



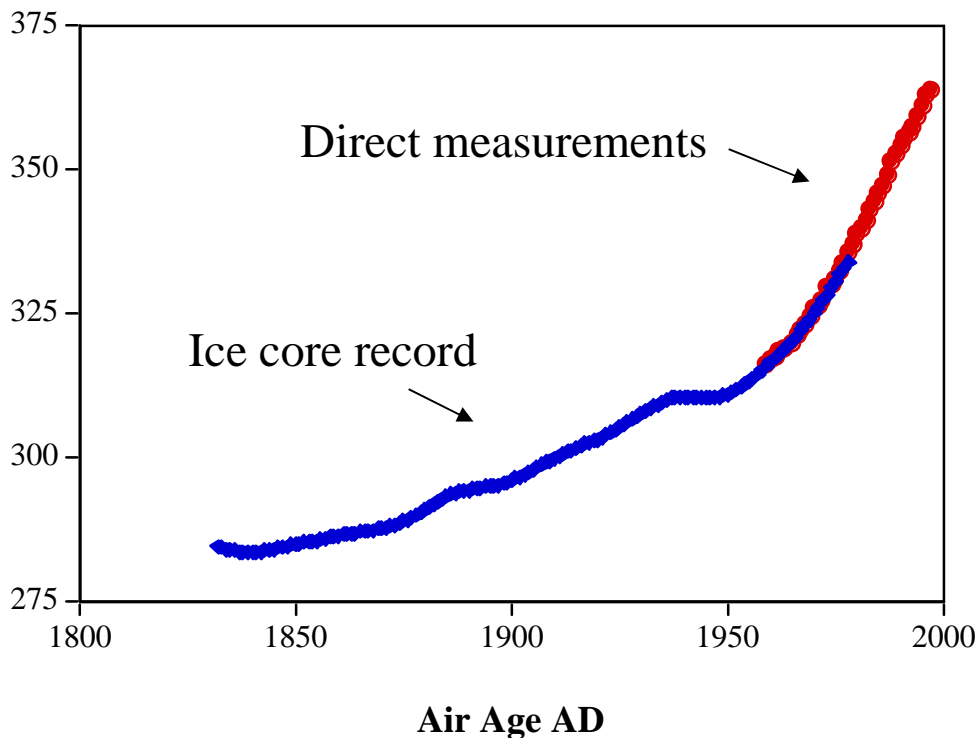
**A tropical Pacific role in
global climate change:
lessons from the past.**

**Yair Rosenthal
Rutgers University**

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

Historic record of atmospheric $p\text{CO}_2$

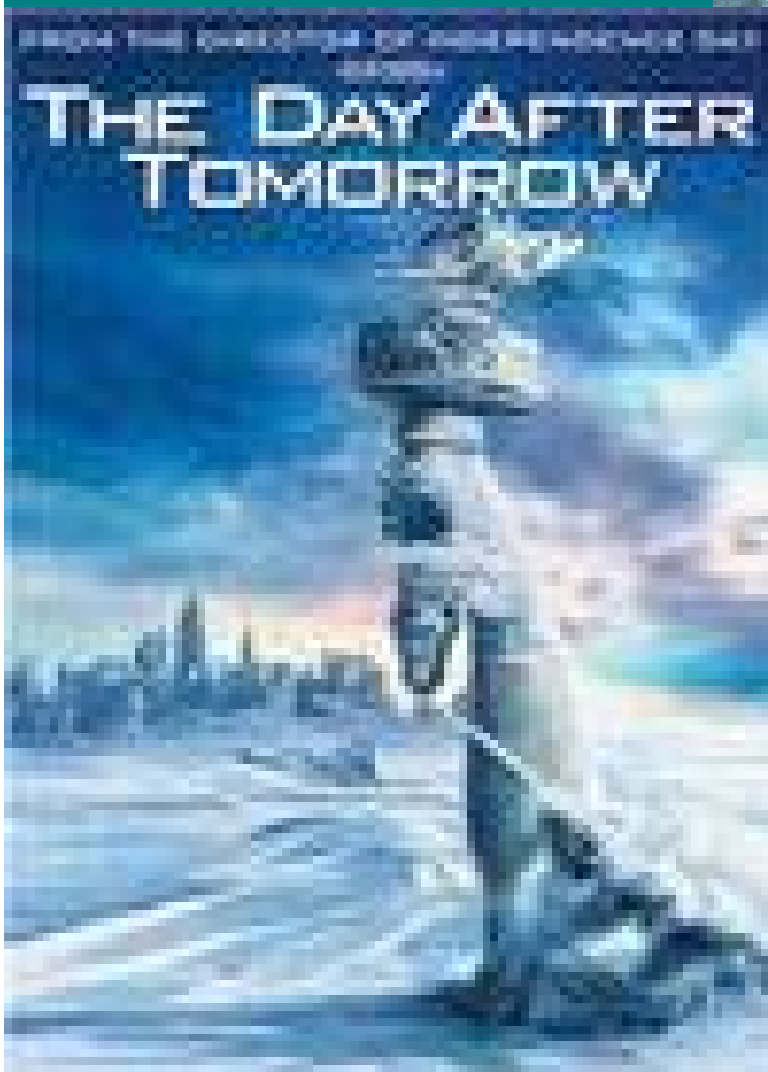
Historic $p\text{CO}_2$ trends



- ◆ Law Dome (Antarctica Ice Core); Etheridge et al.
- Keeling's Mauna Loa, Hawaii

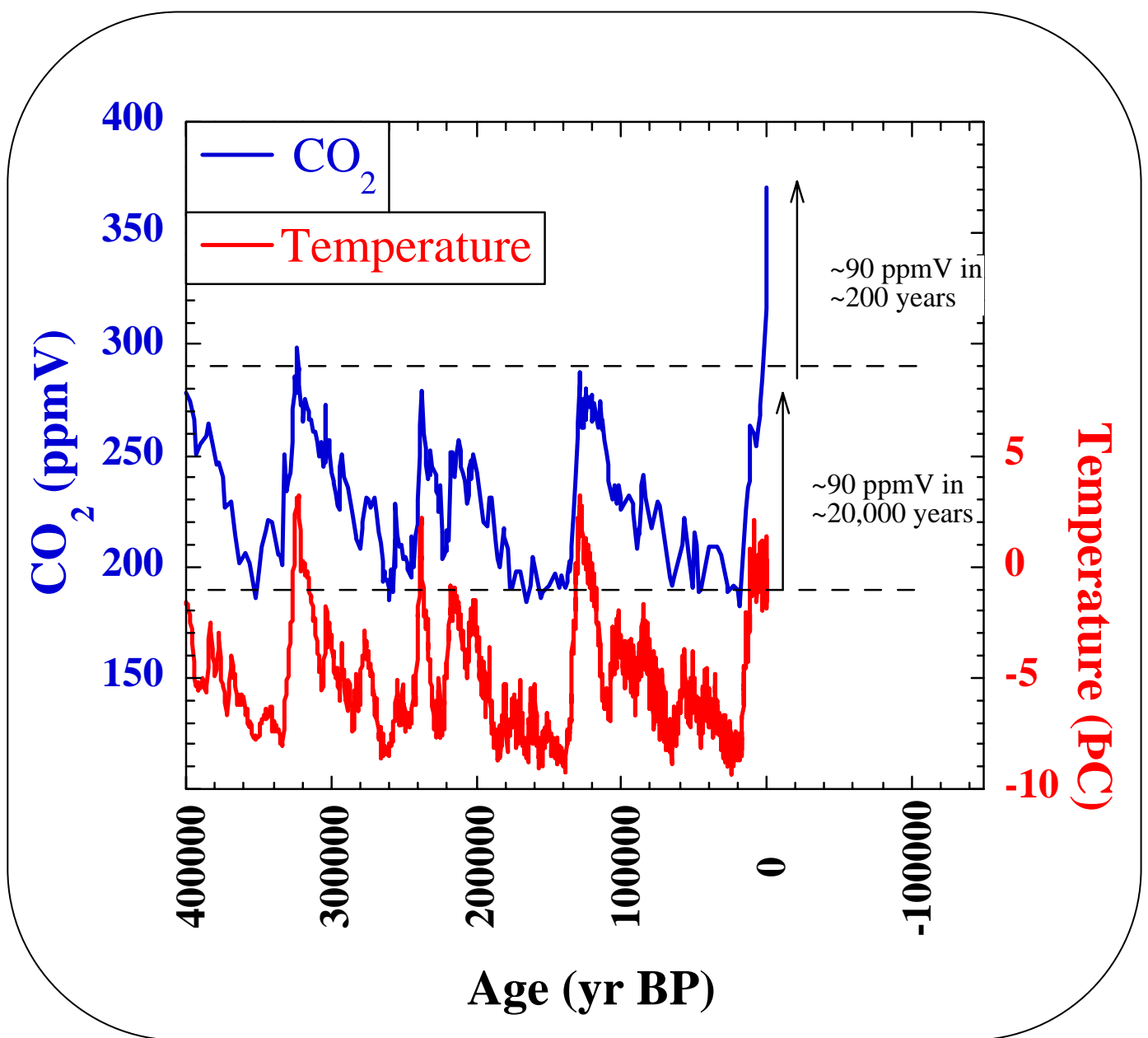
The recent increase in atmospheric CO_2 concentration due to human activities raise concern about the possibility of global warming

