

# Lecture 23: The Last Deglaciation

(21-6k yrs ago)

Ch. 13, p. 229-239

- What factors controlled the climate during 21-6k yrs ago?
- When did the ice sheets melt?
- How did sea level respond?
- What happened to deglacial meltwater and landscapes?
- Mid-deglacial cooling: The Younger Dryas

# The Earth's Climate History

1. Over the last century, the earth's surface temperature has increased by about 0.75°C (about 1.35°F).
2. Little Ice Age = 1350 A.D. – 1850 A.D. (N.H. temperature was lower by 0.5°C, alpine glaciers increased; few sunspots, low solar output)
3. Medieval Warm Period = 950 A.D. – 1,250 A.D. (N.H. warm and dry, Vikings colonized Iceland & Greenland)
4. Holocene Maximum = 5,000-6,000 ybp (1°C warmer than now, warmest of the current interglacial period)
5. Younger-Dryas Event = 12,000 ybp (sudden drop in temperature and portions of N.H. reverted back to glacial conditions)
6. Last Glacial Maximum = 21,000 ybp (maximum North American continental glaciers, lower sea level exposed Bering land bridge allowing human migration from Asia to North America)
7. We are presently living in a long-term **icehouse** climate period, which is comprised of shorter-term *glacial* (e.g., 21,000 ybp) and *interglacial* (e.g., today) periods. There were four periods of Icehouse prior to the current one.
8. For most of the earth's history, the climate was much warmer than today.

# Causes of Climate Change During Deglaciation

## Climate controls:

21k yrs ago

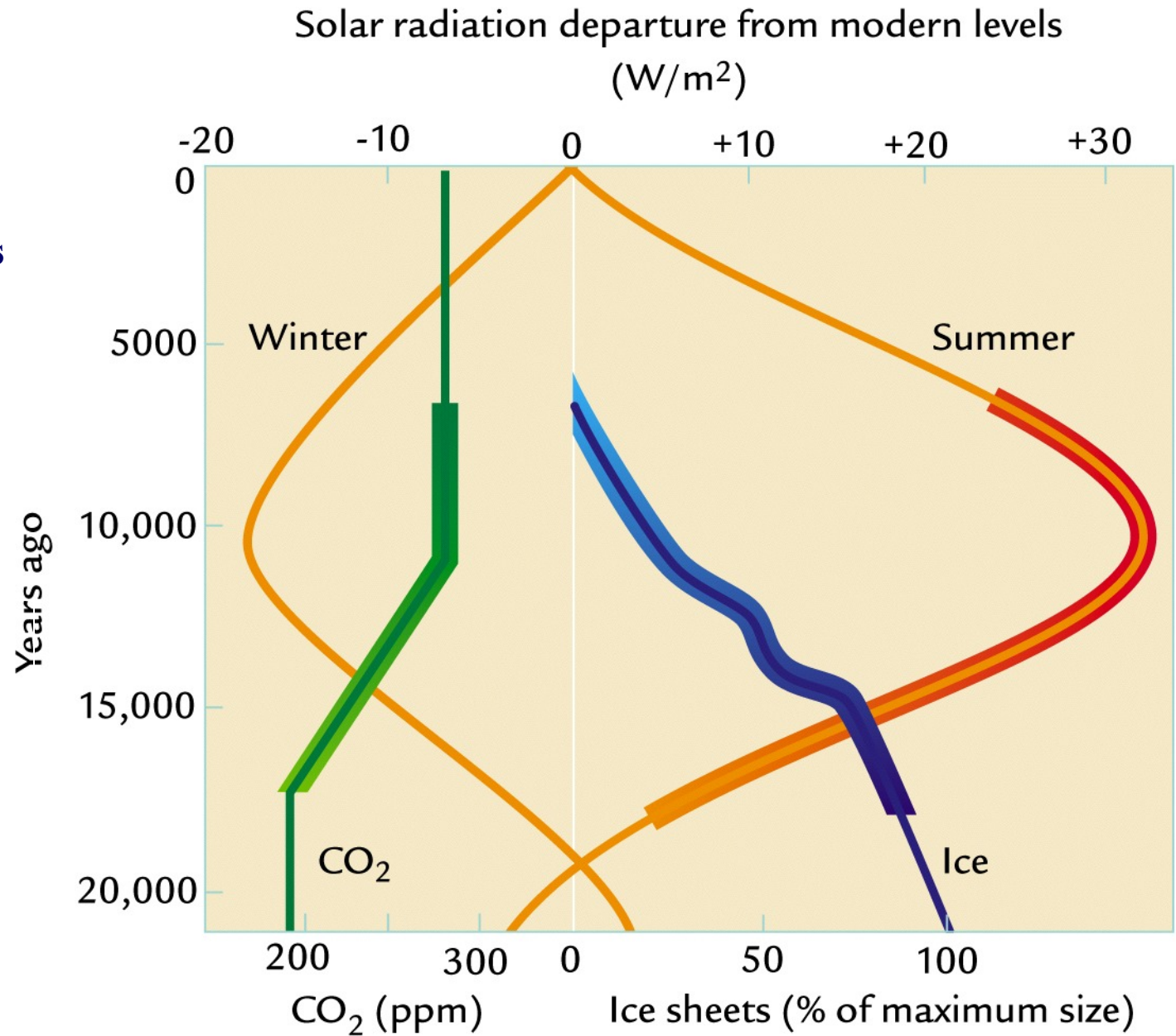
Larger ice sheets

Lower CO<sub>2</sub> (190 ppm)

21-6k yrs ago

Higher summer insolation

Higher CO<sub>2</sub> (280 ppm)

