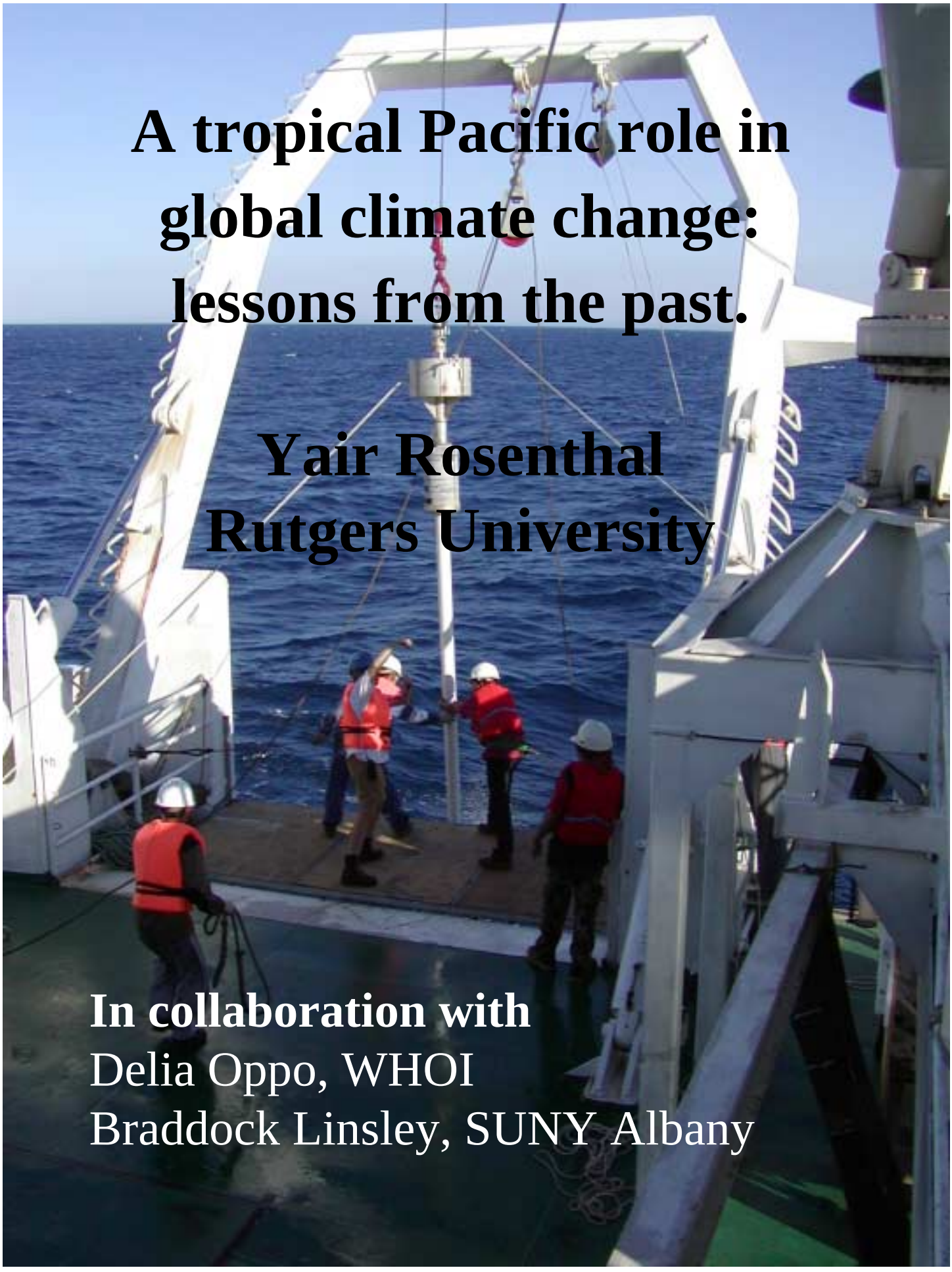
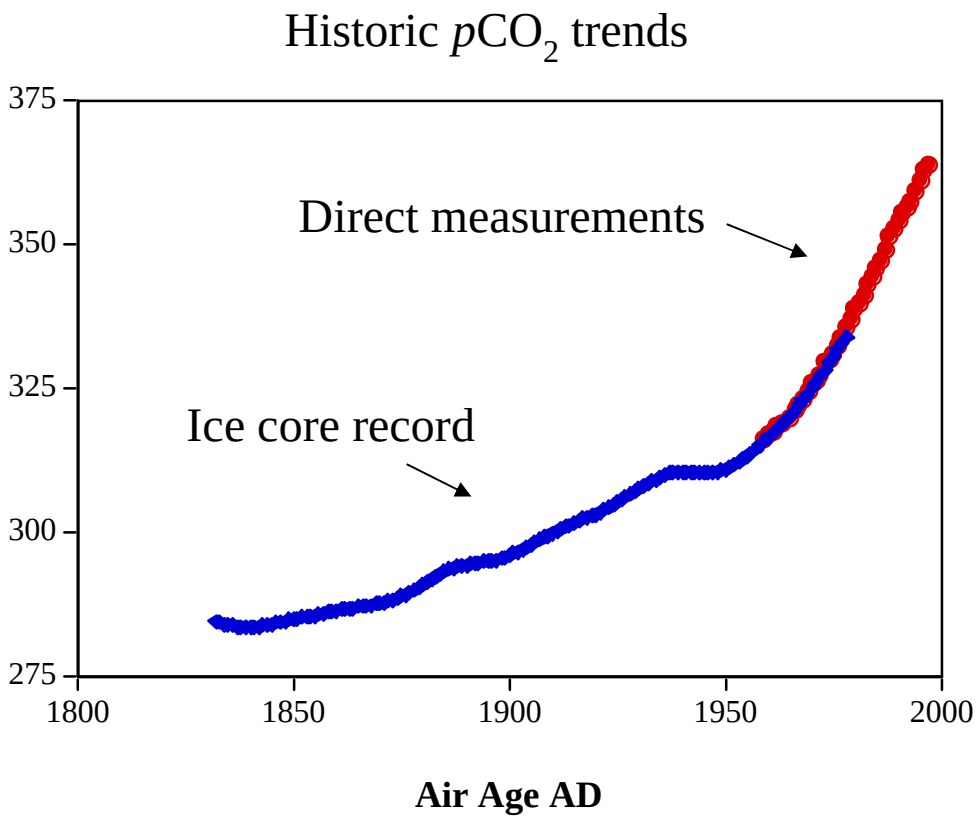


A tropical Pacific role in global climate change: lessons from the past.

Yair Rosenthal
Rutgers University

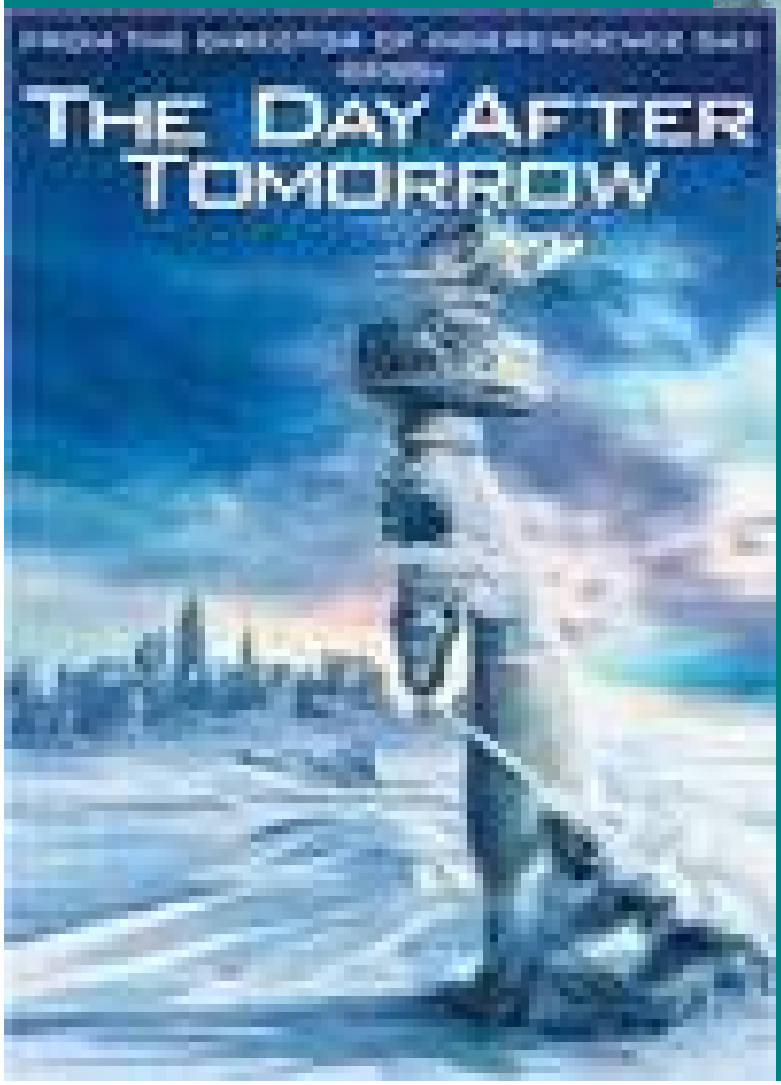
In collaboration with
Delia Oppo, WHOI
Braddock Linsley, SUNY Albany

Historic record of atmospheric pCO_2



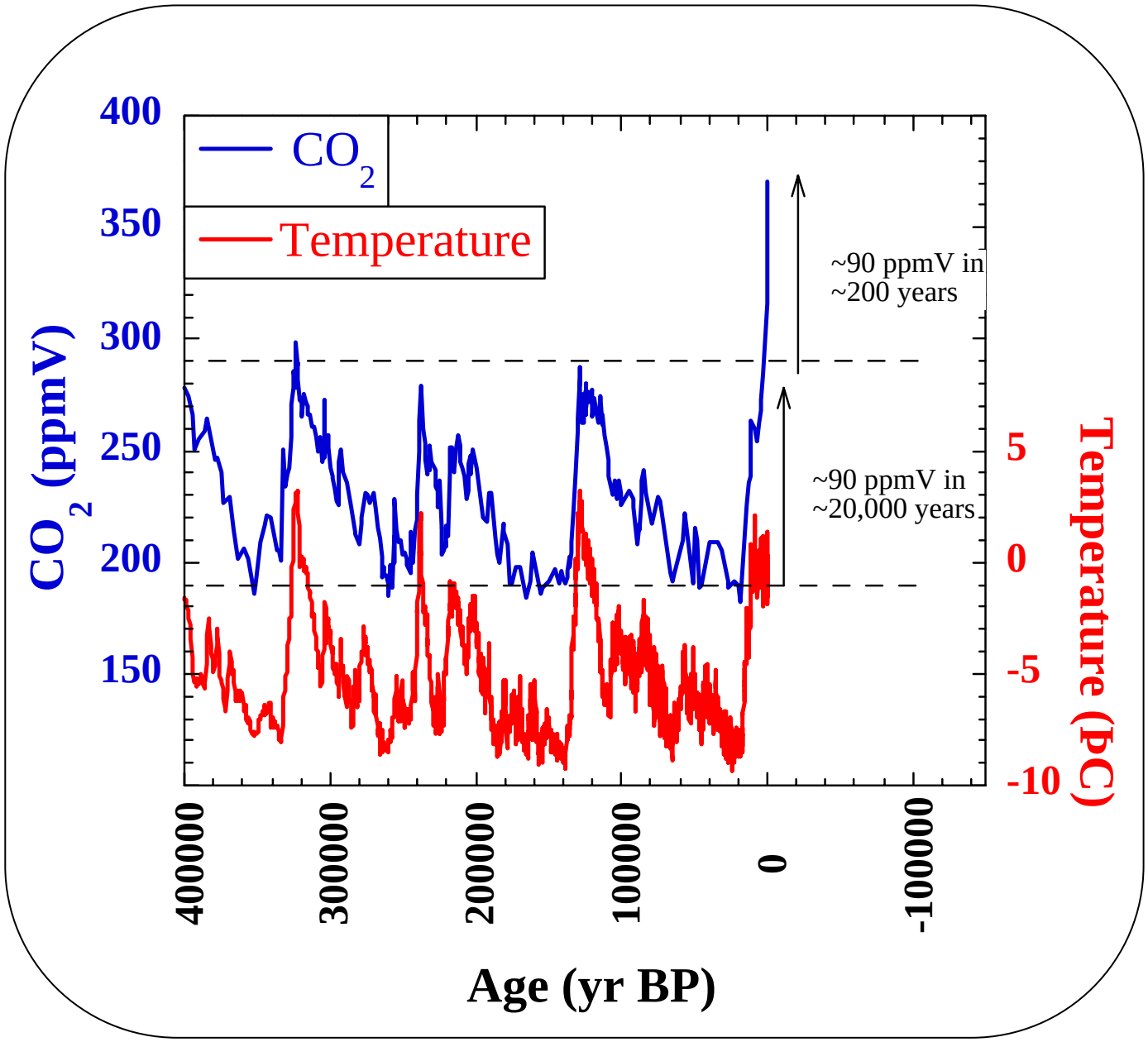
The recent increase in atmospheric CO_2 concentration due to human activities raise concern about the possibility of global warming

