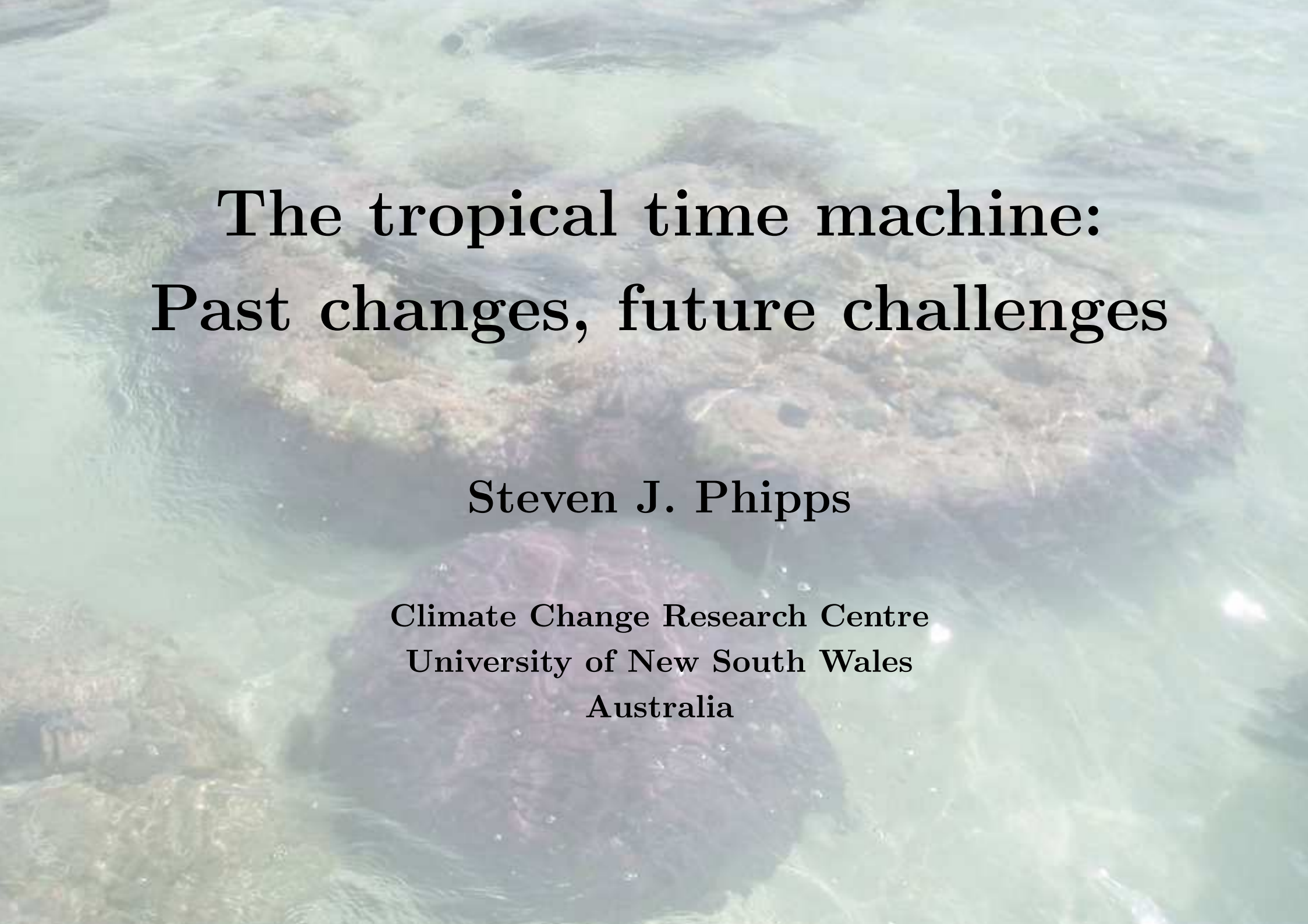


The tropical time machine: Past changes, future challenges

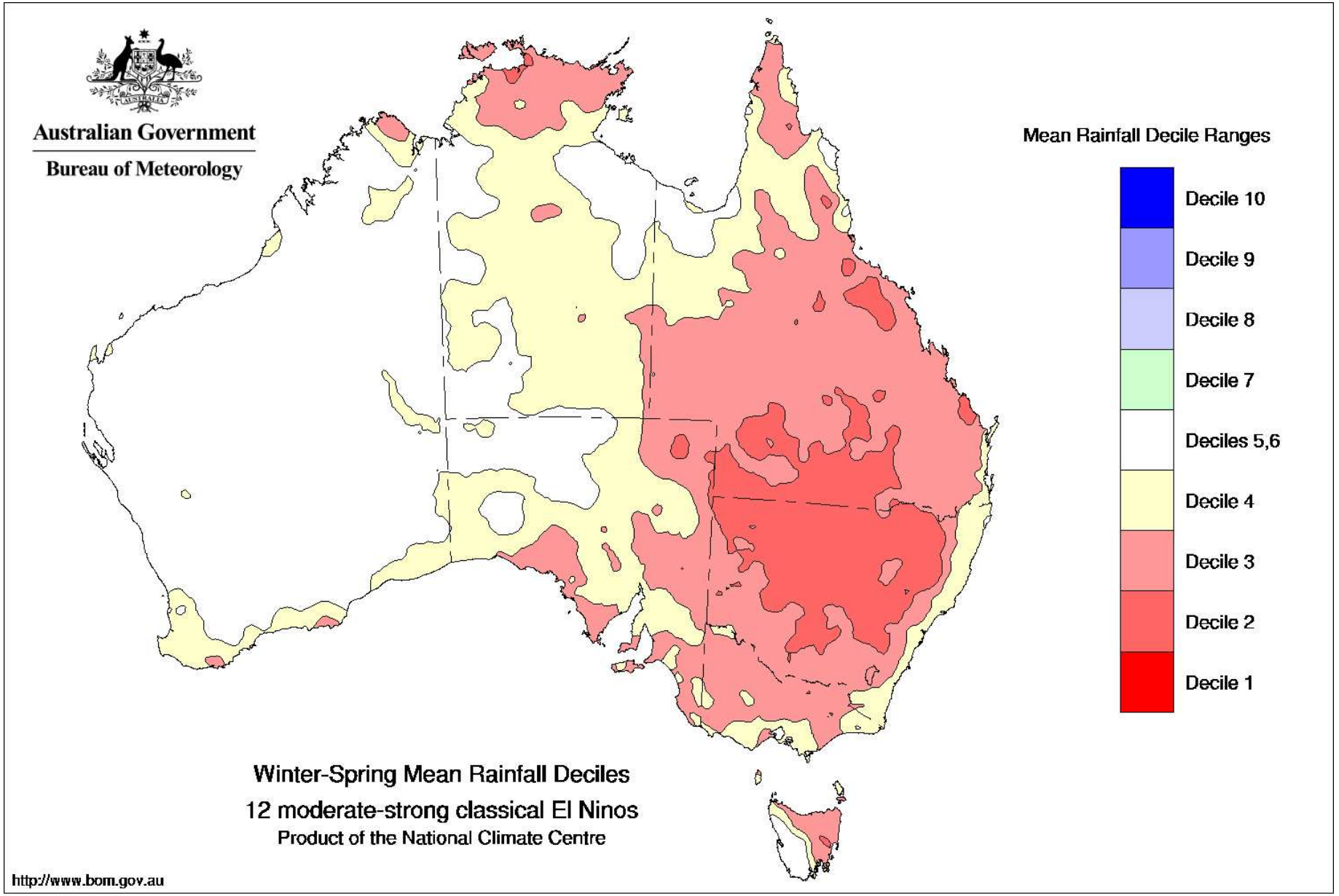
Steven J. Phipps

Climate Change Research Centre
University of New South Wales
Australia

Why does marine science matter?

