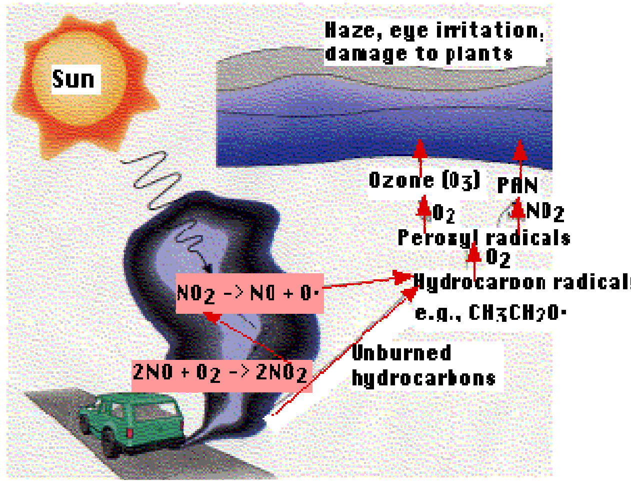
Secondary Pollutants of NO ➔ PHOTOSMOG

Photochemical smog

In bright sunlight

- nitrogen oxides (NOx)
- hydrocarbons and
- oxygen



Interact chemically to produce powerful oxidants like **ozone** (O_3) and **peroxyacetyl nitrate** (**PAN**).

These **secondary pollutants** are damaging to plant life and lead to the formation of photochemical smog. PAN is primarily responsible for the eye irritation.

The figure outlines representative reactions leading to the formation of photochemical smog.

Radicles are atoms or molecules with unpaired electrons. They are very reactive chemically.

The catalytic converter in automobile exhaust systems reduces air pollution by oxidizing hydrocarbons to CO_2 and H_2O and, to a lesser extent, converting nitrogen oxides to N_2 and O_2.

PHOTOSMOG

- was observed for the first time in Los Angeles about 50 years ago.
- present in all metropolitan areas where heavy road traffic is accompanied by clear skies and stagnant atmosphere (sunny day & no wind).
- The sequences of the steps leading to photo smog starts with the formation of nitrogen oxides produced by car engines or during any other combustion process.

$2\,NO + O_2 \rightarrow 2\,NO_2$ $2NO_2 \xrightarrow{sun} NO + \underbrace{O\bullet}_{Atomic\ Oxygen}$

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$$O\bullet + O_2 \rightarrow O_3 (Ozone) \qquad O_3 + NO \rightarrow O_2 + NO_2$$

$$Hydrocarbon + O\bullet \longrightarrow \underbrace{\bullet RO_2}_{alkylperoxy\ radicals}$$

$$\bullet RO_2 + NO \rightarrow NO_2 \quad \bullet RO_2 + O_2 + NO_2 \rightarrow Peroxyacetyl\ nitrate (PAN)$$

EFFECTS OF OZONE

- Although ozone in the stratosphere is essential to sustain life, its presence in the low troposphere is extremely hazardous.
- The ozone molecules oxidize matter and destroy vegetation.
- Its inhalation by humans and animals cause acute and chronic problems of the respiratory tract and lungs.

GLOBAL ATMOSPHERIC POLLUTION

- Ozone depletion
- Global Warming

OZONE DEPLETION

Photochemistry

Photochemical reactions: Chemical reactions which are driven by light

Photoreactions in the upper atmosphere (stratosphere) are responsible for the presence of the ozone layer.

Formation of ozone:

$$O_2 \xrightarrow{\lambda<280} O\bullet + O\bullet$$

$$O_2 + O \longrightarrow O_3$$

Destruction of ozone:

$$O_3 \xrightarrow{280<\lambda<320} O_2 + O\bullet$$

$$O_3 + O \longrightarrow 2O_2$$

These reactions take place in the stratosphere

Both photochemical reactions, creating and destroying ozone, are in dynamic equilibrium and effectively capture all incoming short wavelength UV radiation.

Consequently, almost no radiation of wavelength shorter than 300 nm reaches the surface of the Earth.

FACTORS AFFECTING OZONE DEPLETION

man made chemicals in the atmosphere.

very reactive and quickly disintegrate to harmless components or give rise to secondary air pollutants.

inert and transparent to the light reaching troposphere.