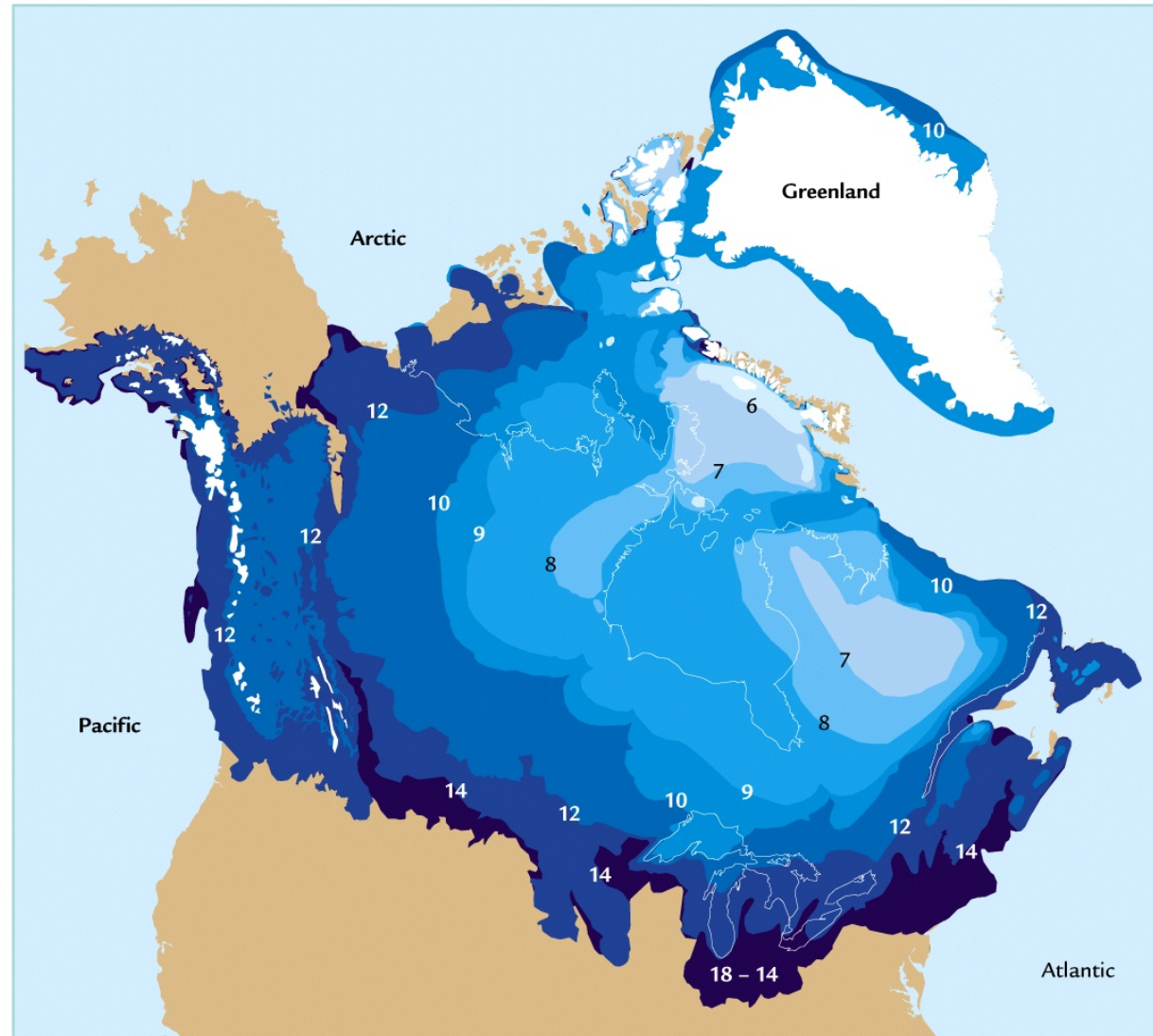


# When Did the Ice Sheets Melt?

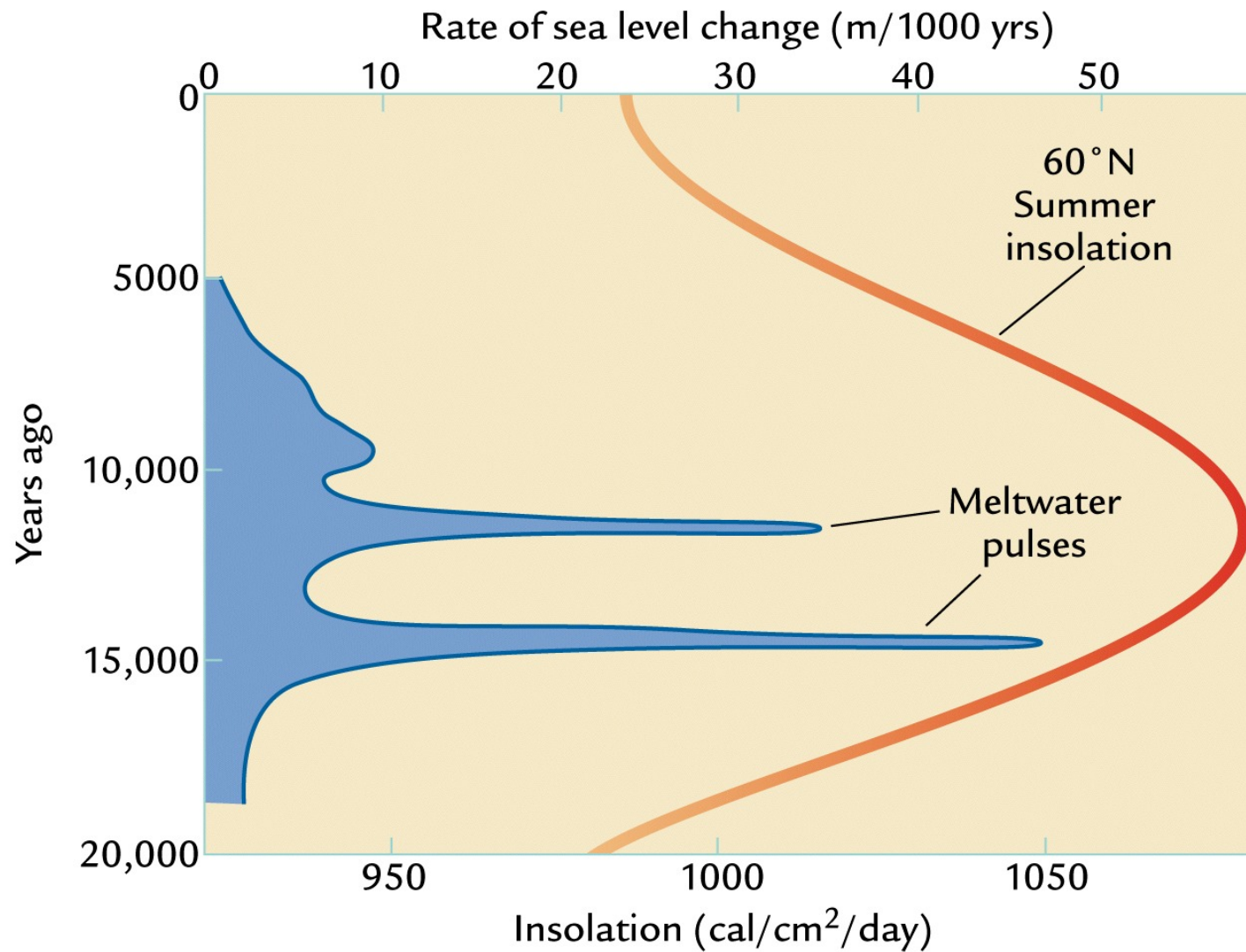
The North American ice sheets began to retreat 15k <sup>14</sup>C years ago, disappeared completely by 6k <sup>14</sup>C years ago.

The retreat of the ice sheet margins can be determined by radiocarbon dating.

The retreat timing agrees with the Milankovitch theory (Chapter 9).

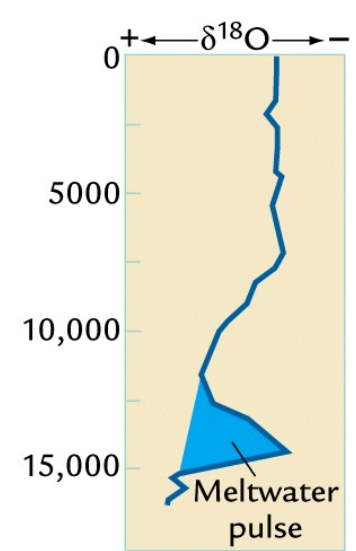
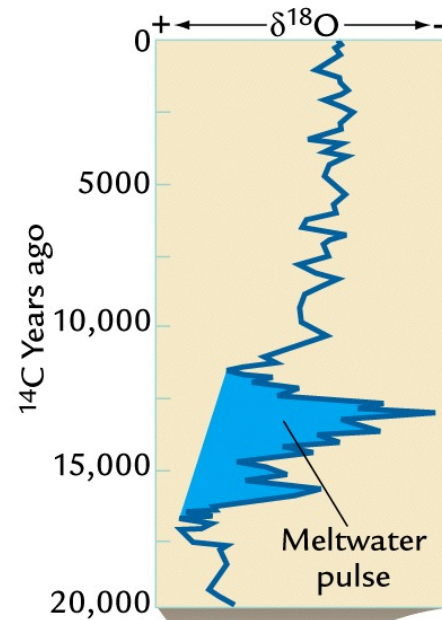
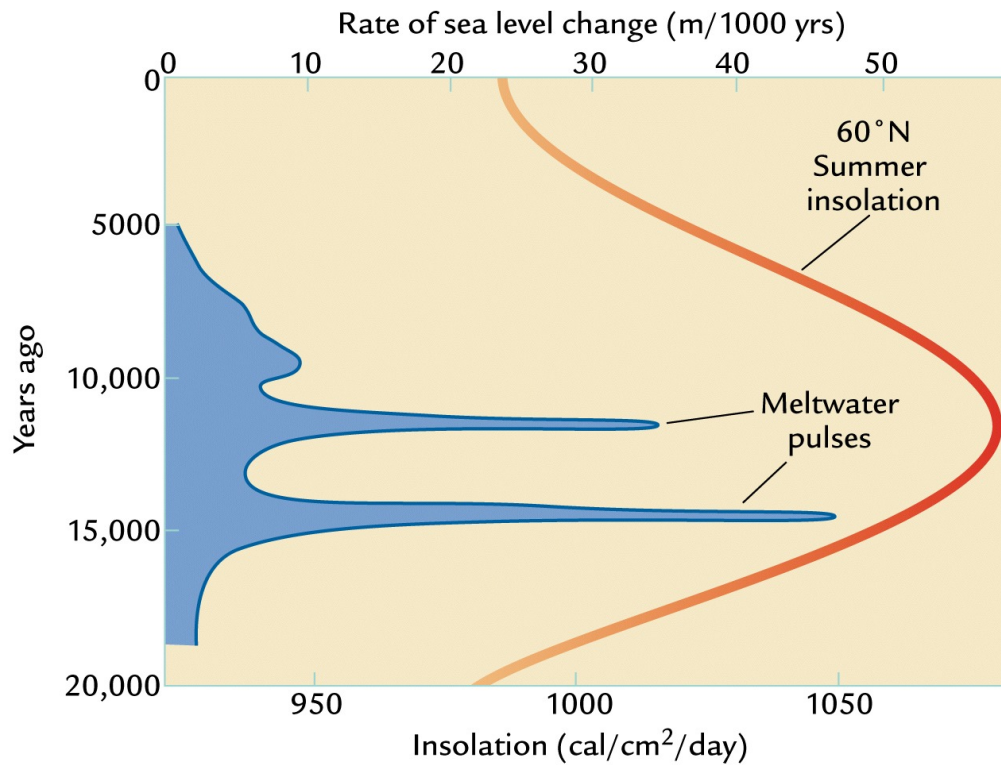


