Lecture 13: Global Climate Change/Global Warming

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GLOBAL
WARMING

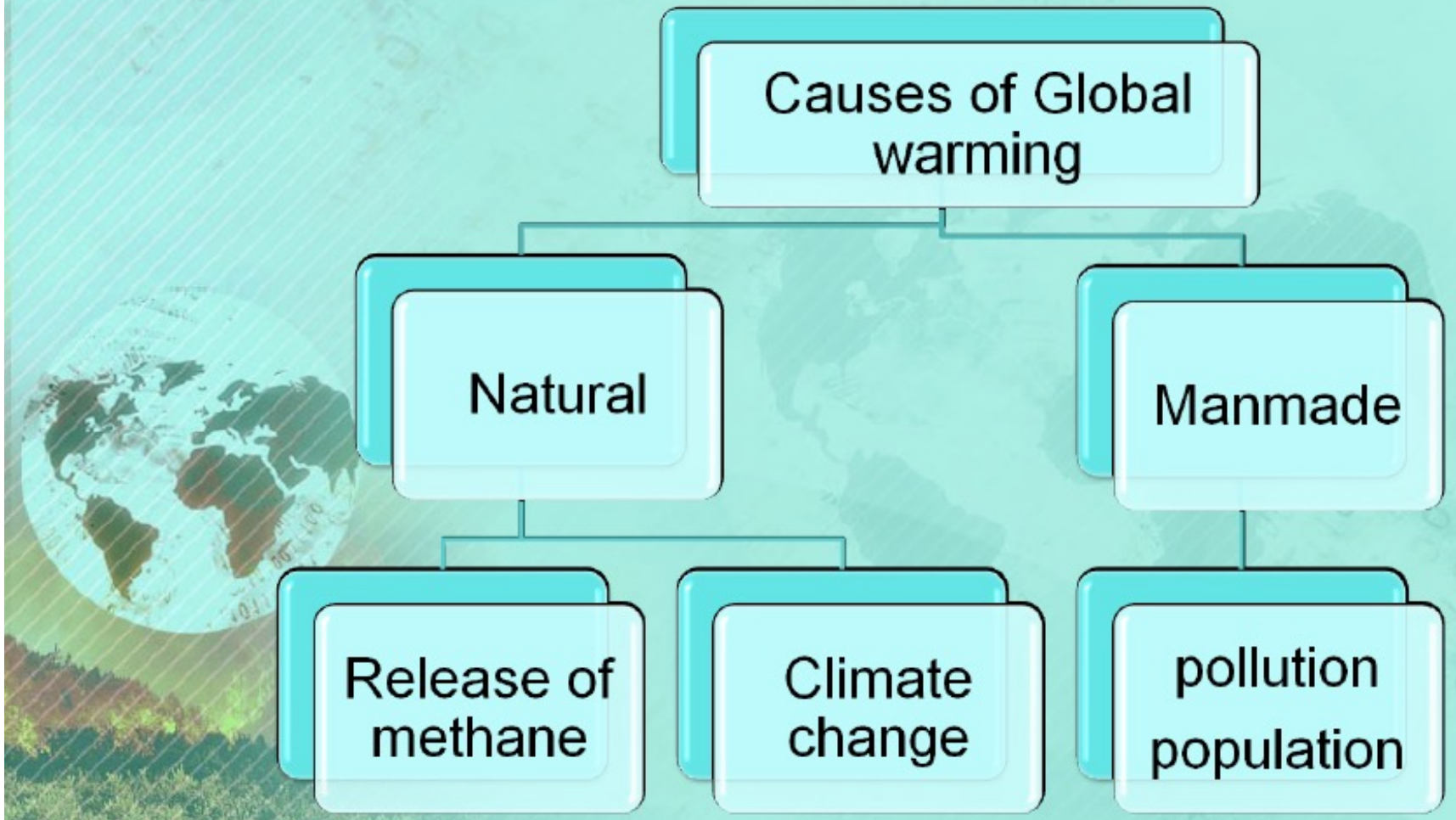
Definition of Global Warming

- An increase in the earth's average atmospheric temperature that causes corresponding changes in climate and that may result from the greenhouse effect.
- Measurable increases in the average temperature of the earth's atmosphere, oceans and land masses.
- Scientists believe that the earth is currently facing a period of rapid warming brought on by rising levels of heat-trapping gases known as green house gases or GHGs.

More about global warming

- The greenhouse effect is caused by increased levels in carbon dioxide, methane, chlorofluorocarbons or CFCs and other pollutants.
- Since the early 20^{th} century, the earth's mean temperature has increased by about 0.8^0C (1.4^0F) with about 2/3 of the increase occurring since 1980.
- Warming of the climate system is unequivocal and scientists are 95-100% certain that it is primarily caused by increasing concentration of GHGs produced by human activities such as consumption of fossil fules and deforestation.

CAUSES OF GLOBAL WARMING



What changes climate?

- **Sun's output**

Incoming solar radiation is the main climate driver. Its energy output increased about 0.1% from 1750 to 1950, increasing temperatures by 0.2°F (0.1°C) in the first part of the 20th century. But since 1979, when we began taking measurements from space, the data show no long-term change in total solar energy, even though Earth has been warming.

- **Earth's orbit**

Repetitive cycles in Earth's orbit that occur over tens of thousands of years can influence the angle and timing of sunlight.

- **Volcanic eruptions**

Huge volcanic eruptions can cool Earth by injecting ash and tiny particles into the stratosphere.

Cont….

- # Drifting continents

In the distant past, drifting continents make a big difference in climate over millions of years by changing ice caps at the poles and by altering ocean currents, which transport heat and cold throughout the ocean depths

- # Greenhouse gases

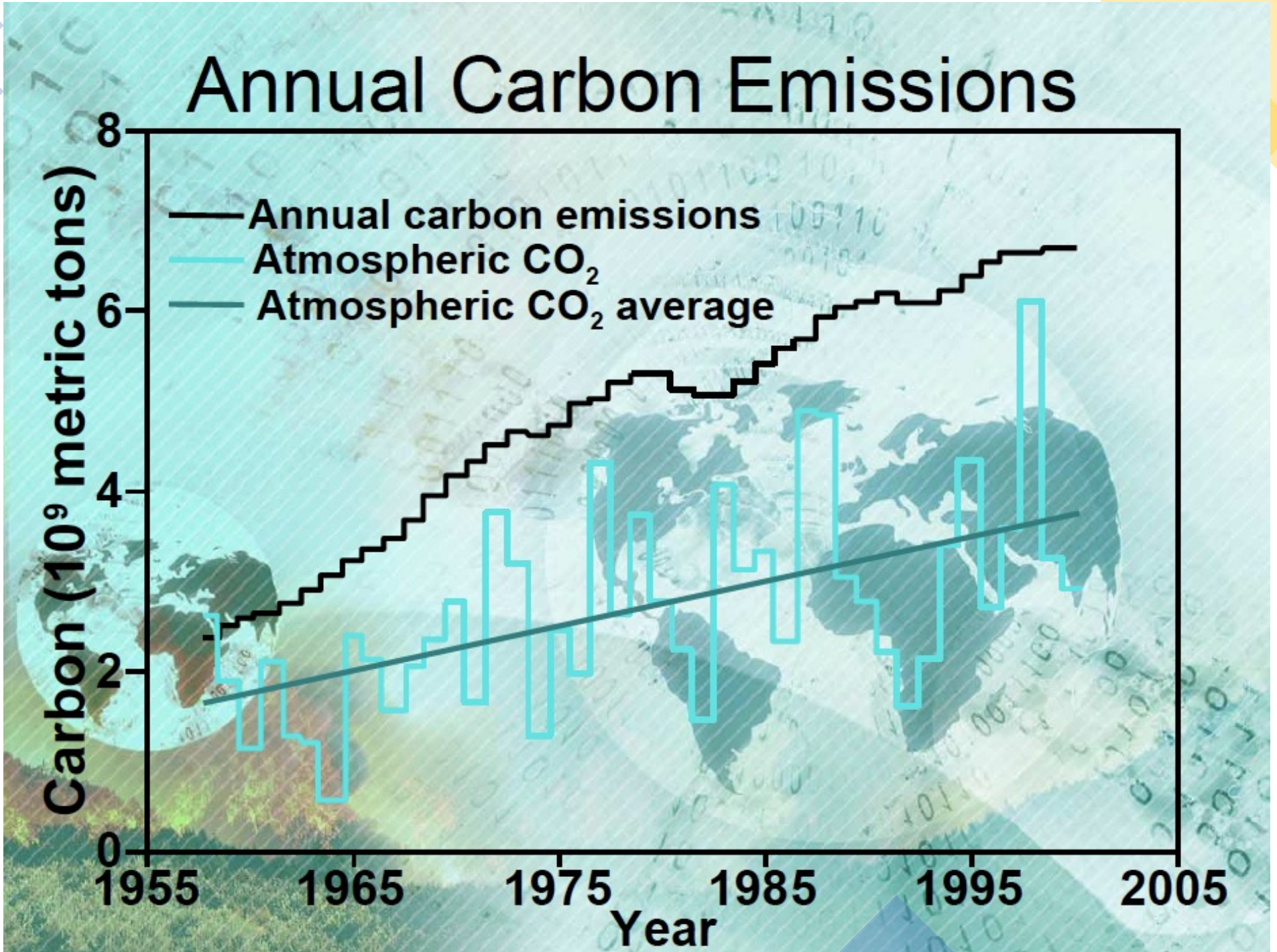
Changes in the concentration of greenhouse gases, which occur both naturally and as a result of human activities influence Earth's climate. Greenhouse gases absorb and emit radiation within the thermal infrared range. This process is the fundamental cause of the greenhouse effect. Greenhouse gases greatly affect the temperature of the Earth; without them, Earth's surface would average about 33 °C colder, which is about 59 °F below the present average of 14 °C (57 °F)

- **Natural causes** are causes that are created by nature.

