Recent Changes in Indo-Pacific Climate Fluctuations

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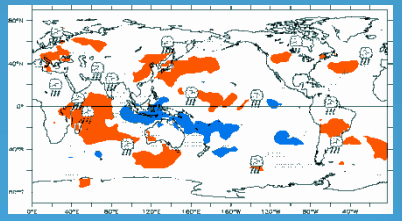
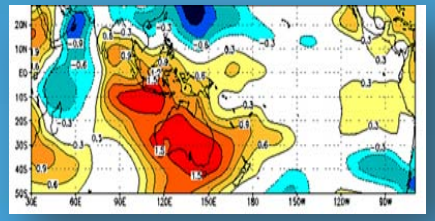
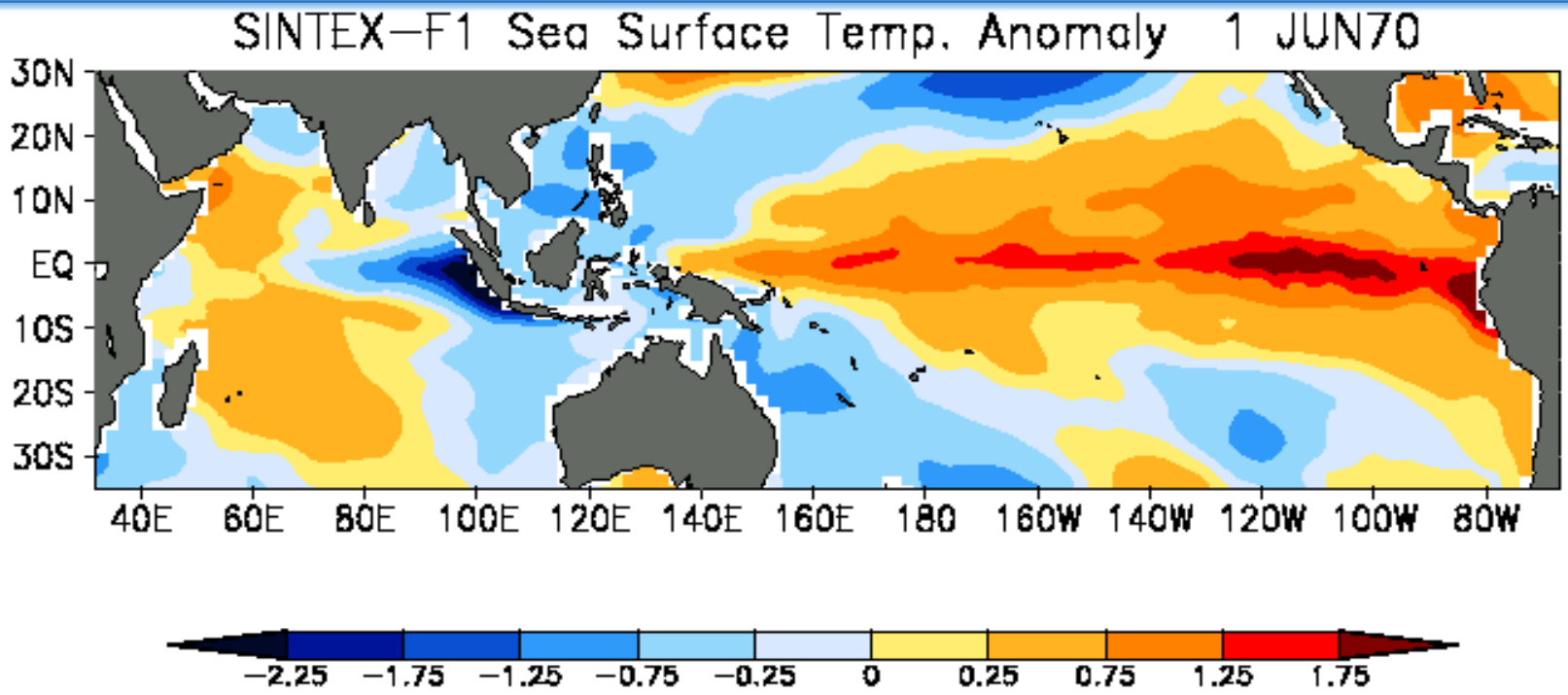
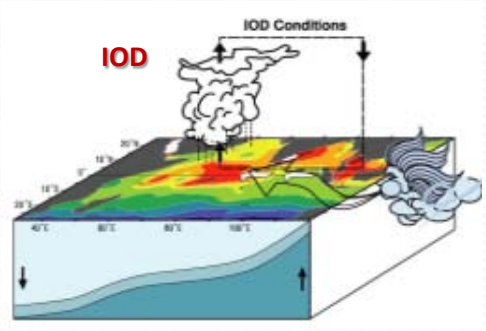




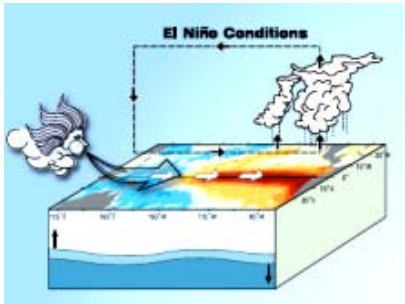
The Indo-Pacific Climate Variations



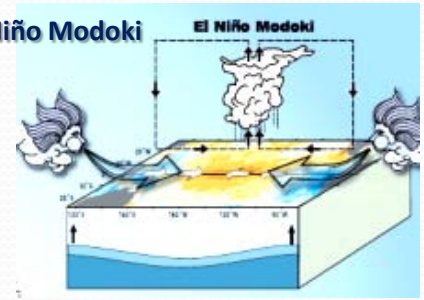
INDO-PACIFIC CLIMATE MODES



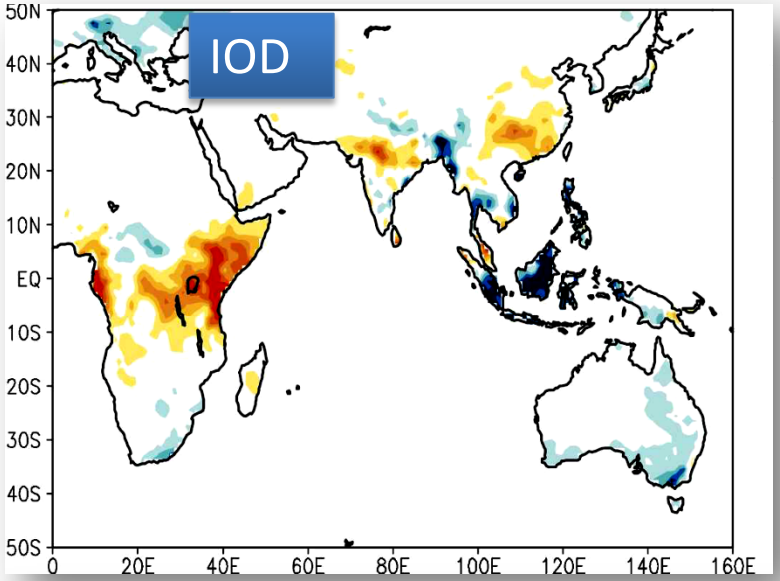
El Niño

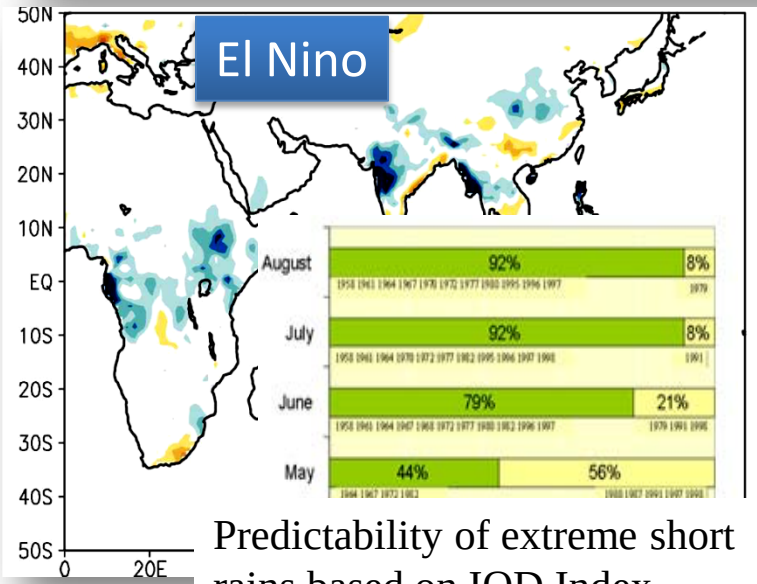


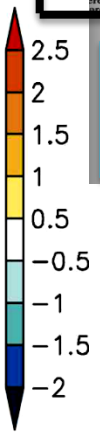
El Niño Modoki



IOD related regional rainfall anomalies: Paramount impact on Short Rains



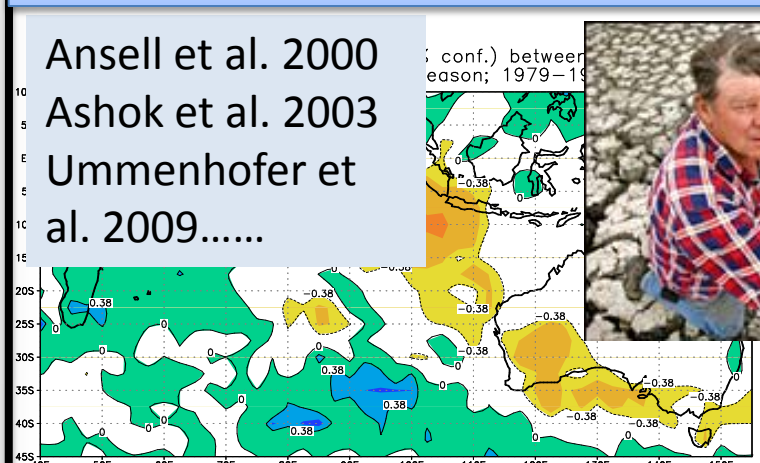




Predictability of extreme short rains based on IOD Index

Australia suffered one of the worst draughts in 2006.

Ansell et al. 2000
Ashok et al. 2003
Ummenhofer et al. 2009……

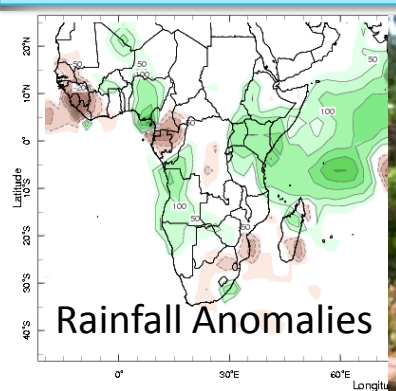


Signal failure

Signal failure as drought wa

EXCLUSIVE

More than one million people in East Africa were affected by the 2006 IOD event.



Rainfall Anomalies

9-member seasonal hindcast experiments

1. Three models with different coupling physics
(with realistic ENSO simulations):

Control run (CTL):

Ocean surface current is neglected:
|**U**a| **U**a for Tau & heat flux.

FCPL run:

Ocean surface current now gives its momentum to the atmosphere:
|**U**a-**U**o| (**U**a-**U**o) for Tau & heat flux.

semiCPL run:

Ocean surface is still kept solid to the atmosphere:
but Tau: |**U**a-**U**o| (**U**a-**U**o).

