



# Public Policy Forum

10 March 2010

## Long-Term Changes in Global Sea Level

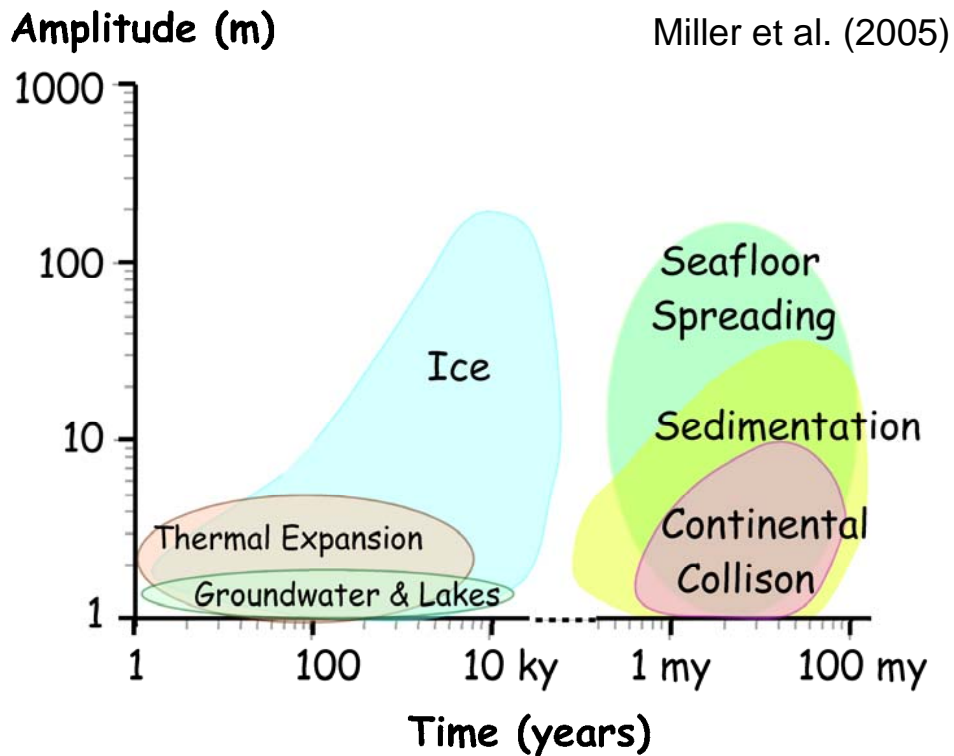
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# Causes and Effects of Global Sea-Level Change



