Earth's Energy comes from the Sun

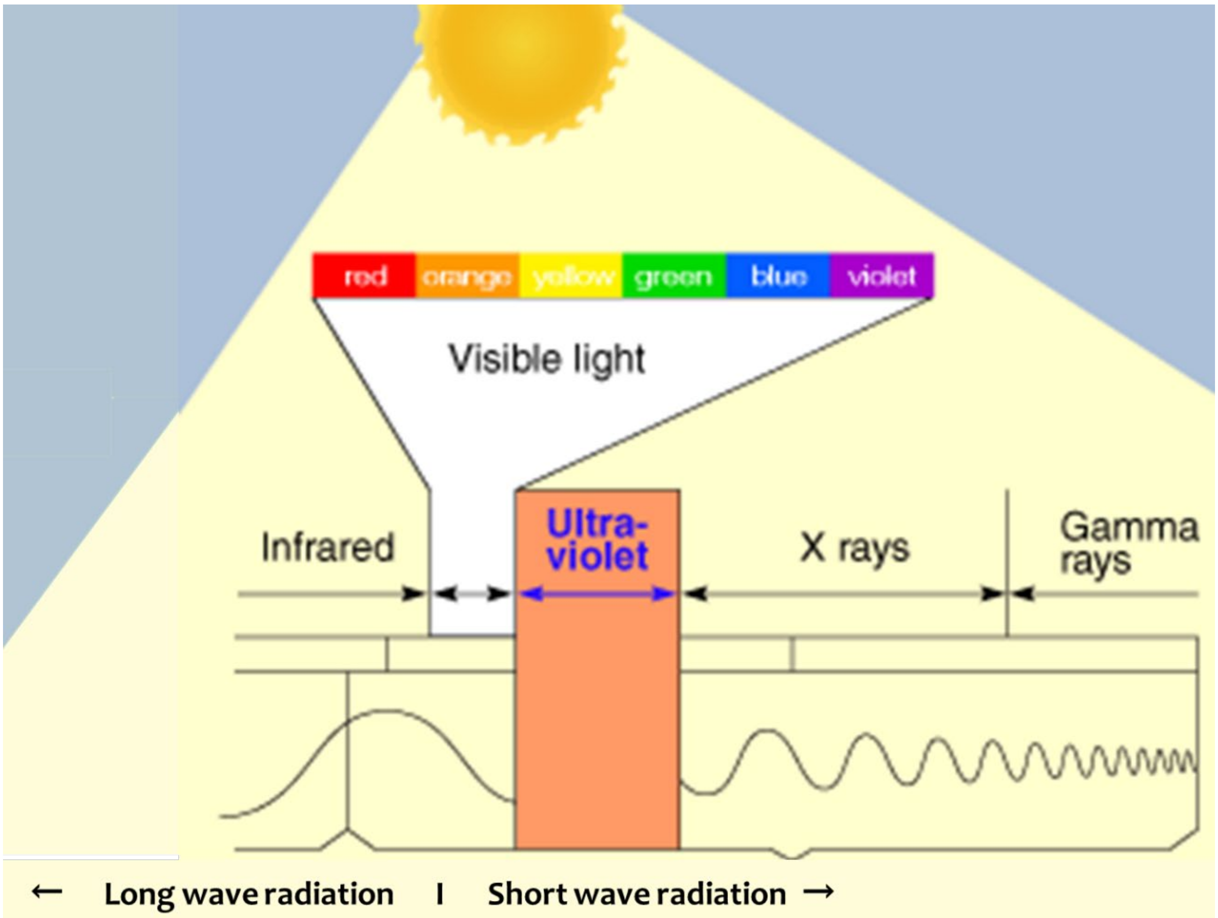
A star is a mass of extremely hot gas. It emits heat and light energy produced by nuclear reactions. The sun consists of extremely hot gases held together in a sphere by gravity. Nuclear reactions occur inside the sun. Hydrogen is changed into helium and huge amounts of energy are released. The interior temperature is 14 million °C, and the surface temperature is 5,800 °C.

The nuclear (fusion) reaction inside the Sun generates electromagnetic radiation in the form of energy: heat (infrared), light (visible), radio waves, Ultra violet. The Sun does make X-rays, but our atmosphere stops them from reaching Earth's surface.

Energy can be transferred as waves.

Light and other types of electromagnetic radiation from the sun and even further away stars travel through space in a vacuum – an area of very little or no atoms. Light does not need matter or a substance through which to travel. Each particular type of electromagnetic radiation, including each different colour of light, has a unique fixed length of wave, called the **wavelength** (λ), that it travels in.

