



Additional Courses Teaching Aspects of Paleoclimatology

- GEOS 108N – Climate Change: Past&Future
- GEOG 322N – Weather & Climate
- GEOS 382 – Global Change
- FOR 407 – Biogeochemistry
- GEOG 550 – Seminar in Paleoclimate & Global Change



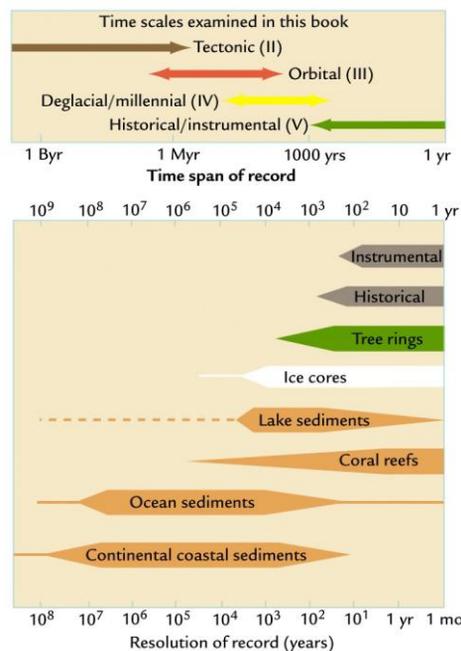
5 billion years of Earth's climate history – take home message

- What is the importance of proxy data?
- Why do scientists study paleoclimate?
- What can paleoclimates tell us about our current climate?
- Any questions on what was covered last time?

