Global Climate Change: From Past to the Future

Yi Zou

Department of Health and Environmental Sciences

yi.zou@xjtlu.edu.cn

- ENV205:
  - Environmental Change: Past, Present and Future
- ENV 306
  - Ecology in a Changing World

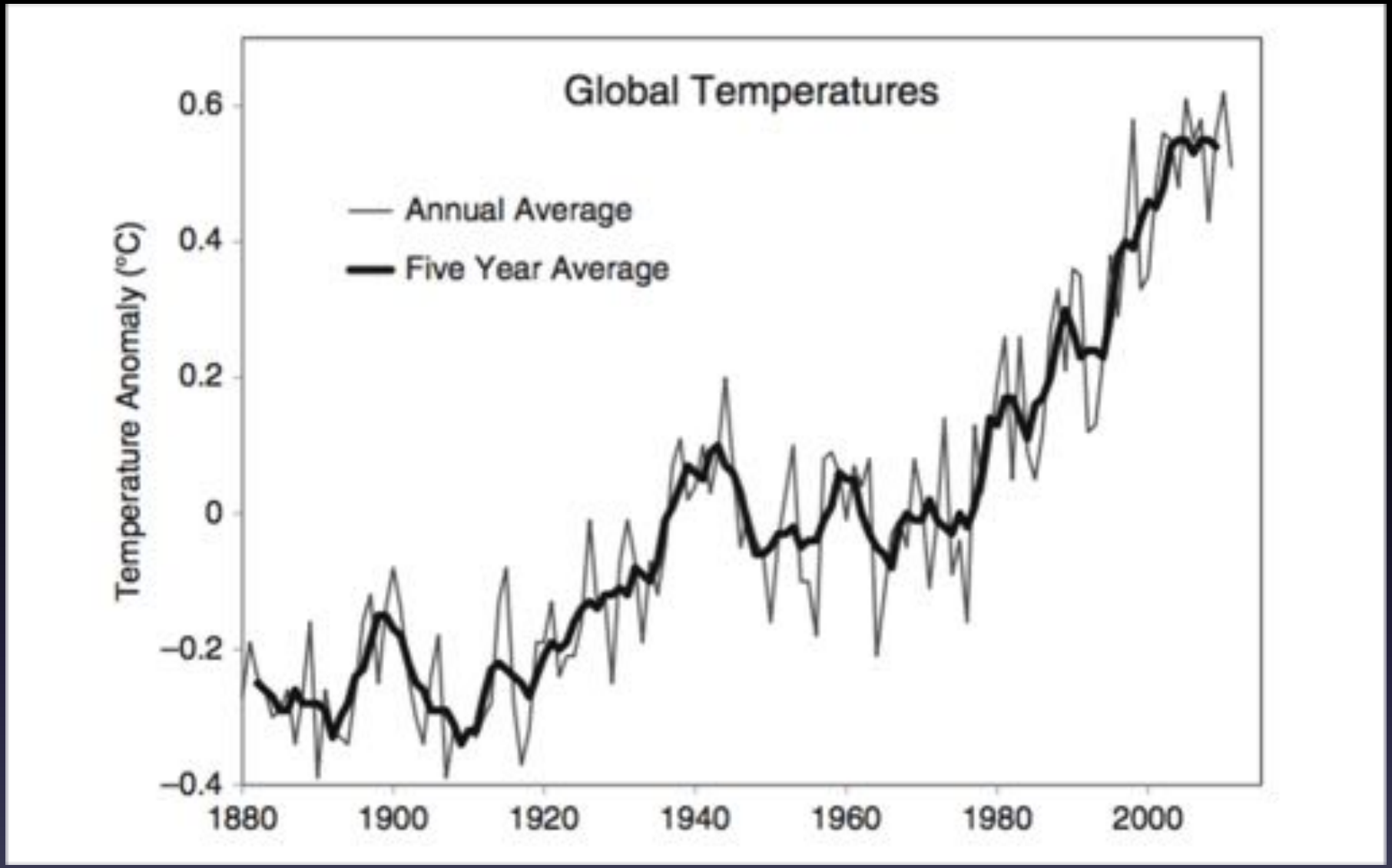
Outline

- What is climate change
- How do we know earth climate
- What will be the climate change in the future
- What are impacts of climate change

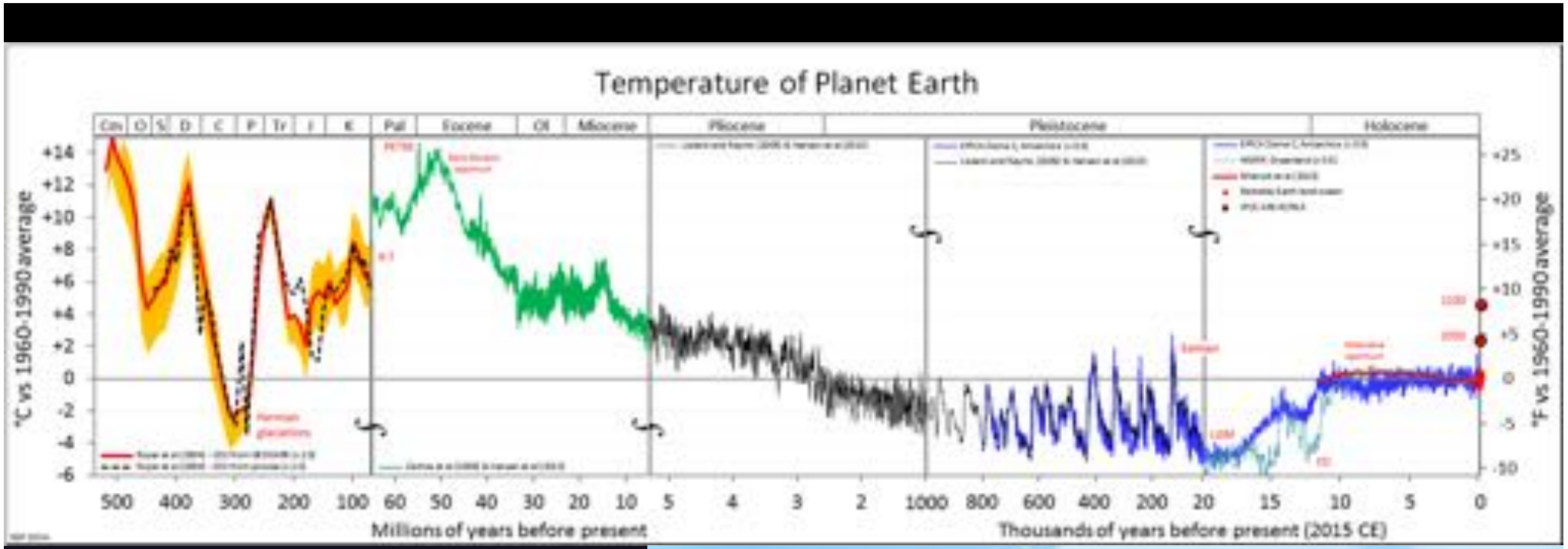
What is climate change ?

Climate and weather

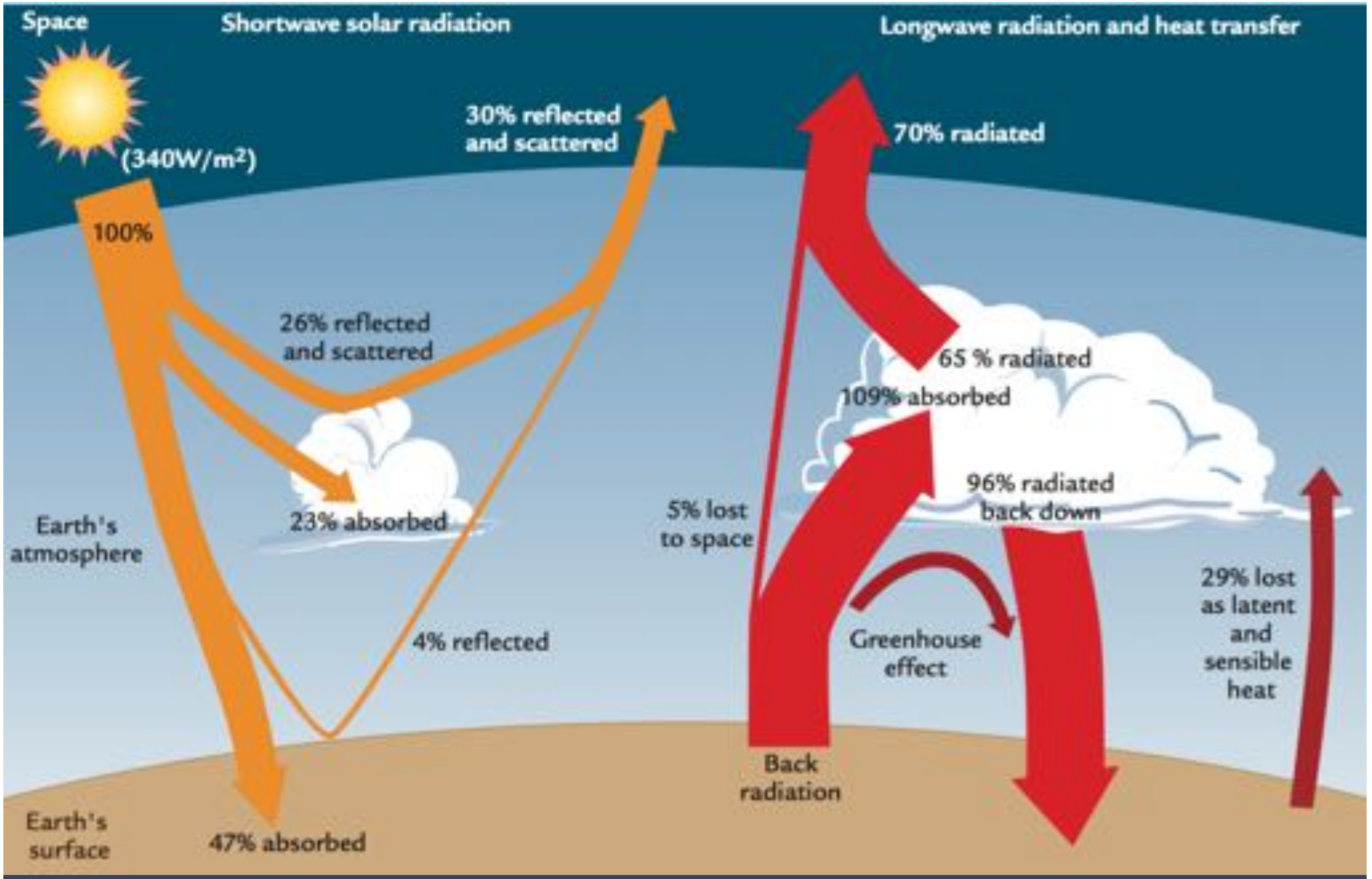
- **Weather**
  - conditions of the atmosphere are over a short period of time
- **Climate**
  - how the atmosphere "behaves" over relatively long periods of time
- **Climate change:**
  - Long-term average of daily weather



Mean global temperature during 1880-2000, 0 is the mean value from 1961-1990 (Farmer and Cook 2012)



Ice age and glaciation



Earth's radiation budget

How do we record changing climate?

