Global Warming

What is it?

Earth has warmed by about 1 º F over the past 100 years. But why? And How?

Scientists are not exactly sure.

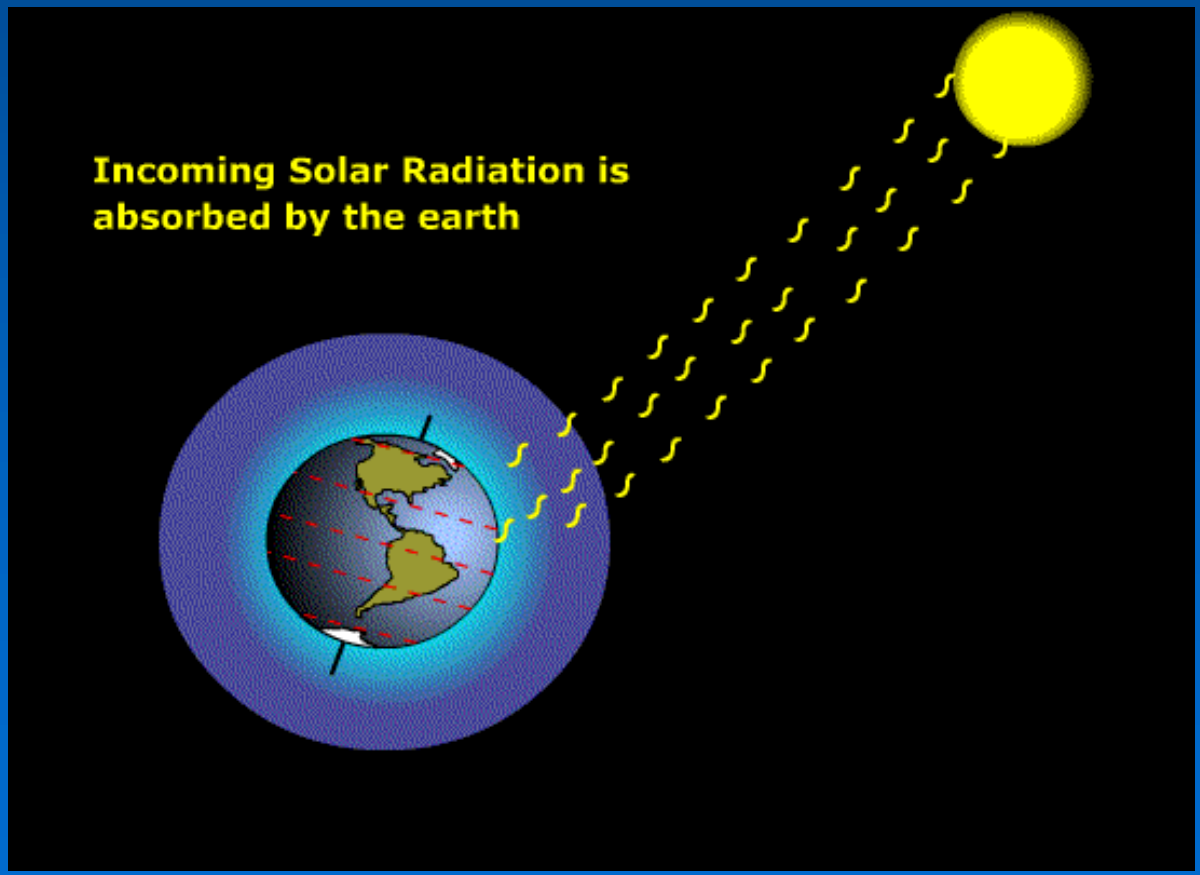
The earth could be getting warm on its own.

However ....

- Many of the world's leading climate scientists think that things people do are helping to make the Earth warmer.
- Scientists are sure about the greenhouse effect. They know that greenhouse gases make the earth warmer by trapping energy in the atmosphere.

What is the Greenhouse effect?

- The greenhouse effect is the rise in temperature that the Earth experiences because certain gases in the atmosphere trap heat from the Sun's rays.

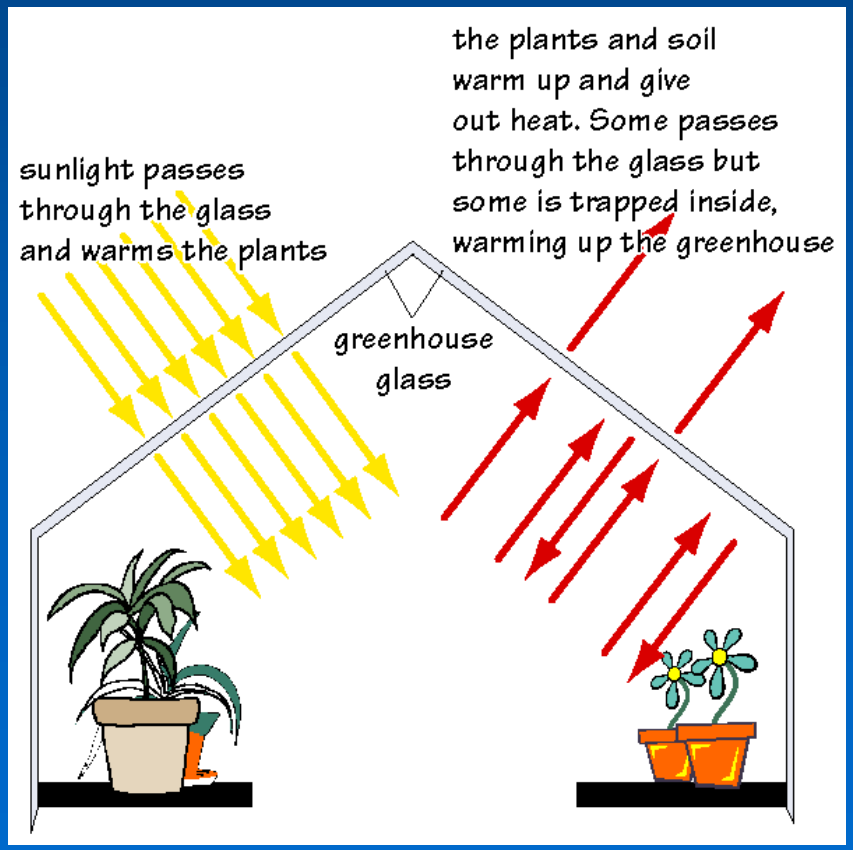


Greenhouse?

