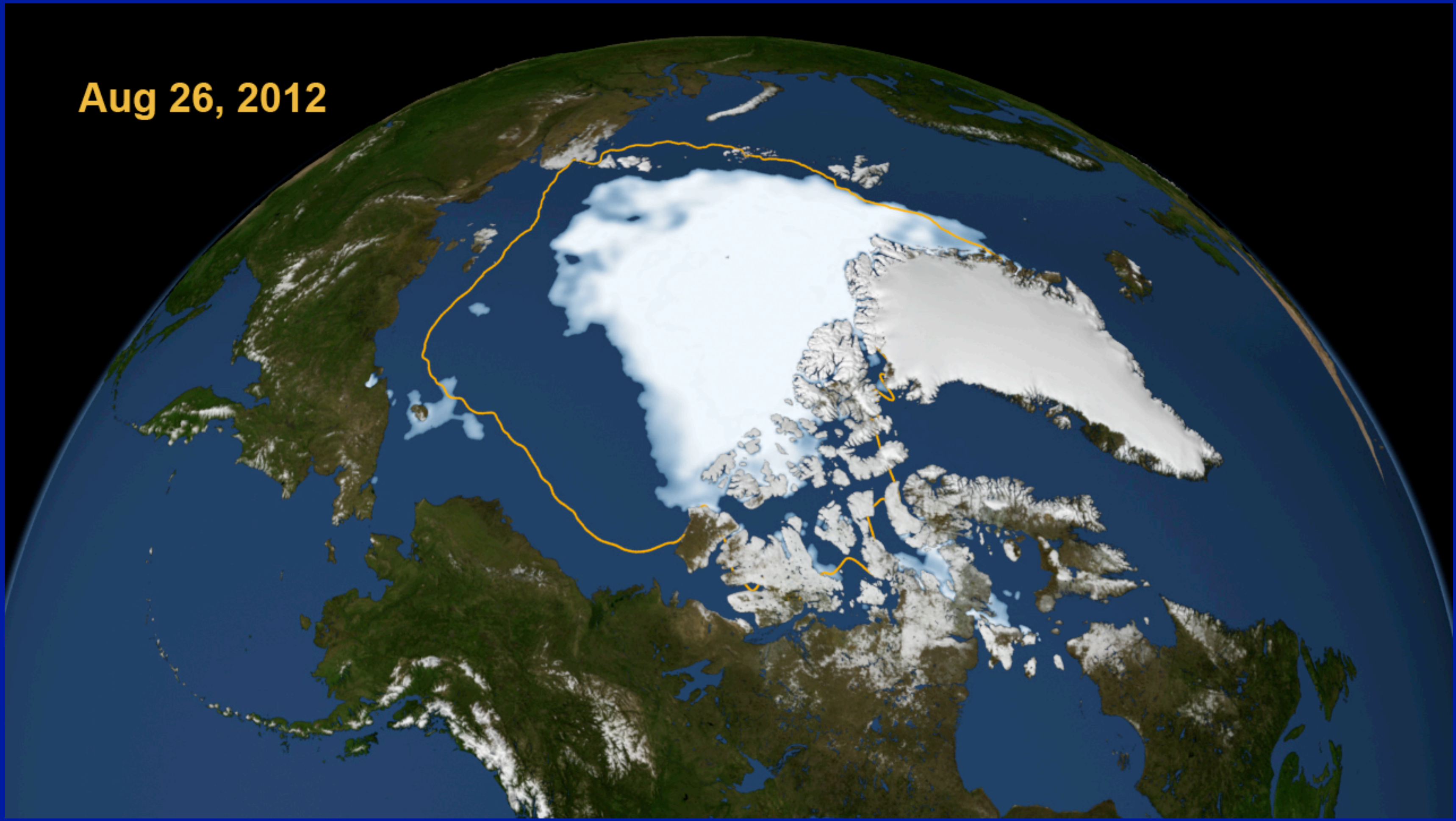
Chapter 19
Global Change

Walking on Thin Ice



Global Change

- Global change- any chemical, biological or physical property change of the planet. Examples include cold temperatures causing ice ages.
- Global climate change- changes in the climate of the Earth.
- Global warming- one aspect of climate change, the warming of the oceans, land masses and atmosphere of the Earth.

The Greenhouse Effect

- When radiation from the sun hits the atmosphere, 1/3 is reflected back.
- Some of the UV radiation is absorbed by the ozone layer and strikes the Earth where it is converted into low-energy infrared radiation.
- The infrared radiation then goes back toward the atmosphere where it is absorbed by greenhouse gasses that radiate most of it back to the Earth.

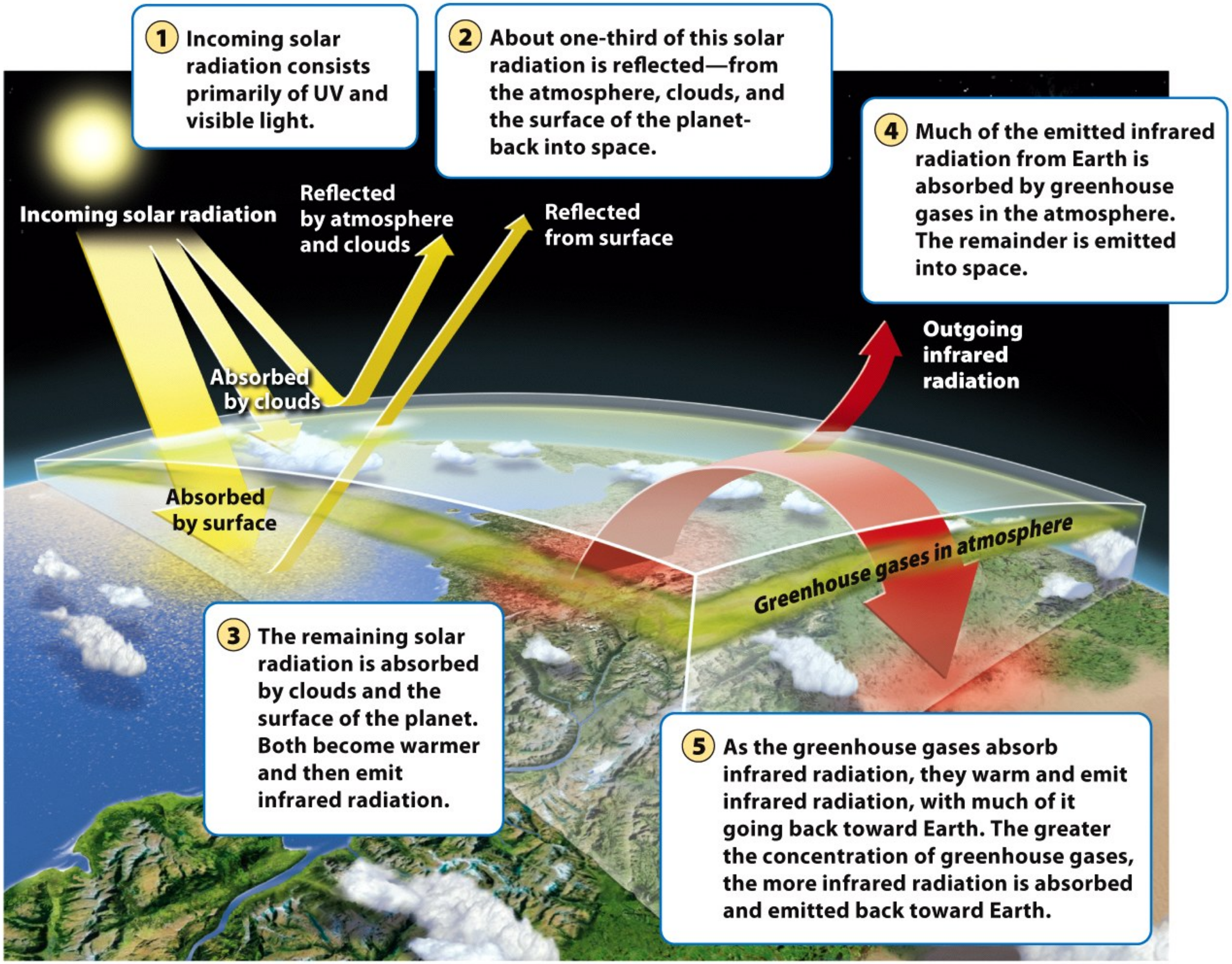


Figure 19.2
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Greenhouse Gases

- Water vapor
- Carbon dioxide
- Methane
- Nitrous oxide
- Ozone

TABLE 19.1 The major greenhouse gases

The major greenhouse gases differ in their ability to absorb infrared radiation and the duration of time that they stay in the atmosphere. The units "ppm" are parts per million.

Greenhouse gas	Concentration in 2010	Global warming potential (over 100 years)	Duration in the atmosphere
Water vapor	Variable with temperature	<1	9 days
Carbon dioxide	390 ppm	1	Highly variable (ranging from years to hundreds of years)
Methane	1.8 ppm	25	12 years
Nitrous oxide	0.3 ppm	300	114 years
Chlorofluorocarbons	0.9 ppm	1,600 to 13,000	55 to >500 years

Source: Data on concentration are from the National Oceanic and Atmospheric Administration. www.esrl.noaa.gov/gmd/aggi. Data on global warming potential are from the United Nations Framework Convention on Climate Change.

Table 19.1
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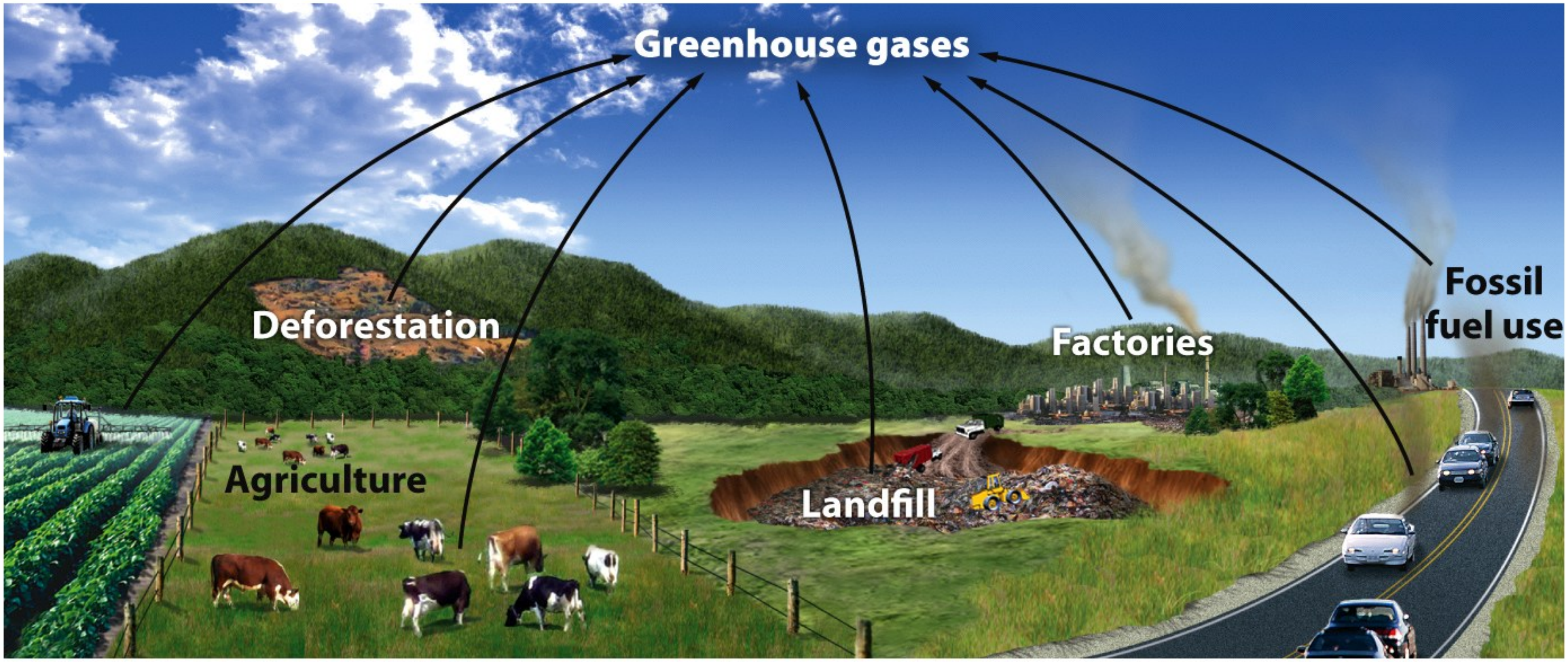
CO2…what does 390 ppm mean?

Natural Greenhouse Gases

- Volcanic eruptions- mainly carbon dioxide
- Methane – from decomposition
- Nitrous oxide- from denitrification
- Water vapor

Anthropogenic Causes of Greenhouse Gases

- Burning of fossil fuels
- Agricultural practices
- Deforestation
- Landfills
- Industrial production- CFC's are an example



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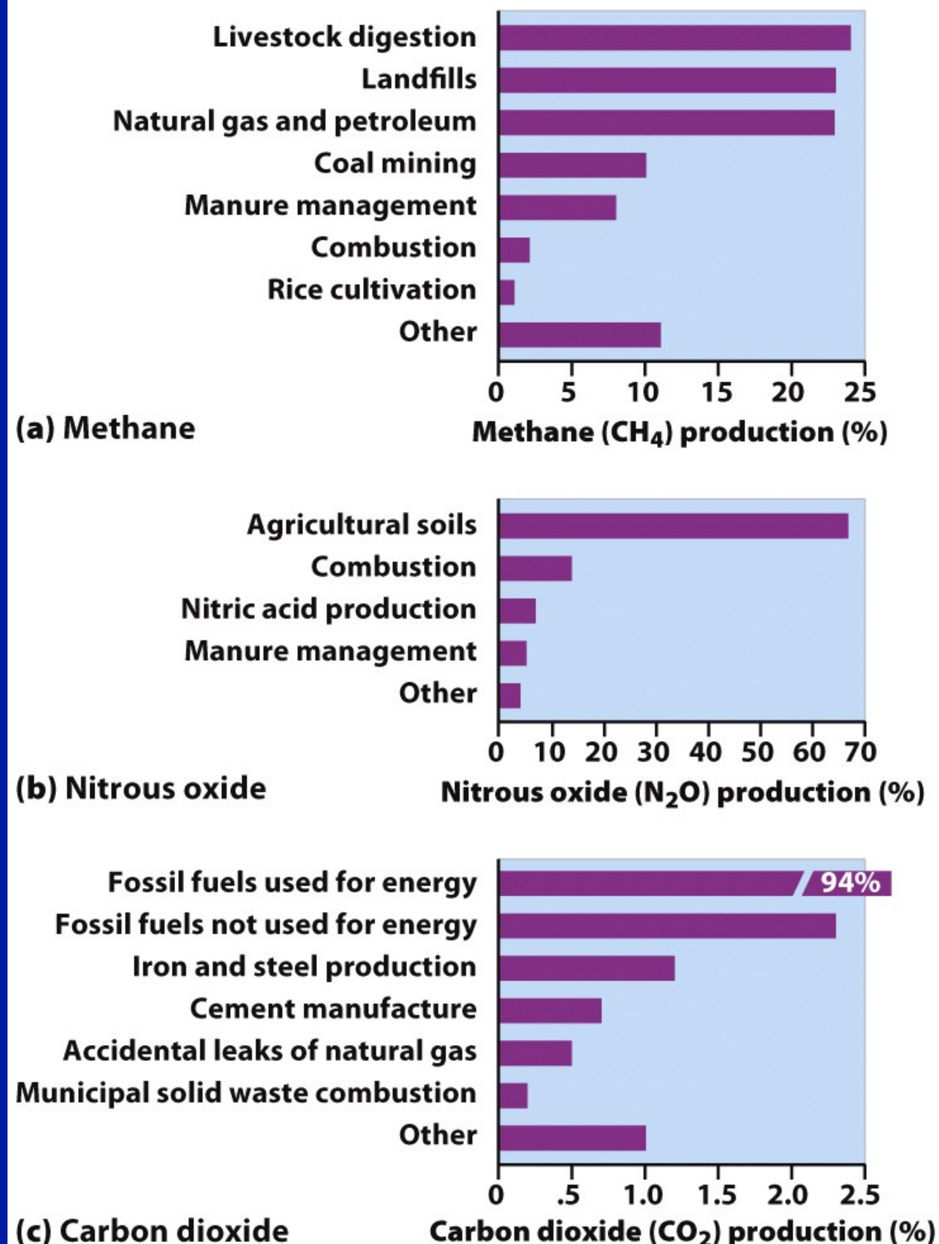
Sources of 3 GHG's:

Methane

Nitrous oxide

Carbon dioxide



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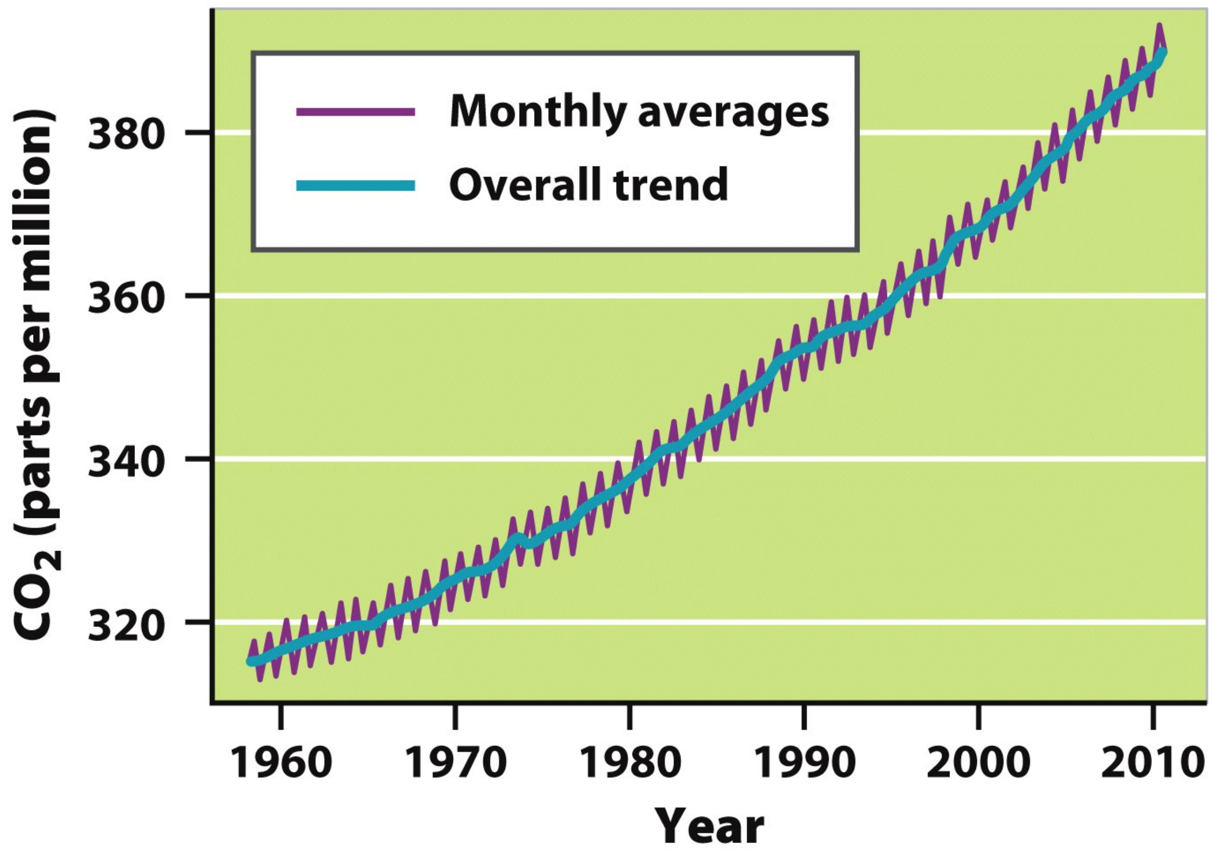
Increasing CO_2 Concentrations

- David Keeling began measuring CO_2 in 1958.

Why is there an increase and decrease each year?



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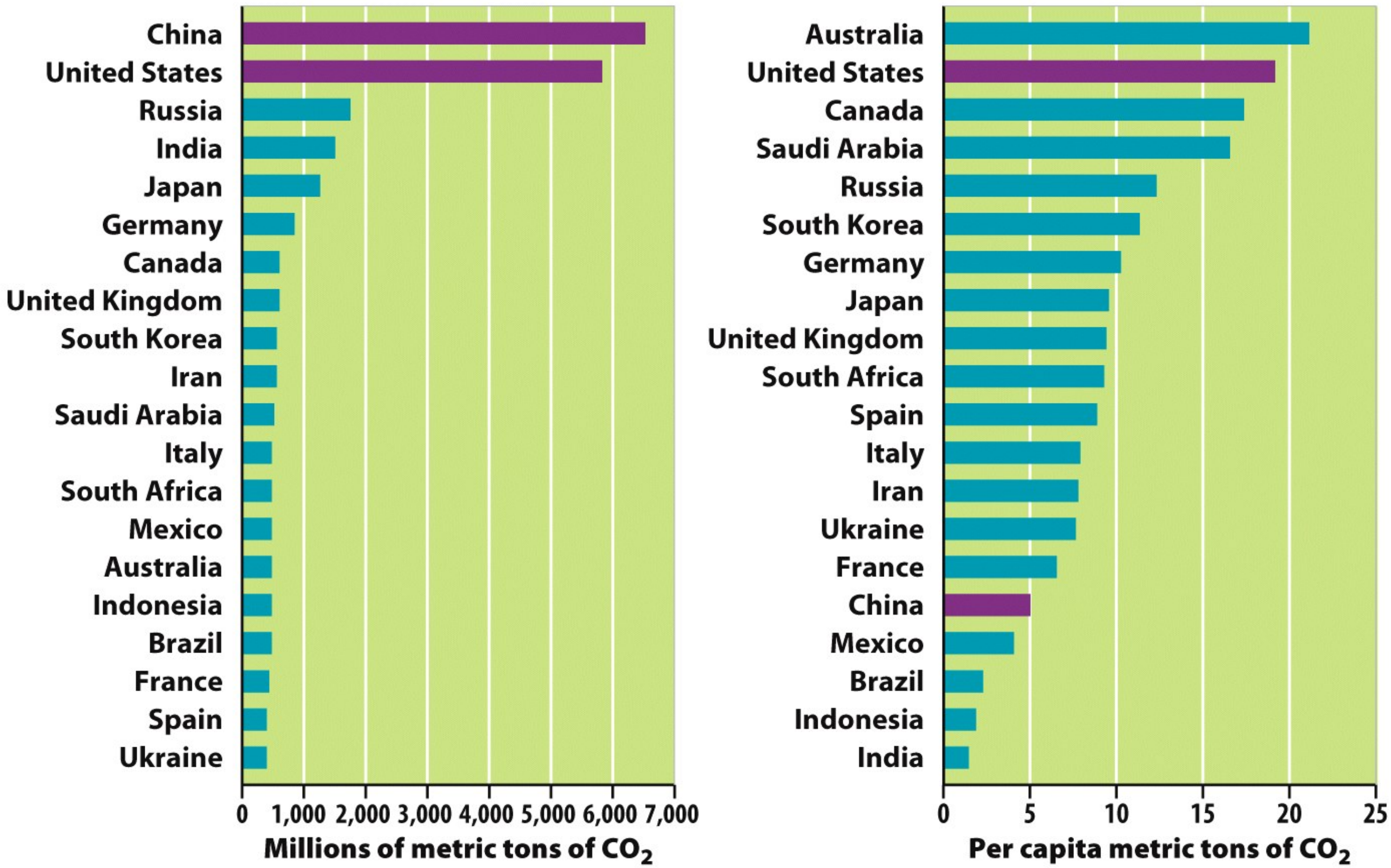
Emissions from the Developed and Developing World



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Global Temperatures since 1880

- Since 1880 temperatures have increased 0.8°C.

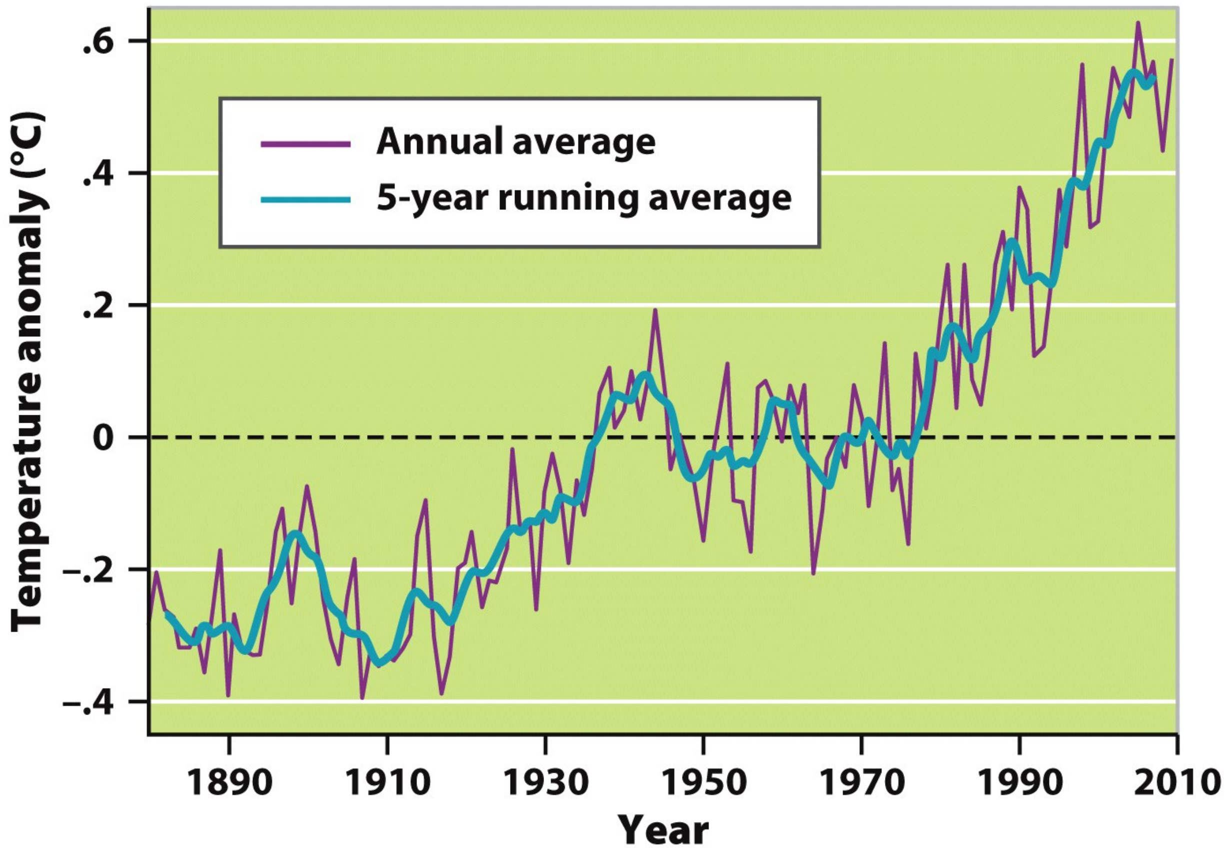

Figure 19.9
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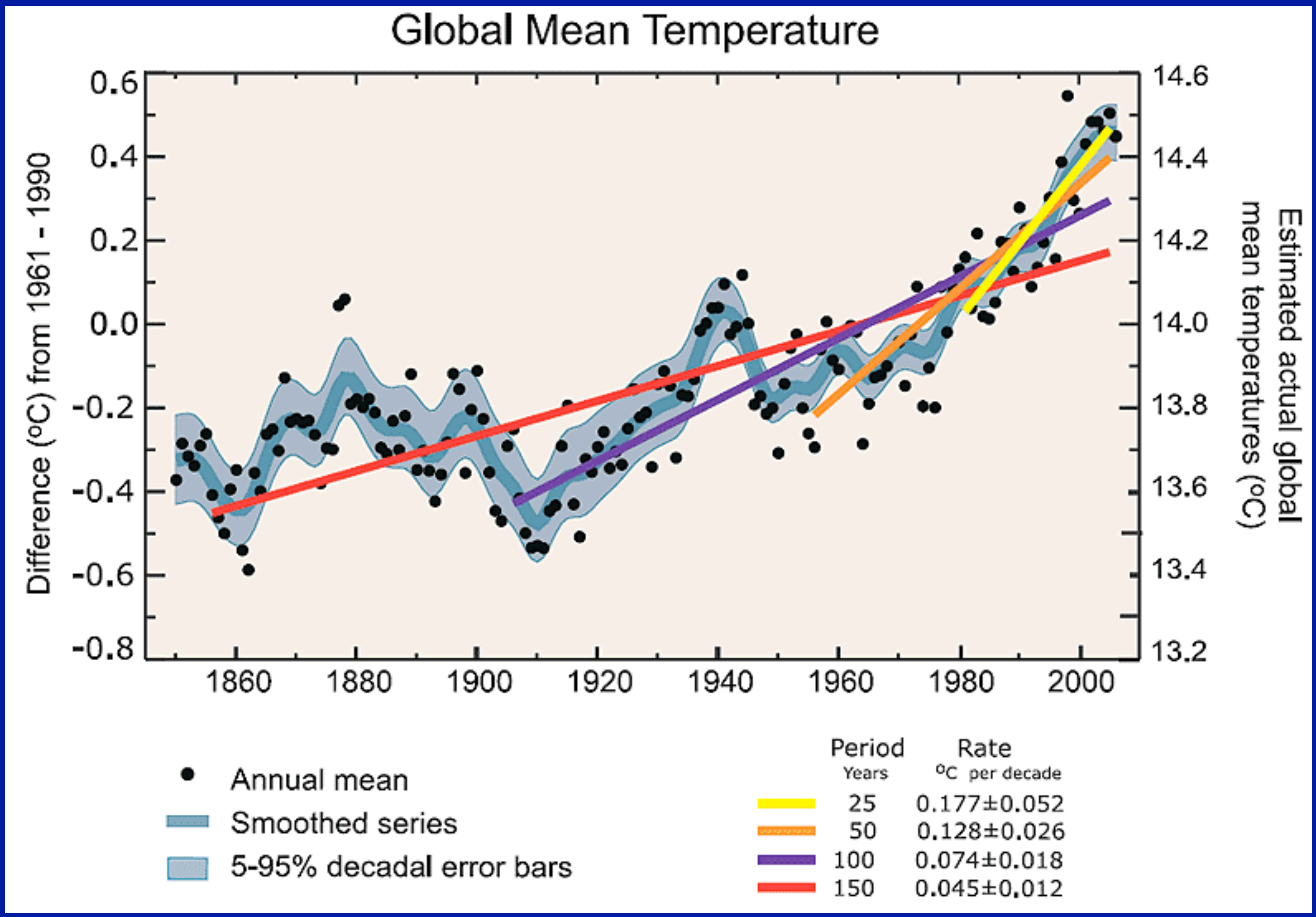
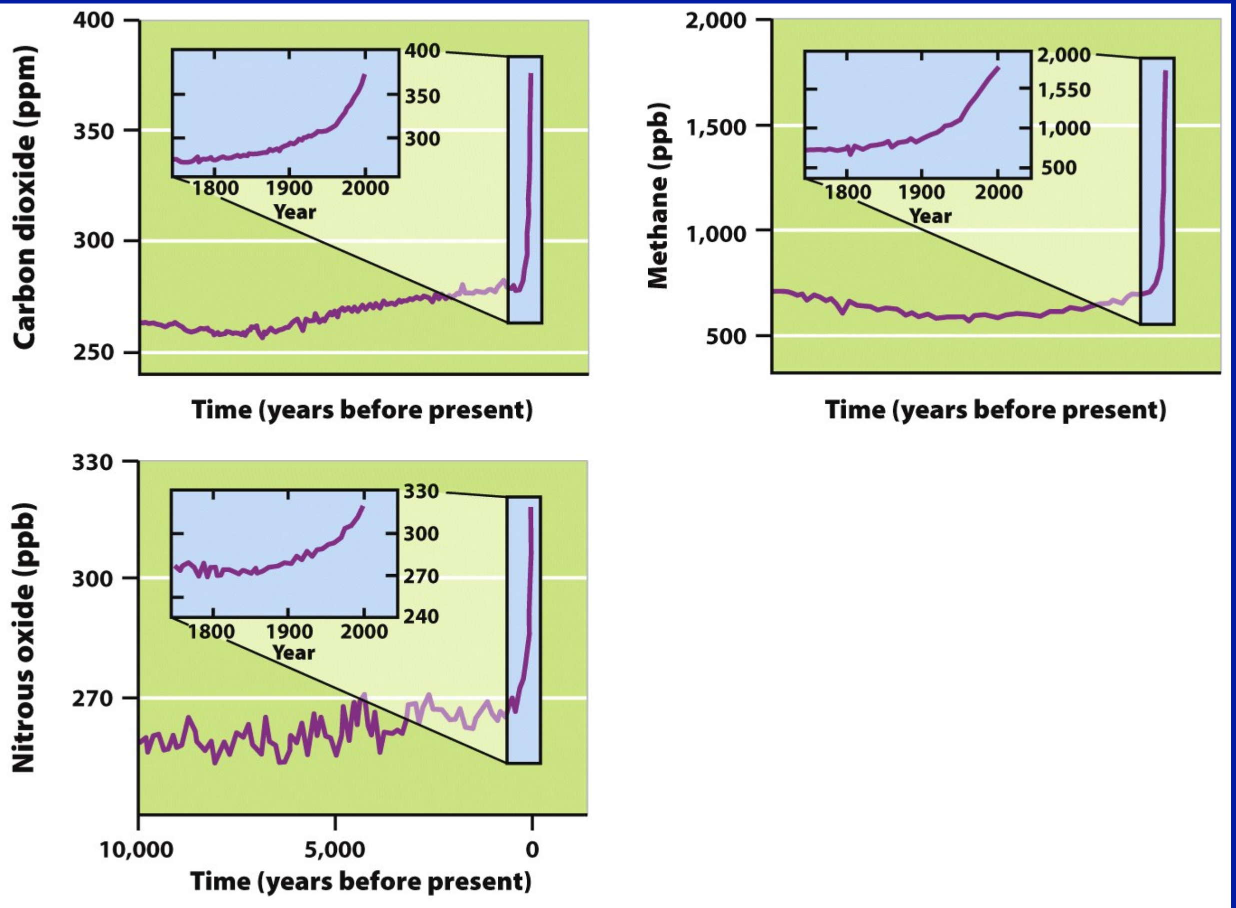
What's Trending?



