The Abdus Salam
International Centre
for Theoretical Physics

United Nations
Educational, Scientific and
Cultural Organization

IAEA
International Atomic Energy Agency

2356-27

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

30 July - 10 August, 2012

Observations of ENSO

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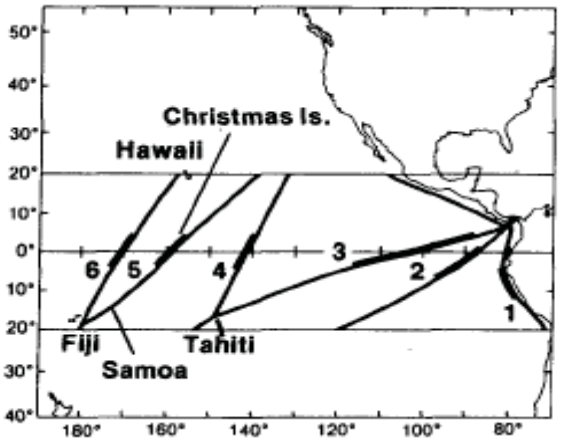
Observations of ENSO

E.S. Sarachik, University of Washington

1. Some Recent History—TOGA
2. The Ocean Observing System
3. The Climatology of Tropical Pacific
4. A Word about Anomalies
5. The evolution of ENSO
6. Decadal Variations of ENSO and The PDO

1. Some Recent History—TOGA

Before TOGA



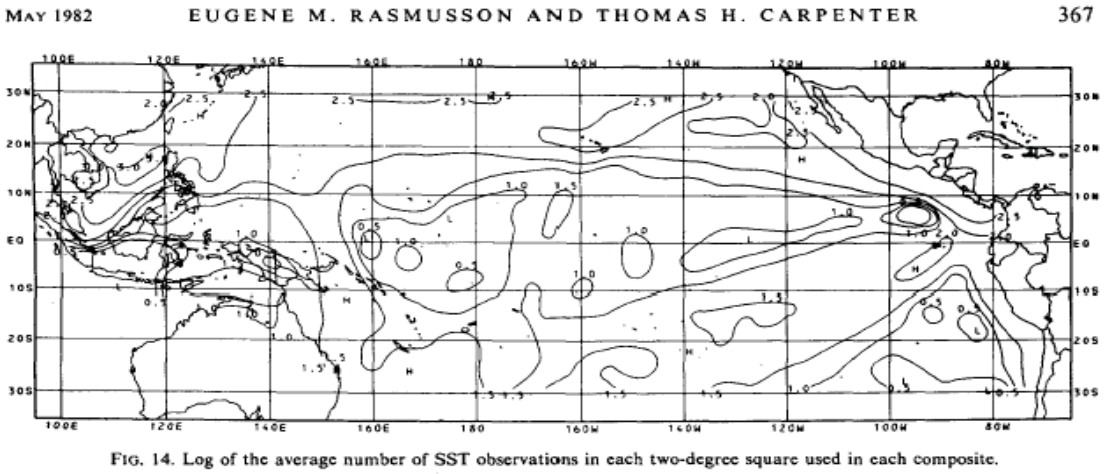


FIG. 14. Log of the average number of SST observations in each two-degree square used in each composite.

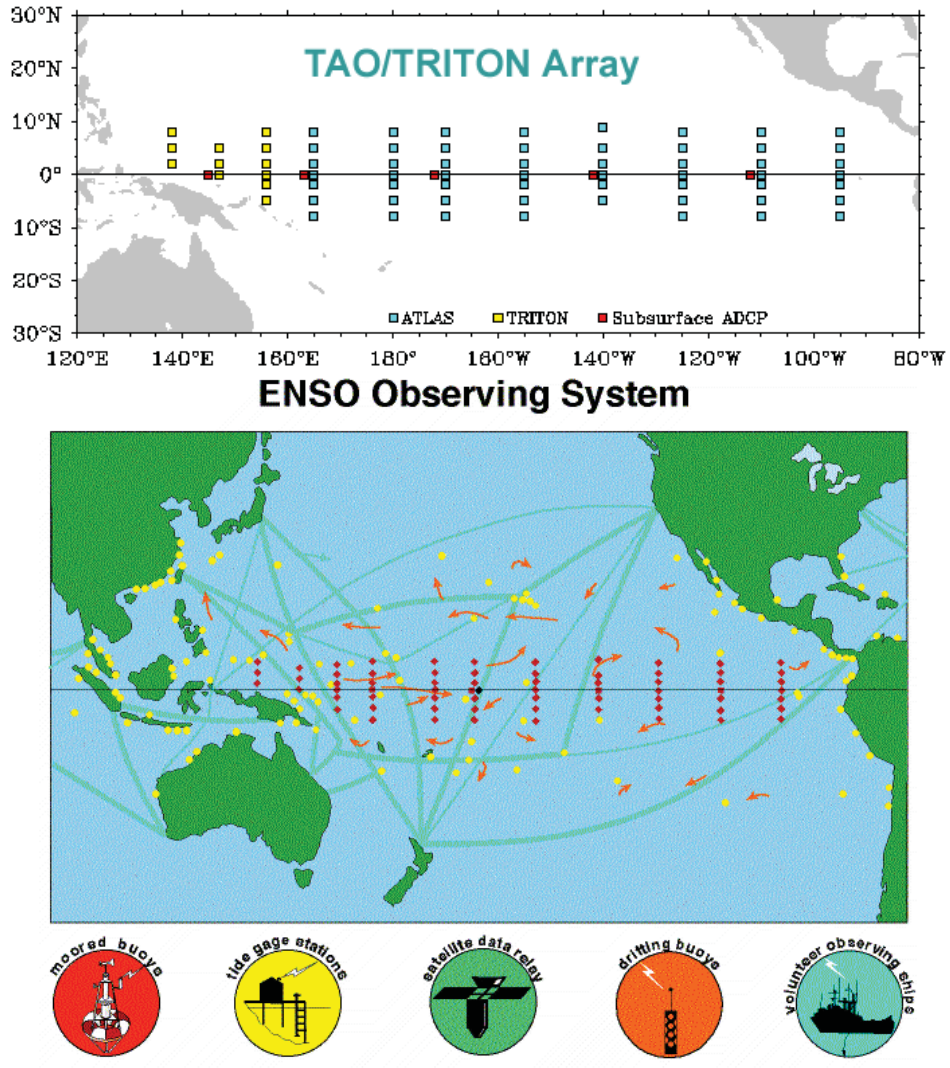
The Goals of TOGA (1985-1995)