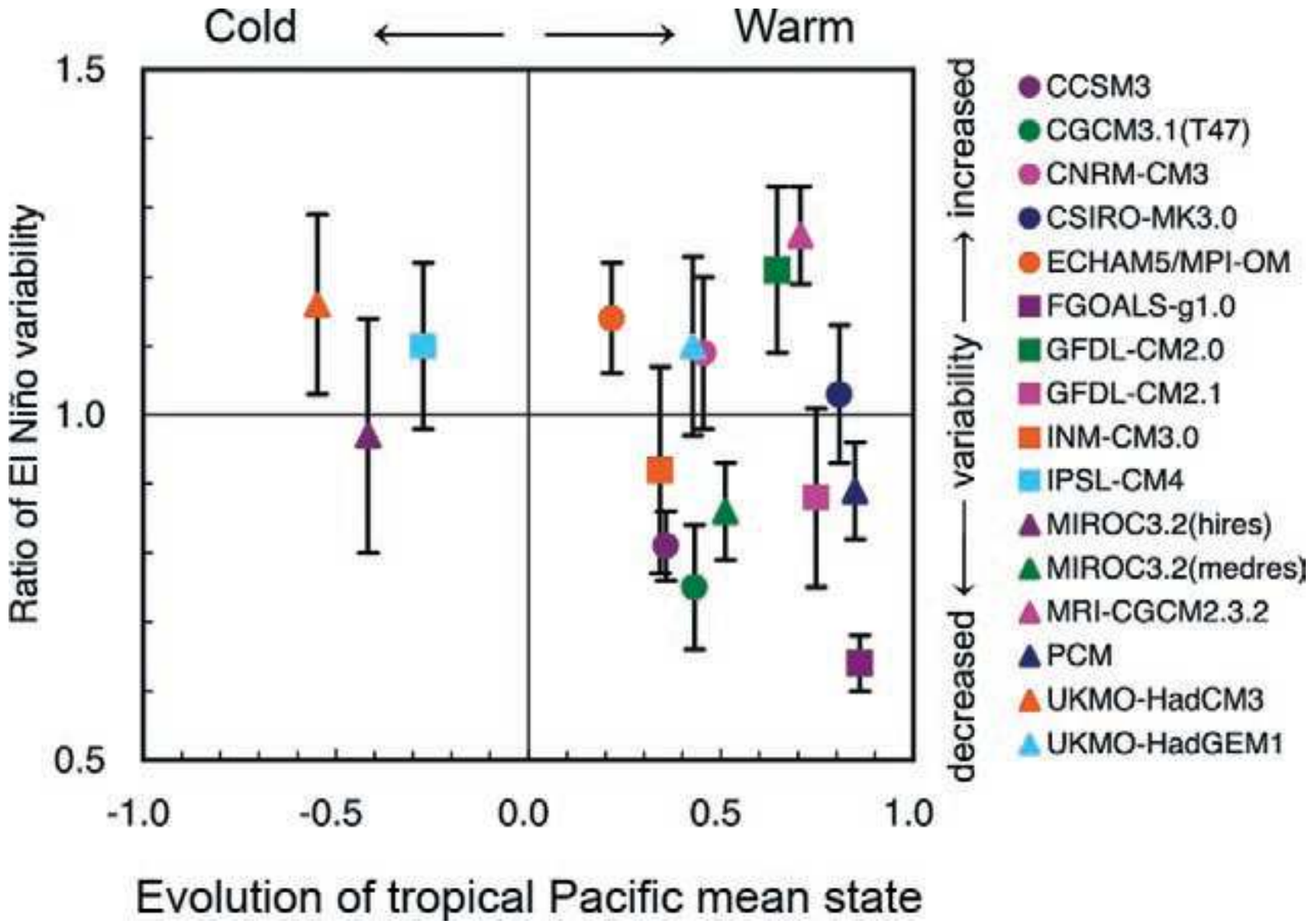
Image courtesy of Getty Images

El Niño events can bring drought to Australia



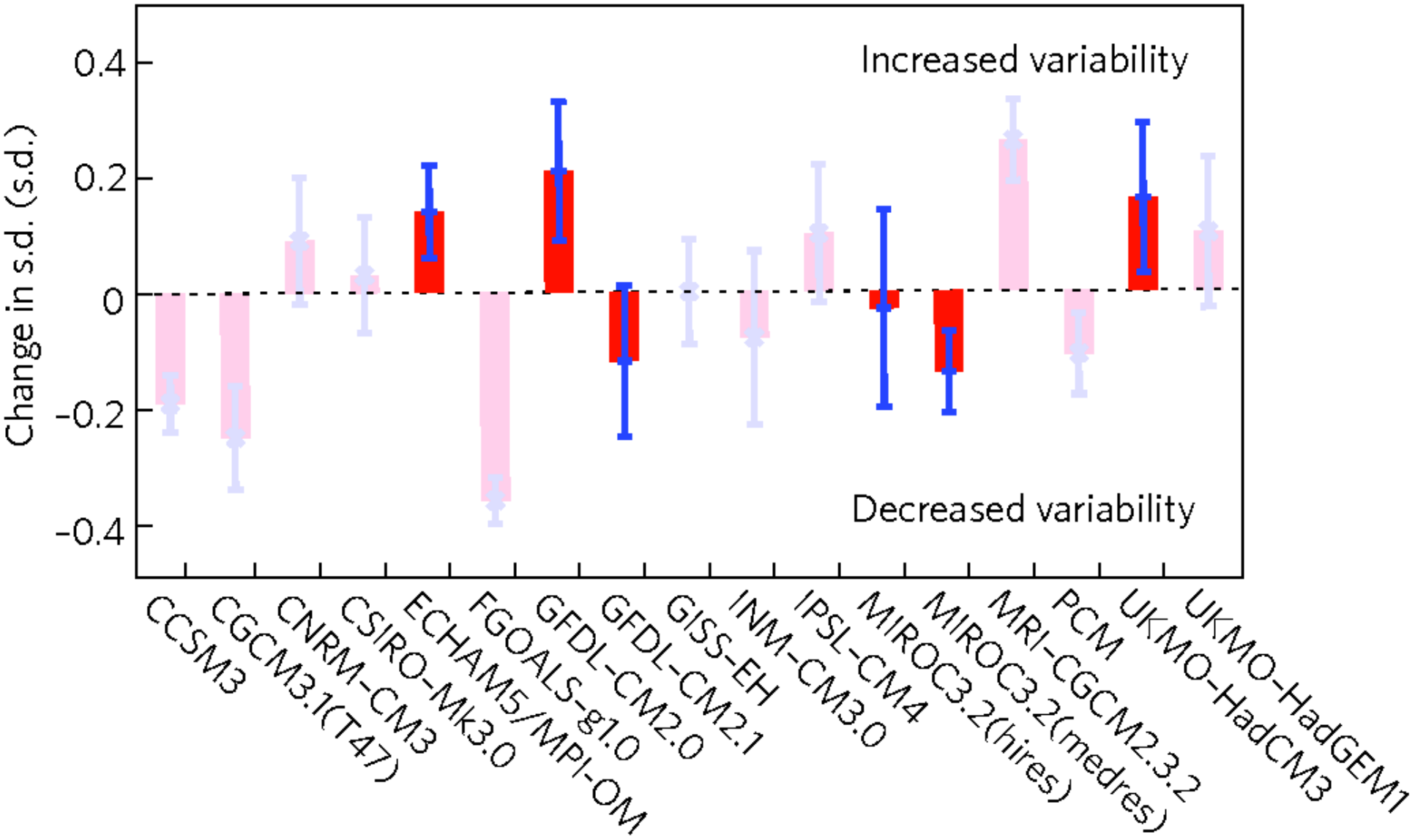
Issued: 08/06/2010

But what about the future?



