Interdecdal variability of intense tropical cyclones in the Southern Hemisphere

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Reference: Cheung, K. K. W., N. Jiang, K. S. Liu, and L. T.-C. Chang, 2012: Interdecadal variability of intense tropical cyclones in the Southern Hemisphere. *Intl. J. Climatol.* (submitted).

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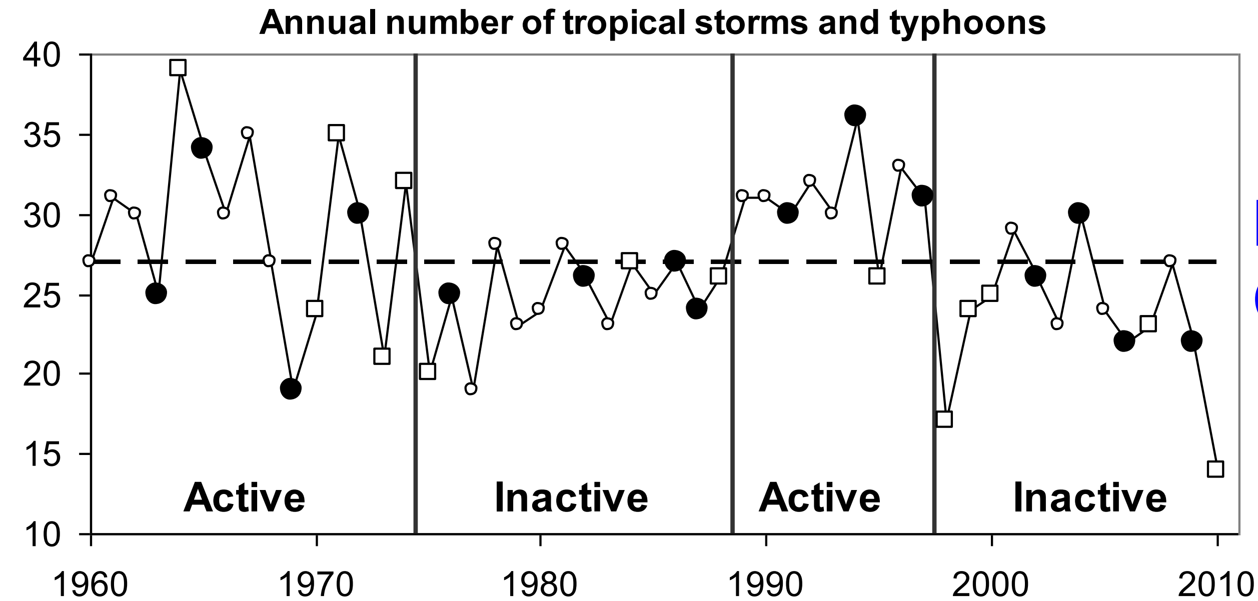
Outline

- Introduction
- Variability of intense TCs in the SH
- Environmental changes
  - SST spatial patterns
  - Vertical wind shear
- Relations with climate variability
- Summary

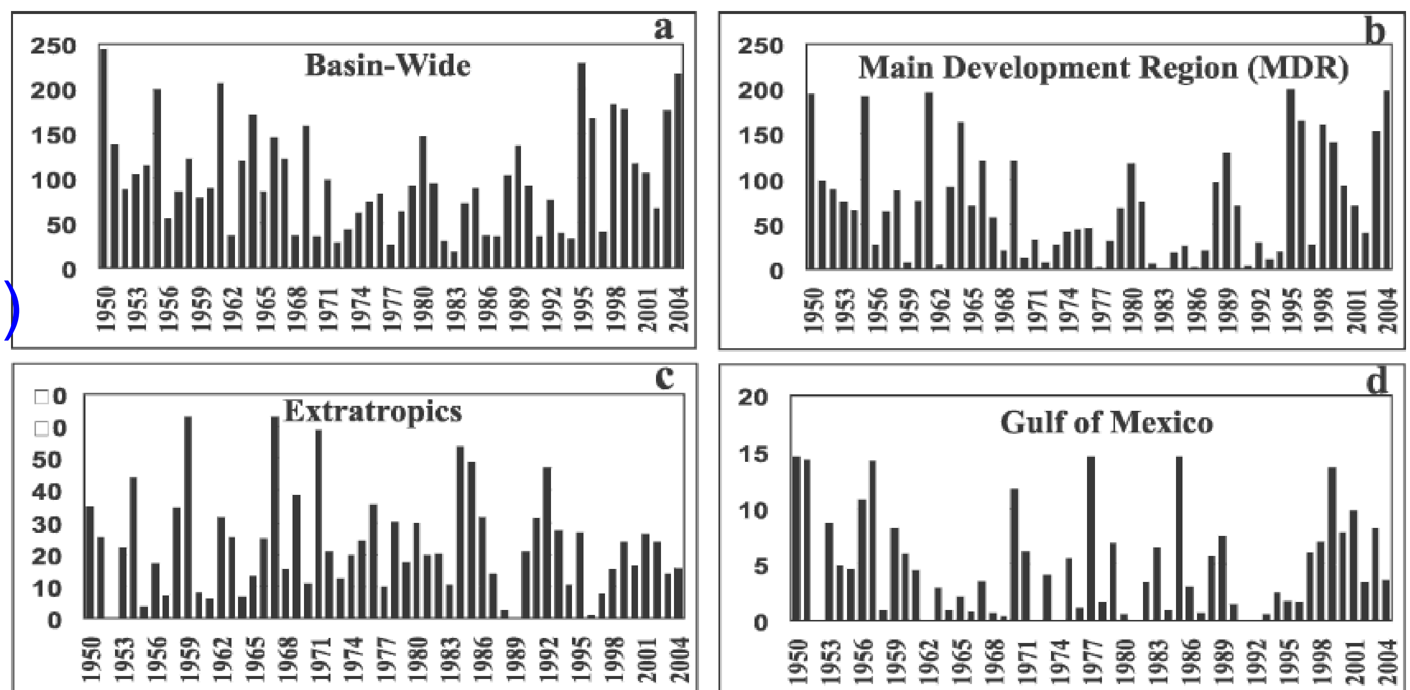
Introduction

- Interannual to interdecadal variability of TC activity exists in various ocean basins, with impacts from both thermodynamic and dynamical factors.
- E.g., WNP TC interdecadal variability is related to vertical wind shear (VWS) and subtropical high activity (Liu and Chan 2012).
- E.g., Atlantic hurricane activity is related to the Atlantic multidecadal (SST) oscillation (Zhang and Delworth 2006; Knight et al. 2006; Bell and Chelliah 2006).



Liu and Chan (2012)

UARY 2006 BELL AND CHELLIAH



Bell and Chelliah (2006)