The Sun releases large amounts of energy. The energy can be **emitted** from the energy source in the form of **electromagnetic radiation** and travels in **electromagnetic waves.** Heat (infrared) is long wave radiation, Light is short wave radiation

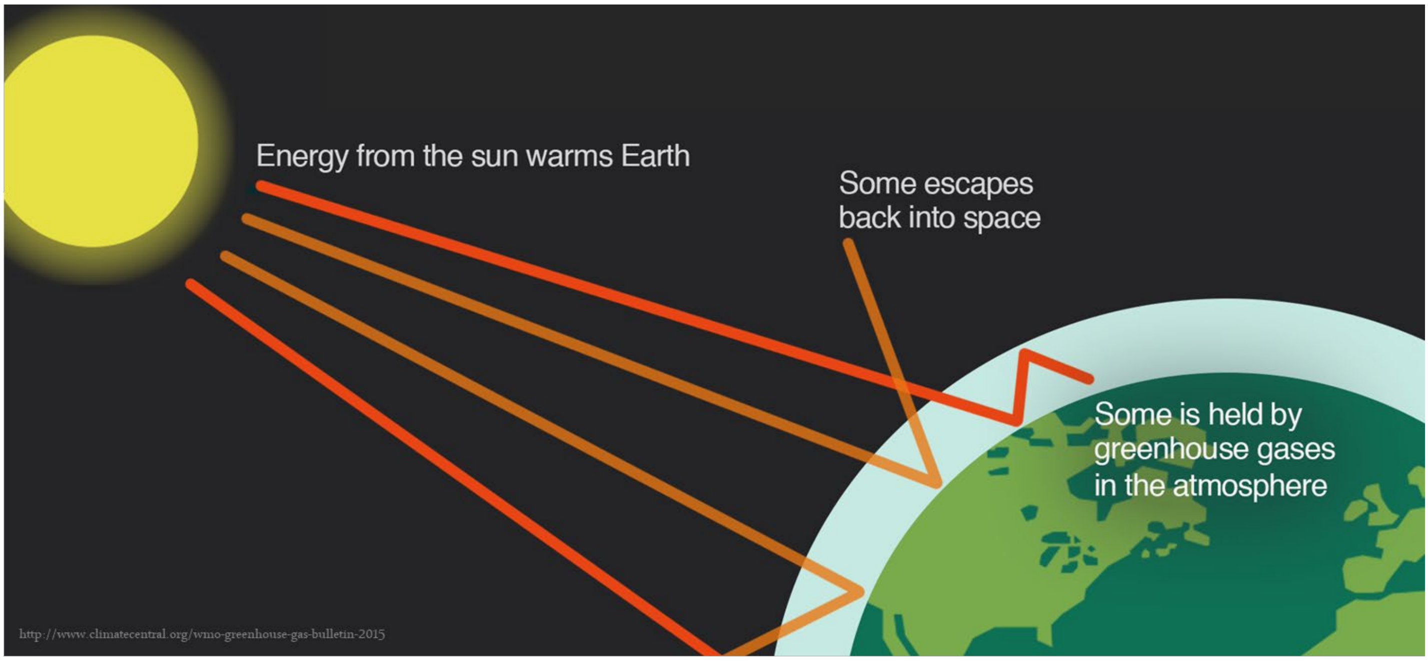


Heat (infrared) radiation has a longer wavelength than light

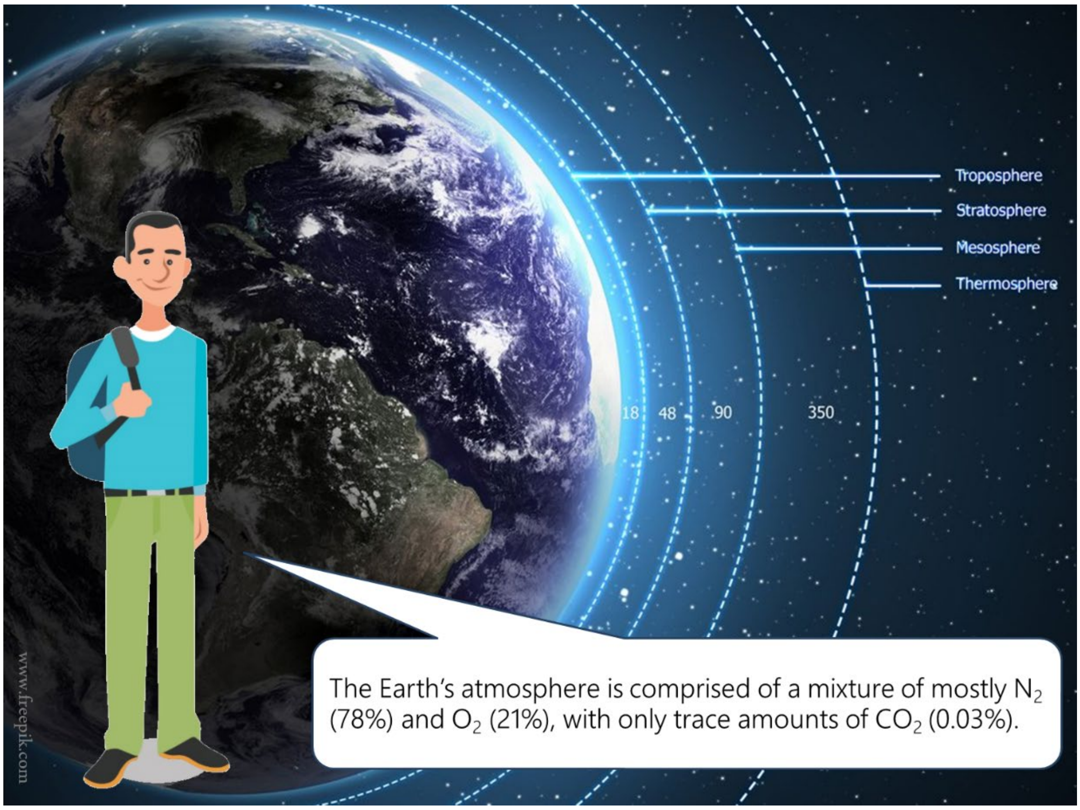
The temperature of the body (source) determines the main type of radiation that is emitted. The Earth is cooler than the Sun, so mainly emits heat, travelling long wavelengths.

