The Abdus Salam
International Centre
for Theoretical Physics

United Nations Educational, Scientific and Cultural Organization

IAEA
International Atomic Energy Agency

2356-23

Targeted Training Activity: ENSO-Monsoon in the Current and Future Climate

30 July - 10 August, 2012

ENSO Overview

SARACHIK Edward Stuart

Joint Institute For the Study of the Atmosphere and Ocean, JISAO
University of Washington, 3737 Brooklyn Ave. NE, Box 355672
Seattle WA 98195-5672
U.S.A.

ENSO Overview

E.S. Sarachik, University of Washington

1. The mean tropical Pacific
2. What is ENSO?
3. Why is ENSO important?
4. Basic Mechanisms
5. Predictability and Prediction
6. Future ENSO

1. The mean tropical Pacific

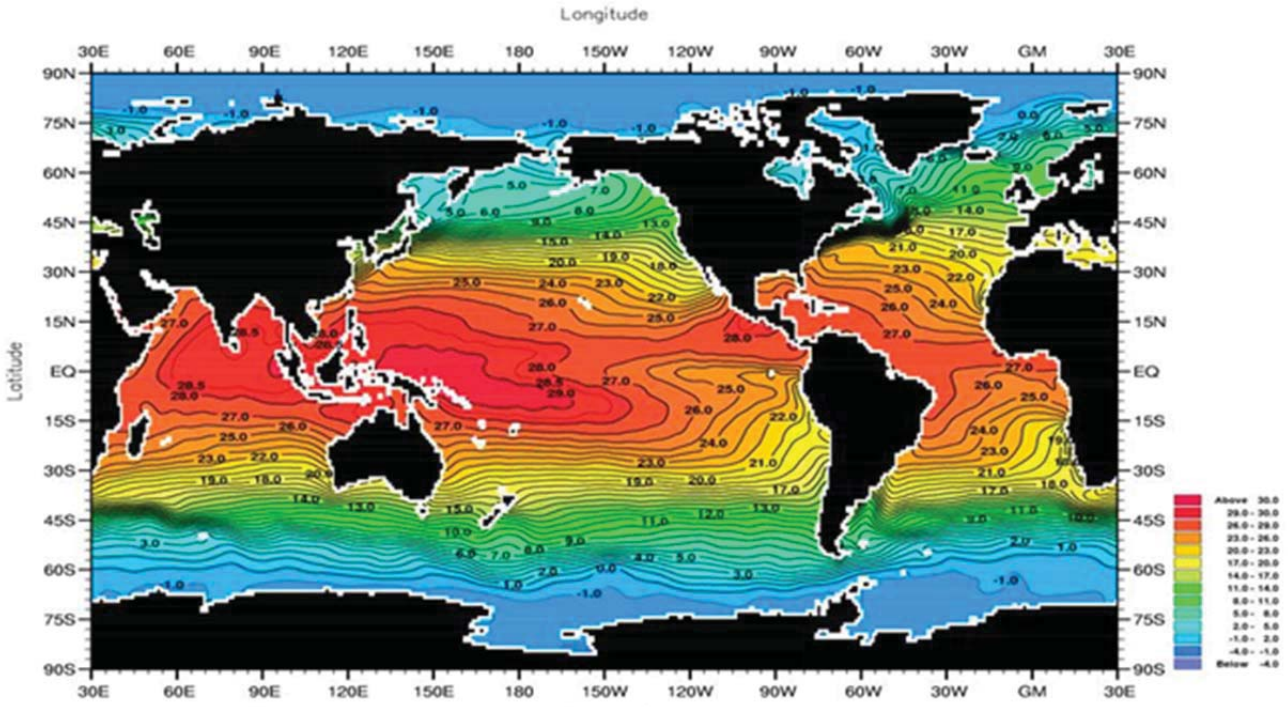
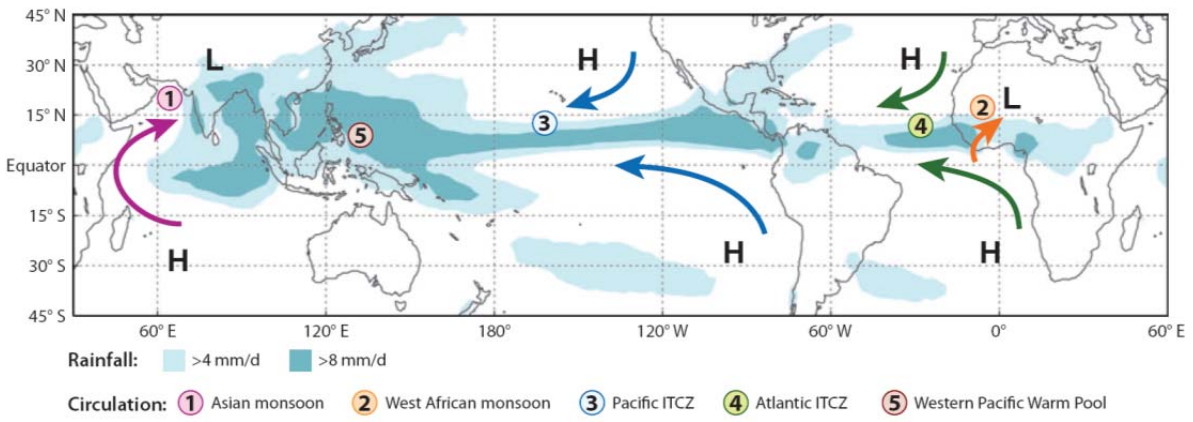
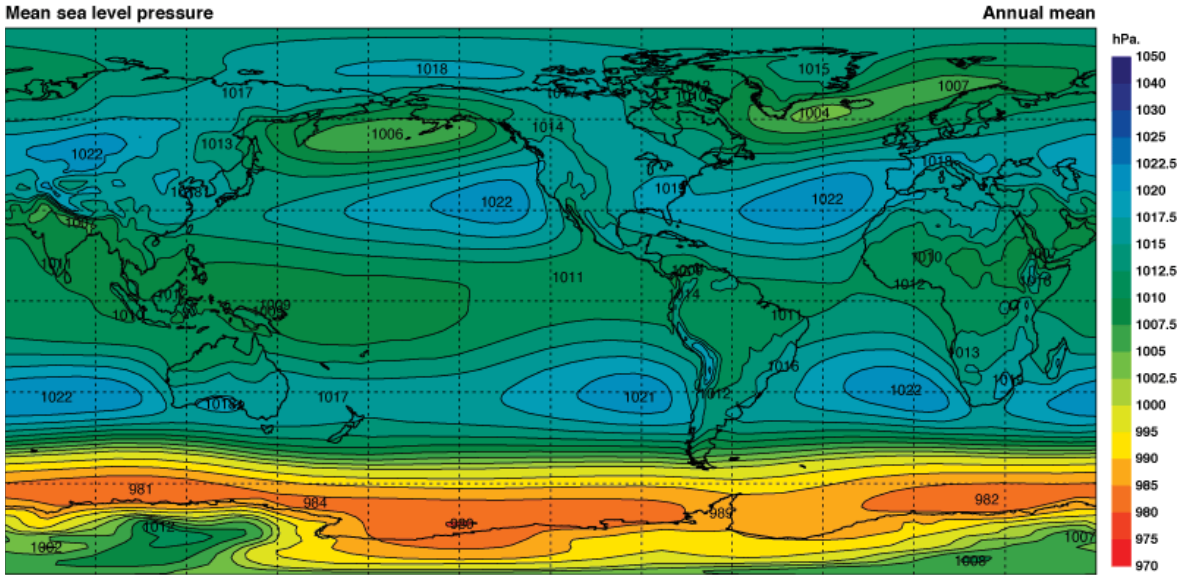


Fig. A2-1. Annual mean temperature (℃) at the surface.

