Tues Feb 18: Outline

Announcements/discussion:
- Tues, 12:30, here: WX discussion (Mark Stoelinga)
- Wed, 12:30, 425 OSB: Sea-ice thickness studies
- Thurs, 3:30, Phys-Astr A118: "Millenial-scale climate change"

Next Friday (Feb 28):
- Option 1: Abstract #2 due
- Option 2: First draft due

Today: Pleistocene Glaciations:
- Evidence
- Timing

Wed: Pleistocene Glaciations:
- Causes
  >orbital parameters
  >amplifiers

Thurs: Volcanoes and Climate
Sun and Climate

Friday: El Nino

Questions

Figure 11-9:
(a) 200,000 years ago, was the volume of water contained in polar ice caps high or low?
(b) Give the time of a major melting event that occurred more than 50,000 years ago. Was solar energy in June in the Northern Hemisphere high or low at that time?
(c) Which panels come from measurements and which ones come from a mathematical model?
(d) In your own words, state the conundrum associated with the eccentricity orbital parameter.
(e) Does δ¹⁸O go up or down during glacial conditions? Why?

Figure 11-4 and Figure 11-9:
(a) Figure 11-4 shows an oscillating system. Identify two major transitions in the nature of the oscillations. Give the time of the transitions and describe.
(b) Does the data in Figure 11-4 agree with the data in Figure 11-9? Find examples of agreement and disagreement.

Tues Feb 19: Outline

Announcements/discussion:
- discussion of WX discussion?
- Wed, 12:30, 425 OSB: Sea-ice thickness studies
- Thurs, 3:30, Phys-Astr A118: "Millenial-scale climate change"

Report grading

Today: Pleistocene Glaciations
- cool movie on "evidence"
- recovery from yesterday's confusion…
  (raise higher-level questions)

Thurs: Volcanoes and Climate
Sun and Climate

Friday: El Nino

Goals for reports:
Critical thinking on a scientific issue.
Clear presentation of an argument that starts with questions, grapples with evidence, and arrives at conclusions that grow out of the source material.
Follows the format of a scientific paper - a method of presentation designed to enable criticism by others.

Grading form:
Format [40]
follows assigned structure
proper citations of source material
style, grammar

Content [40]
accurate, fair use of sources
logic and completeness (e.g. addresses questions?)
short argument (questioning, judging, balancing)
different arguments
focus on scientific (esp. climate) issues

Effort [20]
originality, enthusiasm
use of scientific literature (web counts for less)
incorporation of concepts from course figures or tables that you make or annotate
and that fit into your analysis
[note: figures copied from web without annotation or careful explanation don't count for much]

Pleistocene Glaciations: Overview

Geological evidence
abundant, overwhelmingly convincing
 timing info is not precise (remember Arrhenius, 1896)

Ocean sediments
δ¹⁸O provides record of glacial ice amount
detailed, precise timing information
timing seems to correspond to orbital parameters

Orbital parameters
precession (23 k.y.), tilt (41 k.y.), eccentricity (100 k.y.)

Cause of glacial oscillations (theory)
orbital trigger involving N. Hem. Summer
ice-albedo feedback
CO2 as contributing driver

Problems
eccentricity: tiny trigger but dominant oscillation
timing not always logical for specific events
lapse rate in the Tropics

Wed Feb 20: Outline

Announcements/discussion:
- Sea-ice thickness talk?
- TODAY: 3:30, Phys-Astr A118: "Millenial-scale climate change"

Today and tomorrow:
Pleistocene Glaciations wrap-up
transition to recent climate variations
Volcanoes and Climate
Sun and Climate
El Nino

Theme (or focus) - how these help us evaluate:
- the global warming theory (and criticism of it)
- the potential for future climate change
Pleistocene Glaciations: Overview

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Pleistocene Glaciations: Lessons

1. Current climate is not the only possible one for Earth
   (indeed, glacial conditions seem to be preferred)
2. A change in surface temperature of about -6°C is associated
   with a massive climate shift
3. Global climate and CO₂ appear to be intimately intertwined
4. If the orbital parameter theory is right, small triggers can
   produce major climate changes under some conditions
5. But... there are many remaining questions and enigmas

Paleoclimate: Why study?

We address questions like:
Has climate changed in the past?
How much?
How fast?
The answers provide a context for assessing potential climate
changes in the future.

Moreover, paleoclimate studies may give us insights into
- mechanisms of climate change
- functioning of the Earth system
- stabilizing or amplifying feedbacks

Fri Feb 21: Outline

Announcements/discussion:
- "Millennial-scale climate change" talk

Today:
Recent climate changes
Volcanoes and Climate
Sun and Climate
El Nino

Next week:
Global warming science

Week nine:
Global warming debate
(Tad gone Mon-Thurs)

"Millennial-scale climate change" talk
Eric Steig and Gerard Roe, 20 Feb, 2003

Mostly about glacial periods (not recent)

Are climate changes in N. Hem polar regions related to climate
changes in S. Hem polar regions?
>>> PROBABLY NOT

Lots of statistical analysis (autoregression model):
- thermal inertia in climate system produces variability on
  long time scales: No forcing mechanism as long time
  scales is required to explain this.
- most hypotheses about what drives the climate
  changes at both poles cannot be supported by the data
- climate variability during the Holocene is very different
  from variability during glacial periods

data sets and data quality:
δ¹⁸O in ice-cores responds to temperature, not glacial volume
exquisite knowledge of timing for Greenland ice-cores
due to annual layers
using methane, etc., can transfer this knowledge to Antarctic
ice-cores
ocean sediment cores - timing not well known

Recent climate changes

History of the Holocene (12:232-236 - not required)
- wild swings coming out of latest glaciation
  (Younger-Dryas)
- warm period 5000-6000 yr b.p.
- cool period ~3000 yr b.p.
- Medieval warm ~1000 yr b.p.
- Little Ice Age ~300 yr b.p. (1400-1850 A.D.)
Recent climate changes

Our focus:
Volcanoes and Climate
Sun and Climate
El Nino

Motive: context for assessing the question of future climate change

1. Key criticism of global warming theory:
   - recent warming is natural
   - warming is within the range of natural variability
   - Earth is just coming out of the Little Ice Age
   - variations are all due to the sun (as shown by correlations)

2. Key tests of "energy balance theory of climate change":
   - volcanic events
   - we know the forcing (approximately)
   - we can measure the response

3. Some claims about climate change need careful scrutiny
   - El Nino events are increasingly common and severe

Variations of the Earth’s surface temperature for the past 140 years

Variations of the Earth’s surface temperature for the past 1,000 years

Sunspots Number = 134  (11 Feb, 2003)

http://www.spaceweather.com

Note:
The number of visible spots is roughly the sunspot number divided by 15

http://science.nasa.gov/spaceweather/images2003/20030210/sun030210.gif
http://www.spaceweather.com

http://science.msfc.nasa.gov/ssl/pad/solar/images/zurich.gif
http://science.nasa.gov/spaceweather/images2003/20030210/sun030210.gif
http://www.spaceweather.com
Estimated solar irradiance variations 1750-2000

ENSO Record* … Trend?

*As shown by changes in sea surface temperature (relative to the 1961-1990 average) for the eastern tropical Pacific off Peru.