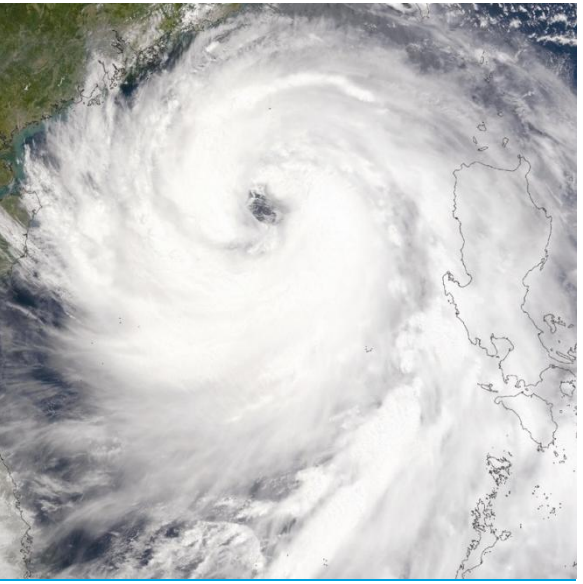
能源及環境學院
SCHOOL OF ENERGY AND ENVIRONMENT

香港城市大學
City University of Hong Kong

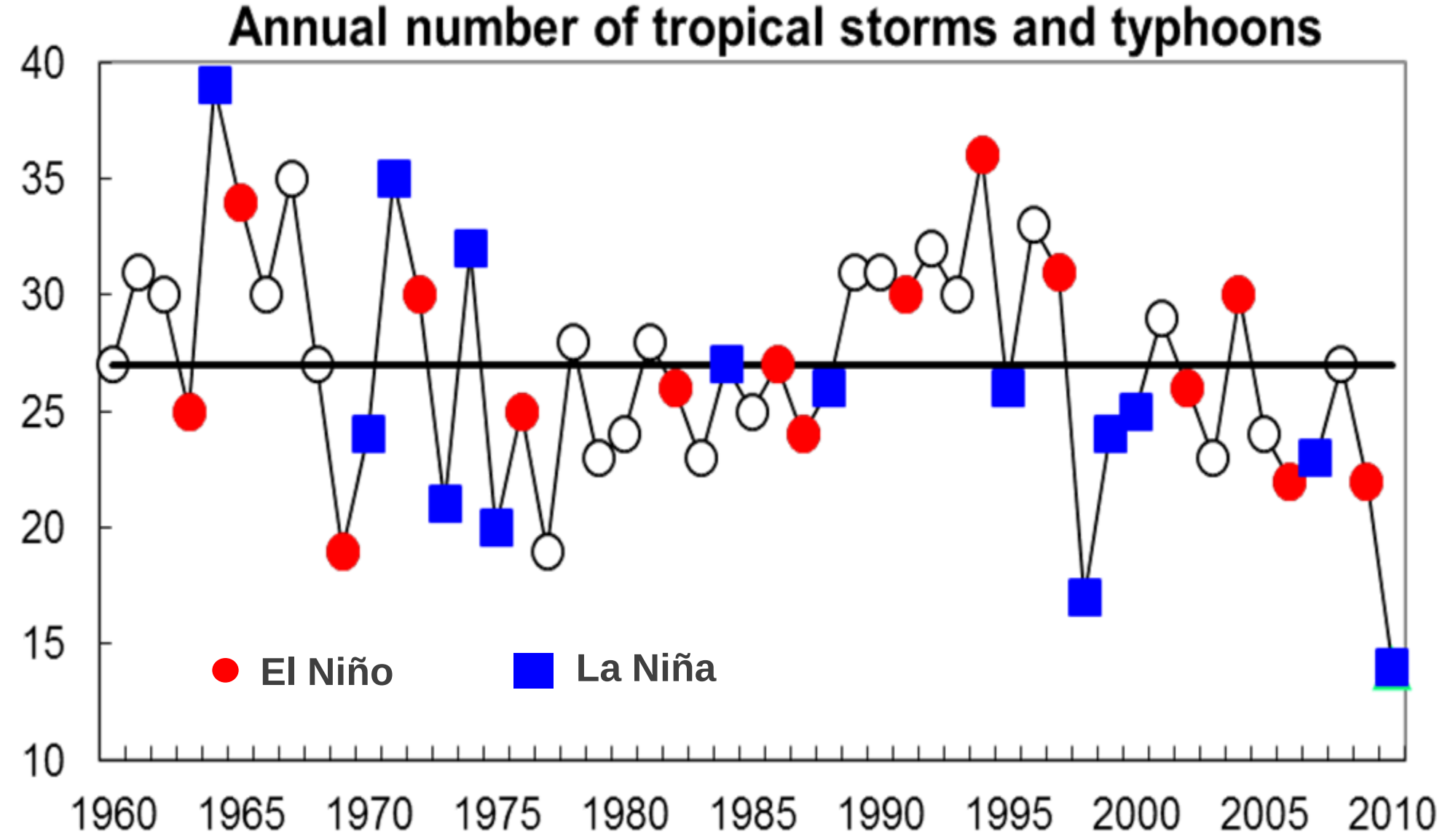


# Tropical Cyclone Climate in the Asia-Pacific Region and the Indian Oceans

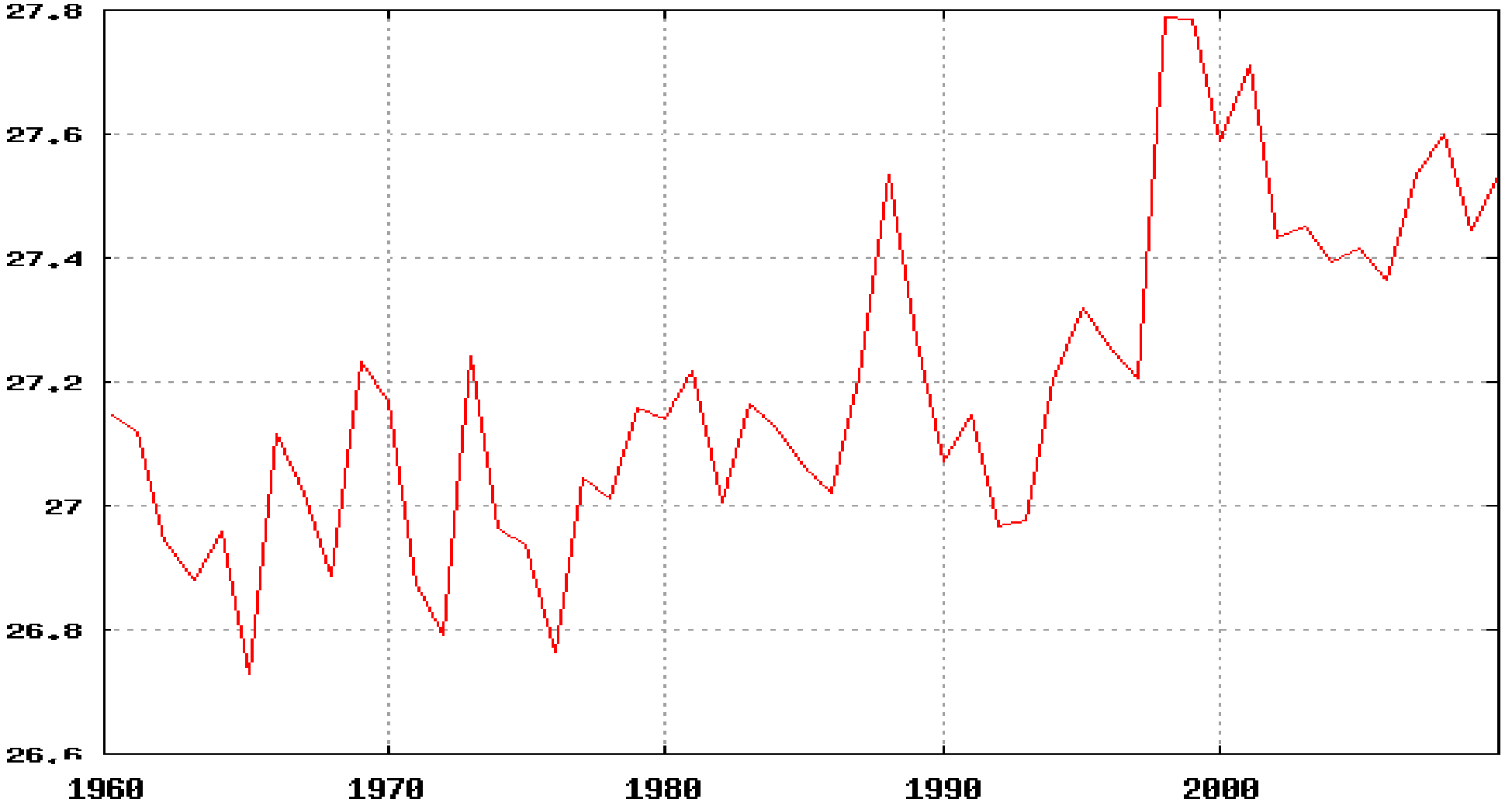

**Johnny Chan**

*Guy Carpenter Asia-Pacific Climate Impact Centre*
*School of Energy and Environment*
*City University of Hong Kong*

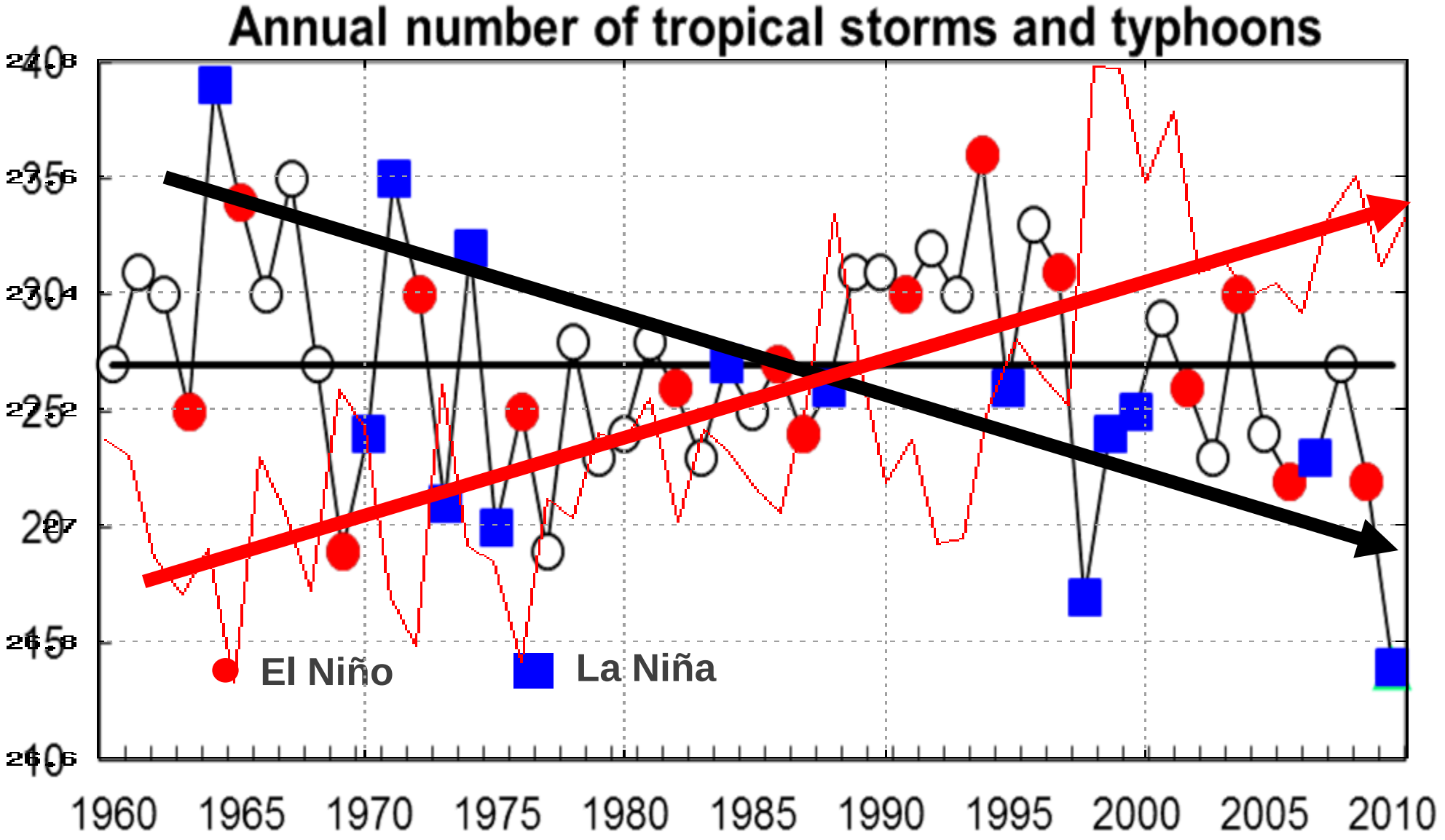
# Annual No. of TS & TY in the western North Pacific



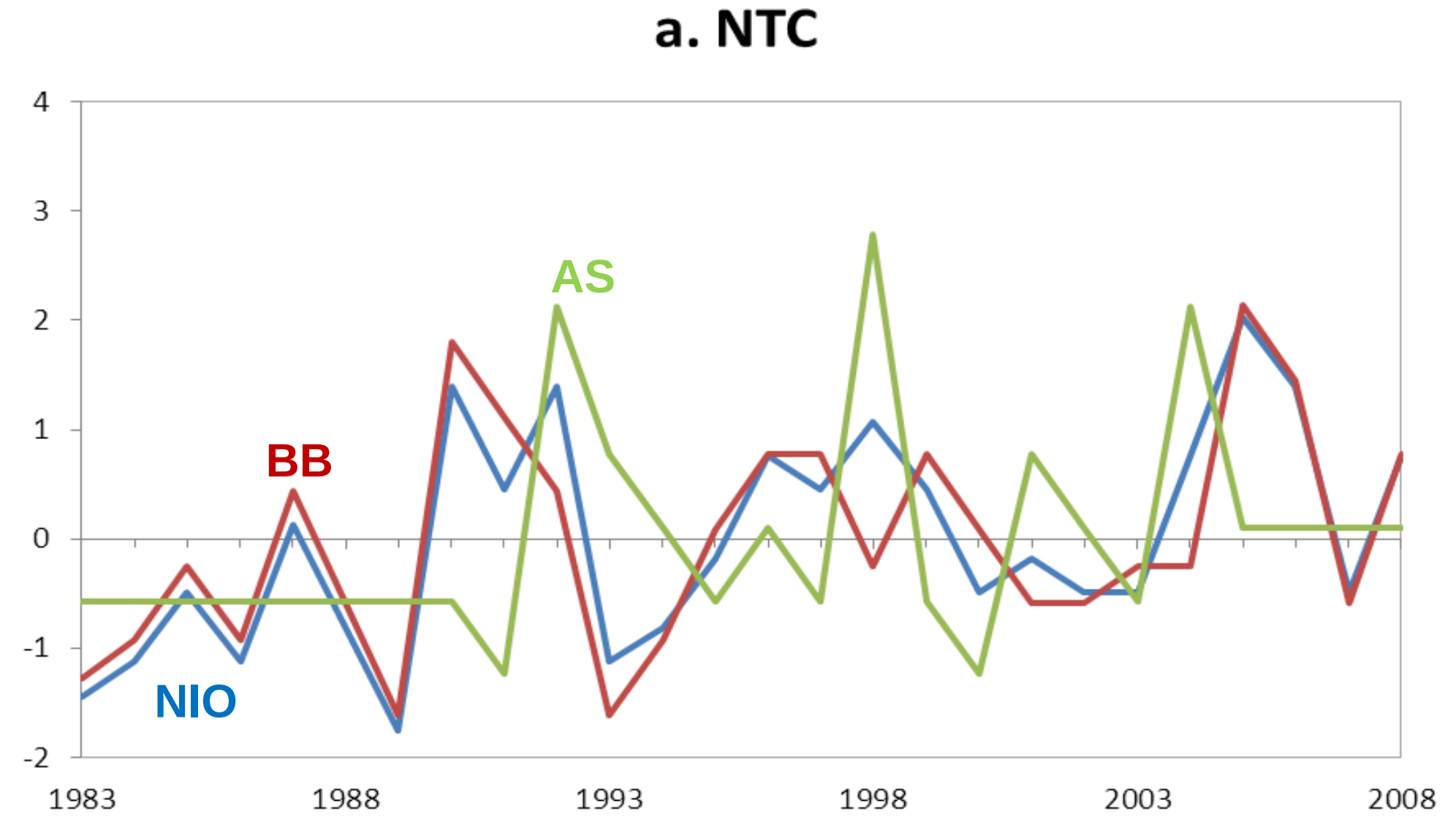
# SST (5-30ºN, 120-160ºE)



