Section 5-6: Paleoclimate

Outline

5-6.1 Introduction

5-6.2 Tools for assessing climate variability over long time periods

5-6.3 Patterns of climate variability over 2-100s of million years ago

5-6.4 Patterns of climate variability during Pleistocene (2 million to 10,000 years ago)

5-6.5 Patterns of climate variability during Holocene (10,000 years ago to present)

5-6.6 Rate of paleoclimate change

GEOG 313/513
Fall 2014
Learning outcomes

- be able to describe some of the important tools that climatologists have used to quantify past climate
- understand that Earth’s climate has been both much warmer and much colder in the distant past
- be able to explain the different forcings that have influence Earth’s climate over eons because of different factors as well as the role of feedbacks
- recognize that although climate sometimes takes 100s to 1000s of years to change, records indicate that sometimes climate changes quickly within 20 years
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Tree rings
Tree rings

- Pith
- Good growing conditions
- Harsh growing conditions
- Annual rings
- Bark

Earlywood
Latewood

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Interpreting climate from tree rings

knowledge.allianz.com/environment/climate_change/?619/earths-climate-history-written-in-ice-wood-stone
Crossdating tree rings to extend record backward in time

www.priweb.org/globalchange/climatechange/studyingcc/scc_01.html.
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Dendrochronology back 2000 years

Bristlecone pine - tree ring widths

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Ice cores
Section 5-6: Paleoclimate

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5-6.6 Rate of paleoclimate change
Geologic periods

Kitchen, 2013

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Changes in climate and $\text{CO}_2$

http://www.clearlight.com/~mhieb/WVFossils/Carboniferous_climate.html
Slow cooling over 10s of millions of years

65 million years of climate change

- Paleocene-Eocene Thermal Maximum
- India collides with Eurasia
- Mid Eocene warming
- Small ice sheets appear
- Late Oligocene warming
- Mid Miocene warming
- Early Greenland glaciation
- Recent glaciations

Oxygen isotope D18O from benthic foraminifera

Antarctic ice develops

Arctic ice develops
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T about 1950

Five Million Years of Climate Change From Sediment Cores

www.globalwarmingart.com
Pleistocene Glacial Periods
Pleistocene Temperature, Sea Level

Temperature and sea level change over the last two million years

- ~5 °C
- ~300'
If West Antarctica sheet melted...

William Haxby, Lamont-Doherty Earth Observatory

5 Meters (18 Feet) Sea Level Rise
CO$_2$ Changes Follow Temperature Changes

Antarctica Vostok ice core

Years before present

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CO$_2$ higher than any time in last 400,000 years
"LGM"

Last Glacial Maximum (18,000 \(^{14}C\) years ago)

Differences in vegetation types

www.esd.ornl.gov/projects/qen/nerc.html

Closed Forest (>70% canopy cover)
Extreme Desert (<2% vegetation cover)
Vegetation cover changes from LGM to present in Europe

Image Credit: Earth’s Climate by W. Ruddiman

Slide courtesy C. Still
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GEOG 313/513
Fall 2014
Holocene Temperature Variations

End of Last Glacial Period

Climatic Optimum?

Recent Proxies

2004

Temperature Anomaly (°C)

Thousands of Years BP

www.globalwarmingart.com
Historical (last 2,000 years) climate change
Section 5-6: Paleoclimate

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Rapid climate change in the past

Greenland GISP core 2

Dansgaard–Oeschger events

Bølling–Allerød event

Younger Dryas event

Thousands of years ago

Temperature (°C)

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Freshening of N. Atlantic, changes in AMOC