2. Initial condition:

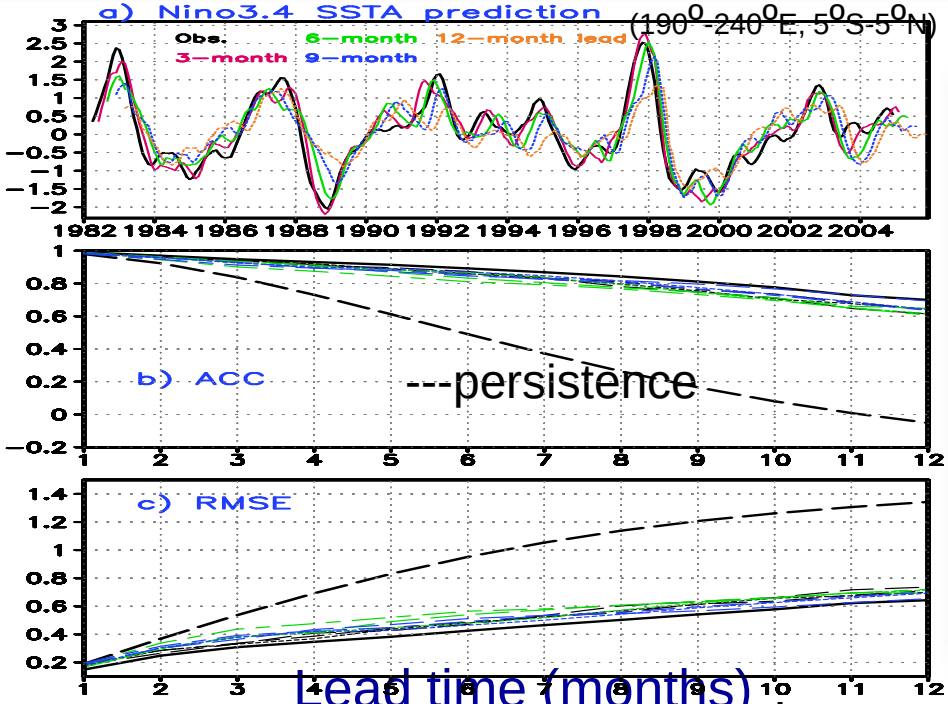
- 1971-1981: Model spin-up
- 1982-2004: A simple coupled SST-nudging scheme

3. Three different restoring timescales for SST-nudging:

- 1day, 2 days, 3 days (weekly NCEP Reynolds data)

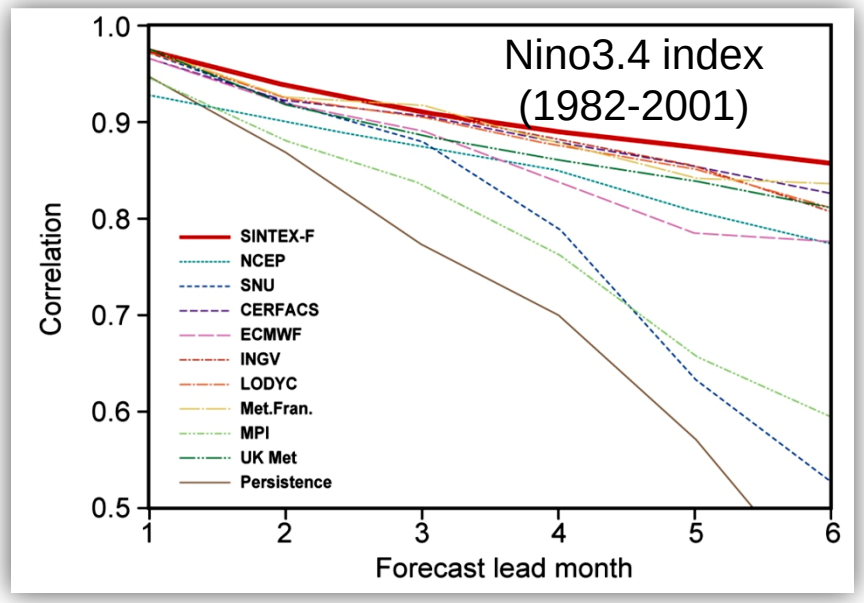
Luo et al., J. Climate, 2005, 4474-4497.

SINTEX-F predictions of seasonal to interannual climate variations

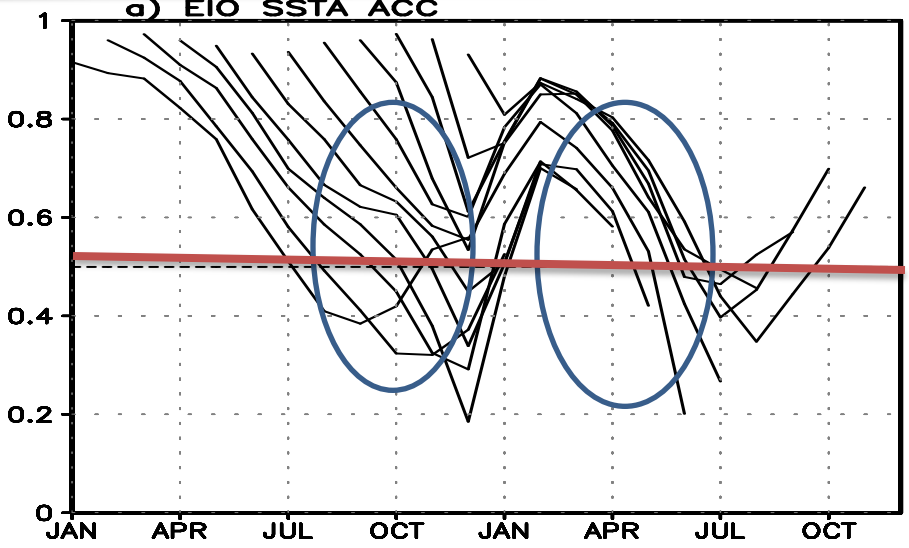


Luo et al. 2005

ENSO prediction skill of 10 coupled GCMs



Jin et al. 2007



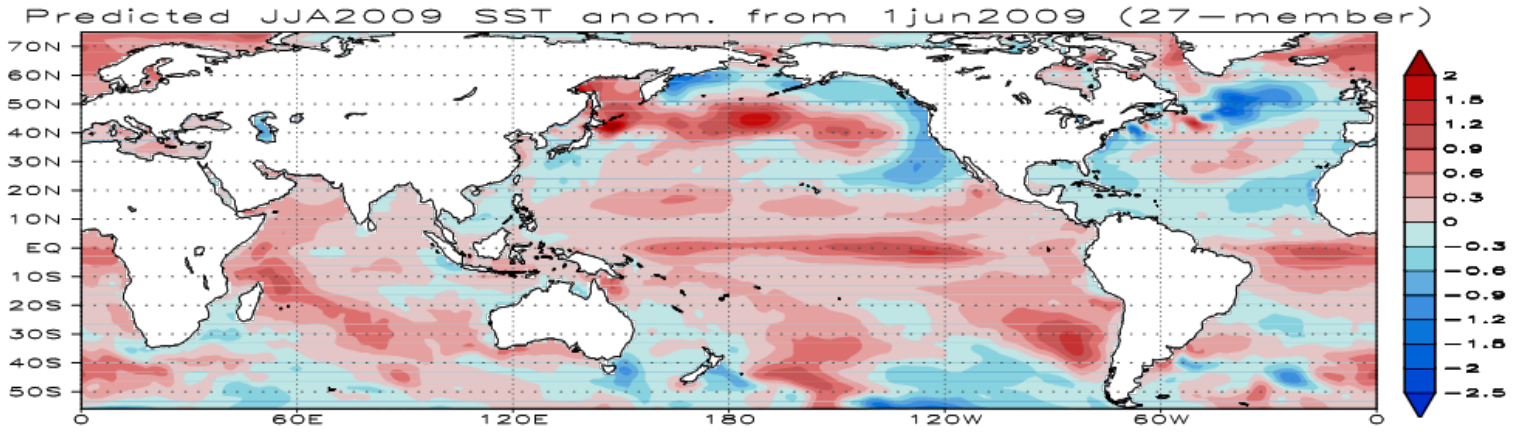
Indian Ocean Dipole

9-member ensemble hindcasts (1982-2004)

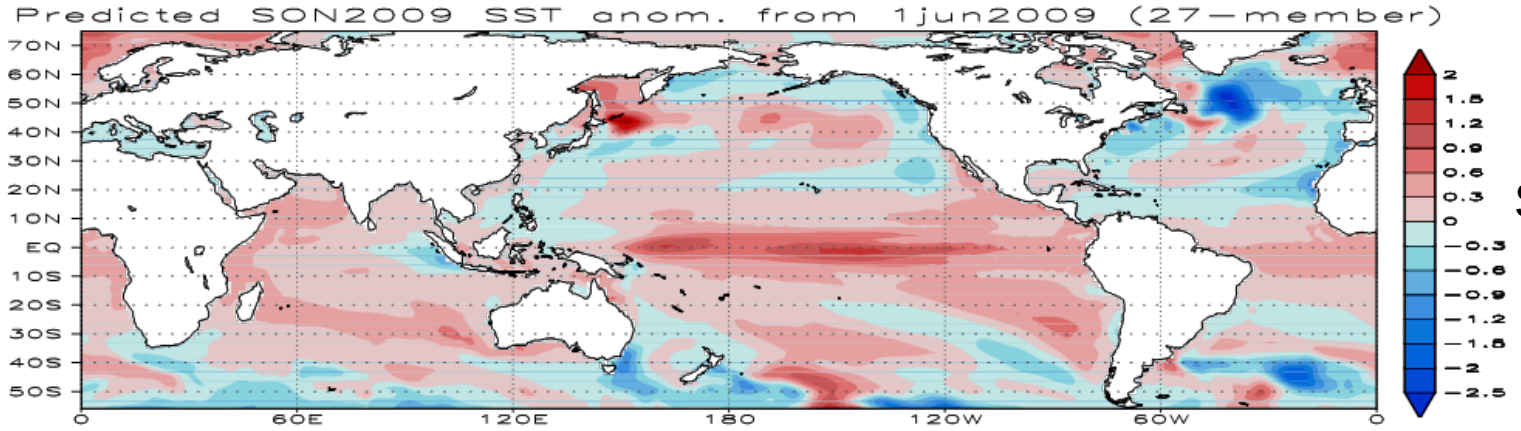
Both winter and spring barriers exist

Luo et al. 2007

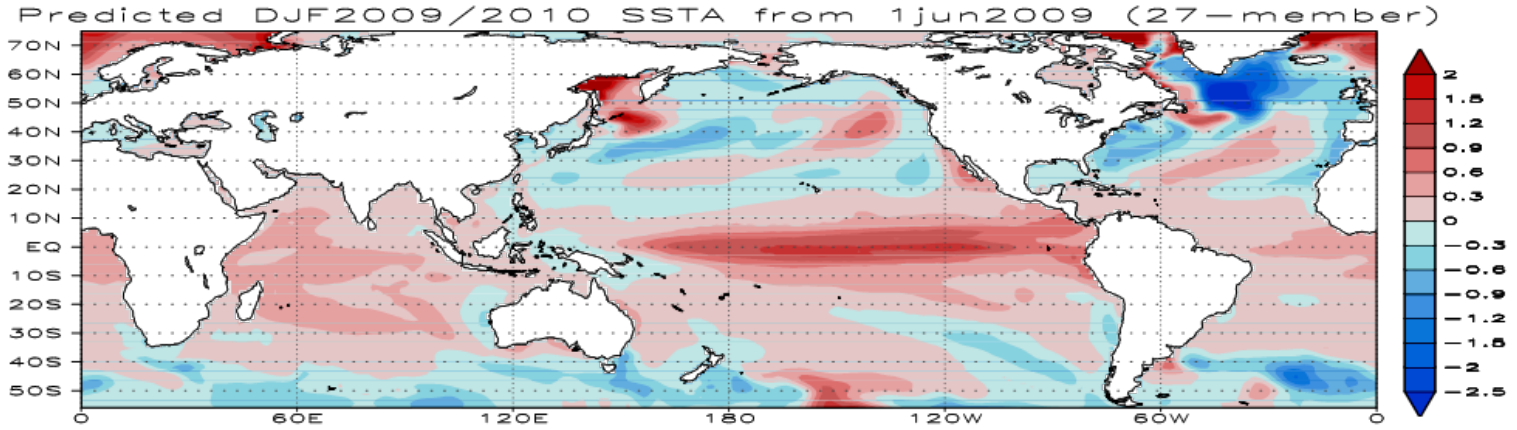
Global SSTA forecasted from 1Jun2009 (27-member mean, SINTEX-F CGCM)



