ATOC 1060-002
OUR CHANGING ENVIRONMENT

Class 22 (Chp 15, Chp 14 Pages 288-290)

Objectives of Today's Class

Chp 15 Global Warming, Part 1: Recent and Future Climate:

Recent climate: The Holocene Climate Change

(Note: The Younger Dryas part is from Chp 14, Pages 288-290.)

Previous classes: long-term changes in climate

Earth history: over 4.6 b.y.

Influence of solar luminosity - 30% less;

High atmospheric CO_2 &CH4 - warm Earth when it was just formed;

Over the Earth's 4.6 b.y. history:

Main glaciations:

[0] Mid-Archean glaciation – 2.9b.y. ago;

(Evidence only found at 2 localities of South Africa; hard to explain; much Less studied than others)

[1] Huronian glaciation - 2.3b.y. ago;

[2] Late Proterozoic - 600-800m.y. ago;

(tillite, dropstone, glacial striation)

[3]Late Ordovician - 440m.y. ago;

[4]Permo-Carboniferous - ~286m.y. ago;

[5]Pleistocene - 1.8m.y.

(fossil records, oxygen isotope)

Atmospheric greenhouse gases (CO_2+CH_4) concentration – major factor for climate change!!

Today:
Short-term climate variability:The Holocene Climate Change

Short time scales:

changes on hundreds-to-thousands years timescales: what are the major factors that Cause climate change in shorter timescales?

Purpose =>

(a) illustrate how the Earth system components interact;

(b) provide background for discussion of global warming.

We have seen: importance of CO_2 on regulating long-term climate change over the Earth's history;

$\Rightarrow$Possible impact of human-induced Increase of CO_2 on future climate.

Global warming - In the context of variability in the climate system that occurs naturally over these short time frames.

10,000 years ago

Era	Period	Epoch	Glaciations	Duration in millions of years	Millions of years ago
CENOZOIC	Quaternary	Holocene	Pleistocene glaciations	0.01	0.01
		Pleistocene		1.8	1.8
	Tertiary	Pliocene		3.5	5.3
		Miocene		18.5	23.8
		Oligocene		9.9	33.7
		Eocene		21.1	54.8
		Paleocene		10.2	65

Last glaciation

Last major continental glaciation: maximum extent: 21,000 years ago.

Holocene: the last glacial retreat (10,000yrs ago) to present.