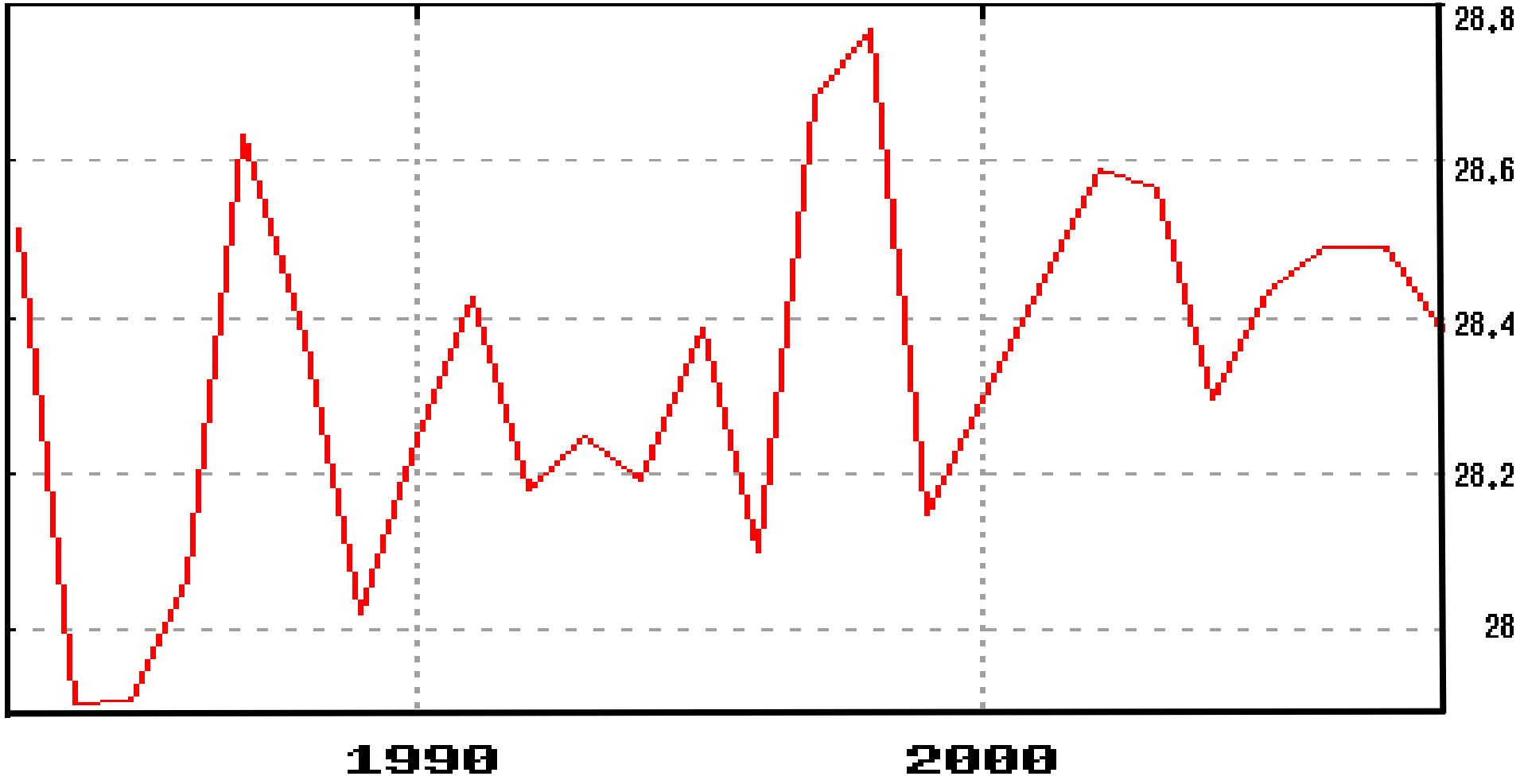
# Annual No. of TS & TY in the western North Pacific



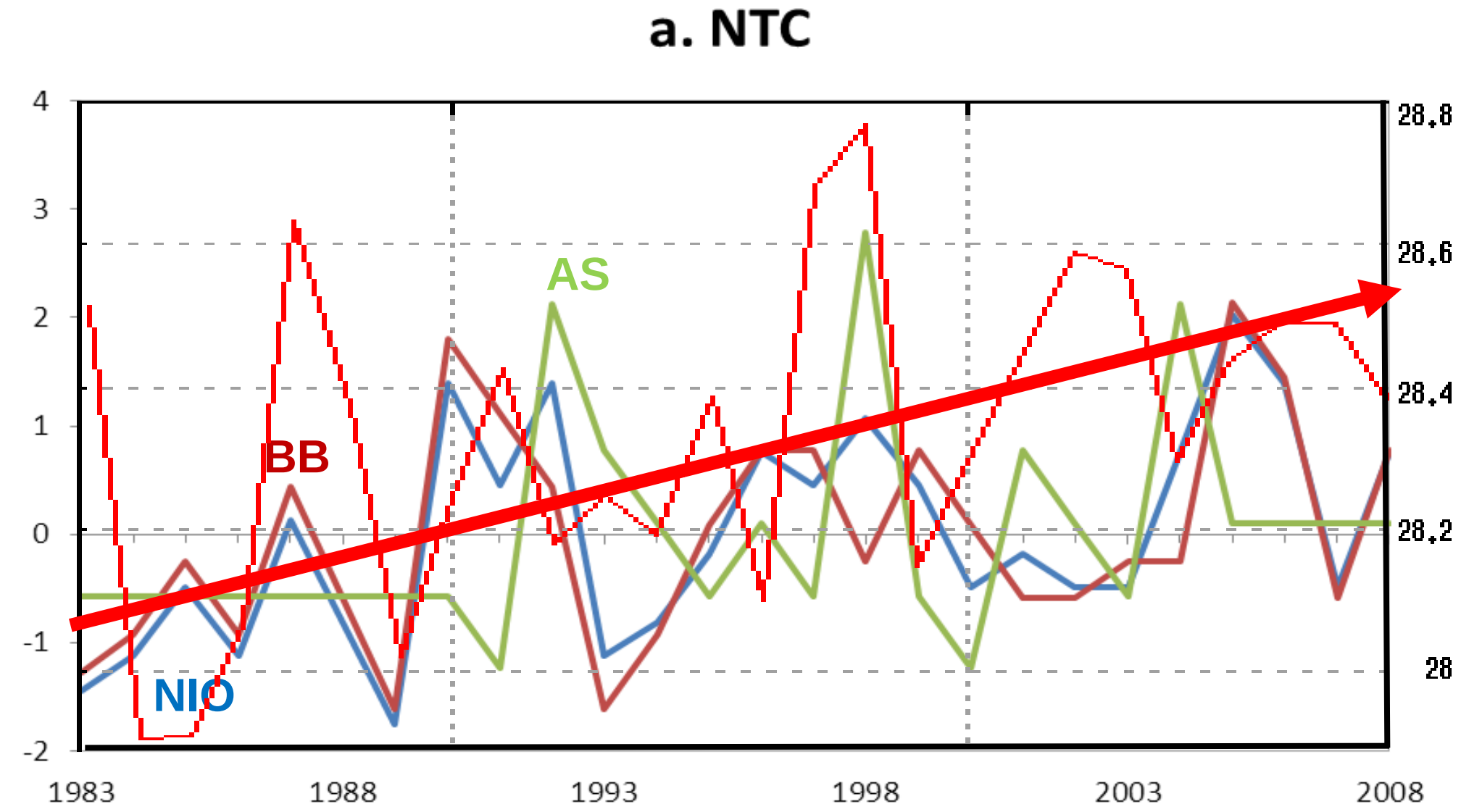
# Anomaly of TC No. in the North Indian Ocean



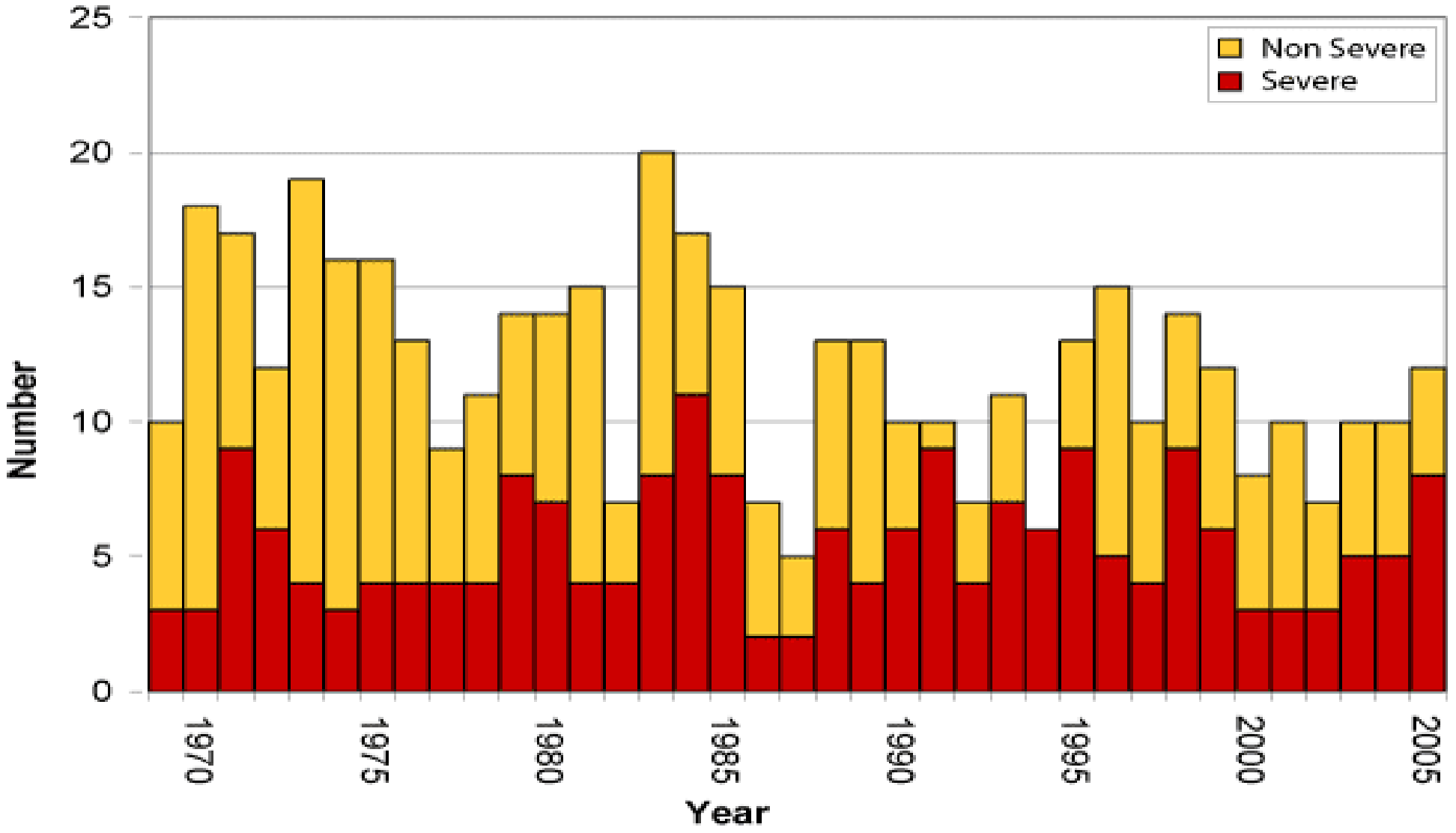
# SST (0-15ºN, 50-100ºE)



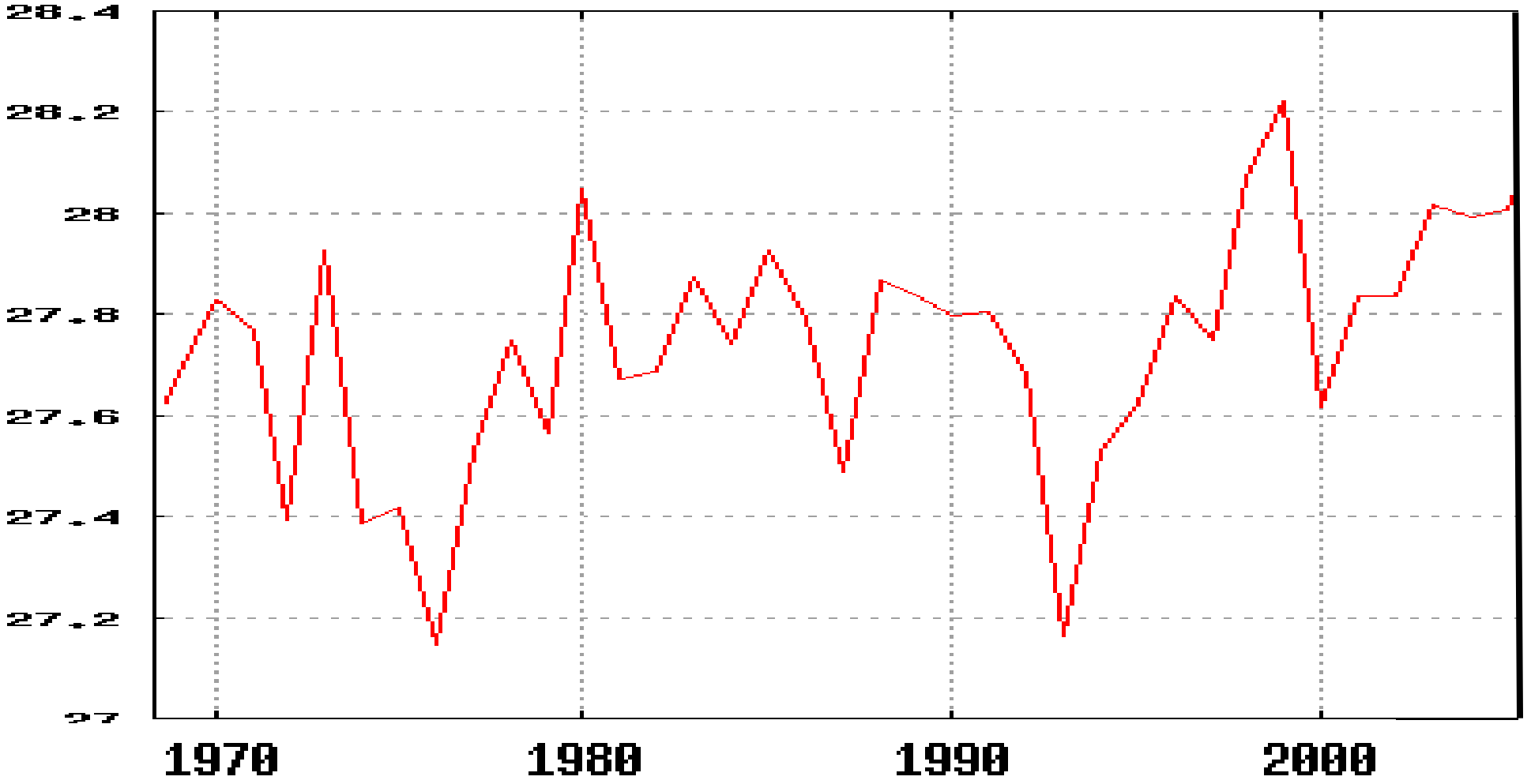
# Anomaly of TC No. in the North Indian Ocean



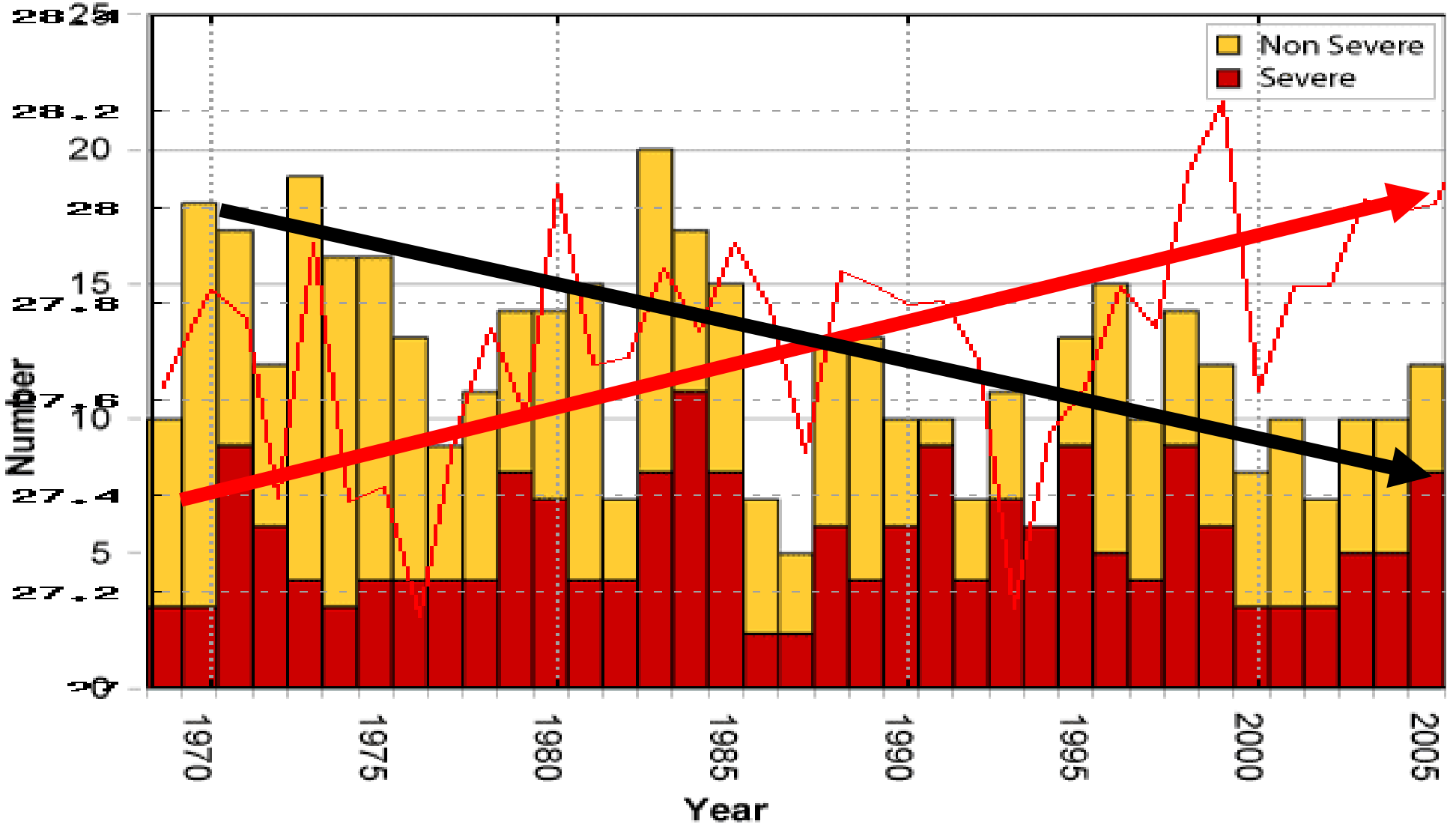
# Annual No. of TCs in the Australian region



