ATOC 1060-002
OUR CHANGING ENVIRONMENT

Class 22 (Chp 15)

Objectives of Today's Class:

The Holocene:

[1] The Little Ice Age and possible causes;

[2] Climate in the past 150 years;

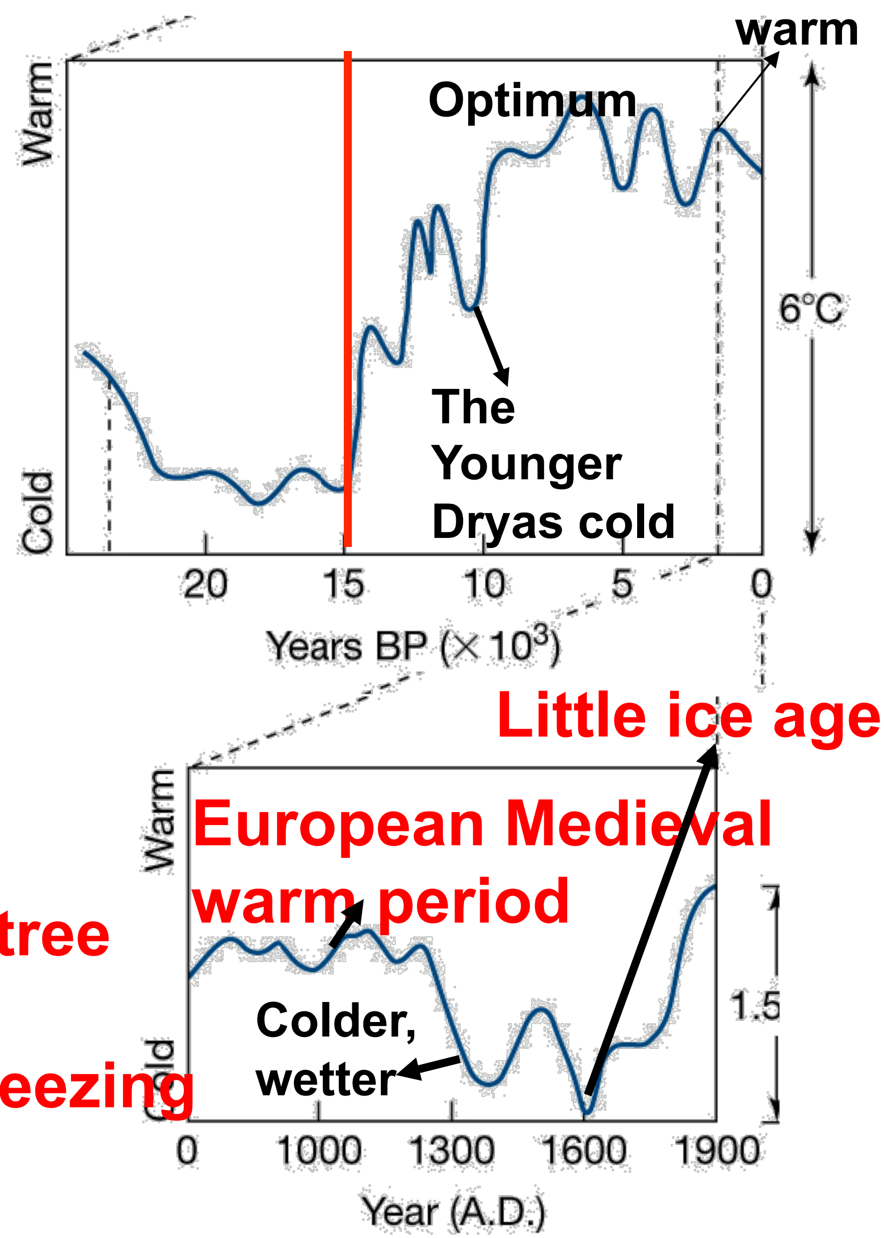
[3] Carbon reservoir and fluxes.

1. The Little Ice Age

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 scale: time period and
duration varied from place
to place.

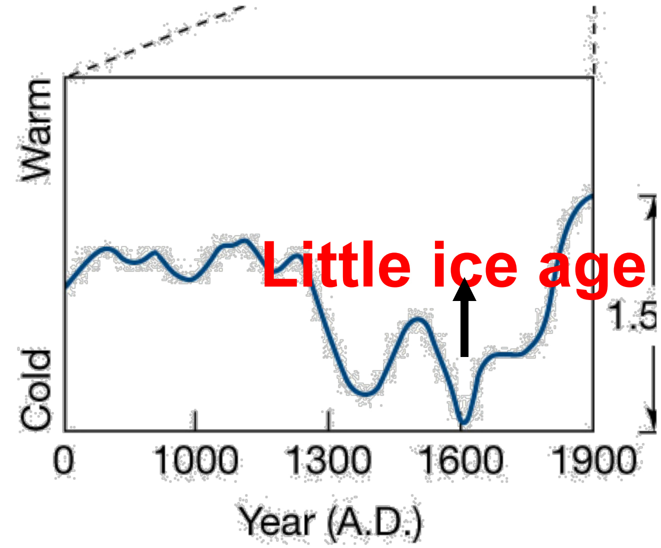
Mountain glaciers, lowering of tree
Lines; increased erosion and
Flooding; sea ice expansion; freezing
canal and rivers.



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

=>

(i) Volcanic eruption;



(ii) changes of solar forcing- possibility;

Possible causes for the Little Ice age:

(i) Volcanic activities – Volcanoes and climate

(Greenland ice cores: high volcanic activity:
1250-1500A.D; 1550-1700A.D.)