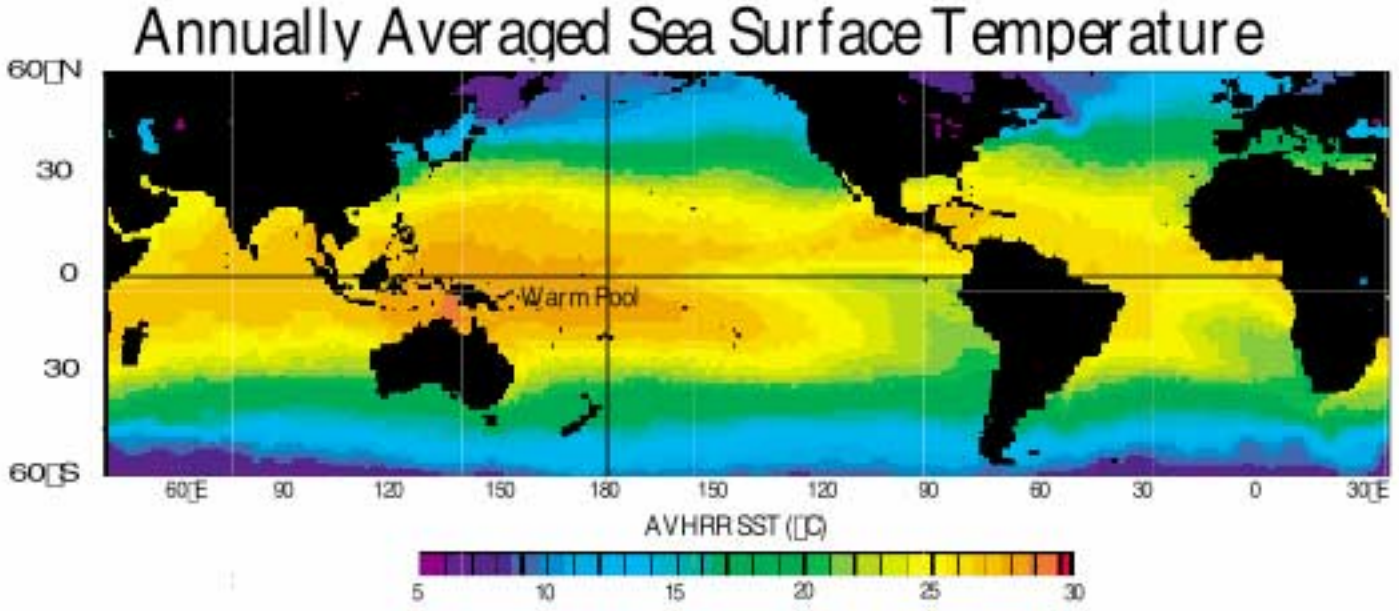
Why should we care about Paleoceanography and Paleoclimatology?

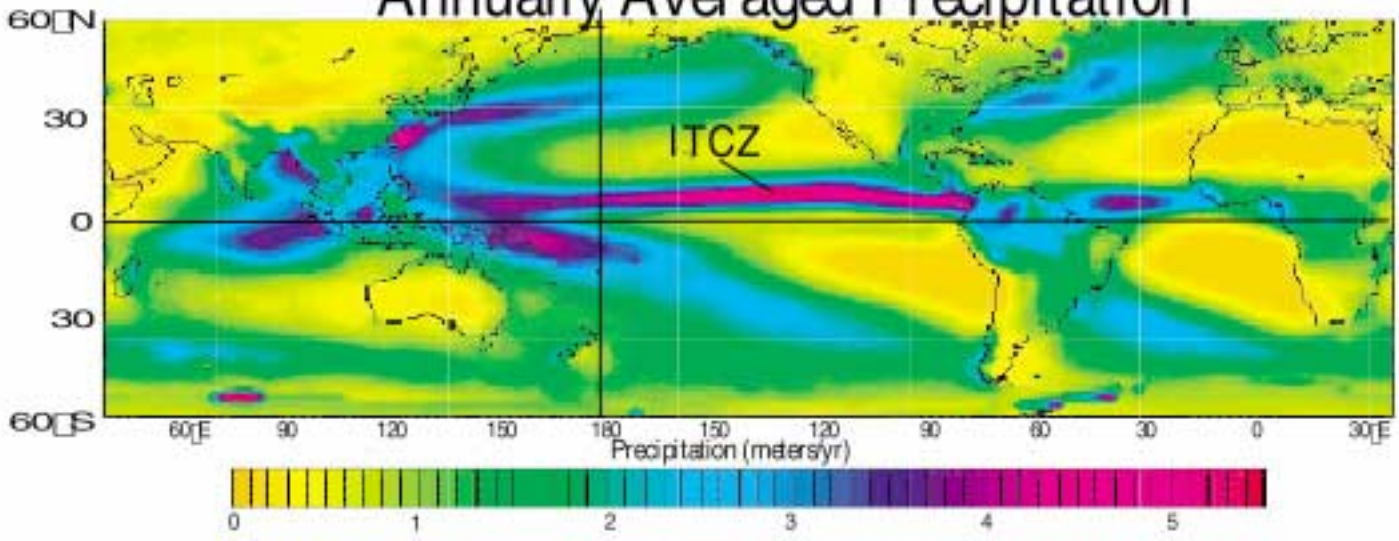


To know better about the day after tomorrow!

CO_2 and climate: The Vostok Ice Core

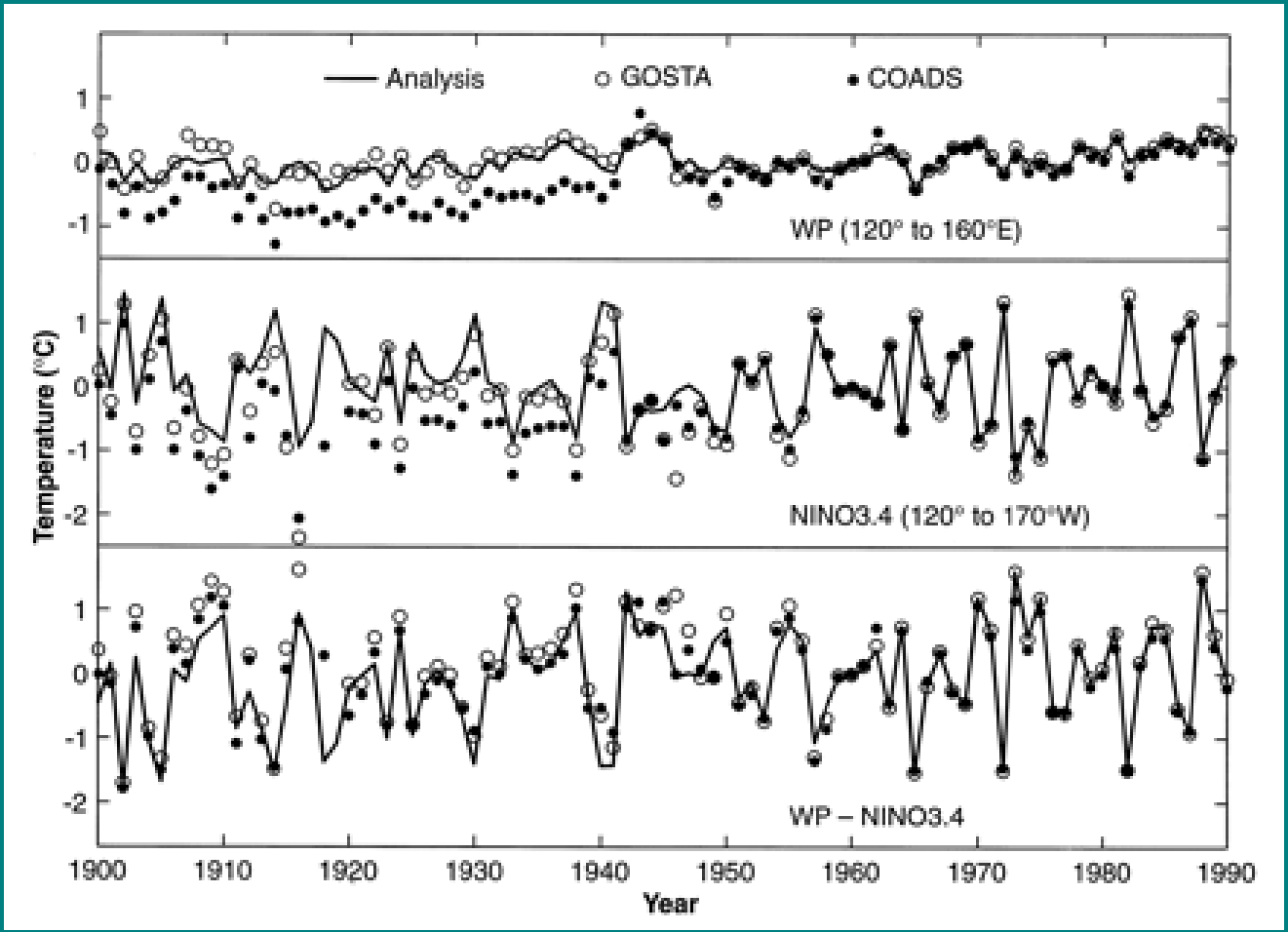



Annually Averaged Sea Surface Temperature
60°N
30
0
30
60°S
Warm Pool
60°E
90
120
150
180
150
120
90
60
30
0
30°E
AVHRR SST (°C)
5
10
15
20
25
30


Annually Averaged Precipitation
60°N
30
0
30
60°S
ITCZ
60°E
90
120
150
180
150
120
90
60
30
0
30°E
Precipitation (meters/yr)
0
1
2
3
4
5

Twentieth-Century Sea Surface Temperature Trends

Mark A. Cane,* Amy C. Clement, Alexey Kaplan,Yochanan Kushnir, Dmitri Pozdnyakov, Richard Seager, Stephen E. Zebiak, Ragu Murtugudde