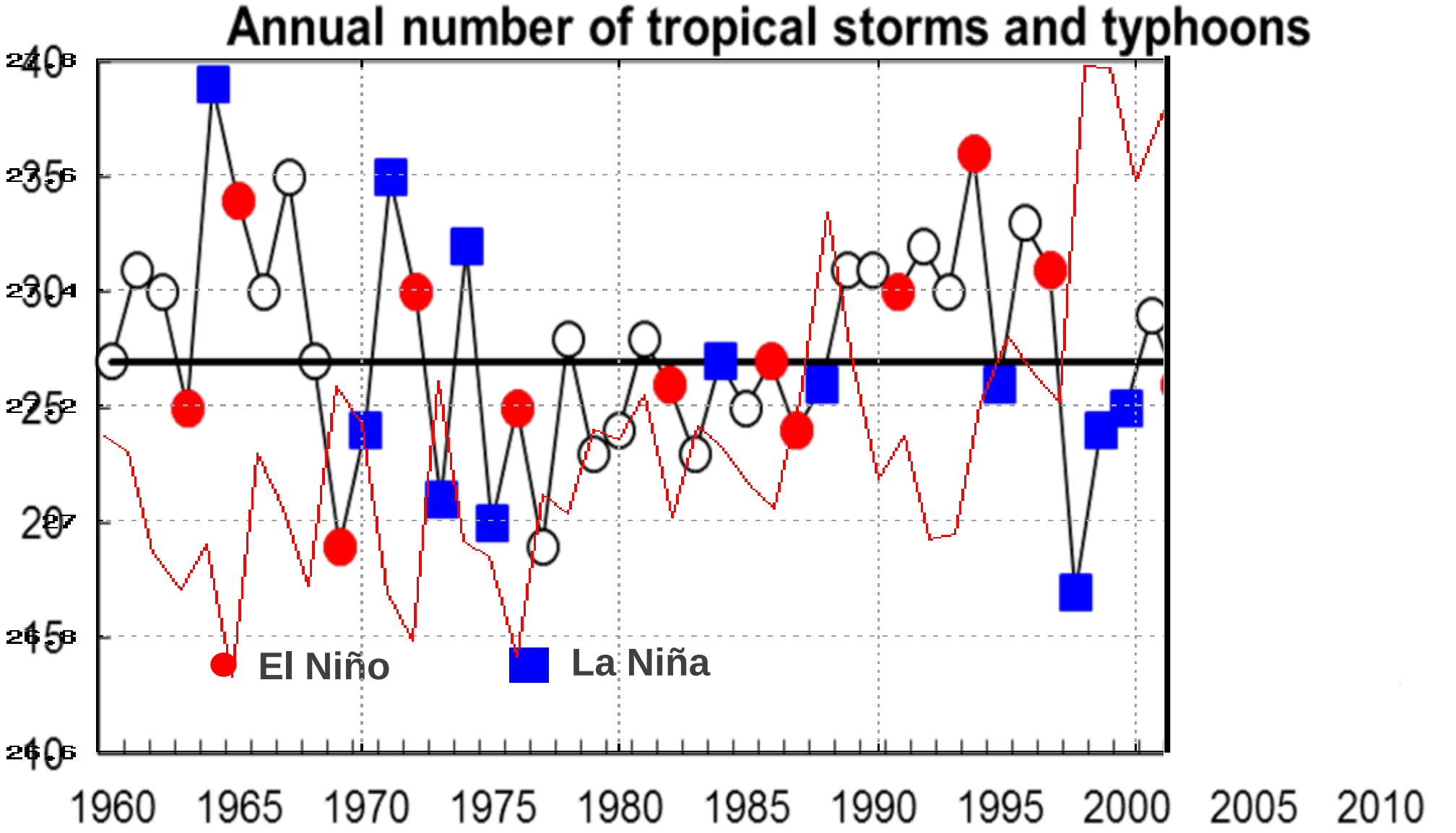
# SST (0-30ºS, 105-160ºE)



# Annual No. of TCs in the Australian region



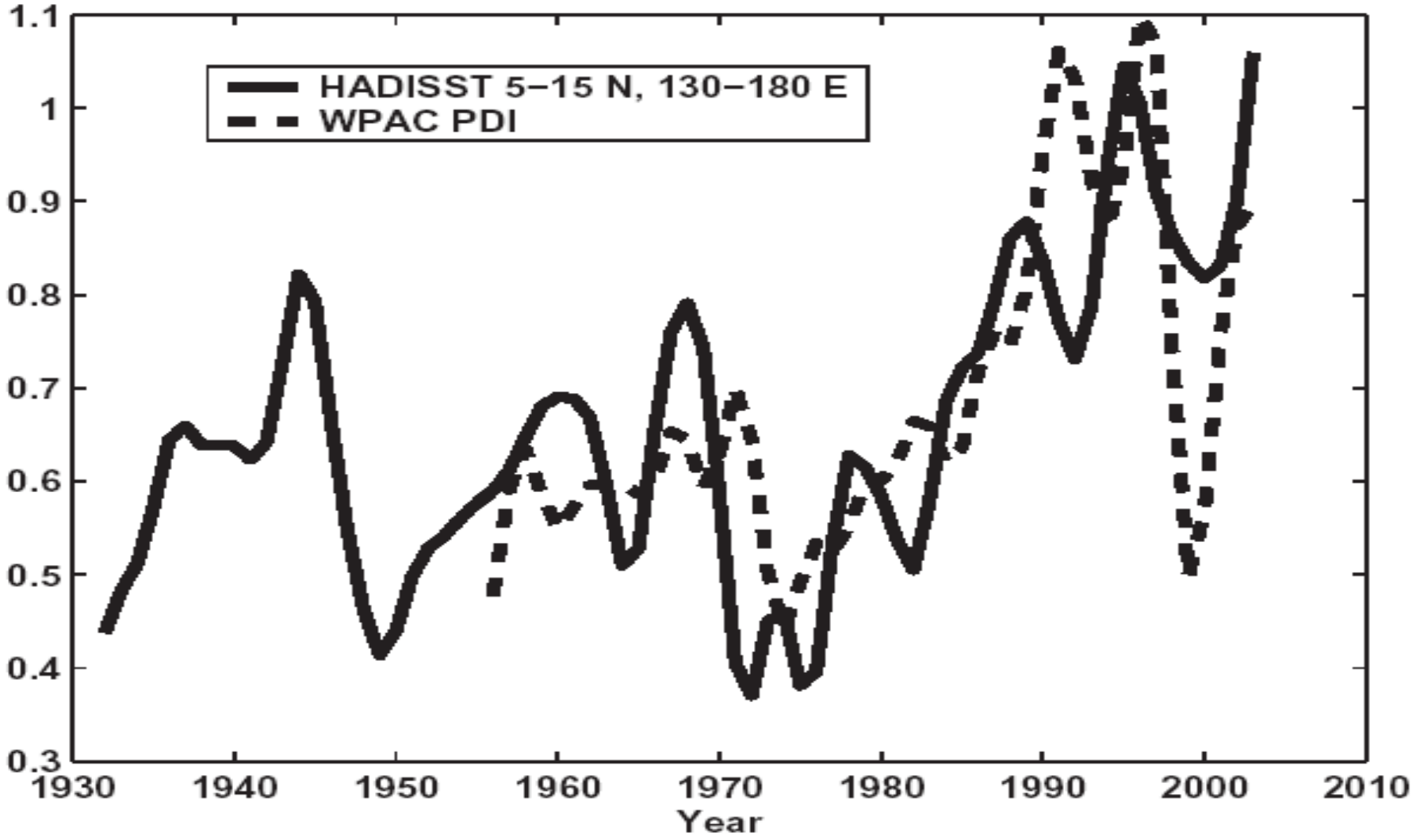
# Annual No. of TS & TY in the western North Pacific