JJA2009



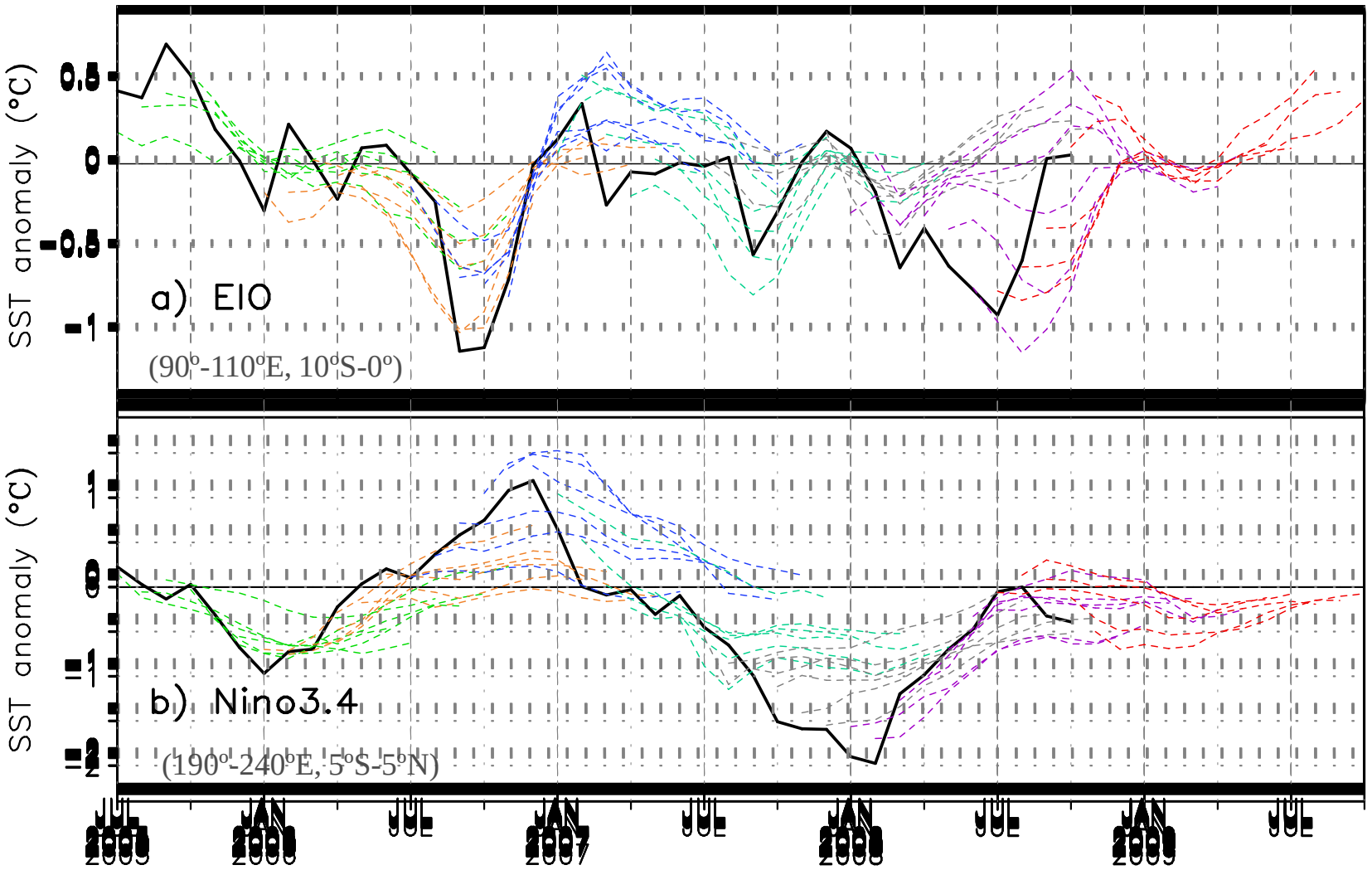
SON2009



DJF09/10

Real time forecasts (27-member)