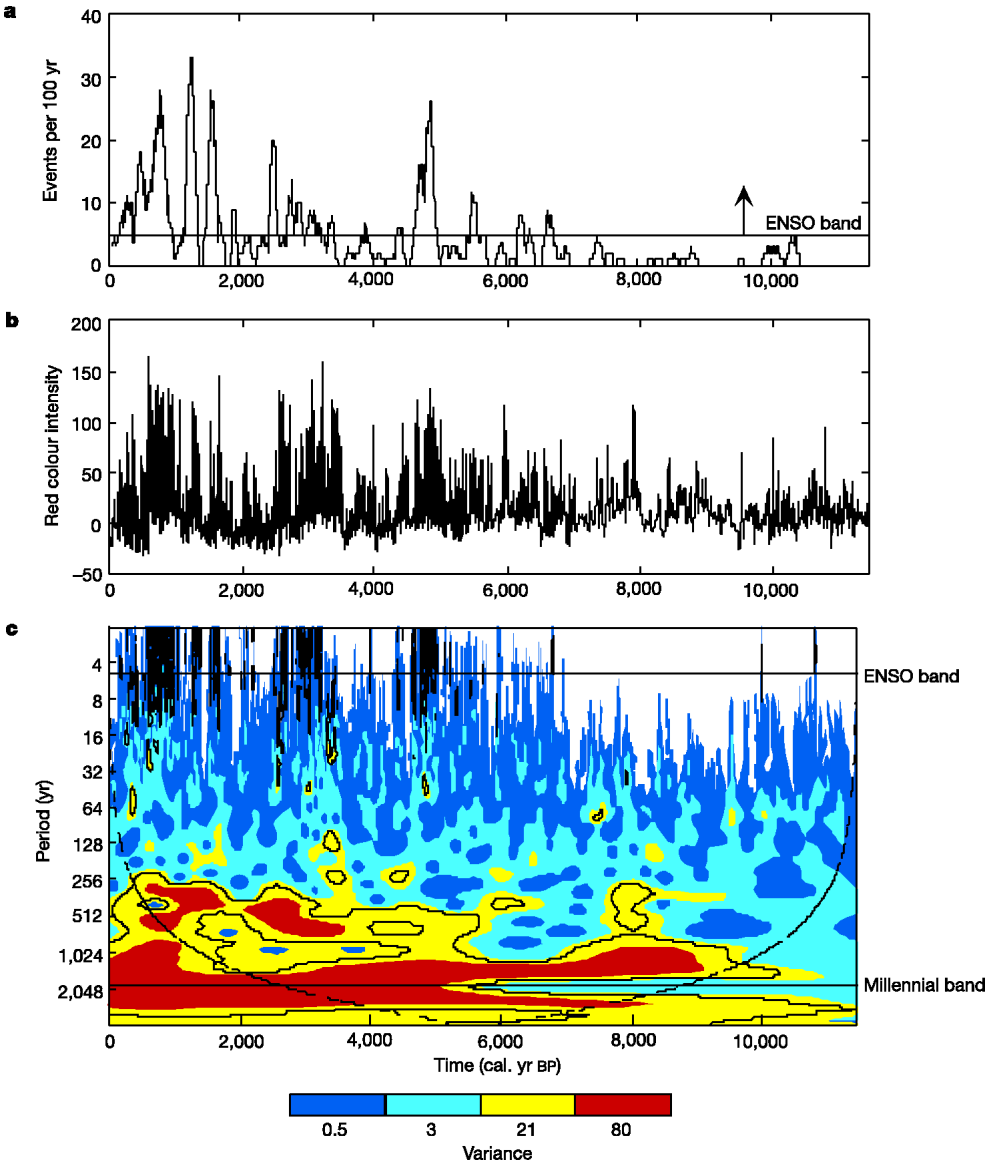
Guilyardi et al. (2009), *Bull. Am. Meteorol. Soc.*

Even the best models disagree



Collins et al. (2010), *Nature Geoscience*

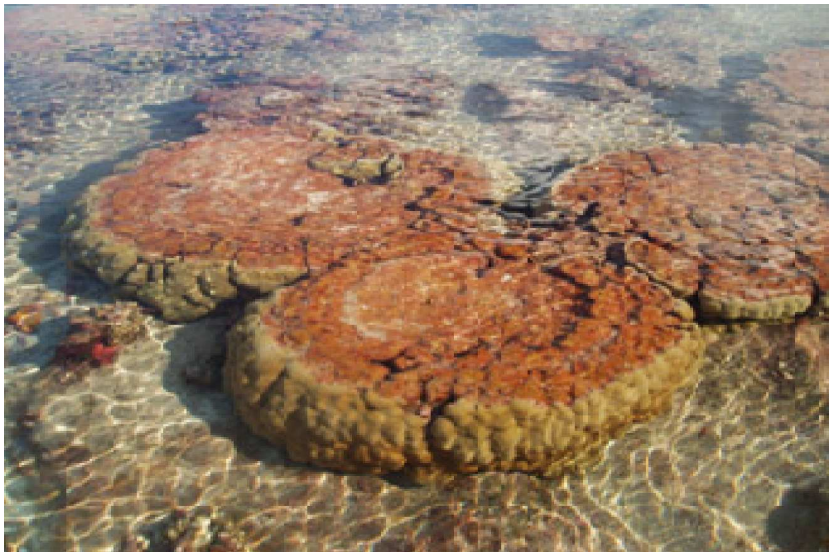
We know that El Niño has changed in the past

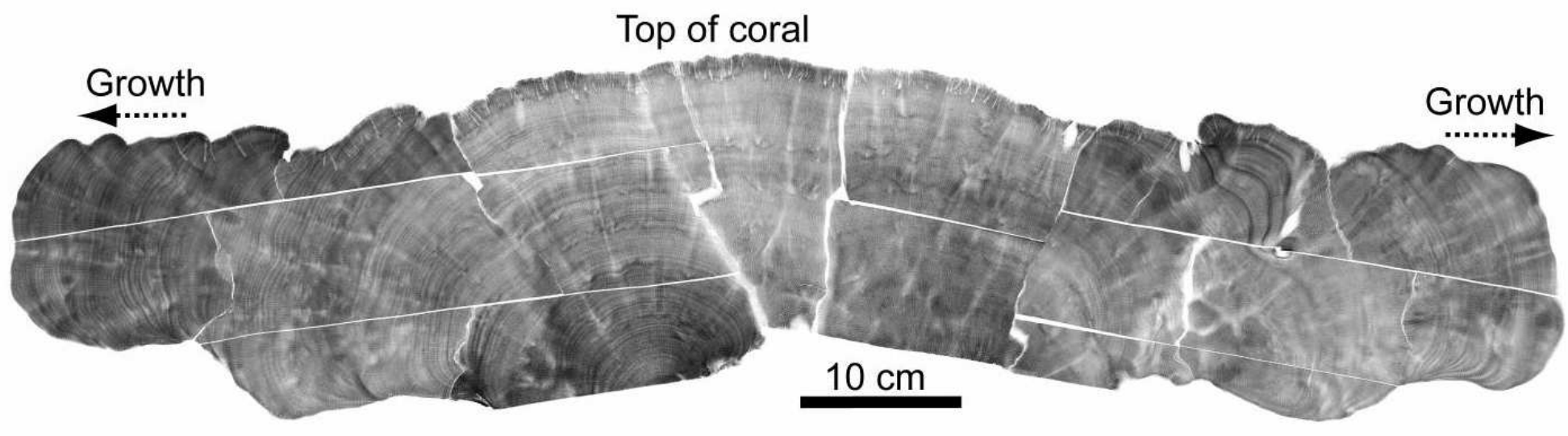


Moy et al. (2002), *Nature*

- ENSO variability has increased over the past 10,000 years
- El Niño events have increased in frequency and magnitude
- Evidence of a peak in ENSO variability at 2–1 ka BP
- Strong variability on centennial and millennial timescales
- These changes provide an opportunity to learn more about ENSO dynamics