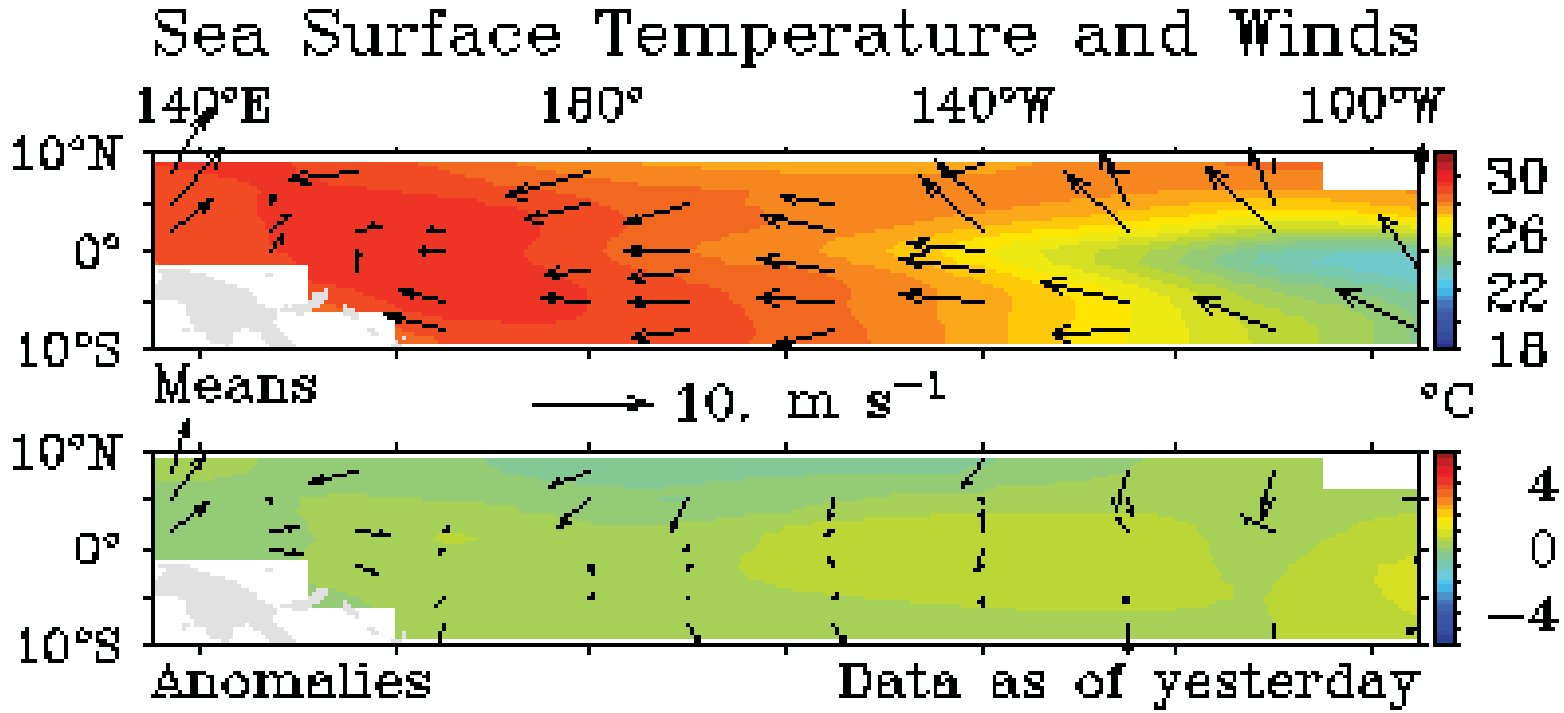
1. TO GAIN A DESCRIPTION OF THE TROPICAL OCEANS AND THE GLOBAL ATMOSPHERE AS A TIME-DEPENDENT SYSTEM, IN ORDER TO DETERMINE THE EXTENT TO WHICH THIS SYSTEM IS PREDICTABLE ON TIME SCALES OF MONTHS TO YEARS, AND TO UNDERSTAND THE MECHANISMS AND PROCESSES UNDERLYING THAT PREDICTABILITY.

2. TO STUDY THE FEASIBILITY OF MODELING THE COUPLED OCEAN-ATMOSPHERE SYSTEM FOR THE PURPOSE OF PREDICTING ITS VARIATIONS ON TIME SCALES OF MONTHS TO YEARS.

3. TO PROVIDE SCIENTIFIC BACKGROUND FOR DESIGNING AN OBSERVING AND DATA TRANSMISSION SYSTEM FOR OPERATIONAL PREDICTION IF THIS CAPABILITY IS DEMONSTRATED BY THE COUPLED OCEAN-ATMOSPHERE SYSTEM.

2. The Ocean Observing System

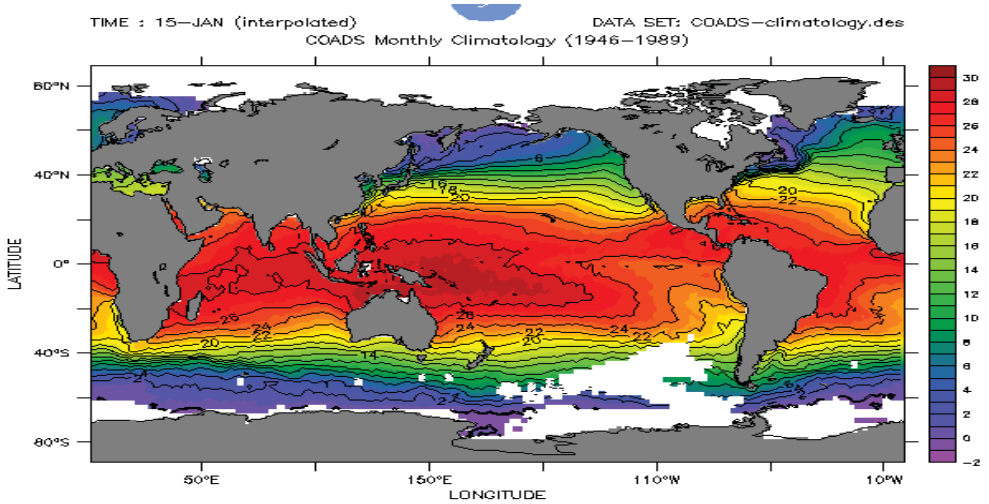




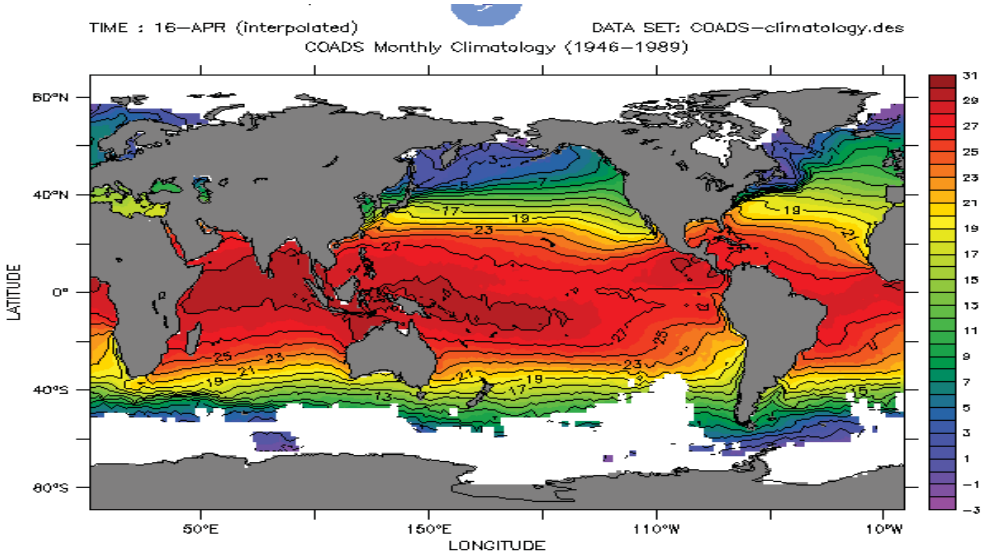
http://www.pmel.noaa.gov/tao/realtime.html