Chloroflurocarbons

- About 50 years ago, a new family of chemicals was discovered and named chloroflurocarbons (CFCs).

- CFCs are also known as Freons, are chemicals with varying numbers of carbon, chlorine, and fluorine atoms.

- Being nontoxic, noncorrosive and nonflammable, CFCs are ideal for foams blowing and aerosols, as industrial solvents and as a cooling medium in refrigerators and air conditioners.

- The production of CFCs quickly climbed to millions of tons yearly.

- CFCs are also very stable molecules,

- stay in the atmosphere for hundreds of years, finally reaching the stratosphere where short wavelength UV radiation eventually breaks them, liberating chlorine radicals.

Destruction of ozone by CFCs

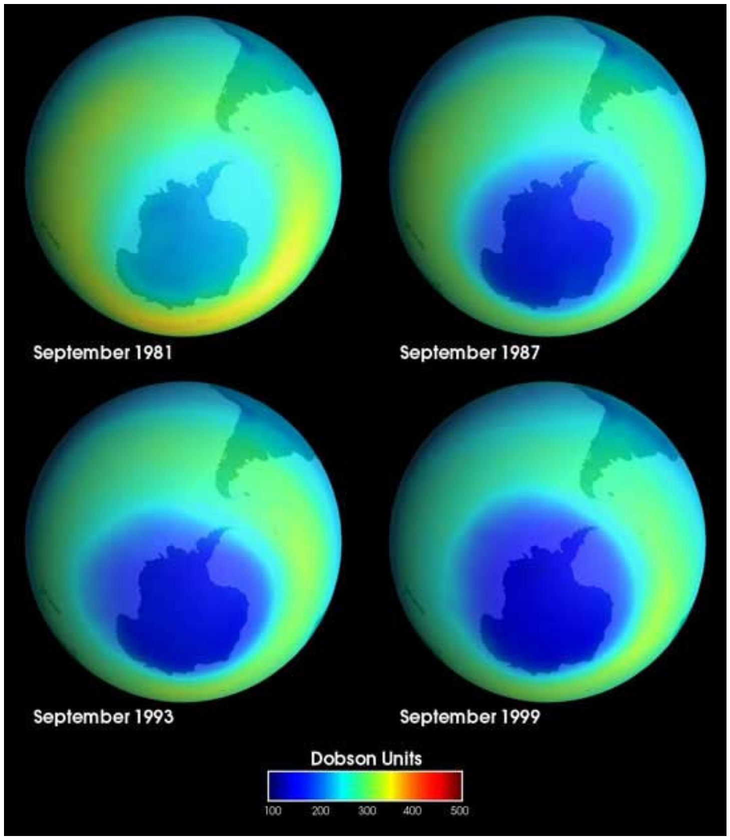
$$CCl_2F_2 + UV \rightarrow Cl + CClF_2$$

$$Cl + O_3 \rightarrow ClO + O_2$$

$$ClO + O \rightarrow Cl + O_2$$

$$O_3 + UV \rightarrow O + O_2$$

net $2O_3 \rightarrow 3O_2$



- Presently, there are about 20 million tons of CFCs in the atmosphere and ozone layer is already severely depleted.

