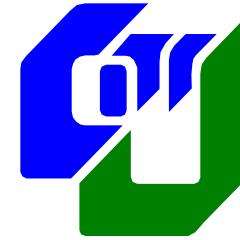




能源及環境學院
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香港城市大學
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Tropical Cyclone Activities in the Asia-Pacific Region: Past Variations and Future Predictions

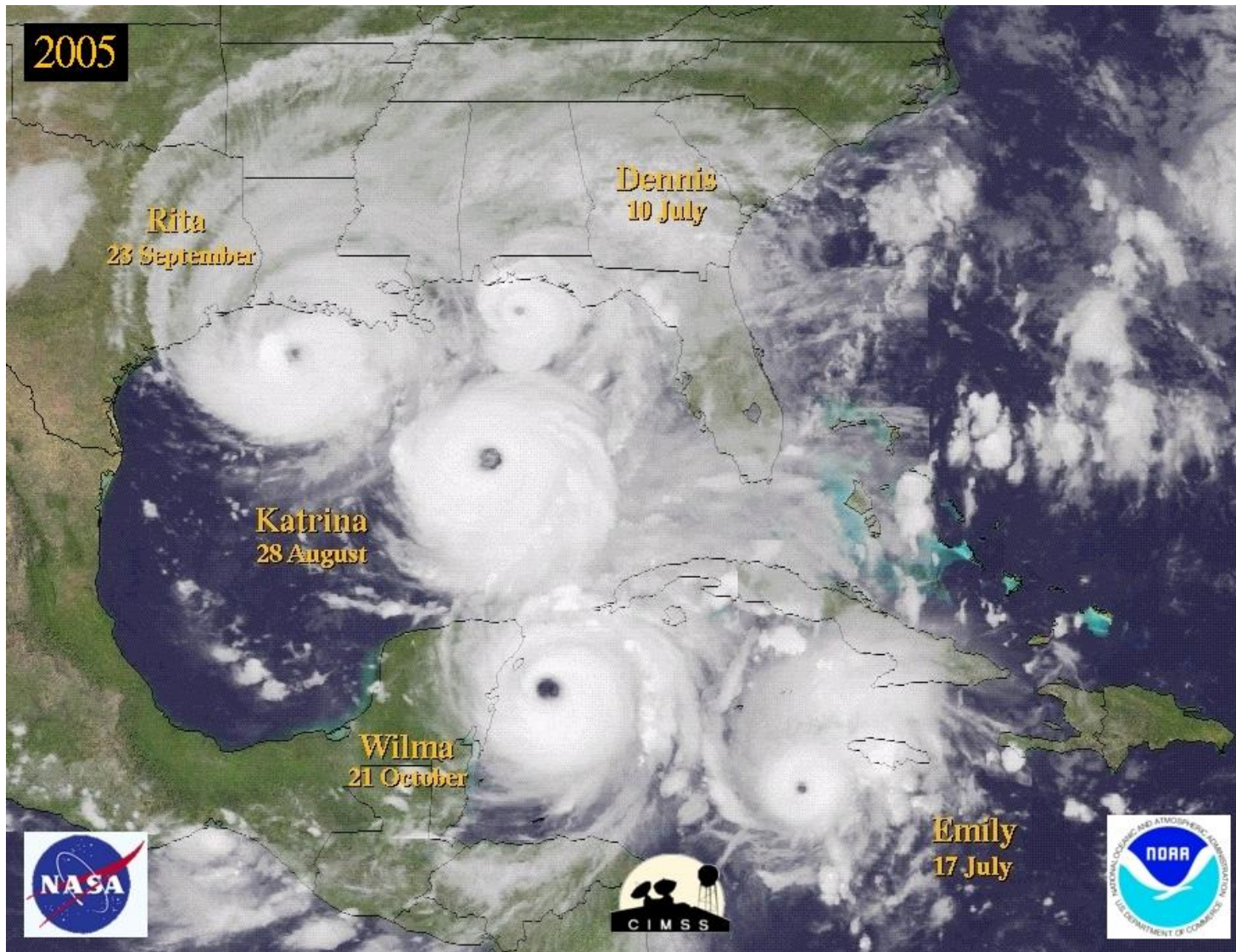
Johnny Chan

Guy Carpenter Asia-Pacific Climate Impact Centre

School of Energy and Environment

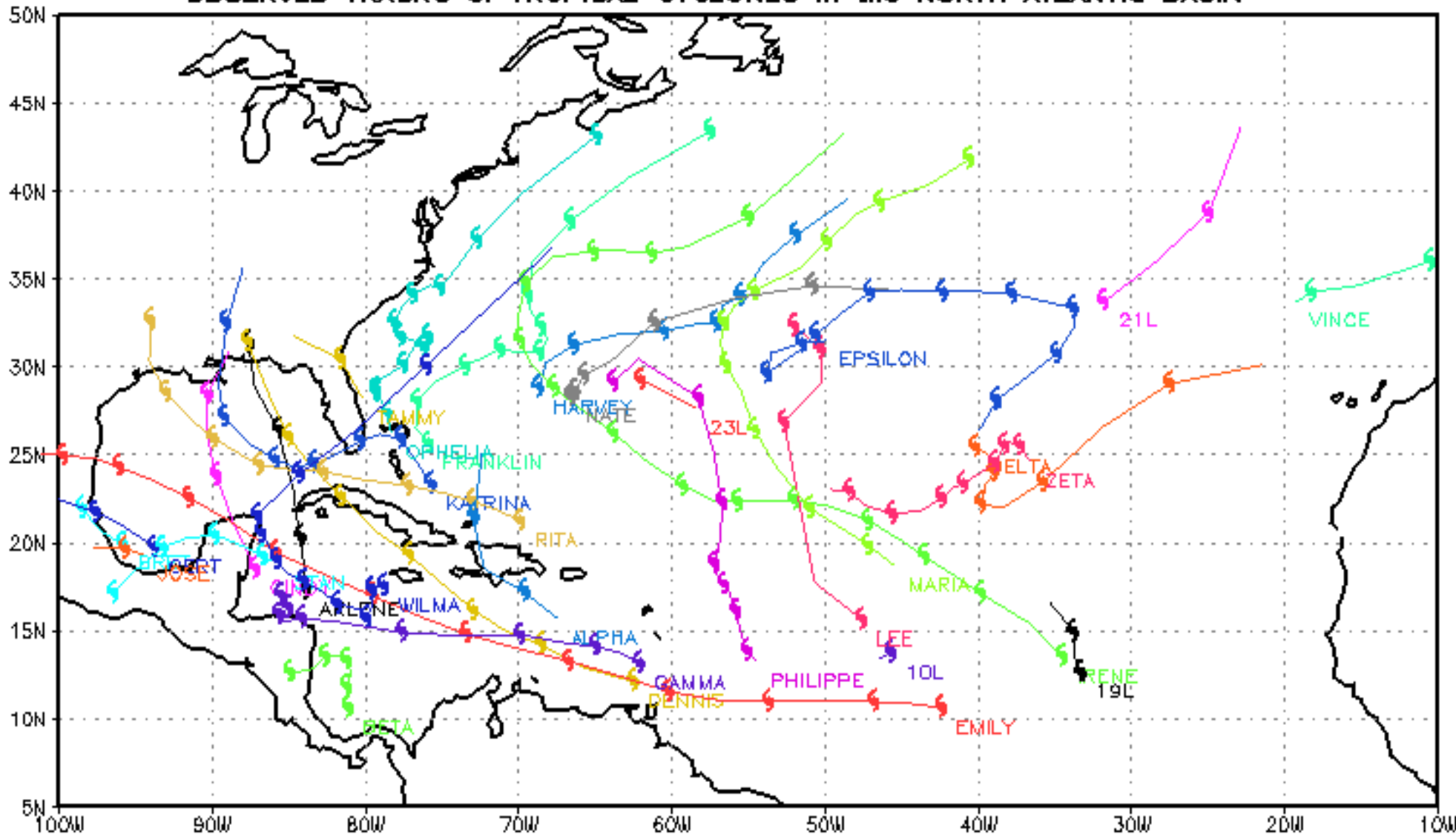
City University of Hong Kong

Atlantic 2005



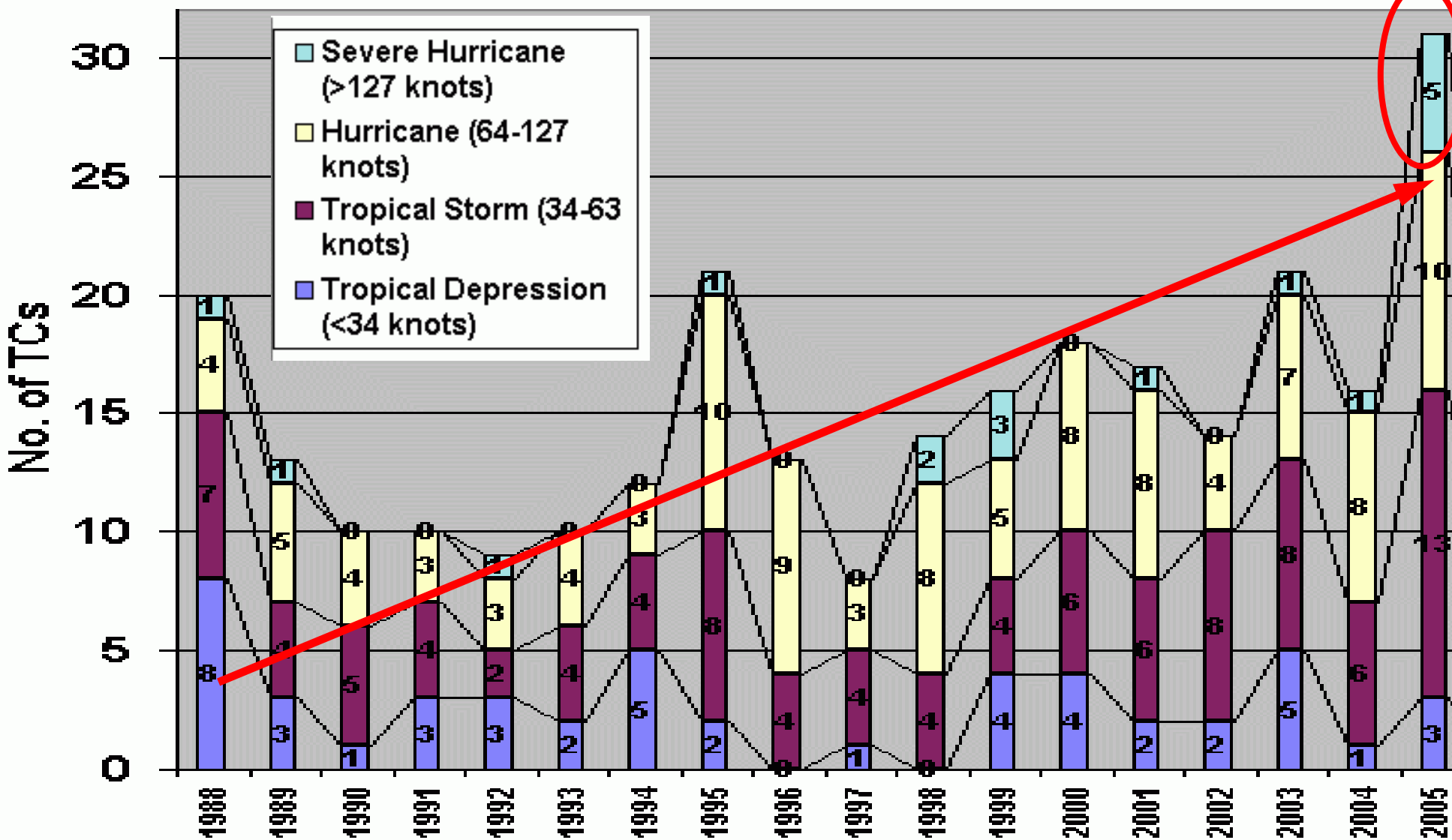
Atlantic 2005

OBSERVED TRACKS of TROPICAL CYCLONES in the NORTH ATLANTIC BASIN

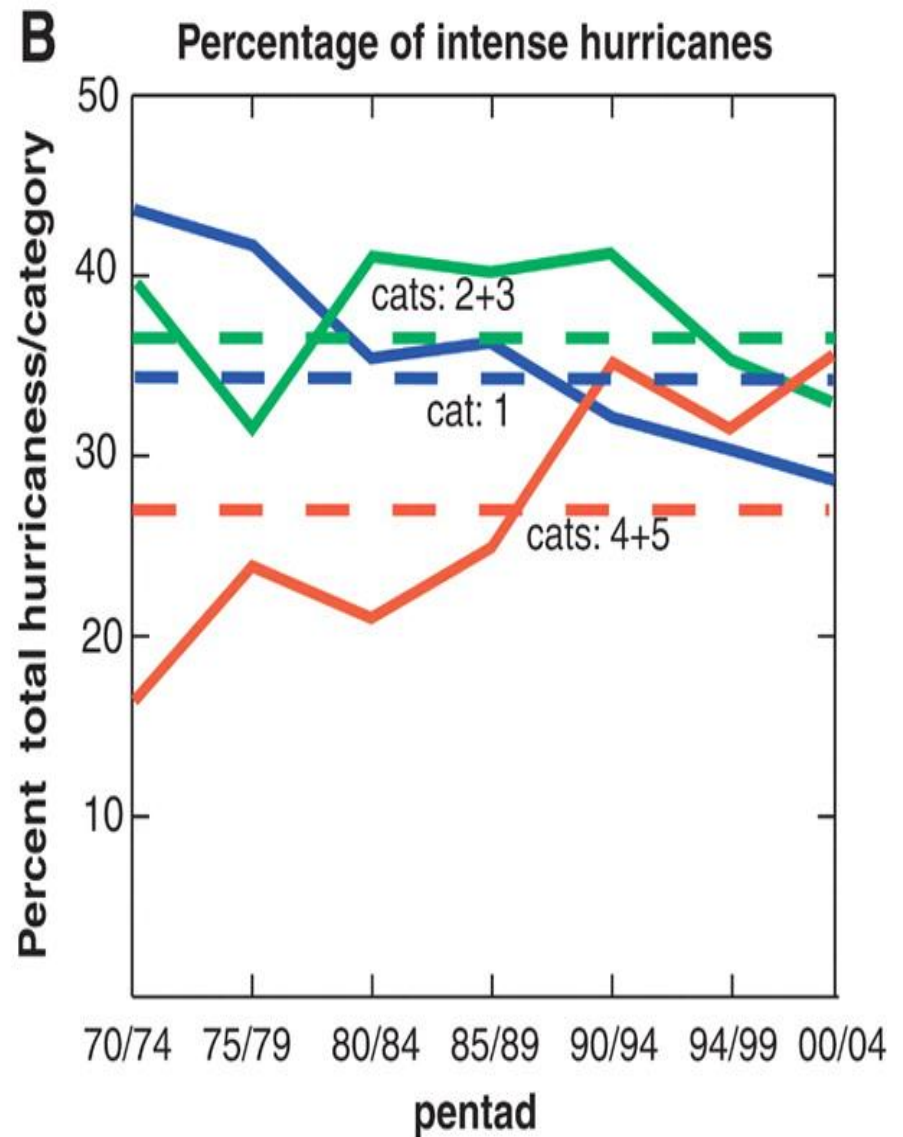
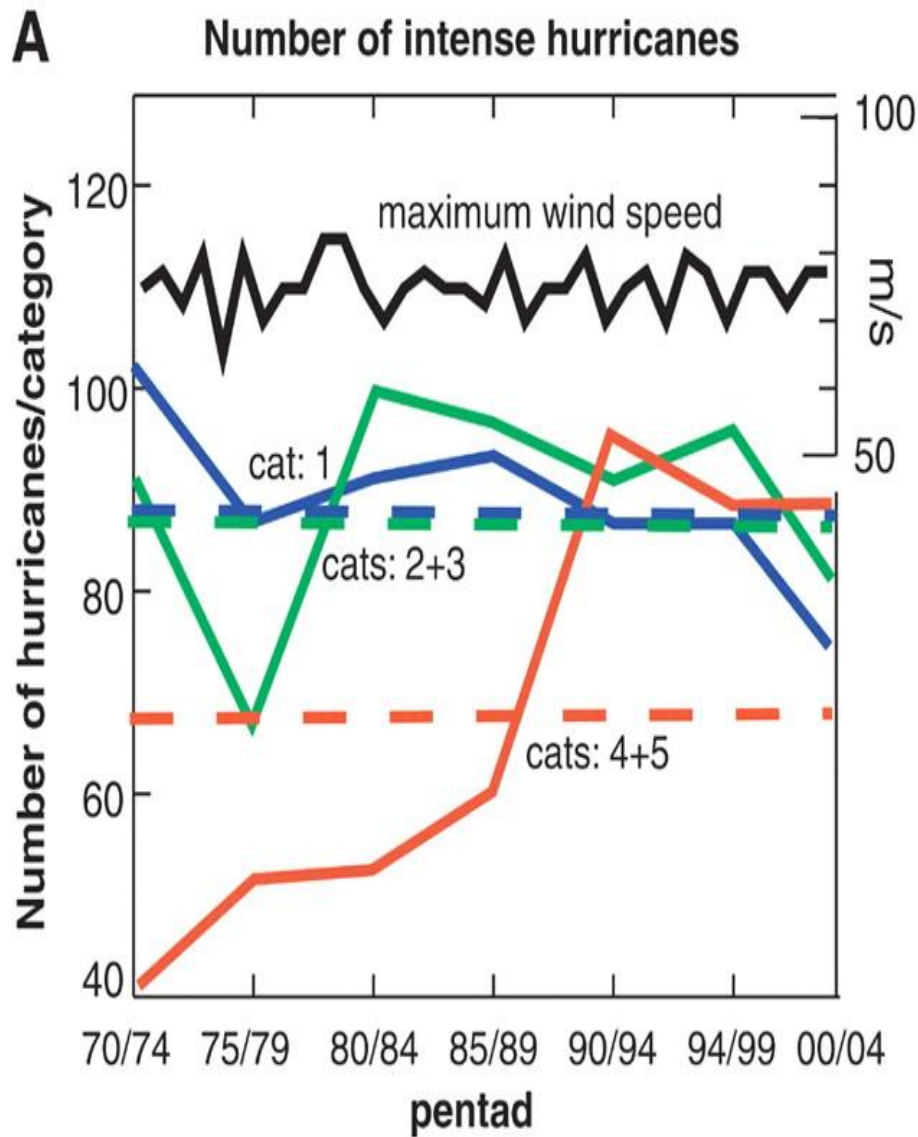