1100-1250A.D.: few volcanic events.

Anthropogenic activity: important after 20th century (1900);

So, Volcanic eruption: (1)ash;
(2) stratosphere SO_2

Volcanic eruption: ash: cool the Earth - ash increases albedo=>reduce solar radiation (ash settles quickly);

SO_2 =>
high altitude stratosphere (15-20km), oxides forming sulfuric acid droplets-aerosol - scatters & reflects solar radiation (also short lived: 1-2 years residence time).

Mount Pinatubo aerosol cloud, Philippines, June 1991 (global effect)

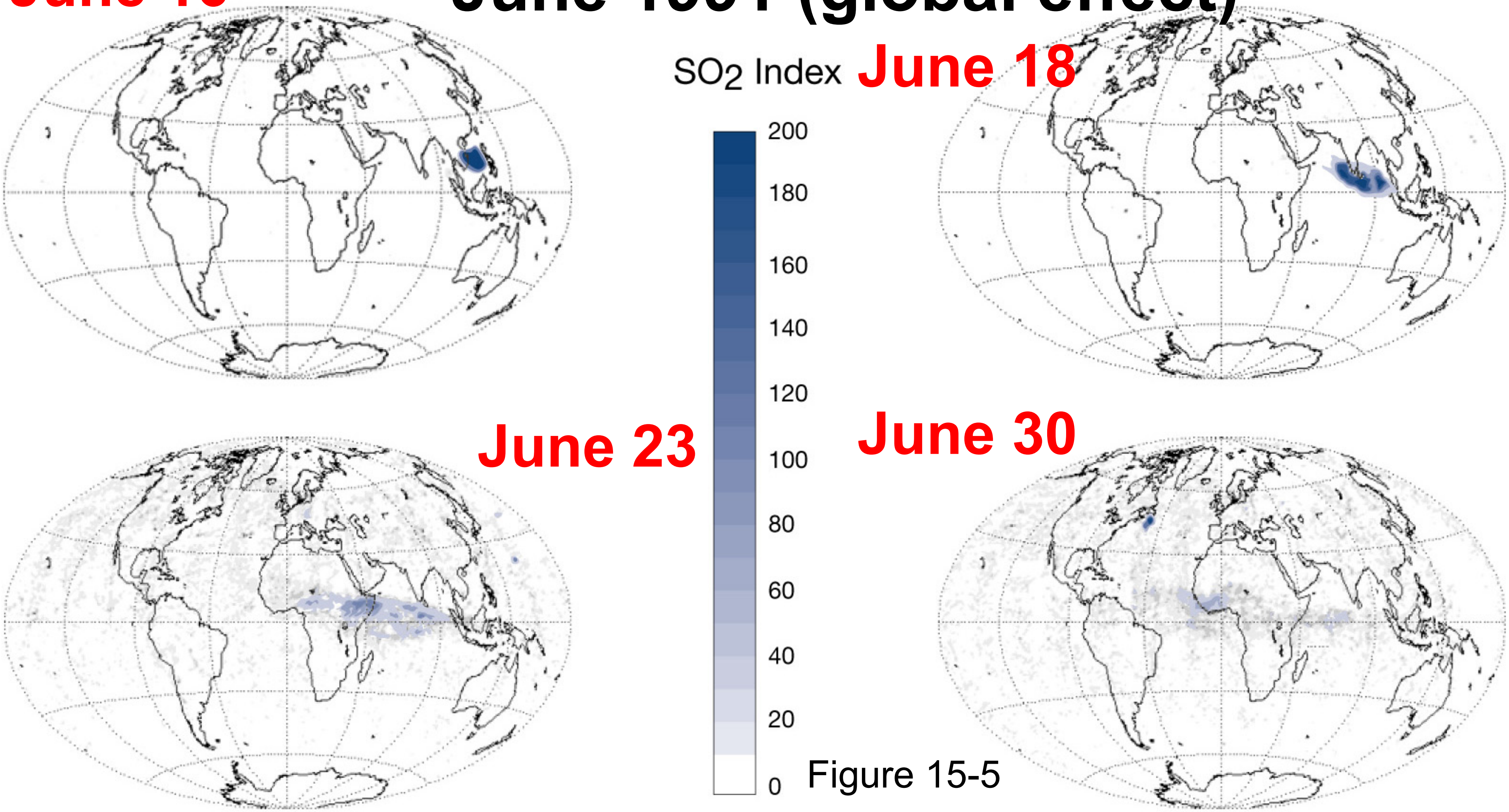


Figure 15-5

Satellite observations: 22 days around globe!