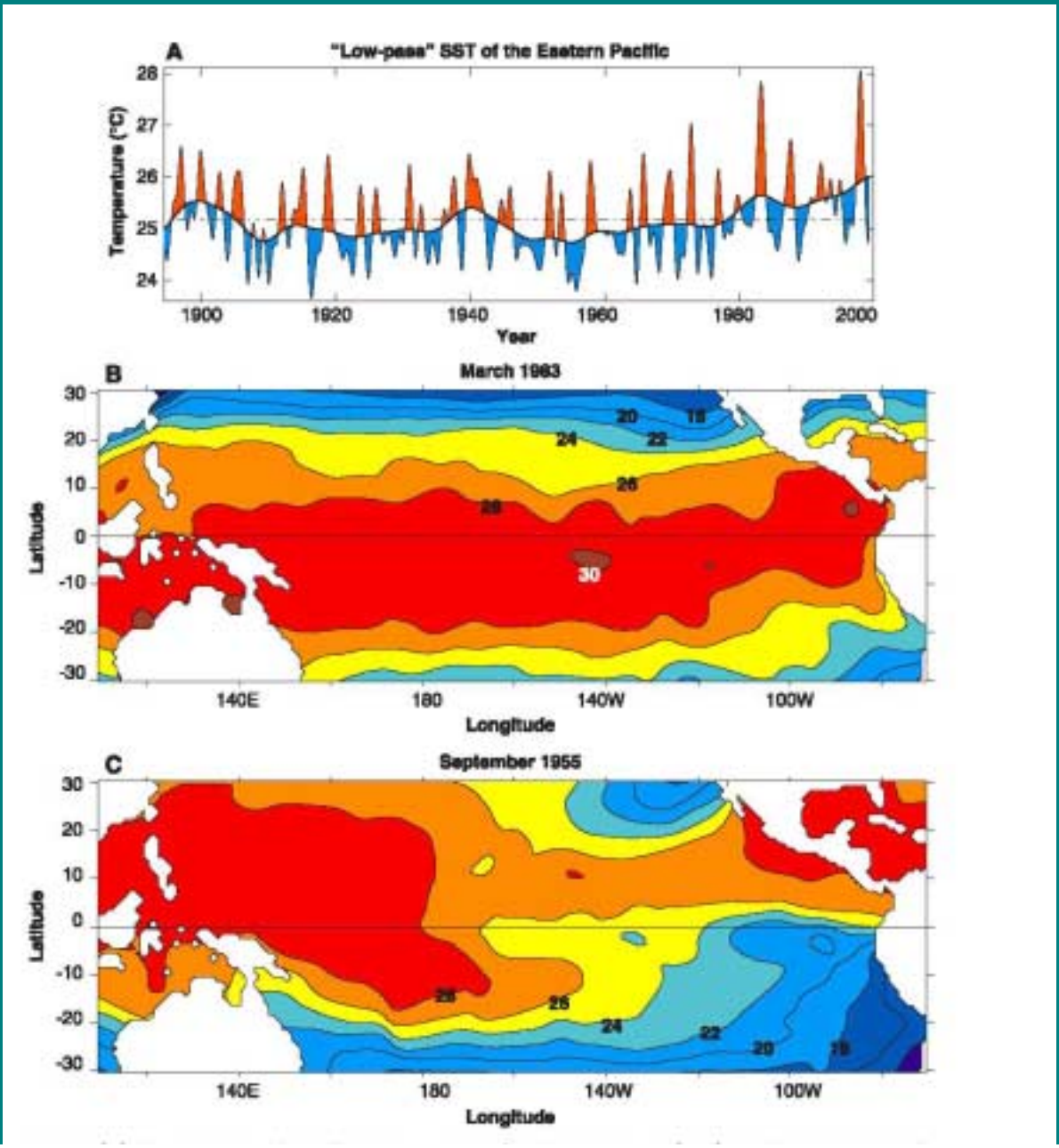
Science 275, 957-960. 1997

El Niño Southern Oscillation

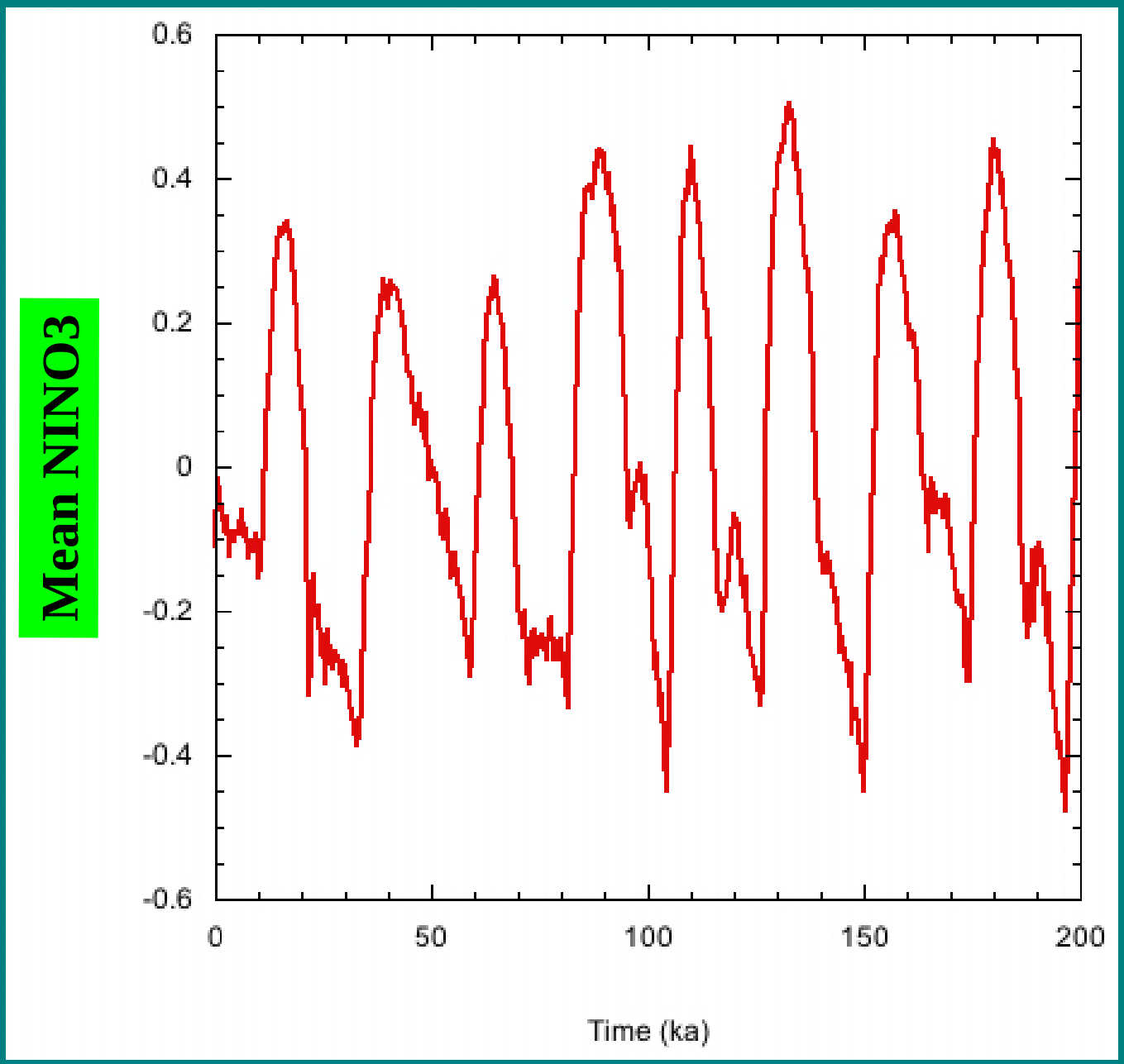
Is El Niño Changing?

Alexey V. Fedorov and S. George Philander

Science 288, 1997-2002, 2000



Clement & Cane model



QUESTIONS

- ***PEPD***

What is the sensitivity of the tropical Pacific Ocean to changes in radiative forcing on different time scales?

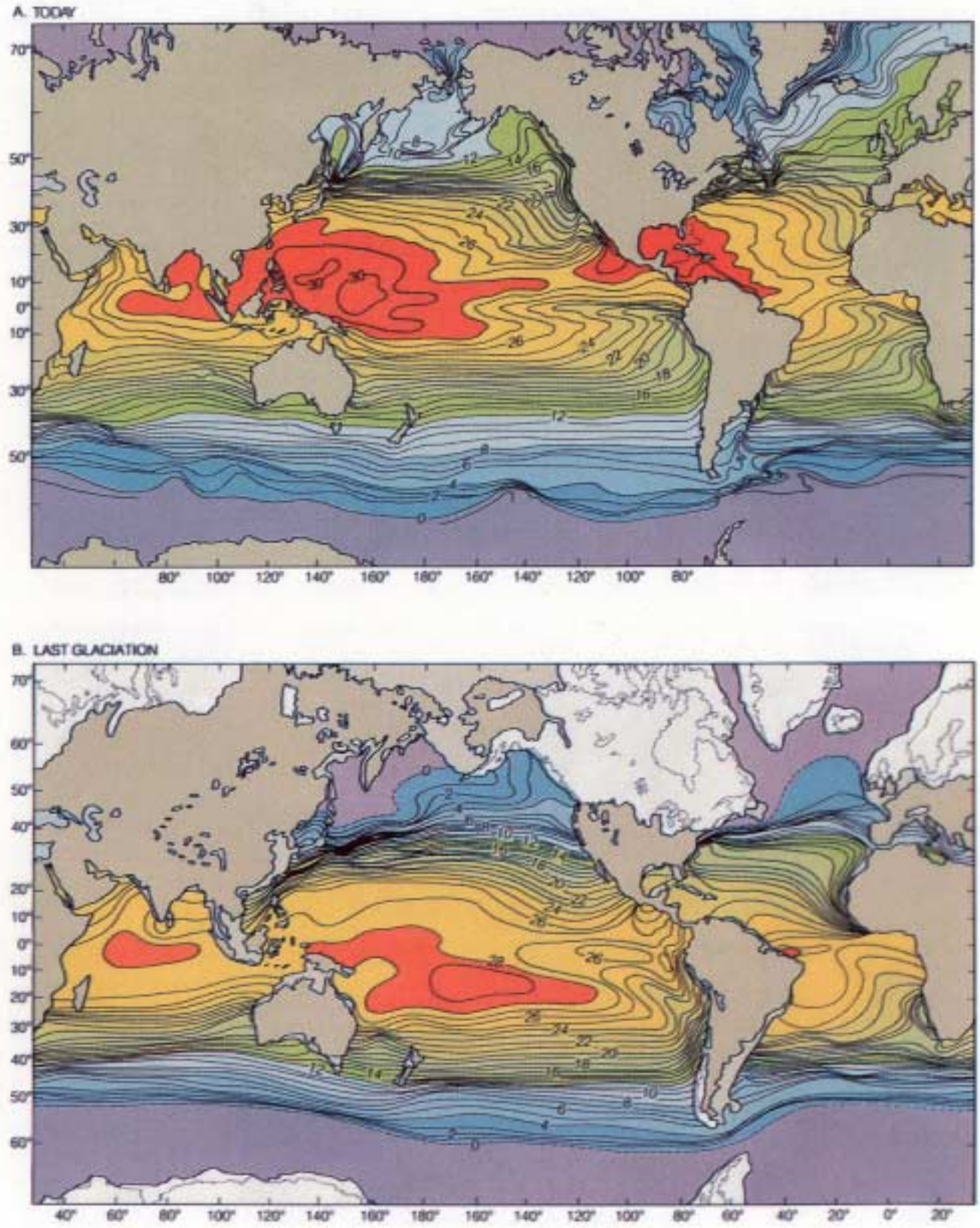
Is there a direct response between tropical SSTs and atmospheric pCO_2 on this time scales

