

Introduction to the Atmosphere

ESS 2017



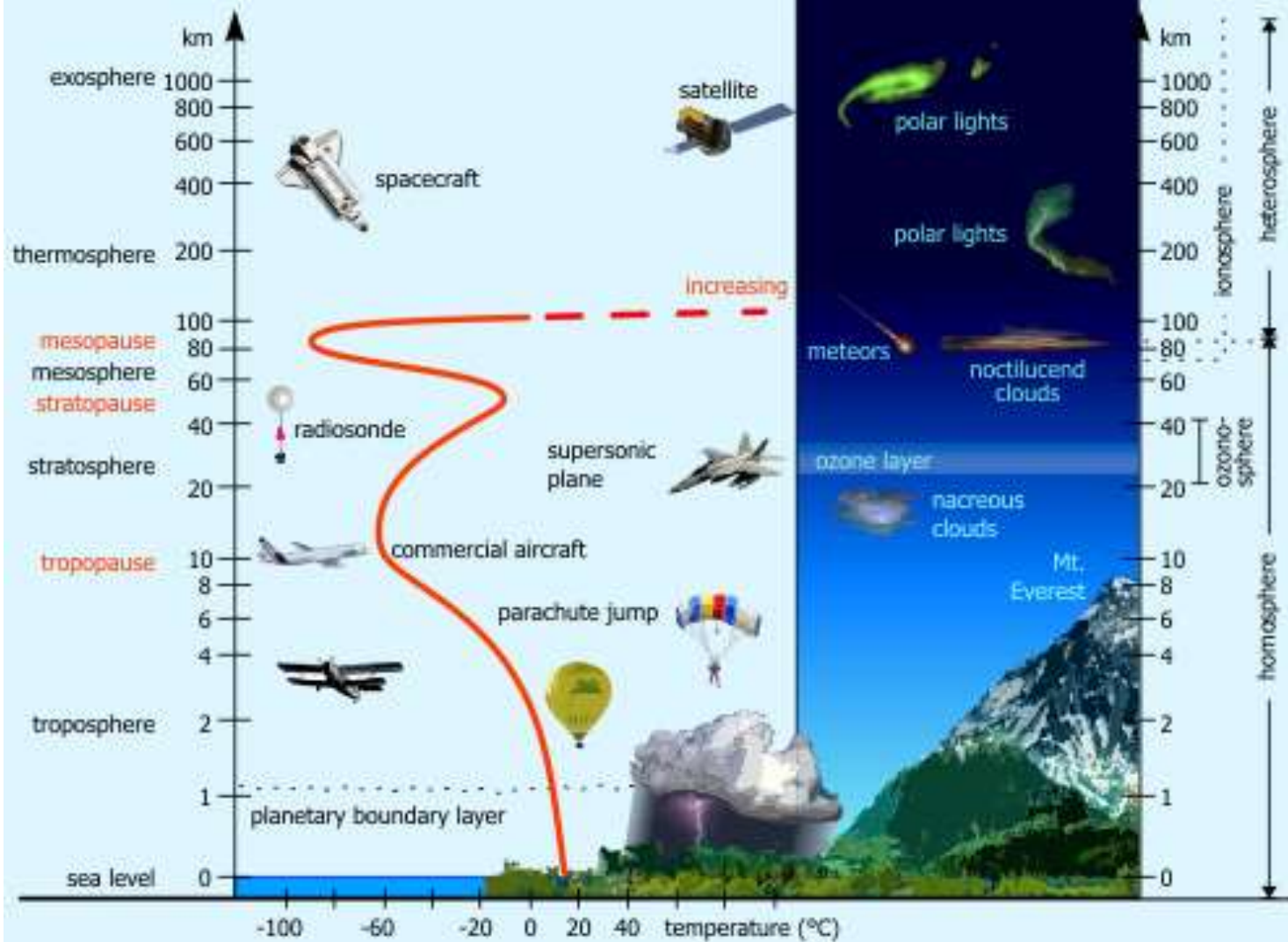
Learning Objectives

I will be able to...