# Glitches in the Deglaciation: Deglacial Two-step



**Data from corals off Barbados in the Caribbean**

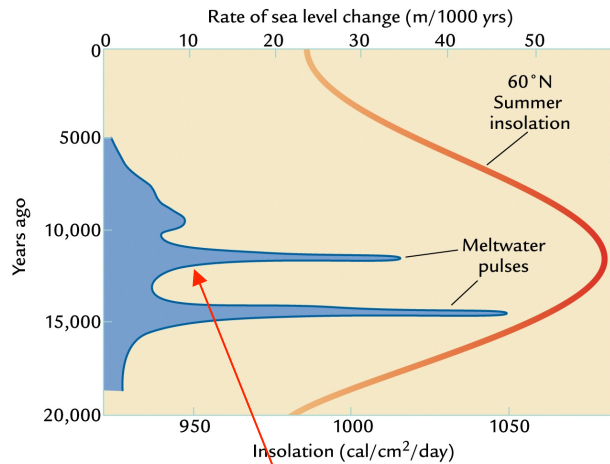
# Local Meltwater Pulses



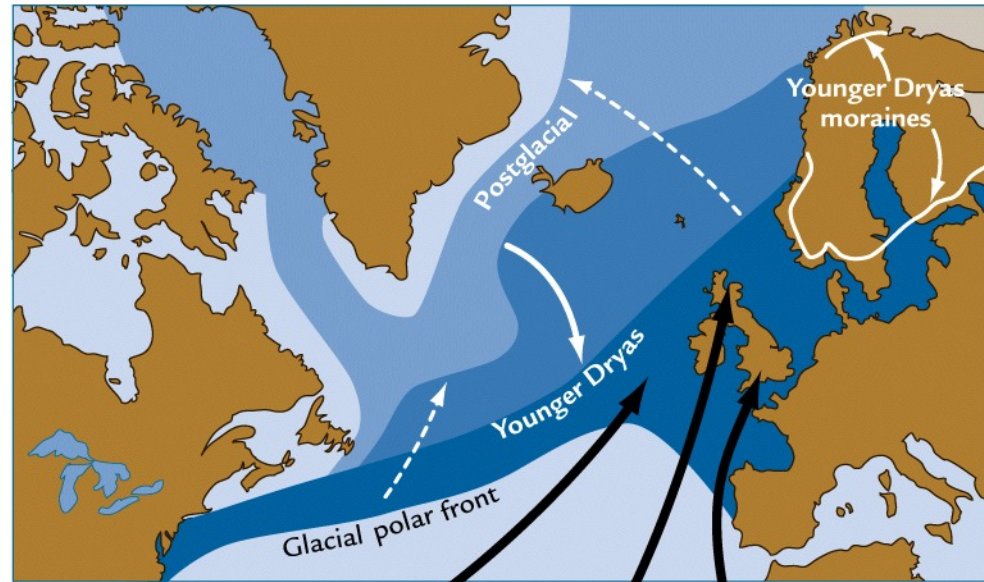
**Data from corals off Barbados in the Caribbean**

