ATOC 1060-002
OUR CHANGING ENVIRONMENT

Class 25 (Chp 16)

Objectives of Today's Class:

Global Warming, Part 2: Impacts, Adaptation, and Mitigation

[1] Changes in sea level;

[2] Effects on ecosystems;

[3] Adapting to global warming;

[4] Policies to slow global warming.

Previous class: Long-term climate warming

Worst case scenario:

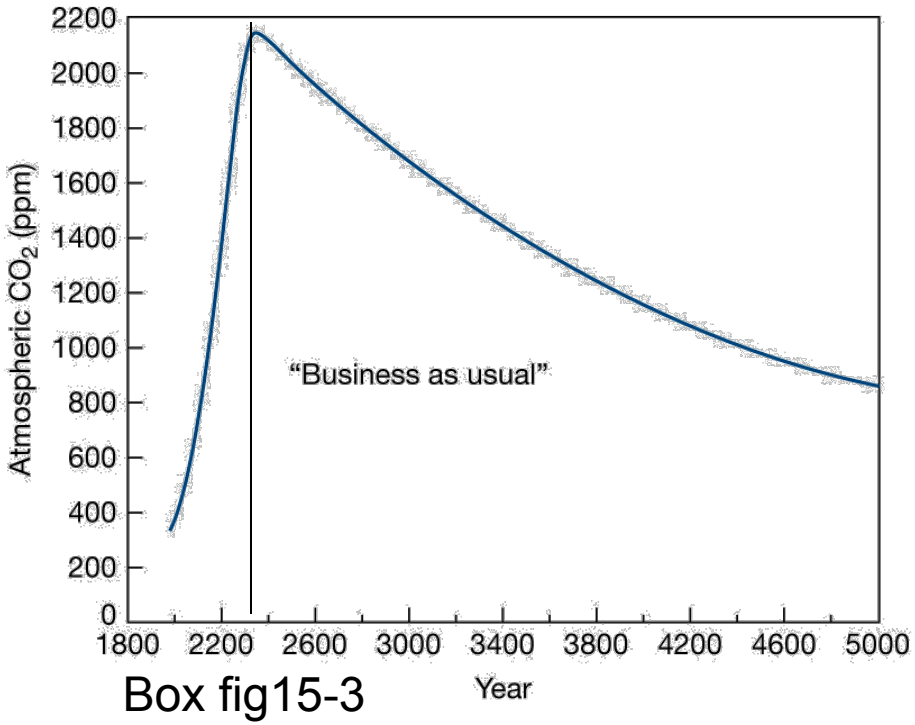
Assume: most fossil fuel reserve - consumed in 400years;

Assume, deforestation continue until - 30% world forest remains;

Model estimate: CO_2 2100ppm in yr 2300 = 8 x pre-industry;

280ppm: yr 1800

Global mean temperature:4.5~13.5C



Box fig15-3

100m.y. global mean:

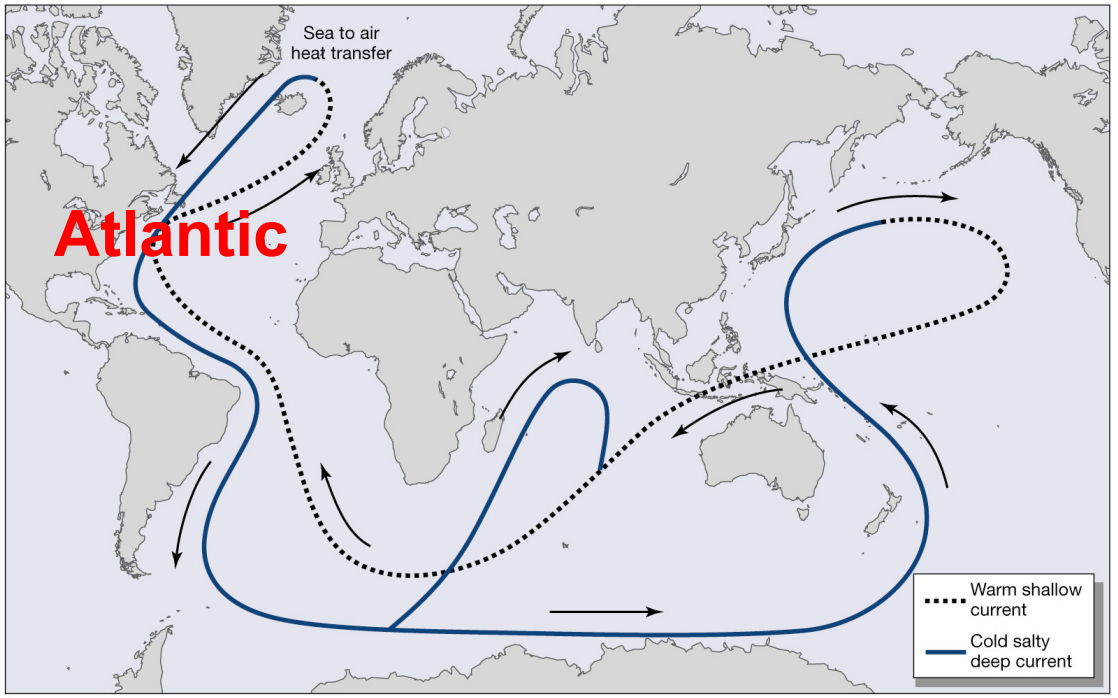
Mesozoic warm: 6-10C warmer;