**Why should we care
about
Paleoceanography
and
Paleoclimatology?**

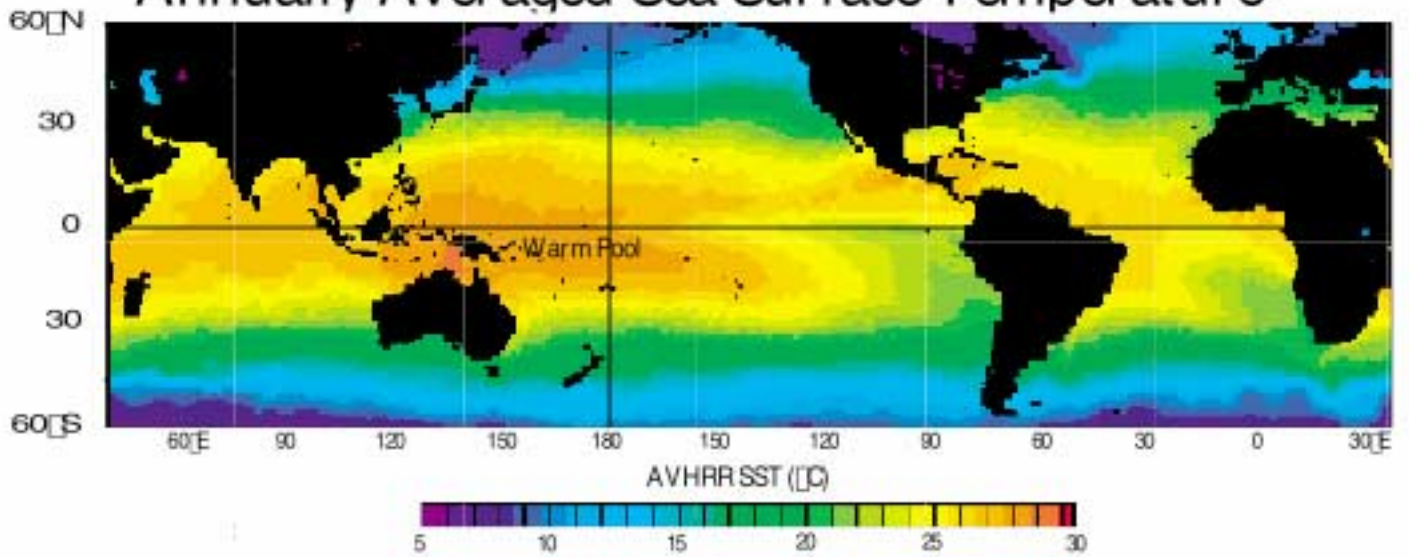


**To know
better about
the day after
tomorrow!**

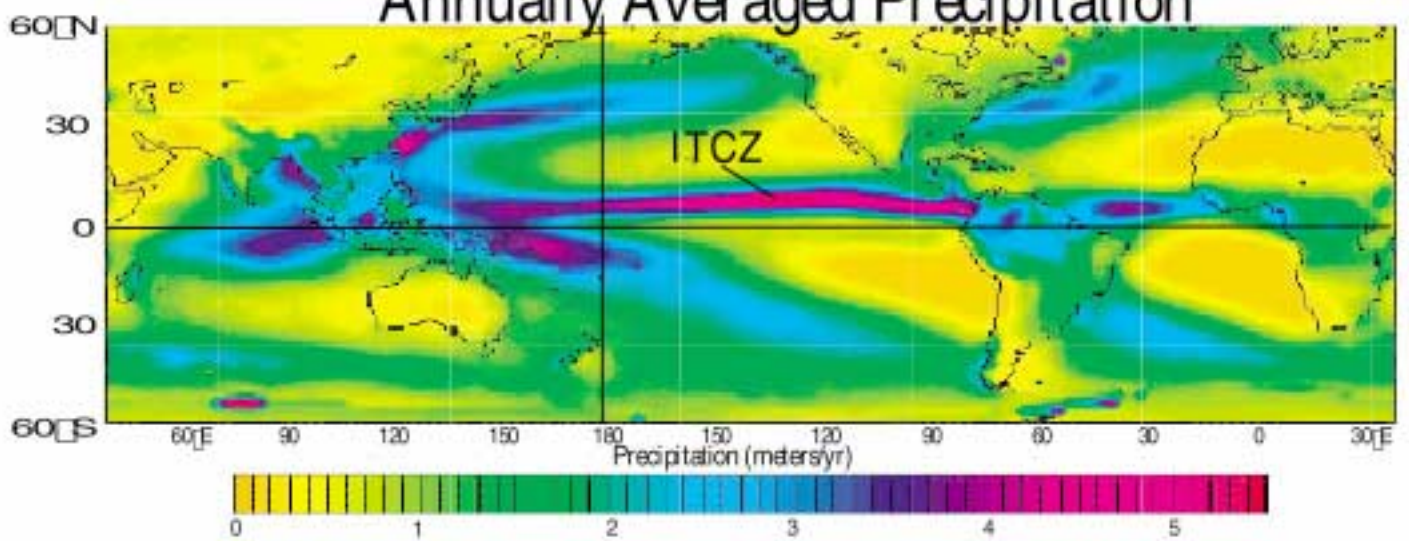
CO₂ and climate: The Vostok Ice Core



Annually Averaged Sea Surface Temperature

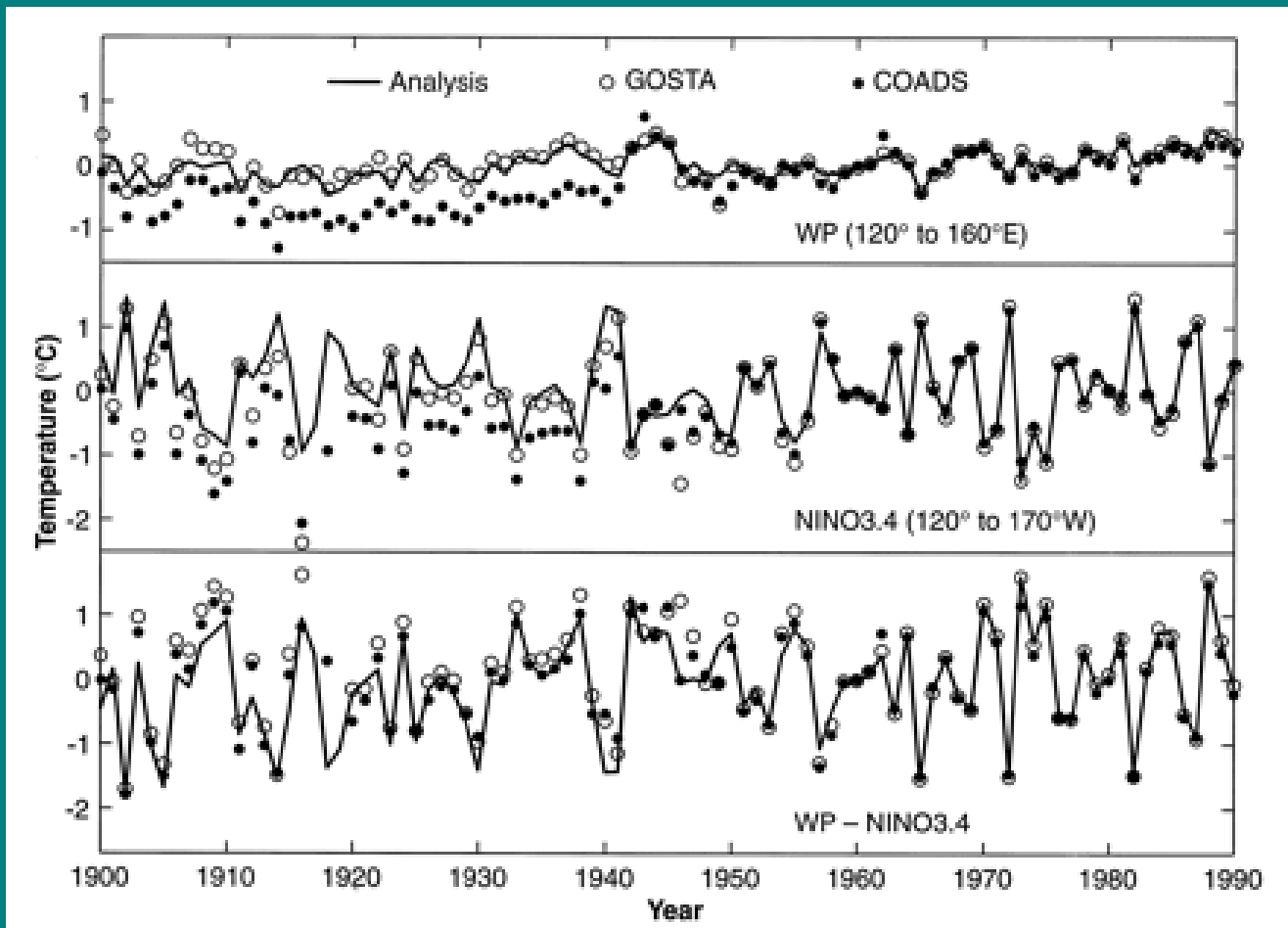


Annually Averaged Precipitation



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

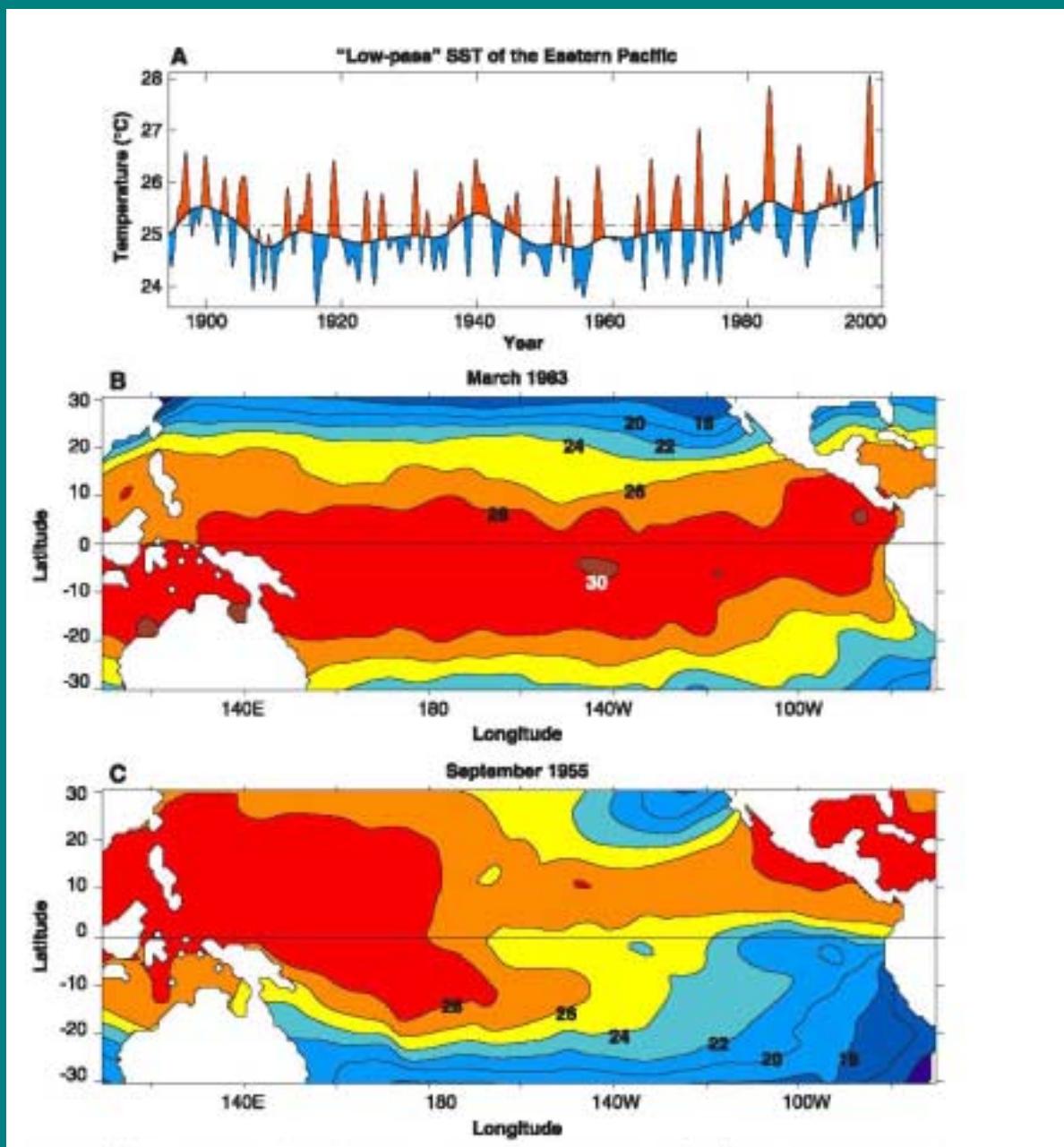
El Niño Southern Oscillation



Is El Niño Changing?