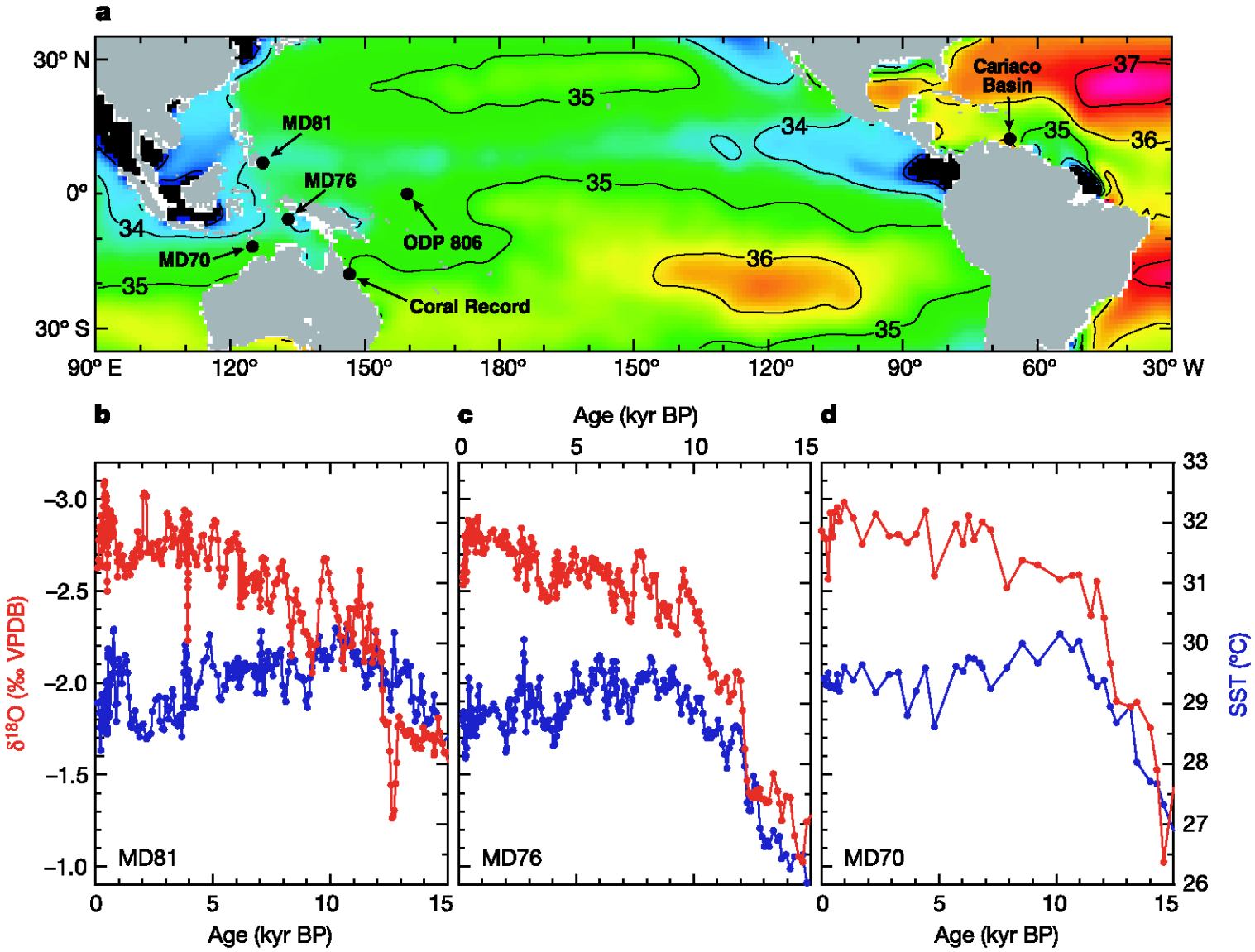
Corals record seasonal changes in the climate