Pleistocene glacier:10C colder

Possible changes in thermohaline circulation

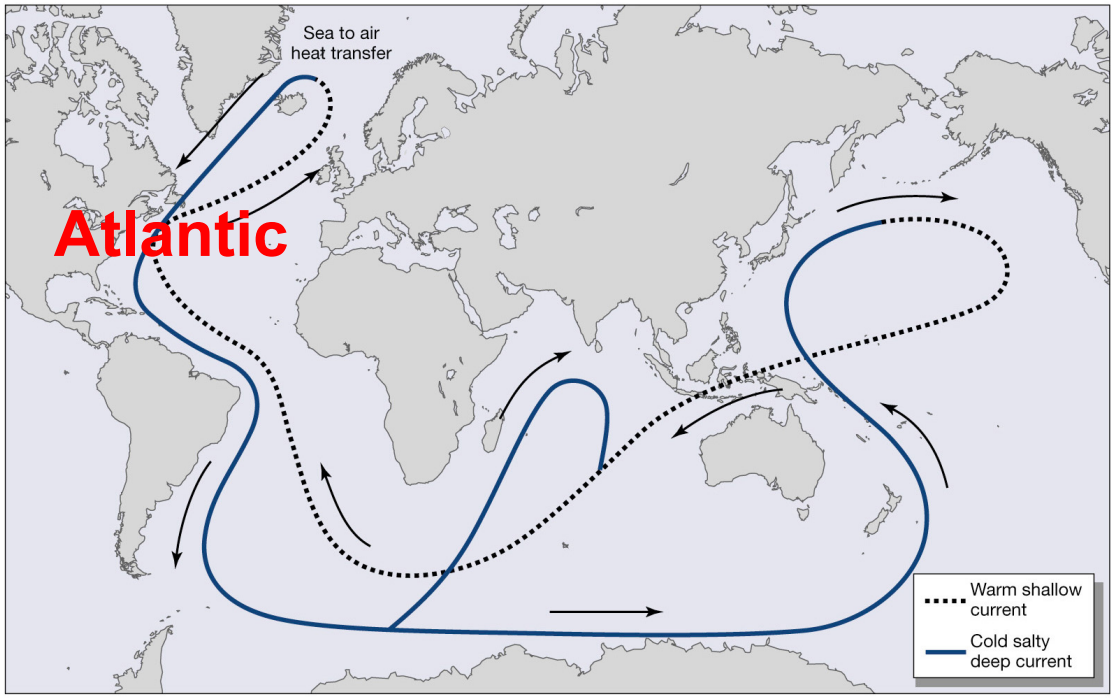
Recall: this circulation – keeps western Europe warm during winter;
this circulation – probably ceased during the Younger Dryas event at the end of the Last Glaciation; - due to the freshwater from the melting Laurentide icesheet, flowed into the North Atlantic – reduced deep water formation;

Warming in the future
- circulation shutdown?



a)Global warming => enhanced hydrological cycle
⇒rainfall + snowfall freshen North Atlantic Ocean
=> reduce deep water formation =>
weaken global thermohaline circulation.
b)Greenland ice sheet melting

Climate models:
not consistent.



Clicker question 6

A. Shutdown of the North Atlantic thermohaline circulation is thought to be the cause for the cold Younger Dryas event;

B. Shutdown of the North Atlantic thermohaline circulation is thought to be the cause for the warm Younger Dryas event;

C. Future warming may enhance the thermohaline circulation by enhancing the deep water formation;

D. Both A and C.

[1] Changes in sea level

Data showing global sea level change:

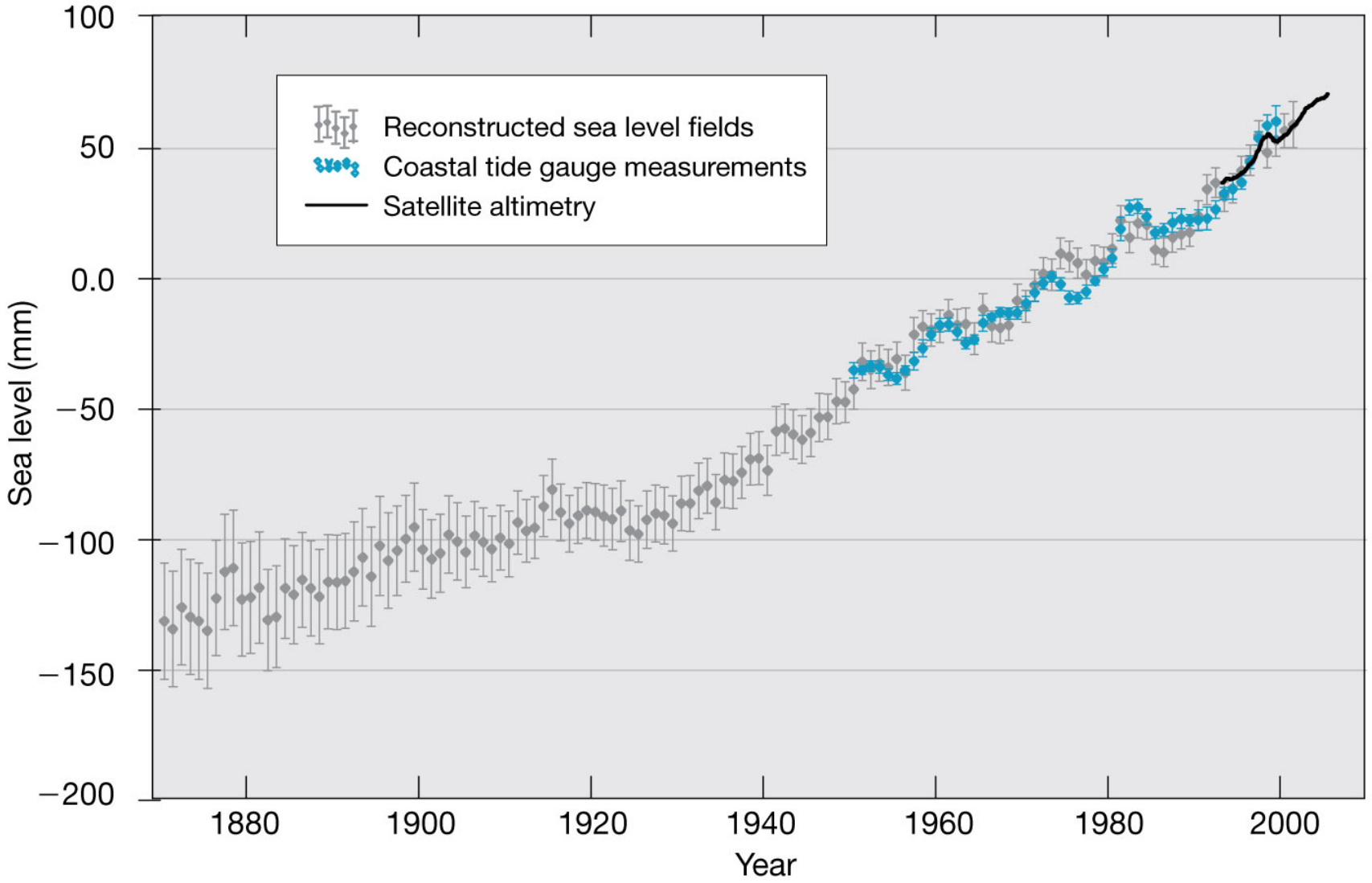


Fig 16-1

IPCC AR4, 2007 estimate:
1961-2003 period: global mean: ~18±5 cm/century;
Thermal expansion: contribute to more than half;
Continental ice melting: 6.9±7.1 cm/century (glaciers and ice caps 5.0±1.8, Greenland ice sheet 0.5±1.2, and Antarctic ice sheet 1.4±4.1): large uncertainties.
Sea ice melting does not affect sea level.

Most recent estimate:
Global mean
using satellite
Altimetry 1992-pres:
melting continental
Ice is the major
Cause for global mean
sea level rise;

Tropics: thermal
expansion.