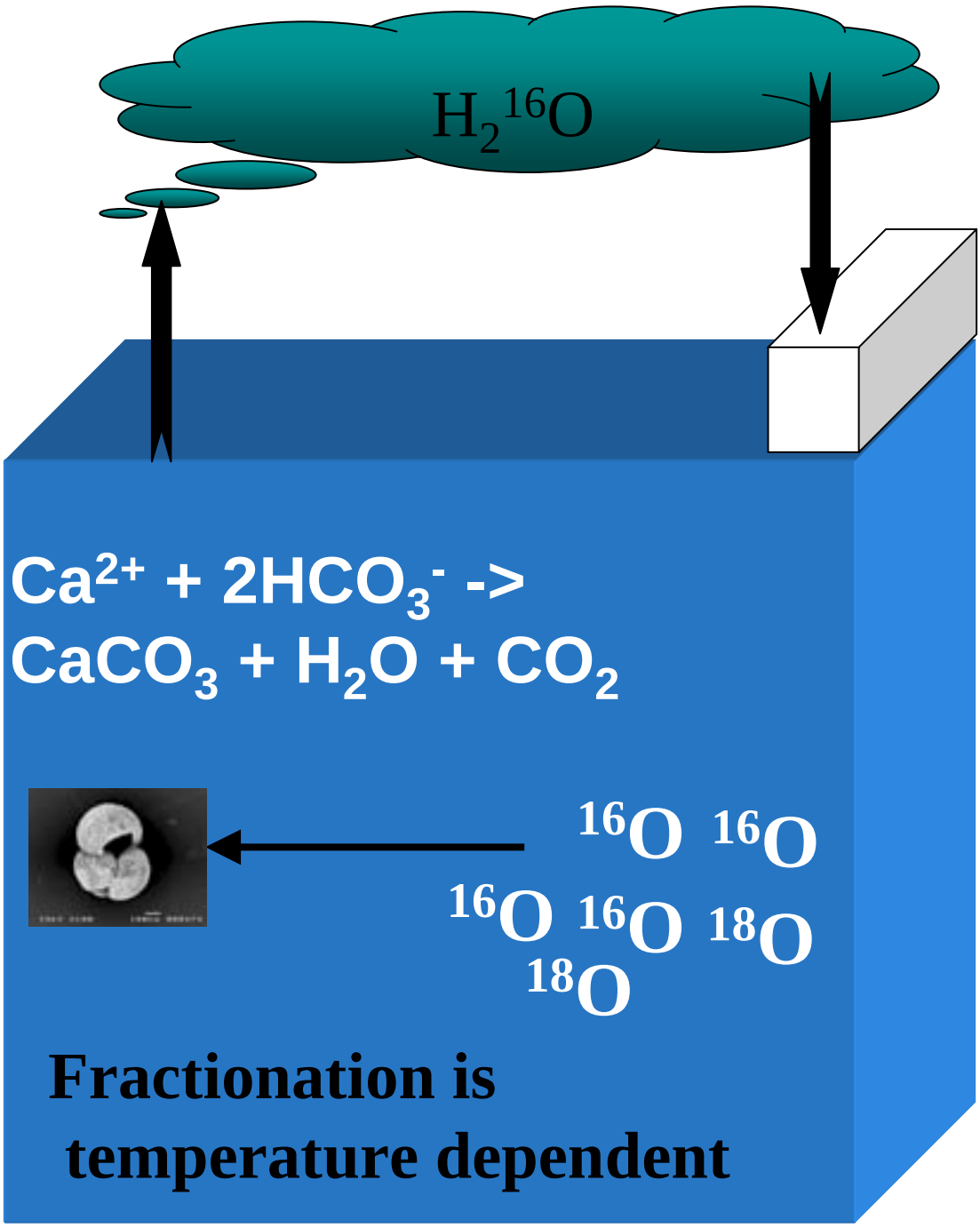
What is the relationship between the background mean climate state and ENSO variability ?

- ***CORE IT***

What is the effect of changes in tropical SST patterns on the ITF?

The CLIMAP Paradigm

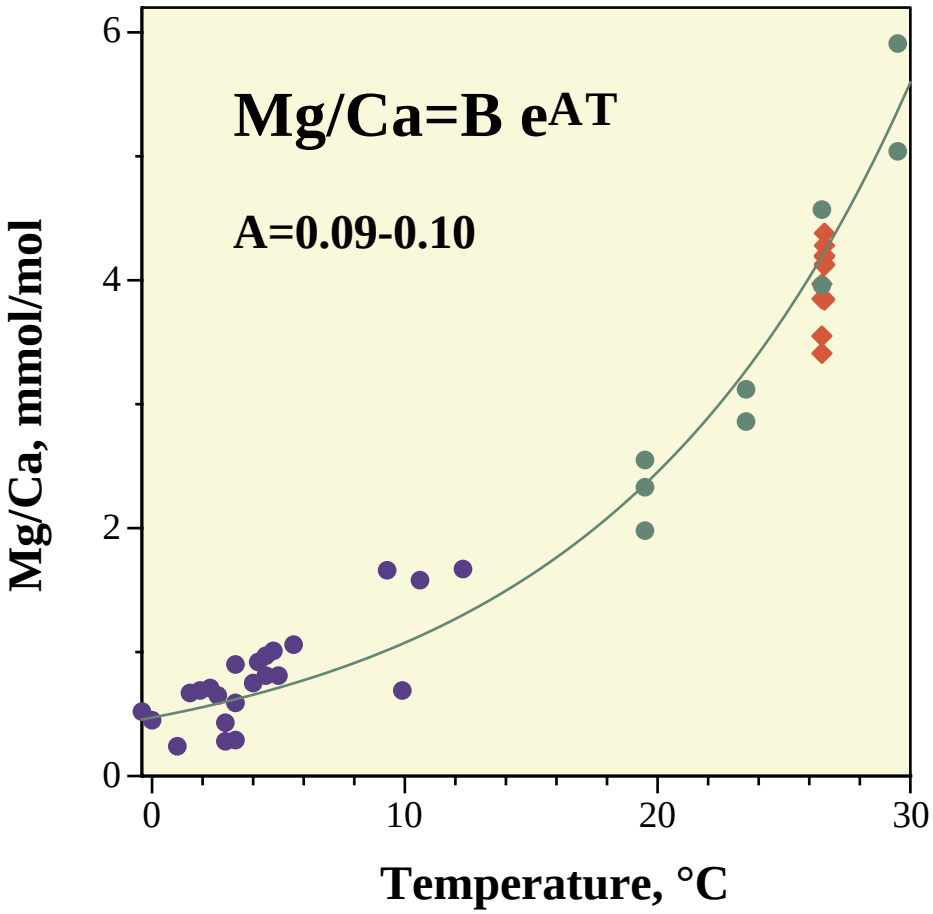




$$\text{Temp} = 16.9 - 4.38\,(\delta c - \delta w) + 0.1\,(\delta c - \delta w)^2$$

Foraminiferal Mg/Ca: A new Paleothermometer

$$CaCO_3 + Mg^{2+} \text{---}K_{eq}\text{---->} MgCO_3 + Ca^{2+}$$



- *N. pachyderma l.* Core tops (Nürnberg, 1995)
- *G. sacculifer* culture (Nürnberg et al., 1996)
- *G. sacculifer Depth transect* Siera Leone Rise (Rosenthal and Boyle, 1993)