- Release of methane gas from arctic tundra and wetlands.

- Methane is a greenhouse gas and a very dangerous gas to our environment.

- Earth goes through a cycle of climate change. This climate change usually lasts about 40,000 years.


Annual Carbon Emissions
Annual carbon emissions
Atmospheric CO_2
Atmospheric CO_2 average
Carbon (10^9 metric tons)
0
2
4
6
8
1955
1965
1975
1985
1995
2005
Year

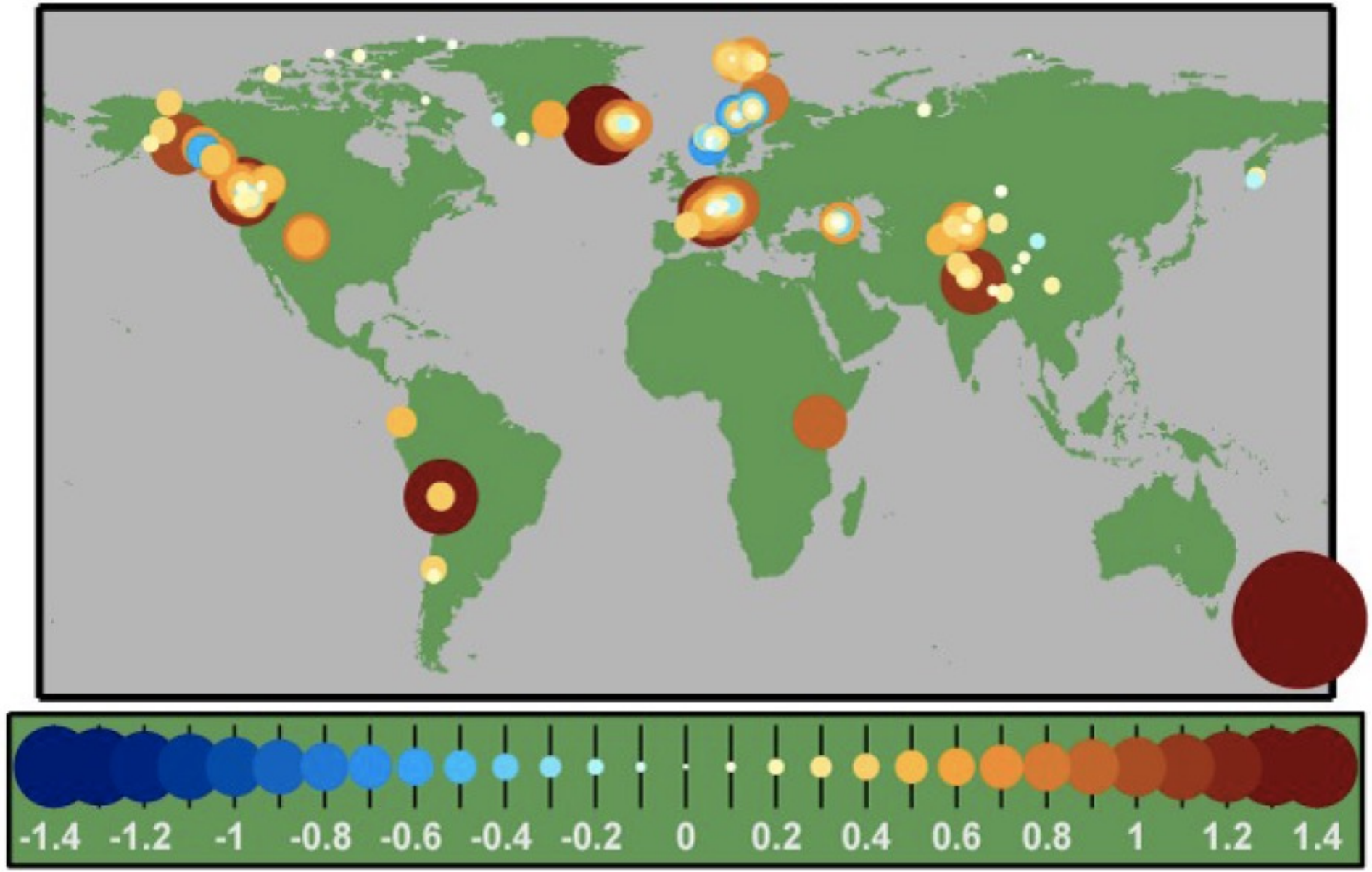
Future Carbon Dioxide Levels

- Increasing CO_2 emissions, especially in China and developing countries
- Likely to double within 150 years:
  - Increased coal usage
  - Increased natural gas usage
  - Decreased petroleum usage (increased cost and decreasing supply)

Observed Parameters

- Highest earth's temperature in last 30 years
- Variations in summer and winter season
- Variations in rain periods
- Unexpected rains, storms
- Melting of snow, rise in ocean level to one feet in last 30 years
- Depletion of glaciers
- Unexpected climate changes

Mountain Glacier Changes Since 1970



Effective Glacier Thinning (m / yr)

Causes of Global Warming

- Global warming is primarily a problem of too much carbon dioxide (CO2) in the atmosphere—which acts as a blanket, trapping heat and warming the planet.

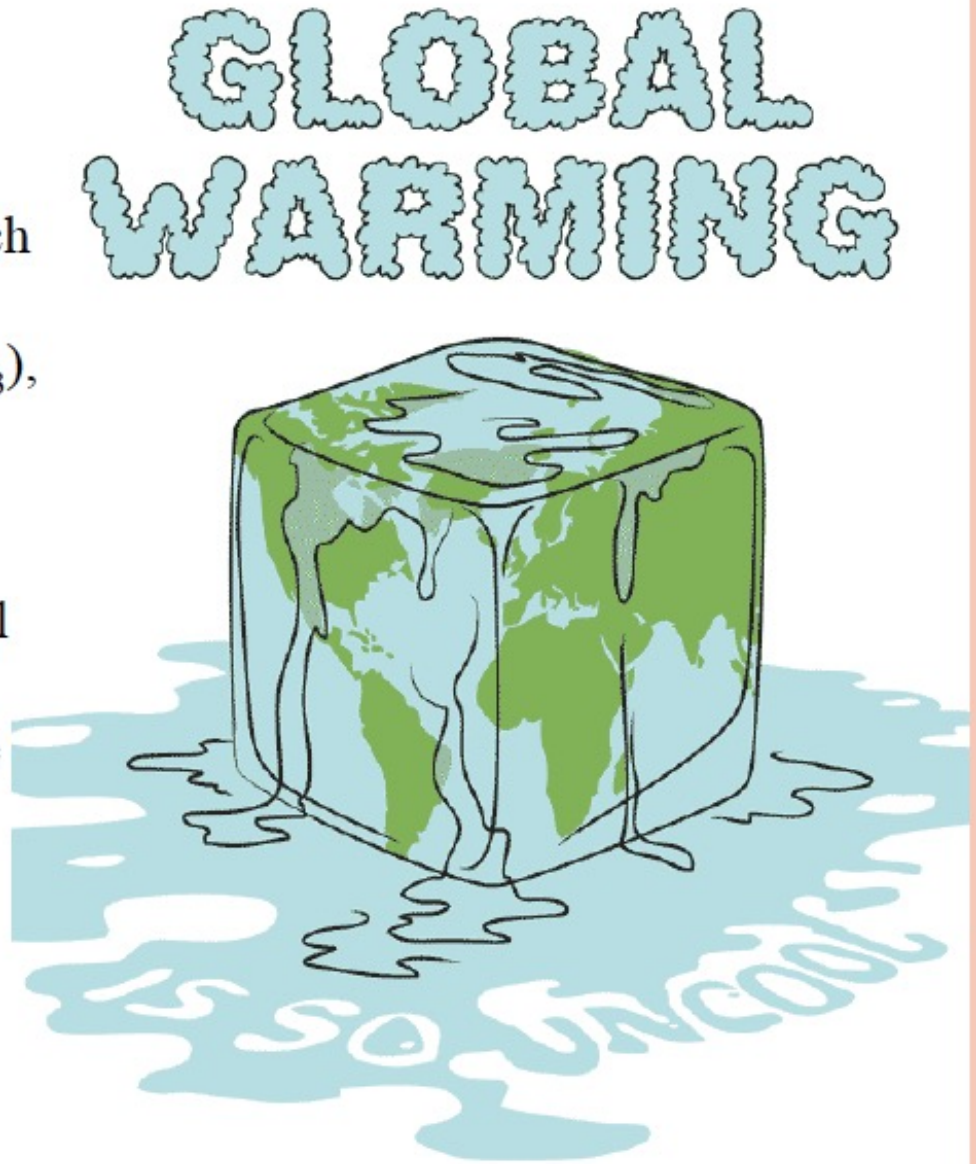
- As we burn fossil fuels like coal, oil and natural gas for energy or cut down and burn forests to create pastures and plantations, carbon accumulates and overloads our atmosphere.

- Certain waste management and agricultural practices aggravate the problem by releasing other potent global warming gases, such as methane and nitrous oxide.

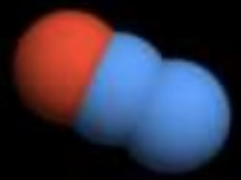
Cont….

- The major greenhouse gases are water vapor, which causes about 36–70% of the greenhouse effect; carbon dioxide (CO_2), which causes 9–26%; methane (CH_4), which causes 4–9%;and ozone (O_3), which causes 3-7%. Clouds also affect the radiation balance.

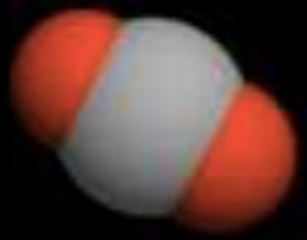
- Human activity since the Industrial Revolution has increased the amount of greenhouse gases in the atmosphere, leading to increased radiative forcing from CO_2, methane, tropospheric ozone, CFCs and nitrous oxide.