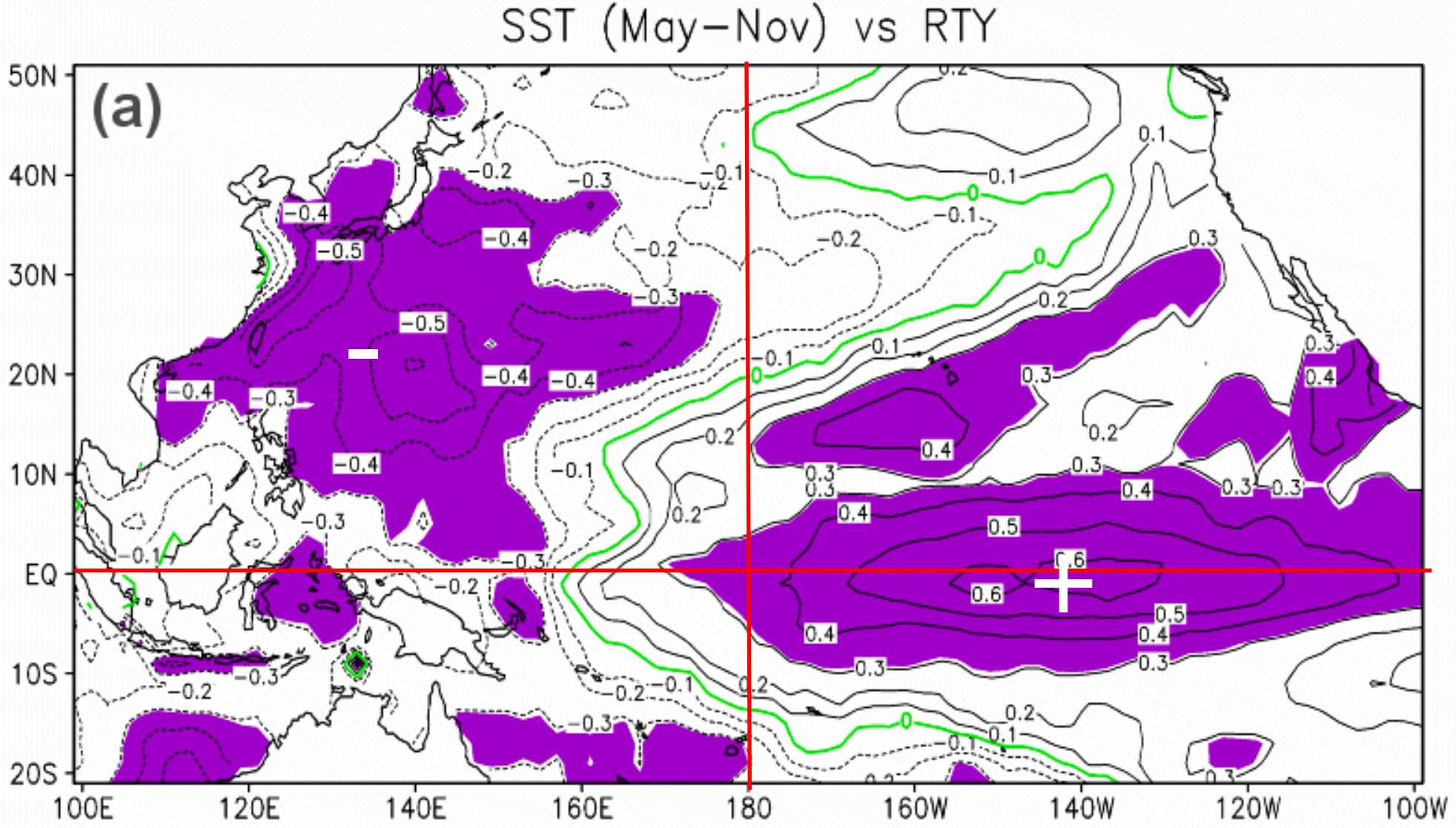
# Emanuel's (2005) *Nature* paper

## W. North Pacific

**PDI: (max wind)$^3$**

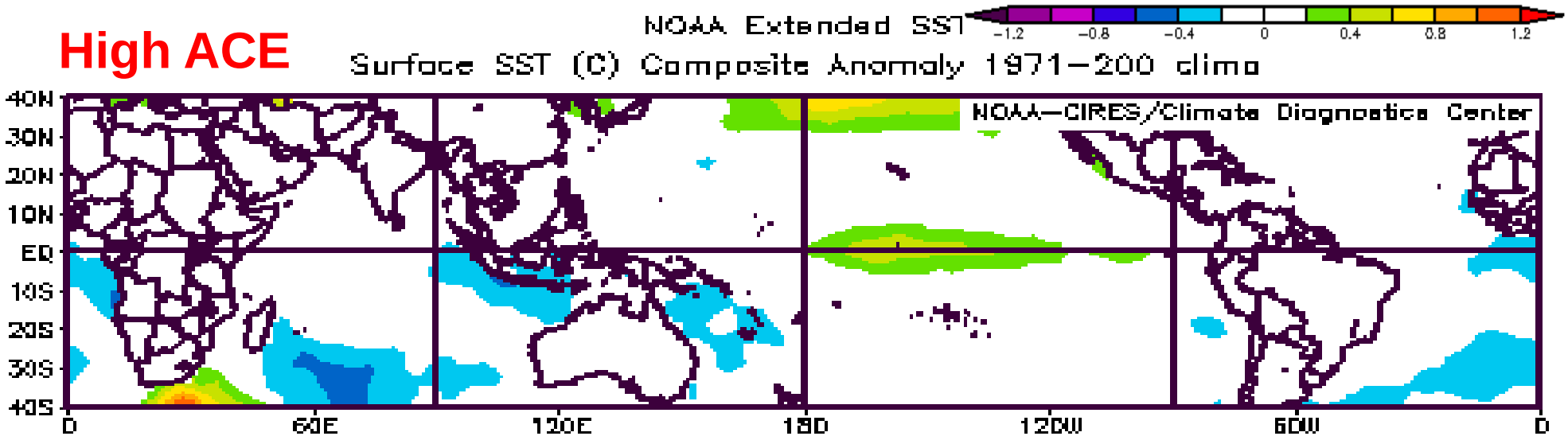


# Correlation between SST (May-Nov) and % of Typhoons

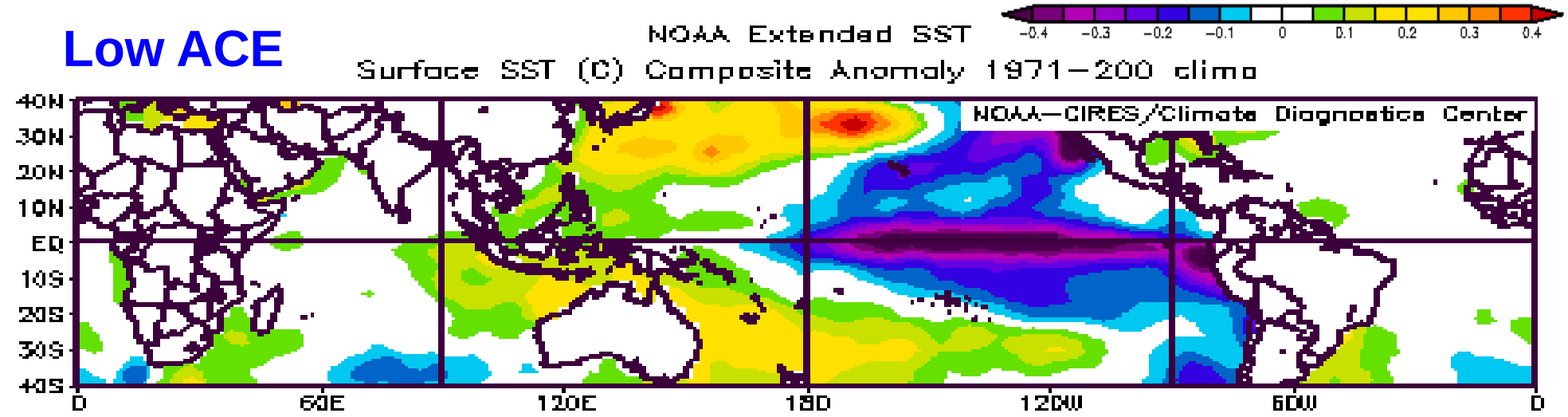


# May-Nov SSTA; High vs. Low ACE (≥|0.5σ|)

**High ACE**

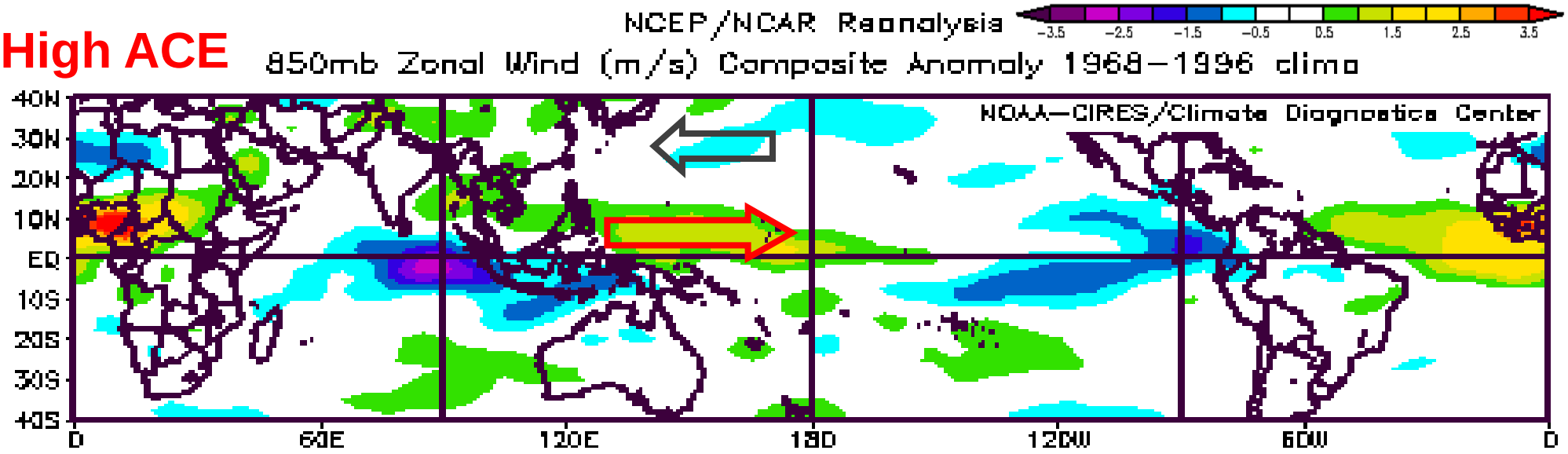



**Low ACE**

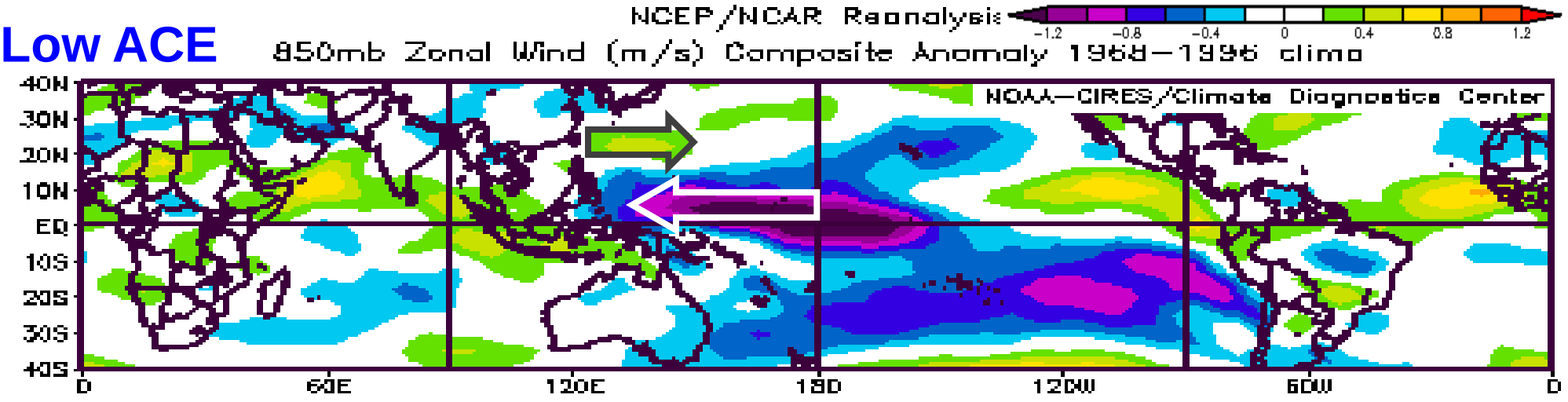


# May-Nov 850U; High vs. Low ACE (≥|0.5σ|)

**High ACE**

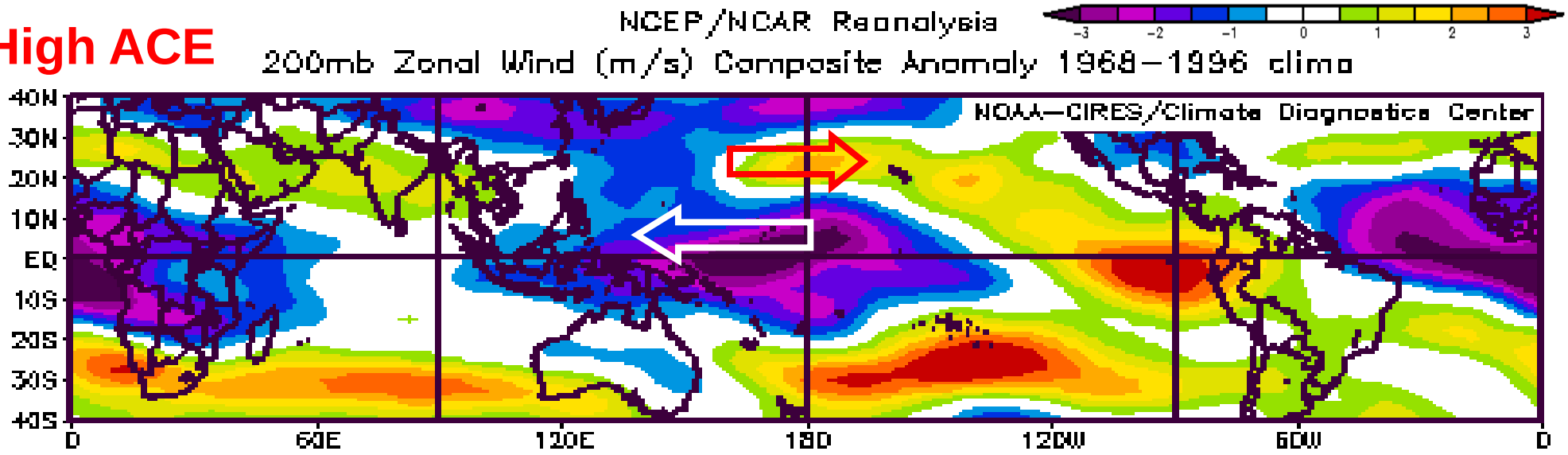



**Low ACE**

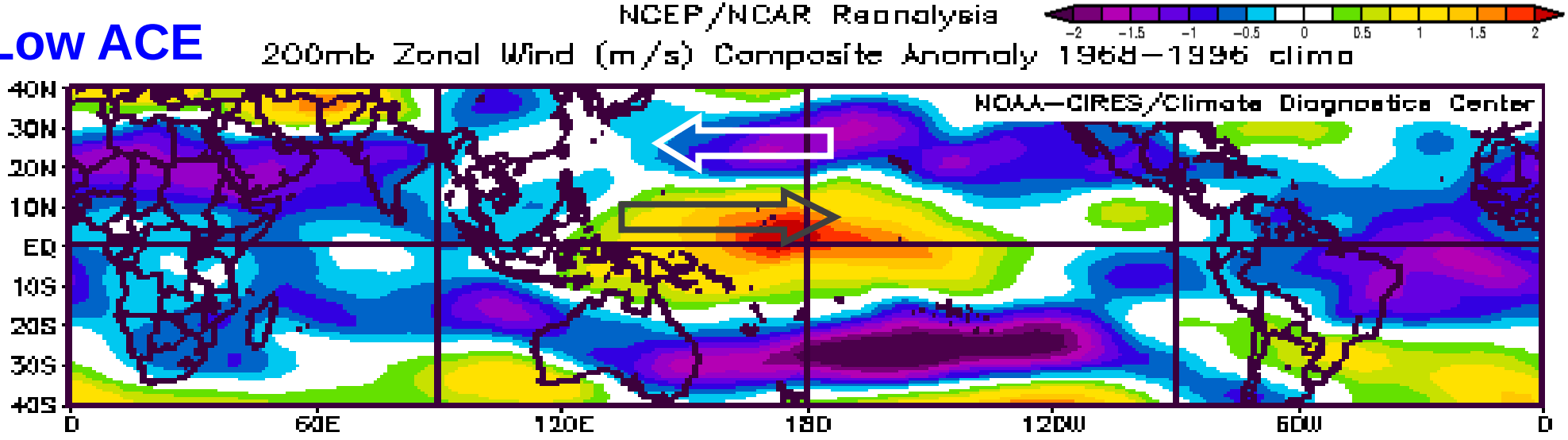


# May-Nov 200U; High vs. Low ACE (≥|0.5σ|)

**High ACE**

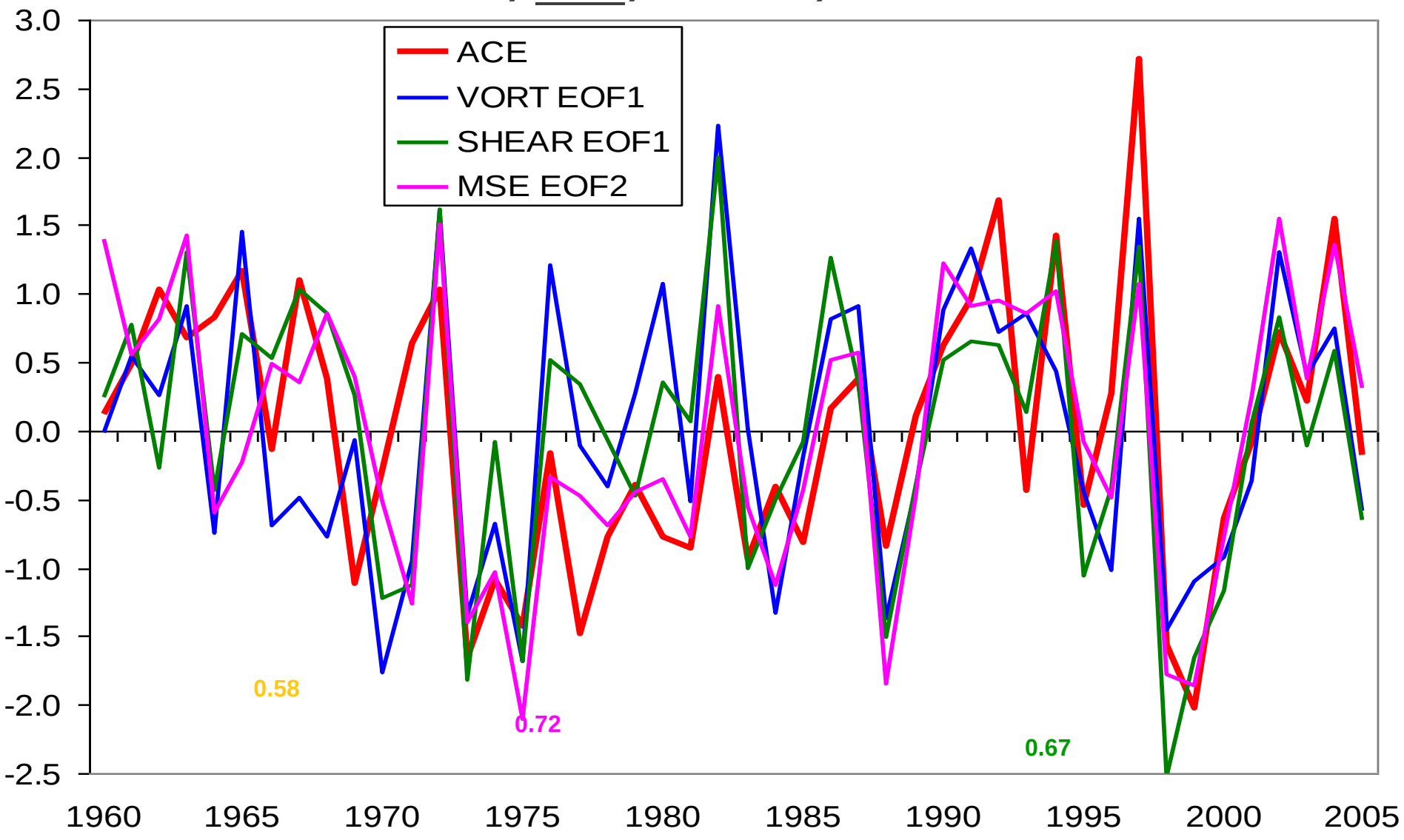



**Low ACE**



# ACE vs.. VORT, SHEAR and MSE

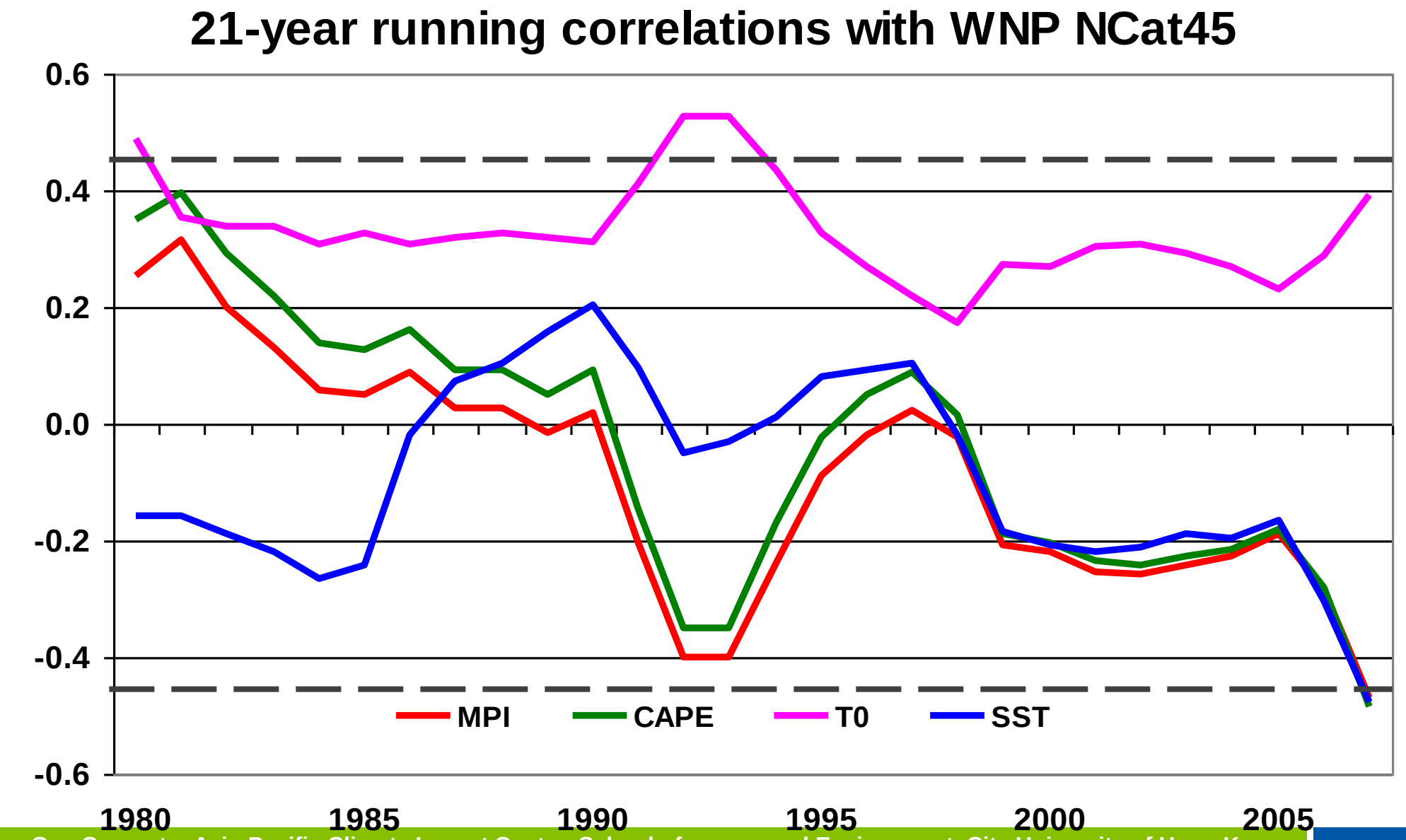
## *Science*, 311, 1713b, *Tellus 2007*



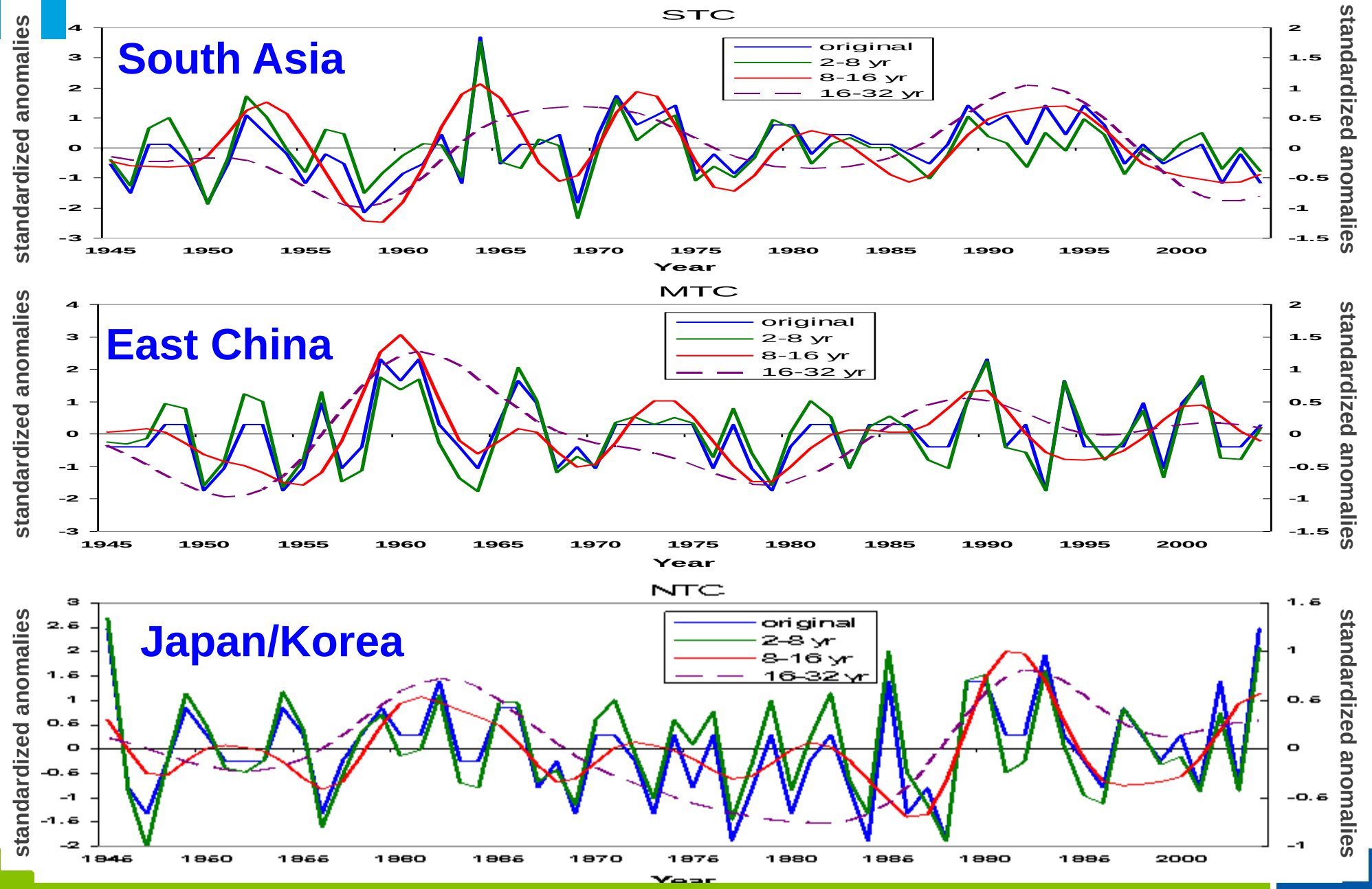
# 21-year running correlations between MPI & NCat45

| 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 | |

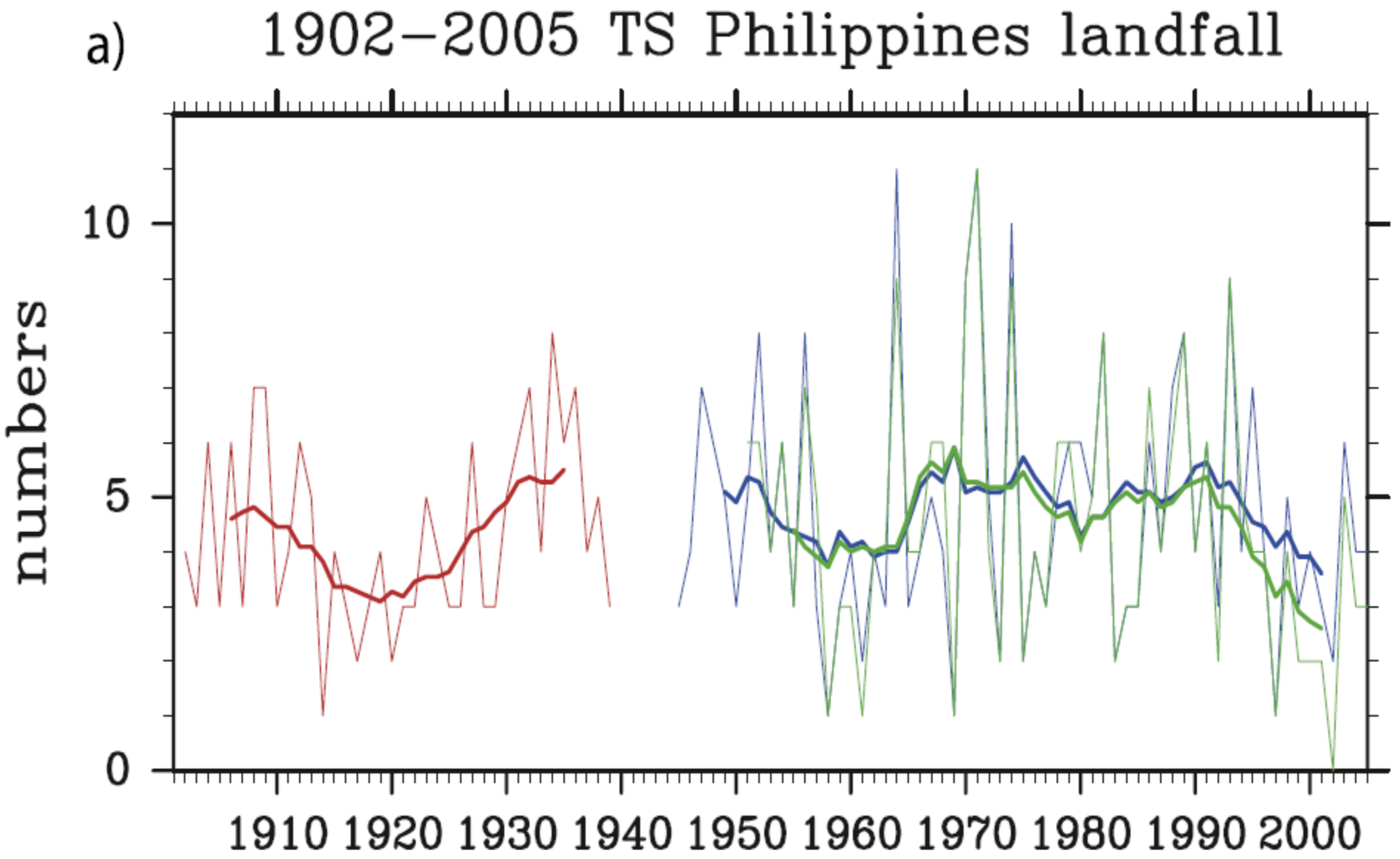
# 21-year running correlations with NCat45 - WNP