http://www.jamstec.go.jp/frcgc/research/d1/iod/index.html



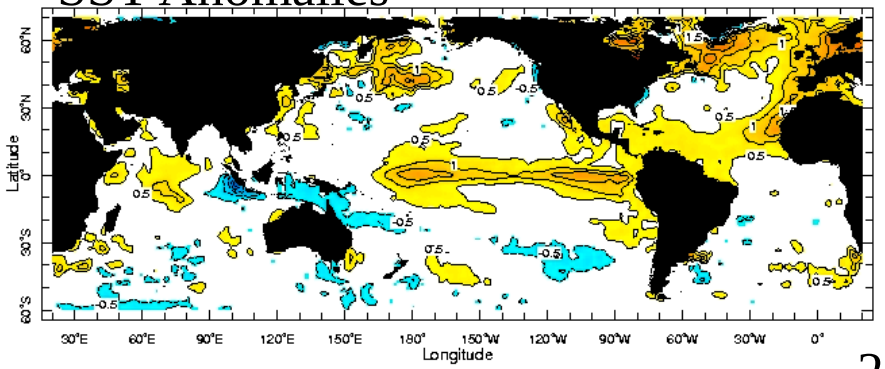
Luo et al. GRL2008, highlighted

THREE CONSECUTIVE POSITIVE IOD EVENTS

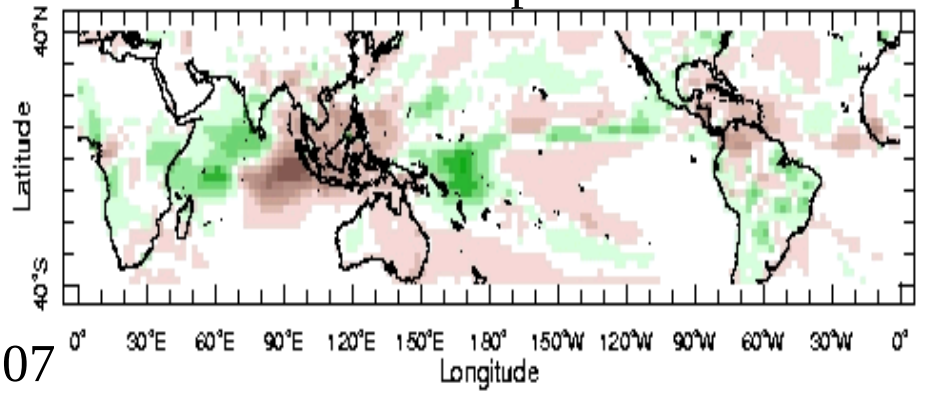
SST Anomalies

Precipitation Anomalies

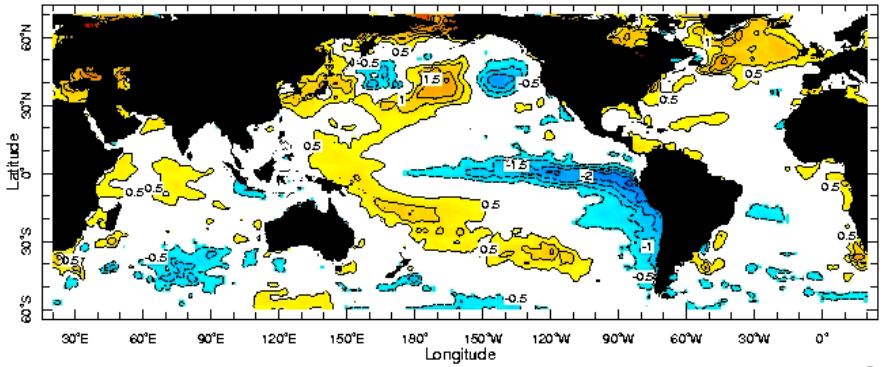
2006



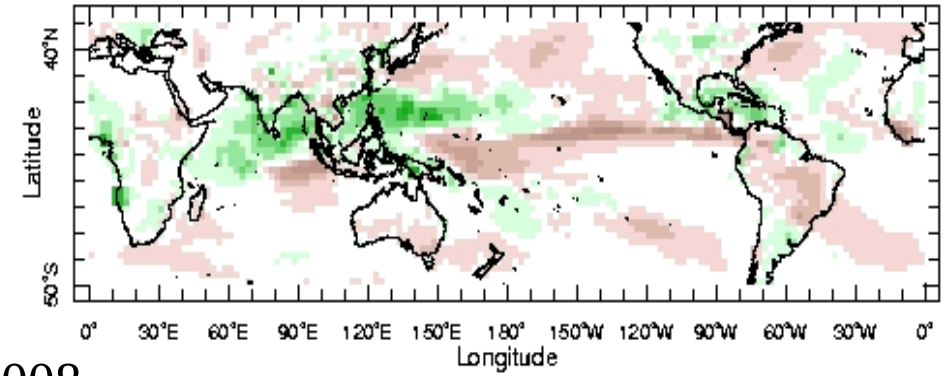
Sep-Nov 2006



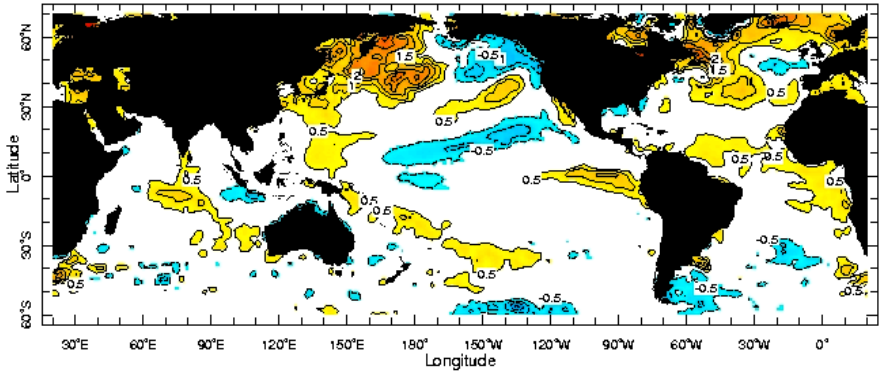
2007



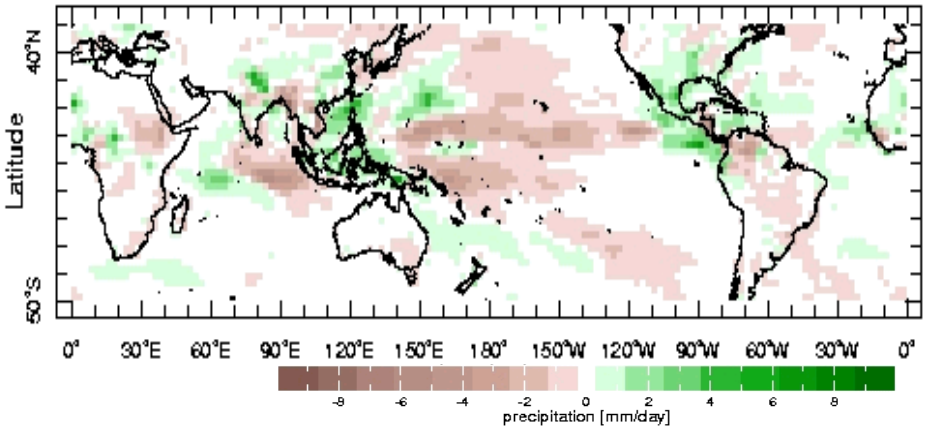
Aug-Oct 2007



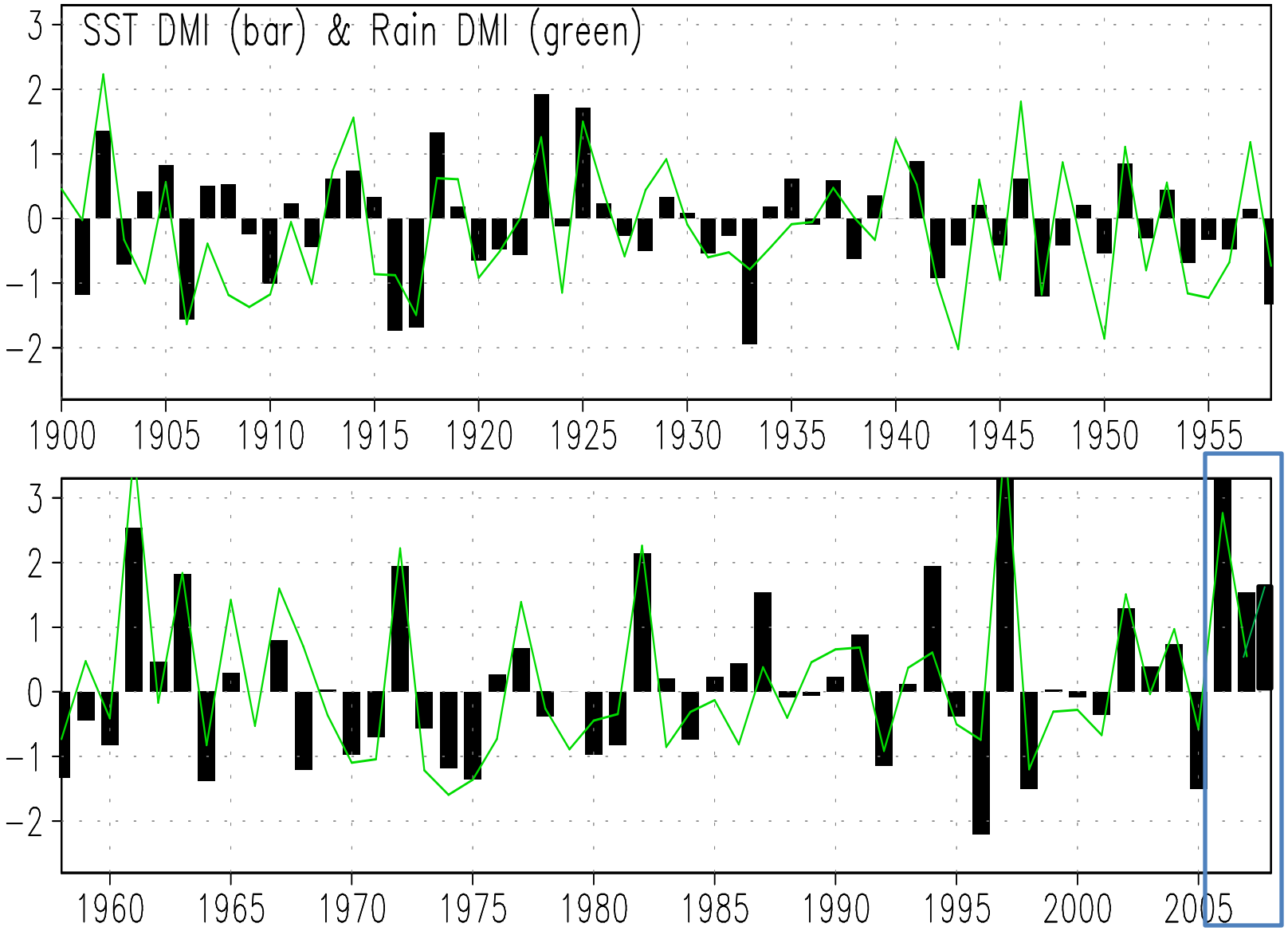
2008



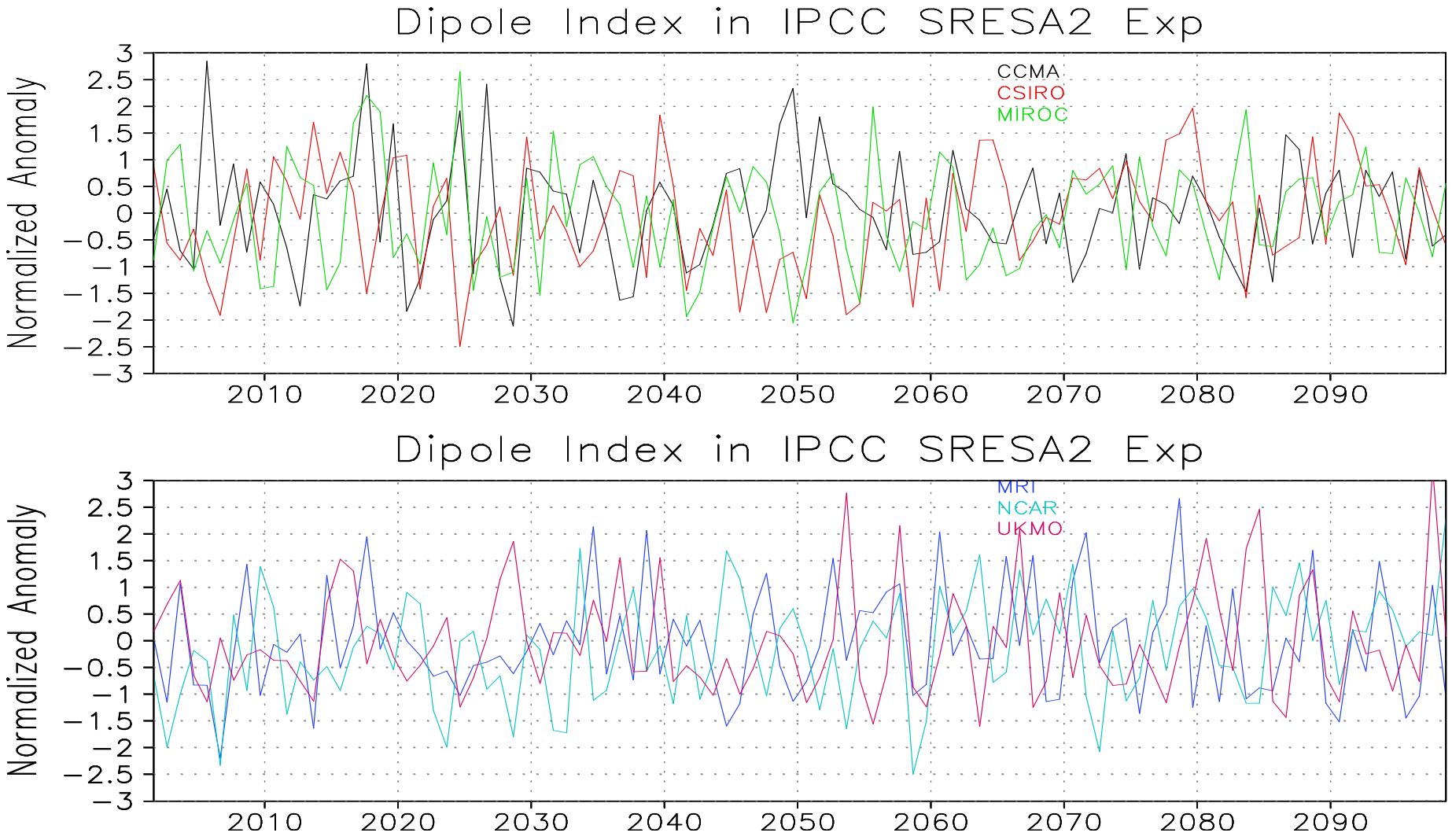
Jul-Sep 2008



Historical records of SST Dipole Index and Rainfall Dipole Index



Behera et al. 2008;GRL


Dipole Index in IPCC SRESA2 Exp
Normalized Anomaly
3
2.5
2
1.5
1
0.5
0
−0.5
−1
−1.5
−2
−2.5
−3
2010
2020
2030
2040
2050
2060
2070
2080
2090
CCMA
CSIRO
MIROC
Dipole Index in IPCC SRESA2 Exp
Normalized Anomaly
MRI
NCAR
UKMO

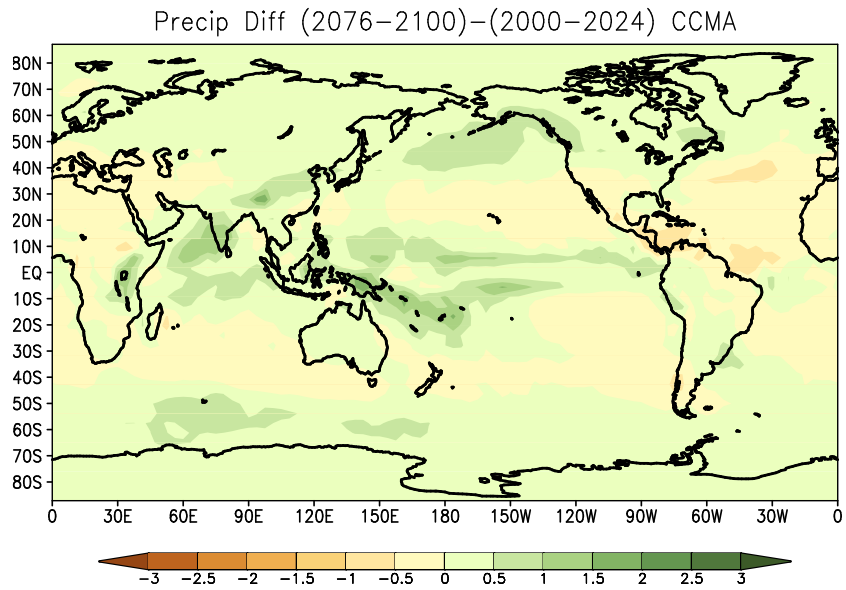
Consecutive pIOD events in IPCC SRESA2 Model Exp.

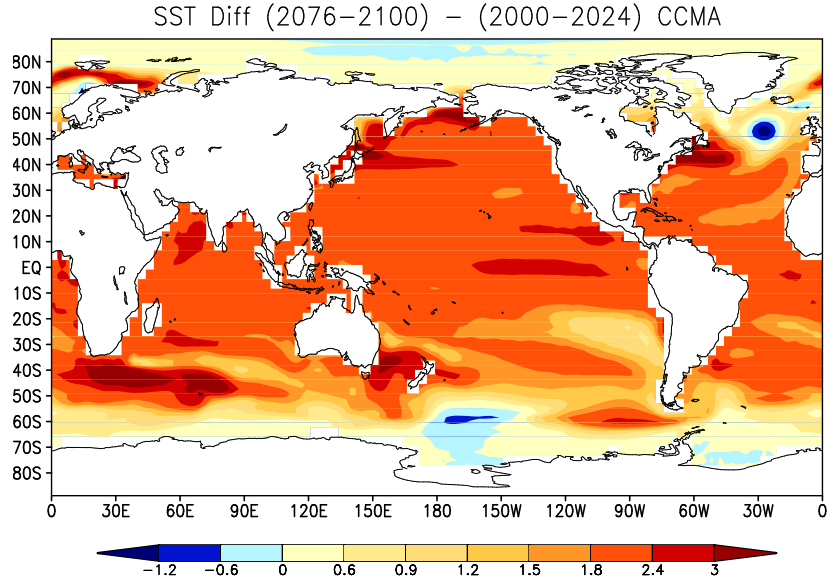
	2001-2025	2026-2050	2051-2075	2076-2100
CCMA		1 double pIOD 2048-49		
CSIRO				
MIROC	1 triple pIOD 2016-17-18			
MRI				
NCAR				
UKMO				

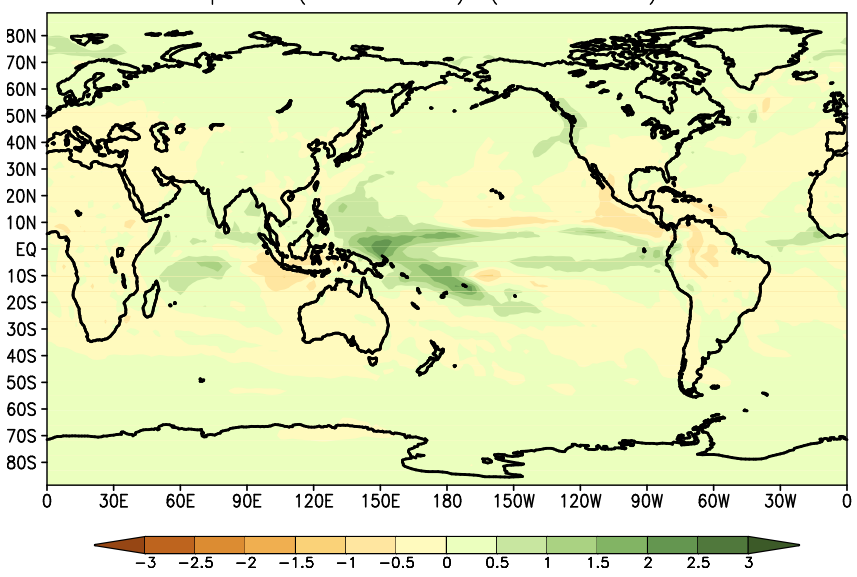
Standard Deviations of DMI and Nino3 in IPCC SRESA2 Model Exp.