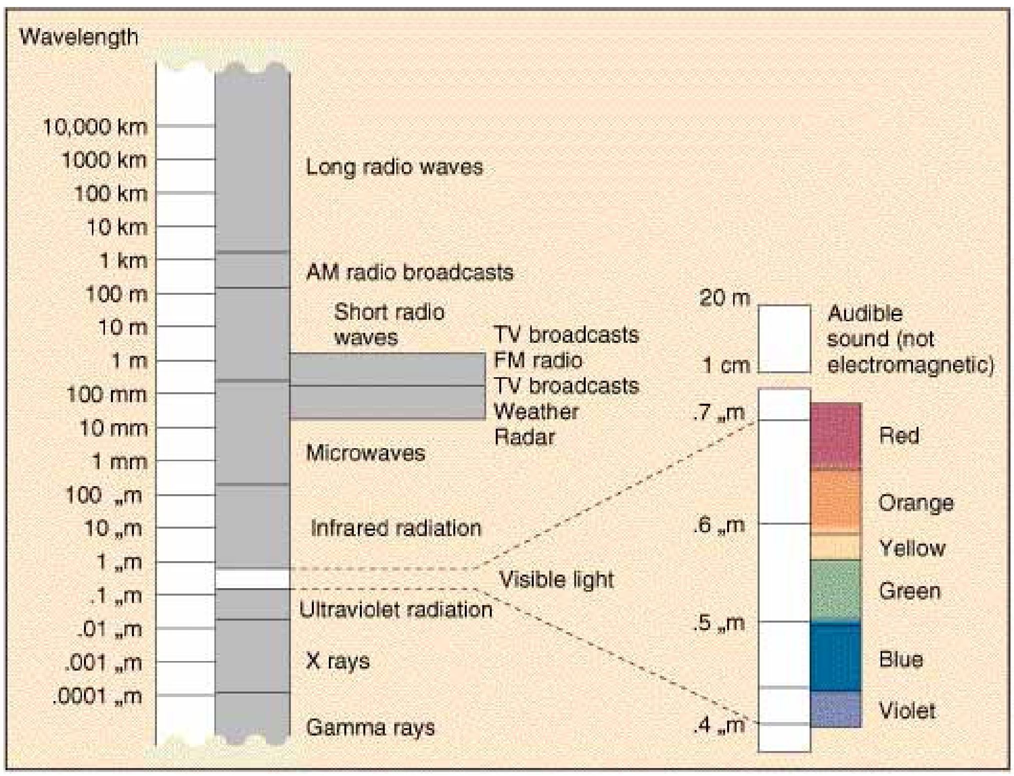
- Consequently more of the short wavelength UV radiation can reach the Earth's surface.

- Even with the total phaseout of CFCs, ozone layer would not be recovered fully in the next 50 years.

- Concentration of CFCs is particularly high in polar regions.

- Complete destruction of ozone layer around the poles, known as the ozone holes.

- Apart from their ozone depleting potential, CFCs are also greenhouse gases. The global warming potential of CFC-11 ($CFCl_3$) is approximately 5000 times greater than that of CO_2.



Potential Effects of Depleted Ozone

It is customary to break up the UV spectrum into two parts:

UV-A: 400 - 320 nm

UV-B: 320 - 290 nm

- The more energetic UV-B portion of the spectrum is responsible for;
    - sunburn,
    - cataracts,
    - potential ecological damage and
    - skin cancer
- It can be absorbed by glass as well as by sunscreens and hats.
- Increased UV-B exposure at the Earth's surface can impact human, agriculture and forest growth, marine ecosystems, biogeochemical cycles, and materials.

Table 1. Potential Effects of UV-B Increases.

Effects	State of Knowledge	Potential Global Impact
Plant Life	Low	High
Aquatic Life	Low	High
Skin Cancer	Moderate to High	Moderate
Immune System	Low	High
Cataracts	Moderate	Low
Climate Impacts*	Moderate	Moderate
Tropospheric Ozone	Moderate	Low**

* Contribution of both stratospheric ozone depletion itself and gases causing such depletion to climate changes.

**Impact could be high in selected areas typified by local or regional scale surface-level ozone pollution problems.

What is being Done?

International Policy

After the presence of ozone hole over Antarctica was confirmed in 1985, many of the world's government decided to act.

In 1987 ➔ The Montreal Protocol was signed which called for 50% reduction in CFCs production by 1999

In 1990 ➔ responding to the accelerating of ozone loss, international delegates met in London and agreed to a total phase out of CFCs by the year 2000

