

Class 10: Paleoclimate I - Industrial & Holocene records

- What is the history of global temperature since the last glacial waned (11,000 years ago)
- Climate/civilization interactions

Learning Objectives

- Understand and be able to sketch the history of global temperatures over the last ~11,000 years
- Describe one hypothesized instance of changing climate influencing an early human civilization
- Describe one hypothesized instance of early humans influencing climate
- Be able to construct a rational argument in defense of or opposition to the hypothesis of anthropogenic climate change starting before the beginning of the industrial revolution around 1850 AD

Field Trip for 195!

- Sign up with link!
- Bring snacks, layers, sturdy shoes, rain gear, notebook/pencil!
- Meeting in parking lot behind Delehanty Hall 10 minutes before trip leaves.

Climate in the News

TheUpshot

THE NEW HEALTH CARE

The Real Problem With Beef

An extensive study confirms that red meat might not be that bad for you. But it is bad for the planet, with chicken and pork less harmful than beef.



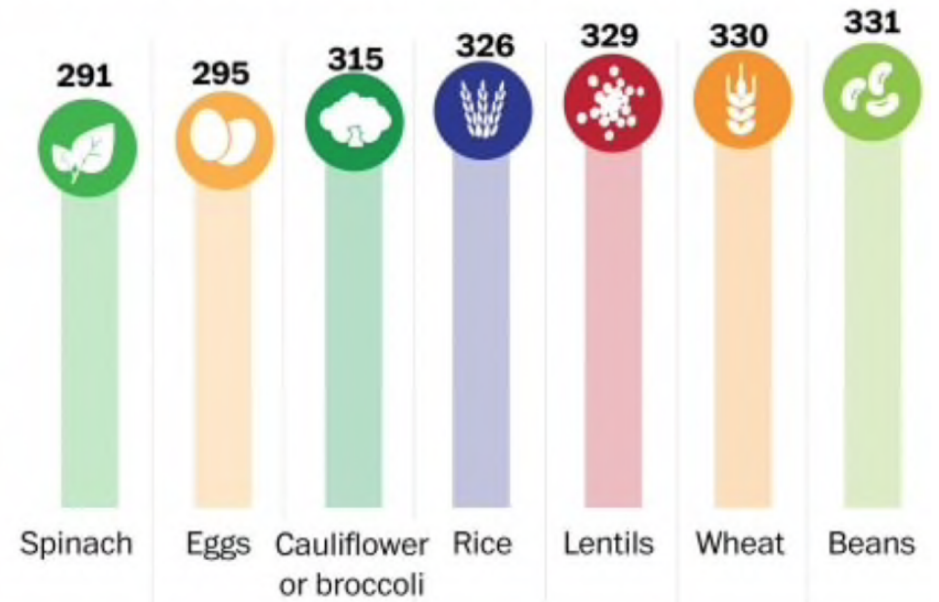
Simple way to lower our carbon footprint

What about the environmental argument? Almost 30 percent of the world's ice-free land is used to raise livestock. We grow a lot of crops to feed animals, and we cut down a lot of forests to do that. But beef, far more than pork or chicken, contributes to environmental harm, in part because it requires much more land. The greenhouse gas production per serving of chicken or pork is about 20 percent that of a serving of beef.



Annual emissions savings if a five-ounce steak is replaced with vegetables once a week

In kilograms of carbon dioxide (or its equivalent in other greenhouse gases)



EQUIVALENT

Gallons of gas:



32.4

32.8

35.0

36.2

36.5

36.7

36.7

LED lightbulbs:



10.4

10.5

11.3

11.6

11.7

11.8

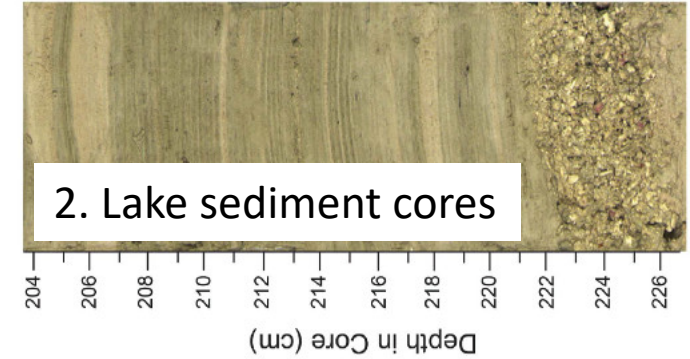
11.8

Review - What is a Paleoclimate Archive?

1. Tree rings

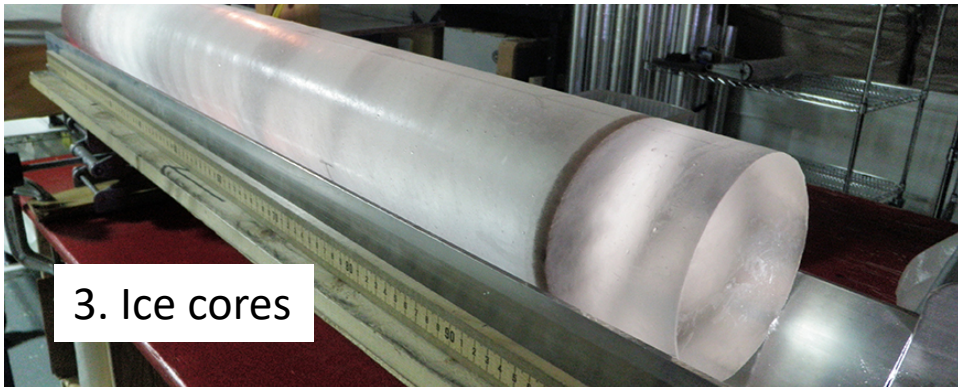


2. Lake sediment cores



Any geologic deposit that preserves direct or indirect evidence (physical, chemical, biological, and isotopic) of past climates

3. Ice cores



4. Packrat middens

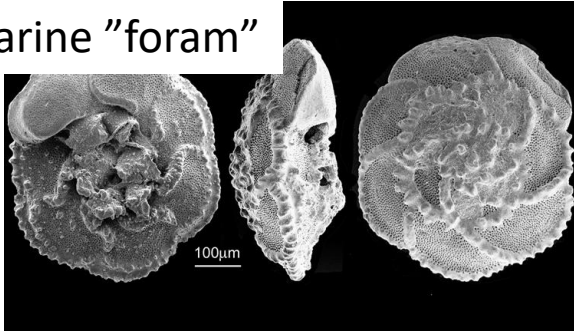


5. Ocean sediment cores



What is a Paleoclimate Proxy?

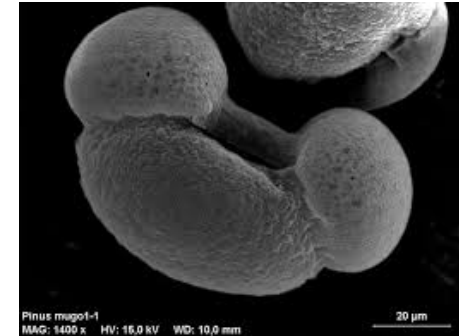
1. Marine "foram"



^{16}O 15.9949 99.76%	^{17}O 16.9991 0.04%	^{18}O 17.9991 0.20%
Stable	Stable	Stable

6. Water Isotope systems

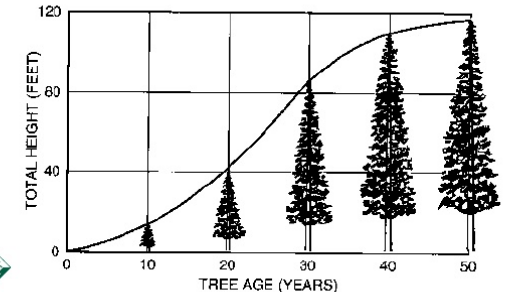
4. Pollen



A property that can be measured (physical, chemical, biological, and isotopic) and varies with changing climate.

5. Tree ring width

Textbook Example: Tree Height vs Years
Similar for diameter.
Relationship of Height (Diameter) to Time is not linear, but is sigmoidal.



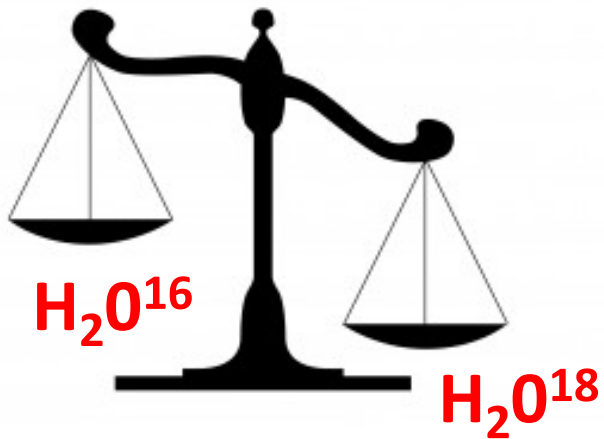
2. Iceberg debris



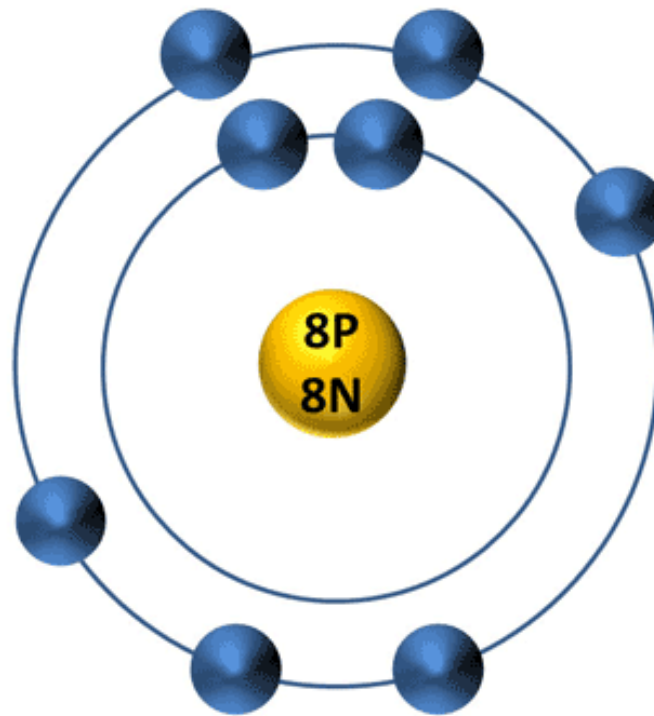
3. Plant fossils

An isotope is the same element (same number of protons) with different numbers of neutrons.

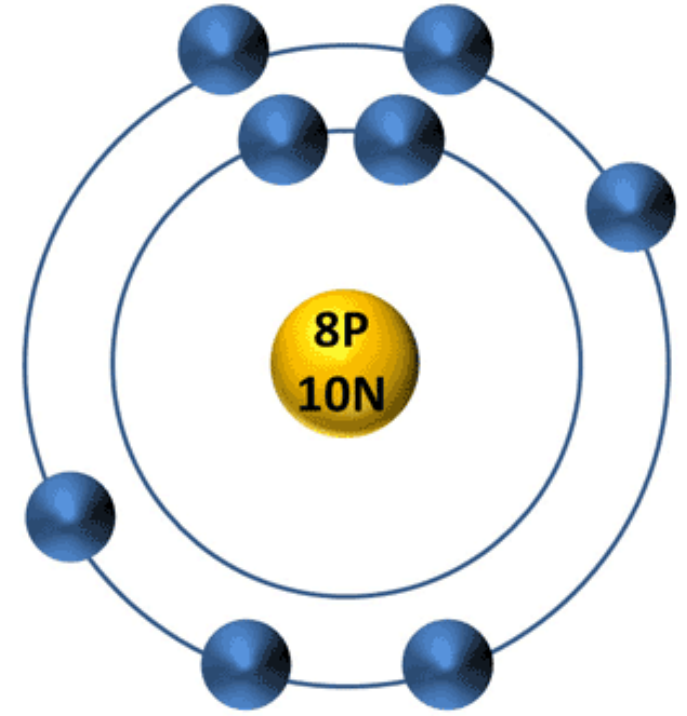
^{16}O 15.9949 99.76%	^{17}O 16.9991 0.04%	^{18}O 17.9991 0.20%
Stable	Stable	Stable