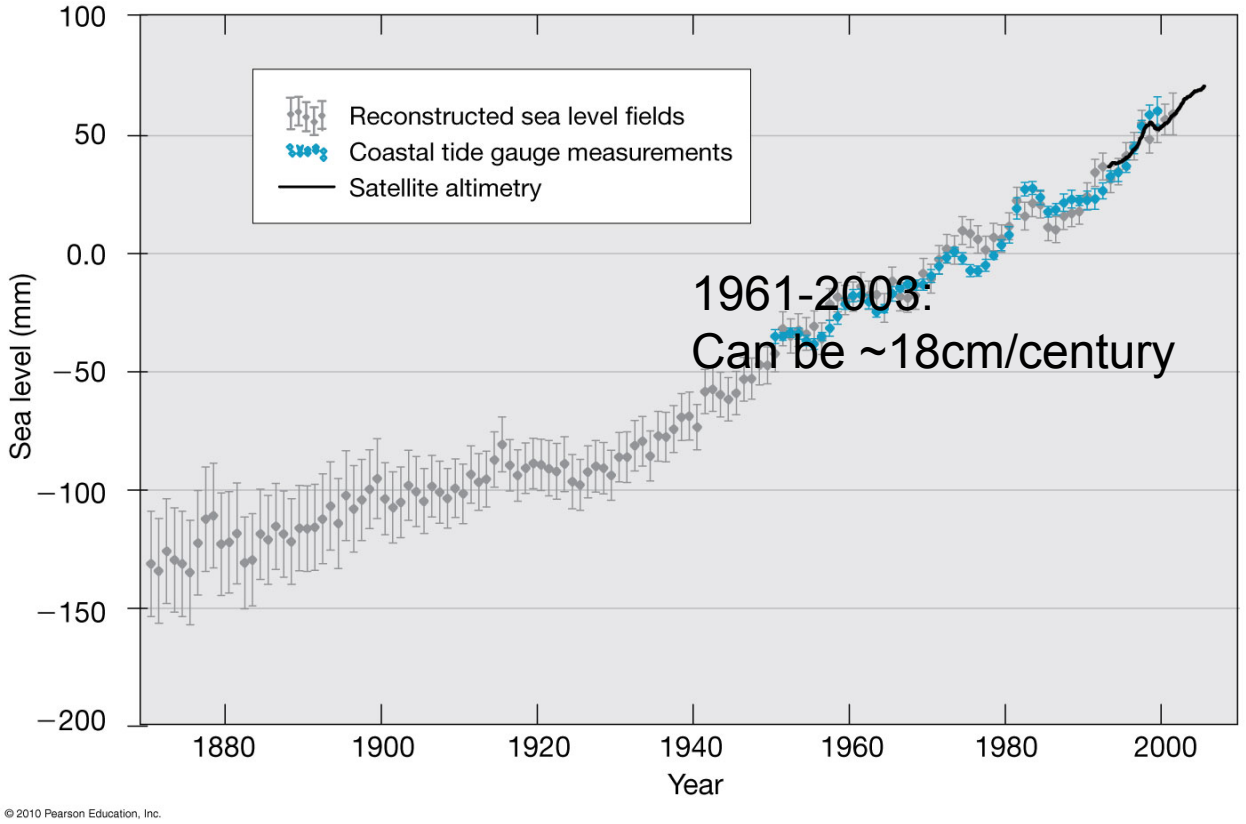


Fig 16-1

Clicker question 1

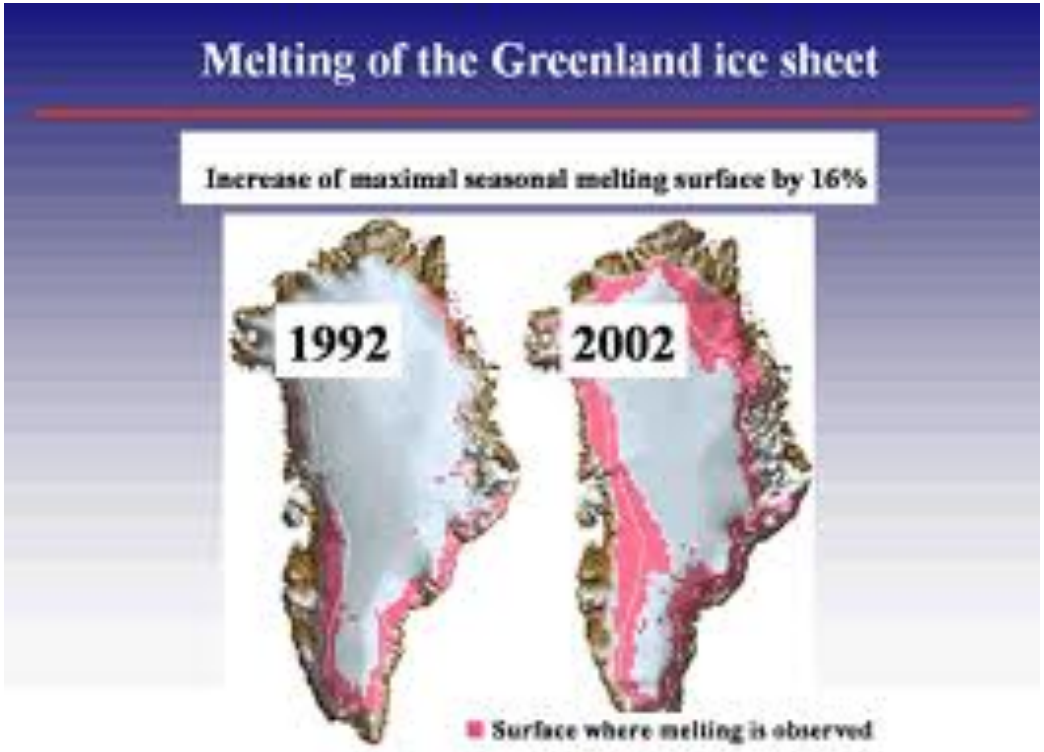
Observational estimates indicate that:

A. Global mean sea level may have increased at a rate of ~18cm/century from 1961 to 2003;
B. Thermal expansion and continental ice melting are both important for the sea level rise;
C. Global warming can increase sea level by melting sea ice;
D. Both A and C;
E. Both A and B.

Future sea level rise

Polar ice caps over the continents:
Greenland & Antarctica;

Greenland: 6~7m sea level (most likely melts);
(observations: melting in fast rate)



Future sea level rise

Polar ice caps over the continents: Greenland & Antarctica;

Antarctic ice sheet: 60~70m sea level;

East Antarctic: increased snowfall due to global warming may thicken the ice sheet (contains most water);

The west Antarctic ice sheet: (5~6m sea level); may melt and contribute to global sea level rise.

(a)

Mountain glaciers: ice fields formed on the Cold upper reaches of mountains.

Andes Mountain Glaciers (Peru, south America): melting in the past

Two centuries after the Little Ice Age; rapidly at present.

If melting continue: ~0.4 eventually.

Projections of future sea-level rise

Include thermal expansion + mountain glaciers + minimal
Contribution from polar ice-sheet melting: 20-50cm to 2100
Pose problems: Gulf coast of
N. America; Bangladesh, islands in S. Pacific & Indian Oceans

Potentially More series: Considering Unstable, Nonlinear Icesheet Dynamics: Calving, etc.