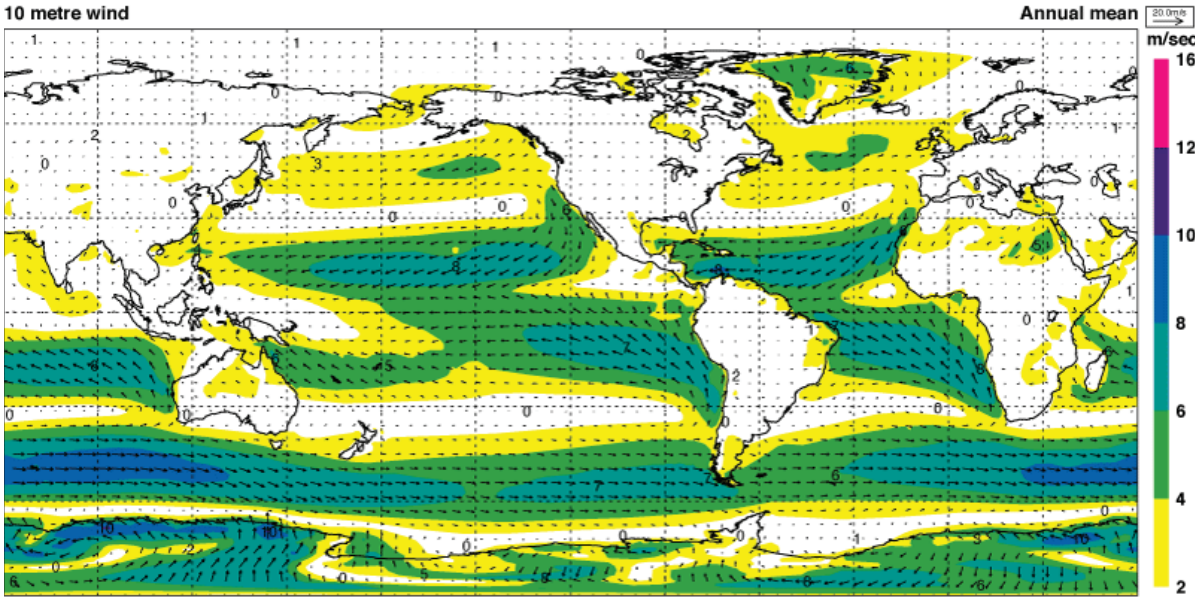
Minimum Value= -1.93 Maximum Value= 29.93 Contour Interval: 1.00


45° N
30° N
15° N
Equator
15° S
30° S
45° S
60° E
120° E
180°
120° W
60° W
0°
60° E
L
H
H
L
H
H
H
1
2
3
4
5
Rainfall:
>4 mm/d
>8 mm/d
Circulation:
1 Asian monsoon
2 West African monsoon
3 Pacific ITCZ
4 Atlantic ITCZ
5 Western Pacific Warm Pool


Mean sea level pressure
Annual mean
hPa.
1050
1040
1030
1025
1022.5
1020
1017.5
1015
1012.5
1010
1007.5
1005
1002.5
1000
995
990
985
980
975
970