Annual No. of TCs in the Atlantic

31



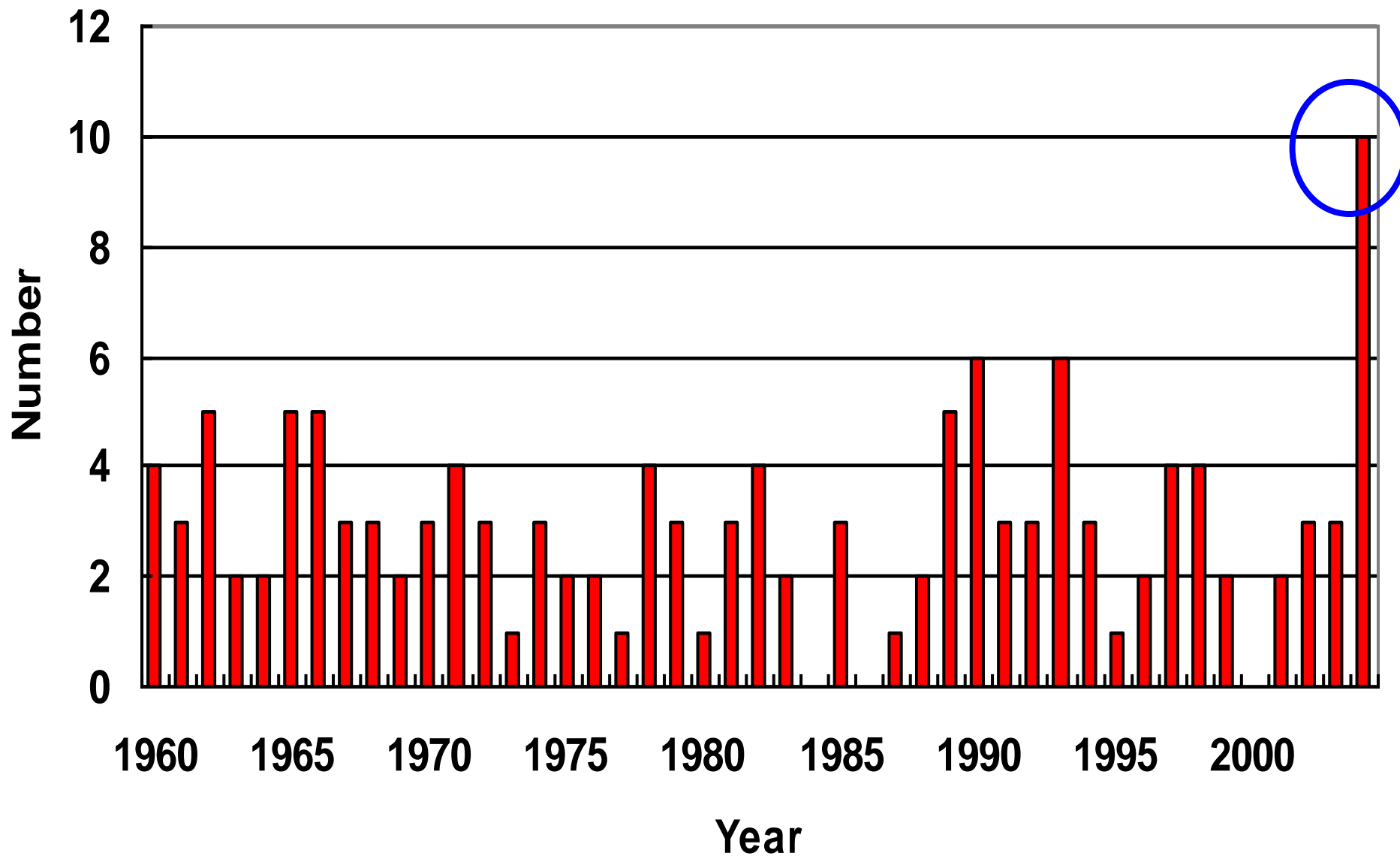
Webster et al.'s (2005) Science paper



Outline

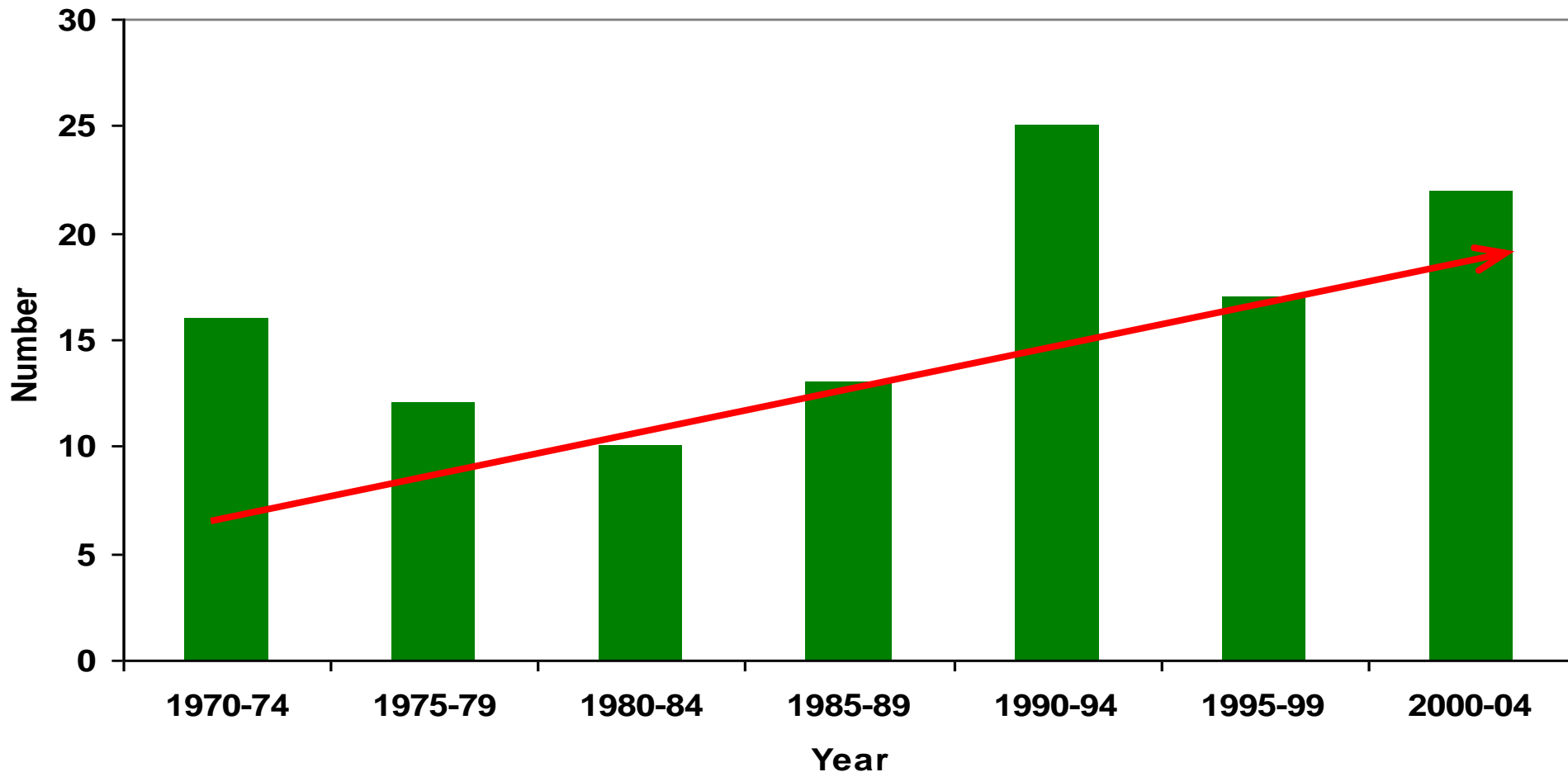
- **Past variations of TC activity**
 - **Western North Pacific**
 - **North Indian Ocean**
 - **Southern Hemisphere**
- **Possible causes of such variations**
- **Future predictions/projections of TC activity**
- **Summary**

Number of Tropical Cyclones Making Landfall in Japan

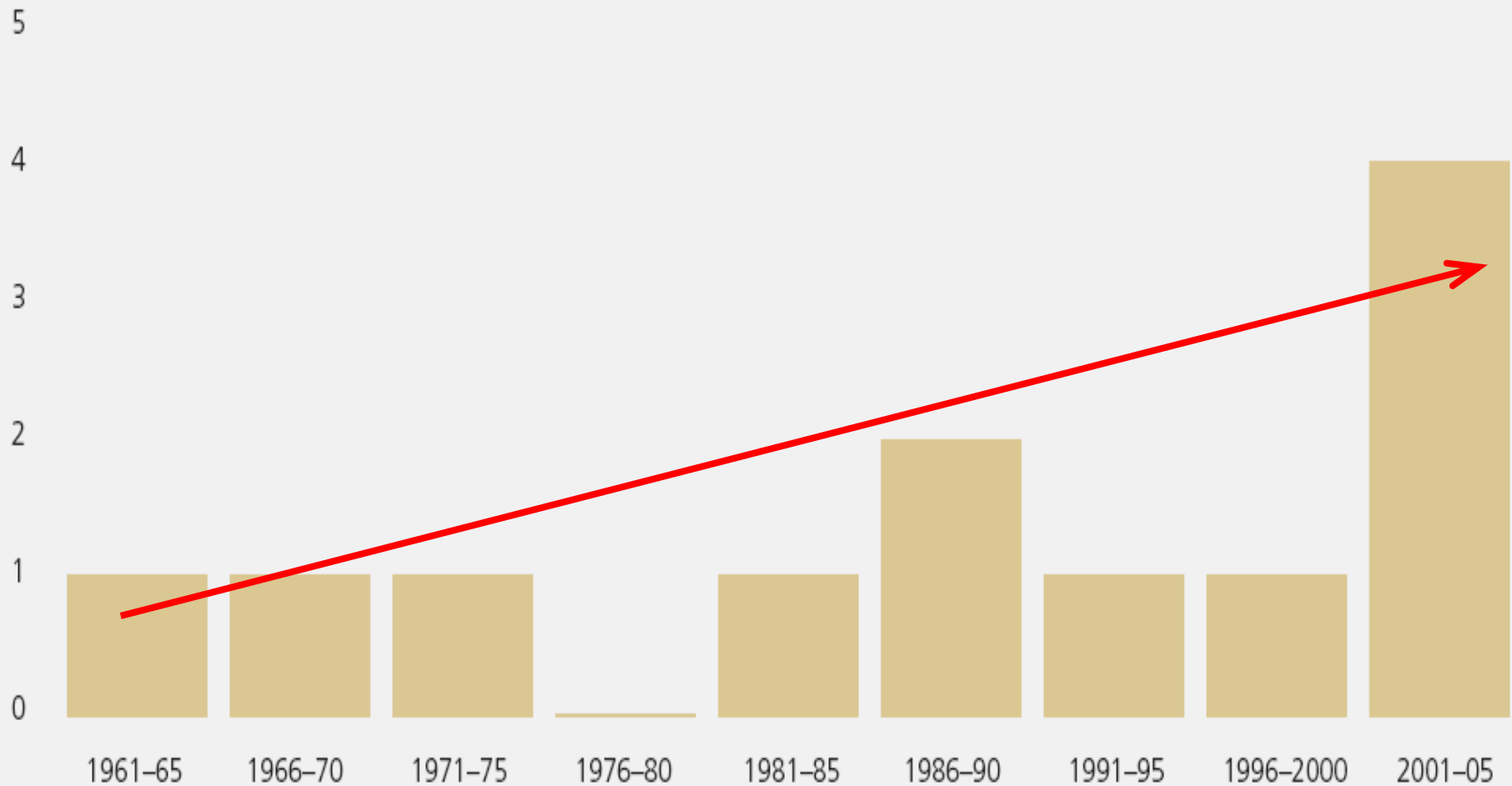


No. of Tropical Cyclones Making Landfall in Japan and Korea Every 5-year period (1970-2004)

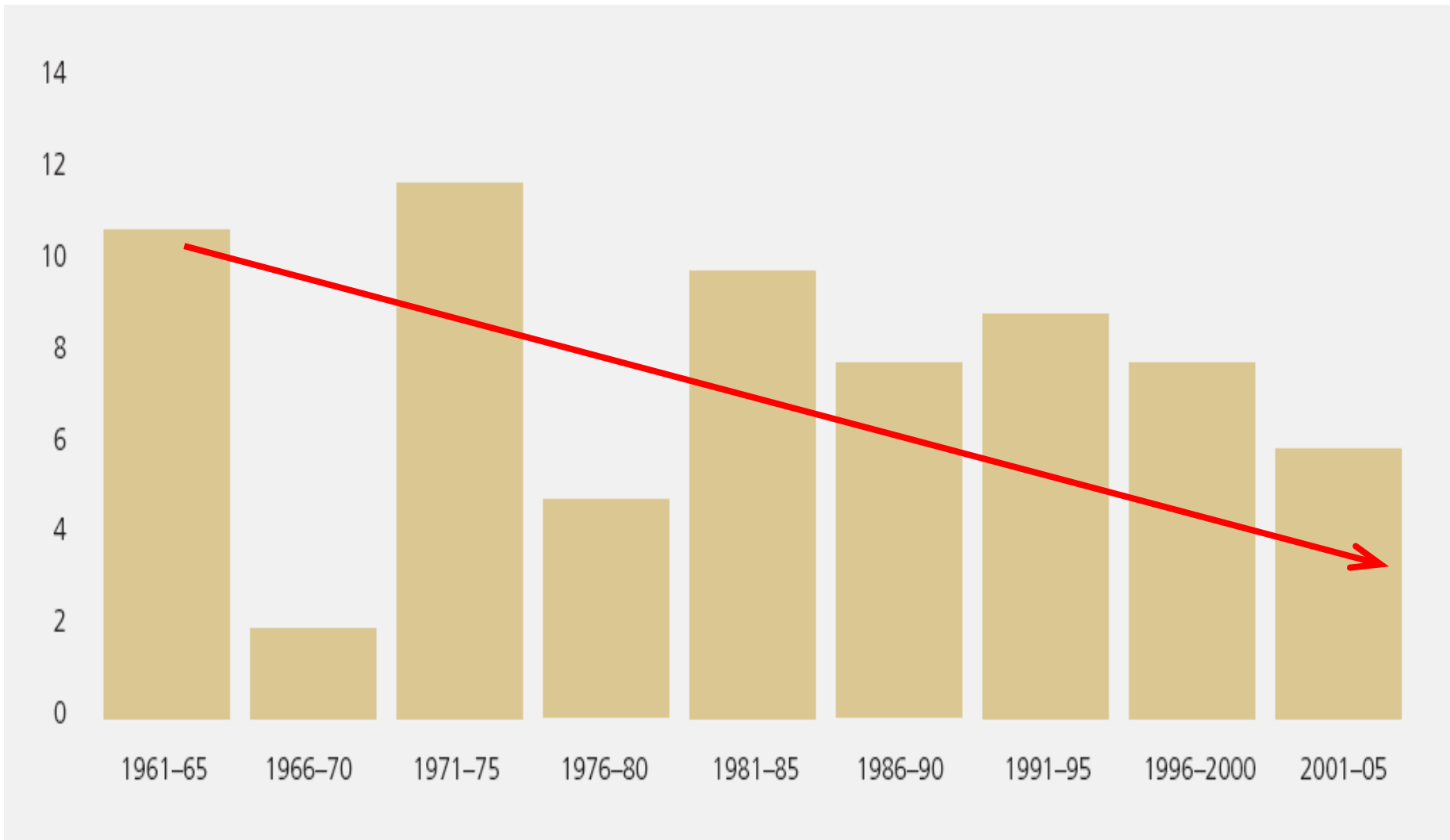
No. of Tropical Cyclones Making Landfall in Japan and Korea



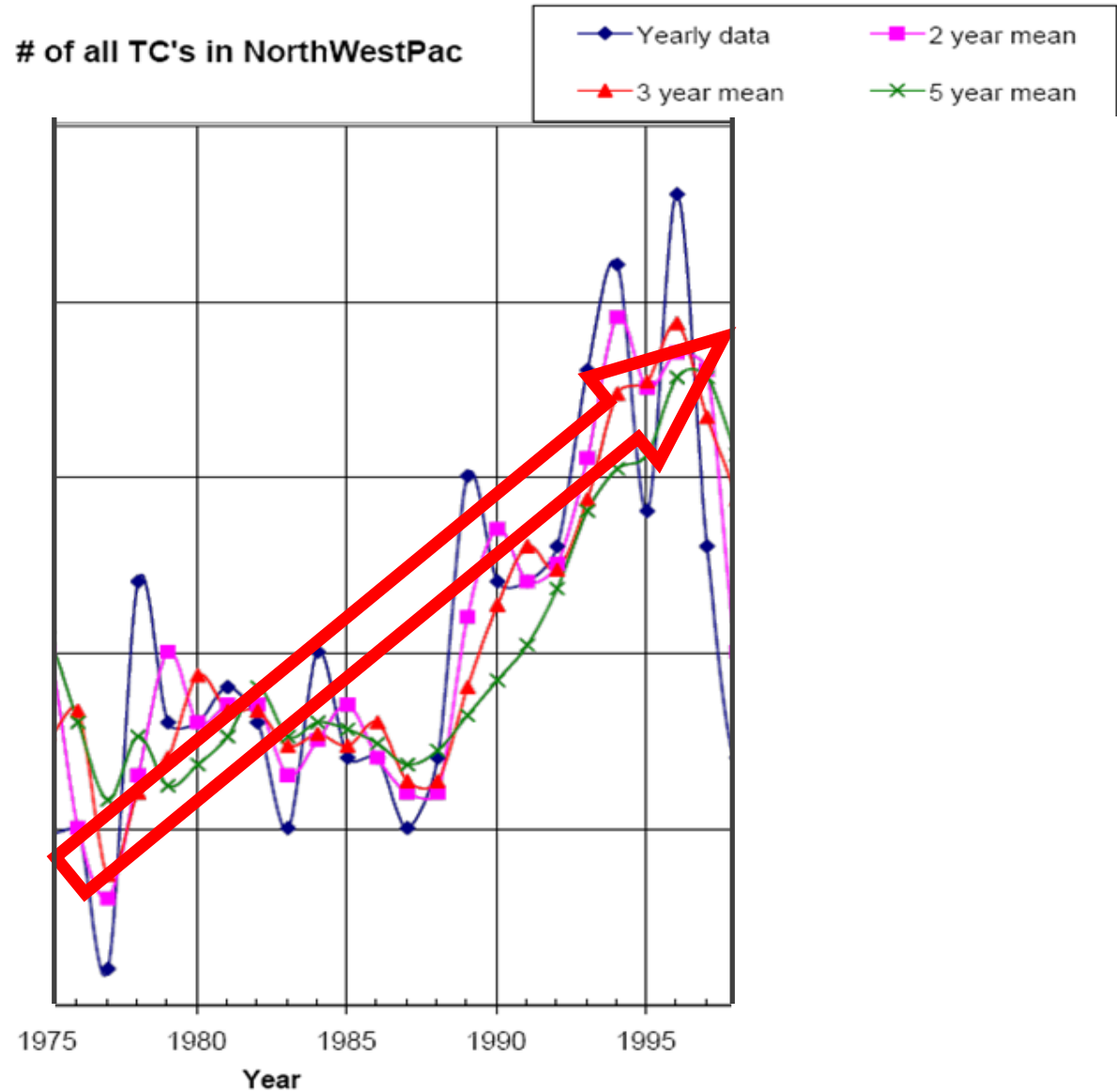
No. of Typhoons Making Landfall in Zhejiang Province Every 5-year period (1960-2005)



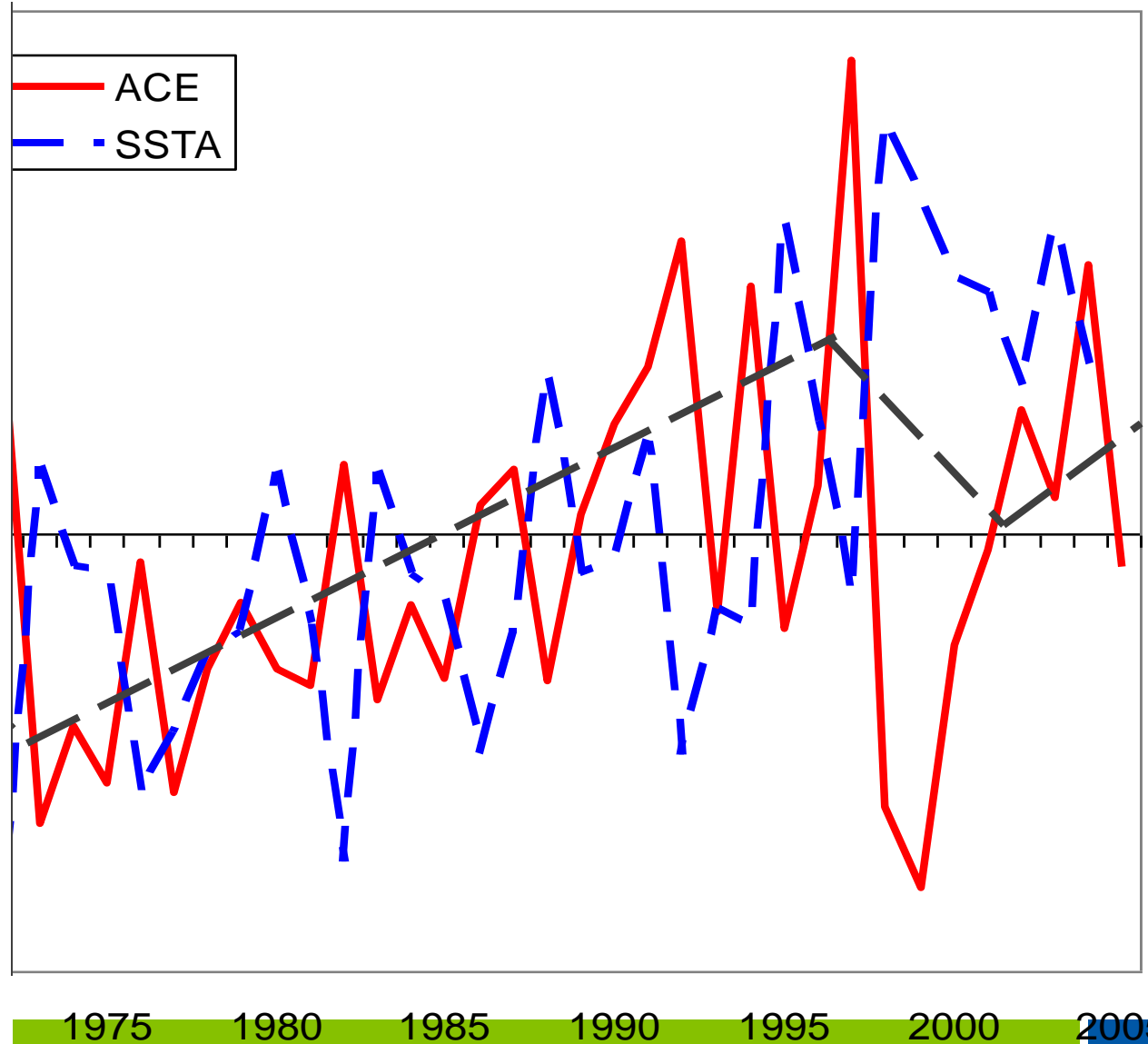
No. of Tropical Cyclones Making Landfall in Southern China Every 5-year period (1960-2005)



