Global Warming and Climate change

Global Warming	Climate Change
➢ Refers to temperature increase in the troposphere.	➢ Refers to changes in any aspects of the earth's climate including temperature, precipitation and storm intensity and patterns.
➢ An increase in Earth's average surface temperature due to rising level of greenhouse gases.	➢ A long-term change in the Earth's climate, or of a region on Earth.

Causes of climate change

1. Anthropogenic Global Warming
2. Bio-thermostat
3. **Variations in Solar Radiation**
   Solar Irradiance
   Sunspot Activity
   Earth-Sun Geometry (Milankovitch cycles)
   Atmospheric Dust and Volcanoes
4. **Distribution of Continents**

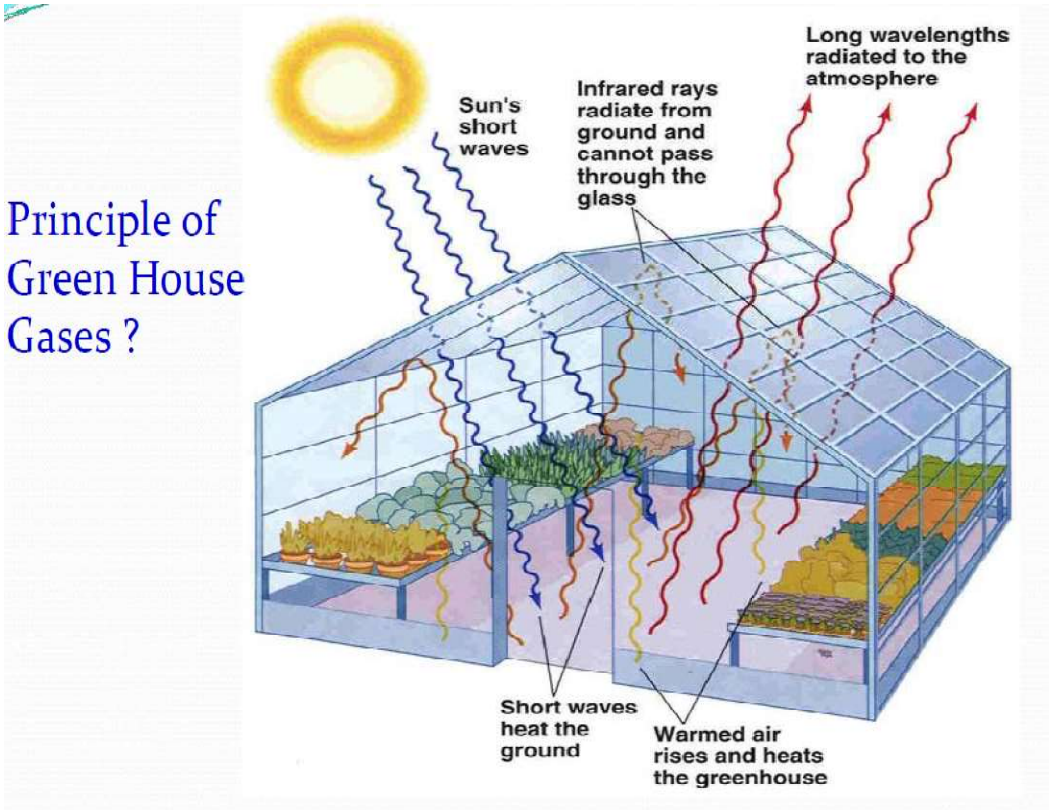
Plate Tectonics

Mountain Building

5. **Ocean Variation**