Explain how atmospheric circulation helps to regulate the global energy balance

Explain the role of albedo in regulating global average temperature through feedback loops

Outline the role of the greenhouse effect in regulating global temperatures



Composition of gases in atmosphere

Gases include

- N_2 = Nitrogen
- O_2 = Oxygen
- O_3 = Ozone
- Ar = Argon
- H_2O = Water (vapour)
- CO_2 = (Carbon dioxide)
- H = Hydrogen
- He = Helium

Troposphere

- $N_2 \approx 78\%$
- $O_2 \approx 21\%$
- Ar $\approx 1\%$
- $H_2O \approx 0.45\%$
- $CO_2 \approx 0.04\%$

**Gas composition
changes with
increasing altitude...**

Stratosphere

- $N_2 \approx 80\%$
- $O_2 \approx 18\%$
- Ar $\approx 1\%$
- $O_3 \approx 1\%$

Ionosphere

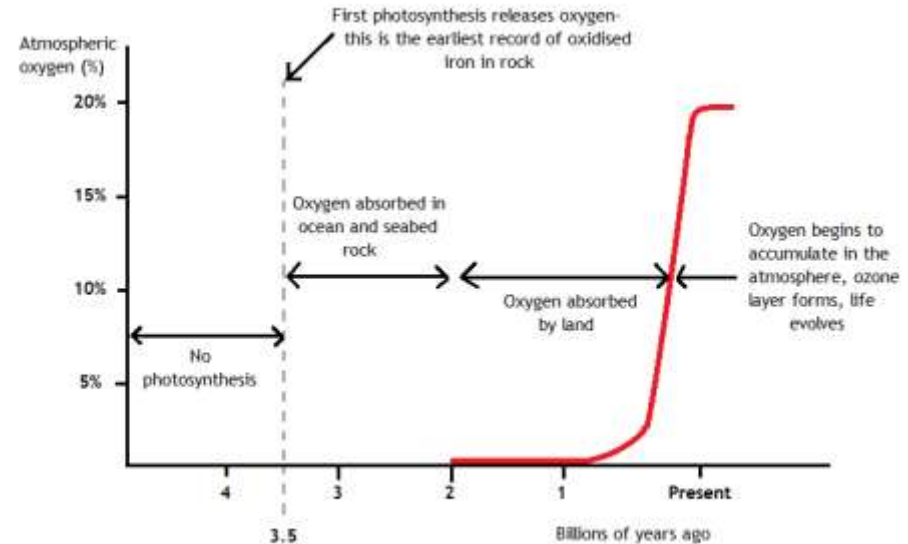
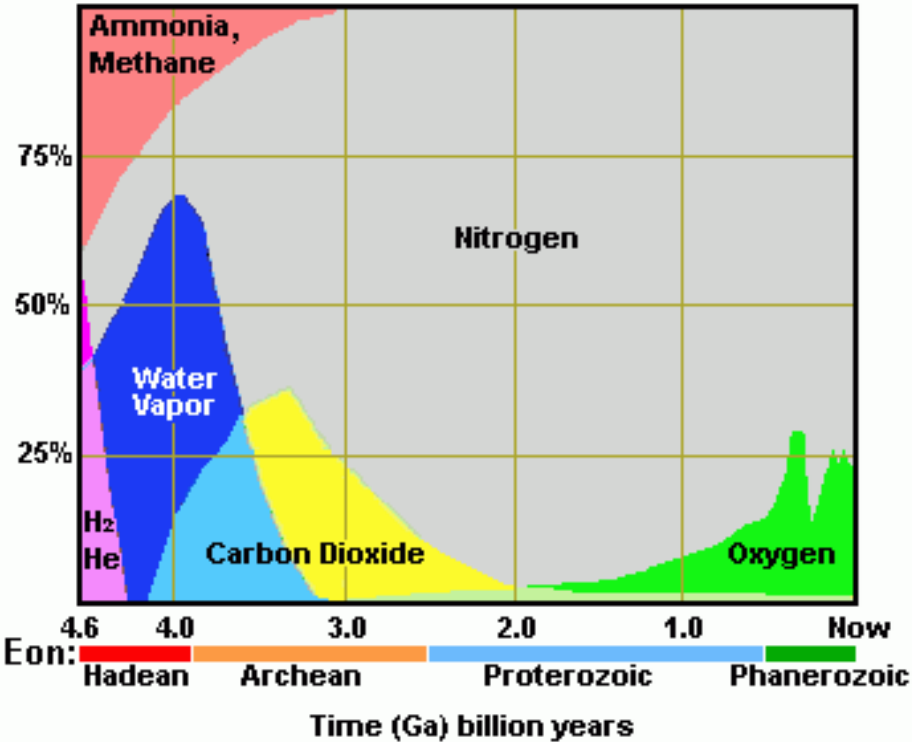
- $N_2 \approx 70\%$
- $O_2 \approx 15\%$
- He $\approx 15\%$