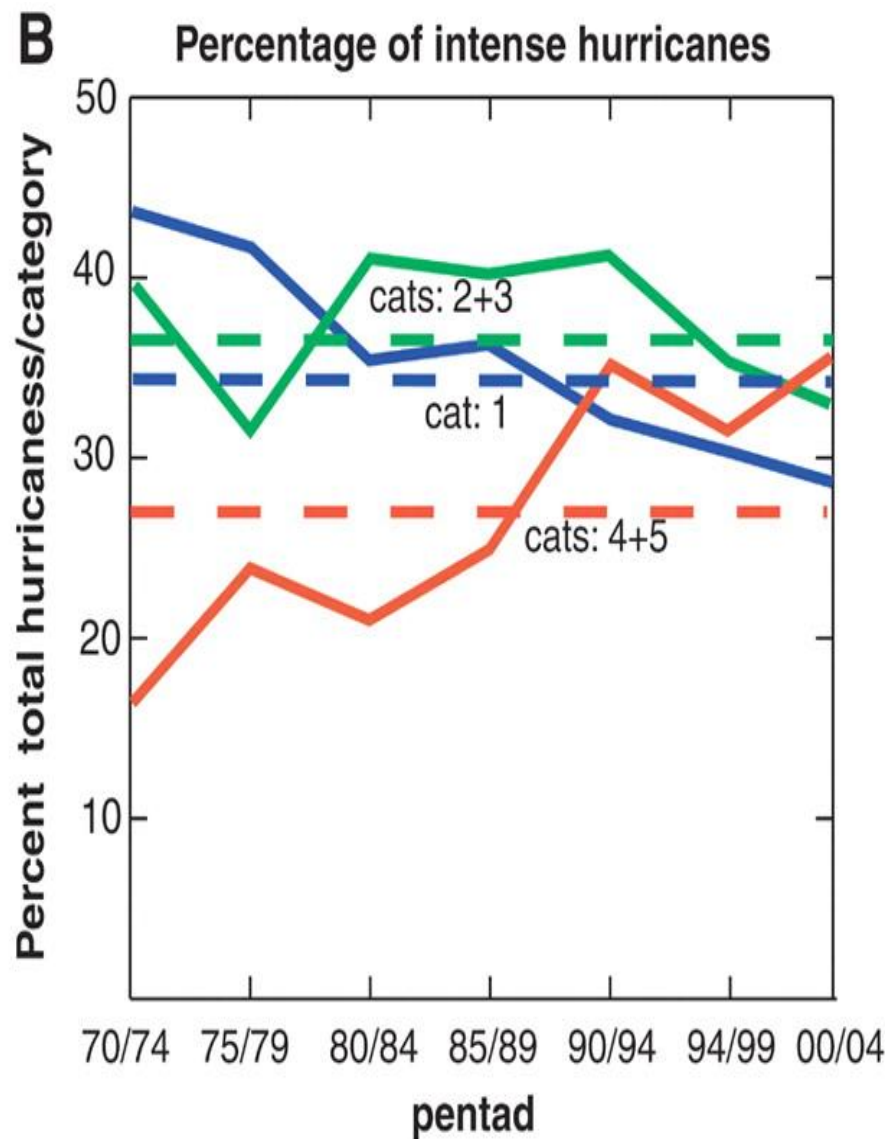
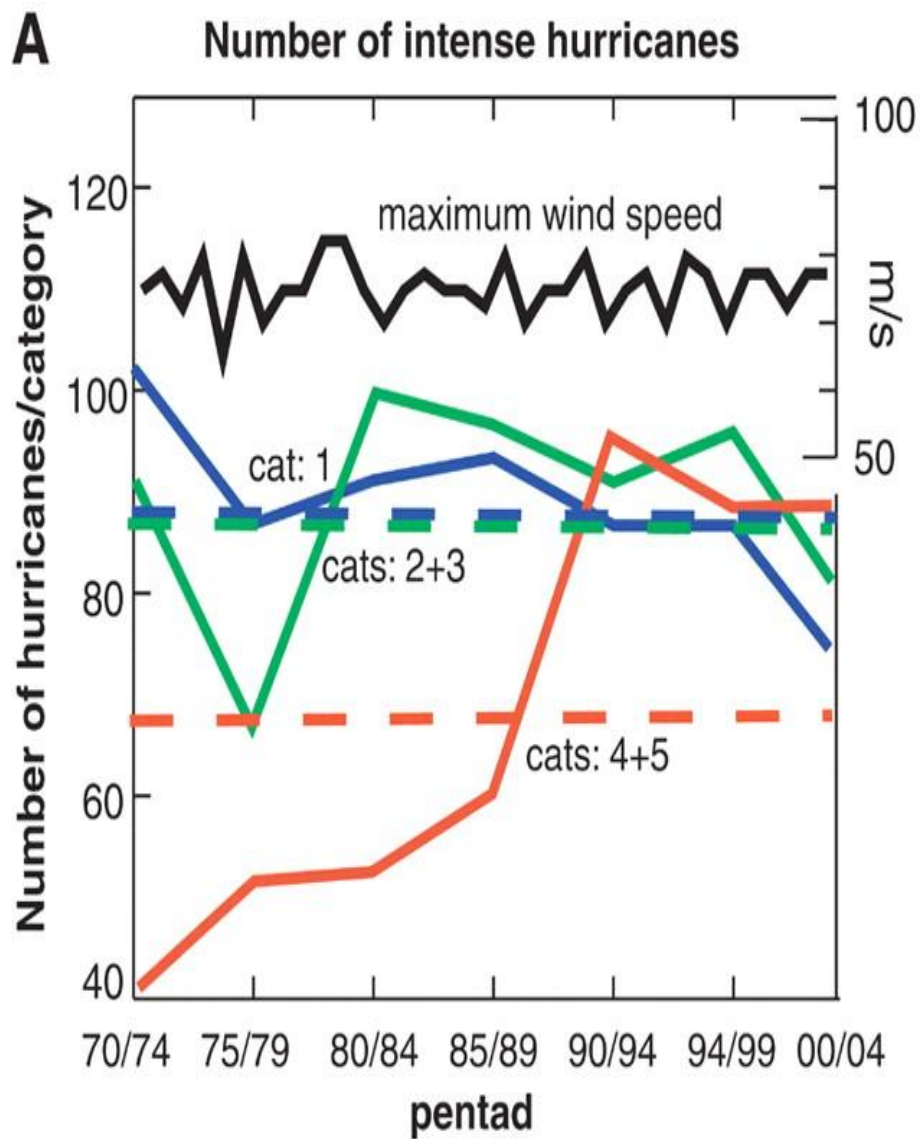
Number of tropical cyclones in the western North Pacific



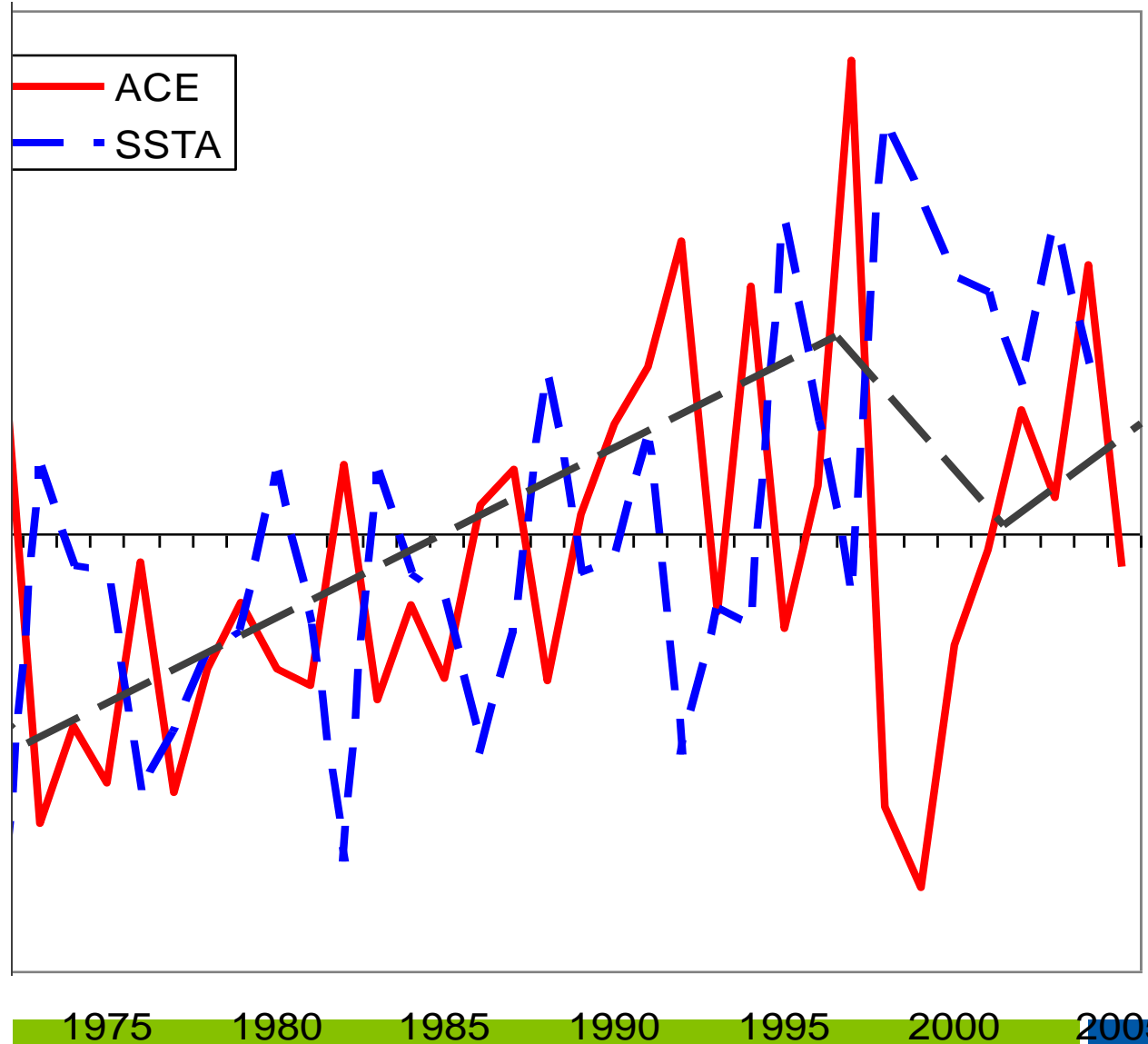
ACE vs. May-Nov SSTA (5-30°N, 120-180°E)



Webster et al.'s (2005) Science paper



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



No. of Category 4 and 5 Typhoons

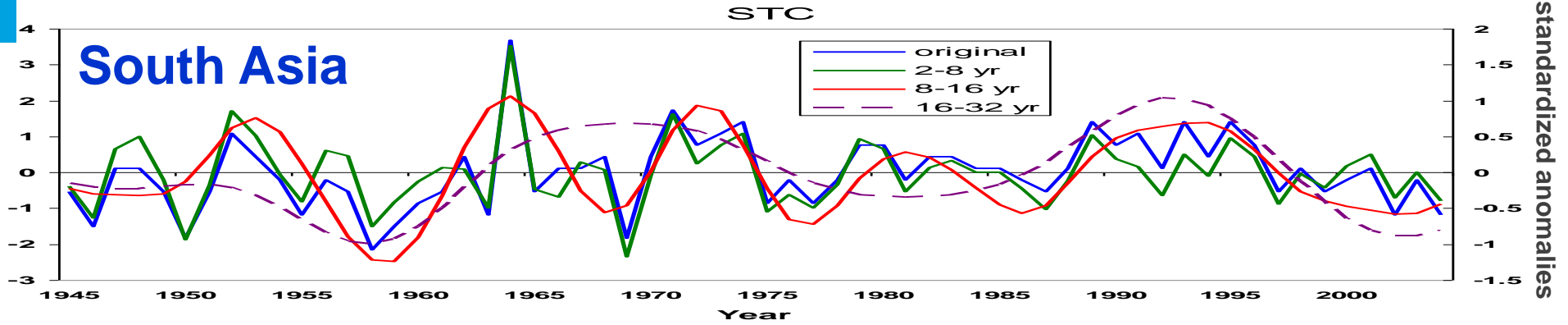
	1975-89	1990-2004
Number	75	115
Percentage	32	42

No. of Category 4 and 5 Typhoons

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

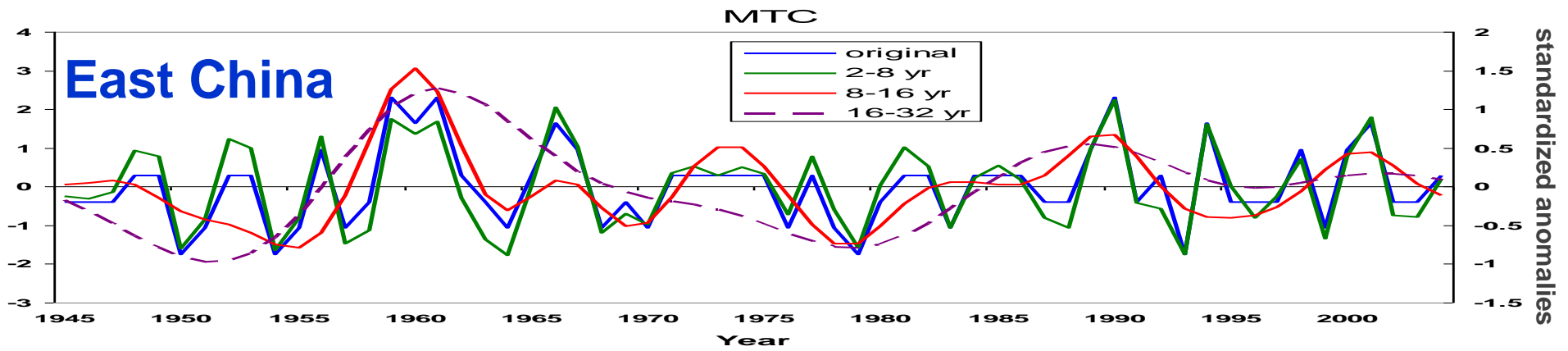
Variations of Landfall in Different Regions in East Asia

standardized anomalies



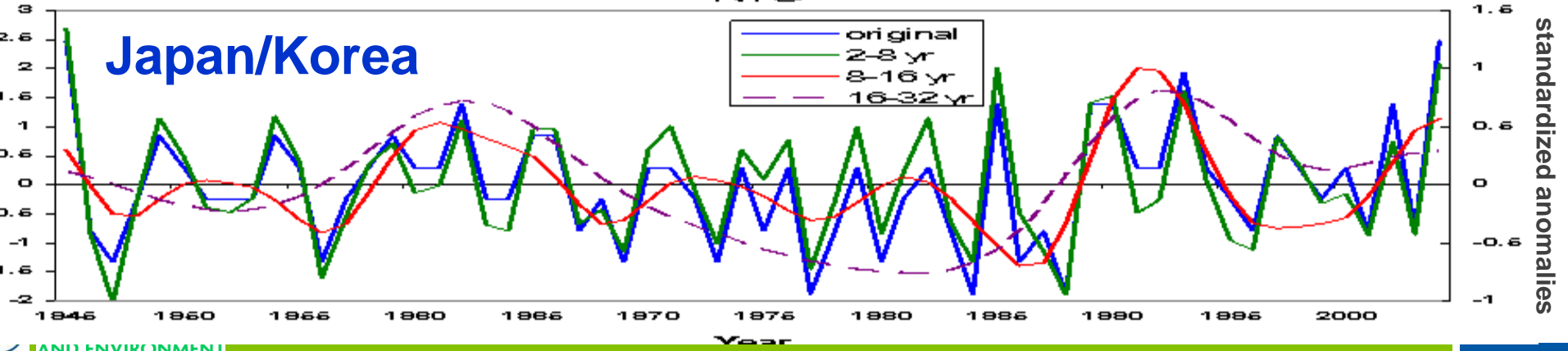
standardized anomalies

standardized anomalies



standardized anomalies

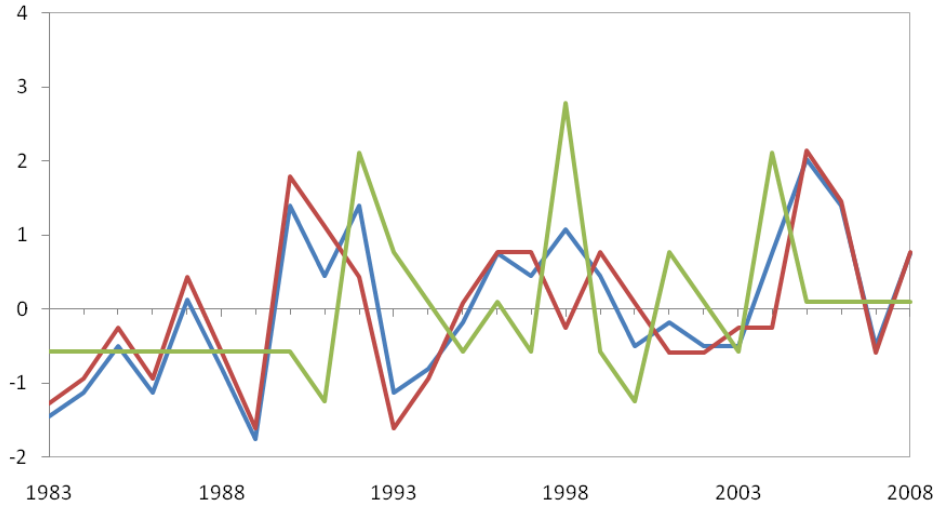
standardized anomalies



standardized anomalies

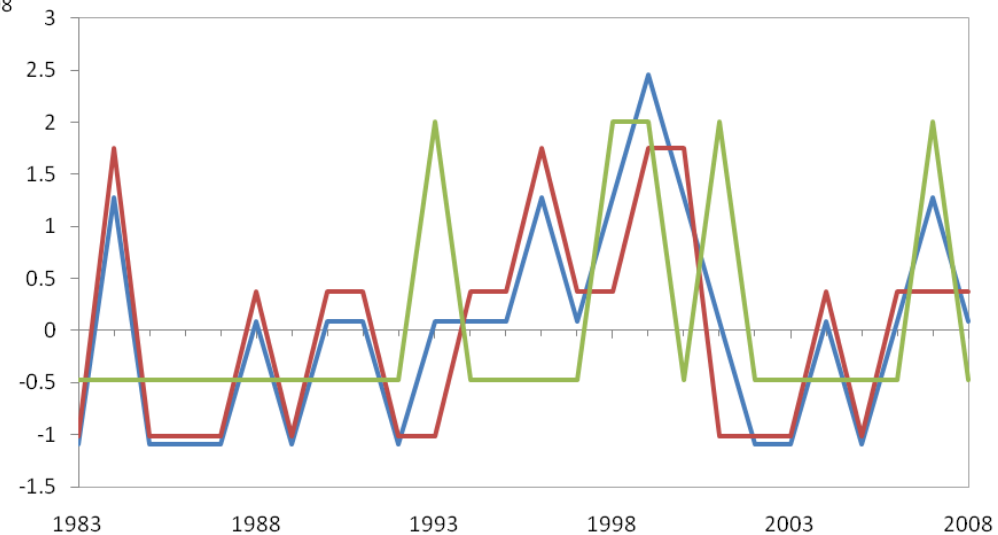
Tropical Cyclone Activity in the North Indian Ocean