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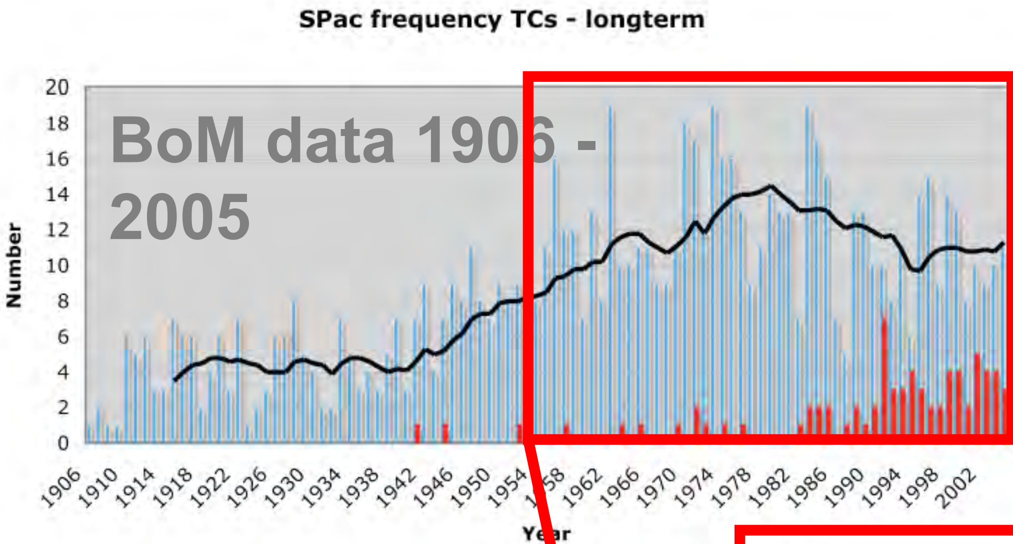
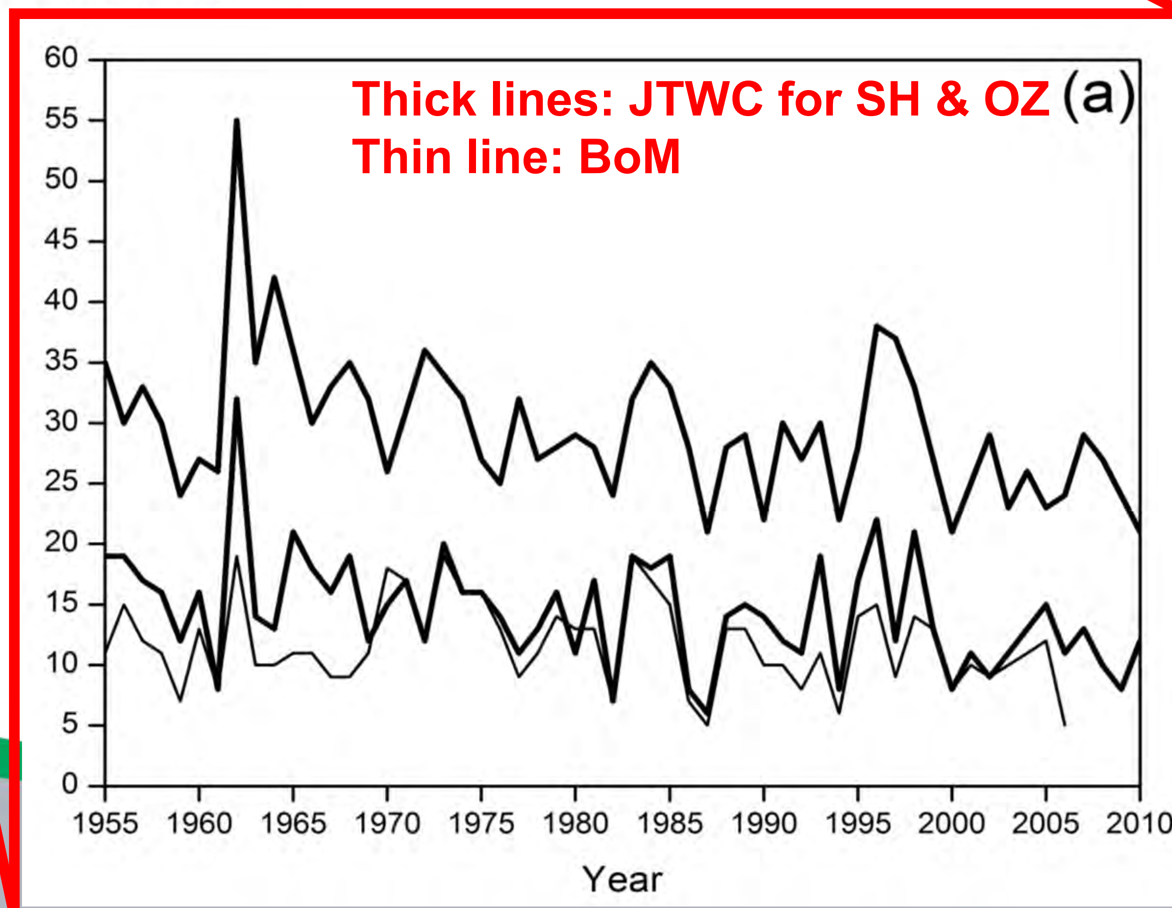
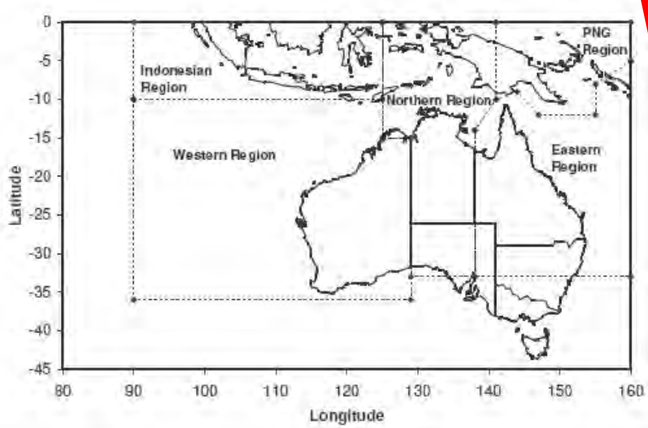
Intense TCs in the SH - Background

- SH TC interannual variability is related to ENSO and the Indian Ocean dipole (IOD) (Liu and Chan 2010).
- There are various sources of TC data for the SH such as the JTWC, BoM, RSMCs such as RSMC La Reunion and RSMC Fiji).
- When satellite observations are available, the TC numbers from different centers basically agree.