Exosphere

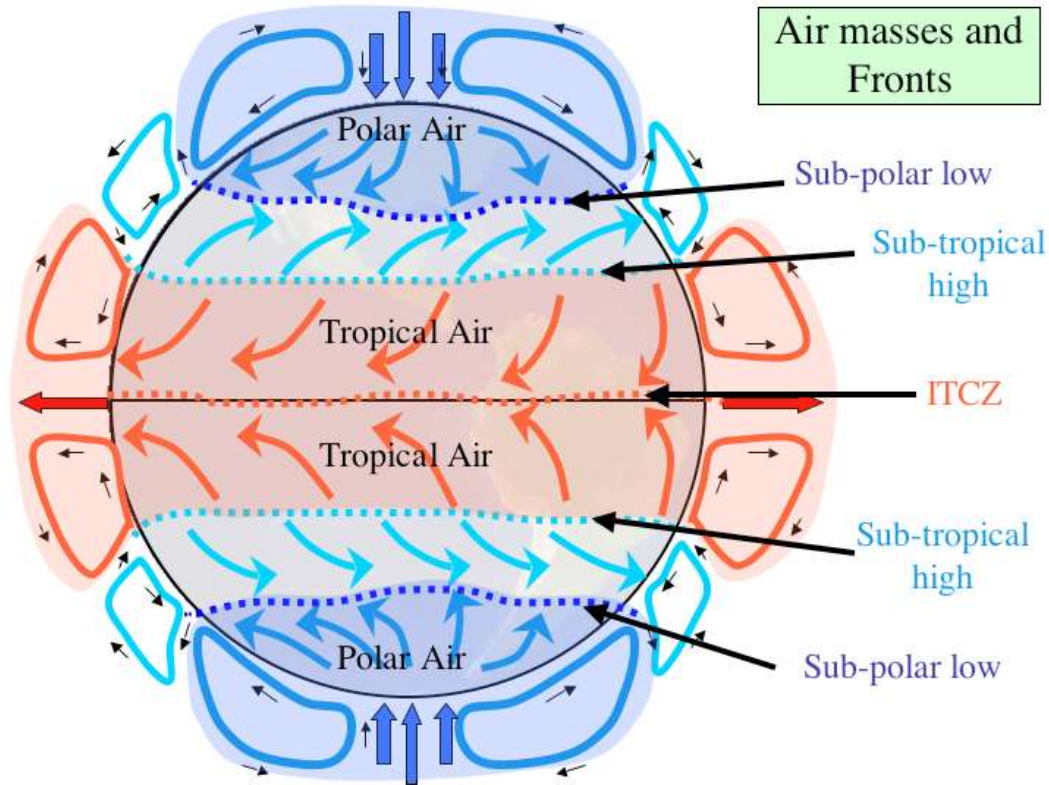
- H $\approx 75\%$
- He $\approx 25\%$

It wasn't always this way...