Oxygen Isotopes

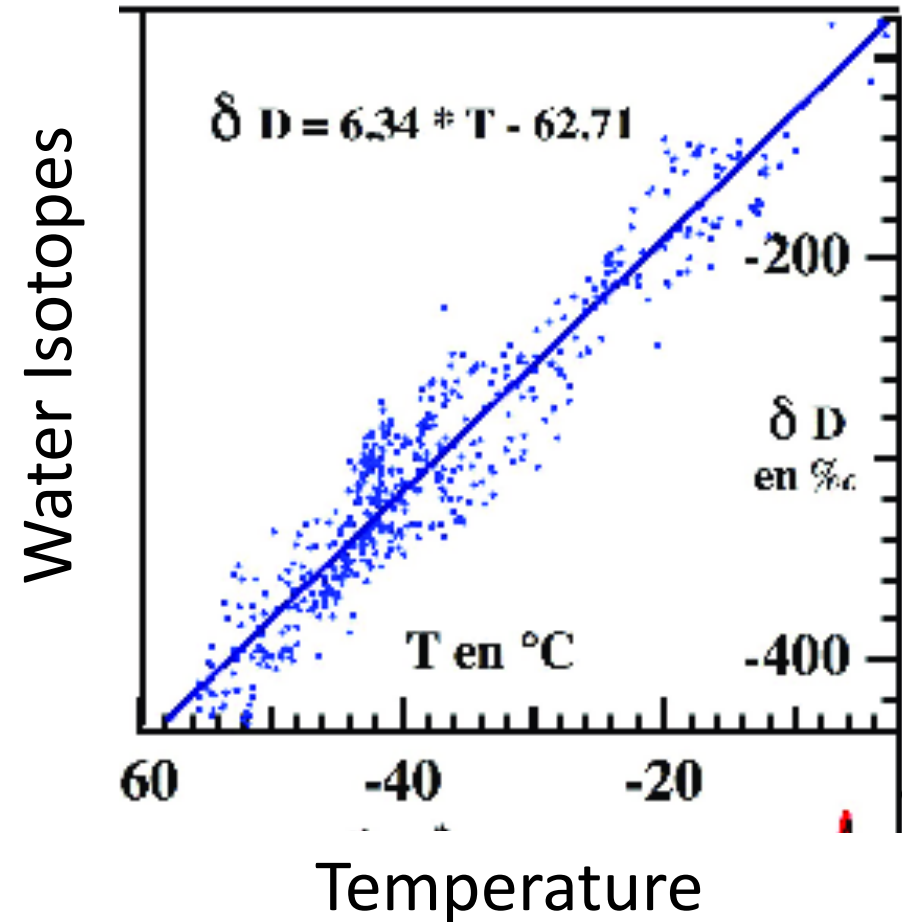
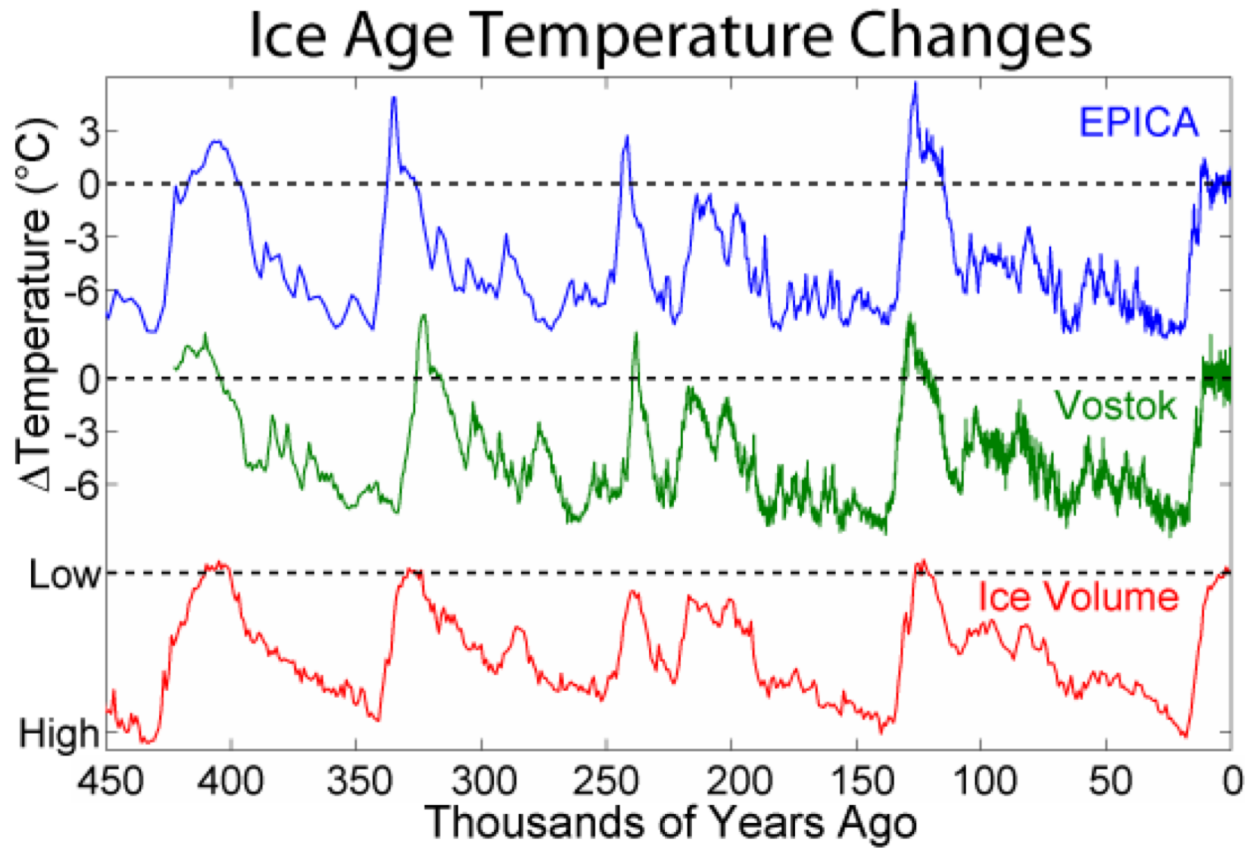


^{16}O Isotope



^{18}O Isotope

Temperature and the isotopes of water are related...if you measure isotopes, you can estimate temperature



Richard Alley – Mr. Greenland

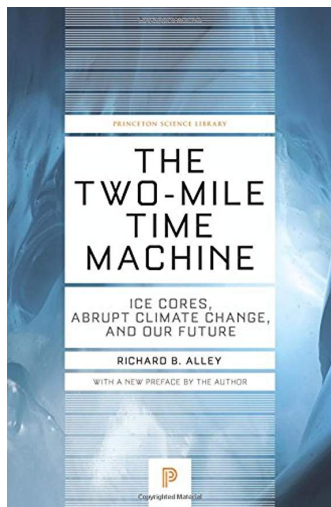
<https://www.youtube.com/watch?v=PKDVC4HJg7c>



The more the climate is forced to change, the more likely it is to hit some unforeseen threshold that can trigger quite fast, surprising and perhaps unpleasant changes.

— *Richard Alley* —

AZ QUOTES



Alley is a Professor of Geology at Penn State who has worked on Greenland for decades. He was instrumental in recovering and interpreting the GISP2 ice core that went 3000+ meters to the base of the ice sheet. He's the author of Two-mile time machine, a popular book about ice cores.

Today's Class (mapped to Learning Objectives)

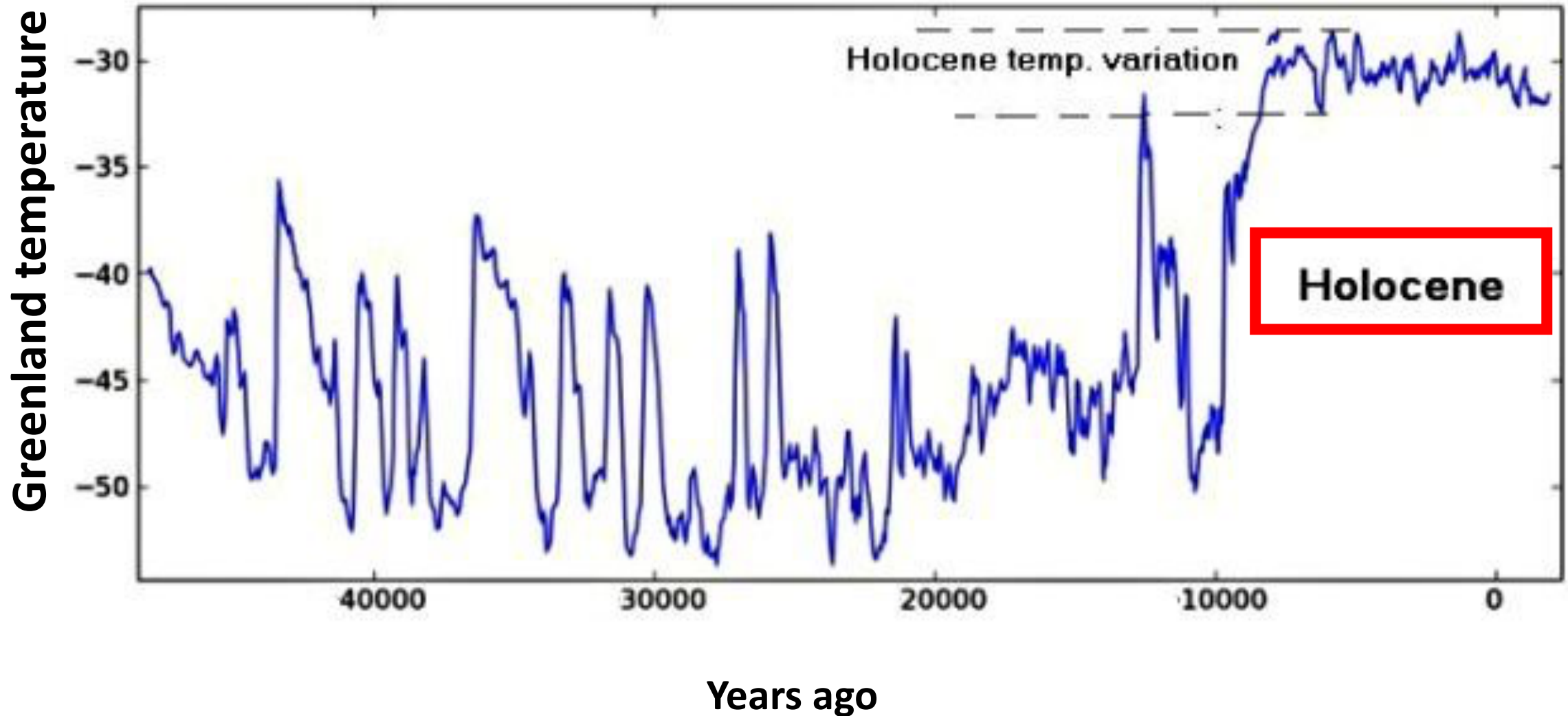
- The history of global temperatures over the last ~11,000 years
- How did changing climate influence early human civilizations
- How did early humans influence climate
- Did anthropogenic climate change starting before the beginning of the industrial revolution around 1850 AD?

Geologic time
(today, the **Holocene**, after
Mike Mann, the rest!)

- Holocene starts 11,000 years ago
- Comparatively warm and stable climate
- Ice sheets mostly melted back
- Development of modern human civilizations

Era	Period	Sub-period	Epoch	
Cenozoic	Quaternary		Holocene	11,000 years
			Pleistocene	
	Neogene		Pliocene	2.6 million years
			Miocene	5.8 million years

What's the big picture (Greenland Ice Sheet data)



The Laurentide ice sheet

The Deglaciation of North America 21,400-1000 years ago

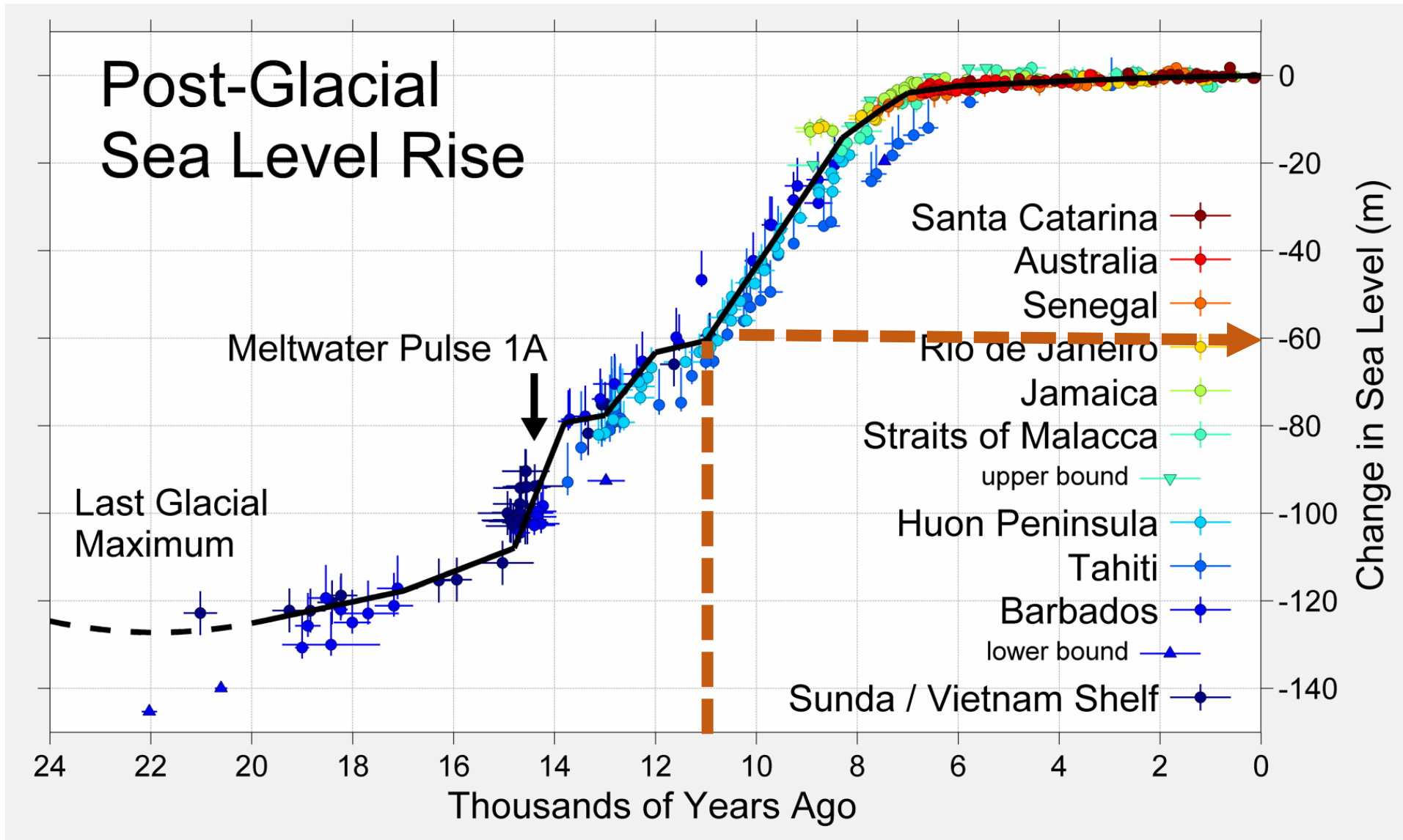
after Arthur S. Dyke, "An Outline of North American Deglaciation ...", 2004
with additions from "The Last Great Ice Sheets", Denton & Hughes, ed., 1981,
Coastlines estimated using Barbados sea level curve after Bard et al., 1990
Great Basin Lakes from
Currey, Atwood, and Mabey, "Map 73: Major Levels ... Lake Bonneville", 1984