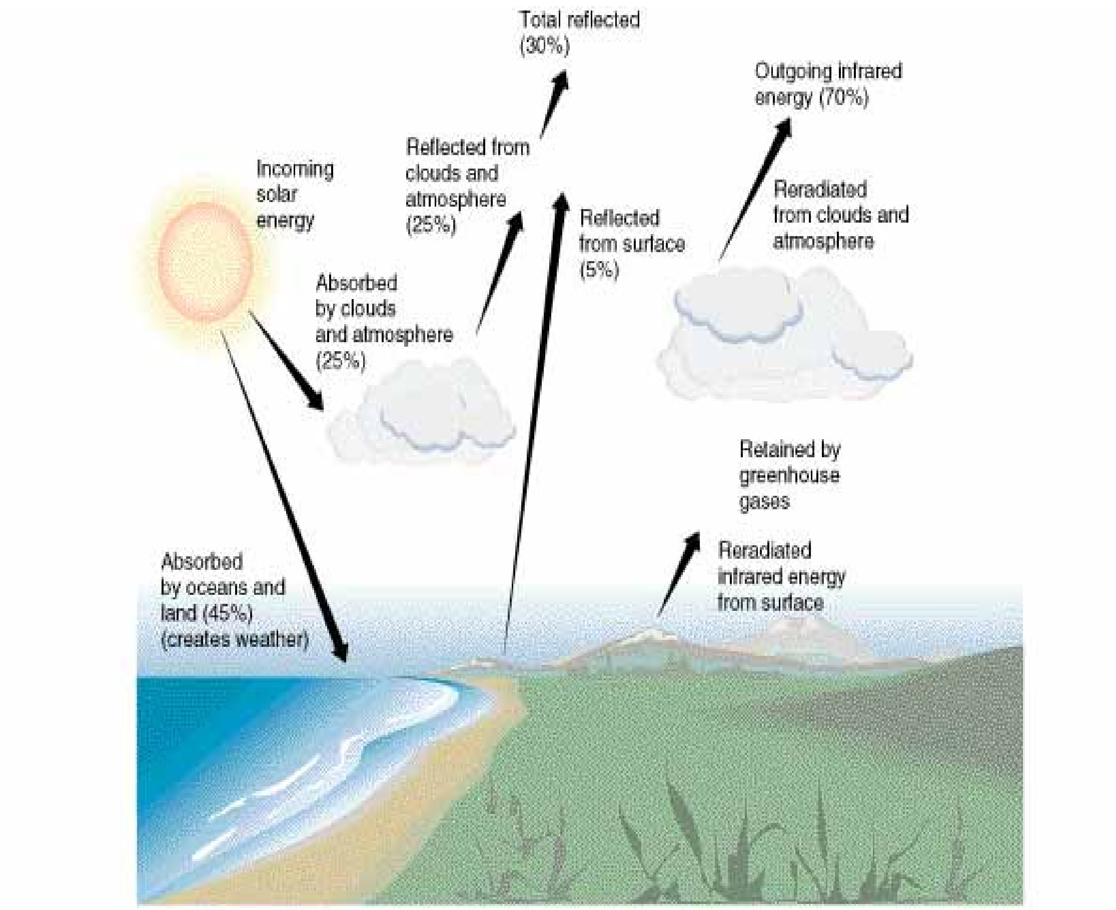
In 1992 ➔ at the Copenhagen Conference, the European Community decided to ban the use of halons present in fire extinguisher by 1994 and CFCs by 1995.

In 1994 ➔ European refrigerator and foam manufacturers used only 15% of CFCs they used in 1986.

The global consumption of CFCs dropped from 1.3 billion kilograms in 1988 to about 360 million kilograms in 1995, 90% being produced in developing countries.

Developing countries especially, India and China do not feel responsible for the destruction of the ozone layer and do not want undergo expensive technology changes

Global Warming



Incoming sun	}	30% reflected back to space 70 % absorbed by the oceans, land and atmosphere