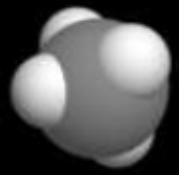
Greenhouse Gases



Nitrous oxide



Carbon dioxide



Methane

Water

Sulfur hexafluoride

Greenhouse Gases

Carbon Dioxide (CO_2)

- Source: Fossil fuel burning, deforestation
- Last 30 years increase: **30%**
- Average atmospheric residence time: **500 year**

Methane (CH_4)

- Source: Rice cultivation, cattle & sheep ranching, decay from landfills, mining
- Last 30 years increase: **145%**
- Average atmospheric residence time: **7-10 years**

Nitrous oxide (N_2O)

- Source: Industry and agriculture (fertilizers)
- Last 30 years increase: **15%**
- Average atmospheric residence time: **140-190 years**

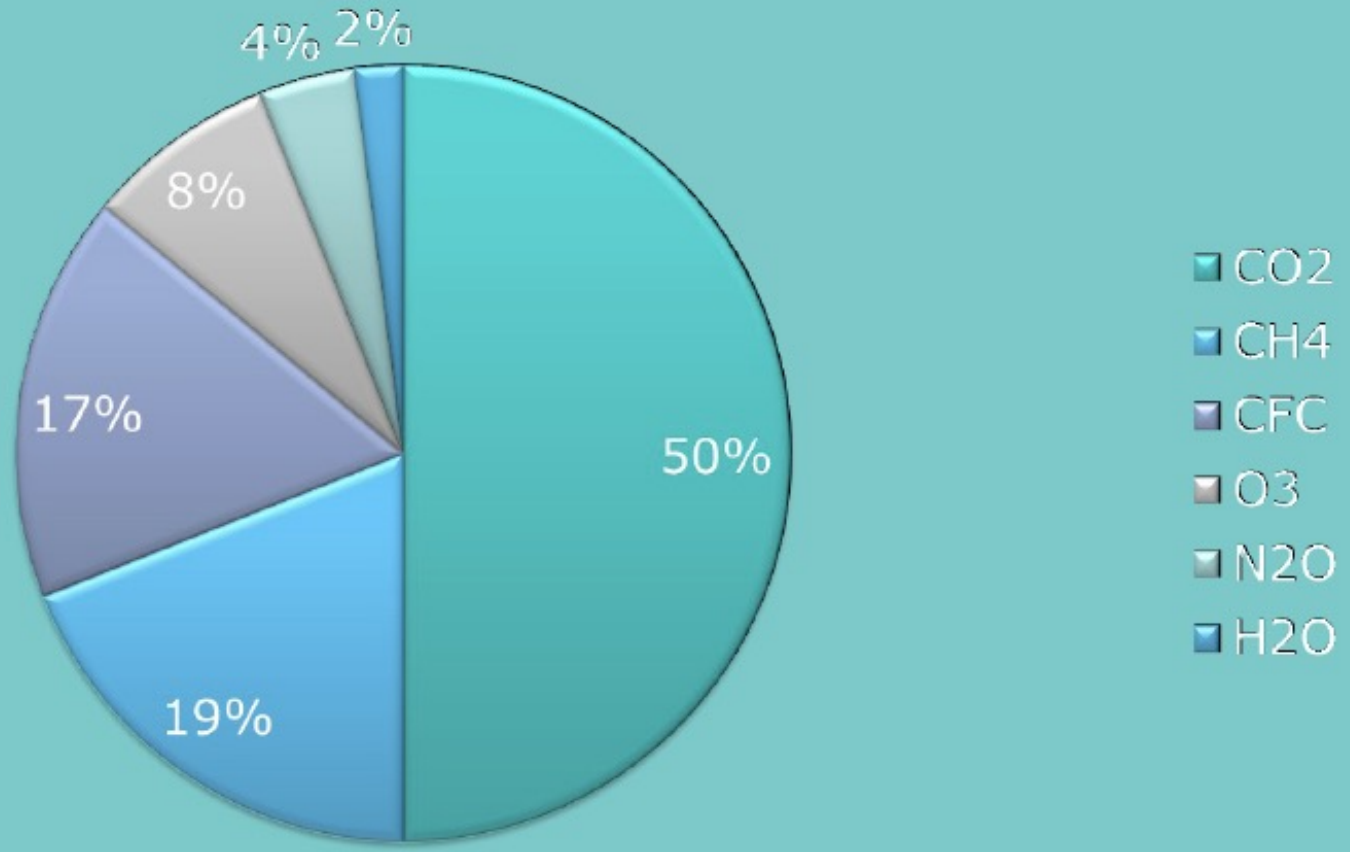
Chlorofluorocarbon

- Sources: Air conditioners, refrigerators, evaporation of industrial solvents, production of plastic foam, etc
- Per year increase : 4%
- Average residence time in atmosphere : 10-15 years

Water vapors

- Strongest greenhouse gas
- because it occur in vapor, cloud droplet and ice crystals and transition between phases

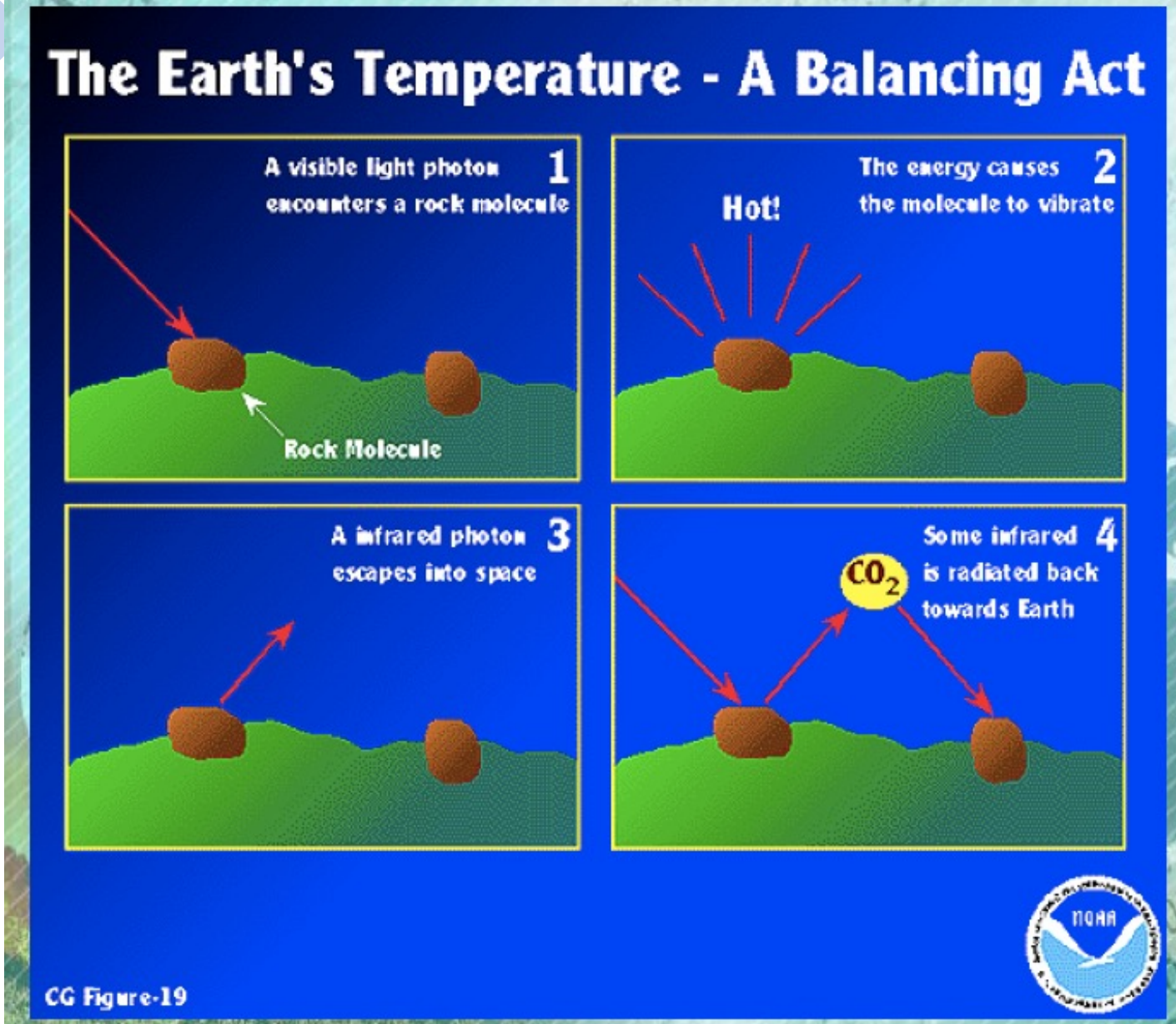
PERCENTAGE COMPOSITION OF GREEN HOUSE GASES