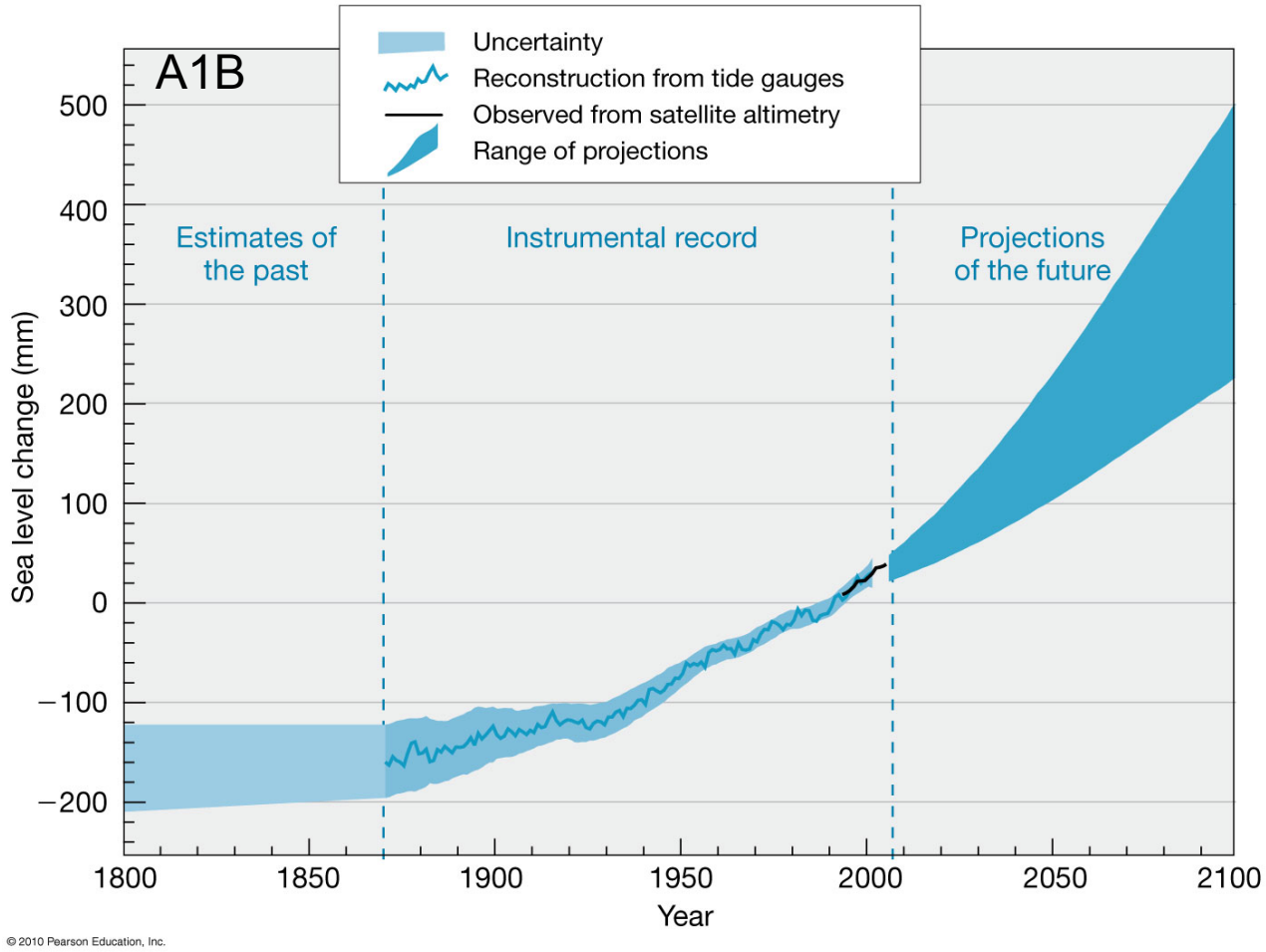


Fig 16-3 IPCC A1B

Clicker question 2

Choose the correct statement.

A. IPCC AR4 projection based on A1B scenario indicated that sea level may increase by 20-50cm by 2100;

B. Estimates in A has large uncertainties due to unstable, nonlinear ice sheet dynamics;

C. The Greenland ice sheet most likely melts, but the West Antarctica ice sheet will thicken;

D. Both A and B;

E. All of above.

[2] Effects on ecosystems

a) Increased CO_2 concentration => can increase plant growth rate (efficient use of water during photosynthesis);

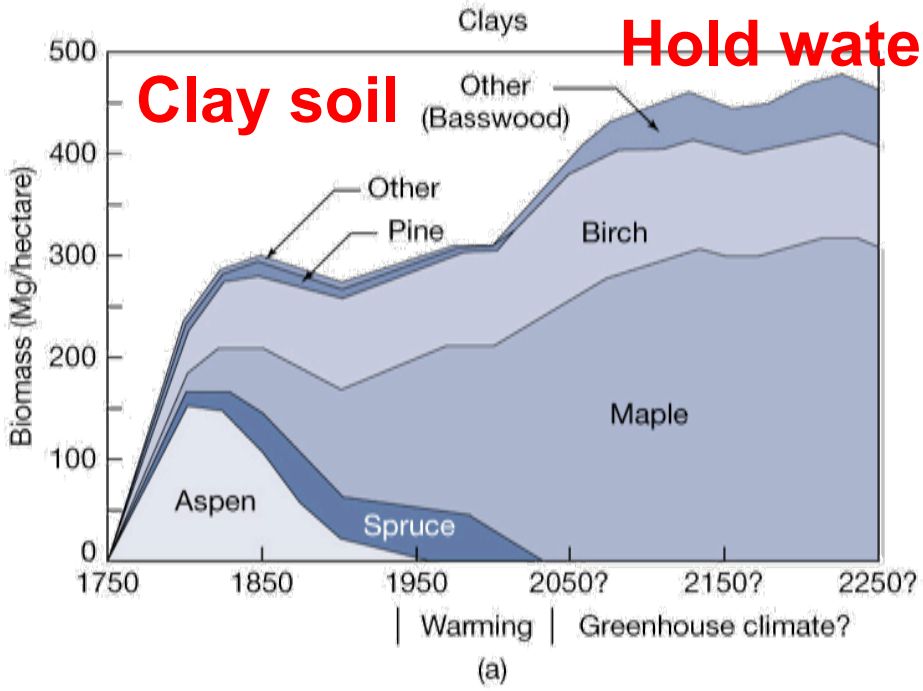
Complicated: depends on water availability & plant species.