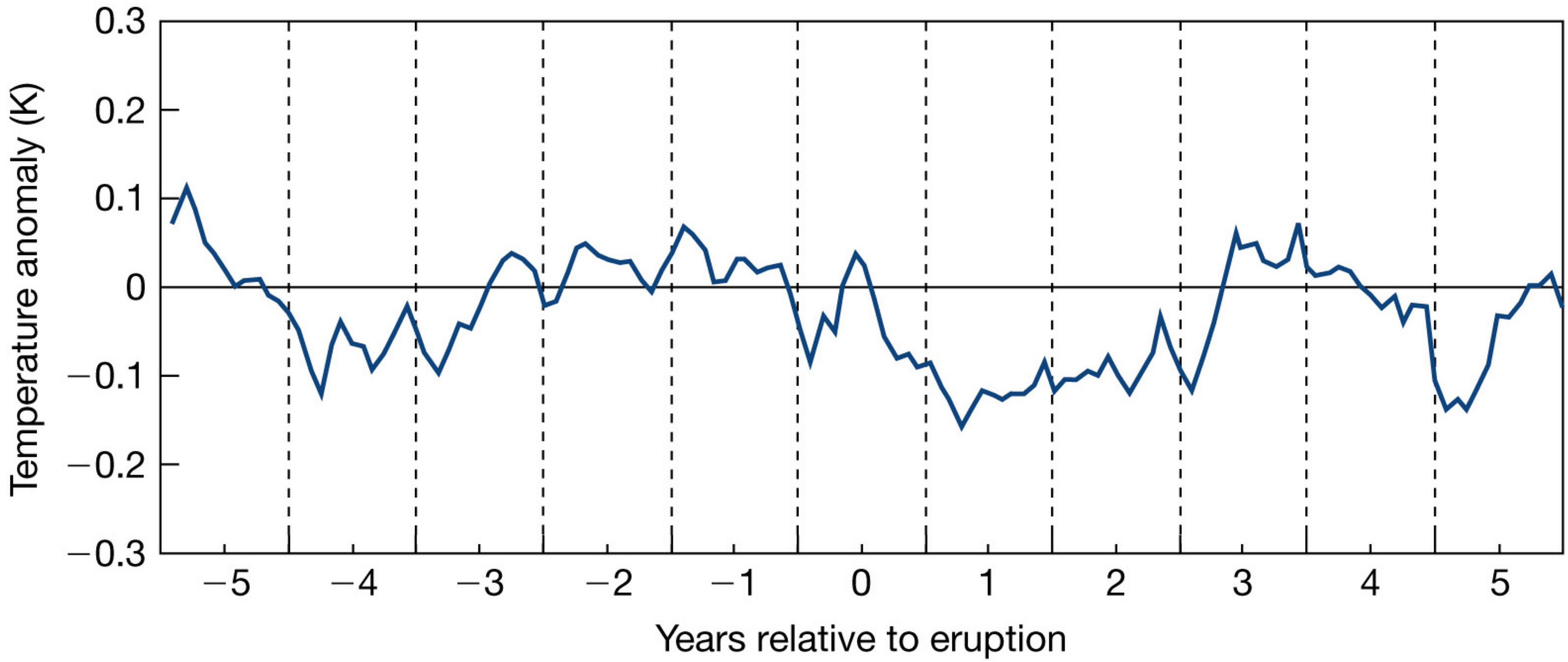
How volcanic eruption affects tropospheric climate? =>Measure or estimate aerosol cloud has on the radiation balance.

A perturbation in the radiation budget caused by the presence of volcanic aerosols is referred to as volcanic aerosol forcing.

Satellite observations: global mean radiation budget & anomalies due to the volcano;

Dramatic increase in albedo => decrease Global mean temperature by 0.5^{o}C by the End of 1992 (1.5 year later).

Global mean temperature changes averaged for 5 major volcanoes



Individual large event: can be 0.3-0.7°C

Regional effects => observations show warm winter in North America, part of Europe and Asia (for several volcanoes in the past century)

Regional differences: increased albedo cools the surface; absorption of longwave radiation by the aerosols in tropical stratosphere enhances east-west circulation at mid-latitudes =>draws more warm air to continents => producing warm winter.

(ii). Changes of solar forcing

Solar variability:sunspot

~11-yr cycle;