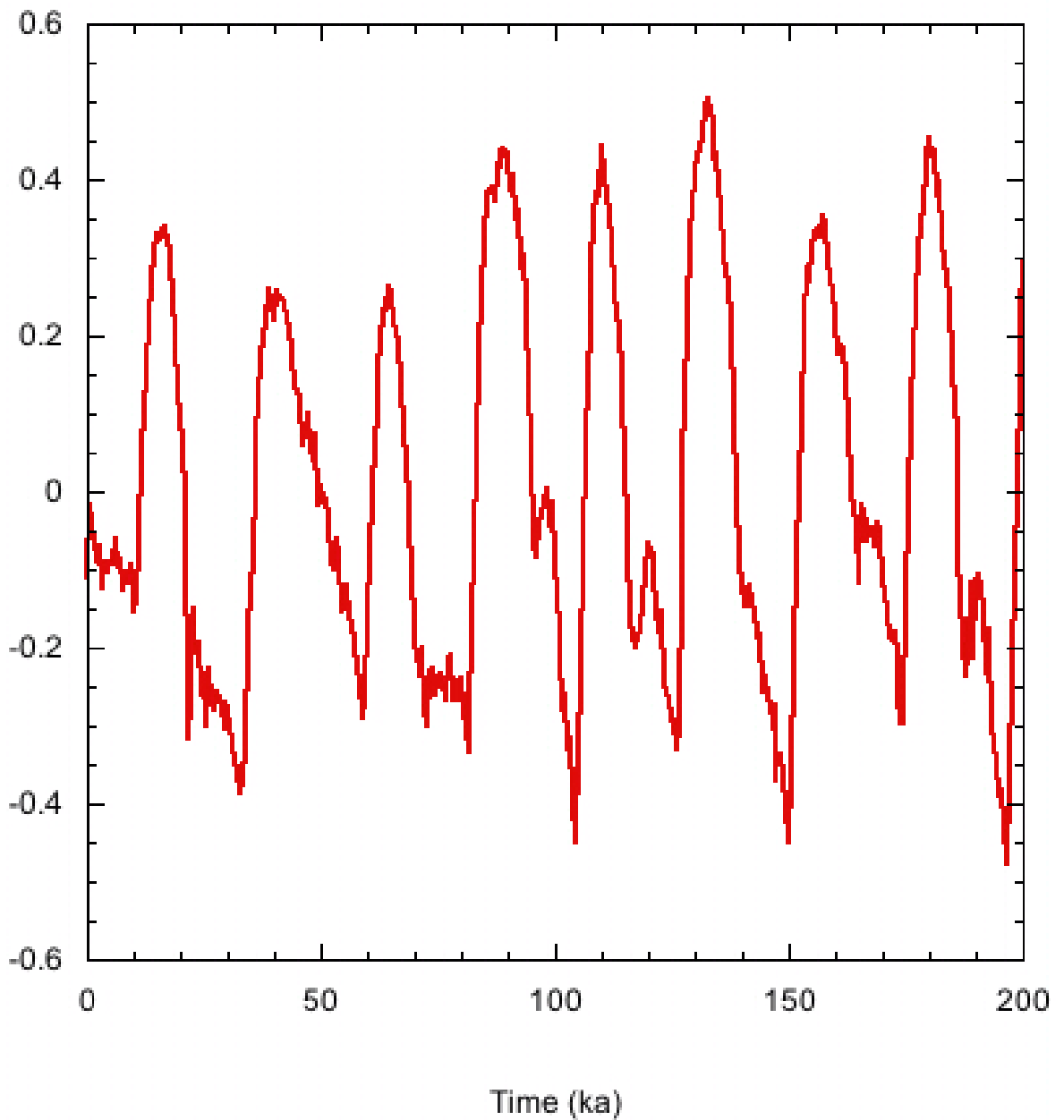
Alexey V. Fedorov and S. George Philander

Science 288, 1997-2002, 2000



Clement & Cane model

Mean NINO3



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 $p\text{CO}_2$ on this time scales

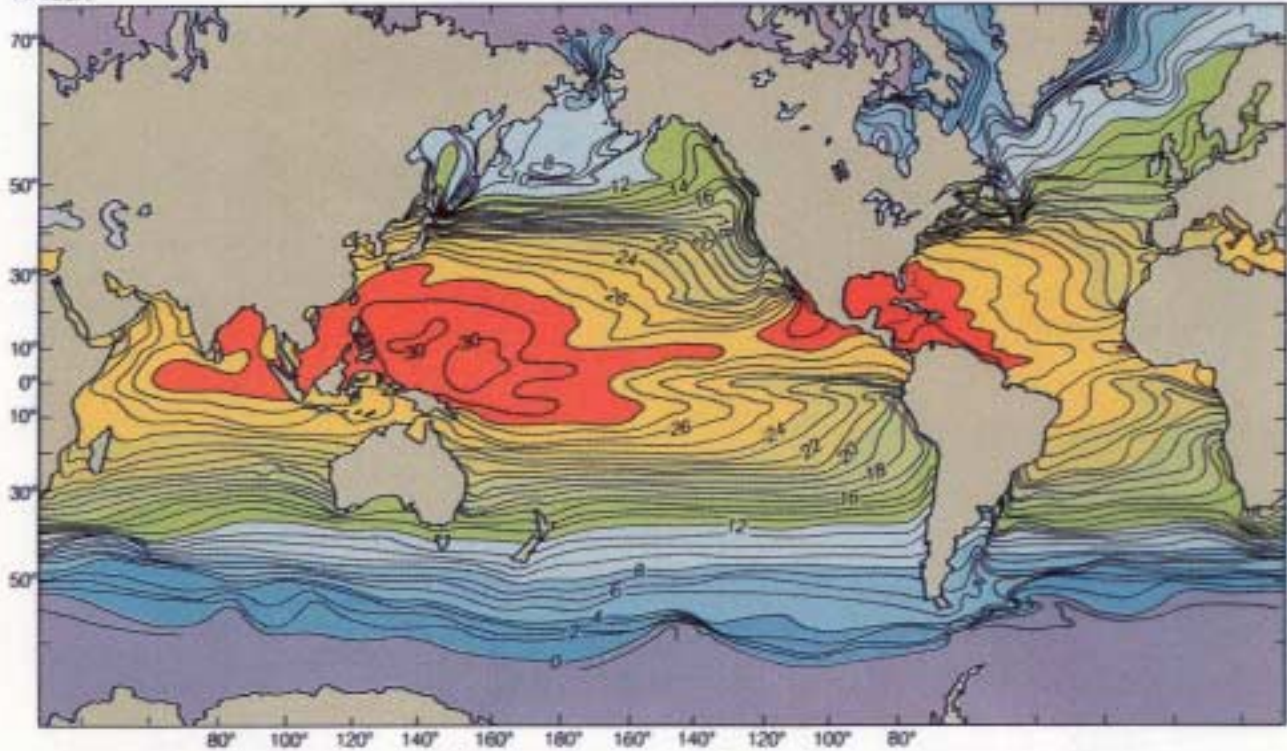
What is the relationship between the background mean climate state and ENSO variability ?

- *CORE IT*

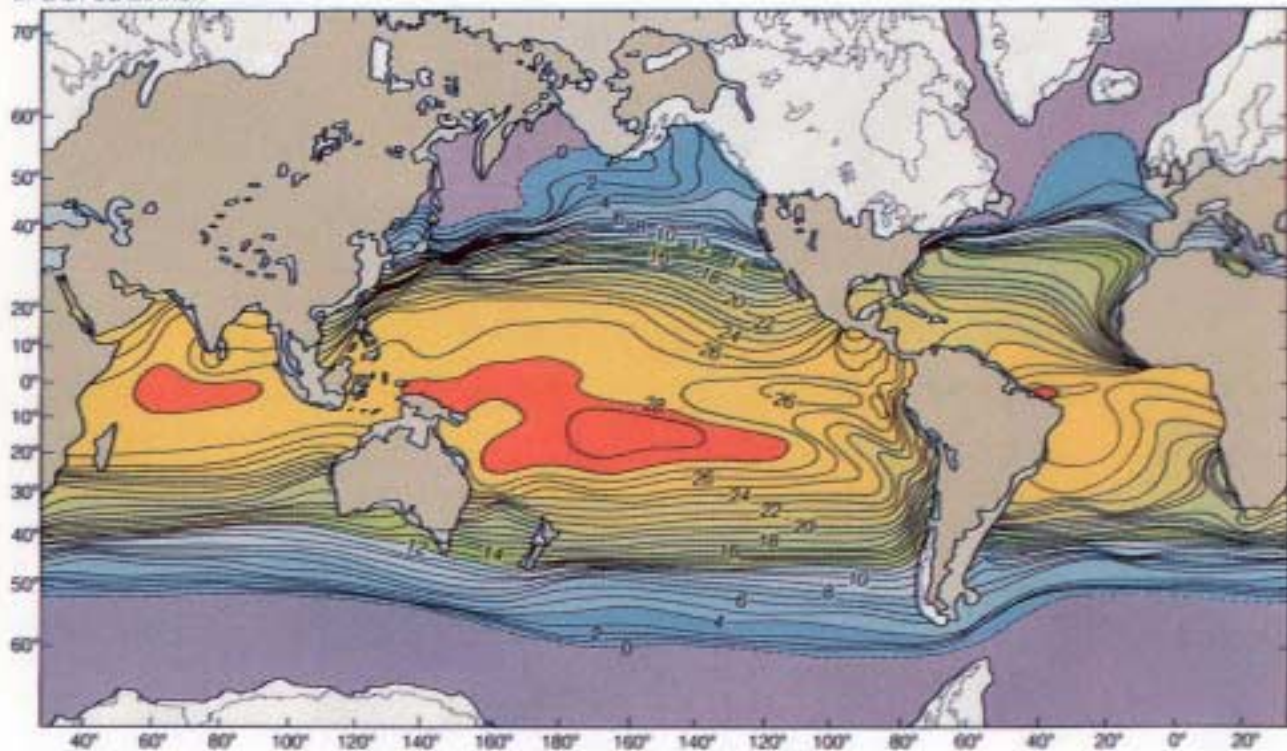
What is the effect of changes in tropical SST patterns on the ITF?