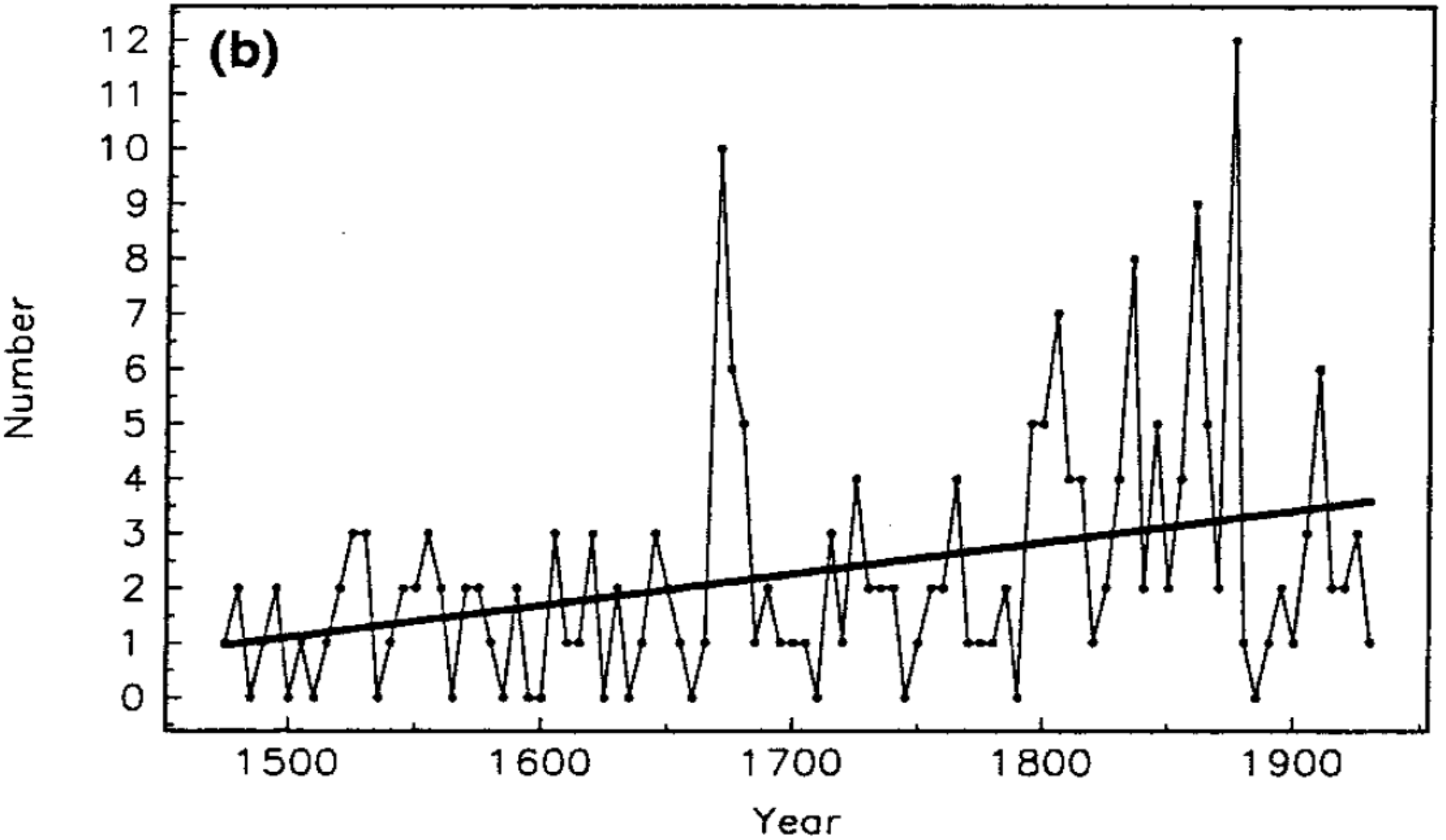
# Variations of Landfall in Each Area at Various Oscillation Periods



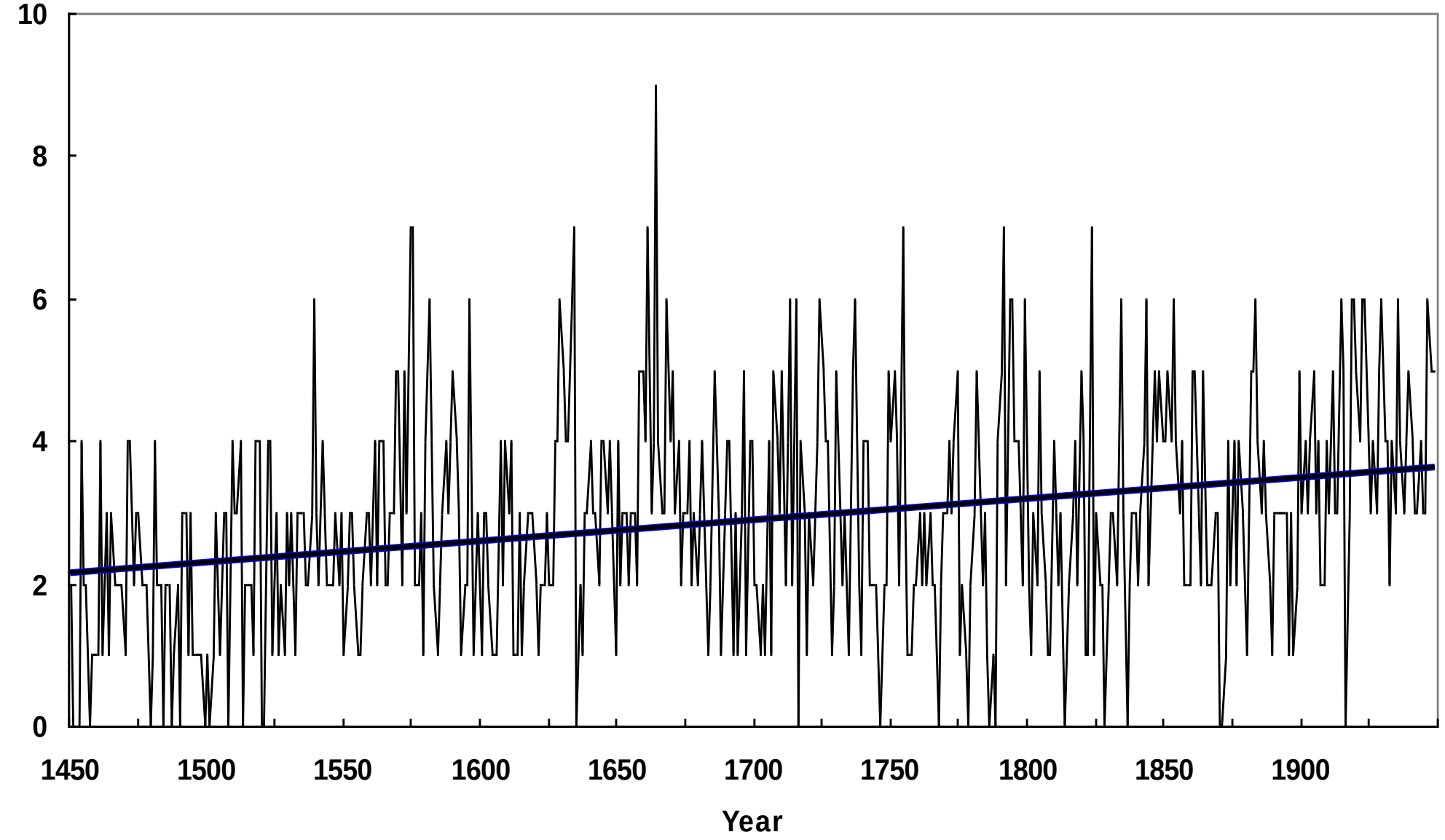
# No. of Landfalling TCs in the Philippines



# No. of Landfalling TCs in South China

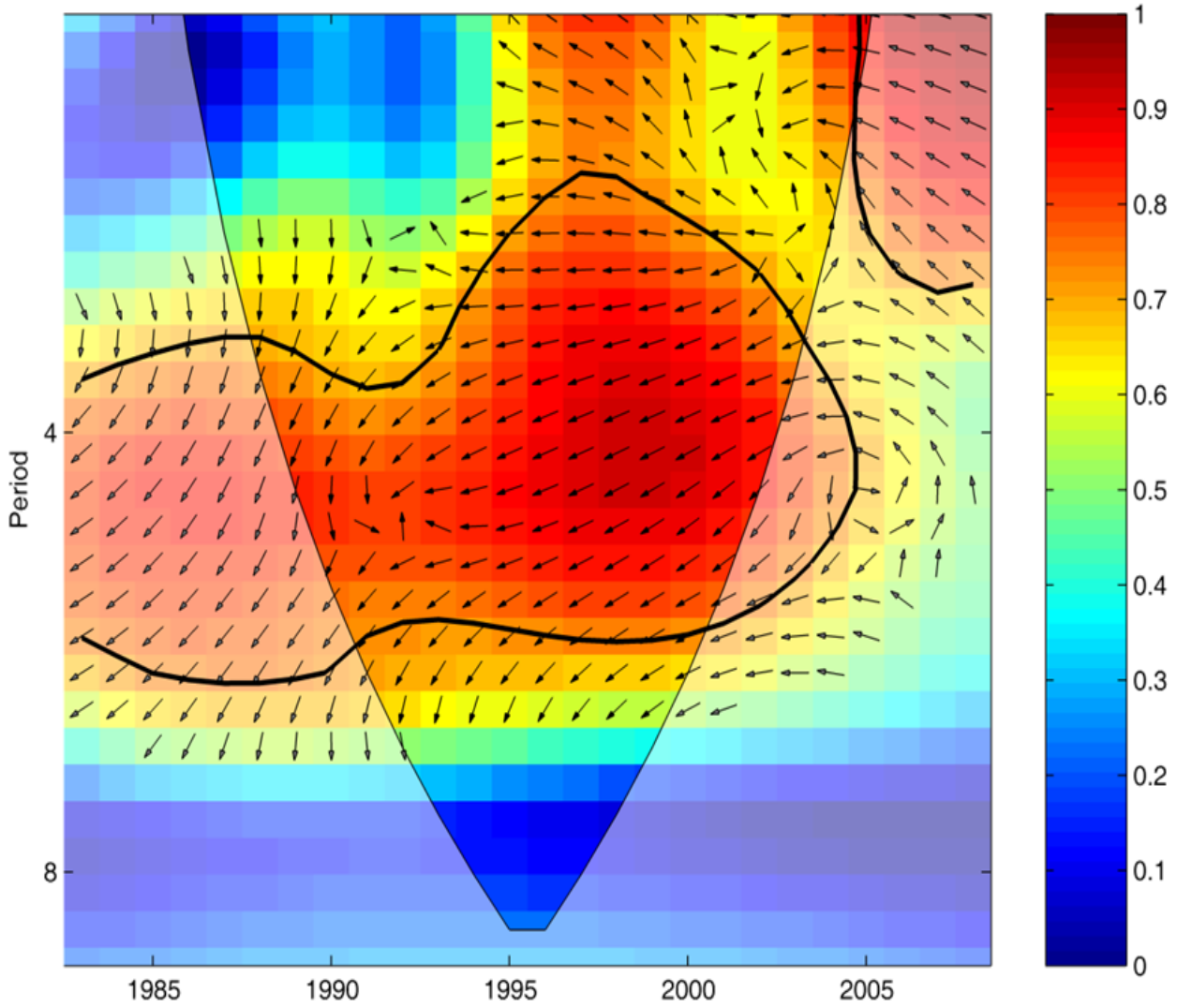


# No. of Landfalling TCs in East China

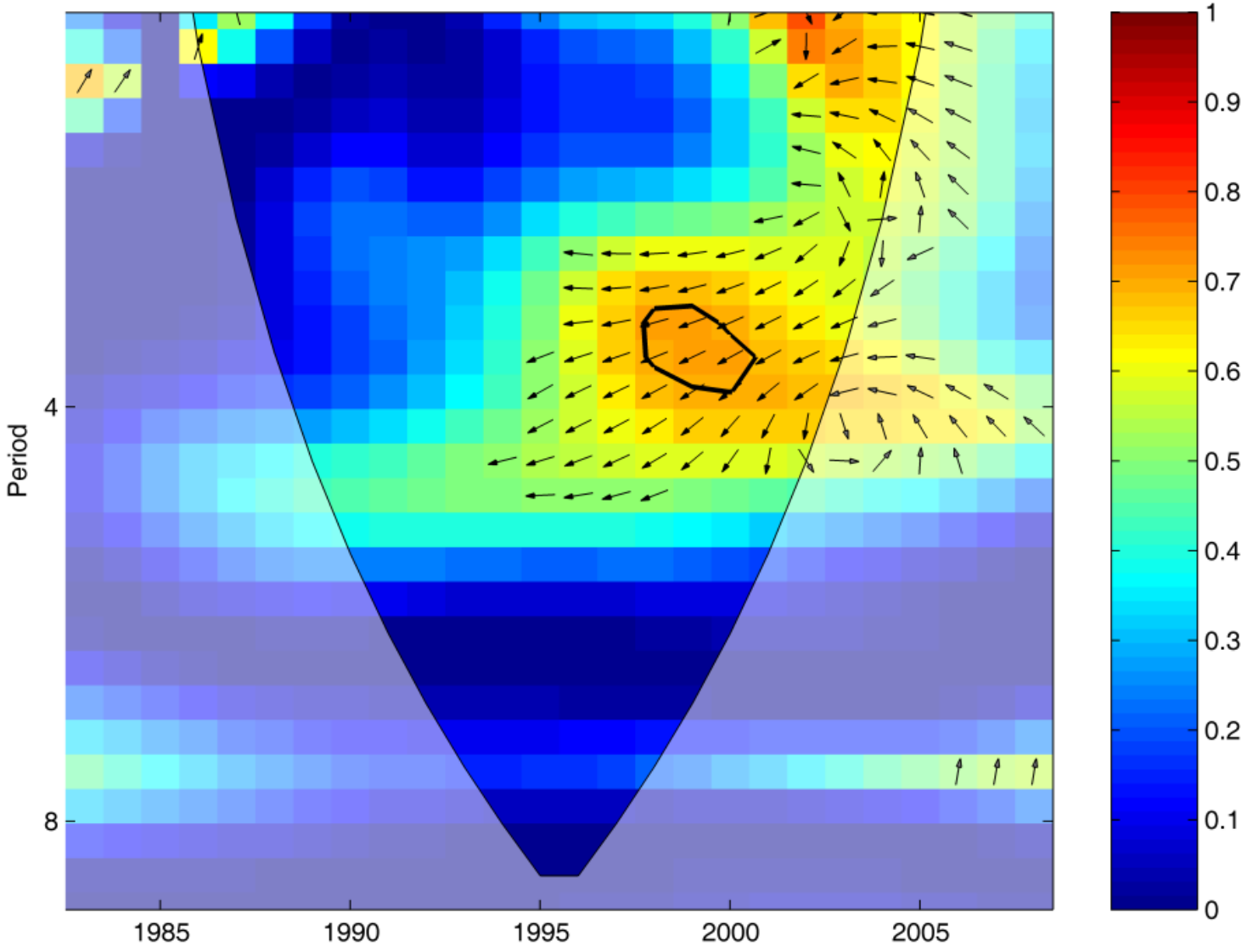


# Correlation between SST and BB TCs

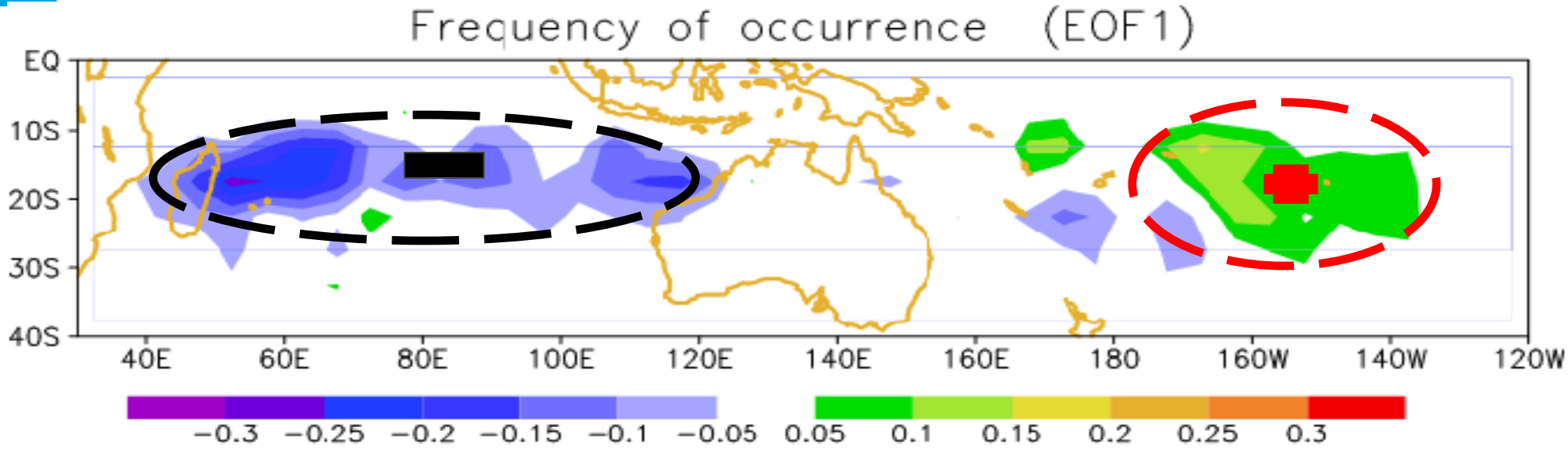
BB local SST VS BB ACE (OND)