Global mean temperature change

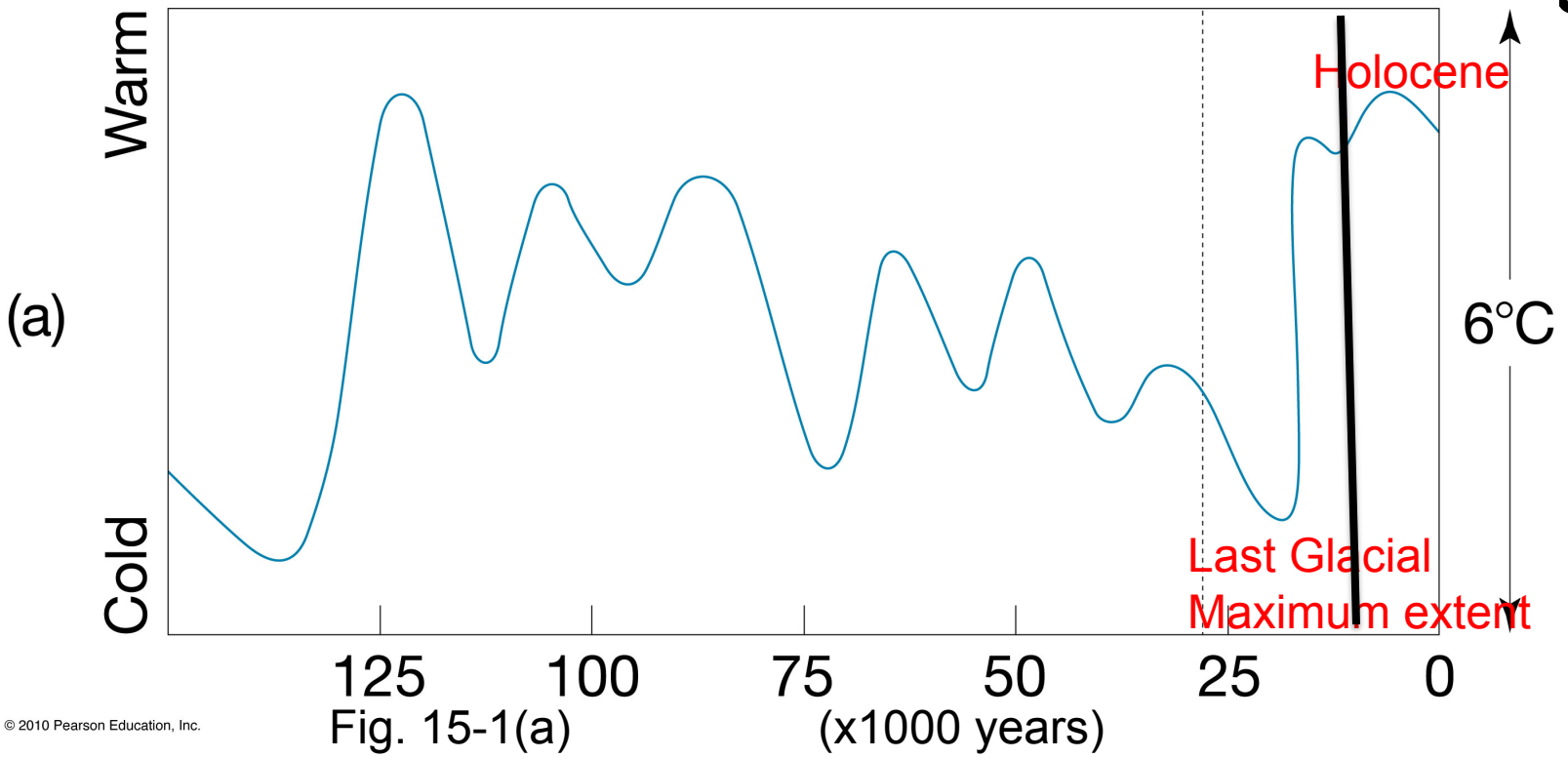


Fig. 15-1(a)

Last major continental glaciation: maximum extent: 21,000 years ago.

Holocene: the last glacial retreat (10,000yrs ago) to present.

Clicker question 1

Choose the correct statement:

A. The last major glaciation occurred in Pleistocene (1.8 m.y. ago);

B. The maximum extent of the last continental glaciation occurred in ~21,000y. Ago;

C. The Holocene period is from the last glacial retreat of about 10,000 years ago to the present;

D. All of the above.

a. The Younger Dryas (Chp 14, Pages 288-290)

In broad term, Earth began to warm:10,000~15,000 years ago; Vegetation began to colonize;

This spread of milder condition – abruptly ended at 10,500 years ago - Younger Dryas event: a cold event, right before the Holocene.
(Dryas wide spread: now only found in arctic or alpine tundra)