Changes in [GHG] of 3 gases



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Temperatures and Greenhouse Gas Concentrations in Past 400,000 Years

- No one was around thousands of years ago to measure temperatures so we use other indirect measurements. Some of these are
  - Changes in species compositions
  - Chemical analyses of ice

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Figure 19.12b
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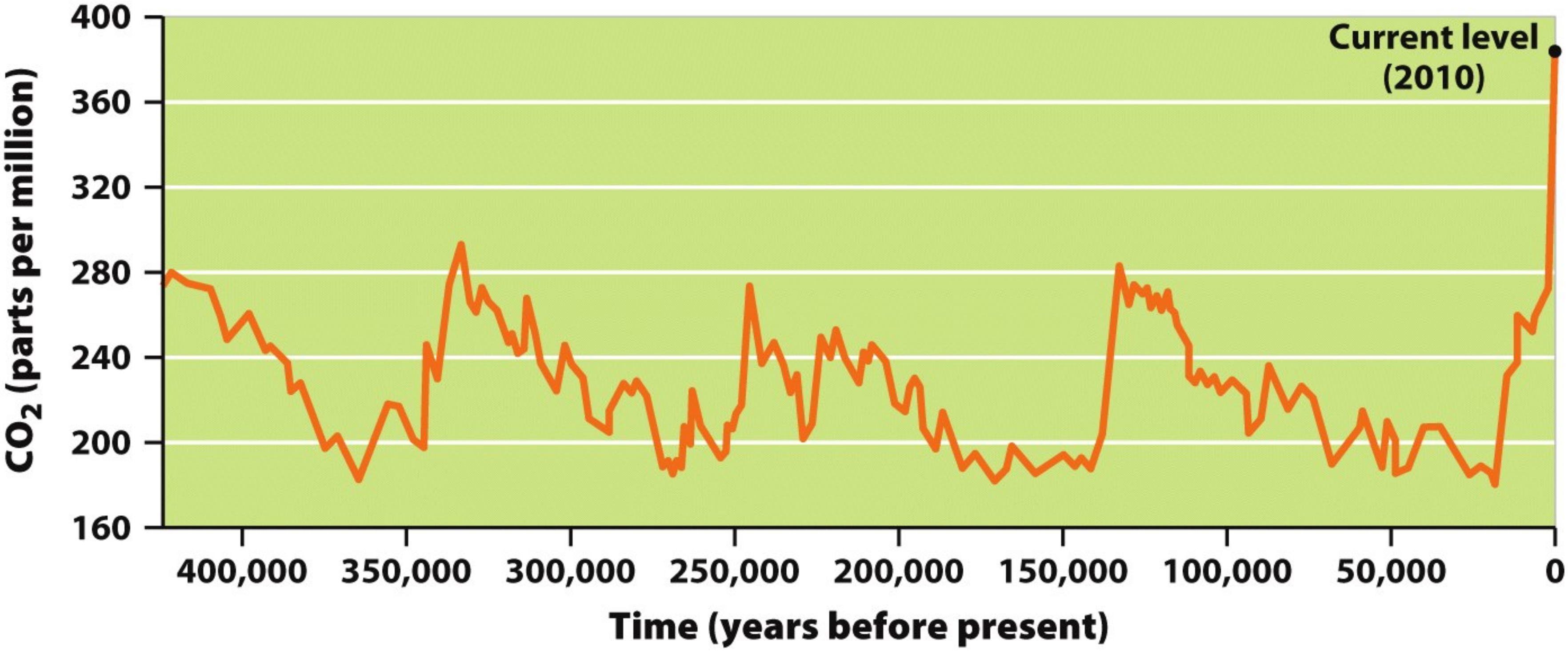

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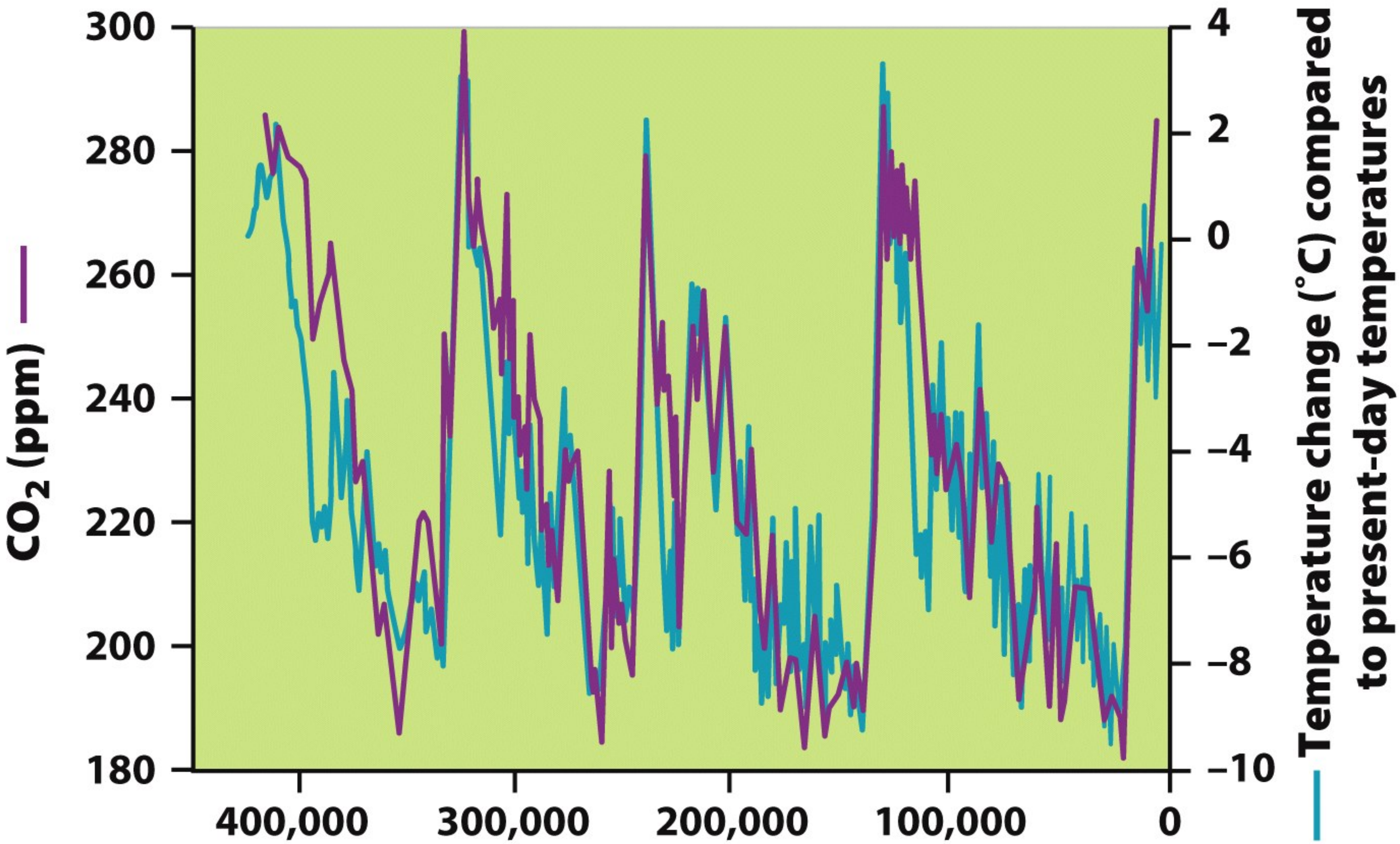
Putting It Together

- We know that an increase in CO_2 in the atmosphere causes a greater capacity for warming through the greenhouse effect.
- When the Earth experiences higher temperatures, the oceans warm and cannot contain as much CO_2 gas and, as a result, they release CO_2 into the atmosphere.



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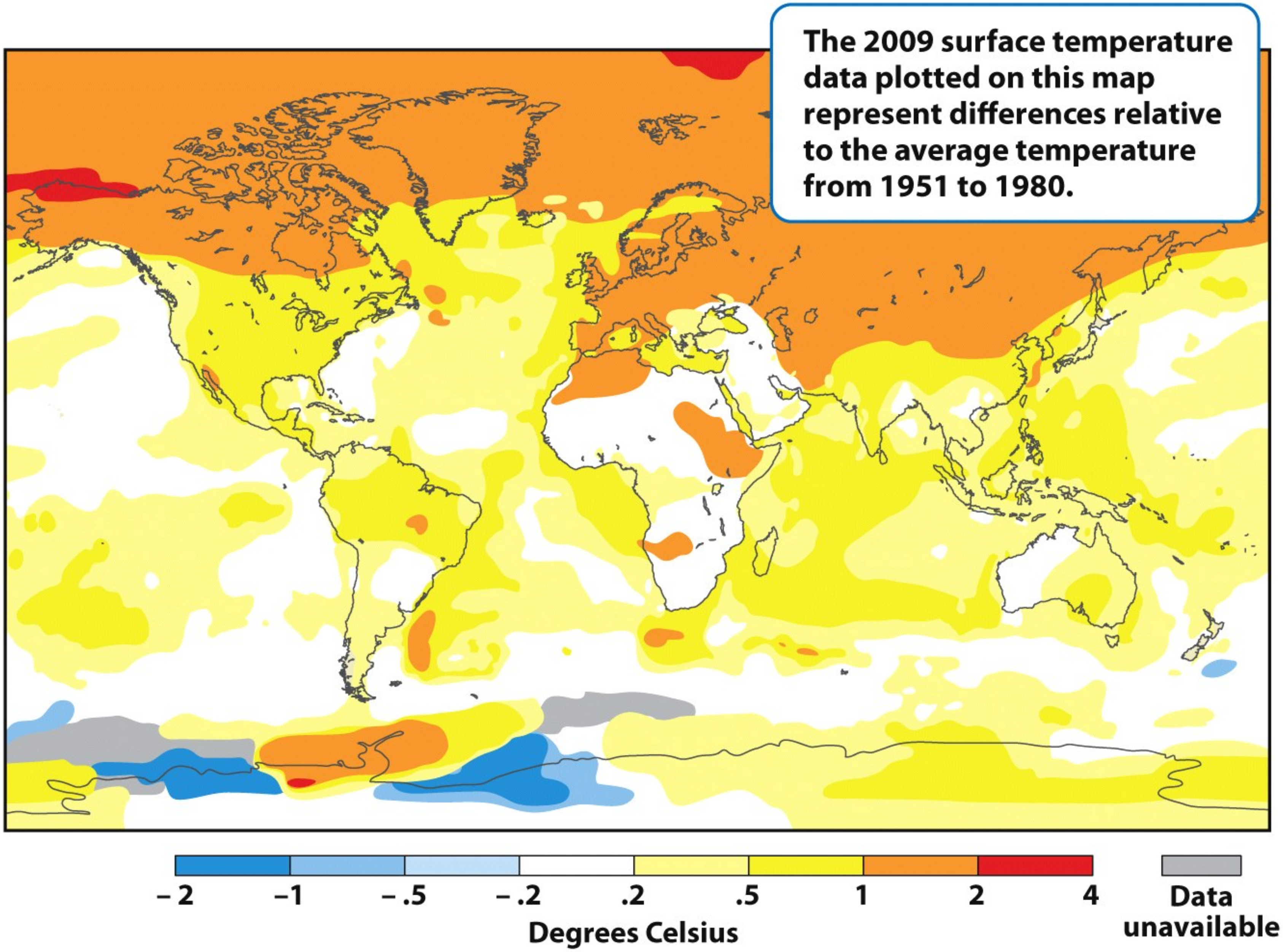

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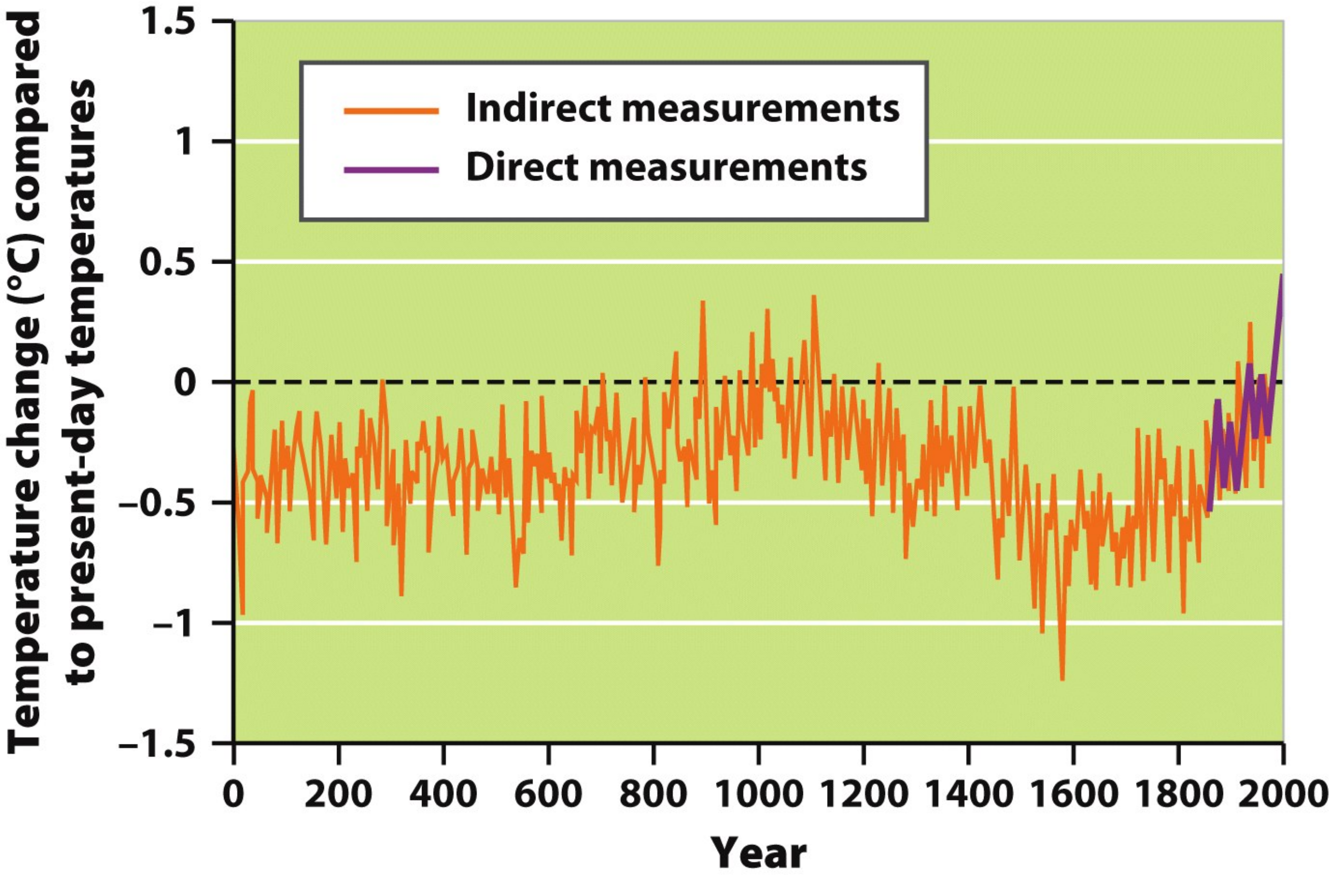
The Past 2000 years