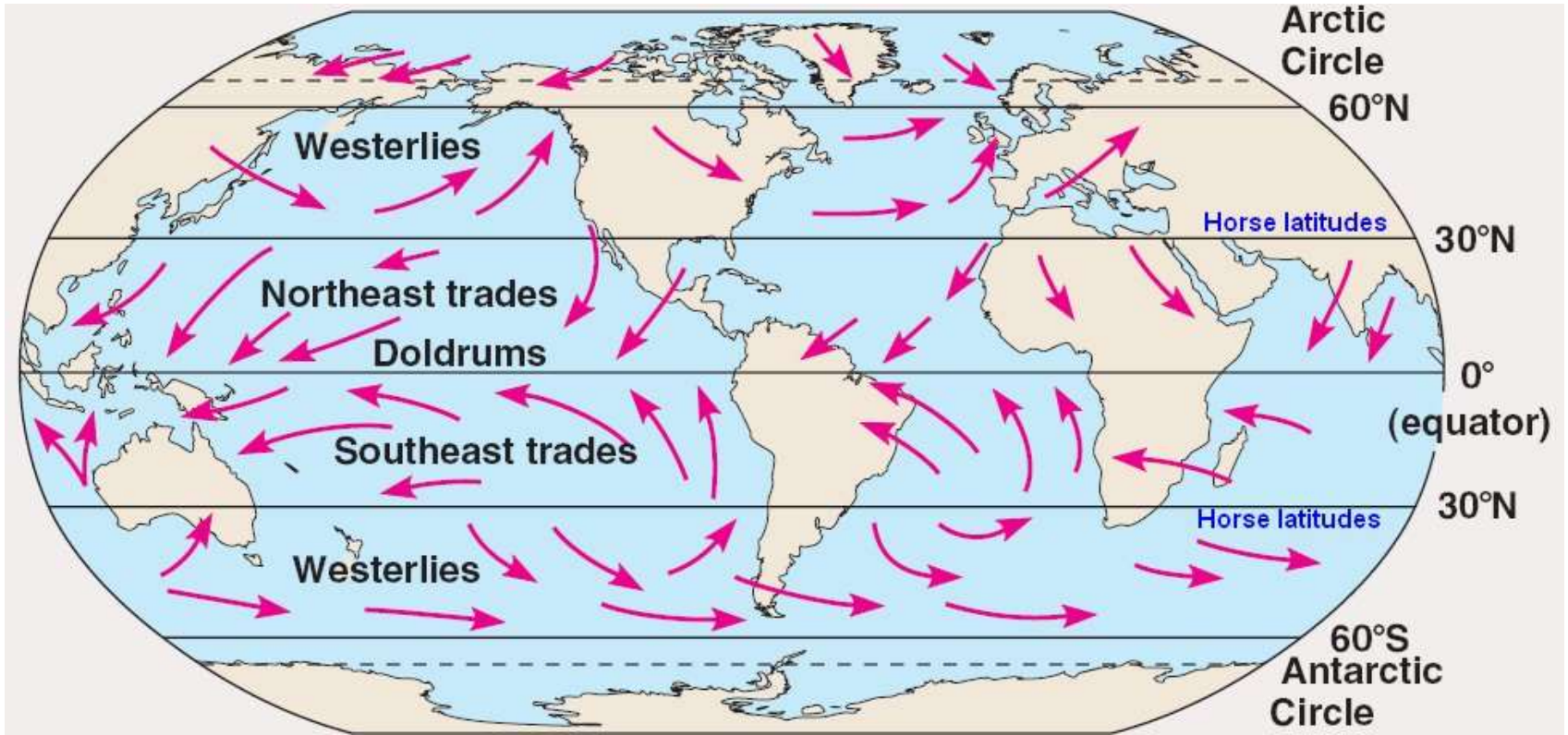
% of Atmosphere Composition of Earth's atmosphere