- held much of the sea-level fall during glacial times (>50 meters)
- didn't fully melt back until about 6000 years ago

Sea level rises as the ice melts

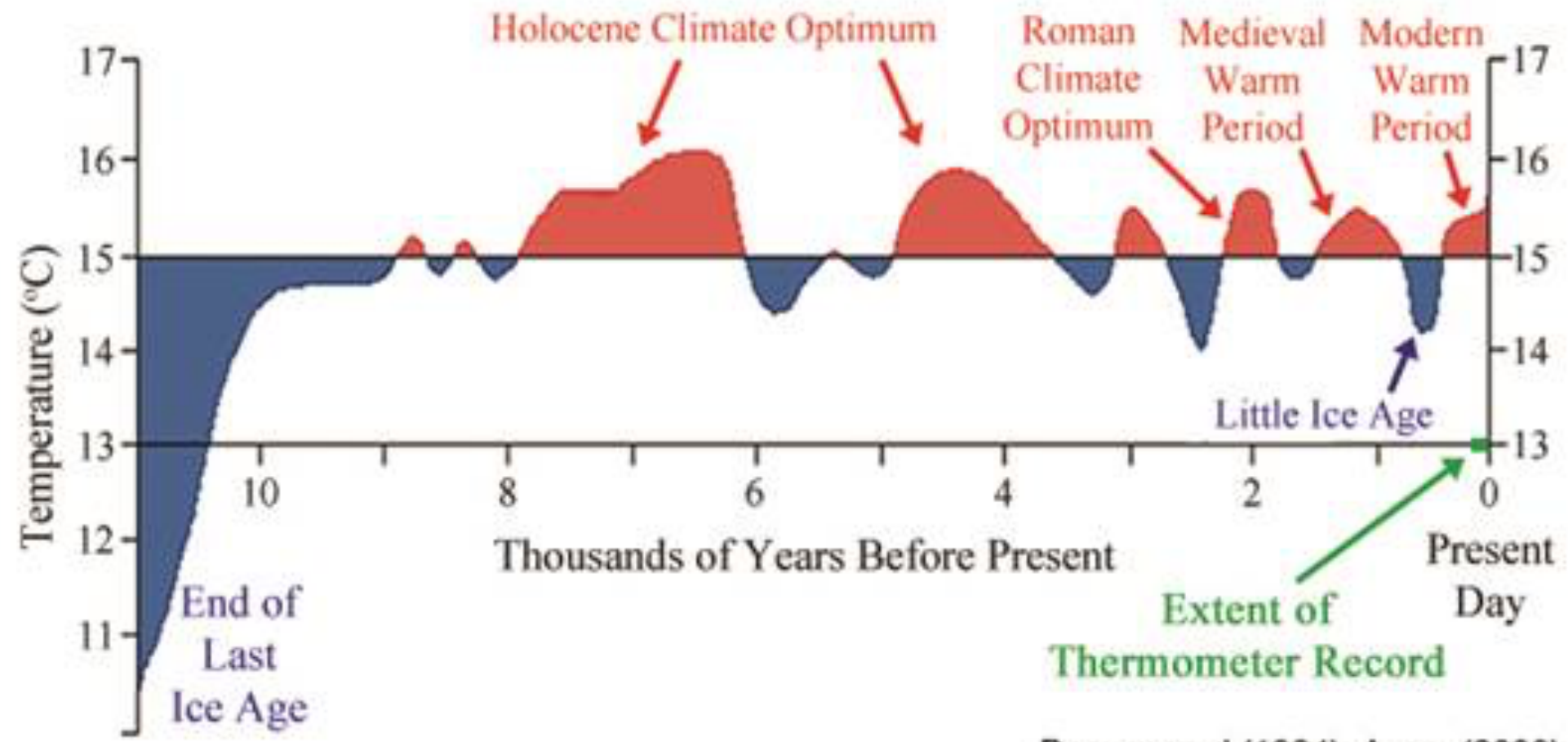
At the start of the Holocene, about 50% of the ice has melted

By 7000 years ago, sea-level is very close to modern levels



Within the Holocene, there are subtle changes in temperature

Temperatures of the Last 10,000 Years
(Ice core data from Crete site in central Greenland)



Daansgaard (1984), Avery (2009)

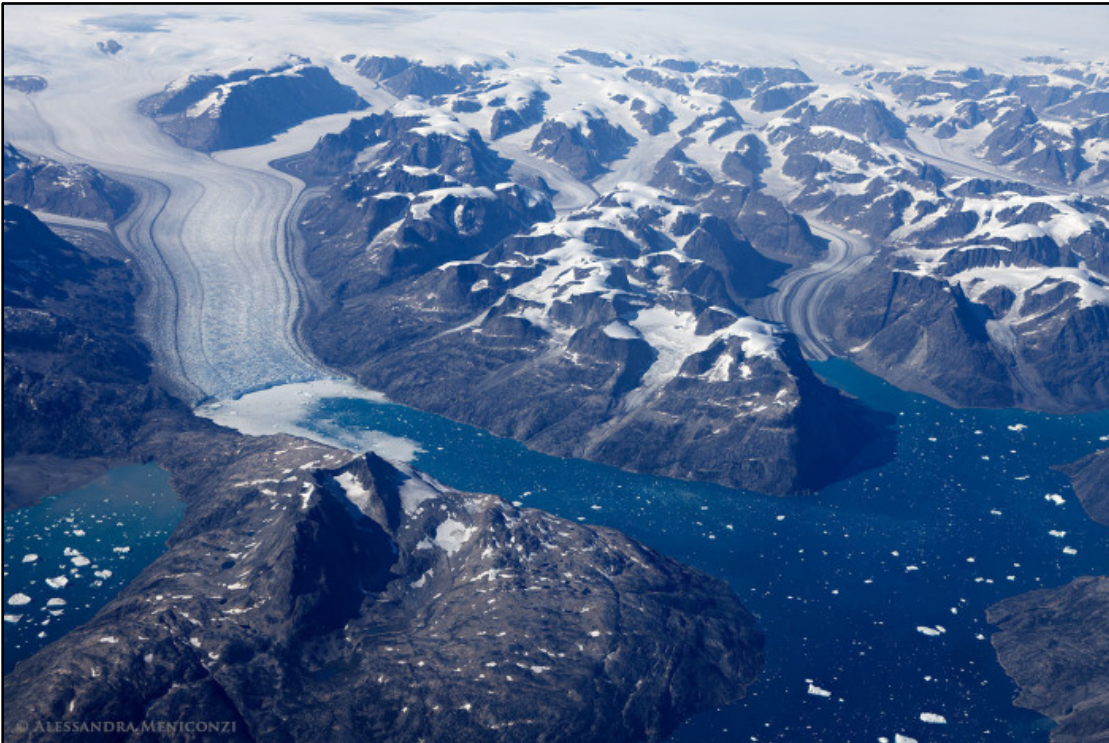
Holocene Climatic Optimum (hypsihermal)



- Mostly Northern Hemisphere phenomenon
- Slightly warmer than “today” (pre industrial)
- Greenland ice margin retreats perhaps kilometers beyond its present location
- Sahara Desert was green (African humid period) – West African monsoon

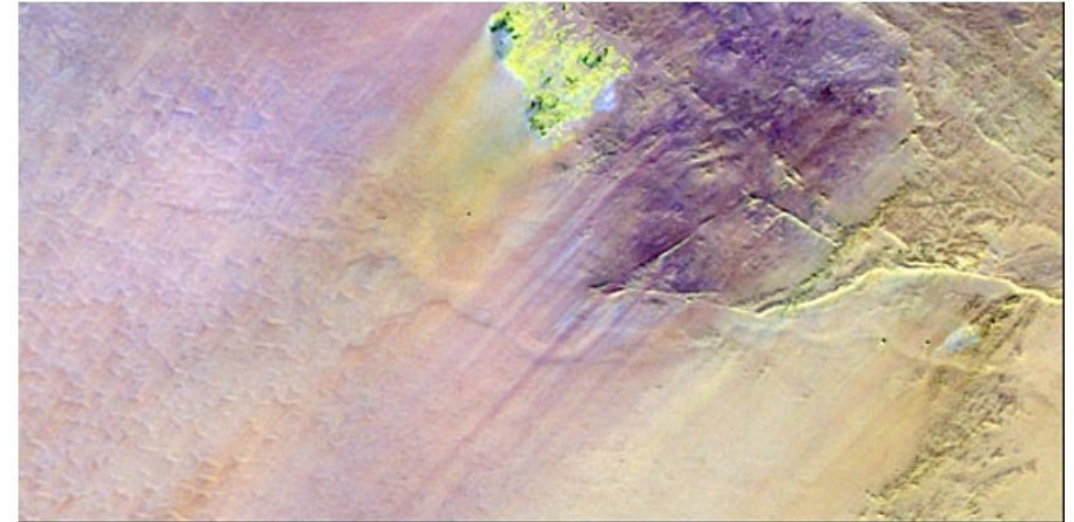
Between 6000 and 3000 years ago Greenland ice margin retreats

- perhaps kilometers beyond its present location
- Advances again and bulldozes marine sediment (and clams)
- Clams found today in glacial sediment (moraines) at edge of the ice
- Dated using carbon and chemical changes (amino acids)

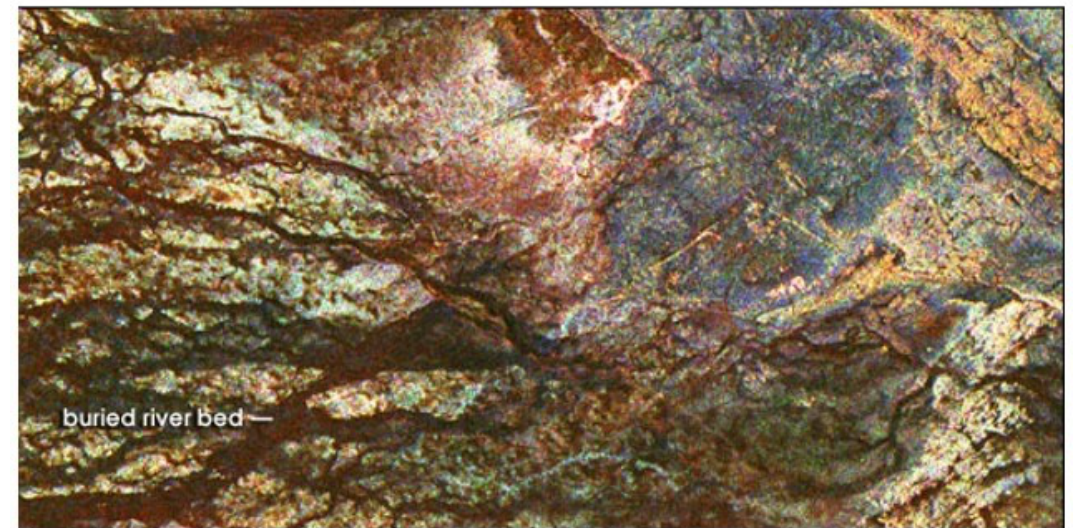


Sahara was wetter until about 5000 years ago

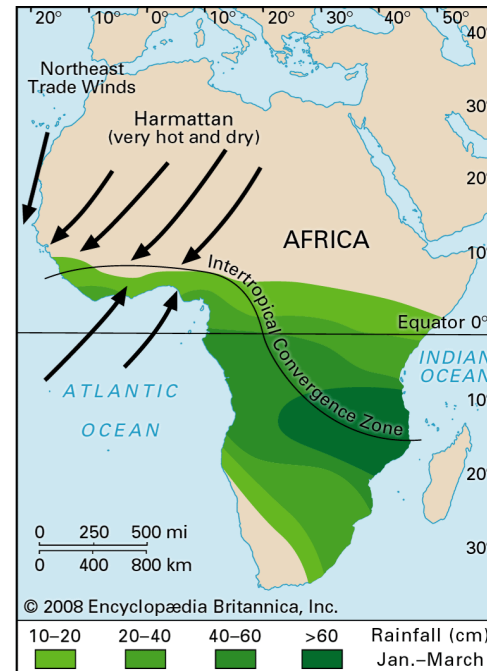
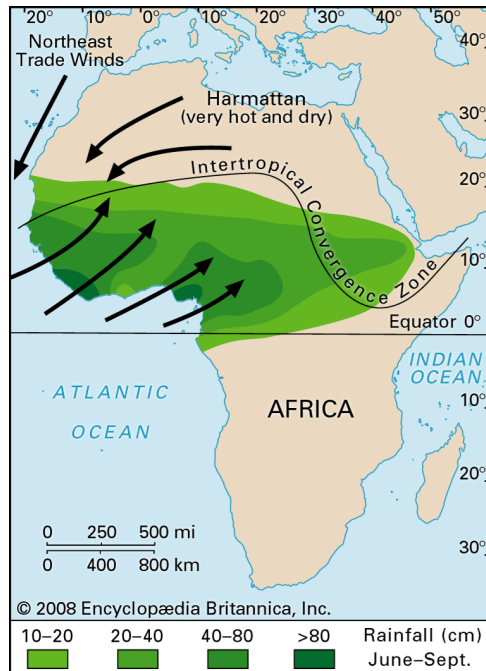
- African Humid Period from 11000-5000 years ago
- West African monsoon shifted north
- Rivers in the desert now hidden under shifting sands
- Lakes in the desert



