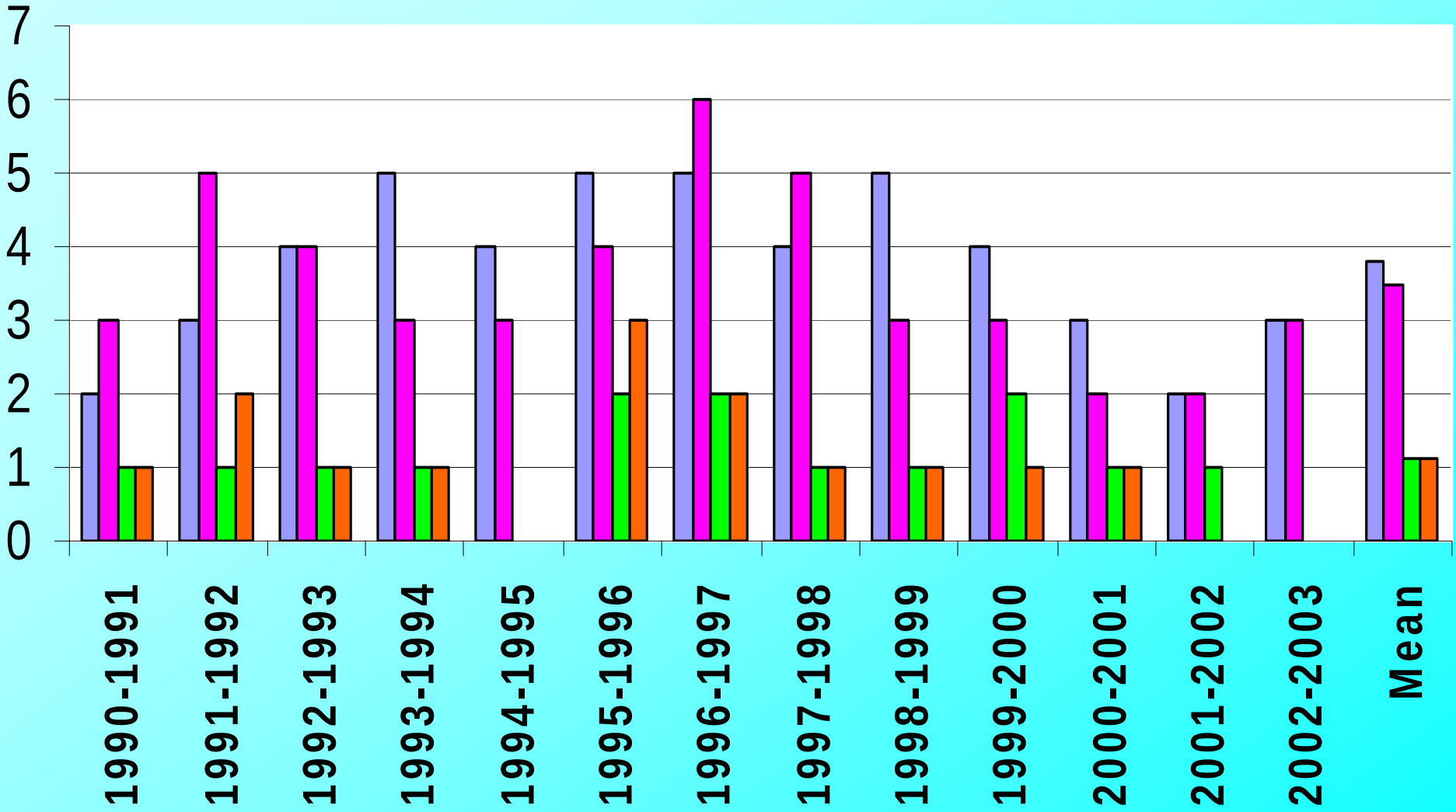




TC Occurrence Frequency averaged over 50 years



QLD TCs: Increased Greenhouse



How can we use this model to study TC climate?

- Verify the model's ability to produce interannual and interdecadal variations
- Integrate the model under various IPCC scenarios
- Perform sensitivity experiments with different SST and GHG forcings
- Seasonal prediction of TC frequency

香港城市大學
City University of Hong Kong

Workshop on Meteorology and Climate over South China
5-8 December 2005, City University of Hong Kong

- air pollution and remote sensing applications
- severe weather
- tropical cyclones
- monsoons and climate change

http://www.ap.cityu.edu.hk/weather-sc/Workshop.htm