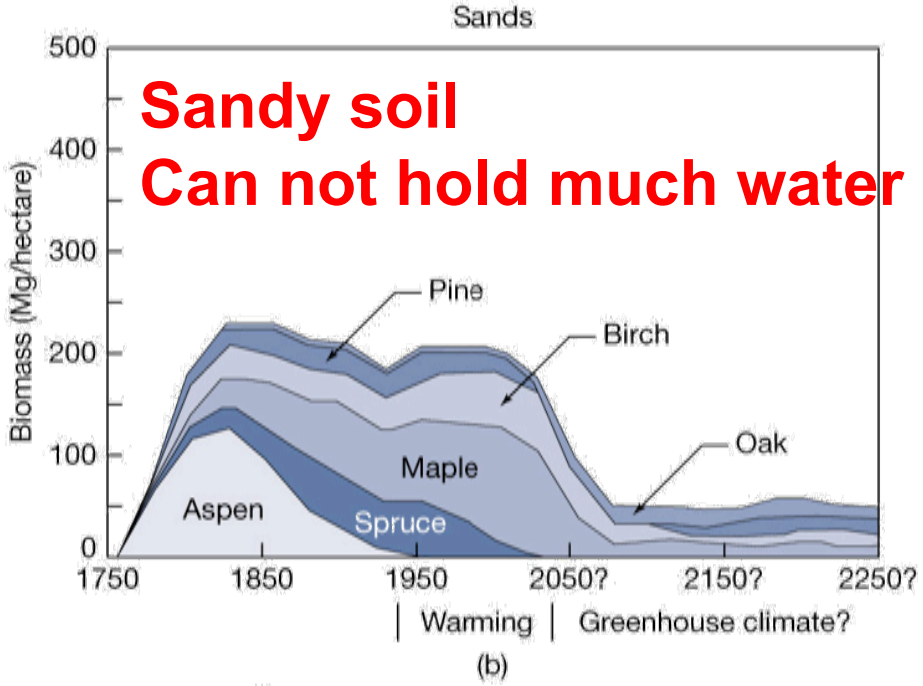
For example: corn, sugarcane, etc, can effectively complete photosynthesis under low CO_2 - won't be affected much.

b) Changes in speciation within forests (temperature, moisture, soil, etc)

Prediction of
Species composition
In Minnesota forests
Under double
CO_2 conditions.

Changes of species
In the future?





Other concerns:
Tropical Insects => spreads to mid-latitudes;
=>affects agriculture;

Tropical diseases: malaria, spreads to mid-latitudes.

Coral bleaching due to the warming, acidification affects ability to grow calcium carbonate skeletons;

Fishery: by affecting upwelling zone.

Partially bleached coral

Human impacts

Likely consequence of global warming:

Intensified hydrological cycle: "rich gets richer, poor gets poorer (enhance flooding and droughts areas)";

⇒May affect fresh water supply (western United States, droughts; 15% world's population depends on mountain glaciers seasonal melting);
sea level rise – intrusion of saltier sea water near coasts
– Bangladesh freshwater contamination;

droughts/floods affect food supply.

Clicker question 3

Global warming may

A. cause changes in speciation within forests;

B. increase the growth of certain types of plants;

C. cause the spreading of tropical insects and diseases to mid-latitudes;

D. Cause coral bleaching, floods and droughts on lands;

E. all of the above.

[3] Adapting to global warming

Even if CO_2 stops increasing,
global temperature will still increase
By ~0.6°C in the next century;
additionally, no obvious
Signs to significantly reduce
Greenhouse gases emissions
in the near future.

⇒Adaption is necessary.

