Public Policy Forum

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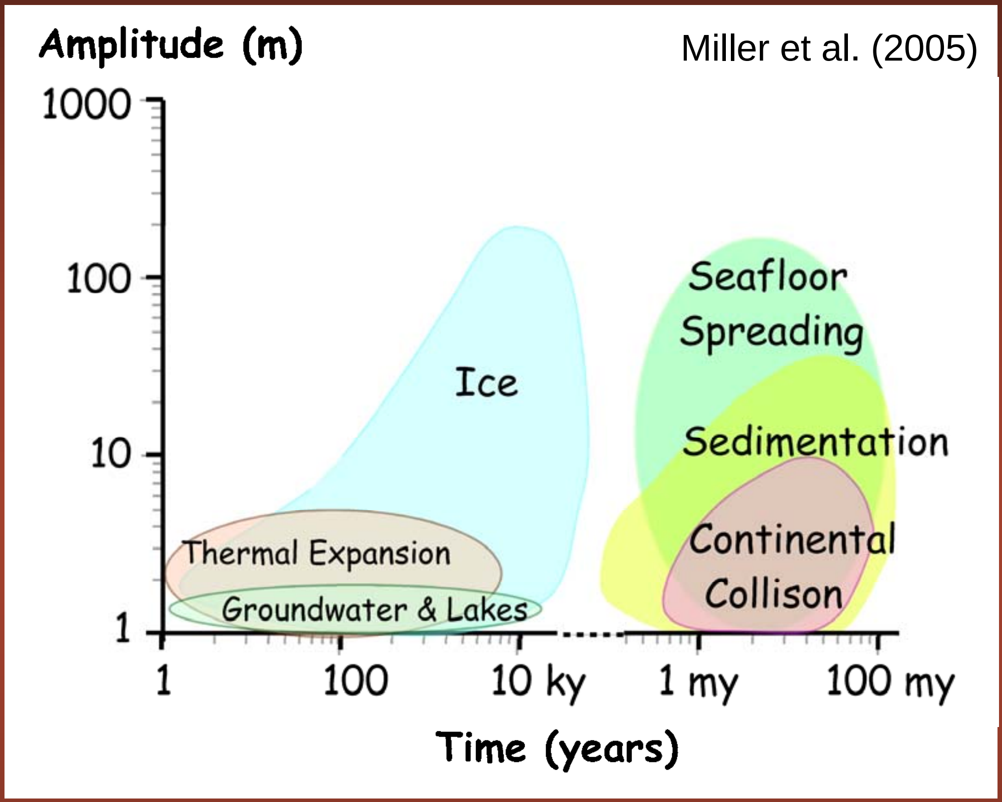
Long-Term Changes in Global Sea Level

Craig S. Fulthorpe

University of Texas Institute for Geophysics

John A. and Katherine G. Jackson School of Geosciences

Causes and Effects of Global Sea-Level Change



Growth and decay of continental ice sheets has been the primary cause of large sea-level changes (e.g., ~120 m lower at last glacial maximum) for at least the last 40 million years

Total potential sea-level rise cause by melting of onshore ice sheets is ~70 m.

- All of Antarctica: ~57-60 m (IPCC)
  - West Antarctic Ice Sheet alone: up to ~7 m
- Greenland: ~7 m

Principal methods for estimating long-term changes in sea-level:

1) Oxygen isotopic record from deep-sea sediments
2) Continental margin sedimentary sequences

1. Oxygen Isotopic Record of Ice Volume and Temperature

• DSDP/ODP/IODP drilling of pelagic sediments has revolutionized climate studies by providing long-term oxygen isotopic records.