Thermohaline Circulation

Anthropogenic global warming

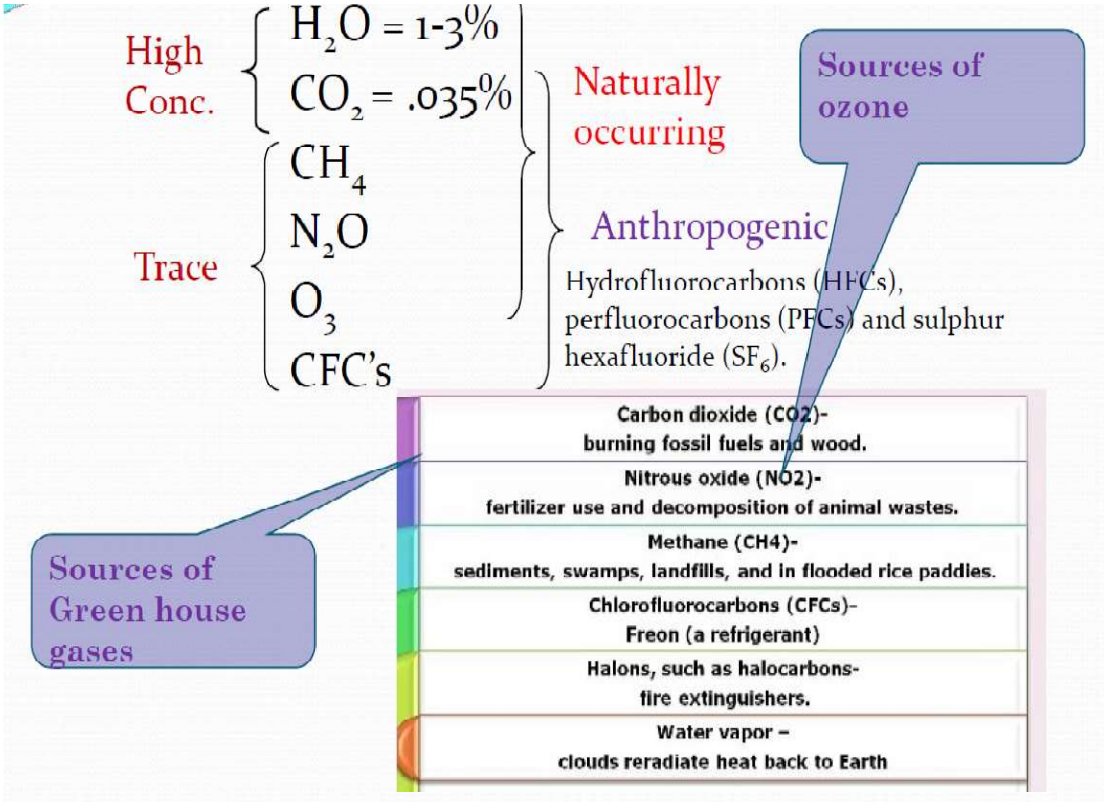


The green net/glass on the roof of the house allow to pass high energy and shorter wavelength sun light to enter the house in day time and in the evening the floor of the house radiate low energy higher wavelength IR radiation (infra red). However the IR radiation can't escape from the house due the green glass/net (not allow to pass IR radiation) thus remain trapped in the house and the house remain warmer in night which facilitate growth of delicate plants. Similarly green house gases like CO_2, Ozone and CH_4 etc not allow the IR radiation released from the earth crust during night time thus elevate global temperature and causes global warming.