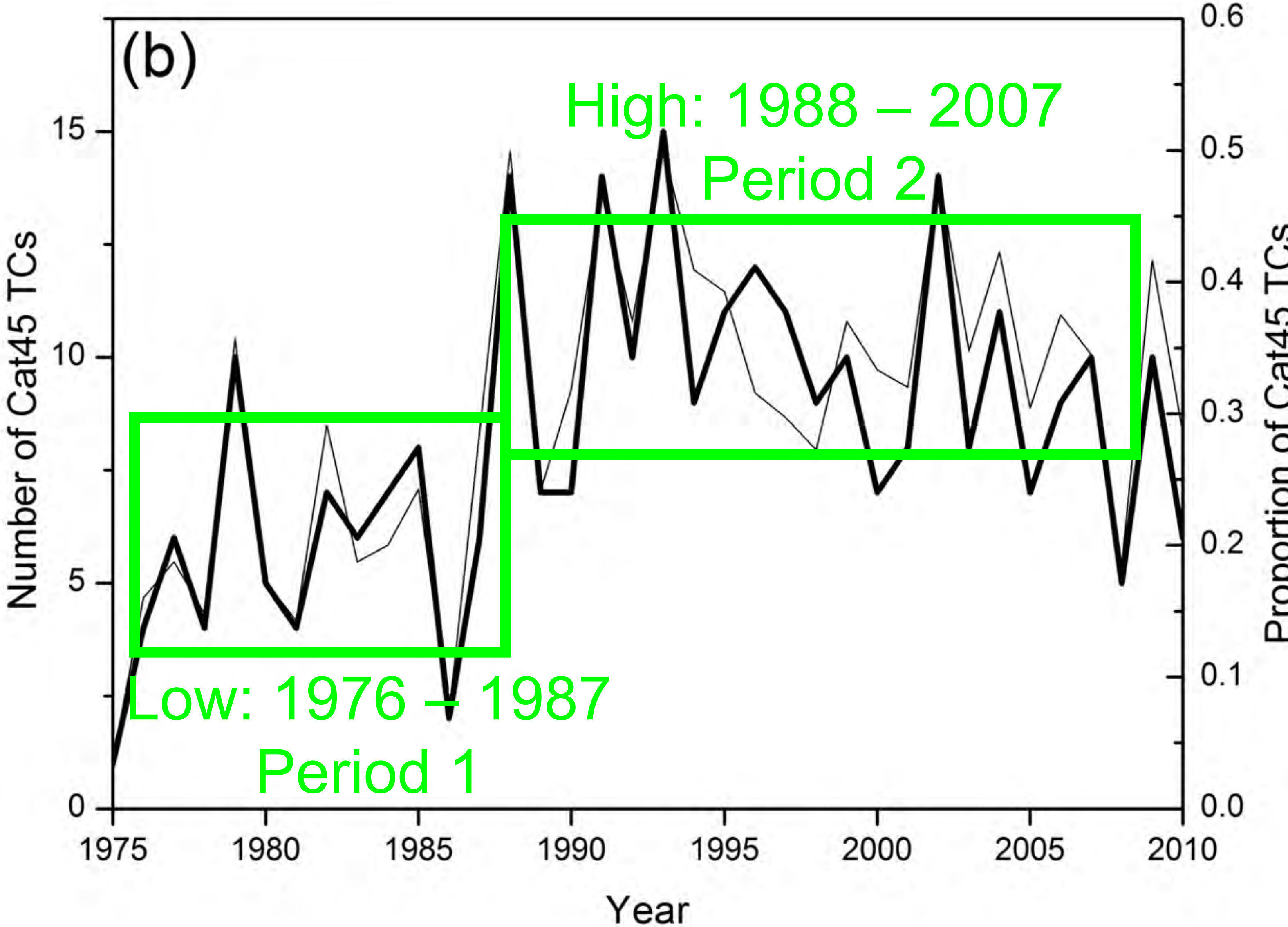


Australian Region
90°E – 160°E



Intense TCs in the SH - Data

- JTWC best tracks
- Period of examination 1976/77-2009/10 in which intensity estimates are quite complete
- Focus on intense TCs ≥ 85 kt (similar to cat-4 and cat-5 in the BoM definition)
- It is quite evident that there was a shift to more intense TCs from 1988/89 until 2007/08.


(b)
High: 1988 – 2007
Period 2
Low: 1976 – 1987
Period 1
Number of Cat45 TCs
Proportion of Cat45 TCs
Year
0
5
10
15
0.0
0.1
0.2
0.3
0.4
0.5
0.6
1975
1980
1985
1990
1995
2000
2005
2010

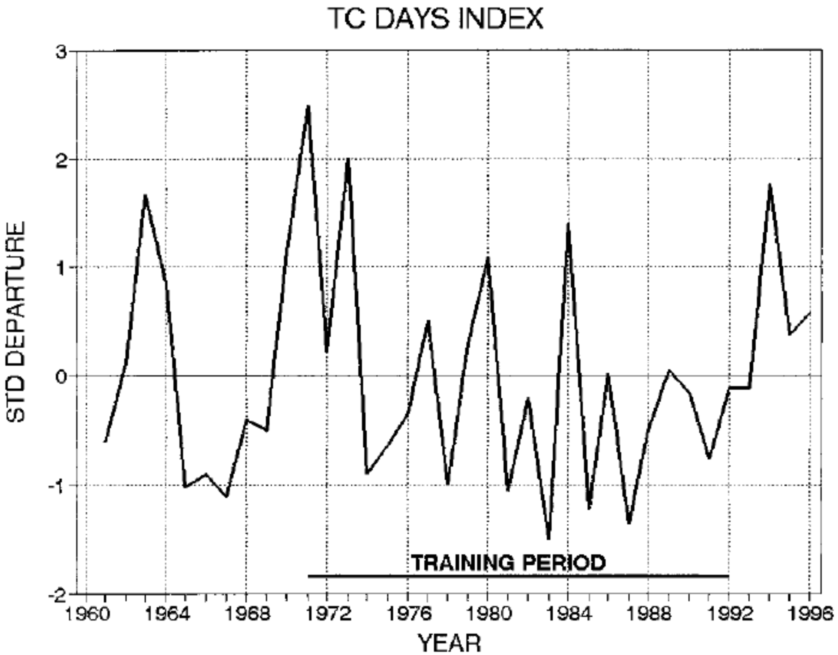
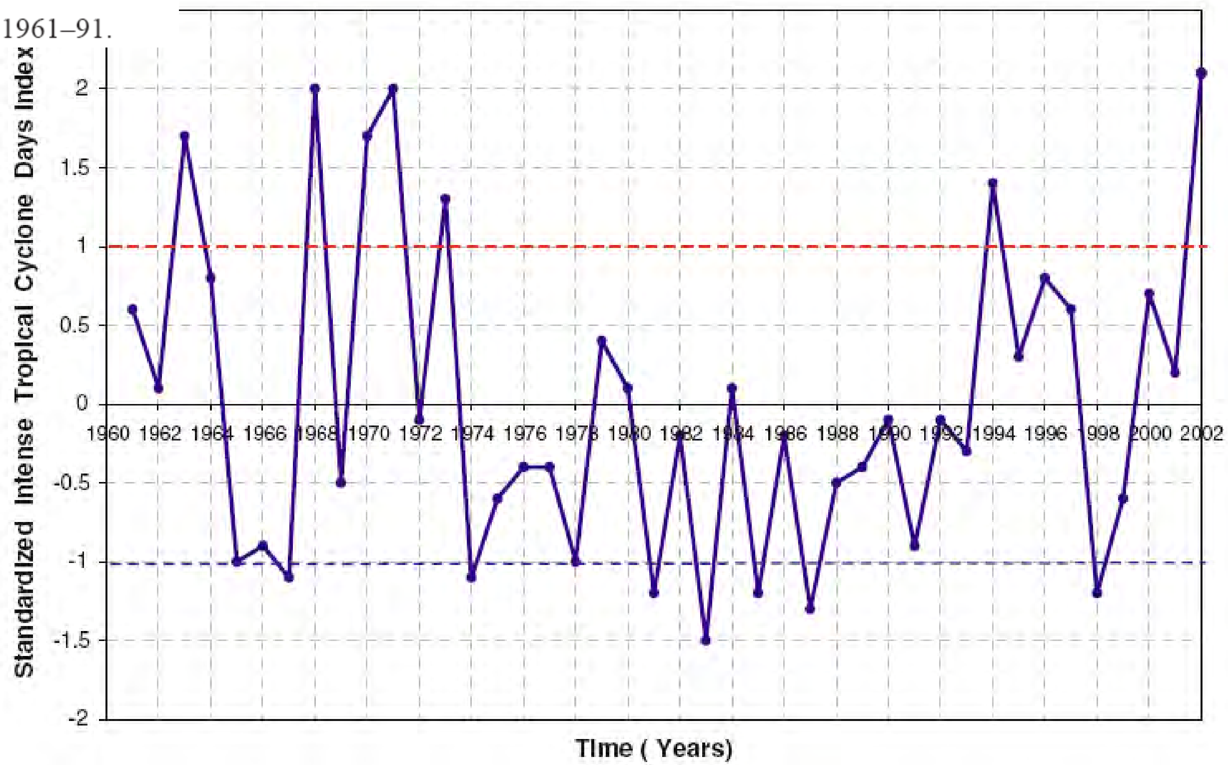