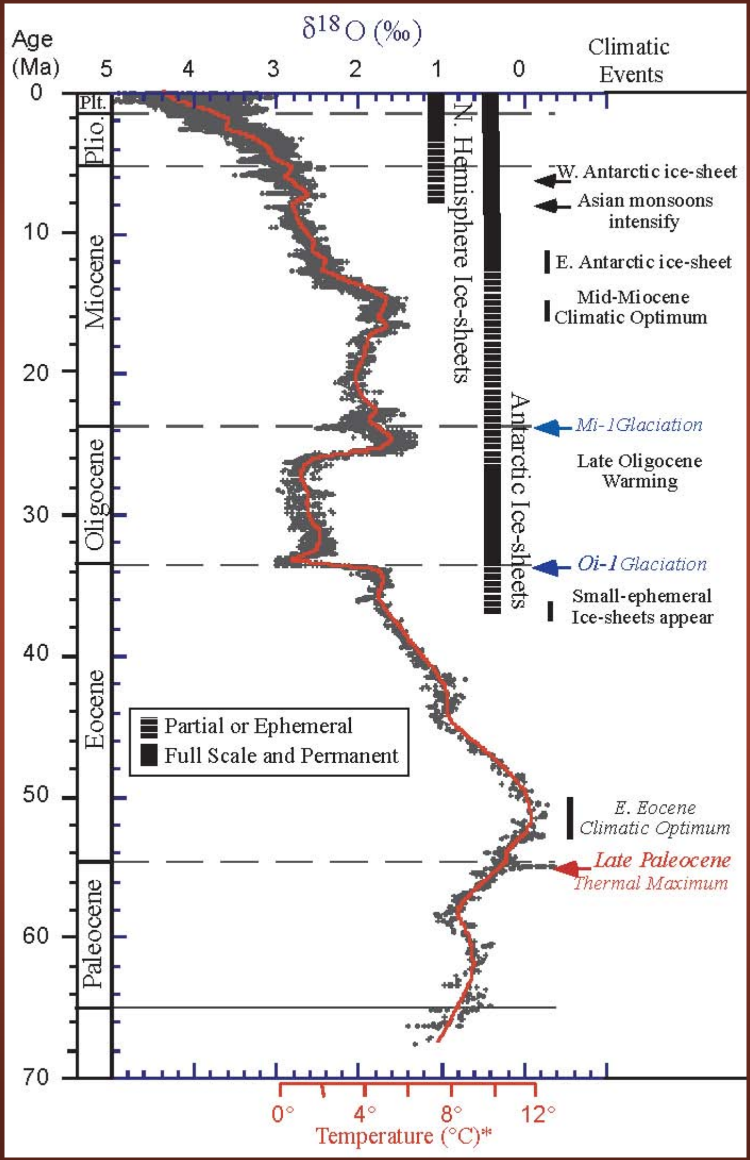
• High-frequency (40 ky – 100 ky), orbitally forced climate change is modulated by long-term changes in plate motion, oceanic gateways and atmospheric CO_2.

Abrupt Events

• PETM (55 Ma): 5-6°C rise in deep-sea temperature in <10 ky (release of methane from marine gas hydrates?)

• Cooling events: Oi-1 (34 Ma), Mi-1 (23 Ma)