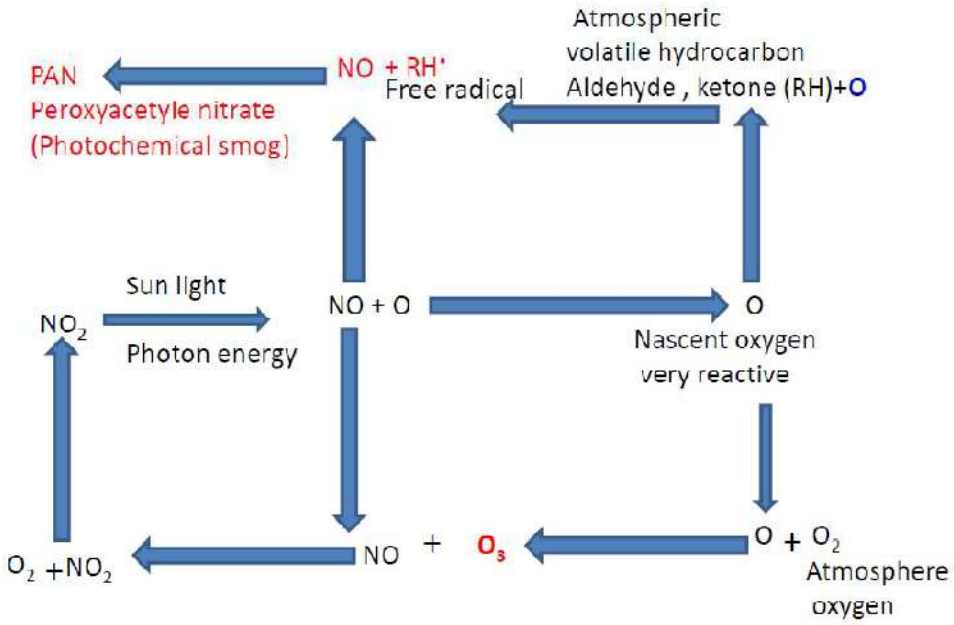
Global warming

1) Carbon dioxide (CO_2) is produced by the burning of fossil fuels (oil, coal, and natural gas) in order to produce energy. Atmospheric CO_2 has increased 35+ % since the early 1800s (15% in last 50 years). The more CO_2 in the atmosphere, the more heat absorbed. CO_2 blocks IR radiation from escaping back into space, much like a pane of glass traps heat in a green house. Other gases do the same thing. However, CO_2 is the most abundant and the one we worry about the most.

Types and sources of Greenhouse Gases



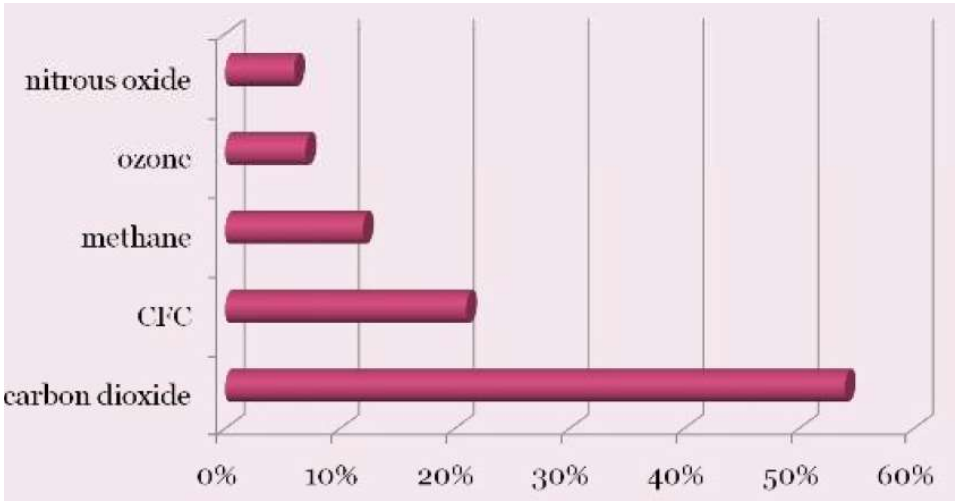
Photochemical smog and formation of ground level ozone (green house gas)



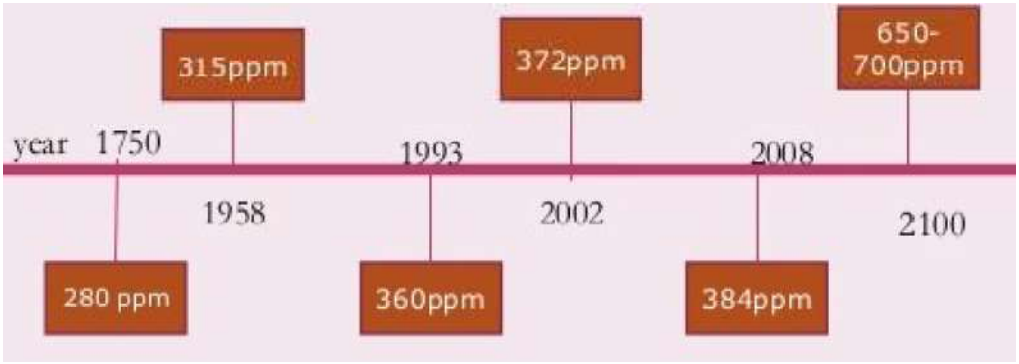
Upon combustion of fossil fuel NO_2 released to atmospheres on from industries and vehicular exhaust gas. In the atmosphere photon energy (light) split NO_2 to NO and nascent

oxygen (very reactive). The nascent oxygen under goes 2 pathway such as (i) formation of ground level ozone (green house gas/ bad ozone) as shown in the diagram which causes global warming. Finally the ozone interacts with the earlier produced NO and forms NO_2 thus the process occurs in a cyclic manner. (ii)In second pathway it the nascnt oxygen interact with atmospheric volatile hydrocarbon to produce free radicals ($RH^{\bullet}$) which interact with NO and produce peroxyacetyle nitrate (PAN) known as photochemical smog form a brownish haze.