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

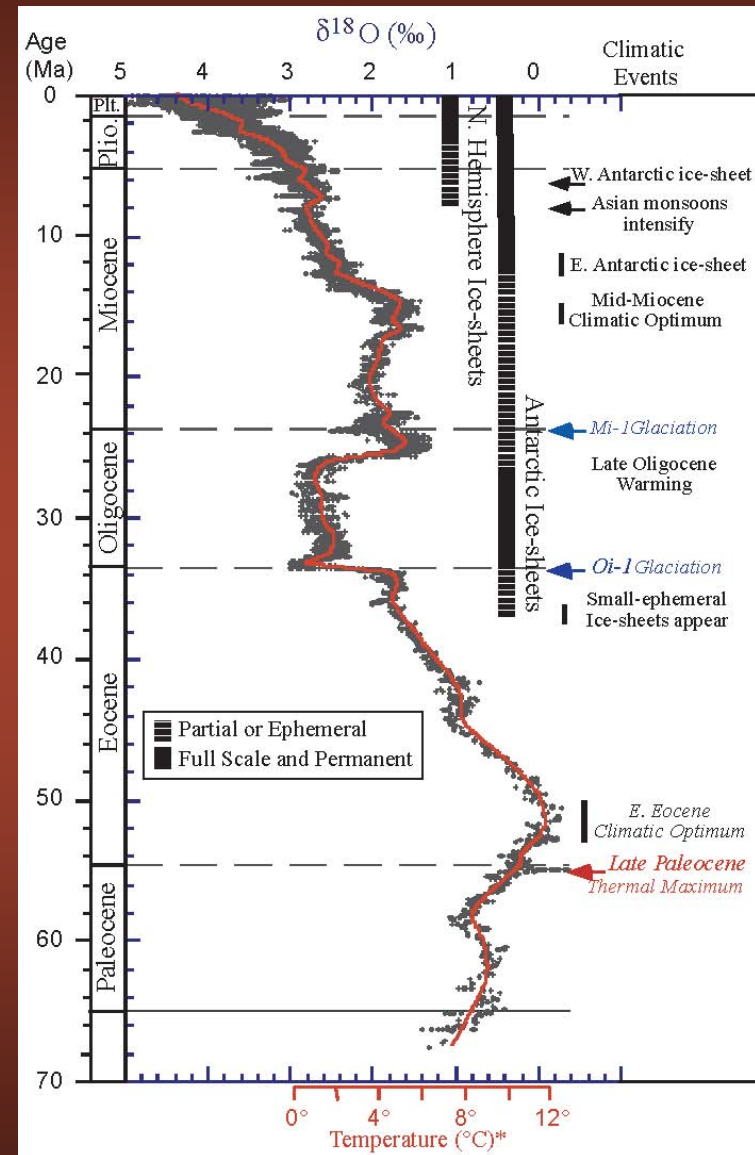
# 1. Oxygen Isotopic Record of Ice Volume and Temperature

- 