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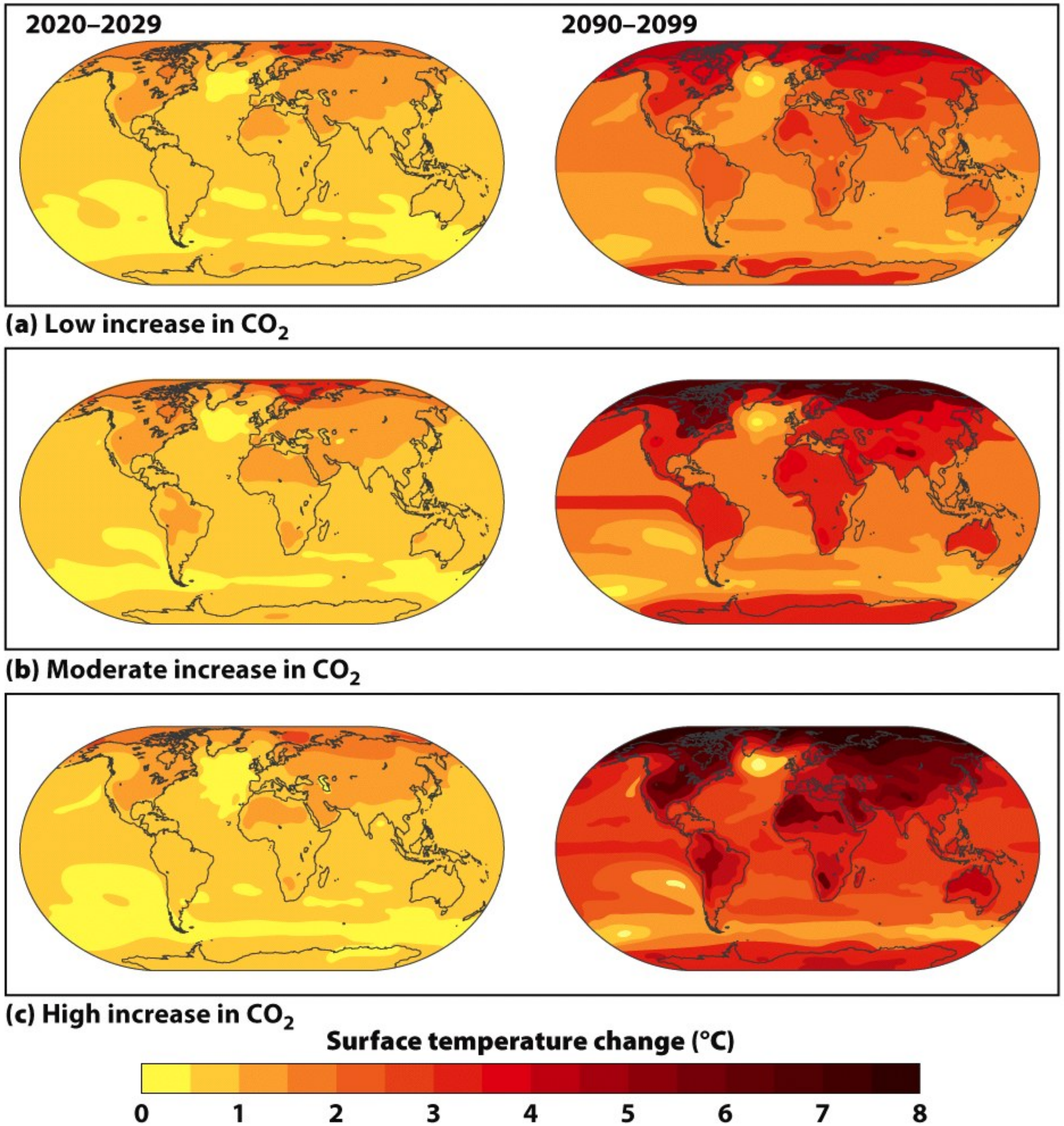

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Feedbacks

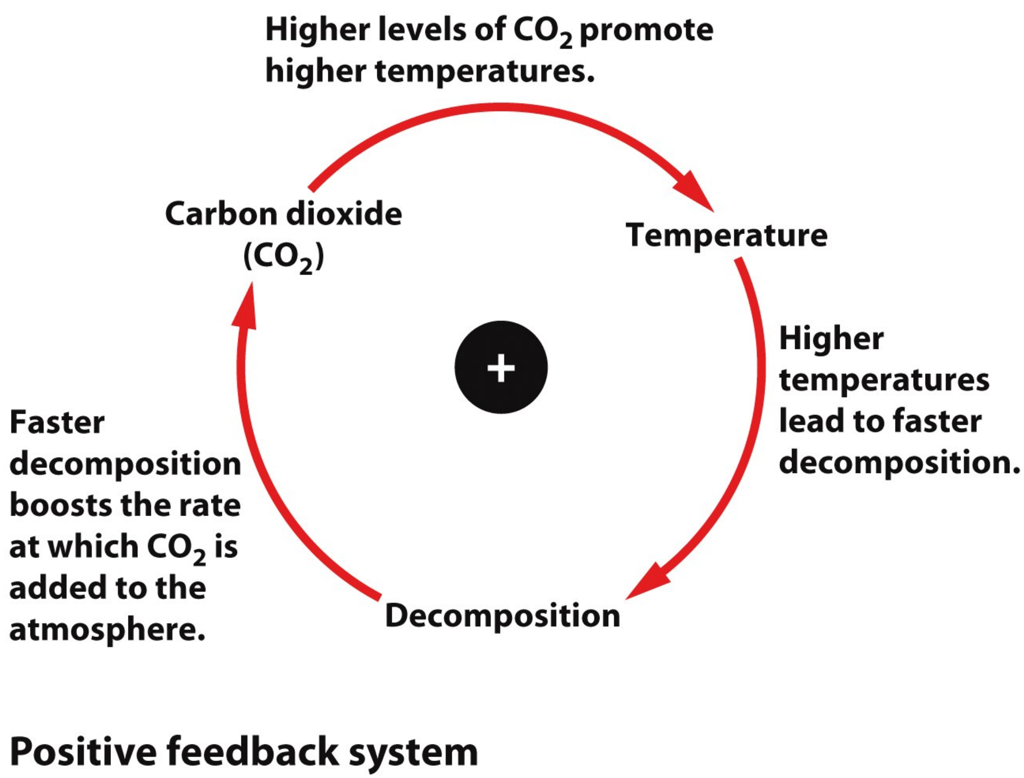

Figure 19.18a
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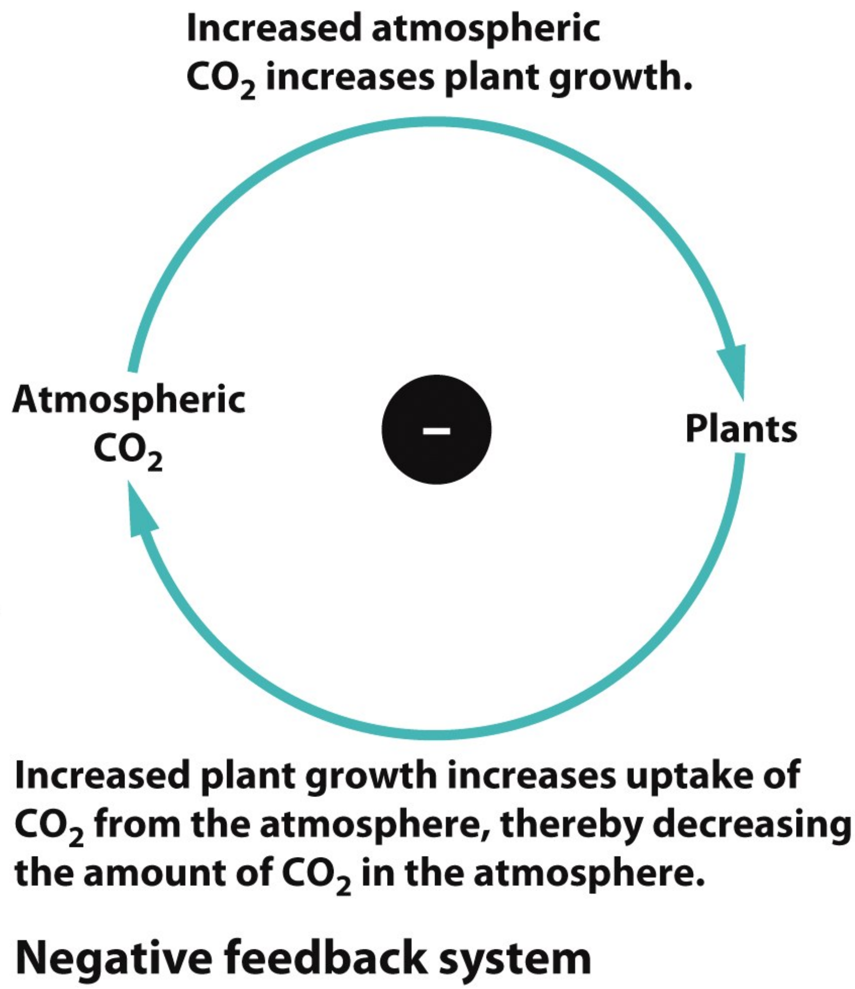

Figure 19.18b
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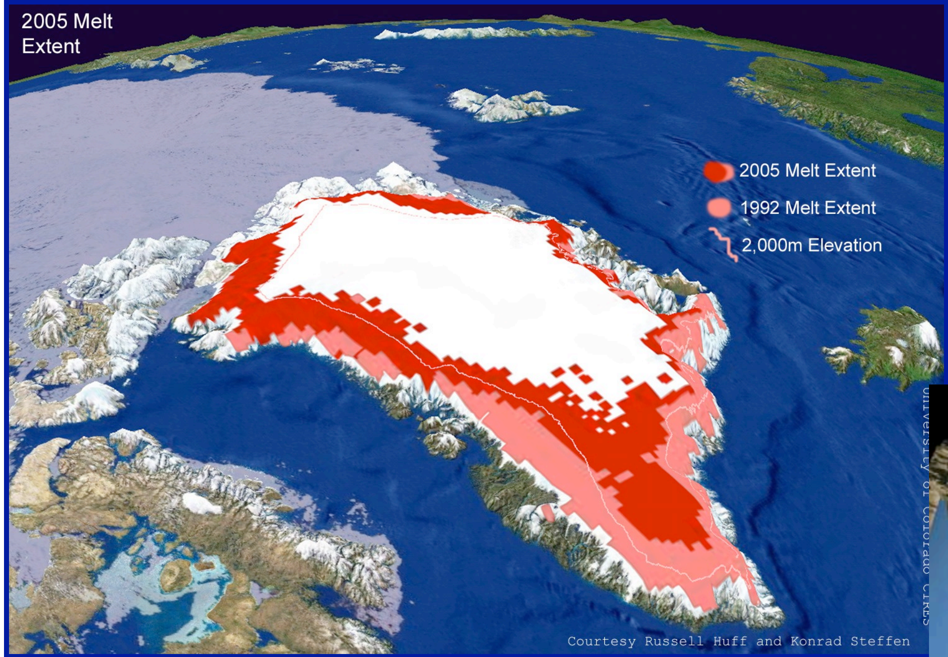
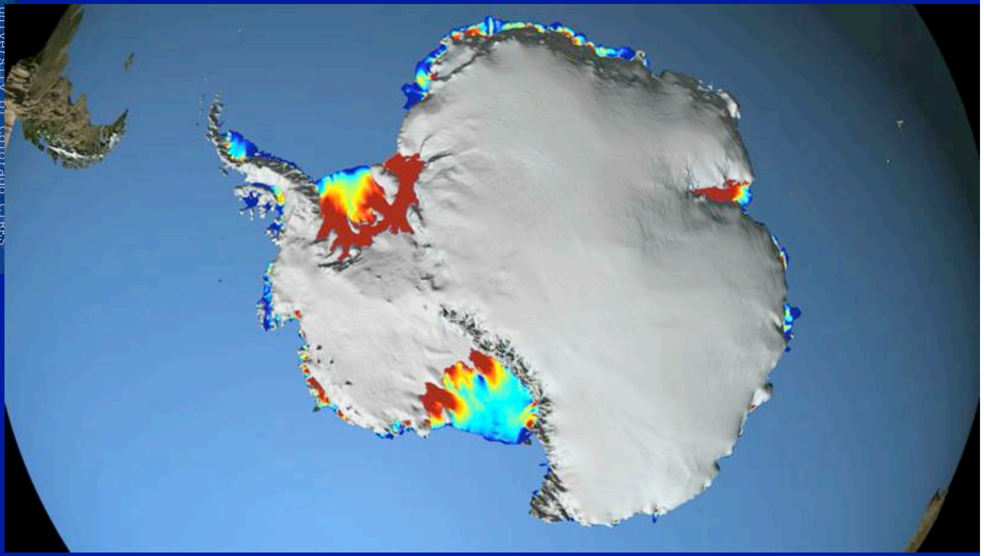
Consequences to the Environment Because of Global Warming

- Melting of polar ice caps, Greenland and Antarctica
- Melting of many glaciers around the world
- Melting of permafrost
- Rising of sea levels due to the melting of glaciers and ice sheets and as water warms it expands
- Extreme Heat waves and Cold spells
- Change in precipitation patterns
- Increase in storm intensity
- Shift in ocean currents

