Climate change and its ecological consequences for New England

New England Association of Environmental Biologists
Bethel Inn
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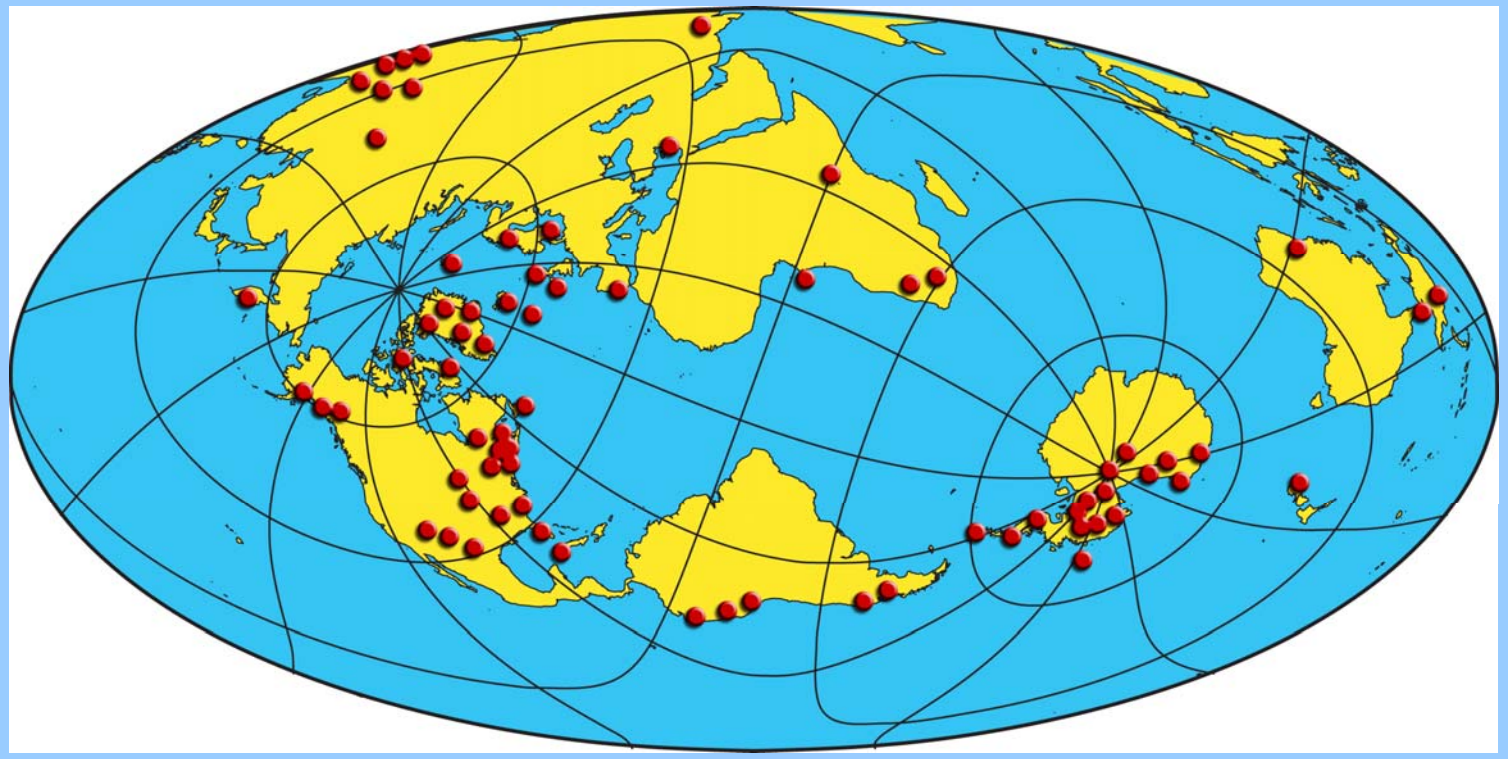
Climate Change Institute

The University of Maine

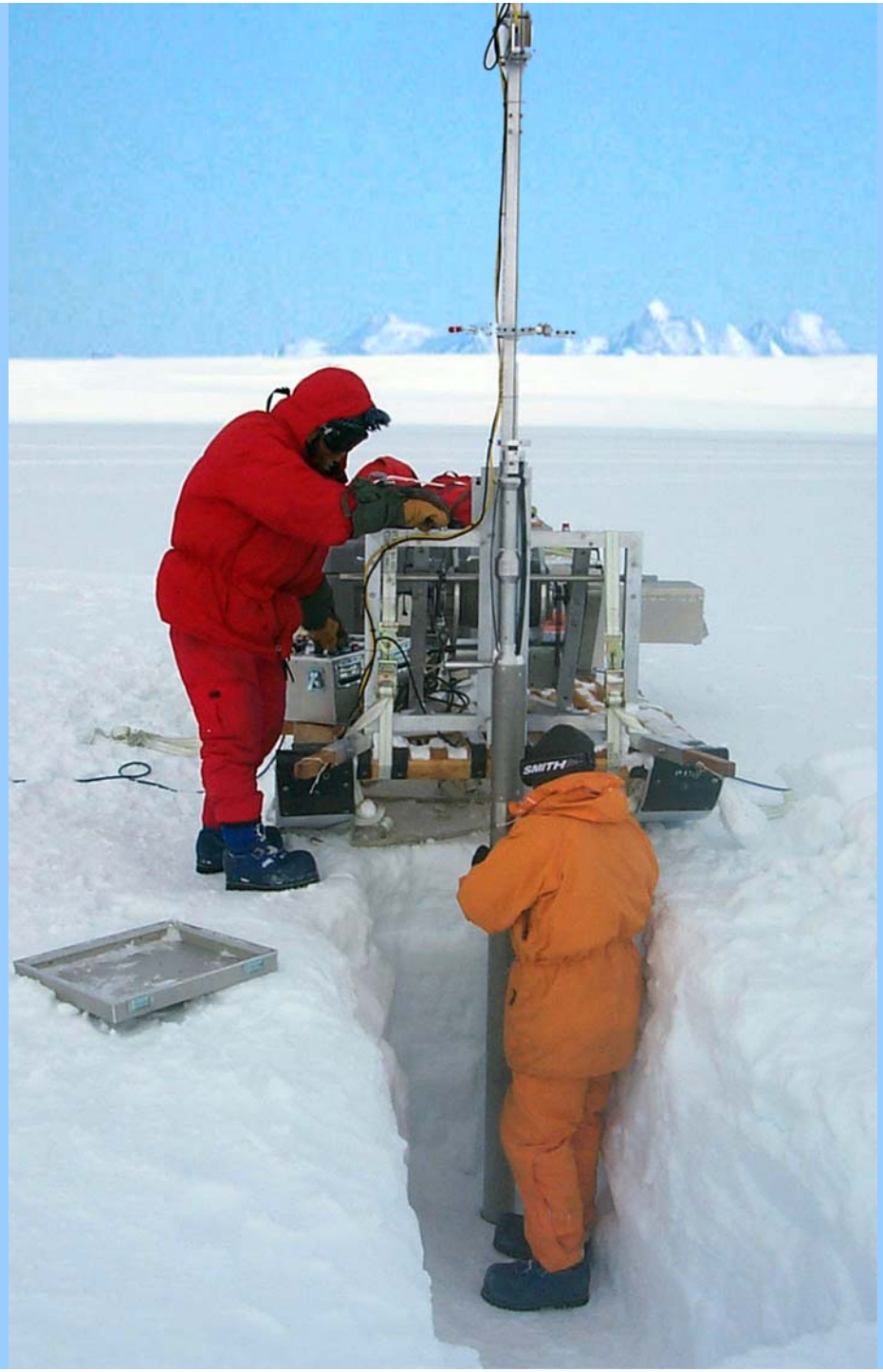


Sites of recent research projects

Climate Change Institute

(formerly Institute for Quaternary and Climate Studies)

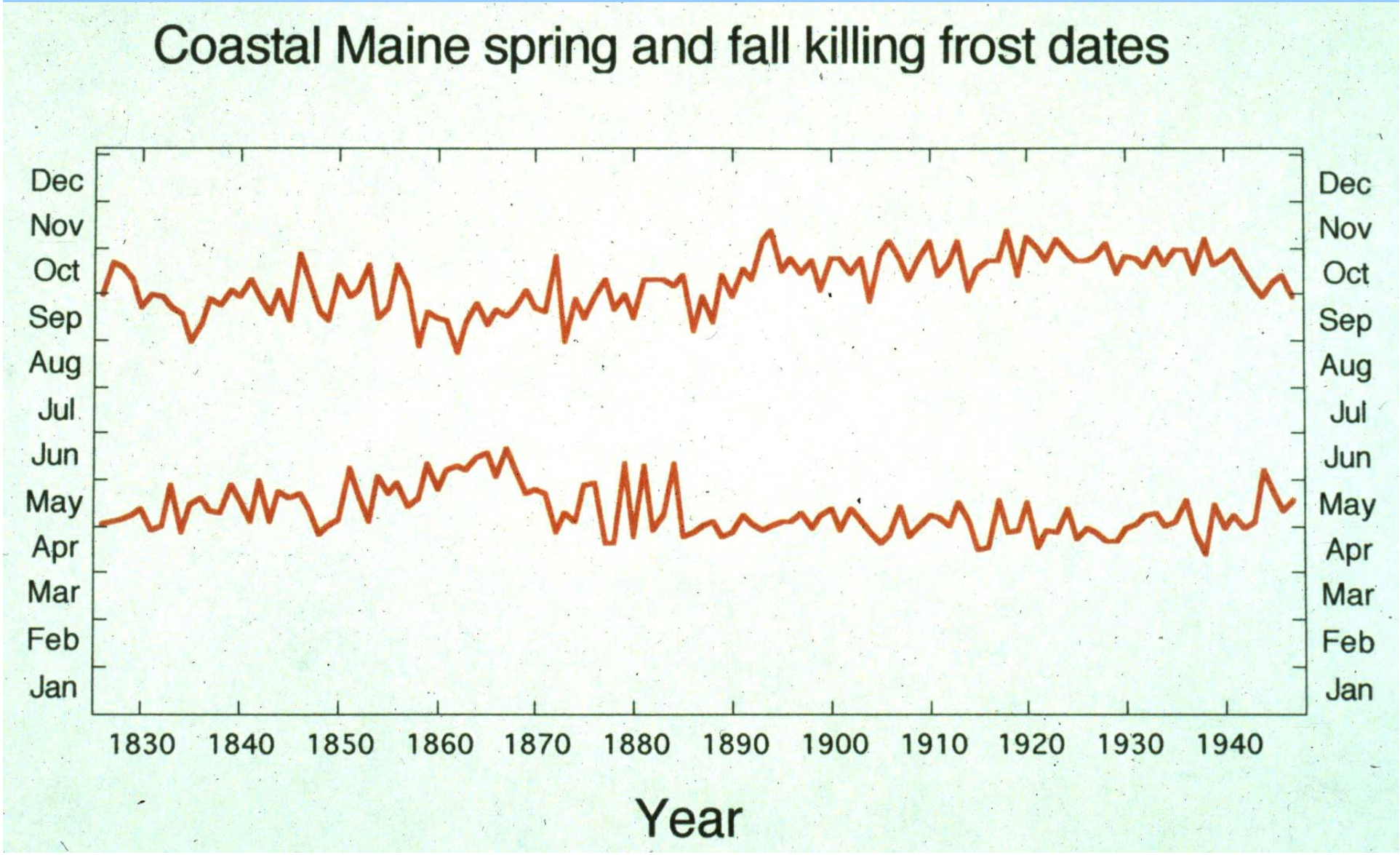
- Climatology/Paleoclimatology
- Historic climatology
- Paleoecology
- Prehistoric archaeology
- Glacial geology and glaciology
- Atmospheric chemistry (incl. ice cores)
- Geochemistry