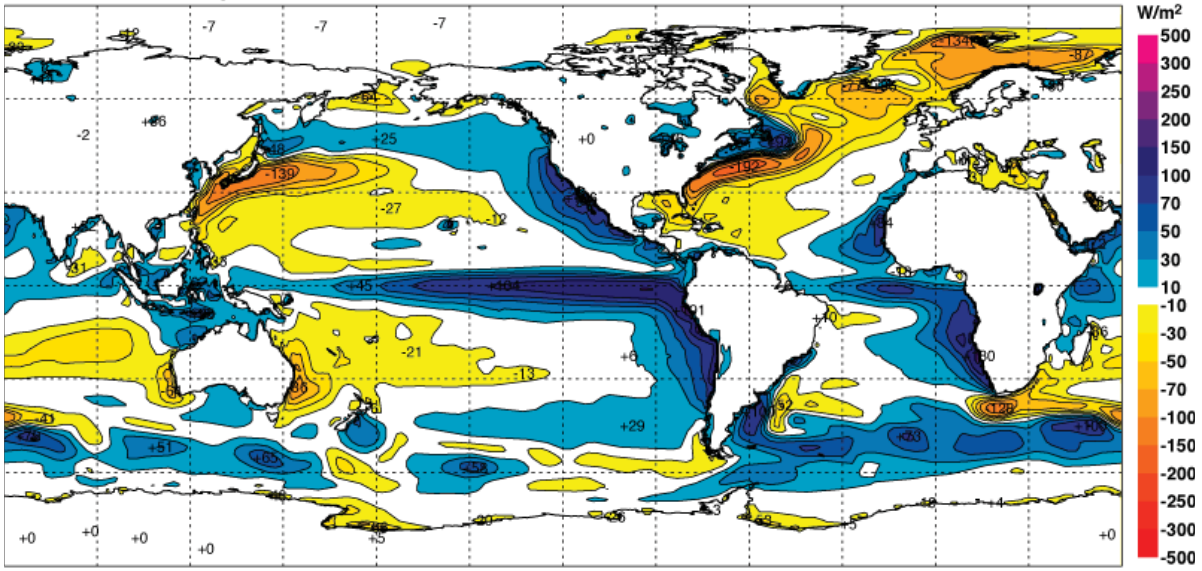
10 metre wind

Annual mean



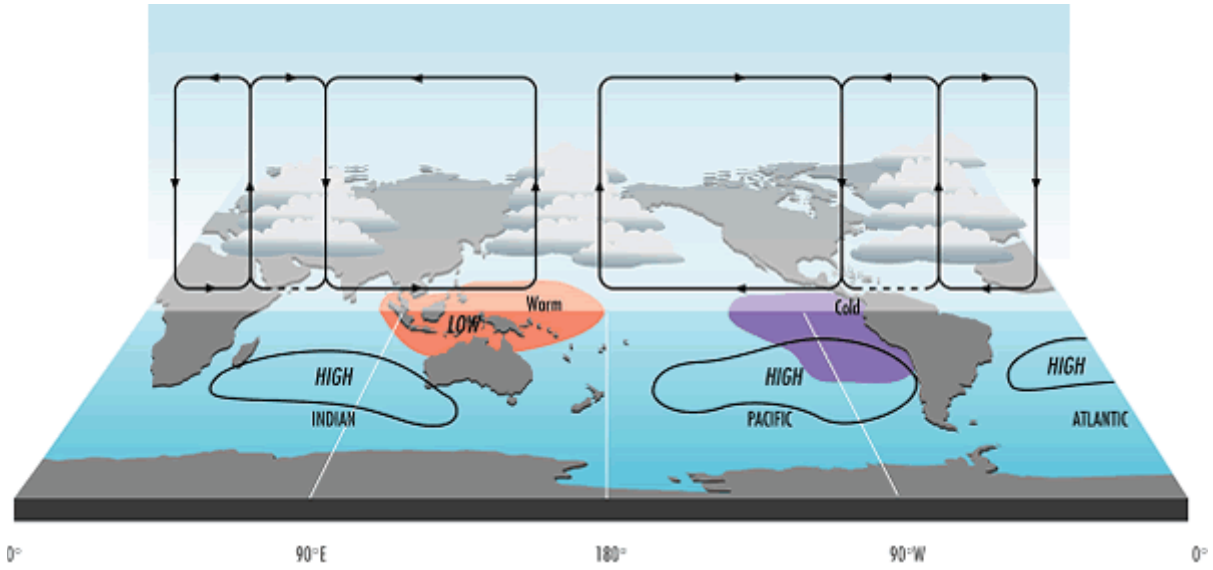
Net surface heat exchange

Annual mean

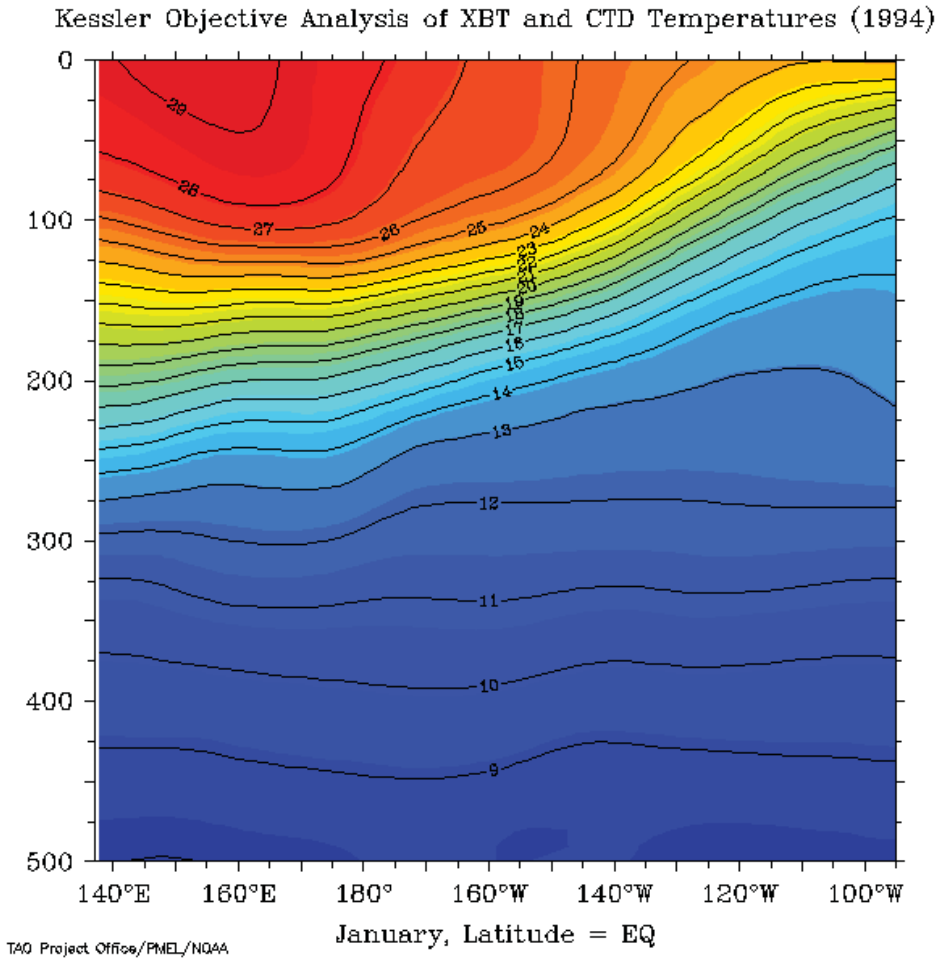


Mean Conditions at Surface in Tropical Pacific: Summary

	W. Pacific	E. Pacific
SST	Warm	Cold
SLP	Low	High
PRECIP	High	Low