Energy moving around the Earth

The short wavelength radiant energy from the Sun travels with little resistance through the Earth's atmosphere until it reaches the surface, where it is absorbed, and then most of the energy re-radiated. The Earth is much cooler than the Sun, so energy travels in longer wavelengths, mostly as infrared radiation (heat).

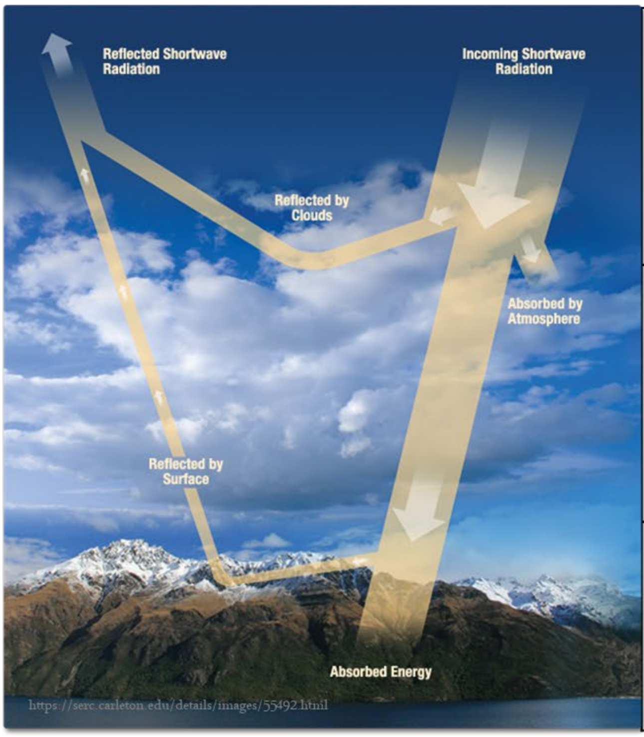


The atmosphere



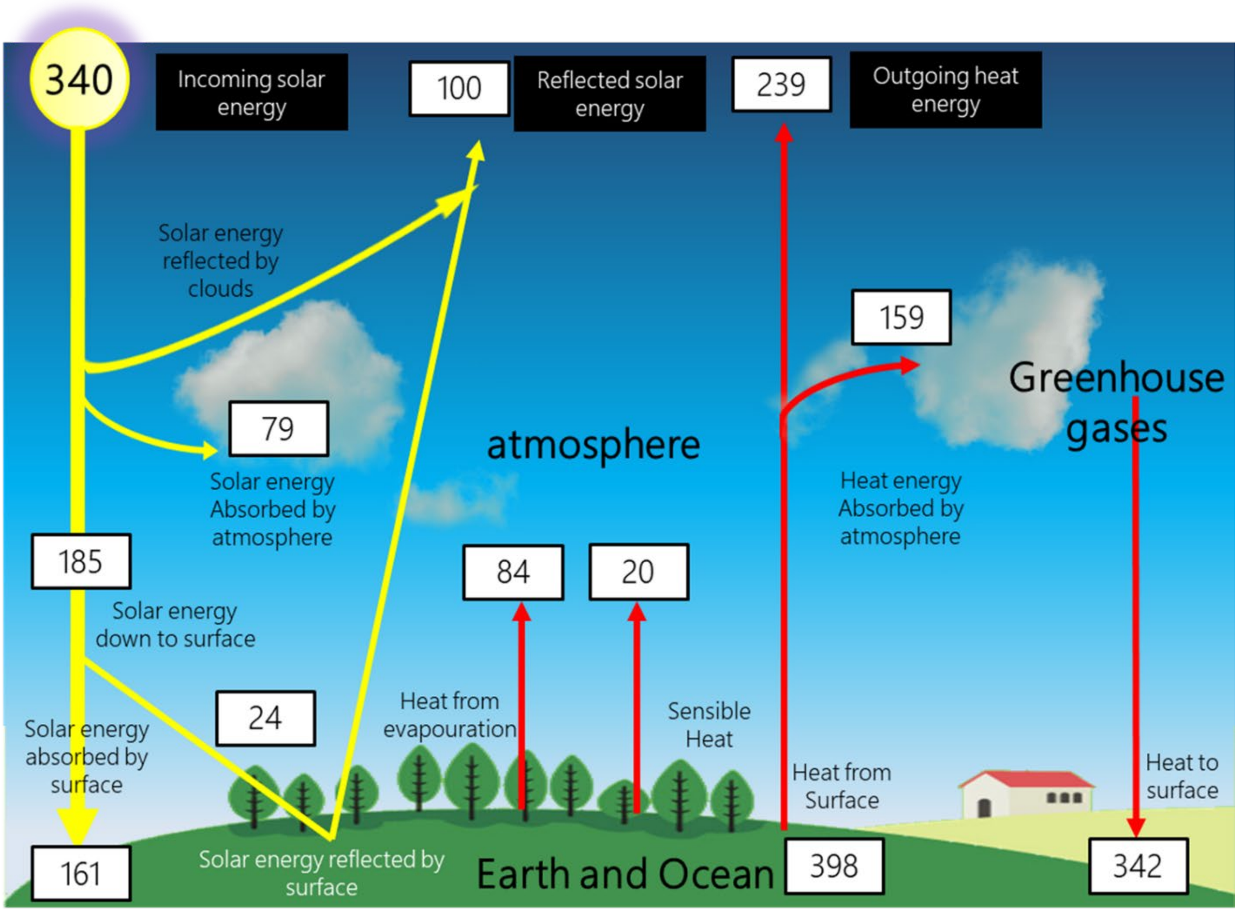
Calculating Earth's Energy Budget

The Energy Budget calculates the total amount of energy entering the Earth's atmosphere (as light energy), and subtracts the total amount leaving (as light and heat). The amount of energy left over will cause the atmosphere to heat.



Total of all Solar (light) energy into Earth's atmosphere	340	Total of all outgoing solar (light) energy from Earth's atmosphere	100