Melting Ice Caps



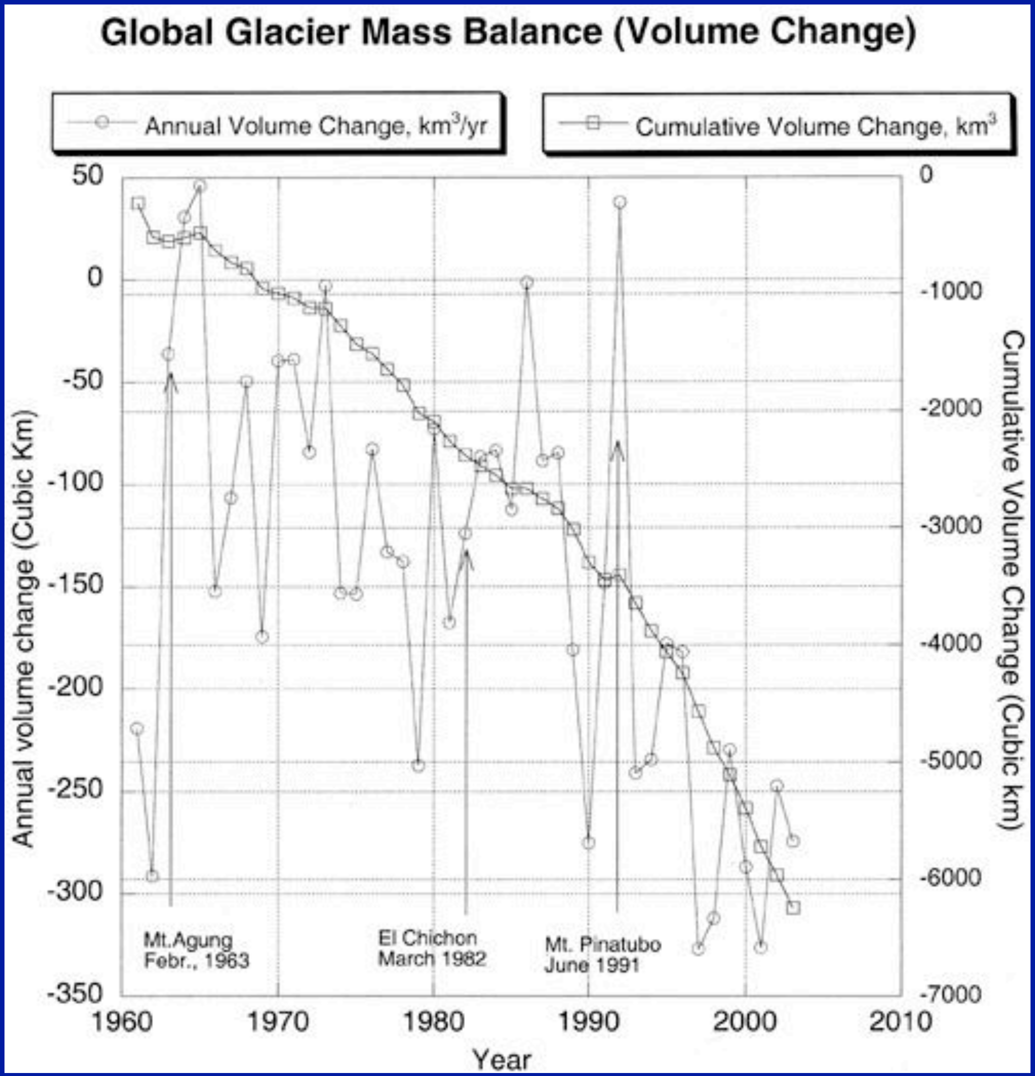
Greenland and Antarctica



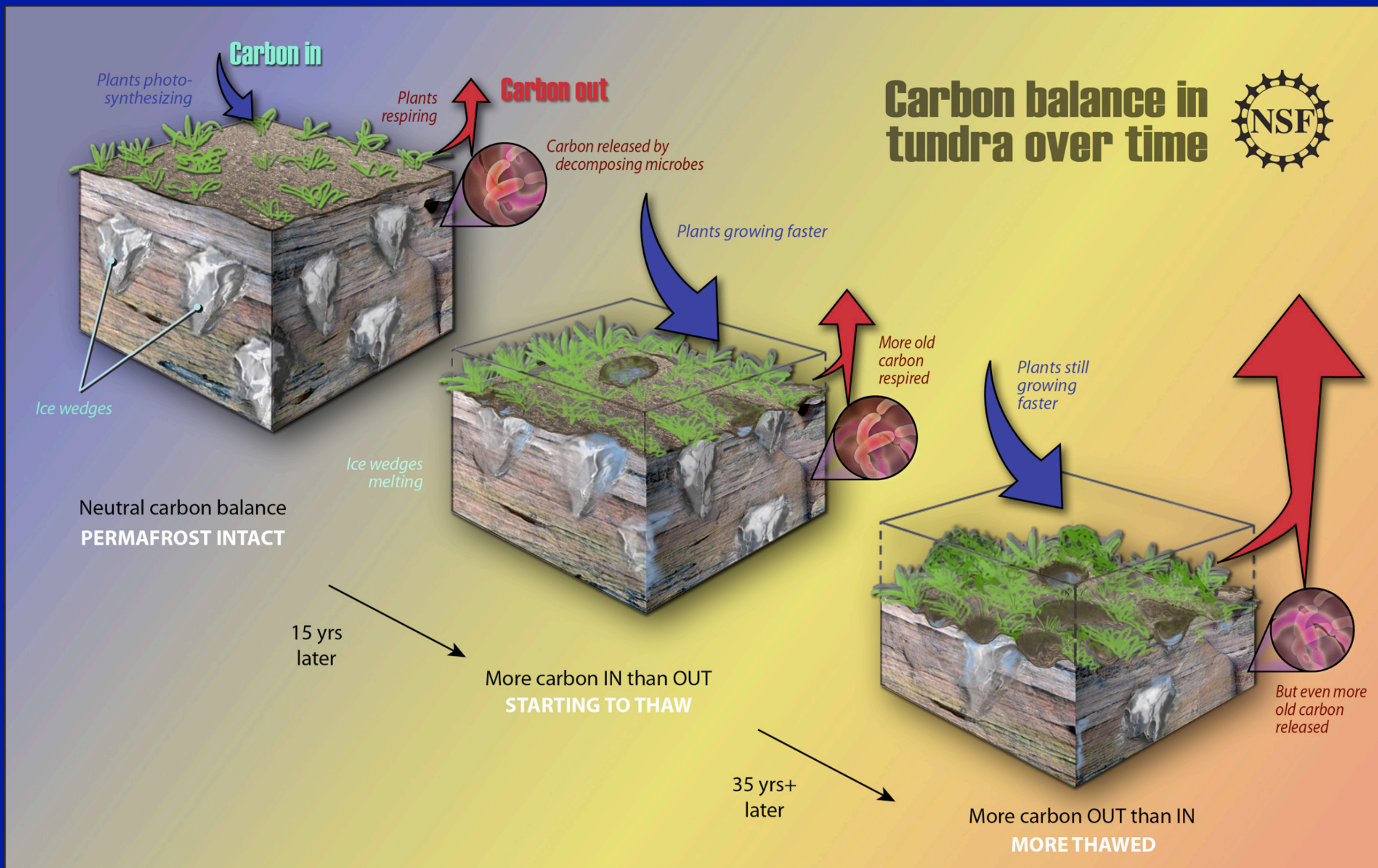
Melting Alpine Glaciers
Muir Glacier in Alaska

1941 2004

Shrinking Glacial Mass



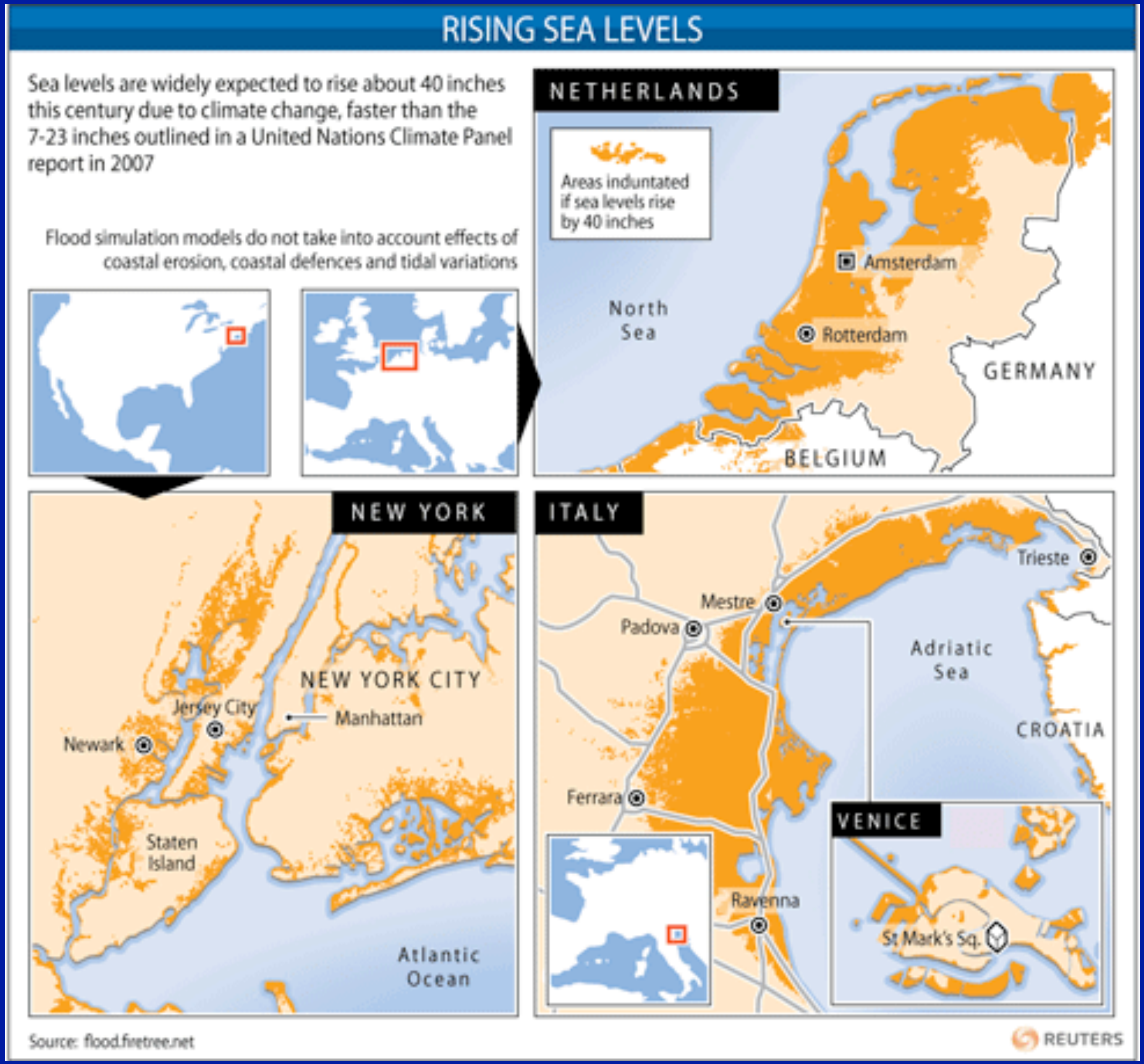
Melting Permafrost



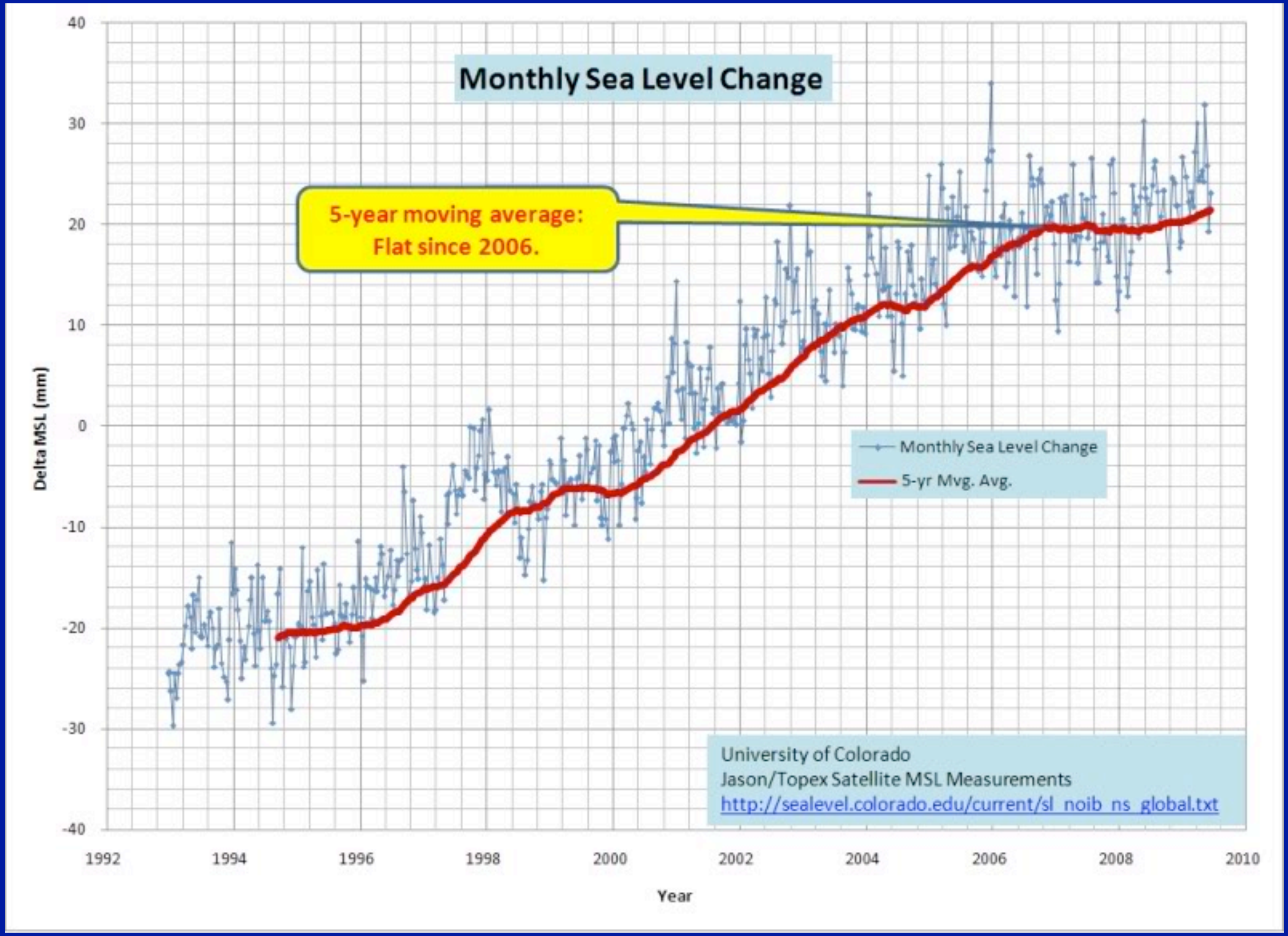
Melting Permafrost

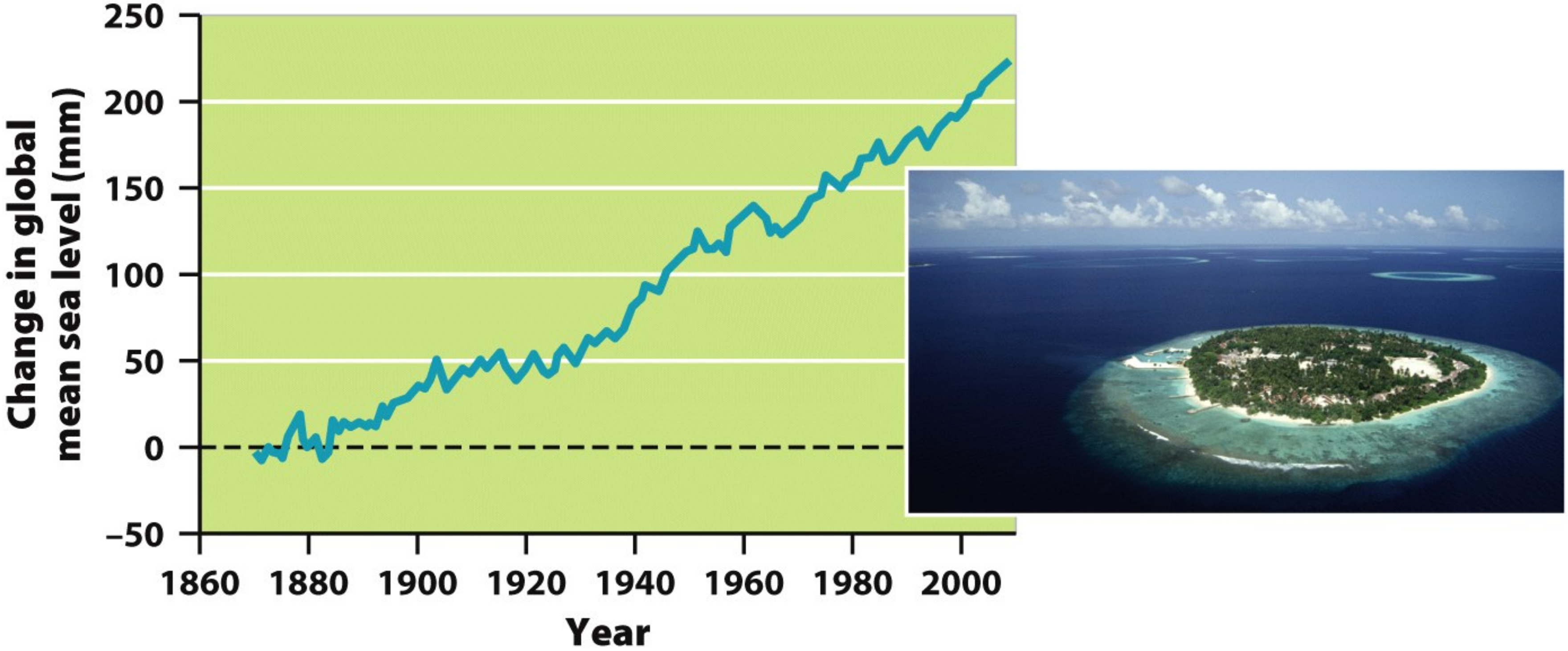
Houses undermined by melting Permafrost

Rising Sea Levels



Sea Level Change





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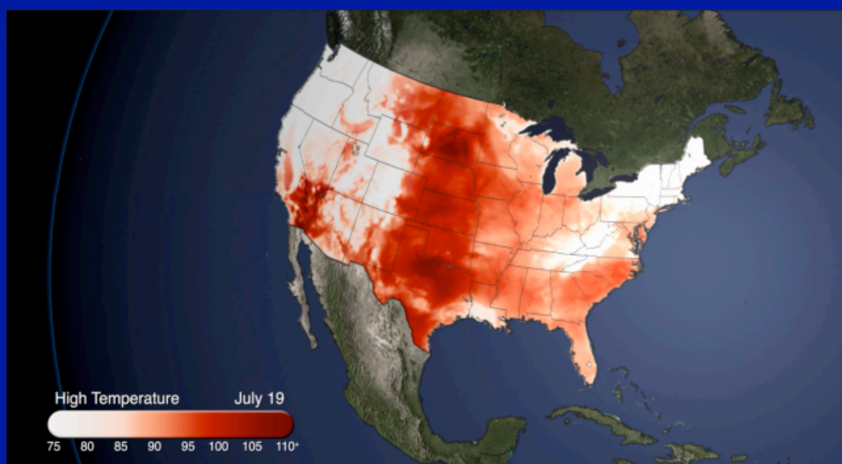
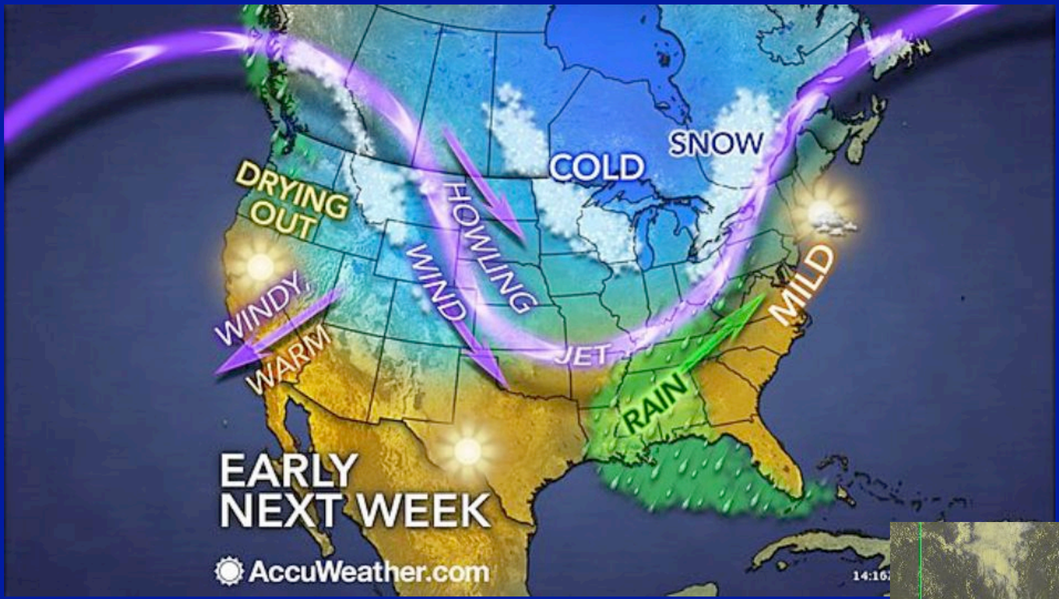
Extreme Weather