**Data from CaCO<sub>3</sub> shells of ocean plankton from the Gulf of Mexico and from the Norwegian Sea**

# Mid-Deglacial Cooling: The Younger Dryas

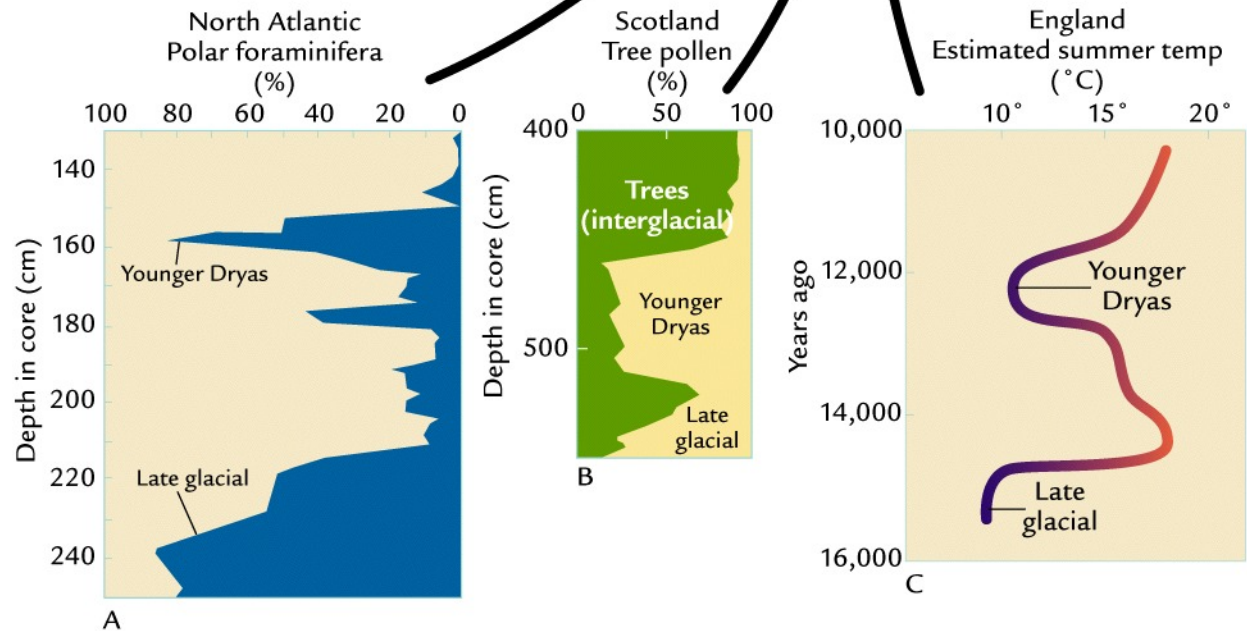


**Data from corals off Barbados in the Caribbean**

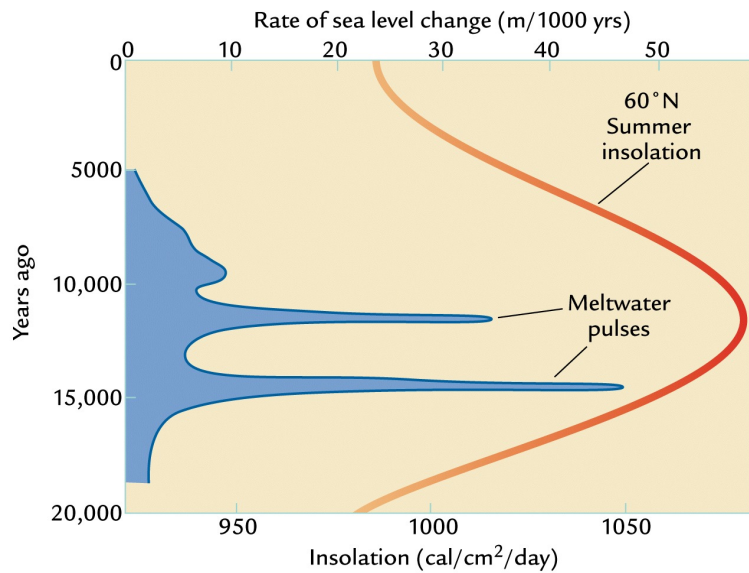


**The mid-deglacial pause in ice melting was accompanied by a brief cold reversal.**

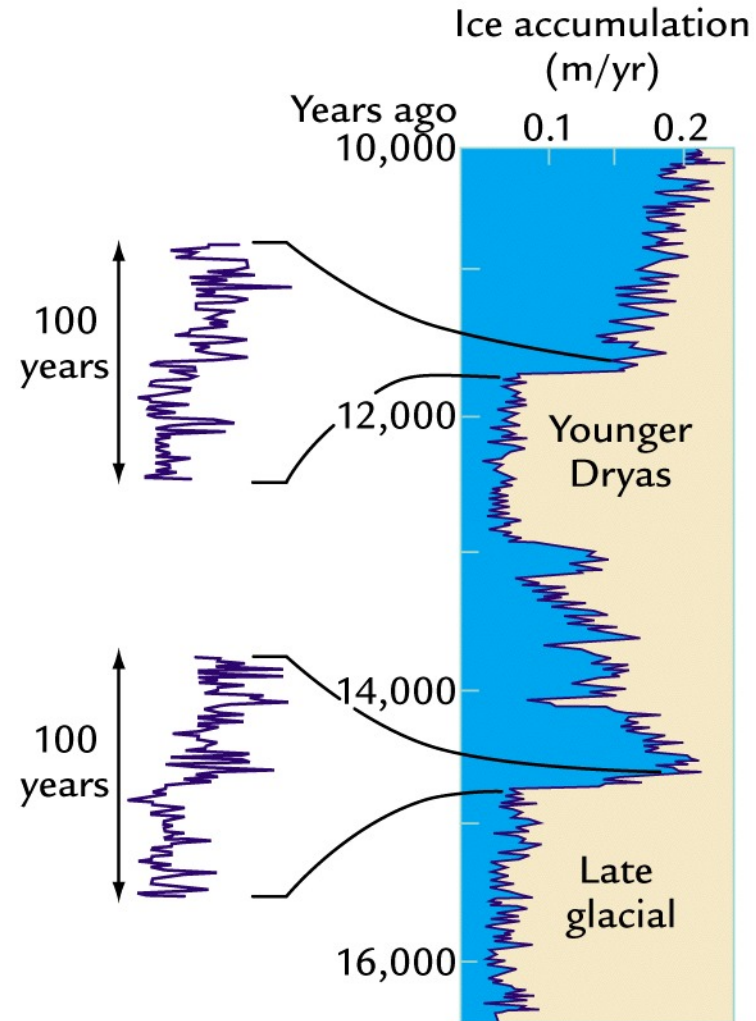
**During this episode, Dryas (an Arctic plant) appeared in Europe – the Younger Dryas event.**



# The Younger Dryas Cold Reversal



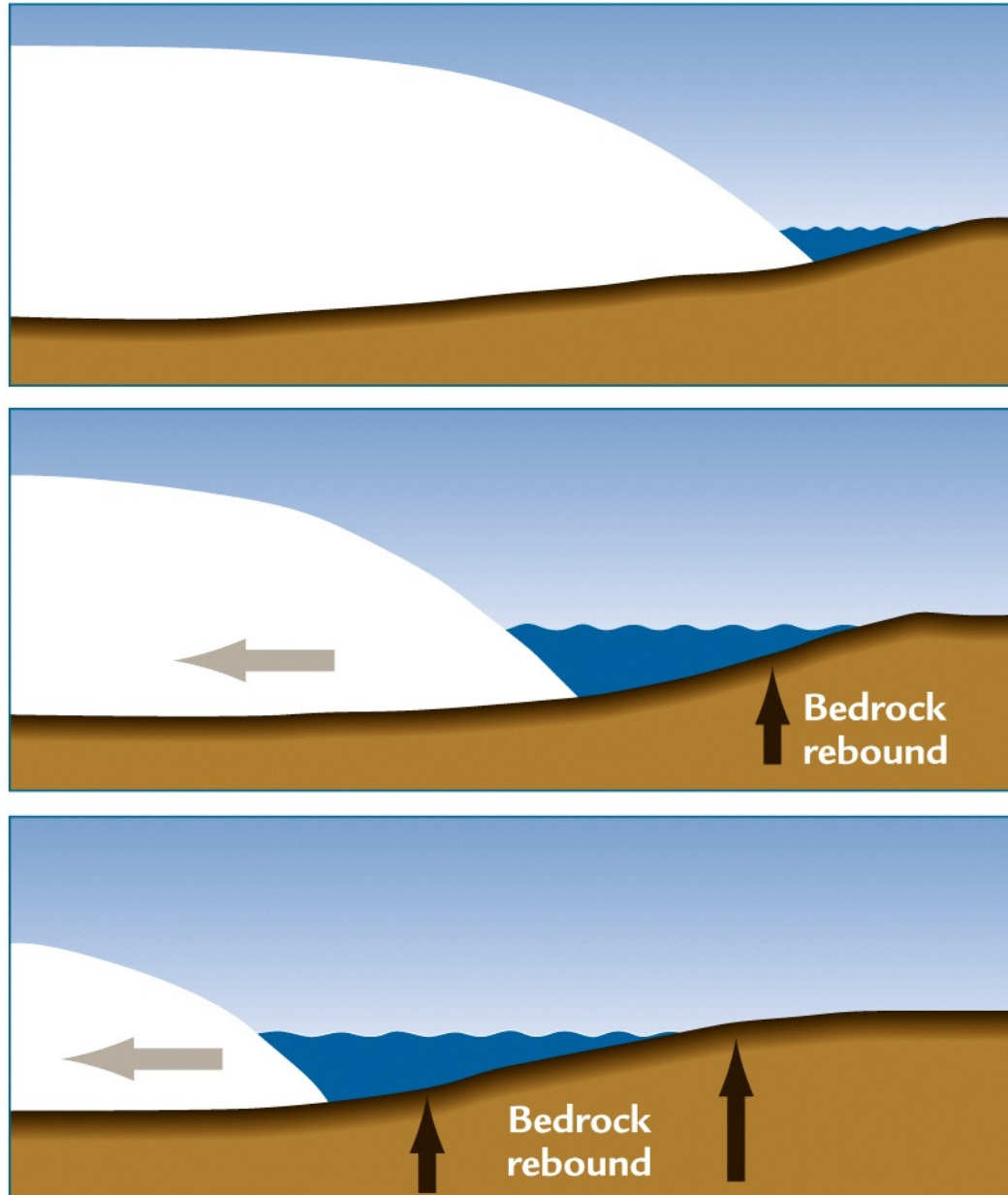
**Data from corals off Barbados in the Caribbean**