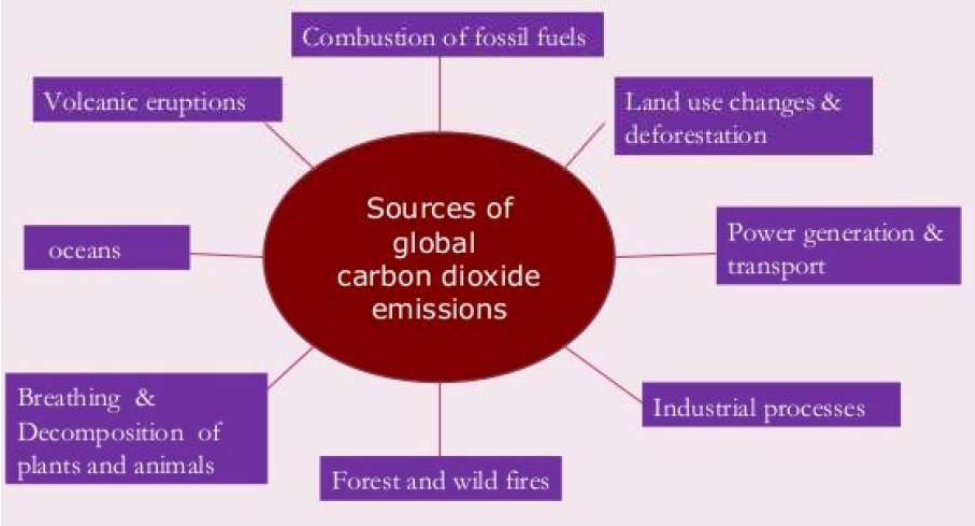
Percentage share of green house gases



Time line of global CO_2 level

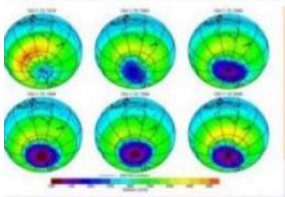


Sources of global CO_2emission



Depletion of stratospheric ozone and climate change

- Ozone (Greek *ozein,* "to smell"), pale blue, highly poisonous gas with a strong odor
- **The tropospheric ozone**(lower atmosphere) is considered a pollutant at ground level,
- **The stratospheric ozone** (upper atmosphere) is called 'the ozone shield'.
- Chlorine reactions deplete ozone in the stratosphere.
- **Ozone depleting gases** are CFC, halons, nitrous oxide, methane, carbon tetrachloride and methyl chloroform.



Ozone depletion results in 'ozone hole' in upper atmosphere. During the 1980s, scientists discovered a "hole" in the ozone over Antarctica.

- **Ozone depletion leads to more UV radiation - skin cancer and cataracts and depression of the immune system.**
- **Each 1% drop in ozone is thought to increase human skin cancer rates by 4-6%.**

Impacts of global warming

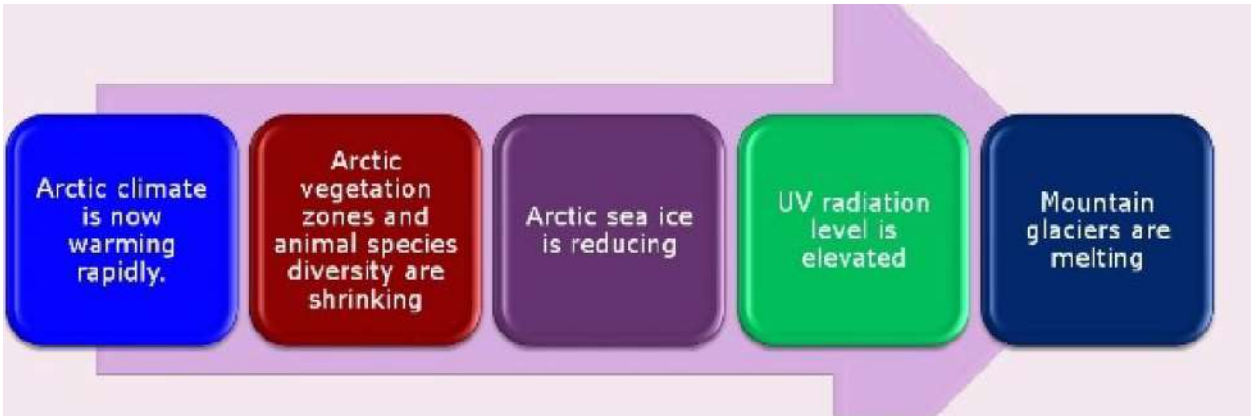
- **Earth's average surface temperature has increased by more than 1.4°F (0.8°C) over the past 100 years**
- By the end of the 21st century, **carbon dioxide concentration** will increase from 490 to 1260 ppm.
- **Global mean sea level** has been rising at an average rate of 1.7 mm/year over the past 100 years. Global sea level rose about 17 cms in the last century
- Both the extent and thickness of **Arctic sea ice** has declined rapidly over the last several decades. The Greenland and Antarctic ice sheets have decreased in mass.
- **Glaciers and ice caps** are retreating everywhere around the world —in the Alps, Himalayas, Andes, Rockies, Alaska and Africa.
- Since the beginning of the Industrial Revolution, **the acidity of surface ocean waters** has increased by about 30 percent.