Record climate change

A varieties of ways to record climate change, some examples include:

- Temperature
  - Earth surface temperature
  - Sea surface temperature
- Precipitation (rainfall,snowfall,humidity,water quality,etc)

Record climate change

- Vegetation
  - Vegetation distribution under different climate
  - Plant biomass

- Sea level
  - tide gauge measurement
  - altimeter measurements (combine satellite orbit)
  - near ocean surface coral reefs (or coastal sediments)
  - uranium series and radiocarbon (predominant dating methods)

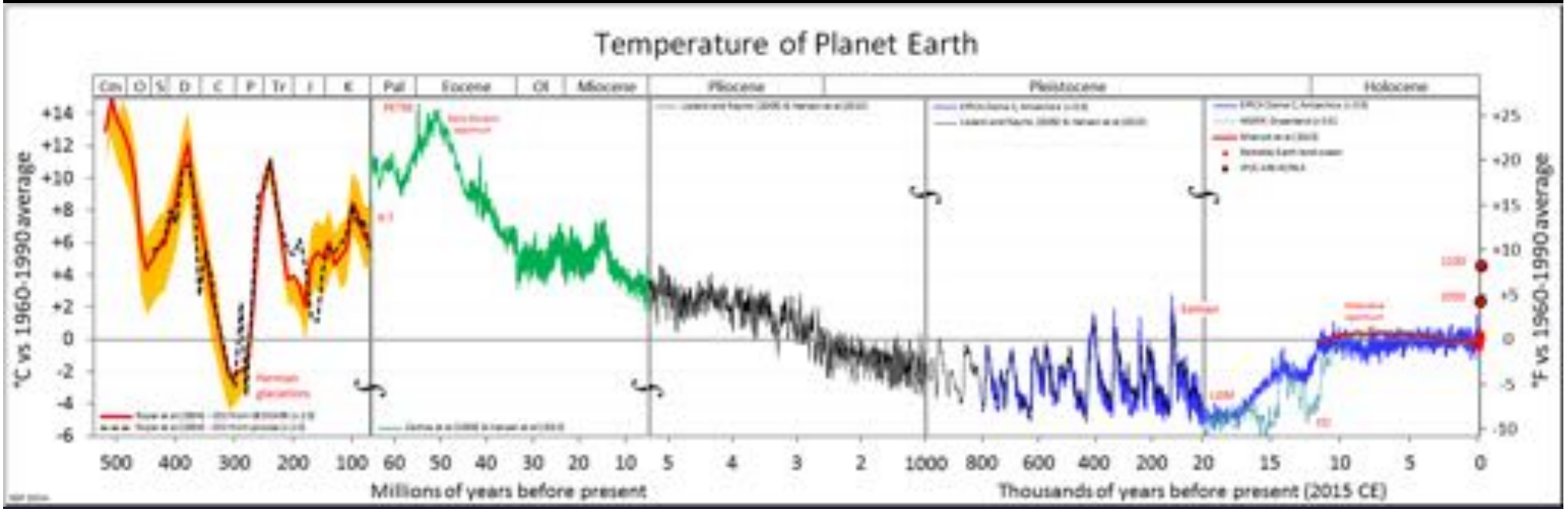
Global temperature was 1-2°C warmer about 5 million years BP, sea level was 15-25 meters higher

Record climate change

- **Glaciers – balance between snow input and melt output**
  - **world glacier inventory (1970) photos and maps**

Petermann Glacier in Northern Greenland (http://www.telegraph.co.uk)

NASA: glacier melting

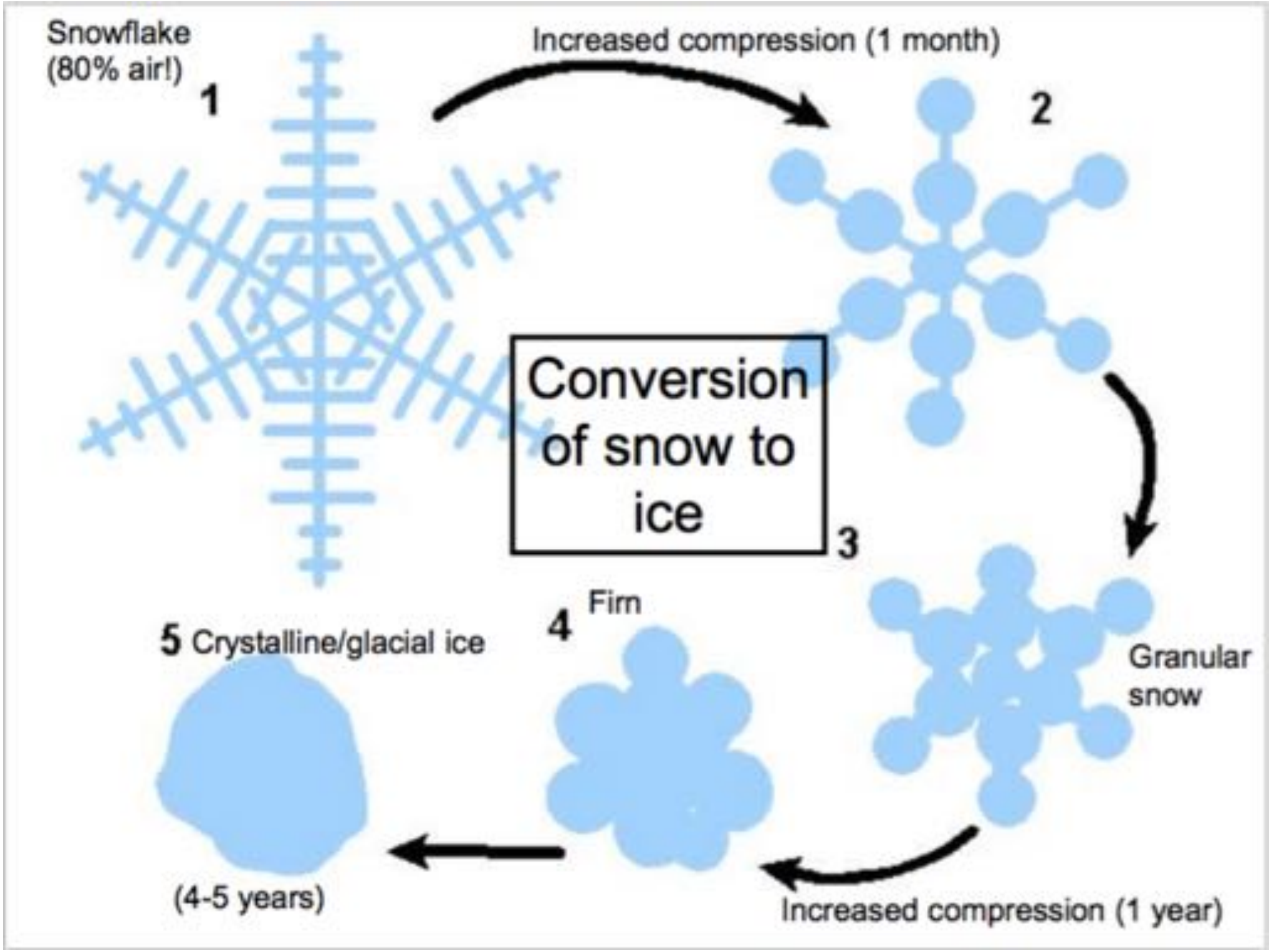


How do scientists get these detailed records?

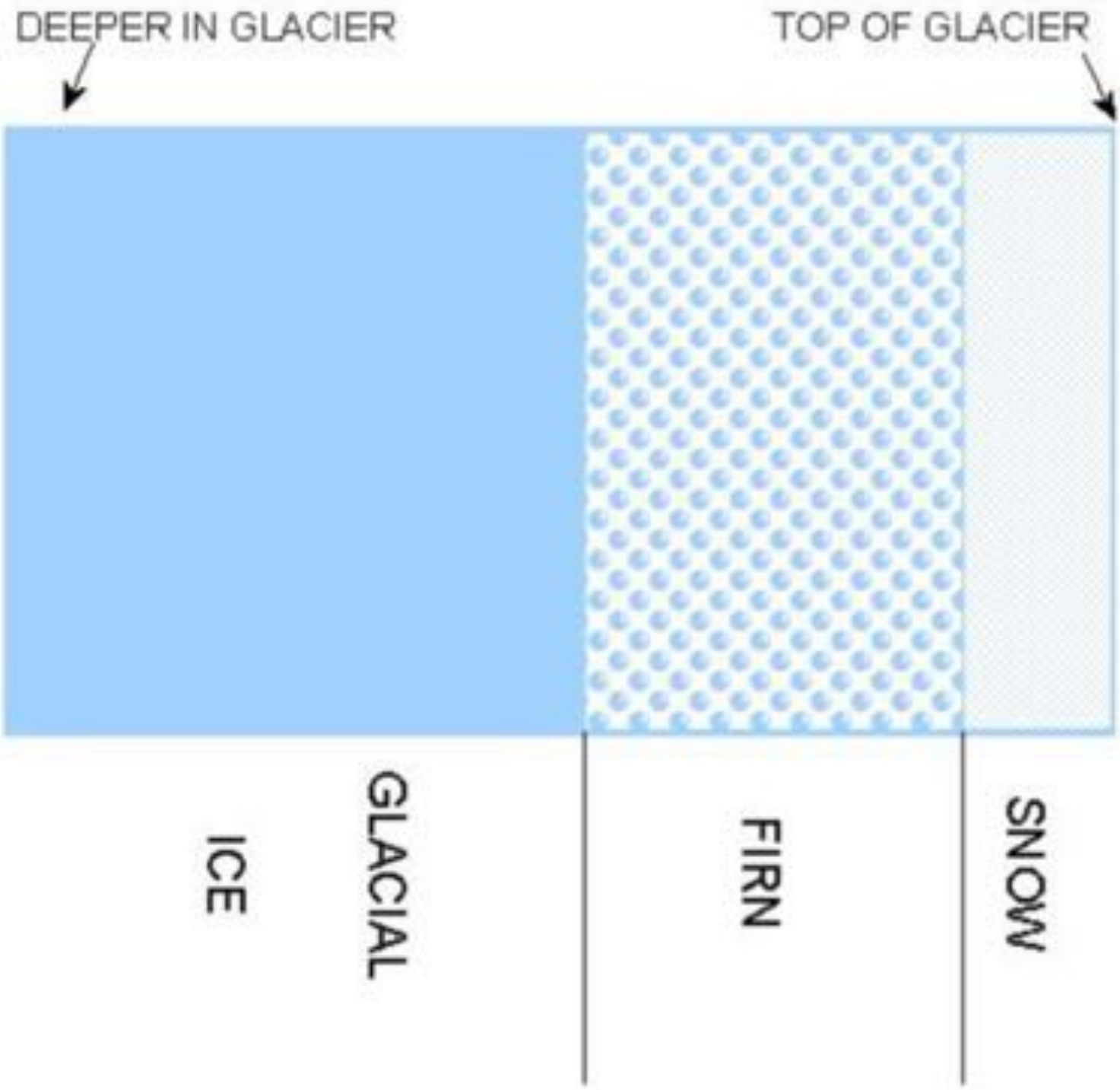
Proxy and Archive

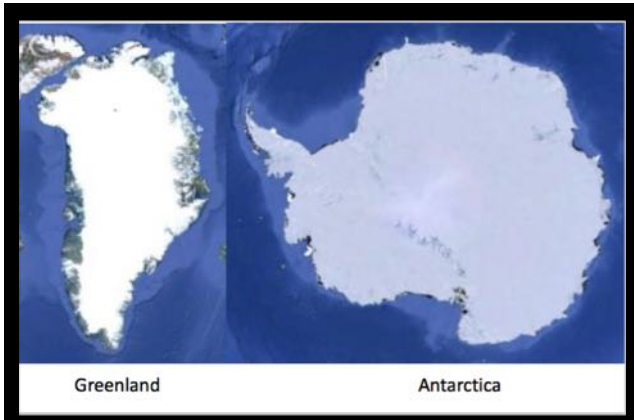
- **Environmental Proxy:** An indirect measurement of past environmental conditions
  - E.g. Oxygen isotope
- **Environmental archive:** the physical setting in which the proxy is "stored" over time
  - e.g. Ice core