**Deglacial ice accumulation in Greenland**



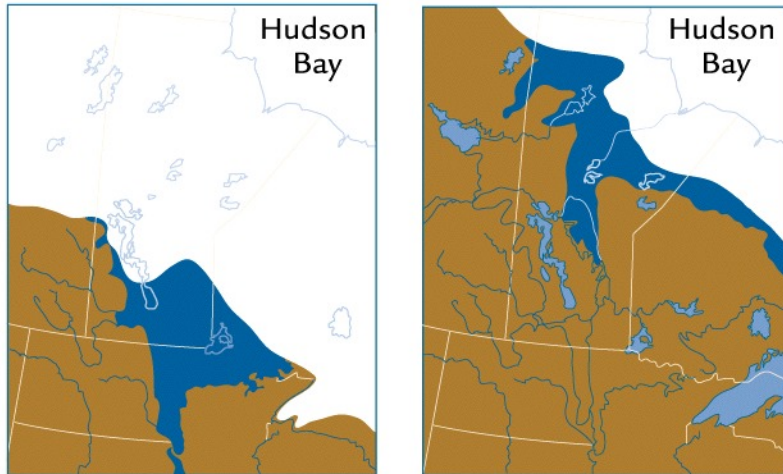
# Proglacial Lakes Moving North



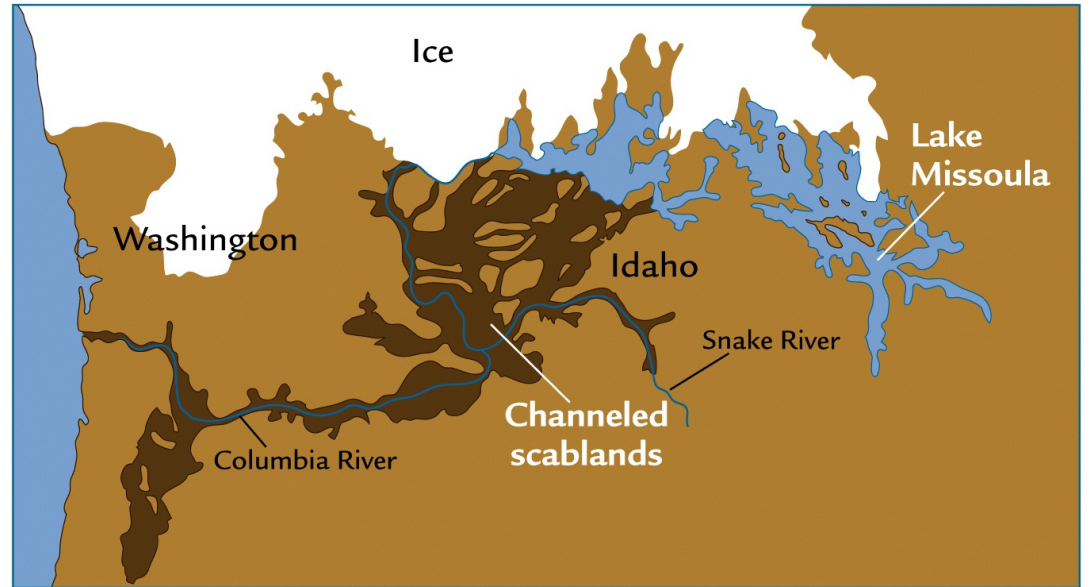
# Glacial Lakes



A Total area covered by deglacial lakes



B Lakes during deglaciation



A

# Routes of Meltwater Flow

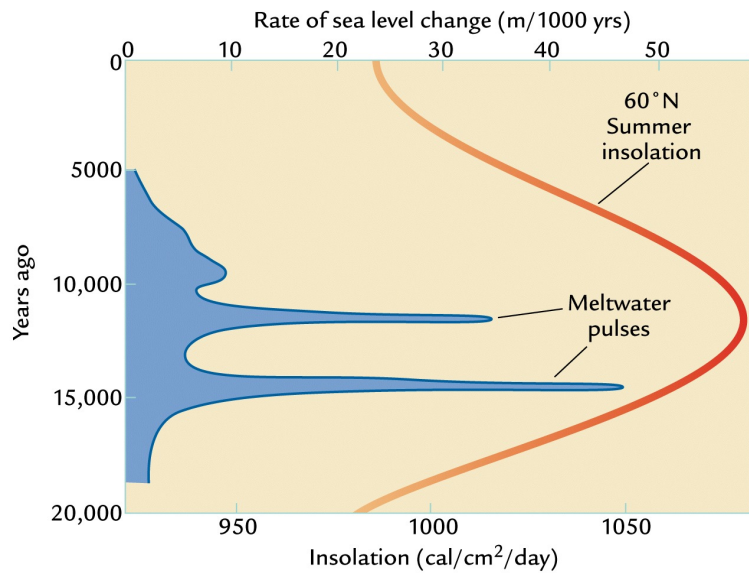


# Deglacial Flooding of Coastlines

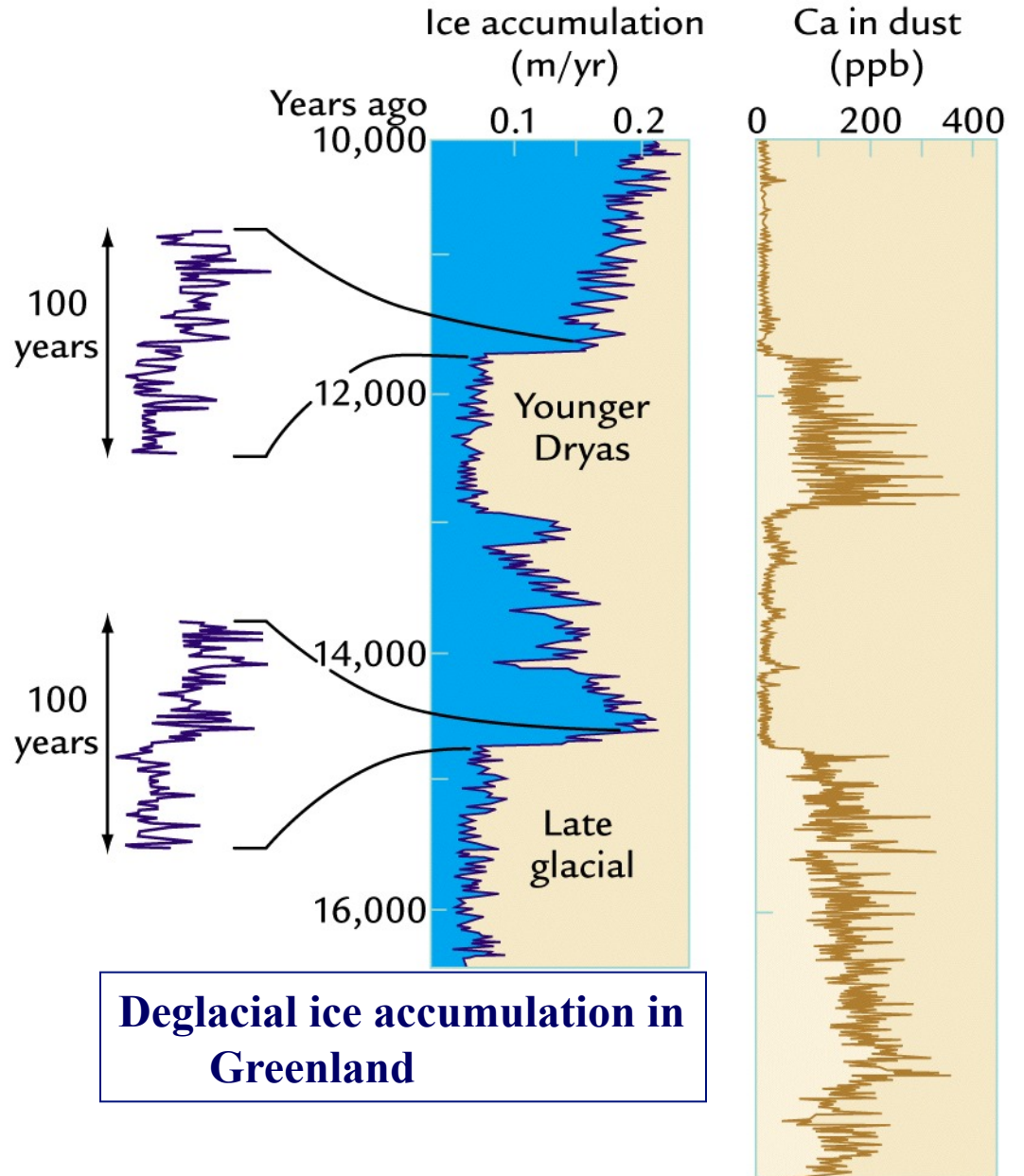


- Land exposed by drop in sea level
- Land created under ice by drop in sea level

# The Younger Dryas Cold Reversal



**Data from corals off Barbados in the Caribbean**



**Deglacial ice accumulation in Greenland**

# Routes of Meltwater Flow



# Deglacial Flooding of Coastlines



- Land exposed by drop in sea level
- Land created under ice by drop in sea level