Climate Change of the Last 2000 Years

Dr. Faith Ann Heinsch
September 9, 2008

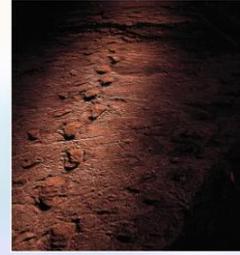
Time scales for Proxy Data



Anthropocene

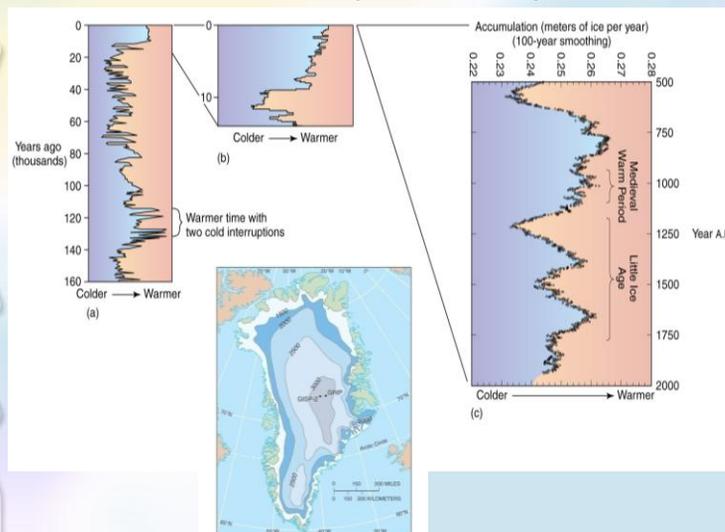


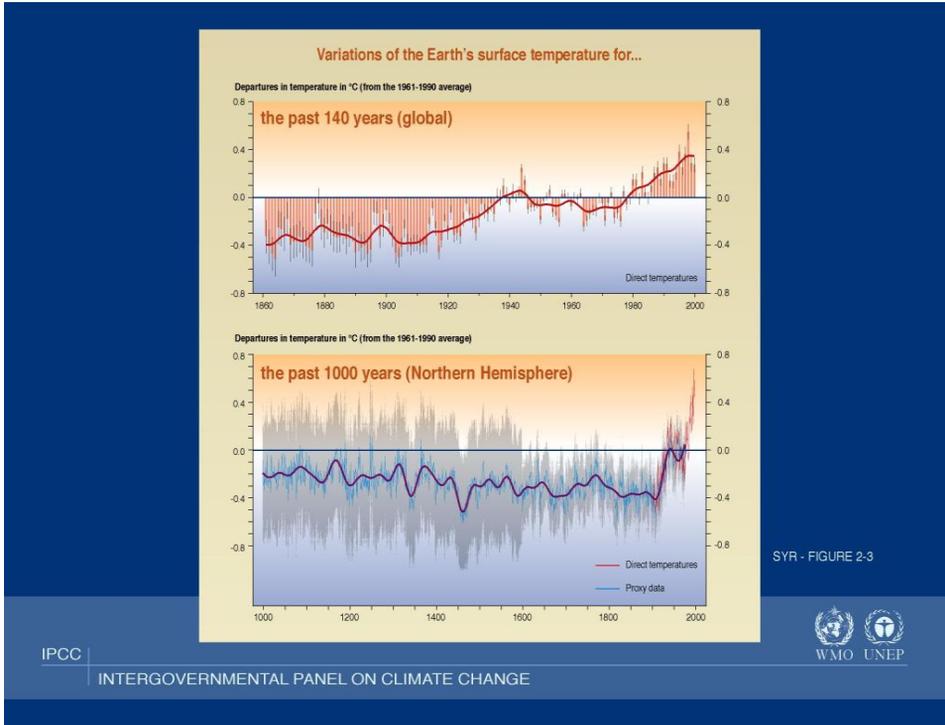
- Term used for climate where humans are the dominate controlling mechanism...
 - Concept first proposed in 1979 by Sagan
 - Phrase coined by Crutzen in 2000
 - Nobel prize winning chemist for his work on ozone depletion
 - No precise start date.
 - May be considered to start in late 18th century
 - Ruddiman proposes it started much earlier...8,000 years ago



Last 2000 years....

- Greenland Ice Cores:
 - High resolution record of temps near Europe...





Medieval Warm Period (~800-1300)

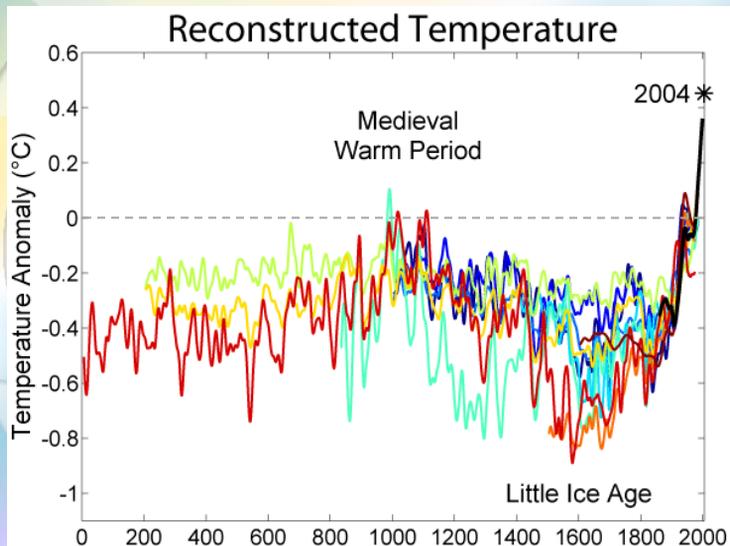
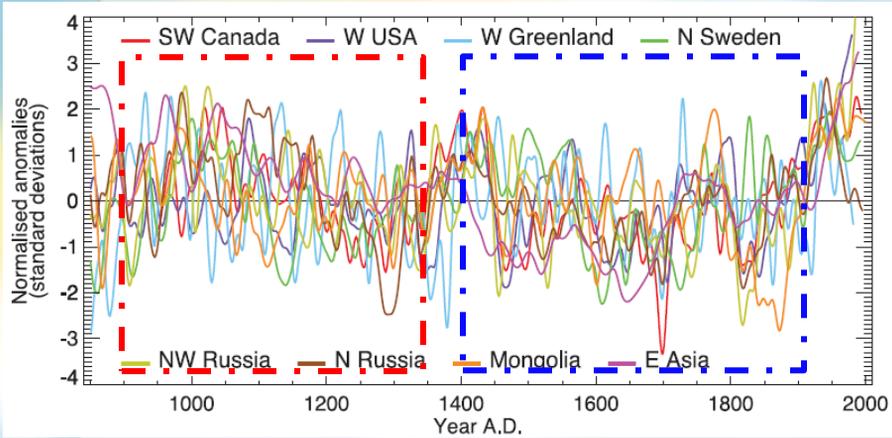