Normal CO_2 Levels

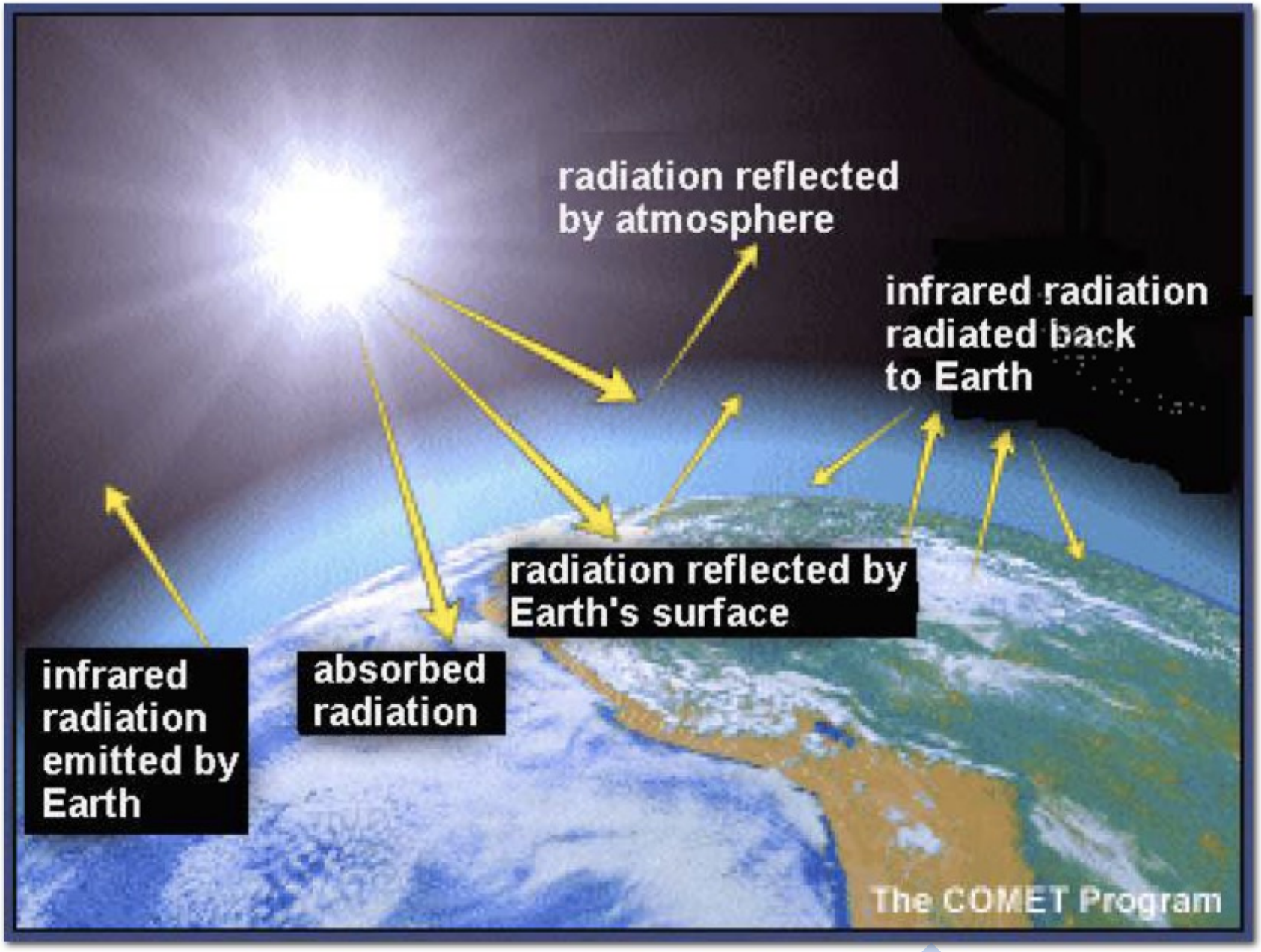
Short Wave and Long Wave Radiation

- Sun emits rays called short wave radiation.
- Short wave radiation is either absorbed intot eh earth's surface or reflected back into space.

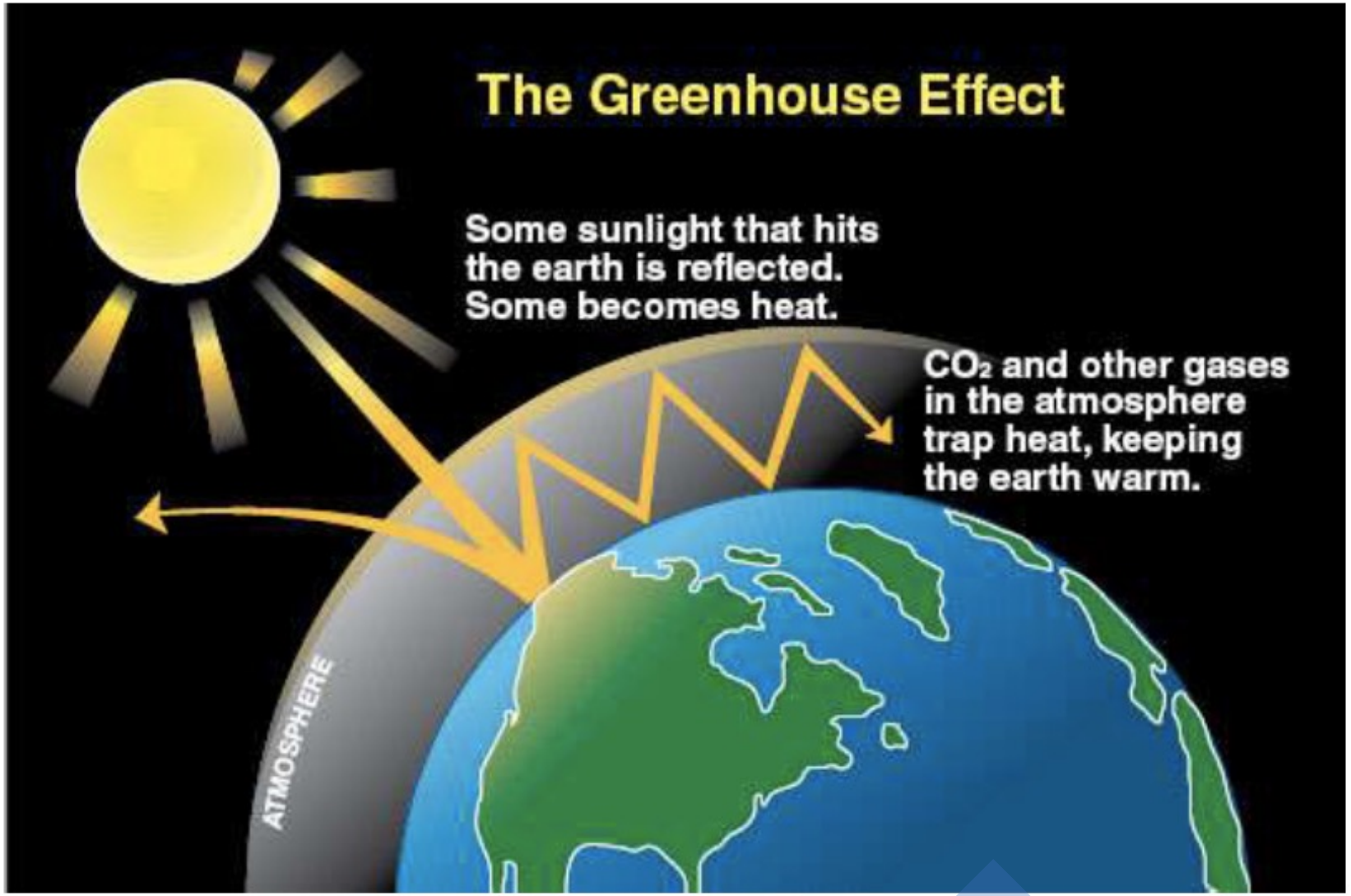


3. Longer, infrared Wavelengths hit Greenhouse gas Molecules in the atmosphere

4. Greenhouse gas Molecules in the Atmosphere emit Infrared radiation Back towards earth


radiation reflected
by atmosphere
infrared radiation
radiated back
to Earth
radiation reflected by
Earth's surface
infrared
radiation
emitted by
Earth
absorbed
radiation
The COMET Program

