

02 Atmosphere

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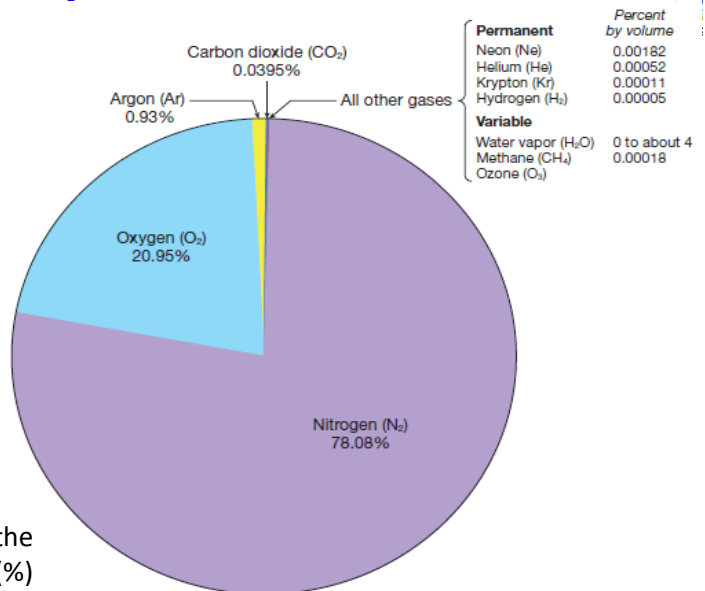
Atmosphere

- **Complex** and **dynamic system** consisting of layers of gases that envelop a planet
- **Environmental sphere** allowing the existence of life on the Earth (essential gasses, water supplies, protection from UV radiation...)
- The place where the **weather** takes place



Composition of the atmosphere

- A mix of gases, solid and liquid particles/aerosols (dust, water vapour, ice crystals, pollen, microbes, air pollutants...)

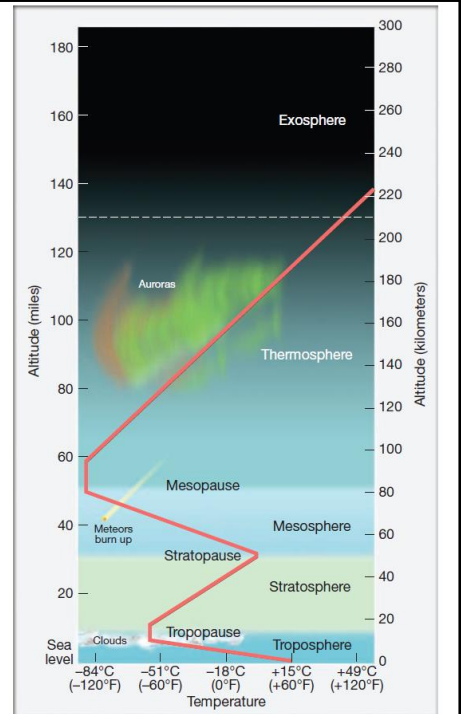


Hess, 2014

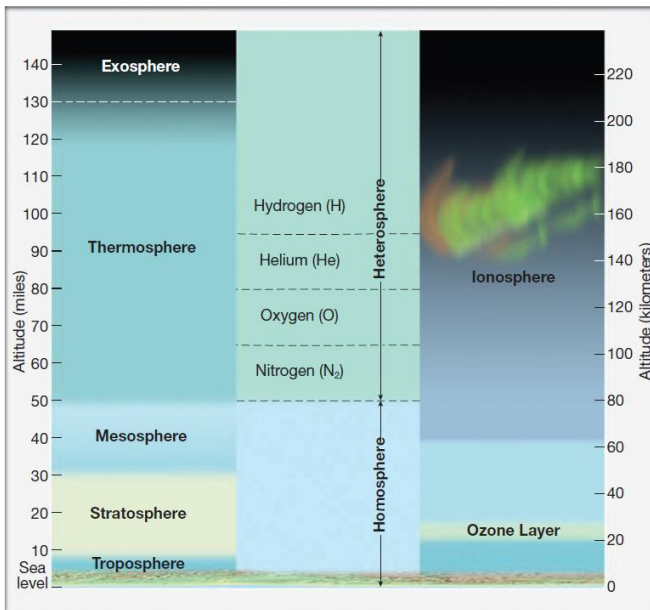
Vertical structure of the atmosphere

- Various possibilities to divide atmosphere into the individual layers (temperature, gas composition, pressure)
- Thermal structure of the atmosphere: **5 thermal layers** (Hess, 2014) →