Influence amount and pattern of precipitation, Drought

1. **Frequent temperature extremes (killer heat waves).**
2. **Changing rainfall patterns.**
3. **Rise in sea levels.**
4. **Frequent storms and coastal flooding**
5. **Changes in regional climate could alter forests, crop yields, and water supplies**
6. **Drought**
7. **Food shortages due to shift in agricultural food production**
8. **Greater warming near the poles**
9. **Air pollution made worse by warming.**
10. **Asthma, bronchitis, emphysema complications**
11. **Expansion of Deserts into existing rangelands.**
12. **Unable to contain spread of infectious diseases**

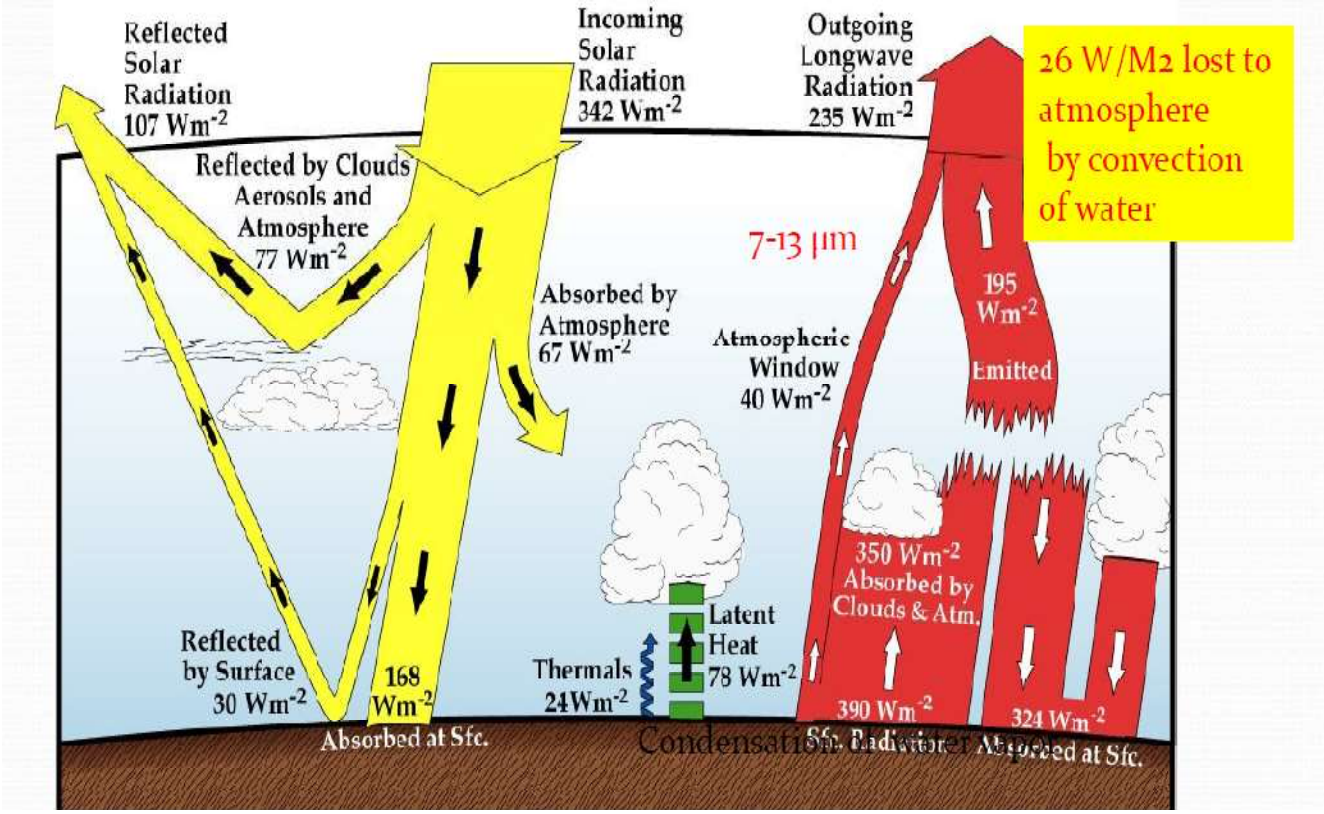
Evidences of climate change

Arctic climate impact assesssment (ACIA, 2004)



Earth energy Budget

Pathway of energy transfer in global average



Global climate change mode