Climate, and sea level, do not always respond linearly to forcing

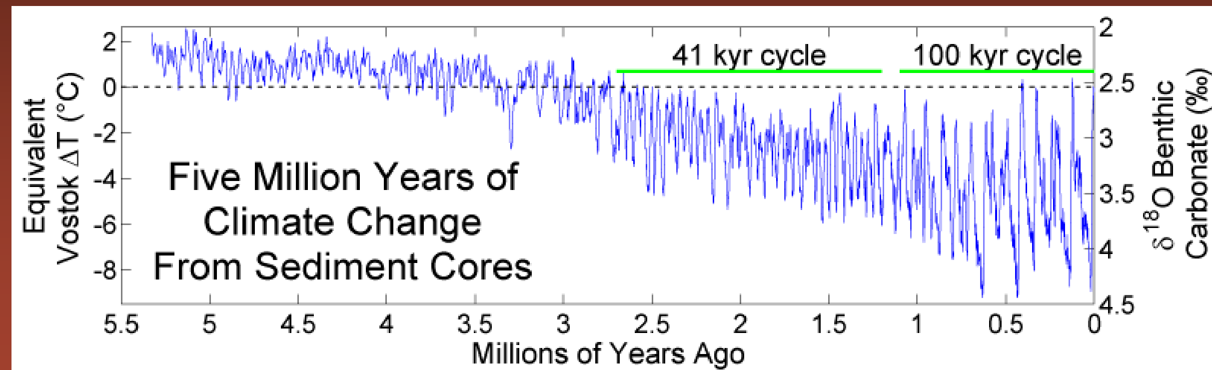


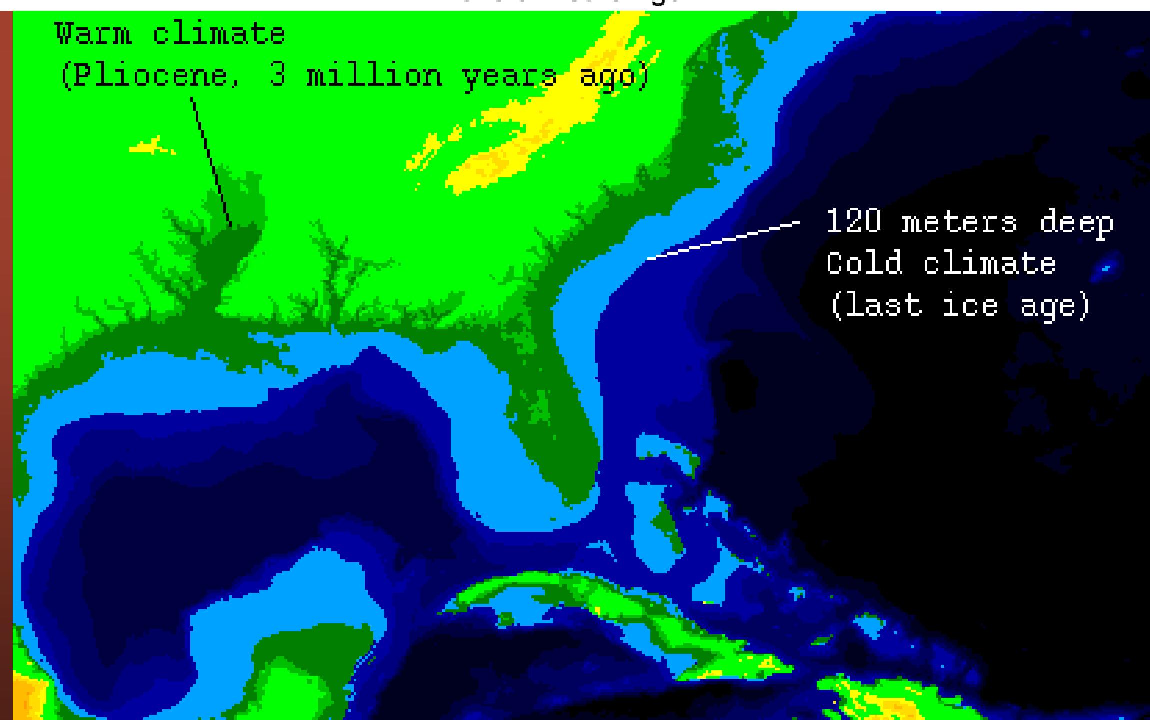
Record from >40 scientific ocean drilling sites (Zachos et al., 2001)

Early Pliocene Warm Period

- No Northern Hemisphere ice, periodic (40 ky) collapse of West Antarctic Ice Sheet.
  - 7-10 m sea-level equivalent.
- CO_2 similar to present, but:
  - ~3°C warmer (IPCC estimate this would require a doubling of CO_2)
  - Sea level ~25 m higher.
- So climate and sea level were more sensitive to CO_2 variation than today.
- Provides a glimpse of the future Earth system.

After Lisiecki and Raymo (2005). Figure by R. Rohde, Global Warming Art project.





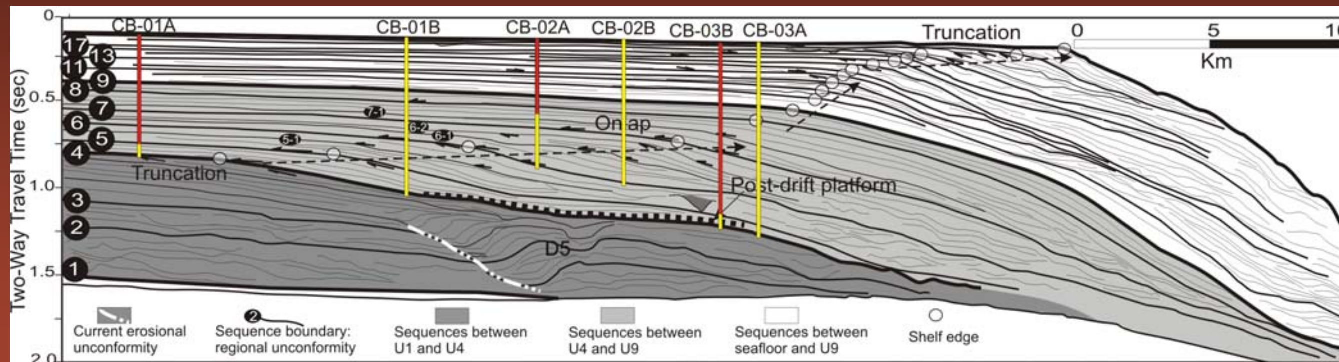
Schweitzer and Thompson (1996); USGS Open-File Report 96-000