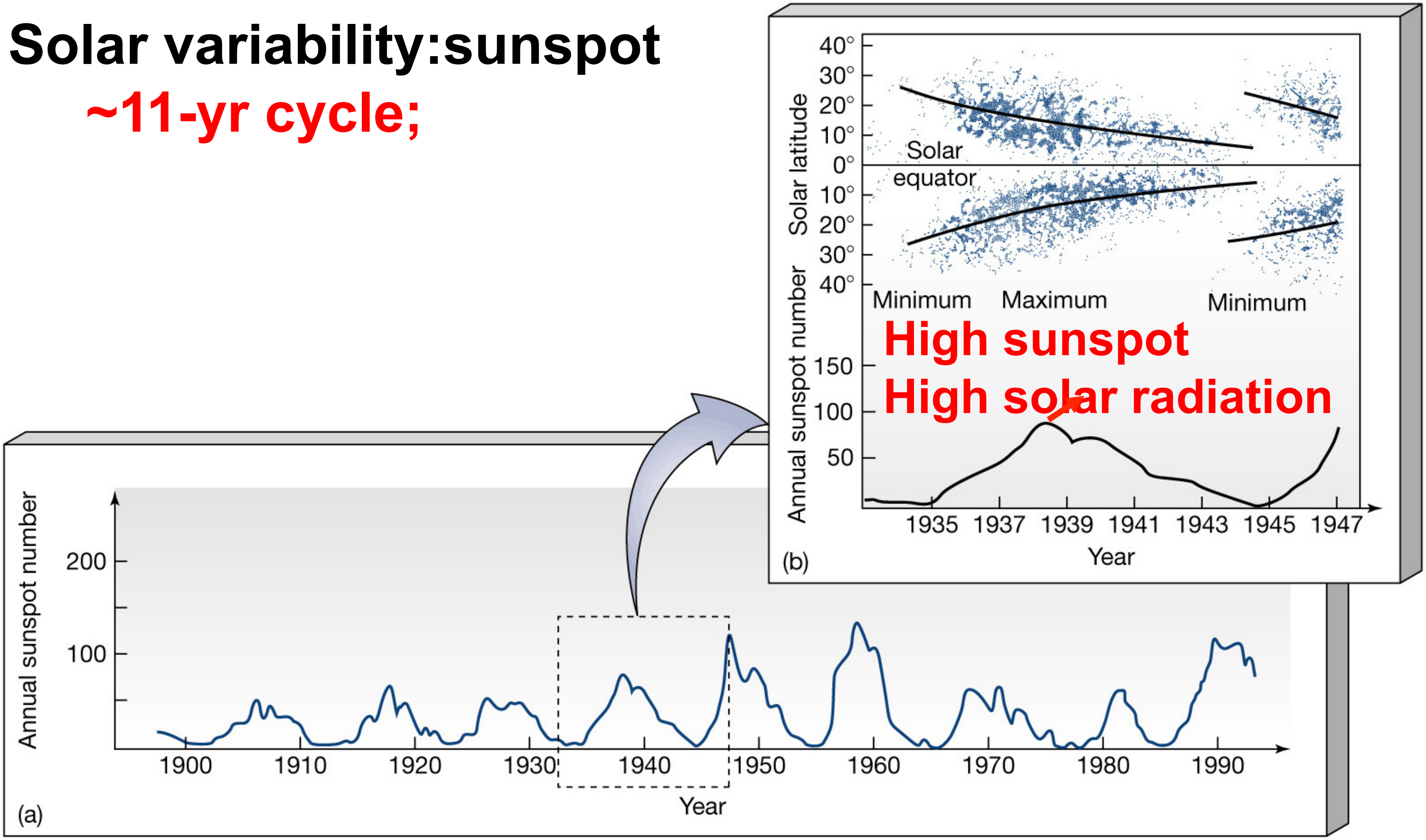
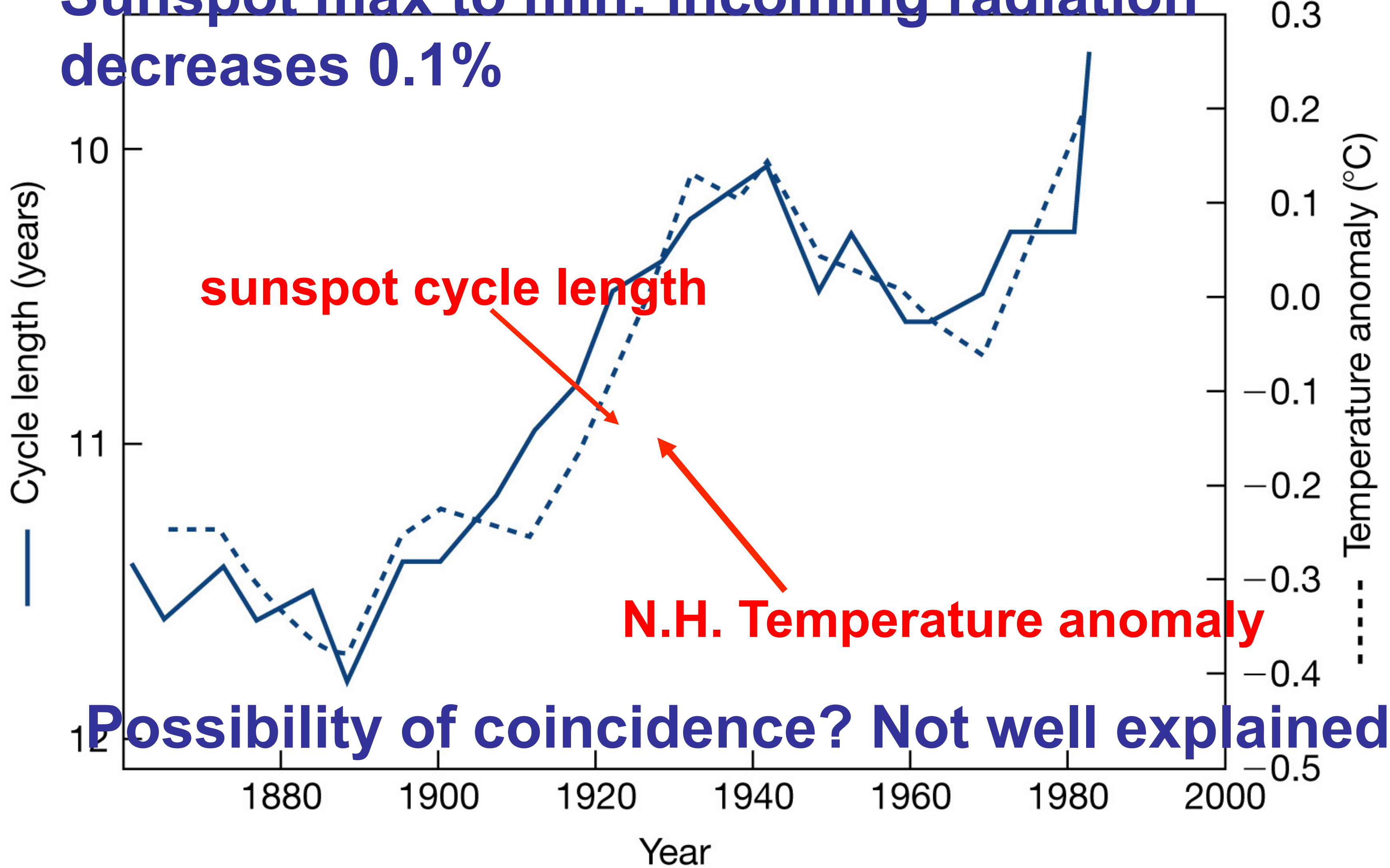