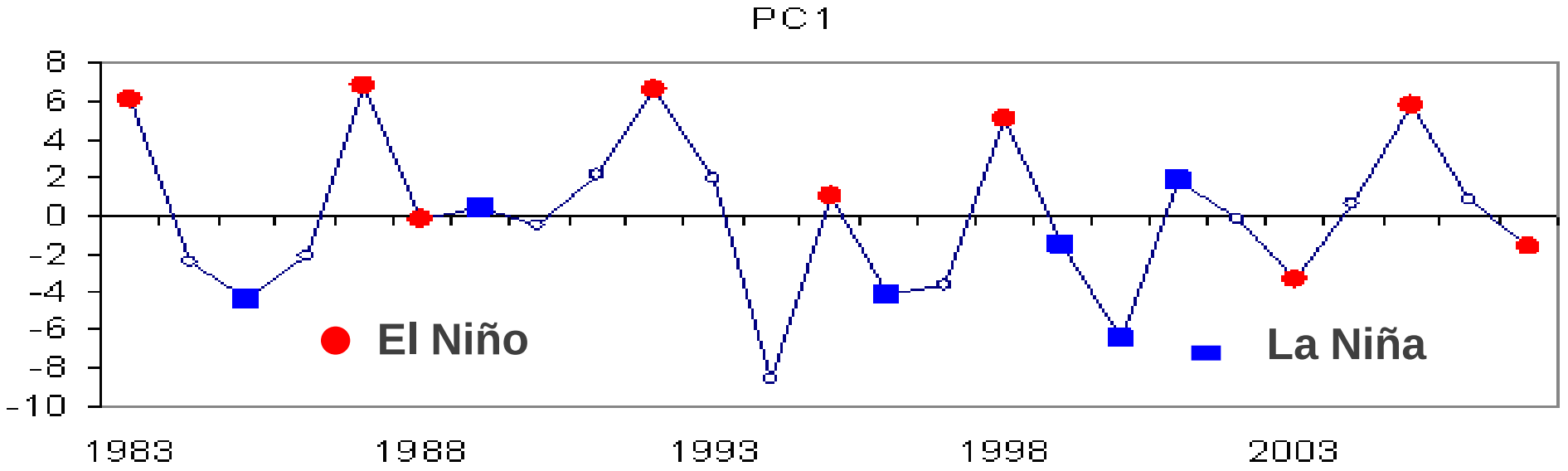


# Correlation between SST and BB TCs after removal of ENSO

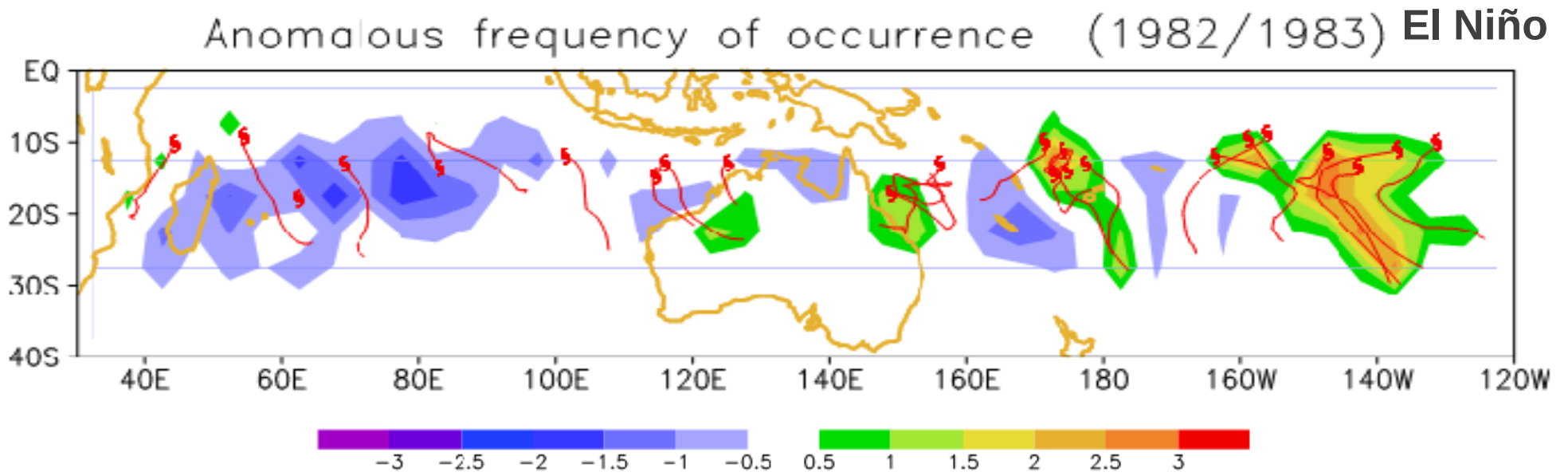


# EOF1 (12.5%)

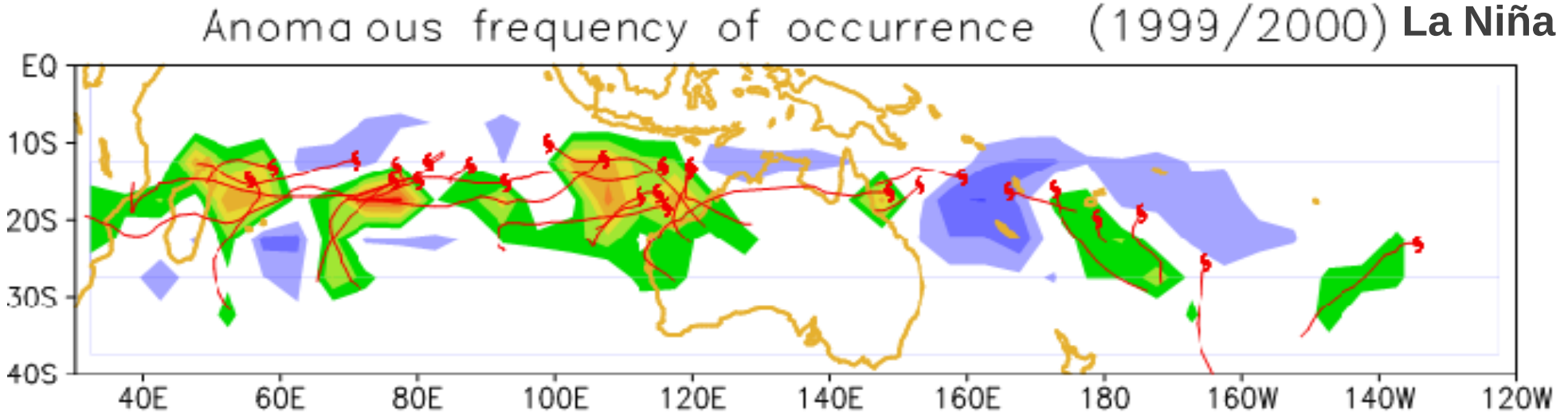

Frequency of occurrence (EOF1)
EQ
10S
20S
30S
40S
40E
60E
80E
100E
120E
140E
160E
180
160W
140W
120W
−0.3 −0.25 −0.2 −0.15 −0.1 −0.05 0.05 0.1 0.15 0.2 0.25 0.3


PC1
8
6
4
2
0
-2
-4
-6
-8
-10
El Niño
La Niña
1983
1988
1993
1998
2003

# Typical Examples for EOF1

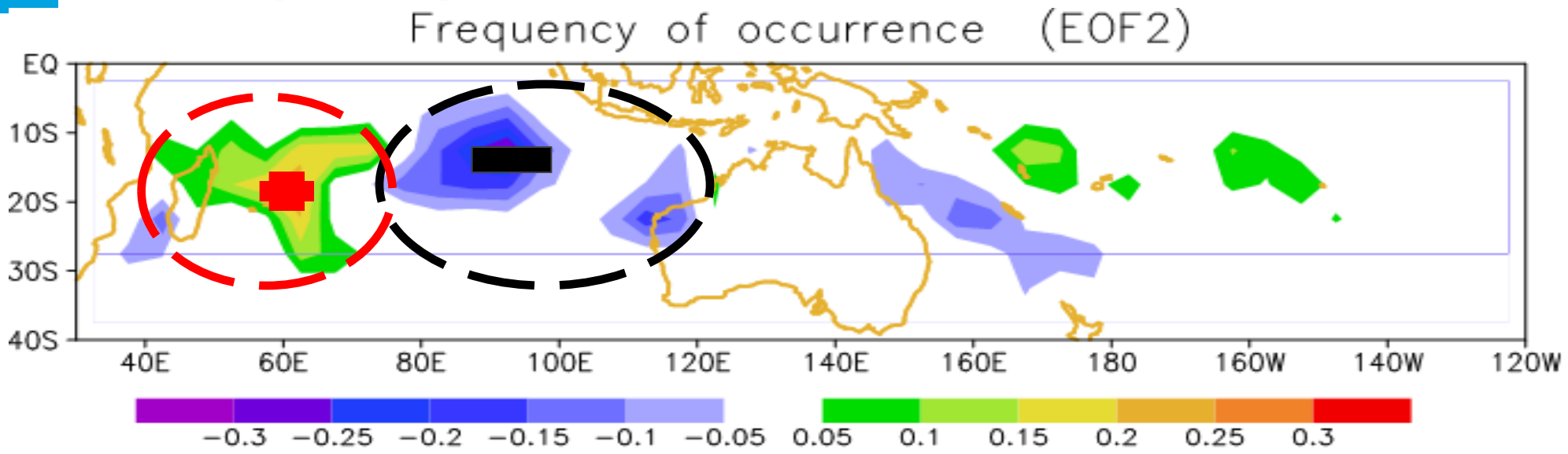


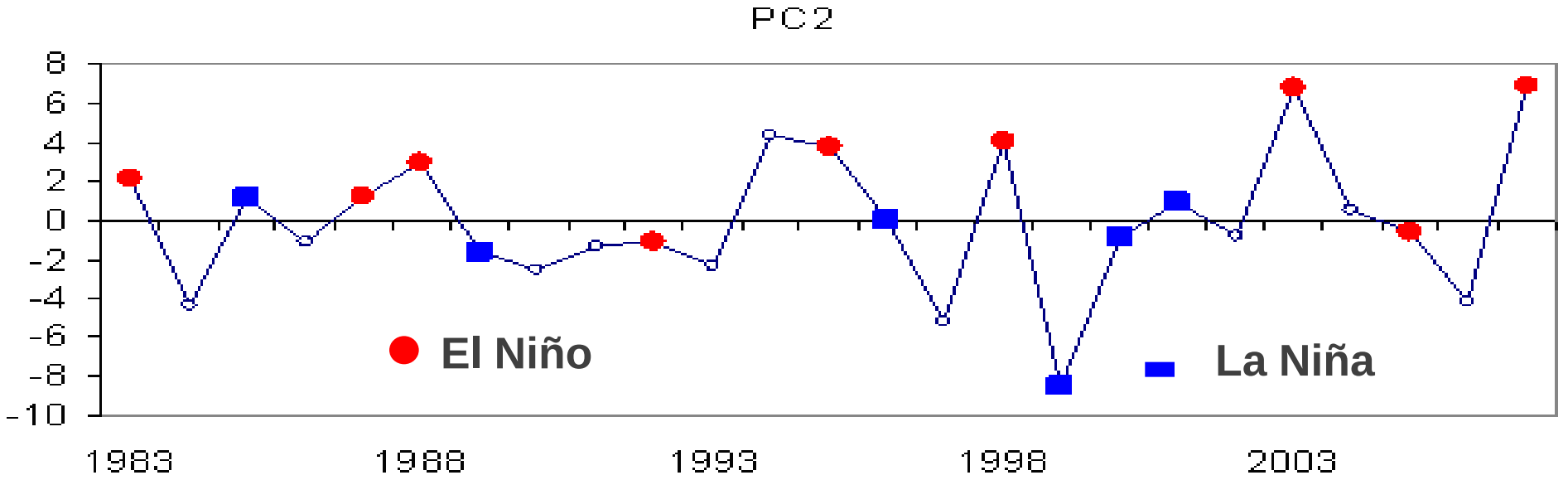

El Niño



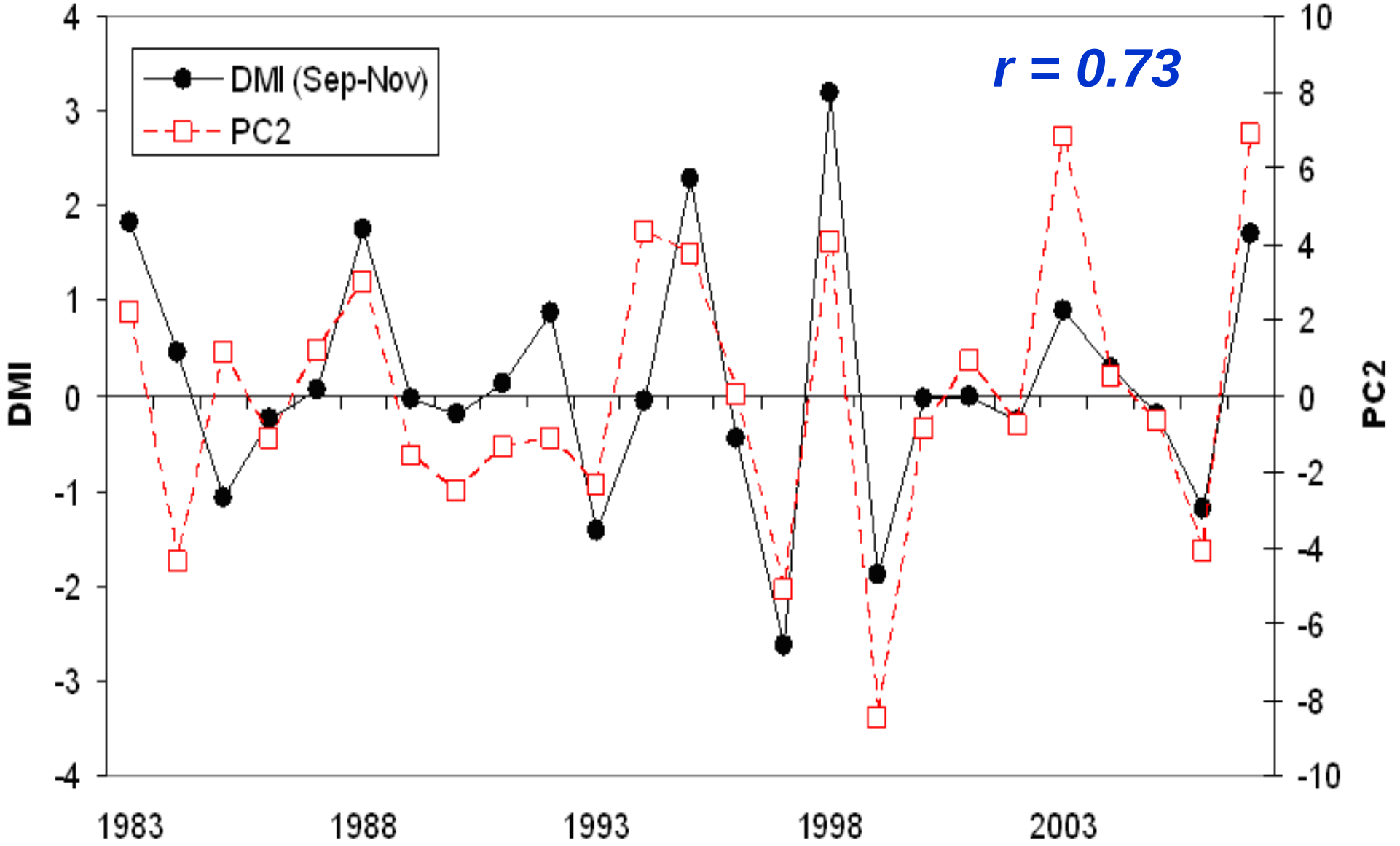

La Niña

# EOF2 (10 %)

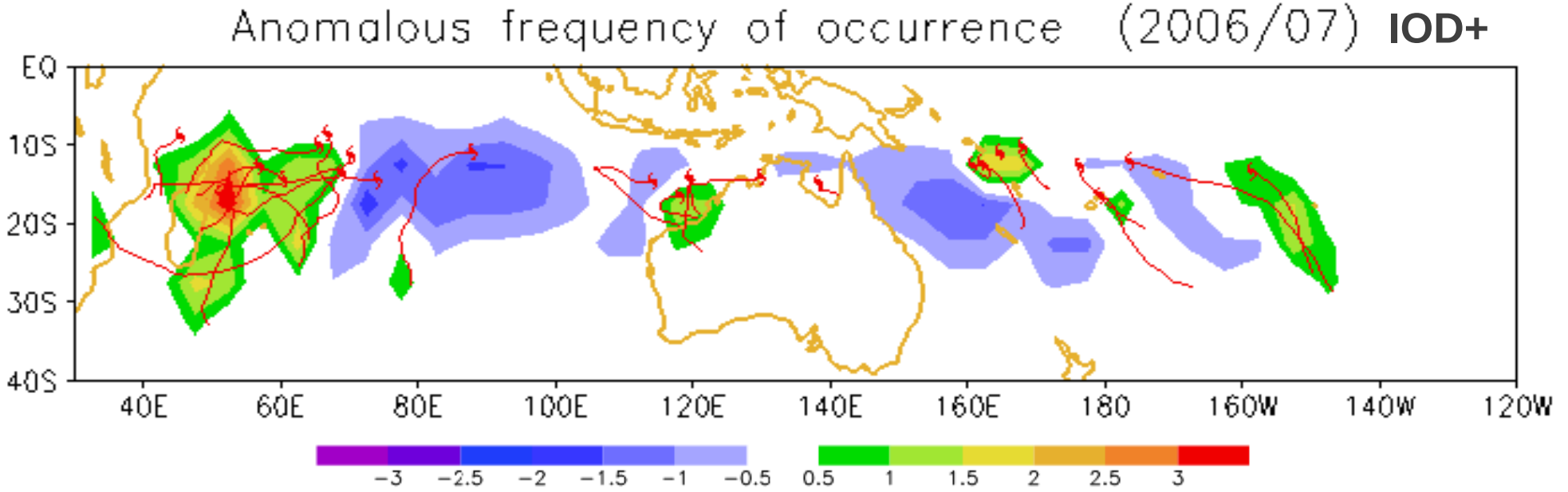

Frequency of occurrence (EOF2)
EQ
10S
20S
30S
40S
40E
60E
80E
100E
120E
140E
160E
180
160W
140W
120W
−0.3 −0.25 −0.2 −0.15 −0.1 −0.05 0.05 0.1 0.15 0.2 0.25 0.3

