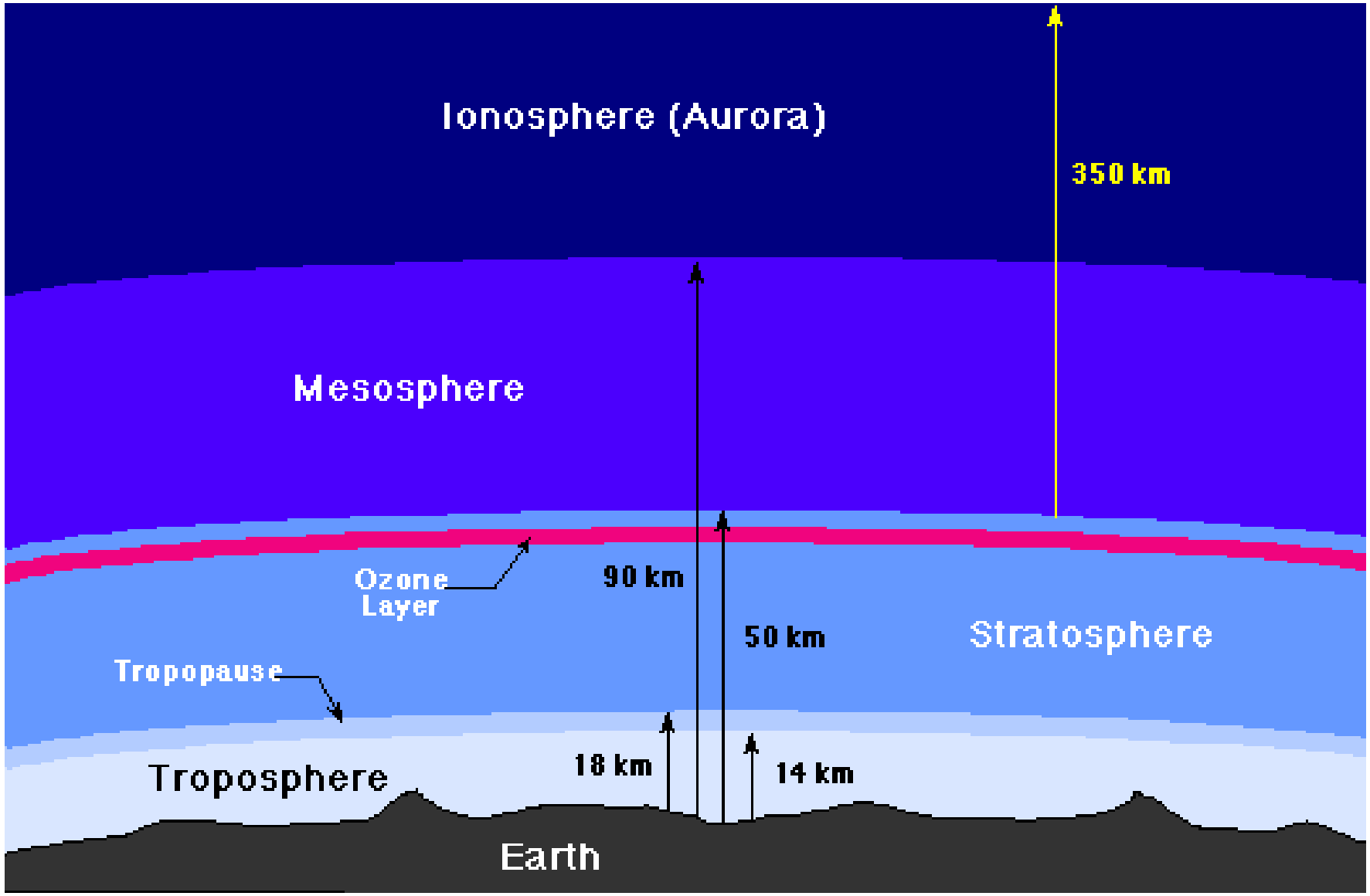
Science of climate change

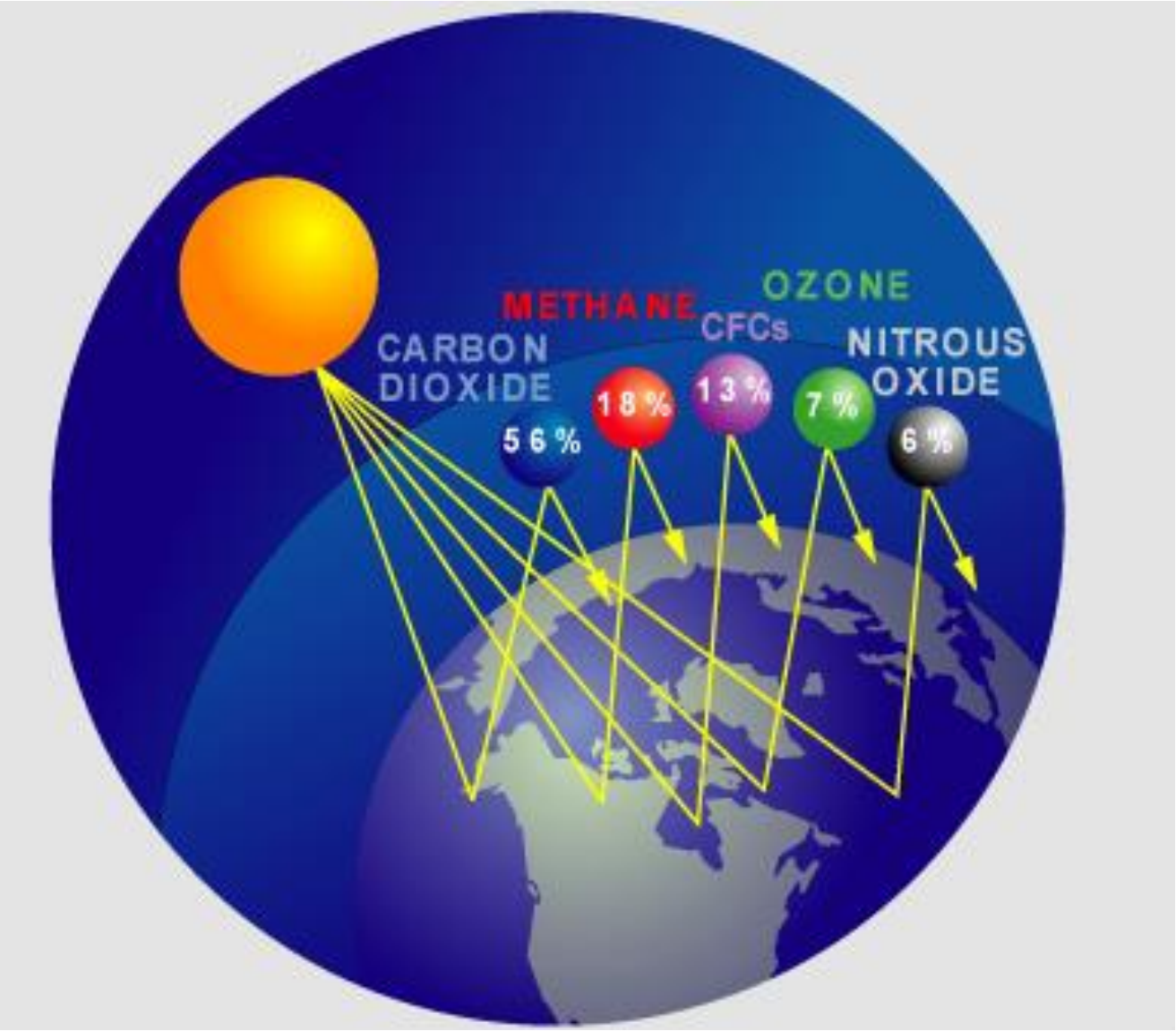
Unit 6

Greenhouse Effect

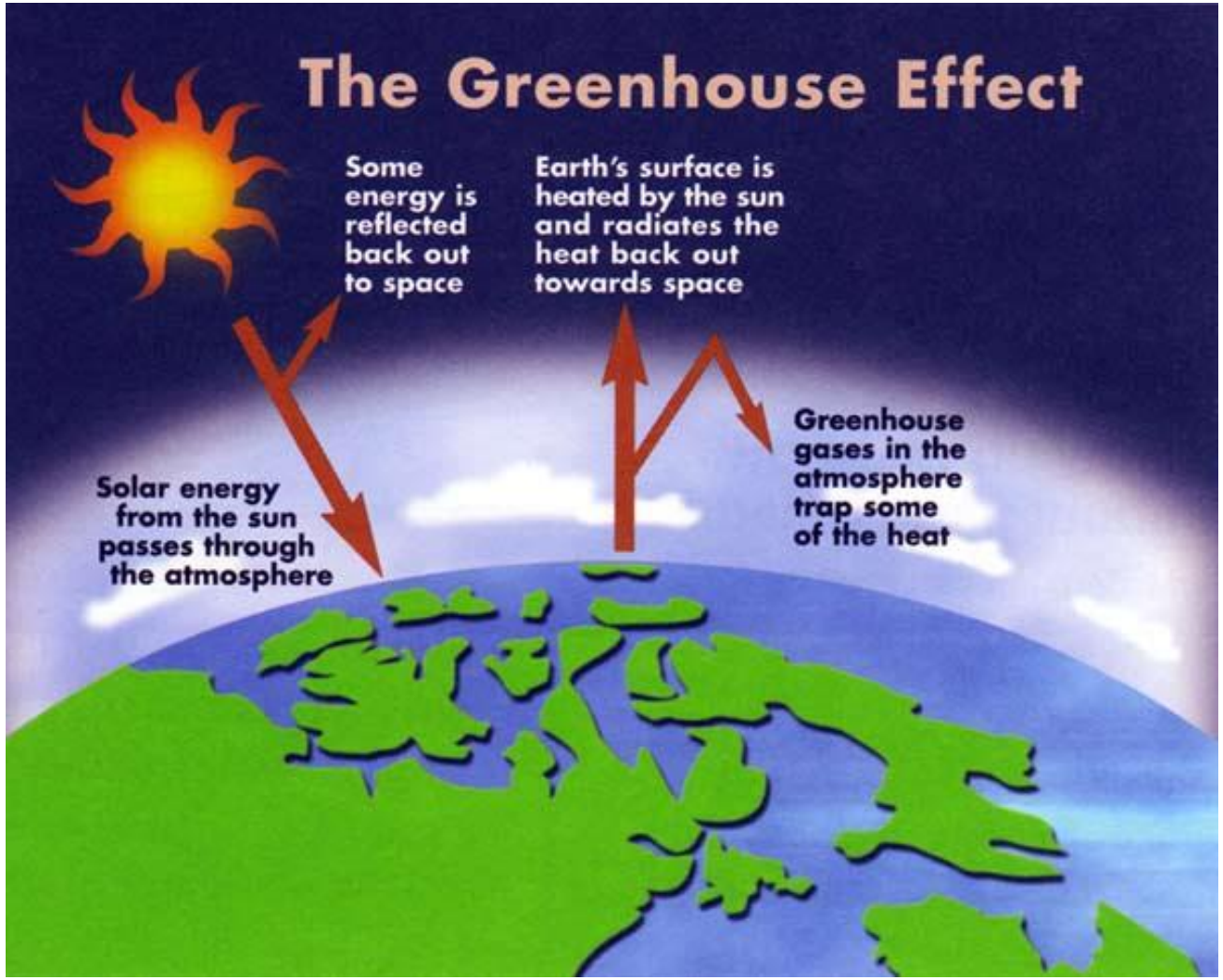
Atmosphere


Ionosphere (Aurora)
350 km
Mesosphere
Ozone Layer
90 km
50 km
Stratosphere
Tropopause
18 km
14 km
Troposphere
Earth

Green House Gases



Examples of Green House Gases are: Methane, Carbon Dioxide, Nitrous Oxide, Ozone, Chlorofluorocarbons


The Greenhouse Effect
Some energy is reflected back out to space
Earth's surface is heated by the sun and radiates the heat back out towards space
Greenhouse gases in the atmosphere trap some of the heat
Solar energy from the sun passes through the atmosphere

Adverse Effect of Greenhouse Gases

1. Global Warming
2. Effect on Hydrological Cycle
3. Rise in High Tide Line of Sea

Global warming

- About 75% of the solar energy reaching the Earth is absorbed on the earth's surface which increases its temperature.
- The rest of the heat radiates back to the atmosphere. Some of the heat is trapped by greenhouse gases, mostly carbon dioxide.
- As carbon dioxide is released by various human activities, it is rapidly increasing. This is causing global warming.
- Human activities during the last few decades of industrialization and population growth have polluted the atmosphere to the extent that it has begun to seriously affect the climate.