Figure 15-4

Satellite measurement:
Sunspot max to min: incoming radiation decreases 0.1%



Possibility of coincidence? Not well explained

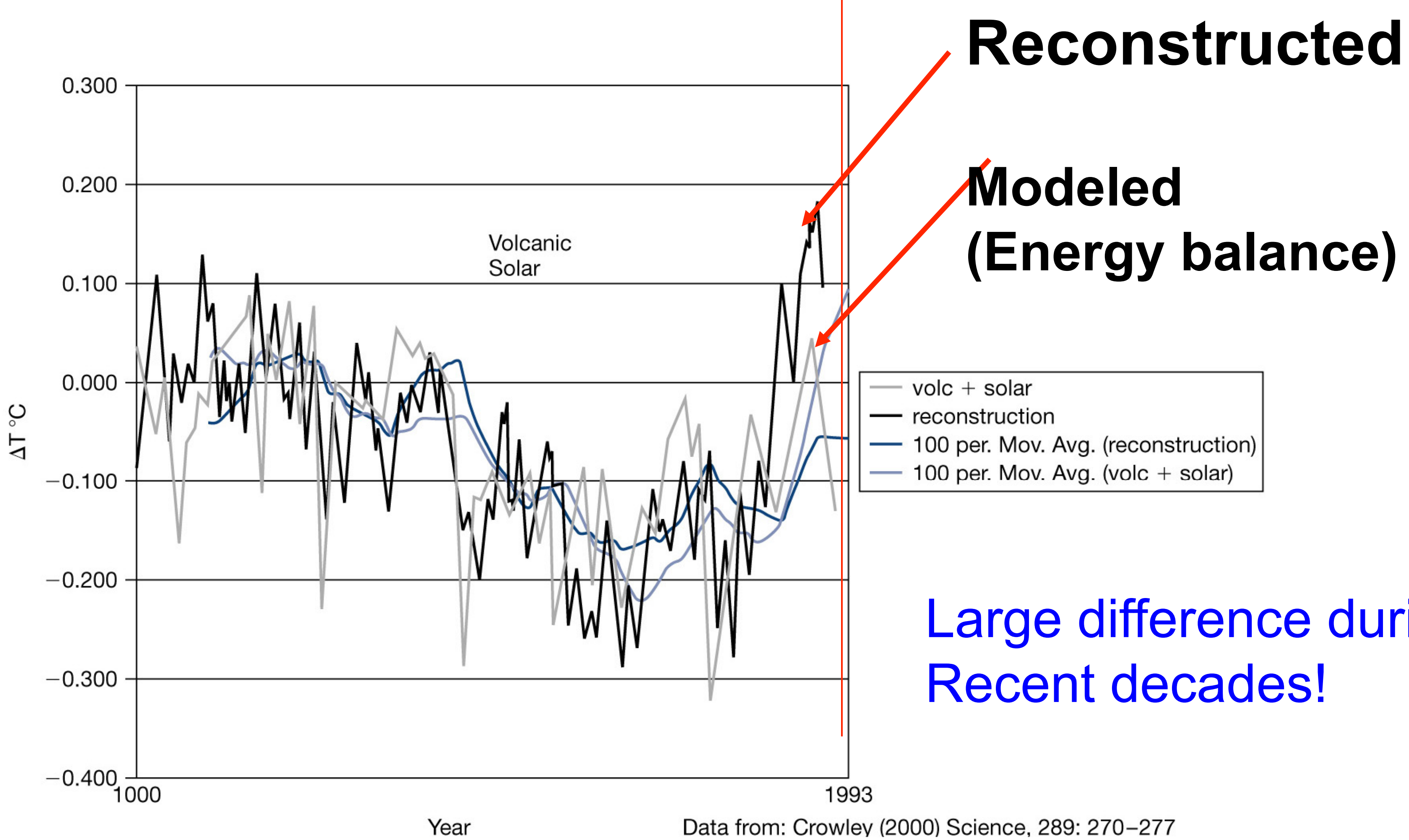
Coincidental? Possibly yes; but other climate changes - sunspots

Gustav Sporer and E.W. Maunder found:
few sunspots 1645-1715 (later part of the Little Ice Age) => Maunder minimum;

Direct observation and proxy data using ^{14}C (high sunspot - low ^{14}C) => The Sporer Minimum (1450-1534),
Wolf Minimum (1282-1342)
12th and 13th centuries: Medieval warm period - Greatest sunspot activities ("affects" climate);