Image Credit: Robert A. Rohde,
Global Warming Art

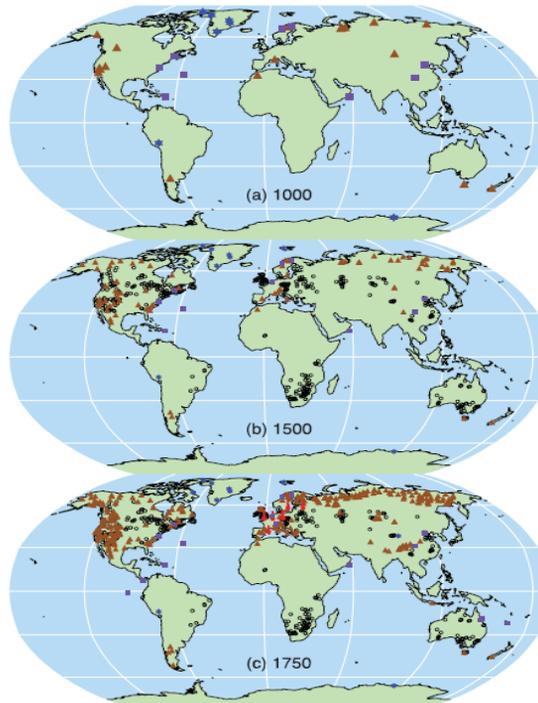
Medieval Warm Period (~800-1300)



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Proxy Records

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Where do they come from?



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Medieval Warm Period (~800-1300) (a.k.a. Medieval Climate Optimum)



Medieval Warm Period (~800-1300)

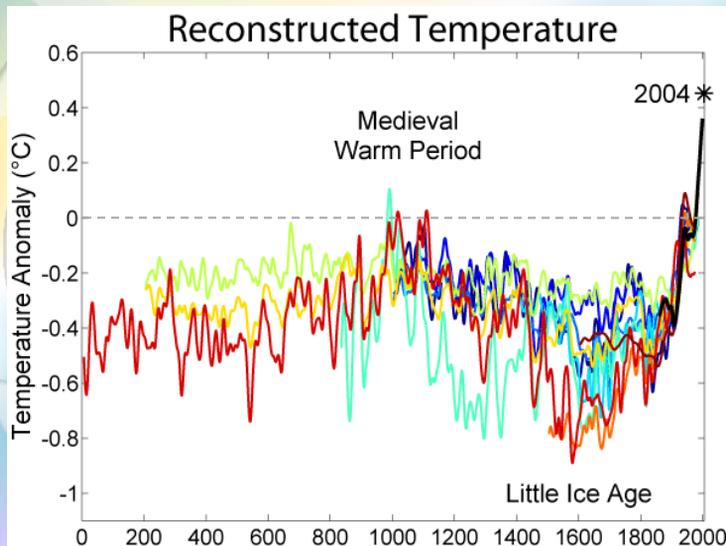
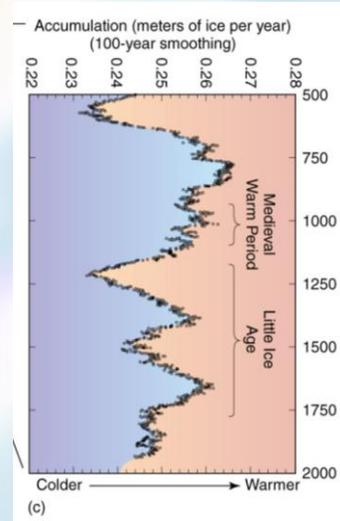


Image Credit: Robert A. Rohde,
Global Warming Art

Medieval Warm Period (~800-1300)