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<sub>2</sub>.

## 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**

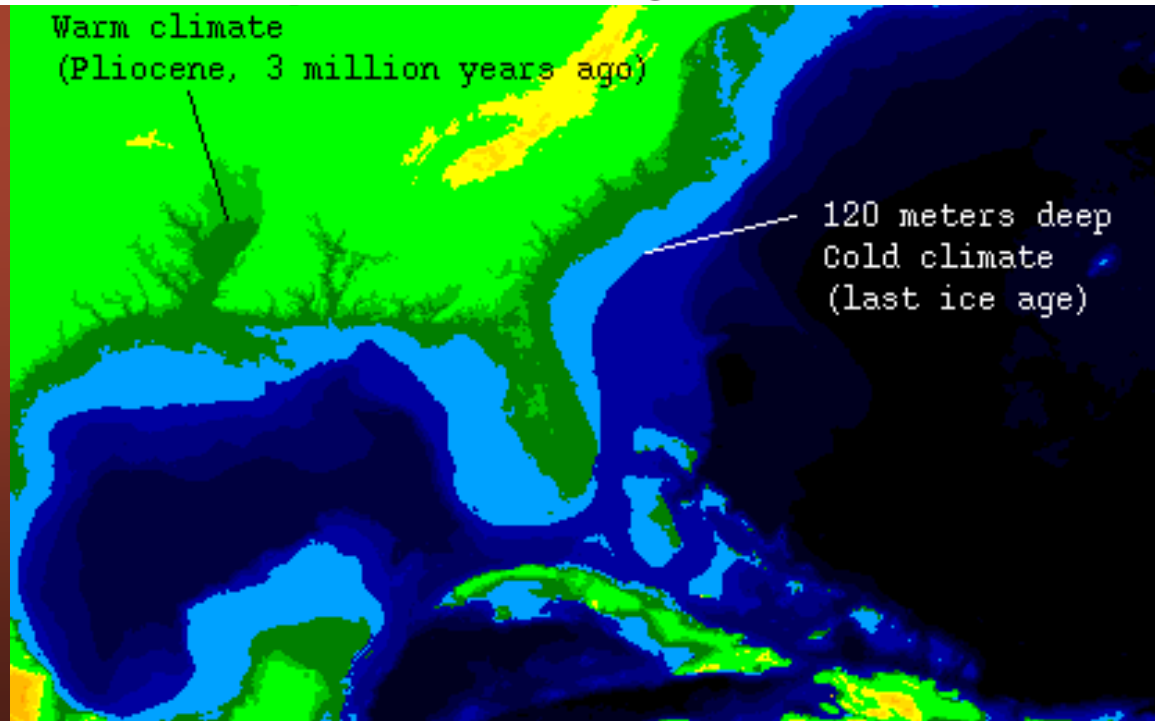
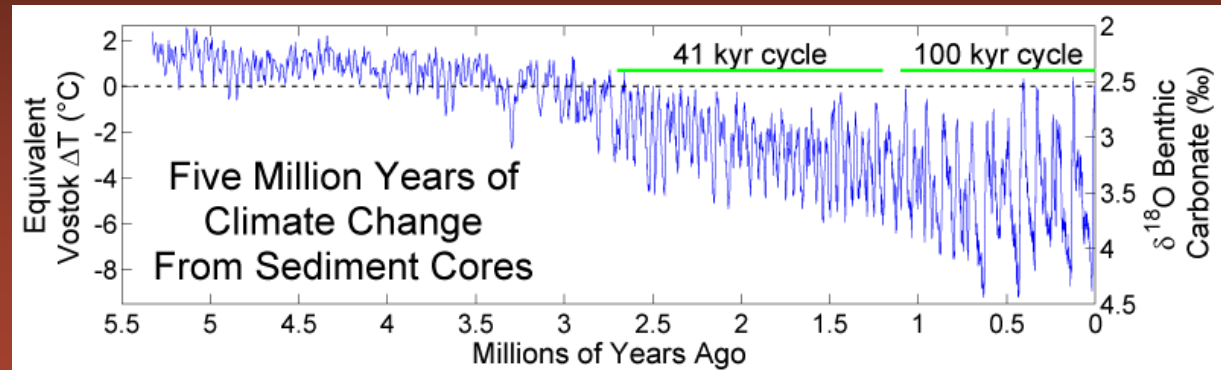