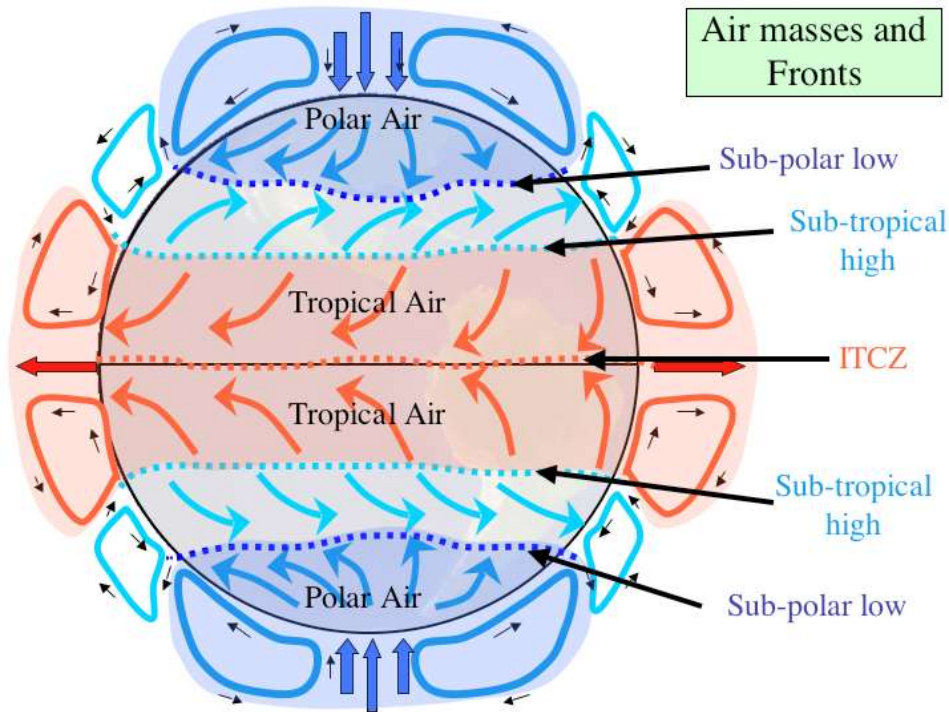
Tricellular model of atmospheric circulation



Prevailing winds on Earth



Tricellular model of atmospheric circulation



Explain how atmospheric circulation helps to regulate the global energy balance.

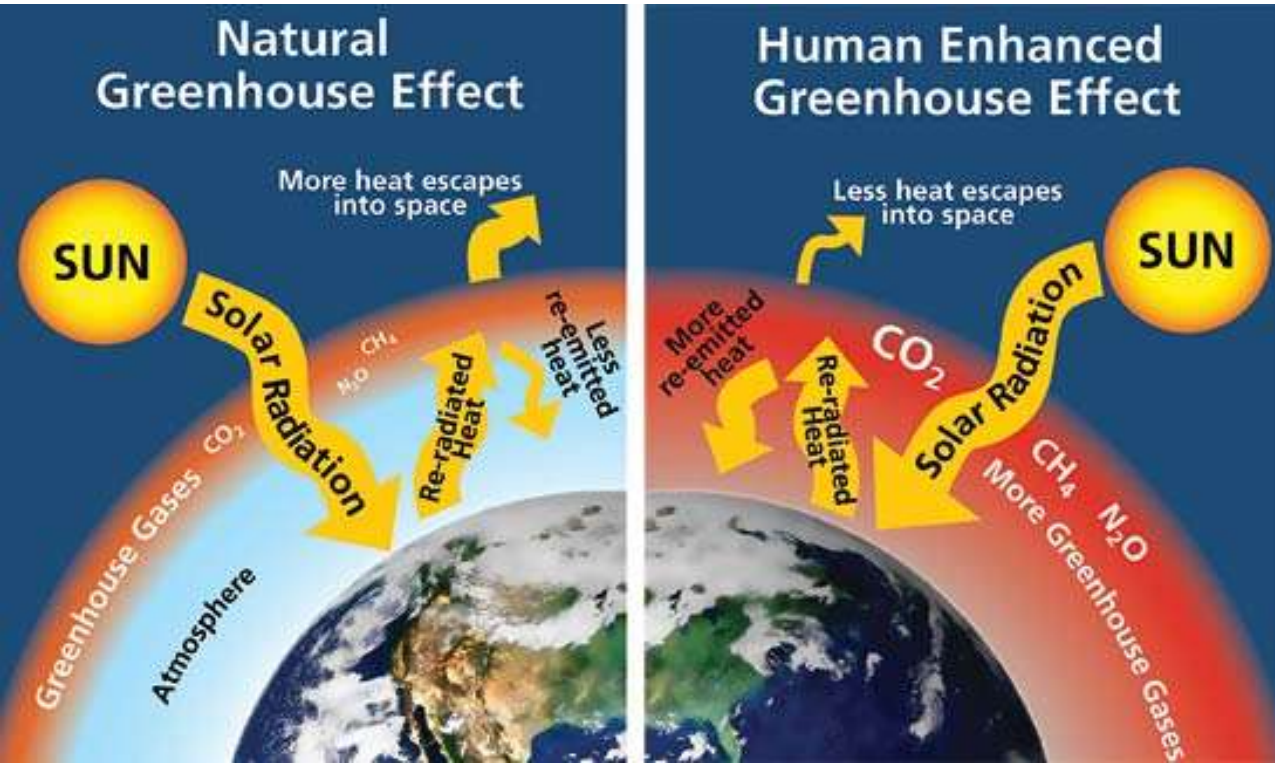
- The tropical zone receives more solar energy (and heat energy)
- There is a net gain in heat energy in the tropics and a net loss at the poles
- Heat energy transfers through the gases in air to areas of lower energy
- The movement of air creates the ocean currents (by friction)
- Heat energy transfers into the oceans...