Example of environmental archive: Ice core


Snowflake
(80% air!)
1
Increased compression (1 month)
2
Conversion of snow to ice
3
Granular snow
Increased compression (1 year)
4 Firn
5 Crystalline/glacial ice
(4-5 years)

Cross-section through upper part of a glacier





Ice sheets

- Ice sheets are the largest glaciers on Earth
  - E.g. Continent-sized masses of ice which overwhelm nearly all the land surface
- Collectively comprise ~95% of all glacier ice on Earth (but not so in the past)
- If all the ice in the world were to melt today sea-level is estimated to rise as much as 60 - 66 m

Annual ice layers (Lowe and Walker, 1997)

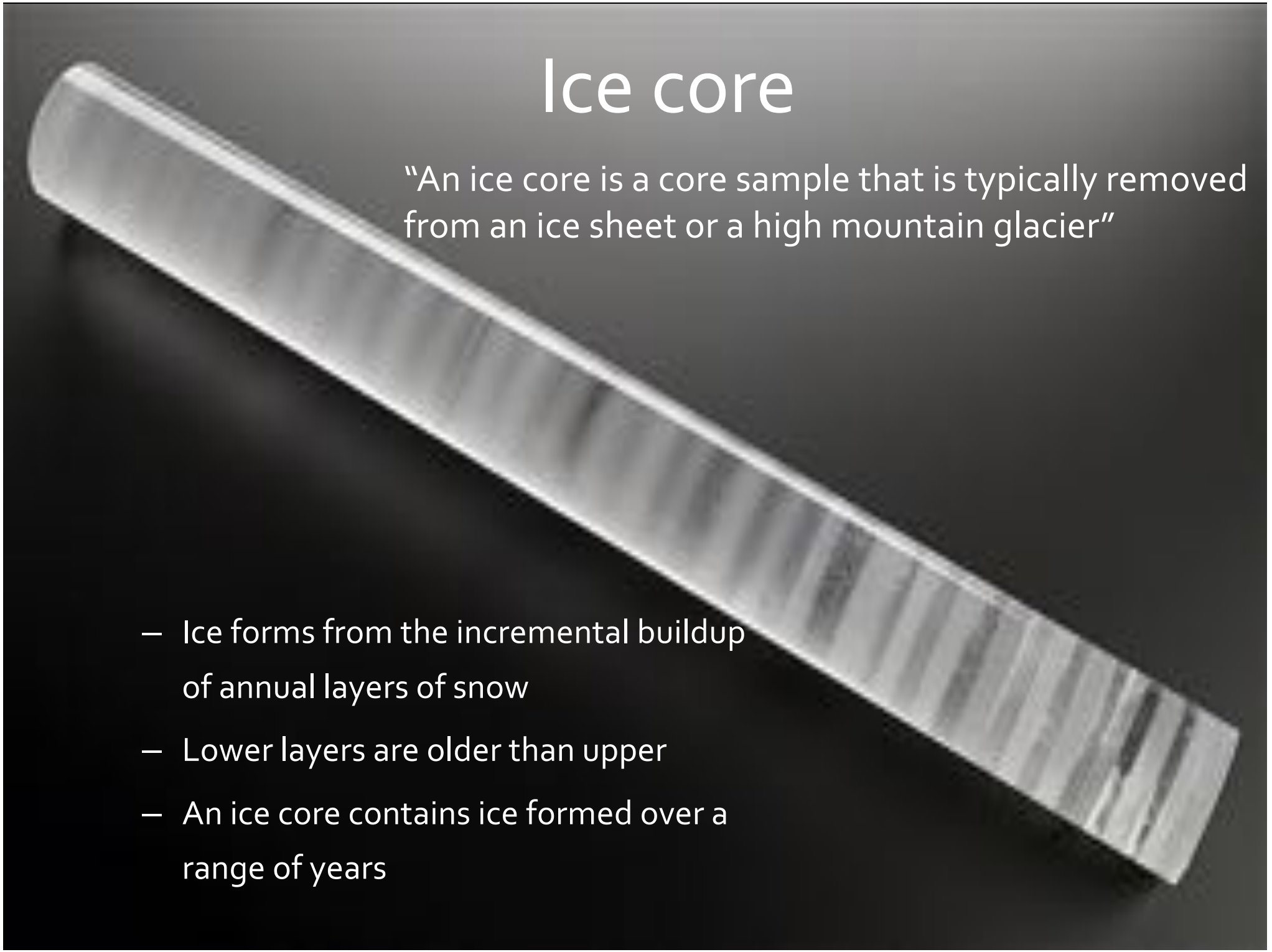
Annual ice layer

How can we get the Information?

- Dark colour in summer
  - Higher concentration of impurities
- Less obvious for deeper ice layers because they become thinner and distorted through pressure
  - Can be detected using light transmission,e.g.X-ray or digital scanners, or on the basis of changes in physical or chemical properties

Ice core

"An ice core is a core sample that is typically removed from an ice sheet or a high mountain glacier"

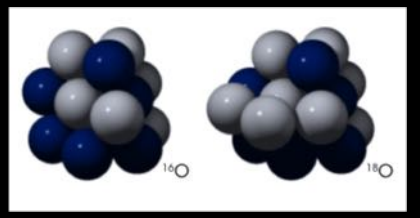


- Ice forms from the incremental buildup of annual layers of snow
- Lower layers are older than upper
- An ice core contains ice formed over a range of years

Ice-accumulation years

- Once an incremental records has been established, each layer of ice can be assigned an age - **Ice-accumulation years:** number of annual layers below present surface

Example of environmental proxy: Oxygen isotope



Oxygen can exist in three isotopic forms (^{16}O, ^{17}O and ^{18}O)

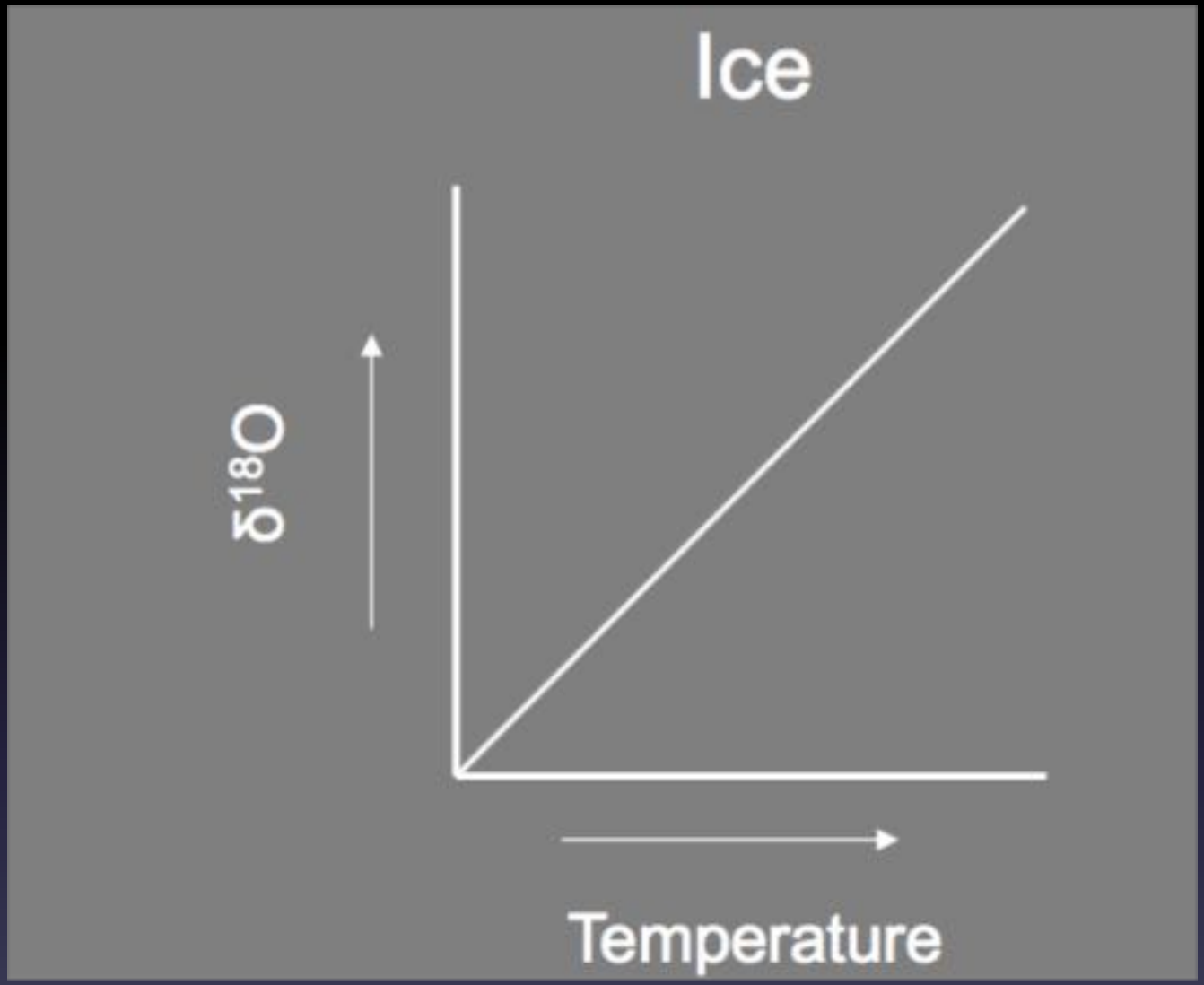
^{16}O and ^{18}O are of importance in oxygen isotope analysis of glacial ice storage