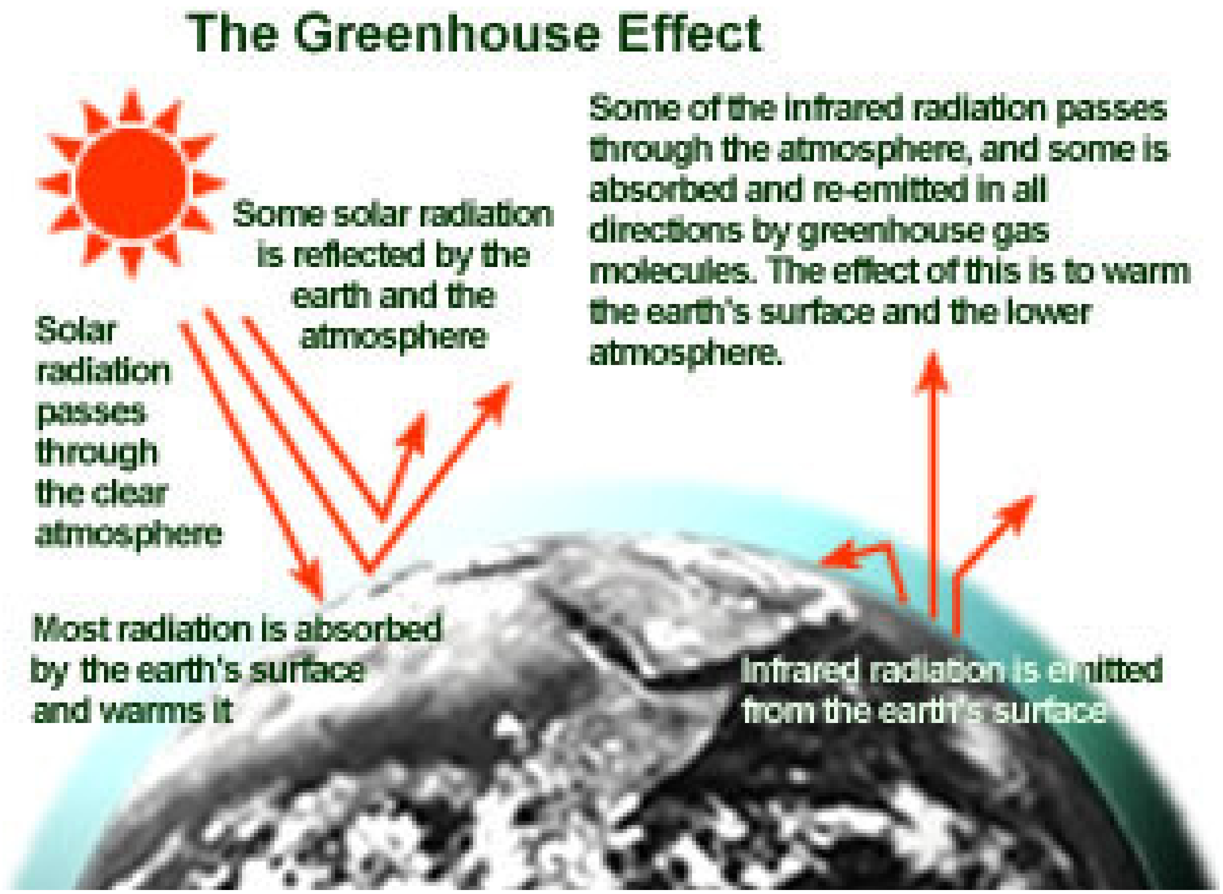
Most of the sun's energy is radiated in the visible part of the spectrum (400 to 700 nm) which passes through the atmosphere without being absorbed and warmed the surface of the Earth.

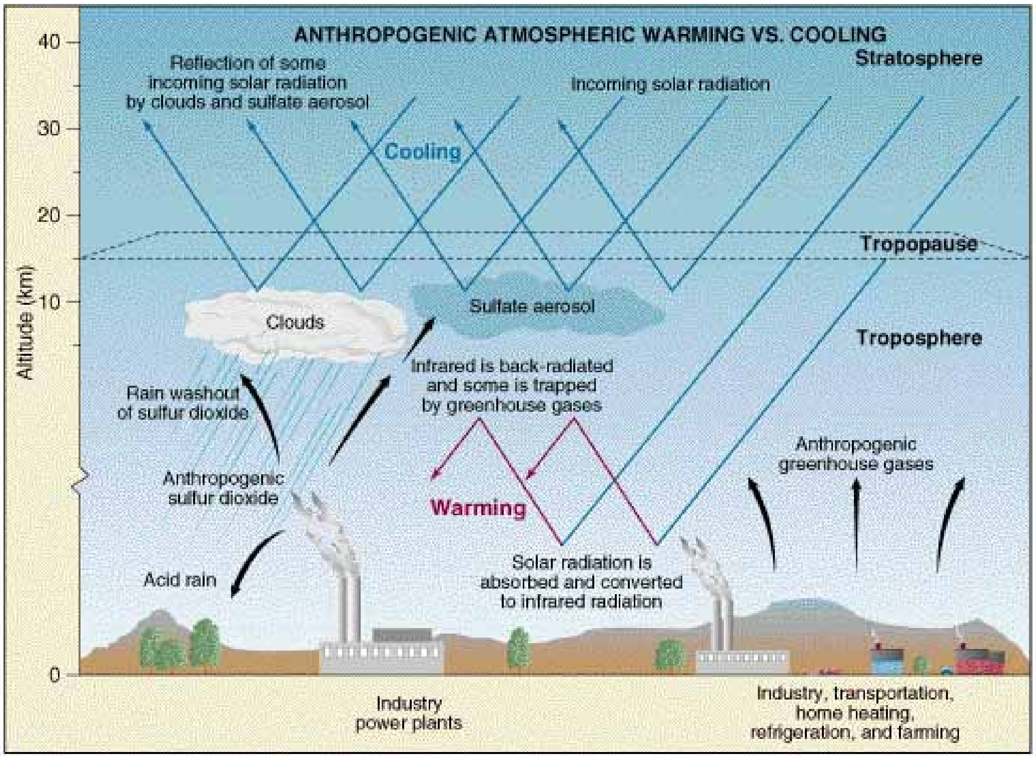
Accordingly, the atmosphere is mainly heated from below, by the warm surface.