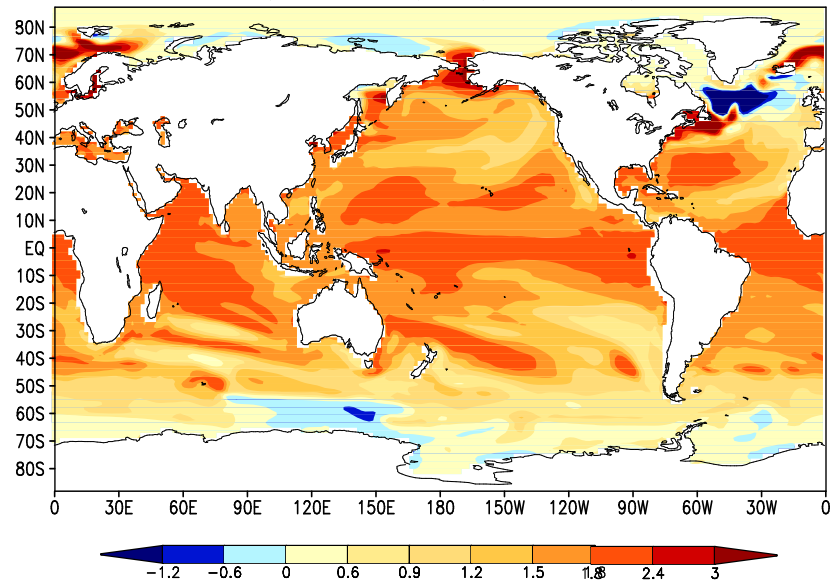
	DMI	Nino3
CCMA	0.34	0.40
CSIRO	0.25	0.83
MIROC	0.85	0.56
MRI	0.3	1.2
NCAR	0.36	0.65
UKMO	0.88	1.04

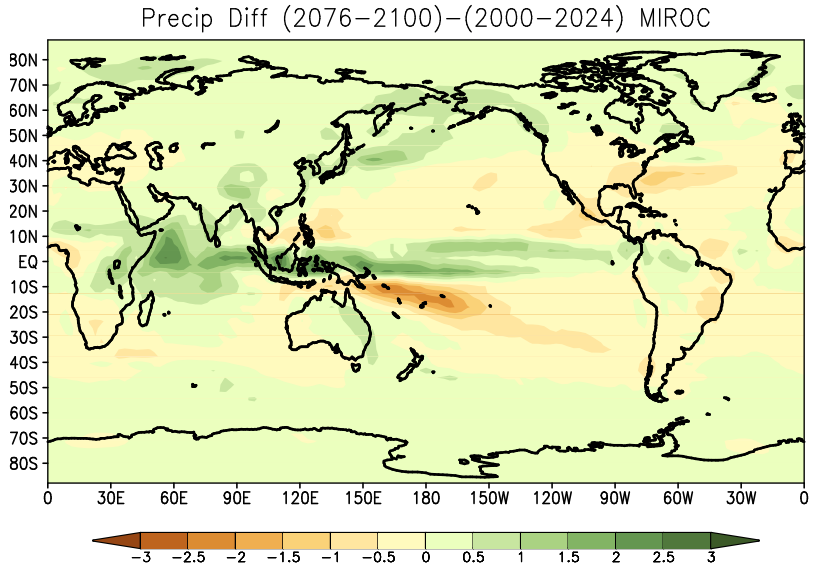
Expected change in background state in 21st century: IPCC Scenario

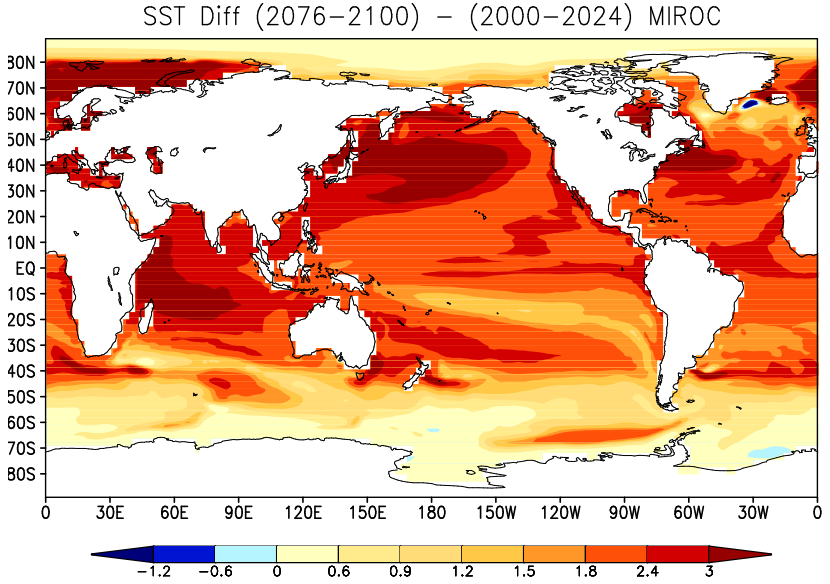


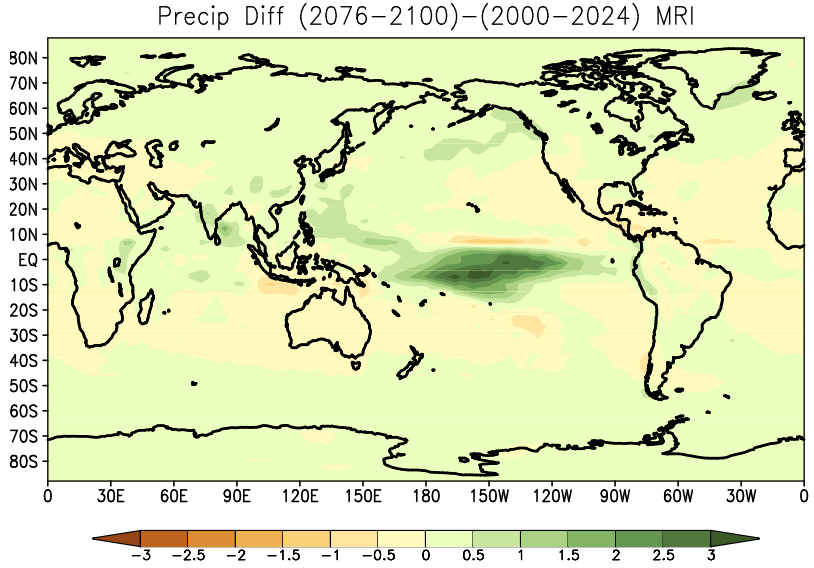


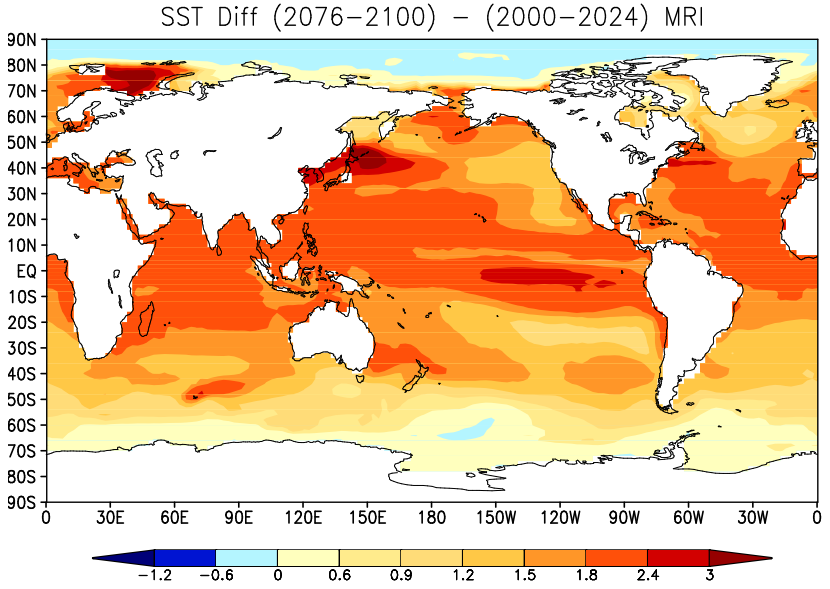


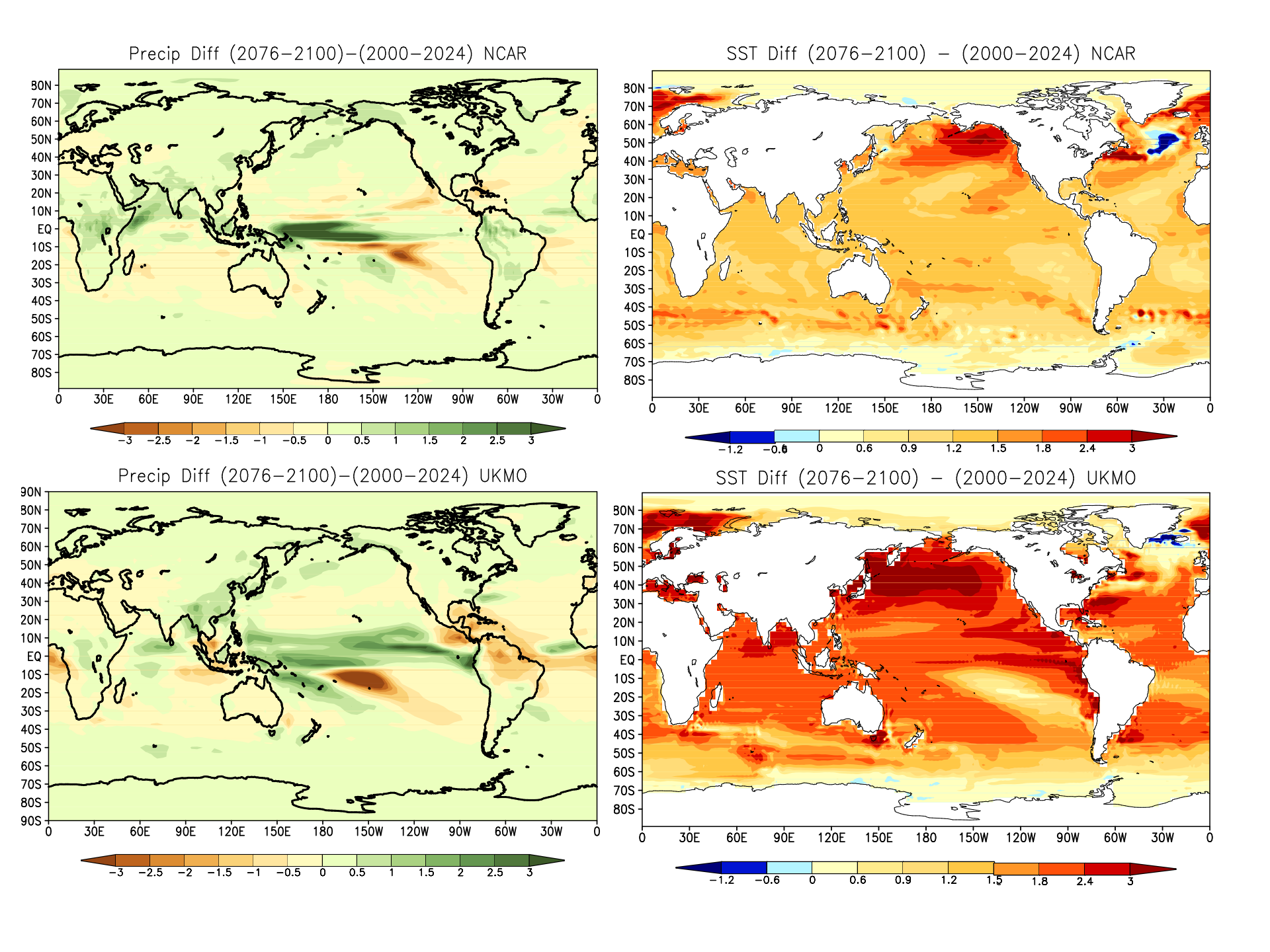



Precip Diff (2076–2100)–(2000–2024) MIROC
80N 70N 60N 50N 40N 30N 20N 10N EQ 10S 20S 30S 40S 50S 60S 70S 80S
0 30E 60E 90E 120E 150E 180 150W 120W 90W 60W 30W 0
−3 −2.5 −2 −1.5 −1 −0.5 0 0.5 1 1.5 2 2.5 3