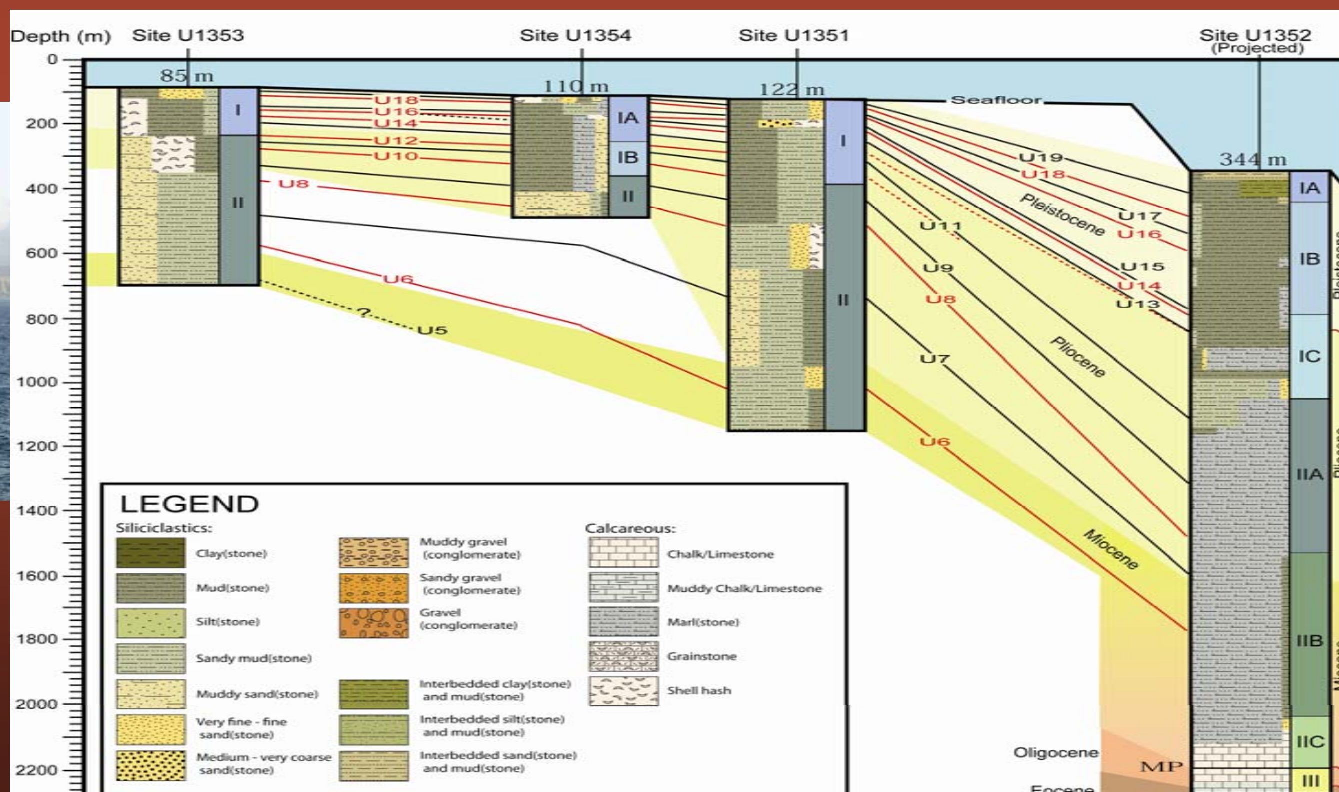
2. Estimating Sea-Level Change Using Continental Margin Drilling Transects