Although direct conduction of heat from the surface warms the atmosphere, the main warming effect rises from the fact that the Earth's surface radiates in the infrared part of the spectrum which is adsorbed by radiation absorbed by some molecules in the lower atmosphere.

The temperature of the earth's surface is determined mainly by the infrared absorbing molecules present in the atmosphere, the most important being water vapour, carbondioxide and ozone.

Trace gases such as methane, ammonia, and certain chlorinated hydrocarbons also add to the heat-retaining properties of the atmosphere.

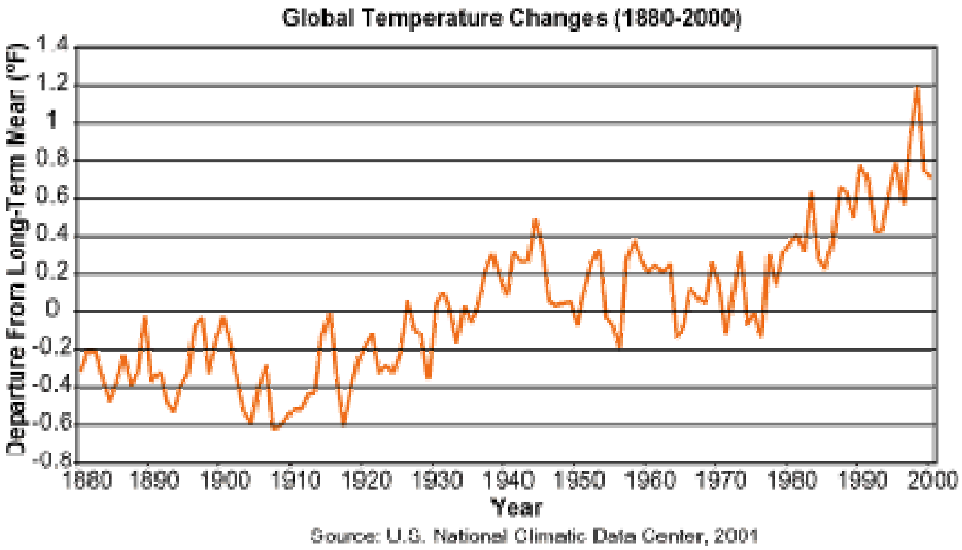

The Greenhouse Effect
Some solar radiation is reflected by the earth and the atmosphere
Some of the infrared radiation passes through the atmosphere, and some is absorbed and re-emitted in all directions by greenhouse gas molecules. The effect of this is to warm the earth's surface and the lower atmosphere.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