3. The Climatology of Tropical Pacific

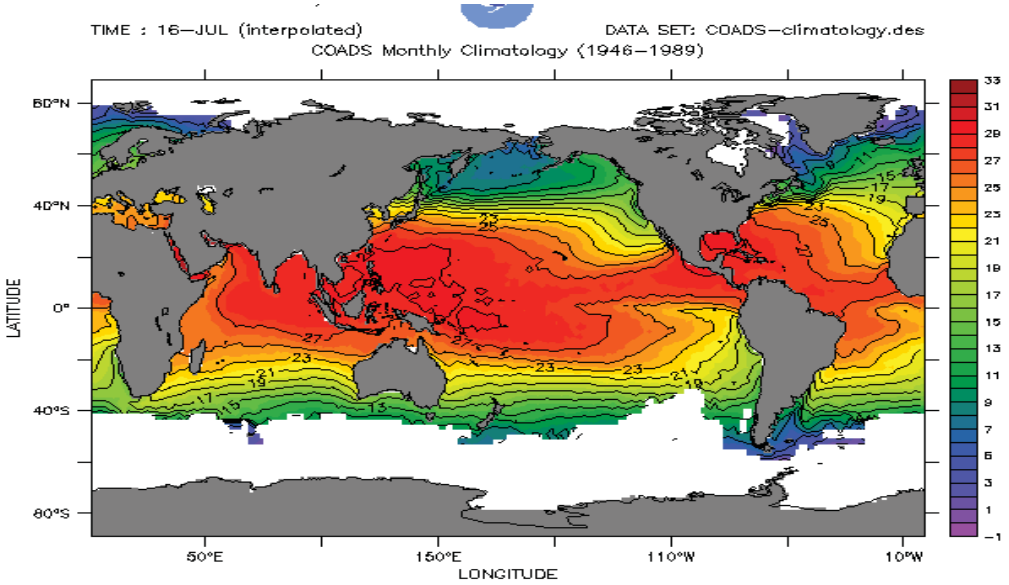
SST



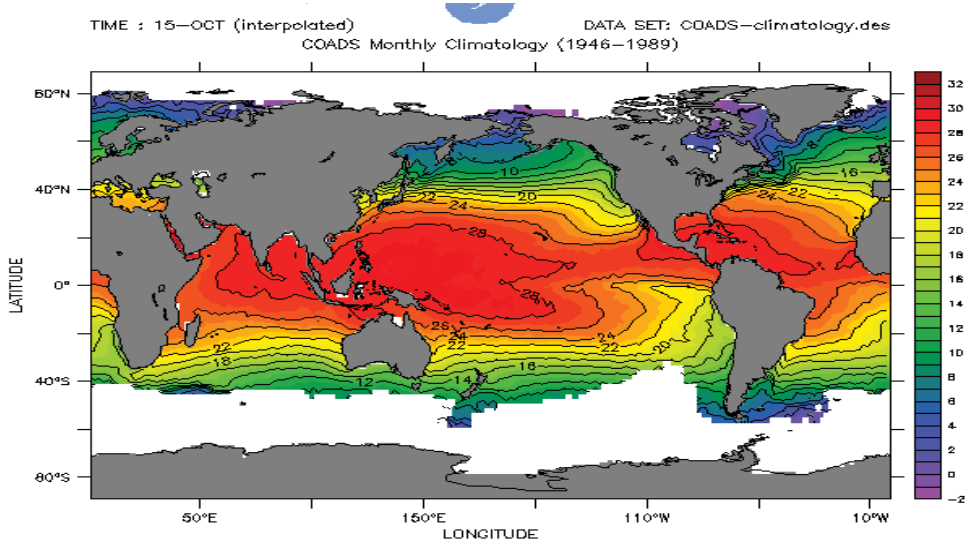
SEA SURFACE TEMPERATURE (Deg C)



SEA SURFACE TEMPERATURE (Deg C)

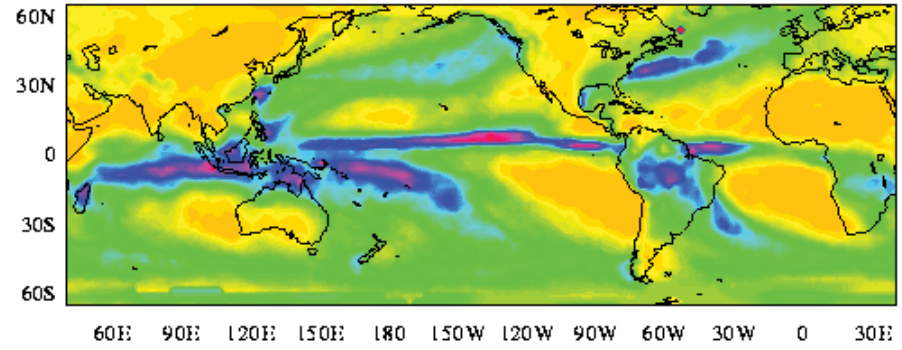


SEA SURFACE TEMPERATURE (Deg C)

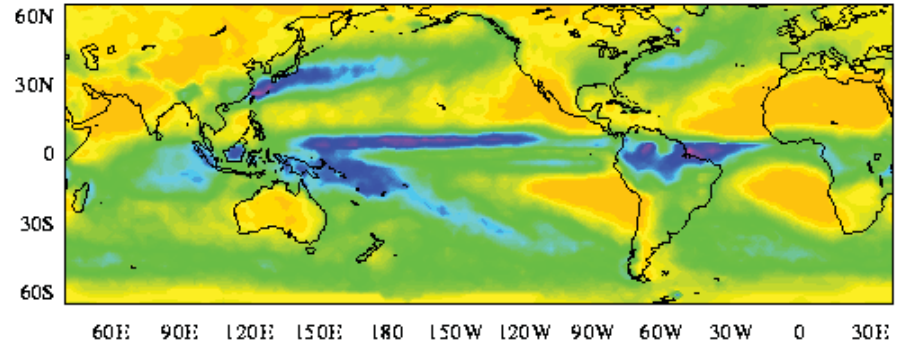


SEA SURFACE TEMPERATURE (Deg C)

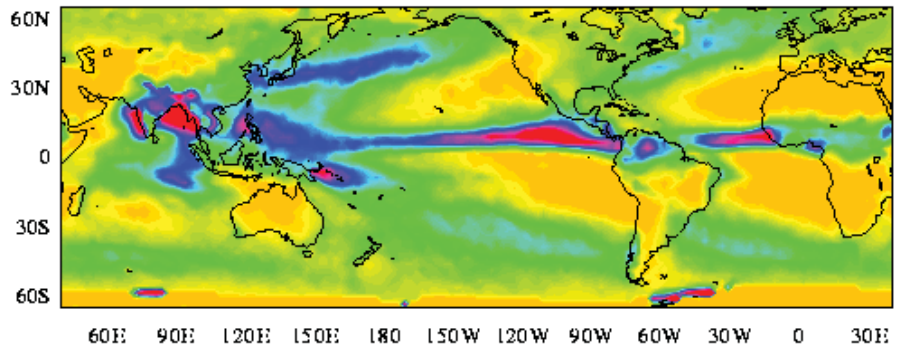
Precip (mm/mo)