- Scattered evidence exists in Europe and the high latitudes surrounding the North Atlantic.
 - Cultivation of Greenland & Iceland
 - Grapes in England?
 - Medieval temperatures were probably 1-2°C above early 20th century levels at various European locations
 - Evidence in Japan, Alaska
 - Regional in nature
 - There were both warmer and colder areas
- Drought was evident in western U.S. (Anasazi), Central America (Mayan) & Africa



Medieval Warm Period (~800-1300)

“Evidence is not sufficient to support a conclusion that hemispheric mean temperatures were as warm, or the extent of warm regions as expansive, as those in the 20th century as a whole, during any period in medieval times.”
(IPCC 2007)

The Little Ice Age (1400-1900)



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The Little Ice Age (1400-1900)

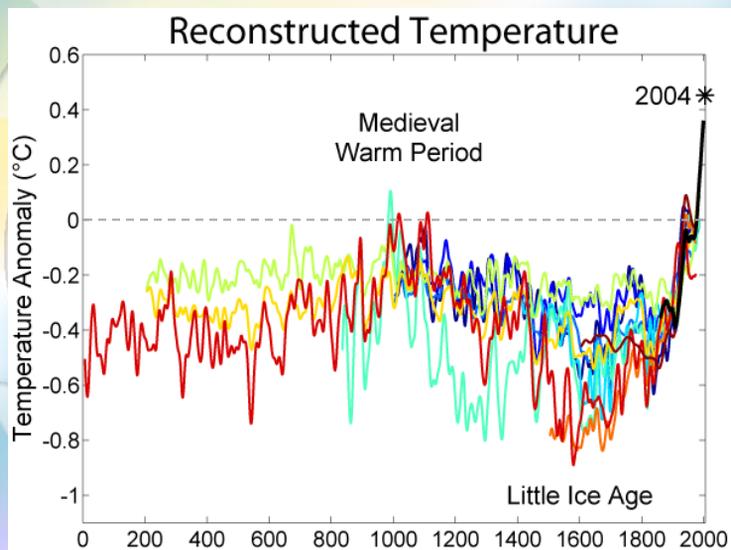
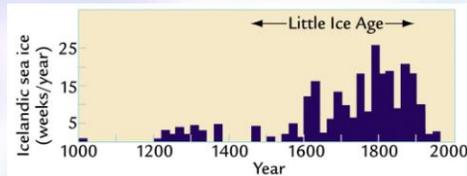


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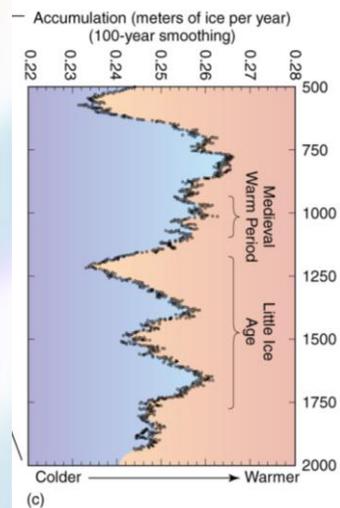
Little Ice Age (1400-1900)

- A modest cooling of the Northern Hemisphere of less than 1°C
 - Glaciers grow in Europe (1000 m lower than in 1850s)
 - Sea ice expansion
- Three minima, each separated by slight warming intervals beginning
 - About 1650
 - About 1770
 - About 1850
- Initially believed to be a global phenomenon; now less clear



Little Ice Age (1400-1900)