- Green houses are used to grow plants, especially in the winter.

How do greenhouses work?

- Greenhouses work by trapping heat from the sun.
- The glass panels of the greenhouse let in light but keep heat from escaping.



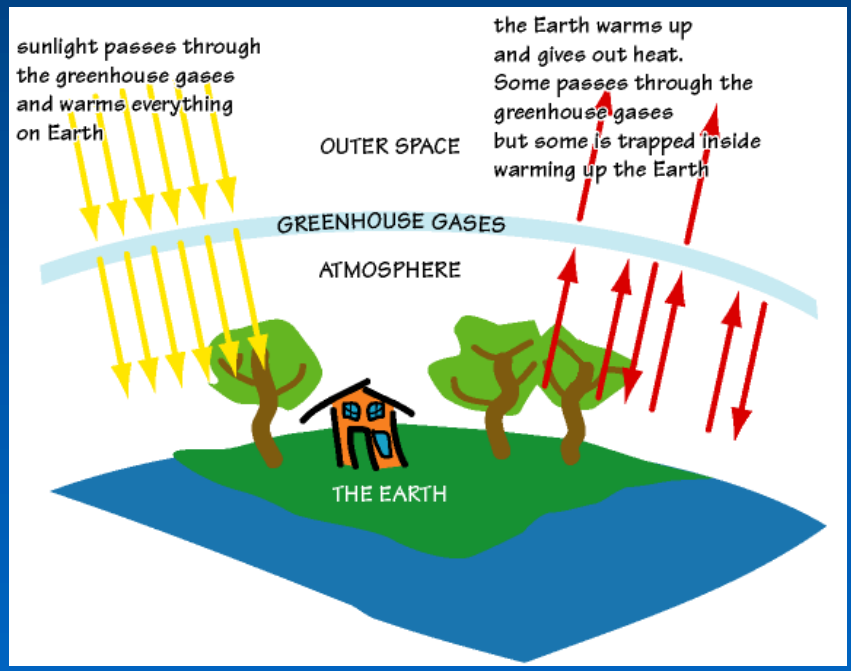
How do greenhouses work?

- This causes the greenhouse to heat up much like the inside of a car parked in sunlight, and keeps the plants warm enough to live in the winter.

The Greenhouse Effect

- Greenhouse gases in the atmosphere behave much like the glass panes in a greenhouse.

- Sunshine enters the Earth's atmosphere passing through the blanket of greenhouse gases.

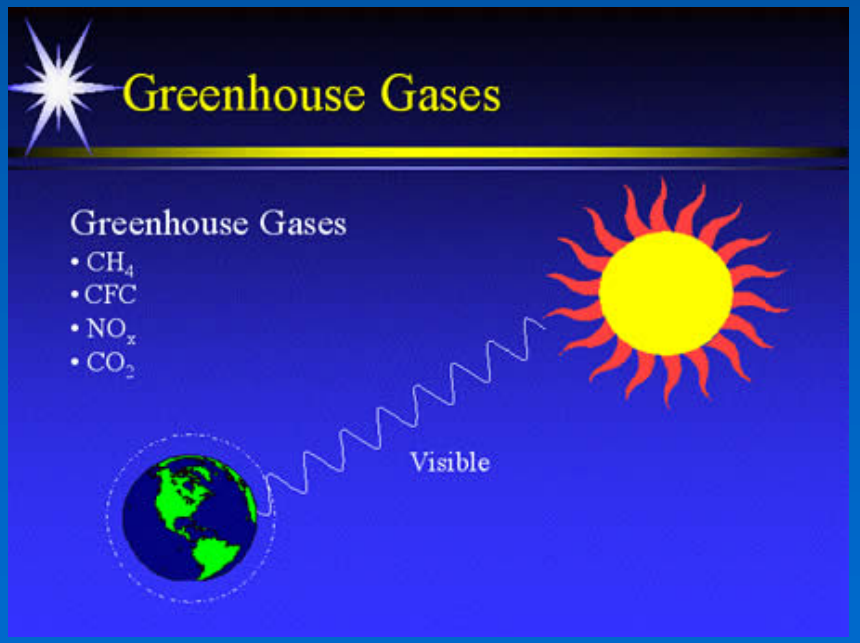


As it reaches the Earth's surface, land, water, and biosphere absorb the sunlight's energy! Once absorbed this energy is sent back into the atmosphere.