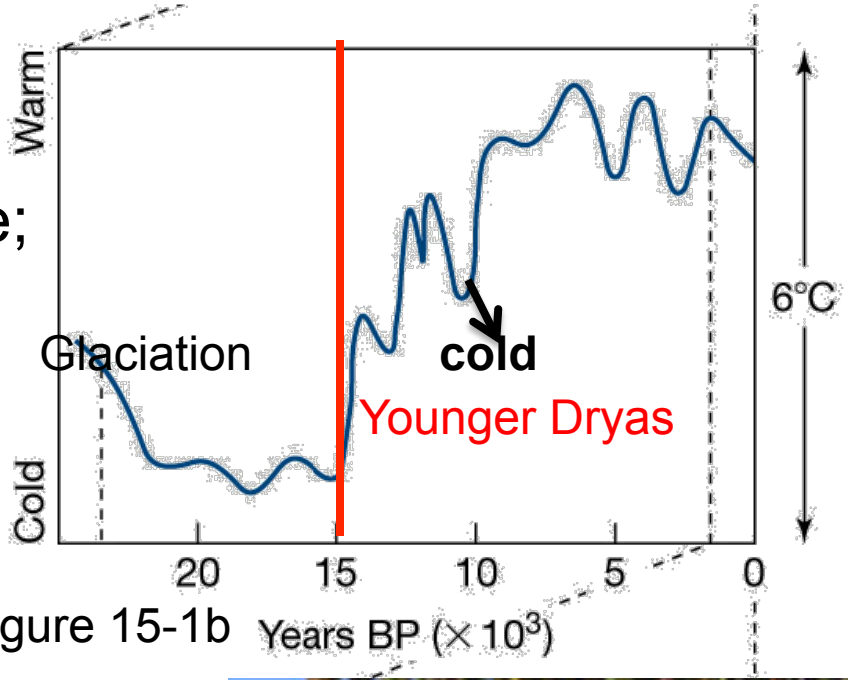
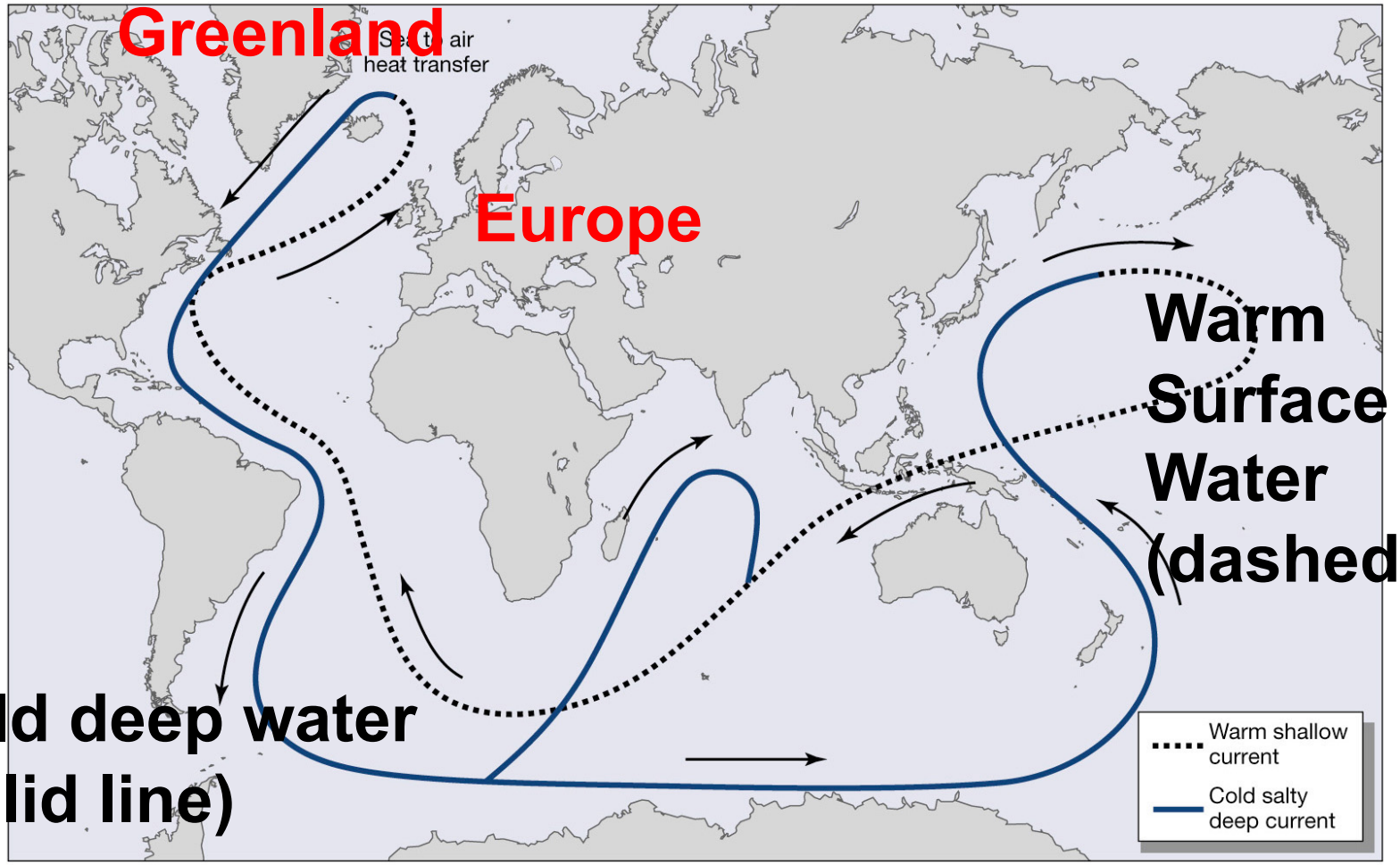


Figure 15-1b

Dryas Octopetala

Younger Dryas: mainly North Atlantic; same time: climate change in other parts of the globe; North Atlantic deep-water formation reduction=> Primary explanation.