High CO2 Levels



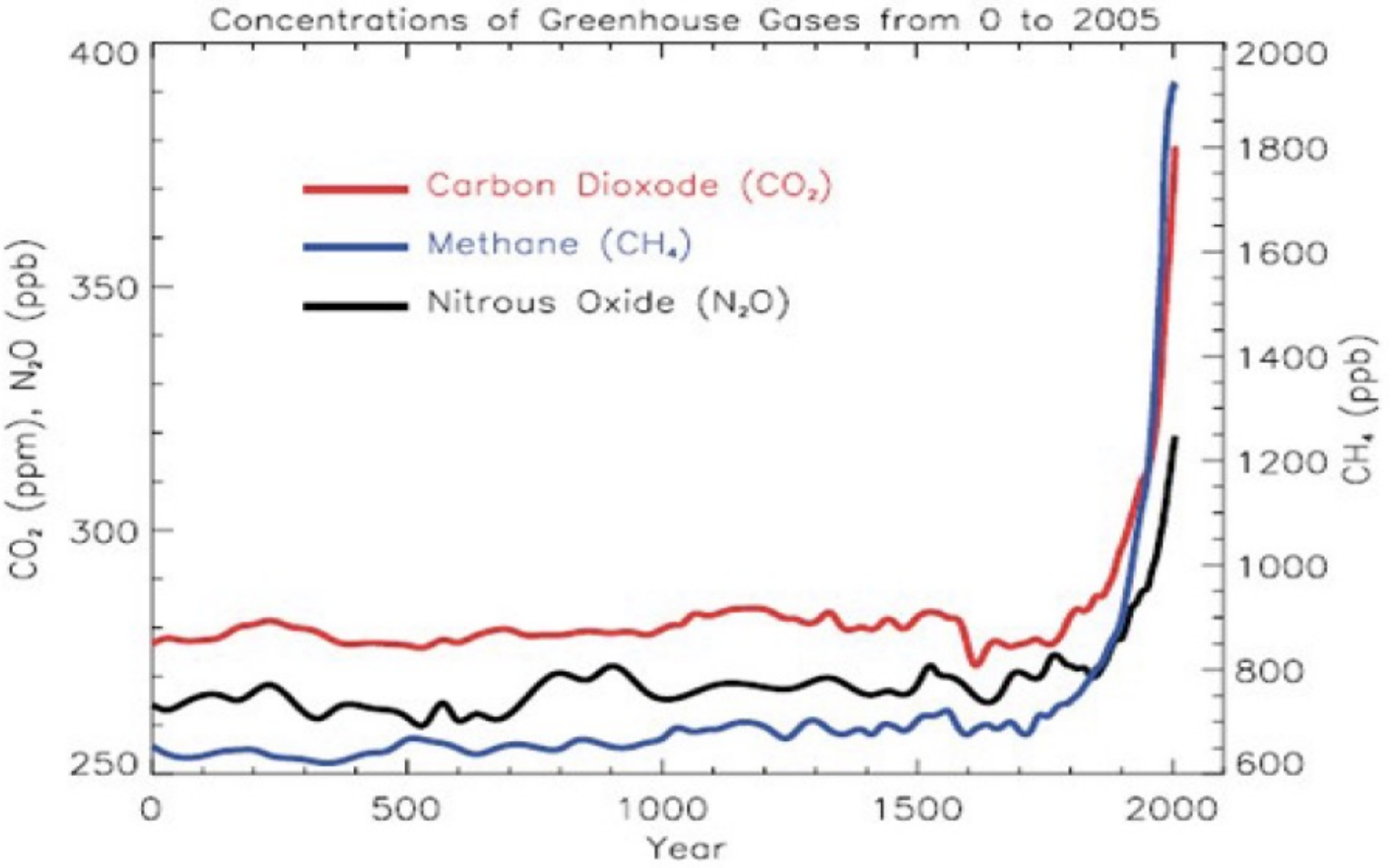
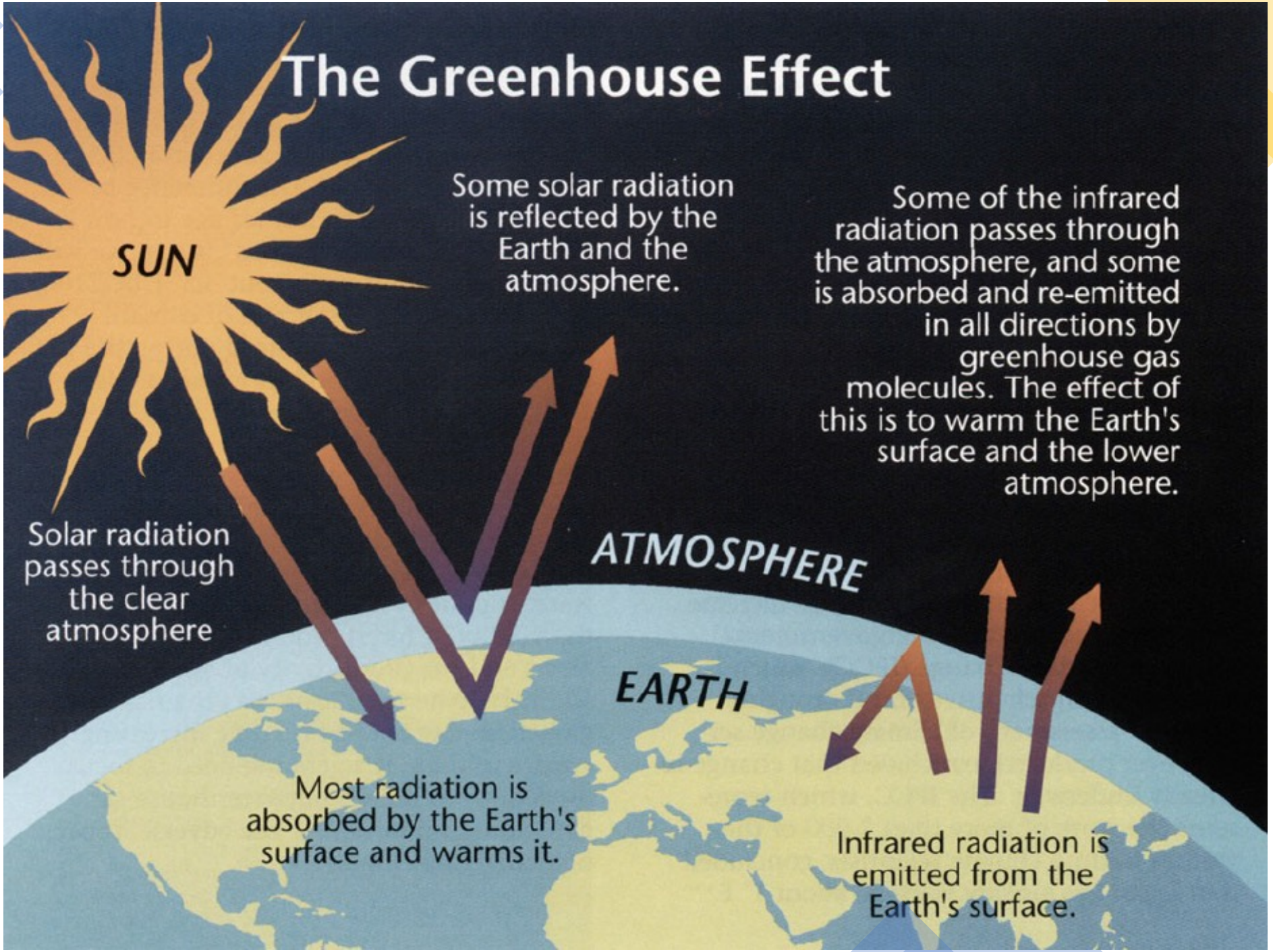


Figure 1. Atmospheric concentrations of important long-lived greenhouse gases over the last 2,000 years. Increases since about 1750 are attributed to human activities in the industrial era. Concentration units are parts per million (ppm) or parts per billion (ppb), indicating the number of molecules of the greenhouse gas per million or billion air molecules, respectively, in an atmospheric sample.

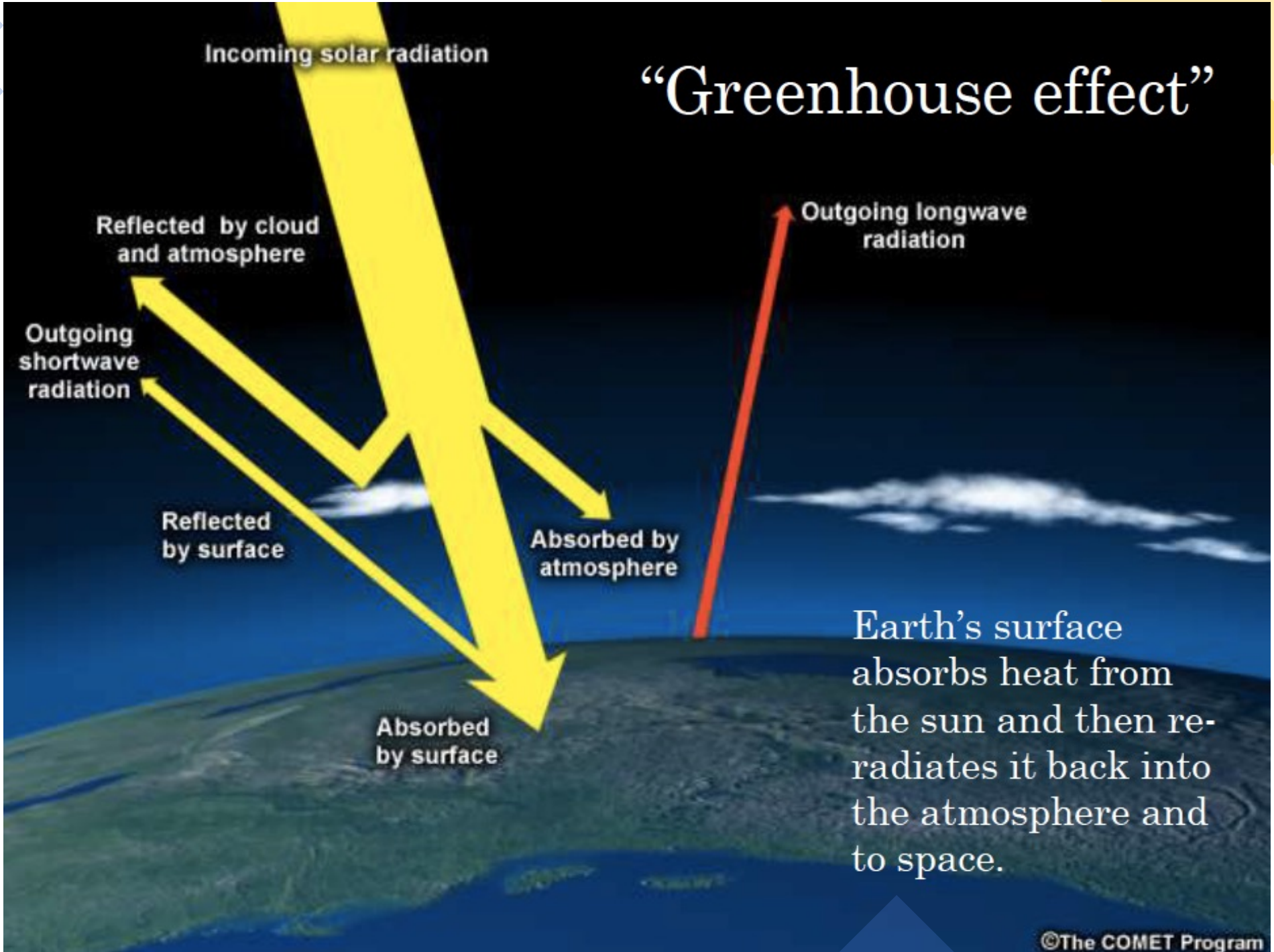
IPCC AR4 FAQ

WHAT IS GREENHOUSE EFFECT ?