- Carbon dioxide in the atmosphere has increased by 31% since pre-industrial times, causing more heat to be trapped in the lower atmosphere.
- There is evidence to show that carbon dioxide levels are still increasing.
- Many countries have signed a convention to reduce greenhouse gases under the United Nations Convention on Climate Change
- Global warming is accelerating faster than what climatologists had calculated a few years ago. In 1995, it was predicted that global warming would rise temperatures by 3.5 to 10 ^{o}C during the 21stcentury, if the present trends continue.
- It is now believed that this could be much greater. This would lead to not only temperature changes but in the amount of rain-fall.

Acid rain

What is acid rain?

- Acid rain is caused by a chemical reaction that begins when compounds like sulfur dioxide and nitrogen oxides are released into the air.
- These substances can rise very high into the atmosphere, where they mix and react with water, oxygen, and other chemicals to form more acidic pollutants, known as acid rain.
- Sulfur dioxide and nitrogen oxides dissolve very easily in water and can be carried very far by the wind.
- As a result, the two compounds can travel long distances where they become part of the rain, sleet, snow, and fog.

Causes of acid rain

- Human activities have released so many different chemicals into the air that they have changed the mix of gases in the atmosphere
- Power plants release the majority of sulfur dioxide and much of the nitrogen oxides when they burn fossil fuels, such as coal, to produce electricity.
- In addition, the exhaust from cars, trucks, and buses releases nitrogen oxides and sulfur dioxide into the air. These pollutants cause acid rain.
- Volcanic eruptions are the natural cause of acid rain.

- Dry Deposition: Dry deposition is the free fall to Earth directly from the atmosphere of atmospheric trace gases and particulate matter. It is a form of acid deposition when gases and dust particles become acidic
- Wet Deposition: Wet deposition is the process whereby atmospheric gases mix with suspended water in the atmosphere and are then washed out through rain, snow or fog.

- Precipitation with a pH lower than 5.6 is considered acidic

Air Pollutants Causing Acid Rain:

1. Sulphur Dioxide
2. Nitrogen Oxides
3. Carbon Dioxide

Chemical Reactions of Air Pollutants and Water:

Sulphur Dioxide:

Sulfur dioxide and Water form Sulfurous Acid (H_2SO_3)

$$\mathbf{SO_2(g) + H_2O(l) \rightarrow H_2SO_3}$$

1. Sulfur Dioxide (SO_2) oxidizes to Sulfur Trioxide (SO_3)

$$\mathbf{2SO_2(g) + O_2(g) \rightarrow 2SO_3}$$

2. Sulfur Trioxide (SO_3) then combines with water forming Sulfuric Acid (H_2SO_4)

$$\mathbf{SO_3(g) + H_2O(l) \rightarrow H_2SO_4}$$

Chemical Reactions of Air Pollutants and Water:

Nitrogen Oxides:

Oxides of Nitrogen like nitrogen dioxide (NO_2) react with water to form nitrous acid (HNO_2) and nitric acid (HNO_3)

$$\mathbf{2NO_2(g) + H_2O(l) \rightarrow HNO_2 + HNO_3}$$

Carbon Dioxide:

Carbon dixide combined with water and forms Carbonic Acid (Minor Element)

$$\mathbf{CO_2 + H_2O \rightarrow H_2CO_3}$$

Effects of Acid Rains

- Plant Life
- Aquatic Life
- Property
- Human and Animal Life

- Poor forest health due to acidification of soil: acid rain can kill nutrient-producing microorganisms
- Acidification of lakes and streams can lead to the death of aquatic life, such as trout and bass
- Acidity can leach mercury out of the soil, causing toxic levels to build up in the fish we eat
- Acid rain can erode buildings and monuments and destroy paint finishes

Ozone depletion

Ozone Depletion:

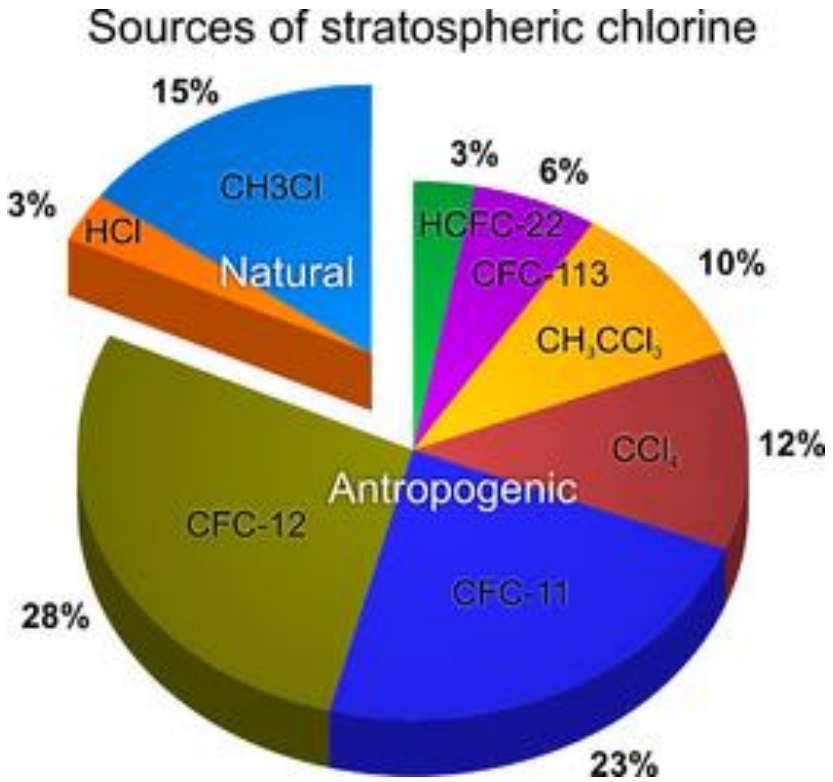
Ozone depletion have two distinct interrelated phenomena

1. a steady decline of about 4% per decade in the total volume of ozone in Earth's Stratosphere (the ozone layer), and
2. a much larger springtime decrease in stratospheric ozone over Earth's polar regions.

This phenomenon is referred as the ozone hole or Ozone Depletion.

Chemical Reactions of Ozone Depletion:

Ozone Depletion mainly occurs due to Stratospheric Chlorine



Thus the element of major concern for Ozone depletion is CFCs which is 60% (28+23+3+6) of Stratospheric Chlorine

Chemical Reactions of Ozone Depletion:

Chemical Reaction with CFCs with Ozone are as follows:

$CFCl_3$ + electromagnetic radiation → $CFCl_2$ + **Cl**

Cl + O_3 → **ClO** + O_2

The chlorine atom changes an ozone molecule to ordinary oxygen

ClO + O_3 → Cl + **2 O_2**

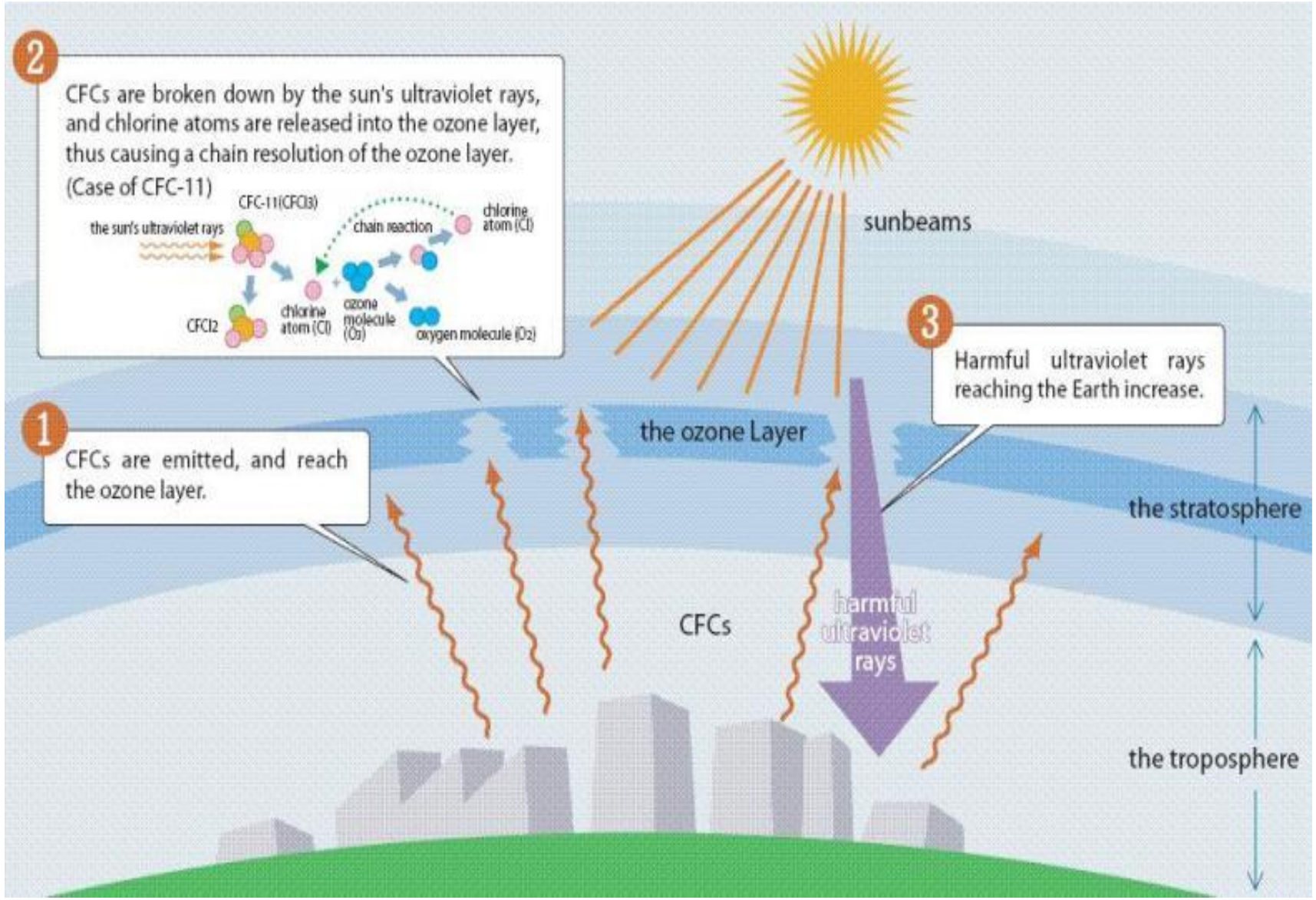
The ClO from the previous reaction destroys a second ozone molecule

This reaction is cyclic. Cl again reacts with ozone and release again Cl

+$2O_2$

This release of Oxygen to atmosphere leads to reduction in ozone molecules and termed as ozone depletion.

Steps in Ozone Depletion



- The destruction of the ozone layer is seen to cause increased cases of skin cancer and cataracts.
- It also causes damage to certain crops and to plankton, thus affecting natures food chains and food webs.
- This in turn causes an increase in carbon dioxide due to the decrease in vegetation.
- With the signing of the Montreal Protocol in1987, a treaty for the protection of the ozone layer, the use of CFCs was to be banned by the year 2000. After 2000, the ozone layer is expected to recover slowly over a period of about 50 years.

Carbon footprint

What is carbon footprint?

- A carbon footprint is the total amount of greenhouse gases (including carbon dioxide and methane) that are generated by our actions.
- The average carbon footprint for a person in the United States is 16 tons, one of the highest rates in the world.
- Globally, the average carbon footprint is closer to 4 tons.
- USA has a per capita emission of 13.7 and for India has a value of 1.74
- To have the best chance of avoiding a 2℃ rise in global temperatures, the average global carbon footprint per year needs to drop to under 2 tons by 2050.

Carbon Footprint….

- We analyze the contribution of 8 categories:
  - **construction,**
  - **shelter,**
  - **food,**
  - **clothing,**
  - **mobility,**
  - **manufactured products,**
  - **services,**
  - **and trade**.

Direct carbon emissions

- Direct or 'scope 1' carbon emissions come from sources that are directly from the site that is producing a product or delivering a service. An example for industry would be the emissions related to burning a fuel on site.
- On the individual level, emissions from personal vehicles or gas burning stoves would fall under scope 1.

Indirect carbon emissions

- Emissions from sources upstream or downstream from the process being studied, also known as scope 2 or scope 3 emissions
- Examples are :
  - Transportation of materials/fuels
  - Any energy used outside of the production facility
  - Wastes produced outside of the production facility
  - Any end-of-life process or treatments
  - Product and waste transportation
  - Emissions associated with selling the product