Annual anomaly of TCs

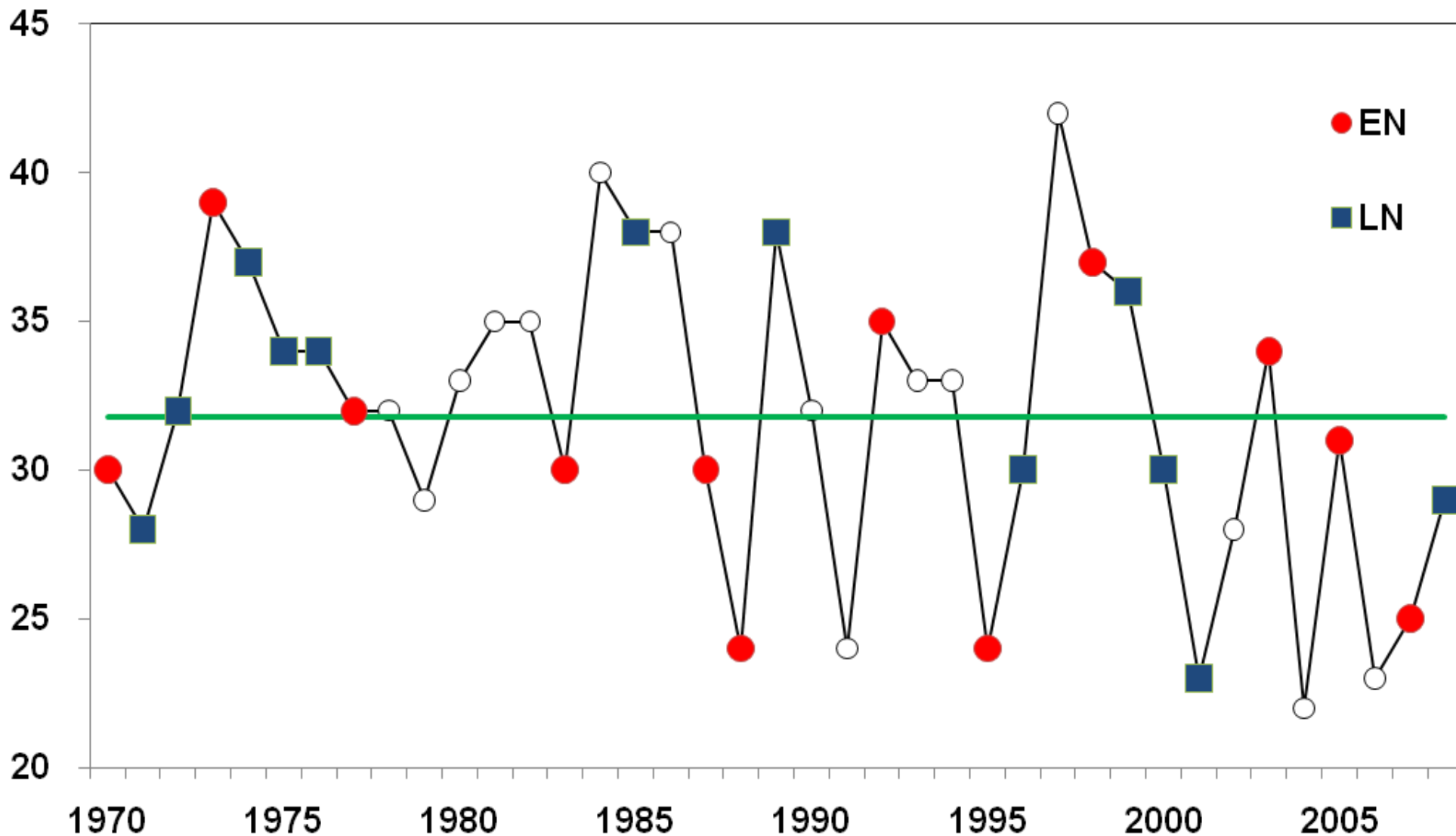


- Entire basin
- Bay of Bengal
- Arabian Sea

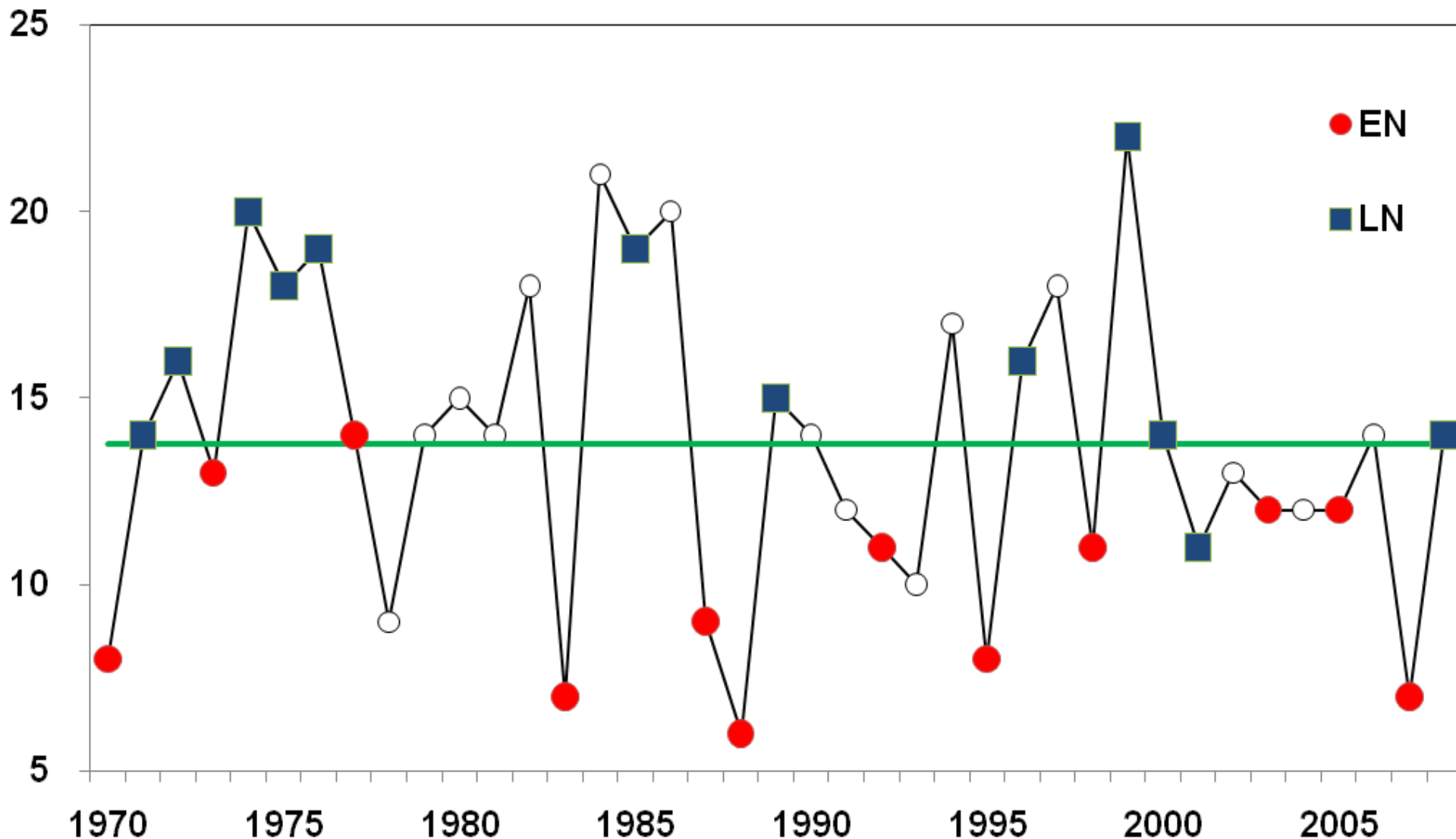
Anomaly of no. of intense TCs



Tropical Cyclone Activity in the Southern Hemisphere

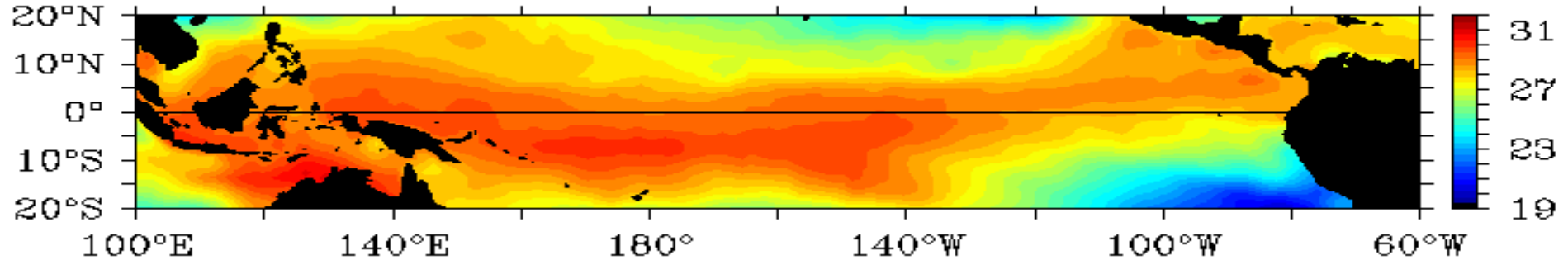


Tropical Cyclone Activity in the Australian region

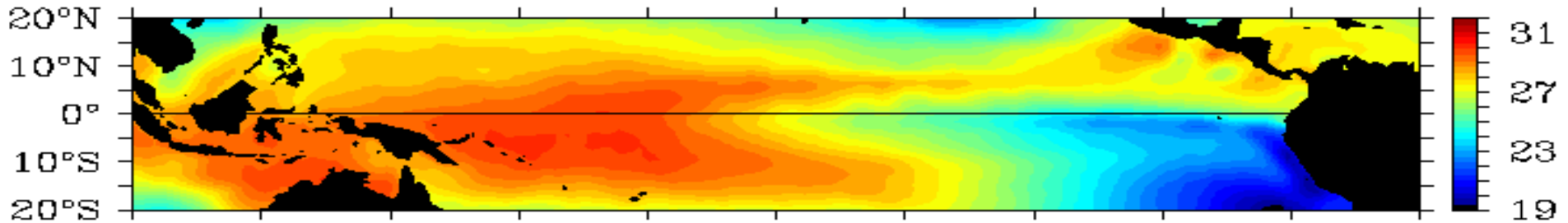


El Niño/Southern Oscillation (ENSO)

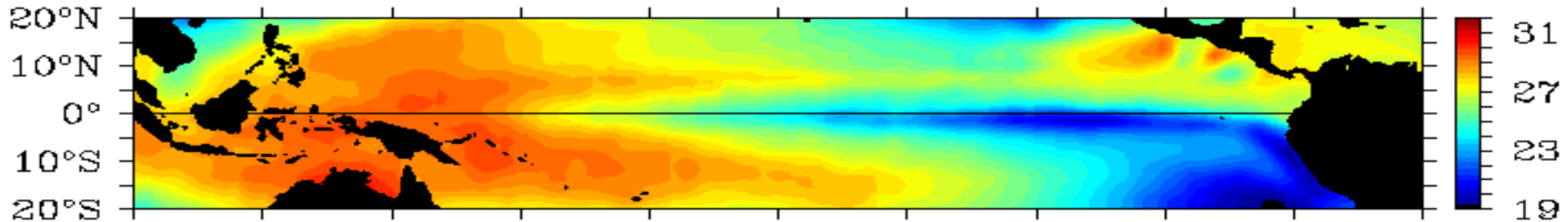
El Niño Conditions December 1997



Normal Conditions December 1990

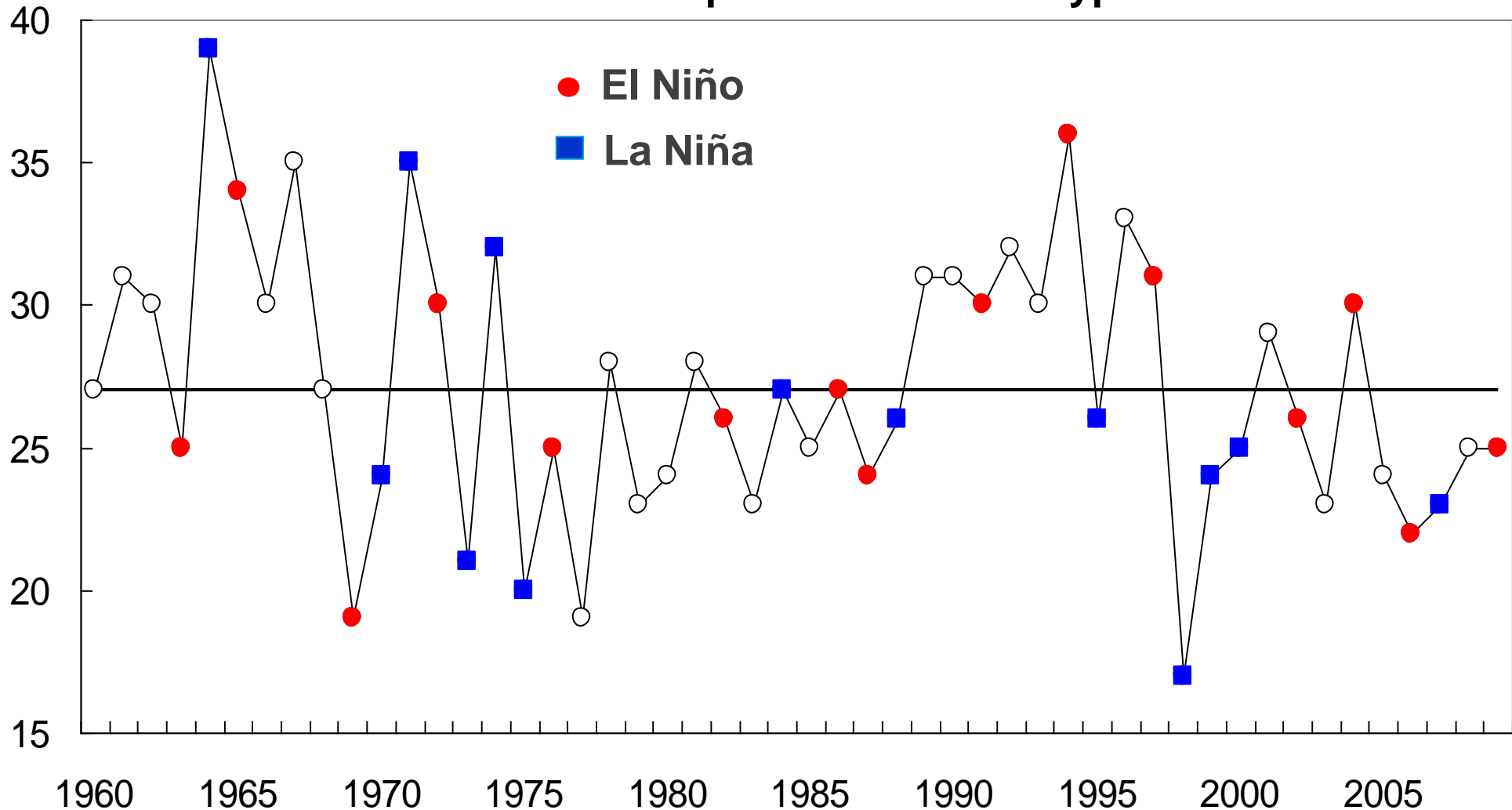


La Nina Conditions December 1988



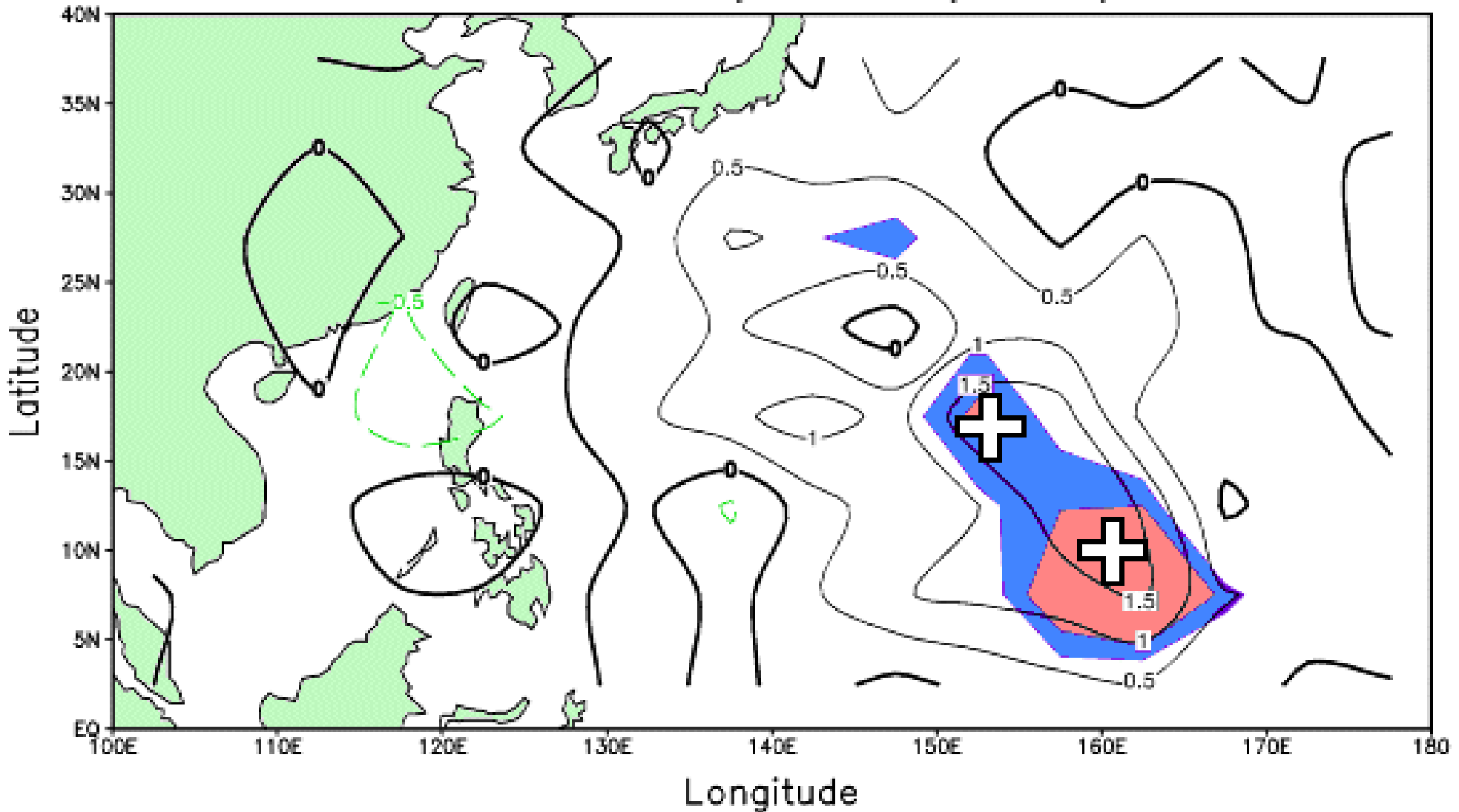
No. of TCs in the western North Pacific

Annual number of tropical storms and typhoons



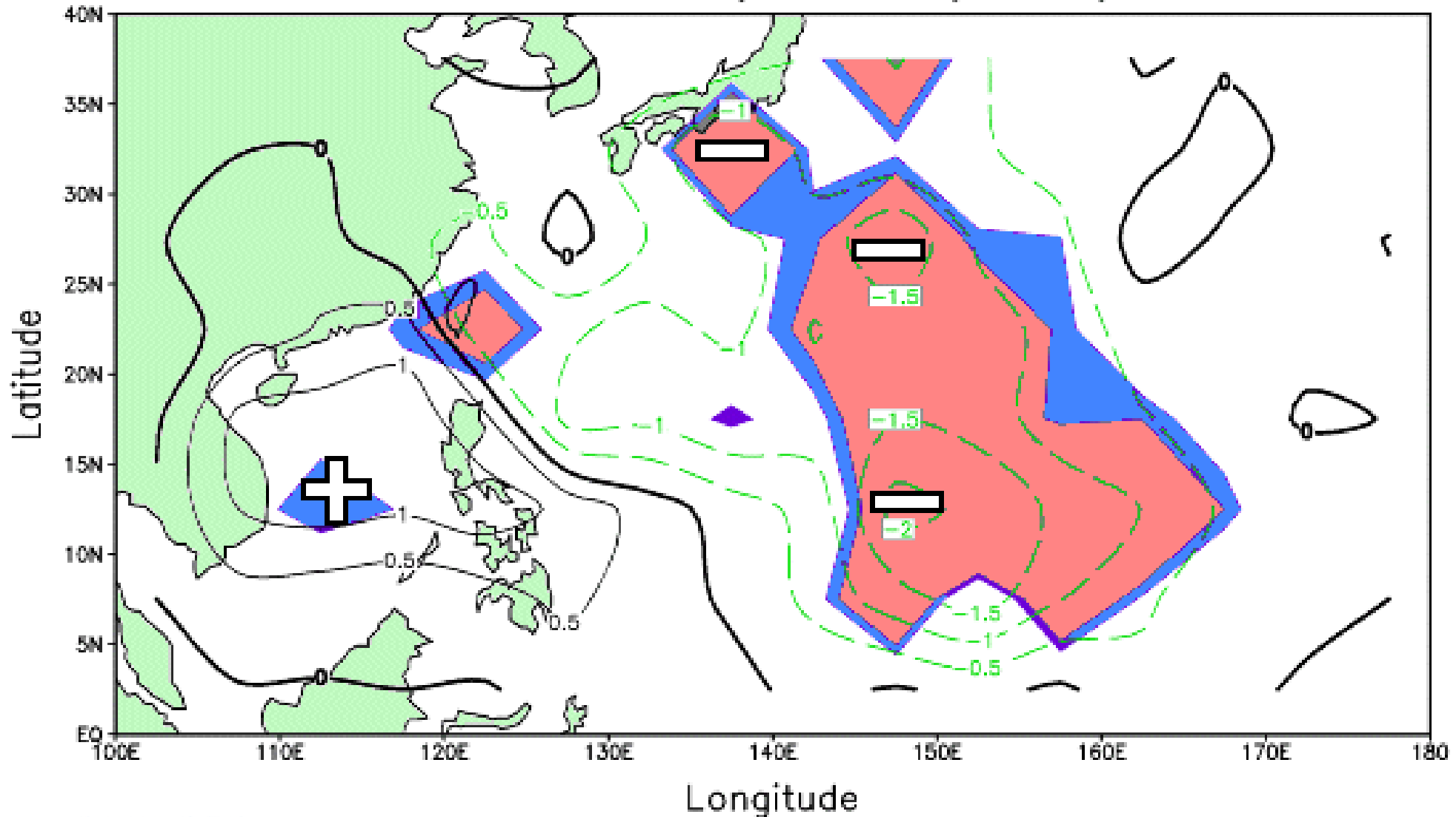
Anomalies in TC Activity During an El Niño year