- First coined by J-Fourier in 1827 and was investigated by Svante Arhenius
- The greenhouse effect is when the temperature rises because the sun's heat and light is trapped
- The Earth's surface thus receives energy from two sources: the sun & the atmosphere
  - As a result the Earth's surface is ~33°C warmer than it would be without an atmosphere


The Greenhouse Effect
SUN
Some solar radiation is reflected by the Earth and the atmosphere.
Some of the infrared radiation passes through the atmosphere, and some is absorbed and re-emitted in all directions by greenhouse gas molecules. The effect of this is to warm the Earth's surface and the lower atmosphere.
Solar radiation passes through the clear atmosphere
ATMOSPHERE
EARTH
Most radiation is absorbed by the Earth's surface and warms it.
Infrared radiation is emitted from the Earth's surface.

“Greenhouse effect”



Earth’s surface absorbs heat from the sun and then re-radiates it back into the atmosphere and to space.

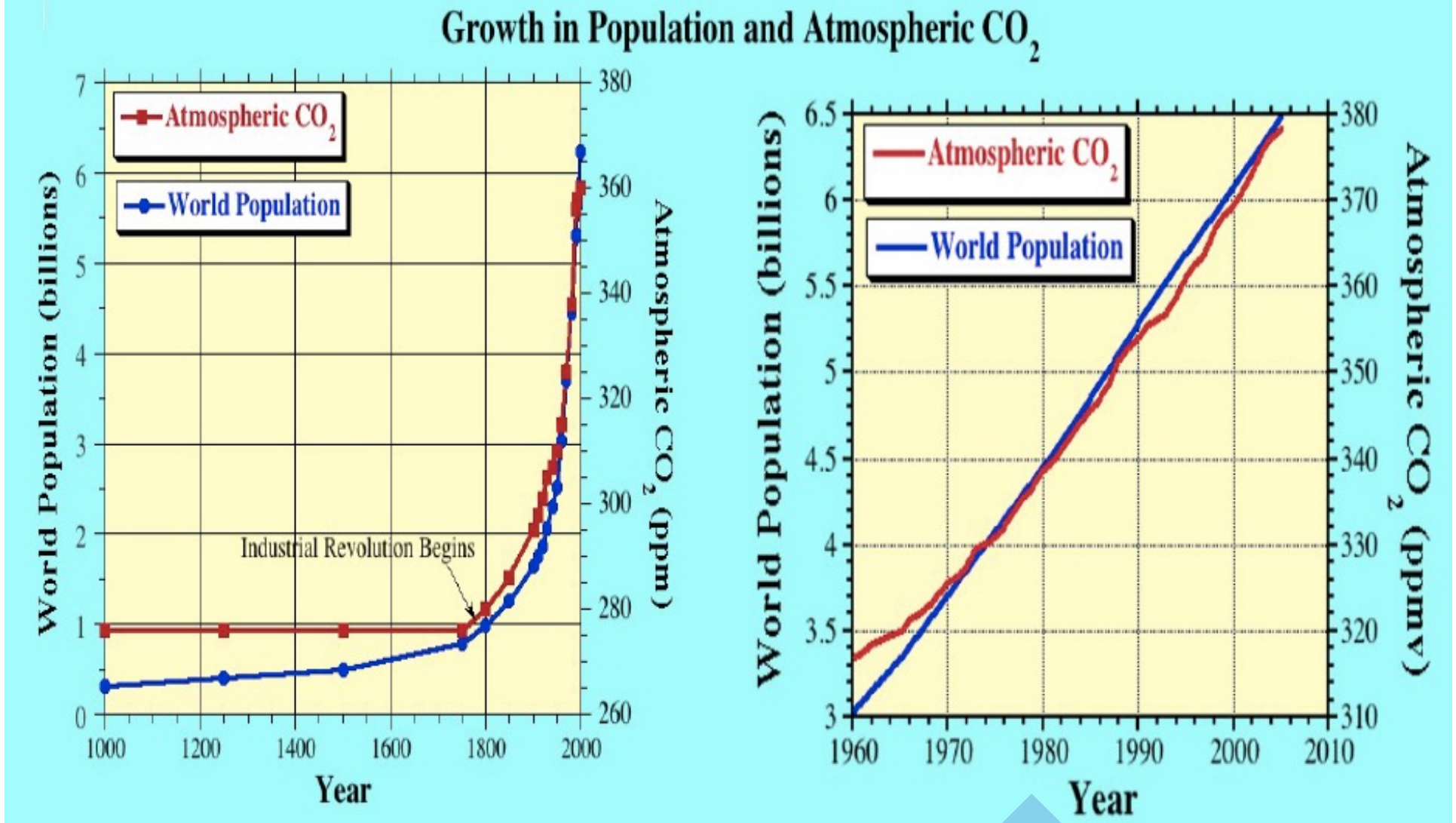
Increasing greenhouse gases trap more heat

Much of this heat is absorbed by greenhouse gases, which then send the heat back to the surface, to other greenhouse gas molecules, or out to space. Though only 1% of atmospheric gases are greenhouse gases, they are extremely powerful heat trappers.

By burning fossil fuels faster and faster, humans are effectively piling on more blankets, heating the planet so much and so quickly that it's hard for Mother Nature and human societies to adapt.

- Pollution is one of the biggest manmade problems leading to global warming
- Burning fossil fuels
- Green house gas CO_2
- Mining coal and oil
- Population
- More food, more methane, more burning of fossil fuels
- Transportation

EFFECT OF POPULATION

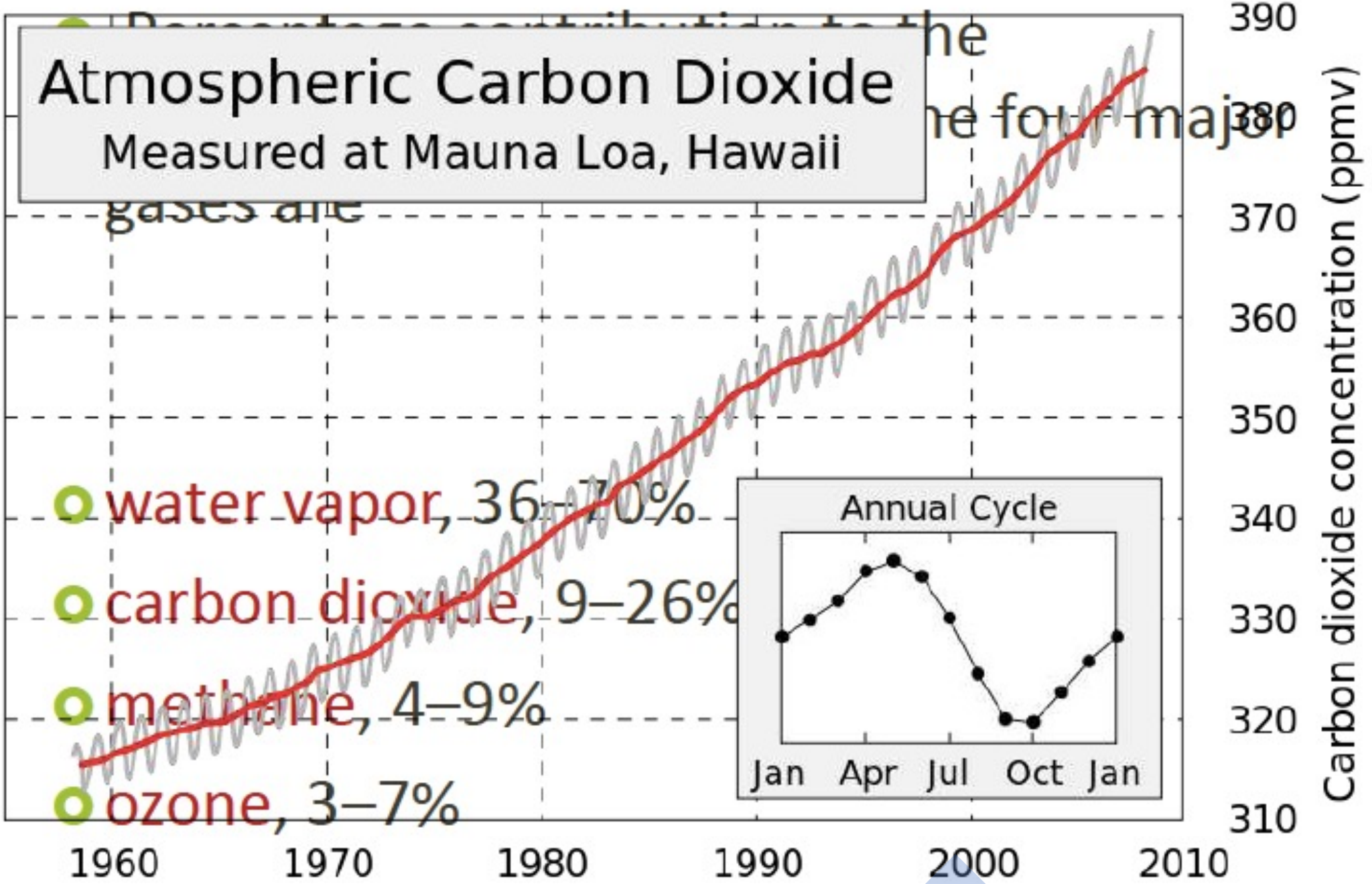


Population and Resources

Nearly 80 million people are added each year to the global population mostly coming from the developing world.