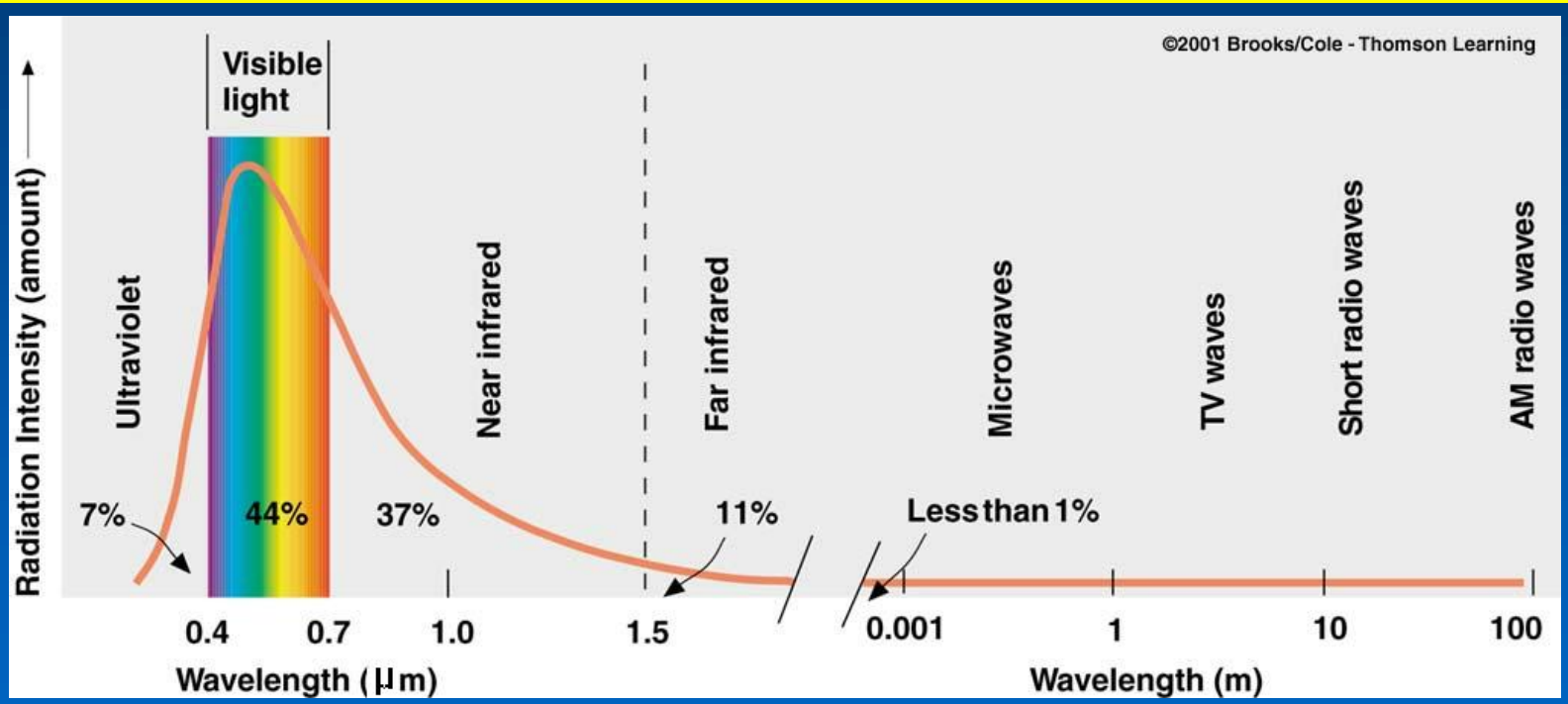
Greenhouse Effect

- Without these gases, heat would escape back into space and Earth's average temperature would be about 60 º F colder.

- Because of how they warm our world, these gases are referred to as greenhouse gases.



Solar Radiation (Sunlight)



- Sunlight is primarily made up of the following:
  - Visible Light (44%)
  - Infrared Radiation (48%)
  - Ultraviolet Radiation (7%)

Unit: 1 μm =

0.000001 m

Earth's Energy Balance

- Energy entering top of atmosphere

= Energy leaving top of atmosphere

- Energy entering the Earth's surface

= Energy leaving Earth's surface

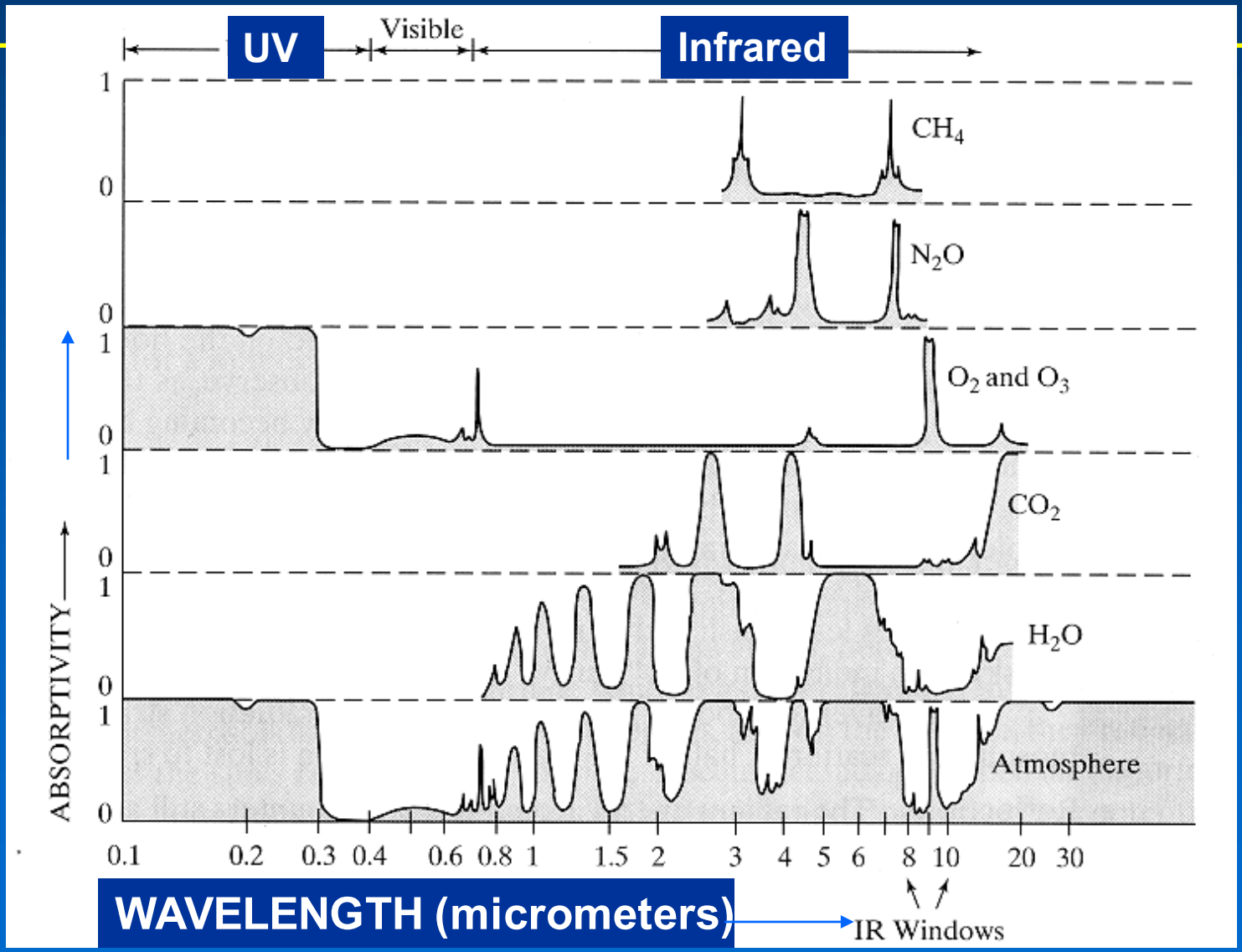
Energy from the Sun

- Sun's energy is either
  - Scattered (reflected away) or
  - Absorbed
- Scattering happens by bouncing off
  - Particles in the atmosphere
  - Earth's surface
- Absorption happens when certain gases absorb the energy
  - The reality is the only certain gases absorb certain wavelengths.