Annual TC activity anomaly, EN year



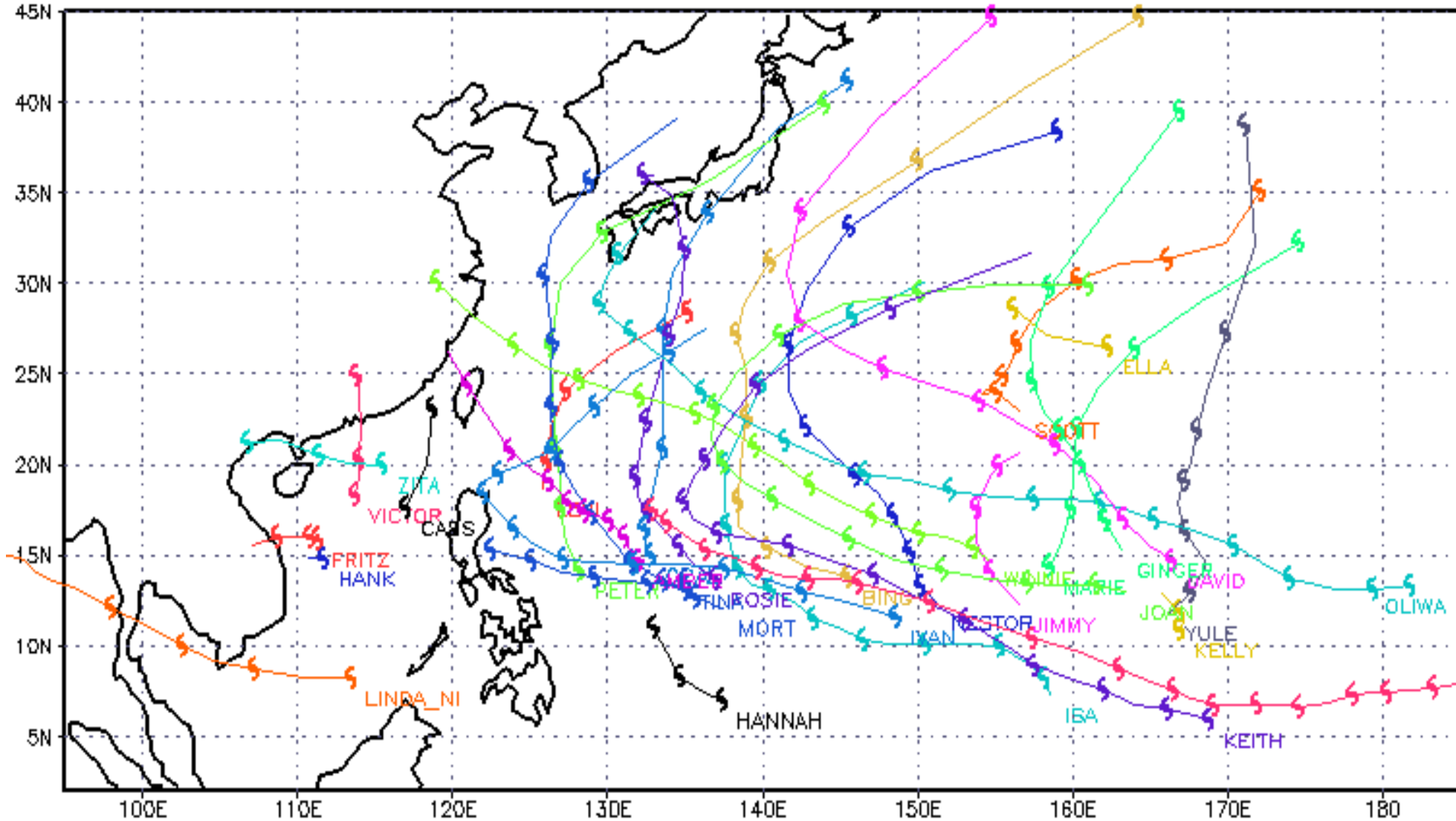
Anomalies in TC Activity During an La Niña year

Annual TC activity anomaly, LN year



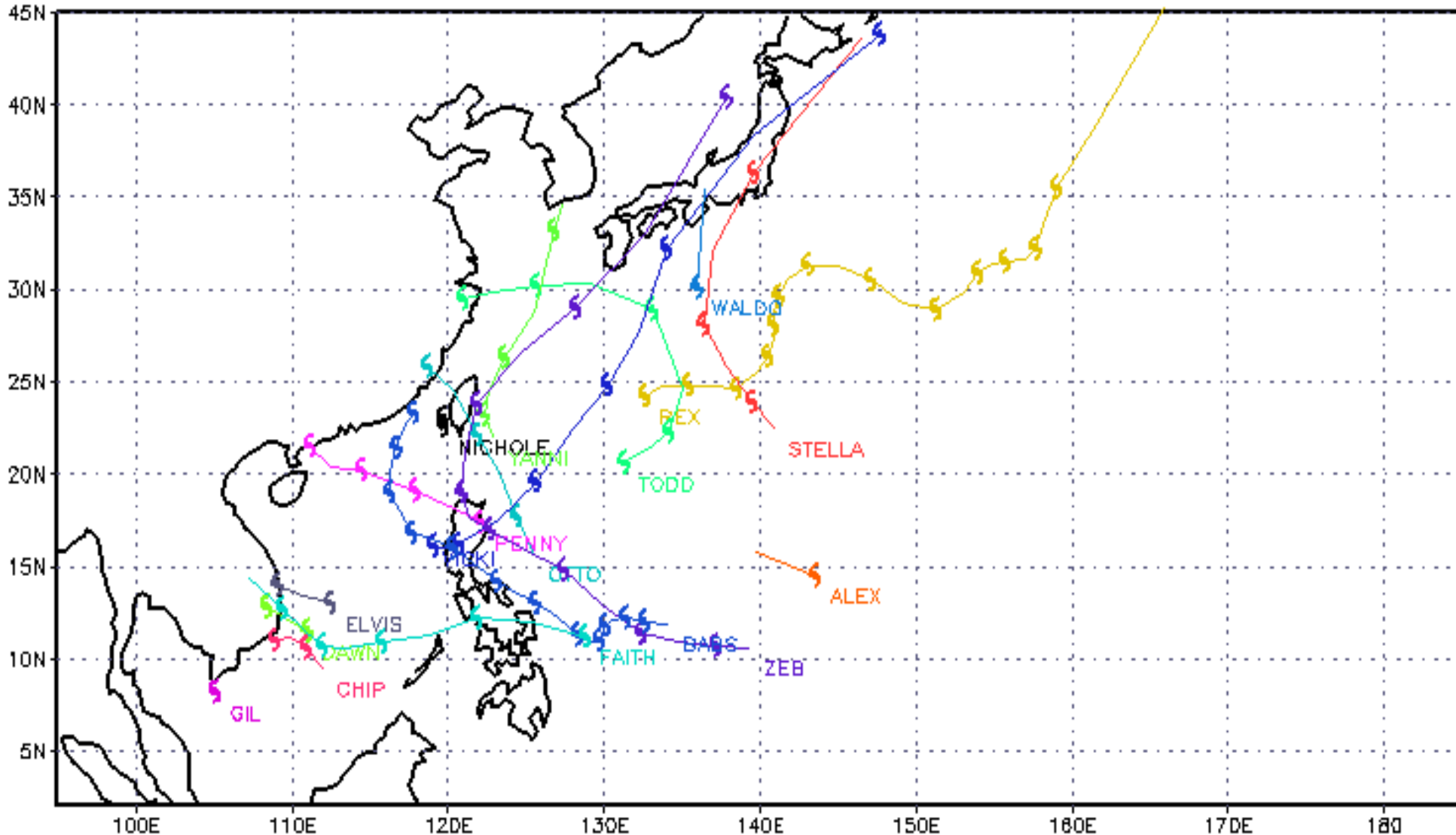
Western North Pacific TCs in 1997 – an El Niño year