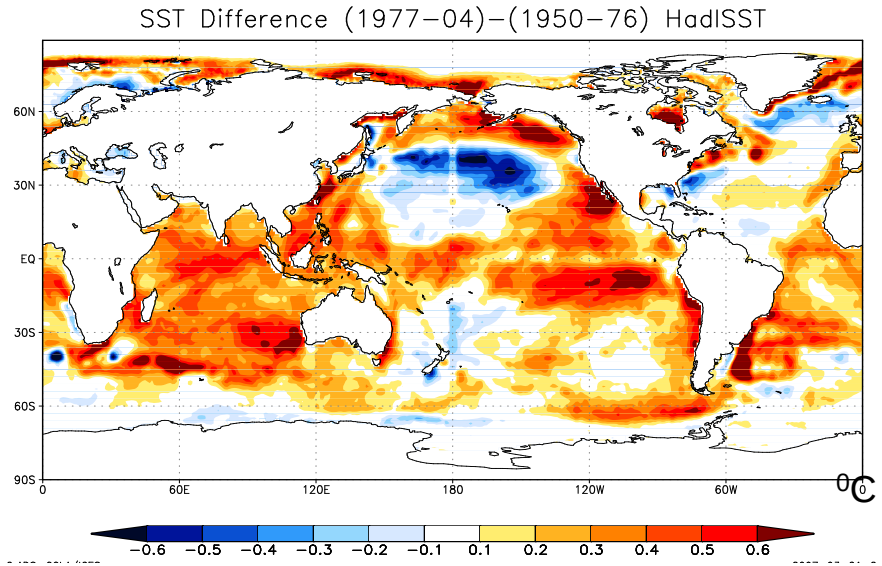

SST Diff (2076–2100) – (2000–2024) MIROC
30N 70N 50N 50N 40N 30N 20N 10N EQ 10S 20S 30S 40S 50S 60S 70S 80S
0 30E 60E 90E 120E 150E 180 150W 120W 90W 60W 30W 0
−1.2 −0.6 0 0.6 0.9 1.2 1.5 1.8 2.4 3

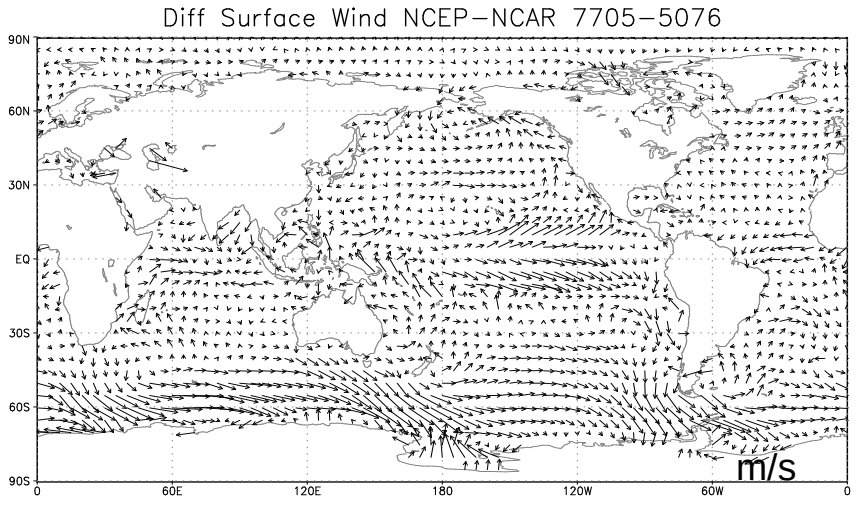

Precip Diff (2076–2100)–(2000–2024) MRI
80N 70N 60N 50N 40N 30N 20N 10N EQ 10S 20S 30S 40S 50S 60S 70S 80S
0 30E 60E 90E 120E 150E 180 150W 120W 90W 60W 30W 0
−3 −2.5 −2 −1.5 −1 −0.5 0 0.5 1 1.5 2 2.5 3

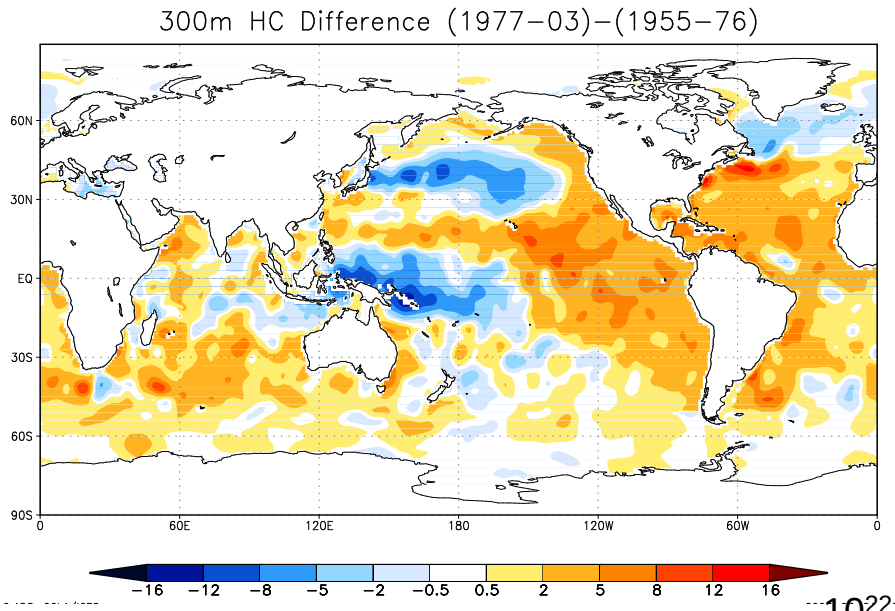

SST Diff (2076–2100) – (2000–2024) MRI
90N 80N 70N 60N 50N 40N 30N 20N 10N EQ 10S 20S 30S 40S 50S 60S 70S 80S 90S
0 30E 60E 90E 120E 150E 180 150W 120W 90W 60W 30W 0
−1.2 −0.6 0 0.6 0.9 1.2 1.5 1.8 2.4 3

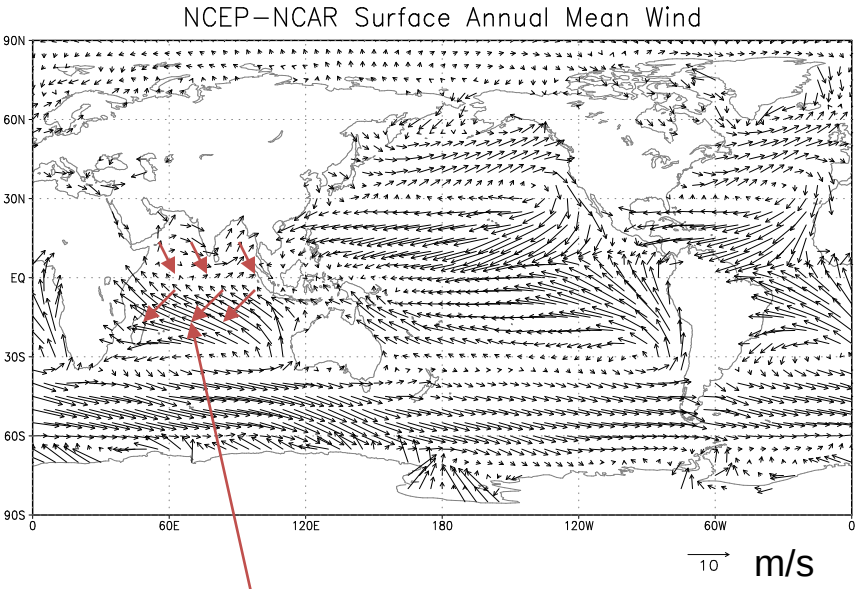

Precip Diff (2076–2100)–(2000–2024) NCAR
SST Diff (2076–2100) – (2000–2024) NCAR
Precip Diff (2076–2100)–(2000–2024) UKMO
SST Diff (2076–2100) – (2000–2024) UKMO
80N 70N 60N 50N 40N 30N 20N 10N EQ 10S 20S 30S 40S 50S 60S 70S 80S
90N 80N 70N 60N 50N 40N 30N 20N 10N EQ 10S 20S 30S 40S 50S 60S 70S 80S 90S
0 30E 60E 90E 120E 150E 180 150W 120W 90W 60W 30W 0
−3 −2.5 −2 −1.5 −1 −0.5 0 0.5 1 1.5 2 2.5 3
−1.2 −0.6 0 0.6 0.9 1.2 1.5 1.8 2.4 3

The changes in SST and heat content in the upper Indian Ocean: The new background state will favor positive IOD events.





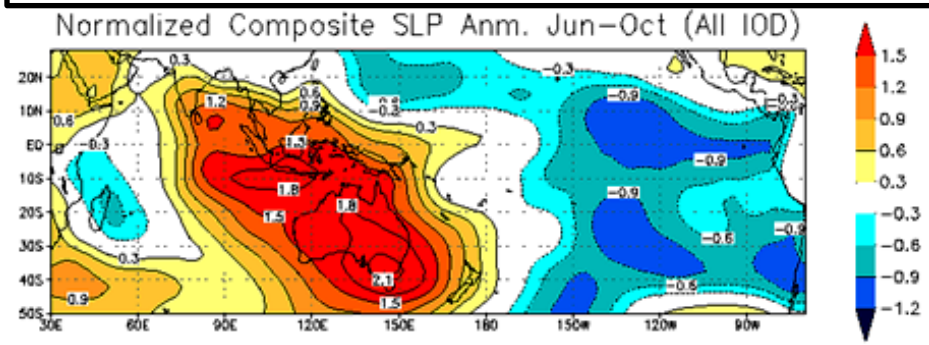


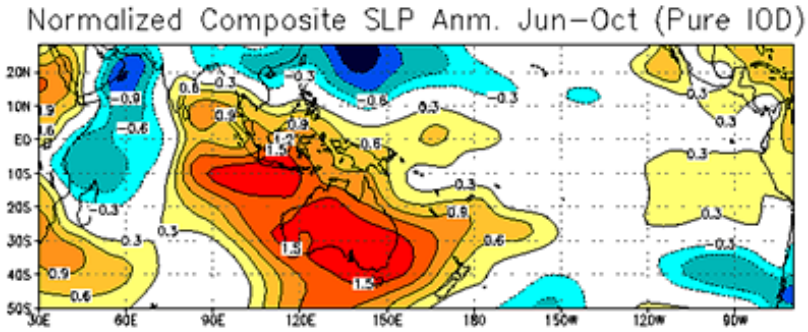


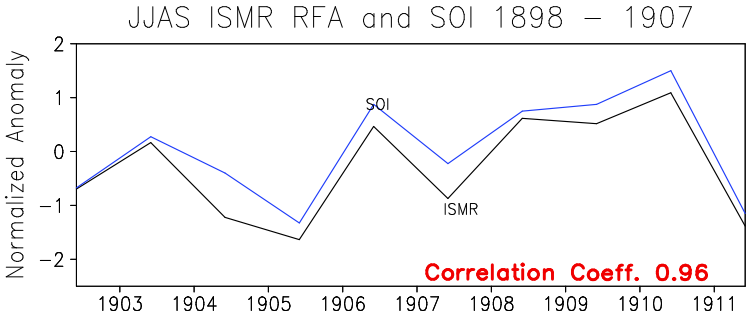
Annual Ekman heat transport; Levitus 1988

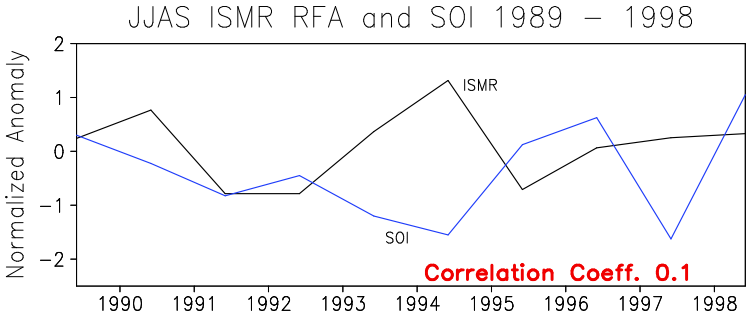
The IOD and the Indian Ocean Pressure Oscillation

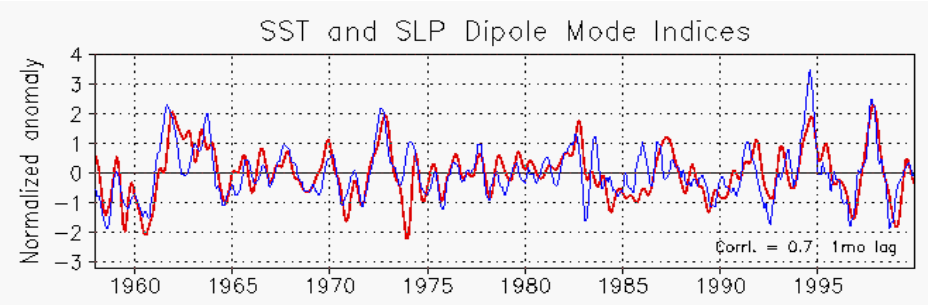
IOD induces Indian Ocean pressure oscillation and influences the sea level pressure variability over Darwin, one pole of the Southern Oscillation.