A blackbody is something that emits (or absorbs) electromagnetic radiation with 100% efficiency at all wavelengths.

Blackbody radiation is the radiation emitted at a characteristic wavelength that depends on the body's absolute temperature.

- Wien's Law - Peak wavelength emitted by a body

  λ_{peak} (in microns) = 2877/TK

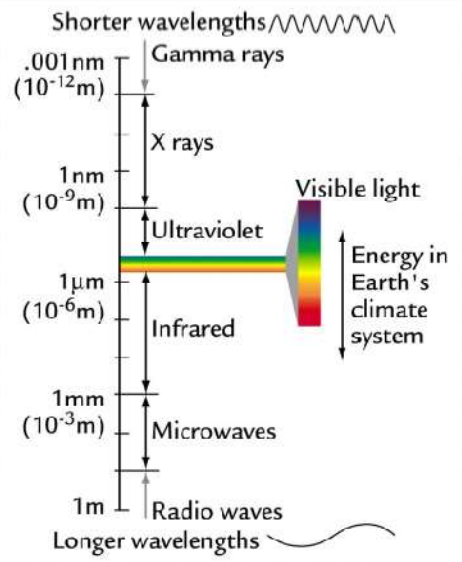
- For Sun:

  5780K = temp of photosphere

  $\lambda_{peak\ sun}$ = 2877/5780

  = 497 nm

  = 4.97×10^{-7} m

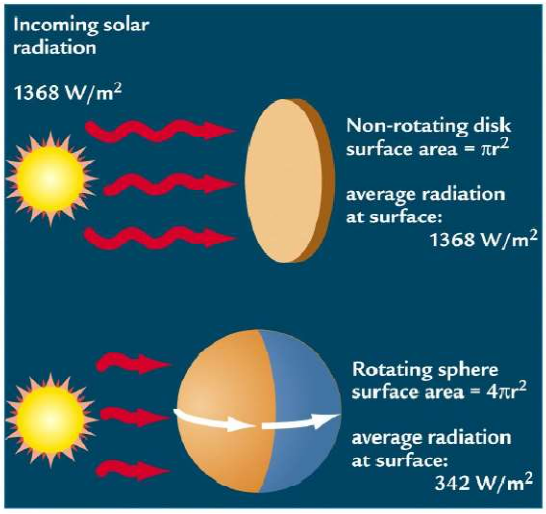


Solar constant

- Stephan-Boltzman Law (Energy emitted)
- $E = \sigma T^4$

  σ = Stephan-Boltzman constant = 5.67×10^{-8} $Wm^{-2}K^{-4}$

- E is proportional to the area under the Planck function curve
- $E_{sun} = 6.3 \times 10^7$ W/m^2
- Only a small fraction of sun's energy is received by the Earth



In the earth

- Incoming radiation is short wave.
- Outgoing radiation is long wave.