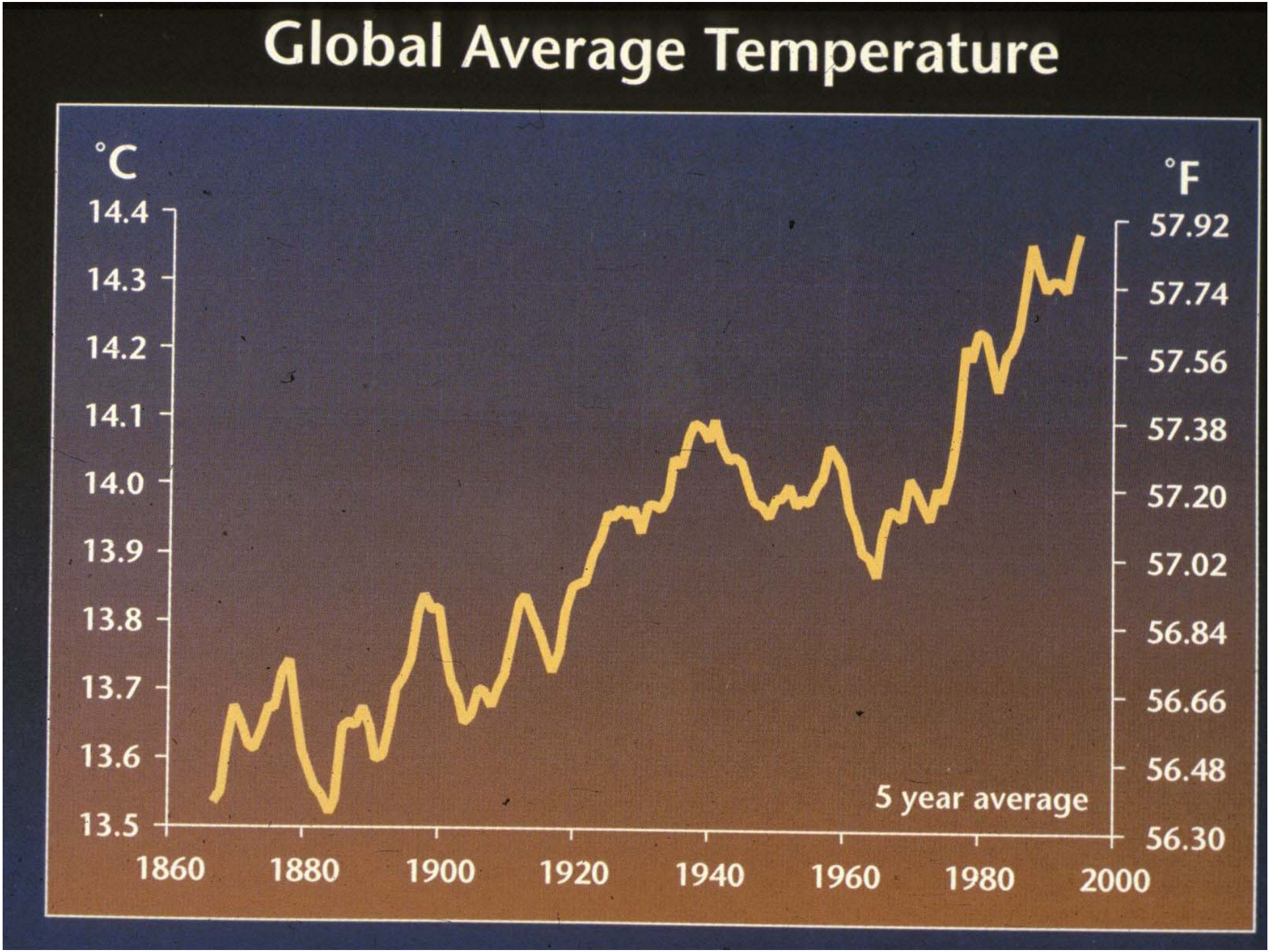
The North's ice-age heritage

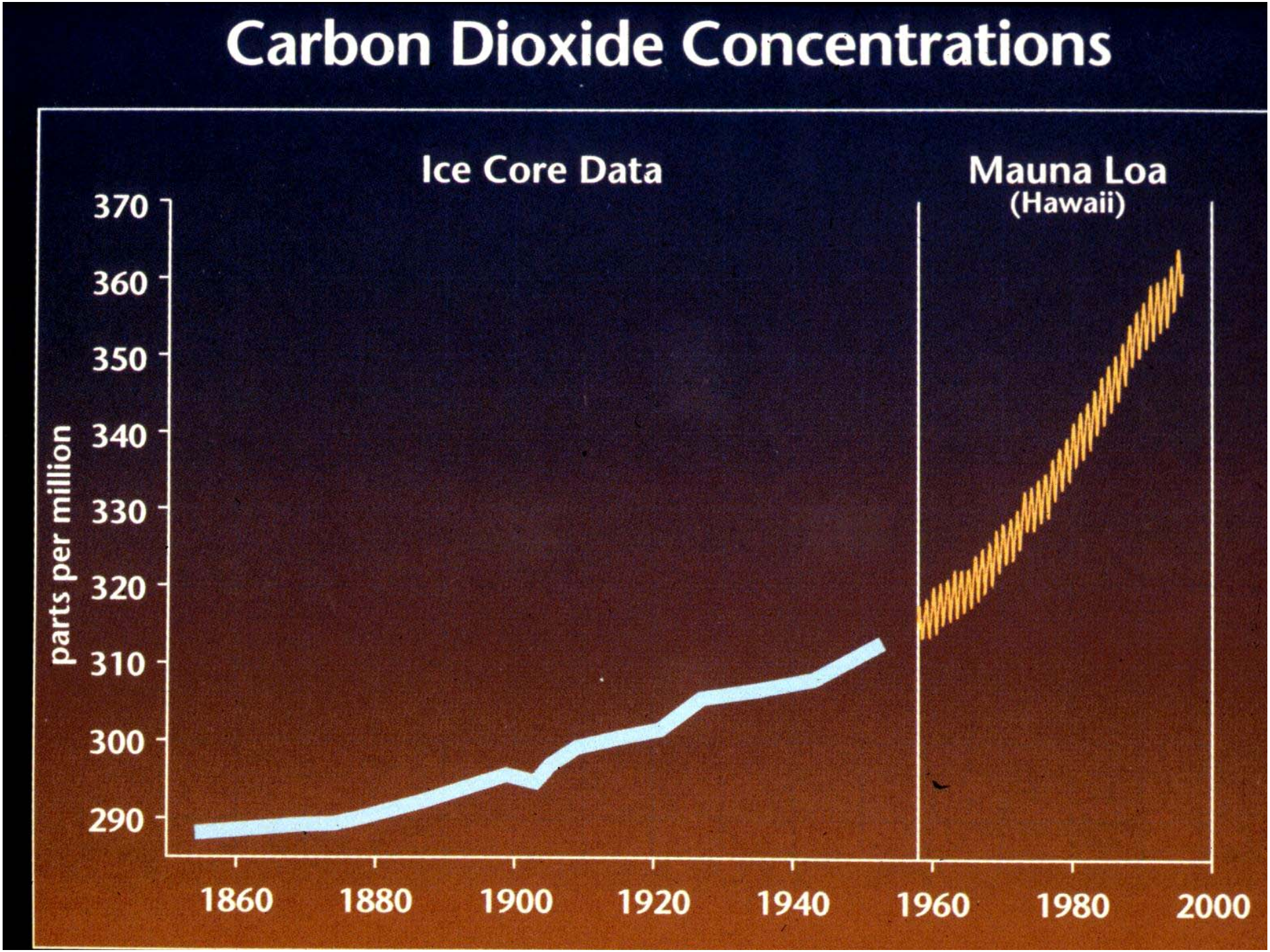
- Landforms were shaped by repeated glaciations
- Eskers and emerged deltas provide sand and gravel and abundant groundwater
- Sea-level has changed significantly
- Prehistoric peoples adapted to changing conditions
- Many modern environmental challenges involve glacially derived materials
- Long-term climate changes have led to major changes in vegetation

Historical records reveal significant changes in New England growing seasons

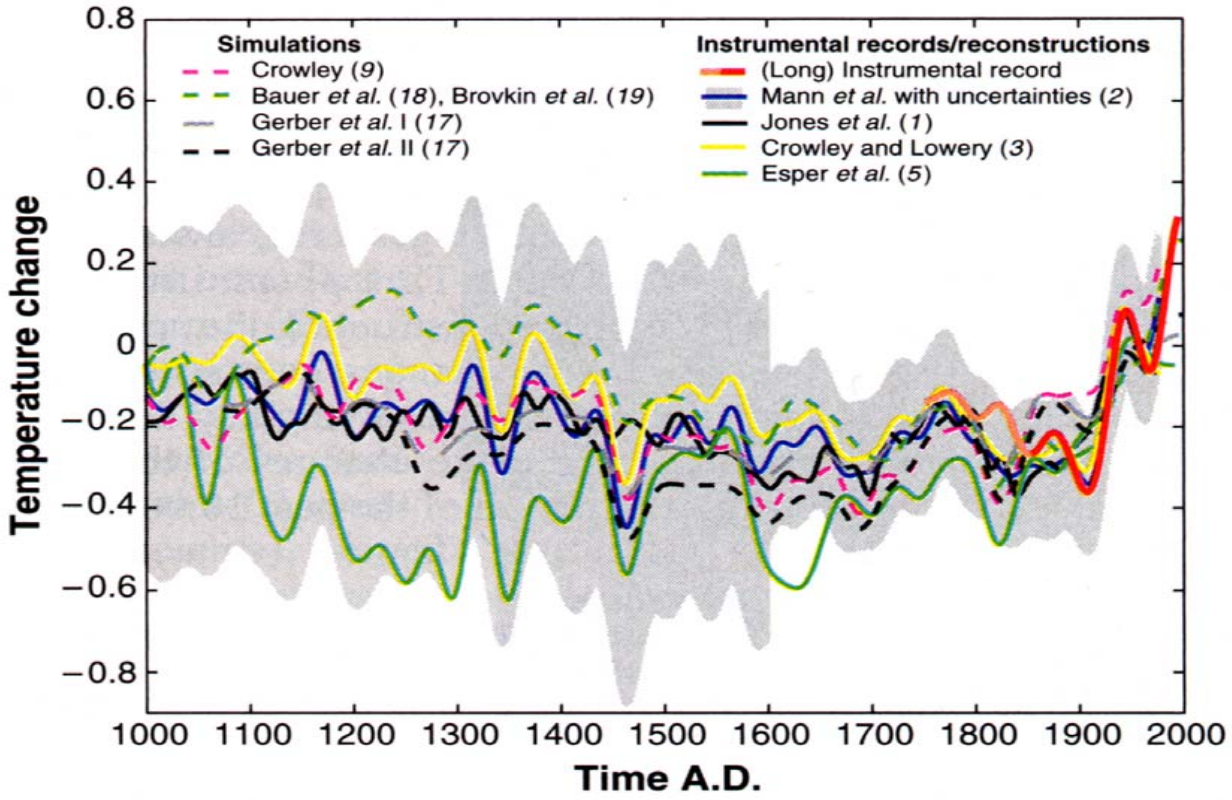


Global Average Temperature




Carbon Dioxide Concentrations
Ice Core Data
Mauna Loa
(Hawaii)
parts per million
370
360
350
340
330
320
310
300
290
1860
1880
1900
1920
1940
1960
1980
2000