OBSERVED TRACKS of TROPICAL CYCLONES in the NORTH-WEST PACIFIC BASIN

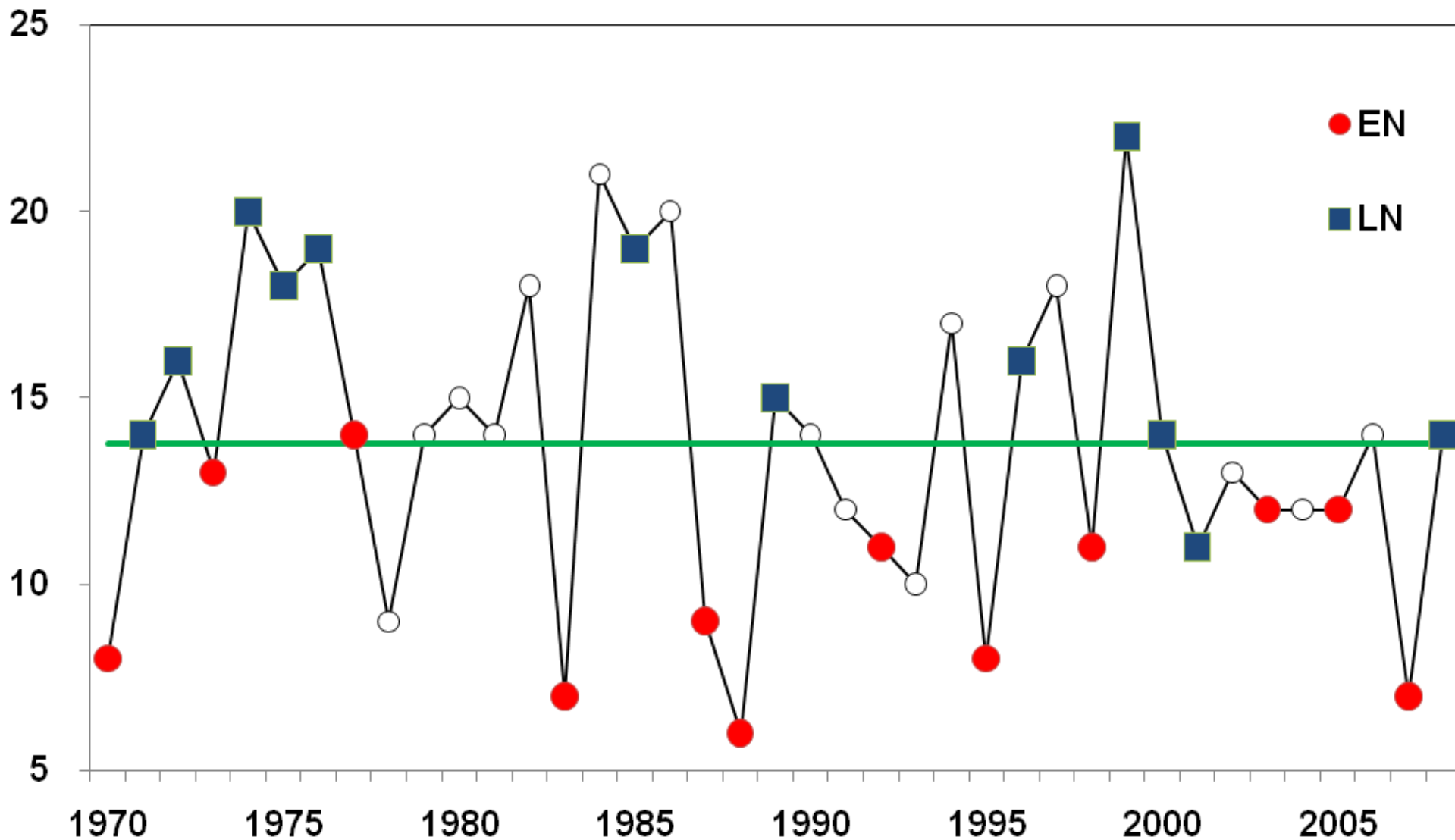


Western North Pacific TCs in 1998 – a La Niña year

OBSERVED TRACKS of TROPICAL CYCLONES in the NORTH-WEST PACIFIC BASIN

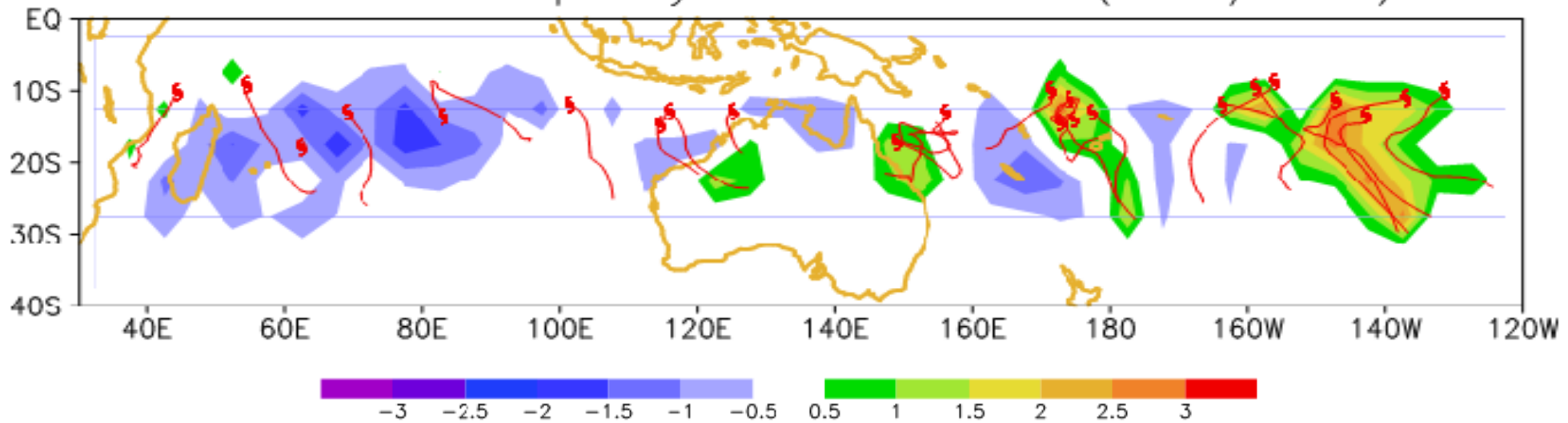


Tropical Cyclone Activity in the Australian region

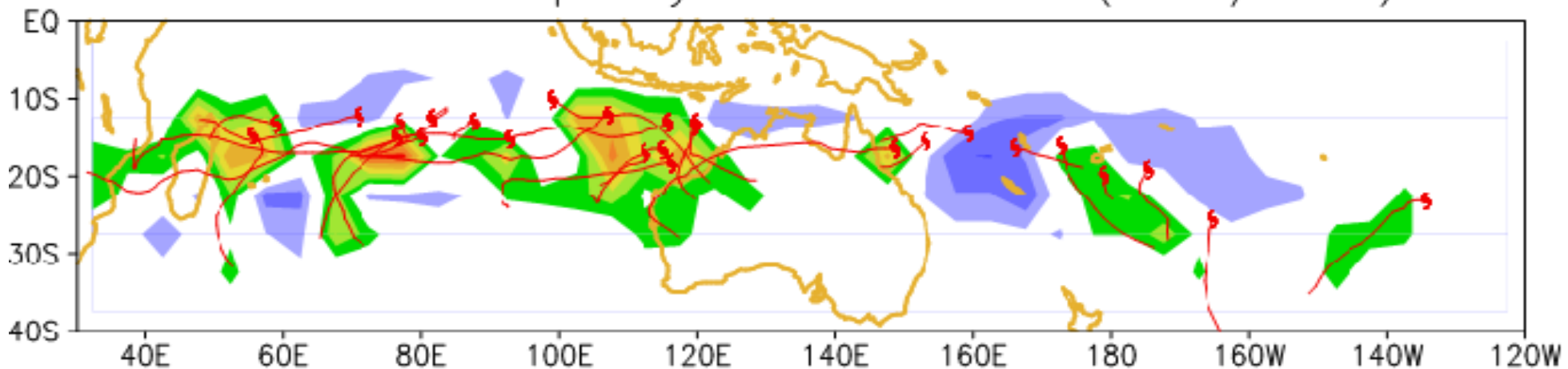


Typical Examples in El Niño and La Niña years

Anomalous frequency of occurrence (1982/1983) **El Niño**

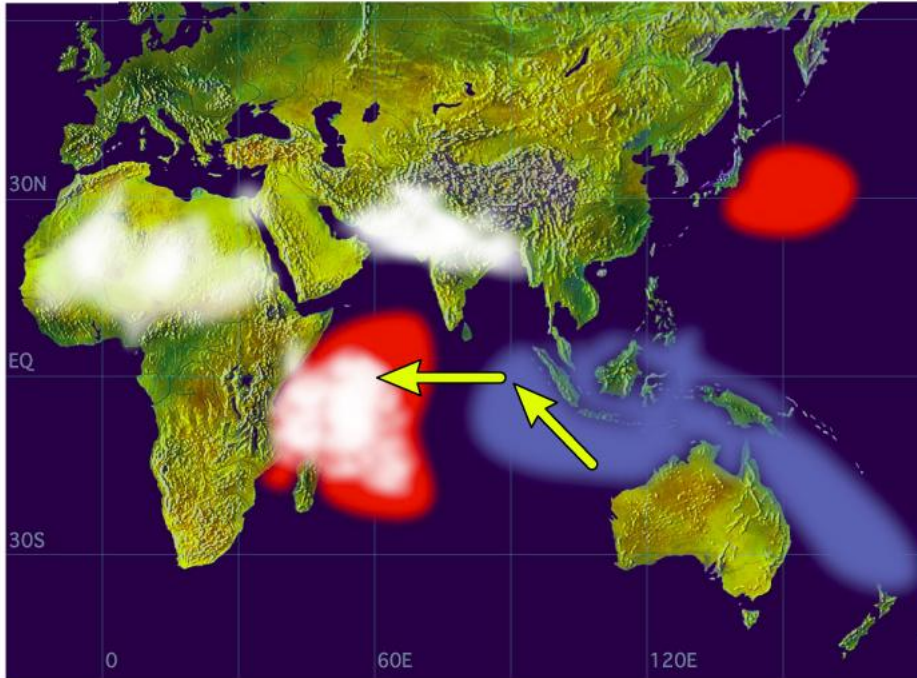


Anomalous frequency of occurrence (1999/2000) **La Niña**



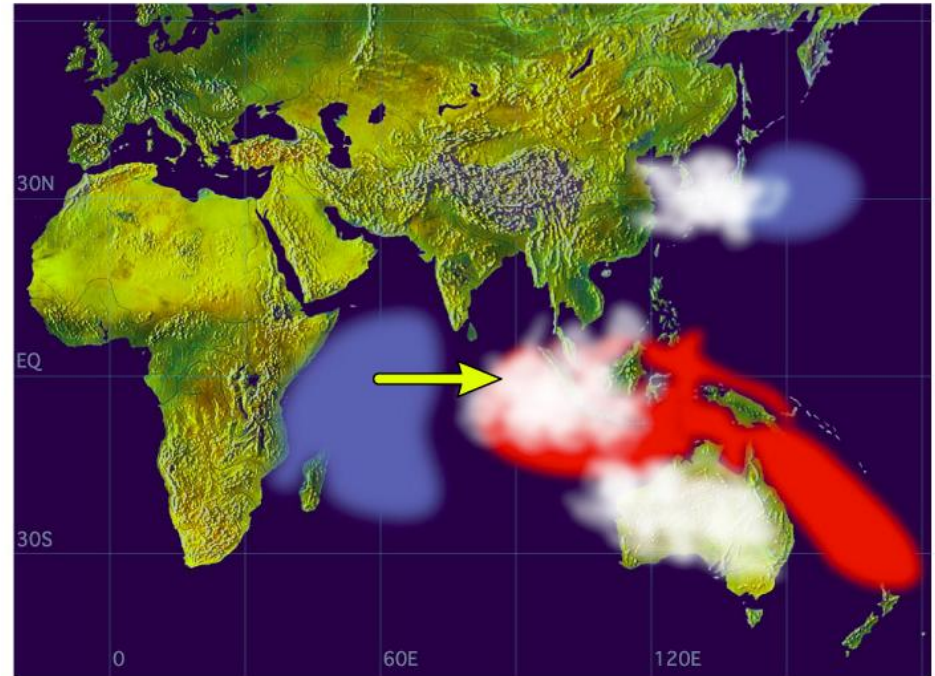
Indian Ocean Dipole

Positive Dipole Mode



positive mode

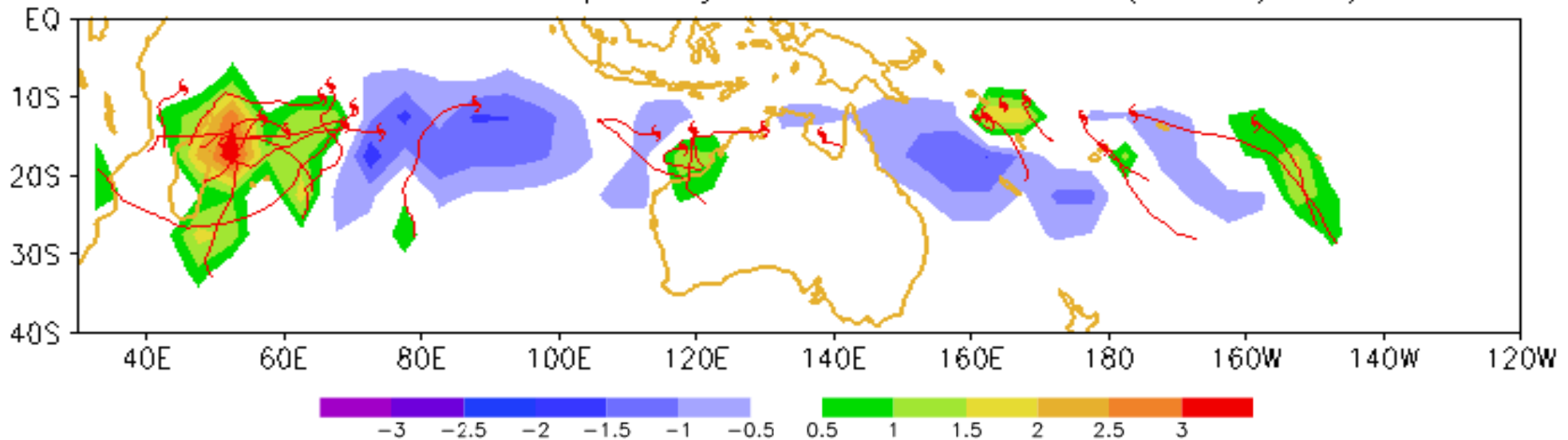
Negative Dipole Mode



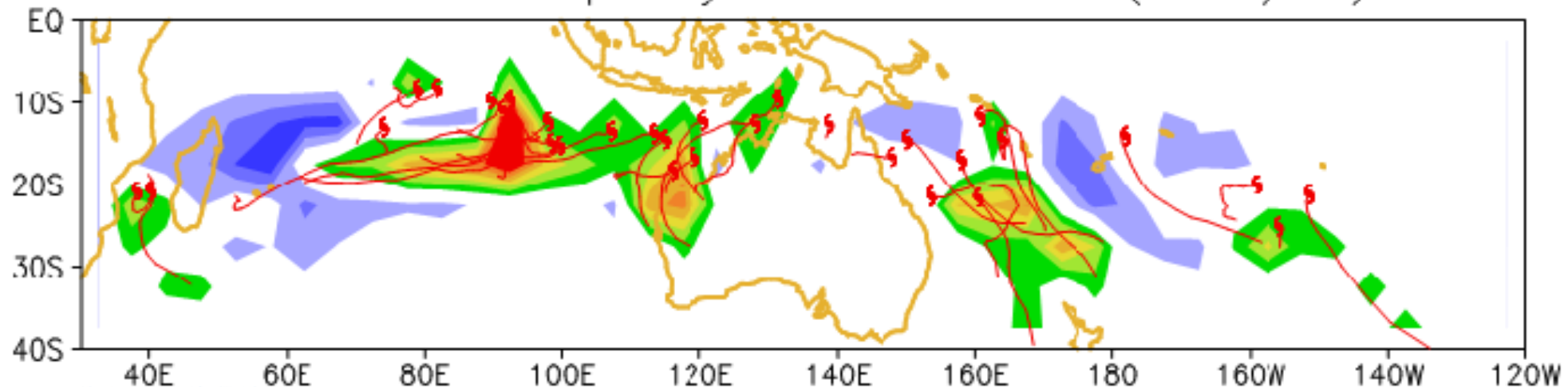
negative mode

Typical Tracks in IOD+ and IOD- years

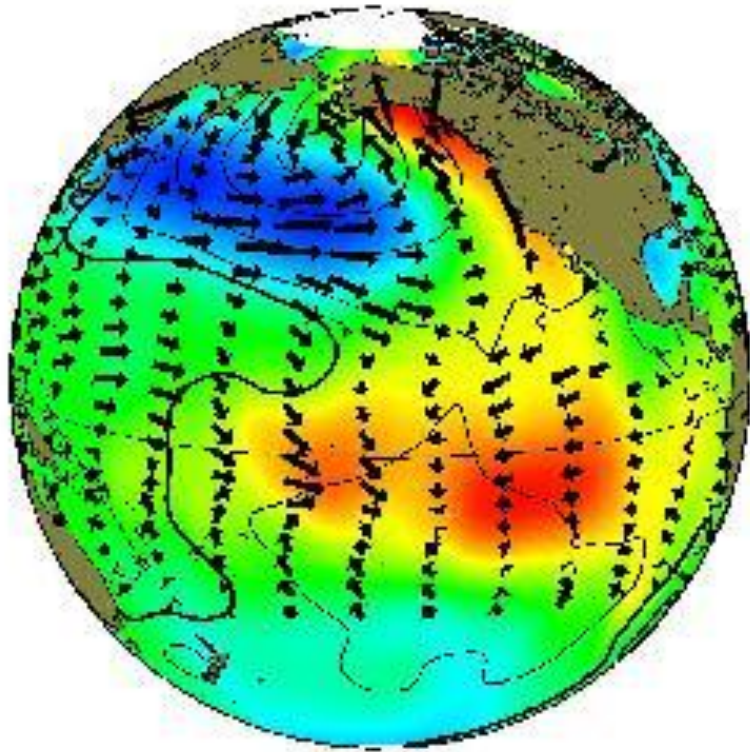
Anomalous frequency of occurrence (2006/07) **IOD+**



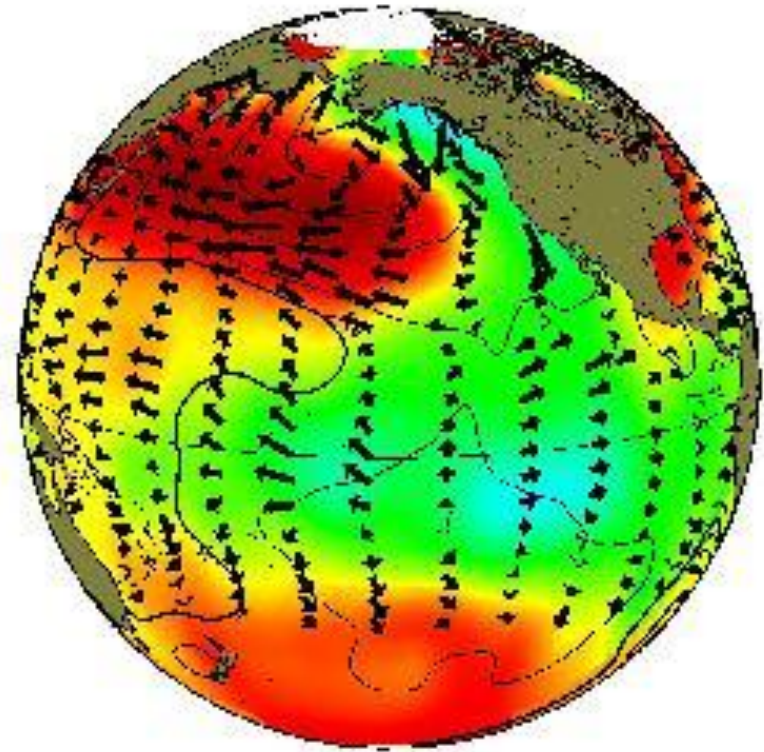
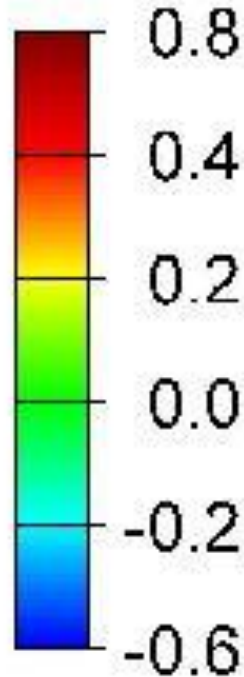
Anomalous frequency of occurrence (1998/99) **IOD-**



Pacific Decadal Oscillation



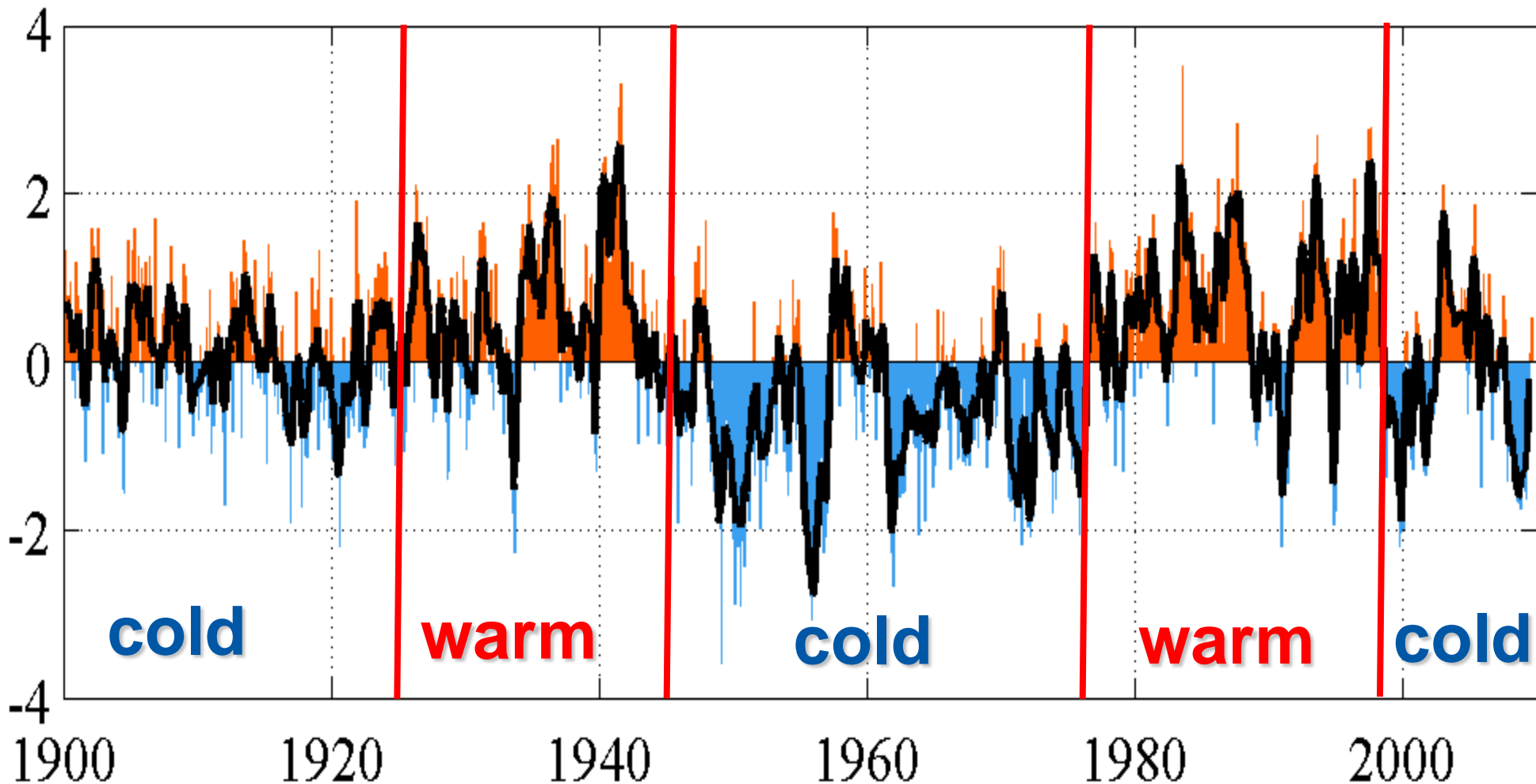
warm phase



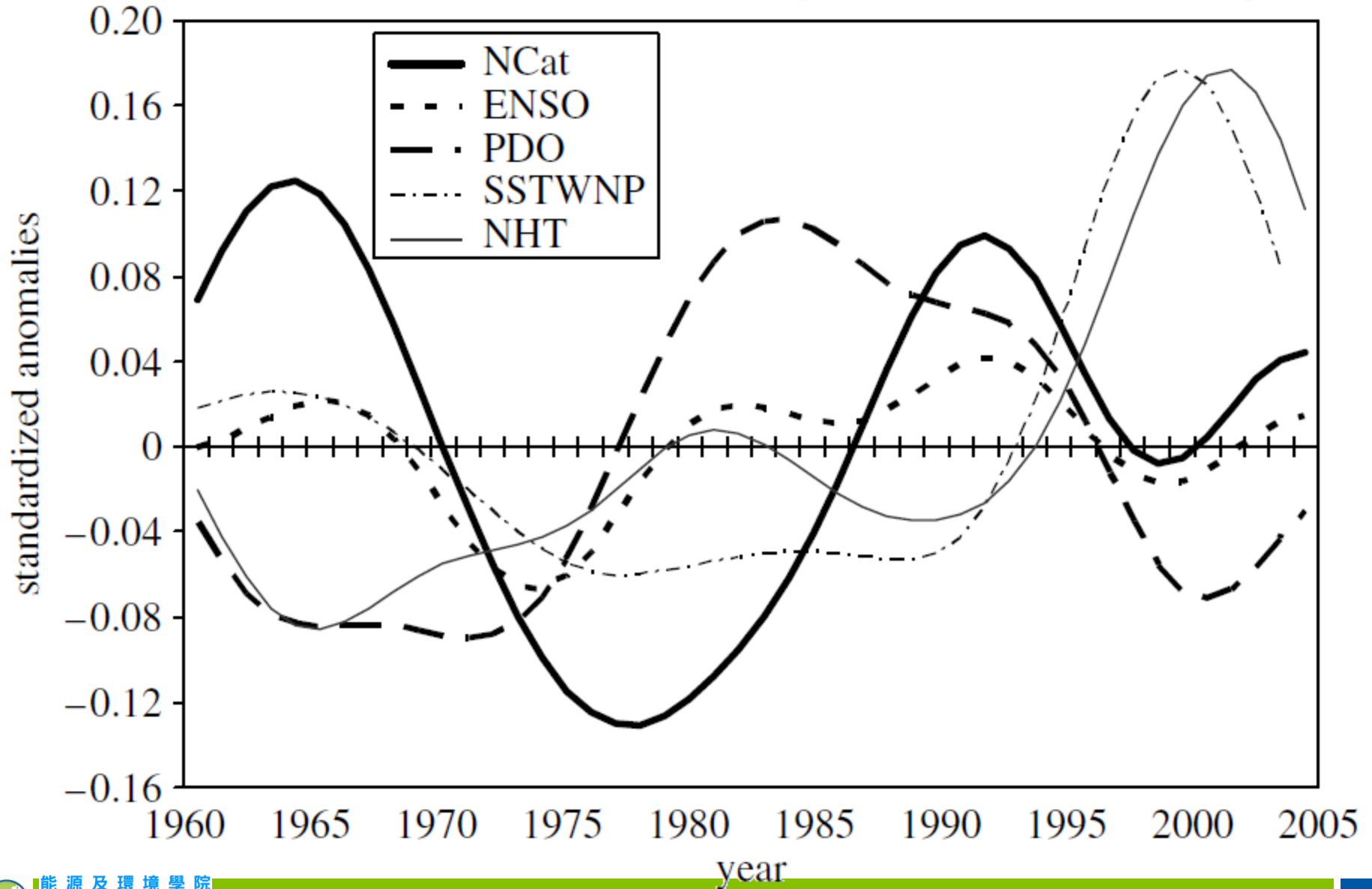
cold phase

Pacific Decadal Oscillation – PDO index

monthly values for the PDO index: 1900-September 2009



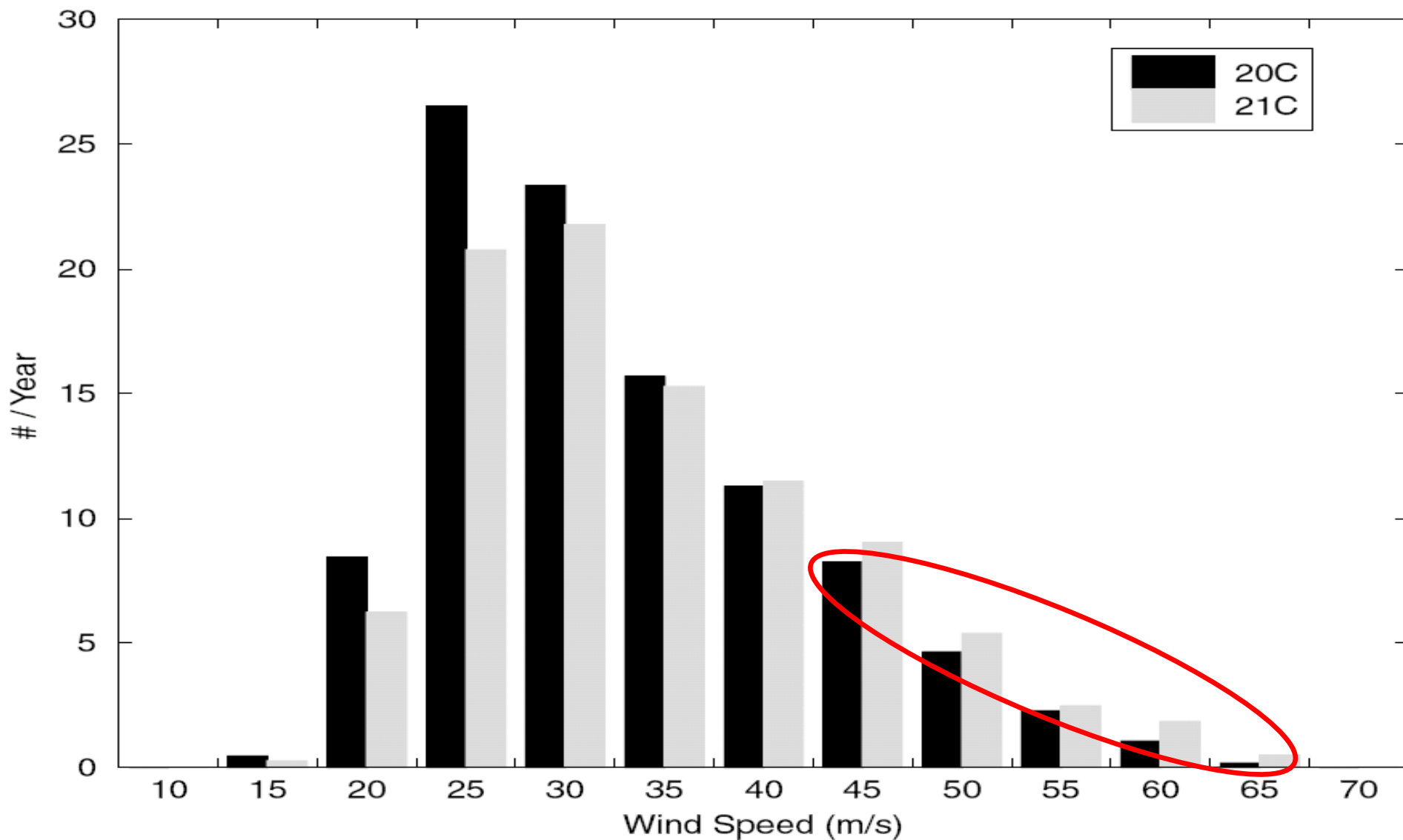
PDO effects on tropical cyclone intensity



