The tropical time machine:
Past changes, future challenges

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Why does marine science matter?
El Niño events can bring drought to Australia.
But what about the future?

Even the best models disagree

Collins et al. (2010), *Nature Geoscience*
We know that El Niño has changed in the past

- 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

Moy et al. (2002), *Nature*
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

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 \( \sim 2-7 \) 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
The precessional cycle is the driving “signal”
Northern summers were warmer 8,000 years ...
... which enhanced the trade winds in the Pacific

Simulated changes in El Niño variability

Temporal and spatial coverage is very limited

But what about the future?

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.