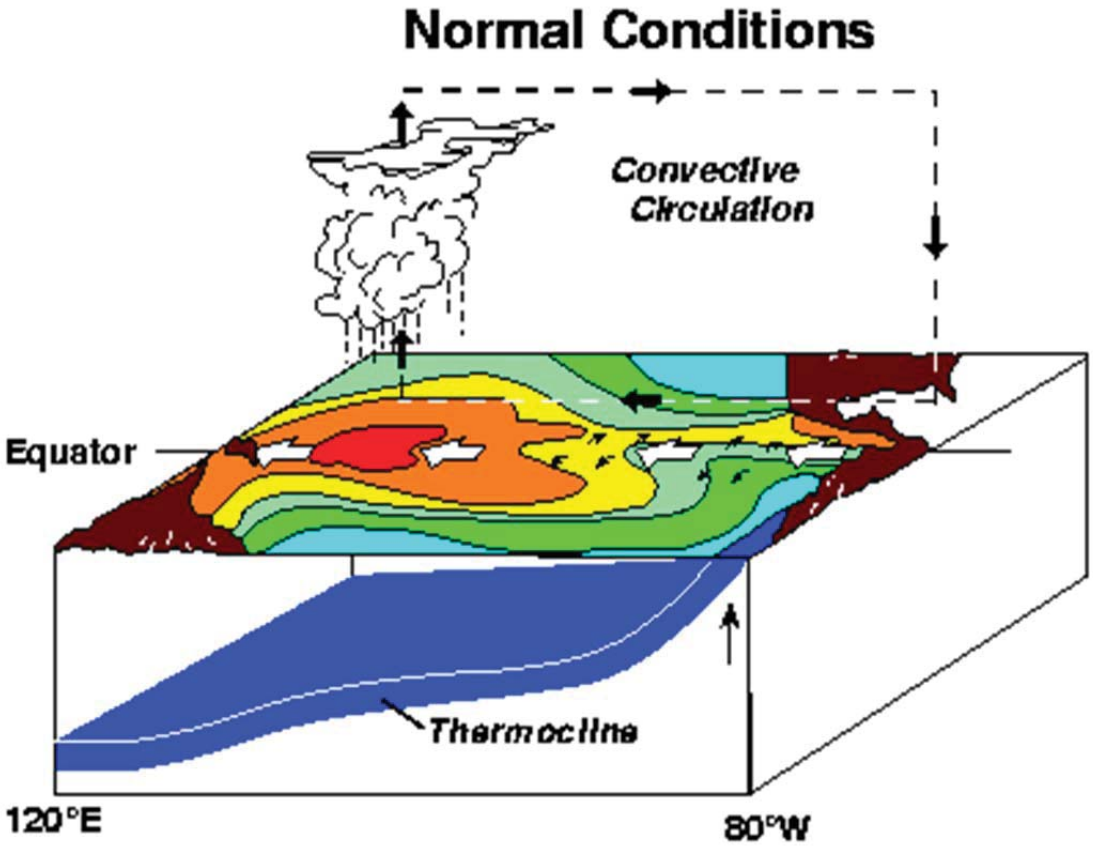


Walker Circulation



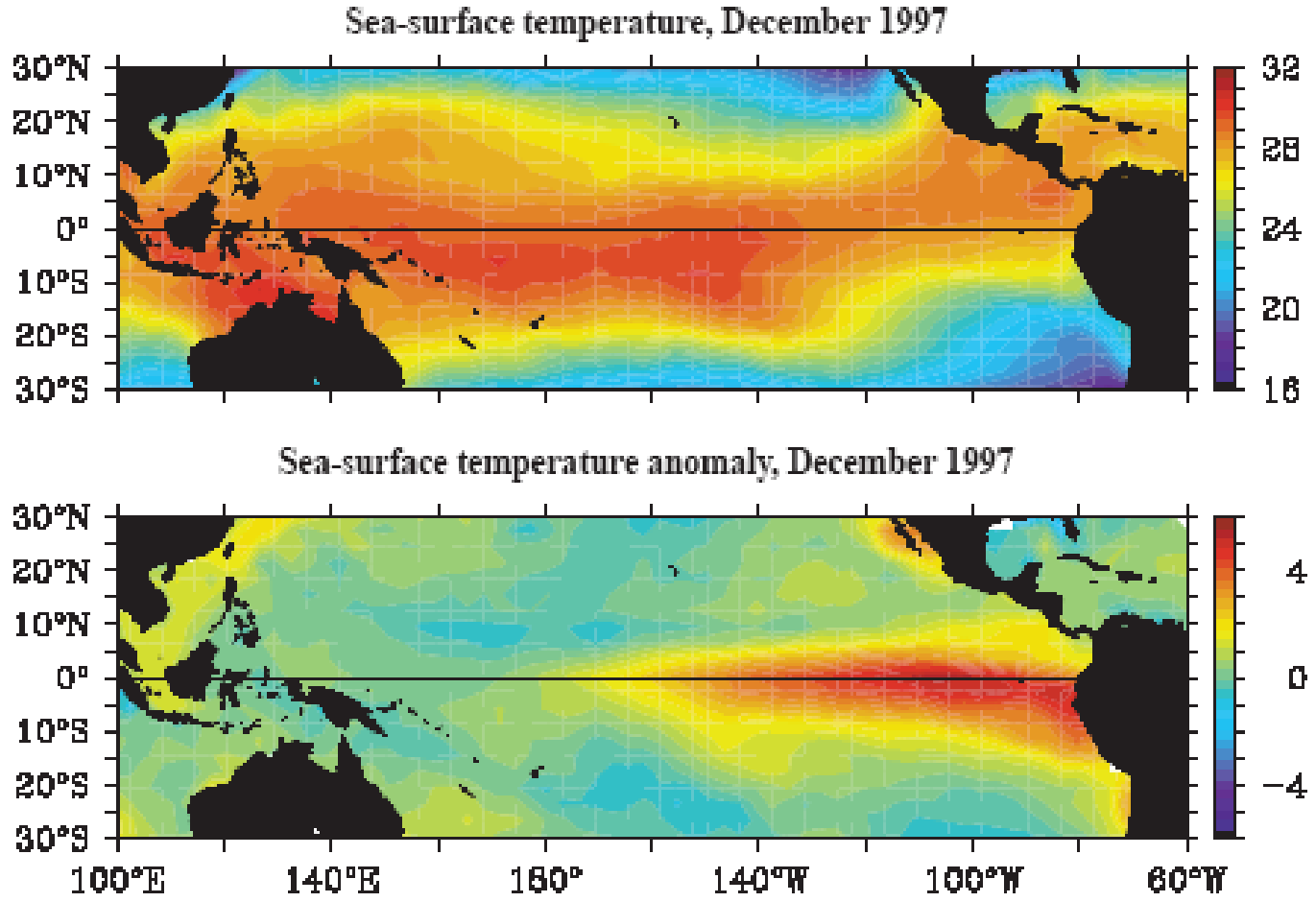
Pacific Ocean Temperature on Equator

Summary Diagram

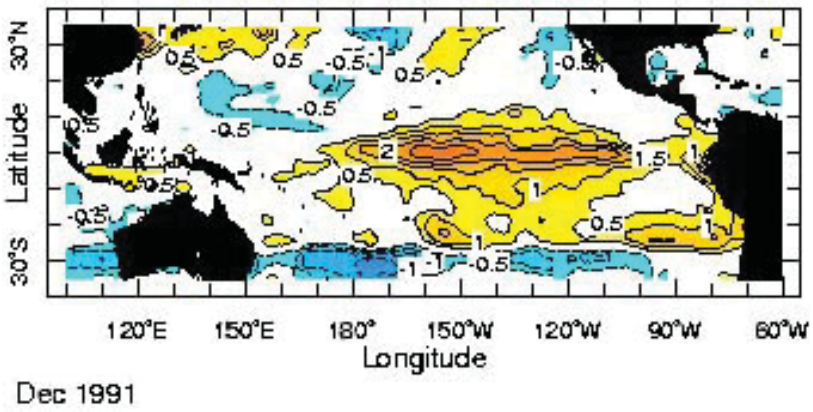


2. What is ENSO?

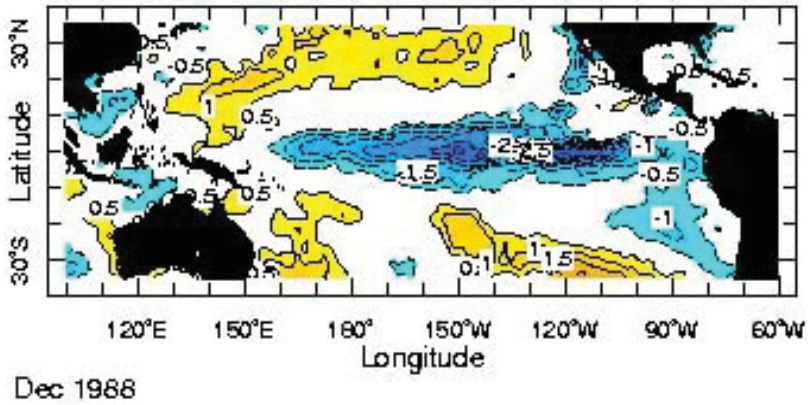
In the Ocean:



[Anomaly: Actual minus Climatology]