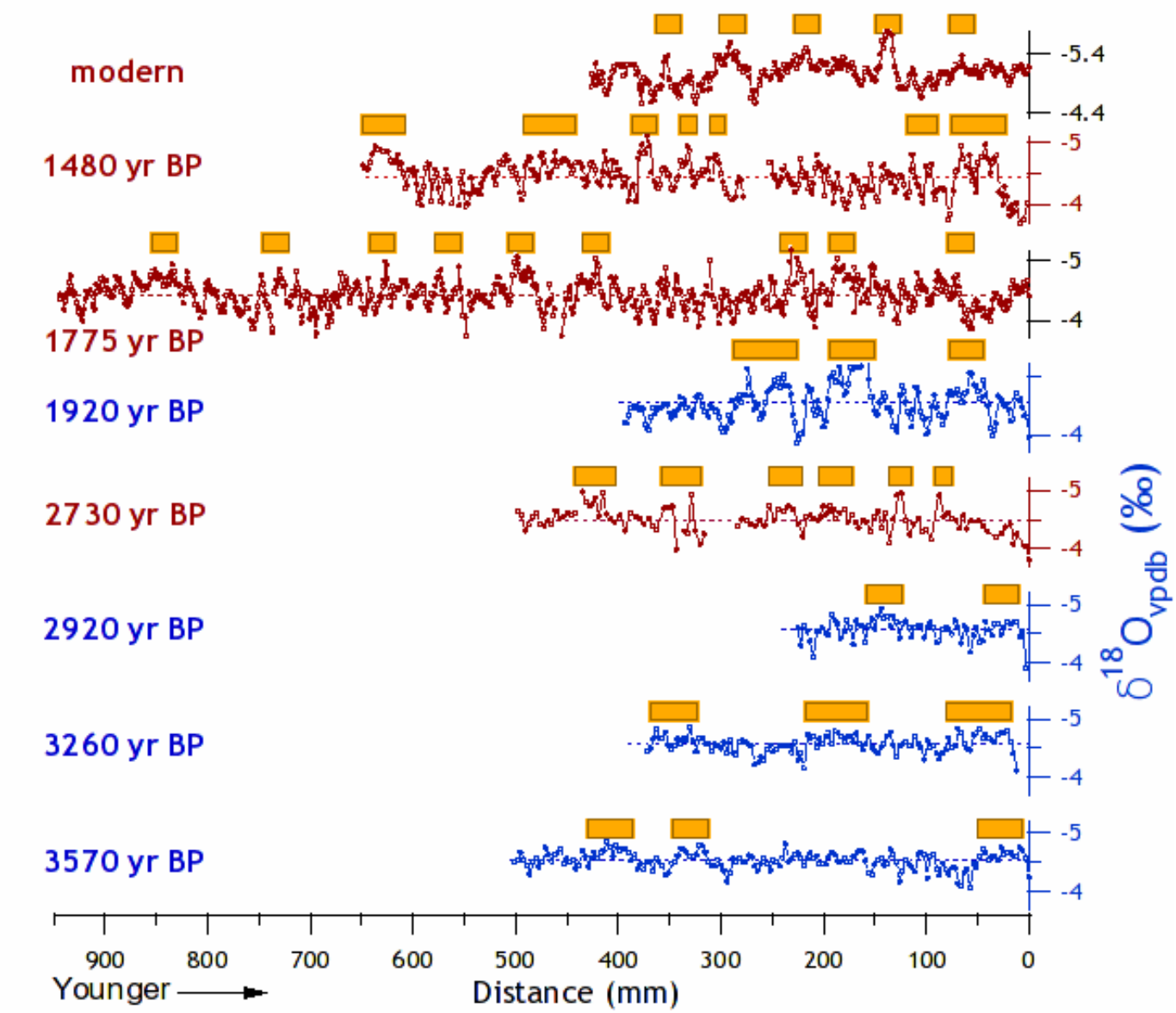
Images courtesy of Helen McGregor

Sediments record changes on longer timescales



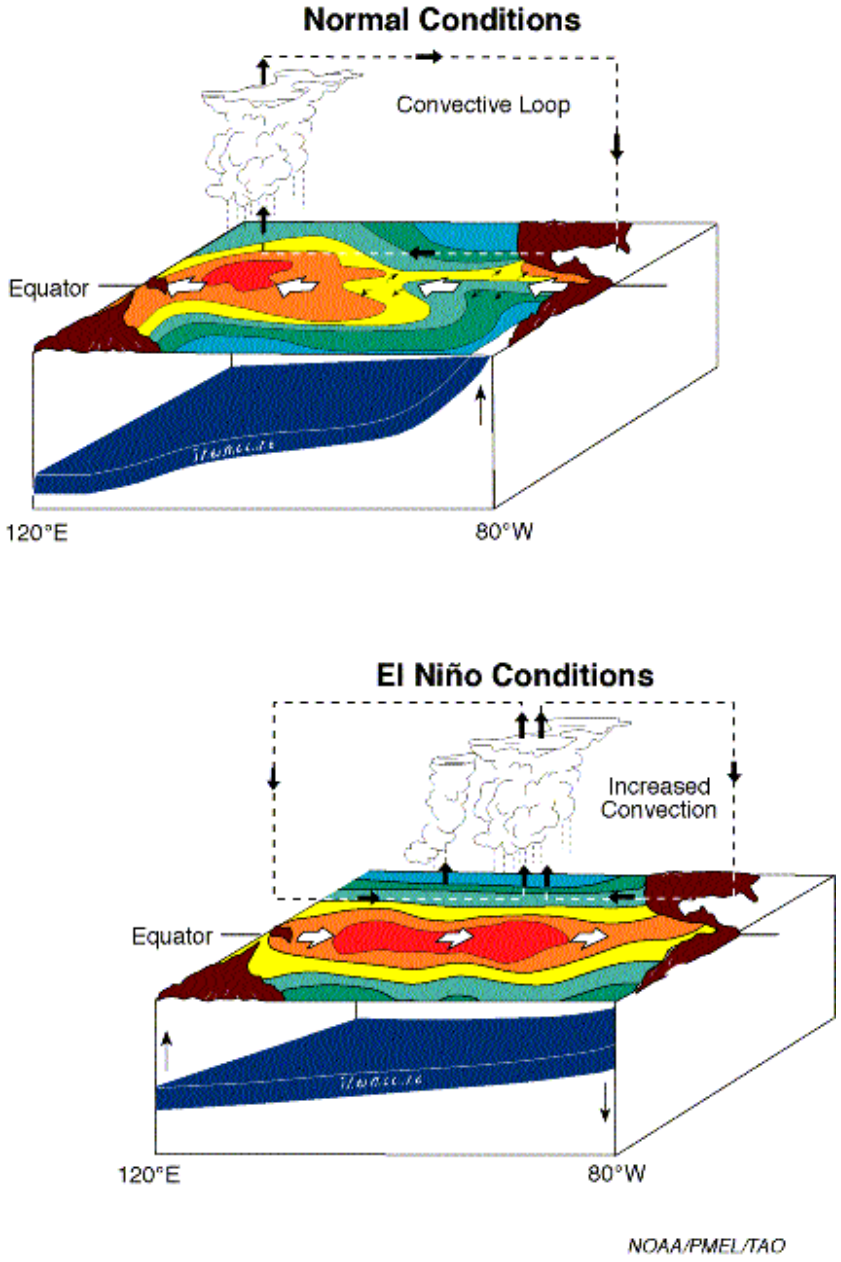
Stott et al. (2004), *Nature*

Corals record individual El Niño events



Woodroffe et al. (2003), *Geophys. Res. Lett.*

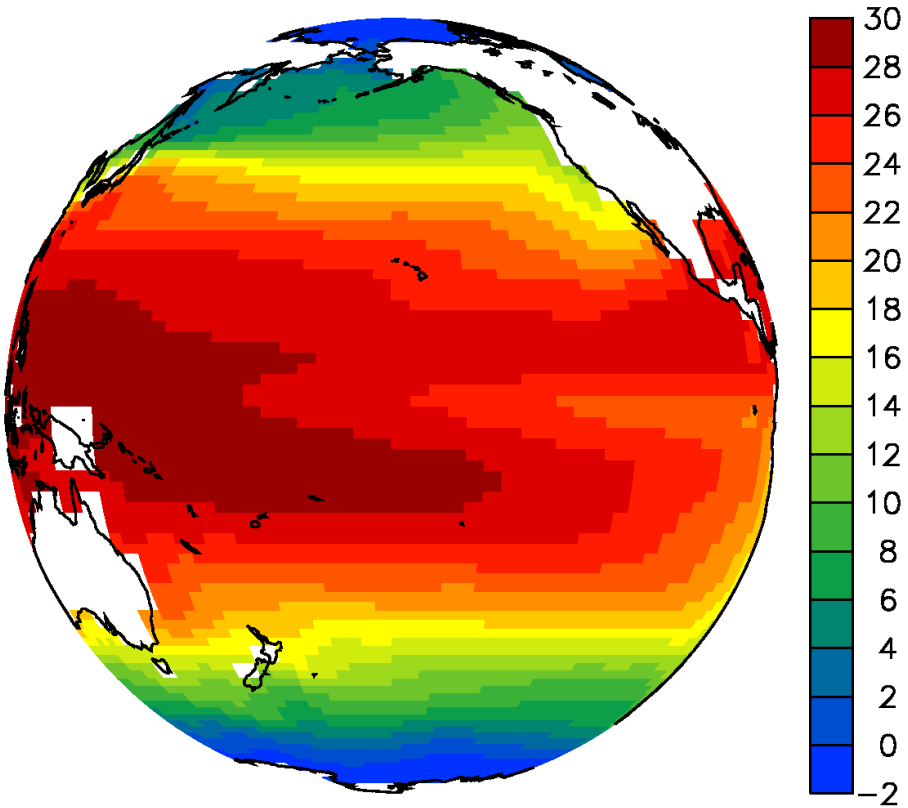
The dynamics of El Niño



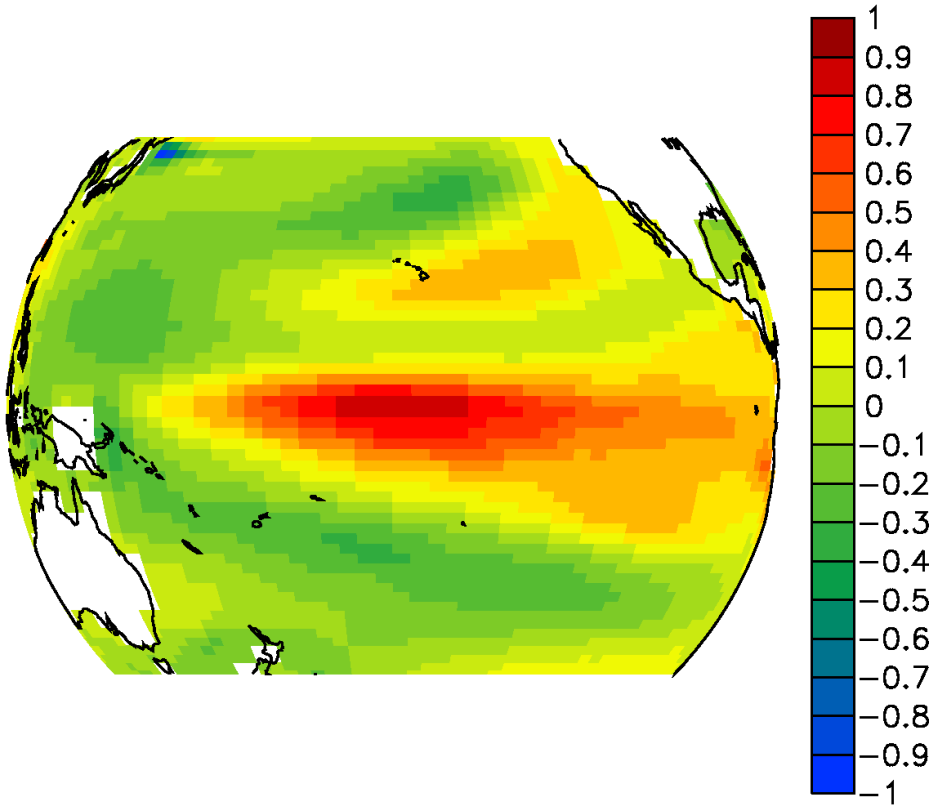
- El Niño–Southern Oscillation (ENSO) is the dominant mode of internal variability within the coupled atmosphere-ocean system
- Irregular period of ∼2–7 years
- Average state of the system involves strong easterly trade winds pushing warm water to the east
- In an El Niño event, these winds slacken and the warm water flows eastwards
- Increased rainfall in the eastern Pacific, reduced rainfall in the west

Climate models provide a dynamical framework

- The CSIRO Mk3L climate system model (Phipps, 2010)
- Includes components which describe the atmosphere, ocean, sea ice and land surface
- Three transient simulations of the past 8,000 years