Record from >40 scientific ocean drilling sites (Zachos et al., 2001)

# Early Pliocene Warm Period

- No Northern Hemisphere ice, periodic (40 kyr) collapse of West Antarctic Ice Sheet.
  - 7-10 m sea-level equivalent.
- CO<sub>2</sub> similar to present, but:
  - ~3°C warmer (IPCC estimate this would require a doubling of CO<sub>2</sub>)
  - Sea level ~25 m higher.
- So climate and sea level were more sensitive to CO<sub>2</sub> 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



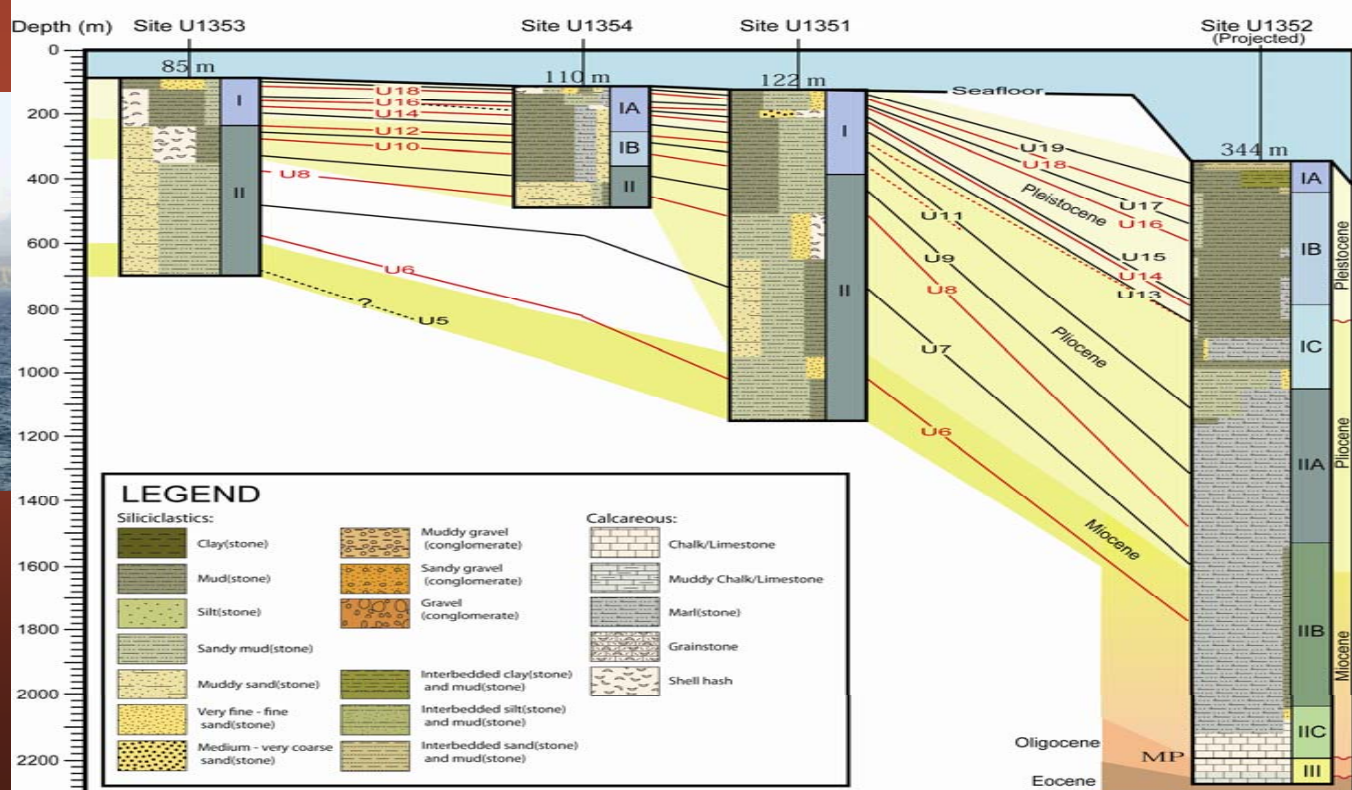
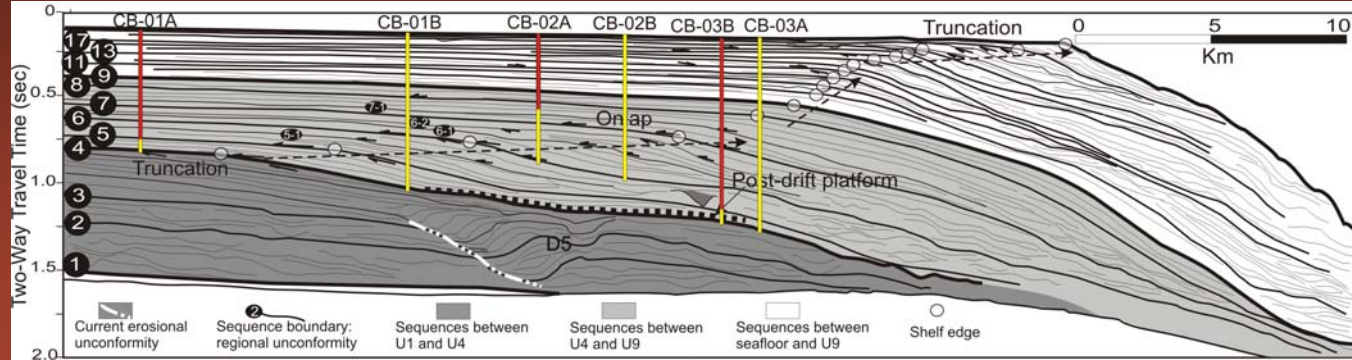
# 2. Estimating Sea-Level Change Using Continental Margin Drilling Transects