- Targets the environment directly affected by sea-level change

Integrated Ocean Drilling Program
United States Implementing Organization

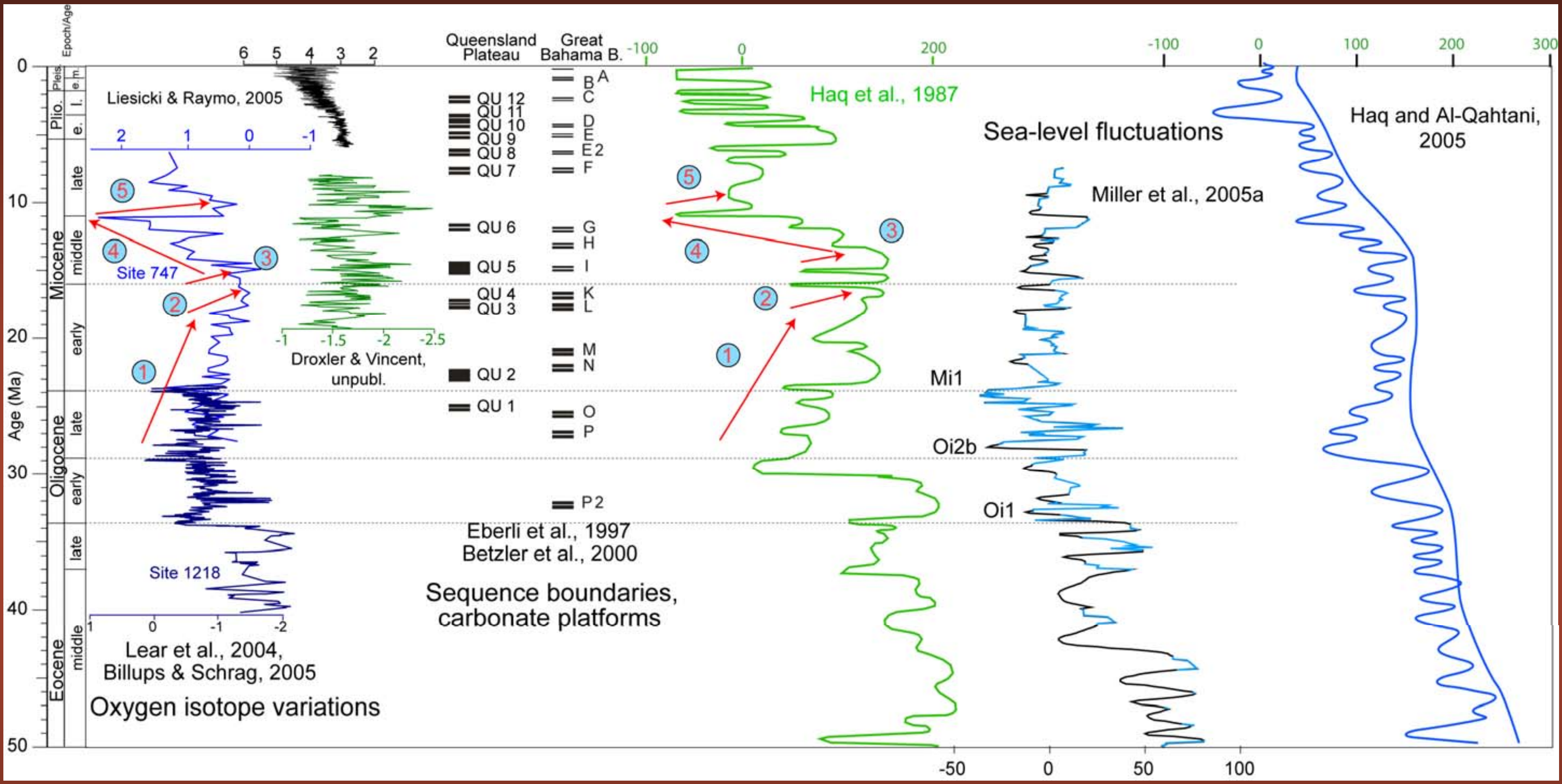
Expedition 317: Canterbury Basin, New Zealand





- **Thick early Pliocene section**

Climatic and Global Sea-Level Records



Stratigraphic signature of the Neogene (Bartek et al., 1991)

Figure by A. Droxler, Rice University

1) Late Oligocene-early Miocene aggradation, backstepping and partial drowning
2) Late early Miocene-early middle Miocene vertical growth or aggradation
3) Earliest middle Miocene downward shift of deposition
4) Late middle Miocene systematic lateral growth (progradation)
5) Late Miocene-early Pliocene re-flooding and aggradation

Importance of Studying Past Sea-Level Change

- The geologic record provides an opportunity to quantify the timing, amplitudes, rates, mechanisms/controls, and effects of global sea-level change.
- This record can tell us:
    - How the earth system has operated during past abrupt climate changes and under past conditions of extreme climate forcing.
    - The potential sea-level response (rates and amplitudes) to elevated CO_2 levels.
- Improved understanding of the long-term record of global sea-level change:
    - Enables critical evaluation of computer model predictions.
    - Improves our ability to predict the societal impact of future sea-level change and allow us to better assess the contribution of greenhouse gases.

THE UNIVERSITY OF TEXAS AT AUSTIN
JACKSON
SCHOOL OF GEOSCIENCES

craig@ig.utexas.edu
www.ig.utexas.edu