Average $^{18}O/^{16}O$ ratio in the natural environment is 1:500

$H_2{}^{16}O$ is drawn into atmosphere in preference in the heavier $H_2{}^{18}O$ (evaporation)

The process is temperature driven

$^{18}O/^{16}O$ ratio in ice core reflect global average temperature



Relationship between temperature and ice core delta ^{18}O

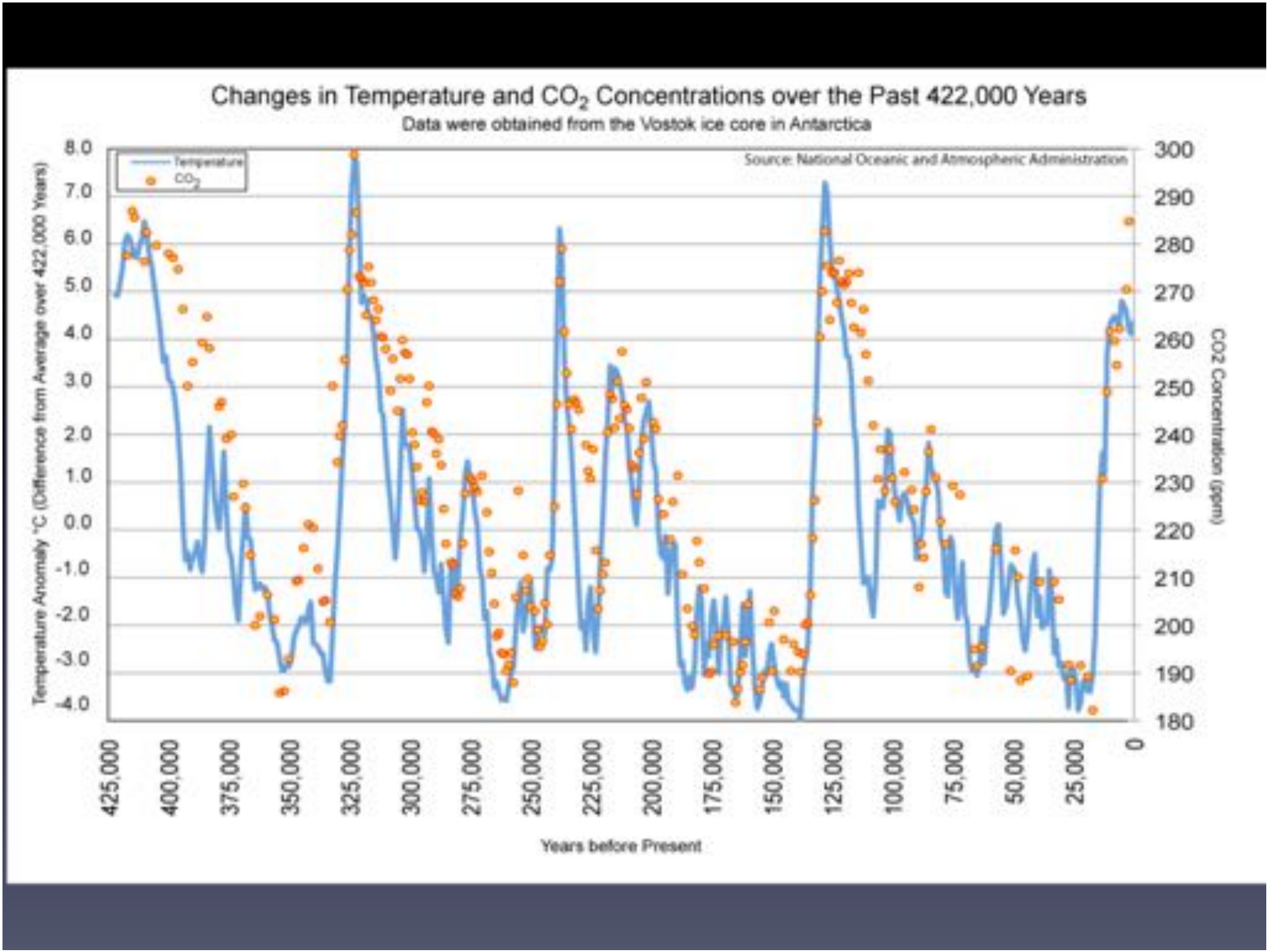
Ice as an indicator of palaeoenvironment

- Trace gases (e.g. carbon dioxide and methane) that become trapped in minute air bubbles within the ice crystals can provide evidence of
  - stable isotopes (e.g. ^{18}O) reflects earth temperature
  - short- and long-term changes in atmospheric gas composition

How human activities influence global climate?

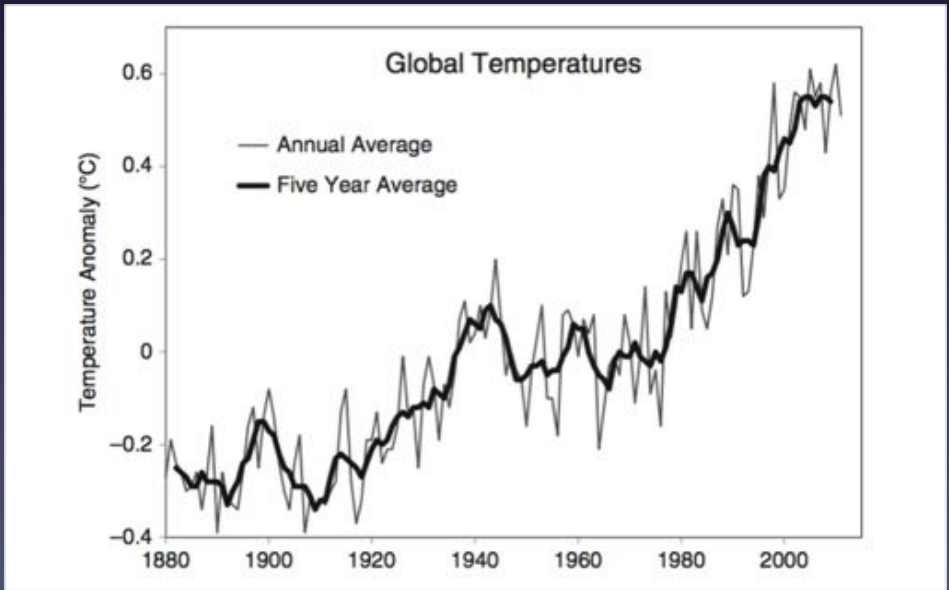
Low Carbon Travel

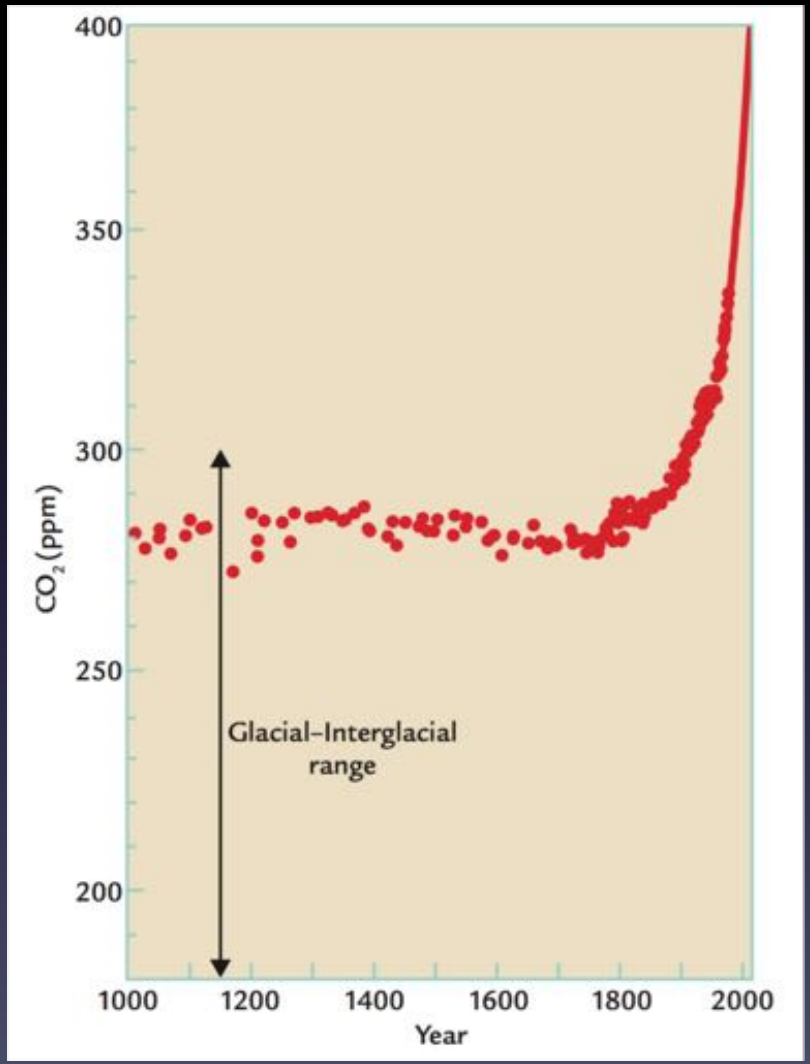
What does that mean?


Changes in Temperature and CO_2 Concentrations over the Past 422,000 Years
Data were obtained from the Vostok ice core in Antarctica
Source: National Oceanic and Atmospheric Administration
Temperature
CO_2
Temperature Anomaly °C (Difference from Average over 422,000 Years)
CO2 Concentration (ppm)
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
300
290
280
270
260
250
240
230
220
210
200
190
180
425,000
400,000
375,000
350,000
325,000
300,000
275,000
250,000
225,000
200,000
175,000
150,000
125,000
100,000
75,000
50,000
25,000
0
Years before Present