Adapting to Sea level rise:

Developing countries:
Bangladesh, Vietnam,
the Maldives;

Shafiqul Islam/WPN

Adapting to Sea level rise:

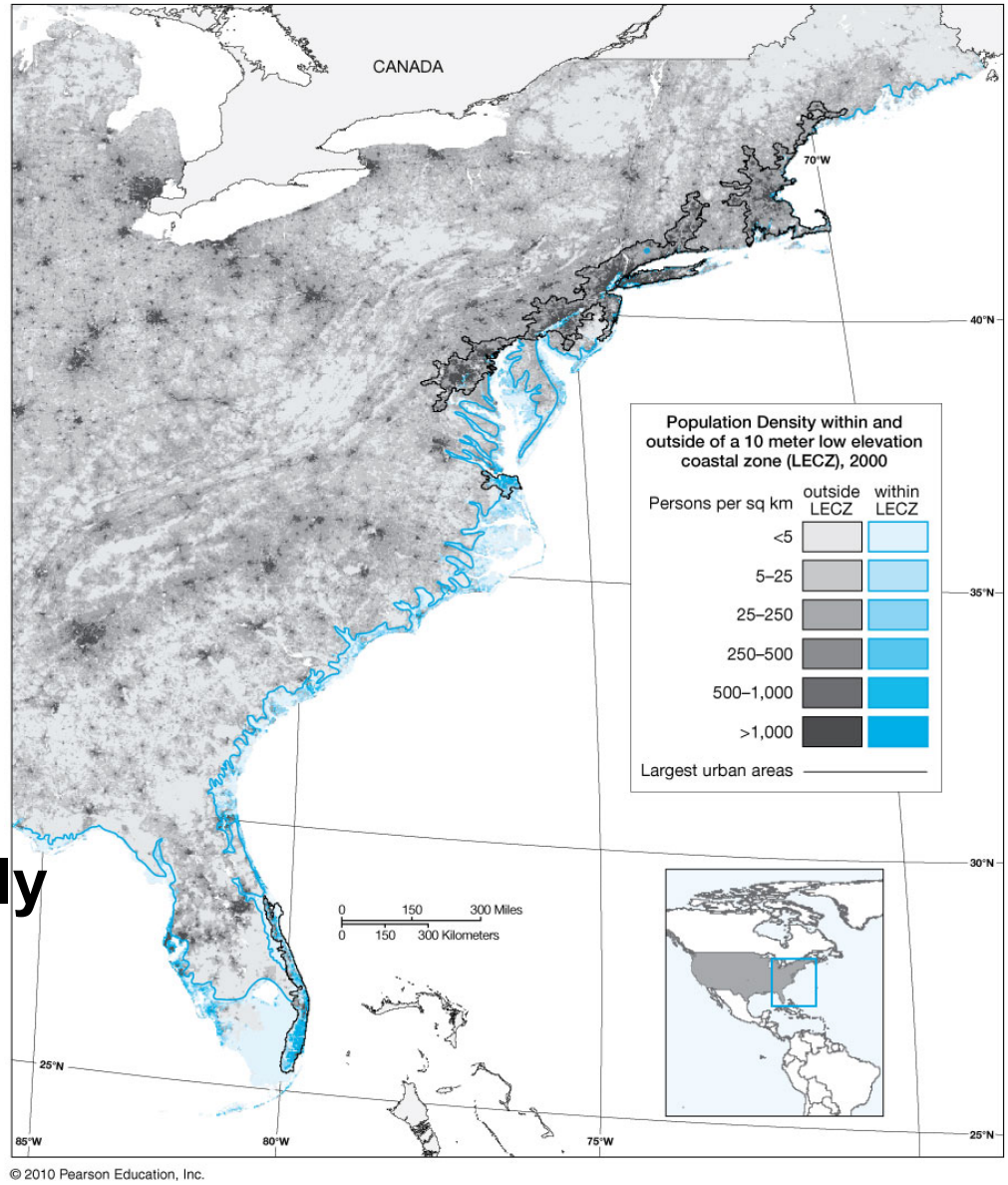
The USA- 20 million people live in LECZ;

Dikes, dams;
Building flood-proof structures, floating agricultural systems;
Move inland.

Adapting to water supply:

Find ways to increase supply & reduce demand:

prospecting ground water, collect rainwater, larger reservoir, process Sea water, reuse, minimize irrigation, urban – metering, pricing)



Clicker question 4

A. Adaptation is necessary, even though CO_2 emission might be reduced in the next century;

B. Adaptation is necessary, since temperature will continue to increase for tens of years even if CO_2 concentration is kept constant;

C. LECZ can adapt to sea level rise by building flood proof structures, dams, dikes, and eventually may have to move inland;

D. Both B and C;

E. all of the above.

[4] Policies to slow global warming

Action now? Global warming is inevitable.
Evidence shows that it is probably has already occurred.

High cost => most societies reluctant to act;
Citizens and governments: wait and see how bad it is before commit any substantial resources to address it.