Foraminifera: unicellular animals

Benthic

Planktonic

Mg/Ca

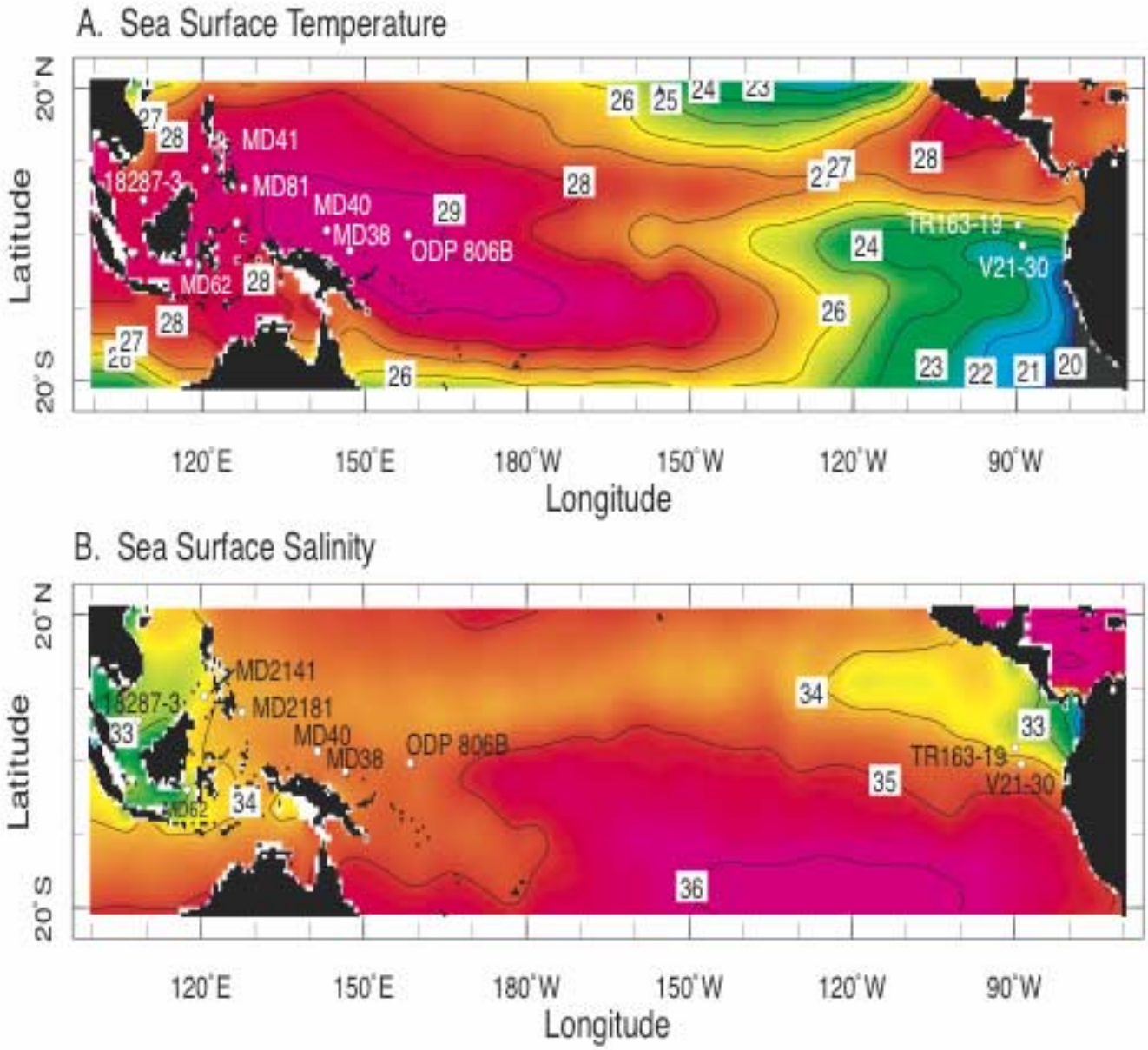
$\delta^{18}O$

Temperature & $\delta^{18}O_{sw}$

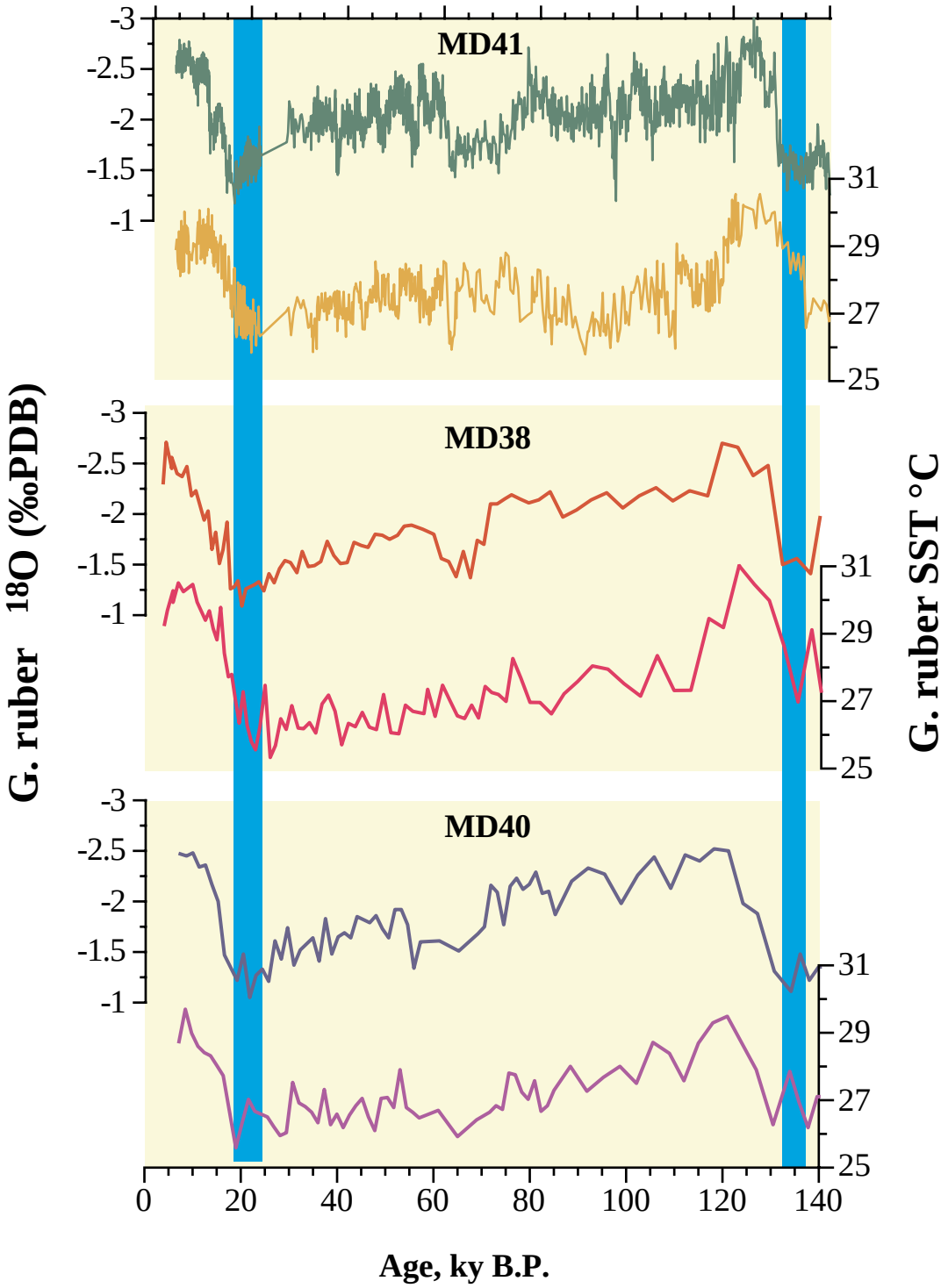
$\delta^{18}O_{sw}$

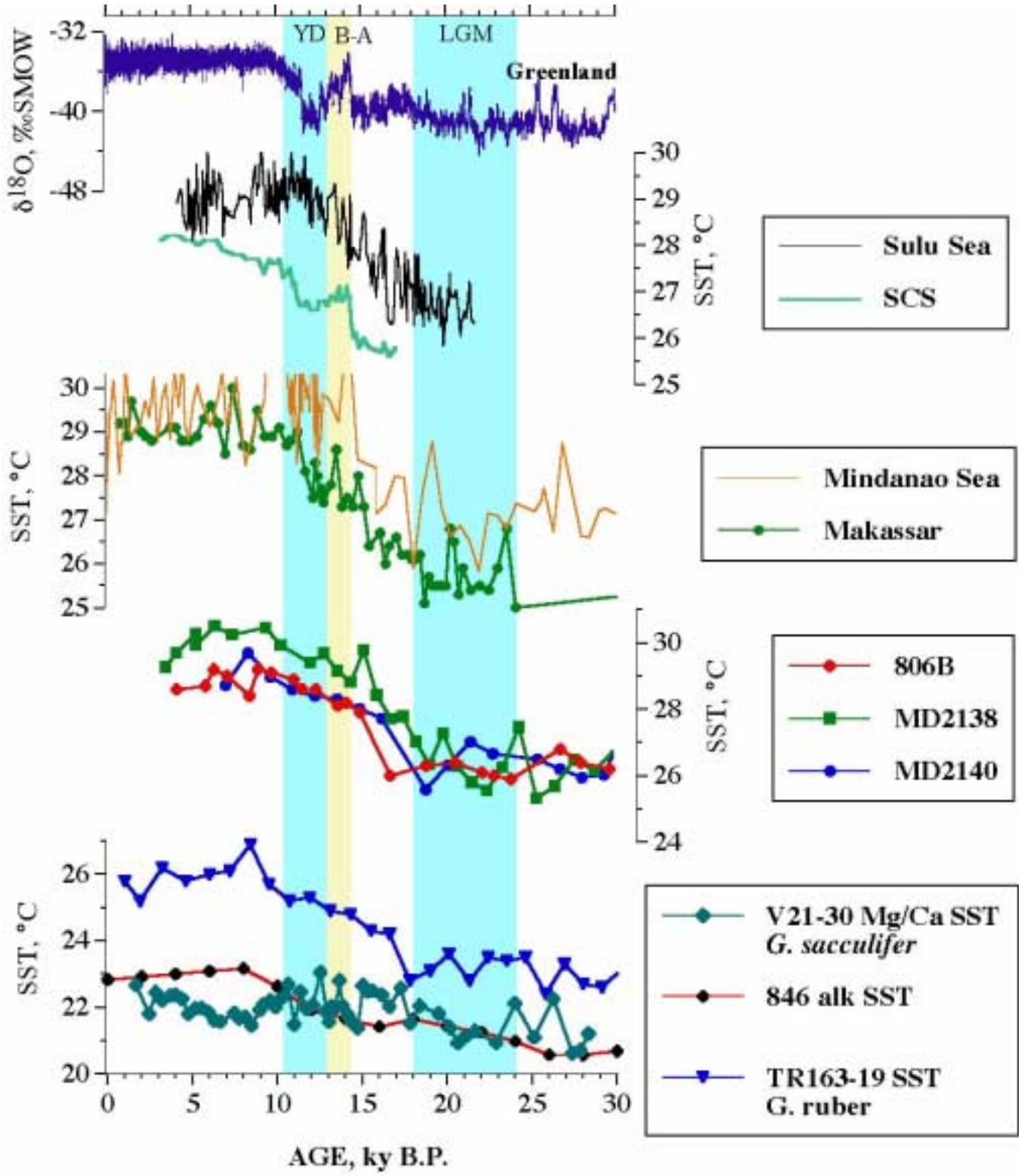
Salinity

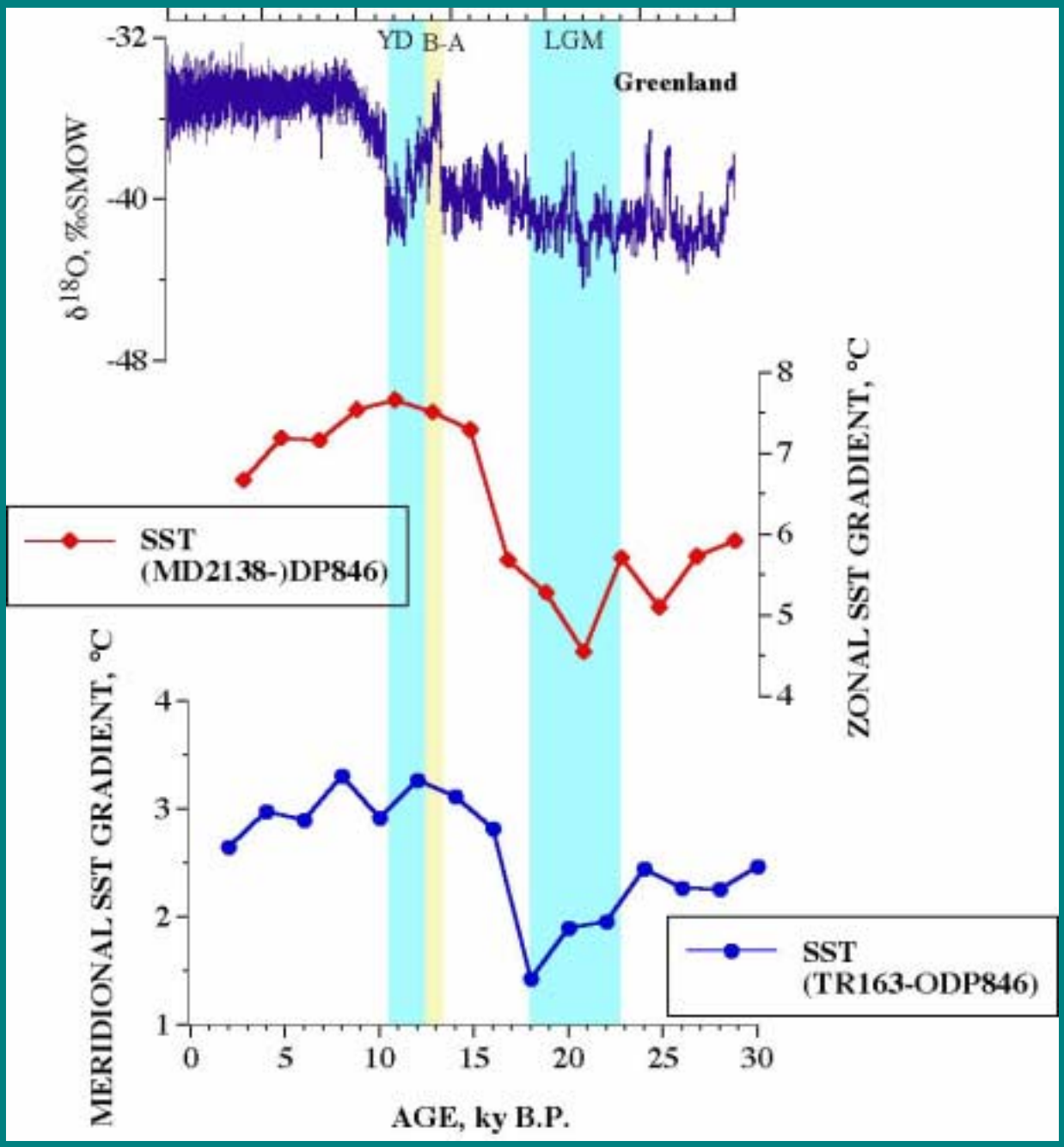
Cores distribution in the equatorial Pacific