		Total of all heat (thermal) energy leaving Earth's atmosphere	239
TOTAL of all energy reaching Earth's atmosphere	340	TOTAL of all energy leaving Earth's surface	339

Difference in energy IN and energy OUT 1 w/m^2 into Earth's atmosphere

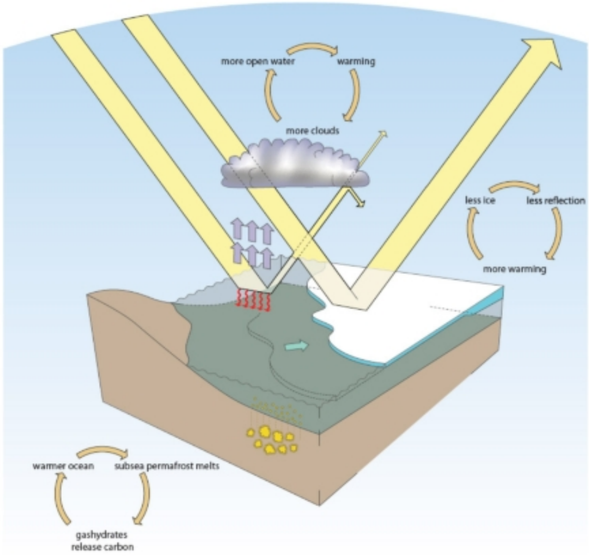


Albedo Effect

Short wave radiation (light), **is** either **reflected** or **absorbed** when it reaches the ground.

White and silver objects **reflect** radiation and very little heat energy is transferred to them, called the albedo effect. Black objects **absorb** radiation and a large proportion of the heat energy is transferred to them. The disappearance of surface ice and snow is reducing the albedo, revealing dark rock or water, therefore, a significantly higher amount of energy is absorbed rather than reflected.

This increases the average temperature near the polar areas and induces even further melting of the ice and snow.