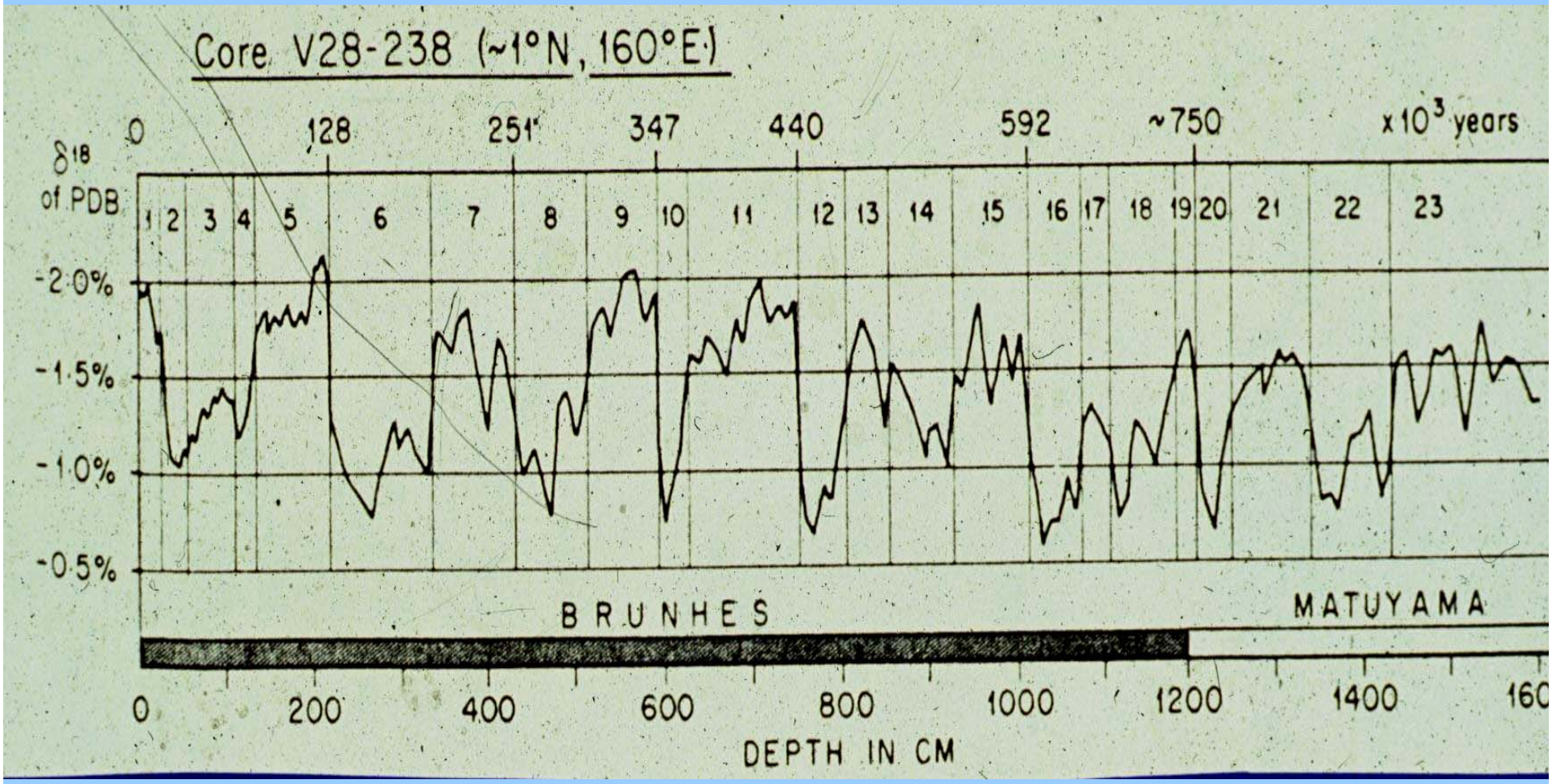
Longer-term records in climate show variability at several time scales



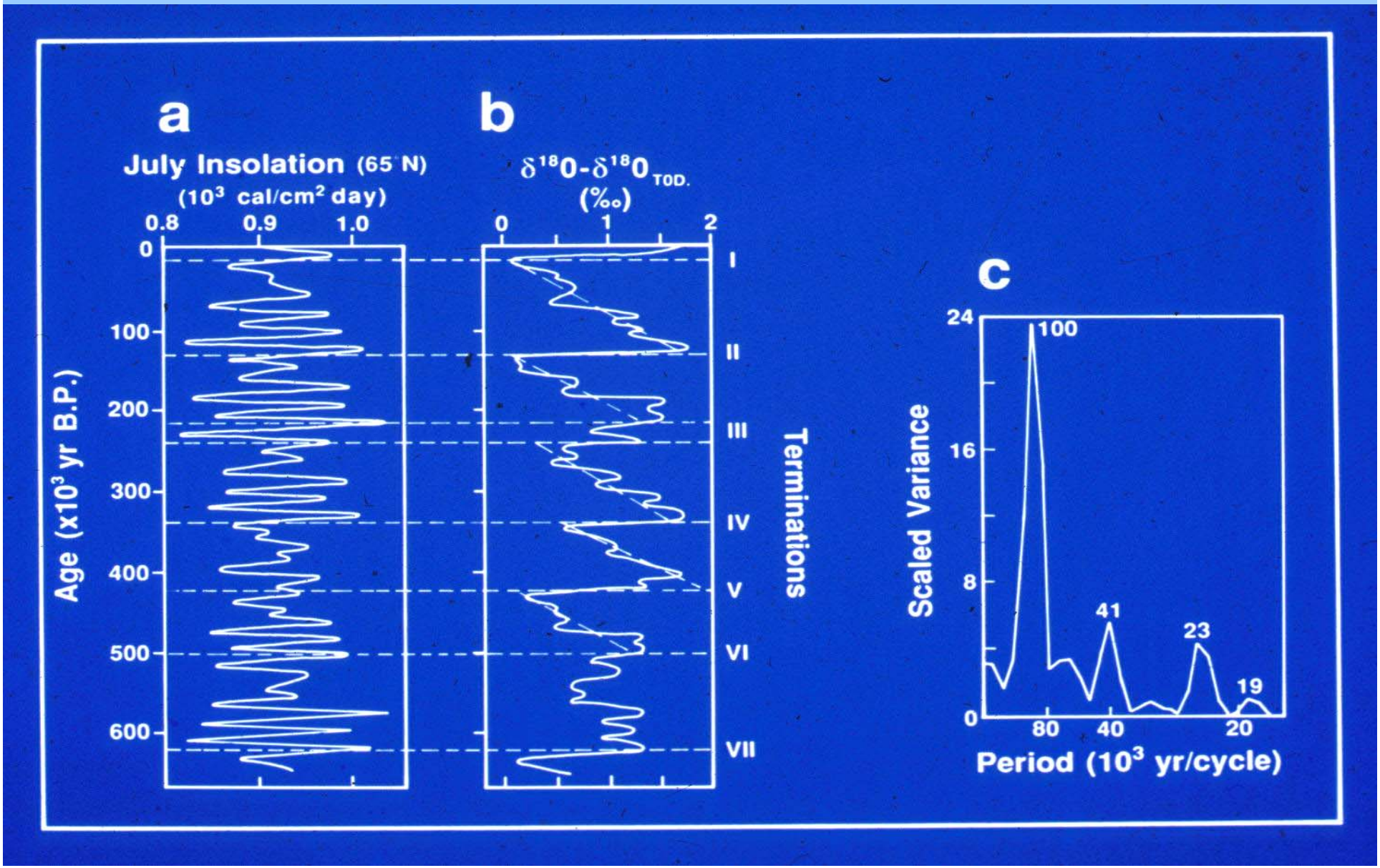
NH temperature histories. Comparison of multiproxy reconstructions of the NH annual mean temperature (*1–3*) with model simulations (*9*, *17–19*). Gerber I, 1.5°C for CO_2 doubling; Gerber II, 2.5°C for CO_2 doubling. Also shown is a reconstruction of summer extratropical continental NH temperatures (*5*). All reconstructions have been scaled to the NH instrumental record (*20*) over the 1856 to 1980 period, and have been smoothed on time scales of >40 years to highlight the long-term variations.

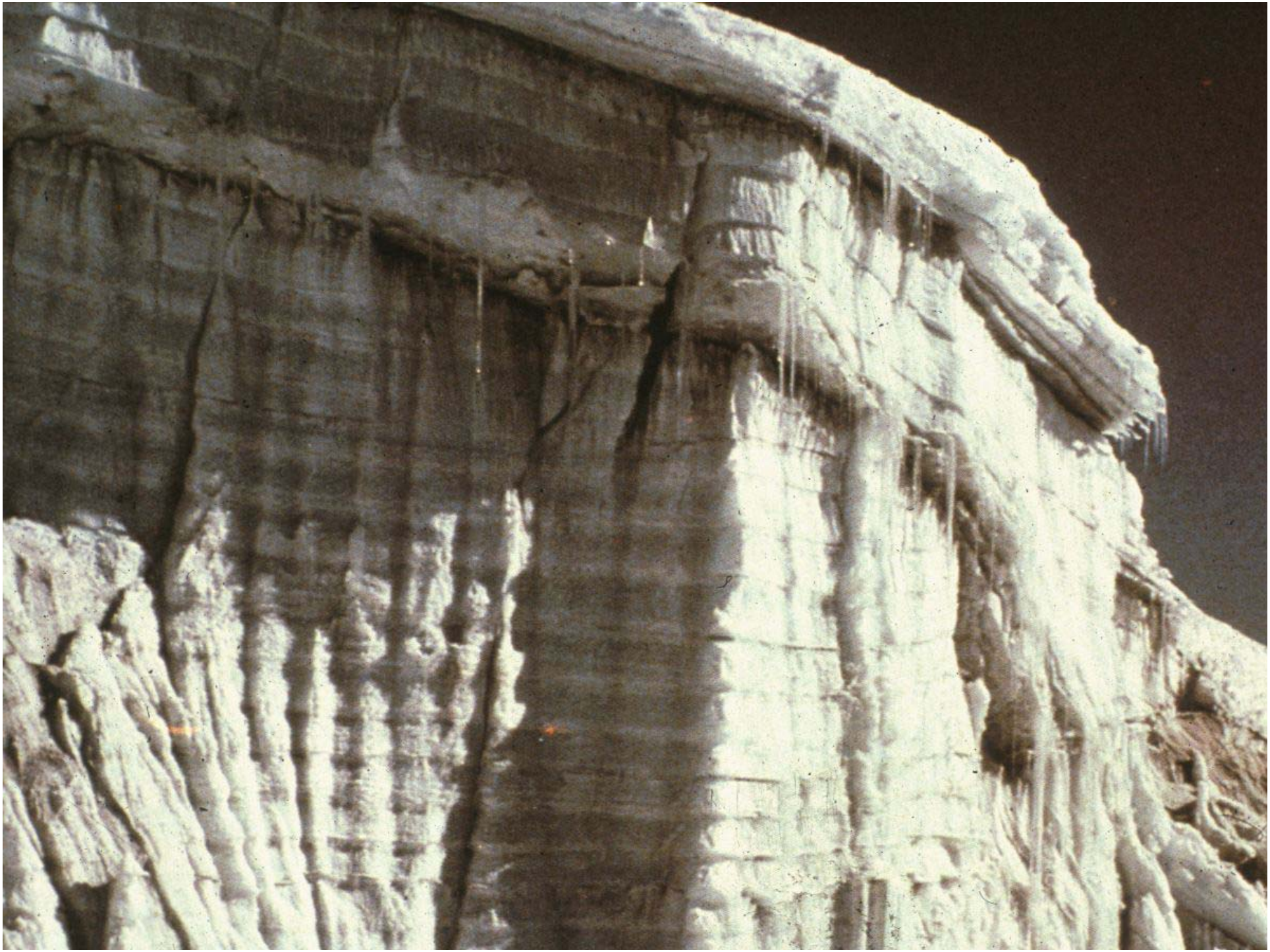

RUSSIA
North Pole
Arctic
Ocean
Greenland
Iceland
Pacific Ocean
Atlantic Ocean
UNITED STATES