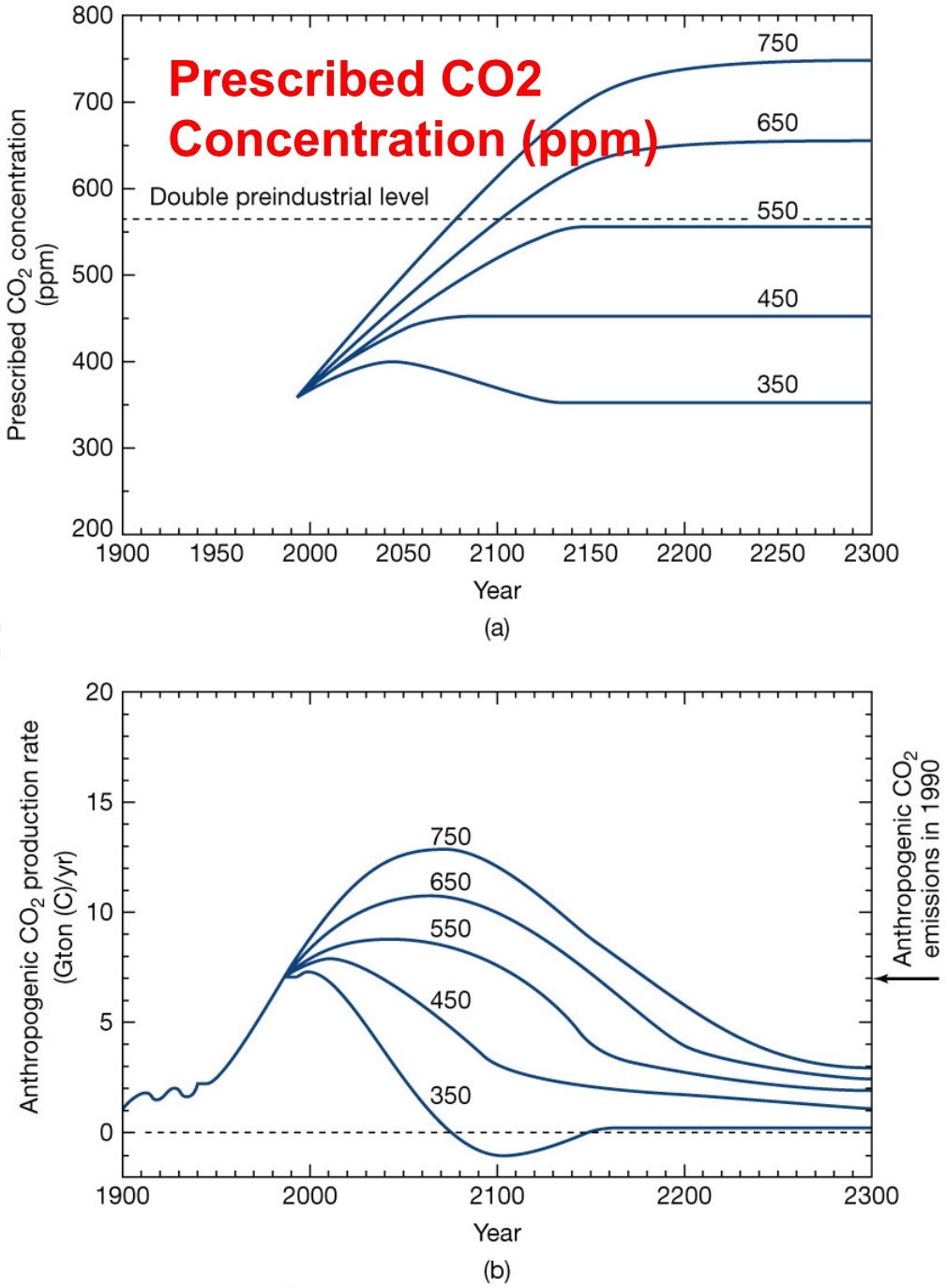
a) The Kyoto Protocol: 1997 – hard measure:

Treaty: economically developed countries: USA, Europe, Japan, cut CO_2 emissions to 5% below 1990 levels;
The US did not sign on it.

b) Energy conservation:
Planting trees; slow down
Global warming; but can't
Solve the problem;

Population increases,
Living standard raises;
Difficult to reduce
fossil fuel to 1Gton/yr;

c) Alternative energy sources.



Clicker question 5

A. Hard measures can be easily taken to dramatically reduce CO_2 emission rate;

B. Since 1997, the Kyoto Protocol has been ratified by 182 counties, including the United States;

C. To stabilize atmospheric CO_2 concentration to 450ppm, a net CO_2 production rate should be reduced from 6 Gton(C)/yr to 1 Gton(C)/yr by 2300;

D. Both B and C;

E. Both A and B.

c) Alternative energy sources

Nuclear energy: nuclear power plant:
nuclear fission of uranium atoms - splitting of uranium atom into two fragments - release energy (no release of CO_2);
but poses own threat to environment (disposal of long-lived radioactive wastes).

Nuclear power: nuclear fusion: combining lightweight atomic nuclei into a heavier nucleus - release energy.

Fusion of hydrogen atoms into helium => technologically daunting task. (prototype: deuterium ^2H and tritium ^3H instead of ^1H).

Wind power: windmills

Tidal power: produces electricity using long floating booms to harness tide energy;

Geothermal power: temperature gradients in solid earth to generate electricity.

Biomass-based fuels: are liquid fuels from plants (growth: absorbs CO_2; burn release CO_2; balanced).

Solar energy; solar isothermal power in sunny areas.

16-9. A nuclear power plant.

16-10. A solar thermal power plant.

d) Carbon capture and storage (CCS)

Trap the CO_2 and bury it – CCS or Carbon sequestration.
Example: Burn coal in pure O_2 rather than air
$\Rightarrow$products or burning are CO_2 and H_2O. Condense, separate.

CCS technology: promising – being further developed by different countries.
Downsides: relatively expansive; long-term effects on Atmospheric CO_2 concentration is unknown.

e) Geoengineering of global climate

Purposely seed the stratosphere with sulfate aerosol particles.

Clicker question 6

To reduce the future CO_2 emissions, we may take the following measures:

A. using alternative energy sources;

B. Increasing energy efficiency and planting more trees;

C. Possibly through CCS technology, but its long term effect is uncertain;

D. Both A and B;

E. All of above.