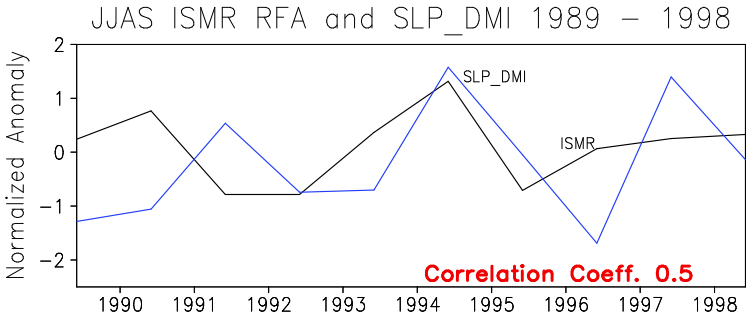






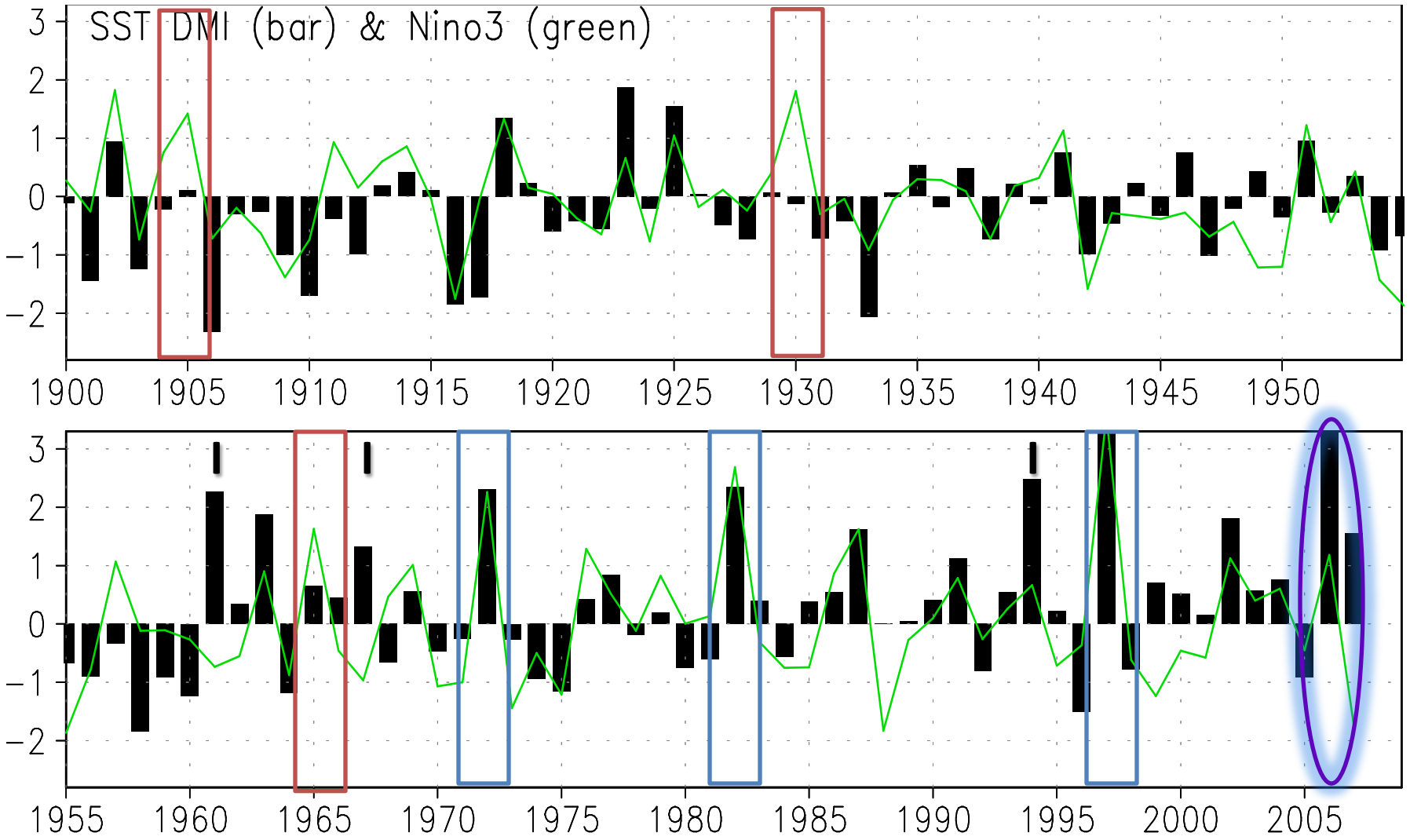






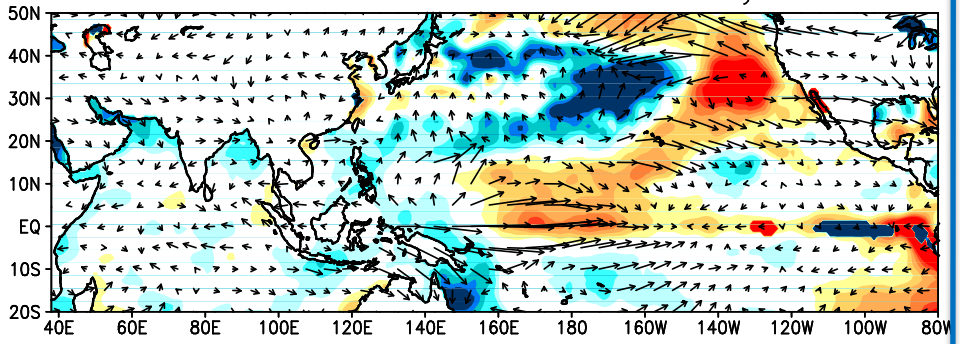
Behera and Yamagata 2003

El Nino Amplifications During Concurrent IODs

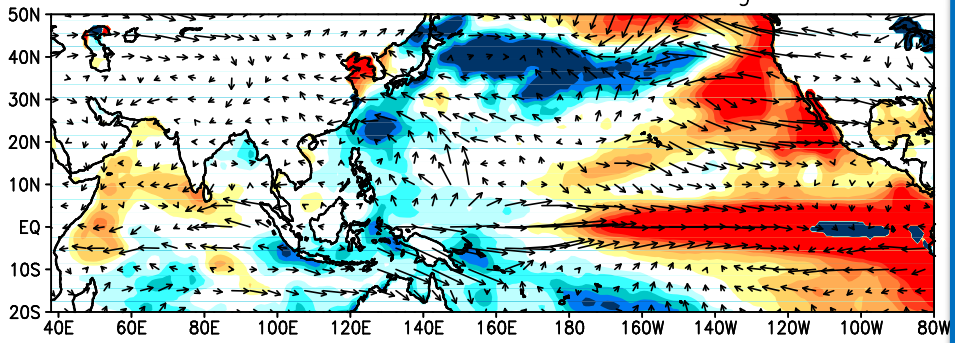


Evolution of IOD and ENSO Events During 1997 and 2006

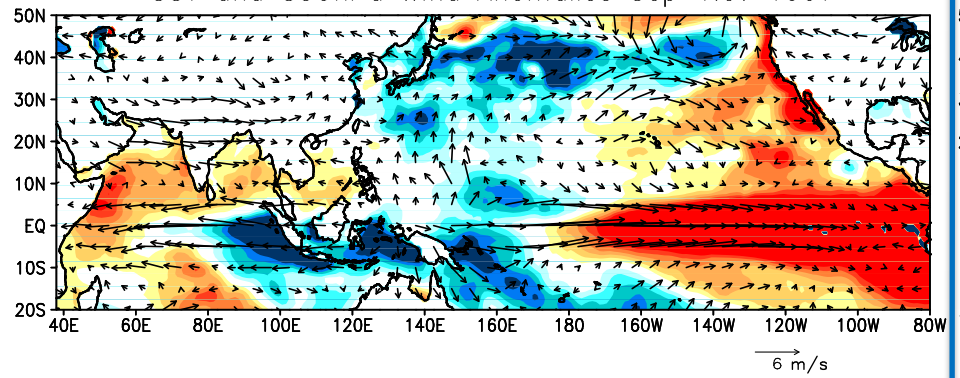
SST and 850hPa Wind Anomalies Mar–May 1997



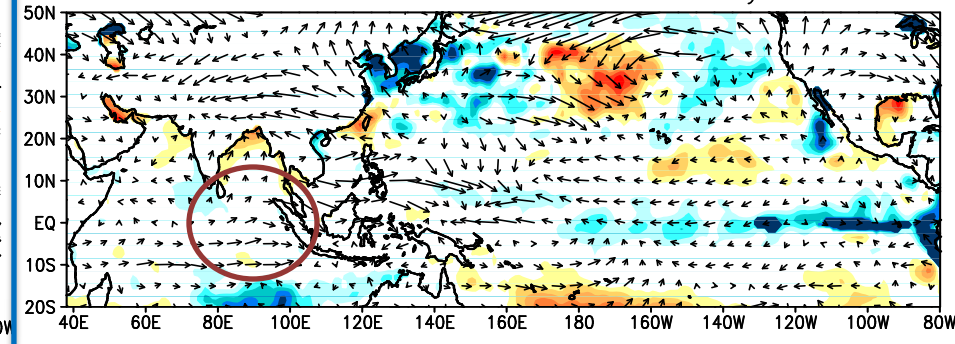
SST and 850hPa Wind Anomalies Jun–Aug 1997



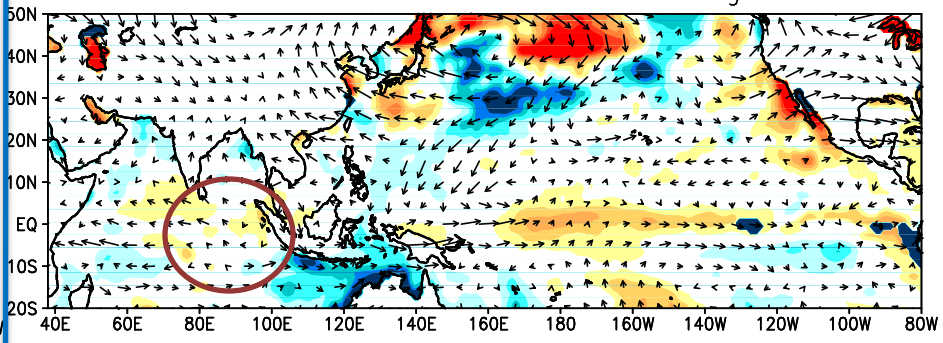
SST and 850hPa Wind Anomalies Sep–Nov 1997