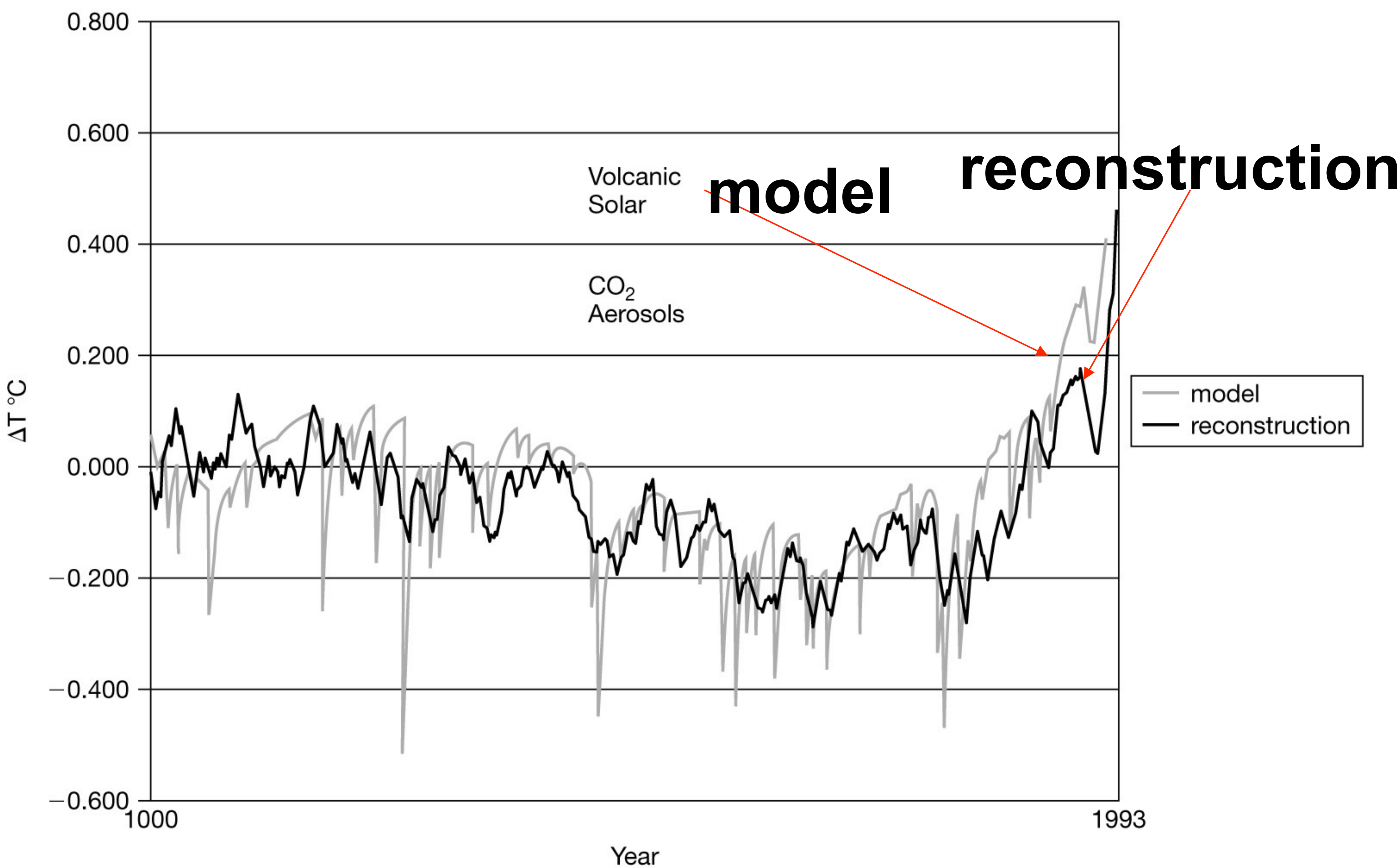
2. Climate during the past 150 years

Since 21,000 years ago (peak glaciation) to present: solar activity (sunspot); shorter scales: volcanoes+ocean circulation (combined effects of all)



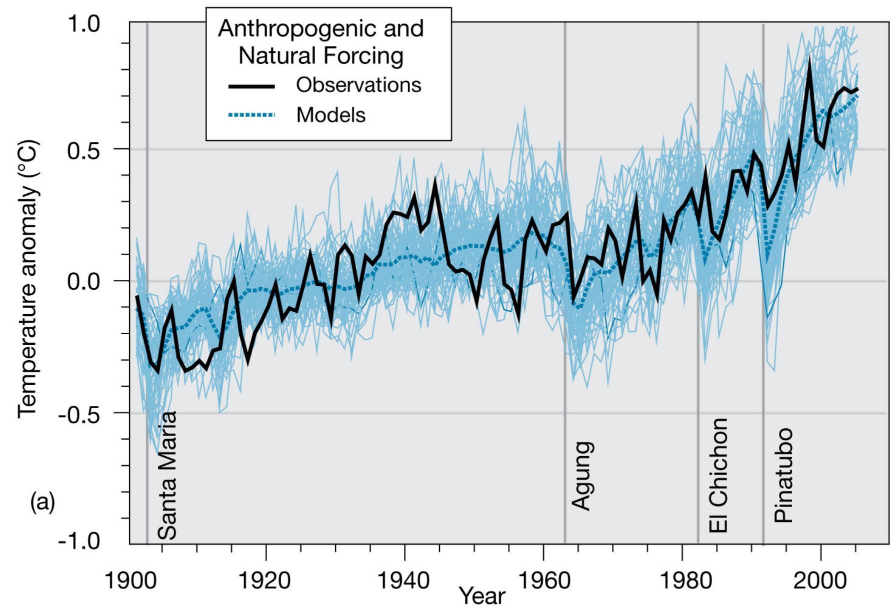
Large difference during Recent decades!

Present, greenhouse gases important



Climate during the past century

Anthropogenic
forcing appear to
Be important in the
past few decades.