Absorption of radiation

- Absorption of shortwave radiation by atmospheric gas molecules is fairly weak;
  - most absorption of shortwave radiation occurs at the Earth's surface.
- Most gases do not interact strongly with longwave radiation, however
  - Greenhouse gas molecules absorb certain wavelengths of longwave radiation.

Absorption Spectra of Atmospheric Gases



CH_4

N_2O

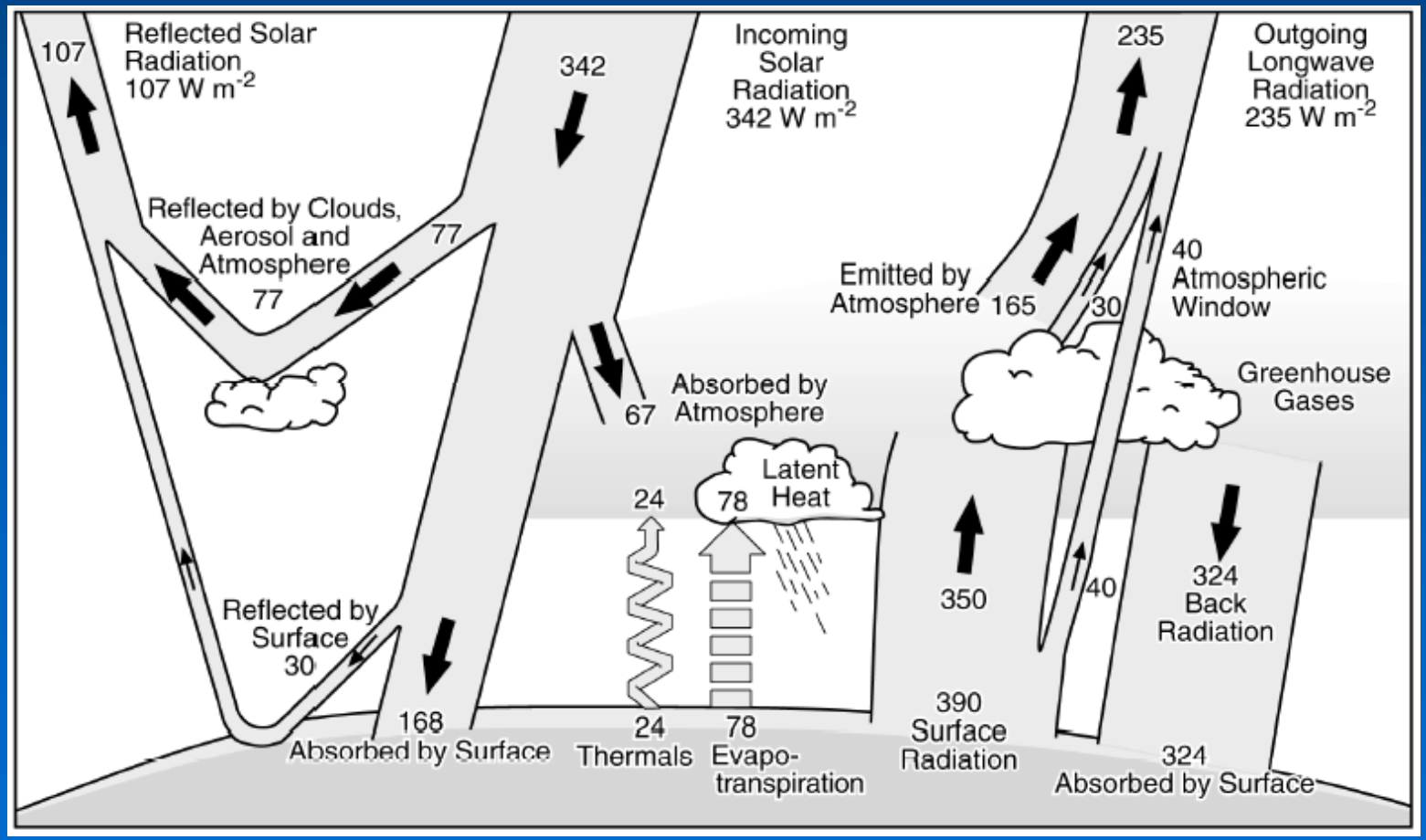
O_2 & O_3

CO_2

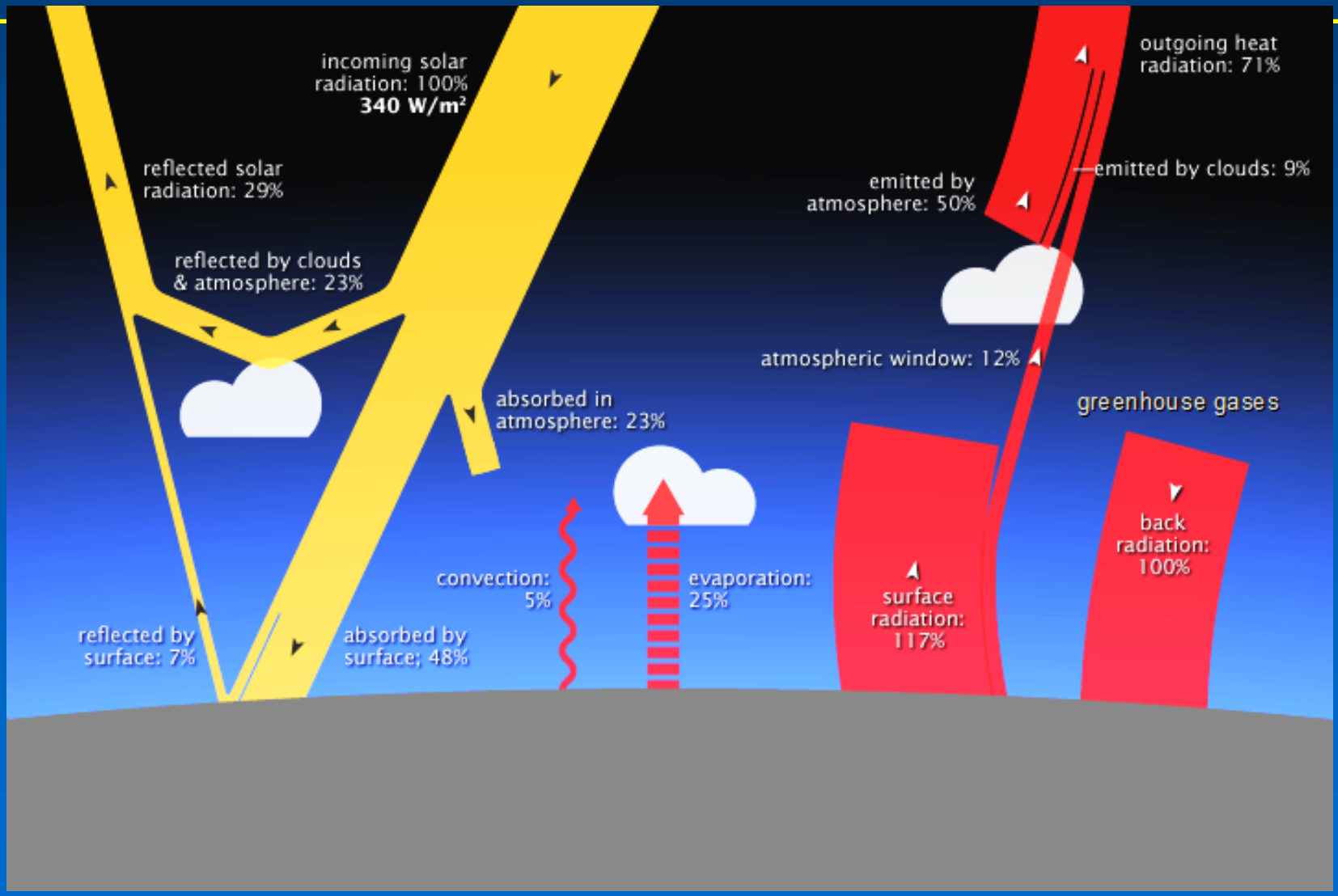
H_2O

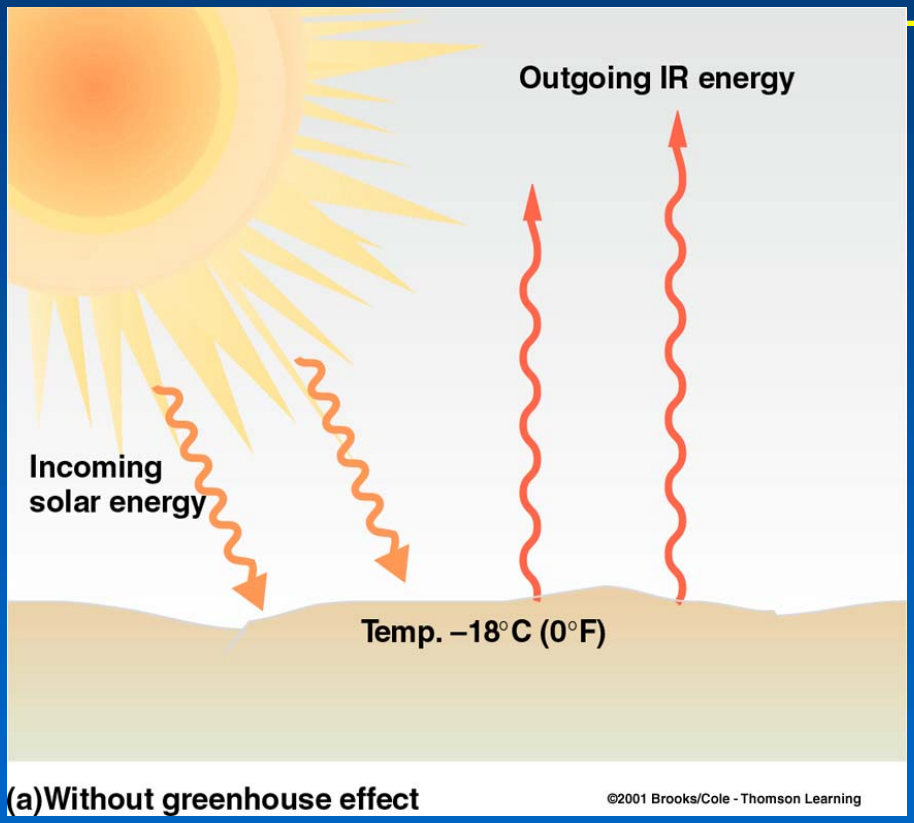
atmosphere

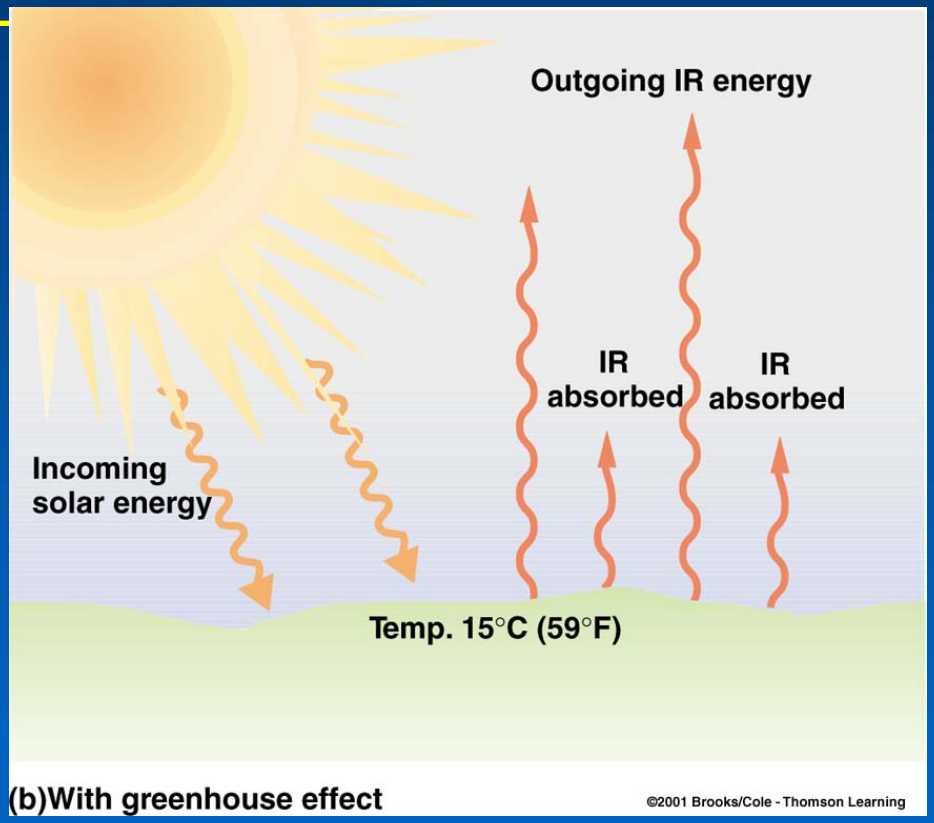
Earth's Energy Budget



Earth's energy budget




Outgoing IR energy
Incoming
solar energy
Temp. –18°C (0°F)