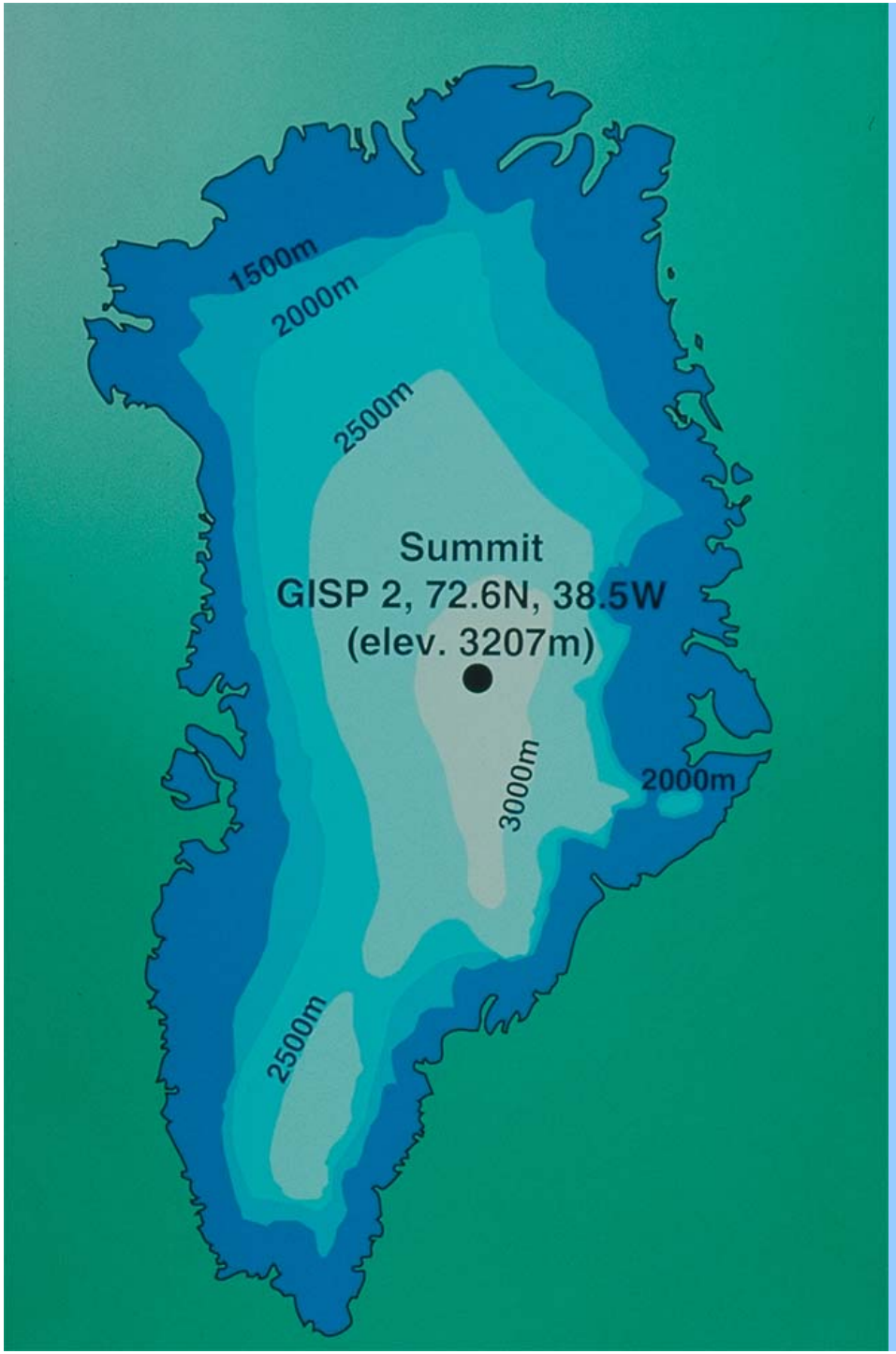
Multiple ice-age cycles characterize the past million years



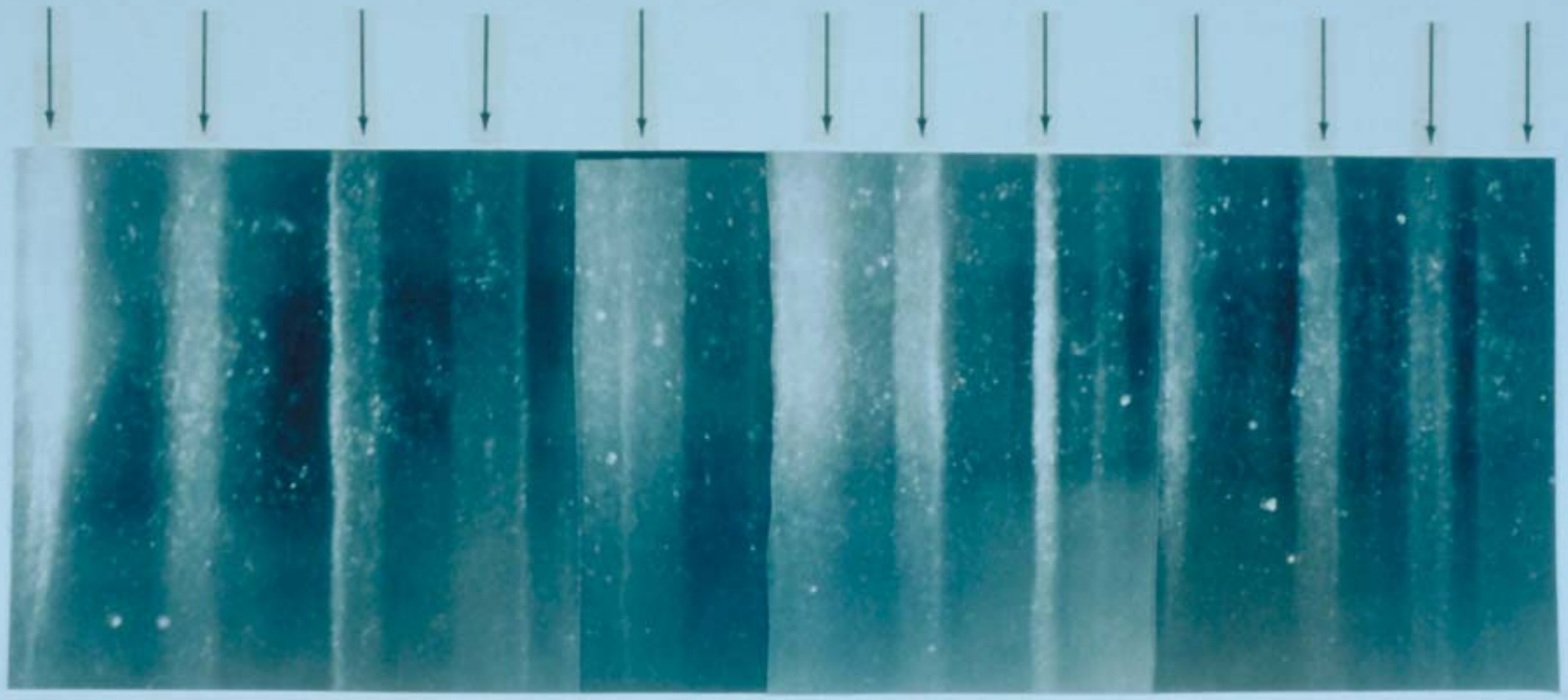
Long-term changes in climate are associated with known cycles in earth's orbital properties: tilt, precession, and eccentricity



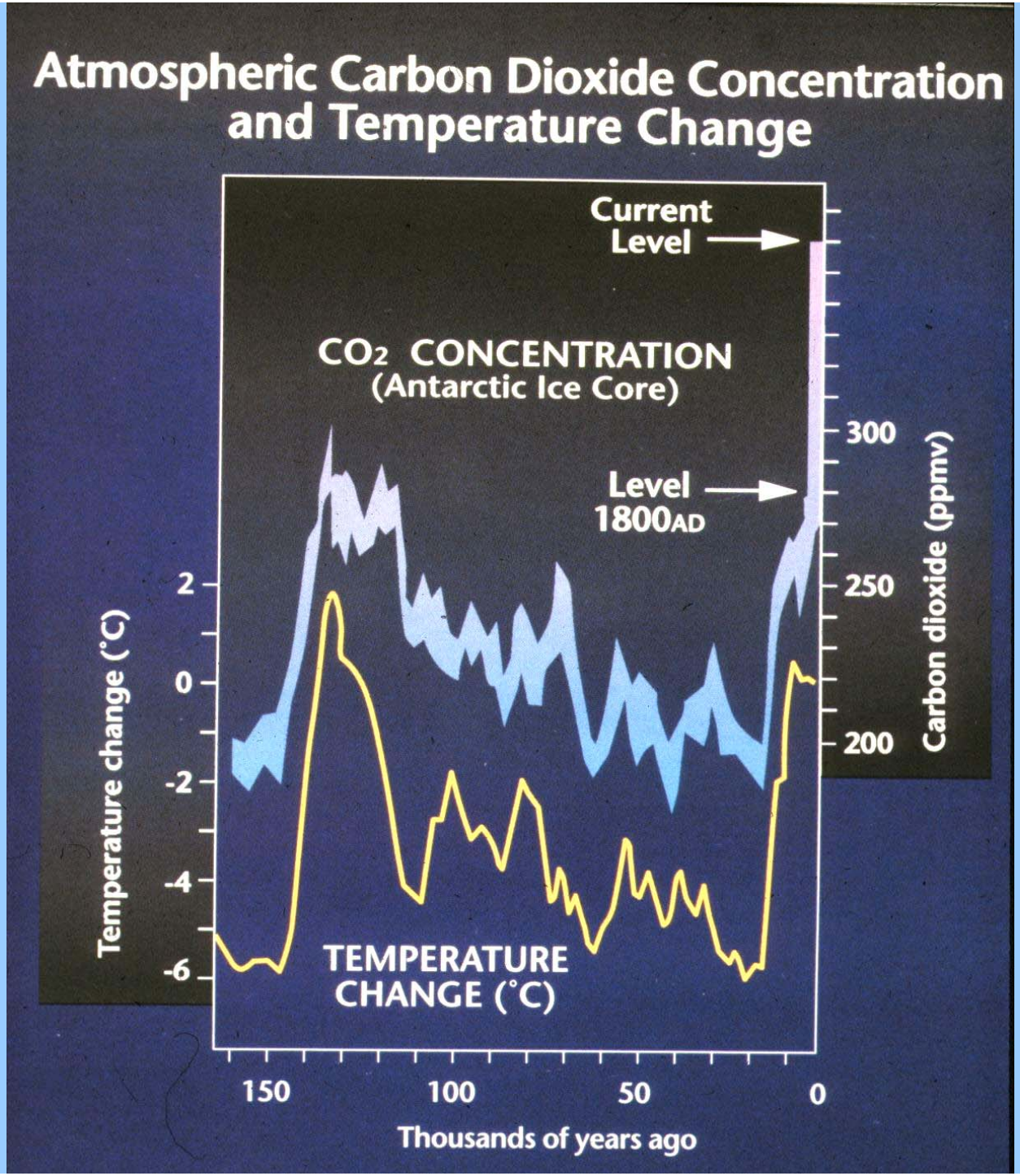




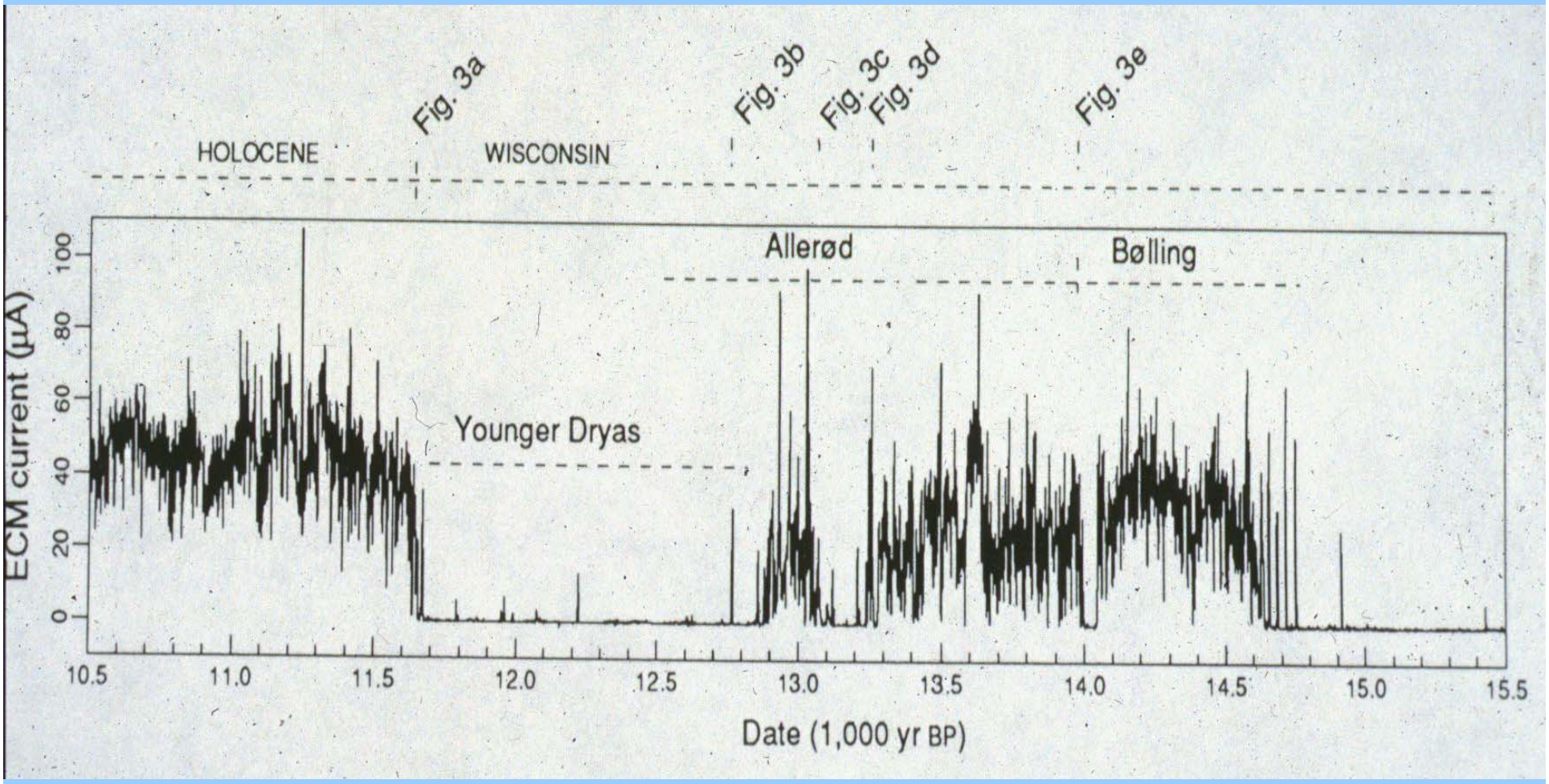
Deep ice cores from Greenland and Antarctica provide highly detailed records of past climate and atmospheric chemistry