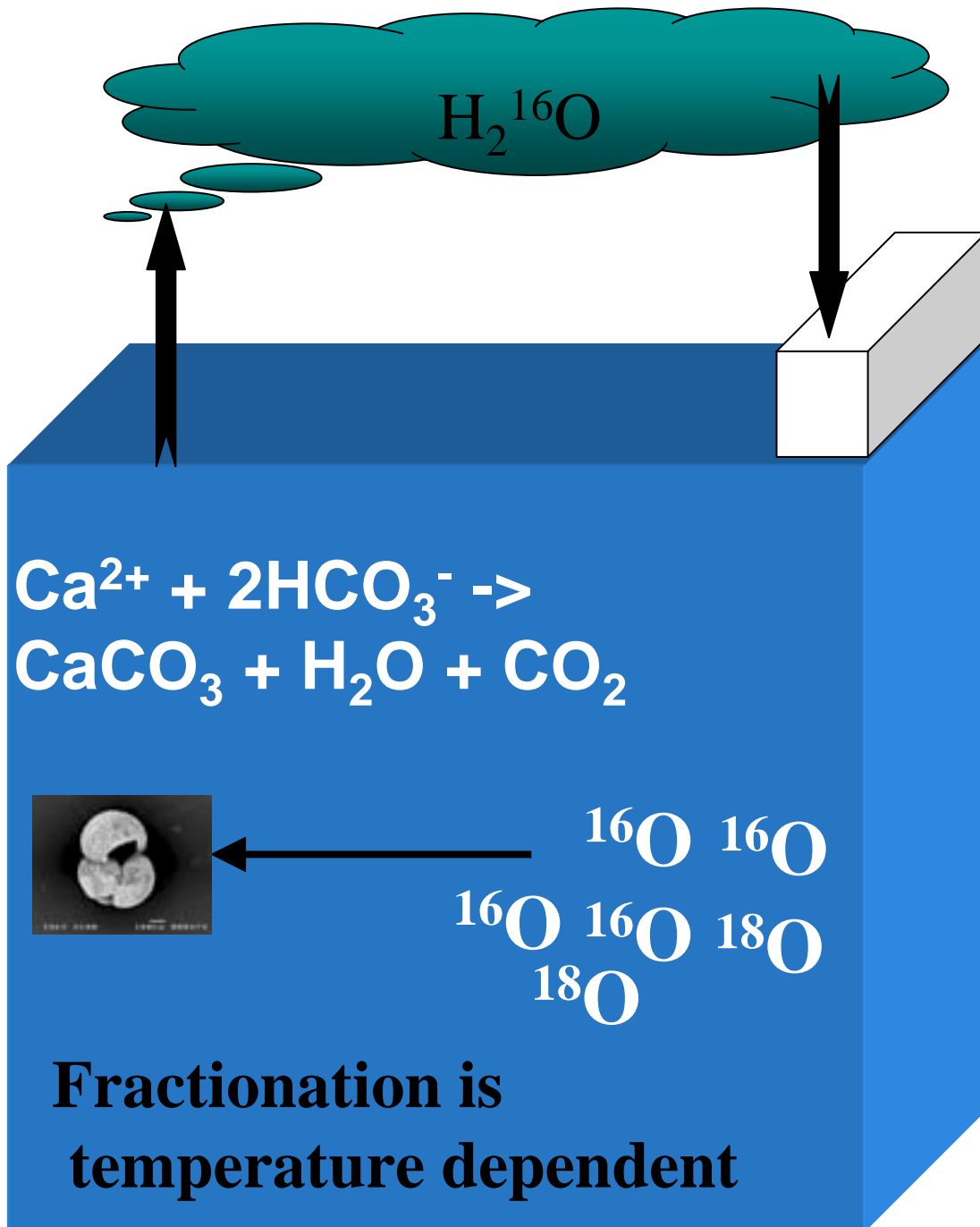
The CLIMAP Paradigm

A. TODAY



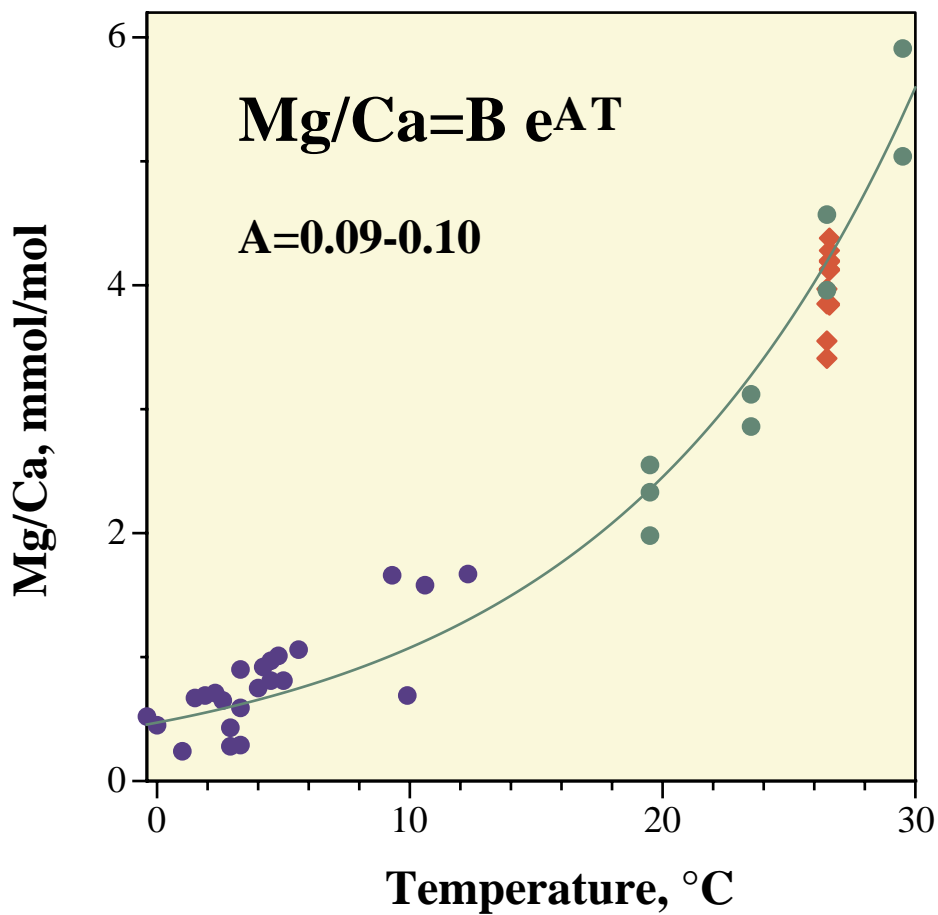
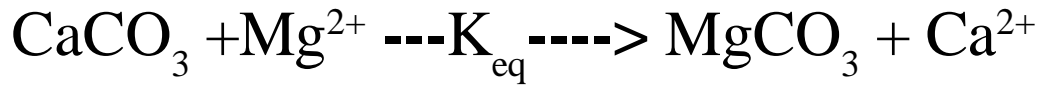
B. LAST GLACIATION





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

Foraminiferal Mg/Ca: A new Paleothermometer



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

Foraminifera: unicellular animals



Benthic

Planktonic

Mg/Ca

$\delta^{18}\text{O}$

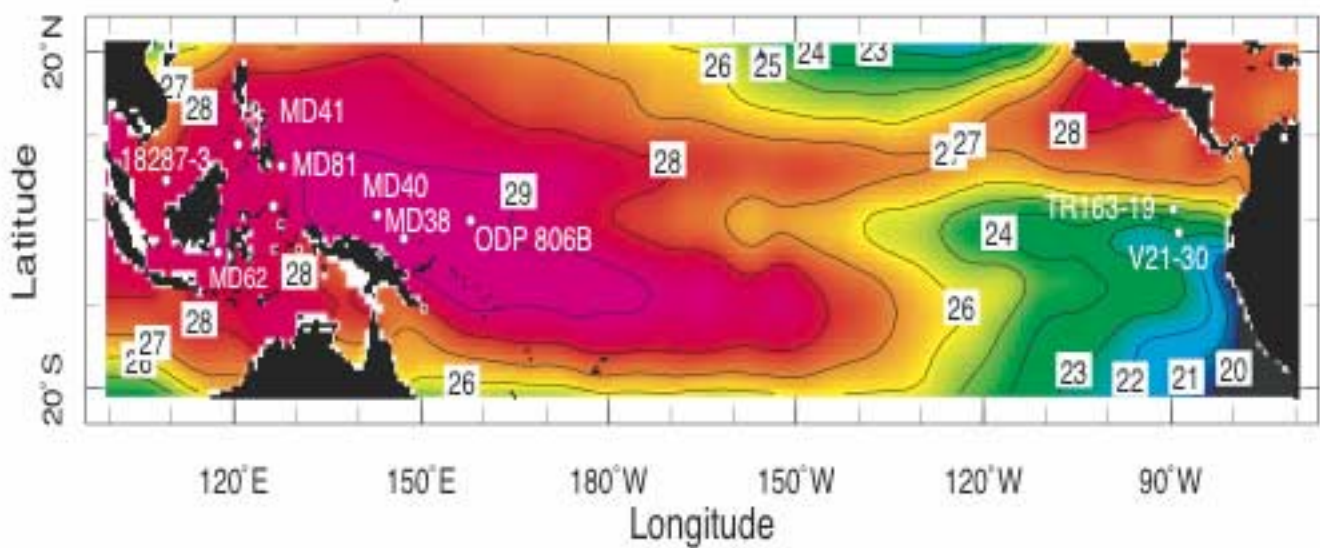
Temperature &
 $\delta^{18}\text{O}_{\text{SW}}$