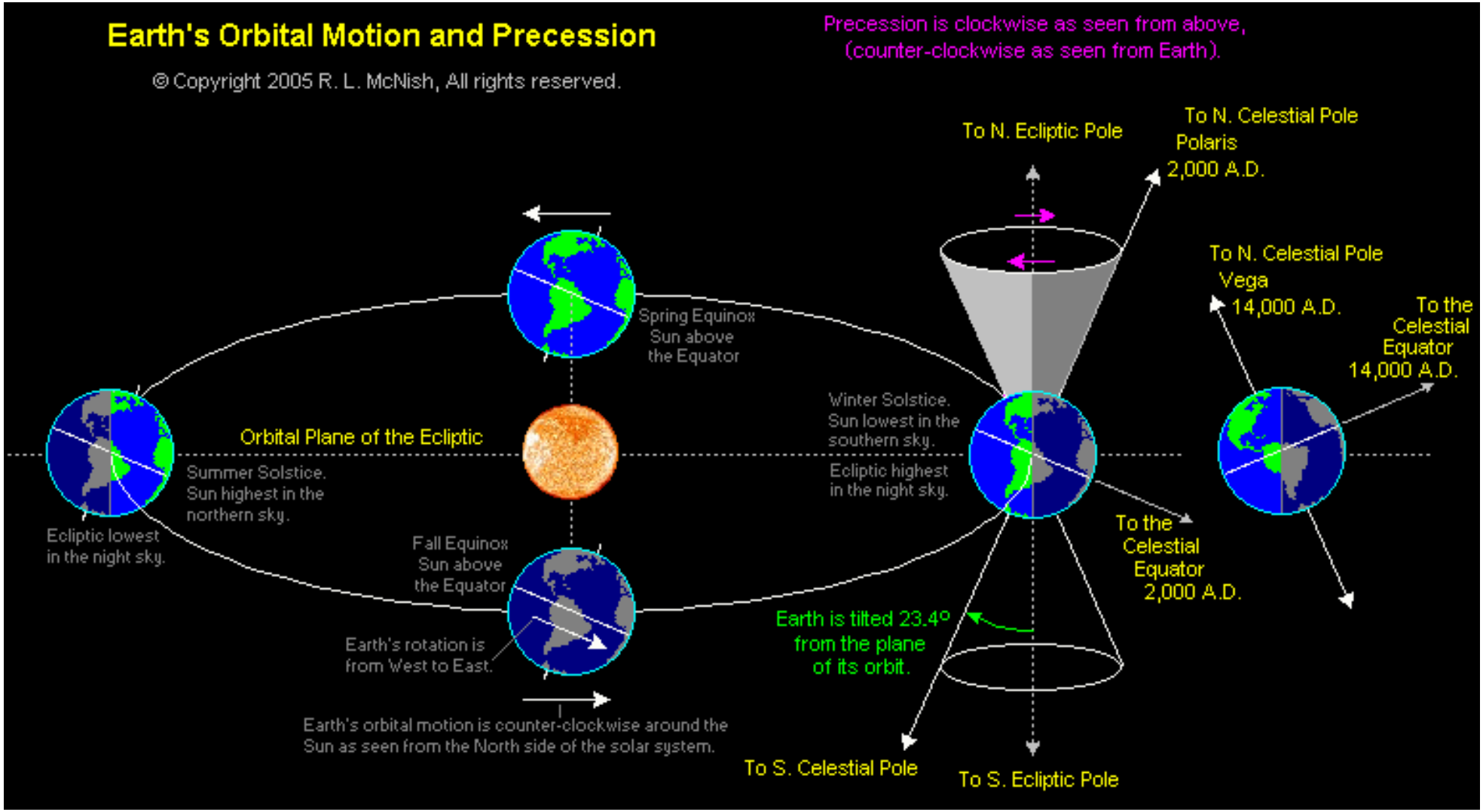


Sea surface temperature (°C)

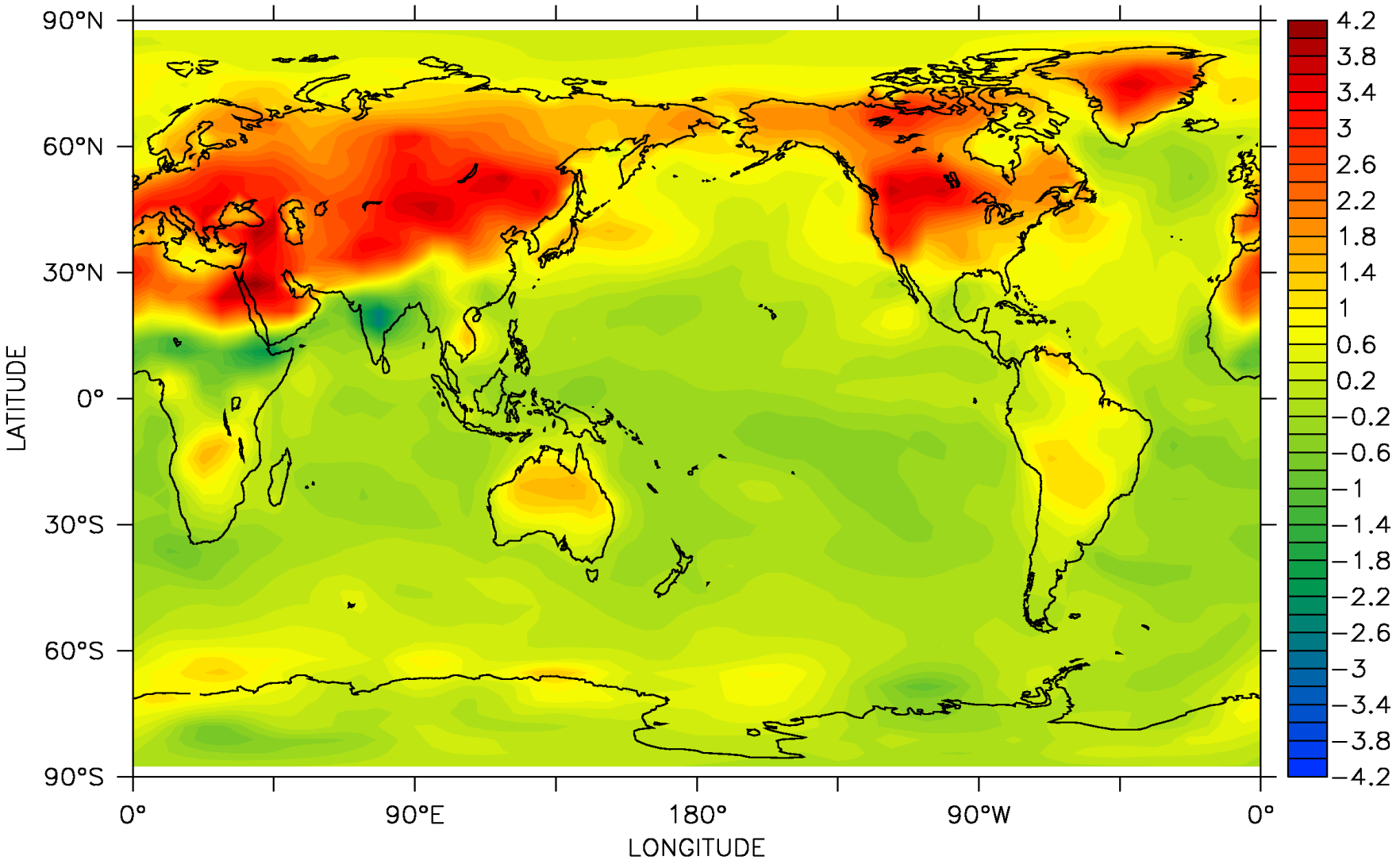


EOF1 of SST anomalies (°C)

The precessional cycle is the driving "signal"