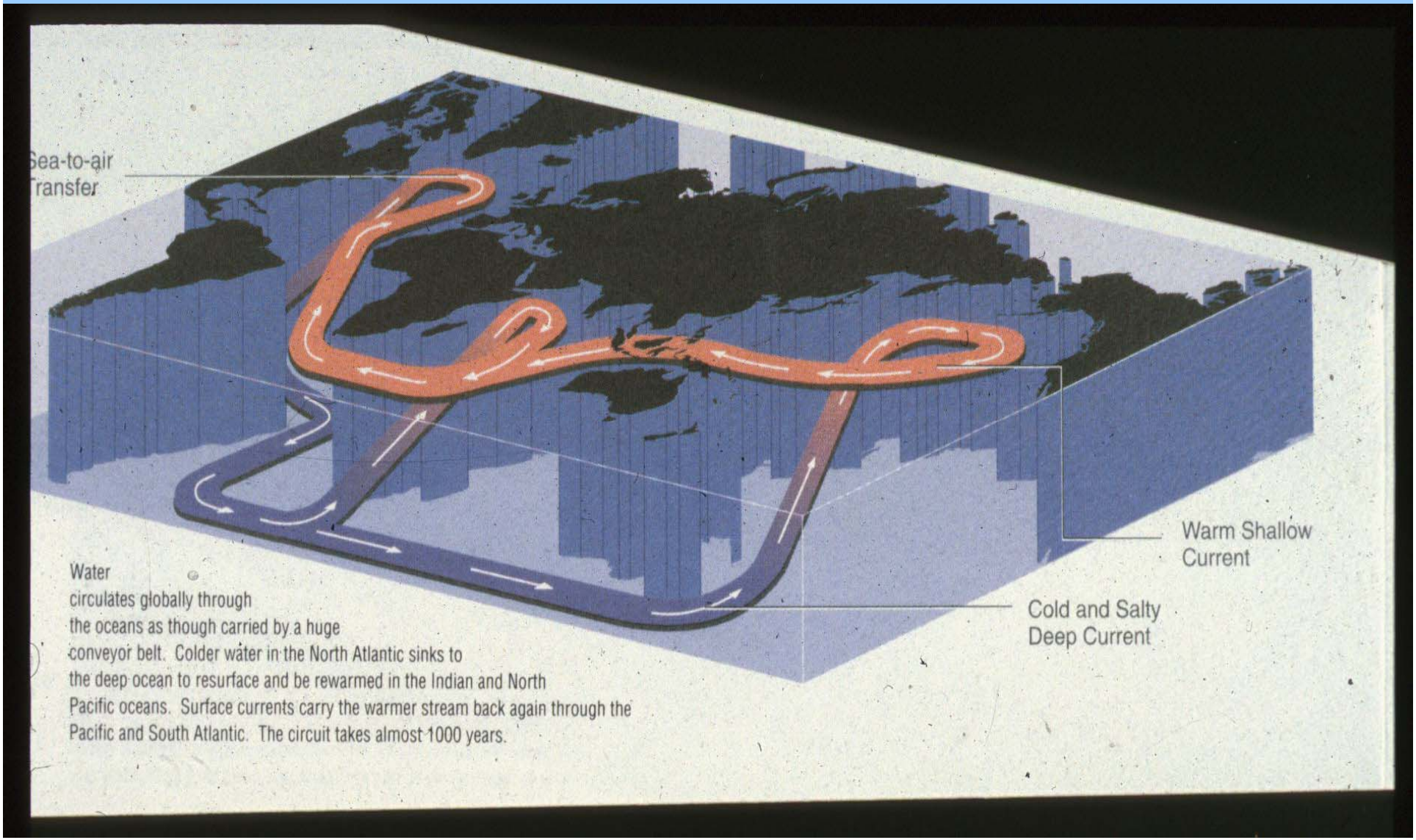
19 cm long section of GISP 2 ice core from 1855 m showing annual layer structure illuminated from below by a fiber optic source. Section contains 11 annual layers with summer layers (arrowed) sandwiched between darker winter layers.

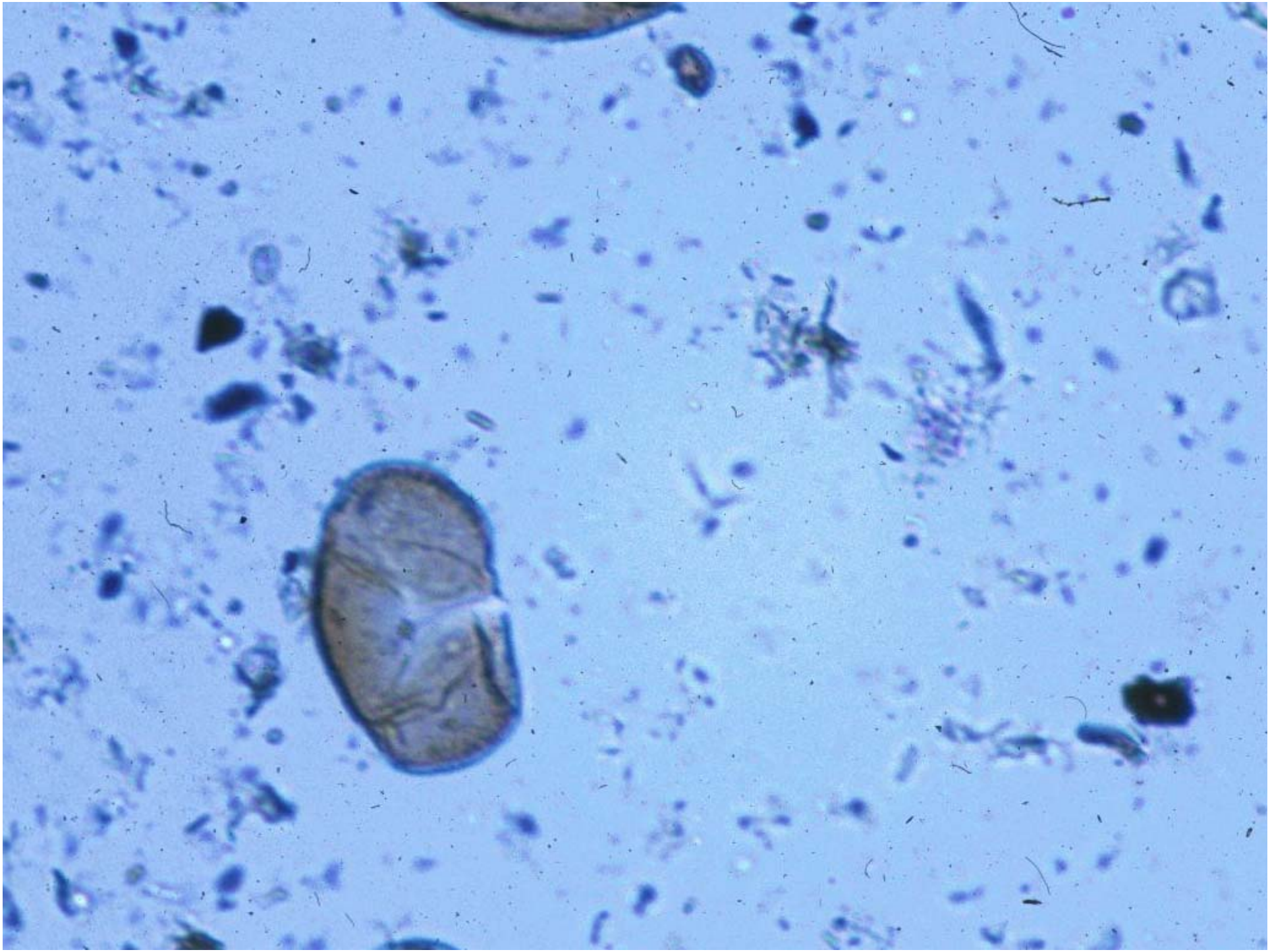

Atmospheric Carbon Dioxide Concentration and Temperature Change
Current Level
CO2 CONCENTRATION
(Antarctic Ice Core)
Level 1800AD
TEMPERATURE CHANGE (°C)
Temperature change (°C)
2
0
-2
-4
-6
300
250
200
Carbon dioxide (ppmv)
150
100
50
0
Thousands of years ago

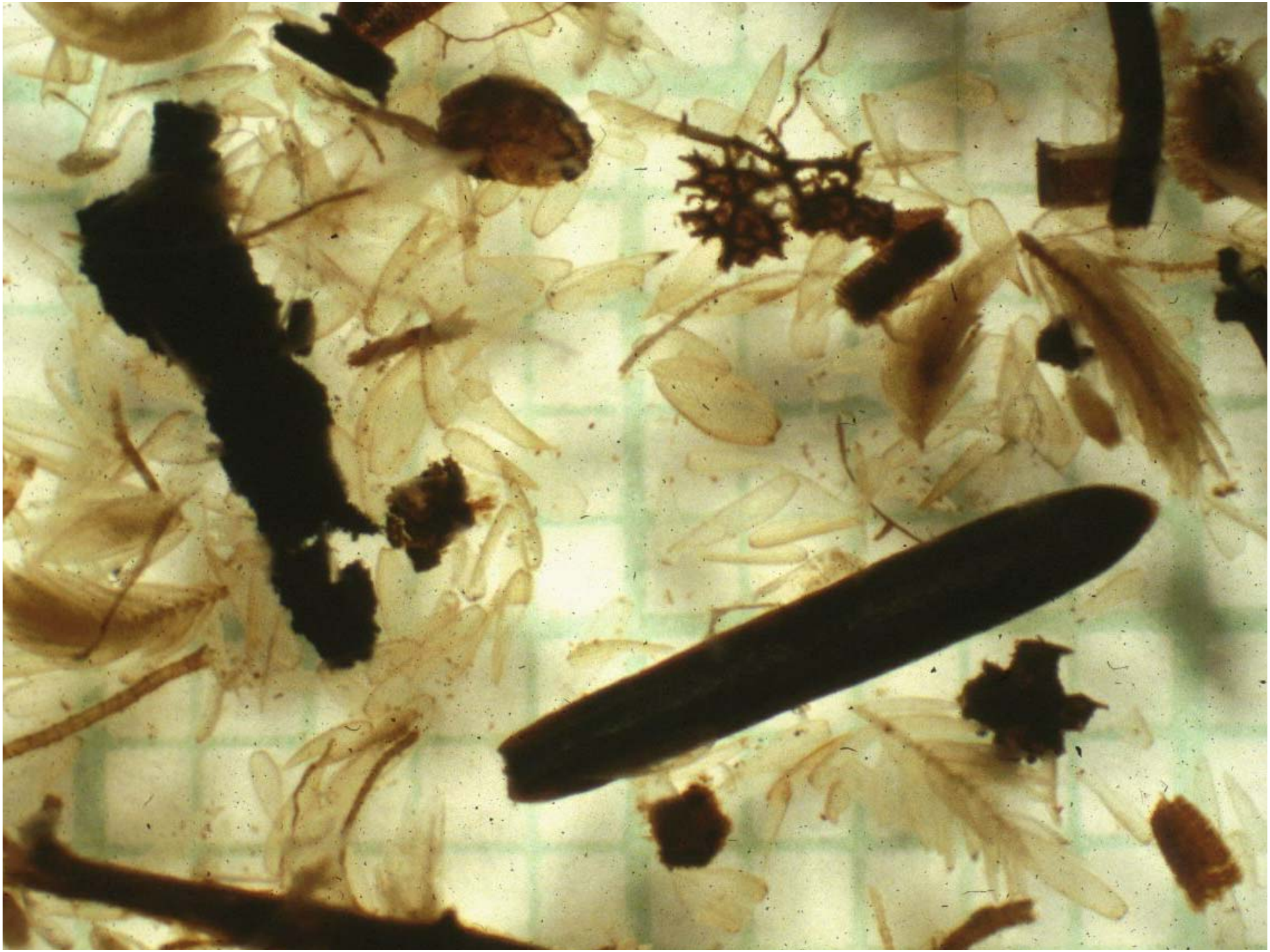
Ice-cores reveal large and abrupt changes in pre-industrial climates