$\delta^{18}\text{O}_{\text{SW}}$

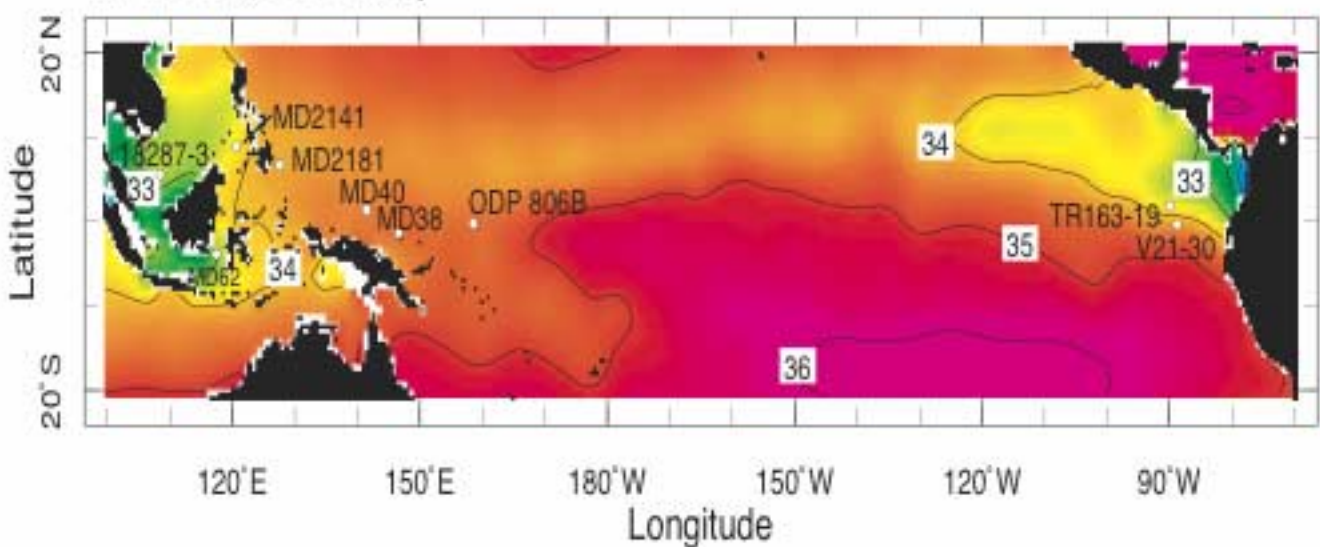
Salinity

Cores distribution in the equatorial Pacific

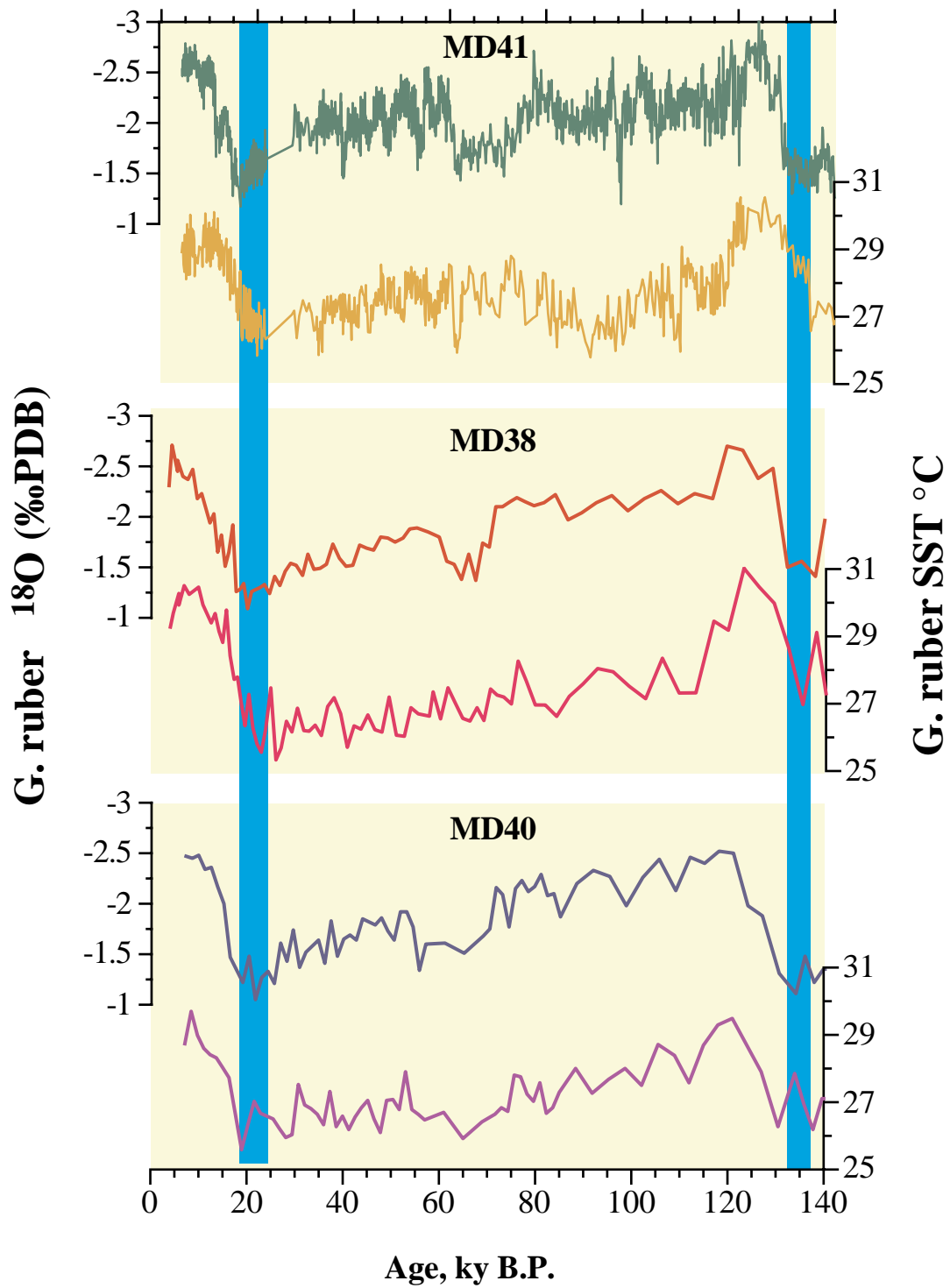
A. Sea Surface Temperature

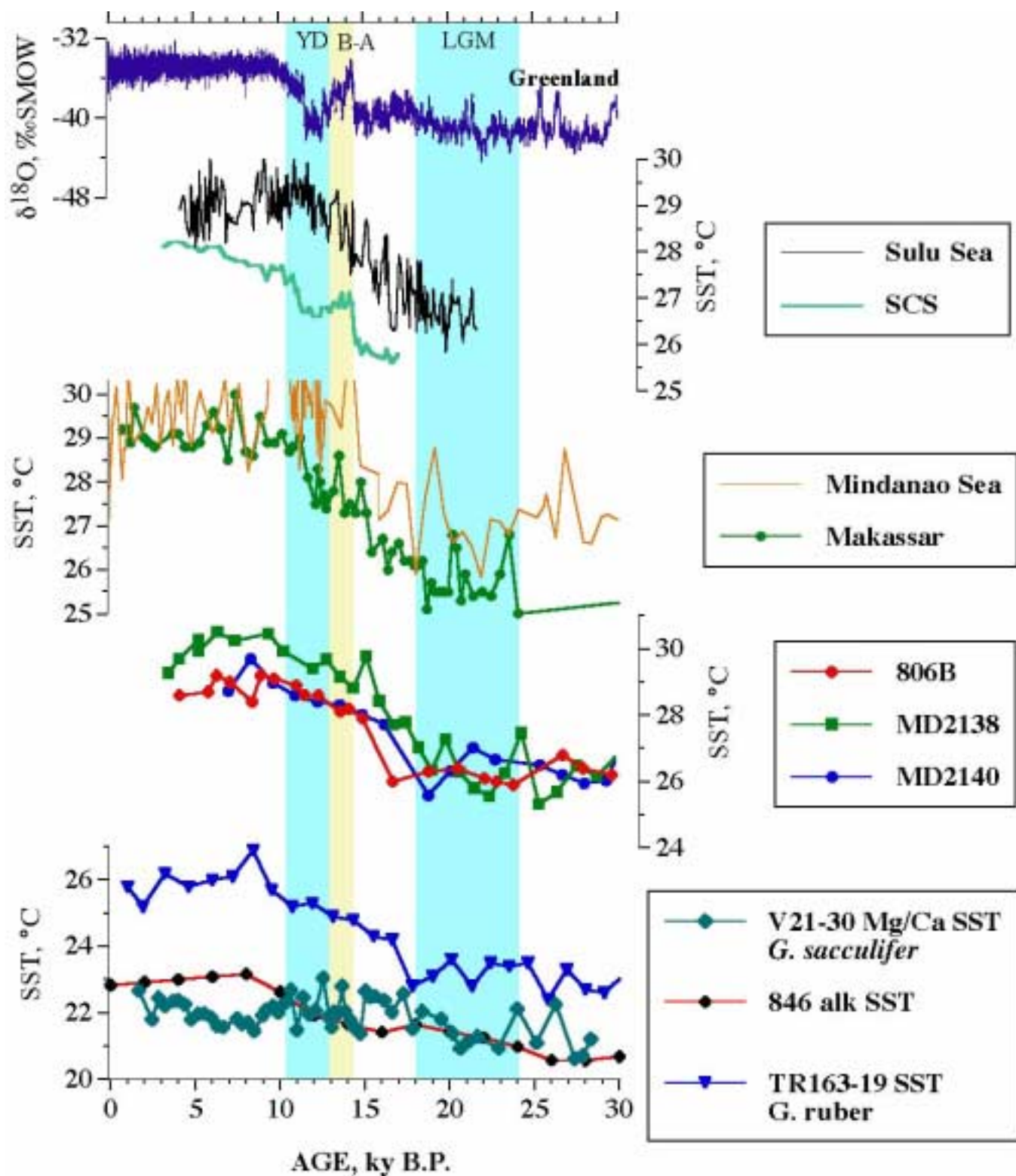


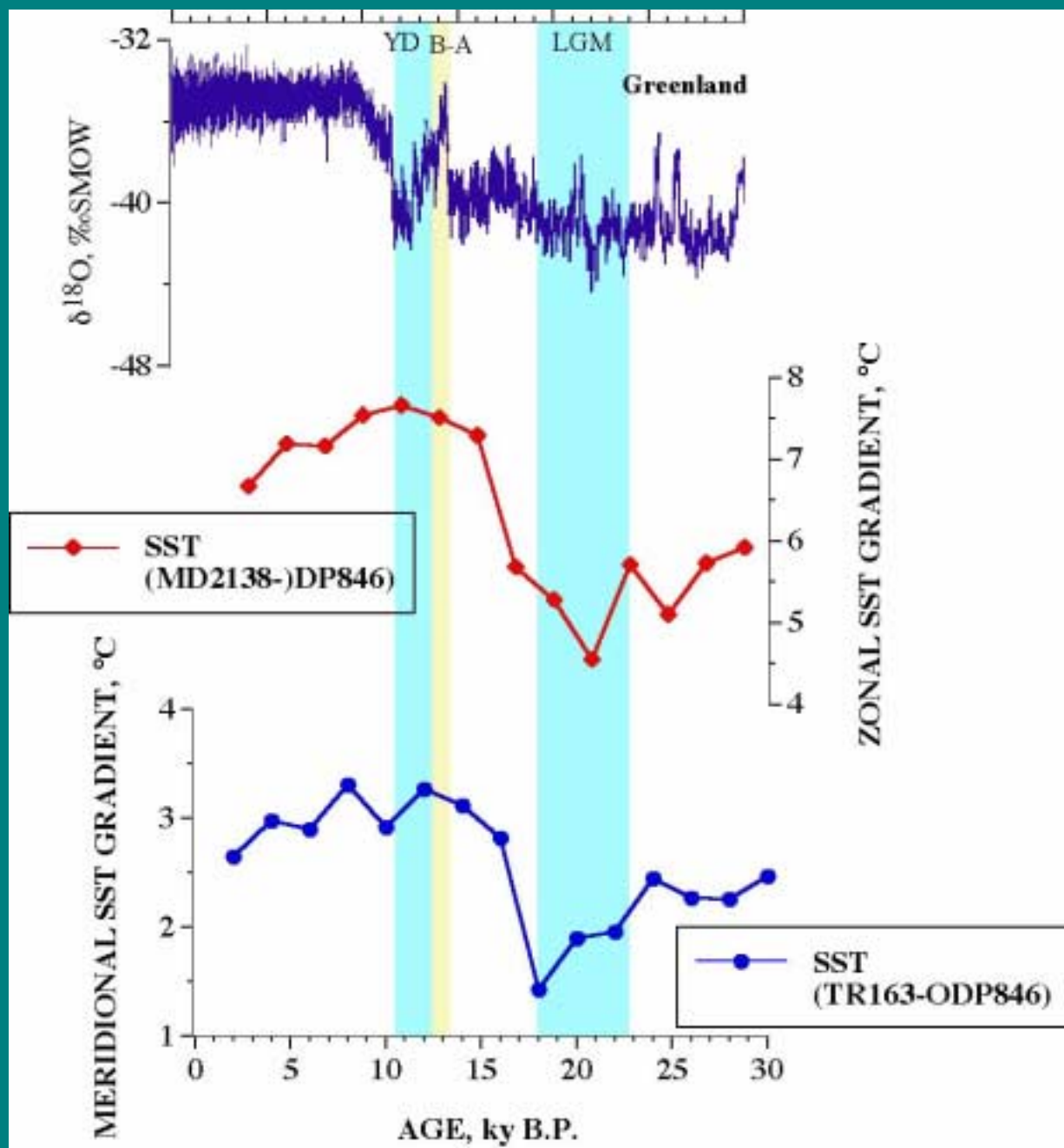