Figure 5-19



Wallace Broecker:

Deglaciation => North America ice sheet melting

=> normally flow south to Gulf of Mexico,

blocked by retreating lobe of ice

=> Flow eastward to Gulf of St Lawrence

⇒Cold fresh water to Northern North Atlantic.

Fresh water lighter than salty water =>

⇒stablize surface layer that would

freeze easily (lower freezing point for fresher

water) =>(I) reduce deep water formation;

=> (ii) pushing ice margin southward.

Cut off the warmer water from Gulf

stream and North Atlantic Drift.

=> Causing the cold event (Younger Dryas).

Clicker question 2

The Younger Dryas is

A. a warm event in Holocene after the deglaciation of the Pleistocene glacier;

B. a cold event near the end of the retreat of the last continental glacier;

C. a cold event caused by the weakening of the Atlantic thermohaline circulation;

D. Both B and C;

E. Both A and C.

b. Proxy climate data

Direct measurements: recent;

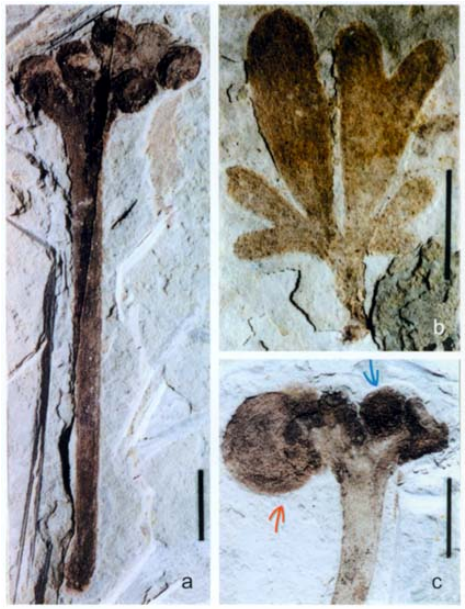
To extend the record backward => proxy data;
Inferred from other evidence.

Sedimentary rocks on land,
Cores drilled in sea floor =>
Fossils in sediments => physical environment organisms lived.

Uniformitarianism: Assume
Fossil plants, animals lived
In same environment as those that exist today.

For the past 10,000 years, we make use of other types of evidence. => ice cores, particularly for earlier part => paleoclimate (past climate) reconstruction.

Palynology: study of pollen and organic micro-fossils. **[pollen grains are preserved in lake sediments & peat bogs, etc. Core drilling: divide into segments going back through time - extract pollen from each layer - reconstruct plant assemblages lived there - then use present day distribution of those assemblages to place constrains on what the environment was like in the past. 30,000-35,000 yrs]**



234 *Solenites murrayana*, a ginkgophyte, 4.55 cm long.

Dendrochronology: a method of dating trees by counting their annual growth rings. **[cross section - rings - each ring one year - tree age - width of each ring indicates amount of growth that year - related to temperature and moisture availability. 5500 years, California.]**

Clicker question 3

Dendrochronology can be used to reconstruct climate by:

A.relating pollen in the sediments to temperature and water availability of past climate;

B. relating micro-fossils in the sediments to temperature and water availability;

C. counting the annual growth rings of trees to date the time, and the width of each ring to reconstruct temperature and water availability;

D. analyzing Oxygen 18 in sediments to reconstruct temperature and water availability.

c. The Holocene warm and cold periods

Assembling Proxy data around the world = > the Holocene displays a considerable climate change and variability. It appears that:

Middle-high latitudes: a dominance temperature change;

Tropics-subtropics: greater changes in moisture availability

⇒Result partly from orbital effects that enhance seasonality & continentality (directly affect temperature regime) and partly from resulting circulation change (e.g., monsoon, affects rainfall).