Anthropogenic causes of the recent Climate change

- Green house gases
  - CO_2
  - CH_4





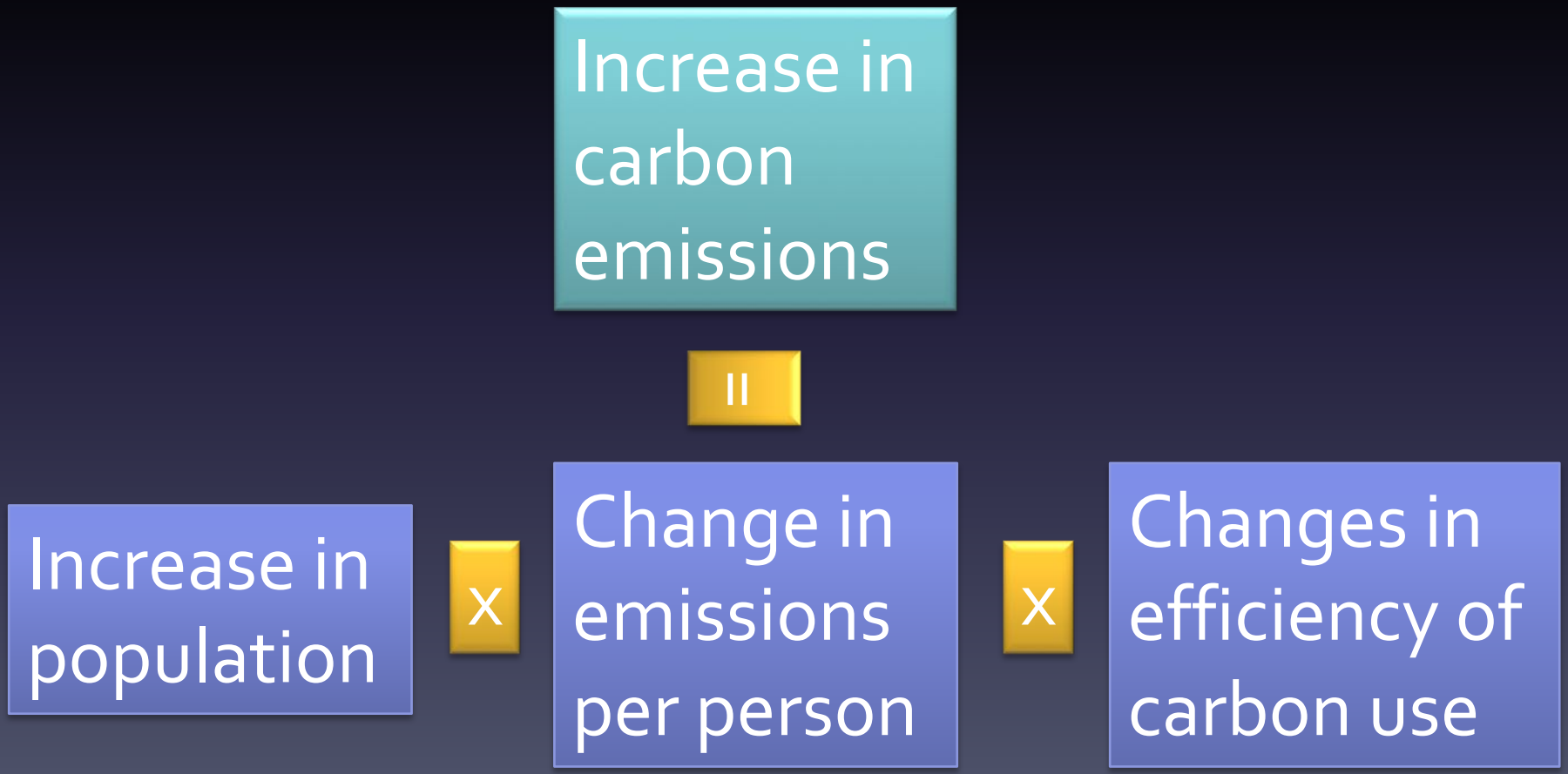
CO_2 concentration changes

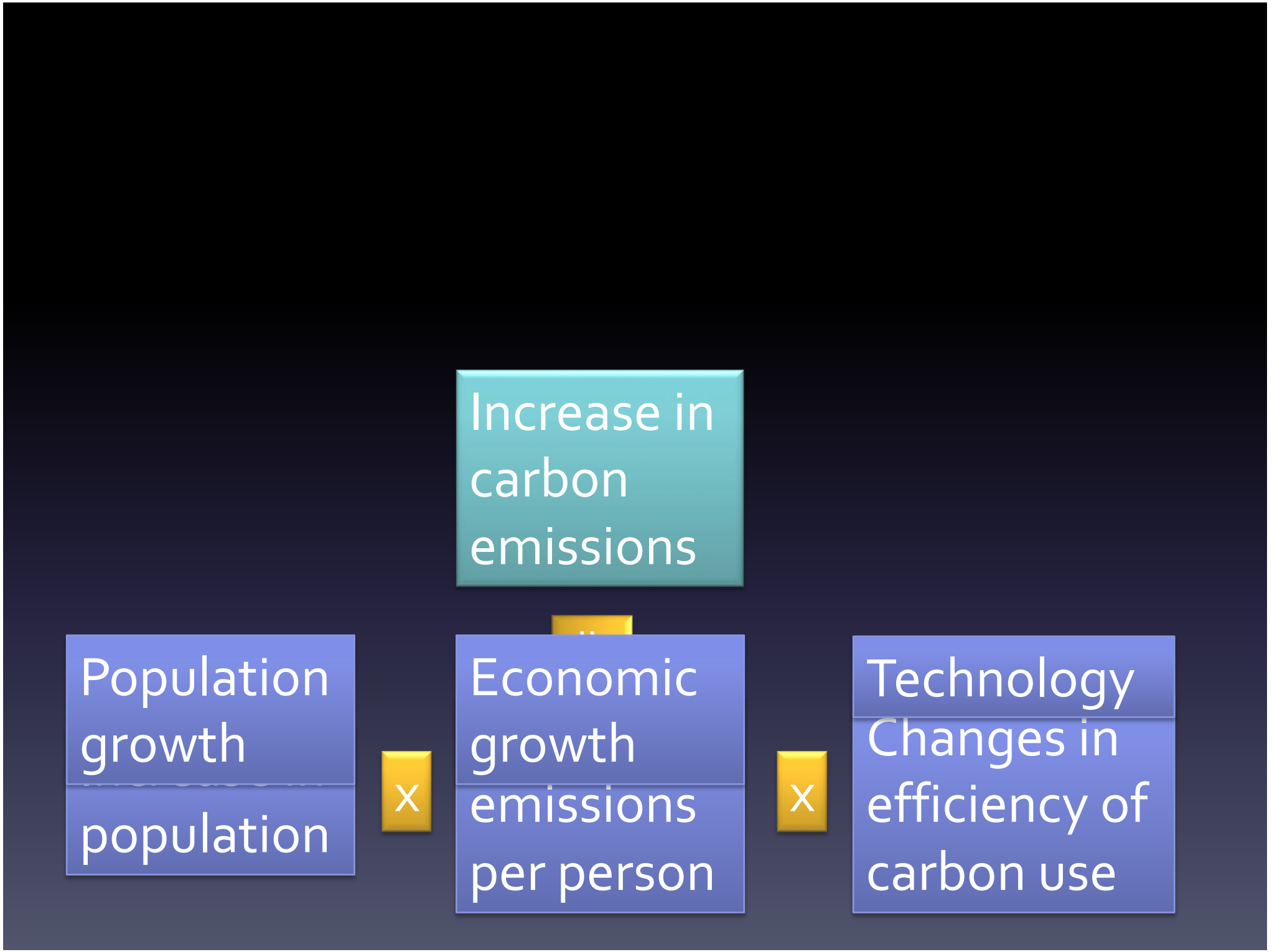
The Intergovernmental Panel on Climate Change (IPCC)

- The IPCC was created to provide policymakers with regular scientific assessments on climate change, its implications and potential future risks, as well as to put forward adaptation and mitigation options

Factors affecting future elevated carbon emission

* Note: The largest driver of future climate will be emissions of greenhouse gases and aerosols from human activities

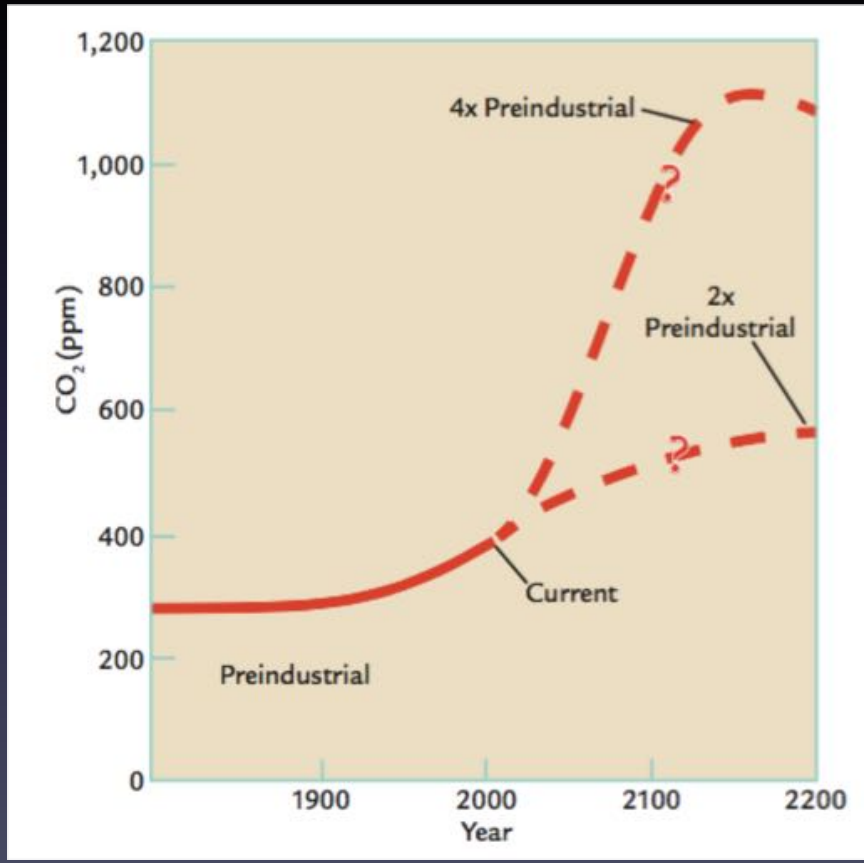



Increase in carbon emissions
Population growth
increase in population
x
Economic growth
emissions per person
x
Technology
Changes in efficiency of carbon use