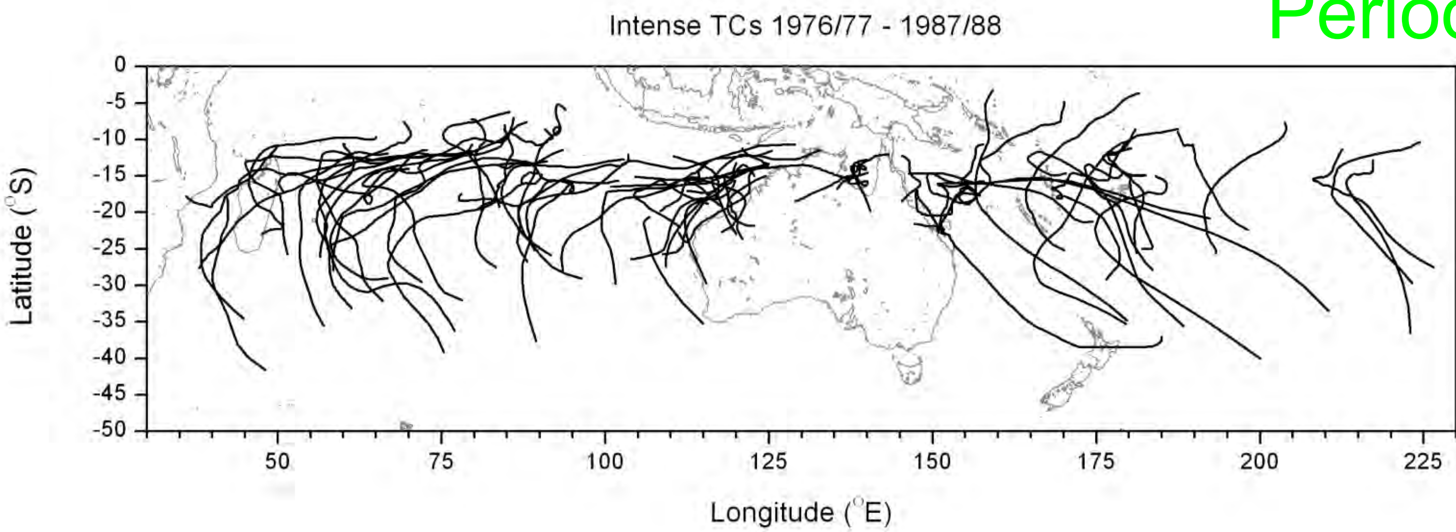
FIG. 2. TC days index time series for the period 1961–91.

TC days index for SWIO 1961-1991 from the Mauritius Meteorological Services and MeteoFrance Reunion (Jury et al. 1999)

Standardized intense TC days anomaly in the SWIO 1961-2002 based on data from the Mauritius Meteorological Services and MeteoFrance Reunion (Chang-Seng and Jury 2010)

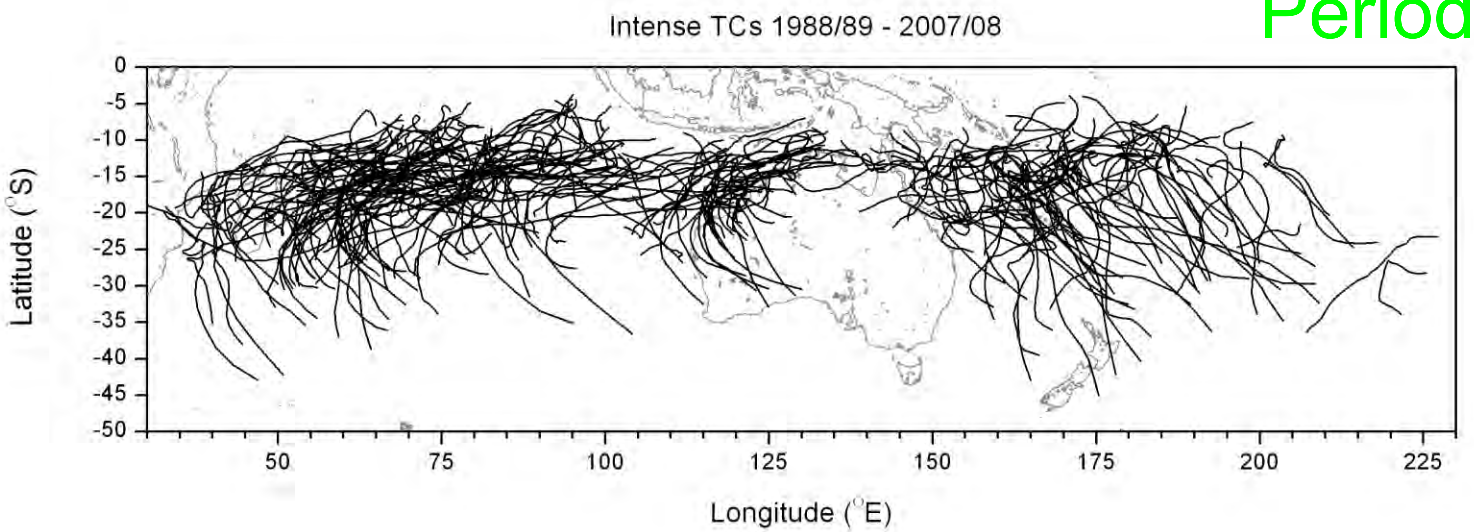


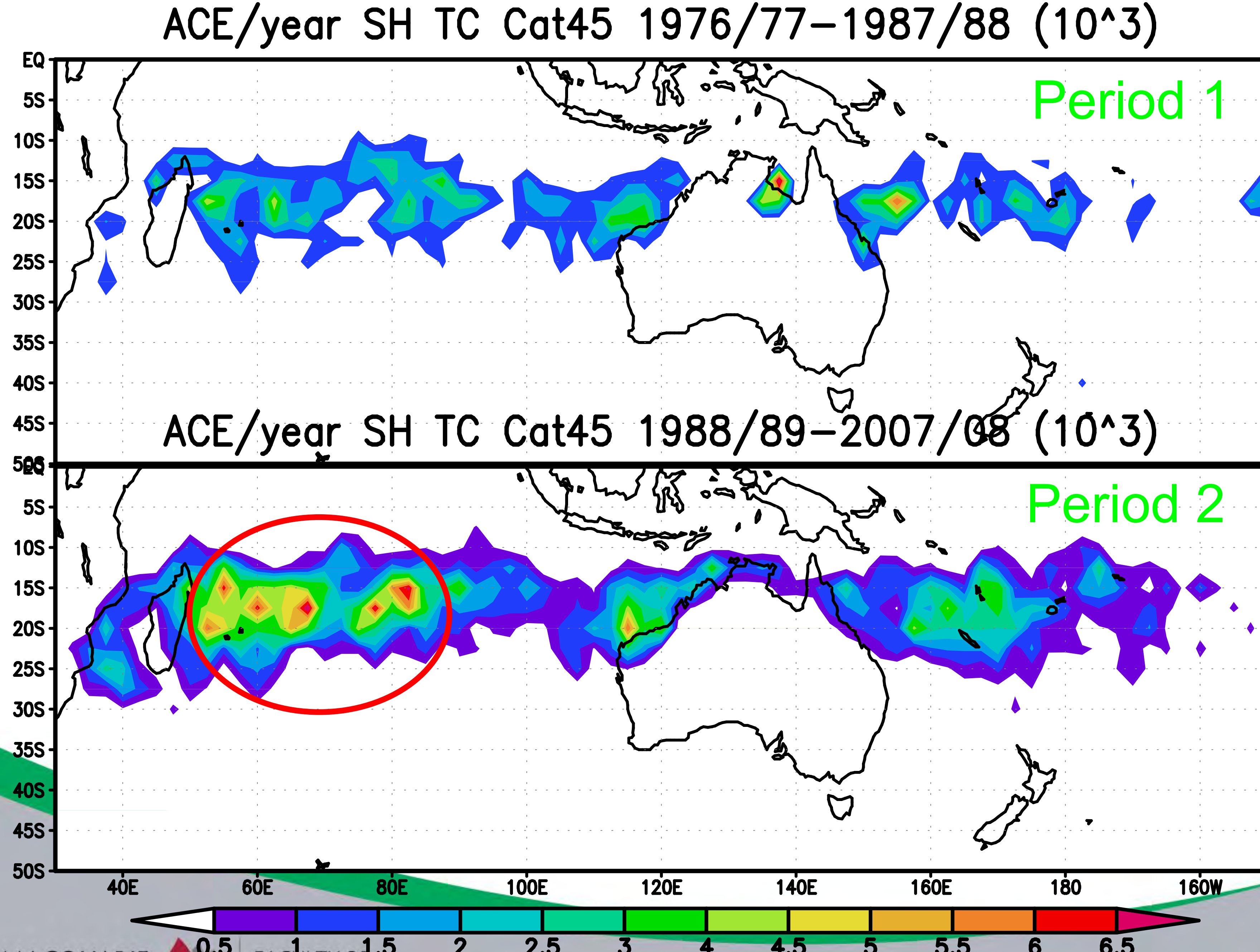
Period 1



There is no obvious change in the locations of the intense TCs.