Greenhouse effect

N_2O = Nitrous oxide

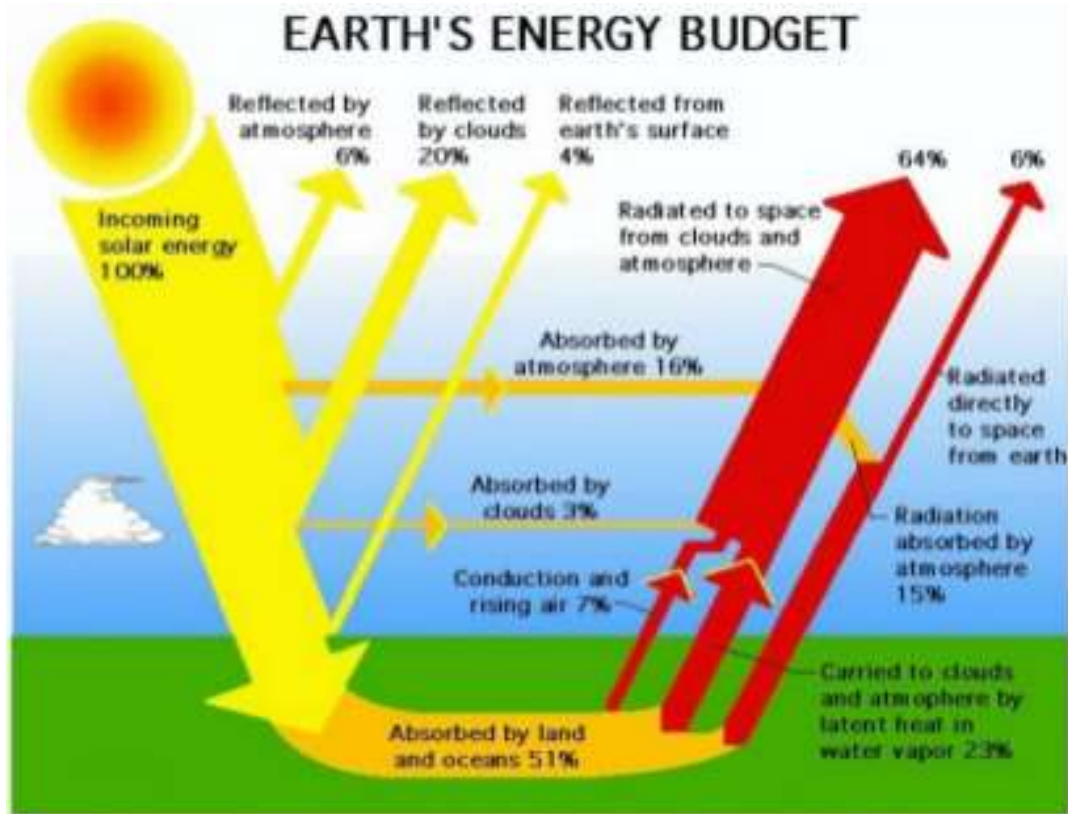
CH_4 = Methane

Outline the role of the greenhouse effect in regulating global temperatures.