HEAT WAVES

COLD SPELLS

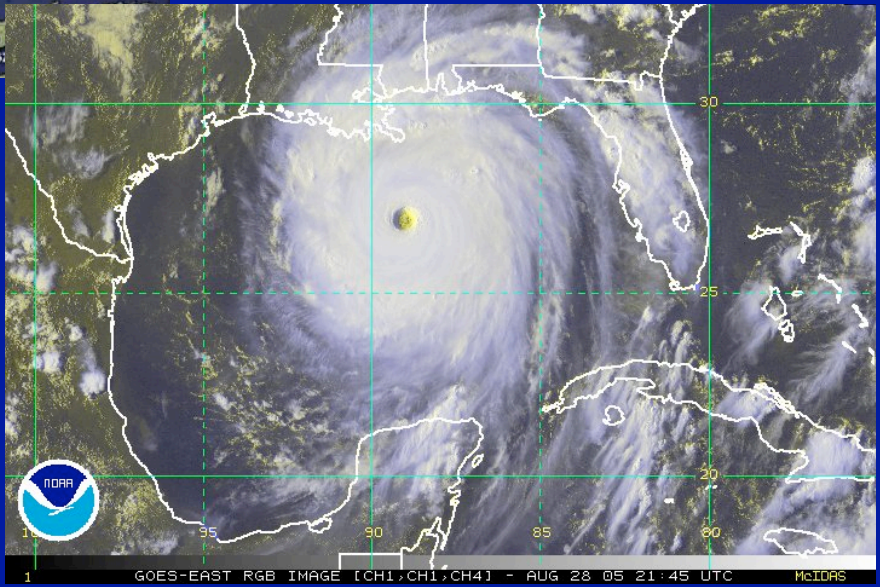


Increased Storm Intensity

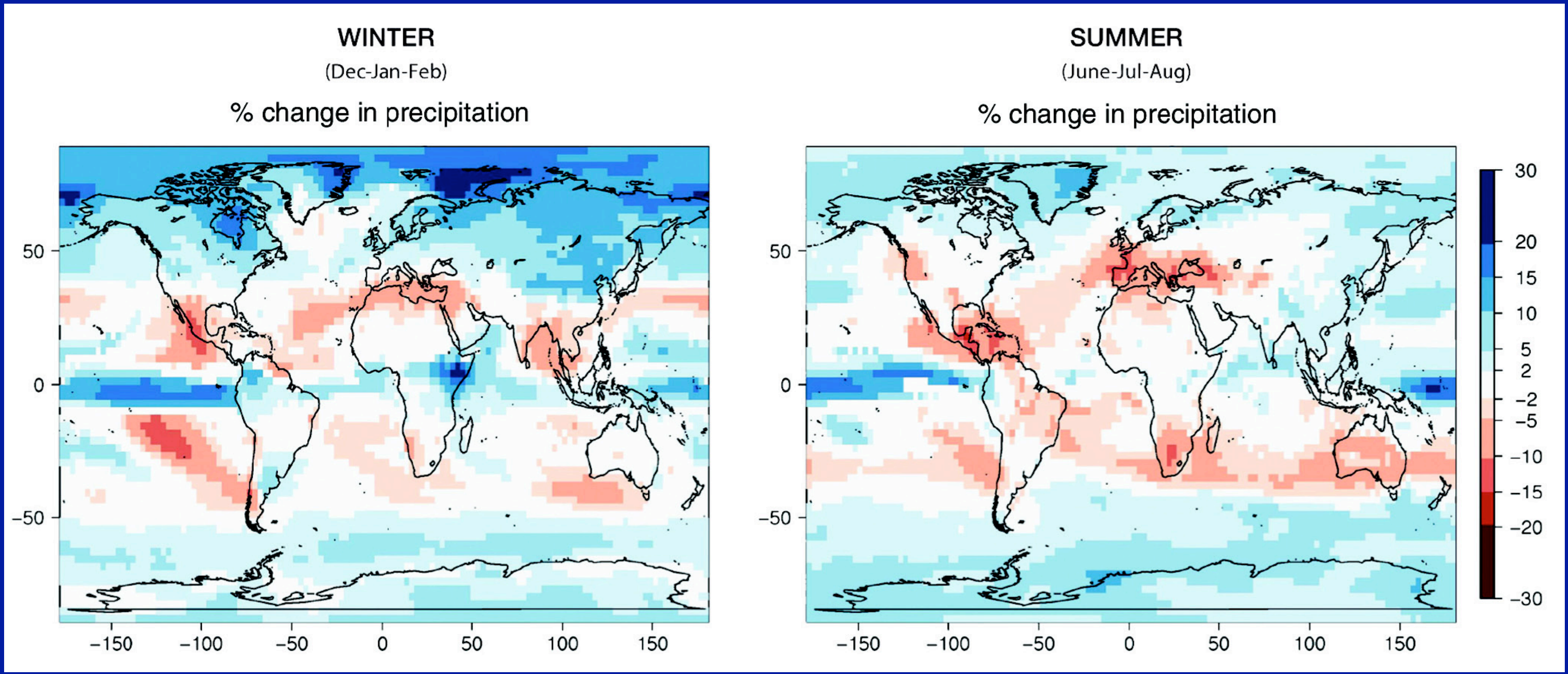


Something for Everybody!

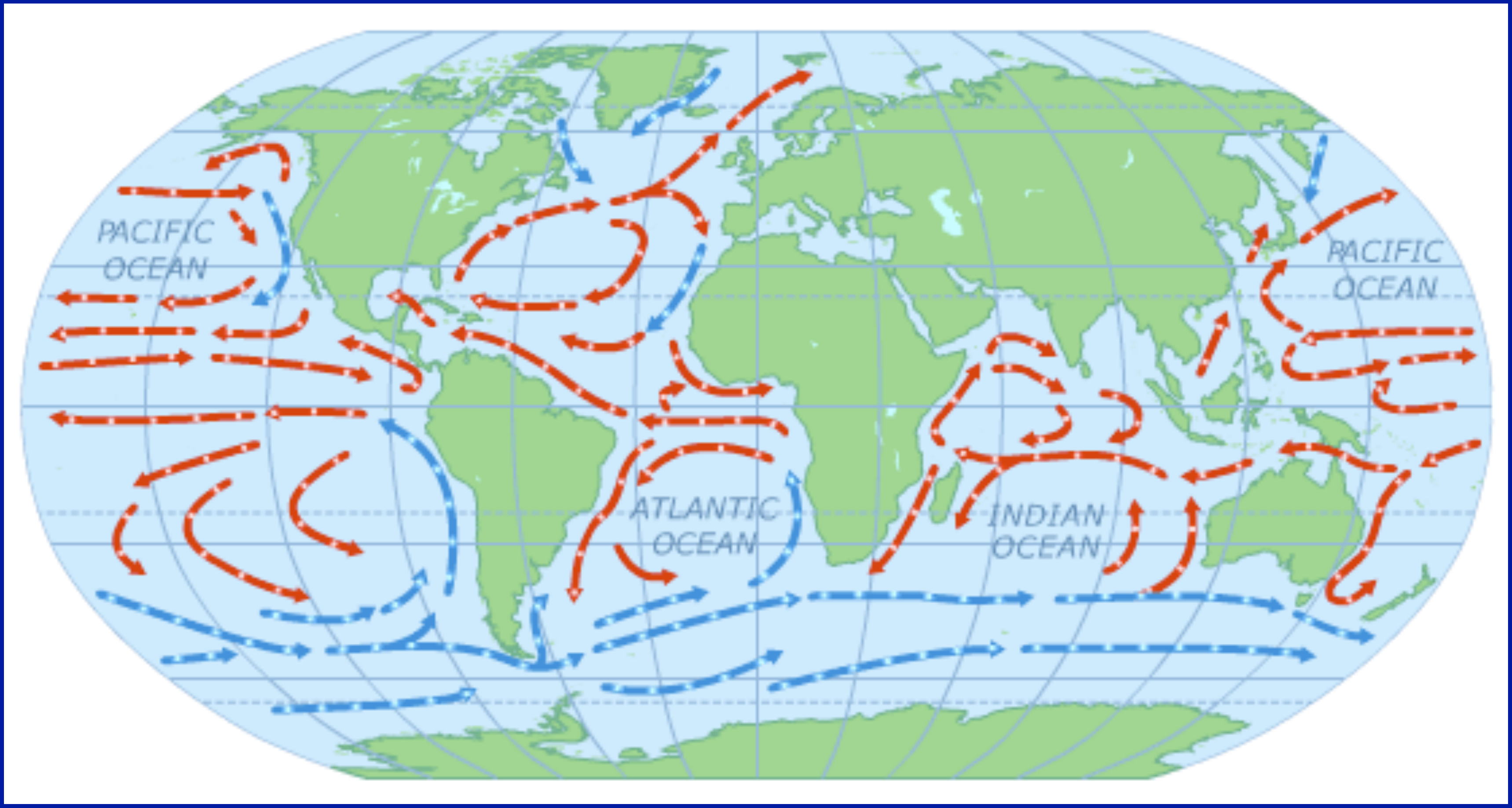
Katrina 2005



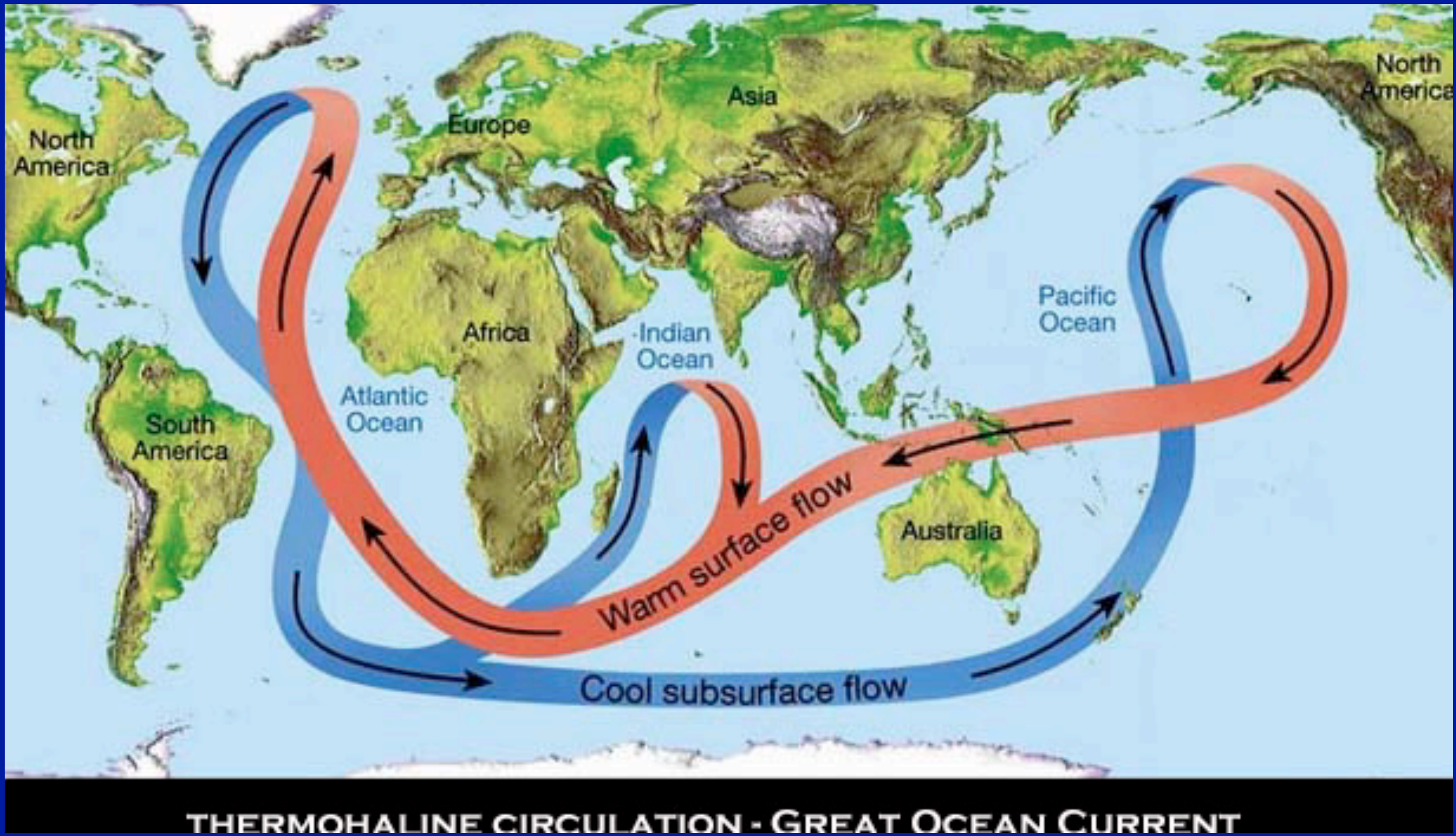
Change in Precipitation Patterns



Shift in Surface Ocean Currents



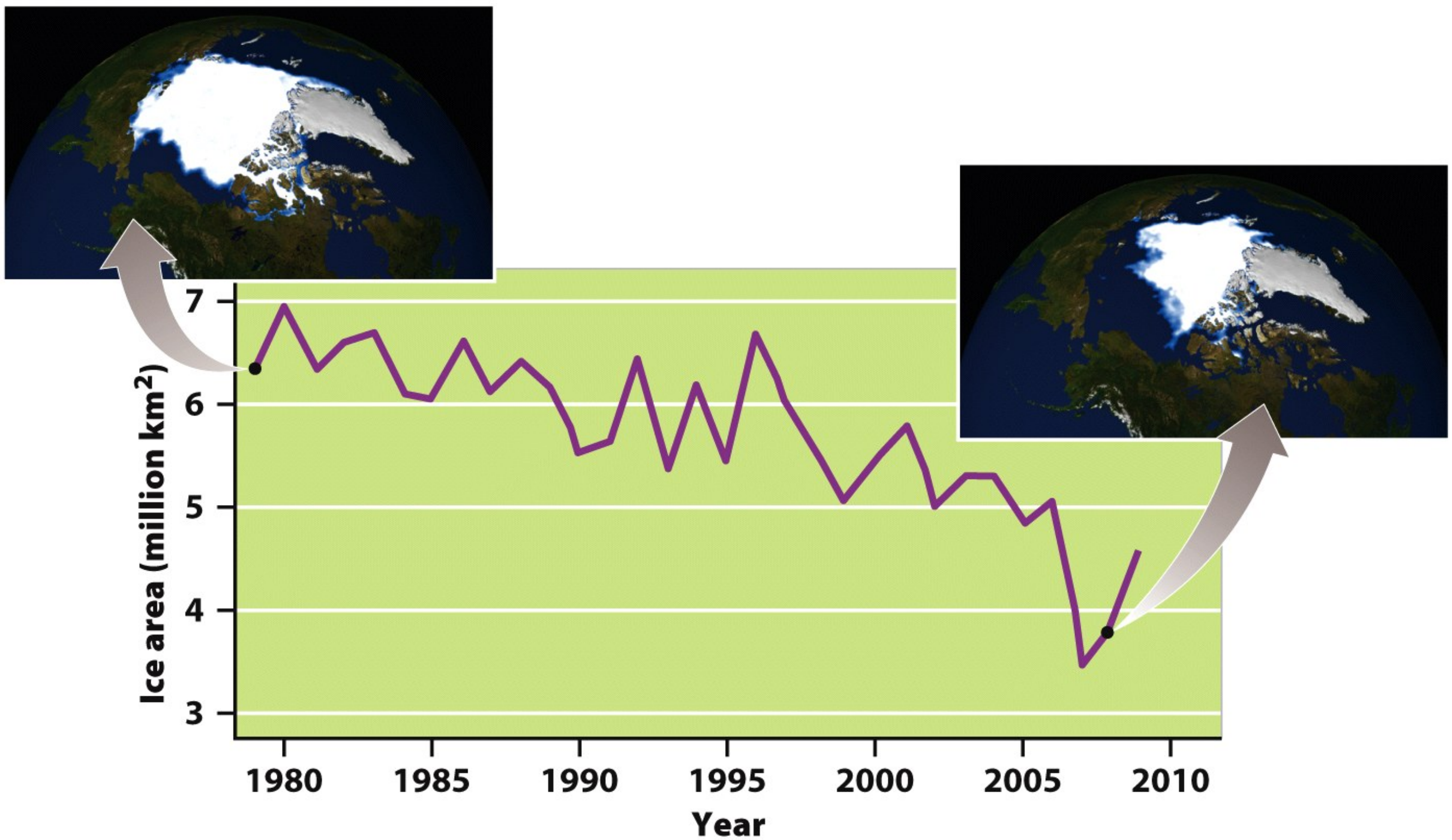
Deep Ocean (Thermohaline) Circulation



Consequences to Living Organisms

- Wild plants and animals can be affected. The growing season for plants has changed and animals have the potential to be harmed if they can't move to better climates.
- Humans may have to relocate, some diseases like those carried by mosquitoes could increase and there could be economic consequences.