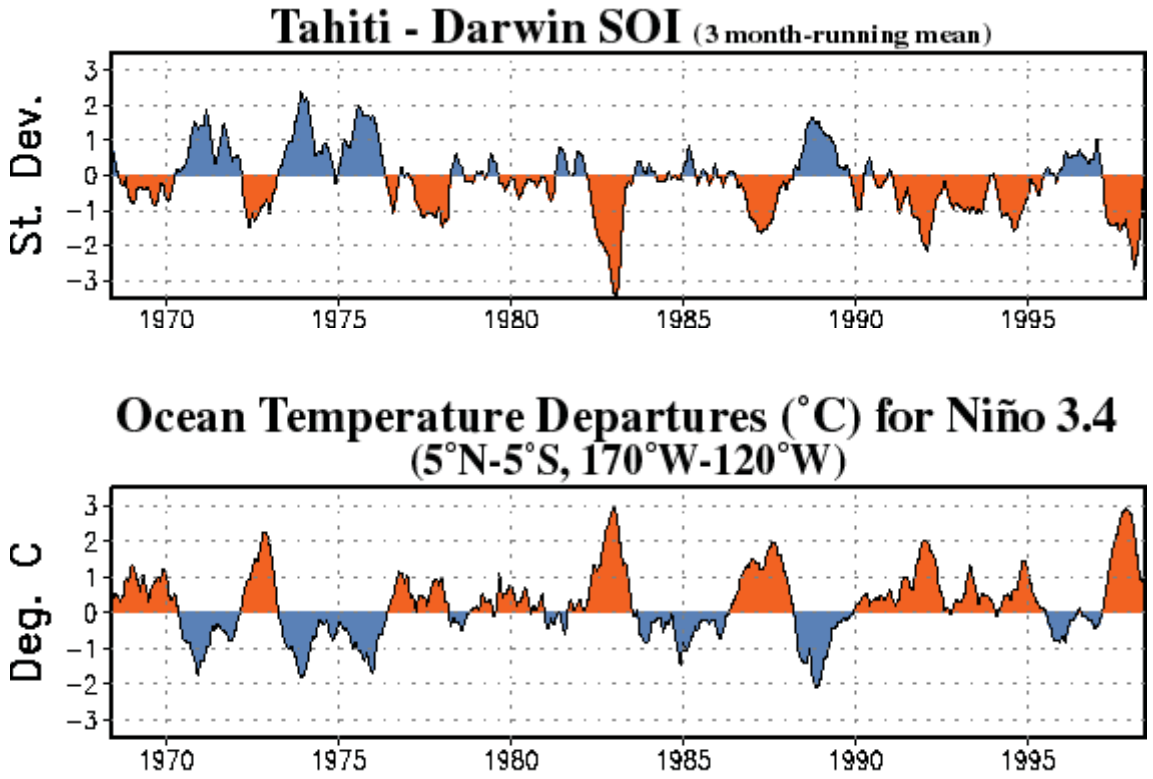
Warm Phase of ENSO



Cold Phase of ENSO

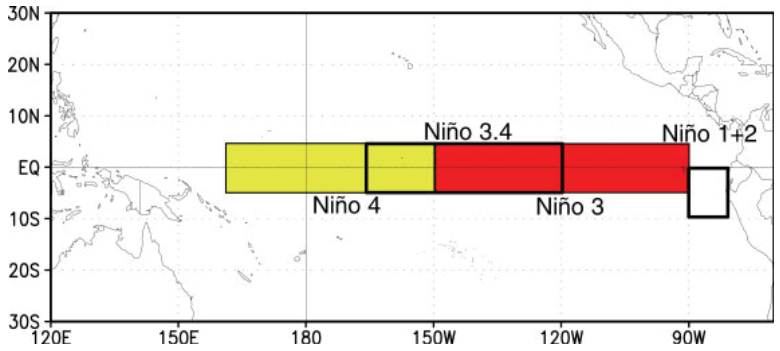
In the Atmosphere:

Southern Oscillation Index (SOI) defined as Sea Level Pressure Difference Anomaly between Tahiti (in East Tropical Pacific) and Darwin (In West Tropical Pacific)



Note: ENSO is irregular but with apparent ~4 year cycle built in

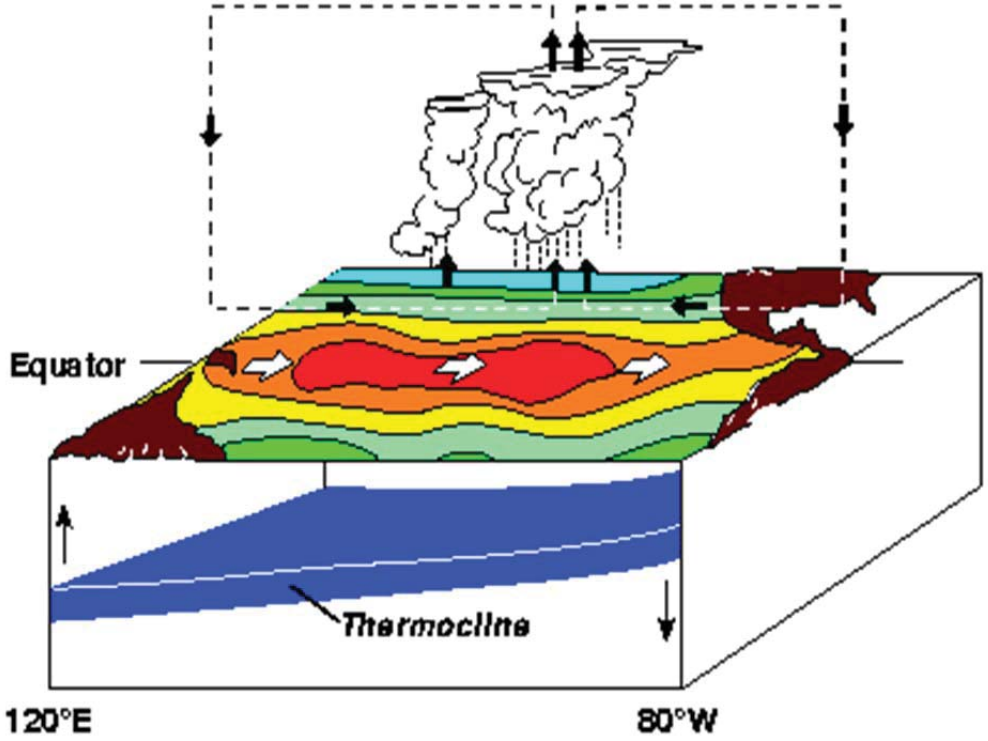
Where:

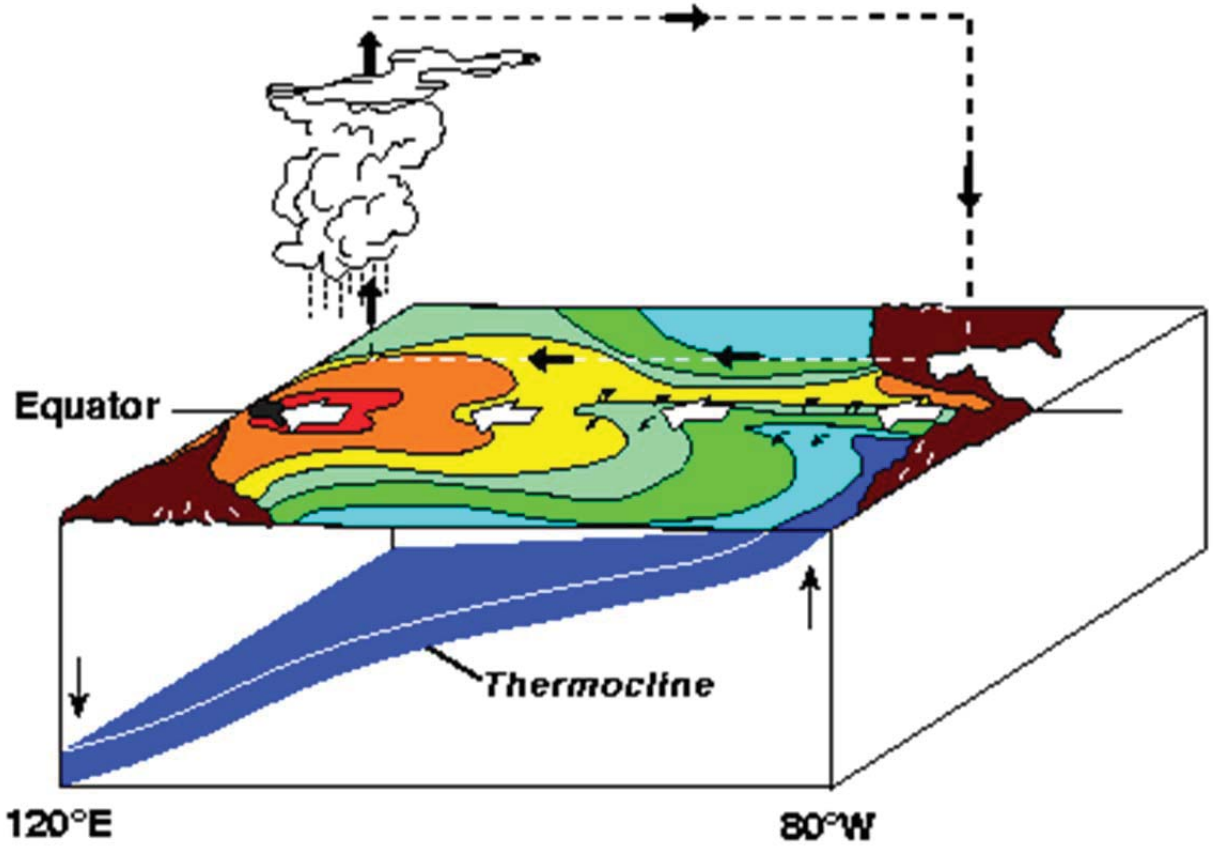


ENSO is therefore El Niño in the Ocean and Southern Oscillation in the Atmosphere.

[The interpretation is that the region of persistent precipitation has expanded eastward during warm phases of ENSO thereby lowering the SLP and left higher SLP behind in the Western Pacific. During Warm phases of ENSO the SOI is negative and during cold phases, positive.]