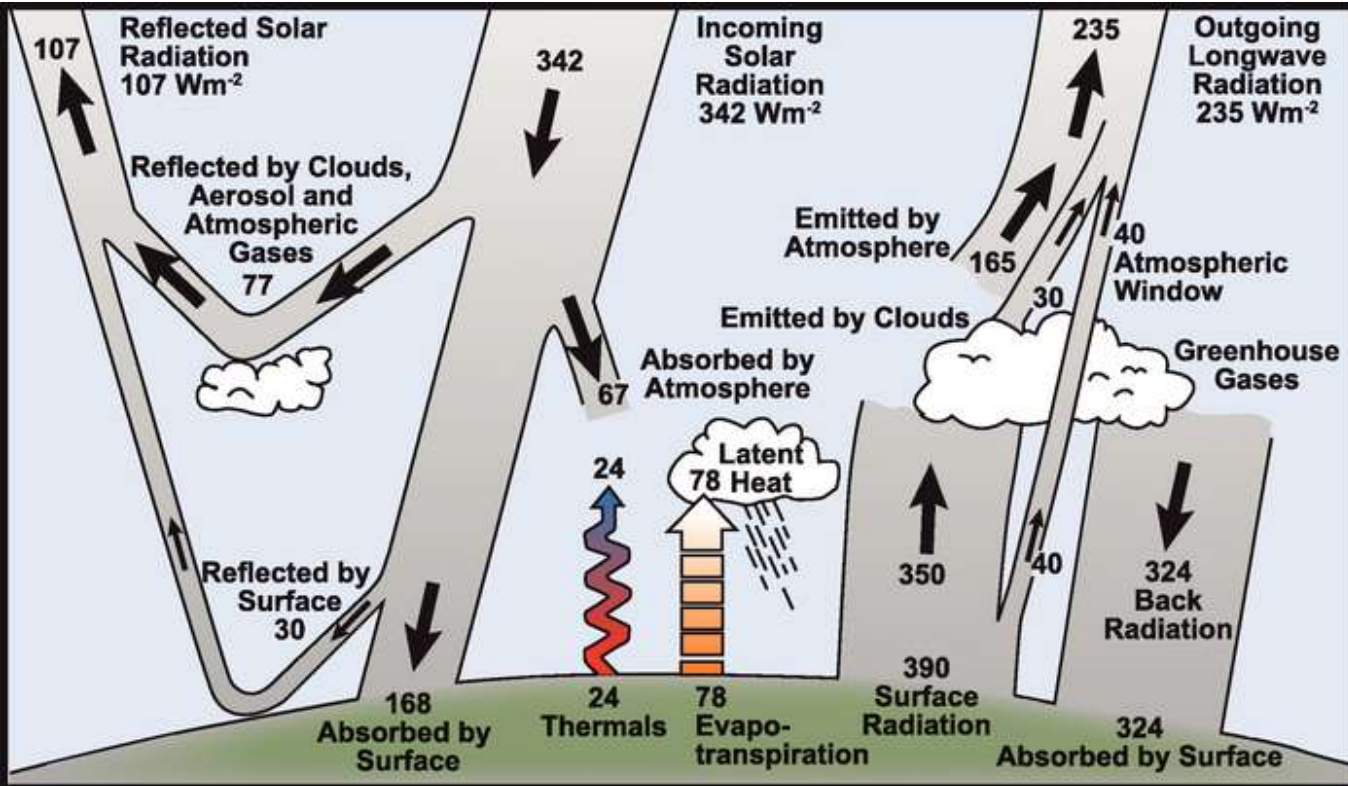


- Equilibrium as stable global temperature is...
- achieved when incoming energy is equal to outgoing energy.
- Increases in GHGs increases absorbed and re-radiated energy, increasing global temperature.

Earth's Energy budget (present day)



Earth's Energy budget (present day)



Wm^{-2} = Watt per square metre = joule per second per m^2

1 joule = the heat energy you lose every 17 ms at rest

1 joule = the energy needed to lift an apple 1 metre off a table

Earth's Energy budget (present day)

Explain the role of albedo in regulating global average temperature through feedback loops.

- Albedo is reflection: by clouds, snow, dark soil, any surface...
- Albedo is complex because of so many factors affecting the materials/structures/energy
- A cloud's albedo depends on several factors e.g. the height, size, number and size of droplets
- The loss of Arctic ice decreases **albedo** and may increase global warming, which triggers a...
- **positive** feedback loop: more energy → higher temperatures → increased evaporation and evapotranspiration → more water vapour → more heat energy is trapped in the atmosphere → ...
- However, an increase in water vapour leads to a **negative** feedback loop: more water vapour → more and bigger clouds → increased albedo → more solar energy reflected into space → lower temperatures