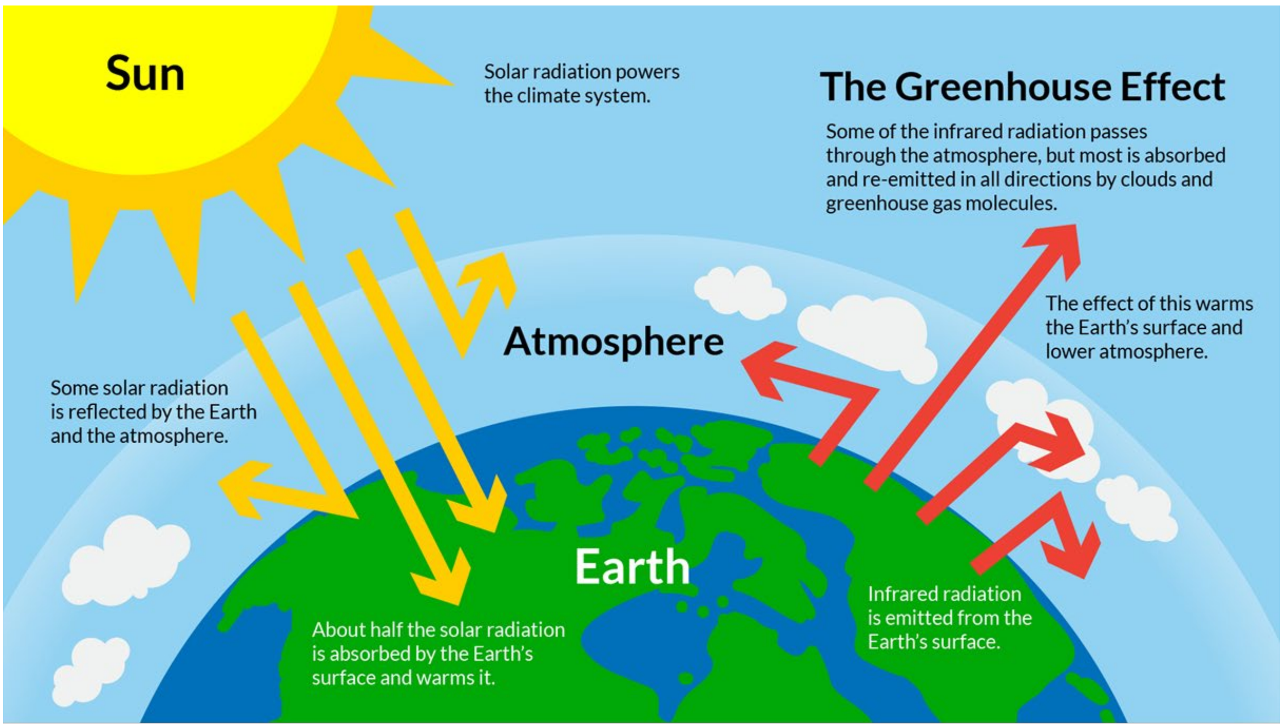


http://www.npolar.no/en/facts/albedo-effect.html

The Greenhouse Effect

The *greenhouse effect* is **very important for life on earth**. Without it, Earth would be too cold to support life. Even during night time, when that half of the Earth's surface is facing away from the Sun, enough heat is retained to keep it warm.

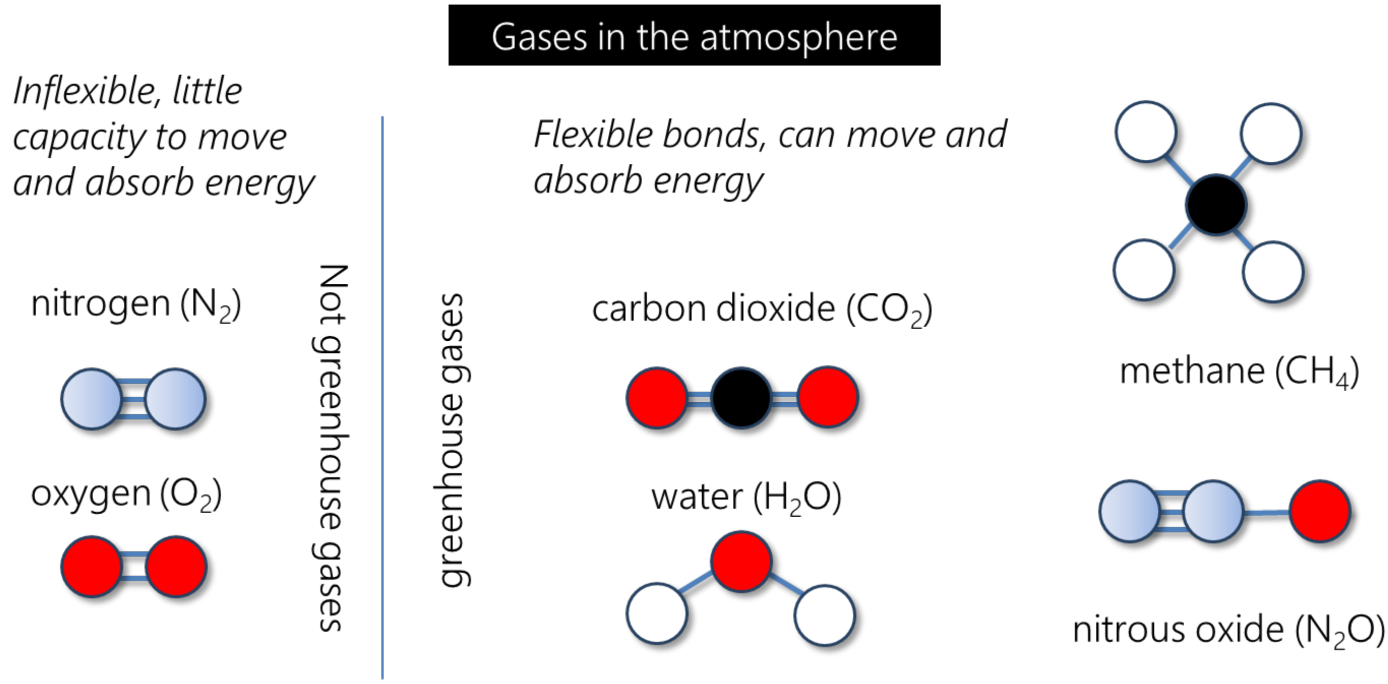
CO_2, H_2O, and methane (CH_4) gases in the atmosphere can *absorb* and *emit (send out)* long wavelength energy (Heat), causing the atmosphere to heat up. The more greenhouse gases, the more energy is kept than released back out into space. This is the principle of the *greenhouse effect.*