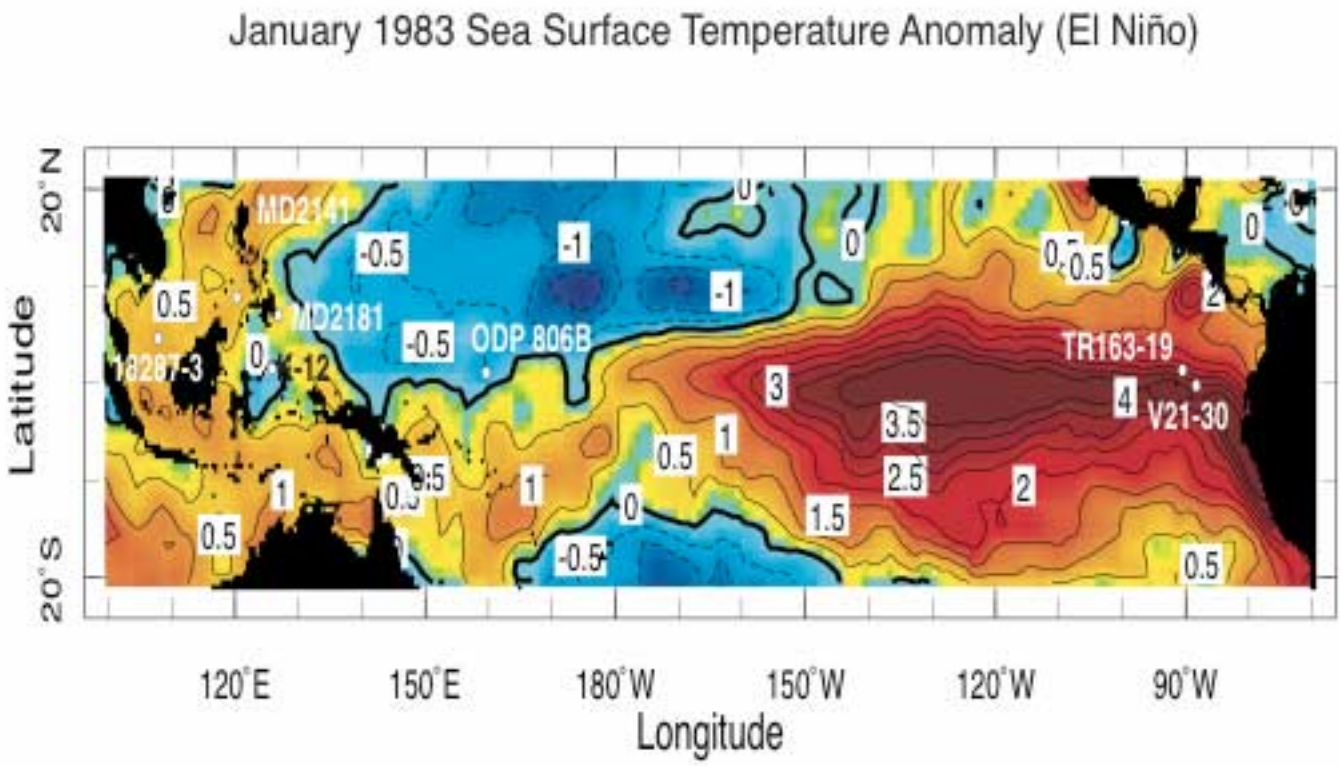
The Last Glacial Cycle



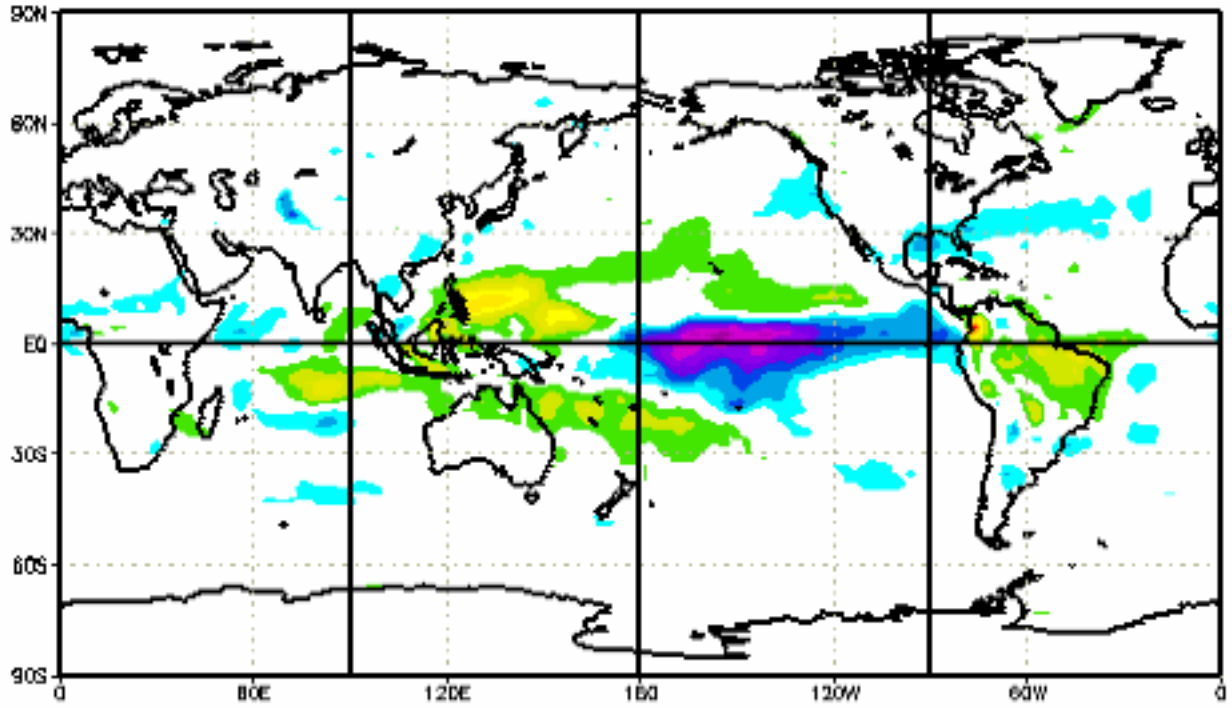

YD
B-A
LGM
Greenland
δ18O, ‰SMOW
-32
-40
-48
SST, °C
30
29
28
27
26
25
Sulu Sea
SCS
Mindanao Sea
Makassar
806B
MD2138
MD2140
24
V21-30 Mg/Ca SST
G. sacculifer
846 alk SST
TR163-19 SST
G. ruber
22
20
0
5
10
15
20
25
AGE, ky B.P.


YD
B-A
LGM
Greenland
-32
-40
-48
δ18O, ‰SMOW
SST
(MD2138-)DP846)
8
7
6
5
4
ZONAL SST GRADIENT, °C
MERIDIONAL SST GRADIENT, °C
4
3
2
1
SST
(TR163-ODP846)
0
5
10
15
20
25
30
AGE, ky B.P.