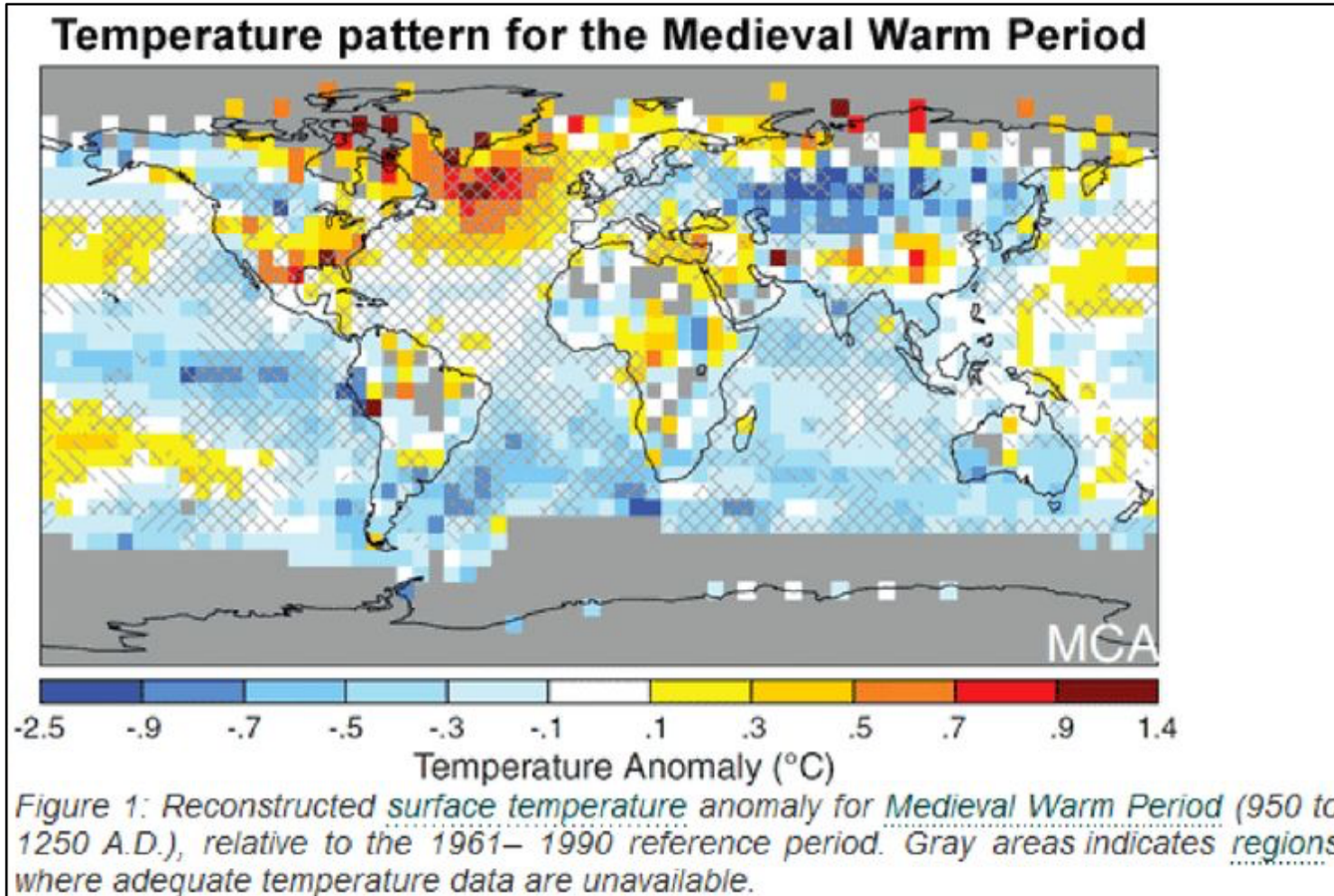
Surface features of the Sahara Desert (Landsat)



Ancient features hidden beneath the surface (radar)

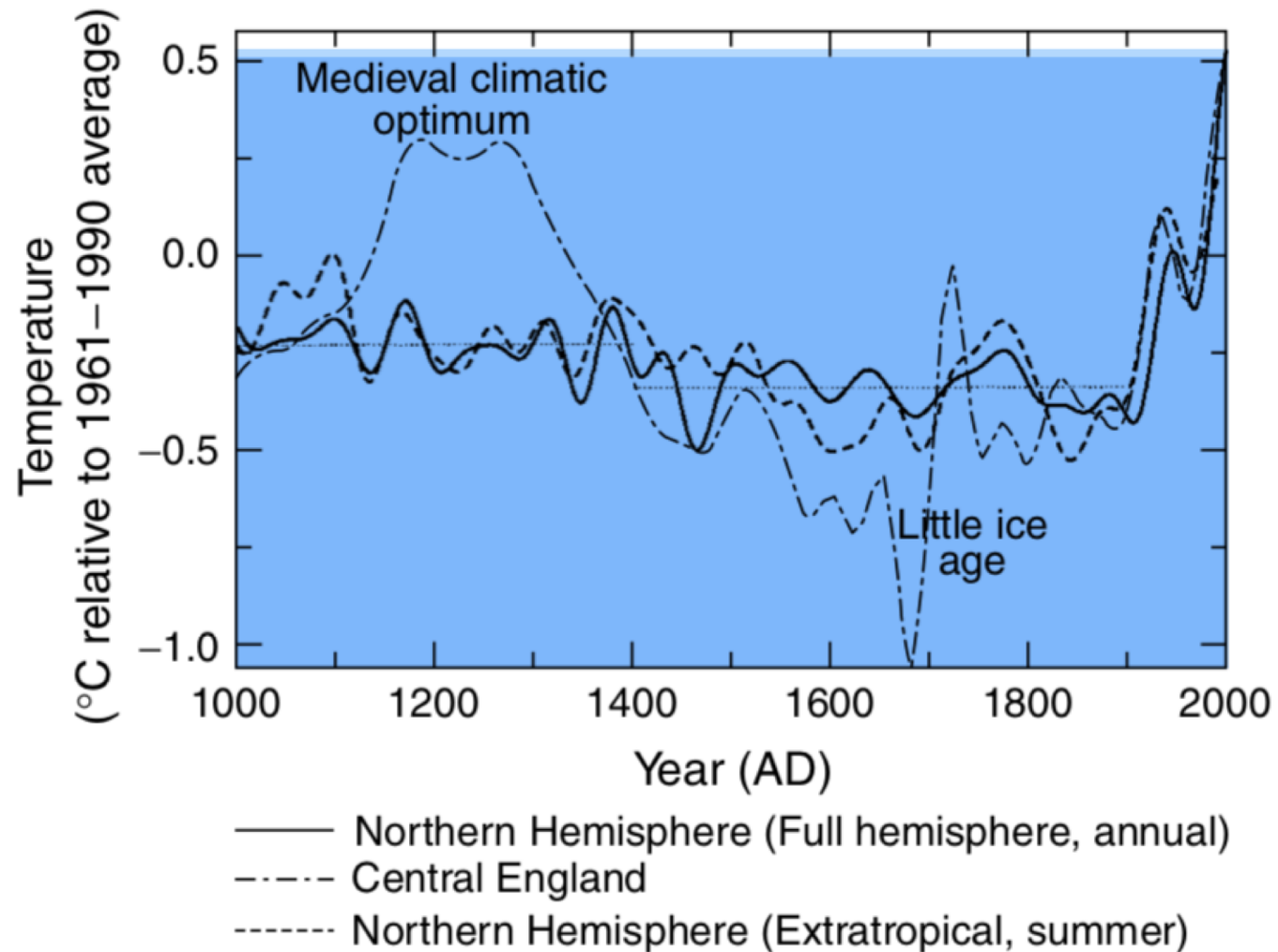


Medieval Warm Period (AKA Medieval Climate Optimum) 900 to 1300 CE



- Agriculture at higher elevation and latitude
- Bountiful harvests in Europe
- Figs and olive north of current range
- Glaciers retreat
- Severe winters were rare

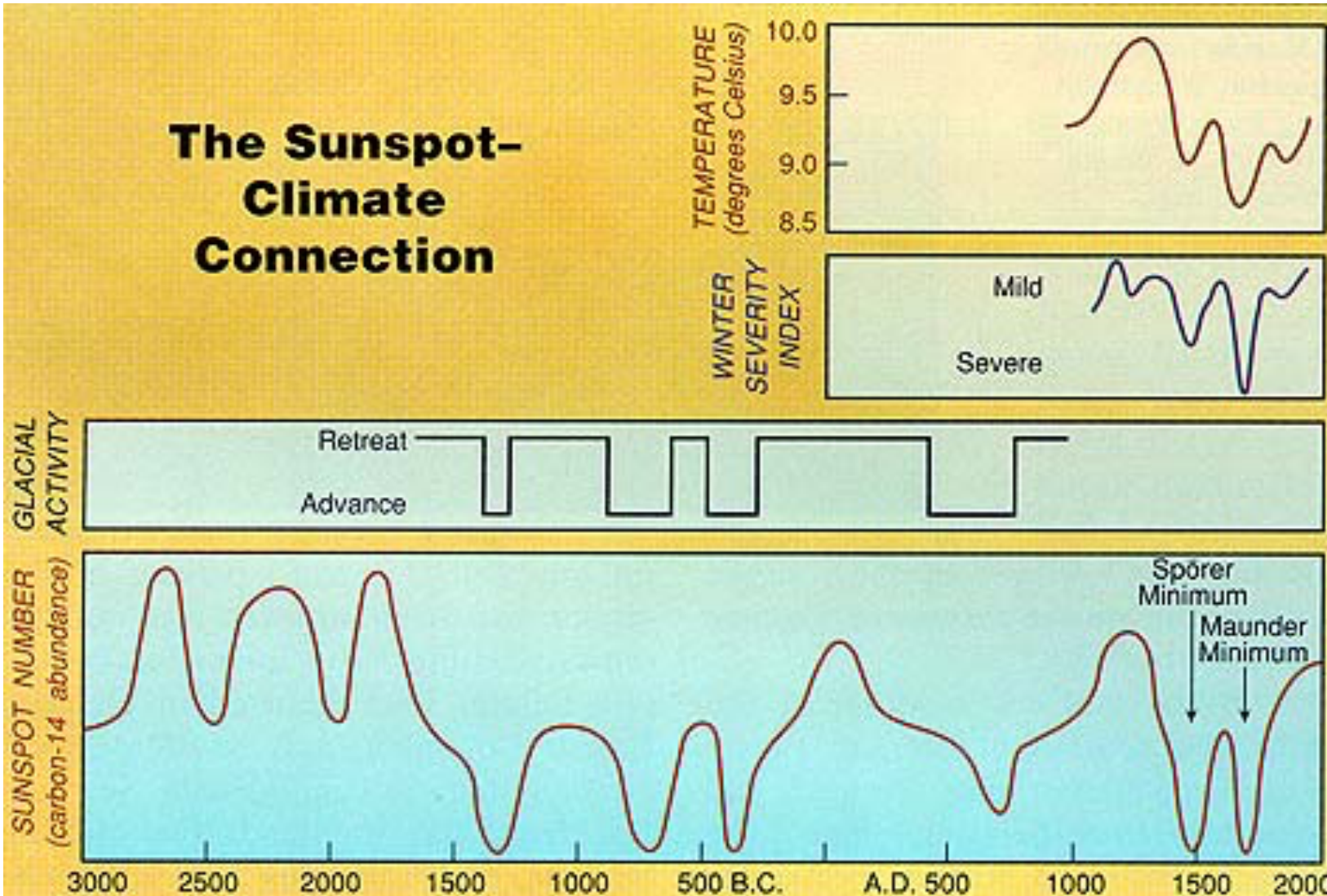
Little Ice Age – again most likely regional (north Atlantic)



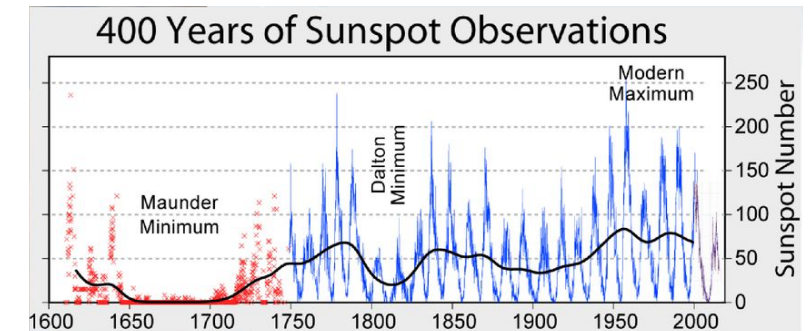
- Dutch canals and the Thames freeze
- Viking settlements abandoned in Greenland
- Glaciers advance



Little Ice Age – again most likely regional (north Atlantic)



- **Maunder Minimum** coincides with lower temperatures.
- Sun is more energetic when there are more sunspots (<1% difference)
- Earth receives slightly more solar energy when there are more sunspots



Today's Class (mapped to Learning Objectives)

- The history of global temperatures over the last ~11,000 years
- How did changing climate influence early human civilizations
- How did early humans influence climate
- Did anthropogenic climate change starting before the beginning of the industrial revolution around 1850 AD?