B. Sea Surface Salinity



The Last Glacial Cycle

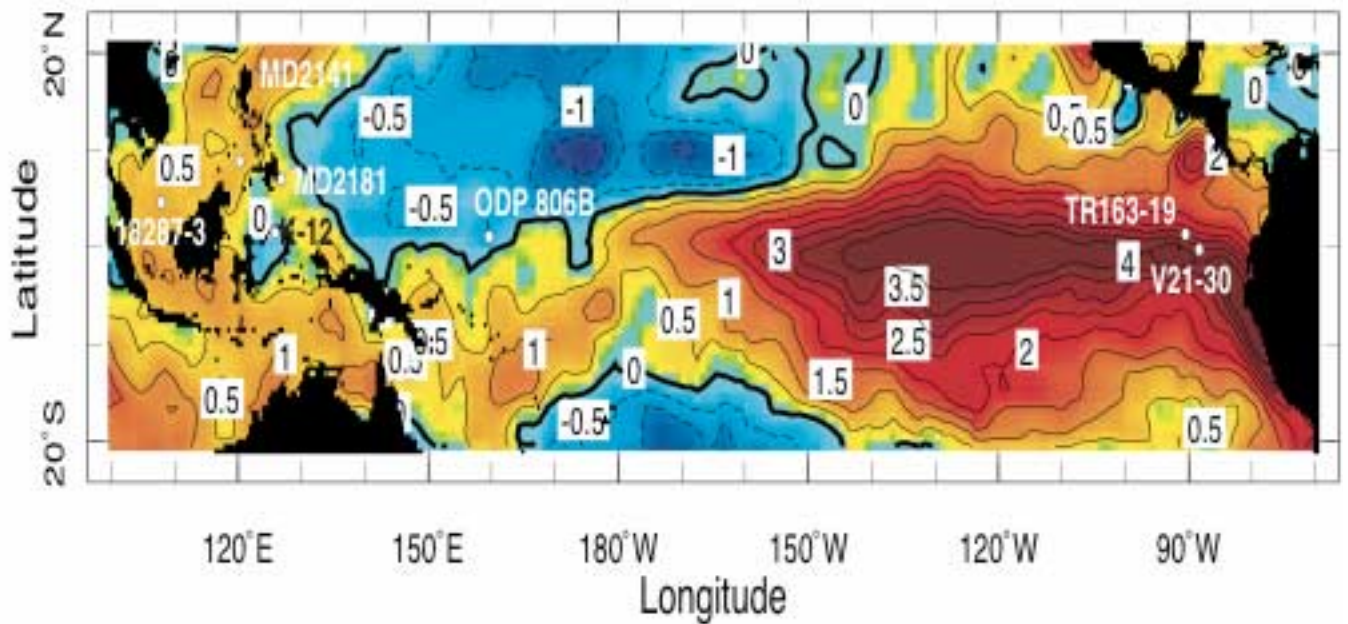




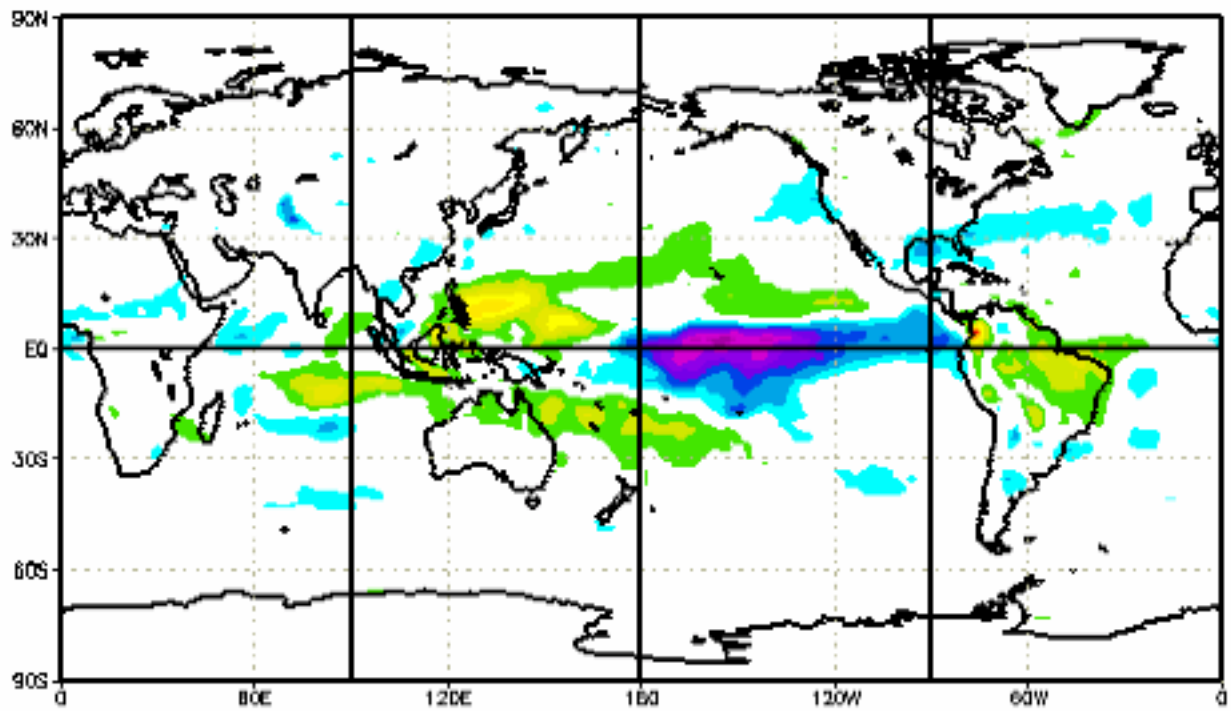


El Niño 1983 winter SST anomalies

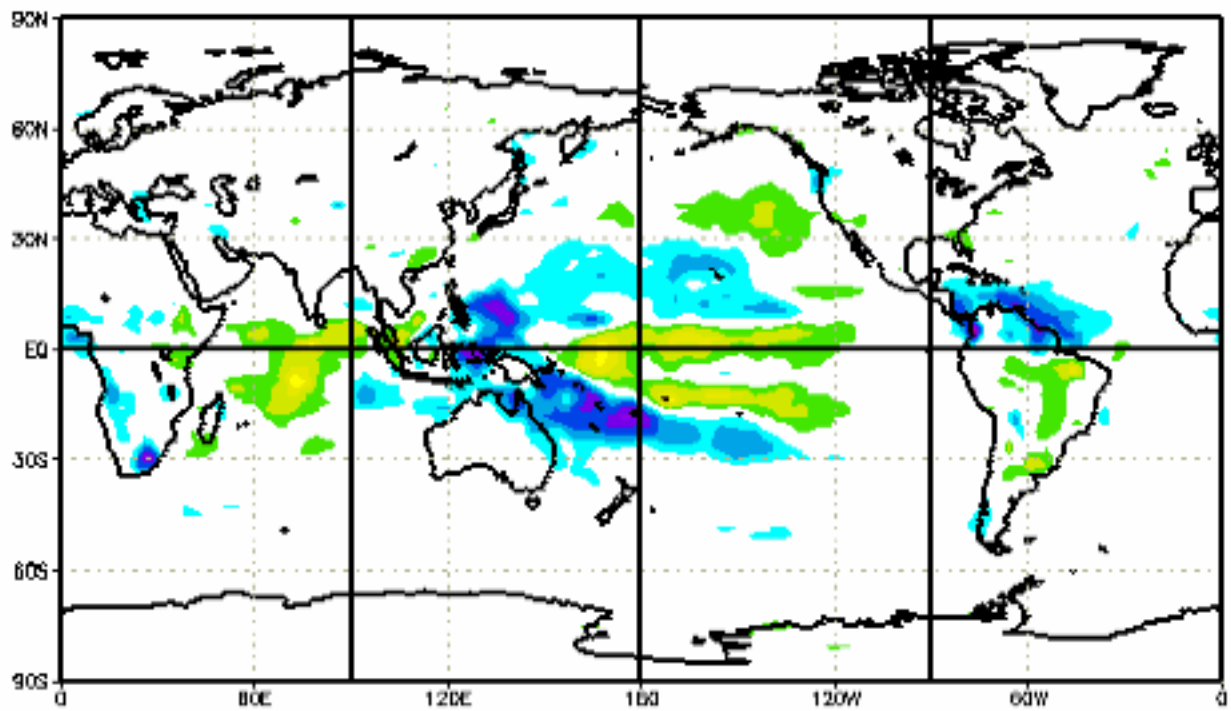
January 1983 Sea Surface Temperature Anomaly (El Niño)