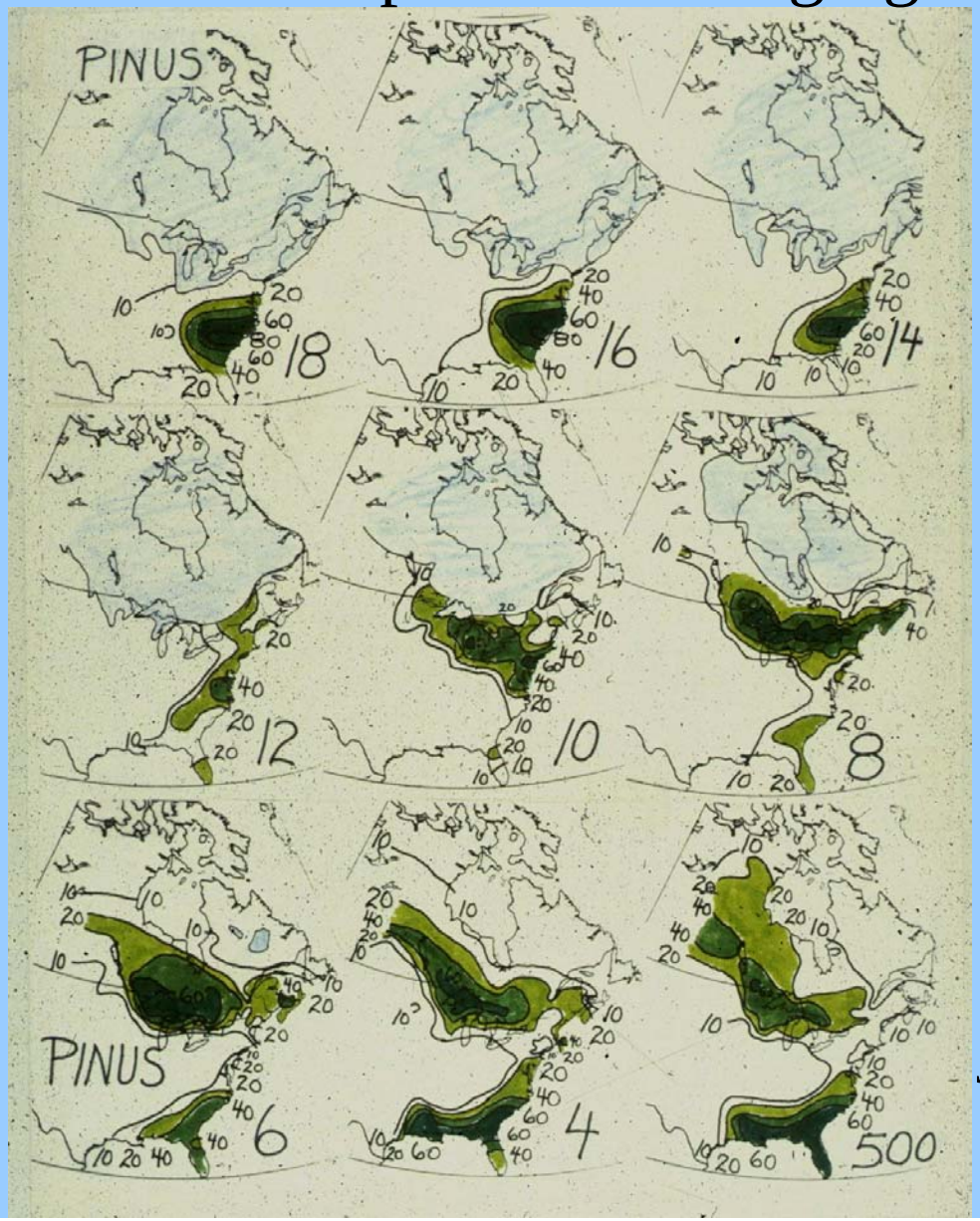
Ocean currents transfer heat (e.g., North Atlantic Deep-Water current)





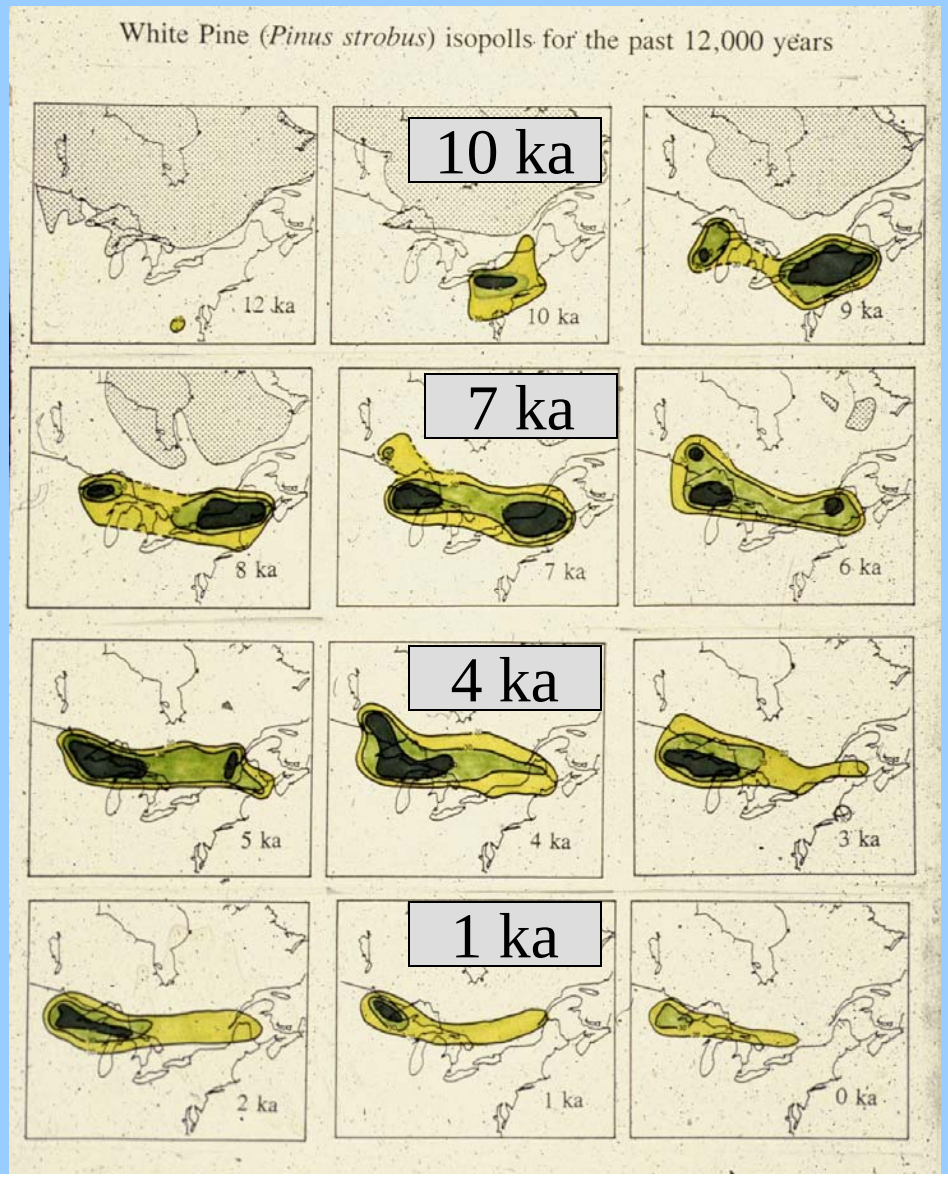


Post-glacial distribution of pines changed in response to changing climate



Jacobson et al. 1987 DNAG v.3
Geol. Soc. Am. pp. 277-288.

Changing abundance of white pine (***Pinus strobus***) during the past 12,000 years

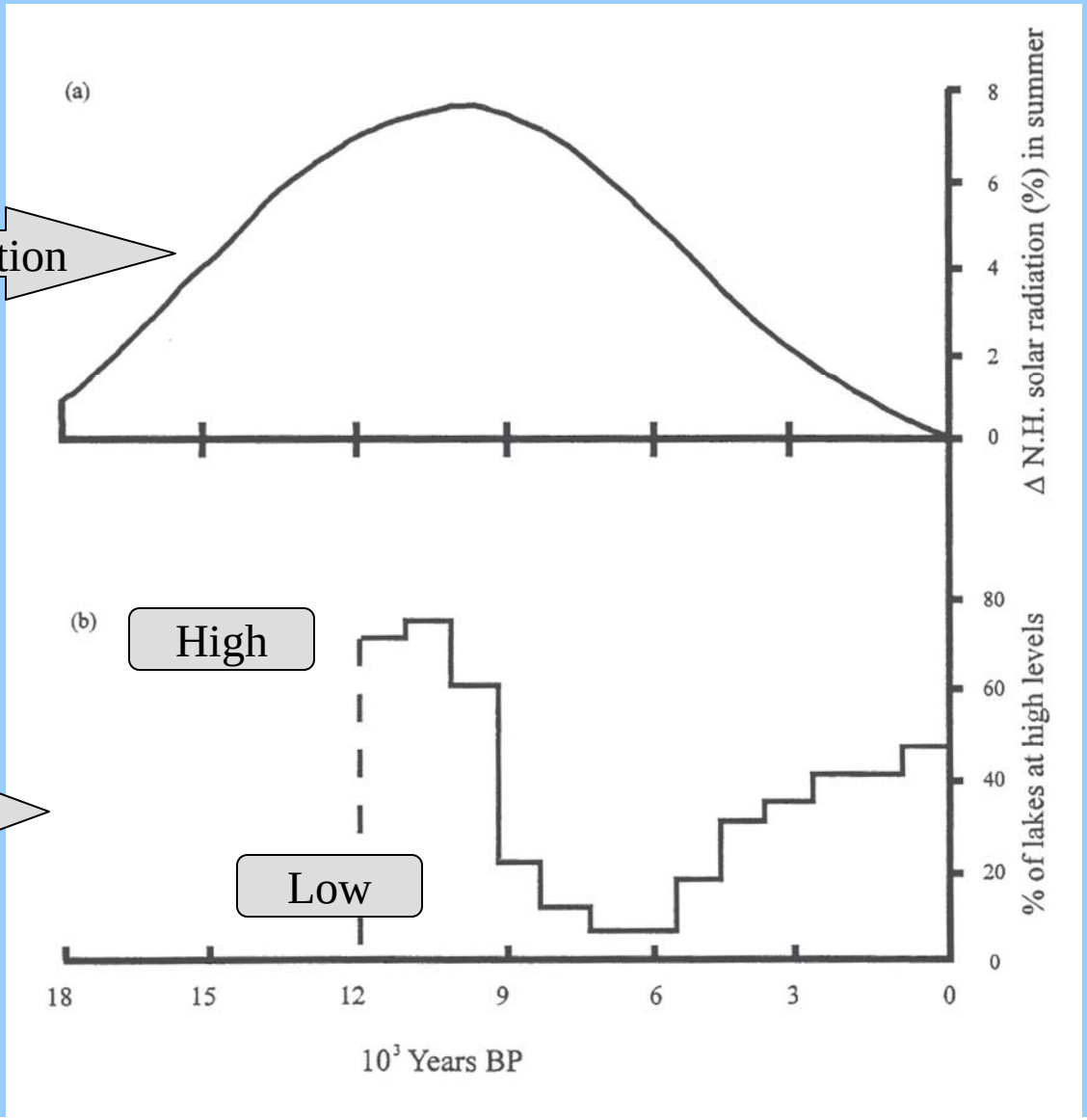


Jacobson & Dieffenbacher-Krall (1995) ***Journal of Forestry*** 93:39-42

Known variation in insolation associated with the precession cycle lead to important changes in seasonality and moisture balance