The Holocene epoch: short-scale variability:

⇒**Have to take into account Human impact! Many significant changes during Holocene - smaller than those (we project) might occur in the future.**

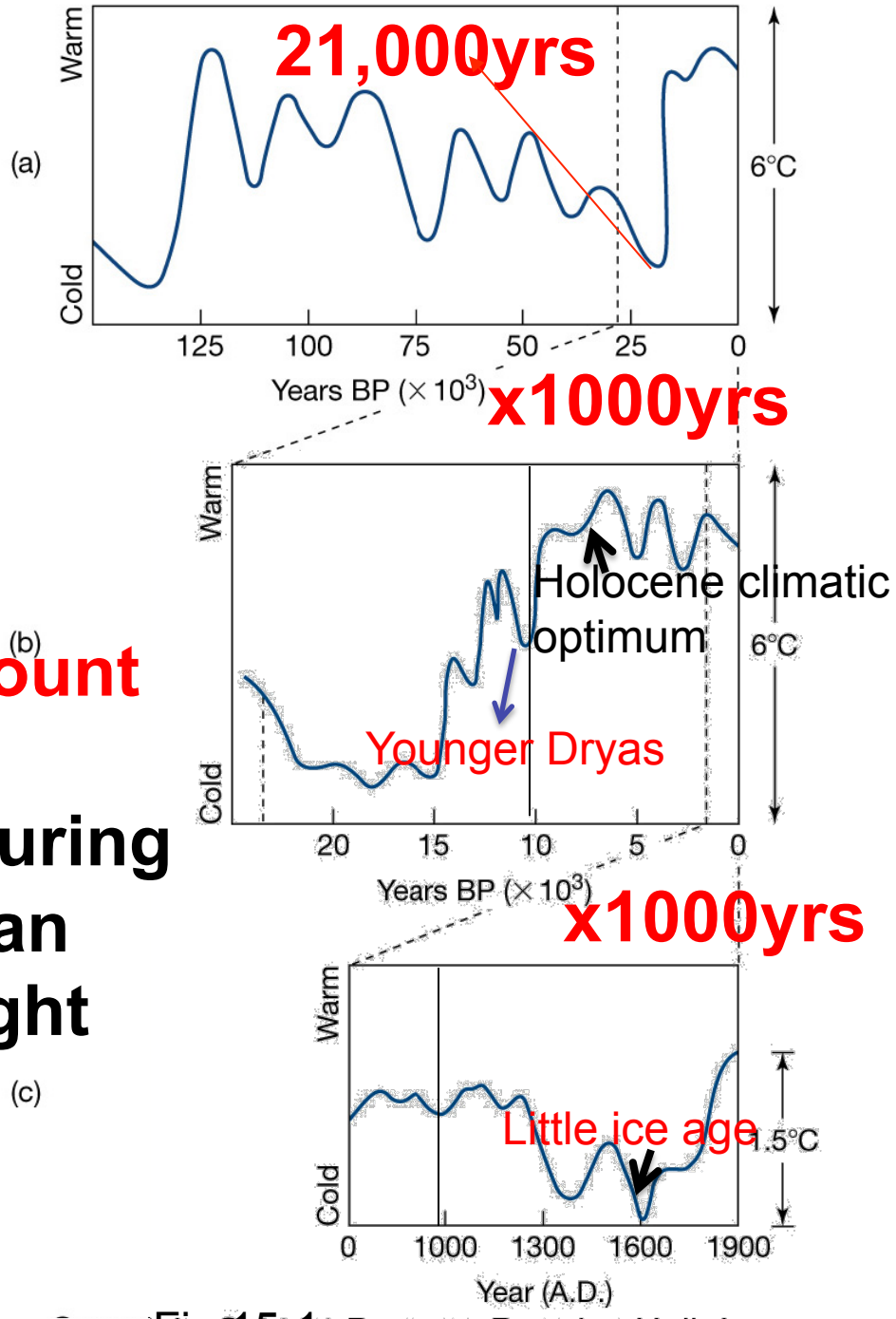


Fig 15-1

Difficult to determine: local or global scale changes.

Consistent records => some locations but not others; magnitudes are different in different locations. We tend to discuss global scale changes; remember that there are large regional differences.

Small mean global temperature => associated with relatively large changes in physical environment.

Mean temperatures at the peak of last glaciation were ~5-6^{o}C colder than the 20th century mean.
800years ago: Vikings Greenland - 0.5C warmer than today;

=> double CO_2 =21st century, 1.5-4^{o}C warmer - bigger than any natural climate change that occurred in the Holocene (10,000yrs).