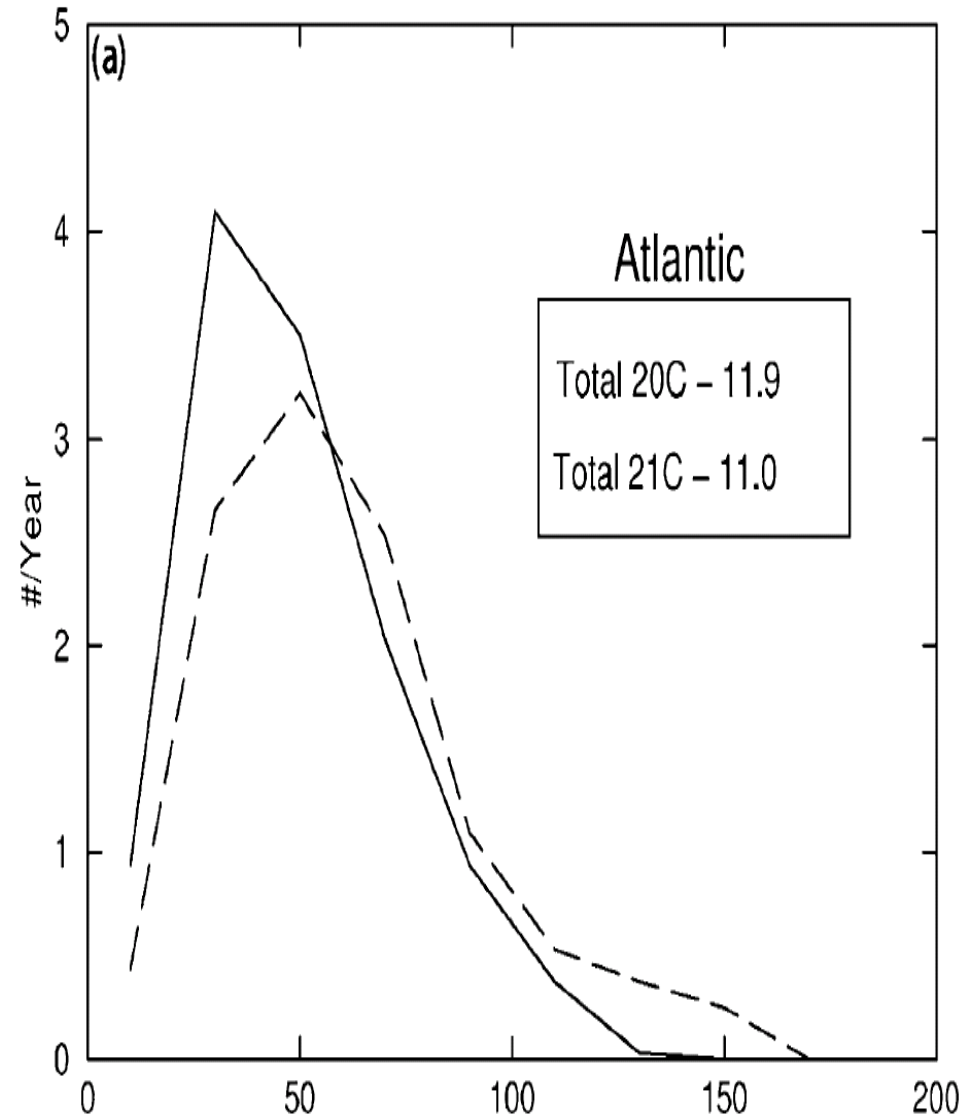
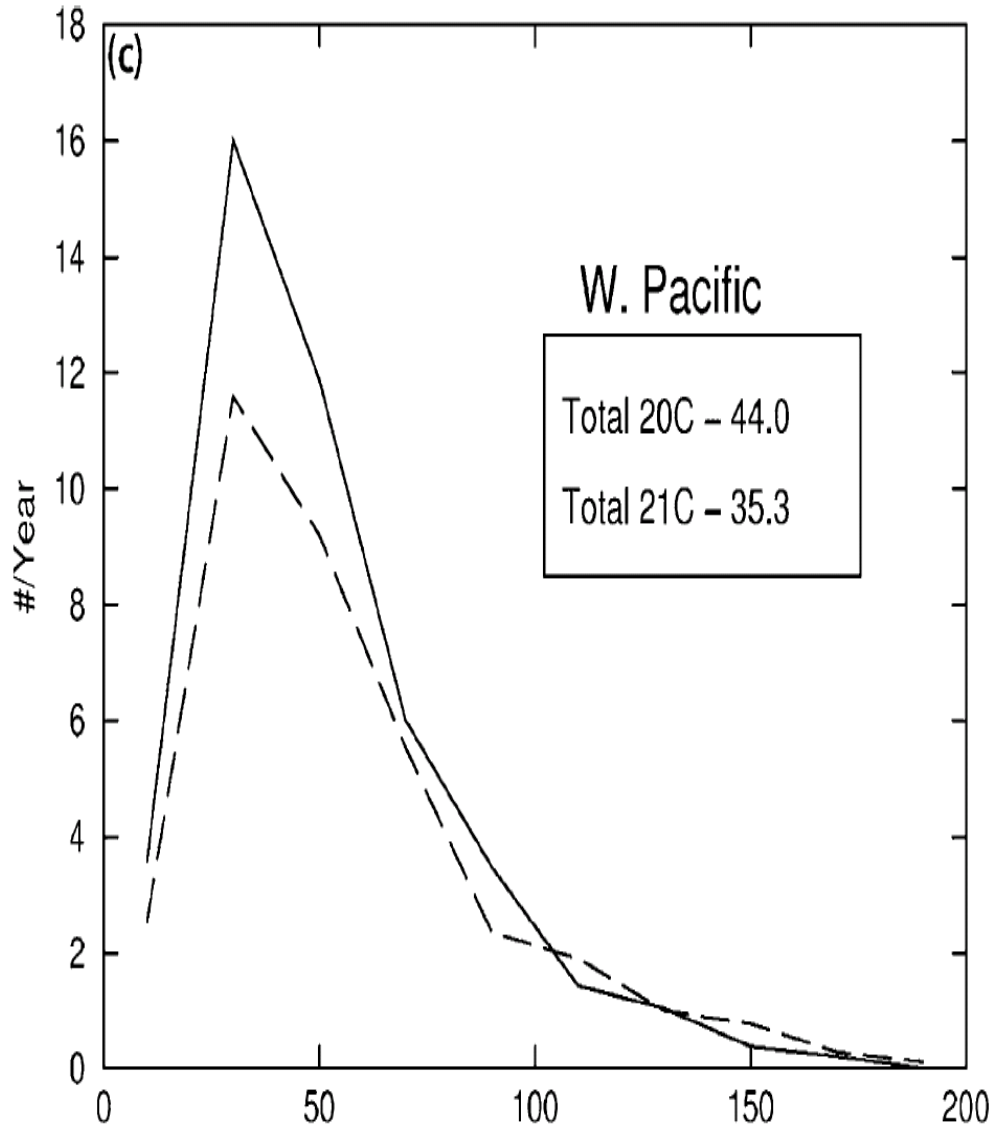
Ratio (%) of number of tropical storms in global warming experiment to number without global warming

Experiment	Blue/red: statistically-significant values								
	Global	NH	SH	N Atl.	WN Pac.	Ocean basin			
						NE Pac.	N Indian	S Indian	SW Pac.
10y 1xCO ₂ , 2xCO ₂	66	72	61	161	34	33	109	43	69
10y 1xCO ₂ 2xCO ₂ from 115y CO ₂ 1% pa	102			86	111	91	116	124	99
15y IS95a 2082-2097	94	97	90	75	70	180	142	110	82
10y A1B 2080-2099	70	72	68	134	62	66	48	72	57
2071-2100, A1B		92		92	80	104	74		
2071-2100, A1B		90		87	72	93	49		
A1B, 2180-2200			86	102	106	95	92		

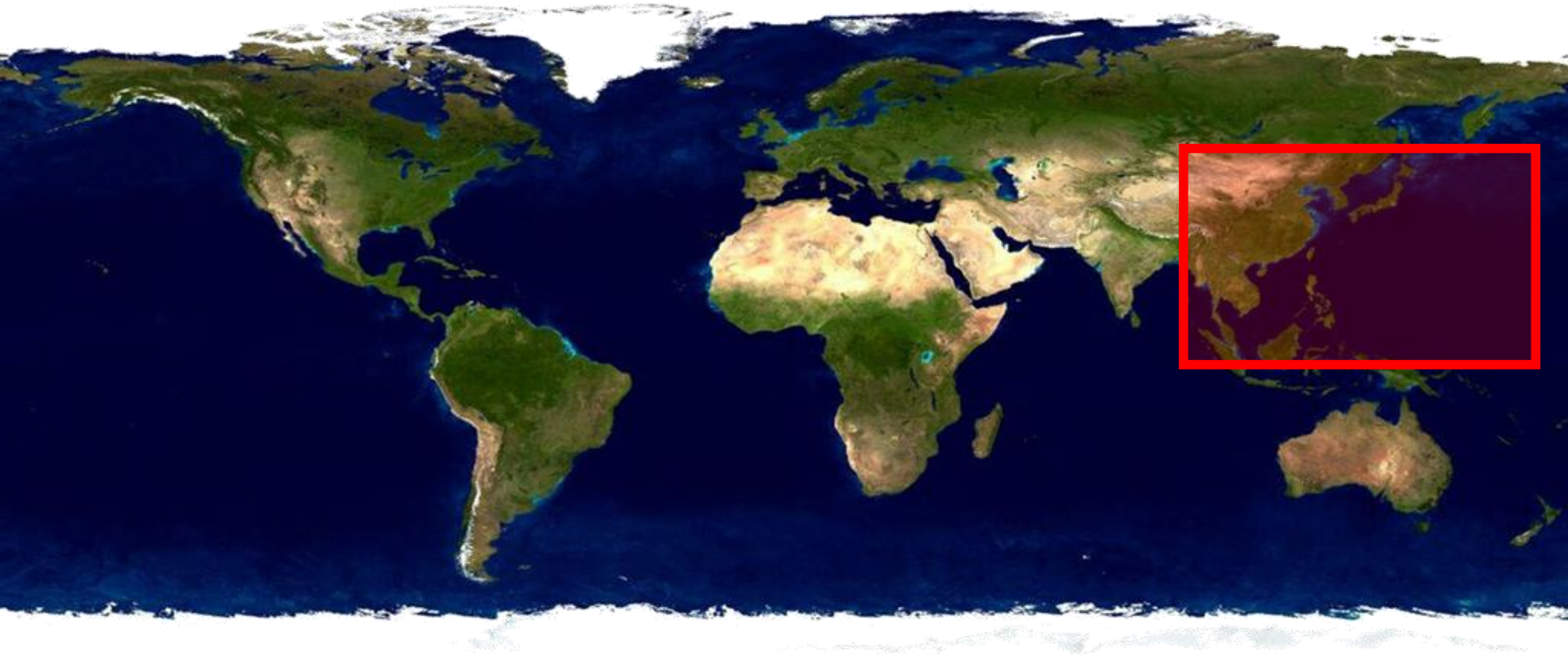
Distribution of Maximum Wind Speeds for 20th and 21st Century Simulations (Northern Hemisphere)



Distribution of Maximum Rotation for 20th and 21st Century Simulations

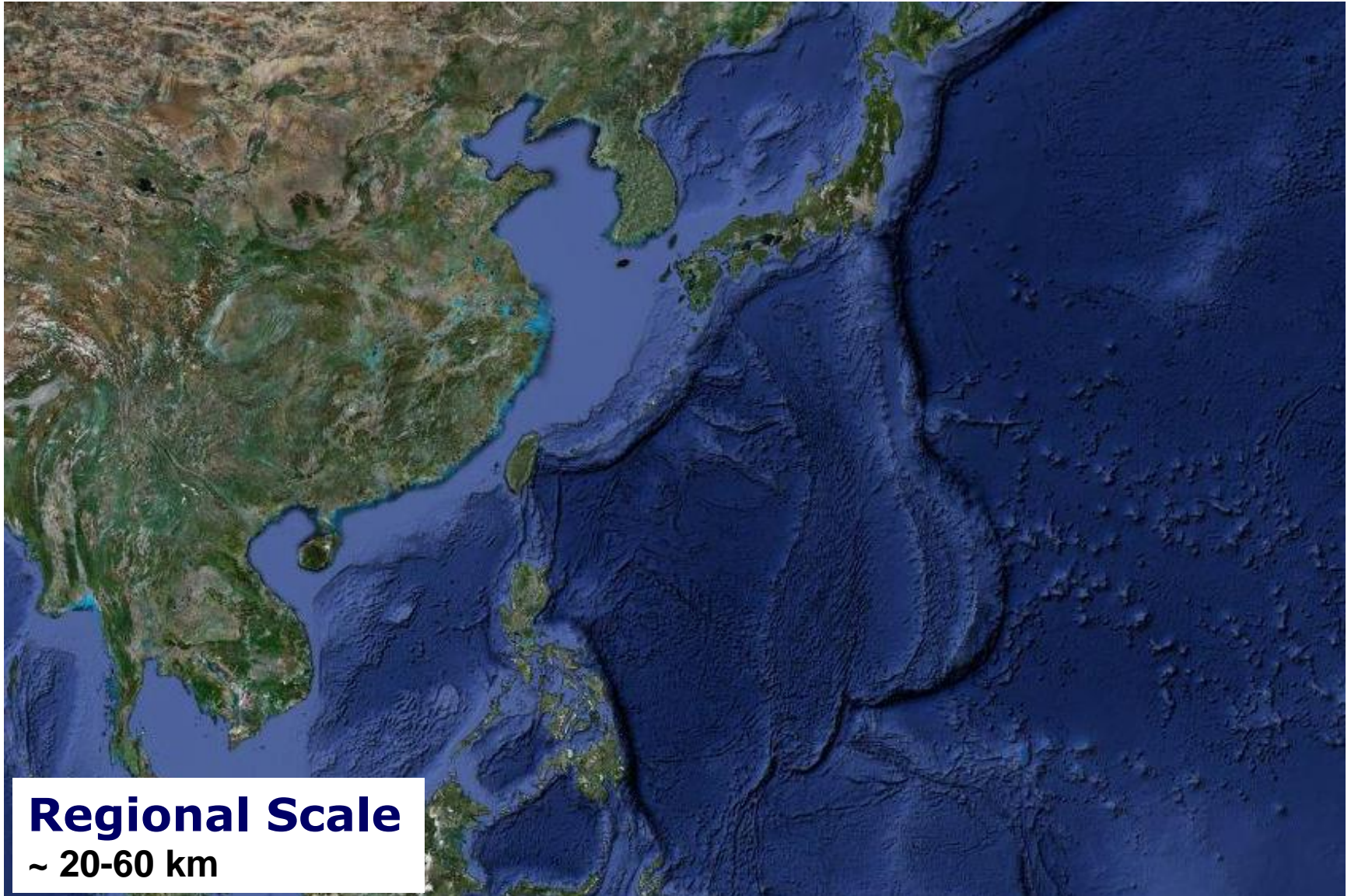


Dynamical downscaling

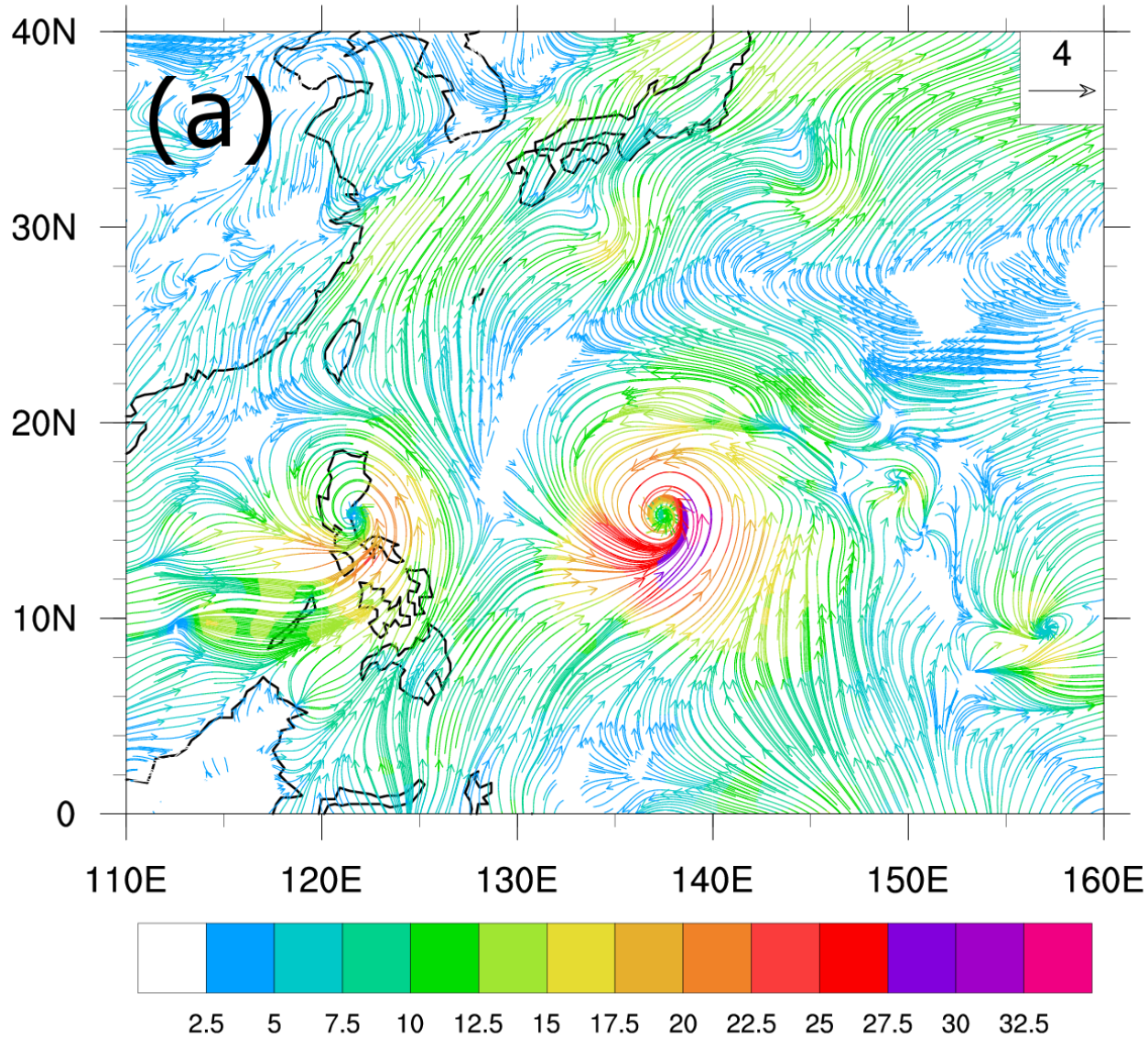


Global Scale, ~ 200 km

Dynamical downscaling

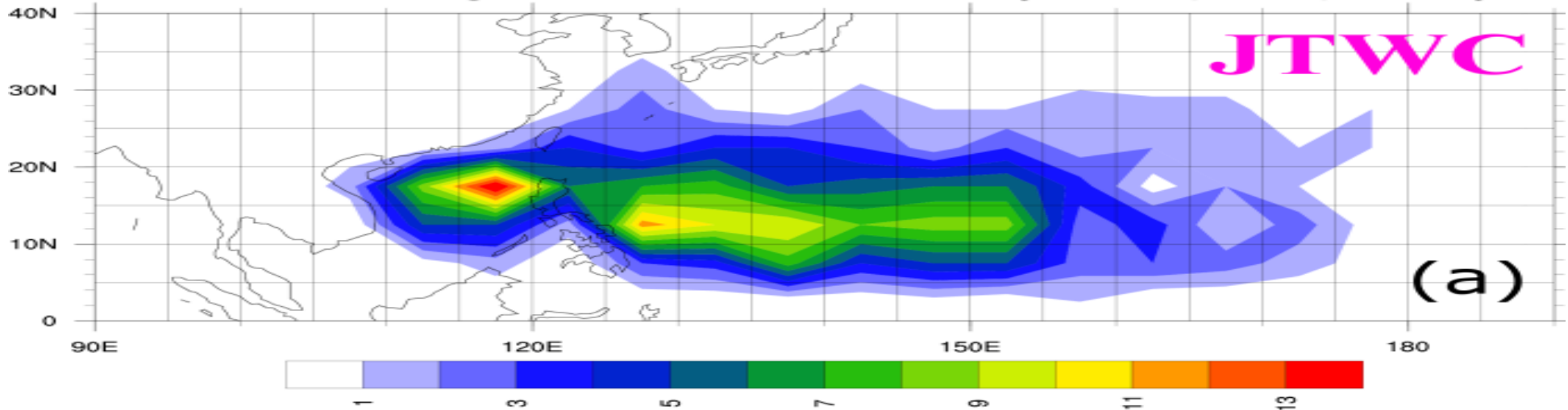


Example of a tropical cyclone in the model

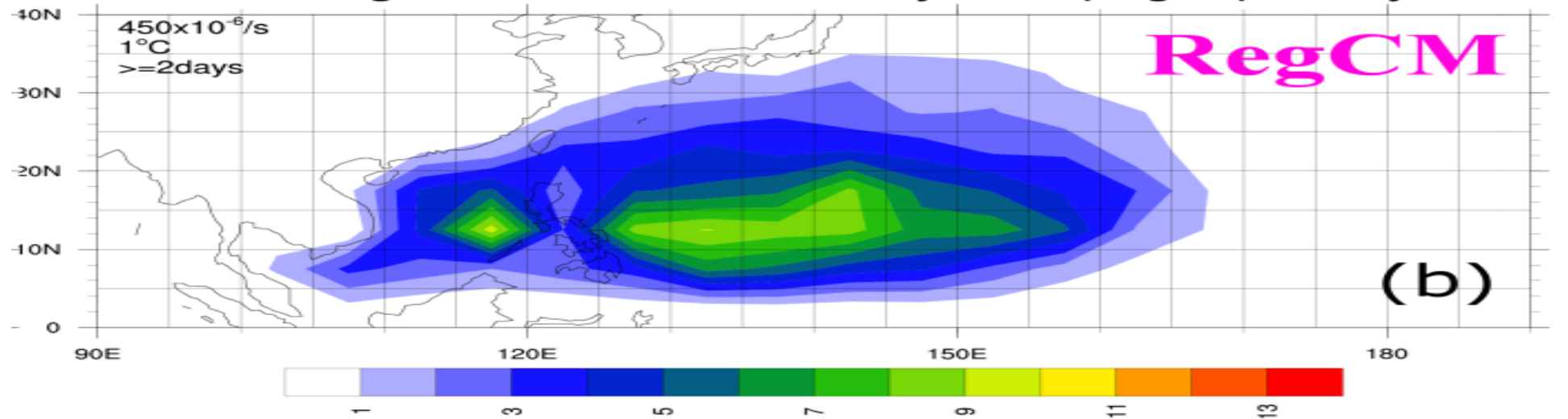


Model Climatology (1982-2001, May to Oct)