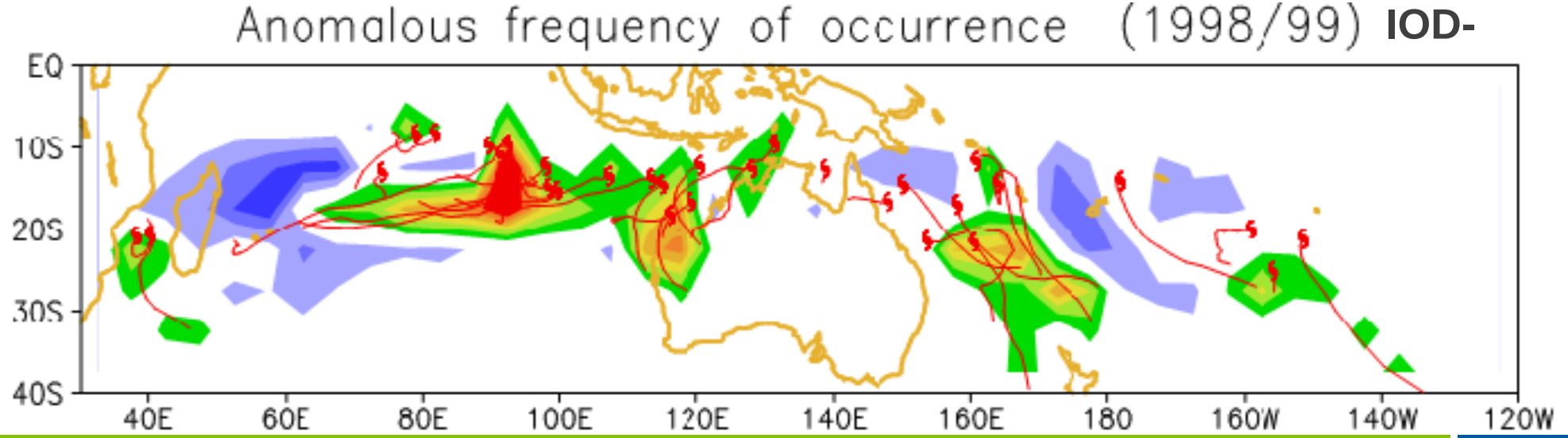

PC2
8
6
4
2
0
-2
-4
-6
-8
-10
El Niño
La Niña
1983
1988
1993
1998
2003

# Dipole Mode Index (Sep-Nov) vs PC2

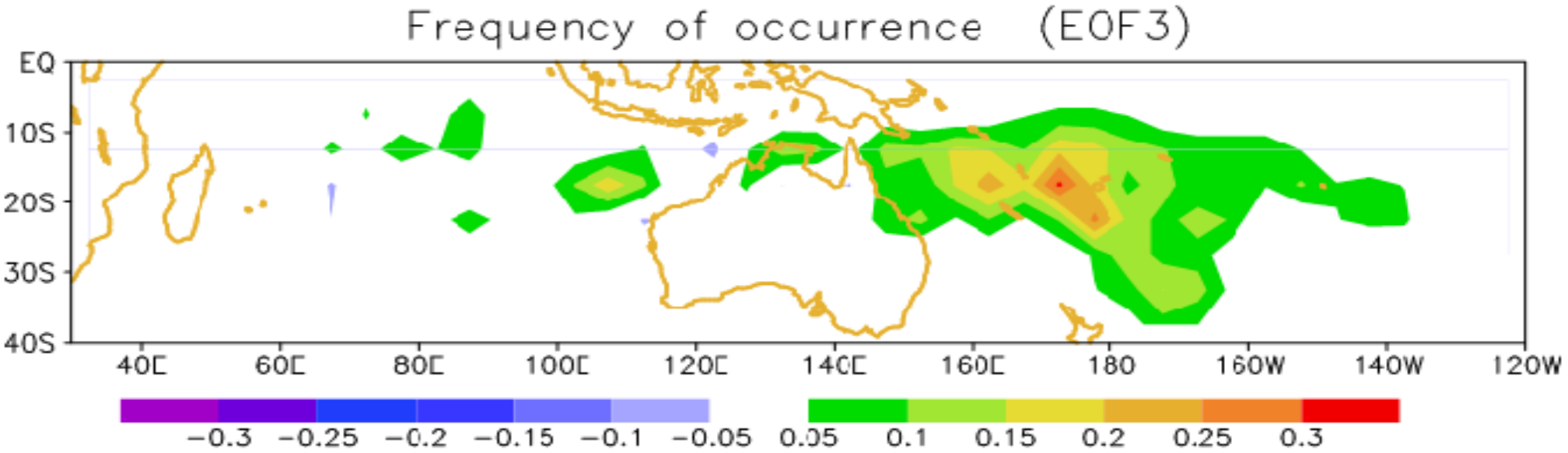


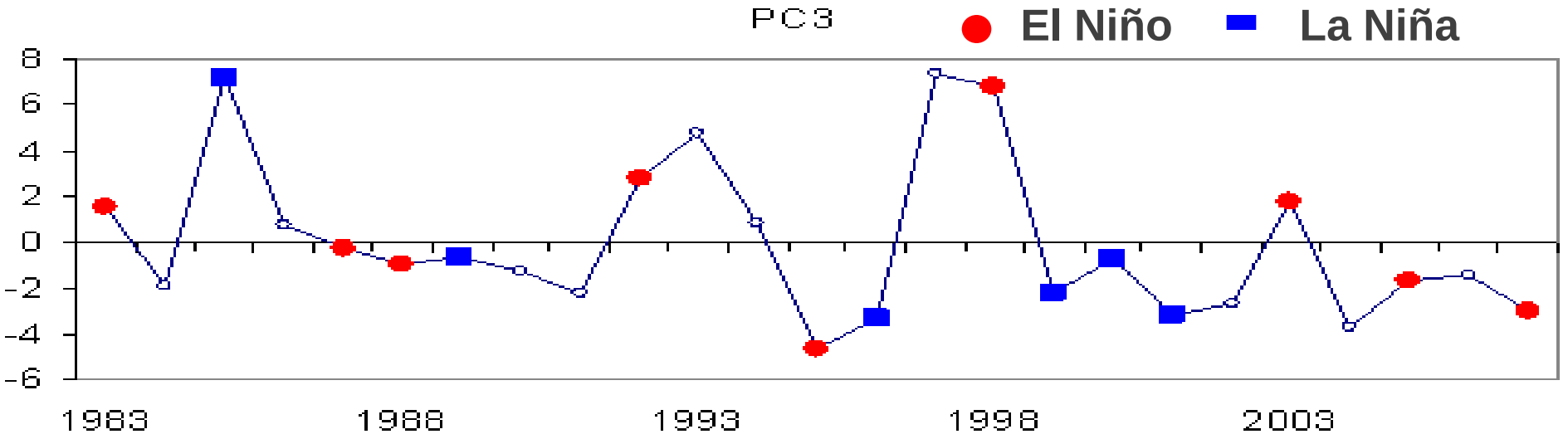
# Typical Tracks in IOD+ and IOD- years



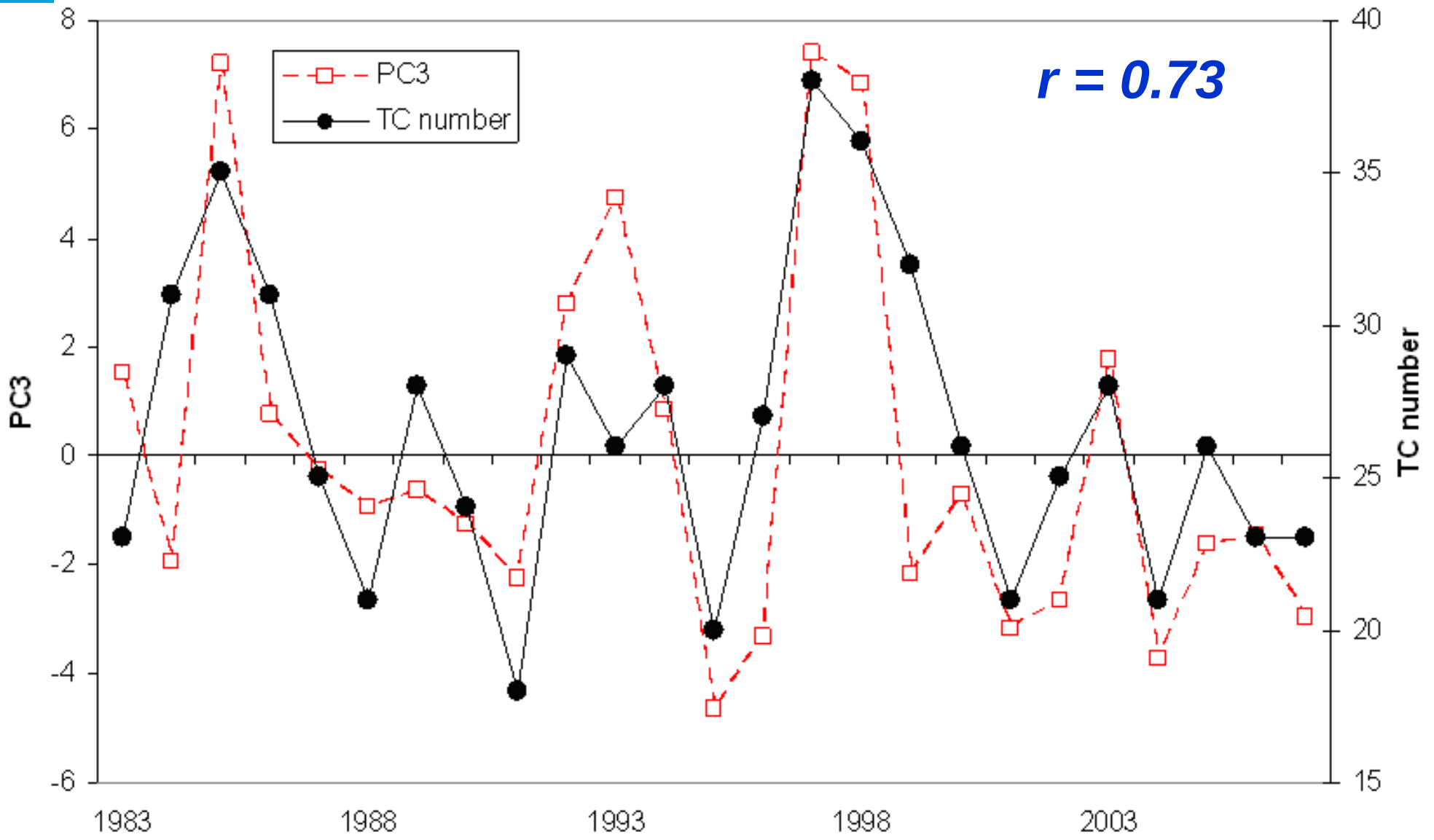



# EOF3 (9.1 %)

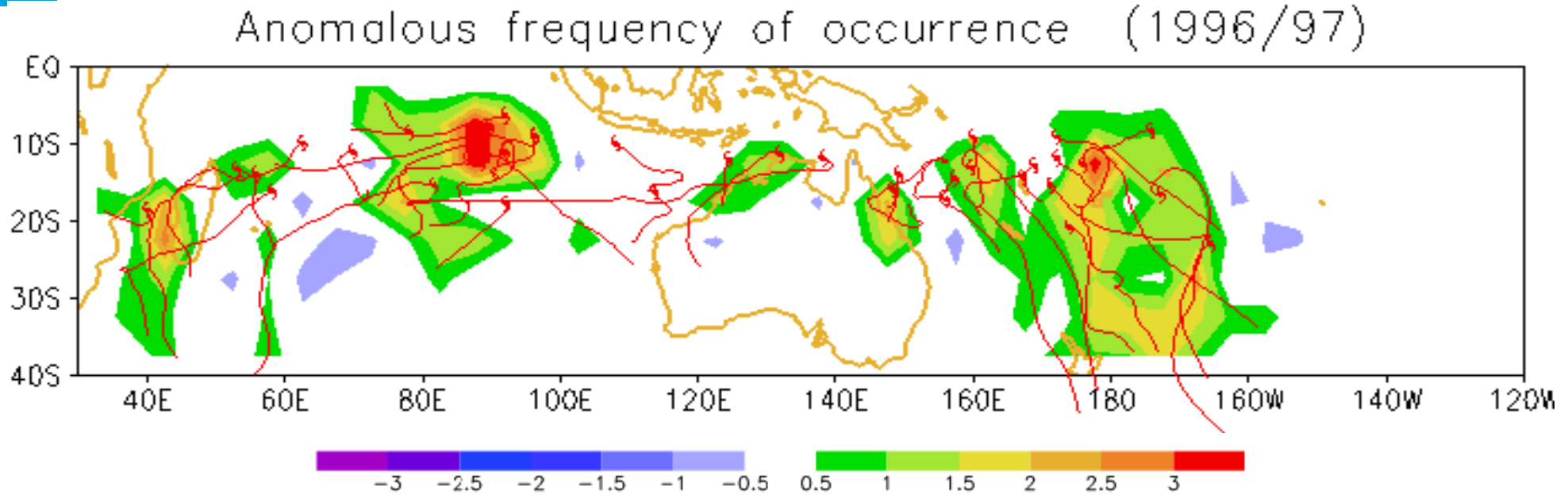

Frequency of occurrence (EOF3)
EQ
10S
20S
30S
40S
40E
60E
80E
100E
120E
140E
160E
180
160W
140W
120W
−0.3 −0.25 −0.2 −0.15 −0.1 −0.05
0.05 0.1 0.15 0.2 0.25 0.3

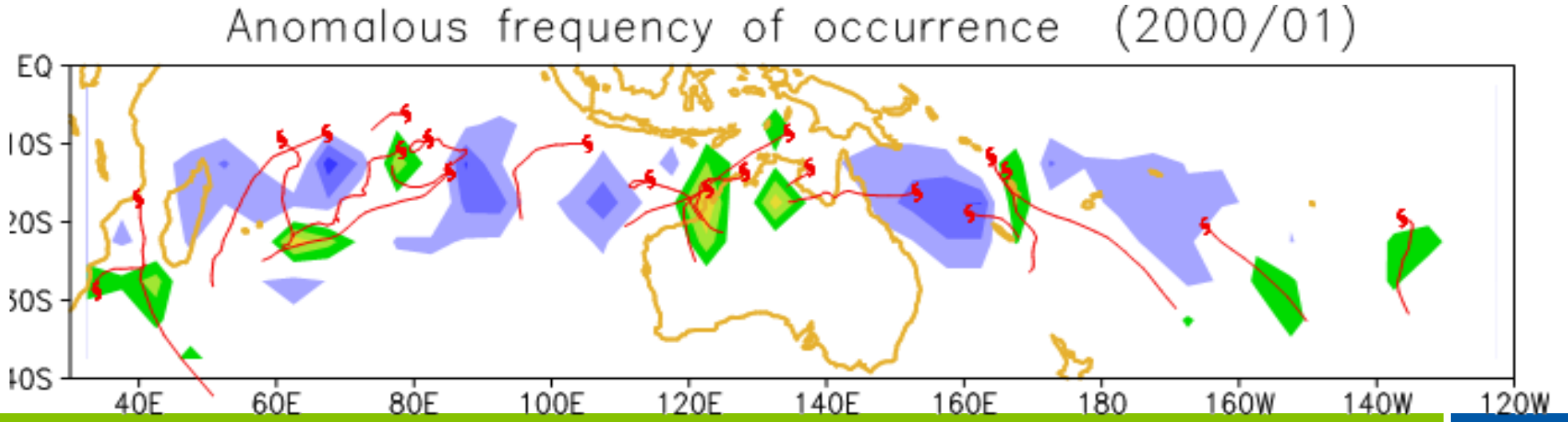

PC3
El Niño
La Niña
8
6
4
2
0
-2
-4
-6
1983
1988
1993
1998
2003

# No. of Southern Hemisphere TCs vs PC3



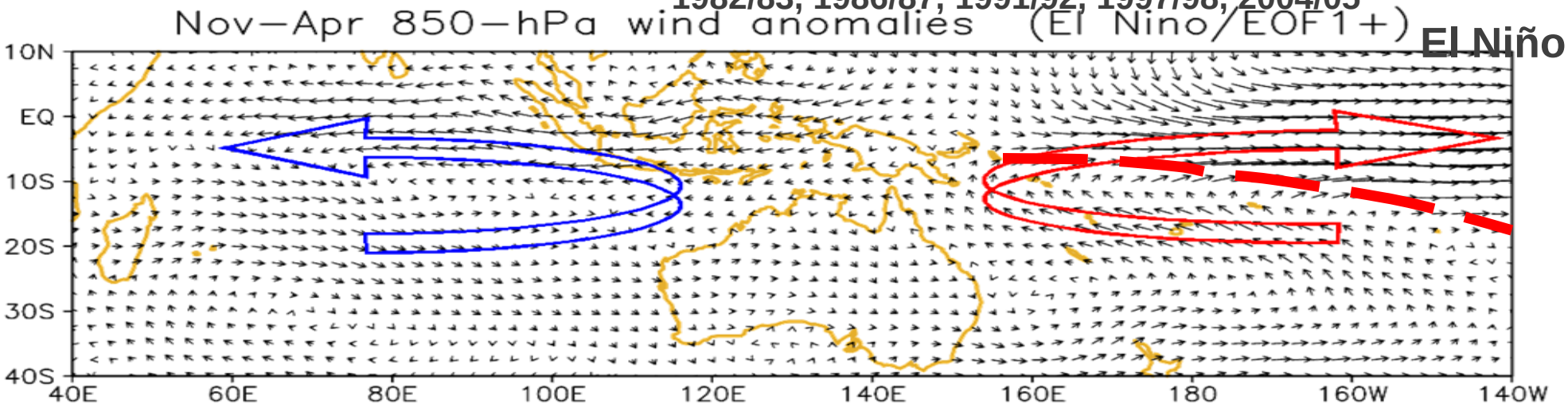
# Typical track patterns in high and low activity years