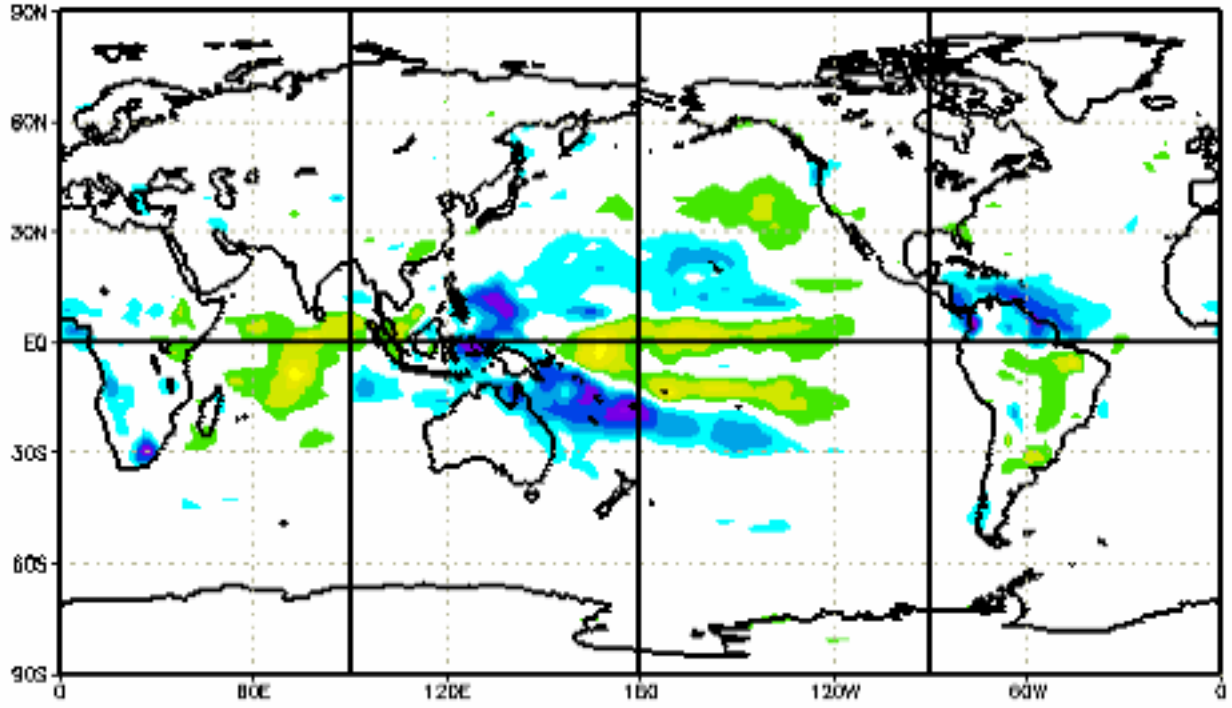
El Niño 1983 winter SST anomalies



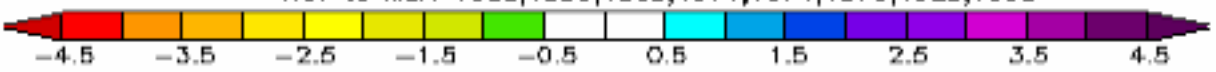
El Nino
NCEP/NCAR Reanalysis

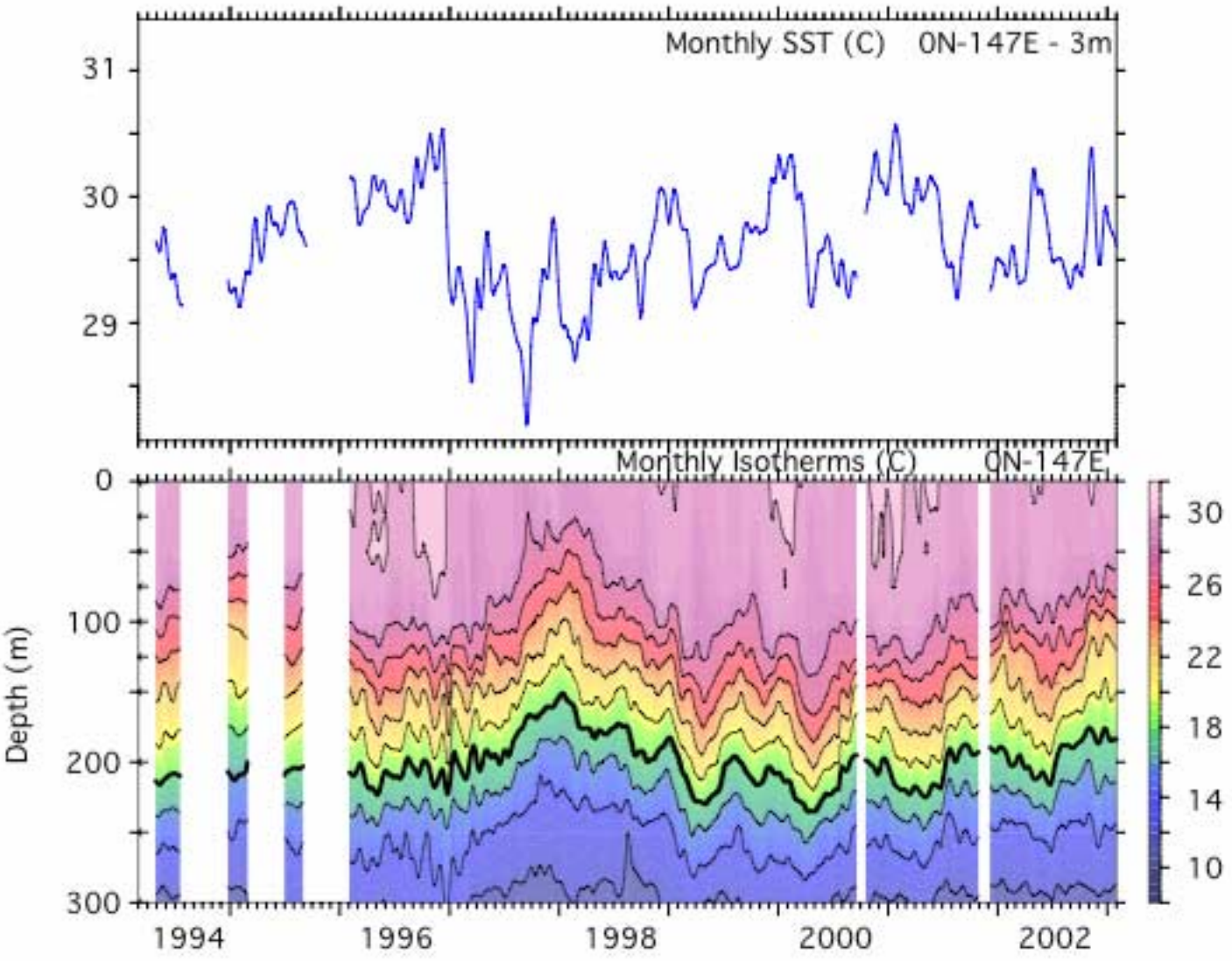


La Nina
NCEP/NCAR Reanalysis

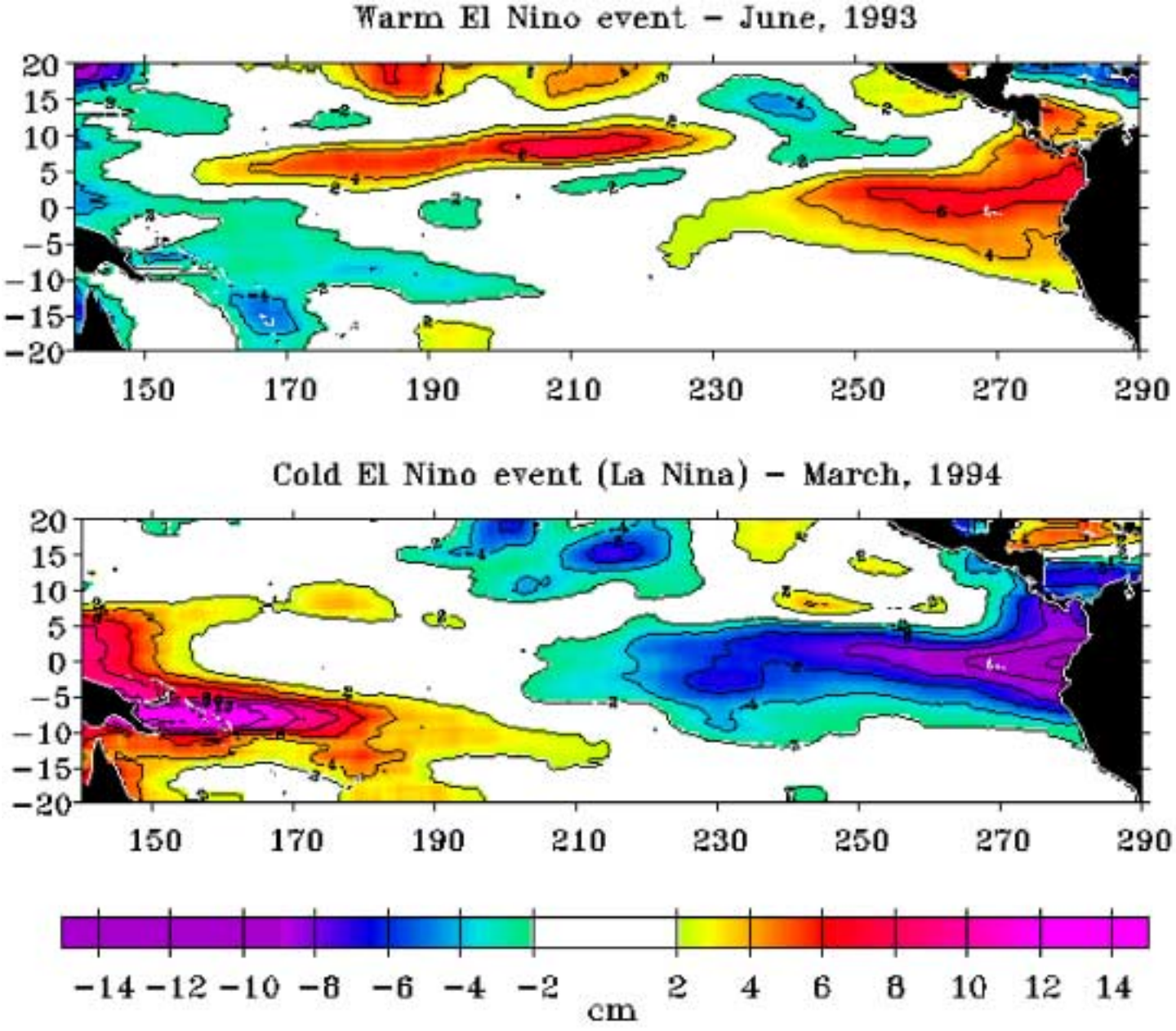


Precipitation Rate (in/mn) Composite Anomaly
Nov to Mar: 1955,1958,1965,1971,1974,1976,1989,1998

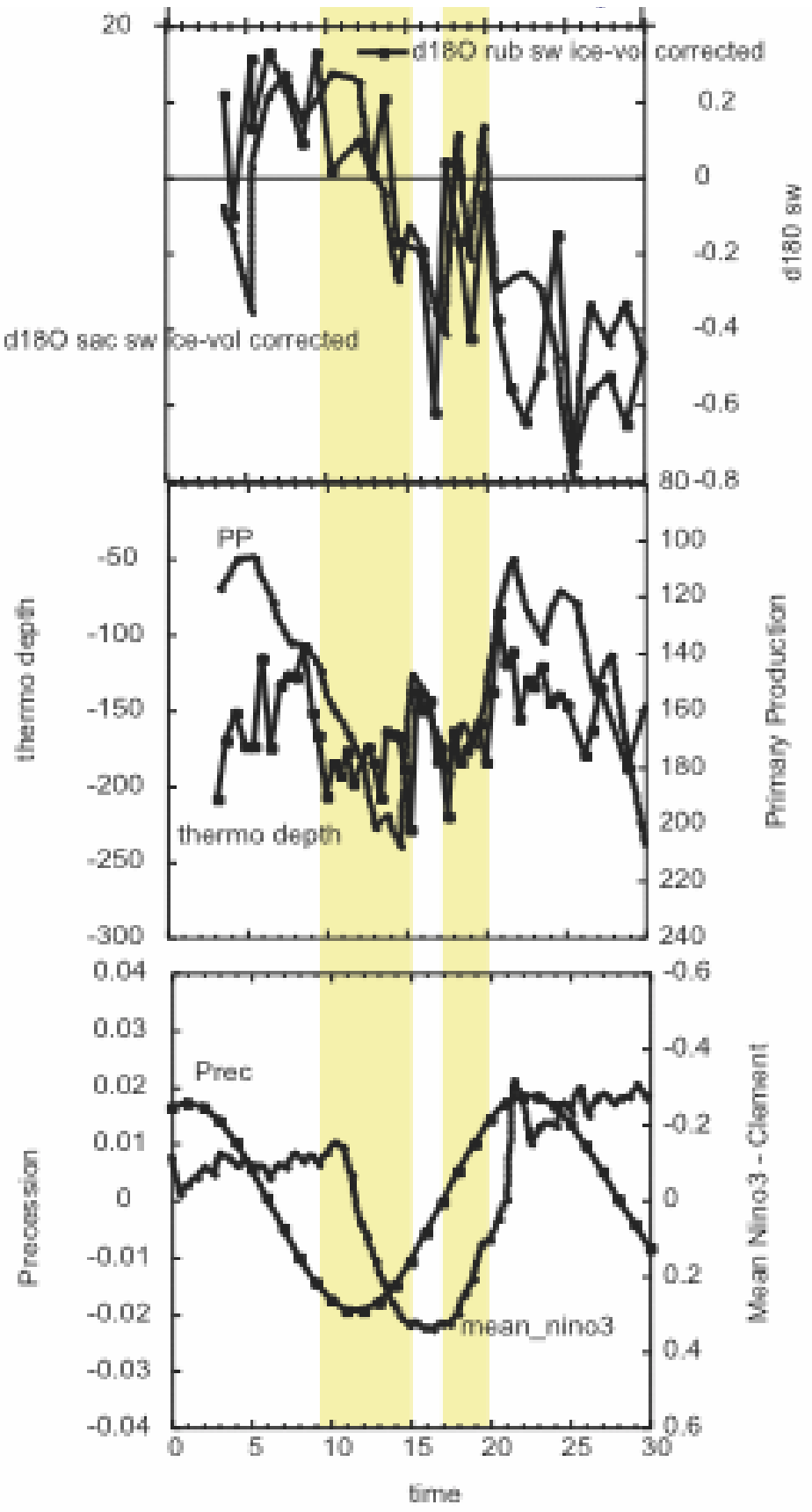



Monthly SST (C) 0N-147E - 3m
31
30
29
Monthly Isotherms (C) 0N-147E
0
100
200
300
Depth (m)
1994
1996
1998
2000
2002
30
26
22
18
14
10

ENSO related variations in tropical sea level hight: Observations from TOPEX Posiedon



From: JPL


d18O rub sw ice-vo corrected
d18O sac sw ice-vol corrected
d18O sw
PP
thermo depth
thermo depth
Primary Production
Prec
mean_nino3
Precession
Mean Nino3 - Clement
time