Period 2





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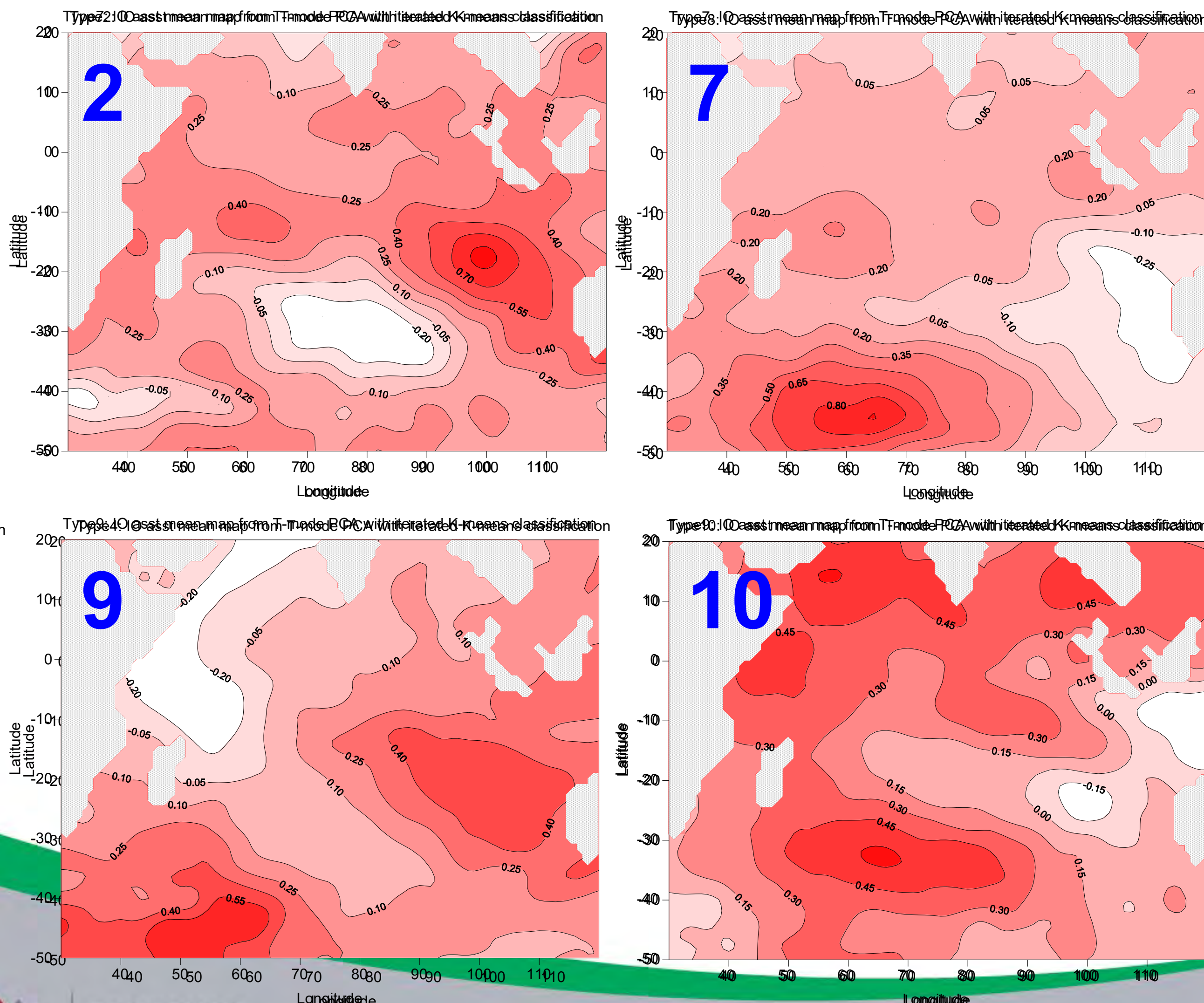
Environmental changes - SST

- Analysis of NOAA ERSST data in the IO during 1976-2008 using obliquely rotated T-mode (spatial correlation) PCA followed by iterated k-means (Jiang 2010, Jiang et al. 2011).
- 12 types of SST pattern are identified
- There are shifts in the dominating patterns from Period 1 to Period 2

		TC Period				Subtotal	
		1: 76-87		2: 88-08			
		Count	Column Valid N %	Count	Column Valid N %	Count	Column Valid N %
QCL_3 iterate:Cluster id 6pcs	1	21	14.6%	29	11.5%	50	12.6%
	2	15	10.4%	3	1.2%	18	4.5%
	3	14	9.7%	27	10.7%	41	10.4%
	4	5	3.5%	23	9.1%	28	7.1%
	5	0	.0%	36	14.3%	36	9.1%
	6	1	.7%	34	13.5%	35	8.8%
	7	26	18.1%	13	5.2%	39	9.8%
	8	4	2.8%	19	7.5%	23	5.8%
	9	21	14.6%	18	7.1%	39	9.8%
	10	15	10.4%	6	2.4%	21	5.3%
	11	16	11.1%	21	8.3%	37	9.3%
	12	6	4.2%	23	9.1%	29	7.3%