Consequences for Ice Caps



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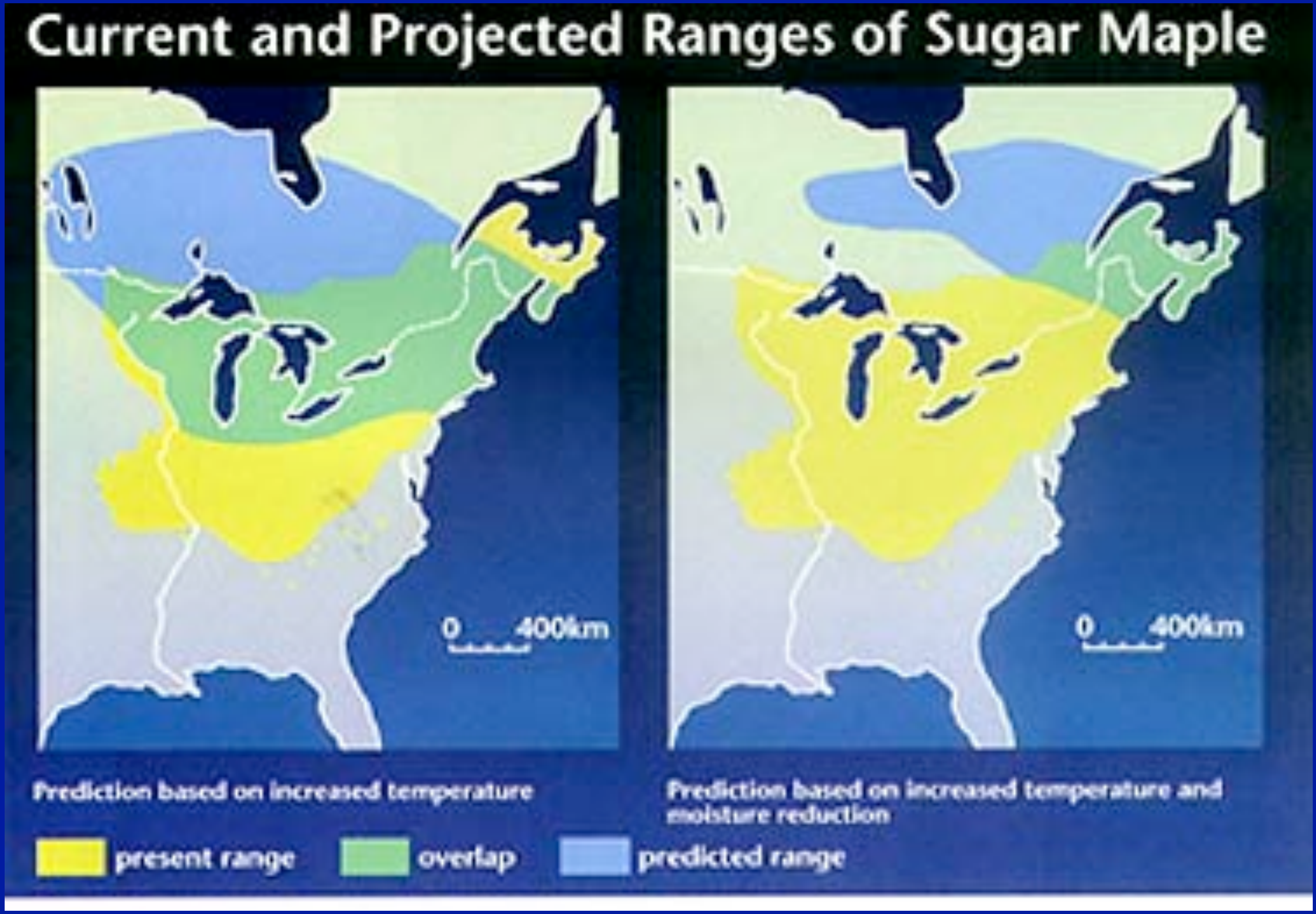
Consequences for Plants



Consequences for Animals

This bird's chicks are no longer hatching in sync with their primary food source.

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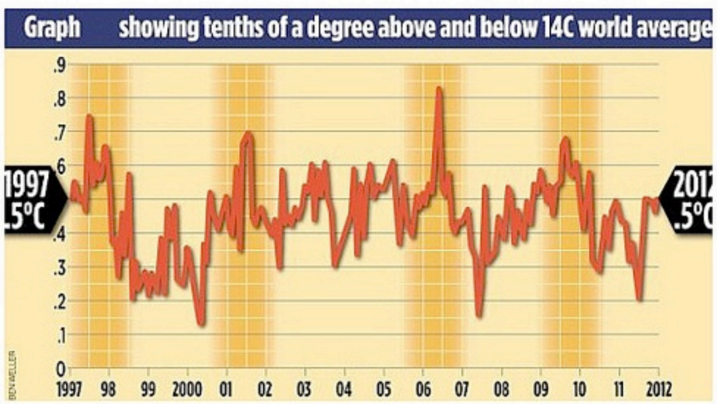
Spread of diseases and disease carriers

The Controversy of Climate Change

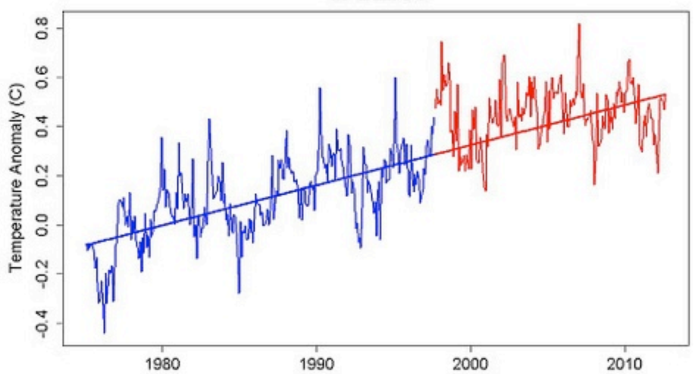
- The fundamental basis of climate change- that greenhouse gas concentrations are increasing and that this will lead to global warming is not in dispute among the vast majority of scientists.
- What is unclear is how much world temperatures will increase for a given change in greenhouse gases, because that depends on the different feedback loops.

Controversy? No…Consensus!

Not this...



This.



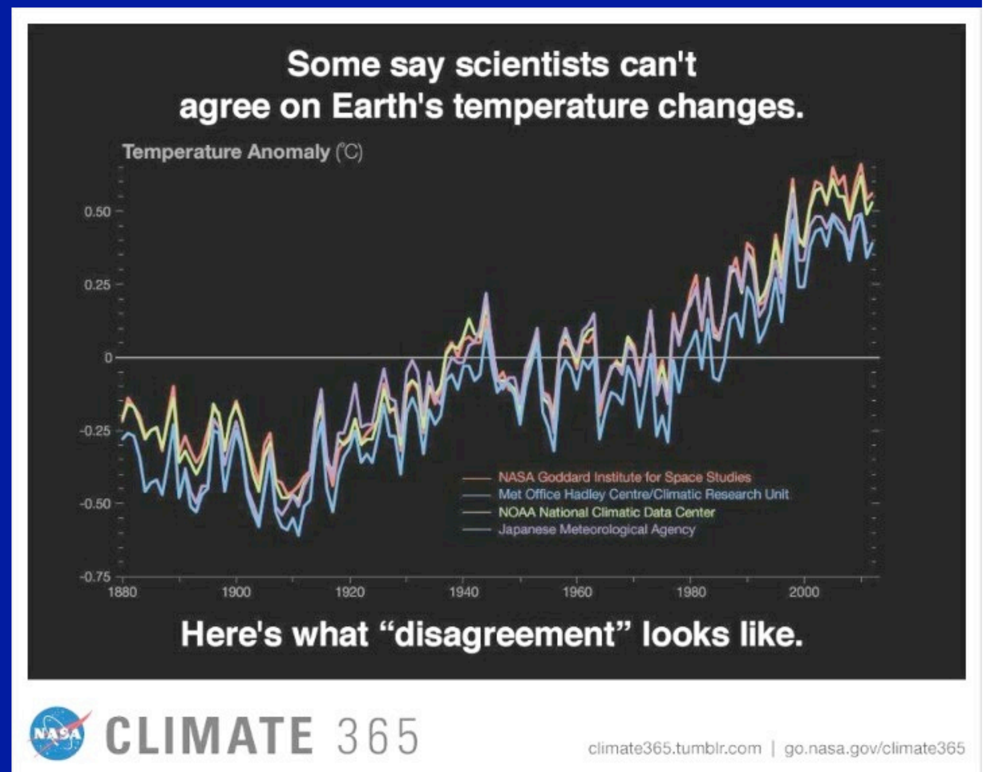


TABLE 19.2	The 2007 assessment of global change by the Intergovernmental Panel on Climate Change (IPCC)		

The scientists considered the likelihood that specific changes have occurred, the likelihood that humans contributed to the change, and the likelihood that current trends will continue.

Definitions: More likely than not = more than 50% certain; Likely = more than 60% certain; Very likely = more than 90% certain; Virtually certain = more than 99% certain.

Phenomenon and direction of trend	Likelihood that trend occurred in late 20th century (typically post-1960)	Likelihood of a human contribution to observed trend	Likelihood of future trends based on projections for 21st century from *Special Report on Emissions Scenarios*
Warmer and fewer cold days and nights over most land areas	Very likely	Likely	Virtually certain
Warmer and more frequent hot days and nights over most land areas	Very likely	Likely (nights)	Virtually certain
Warm spells/heat waves. Frequency increases over most land areas	Likely	More likely than not	Very likely
Heavy precipitation events. Frequency (or proportion of total rainfall from heavy falls) increases over most areas	Likely	More likely than not	Very likely
Area affected by droughts increases	Likely in many regions since 1970s	More likely than not	Likely
Intense tropical cyclone activity increases	Likely in some regions since 1970	More likely than not	Likely
Increased incidence of extreme high sea level (excludes tsunamis)	Likely	More likely than not	Likely

Table 19.2
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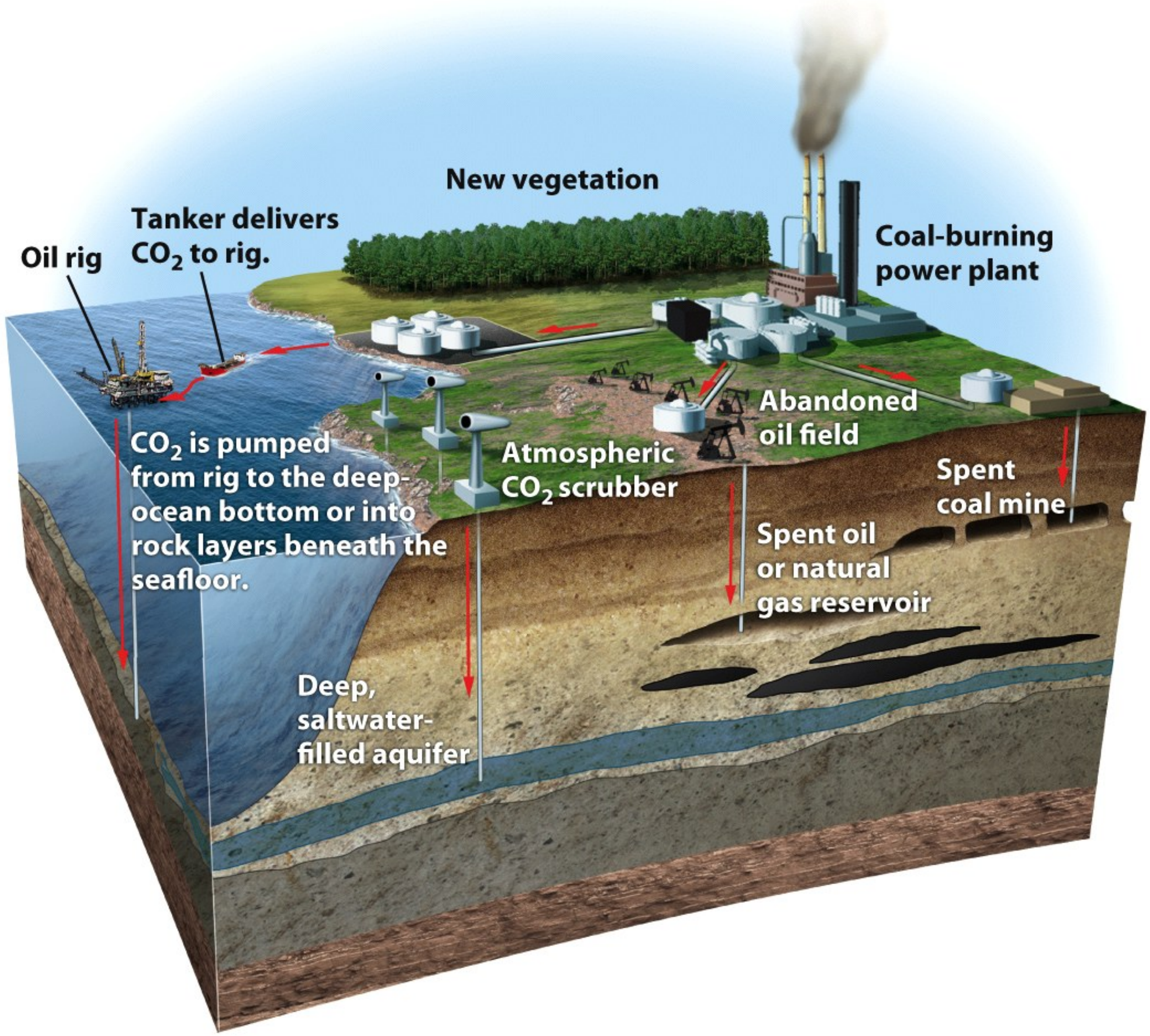
The Kyoto Protocol

- In 1997, representatives of the nations of the world went to Kyoto, Japan to discuss how best to control the emissions contributing to global warming.
- The agreement was that emissions of greenhouse gases from all industrialized countries will be reduced to 5.2% below their 1990 levels by 2012.
- Developing nations did not have emission limits imposed by the protocol.

Carbon Sequestration

- An approach involving taking CO_2 out of the atmosphere.
- Some methods include storing carbon in agricultural soils or retiring agricultural land and allowing it to become pasture or forest.
- Researchers are looking at cost-effective ways of capturing CO_2 from the air, from coal-burning power stations, and from other emission sources.
- This captured CO_2 would be compressed and pumped into abandoned oil wells or the deep ocean.