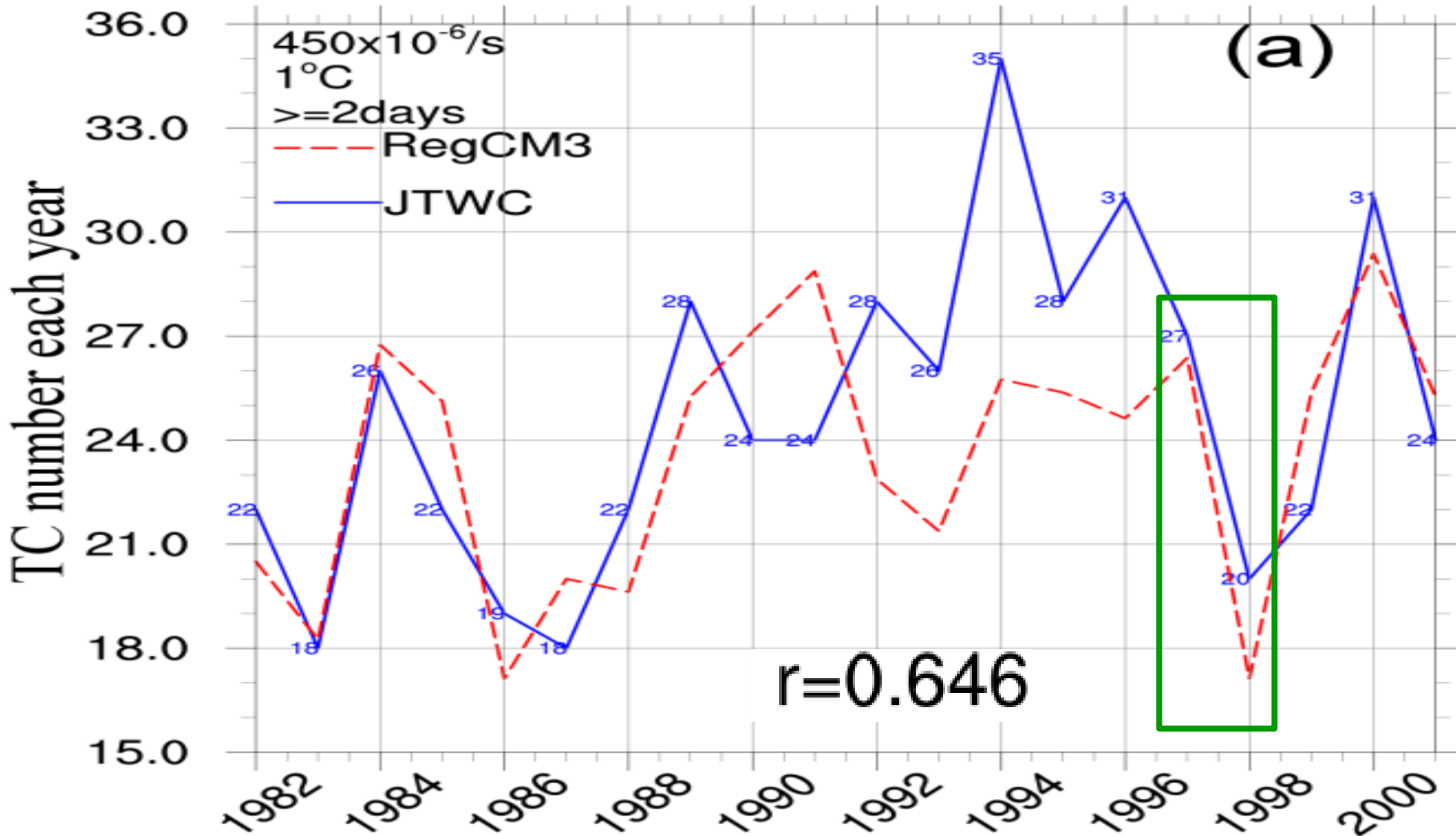
annual-mean TC genesis in 1982 to 2001 may to oct (JTWC) 5° / 10yrs



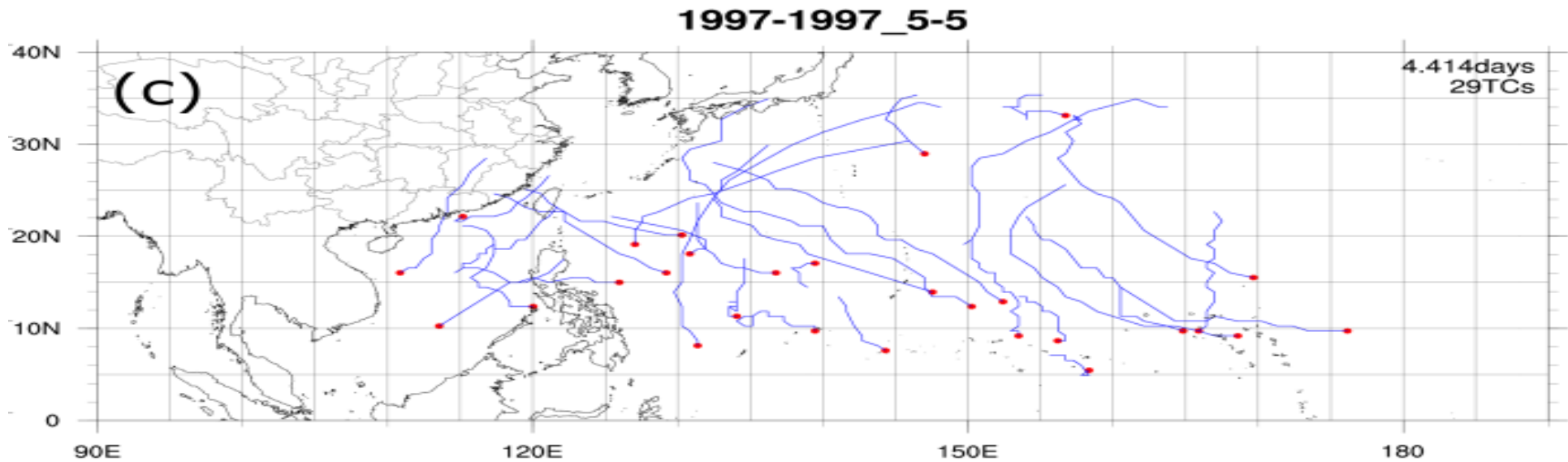
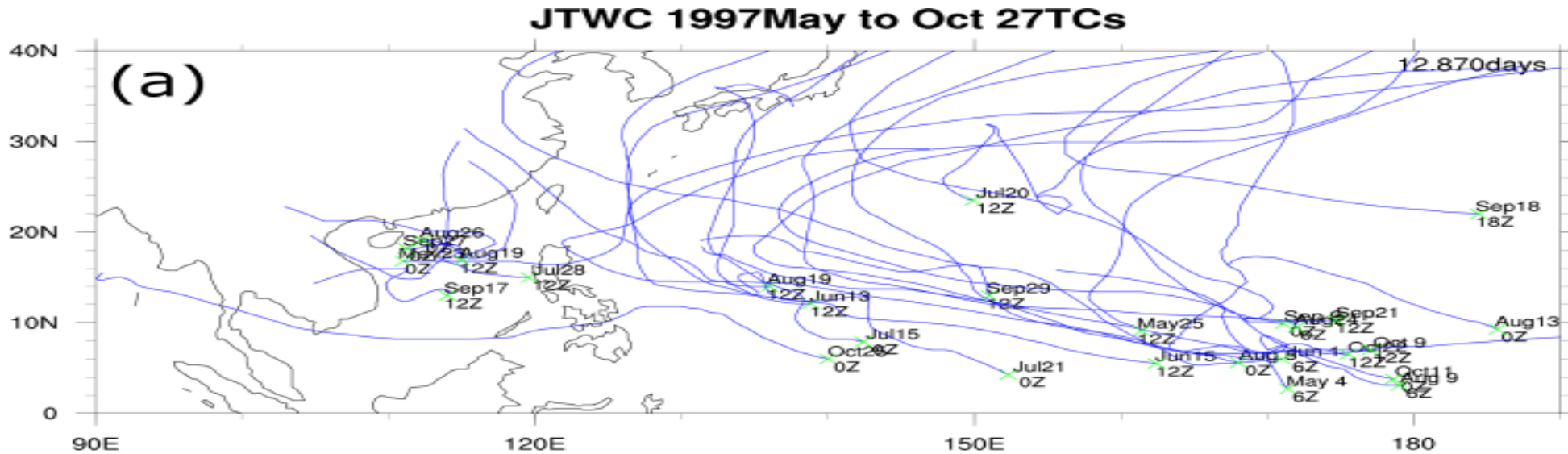
mean TC genesis in 1982 to 2001 may to oct (RegCM) 5° / 10yrs



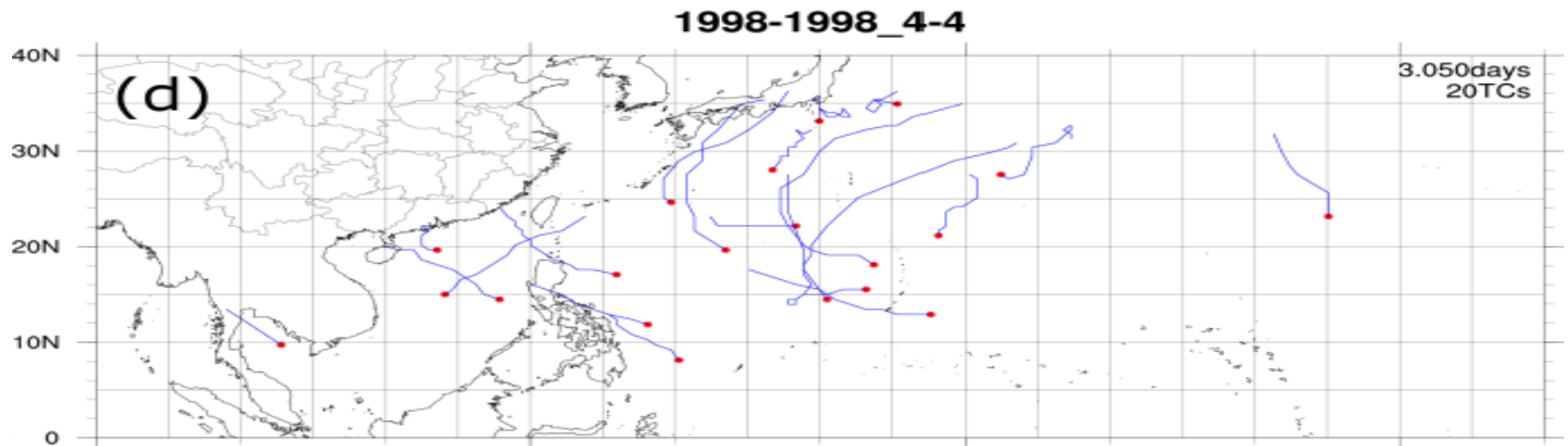
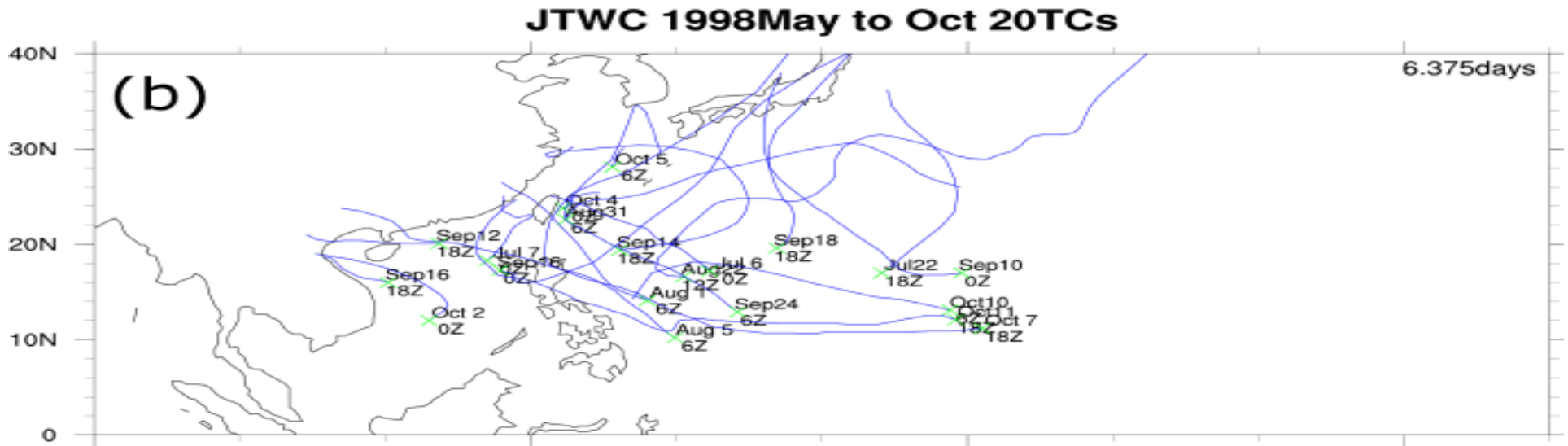
Model Climatology (1982-2001, May to Oct)



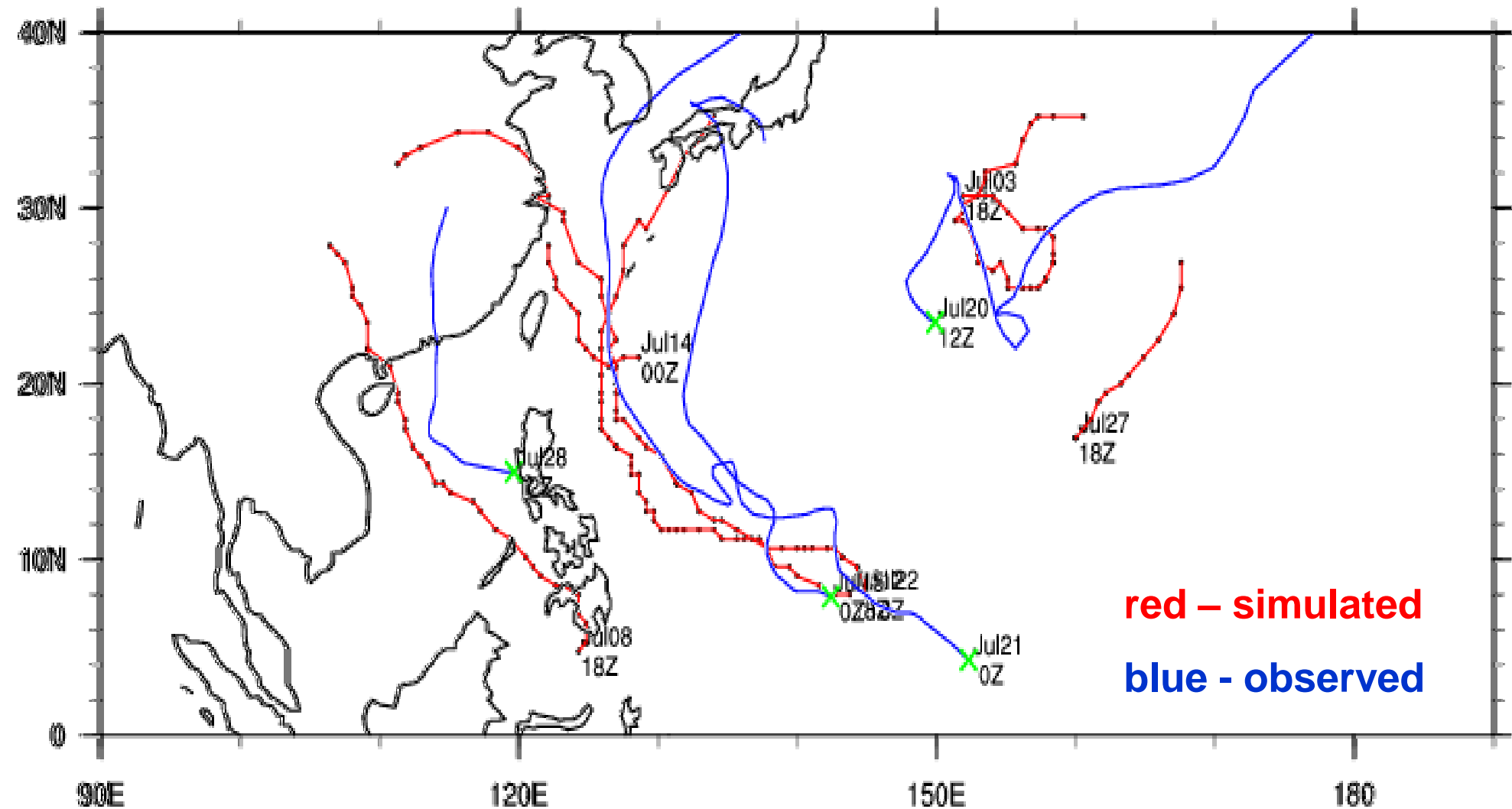
Model vs. Observed (1997, May to Oct)



Model vs. Observed (1998, May to Oct)



Example of simulation of a 3-month forecast



Summary

- **Tropical cyclone activity does not show any trend in any of the Asia-Pacific ocean basins. In other words, global warming is not contributing to the observed variations in TC activity.**
- **Instead, TC activity goes through large-amplitude variations on time scales from a few years to a few decades.**

Summary

- **The El Niño phenomenon is an important factor in contributing towards the variations in TC activity in each of the regions, as well as the variations in TC landfall locations.**
- **Other atmospheric and ocean conditions are also likely to affect such variations but more research is necessary to ascertain the physical processes involved.**

Summary

- **Future projections suggest the possibility of higher frequency of intense TCs although the percentage change is small.**
- **Improved predictions of TC activity on a seasonal scale may come through better regional model integrations.**