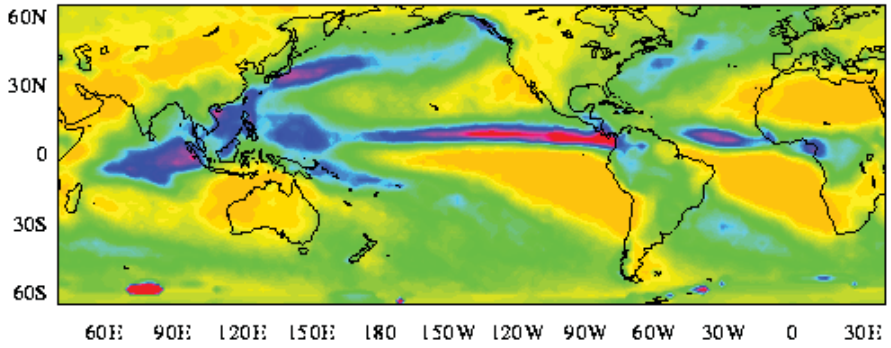
Jan



April



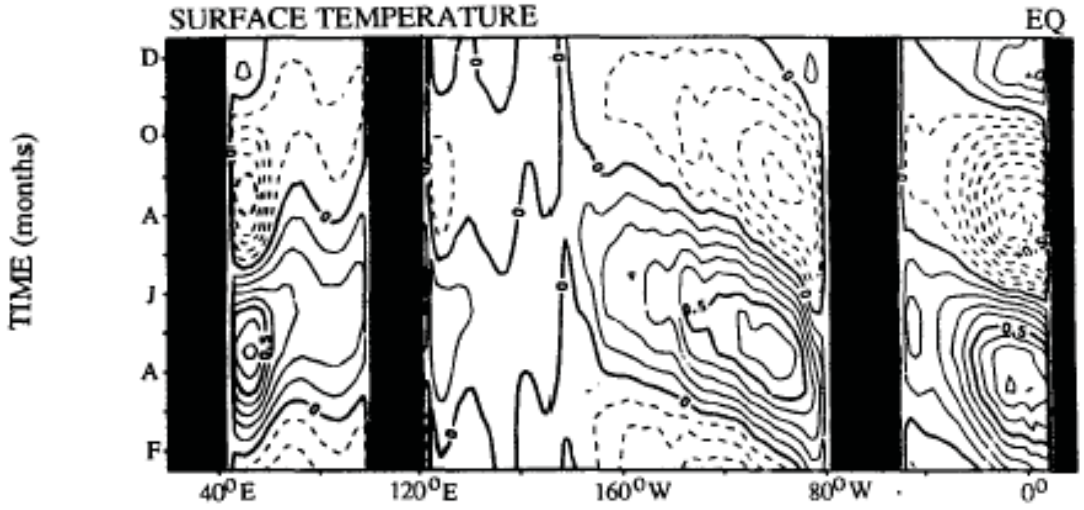
July

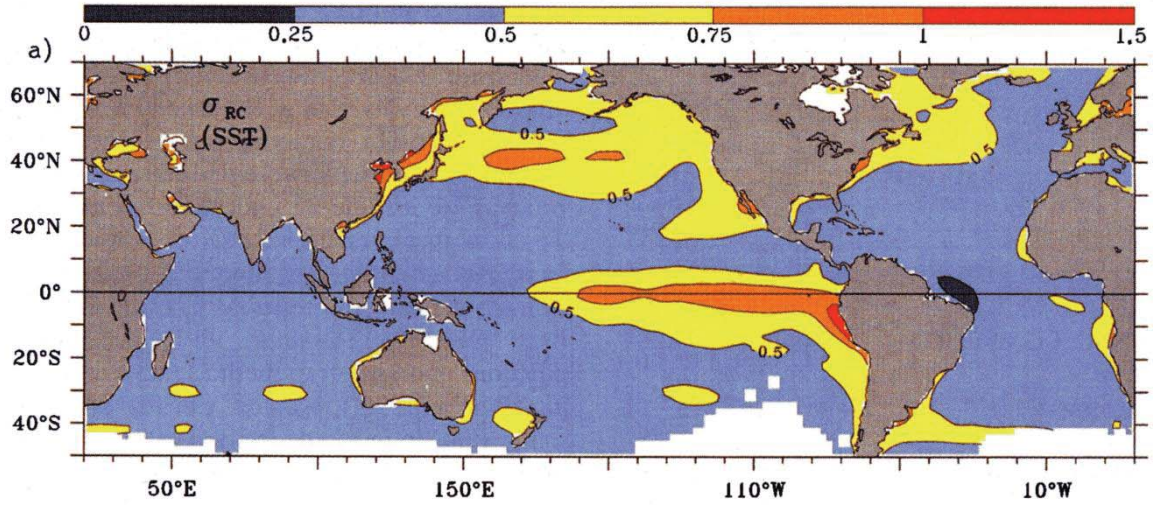


October

AND HEAT FLUX OPPOSES THE SST.