Climate and its effect on civilizations - Maya

PALEOCLIMATOLOGY

Quantification of drought during the collapse of the classic Maya civilization

Nicholas P. Evans^{1*}, Thomas K. Bauska¹, Fernando Gázquez-Sánchez¹, Mark Brenner², Jason H. Curtis², David A. Hodell¹

The demise of Lowland Classic Maya civilization during the Terminal Classic Period (~800 to 1000 CE) is a well-cited example of how past climate may have affected ancient societies. Attempts to estimate the magnitude of hydrologic change, however,



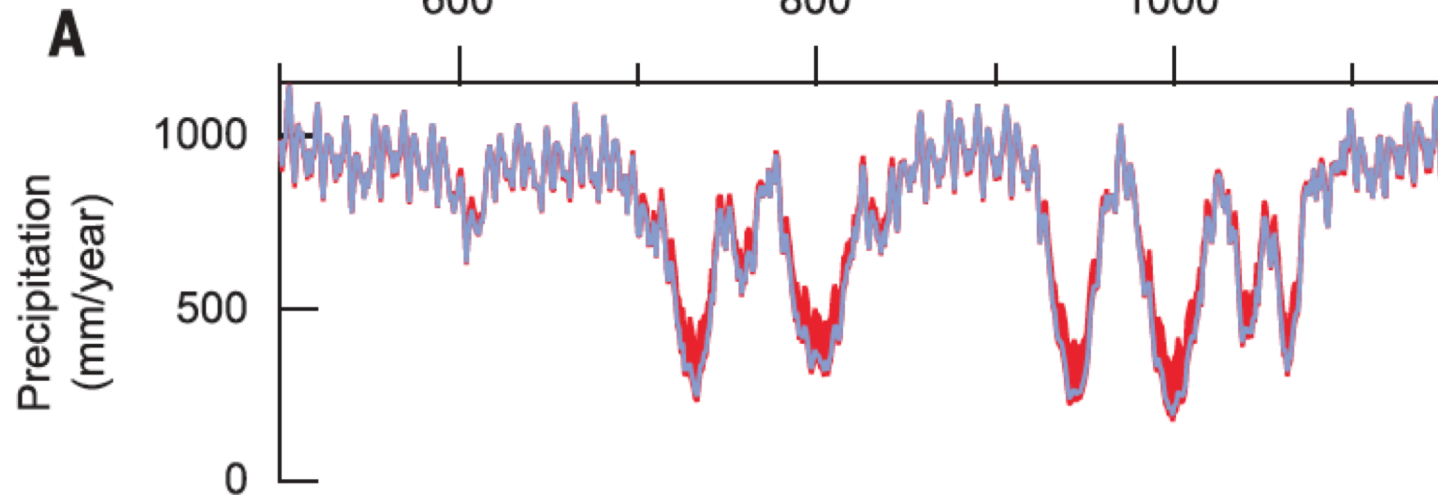
ARCHAEOLOGY

A publication of the Archaeological Institute of America

HOME NEWS MAGAZINE VIDEOS PODCASTS READER INFO TRAVEL
SUBSCRIBE

Scientists Measure Maya Drought With “Fossil Water”

Date (CE)



- Gypsum deposited in a lake holds water from the past.
- Oxygen isotopes in that water reveal draughts.

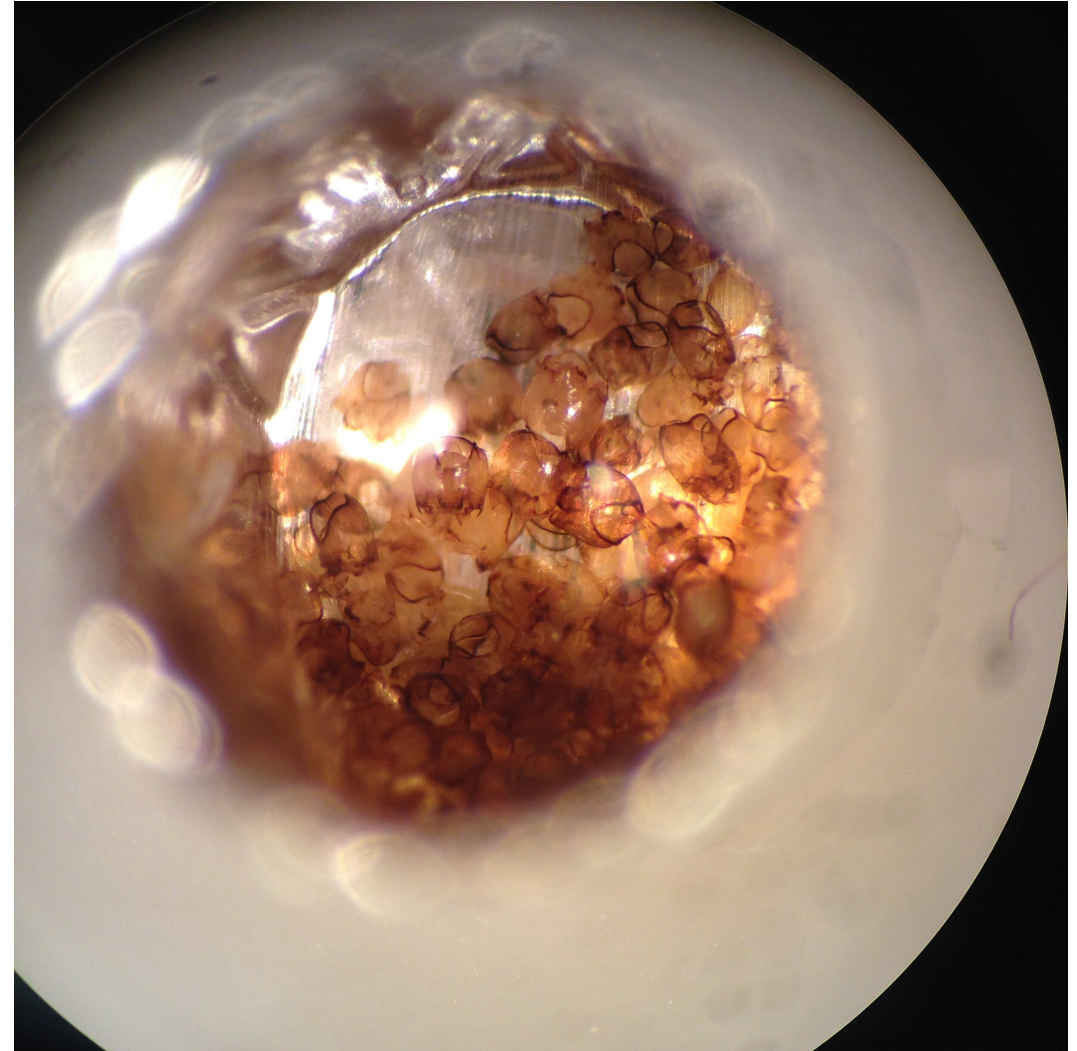


Vikings settle Greenland before 1000 CE when climate is warm (~2500 people?)



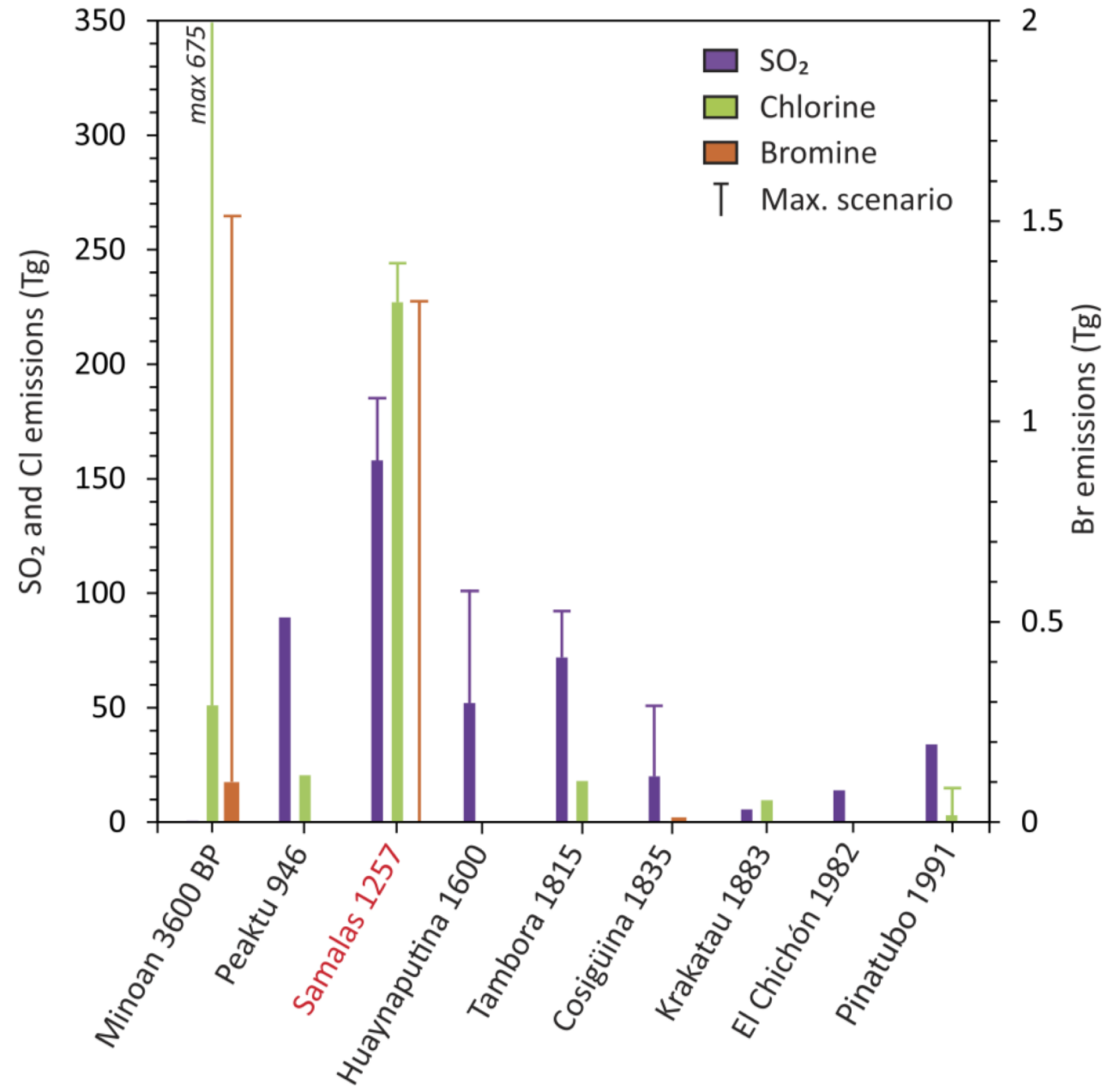
The last Vikings leave/die by 1400 CE

- Exit seems planned, no valuables left behind.
- Likely driven by cooling, crop and animal failure?
- 1 degree C drop in temperature
- Possibly global, at least North Atlantic
- Oxygen isotope in lake fly parts tells water isotopes and thus, temperature



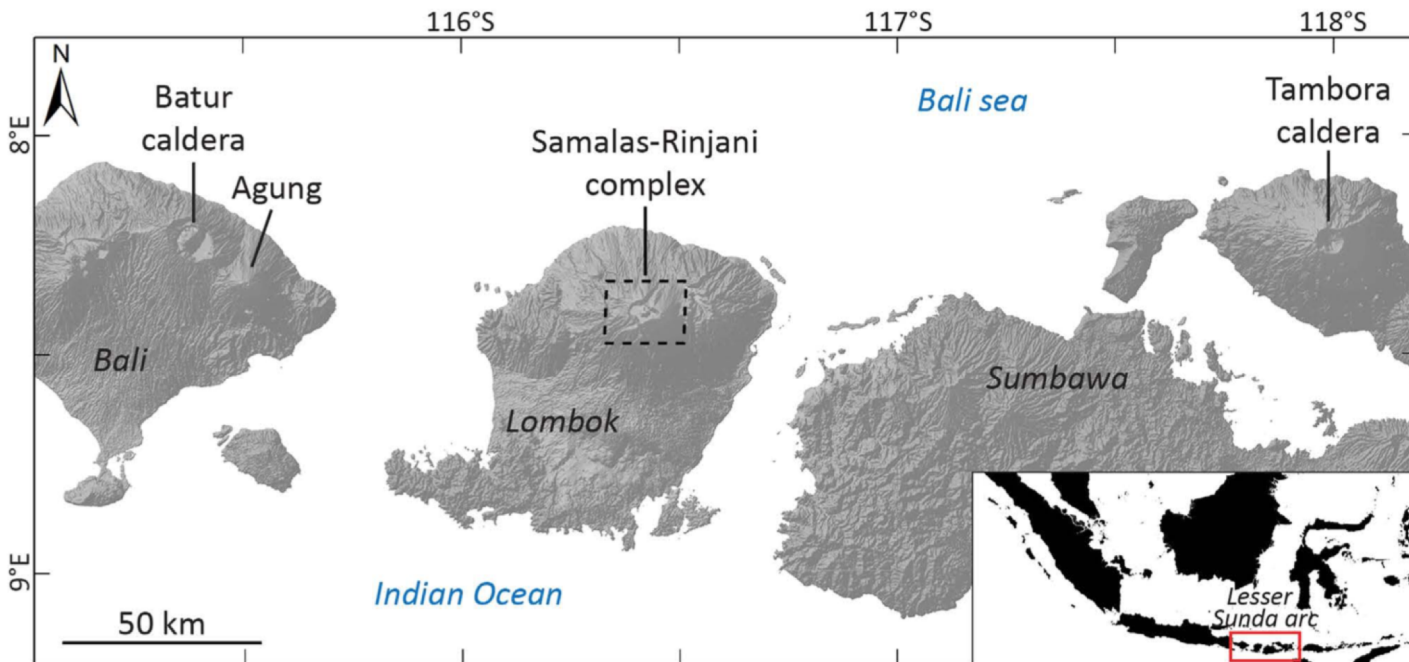
Large volcanic eruptions are important for global climate on short timescales

- Large eruptions cool the Earth
- Sulfate aerosols block sunlight
- Last years to decades at most



Mt Samalas (1257) – erupts at end of Medieval Optimum

- Mt Samalas released 158 million tons of sulphur dioxide and 227 millions tons of chlorine
- This is the greatest and the most powerful eruption of the last 7,000 years.