Climate in the future

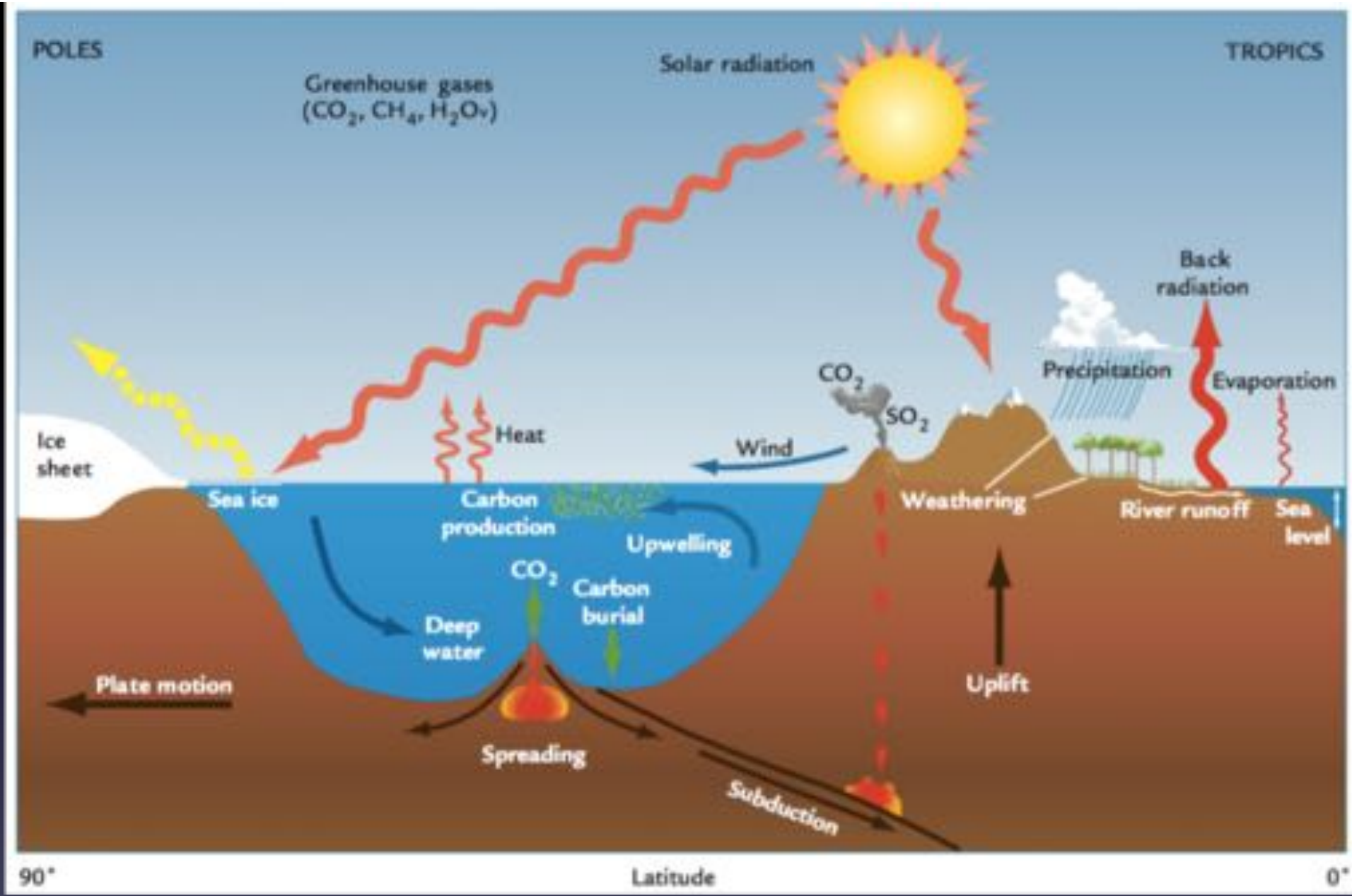
- IPCC projection of CO2 in 2100
  - ~ 3 X CO_2 of preindustrial concentration
  - ~4.5 °C warming on global average

Temperature increases at polar and near-polar latitudes will be twice that large



Impacts of climate change?

-the good and the bad

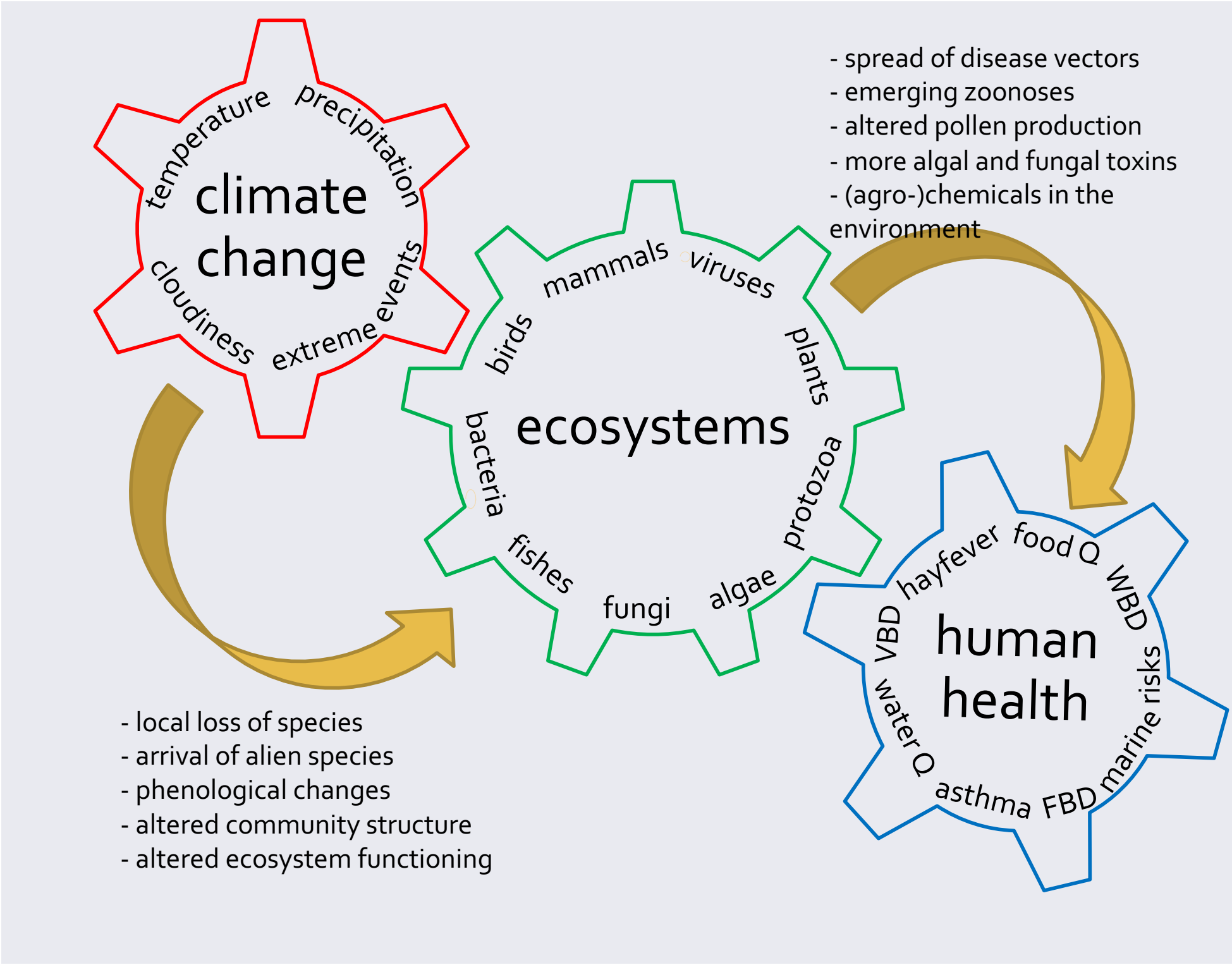


Studies of Earth's climate cover a wide range of processes

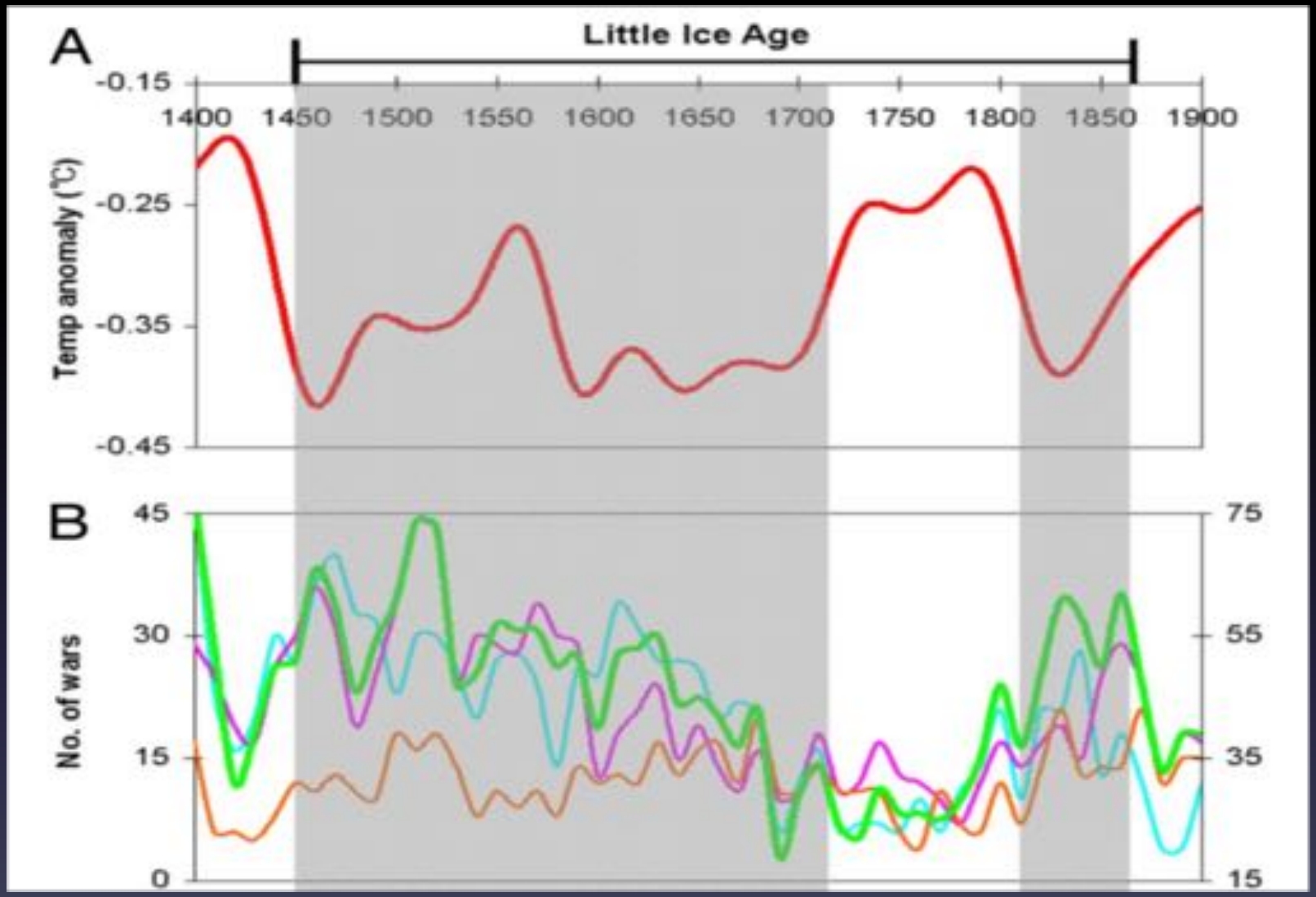
Ruddiman, W.F. (2008)

Major components of the climate system: air, water, ice, land and vegetation

Processes at work within the climate system: e.g. precipitation, evaporation, and winds


climate change
temperature
precipitation
extreme events
cloudiness
ecosystems
mammals
viruses
plants
protozoa
algae
fungi
fishes
bacteria
birds
human health
hayfever
food Q
WBD
marine risks
FBD
asthma
water Q
VBD
- spread of disease vectors
- emerging zoonoses
- altered pollen production
- more algal and fungal toxins
- (agro-)chemicals in the environment
- local loss of species
- arrival of alien species
- phenological changes
- altered community structure
- altered ecosystem functioning

Climate change and war



A.D. 1400–1900.