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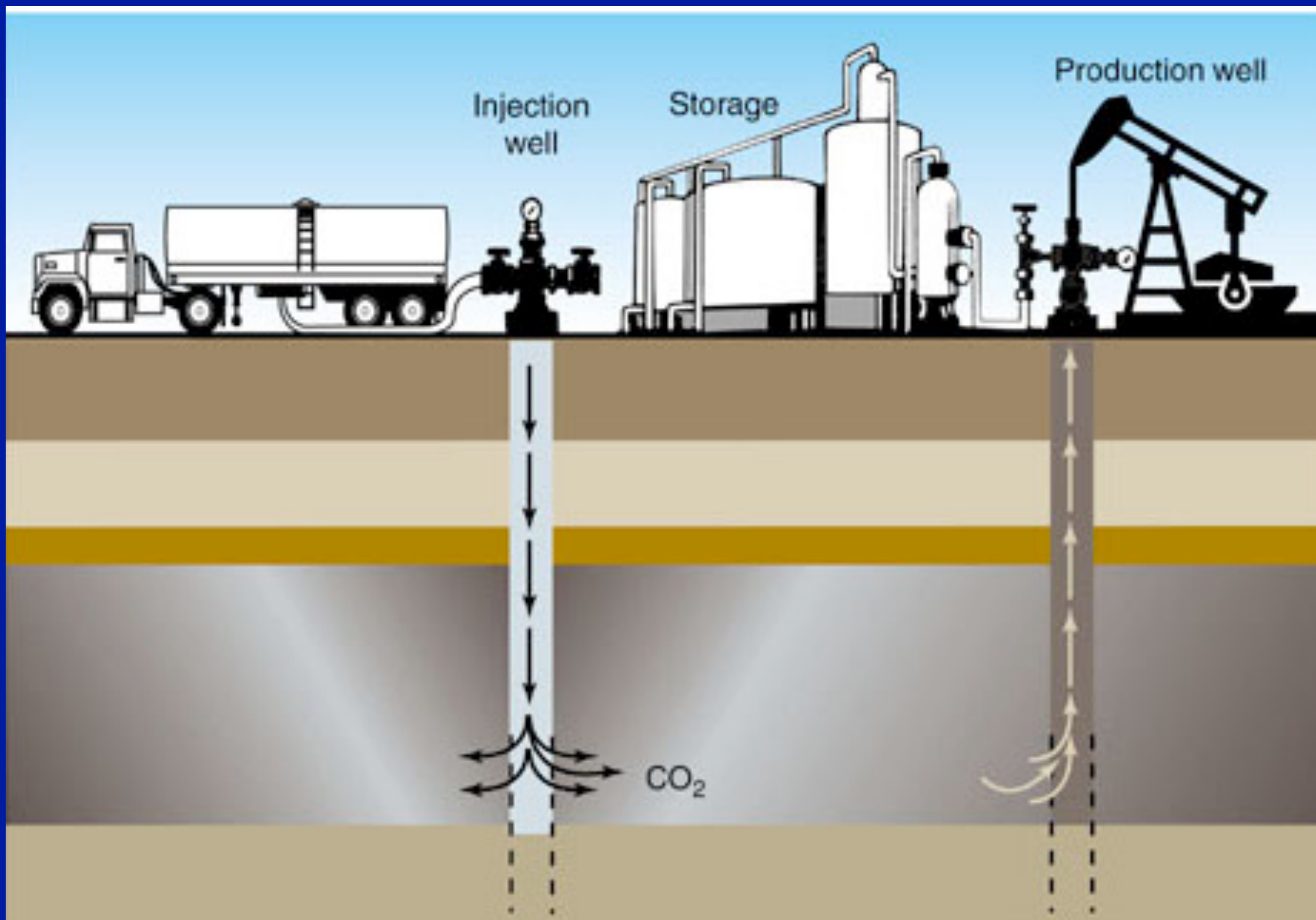
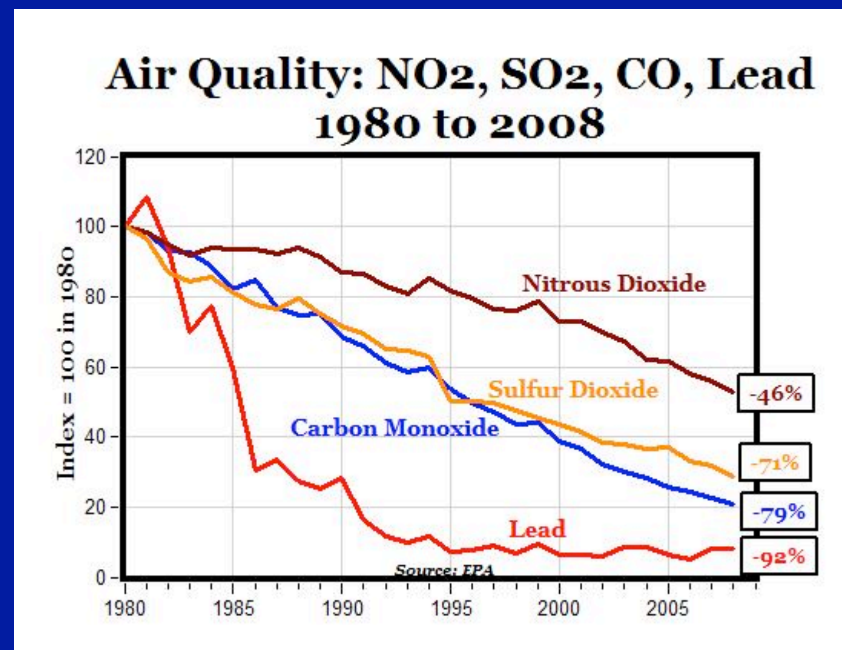
Using Carbon injection to "juice" older wells…



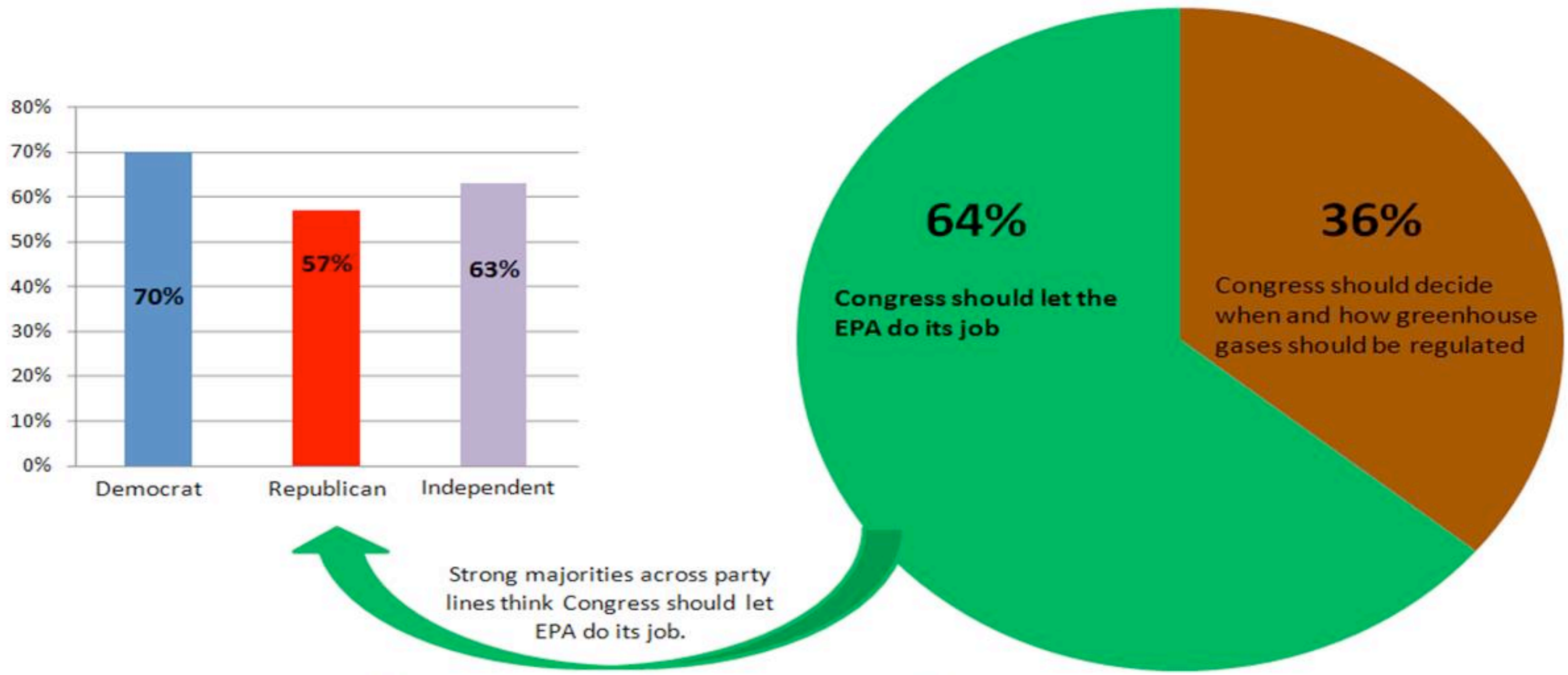
EPA and the Clean Air Act

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY



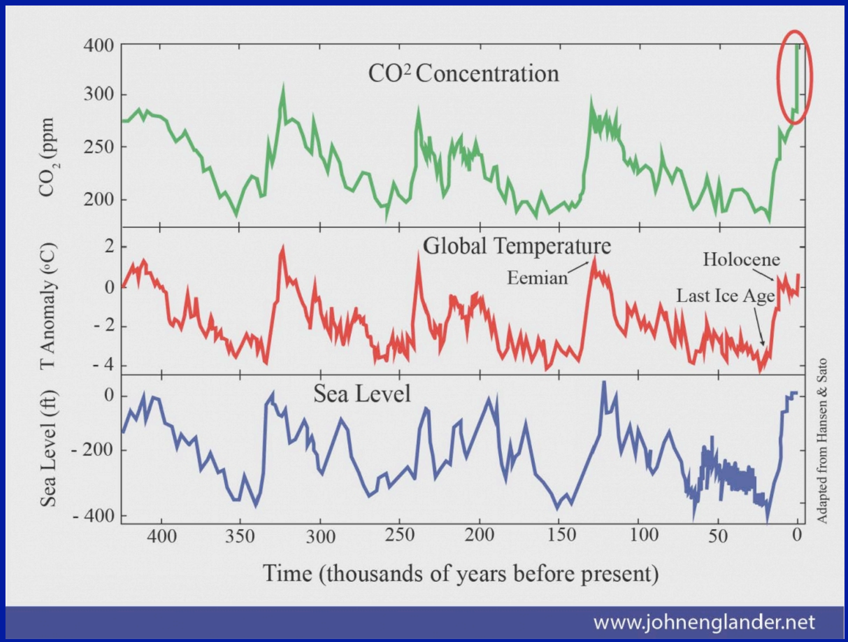
Allowing EPA to do its job

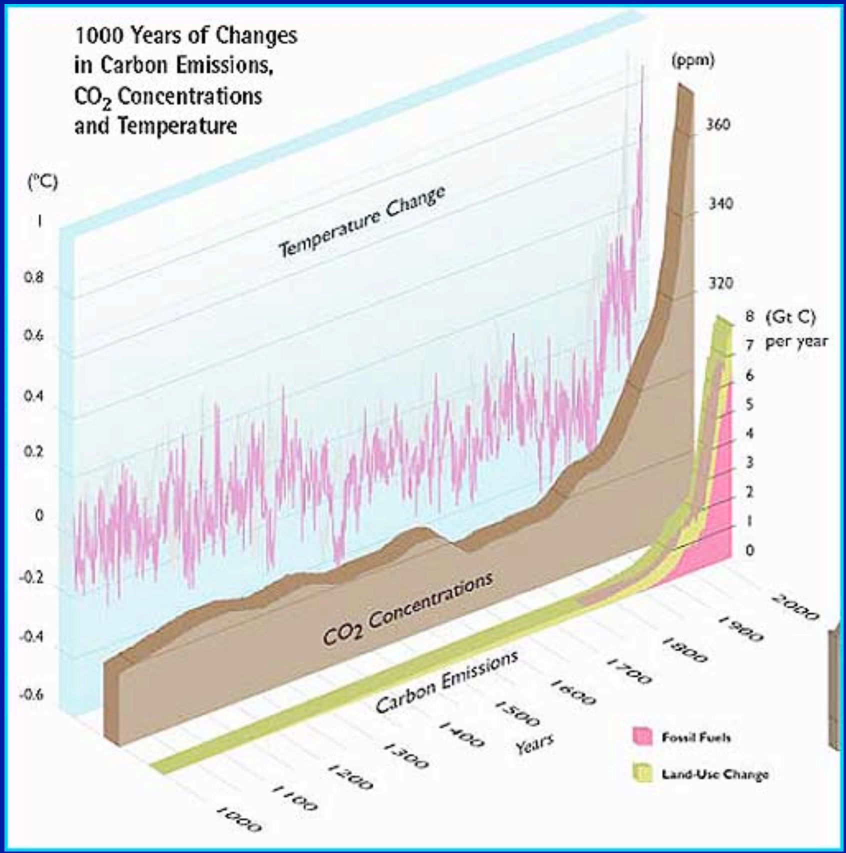
Should Congress Decide When and How to Regulate Greenhouse Gases or Should Congress Let EPA Do its Job?

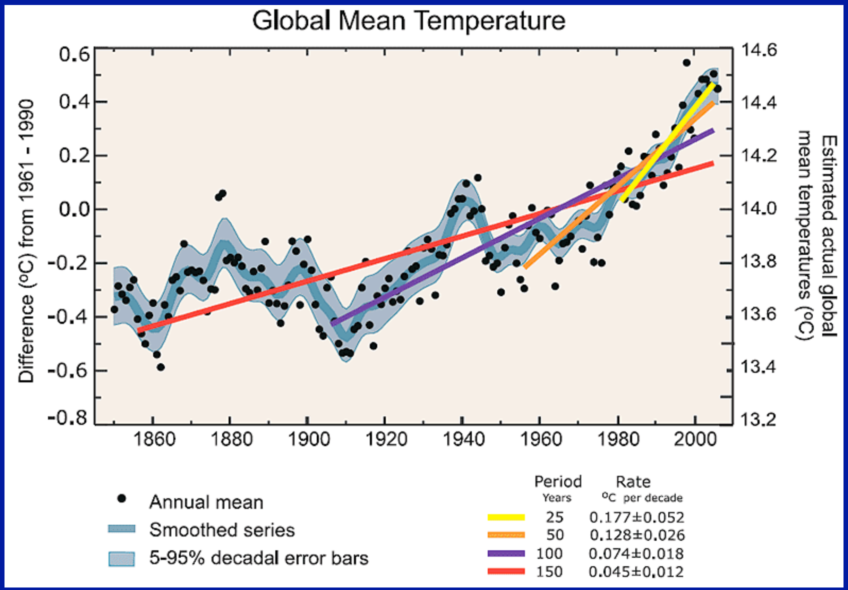


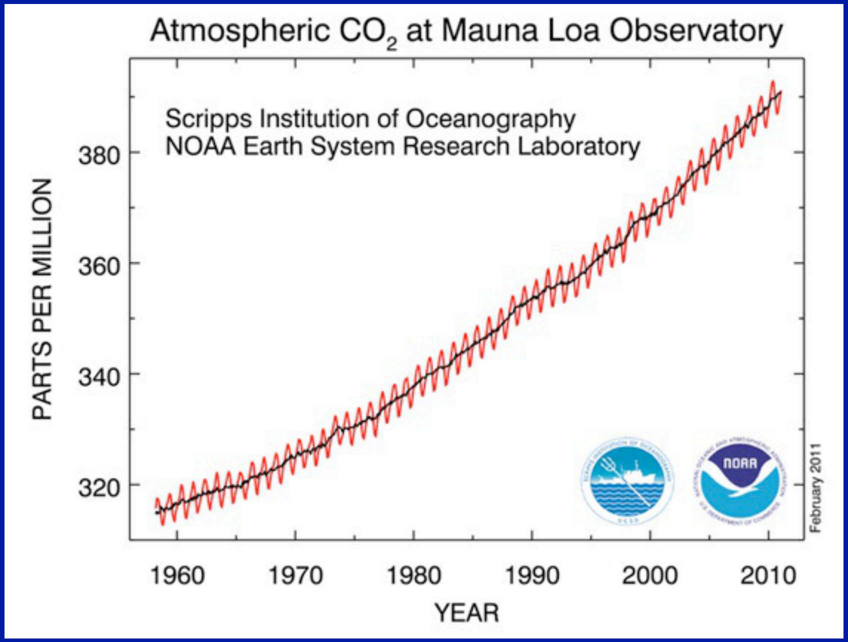
Some special interests say Congress should step in and prevent the EPA from limiting carbon dioxide pollution. For example, the head of the America Petroleum Institute says Congress should decide when and how greenhouse gases should be regulated. But other public interest groups say Congress should let EPA do its job. The head of the American Public Health Association says that blocking the EPA's work to reduce carbon pollution could mean the difference between a healthy life for many Americans or battling chronic debilitating illness. Which view do you support?

Source: PPP Polling for NRDC, released 2-23-11.


CO2 Concentration
Global Temperature
Eemian
Holocene
Last Ice Age
Sea Level
CO_2 (ppm)
T Anomaly (°C)
Sea Level (ft)
Time (thousands of years before present)
Adapted from Hansen & Sato
www.johnenglander.net


1000 Years of Changes
in Carbon Emissions,
CO_2 Concentrations
and Temperature
(°C)
(ppm)
Temperature Change
CO_2 Concentrations
Carbon Emissions
(Gt C)
per year
Years
Fossil Fuels
Land-Use Change


Global Mean Temperature
Difference (ºC) from 1961 - 1990
Estimated actual global mean temperatures (ºC)
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
14.6
14.4
14.2
14.0
13.8
13.6
13.4
13.2
1860
1880
1900
1920
1940
1960
1980
2000
Annual mean
Smoothed series
5-95% decadal error bars
Period Years
Rate ºC per decade
25 0.177±0.052
50 0.128±0.026
100 0.074±0.018
150 0.045±0.012


Atmospheric CO2 at Mauna Loa Observatory
Scripps Institution of Oceanography
NOAA Earth System Research Laboratory
PARTS PER MILLION
380
360
340
320
1960
1970
1980
1990
2000
2010
YEAR
February 2011