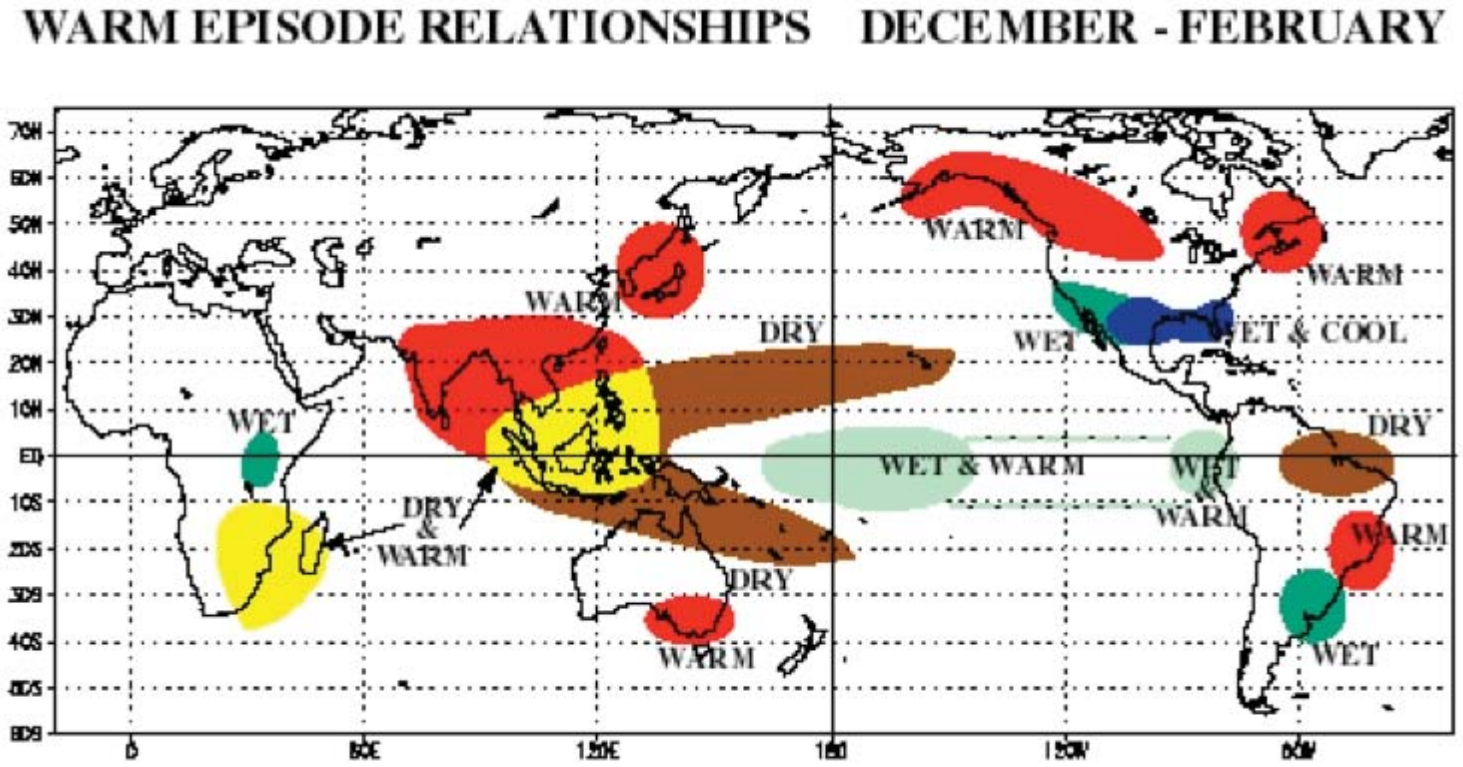
Warm Phase of ENSO

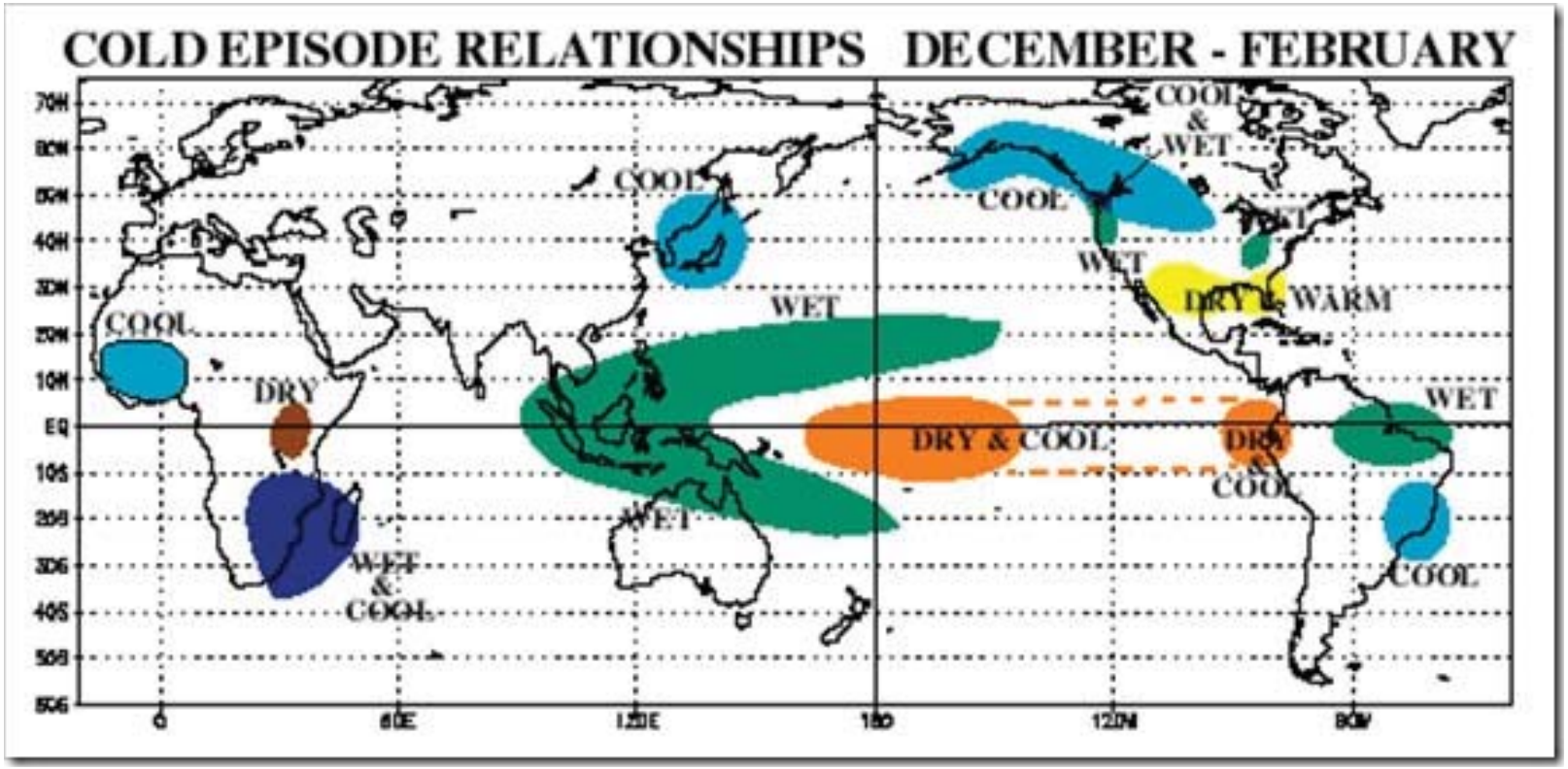




Cold Phase of ENSO

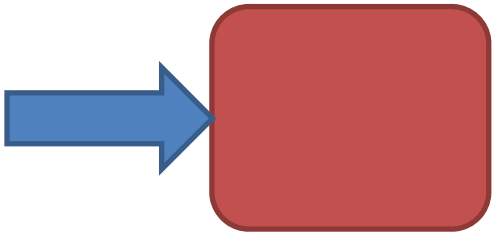
3. Why is ENSO important?