(a)Without greenhouse effect
©2001 Brooks/Cole - Thomson Learning


Outgoing IR energy
IR
absorbed
IR
absorbed
Incoming
solar energy
Temp. 15°C (59°F)
(b)With greenhouse effect
©2001 Brooks/Cole - Thomson Learning

Greenhouse Effect

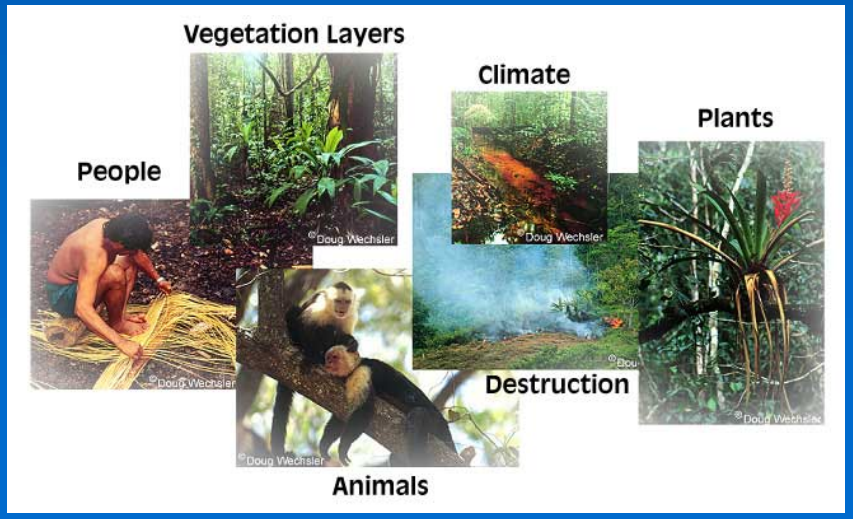
Sequence of steps:

1. Solar radiation absorbed by earth's surface.
2. Earth gives off infrared radiation.
3. Greenhouse gases absorb some of the Earth's infrared radiation.
4. Greenhouse gases (water and CO2) give off infrared radiation in all directions.
5. Earth absorbs downward directed infrared radiation

Result: warmer surface temperature

The greenhouse effect is important.

- Without the greenhouse effect, the Earth would not be warm enough for humans to live.