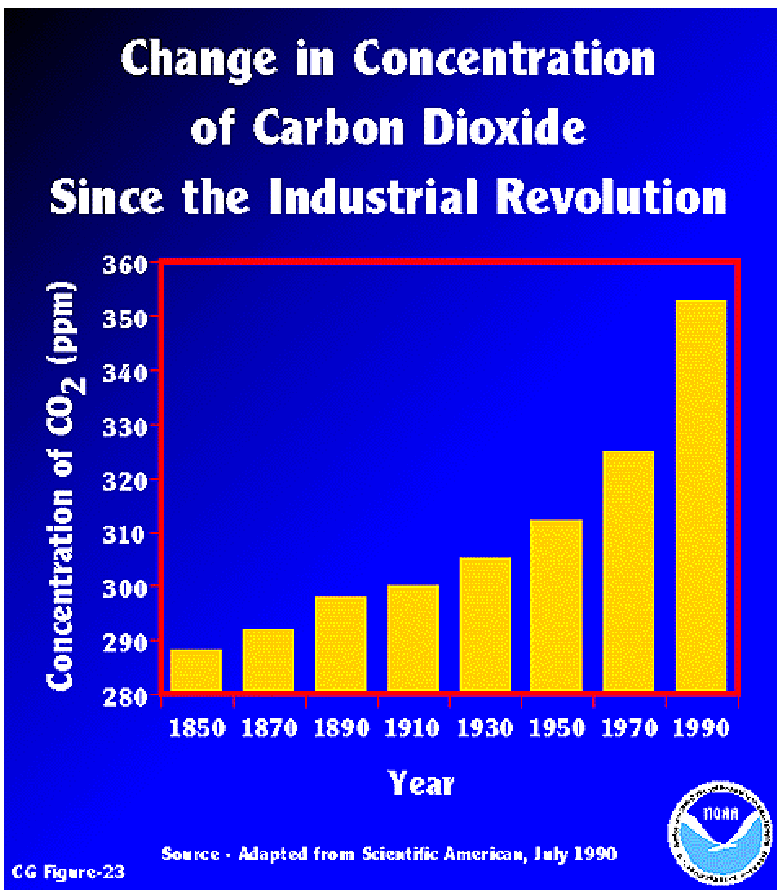
Anthropogenic factors affect atmospheric warming and cooling; some gases promote global warming, others cause cooling.

- Some greenhouse gases occur naturally in the atmosphere, while others result from human activities.
- Naturally occurring greenhouse gases include water vapor, carbon dioxide, methane, nitrous oxide, and ozone.

- Certain human activities, however, add to the levels of most of these naturally occurring gases:
    - $CO2$
    - methane
        - emitted during the production and transport of coal, natural gas, and oil. Methane emissions also result from the decomposition of organic wastes in municipal solid waste landfills, and the raising of livestock.
    - nitrous oxide
    - Hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), & sulfur hexafluoride (SF6)
        - generated in a variety of industrial processes