COLD EPISODE RELATIONSHIPS DECEMBER - FEBRUARY
COOL
COOL & WET
COOL
WET
DRY & WARM
WET
COOL
DRY
WET
DRY & COOL
DRY & COOL
WET
WET & COOL
WET
COOL
70N
60N
50N
40N
30N
20N
10N
EQ
10S
20S
30S
40S
50S
0
60E
120E
180
120W
60W

4. Basic Mechanisms

Imagine a warm patch of water on the equator. If the warm patch induces a westerly wind patch to the west of the warm patch:

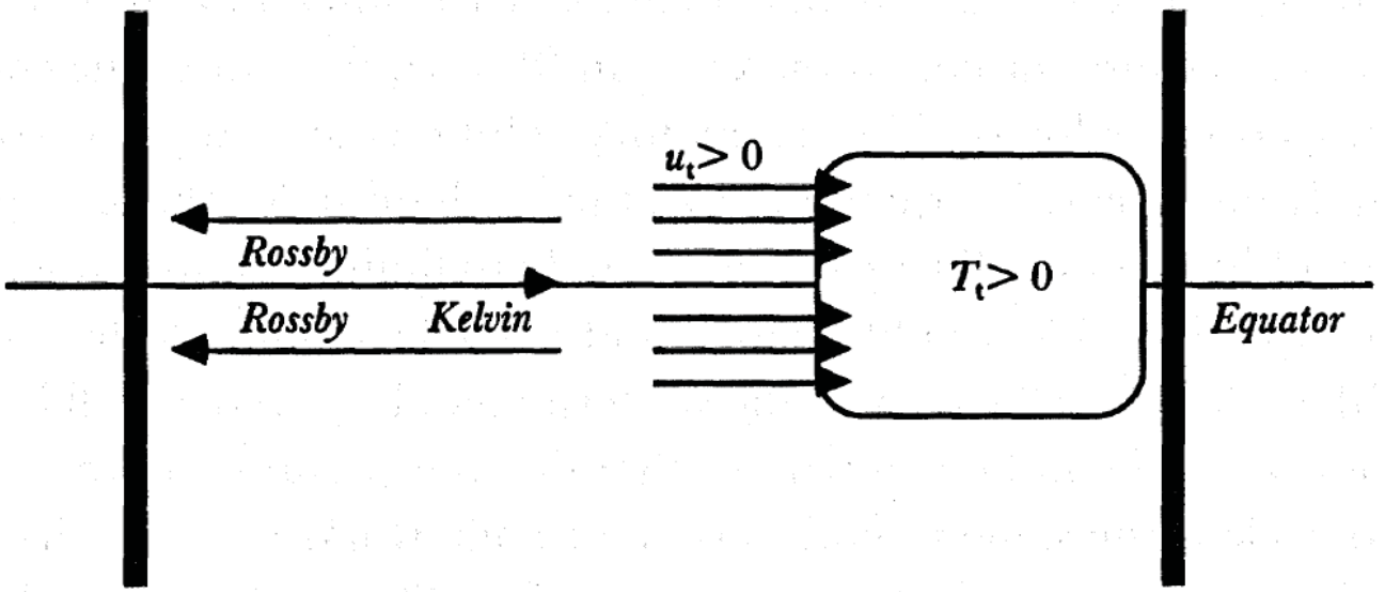


The Westerly wind patch:

- Advects warm water from the Western Pacific
- Reduces Upwelling
- Reduces the meridional advection of cold water away from the equatorial zone

Therefore the already warm patch WARMS

When Oceanic Long waves are involved:



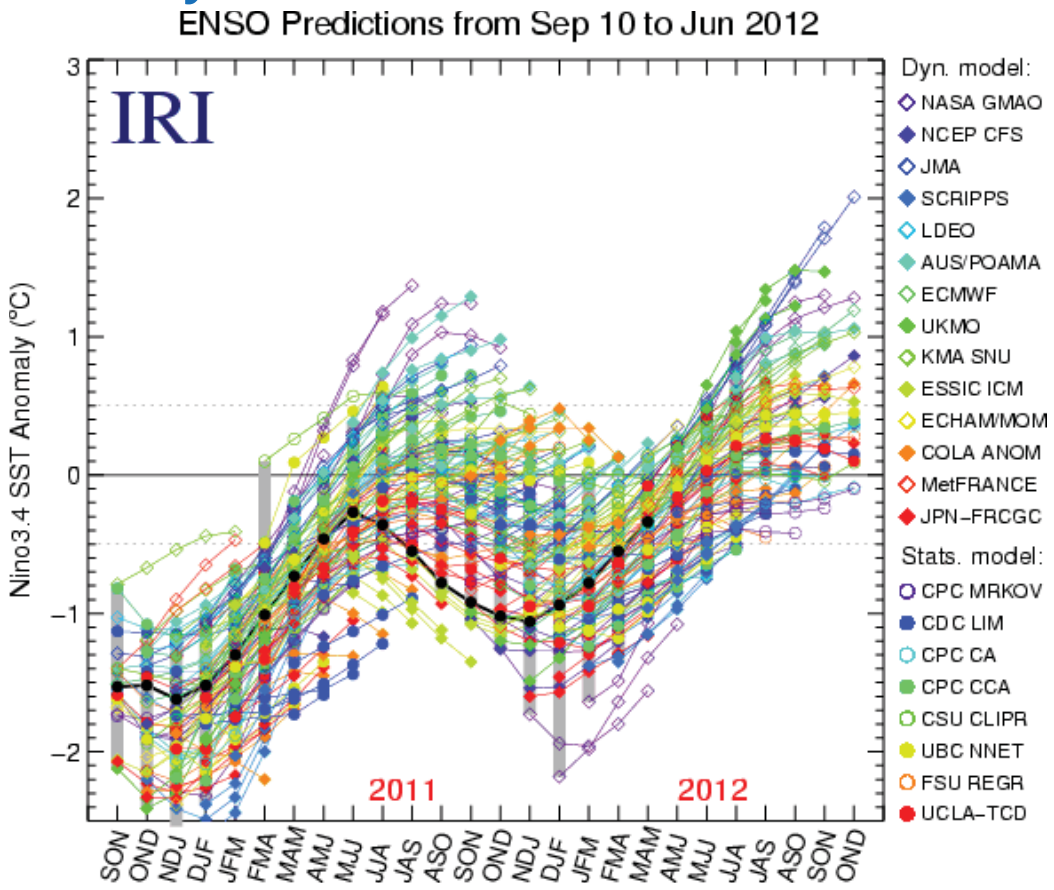
The mechanism outlined above is for a periodic oscillation of periodicity 4 years called the “Delayed Oscillator Mechanism”. The delay τ is time waves take to hit western boundary and return.