http://www.ecmwf.int/research/era/ERA-40/ERA-40_Atlas/docs/index.html


SURFACE TEMPERATURE
EQ
TIME (months)
D
O
A
J
A
F
40°E
120°E
160°W
80°W
0°


0
0.25
0.5
0.75
1
1.5
a)
60°N
40°N
20°N
0°
20°S
40°S
σ RC (SST)
50°E
150°E
110°W
10°W

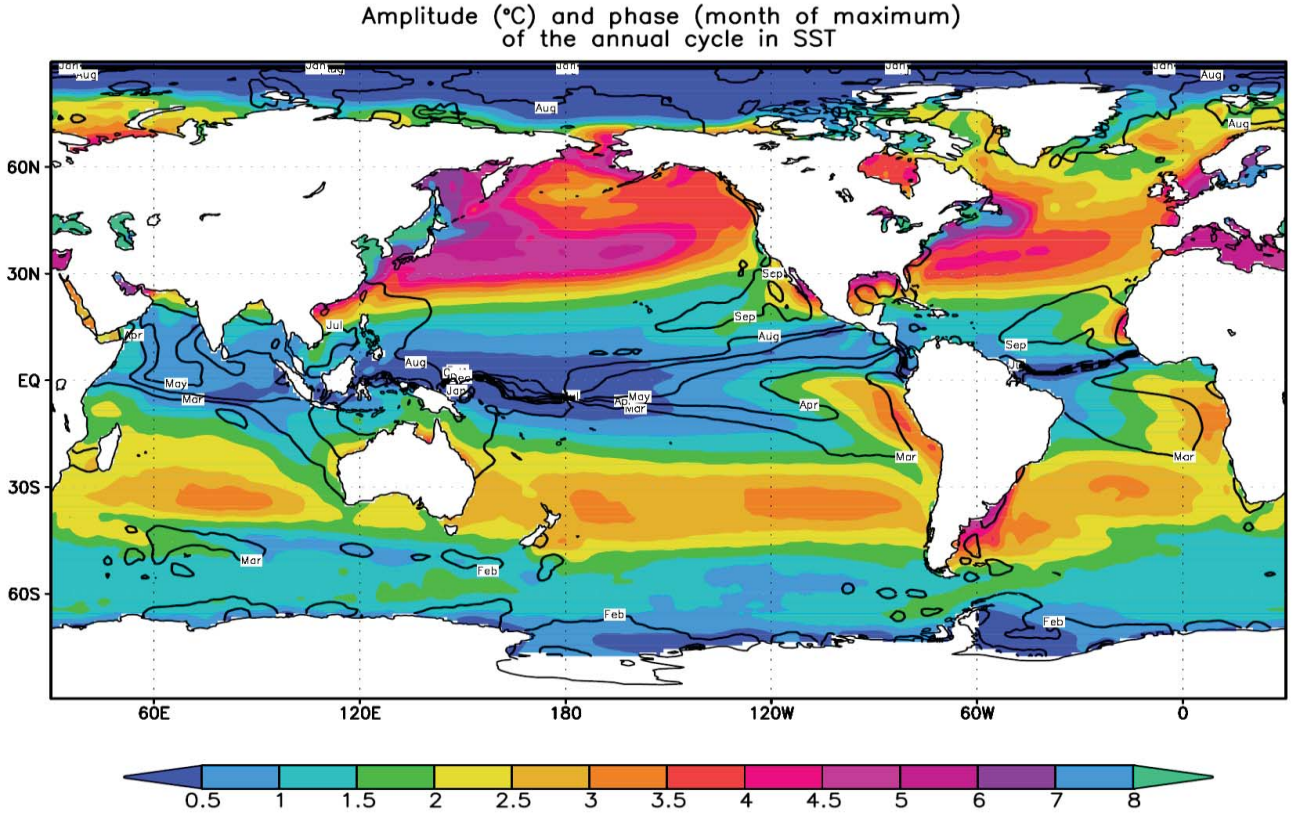
4. A Word about Anomalies

Defining Anomalies

►**Average Each Month Separately: the Progression of Monthly Quantities is the Climatology**

►**Implies that the Climatology Contains Both Higher and Lower Frequencies**

►**The Annual Cycle is the First Harmonic of the Climatology (in a Fourier Sense)**



►An **Anomaly** is the Difference Between the Actual Value and the Climatology

►But What if the Climatology is Non-Stationary?

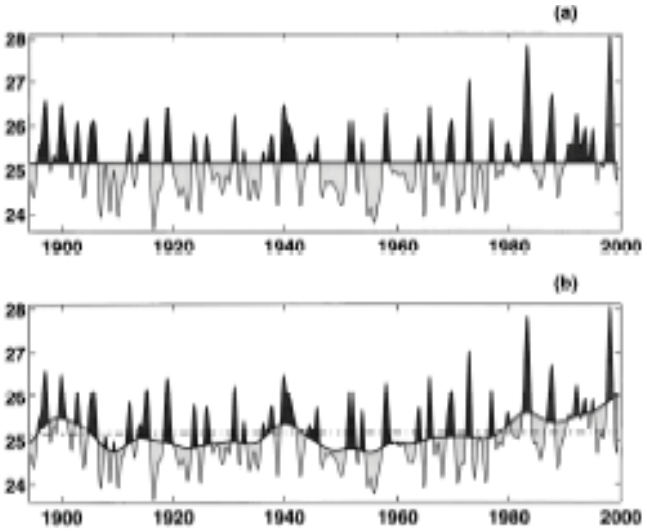


FIG. 1. The interannual oscillations in SST (in °C) at the equator in the eastern Pacific (averaged over the area 5°S–5°N, 80°–120°W) are shown on the background of (a) the time-averaged temperature for the century (b) the low-frequency interdecadal changes. The plots are obtained by applying, to the available measurements, two different low-pass filters with the cutoff frequencies of approximately 0.9 and 0.09 yr^{-1}. The darker (lighter) part of the graph indicates El Niño (La Niña).

►IN ORDER TO CORRECTLY DEFINE ANOMALIES, WE WOULD HAVE TO HAVE A MODEL FOR THE SLOWLY CHANGING CLIMATOLOGY--- THIS WE DO NOT HAVE.

5. The evolution of ENSO

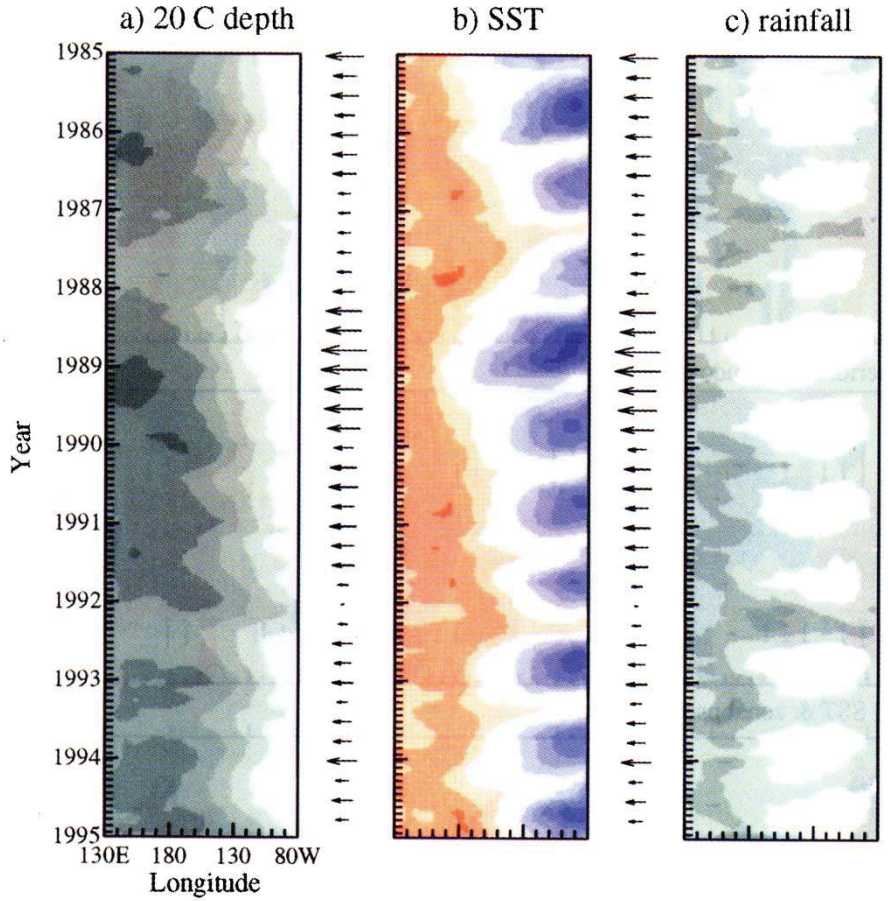


Plate 4. As in Plate 3, but for total fields. Progressively darker shading is for 20°C isotherm depths > 60, 90, ..., 180 m and rainfall amounts > 5, 20, 35 cm month^{-1}. SSTs < 26°, 25°, ... 22°C (>28°, 29°, 30°C) indicated by blue (red) shading with progressively greater saturation. The largest magnitude zonal pseudostress is –45 m^2 s^{-2}.