Year without a summer...1816...Mt Tambora erupts



The effect of short term climate change on people was dramatic

- The snow was 18 inches deep in Cabot, Vt., on June 8.
- Over all of New England, freezing temperatures in July, a killer frost in August.
- "The most gloomy and extraordinary weather ever seen," according to one Vermont farmer.
- Mary Shelly (Wollstonecraft), who had run off with Percy Shelly (an affair, he was married), was cooped up in a house by Lake Geneva (Switzerland). During the a cold, rainy miserable summer; she wrote *Frankenstein*.



Today's Class (mapped to Learning Objectives)

- The history of global temperatures over the last ~11,000 years
- How did changing climate influence early human civilizations
- How did early humans influence climate
- Did anthropogenic climate change starting before the beginning of the industrial revolution around 1850 AD?

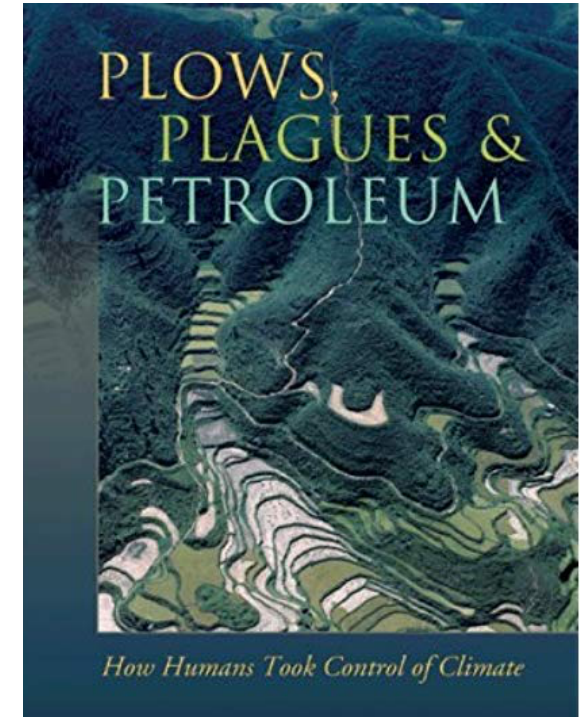
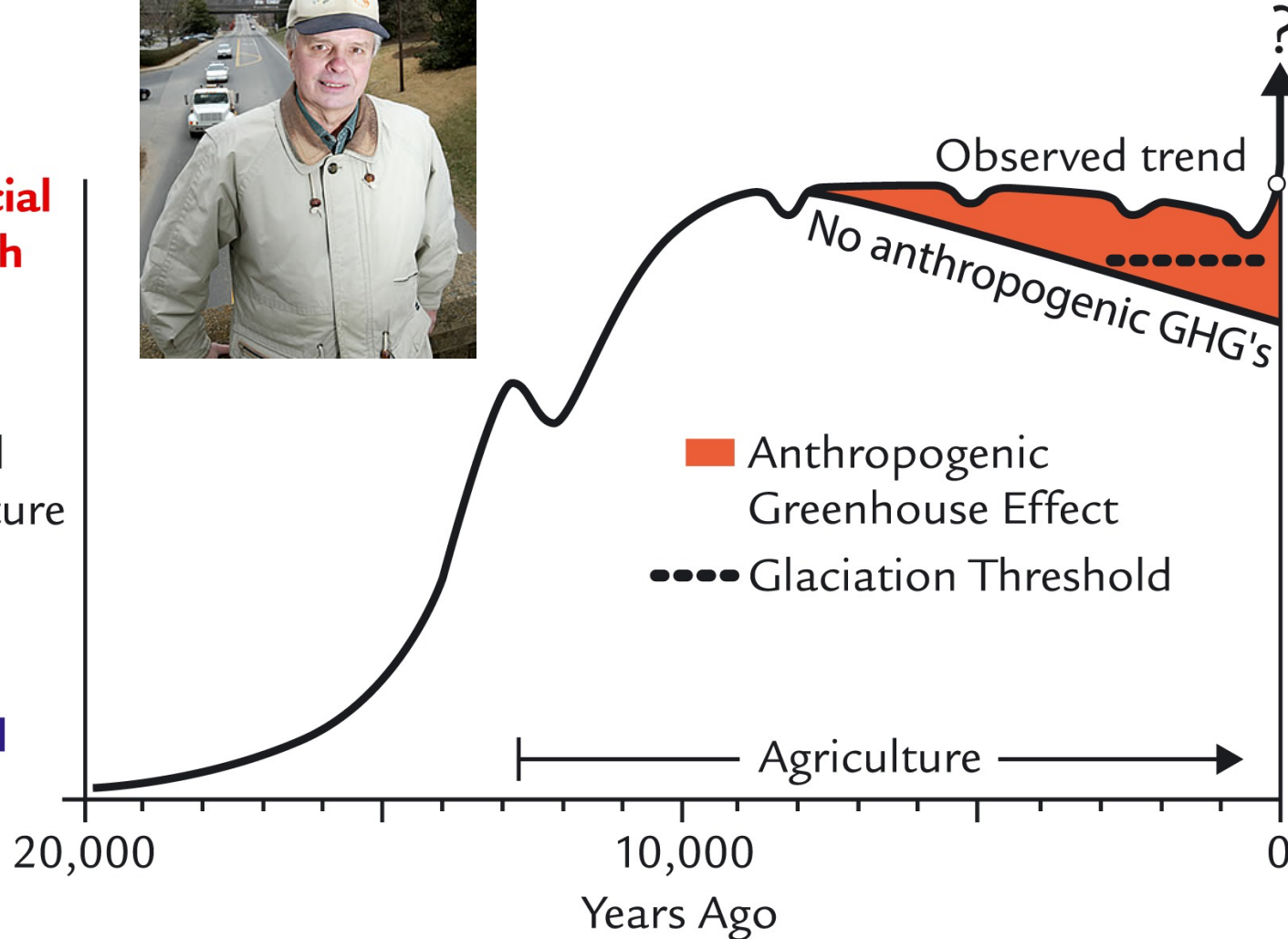
Did early humans influence climate?



Interglacial
Warmth

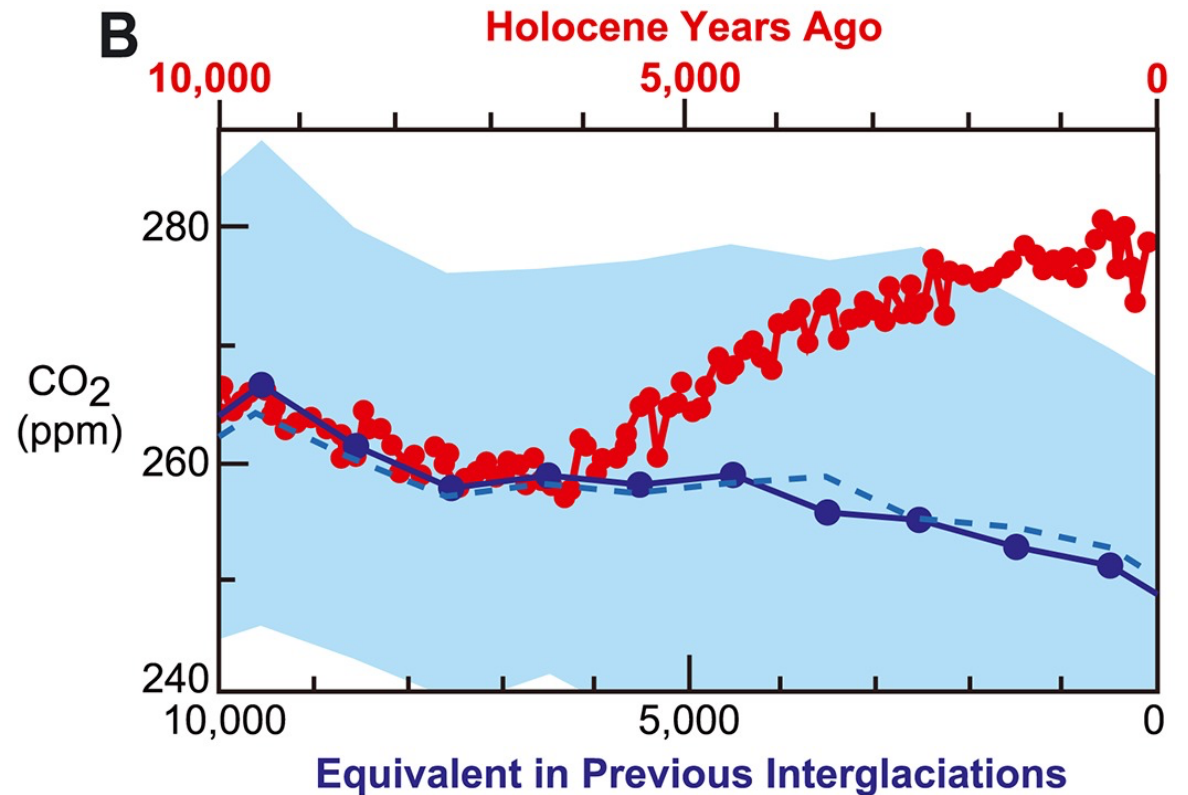
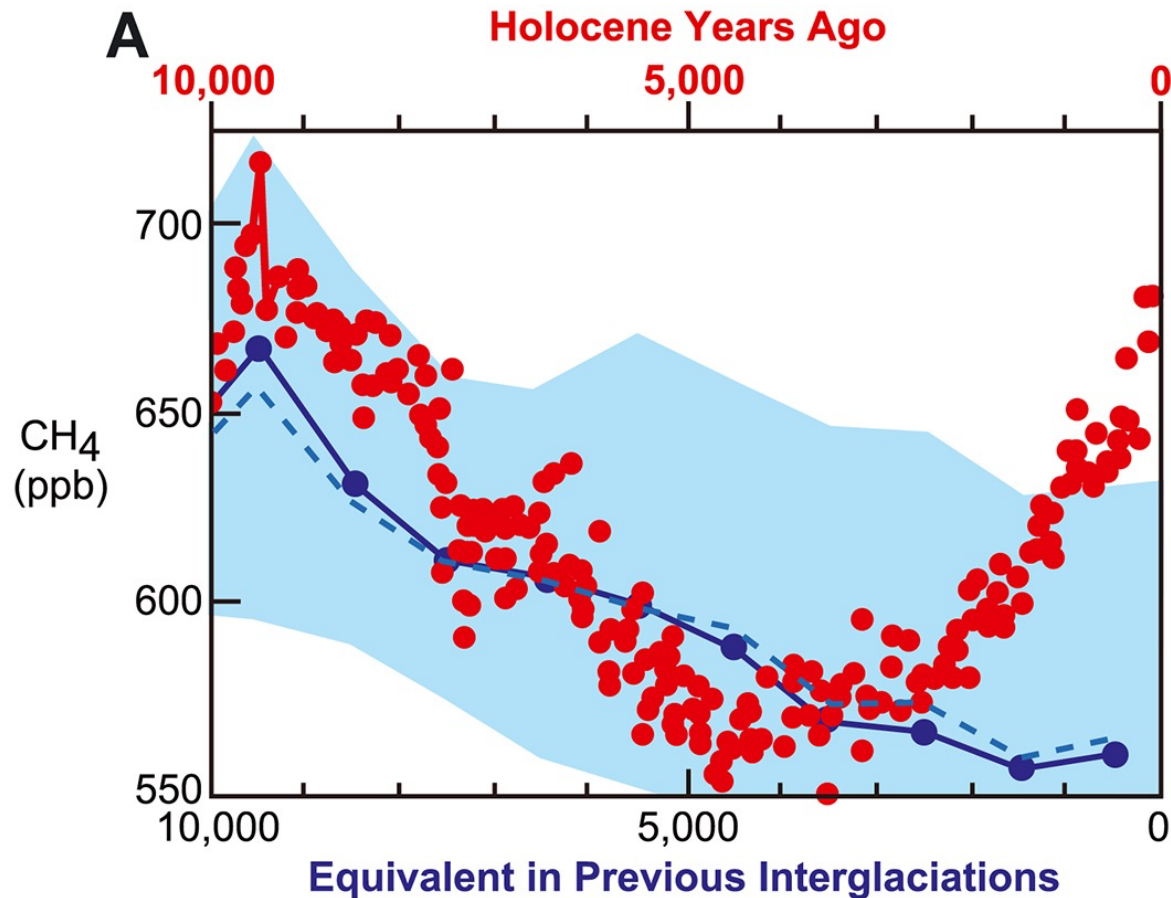
Global
Temperature

Glacial
Cold



Is Holocene
climate stability
natural or
human caused?