- But if the greenhouse effect becomes stronger, it could make the Earth warmer than usual.
- Even a little warming causes problems for plants and animals.



What are these gases?

- The greenhouse gases are:
  - Water Vapour
  - Carbon dioxide
  - Nitrous Oxide
  - Methane
  - CFCs
  - Ozone

Water Vapour

- Water vapor accounts for the largest percentage of the greenhouse effect, 36 - 66% for clear sky conditions, 66-85% when including clouds
- The water vapour content in the atmosphere is constant which means it hasn't changed.

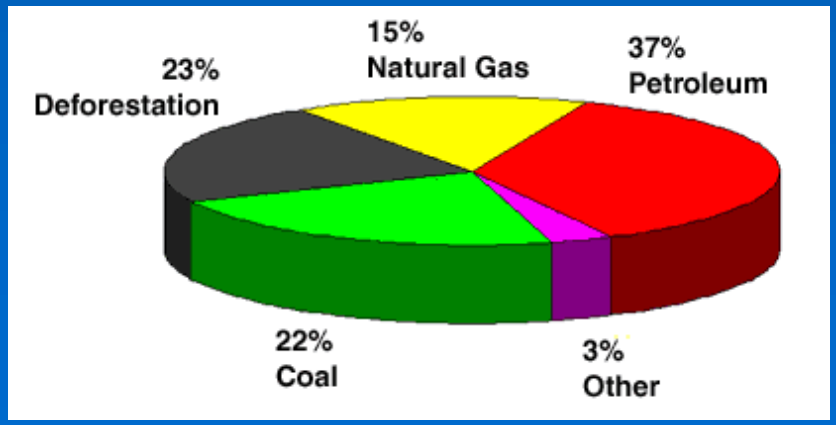
Water Vapour

- Human activities have little impact on the level of water vapour.