N. Hemis. summer insolation

Lake-level changes



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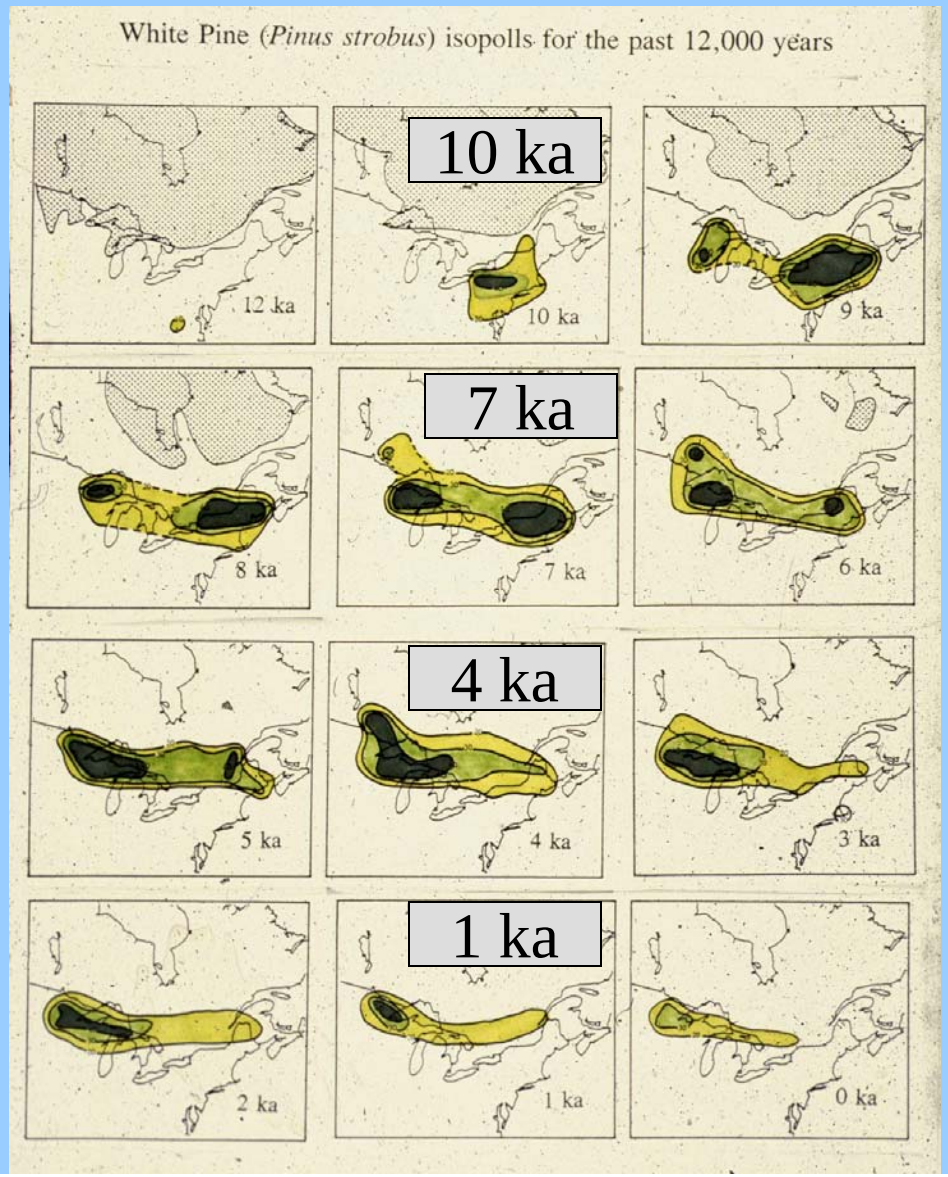

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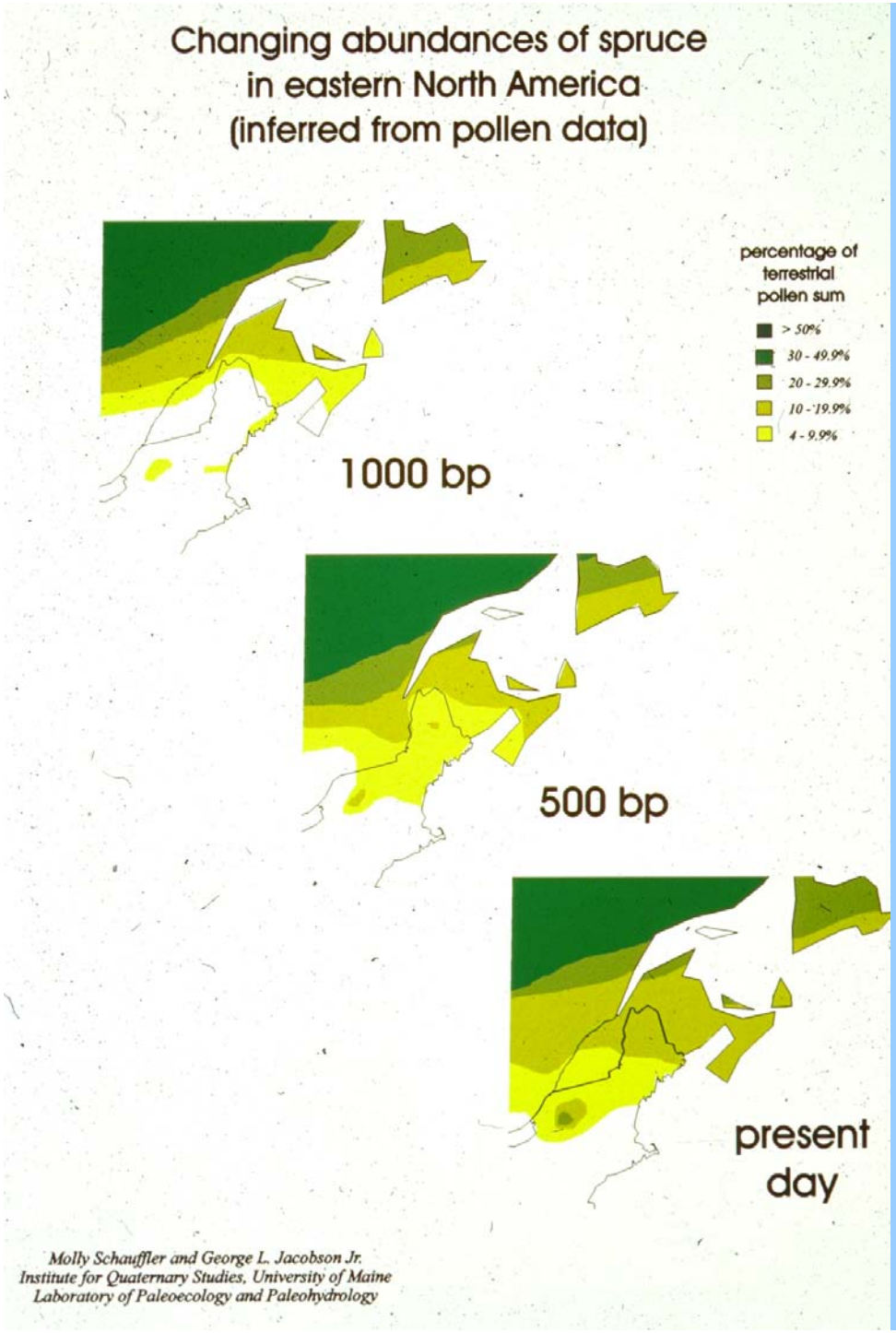
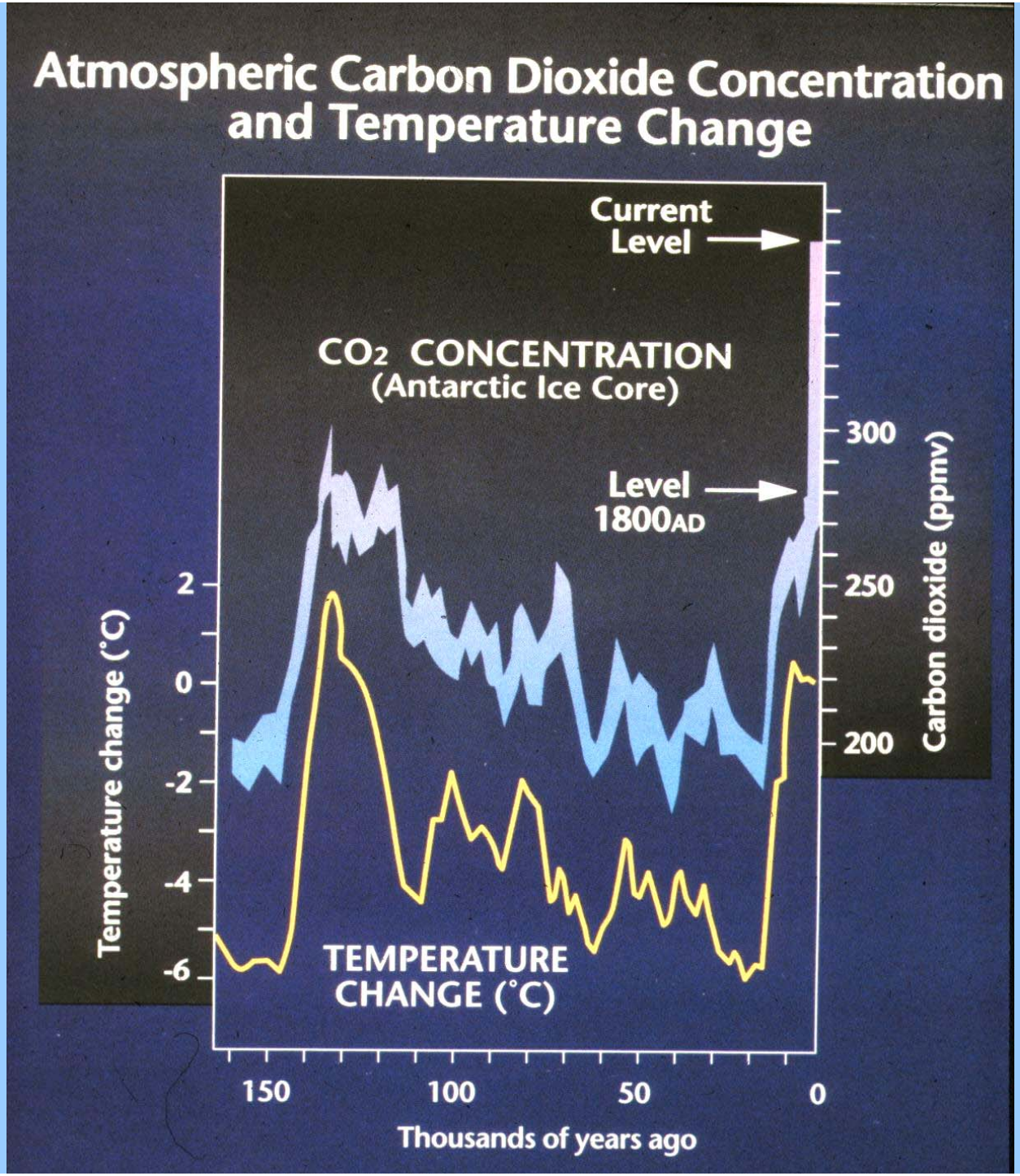
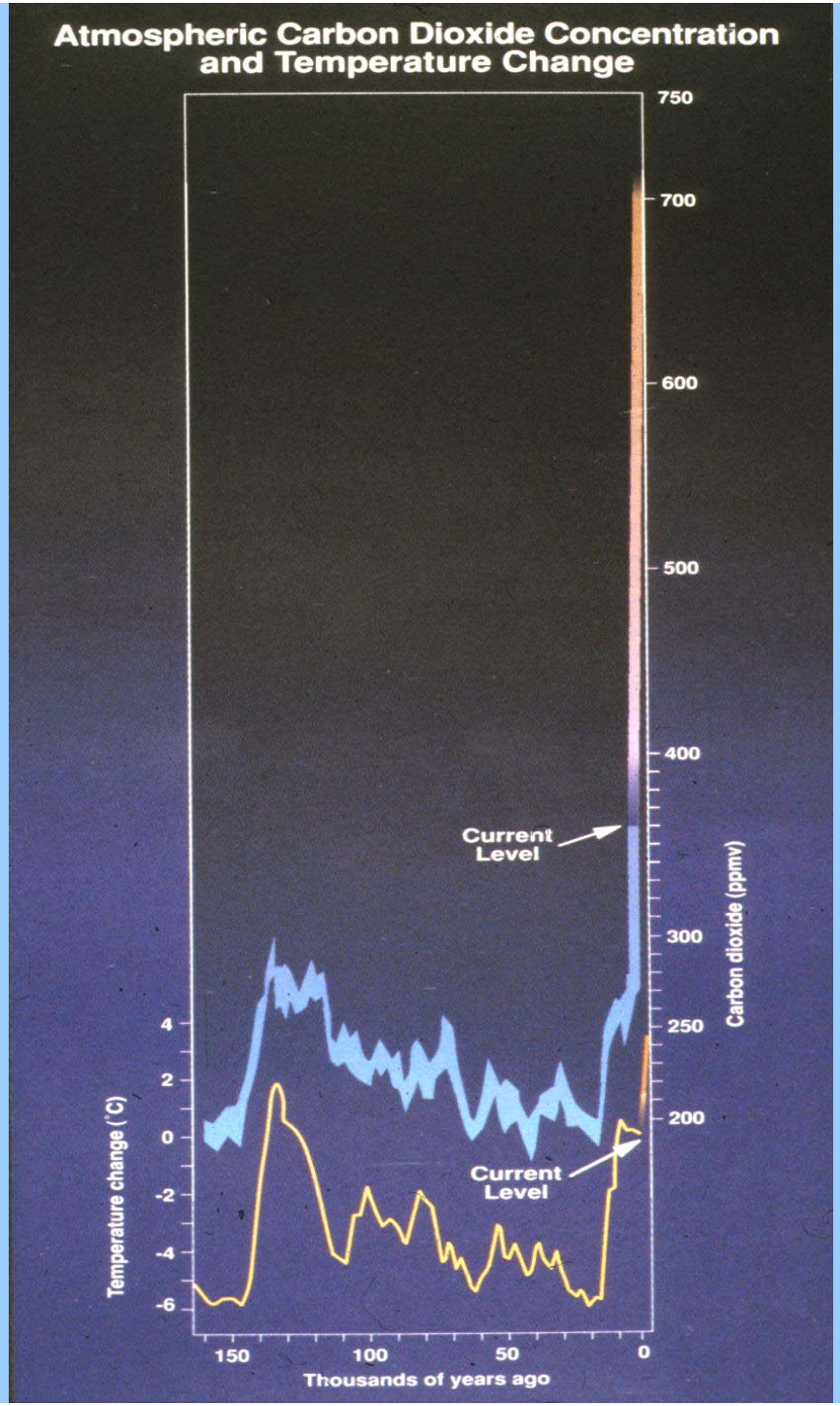
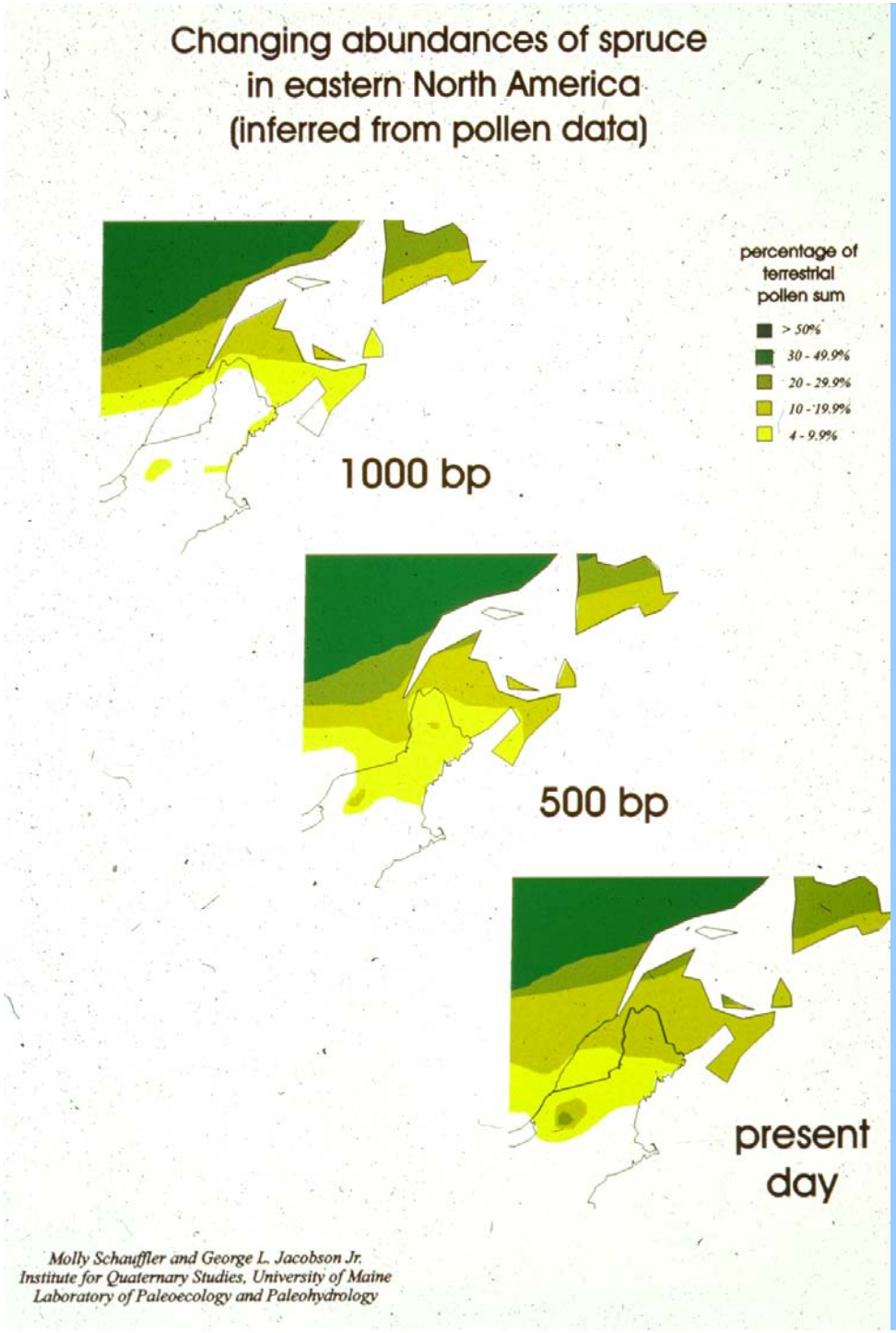