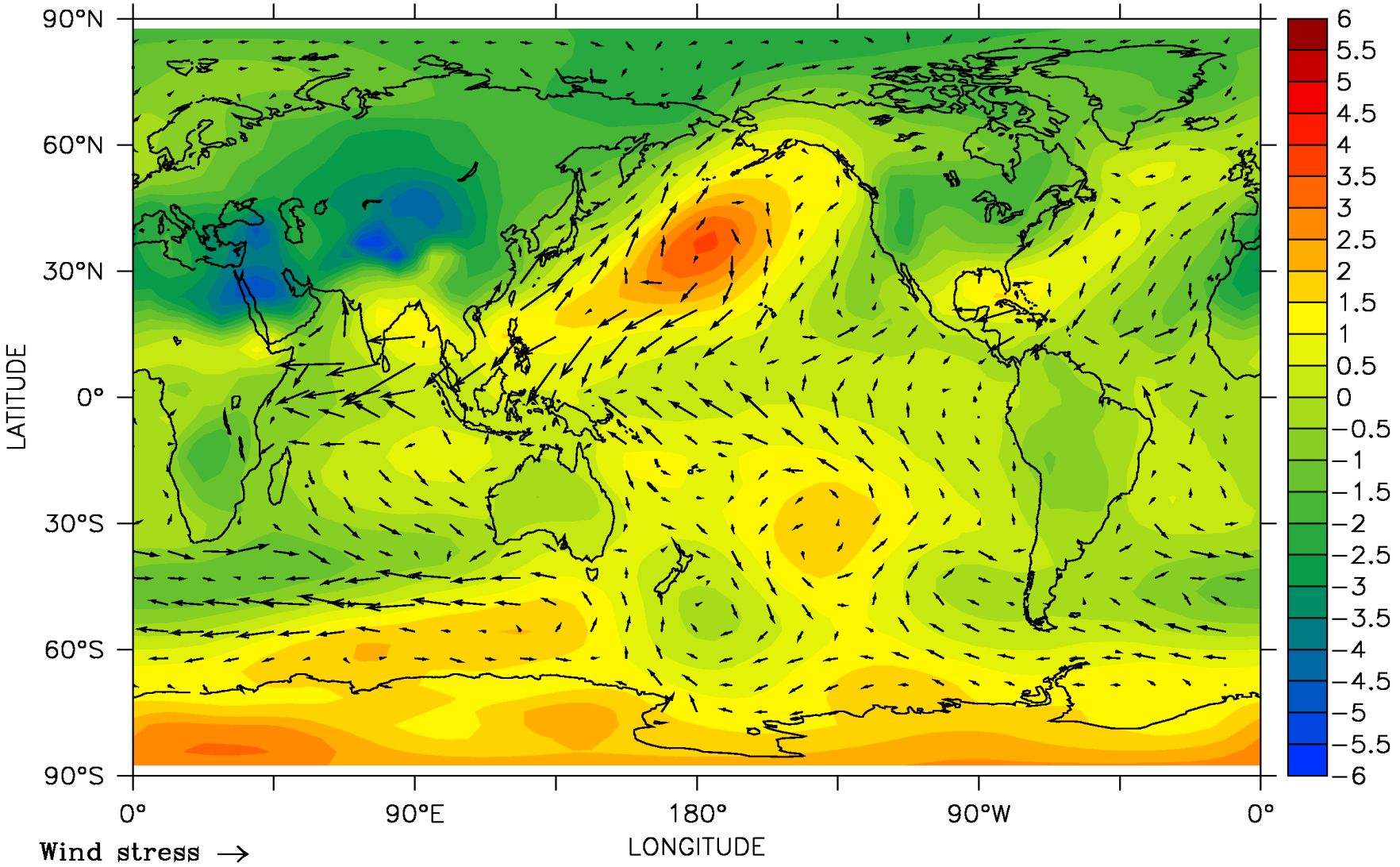
Northern summers were warmer 8,000 years ...



June–July–August surface air temperature anomaly (°C)

Phipps and Brown (2010), *IOP Conf. Series: Earth and Env. Sci.*

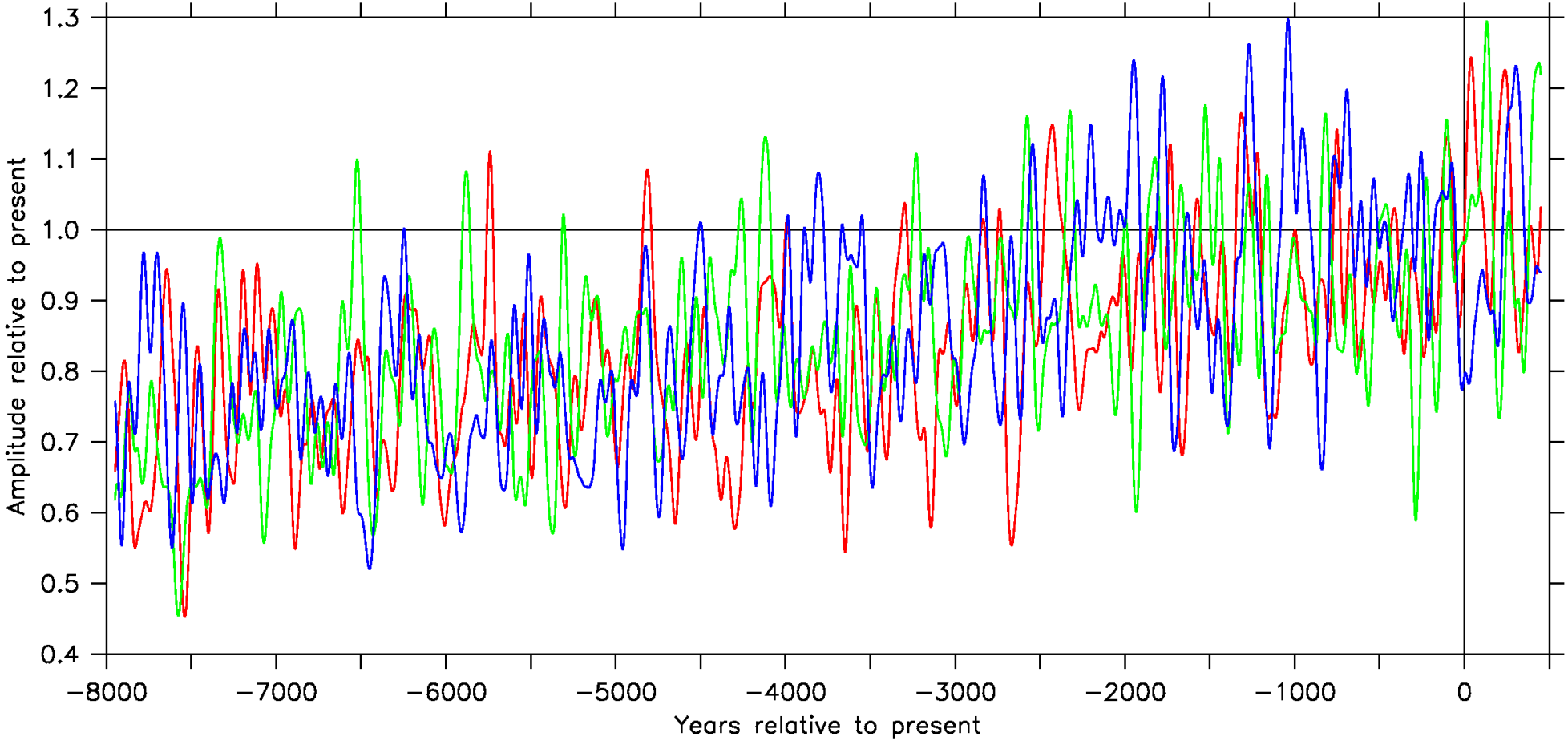
... which enhanced the trade winds in the Pacific



June–July–August mean sea level pressure anomaly (hPa)

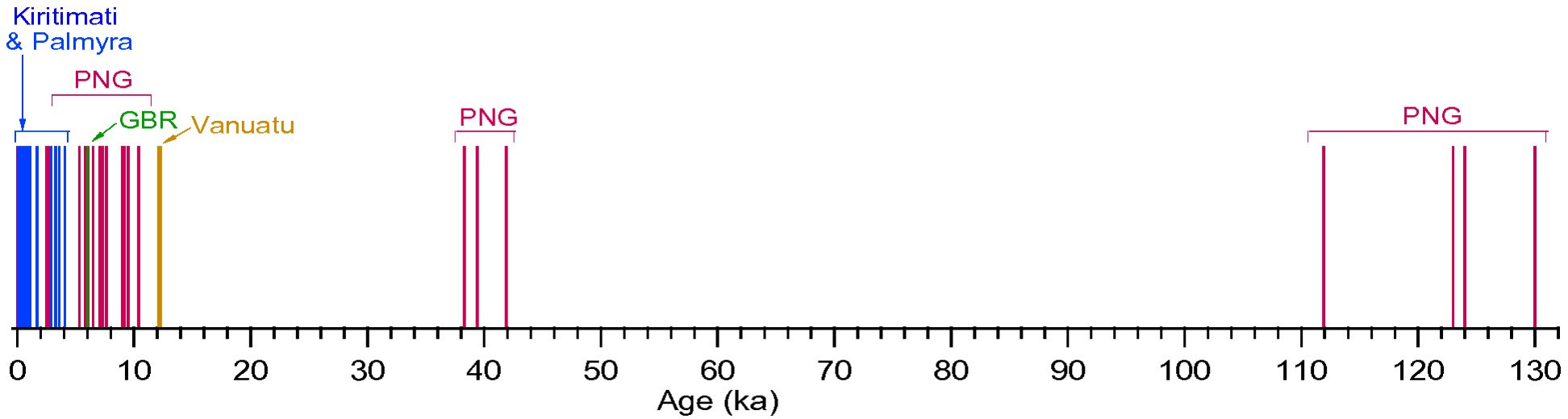
Phipps and Brown (2010), *IOP Conf. Series: Earth and Env. Sci.*