Carbon Dioxide

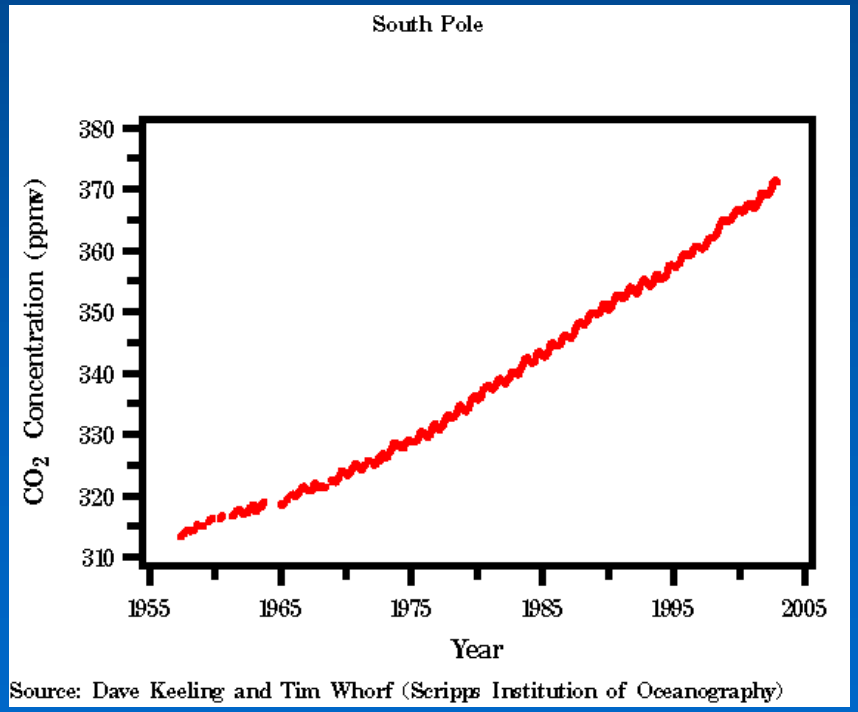
- Carbon Dioxide is probably the most important of the greenhouse gases and is currently responsible for 60 % of the 'enhanced greenhouse effect'
- Enhanced
  - Human activities, not natural.

Global carbon dioxide emissions



Carbon Dioxide

- For the past 100 years, the amount of carbon dioxide in our atmosphere seems to have been increasing.



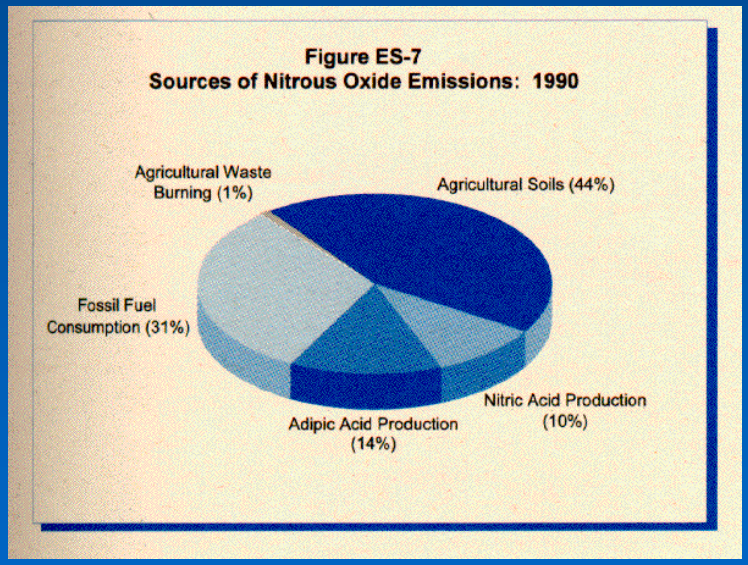
Source: Dave Keeling and Tim Whorf (Scripps Institution of Oceanography)

Nitrous Oxide (N_2O)

- Nitrous oxide makes up an extremely small amount of the atmosphere –less than one-thousandth as abundant as carbon dioxide.
- However it is 200 to 300 times more effective in trapping heat than carbon dioxide.

Nitrous Oxide

- Nitrous Oxide has one of the longest atmosphere lifetimes of the greenhouse gases, lasting for up to 150 years.



- Since the Industrial Revolution, the level of nitrous oxide in the atmosphere has increased by 16%.

Nitrous Oxide

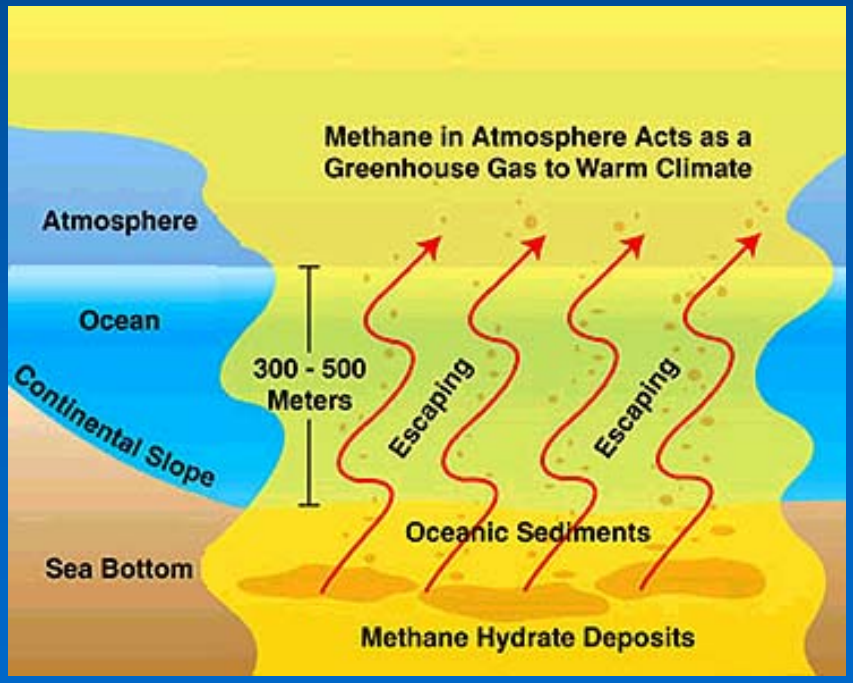
- The impact of human activities
  - Burning fossil fuels and wood
  - Widespread use of fertilizers
  - Sewage treatment plants

Where do all nitrous oxide gases come from?

- **Nitrous Oxide**
  - **Vehicle exhaust**
  - **Nitrogen based fertilisers**

Methane (CH_4)

- Methane occurs in lower concentrations than CO_2 but it produces 21 times as much warming as carbon dioxide.