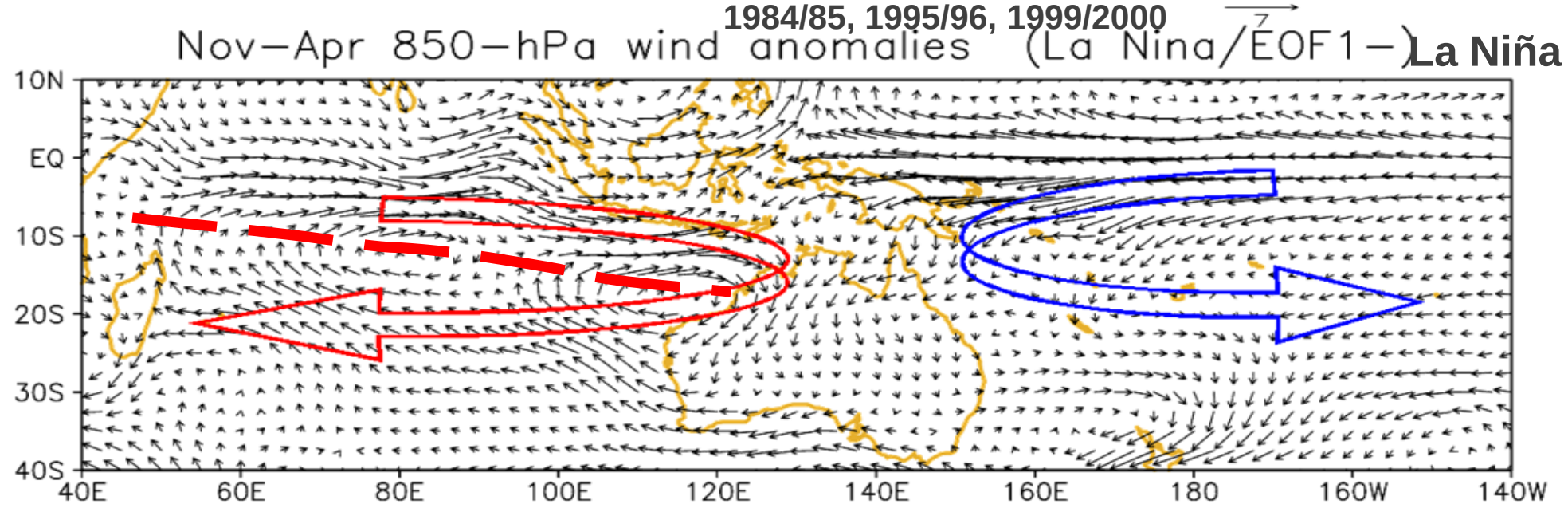
# Nov-Apr 850-hPa wind anomalies EOF1+ vs EOF1-

1982/83, 1986/87, 1991/92, 1997/98, 2004/05



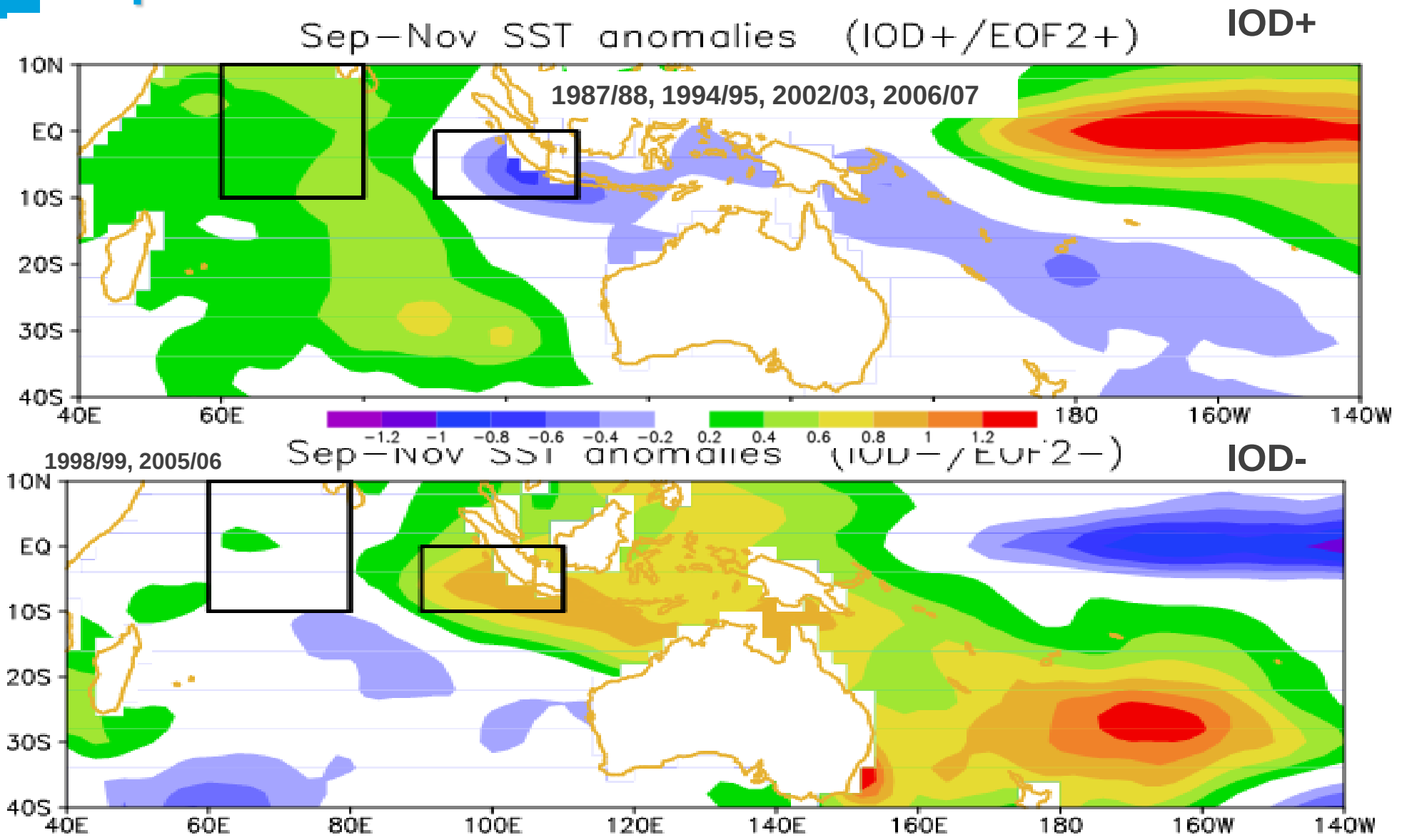

El Niño

1984/85, 1995/96, 1999/2000




La Niña

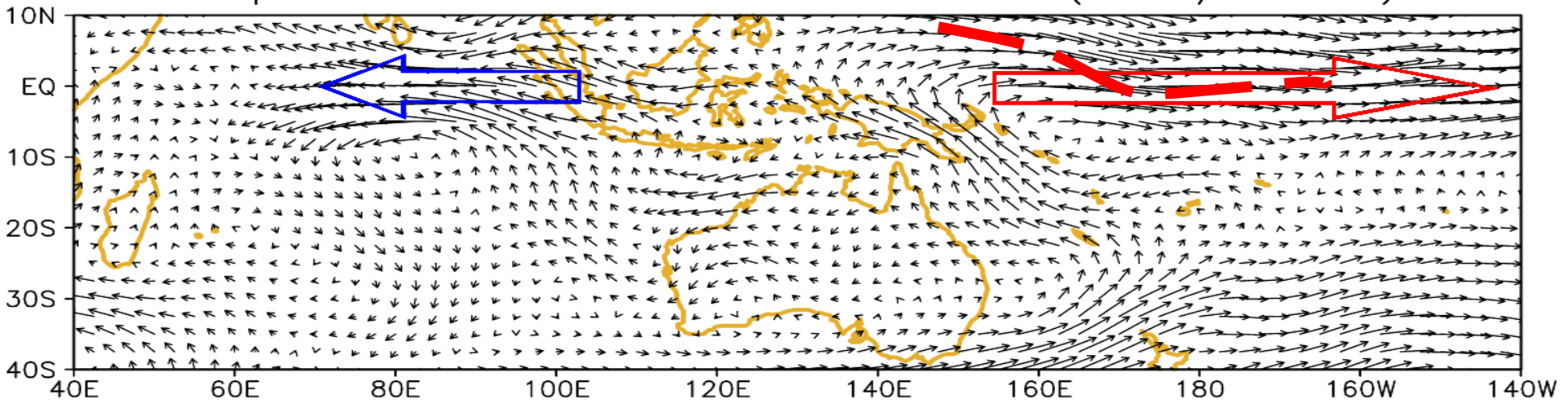
# Sep-Nov SST anomalies EOF2+ vs EOF2-



# Sep-Nov 850-hPa wind anomalies EOF2+ vs EOF2-

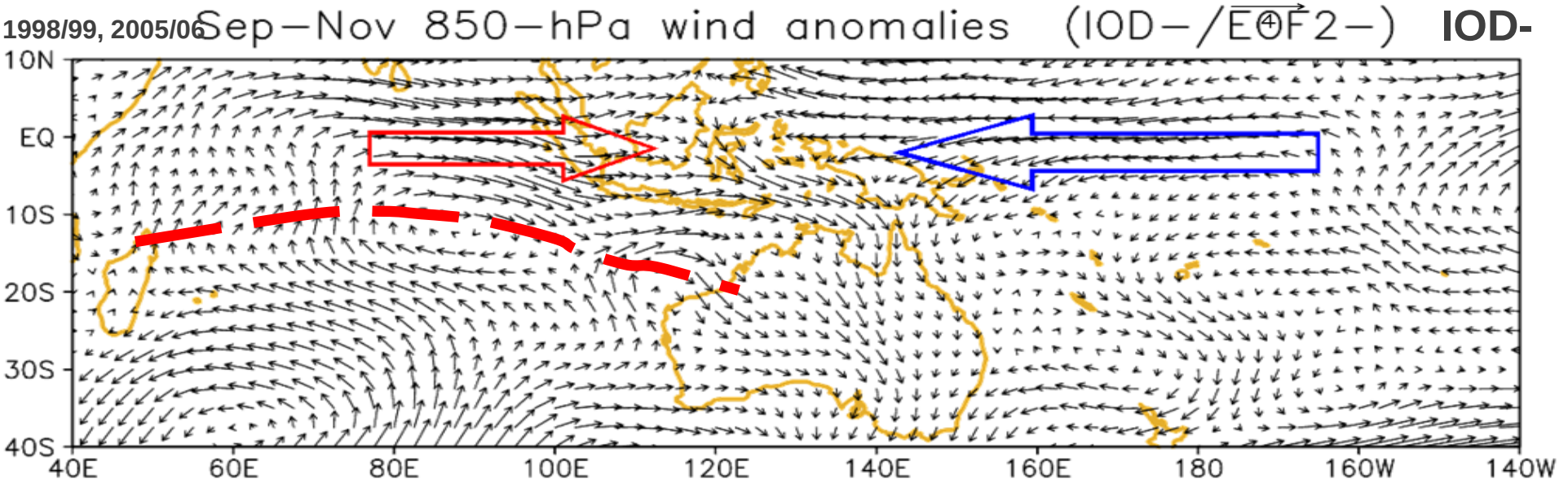
**1987/88, 1994/95, 2002/03, 2006/07**

**IOD+**



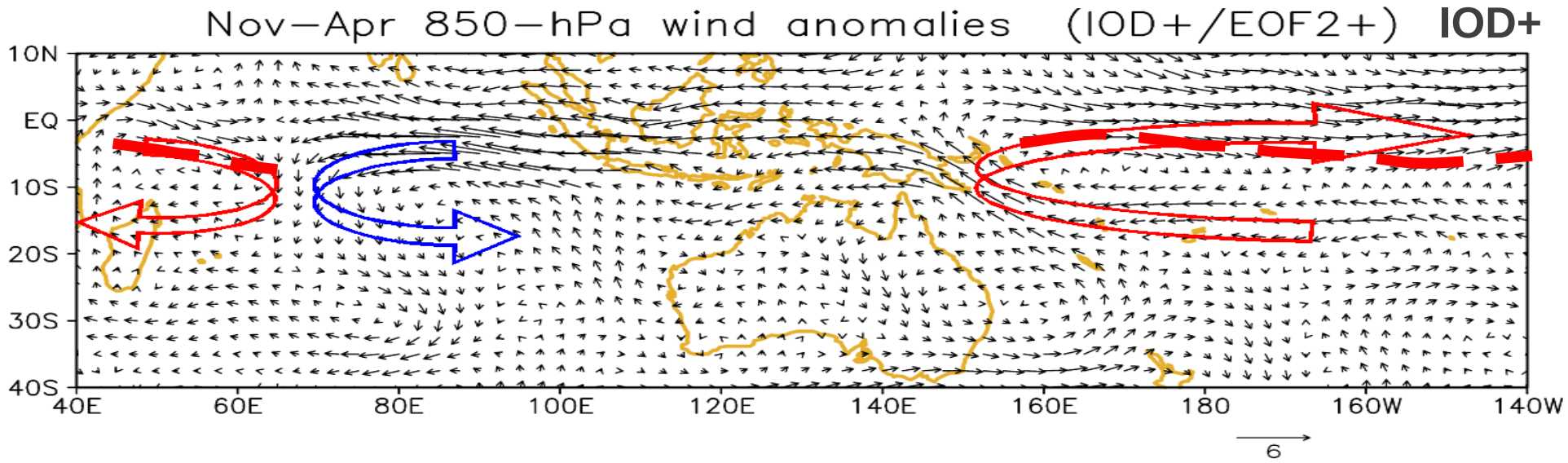

**1998/99, 2005/06**

**IOD-**

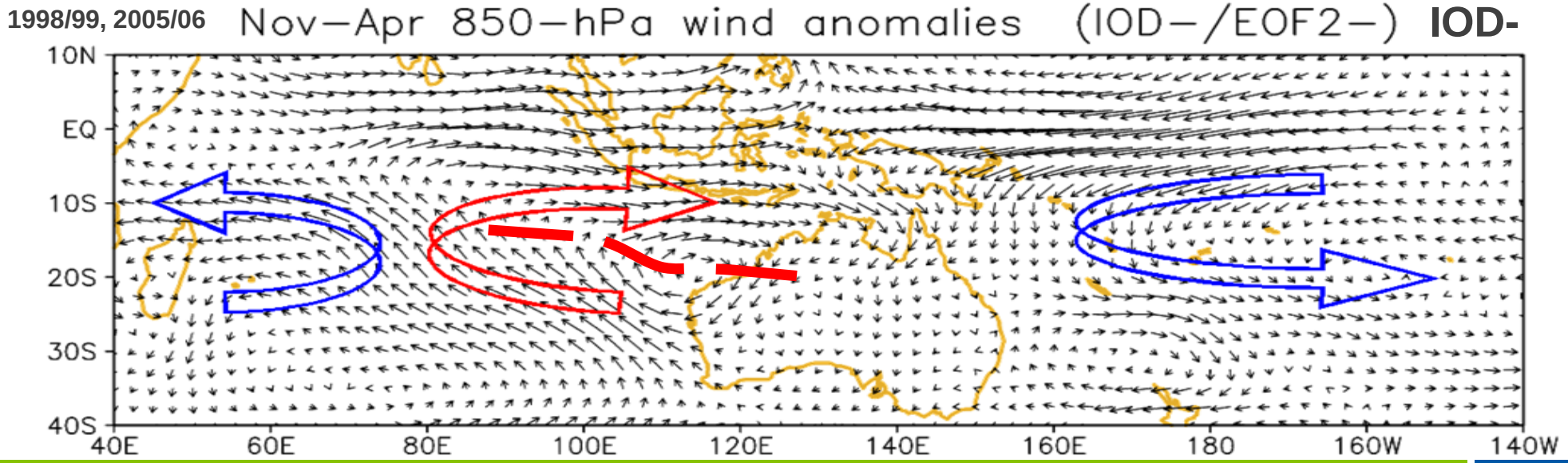


# Nov-Apr 850-hPa wind anomalies EOF2+ vs EOF2-

1987/88, 1994/95, 2002/03, 2006/07




1998/99, 2005/06



# Summary

- **Variations of TC activity on climate (interannual or interdecadal) time scales in the western North Pacific, Indian Oceans and the Southern Hemisphere cannot be explained by *local* SST variations, which suggests that global warming cannot be attributed to the observed TC variability.**
- **Dynamic factors (horizontal and vertical shear), which can be forced by *remote* SST variations such as ENSO or IOD, are mainly responsible for the observed TC variability in these regions.**
- **Models must be demonstrated to be capable of simulating variations in these dynamic factors before their predictions can be used to project future TC activity in these regions.**