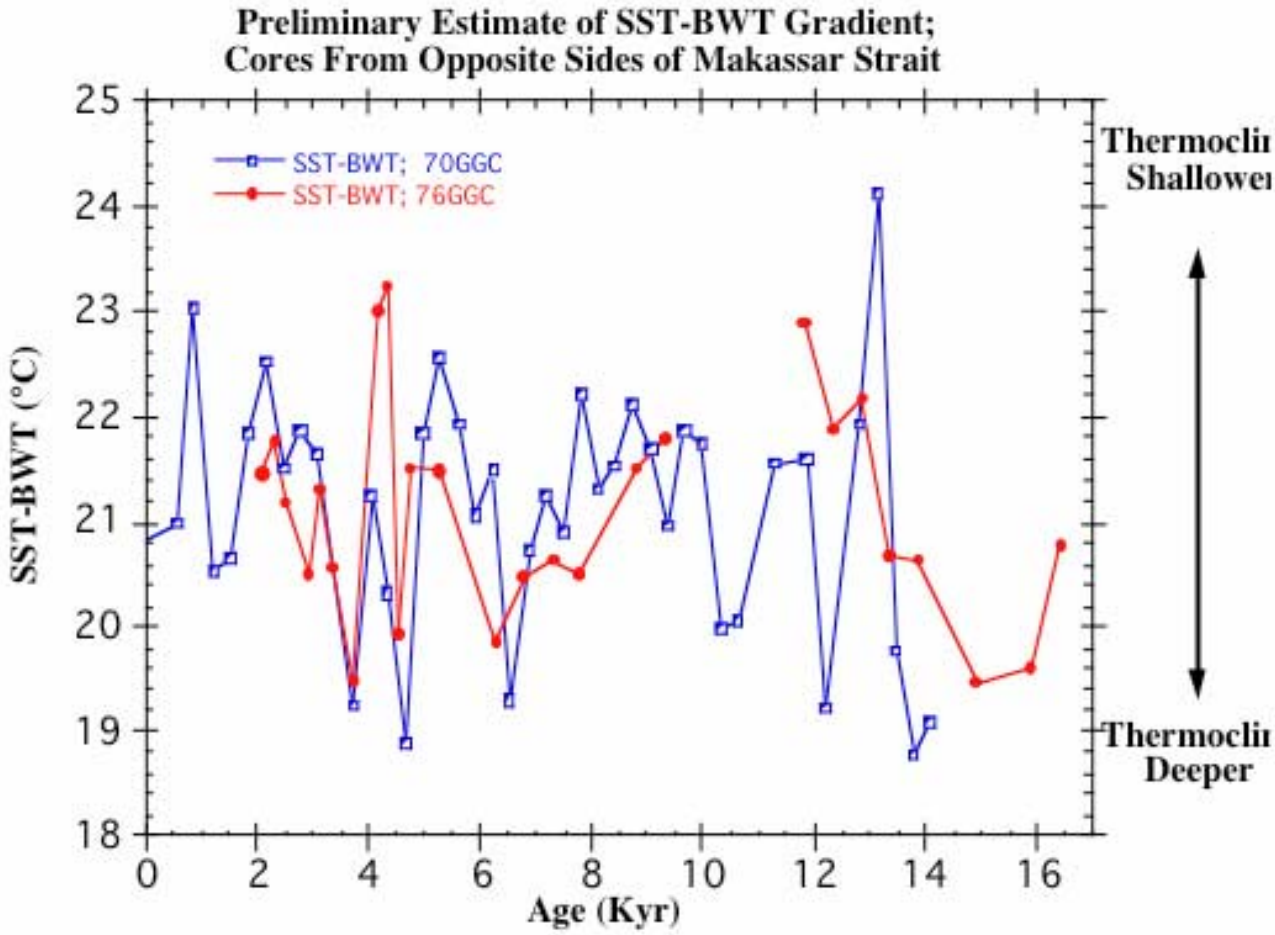
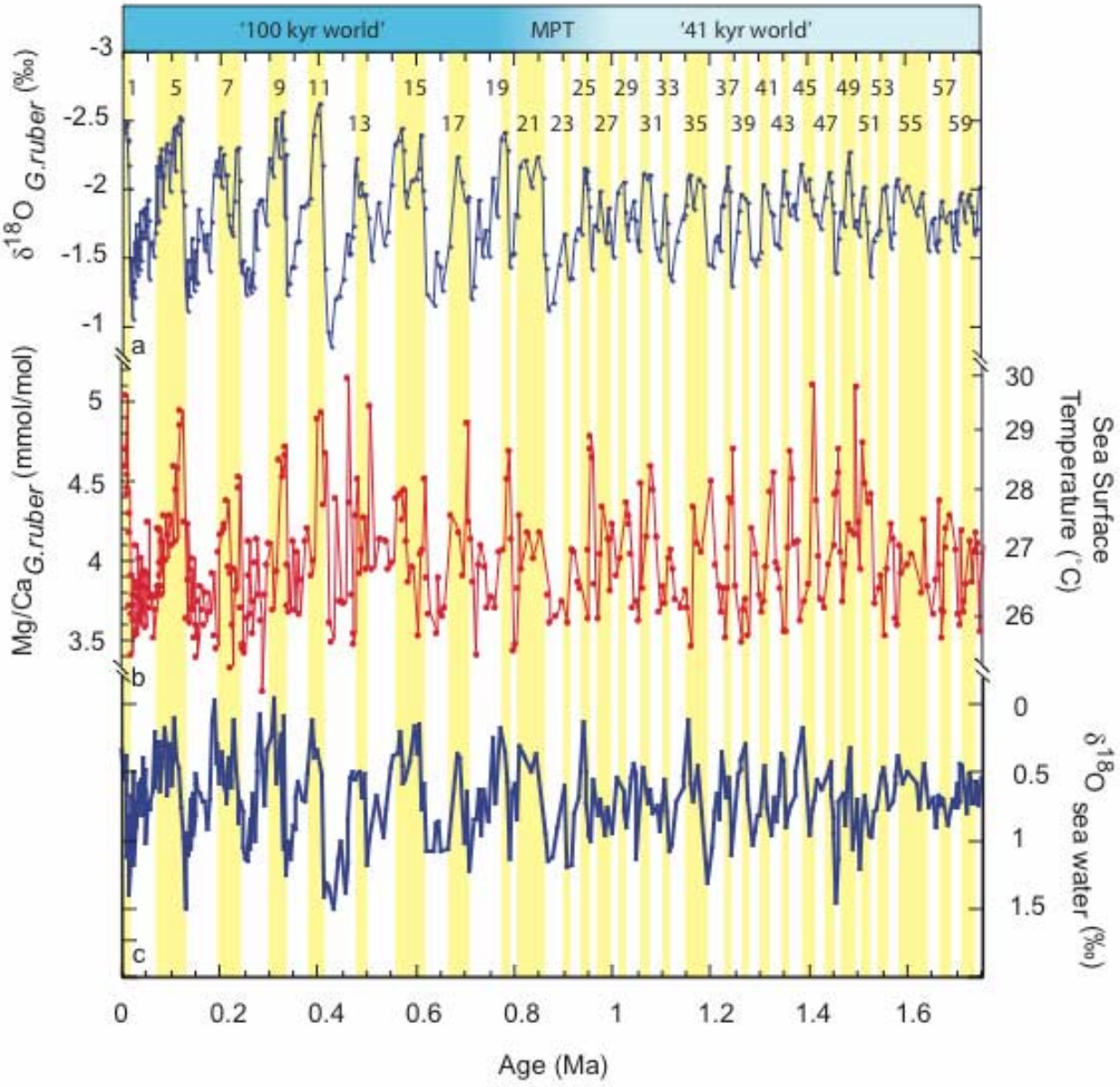
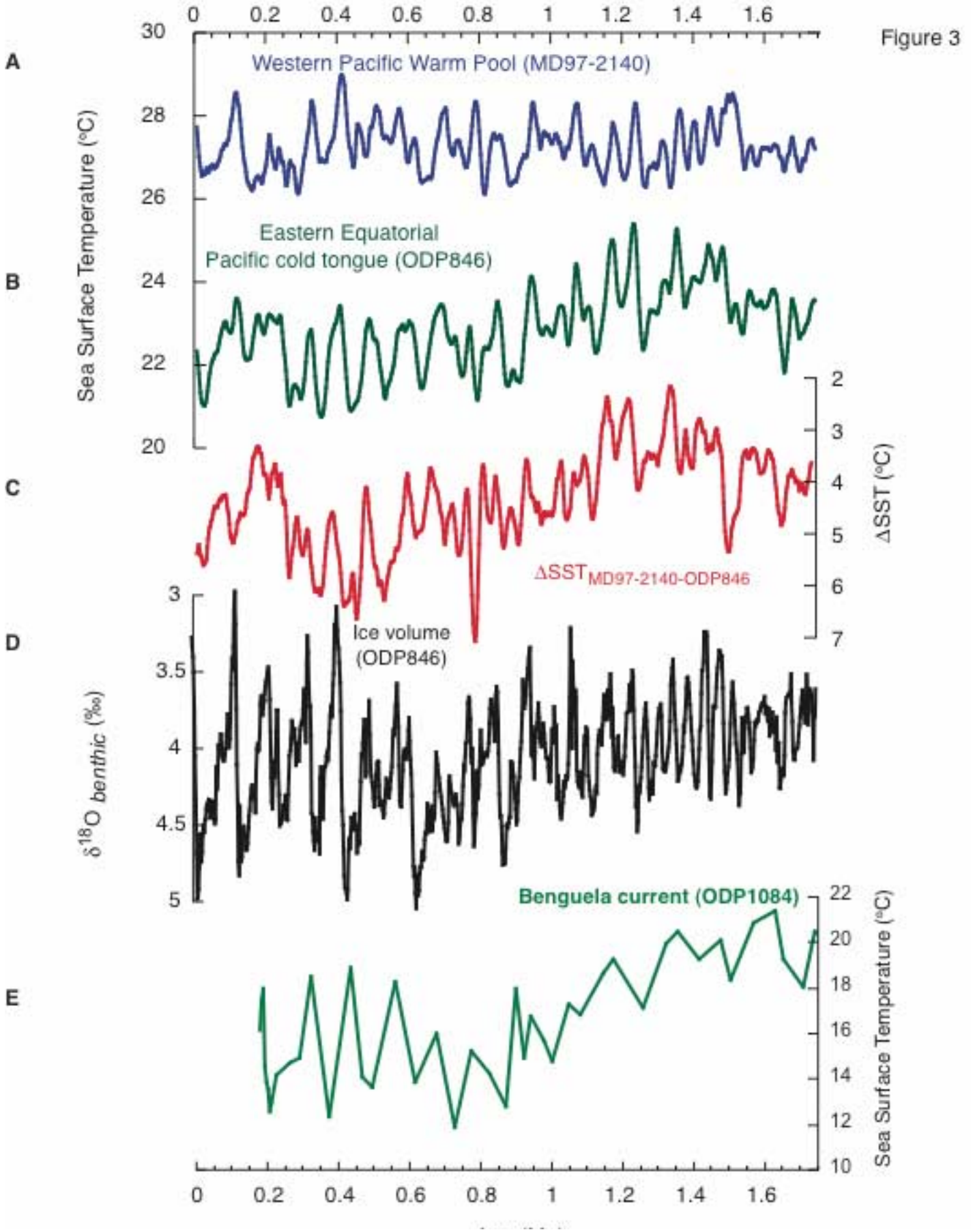

Preliminary Estimate of SST-BWT Gradient;
Cores From Opposite Sides of Makassar Strait
SST-BWT; 70GGC
SST-BWT; 76GGC
SST-BWT (°C)
Age (Kyr)
Thermocli
Shallowe
Thermocli
Deeper

Figure 1



Pleistocene climate variability in the WPWP

Figure 3


A
B
C
D
E
Western Pacific Warm Pool (MD97-2140)
Eastern Equatorial
Pacific cold tongue (ODP846)
Sea Surface Temperature (°C)
ΔSST (°C)
ΔSST MD97-2140-ODP846
Ice volume
(ODP846)
δ18O benthic (‰)
Benguela current (ODP1084)
Sea Surface Temperature (°C)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6

Conclusions

- Tropical Pacific SST were about 2.5±0.5°C cooler during the LGM than at present.

- The 2.5°C LGM cooling is much larger than the recent equatorial Pacific warming for the same pCO_2 change (90 ppmV).

  Why? Transient? Feedbacks?

- Glacial cooling might have not been uniform over the tropical Pacific. It is still debated whether it was in more of “El Niño”-like or “La Niña”-like mode. These changes in SST patterns is a common feature throughout the Pleistocene.

Conclusions (cont.)

- Comparable amplitude millennial-scale changes in Makassar Strait thermocline depth occurred both during the deglaciation and the Holocene. The 3°C changes in SST-BWT gradient between the surface and 450m translate into ~200m displacements of the main thermocline, based on current thermocline structure, and are about twice the variability observed in recent mooring measurements.

So, why is this of interest for us here in Israel?

A strong correlation is observed between an El Niño index and rainfall in the Jerusalem region (Yakir et al., 1996). *But why does it hold only for 1970-90 ?*

(26)

Global Change Biology (1996) 2, 97–100

Rapid Communication

El Niño and tree growth near Jerusalem over the last 20 years

DAN YAKIR,* SIMCHA LEV-YADUN† and AVRAHAM ZANGVIL‡
Departments of Environmental Sciences and Energy Research and Plant Genetics†, The Weizmann Institute of Science, Rehovot 76100, Israel; ‡Department of Meteorology, Blaustein Institute for Desert Research, Sede Boker 84990, Israel*

Abstract

A strong correlation is observed between an El Niño index (anomalies in tropical Pacific sea surface temperature) and rainfall in the Judean foothills near Jerusalem over the past 20 years. These relationships clearly influenced the growth of local pine trees, as reflected in the width of their annual tree rings. The ability to predict El Niño events about a year in advance lend a special significance to relationships reported here for ecology, agriculture and water management in this climatic transition zone. To help explain the observed, long-range teleconnection we propose a possible mechanism based on a newly identified direct cloud connection between equatorial Africa (more directly affected by El Niño) and the Southeastern Mediterranean shoreland. The penetration and contribution of the moisture current from equatorial Africa to this region may depend on a shift in the usual rain generating moisture currents to southwesterly trajectories (passing over north Africa). The occurrence of such shifts is supported by the observed decrease in the mean ^{18}O content of the local precipitation during El Niño winters.

Keywords: climate, El Niño, oxygen 18, plant growth, rainfall, tree rings

Received 16 February 1996; revision accepted 2 April 1996

- Proposed correlation among Red Sea surface salinity, Indian Ocean SST and SOI (Klein et al., 1996), i.e., low SSS correlates with strong NE monsoon Red Sea inflow (high Indian Ocean SST) and negative phase of ENSO (La Niña). *How far north does this extends?* El Niño warming was implicated with enhanced coral bleaching. *Mechanisms? Waiting for Dan Tchernov*
- Late Quaternary increased in seasonal rainfall is deduced from Sinai corals (Klein et al., 1990).