Zhang et al., 2017 PNAS

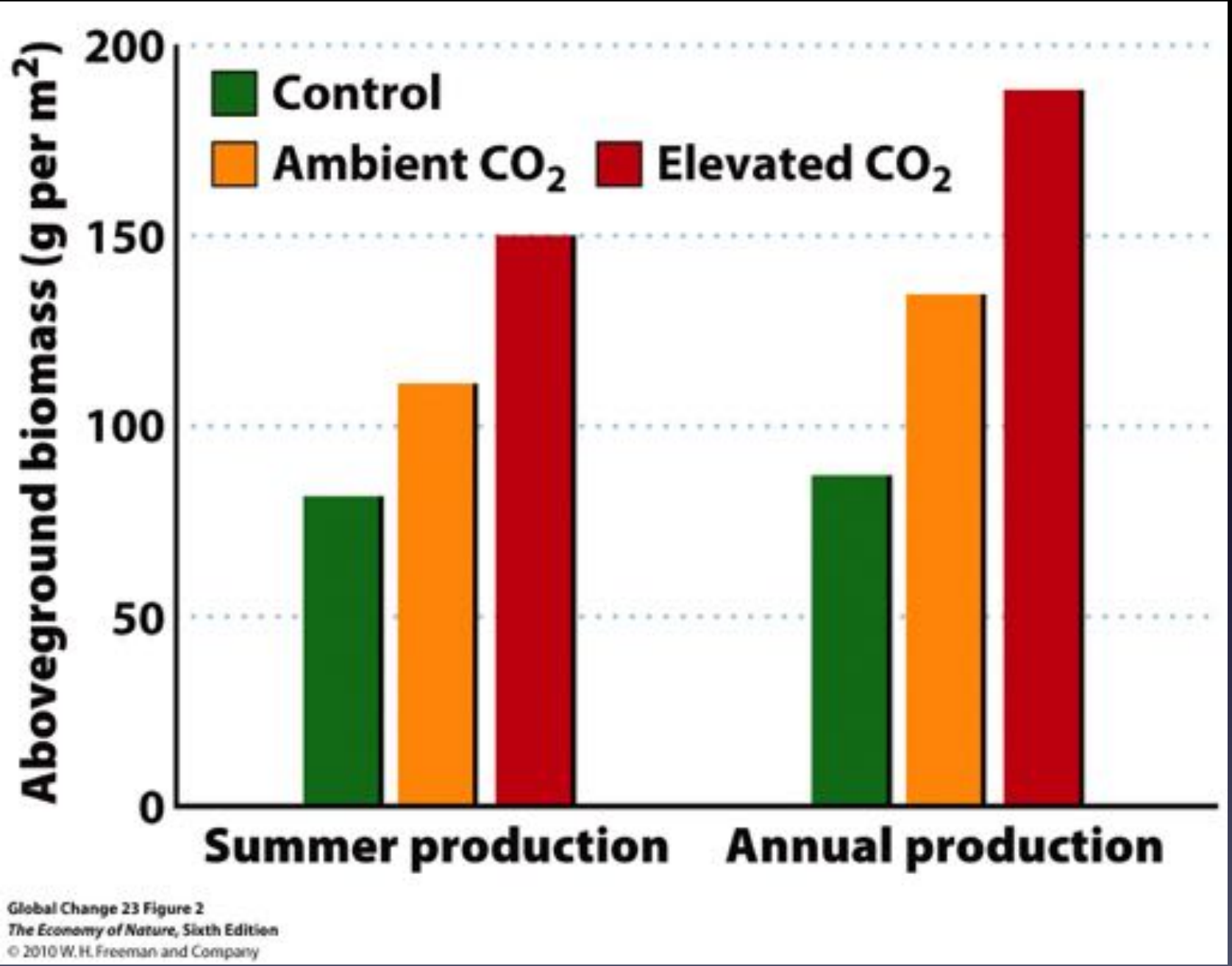
(A) Temperature anomaly (°C)

(B) Number of wars in the Northern Hemisphere (bright green), Asia (pink), Europe (turquoise), and the arid areas in the NH (orange).

Free-air CO_2 enrichment experiments (FACE)

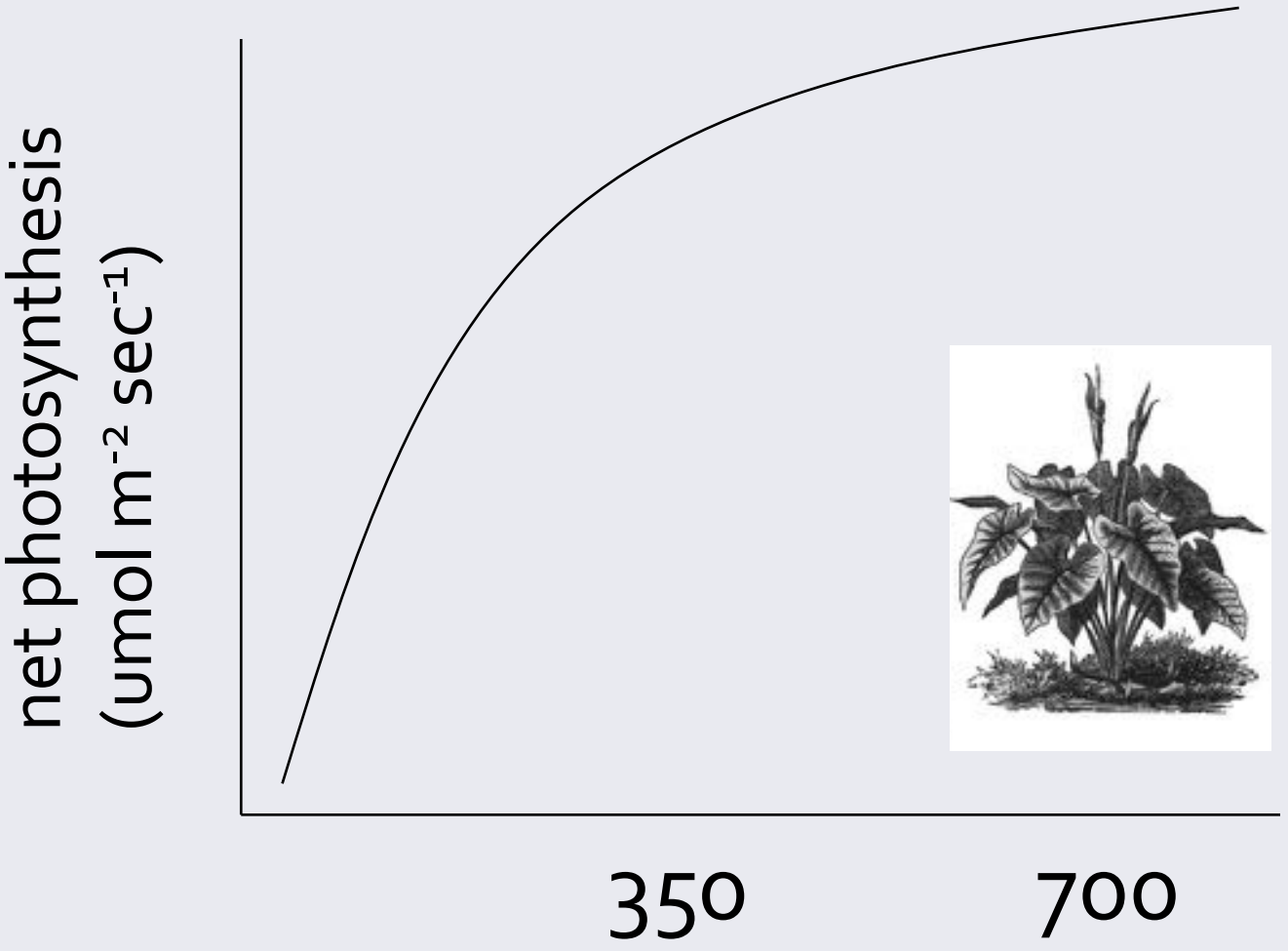
Raises the concentration of CO_2 in a specified area and allows the response of plant growth to be measured

Experimental evidence of effect of elevated CO_2.