Clicker question 4

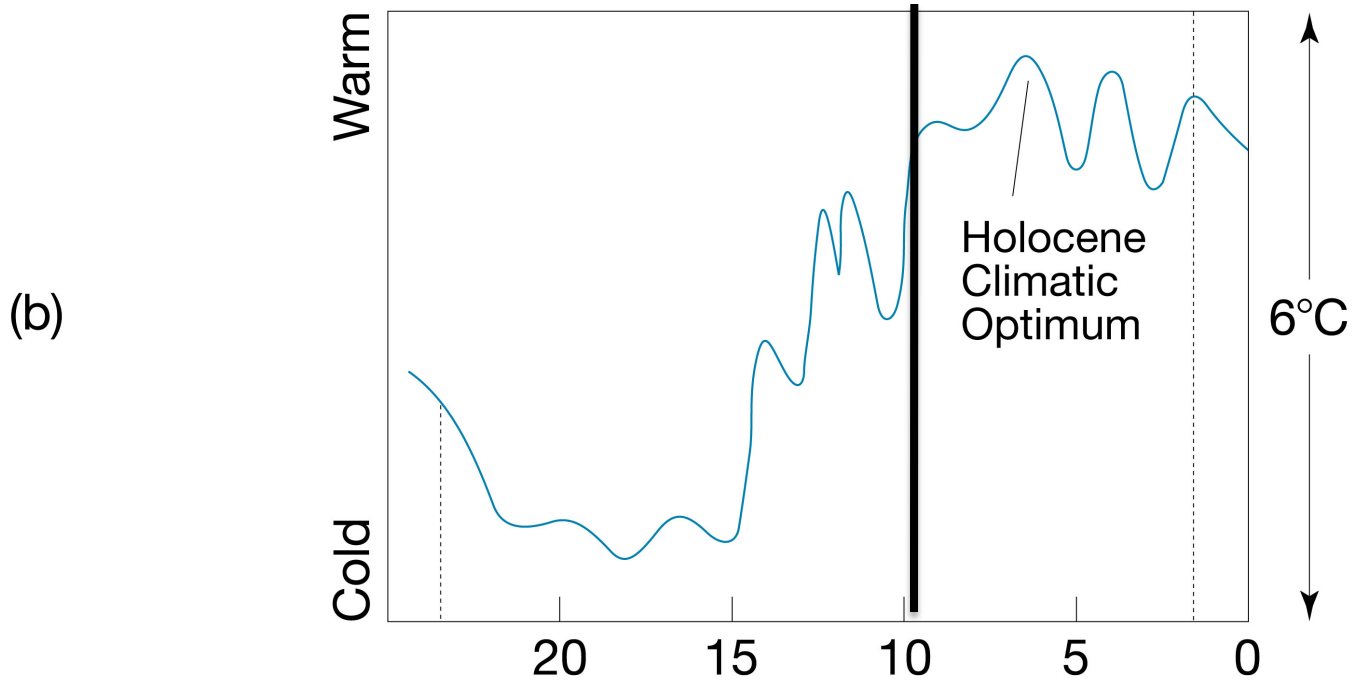
During the Holocene, the Earth's temperature

A. has experienced large amplitude changes due to glaciation-interglacial cycles;
B. has large amplitude decrease due to glaciation;
C. has experienced extreme events;
D. Has small amplitude variability, which is smaller than the suggested future temperature increase caused by double CO_2.

d. The Holocene Climatic Optimum

Following the Younger Dryas - constant climate - relatively slow warming persisted - next several thousands years => the Holocene Climatic Optimum.

Evidence: mid-Holocene(5000-6000yrs ago)- warmer than 20th century record.