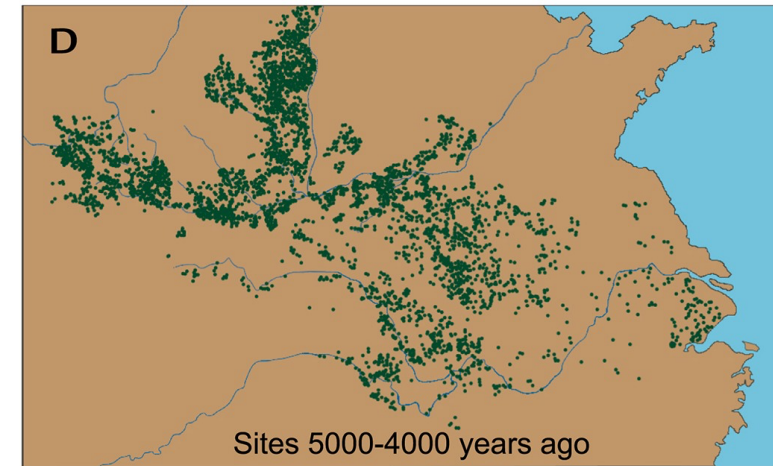
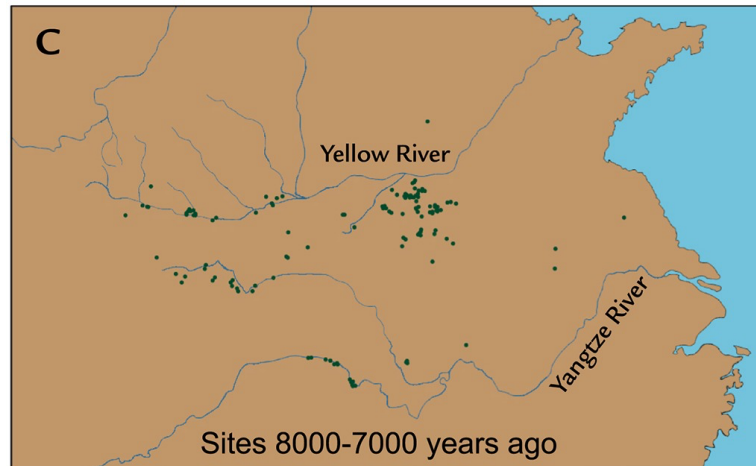
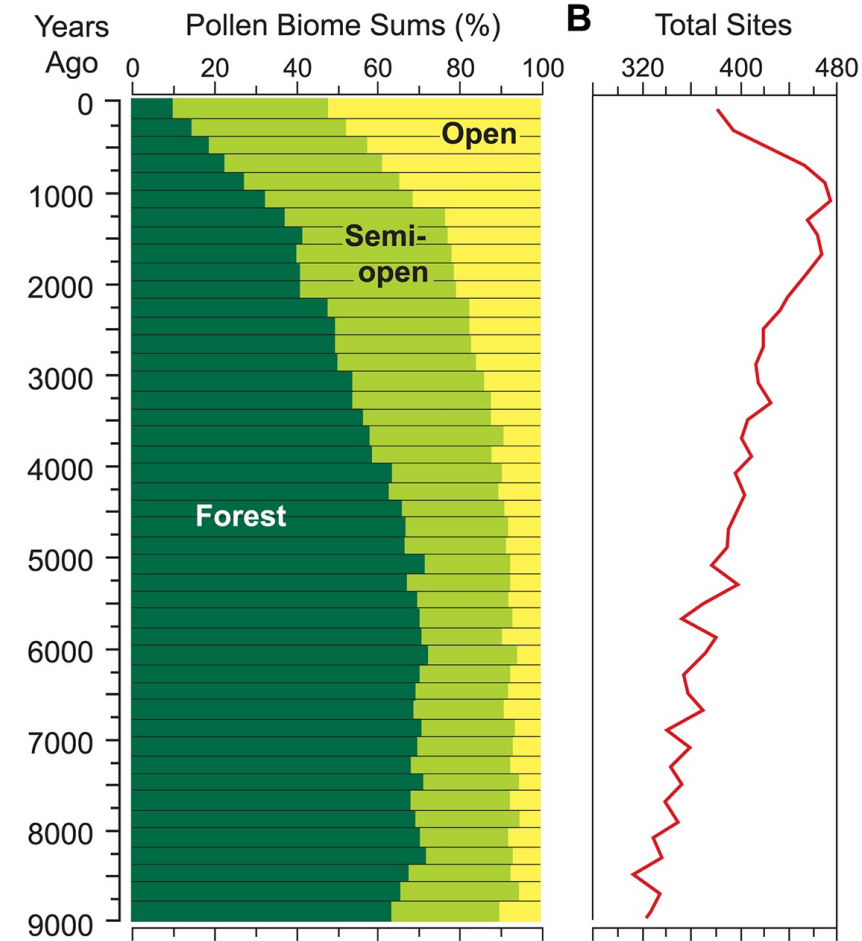
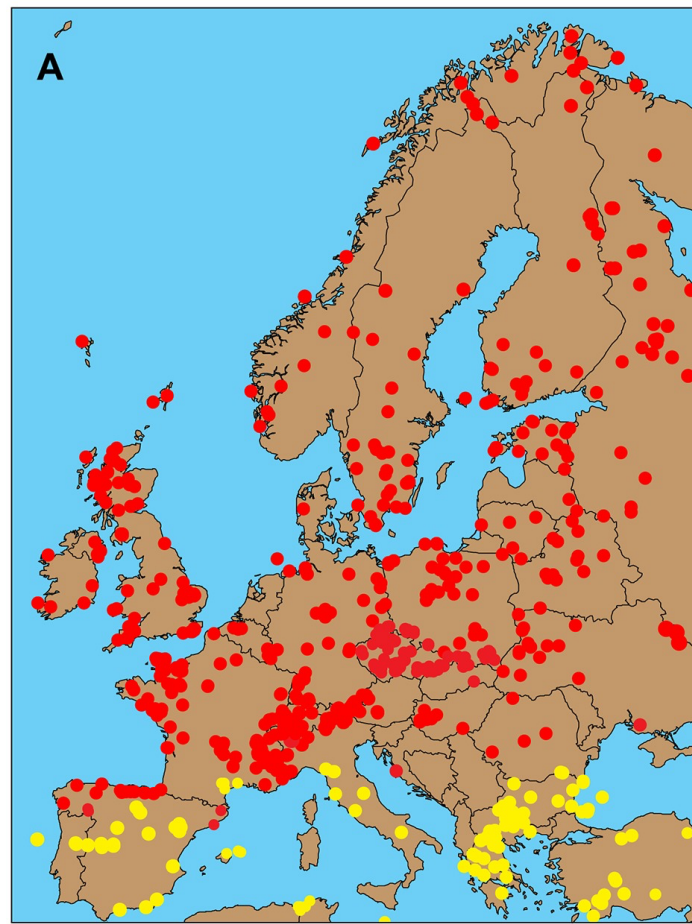
CO₂ (carbon dioxide) and CH₄ (methane) in the Holocene do NOT follow the pattern of earlier interglacials...



Are people to blame for rising CO₂ by changing landuse over 9000 years?

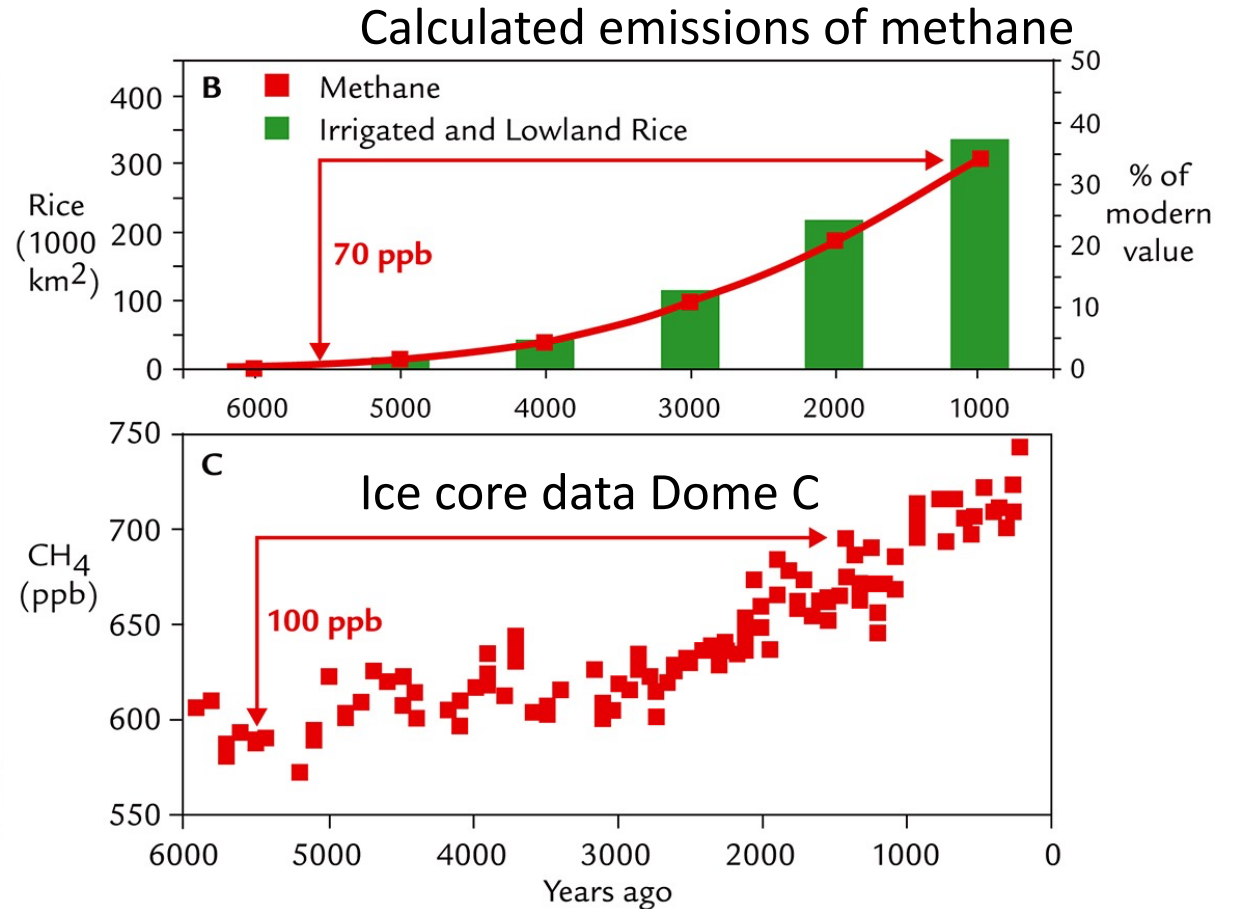
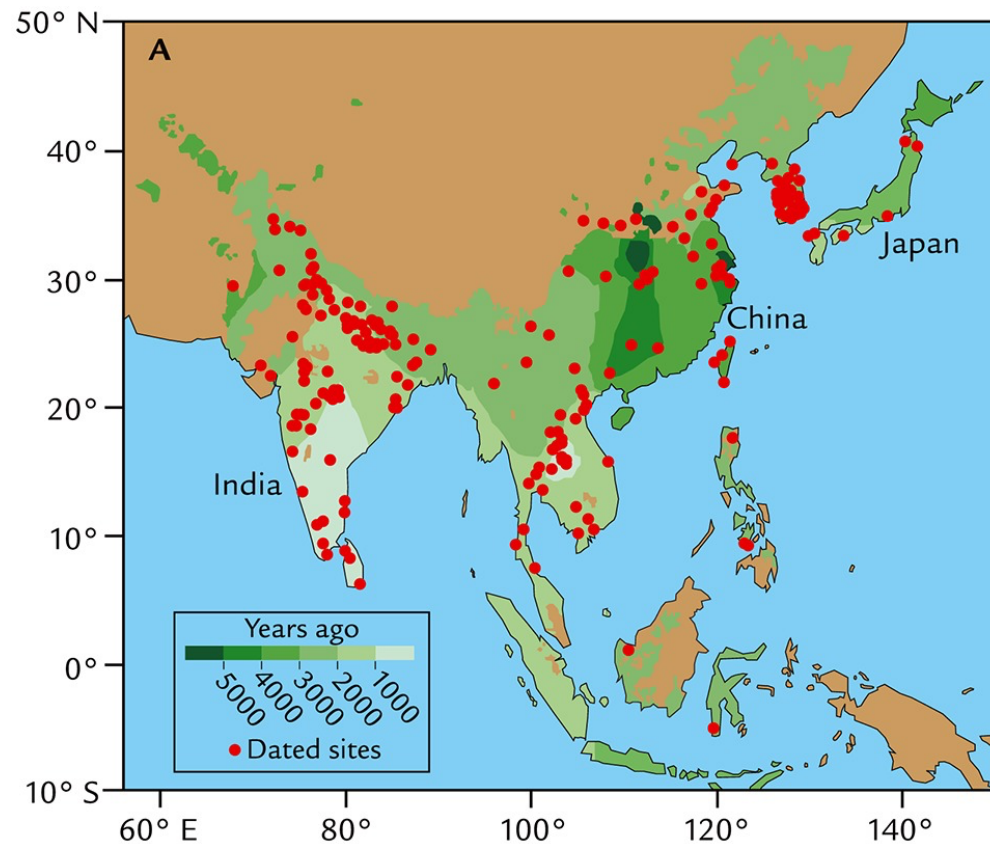


Axe wielding: a Bronze Age rock painting from Tanum, Bohuslan, Sweden – 4000 years ago.