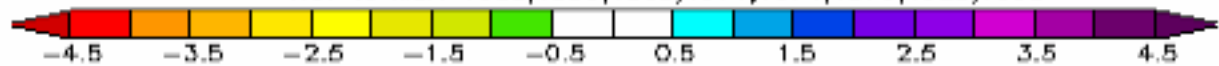
El Nino
NCEP/NCAR Reanalysis

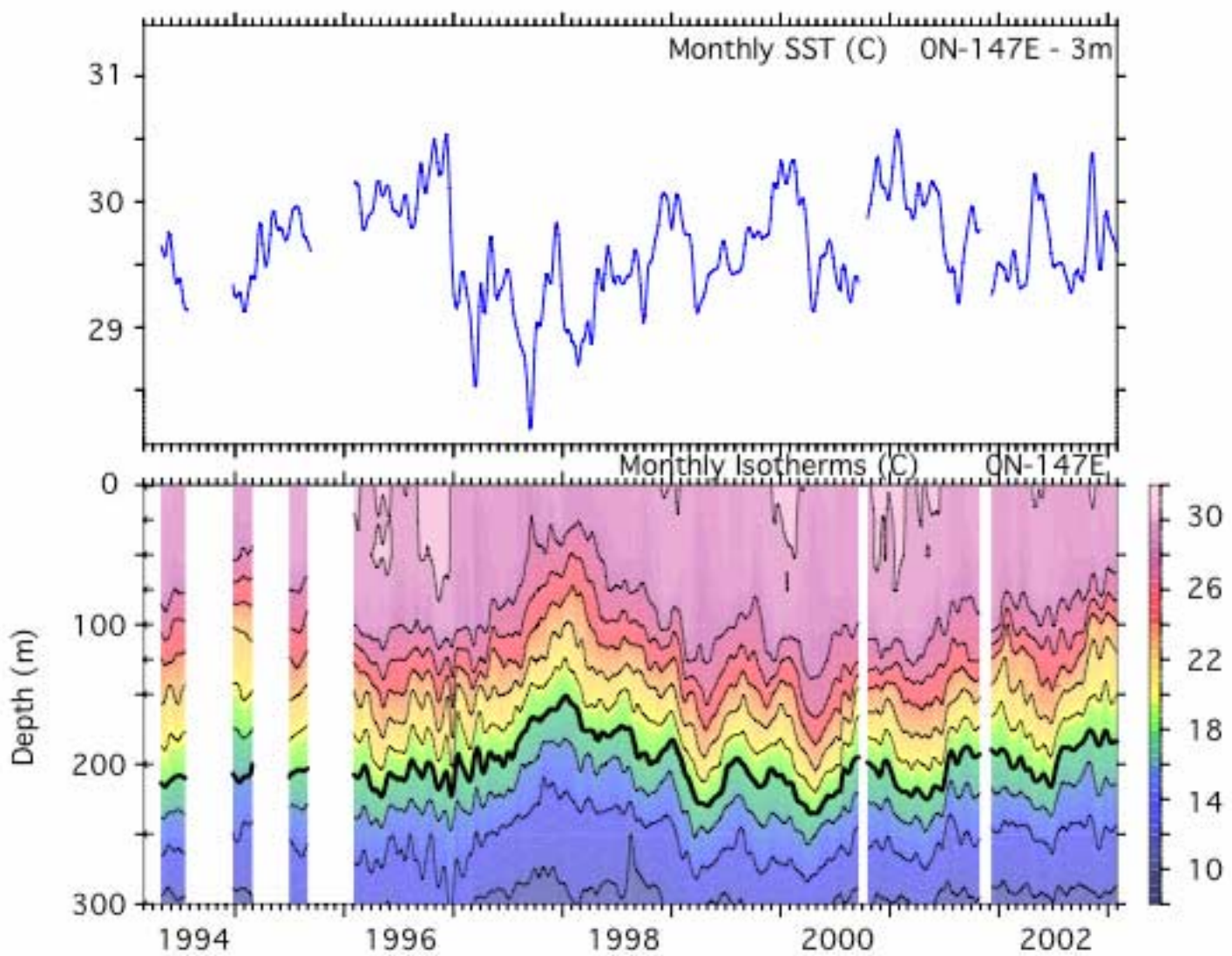


La Nina
NCEP/NCAR Reanalysis



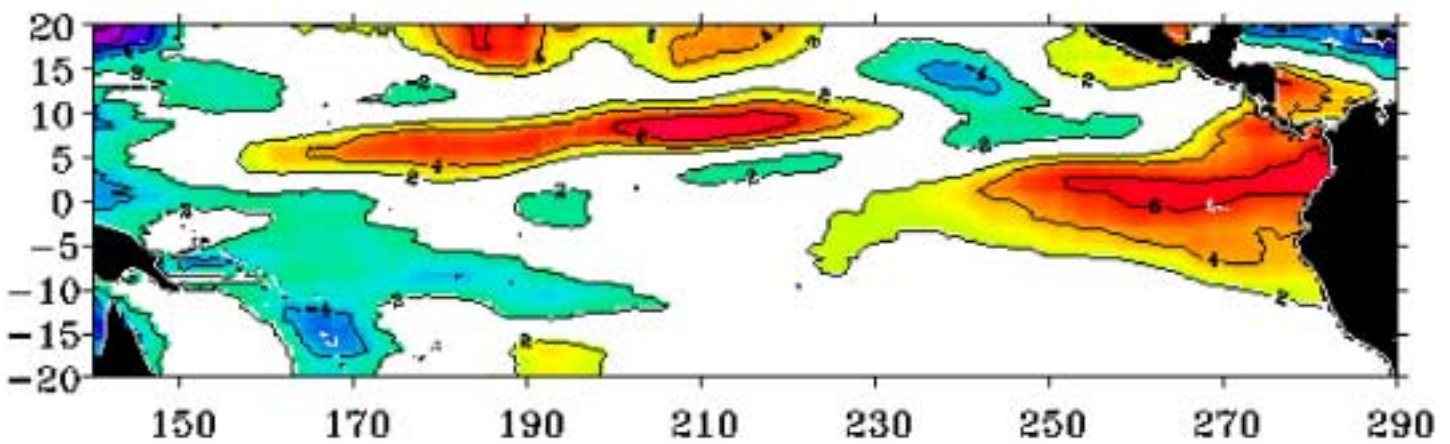
Precipitation Rate (in/mn) Composite Anomaly
Nov to Mar: 1955, 1958, 1985, 1971, 1974, 1976, 1989, 1998



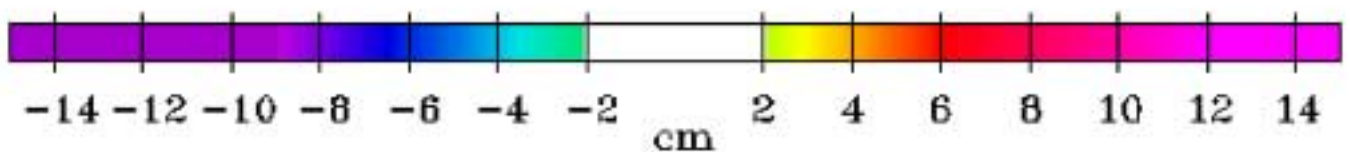
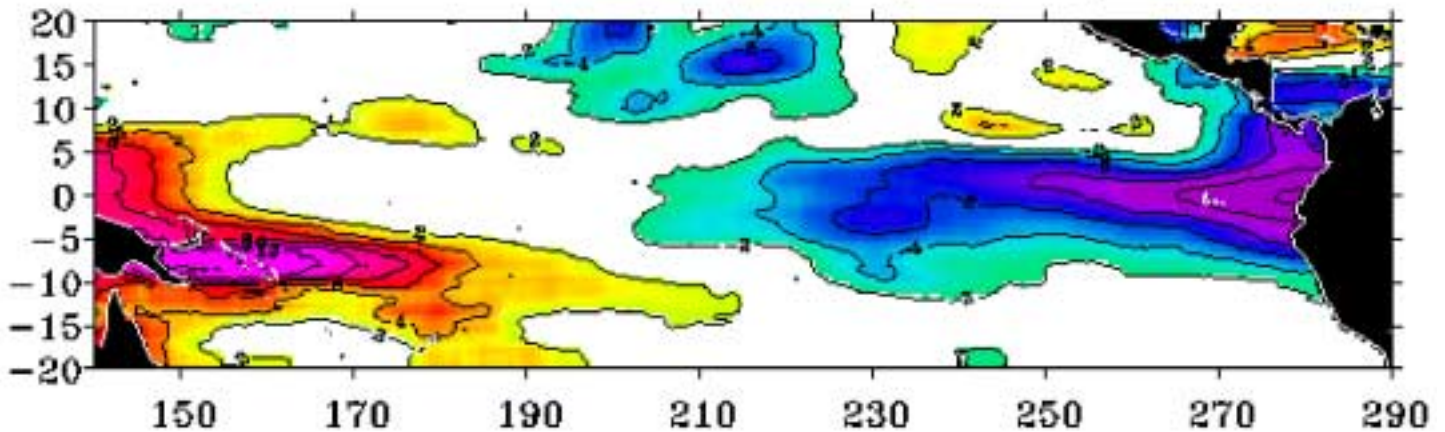


ENSO related variations in tropical sea level high: Observations from TOPEX Posidon