Greenhouse Gases Diagram Fileearths Greenhouse Effect Us Epa 2012 Wikimedia Commons intended for Greenhouse Gases Diagram.

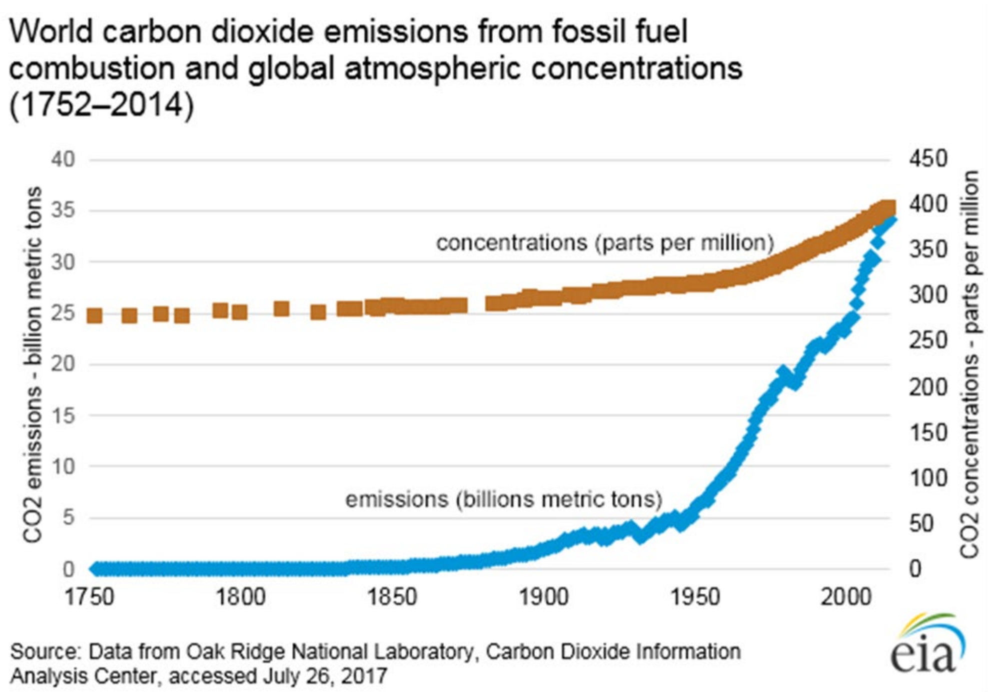
Greenhouse Gases

The gases that absorb the infrared radiation are known as greenhouse gases. Some gases, such as O_2 and N_2 are insignificant regarding the greenhouse effect, due to their particular molecular structure. CH_4 and H_2O are 'stronger' GHG than CO_2, but due to the shorter time they stay in the atmosphere they have less influence. H_2O cycles rapidly through the atmosphere and CH_4 breaks down after around 12 years, compared to CO_2, which remains for hundreds of years.