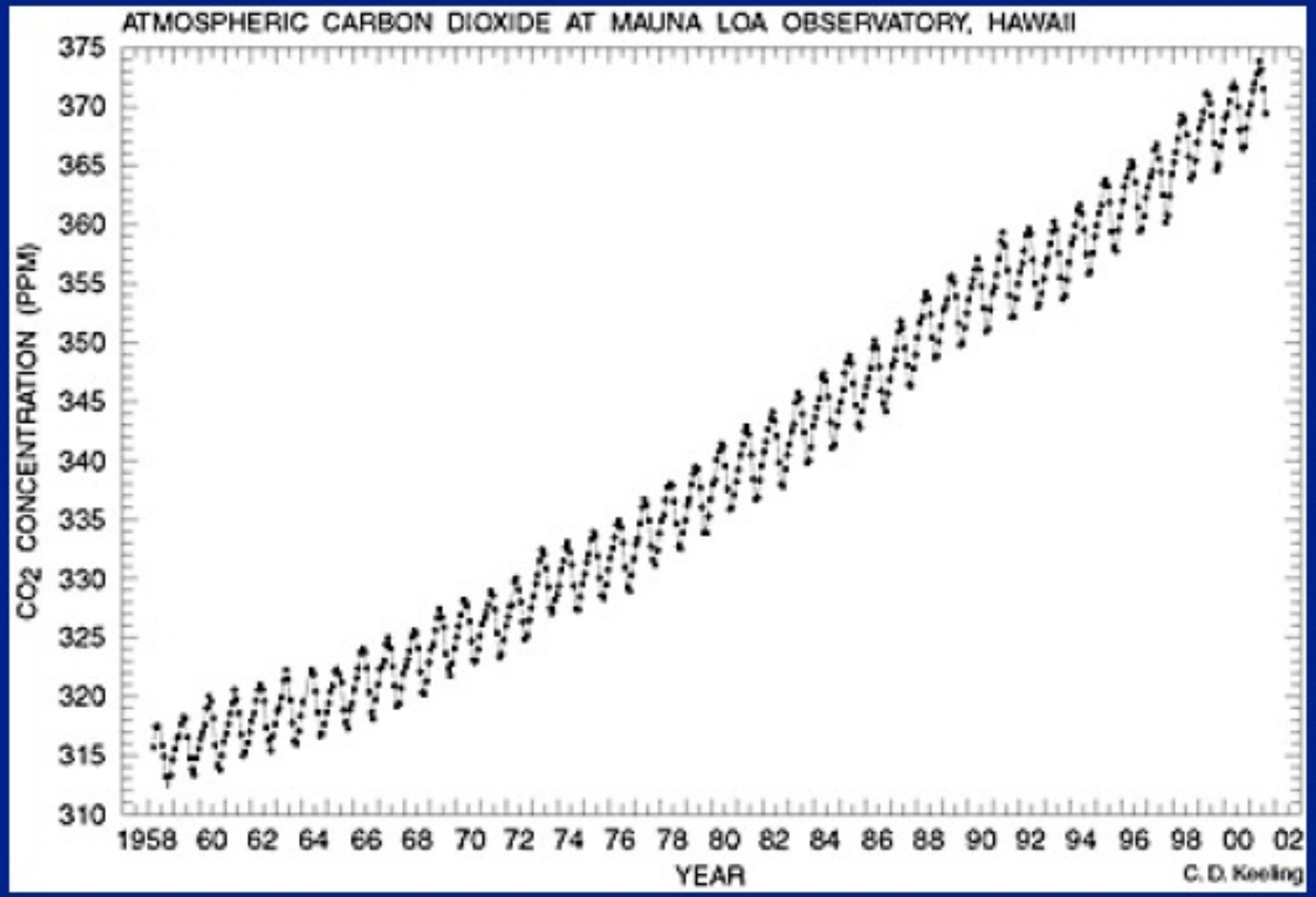
Burgeoning population puts additional stress to the already strained resources and system.

However nearly 95% of the earth's resources are consumed by only 20% of the world's population living in the developed world.


Atmospheric Carbon Dioxide
Measured at Mauna Loa, Hawaii
water vapor, 36–70%
carbon dioxide, 9–26%
methane, 4–9%
ozone, 3–7%
Annual Cycle
Jan
Apr
Jul
Oct
Jan
1960
1970
1980
1990
2000
2010
310
320
330
340
350
360
370
380
390
Carbon dioxide concentration (ppmv)

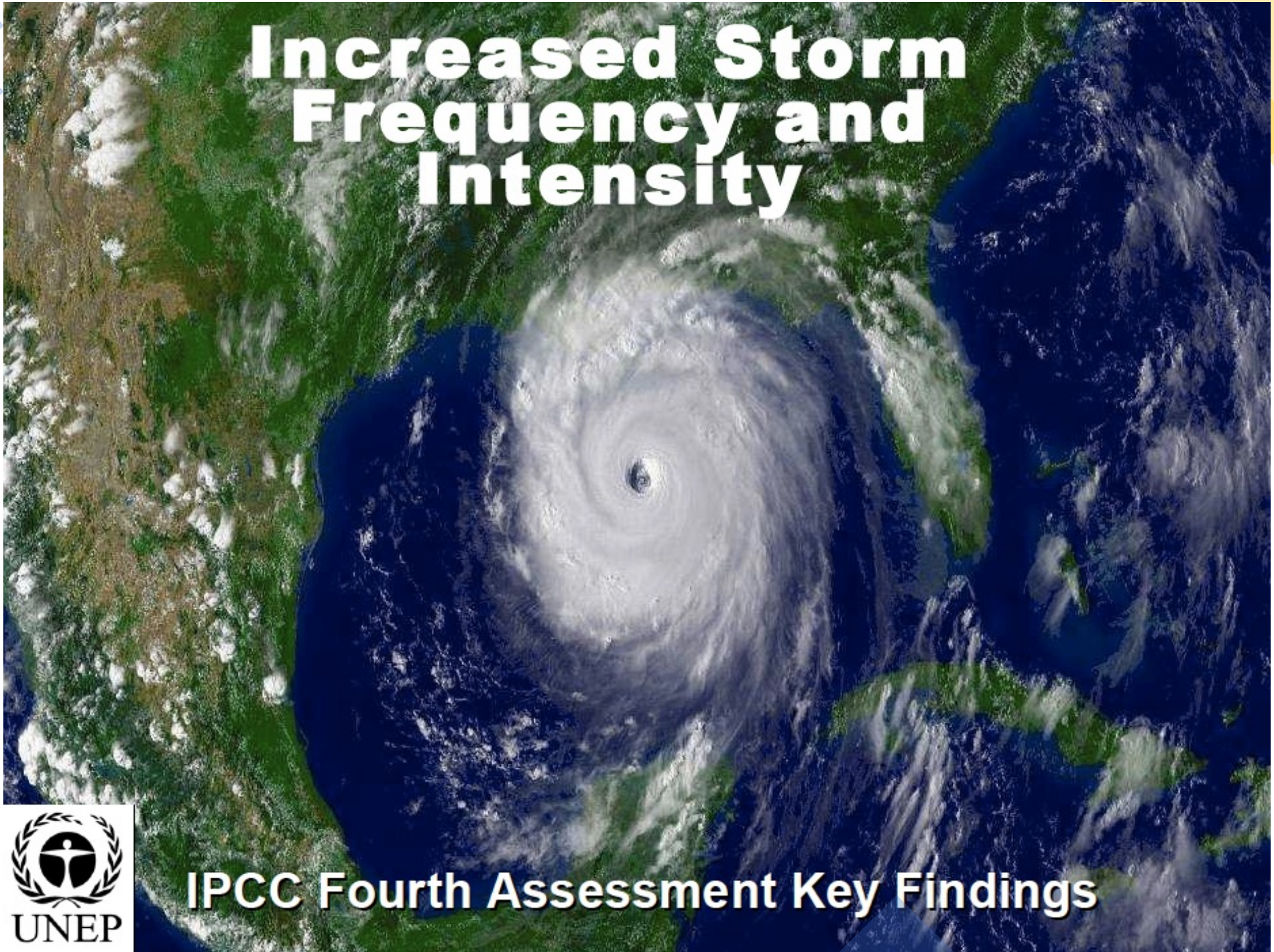
concentrations of carbon dioxide.

Is it due to human activity?



Effects of Global Warming

- Sea level rise is accelerating.
- Planet's temperature is rising.
- Dangerous heat waves are becoming more common.
- Extreme storm events are increasing in many areas. More severe droughts are occurring in others. Warmer weathers favoring prairie fires and prairie droughts.
- These have significant and serious effects on human health.
- Canada's Arctic region's sea ice is shrinking.
- In British Columbia, salmon survival decreased by 1/3 since early 1990s.
- Decrease in the population of polar bears