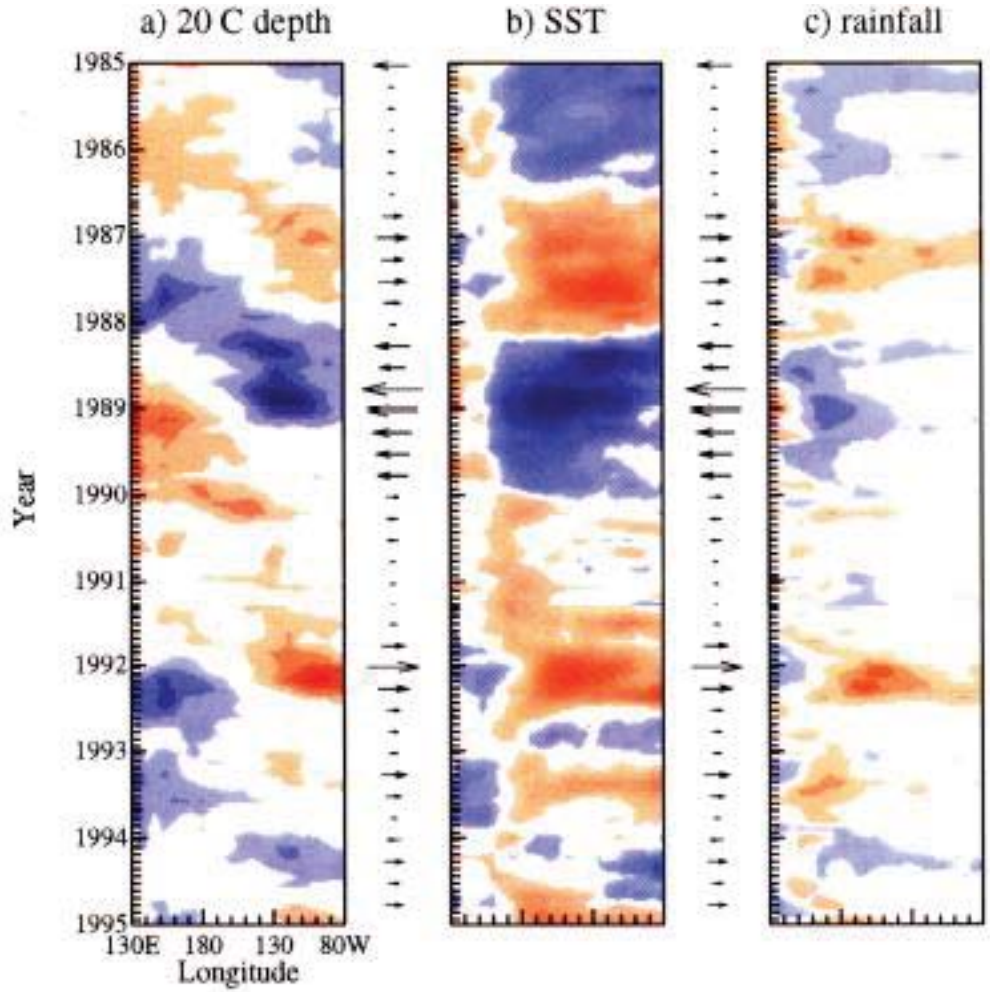


Plate 3. Time-longitude diagram of anomalies in the equatorial Pacific for (a) 20°C isotherm depth (4.5°N–4.5°S), (b) SST (4°N–4°S), and (c) rainfall (5°N–5°S) for the TOGA decade starting January 1, 1995. Arrows represent area-average zonal pseudostress over 4°N–4°S, 151°E–141°W. Positive (negative) values are indicated by red (blue) shading. Lightest (saturated) shading denotes isotherm depth, SST, and rainfall anomalies > 10 m, 0.25°C, and 5 cm month^{-1} (40 m, 2°C, and 25 cm month^{-1}) in magnitude, respectively. The largest magnitude zonal stress anomaly is −24 m^2 s^{-2}. Isotherm depths are taken from the ocean data assimilation model at NOAA/NCEP; pseudostress from Florida State University [*Stricherz et al.*, 1992]; SST from NOAA/NCEP [*Reynolds and Smith*, 1994], and microwave sounding unit (MSU) rainfall from the NASA/Marshall Space Flight Center [*Spencer*, 1993].