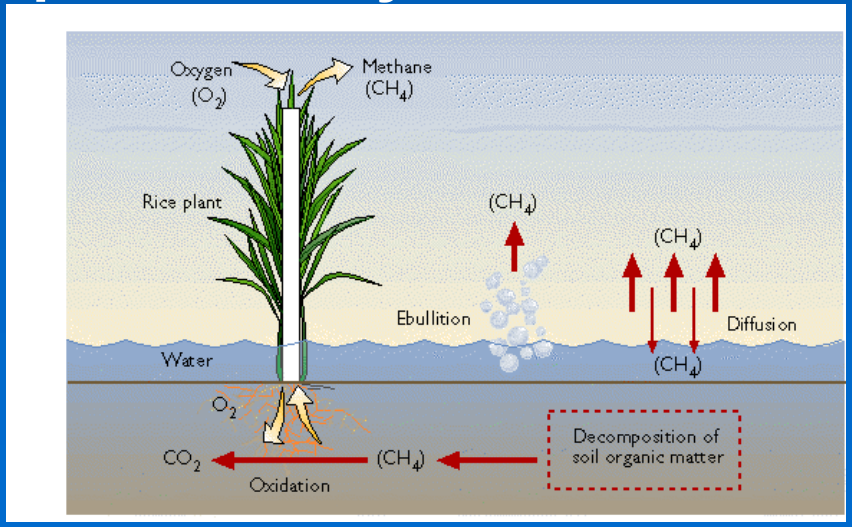


Methane

- Methane accounts for 20% of the 'enhanced greenhouse effect'.
- It remains in the atmosphere for 10-12 years. (Less than other greenhouse gases)

Methane

- **Human Activities**
  - **An increase in livestock farming and rice growing has led to an increase in atmospheric methane. Other sources are the extraction of fossil fuels, landfill sites.**
  - **Methane concentration in the atmosphere has more than doubled during the last 200 yr. Some of this methane is produced by ricefields**

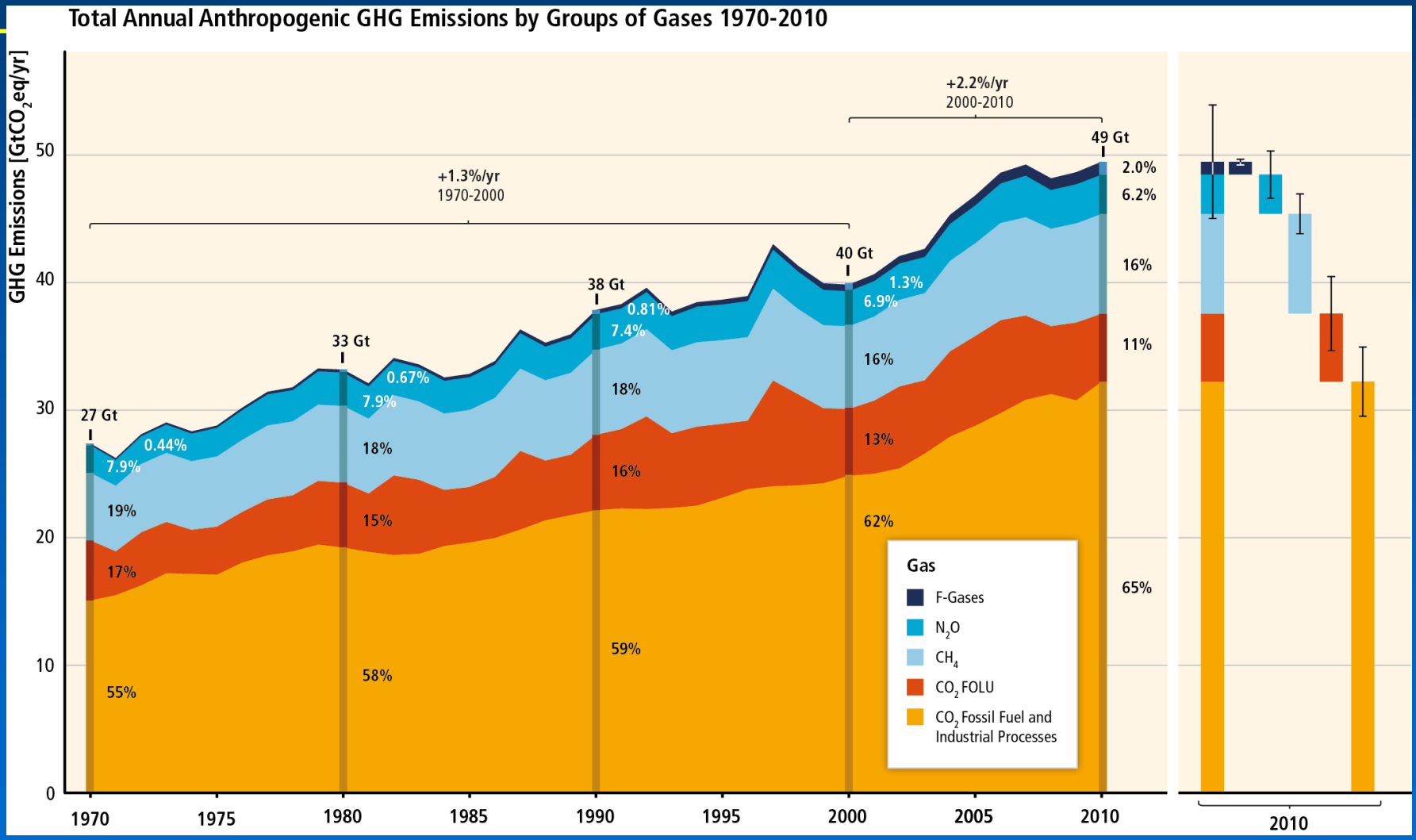


Where do all the methane gases come from?

- Methane
  - Produced by bacteria living in swampy areas.
    - Wet rice cultivation
  - Waste in landfills
  - Rearing of livestock
    - When cows belch (burp)
  - Each molecule can trap 20 times as much heat as a CO_2 molecule.

Where do all the CFCs come from?

- CFCs (Chlorofluorocarbons)
  - Aerosol sprays
  - Making foam packaging
  - Coolants in fridge and air cons
  - Cleaning solvents
  - ➢ Each CFC molecule can trap as much heat as 100 000 CO_2 molecule.
  - ➢ Can remain in the atmosphere for a long time (up to 20 000 years)



Source: IPCC WGIII;
CO2 emissons from forestry and other land use: CO2 FOLU