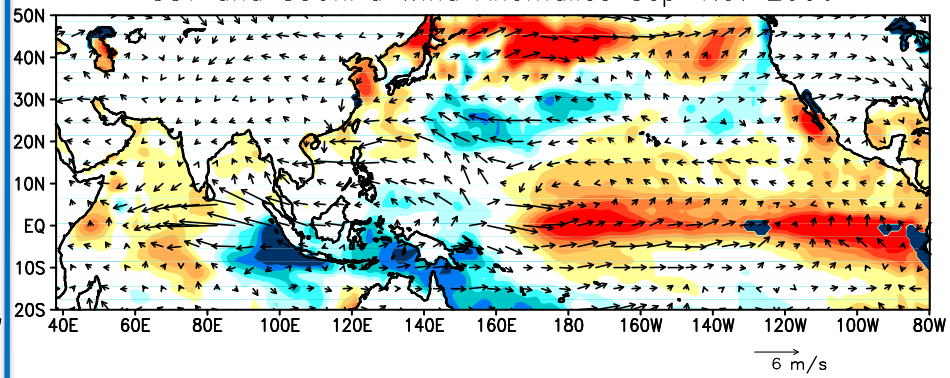
SST and 850hPa Wind Anomalies Mar–May 2006



SST and 850hPa Wind Anomalies Jun–Aug 2006

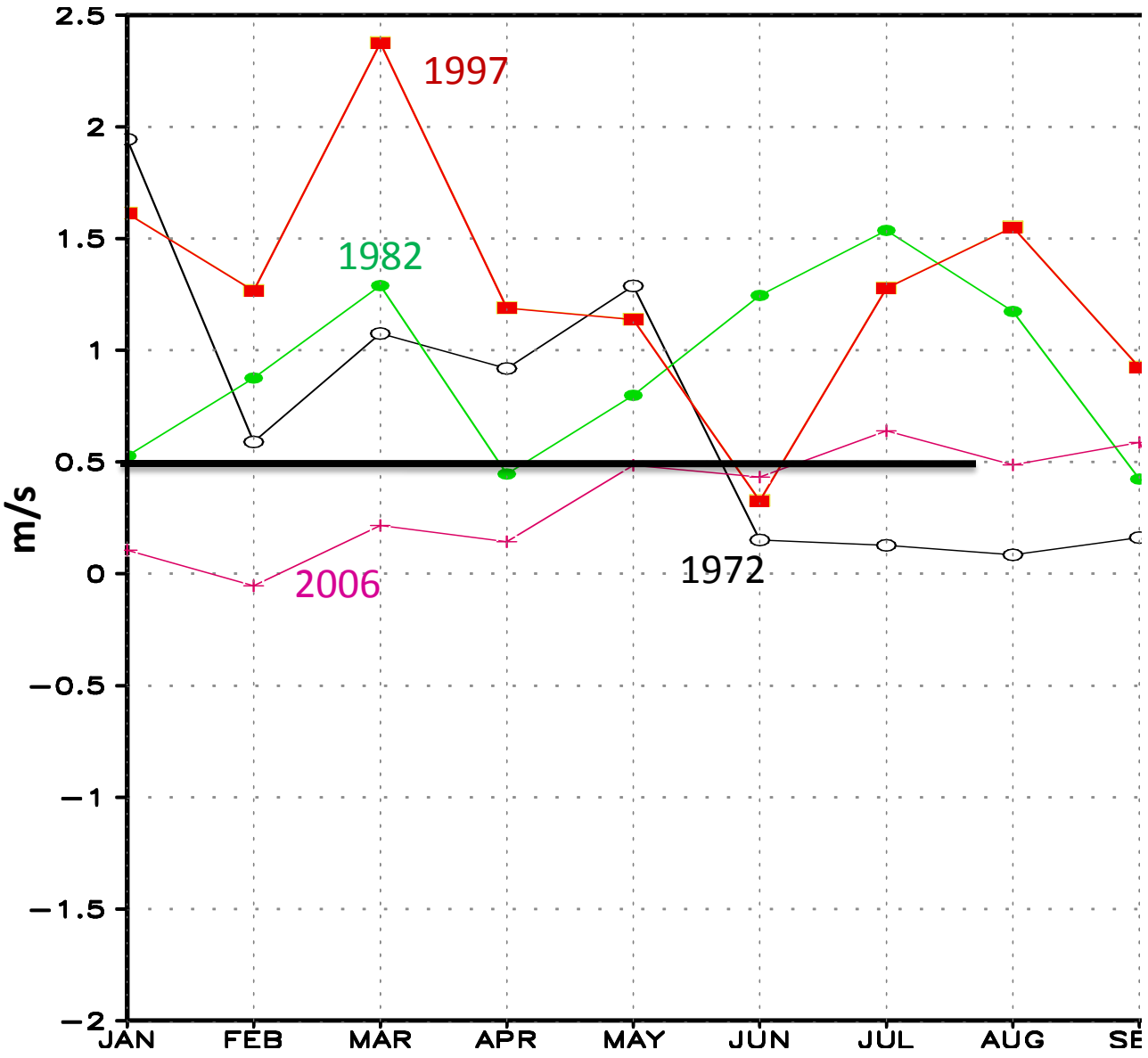


SST and 850hPa Wind Anomalies Sep–Nov 2006



Zonal Wind Anomalies in Equatorial Western Pacific

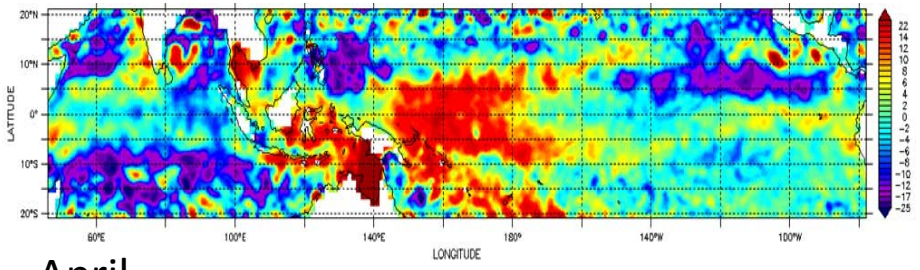
Because of the delayed development of IOD, the zonal wind anomalies are weaker during the first half of 2006 as compared to that of 1997.



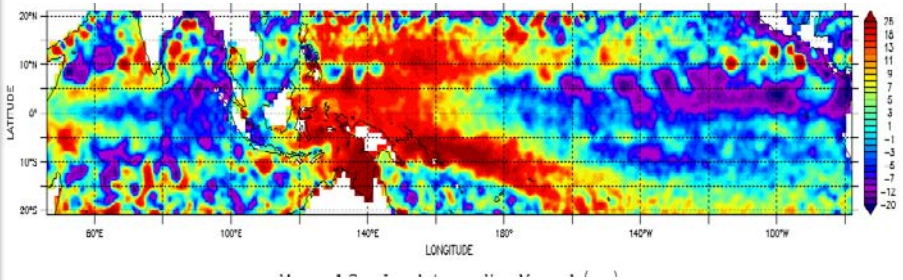
Evolution of Sea Level Anomalies in tropical Indian and Pacific Oceans

March

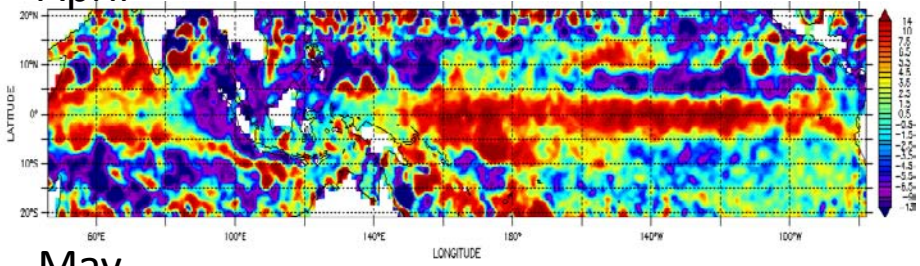
1997

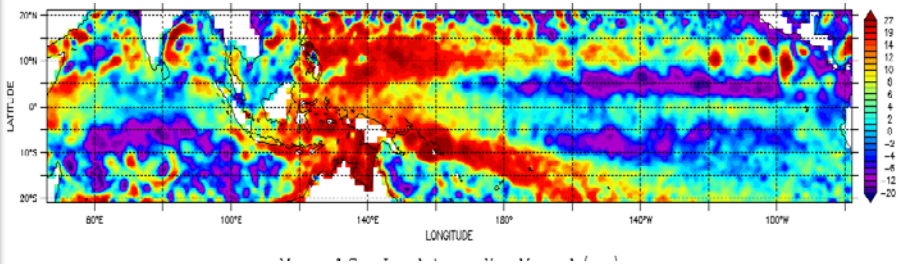


2006

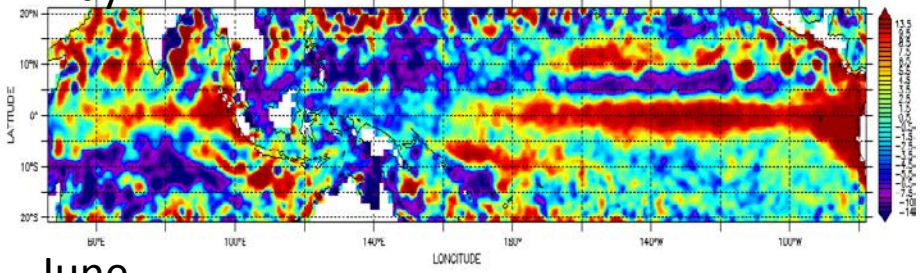


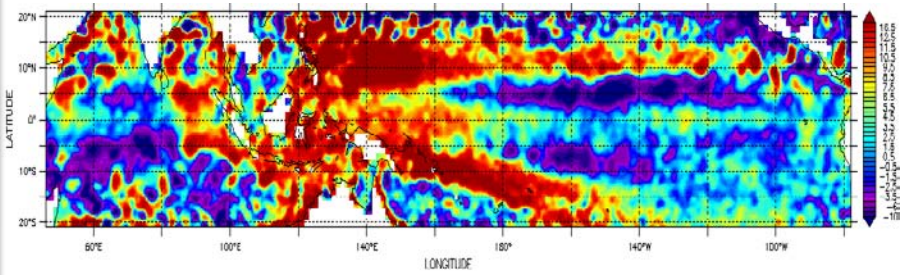
April



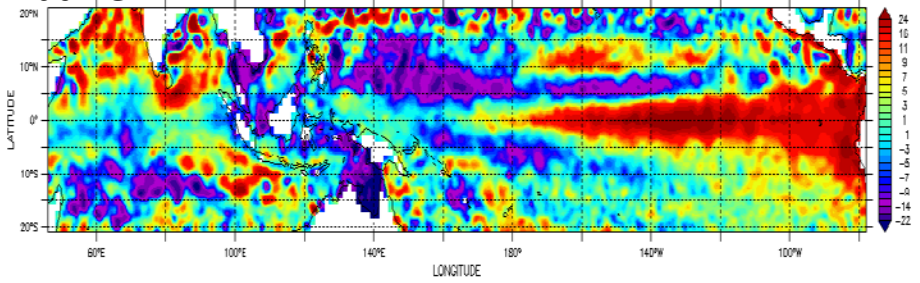


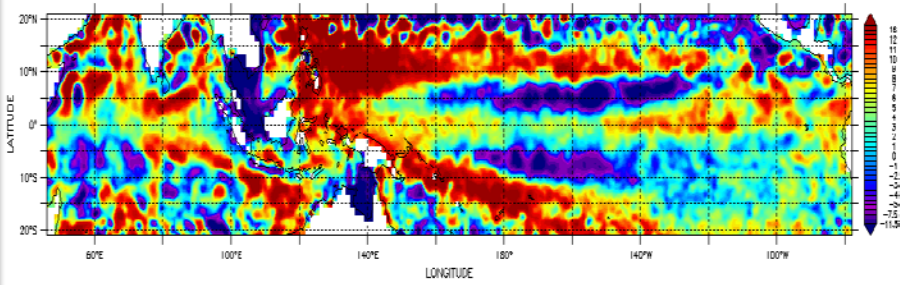
May





June





Climate variation and change in Indo-Pacific Oceans

- Besides ENSO, IOD has significant impacts on many parts of the world.
- A change in the background state in the Indian Ocean is apparently favoring frequent occurrences of positive IODs in recent years.
- ENSO and IOD are now predictable at least a season ahead.
- It is important to understand and predict the long term trends of IOD and its interaction with ENSO to improve their predictability.