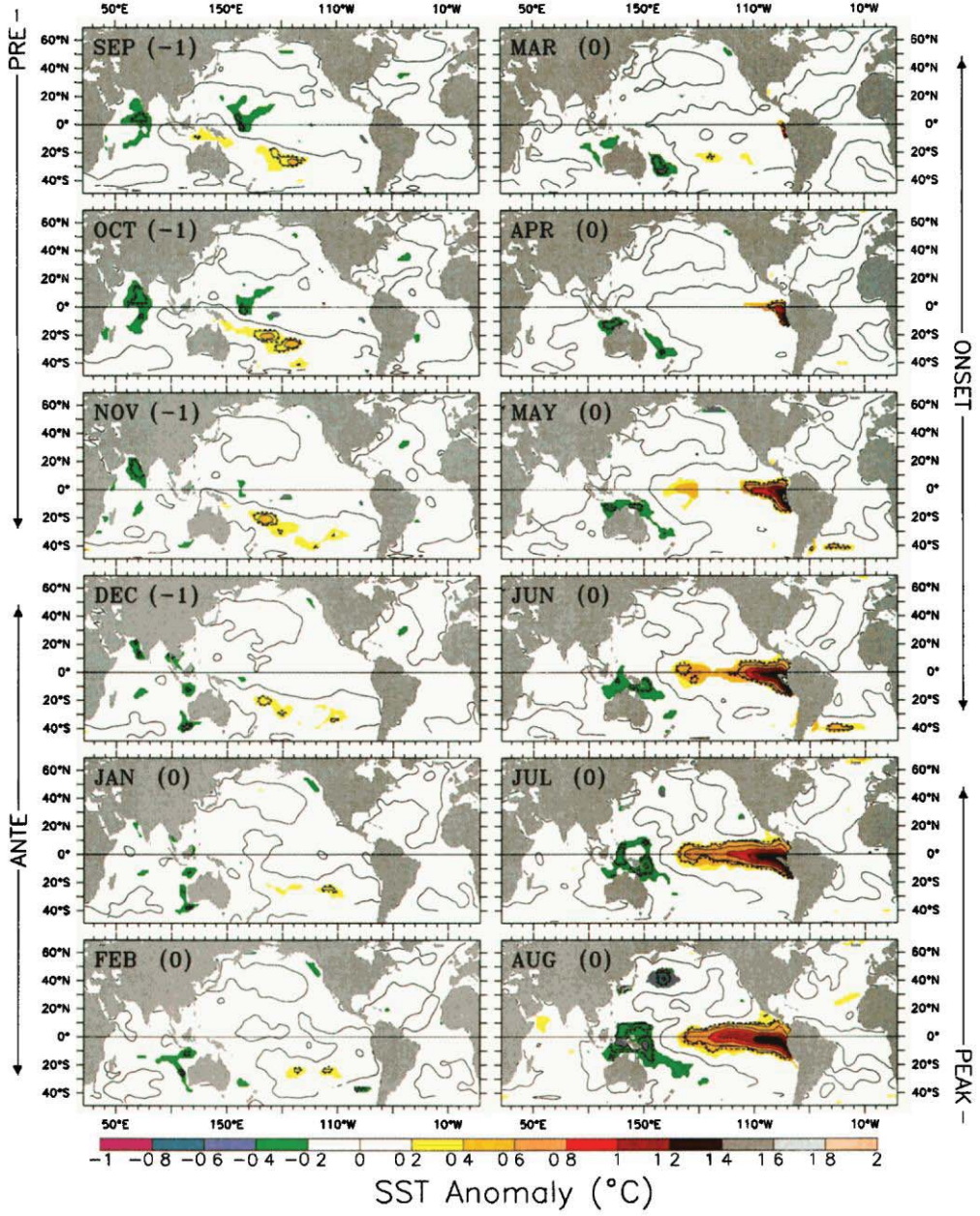
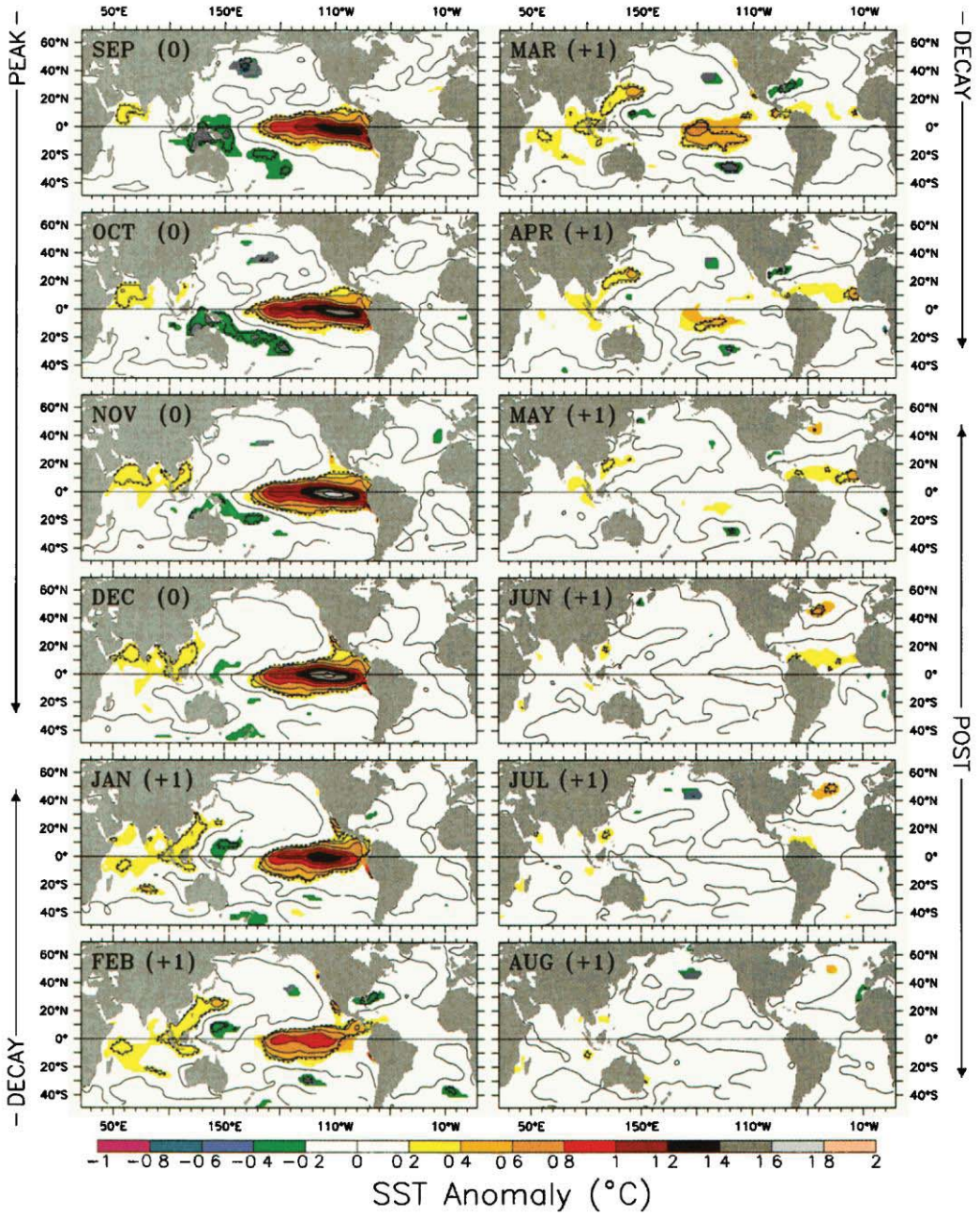
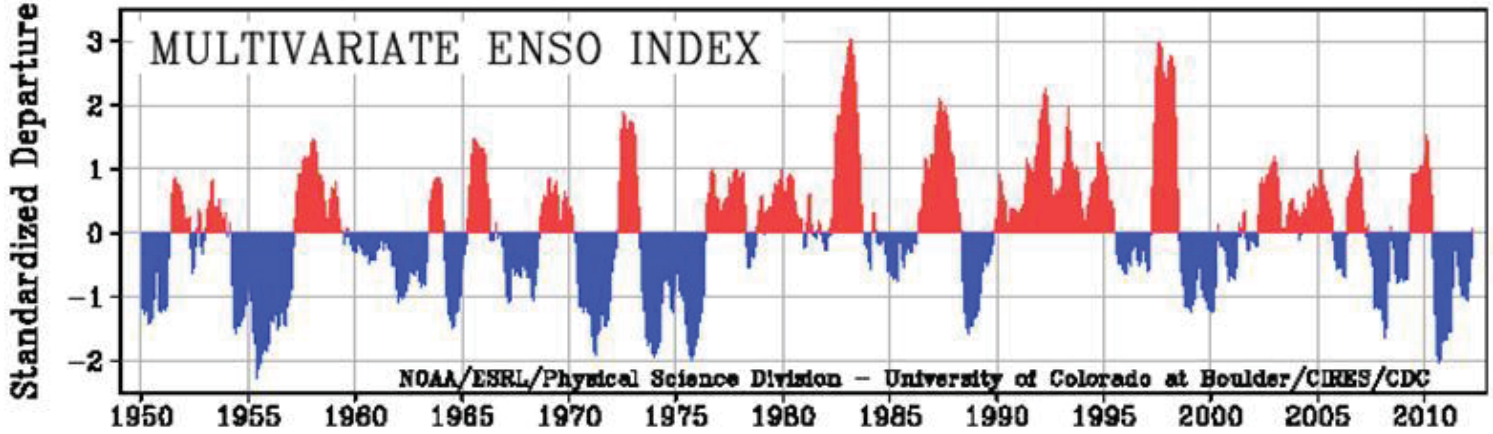


Plate 3. (continued)


PEAK
DECAY
DECAY
POST
SEP (0)
OCT (0)
NOV (0)
DEC (0)
JAN (+1)
FEB (+1)
MAR (+1)
APR (+1)
MAY (+1)
JUN (+1)
JUL (+1)
AUG (+1)
50°E
150°E
110°W
10°W
60°N
40°N
20°N
0°
20°S
40°S
−1 −0 8 −0 6 −0 4 −0 2 0 0 2 0 4 0 6 0 8 1 1 2 1 4 1 6 1 8 2
SST Anomaly (°C)