Increased Storm Frequency and Intensity
UNEP
IPCC Fourth Assessment Key Findings

Increasing temperatures and changing landscapes of the Arctic circle

- 1> Will endanger several species. Only those who adapt will survive

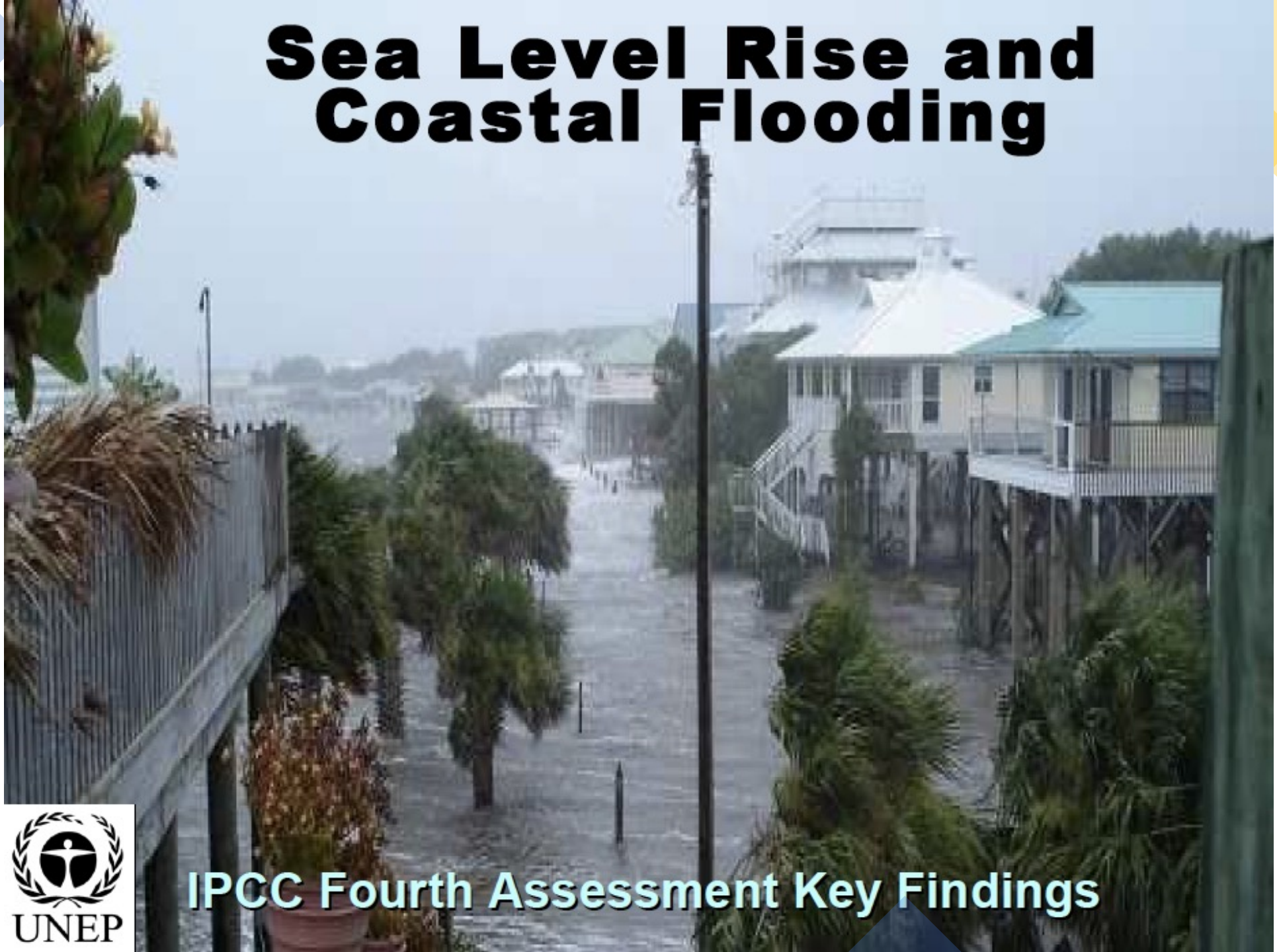
- 2> Increased temperature could lead to extinction of up to one million species. And we can not exist without diversity of species on Earth

Melting Ice: Unbalanced Global Ecosystem

- 1>Desalination due to melting of polar ice caps.

  2>Leading to change in current patterns and further erratic change in climate leading to loss of indigenous species

Sea Level Rise and Coastal Flooding



IPCC Fourth Assessment Key Findings

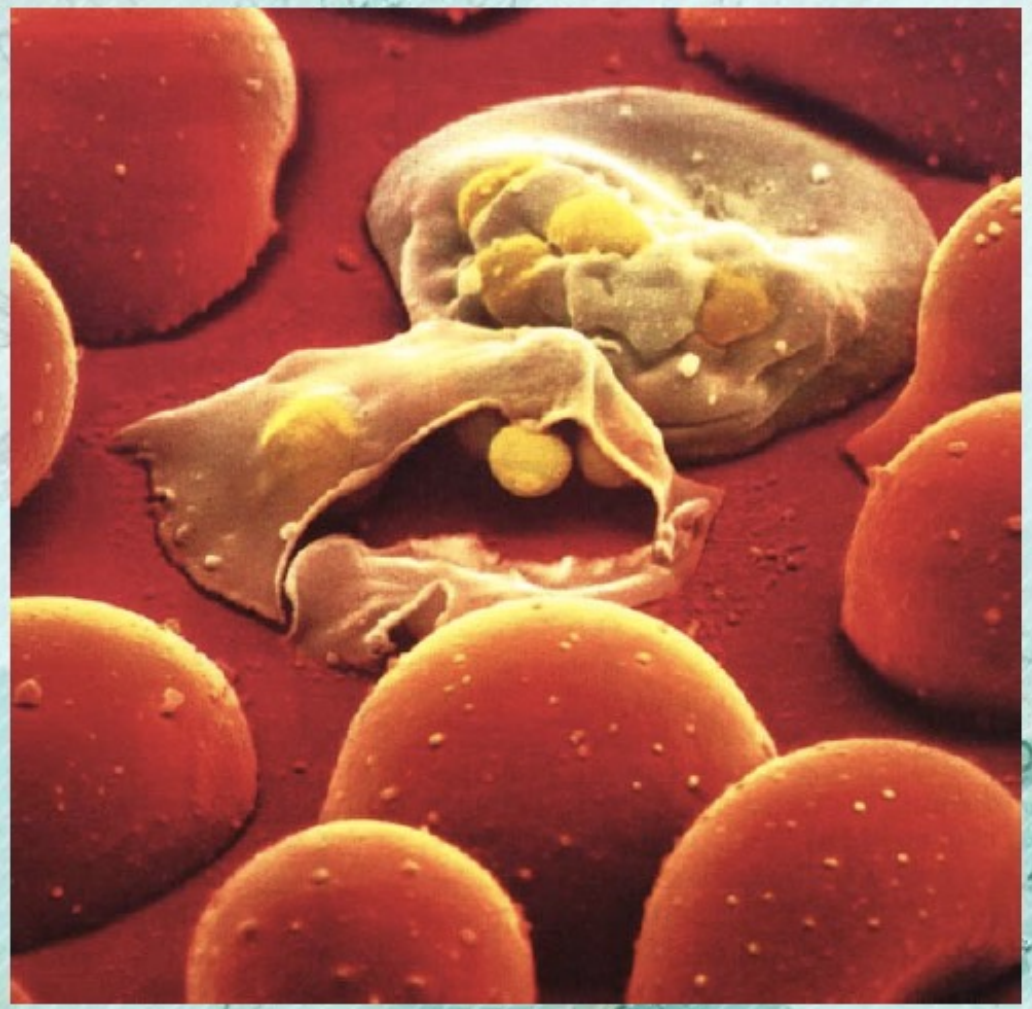
UNEP


1> Droughts will be the largest in Africa
2> There is 90% chance that 3 billion people worldwide having to choose between family moved to areas with milder climatic conditions or starvation due to climate change in the next 100 years
Increased Drought


Increasing Risk of
Catastrophic Fires

Spread of Disease

- After warming the Nordic countries, diseases carried by insects migrate north, bringing plague and disease with them. Scientists believe that in some countries due to global warming, malaria has not been completely exterminated.



CASE STUDIES

Damage to coral reefs, Pacific

The severity of periodic warming due to El Nino in 1997 in the Pacific led to the most serious death in coral ever known. It is estimated that about 10% of the Earth's coral reefs were dead, another 30 % were seriously affected and another 30% were degraded. The Global Coral Reef Monitoring Network Townsville, Australia, has predicted that all the reefs could be dead by 2050.

Butterfly populations in the United Kingdom

Global warming is leading to an early arrival of butterflies in Britain. Scientists say that butterflies can now be spotted much earlier every year in the last two decades. Some, like the red admiral, can now be seen a month earlier than was the case in the mid – 1970s. Others, like the peacock and the orange tip are appearing between 15 and 25 days earlier than in the past. Future rise in temperature is likely to have a detrimental effect on these butterflies. Some butterflies whichneed cooler temperatures might suffer.


Global Warming impacts will cost
20 times more than reducing our
emissions *now*.*

The Kyoto Protocol

- December 1997 – 180 countries

agreement among industrialized countries to reduce emission of six greenhouse gases

Canada – agreed to cut emissions

US – withdrew in 2001. US has been responsible for 25% of worldwide emissions. This withdrawal was a big setback to the Kyoto Protocol.

How to Reduce Global Warming

- Produce more fuel-efficient vehicles.
- Reduce vehicle use.
- Improve energy efficiency in buildings.
- Develop carbon capture and storage processes.
- Increase solar power.
- Stop deforestation.

Reduce our consumption of fossil fuels

Because greenhouse gas emissions are tied very closely to our energy consumption, using less fossil fuel based energy puts fewer greenhouse gases into the atmosphere.

This will help slow global warming.

Producing more and more electricity thanks to wind or water power

Use fewer and fewer power stations

Small changes really add up

Replace your old refrigerator with a new Energy Star:
Annual savings:
$90; 700 pounds CO_2

Set your thermostat down a few degrees in the winter
Annual savings:
$135; 1400 pounds CO_2

Drive JUST 10 fewer miles per week
Annual savings:
$80; 520 pounds CO_2

Wash clothes in cold water only
Annual savings:
$70; 500 pounds CO_2

Reduce your garbage by 10% through greater recycling or reduced packaging
Annual savings:
1200 pounds CO_2

Caulk and weather-strip around doors and windows
Annual savings:
$80; 650 pounds CO_2

* These are mid-range estimates from published sources; your savings may vary.

We can make some simple substitutions

Replacing just 1 incandescent light bulb with 1 compact florescent bulb saves about 150 pounds of carbon dioxide per year!

Source: http://www.energystar.gov

Building vehicles that :

- use less petrol or energy
- and are equipped with catalytic converters

Steps which We Can Take

- Reuse shopping bags
- Plant a tree.
- Buy fresh foods instead of frozen.
- Start a car pool with your co-workers or classmates.
- Keep your car tuned up.
- Protect forests worldwide.
- Fly less.

Thank you.