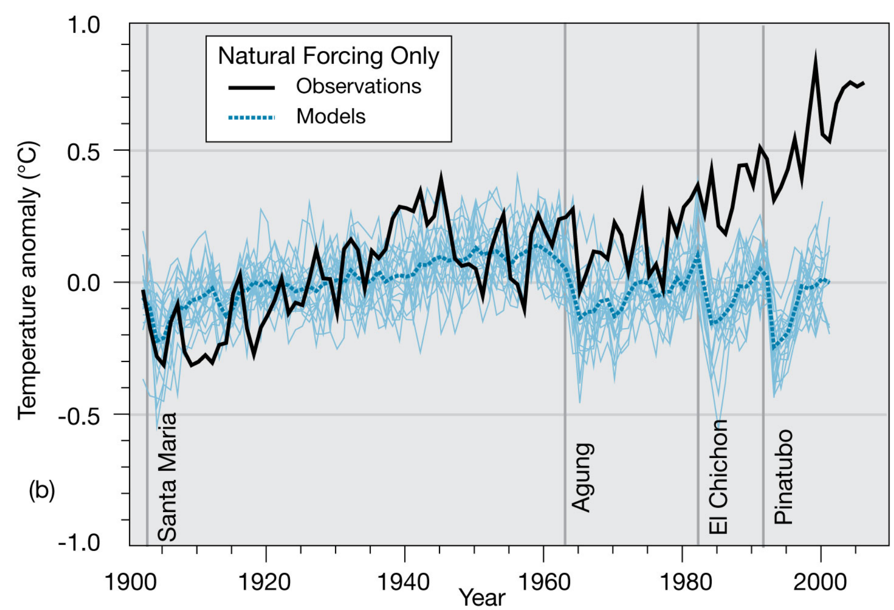


Fig. 15-5

3. Carbon reservoirs and fluxes

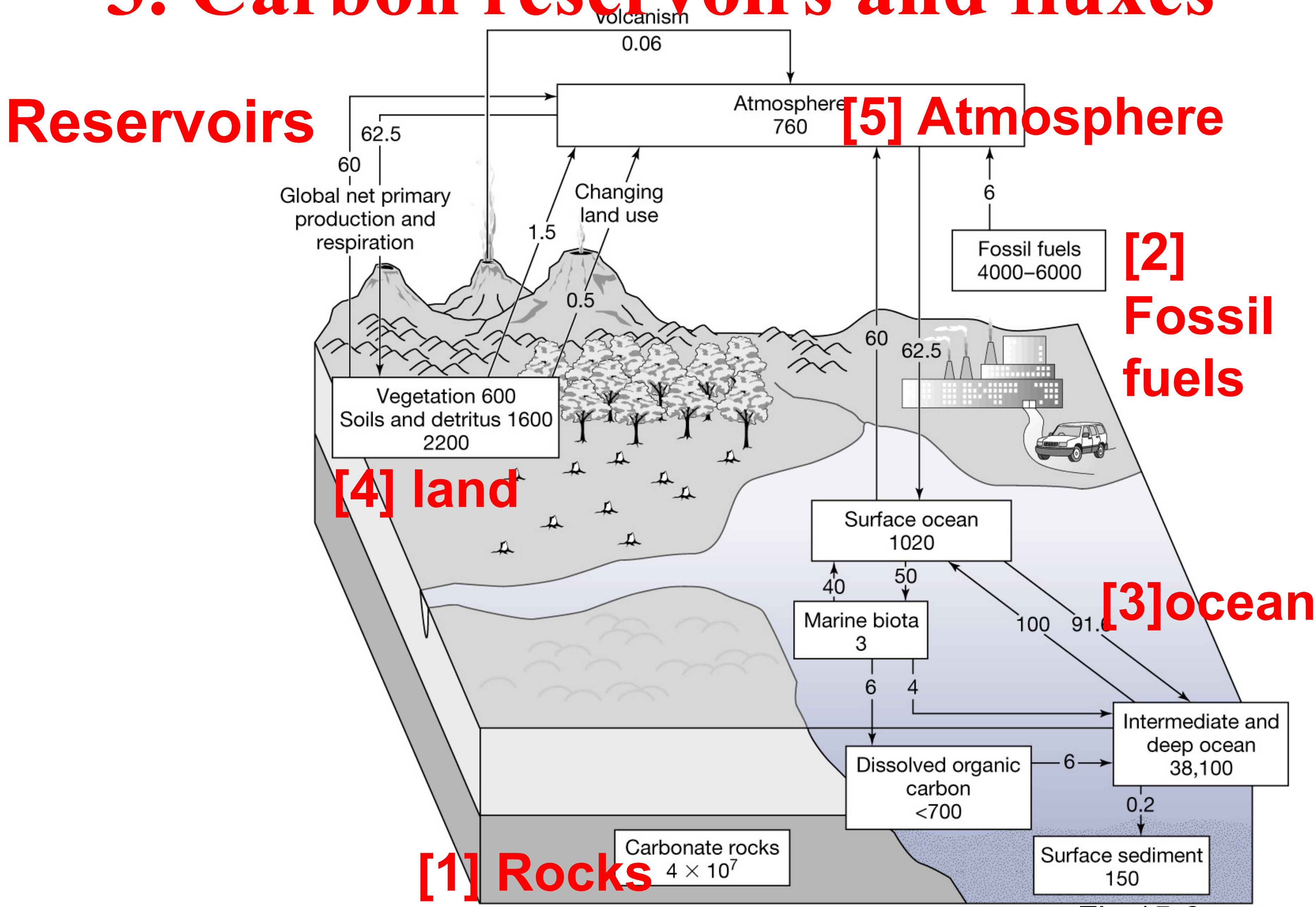


Fig 15-6

Natural reservoirs and fluxes (rates)

Carbonic rocks;
0.06Gton/year;
volcanism/silicate weathering

Fossil fuels: 6Gton/yr;
NOT balanced

ocean<->atm;
60Gton/year;
balanced;

atm<->terrestrial
biosphere;
60Gton/year;

Fig 16-1

Rates of fossil-fuel burning and deforestation

Fossil fuel formation: natural process;

Fossil-fuel burning: anthropogenic;

Fossil fuel: coal, oil, natural gas => burning,

Products: CO_2+H_2O;

Flux: 6Gton/year; since formation of fossil fuel is slow (millions of years), this fast burning 3Gton/year CO_2 accumulate in atmosphere;

⇒global warming, depletion of oil reserves.