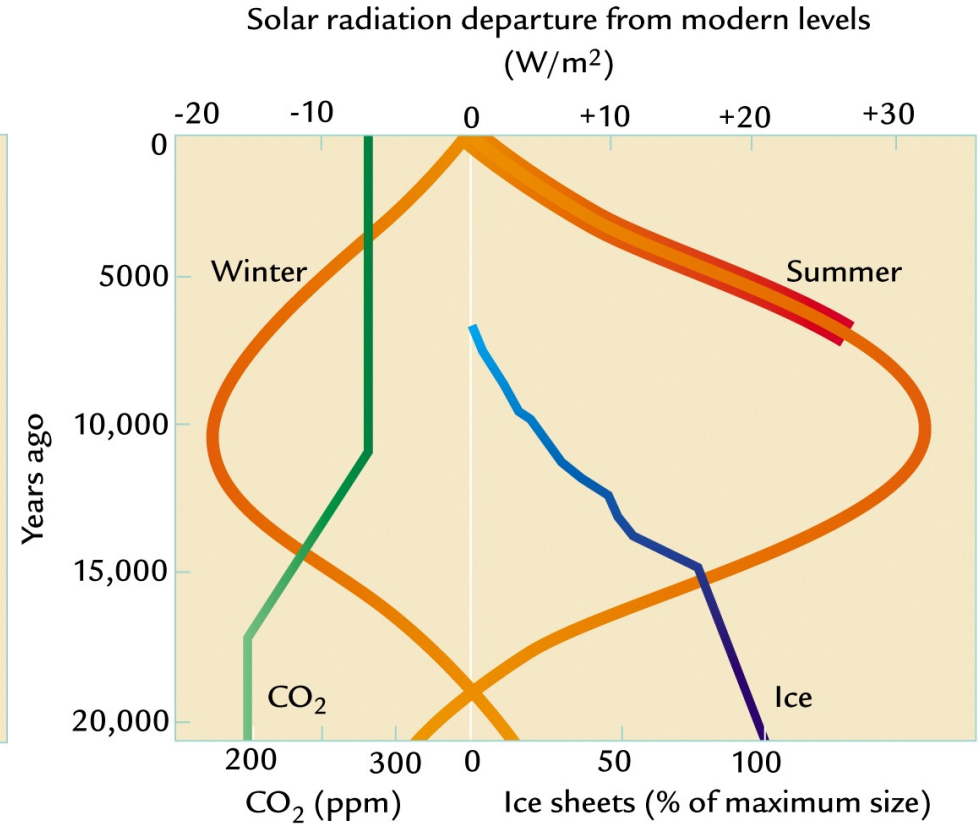
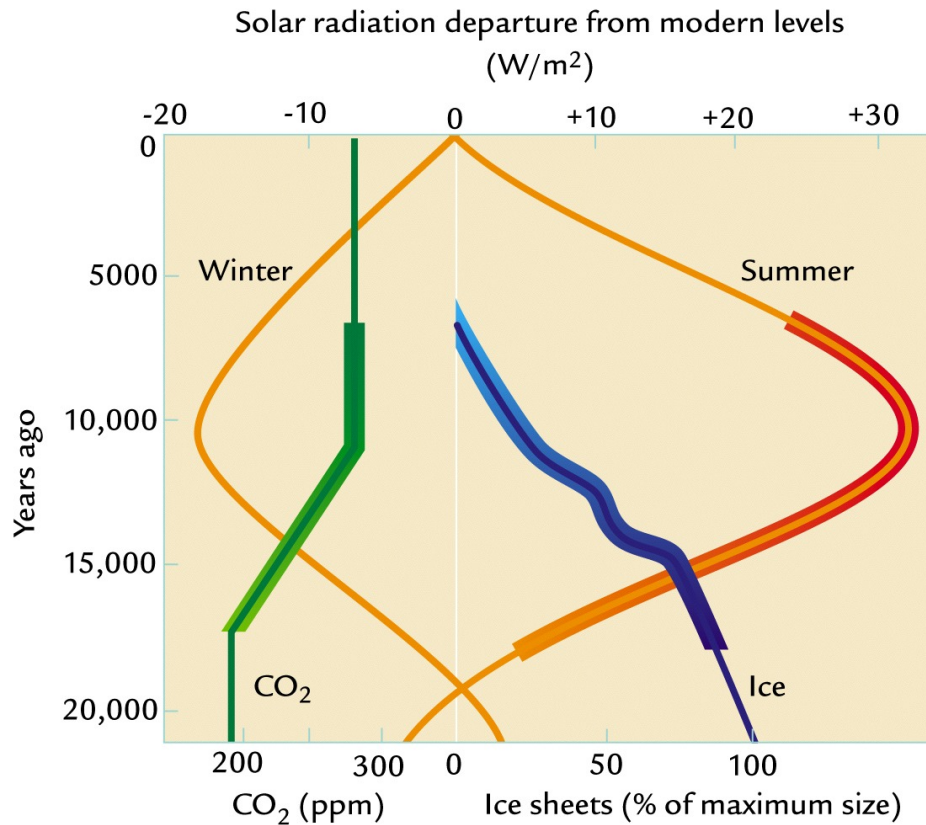
# Climate Change in the Last 7,000 Years

Ch. 13, p. 239-249

- The strength of tropical monsoons
- The warmth of northern high-latitude summers
- Vegetation responses
- Bedrock rebounding and associated sea level change