Studies from Europe: pollen record shows little evidence of big climate shifts;

======= other parts show climate difference:
East Africa & Sahara (lake level): wetter than today;
Mediterranean Sea: higher summer rainfall;
Tarim basin: now desert; then forest & populated.
=> Resulted from (Land use + climate change)

Clicker's question 5

Choose the correct and complete statement:

A. Following the Younger Dryas event, intensive cooling episodes occurred over the next several thousand years;
B. The Younger Dryas event is followed by relatively slow warming over the next several thousand years, which is called the Holocene Climatic Optimum;
C. The Mid-Holocene climate was much colder than today's climate;
D. Both B and C.

e. The Medieval Warm Period and the little ice age

After the Holocene Climatic Optimum, temperature falls: Minimum ~3000years ago, rose again – Medieval Warm Period;

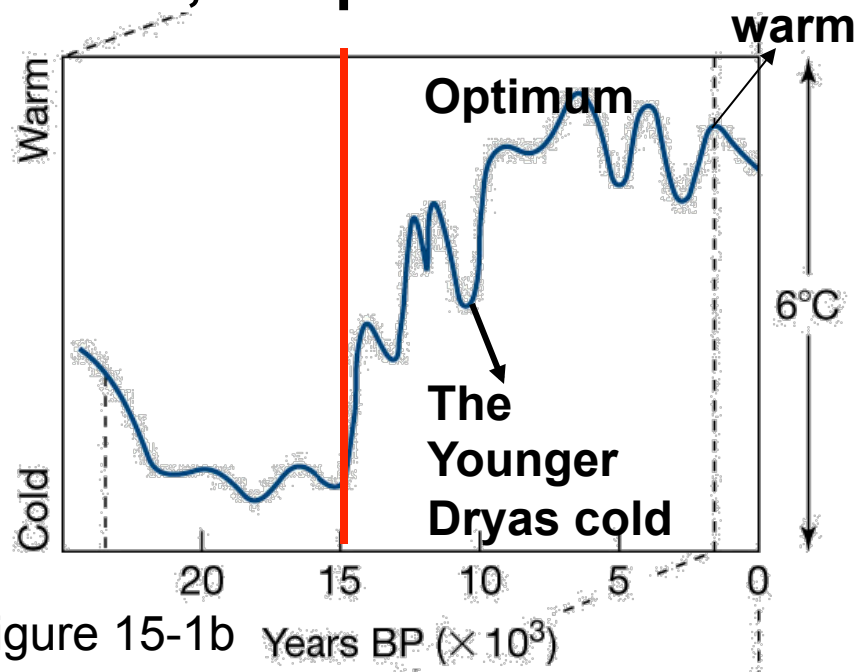
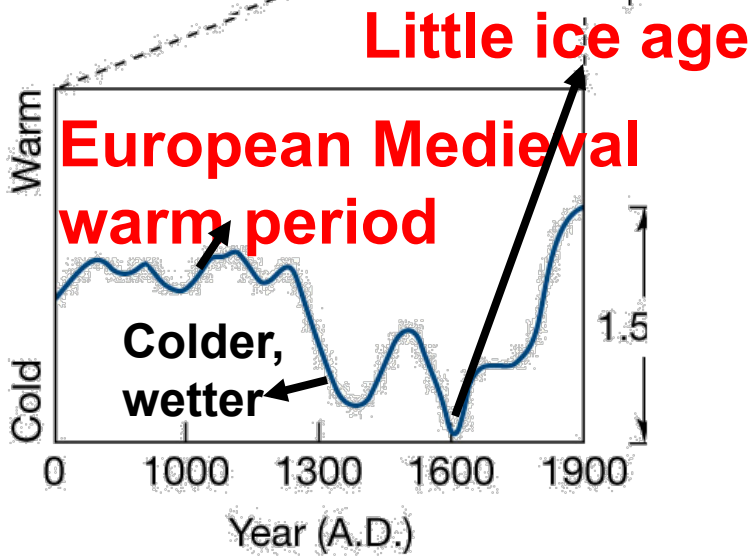


Figure 15-1b

Little ice age: first thought local to western Europe and North Atlantic (since late 1500s).

Evidence in Asia, Himalaya, South America, new Zealand, and Antarctica => may be Global.

Possible Reason? No retreating continental ice sheet to reduce thermohaline circulation.



(a) (b)

Fig. 15-2. (a) 1850, Swiss Alps; showing extension of the glaciers during the Waning phase of the Little ice age; (b) 1966.

Clicker's question 6

Choose the correct and complete statement:

A. Following the Holocene Climatic Optimum, temperature falls until the Little ice age;
B. Following the Holocene Climatic Optimum, temperature falls to a minimum around 3000years ago, and then rose again;
C. The Little Ice Age marked the end of the Medieval warm period, and this cold event is confined to the North Pole;
D. Both B and C.