Consumption rate >> formation rate

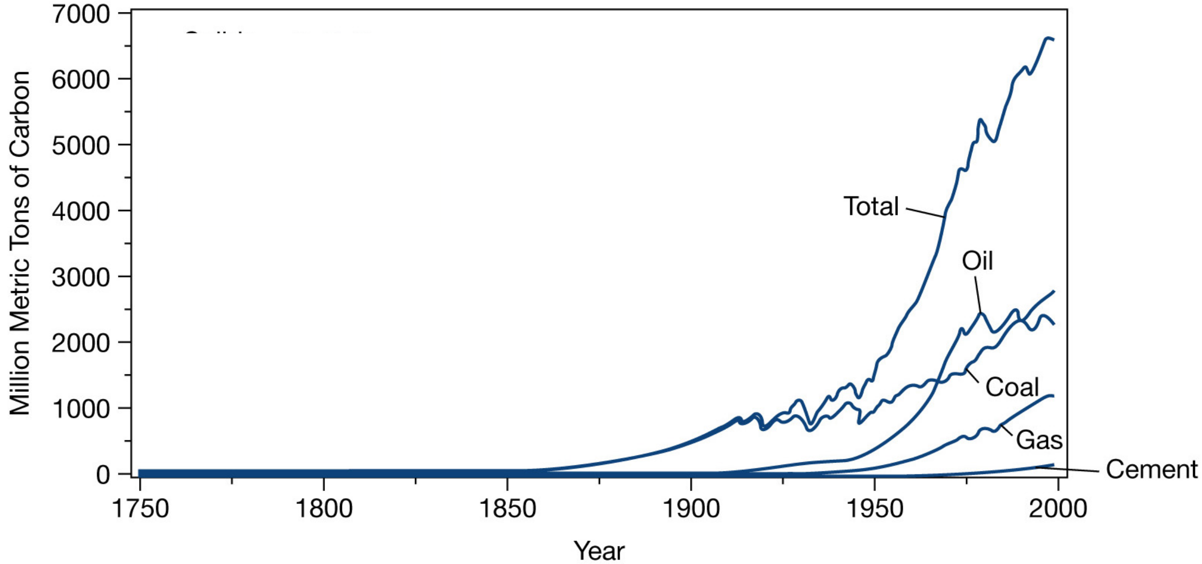
Deforestation: ~1.5 Gton/year CO_2;

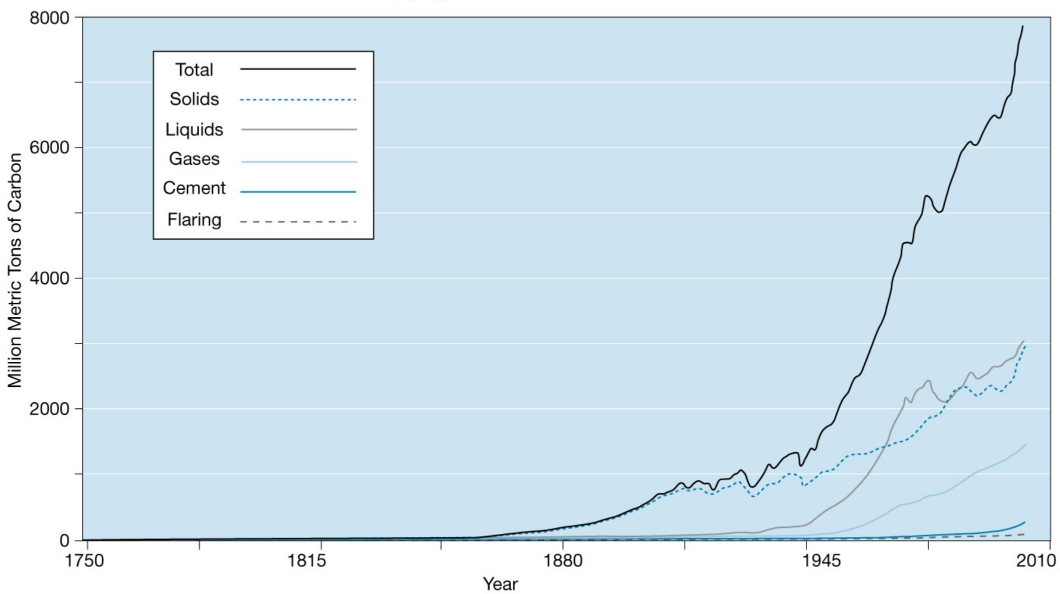
(1Gton=10^9 ton; 1ton=1000kg)

Fig 16-1

Coal, oil, & natural gas consumption rates

CO_2 emission rate





Anthropogenic!

Keeling curve