# Causes of Climate Change Since Deglaciation



## Climate controls:

21k yrs ago

Large ice sheets

Low CO<sub>2</sub>

21-6k yrs ago

Increasing summer insolation

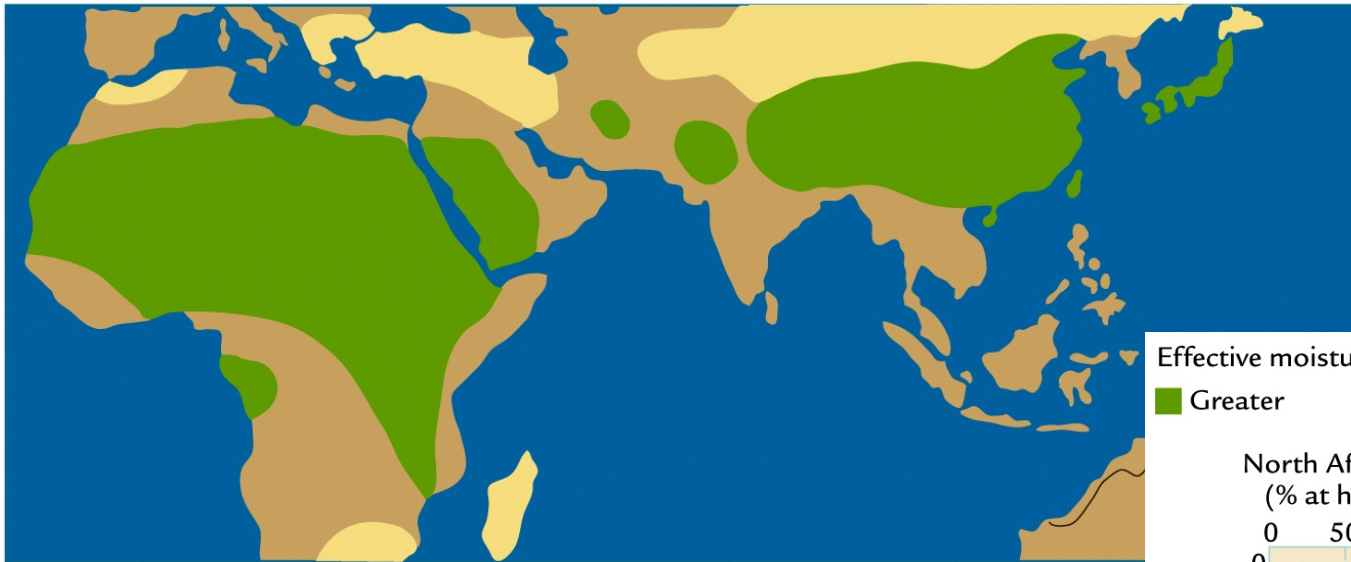
Increasing CO<sub>2</sub>

6-0k yrs ago

Decreasing summer insolation

High CO<sub>2</sub>

# Stronger, Then Weaker Monsoons



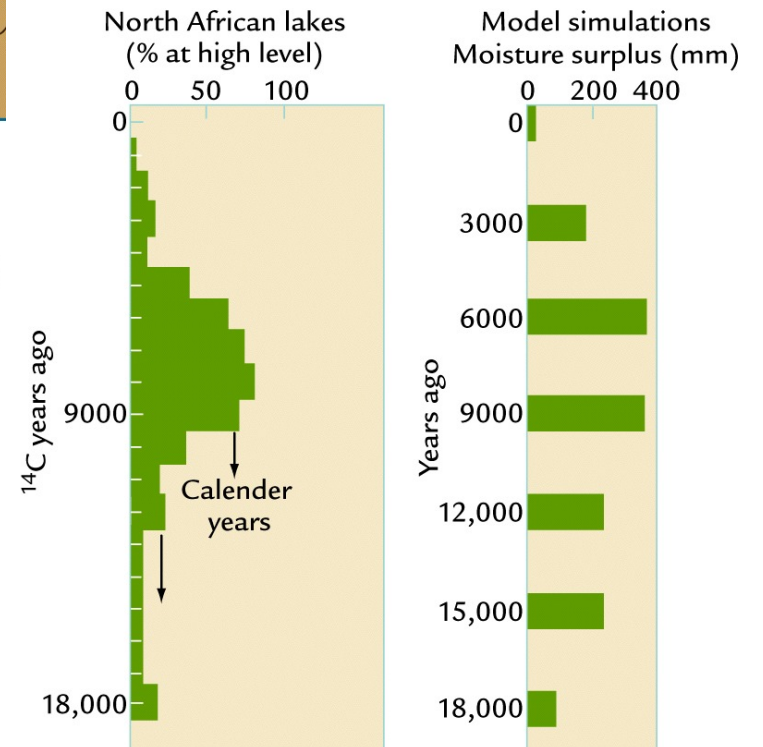
Effective moisture (9000 years ago versus today)  
 Greater Less Same

## B Observations

Effective moisture (9000 years ago versus today)

Greater Less Same

**High lake levels in the north tropics  
 9000 years ago**



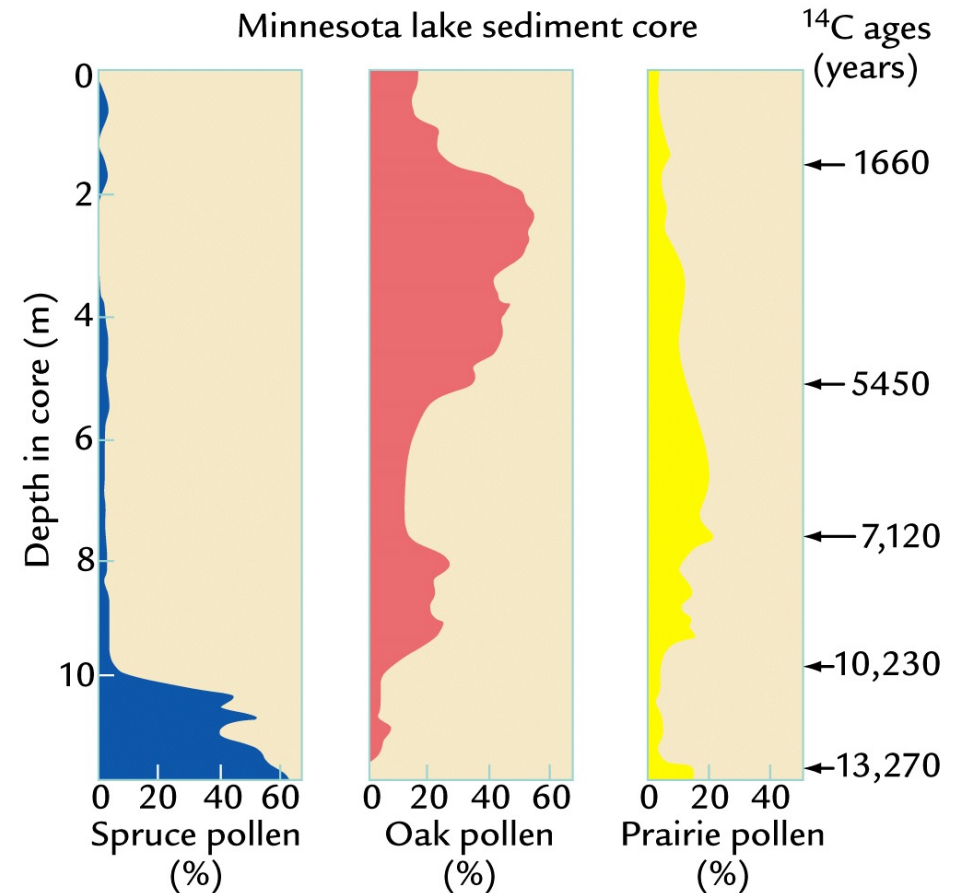
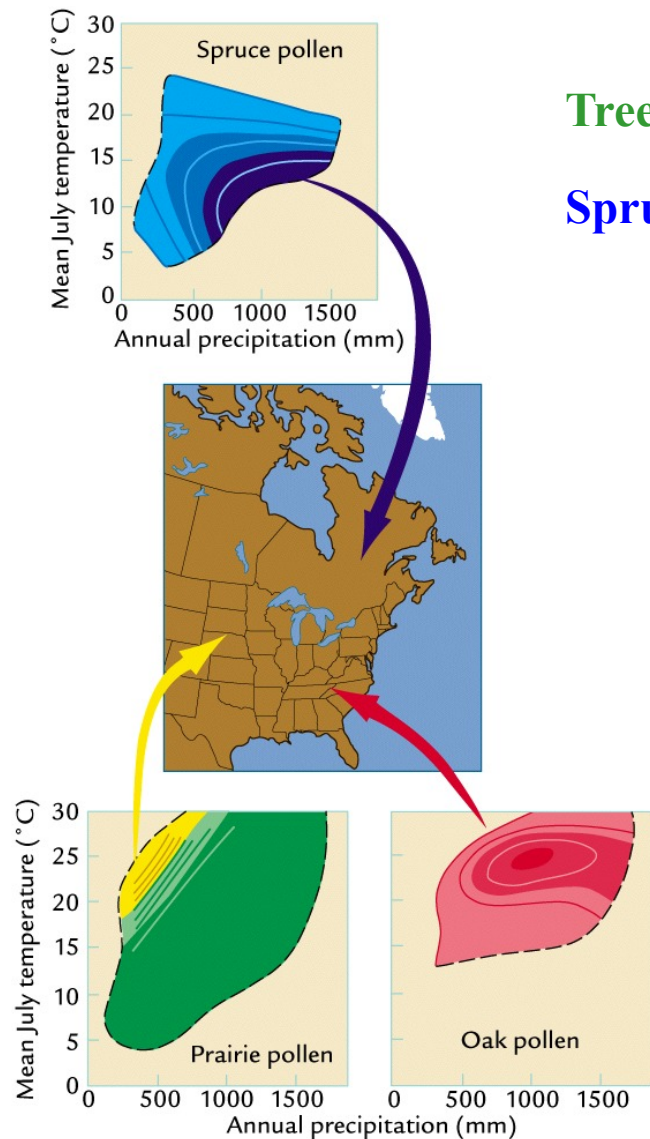
C Data-model comparison versus time

# Pollen Percentages and Climate on the Continents (Revisit)

Prairie grasses and herbs are most abundant where rainfall is low.

Tree pollen is more common in wetter eastern regions.