The ‘cold’ patterns in Period 1



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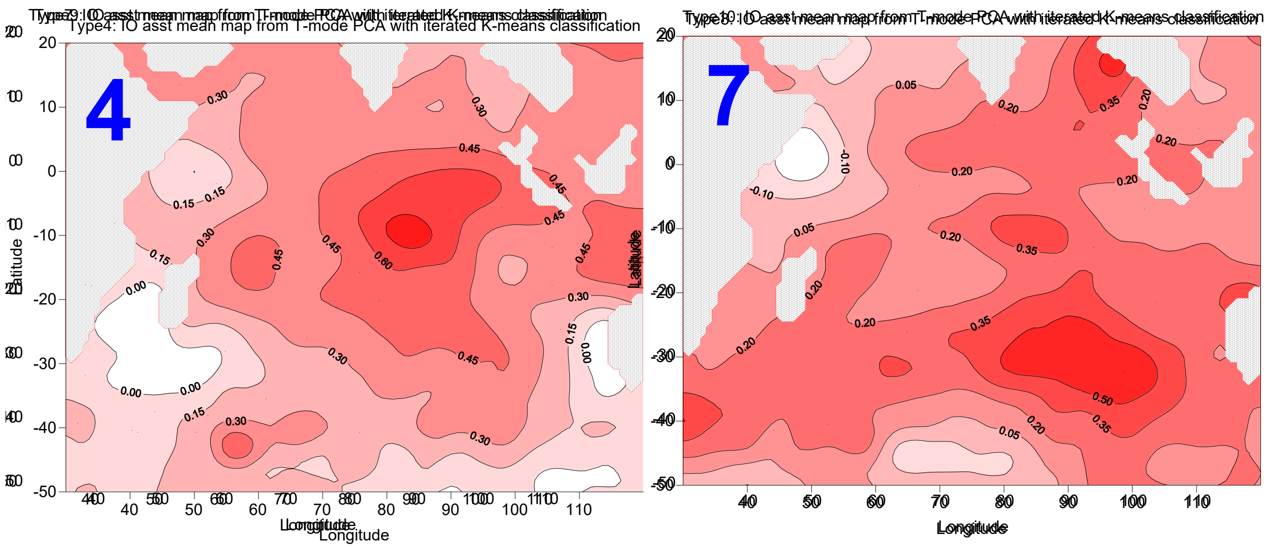
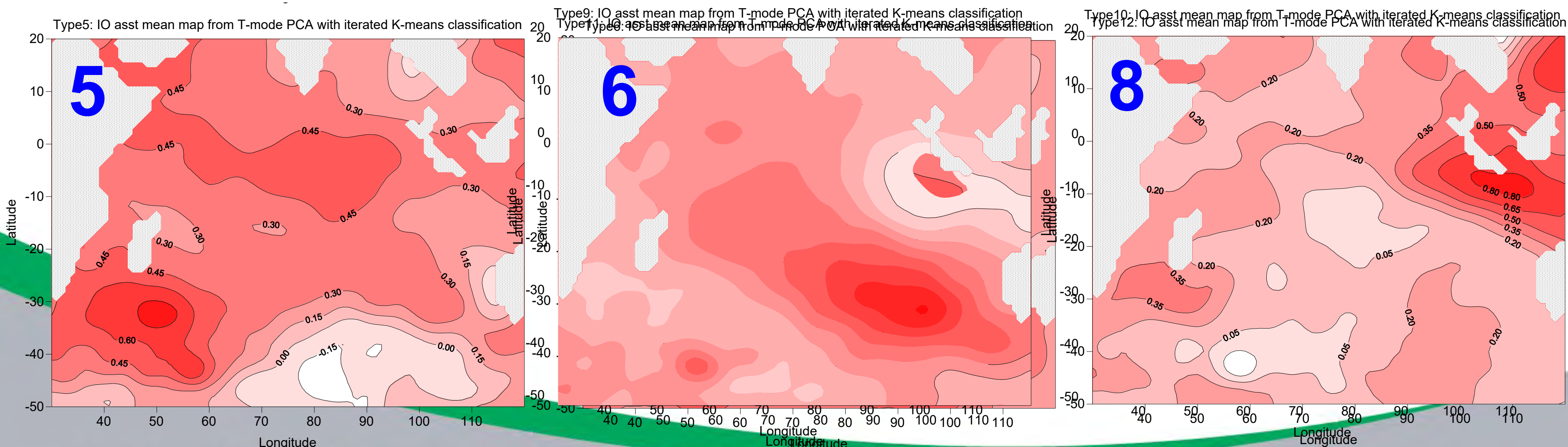
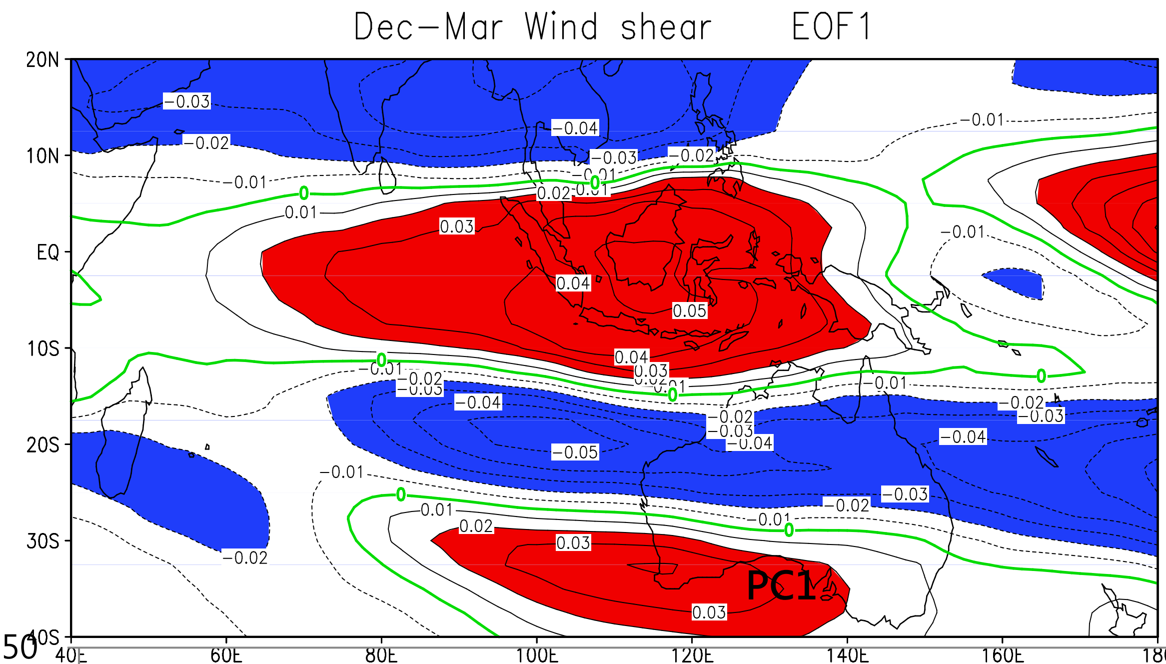
The ‘warm’ patterns in Period 2





Environmental changes - VWS

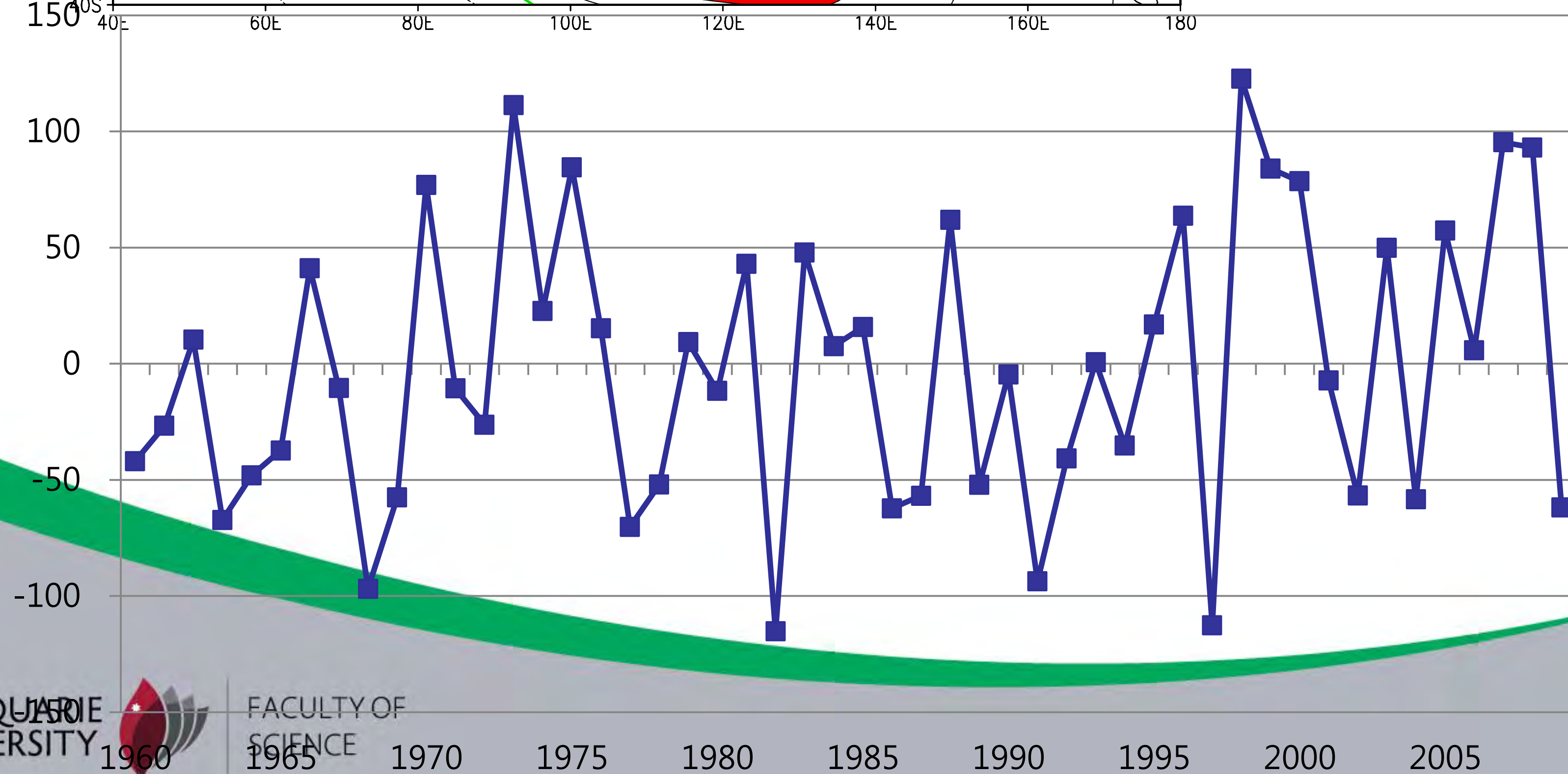
- EOF analysis of 200-850-hPa zonal vertical shear anomaly during DJFM of 1960-2009 using NCEP reanalysis data
- The first mode (34.6% variance) is ENSO mode because it highly correlates with the first Pacific mode
- The second mode (11.8% variance) has PC time series showing a shift to lower VWS magnitude during late 1980s.