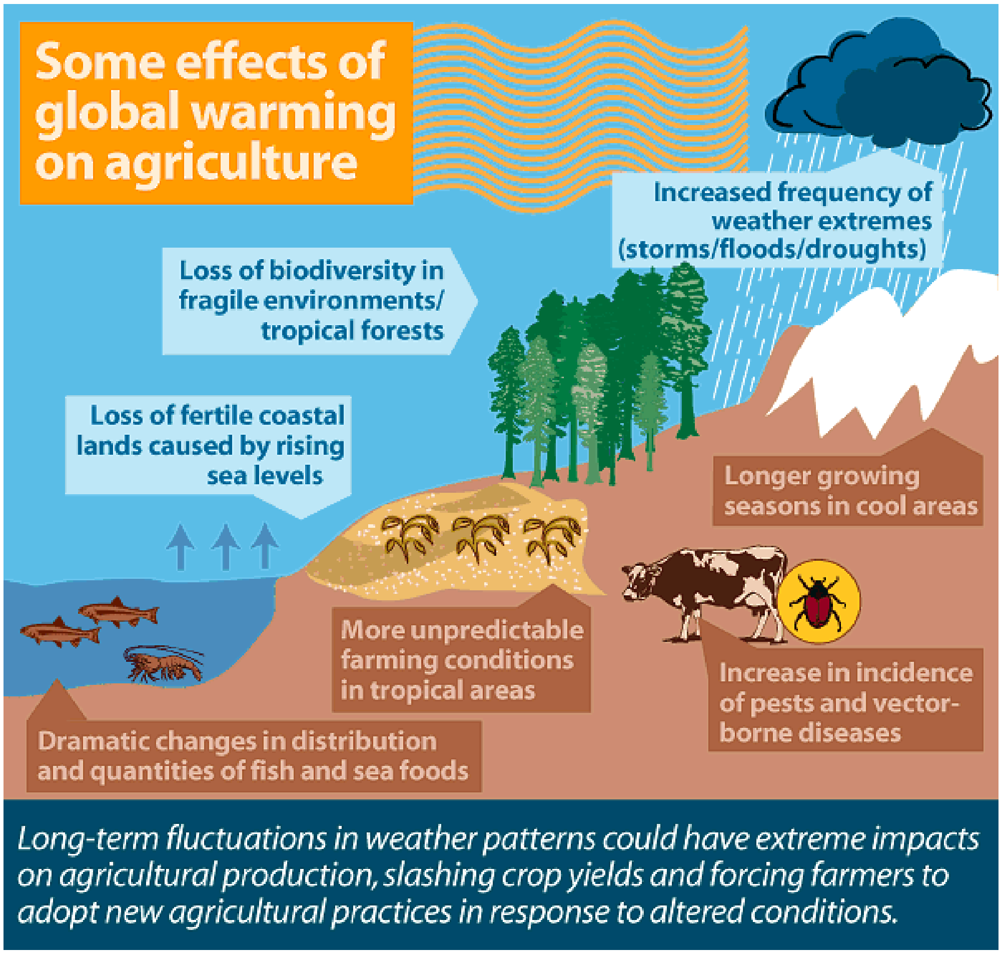


CO_2 levels in the atmosphere have risen substantially



Possible Effects of a Warmer World

- <u>Changes in food production</u>



<u>Reductions in biodiversity</u>

- Plants and animals generally react to consistently warmer temperatures by moving to higher latitudes and elevations. Recent studies reveal that some species have already started to shift their ranges, consistent with warming trends. Many populations and species may become more vulnerable to declining numbers or extinction if warming occurs faster than they can respond or if human development presents barriers to their migration.

- Rise in sea level
  - Warmer temperatures increase melting of mountain glaciers and cause ocean water to expand. Largely as a result of these effects, global sea level has risen 4 to 10 inches over the past 100 years. With additional warming, sea level is projected to rise from half a foot to 3 feet more during the next 100 years. On average, 50 to 100 feet of beach are lost for every foot of sea-level rise.
- More extreme weather
  - climate change will lead to more hurricanes, floods, and droughts

- <u>Threats to human health</u>
    - As temperatures rise, disease-carrying mosquitoes and rodents move into new areas, infecting people in their wake. Global warming will likely put as much as 65% of the world's population at risk of infection—an increase of 20%. Scientists at the Harvard Medical School have linked recent U.S. outbreaks of dengue ("break bone") fever, malaria, hantavirus and other diseases to climate change.

Slowing Global Warming

- Cut fossil fuel use
  - Car makers could dramatically increase the fuel economy of their cars and trucks.
  - Most electric utilities still use coal to produce electricity, spewing millions of tons of carbon dioxide and other pollution into the atmosphere every year. Part of the problem could be solved by converting these plants to burn cleaner natural gas.
- Improve energy efficiency
  - Our cars and light trucks, home appliances and power plants could be made much more efficient by simply installing the best current technology. Energy efficiency is the cleanest, safest, most economical way to begin to curb global warming.
  - We could do much more to save energy in our homes and office buildings. More energy efficient lighting, heating and air-conditioning

could keep millions of tons of carbon dioxide out of our air each year.

- Reduce deforestation & plant trees
    - Because global vegetation and soils contain about three times as much carbon as the planet's atmosphere, terrestrial ecosystems offer an opportunity to absorb and store (sequester) a significant amount of carbon dioxide from the atmosphere. By planting trees, preserving forests, and changing cultivation practices to increase soil carbon, for example, it is possible to increase the size of carbon sinks.
- <u>Slow human population growth</u>

<u>Effects of Air Pollution on Human Health</u>

- Much evidence links air pollutants to respiratory & other diseases in humans
- Examples of air pollution-related diseases:
    - Pulmonary irritation & impaired lung function:
        - chronic bronchitis
        - emphysema
    - Cancer
    - Systemic toxicity:
        - Lead
        - Mercury
    - Increased susceptibility to disease

Effects of Air Pollution on other animals & plants:

- Wild & domestic animals probably affected in the same ways as humans
- Plants damaged by ozone, sulfur dioxide, & acids:
    - ozone - weakens pine needles & makes them more susceptible to insects & diseases
    - sulfur dioxide - suppresses growth
    - acid - damages leaves & needles & also removes nutrients