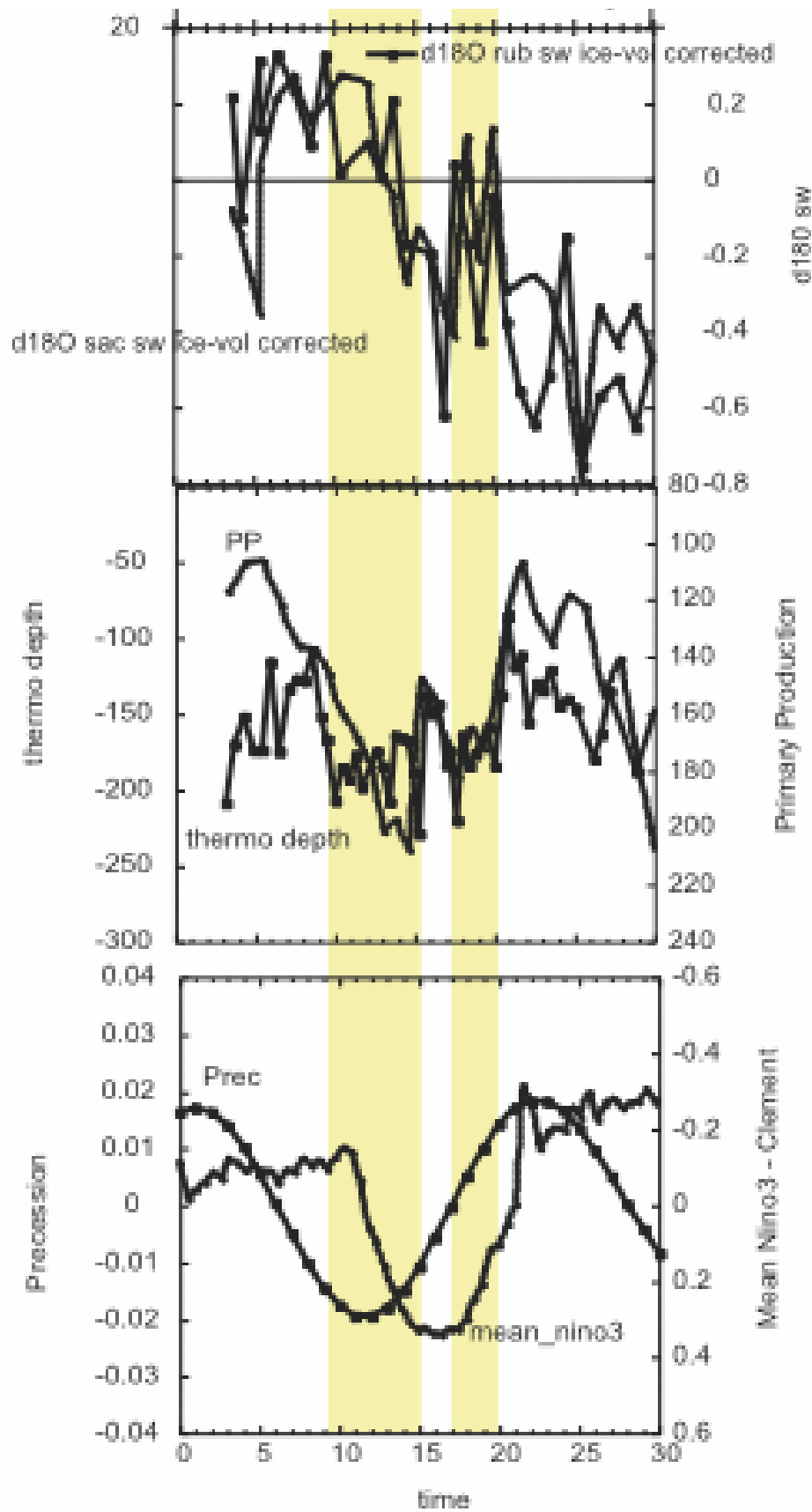
Warm El Nino event - June, 1993



Cold El Nino event (La Nina) - March, 1994



From: JPL



**Preliminary Estimate of SST-BWT Gradient;
Cores From Opposite Sides of Makassar Strait**

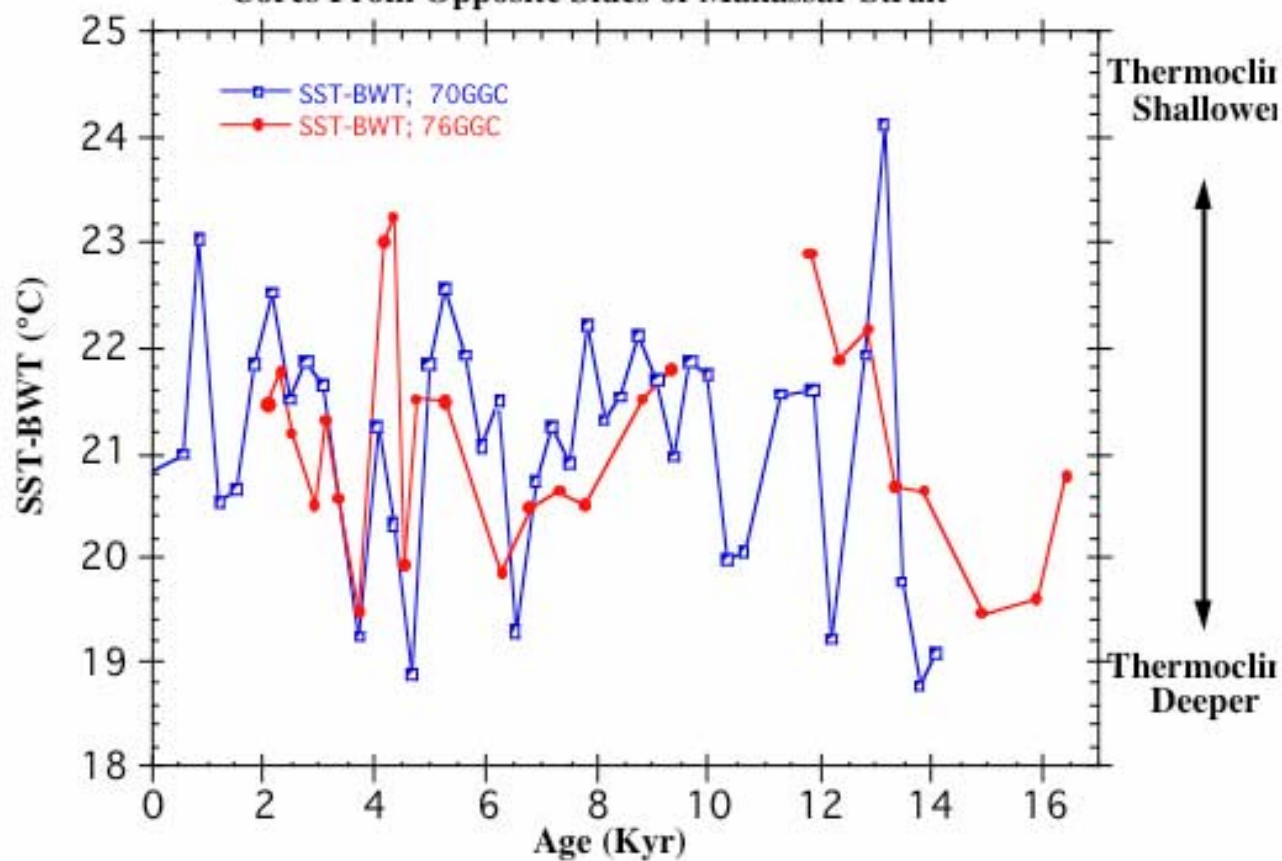
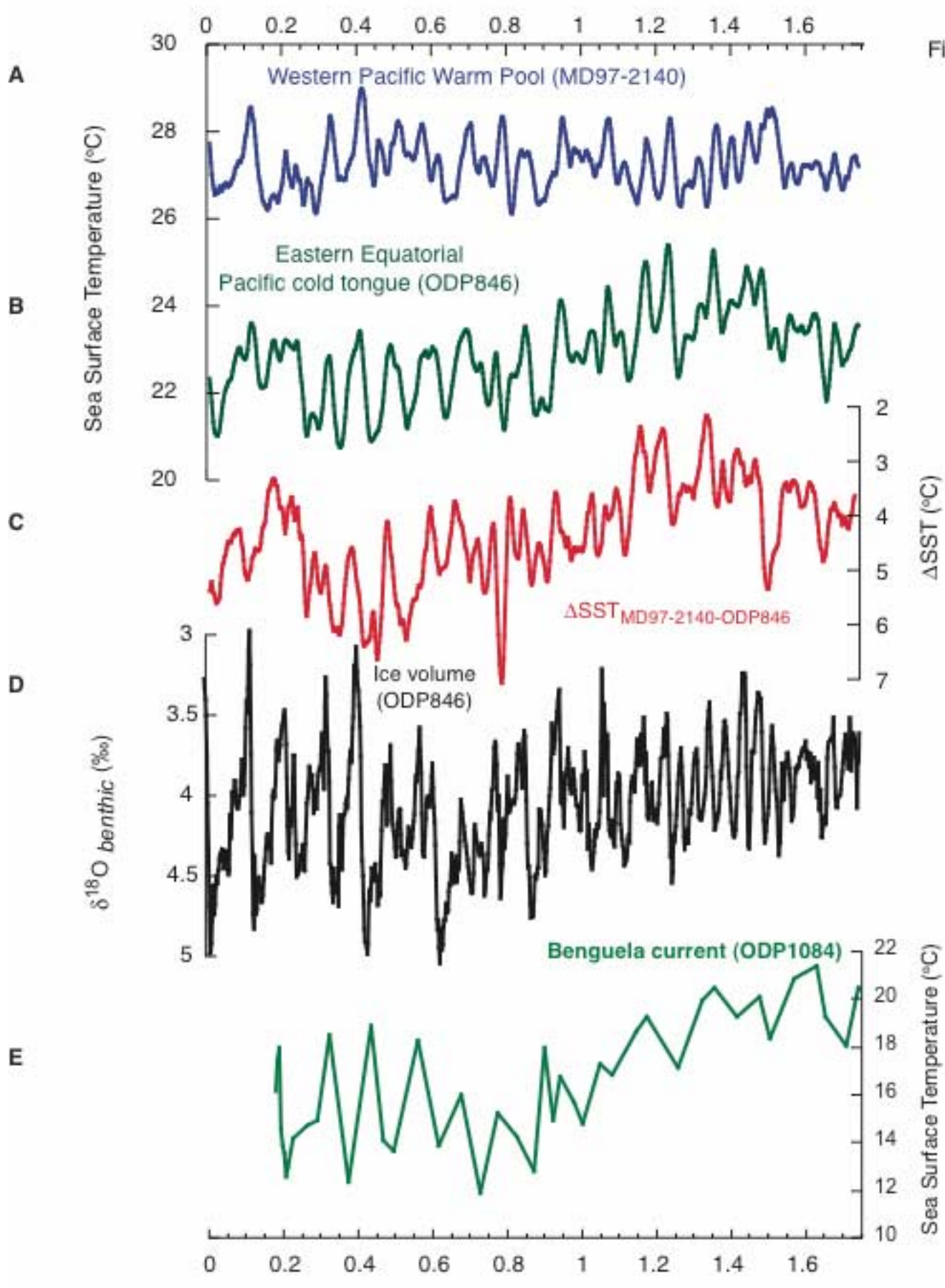


Figure 3



Conclusions

- Tropical Pacific SST were about $2.5 \pm 0.5^\circ\text{C}$ 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 $p\text{CO}_2$ 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 ?*

Global Change Biology (1996) 2, 97-101

26

Rapid Communication

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

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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 ¹⁸O content of the local precipitation during El Niño winters.

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

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- 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).