Human activity increases Greenhouse gas concentration in the atmosphere

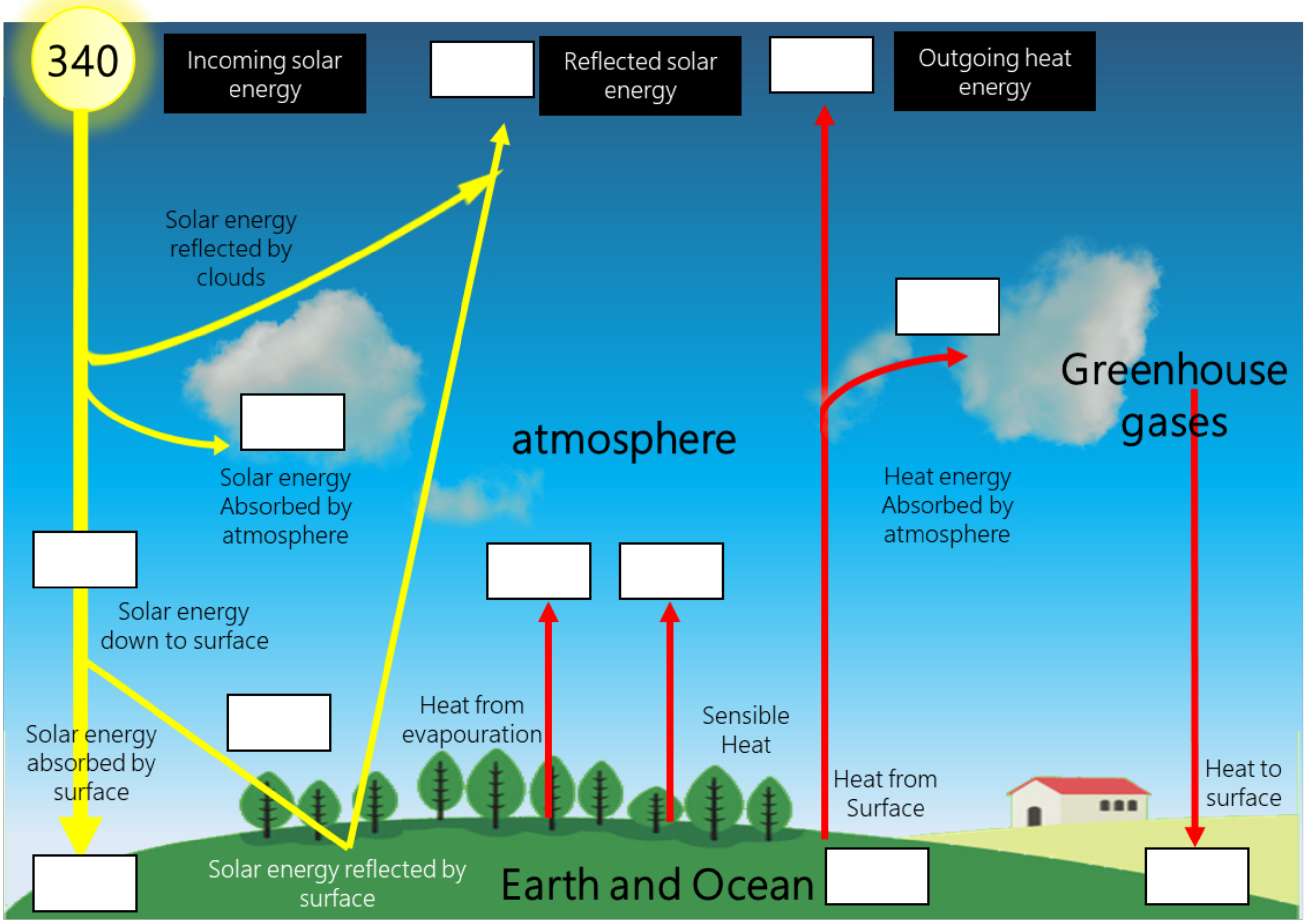
Shifts in the past atmospheric concentrations of CO_2 are linked to natural fluctuations (changes) in the climate, but it is now apparent that the predominant (main) factor in current climate change is human caused emissions of greenhouse gases.



https://www.eia.gov/energyexplained/print.php?page=environment_how_ghg_affect_climate

1. Add the values to the correct labels on the diagram

Contribution	Energy (Watts/m^2)
TOTAL Incoming solar energy	340
TOTAL Reflected Solar energy	100
Solar energy absorbed by atmosphere	79
Solar energy down to surface	185
Solar energy reflected by surface	24
Solar energy absorbed by surface	161
Heat from Evaporation	84
Sensible heat	20
TOTAL Outgoing heat (thermal) energy	239
Heat (Thermal) energy up from surface	398
Heat (Thermal) energy down from surface	342



Energy budget values based on IPCC AR5

2. Calculating Earth's Energy Budget: Use the information form the previous diagram to calculate

Total of all Solar (light) energy into Earth's atmosphere		Total of all outgoing solar (light) energy from Earth's atmosphere	
		Total of all heat (thermal) energy leaving Earth's atmosphere	
TOTAL of all energy reaching Earth's atmosphere		TOTAL of all energy leaving Earth's surface	