$$\frac{dT}{dt} = cT(t) - bT(t-\tau) \quad \text{with } b > c.$$

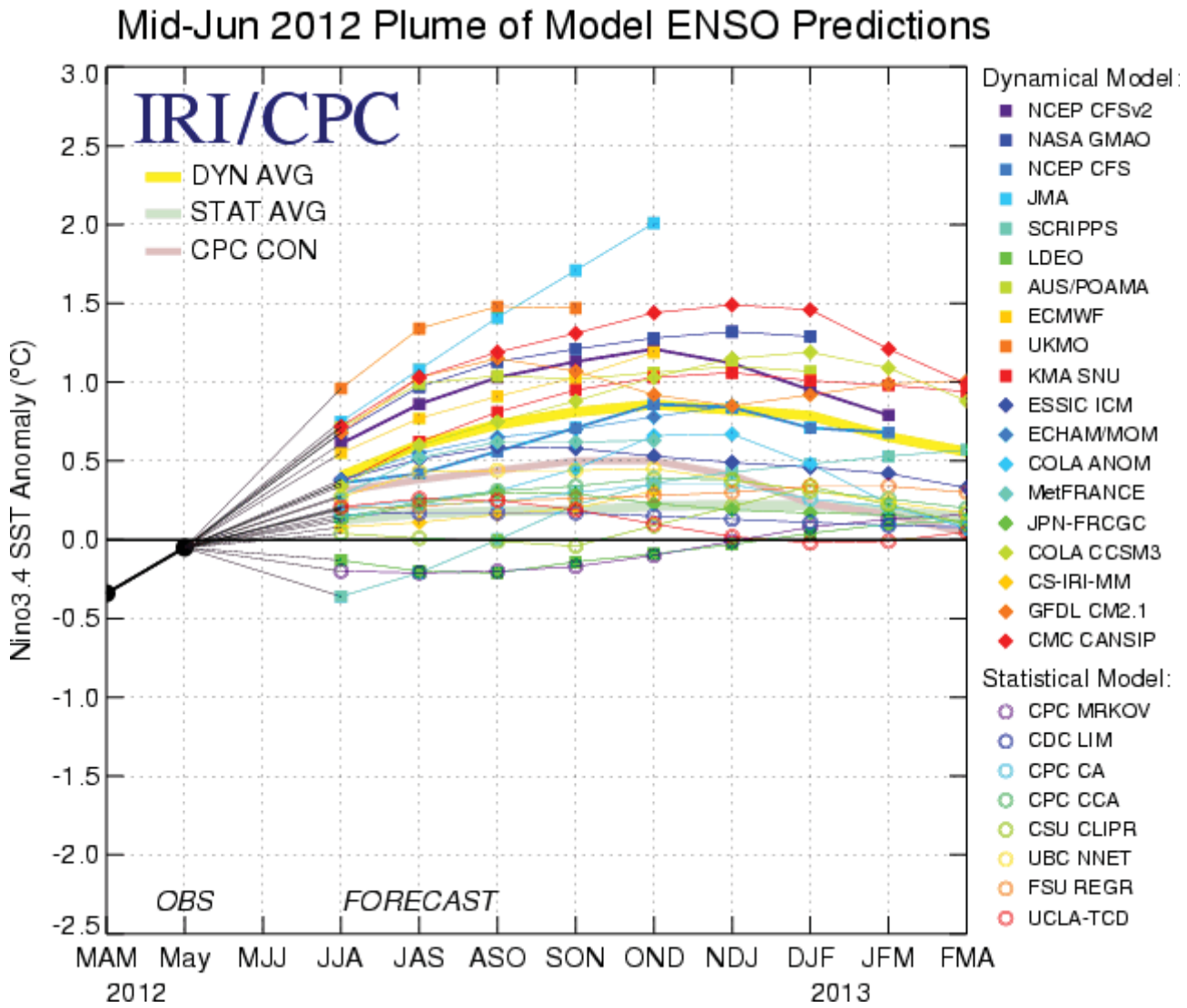
Basic Issues:

How do SST changes generate wind changes?
How do wind changes generate SST changes?
Why ~4 years?
Why irregular?

5. Predictability and Prediction



Predictions are routinely made and have real (but limited) skill


Mid-Jun 2012 Plume of Model ENSO Predictions
IRI/CPC
DYN AVG
STAT AVG
CPC CON
Nino3.4 SST Anomaly (°C)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
OBS
FORECAST
MAM
May
MJJ
JJA
JAS
ASO
SON
OND
NDJ
DJF
JFM
FMA
2012
2013
Dynamical Model:
NCEP CFSv2
NASA GMAO
NCEP CFS
JMA
SCRIPPS
LDEO
AUS/POAMA
ECMWF
UKMO
KMA SNU
ESSIC ICM
ECHAM/MOM
COLA ANOM
MetFRANCE
JPN-FRCGC
COLA CCSM3
CS-IRI-MM
GFDL CM2.1
CMC CANSIP
Statistical Model:
CPC MRKOV
CDC LIM
CPC CA
CPC CCA
CSU CLIPR
UBC NNET
FSU REGR
UCLA-TCD

6. Future ENSO

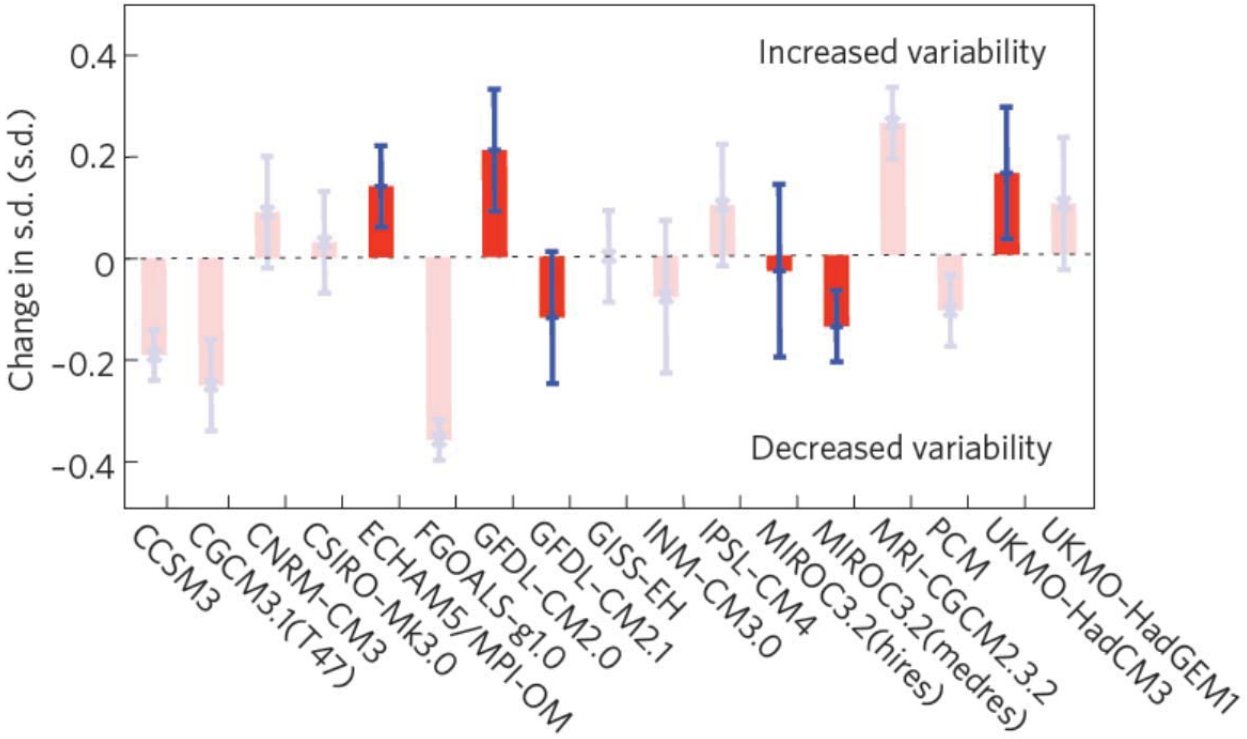


Figure 3 | Projected changes in the amplitude of ENSO variability, as a response to global warming, from the CMIP3 models[8,9]. The

We Just Don't Know!