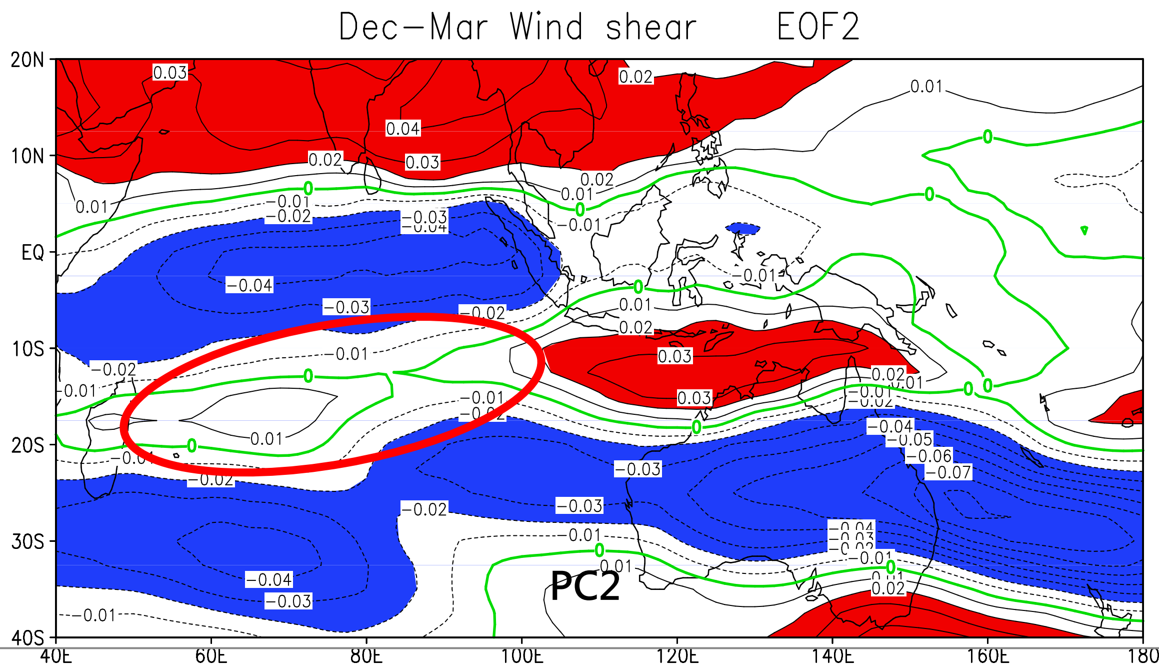


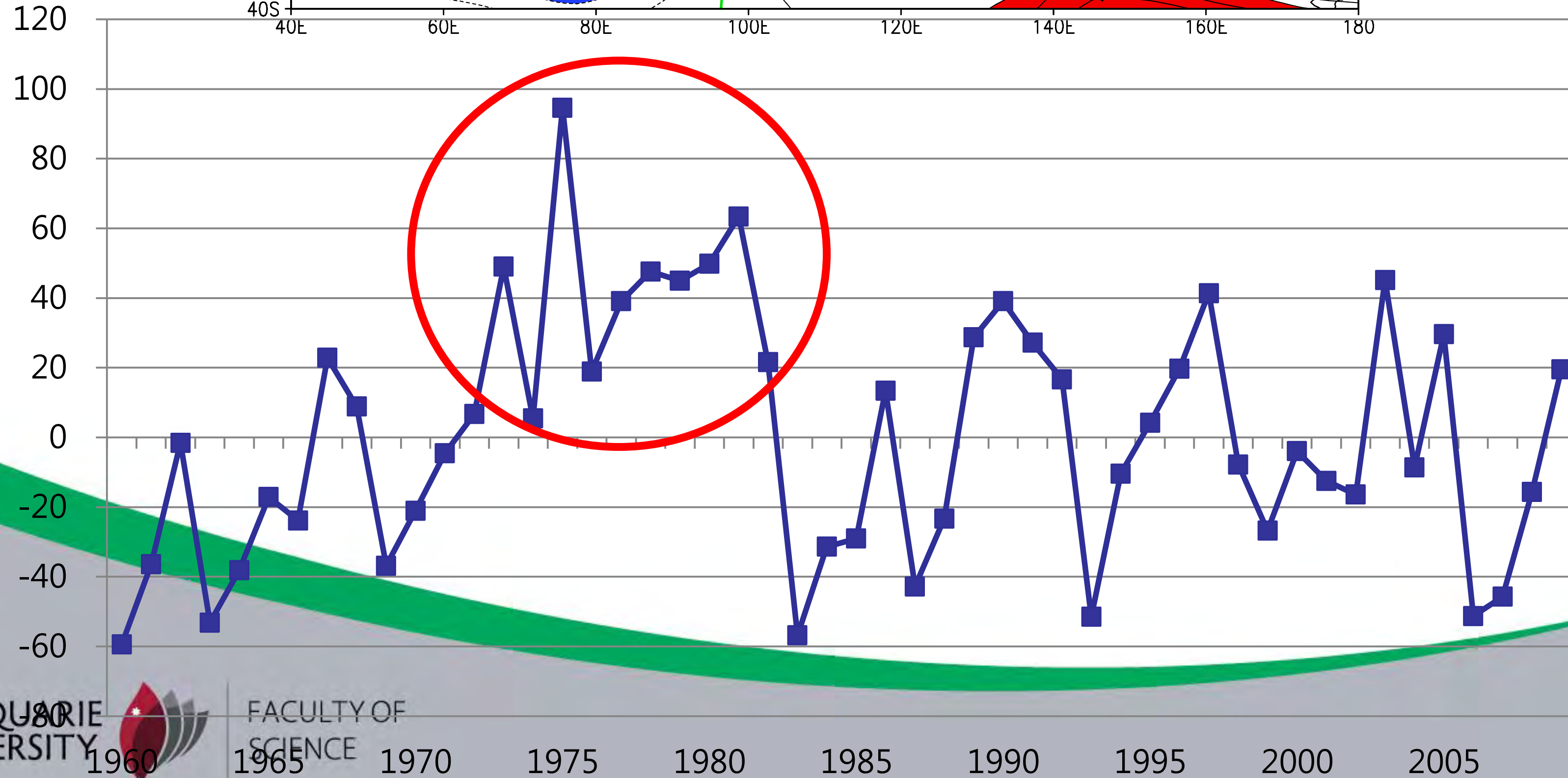
ENSO mode:

1. High correlation with Pacific domain PC1

2. High correlation with Nino 3.4



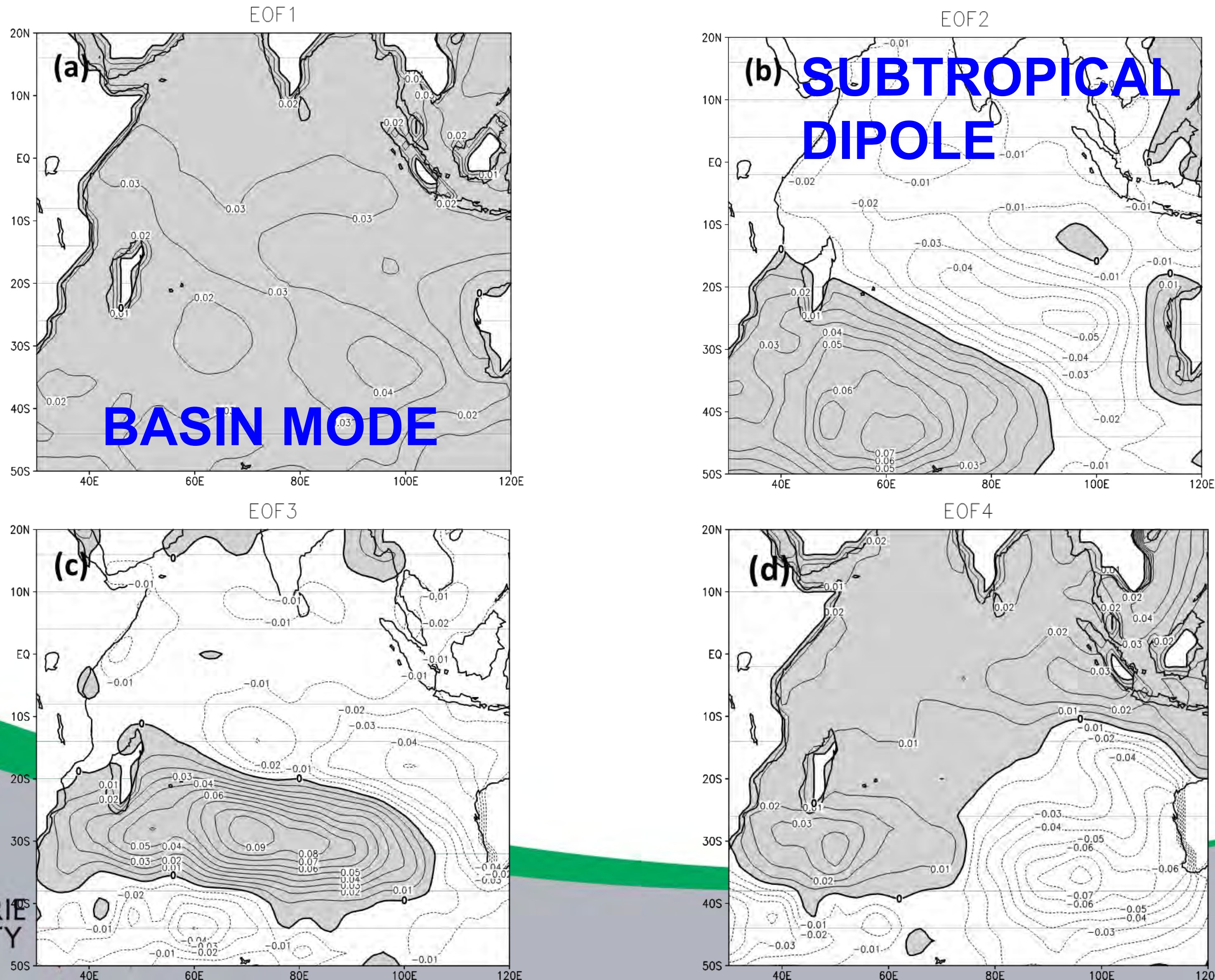

Dec–Mar Wind shear EOF2
20N
10N
EQ
10S
20S
30S
40S
40E
60E
80E
100E
120E
140E
160E
180
PC2


120
100
80
60
40
20
0
-20
-40
-60
-80
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005

Relations with climate variability in the Indian Ocean

- The EOF modes of VWS not significantly correlated with the dipole mode index (0.05 level).
- Both EOF modes of VWS significantly correlated with the subtropical dipole index (r=0.52, 0.32, 0.05 level).

EOFs of DJFM SSTA



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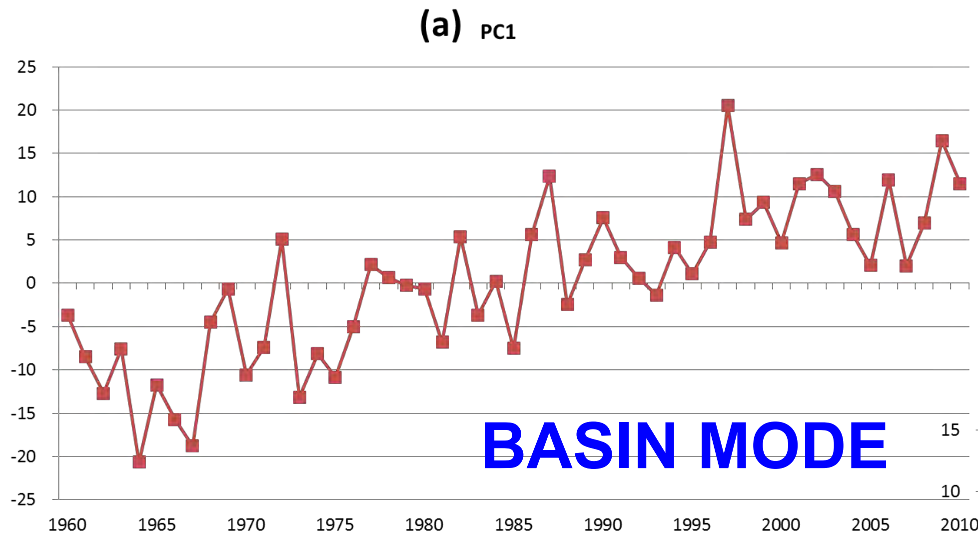
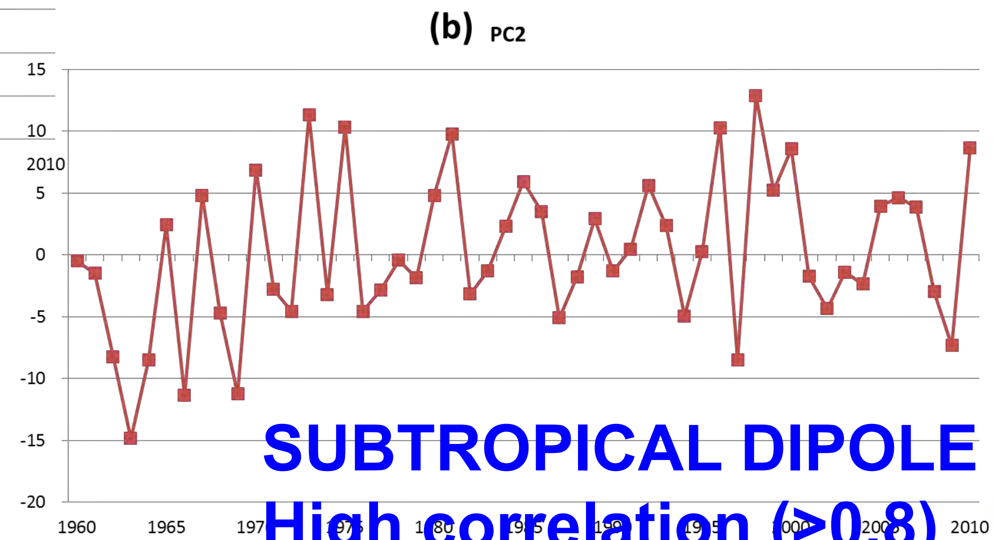
EOFs of DJFM SSTA



BASIN MODE



SUBTROPICAL DIPOLE

High correlation (>0.8) with SDI

Relation between VWS and SST modes

- The correlations between VWS-PC1 and VWS-PC2 and SST-PC2 (subtropical dipole) are significant at 0.05 level (r=0.57, 0.29)
- That is, the variability of VWS is likely modulated by the subtropical dipole, which is established by pressure and temperature gradient between subtropical high and continental low during Austral summer (Behera and Yamagata 2001)

Summary

- There was a shift from low intense TC activity to high activity from Period 1 (76/77-87/88) to Period 2 (88/89-07/08) in the SH (especially SWIO).
- There are associated changes in SST patterns and average VWS magnitude.
- The subtropical dipole in the SIO is likely the climate mode responsible for identified changes in SST and VWS.