6. Decadal Variations of ENSO: The PDO



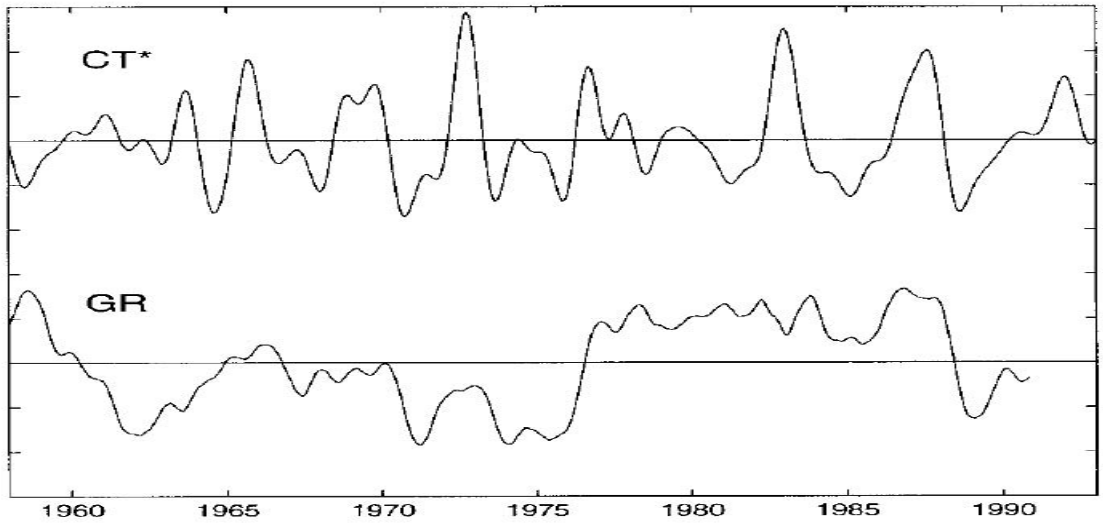
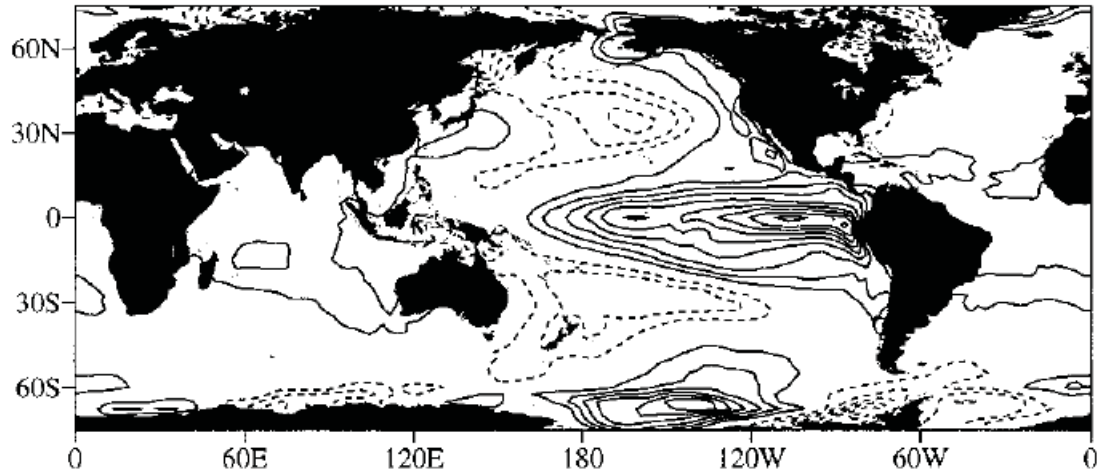
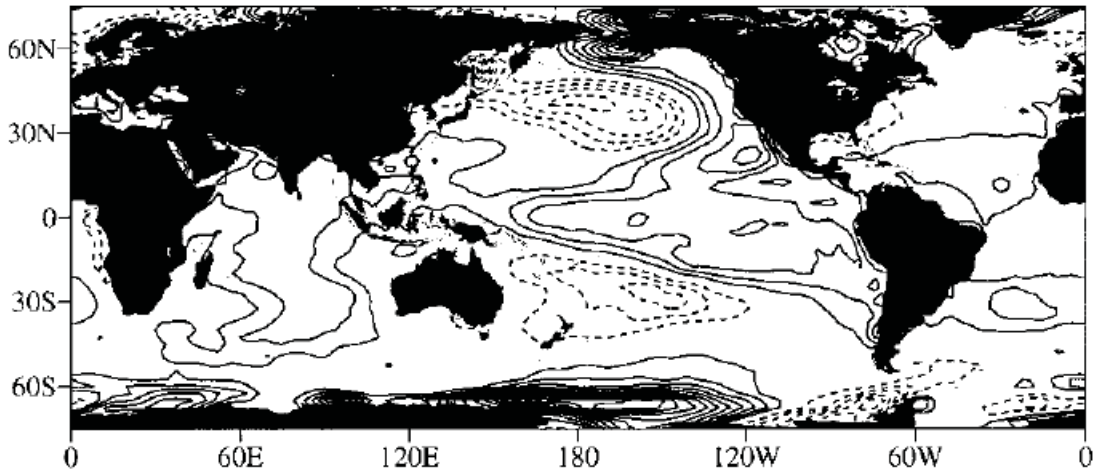


FIG. 1. Normalized time series of the 6-yr high-pass filtered cold tongue index (CT*) and global residual (GR). The interval between tick marks is 1.0 std dev.

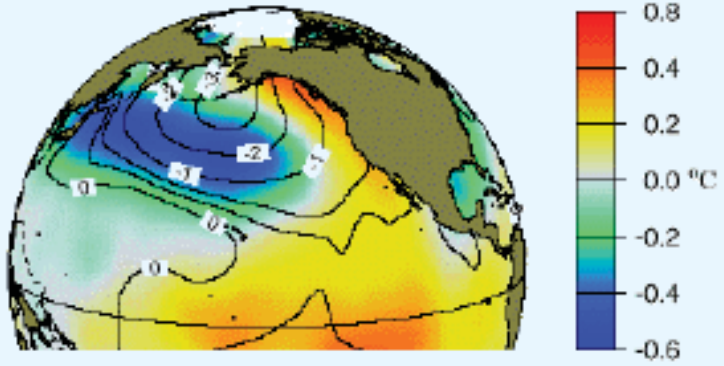
< CT*, SST >


60N
30N
0
30S
60S
0
60E
120E
180
120W
60W
0

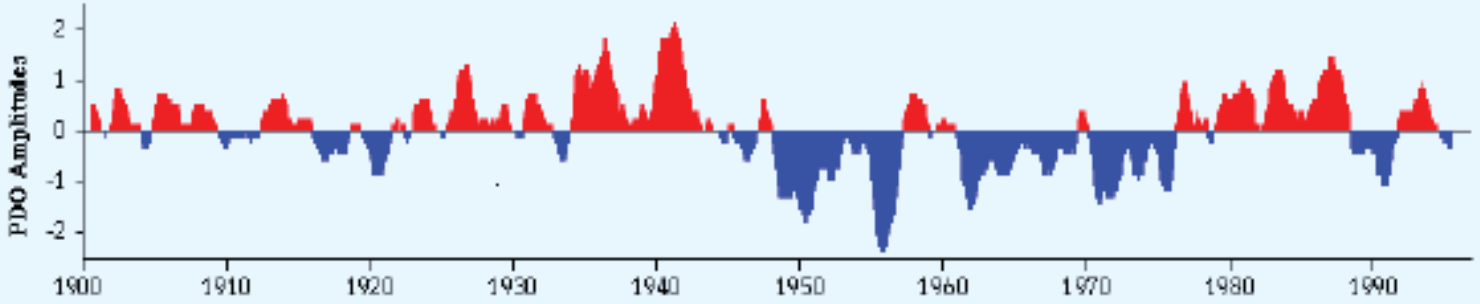
< GR, SST >


60N
30N
0
30S
60S
0
60E
120E
180
120W
60W
0

The Pacific Decadal Oscillation (PDO)



SST (colors) and SLP (contours)
Regressed onto the PDO index



From Mantua et al. (1997)

Pacific Decadal Oscillation