Spruce populations became more abundant south of Canada only in the past 1000 years as conditions became cooler and moister

Schauffler and Jacobson (2002) ***Journal of Ecology*** 90:235-250.

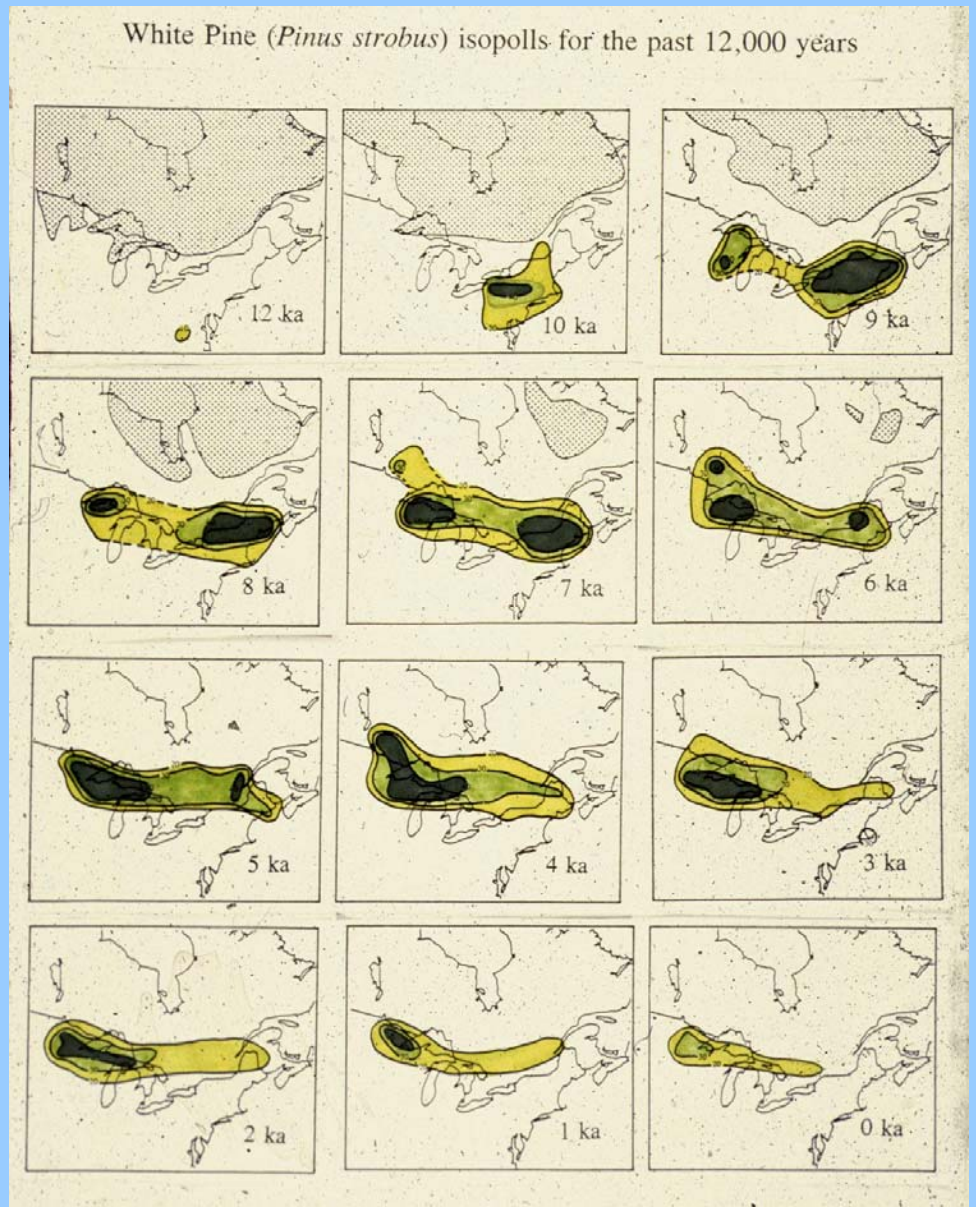

Atmospheric Carbon Dioxide Concentration and Temperature Change
Current Level
CO2 CONCENTRATION
(Antarctic Ice Core)
Level 1800AD
TEMPERATURE CHANGE (°C)
Temperature change (°C)
2
0
-2
-4
-6
300
250
200
Carbon dioxide (ppmv)
150
100
50
0
Thousands of years ago


Atmospheric Carbon Dioxide Concentration and Temperature Change
750
700
600
500
400
300
250
200
Carbon dioxide (ppmv)
Current Level
Current Level
4
2
0
-2
-4
-6
Temperature change (°C)
150
100
50
0
Thousands of years ago



Will spruce-fir forests continue to prosper in northern New England?

Will future climates again favor abundant white pine?



Implications for Northeastern ecosystems

- The regional climate is certain to change in upcoming decades, as it has in the past
- Likely scenarios involve warmer mean-annual temperatures and milder winters
- Forests will respond to changing climate (shifts in composition and growth rate)
- Decisions about natural areas should assume changes (see Hunter, Jacobson, Webb (1988) ***Conservation Biology*** 2:375-385)

Environmental monitoring for the future:

- Phenology (seasonality) of biological phenomena
- Changing range limits of plants and animals
- Climate patterns (with high spatial resolution)
- Atmospheric chemistry
- Water chemistry
- Coastal erosion and water quality
- others….

Maine's sea level has changed continuously since the last ice age