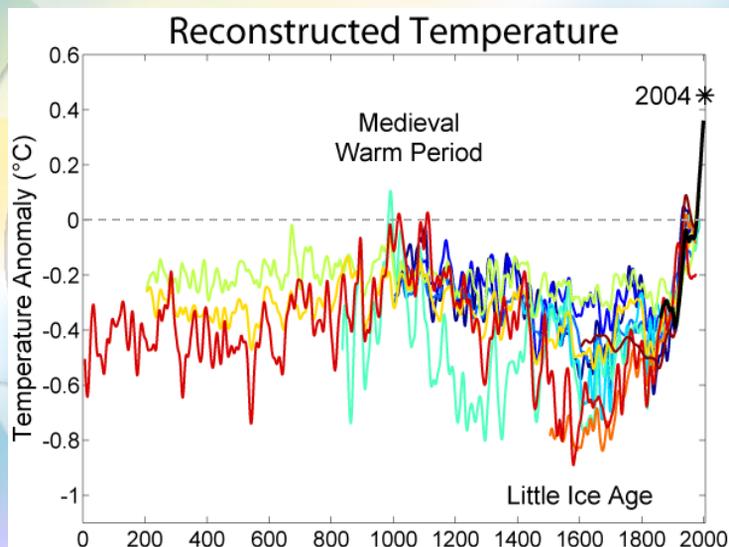
- Colder winters & shorter growing season meant crop failure and localized famine in northern regions of Europe
 - Great Famine of 1315-1317 (full recovery in 1322)
 - By the 1700s, cultivated land (MWP) in Iceland was covered by ice
- Settlements in Greenland were abandoned
 - Marginal climate?
 - Conflicts with native peoples?
- Large-scale advances of glaciers
- **Not a "true" ice age** since major ice sheets did not form



Proposed causes of climate change from 1000-1850

- Orbital forcing
 - Decreasing summer insolation (tilt and precession cycles)
 - Only explains about half the amount observed in reconstruction for northern hemisphere (0.1°C)
- Millennial bipolar seesaw
 - Insufficient data to test
- Solar variability
 - Maunder Minimum
 - 11-year Sunspot cycle
 - Recent research minimizes this effect

The Little Ice Age (1400-1900)



*Image Credit: Robert A. Rohde,
Global Warming Art*

Proposed causes of climate change from 1000-1850

- Volcanic eruptions



- Sulfate aerosols
- The more frequent clusters of eruptions after 1300 could have contributed to the small cooling trend in the LIA

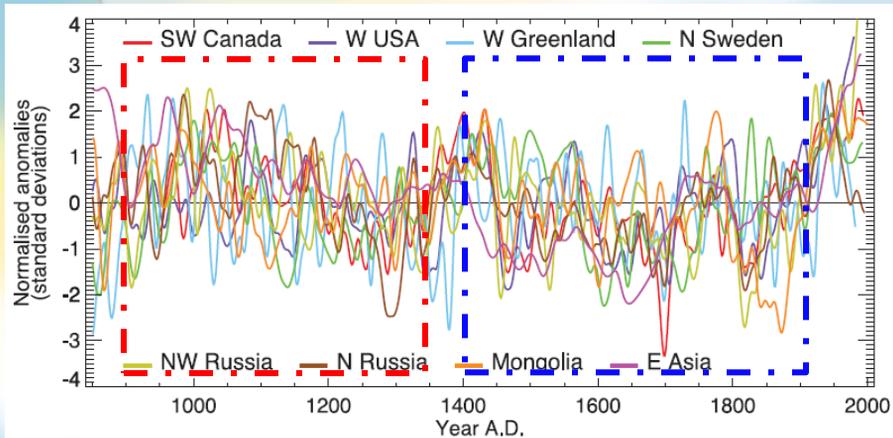
- Greenhouse-Gases

- Drop in CO₂ concentration by 7-8 ppm from 100-1200 to 1600-1800
 - Solar-volcanic changes
 - Anthropogenic hypothesis
 - Reforestation of agricultural land
 - The "Black Death" (bubonic plague)
 - The American Pandemic (host of diseases)

Proposed causes of climate change from 1000-1850

- Evidence for MWP is uncertain
 - Fewer records; larger uncertainties
- Estimated cooling from 1000 years ago into the LIA is small
- Any or all of several factors could have played a causal role
- Far greater geographic coverage is needed to define the *global* climatic response
 - Notion of MWA & LIA is valid for trends across eastern Canada, Greenland, Iceland, northern Europe – what about rest of earth's surface (90-95%)?
- No such ambiguity exists about the large, rapid and global warming since 1850

Medieval Warm Period (~800-1300)



IPCC 2007

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