- If the Earth is a blackbody at steady state
  - Incoming = outgoing
  - $Energy_{in} = Energy_{out}$

Earth- Incoming radiation

- Solar radiation intersects Earth as a disk (πr^2)

- $Energy_{in}$ = $Energy_{in}$ from sun (S) – Reflected Solar Energy

  $= \pi r^2 S - \pi r^2 S\alpha$

  Where:

  r = radius of Earth (6360 km)

  S = solar constant (1368 W/m^2)

  α = albedo (earth's reflectivity) (~30%)

  $= \pi r^2 S (1- \alpha)$

Earth out going radiation

- Earth radiates as a sphere with area $4\pi r^2$ (m^2)
- Stephan-Boltzmann equations defines outgoing energy based on radiating temperature

- $Energy_{out} = 4\pi r^2 \sigma T_e^4$

  (units $(m^2)(Wm^{-2}K^{-4})(K^4) = W$

  Total energy emitted by the Earth

Earth's Radiation Budget

- If the earth were a black body the in = out
- Set incoming = outgoing

$\pi r^2 S (1- \alpha) = 4\pi r^2 \sigma T_e^4$

Simplify:

$S/4 (1- \alpha) = \sigma T_e^4$

Solve for T_e

$T_e = 255K$ (-18 °C)

- Earth's actual surface temperature

$T_s = 288K$ (15°C)

λ_{peak} (μm) = 2877/288 = 10 μm (IR)

$T_s - T_e = 288 - 255 = 33$

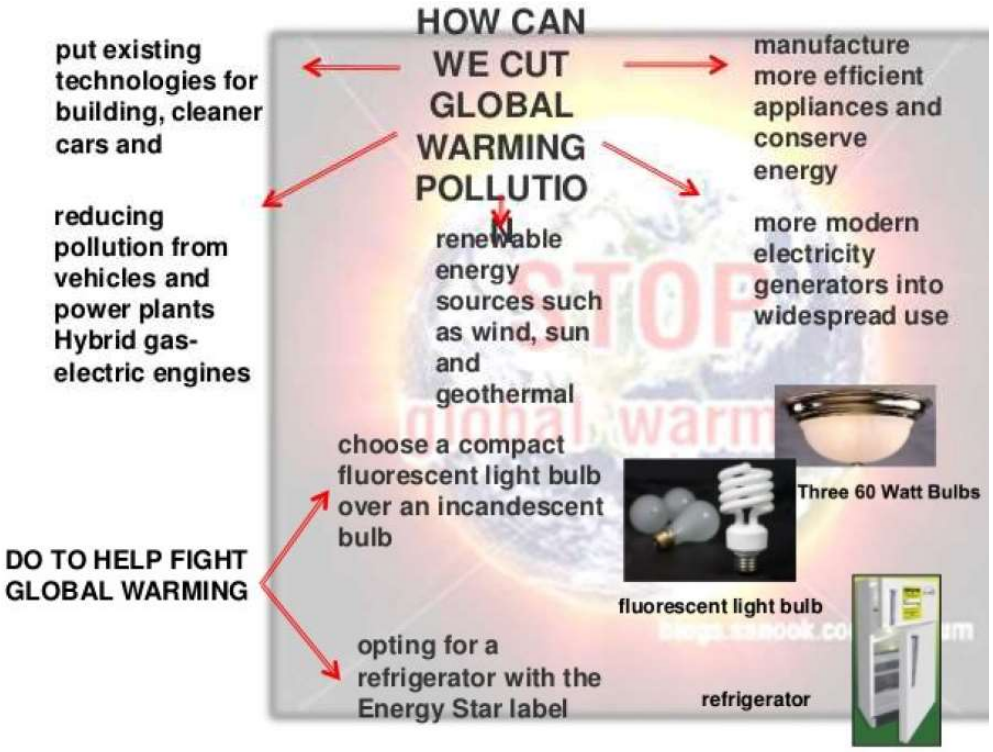
= Earth's natural greenhouse

- Interactions within atmosphere alter radiation budget (Earth is not a black body)
- Greenhouse Effect

Mitigation of Global warming

- Conservation
  - Reduce energy needs
  - Recycling
- Alternate energy sources
  - Nuclear
  - Wind
  - Geothermal
  - Hydroelectric
  - Solar
  - Fusion?

- Use less heat and air conditioning
- Drive less and drive smart
- Factory install smoke filters
- Plant a tree
- Vehicles use unleaded petrol
- Enforce the law on behalf of polluting the environment
- Environmental campaign



Storage of CO_2 in Geological Formations

1. Depleted oil and gas reservoirs
2. CO_2 in enhanced oil and gas recovery
3. CO_2 in enhanced coal bed methane recovery