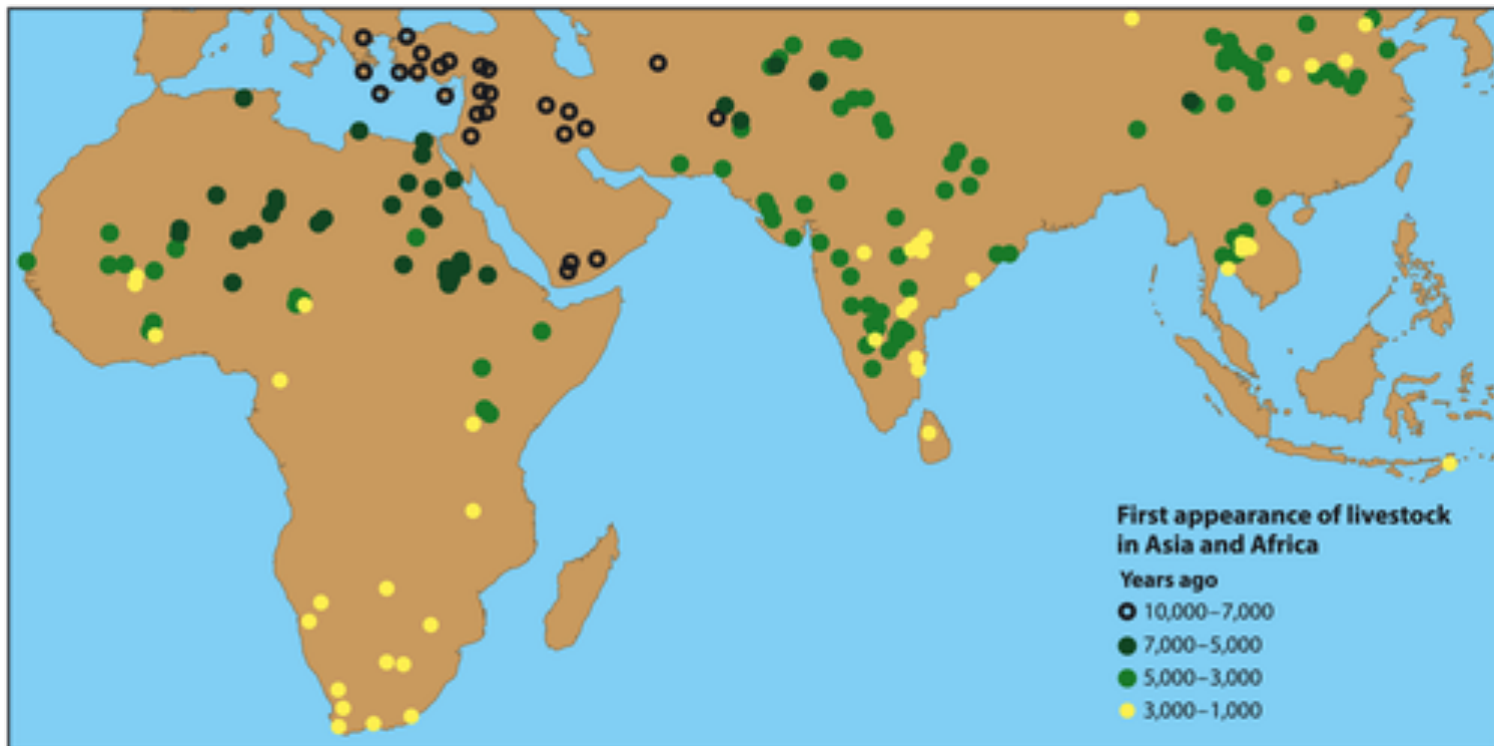
Ruddiman (your textbook author) thinks people have been affecting climate for millennia

Rice farming generates methane

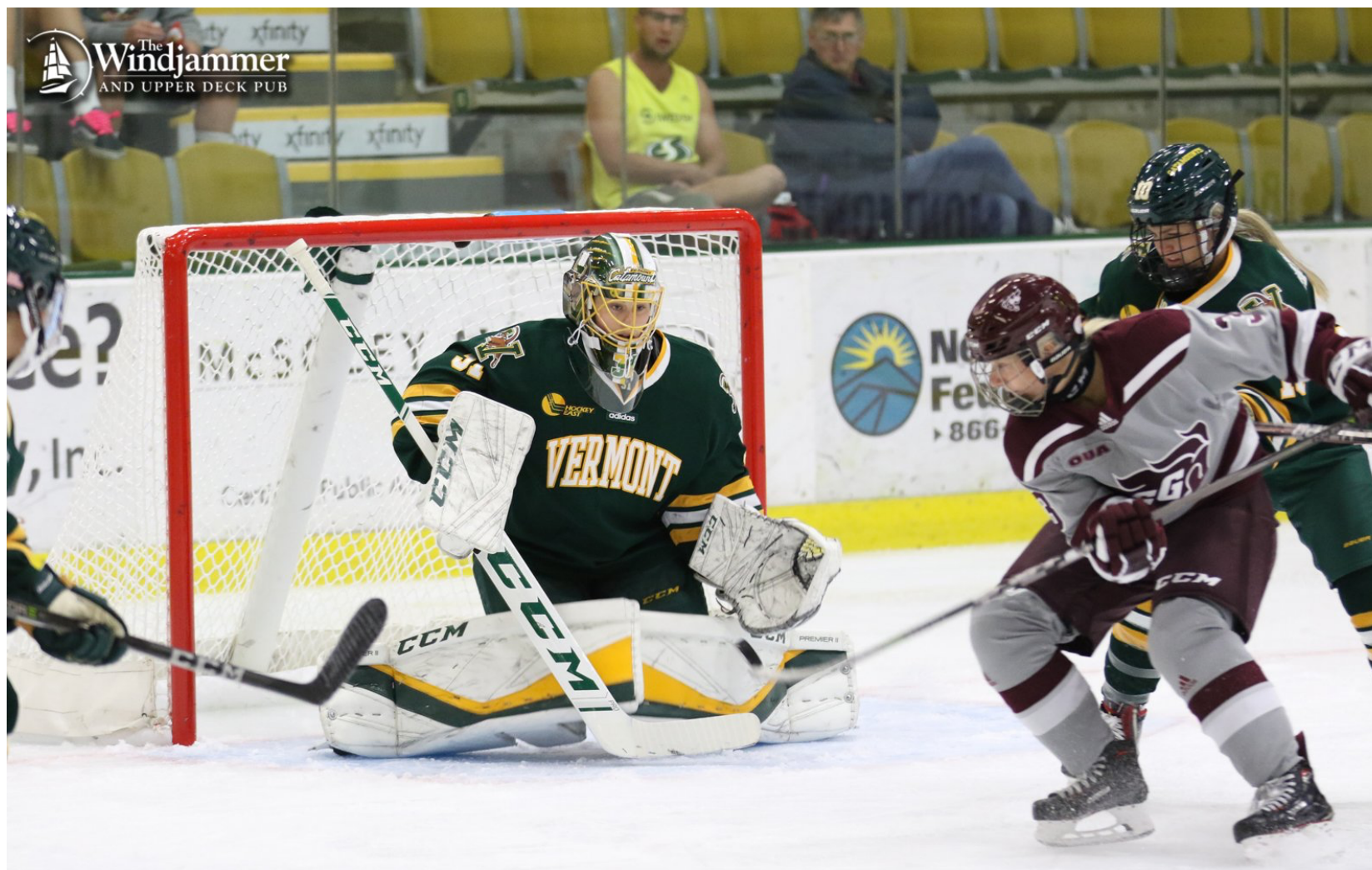


Cow flatulence (methane) starts as much as 10,000 years ago with animal domestication

- ruminants generate methane
- methanogenic microorganisms
- animal feed is a crucial factor
- a sheep produces 1/6 the methane of a cow

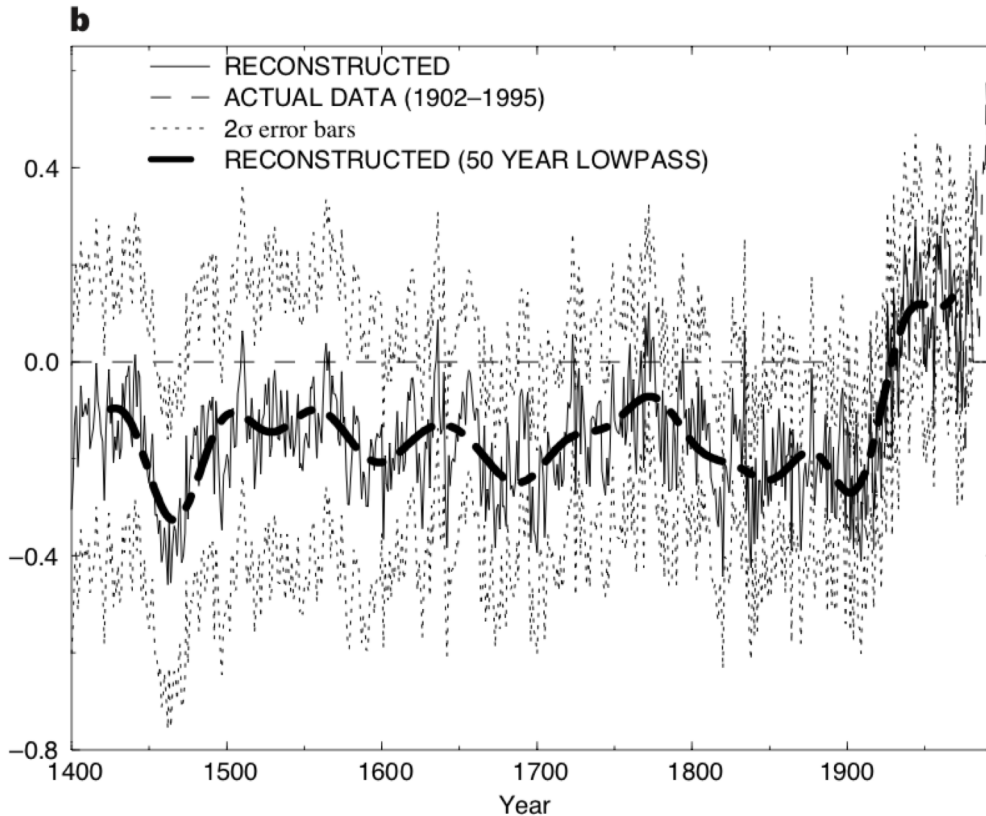


And finally, the Hockey Stick



Mike Mann and co authors, 1998 – The hockey stick

articles



Global-scale temperature patterns and climate forcing over the past six centuries

Michael E. Mann*, Raymond S. Bradley* & Malcolm K. Hughes†

* Department of Geosciences, University of Massachusetts, Amherst, Massachusetts 01003-5820, USA

† Laboratory of Tree Ring Research, University of Arizona, Tucson, Arizona 85721, USA

Spatially resolved global reconstructions of annual surface temperature patterns over the past six centuries are based on the multivariate calibration of widely distributed high-resolution proxy climate indicators. Time-dependent correlations of the reconstructions with time-series records representing changes in greenhouse-gas concentrations, solar irradiance, and volcanic aerosols suggest that each of these factors has contributed to the climate variability of the past 400 years, with greenhouse gases emerging as the dominant forcing during the twentieth century. Northern Hemisphere mean annual temperatures for three of the past eight years are warmer than any other year since (at least) AD 1400.

Over to last 21 years, dozens of independent studies have confirmed the validity of Mann's work

Michael Mann PhD
Interviewed
December, 2014
San Francisco

NEXT WEEK (this is critical)

NO CLASS ON TUESDAY – classroom in use

THURSDAY – 2 classes

1. Regular Class time – Mike Mann presenting and QUIZ (Ruddiman, Chapter 17 and Mann readings)
2. Mike's talk at Ira Allen Theater (get there before 430 in case it fills!)*

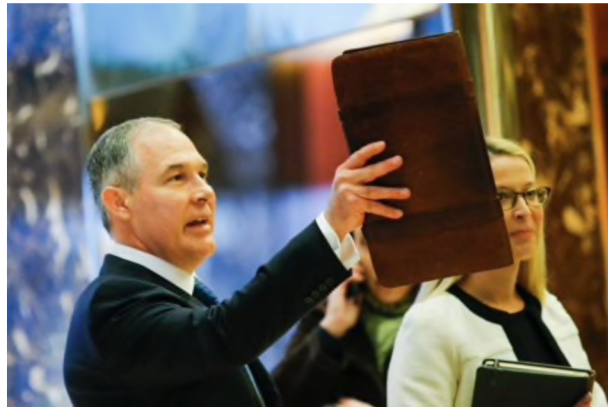
*If you have another class and can't make it to Mike's afternoon talk, send me an email and we will work it out.

Mike Mann – get to know him before next week.

<https://www.michaelmann.net>

Opinions

I'm a scientist who has gotten death threats. I fear what may happen under Trump.



Donald Trump's pick of Scott Pruitt for Environmental Protection Agency administrator is just one of many ominous signs. (Eduardo Munoz Alvarez/AFP/Getty Images)

By **Michael E. Mann**

Ad closed by Google

Report this ad

Why this ad? ▷

<https://www.washingtonpost.com/opinions/this-is-what-the-coming-attack-on-climate-science-could-look-like/2016/12/16/e015cc24-bd8c-11e6-94ac-3d324840106c>

DAN AND CAROLE BURACK
PRESIDENT'S DISTINGUISHED LECTURE SERIES

Portrait drawn by Matthew Stanton

CLIMATE WARS

A RETURN TO THE MADHOUSE: CLIMATE CHANGE DENIAL IN THE AGE OF TRUMP

MICHAEL MANN, PH.D.
*Professor of Atmospheric Science, Pennsylvania State University
Winner of the AAAS Public Engagement with Science Award and the Tyler Prize
Author of Dire Predictions, The Hockey Stick and the Climate Wars, The Madhouse Effect,
and The Tantrum that Saved the World*

With the election of Donald Trump as president of the United States, climate denialism has reached the highest level of US government. Distraction, denial and delay, and the exploitation of fossil fuels, are standing in as policy. In this talk, I will review the scientific evidence of climate change, give the reasons we should care, and identify the efforts by special interests and partisan political figures to confuse the public, attack science and scientists, and deny the problem. I will also explain why, despite the challenges, I'm optimistic we will prevail and avert catastrophic climate change impacts.

Date
Thursday, October 10

Time
4:30 – 5:30 p.m.

Location
Ira Allen Chapel, UVM
Reception and book signing immediately following in the Ifshin Hall Atrium

Sponsored by the Department of Geology, with support from the Gund Institute for Environment, the Environmental Program, the Consulting Archeology Program, the Geography Department, and the College of Engineering and Mathematical Sciences

For more information:
Professor Paul Bierman, pbierman@uvm.edu
For ADA accommodations: (802) 656-3033

THIS EVENT IS FREE AND OPEN TO THE PUBLIC.