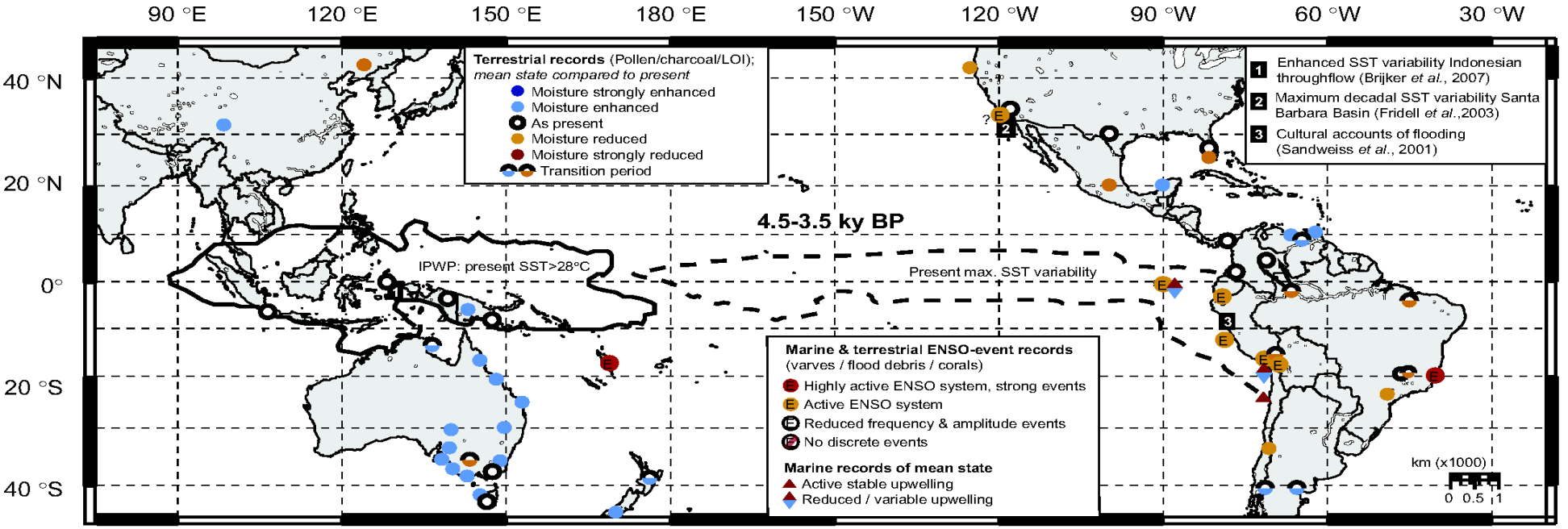
Simulated changes in El Niño variability



Phipps and McGregor (in prep.), *Geophys. Res. Lett.*

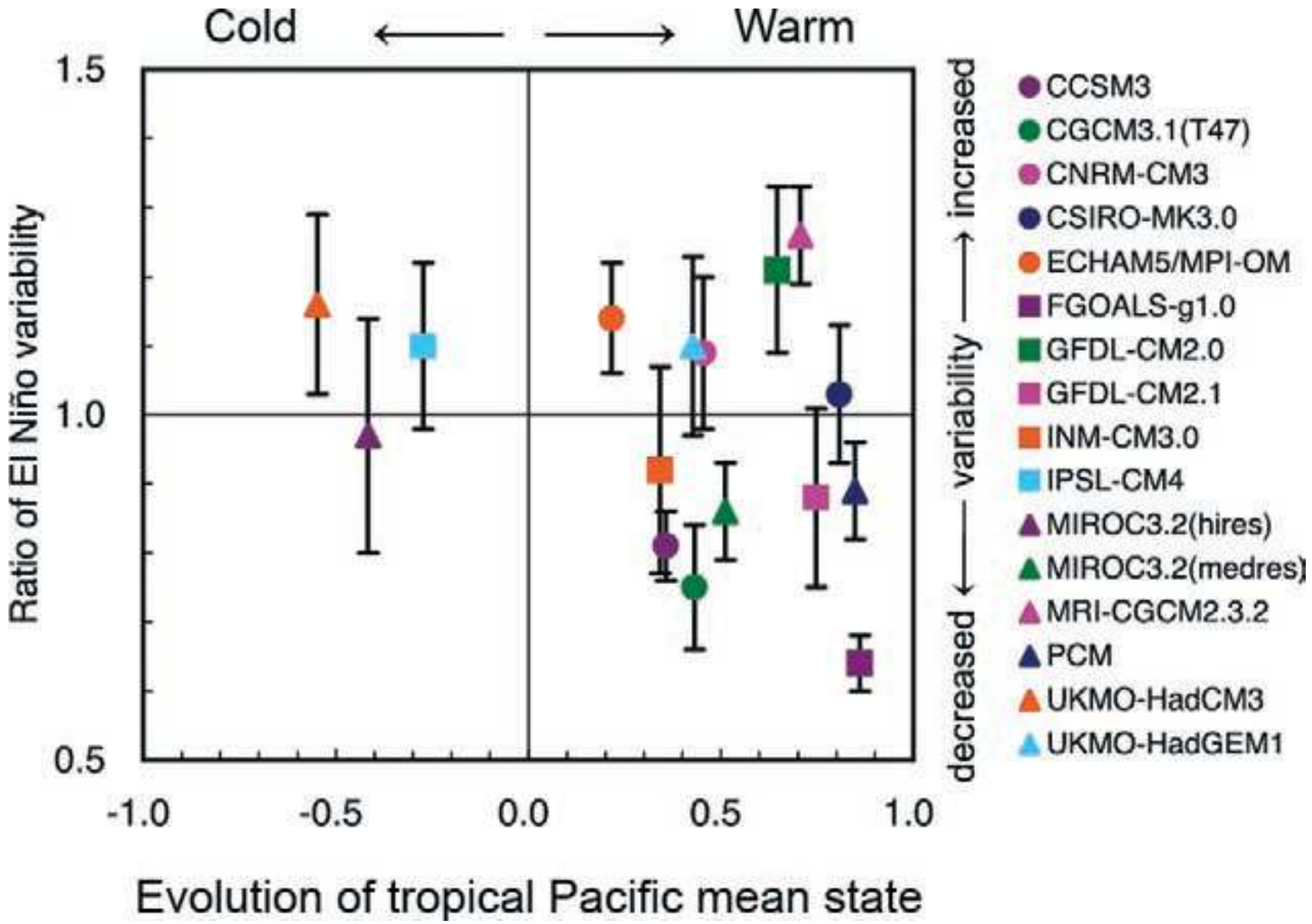
Temporal and spatial coverage is very limited





Helen McGregor / Donders et al. (2008), *Quaternary Sci. Rev.*

But what about the future?



Guilyardi et al. (2009), *Bull. Am. Meteorol. Soc.*

Future challenges

- Extend the temporal and spatial coverage of the marine record, particularly in the Southern Hemisphere

- Fully integrate the palaeoclimate record with climate system models

If we can rise to these challenges, then the time machine on the ocean floor can tell us about the future, as well as the past, of the Earth's climate.

The Past's So Bright, I Gotta Wear Shades...

Timbuk 3 (1986), *Greetings from Timbuk 3*