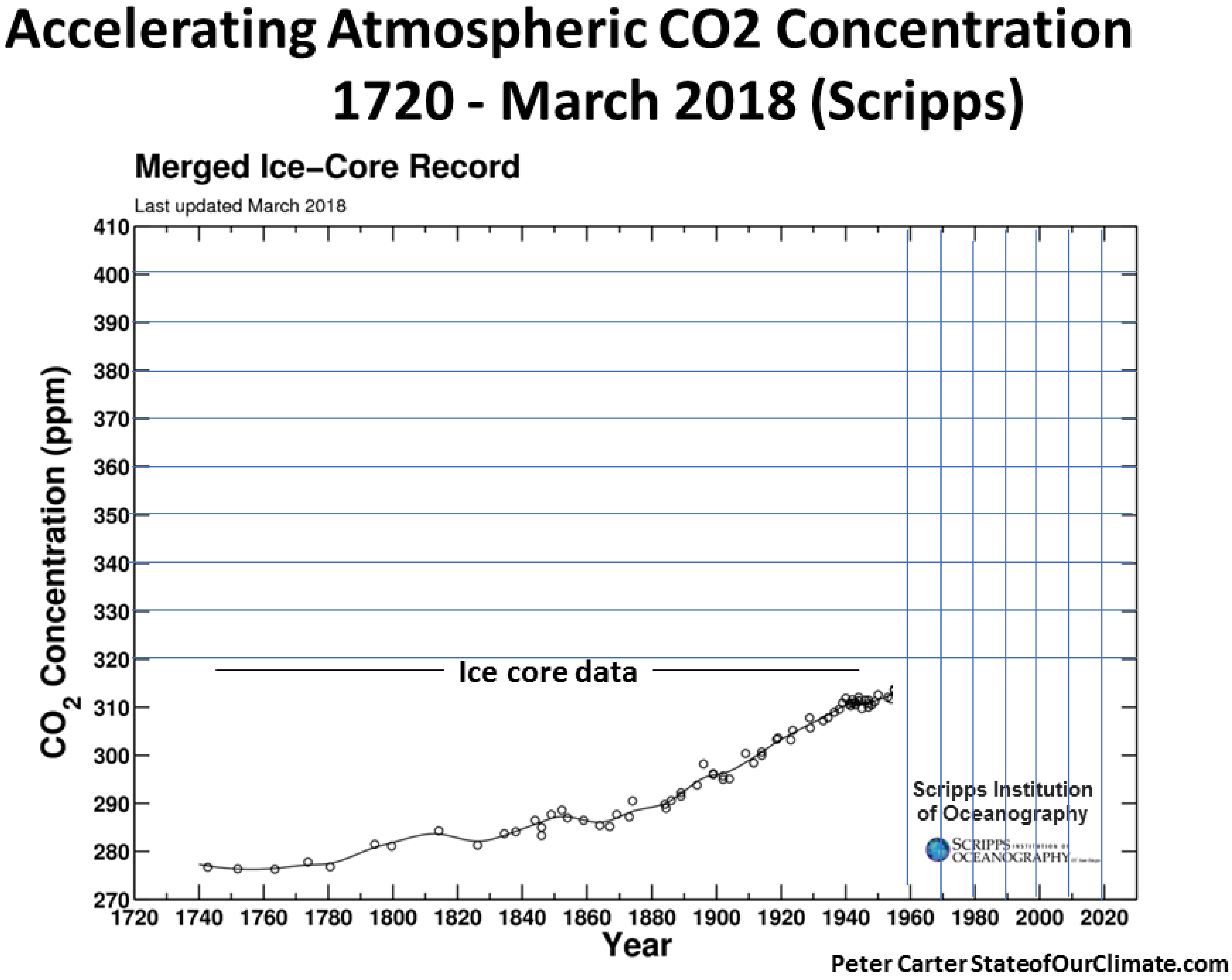
3. Difference in energy IN and energy OUT _________________ w/m^2 in the atmosphere

4. What effect will this difference have on Earth's overall energy, and therefore temperature?

5. Discuss what might happen to the Earth's energy budget in these two following scenarios

   a. Increase of Carbon dioxide emissions (Greenhouse gas)
   b. Decrease of land ice from increasing warming, reducing light reflected by surface (Albedo effect)

6. Use the following data to continue plotting a line graph of CO_2 concentration in the atmosphere over time. Use a ruler to find correct concentration reading.



Year CO_2 data collected	CO_2 concentration in the atmosphere (ppm)
1960	317
1965	320
1970	325
1975	331
1980	339
1985	346
1990	354
1995	361
2000	370

Year CO_2 data collected	CO_2 concentration in the atmosphere (ppm)
2002	373
2004	377
2006	382
2008	385
2010	389
2012	394
2014	399
2016	403
2018	407 (currently)

data collected from Mauna Loa, Hawaii observatory