- Targets the environment directly affected by sea-level change



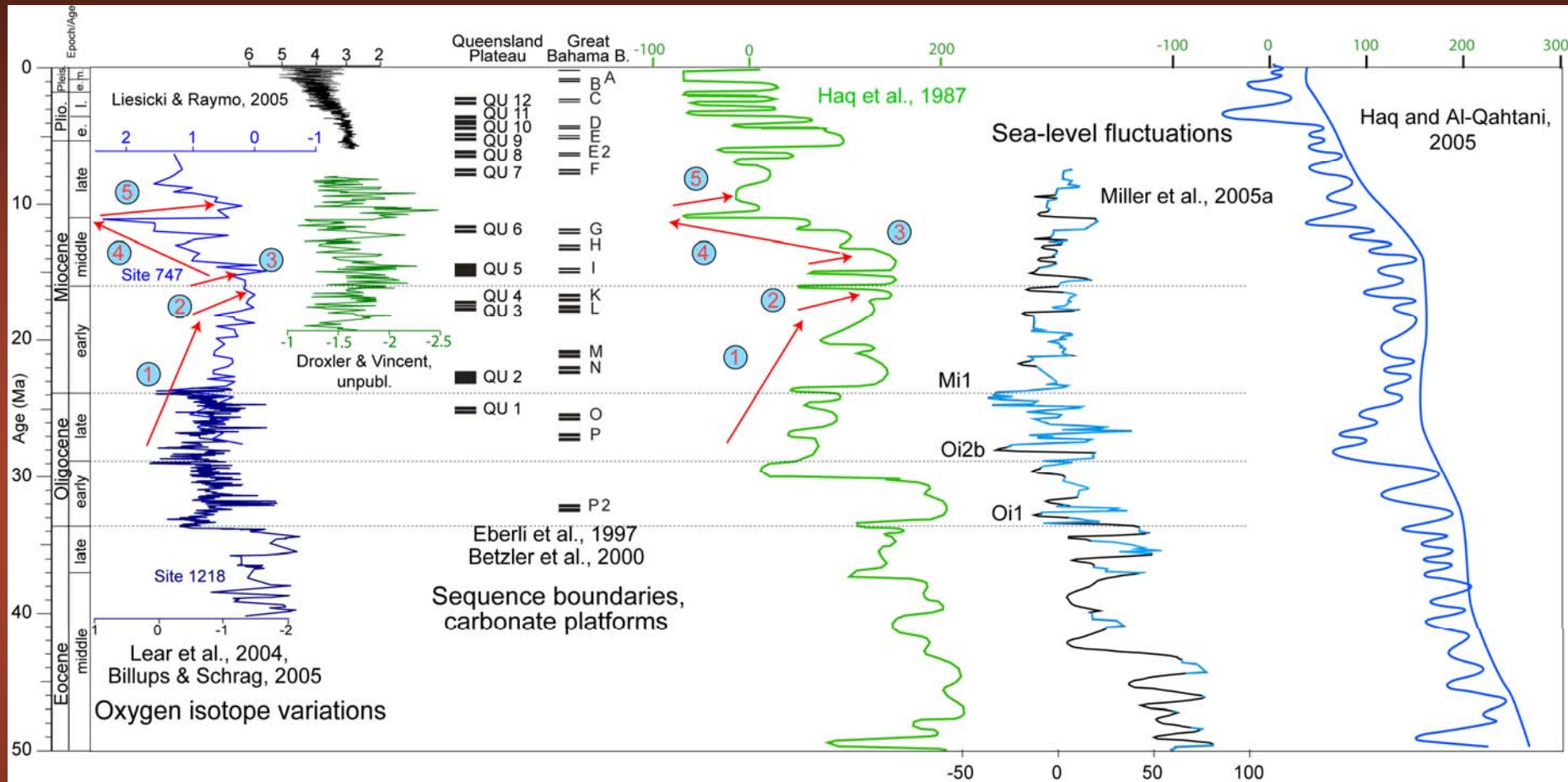
Integrated Ocean Drilling Program  
United States Implementing Organization

## 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<sub>2</sub> 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.