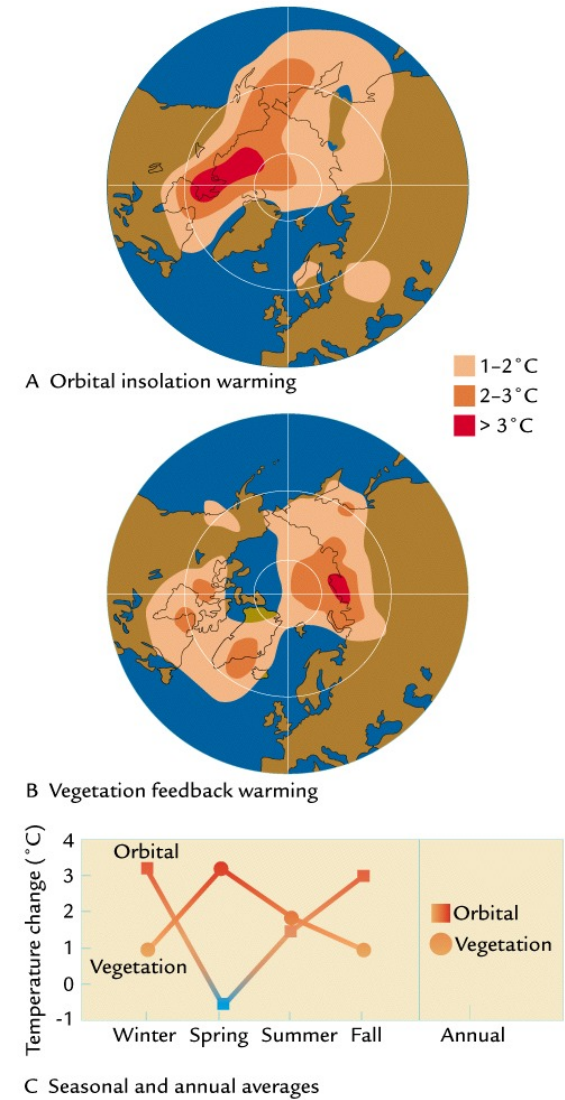
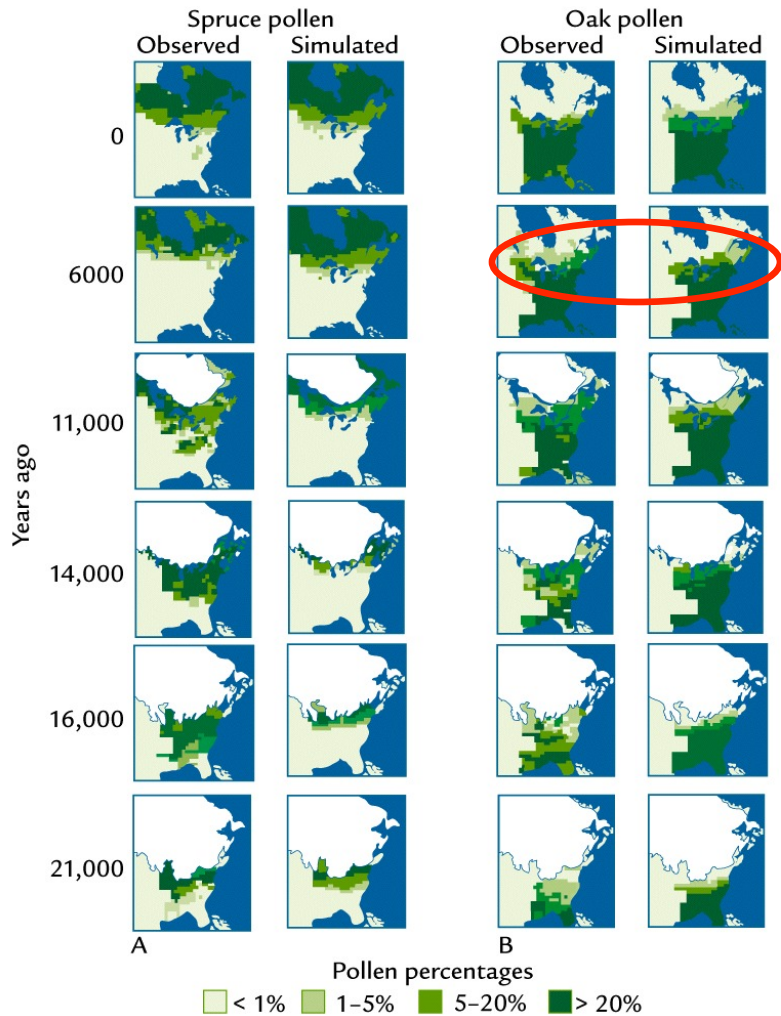
Spruce trees are common in the colder north, oak in the warmer south.



# Peak Warmth 6000 Years Ago

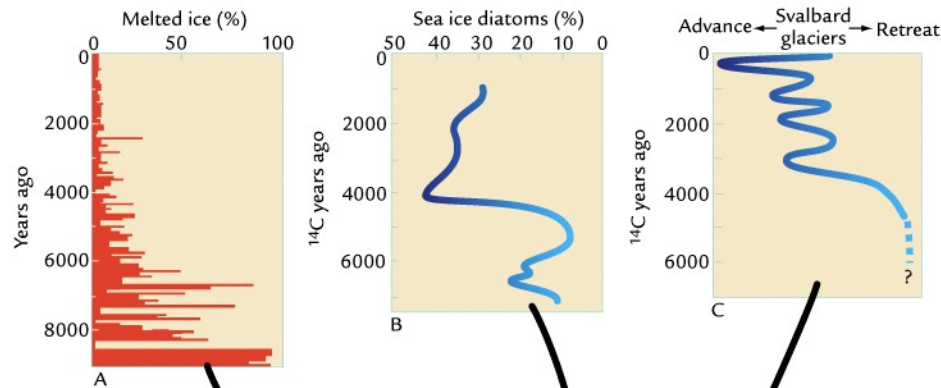
Summer insolation 6000 years ago was still 5% higher than today, which warmed high latitudes (Canada).

Northward expansion of low-albedo forest into high-albedo tundra doubles this regional warming (Asia).

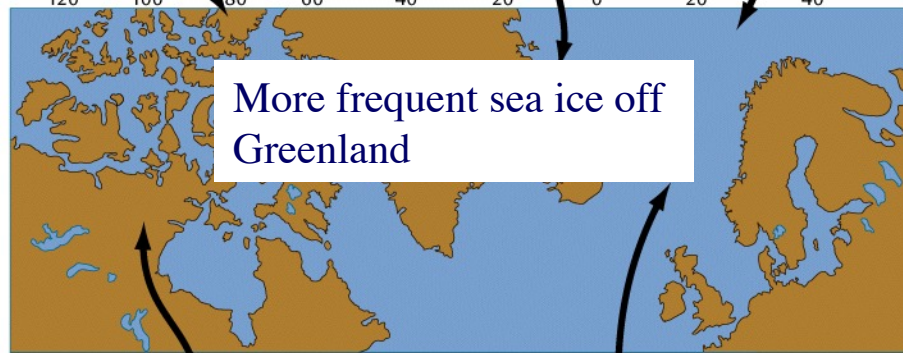


# Warmer, Then Cooler North Polar Summers

Less frequent summer ice melting in Arctic islands

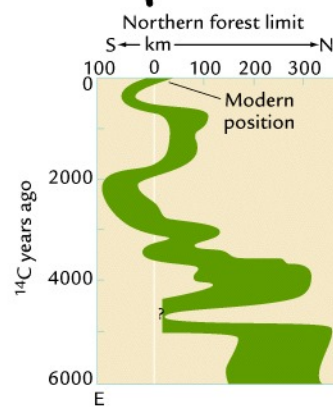


Advances of ice caps on Arctic islands north of Europe

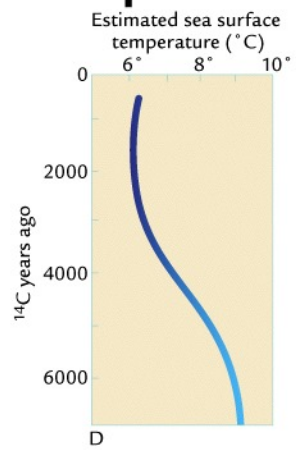


More frequent sea ice off Greenland

Southward shift of tundra/forest boundary in northern Canada



Lower temperatures in the Atlantic Ocean west of southern Norway



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