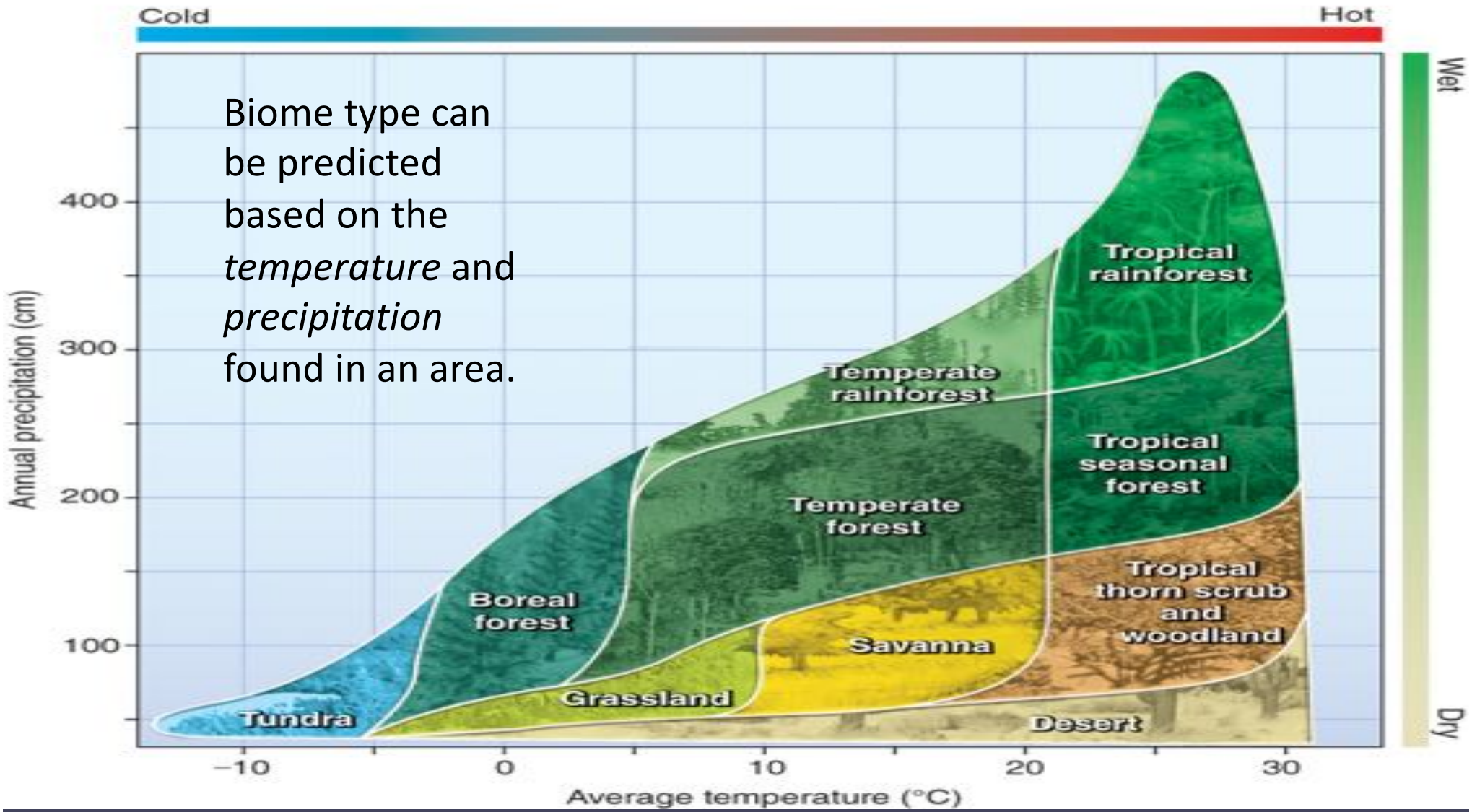


Global Change 23 Figure 2
The Economy of Nature, Sixth Edition

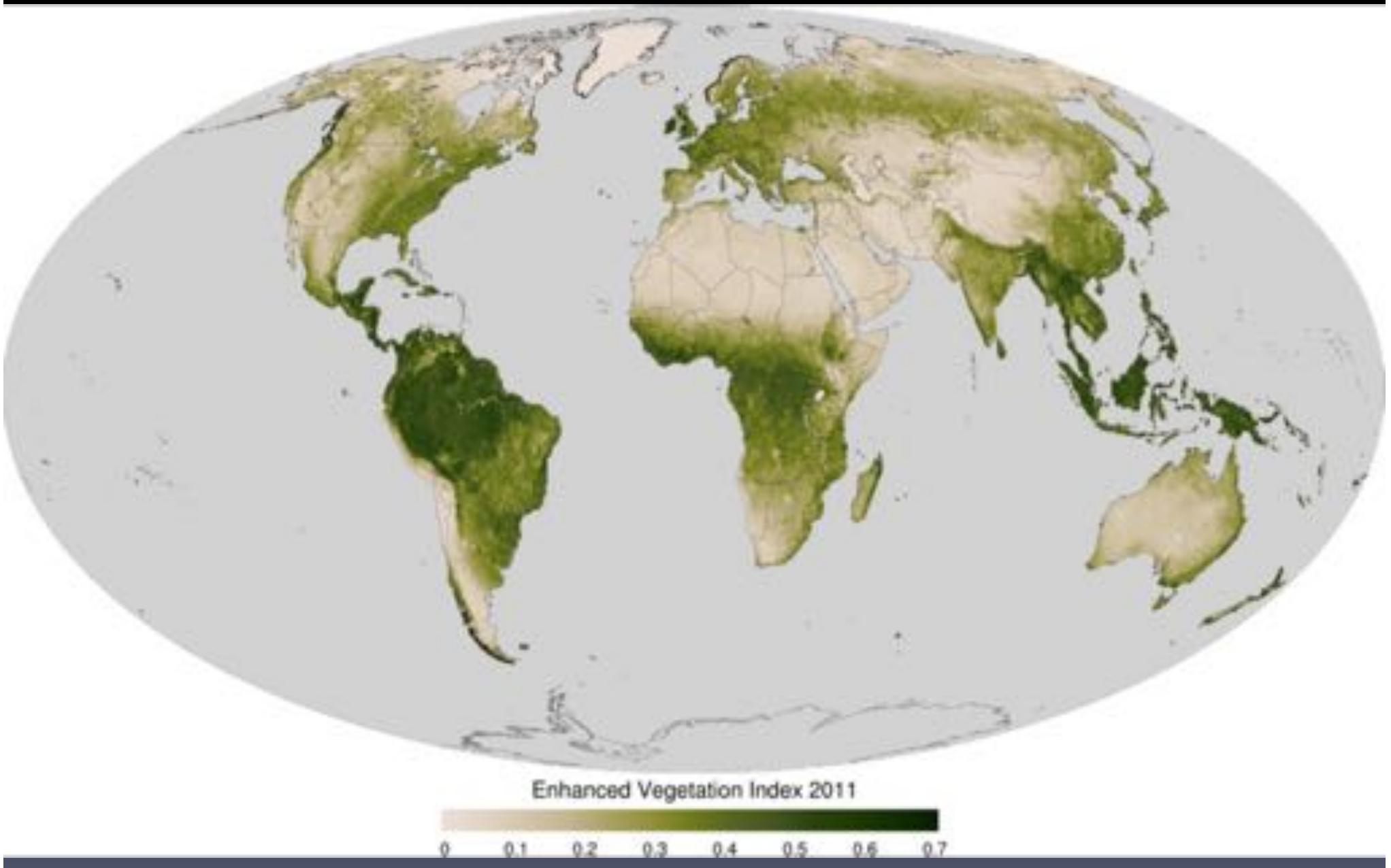
Leaf Level Photosynthesis



Biome type can be predicted based on the *temperature* and *precipitation* found in an area.



Global vegetation cover (based on enhanced vegetation index)



Latitude

Are there biological effects of increasing atmospheric CO2?

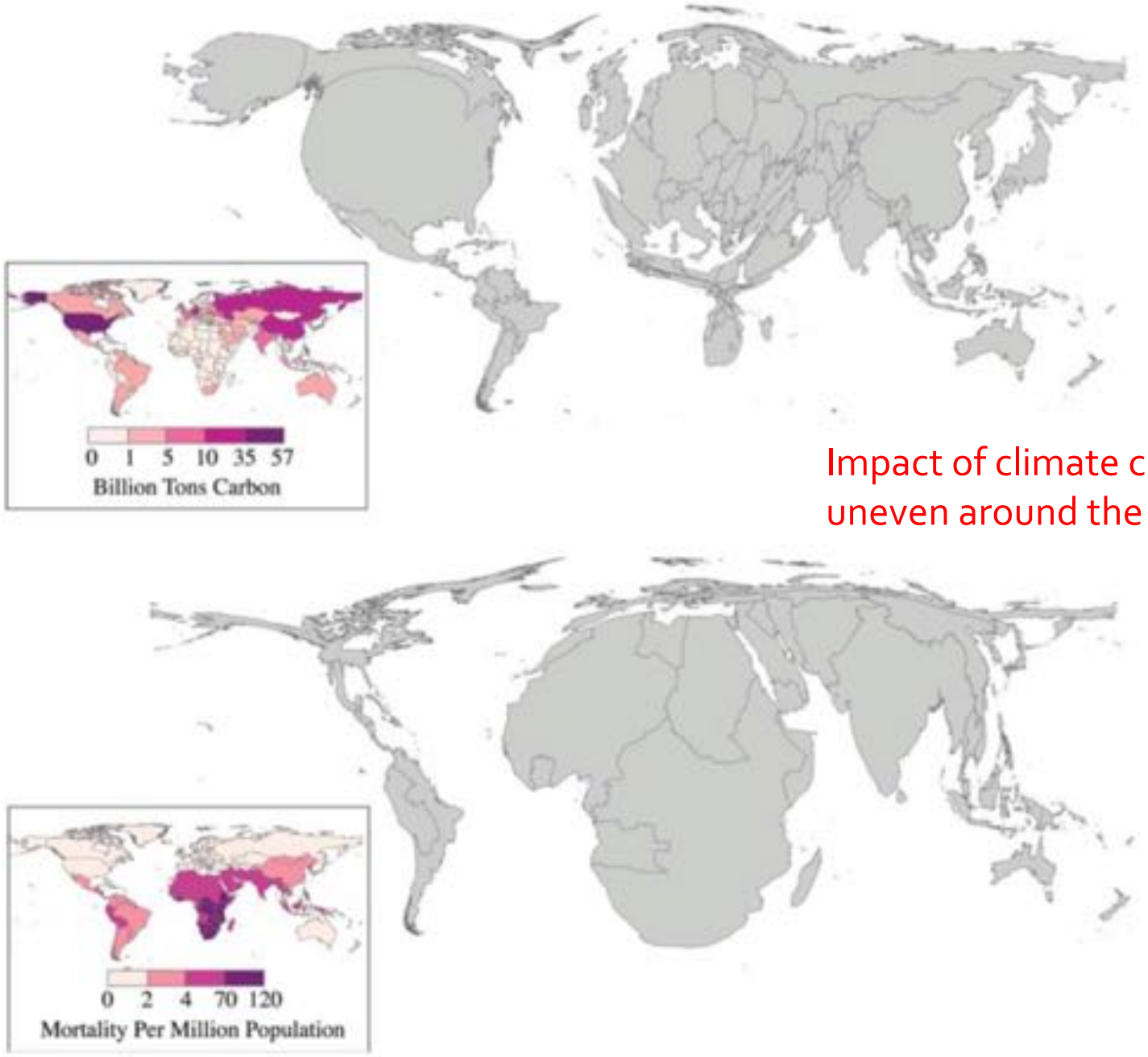
Yes - direct effects.

positive effects on photosynthesis rates globally

changes in food quality

Yes - indirect effects.

changes in plant distribution affecting animal distributions



Impact of climate change is uneven around the world!

Patz et al 2007

Comparison of undepleted cumulative carbon dioxide (CO_2) emissions (by country) for 1950 to 2000* versus the regional distribution of four climate-sensitive health effects (malaria, malnutrition, diarrhea, and inland flood-related fatalities).

Politicians (US) and global warming

- ***Ronald Reagan (1981-1989)***
  - Had a background as an actor, was ignorant of scientific issues and made no attempt to educate himself in any of them. He surrounded himself with scientists who supported weapons of mass destruction during the "cold war", and were not knowledgeable of or did not care about environmental issues.

- ***George W. Bush (2001-2009)***
  - In March 2001, the Bush Administration announced that it would not implement the Kyoto Protocol. In February 2002, Bush announced his alternative to the Kyoto Protocol, by bringing forth a plan to reduce the intensity of greenhouse gasses by 18 percent over 10 years.
  - Emissions would still continue to grow, but at a slower pace

- ***Al Gore (Vice president 1993-2001)***
  - An American politician and environmentalist
  - <An Inconvenient Truth>
  - Educate citizens about global warming via a comprehensive slides
  - Won Nobel Peace Price in 2007

- ***Barack Obama (2009-2017)***
  - November 17, US will enter a cap and trade system to limit global warming.
  - The president has established a new office in the White House, the White House Office of Energy and Climate Change Policy

- ***Donald Trump(2017-)***
  - Questioned if climate change is real and has indicated that he will focus his efforts on other causes as president
  - Cut about 31% of the Environmental Protection Agency (EPA) as a result of budget decreases, to about $2.6 billion from its current $8.2 billion budget


DONALD TRUMP (R)
PRESIDENTIAL CANDIDATE
the O'Reilly FACTOR

Thank you !