Hess, 2014



Vertical structure of the atmosphere



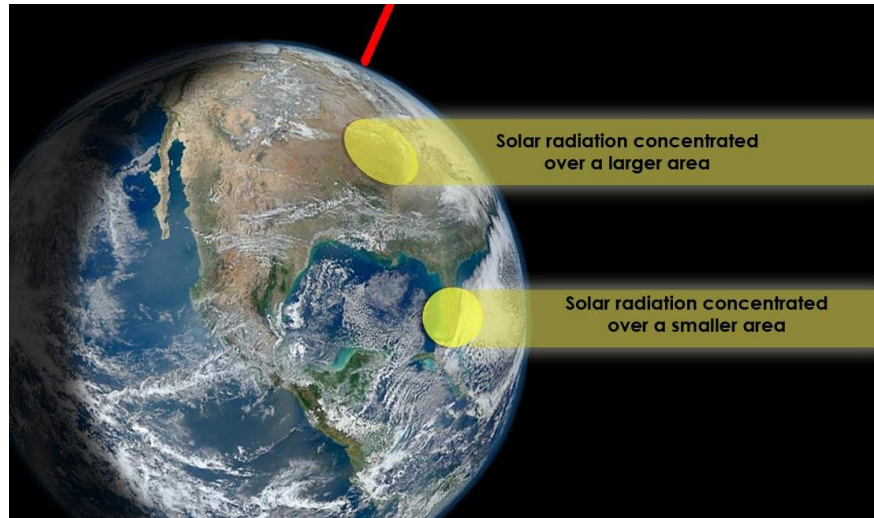
Hess, 2014

Total atmospheric mass:
 5.157×10^{18} kg

- 50% of the total mass occurs in the 5-6 km layer,
- 75% in the 0-11 km layer,
- 99% in the 0-36 km layer

Controls of weather and climate

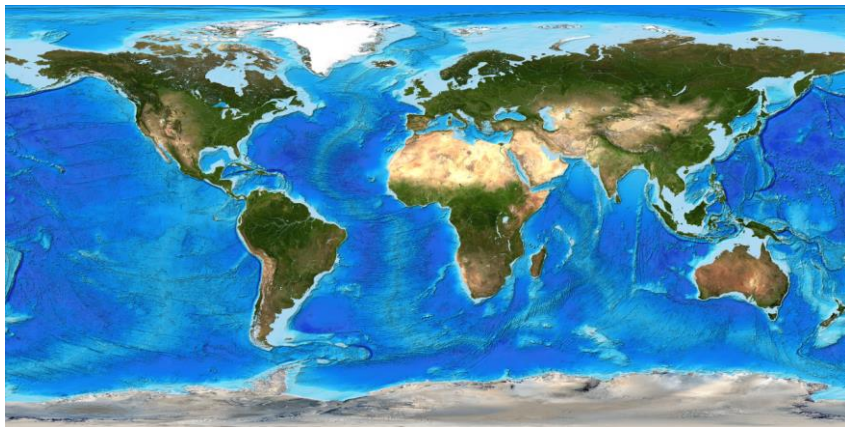
1. Latitude



<https://www.ces.fau.edu/nasa/module-3/why-does-temperature-vary/angle-of-the-sun.php>

Controls of weather and climate

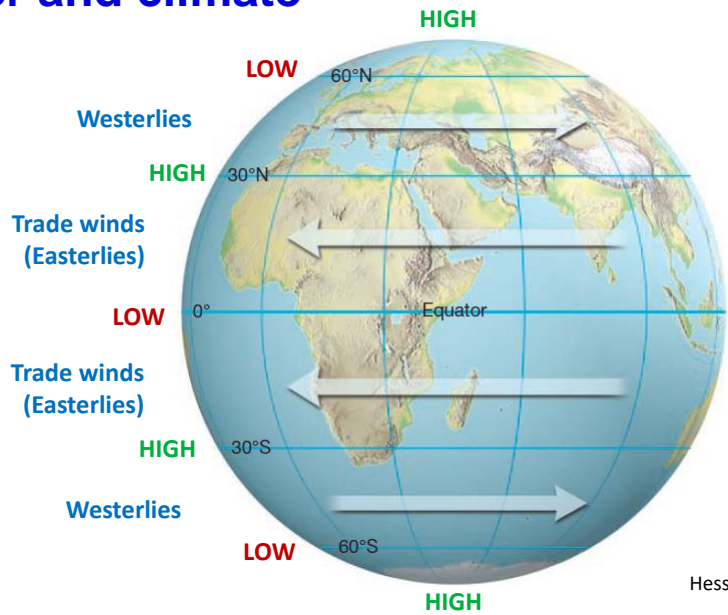
2. Land-water distribution



Oceans warm more slowly than land due to the higher **heat capacity** of water.

Controls of weather and climate

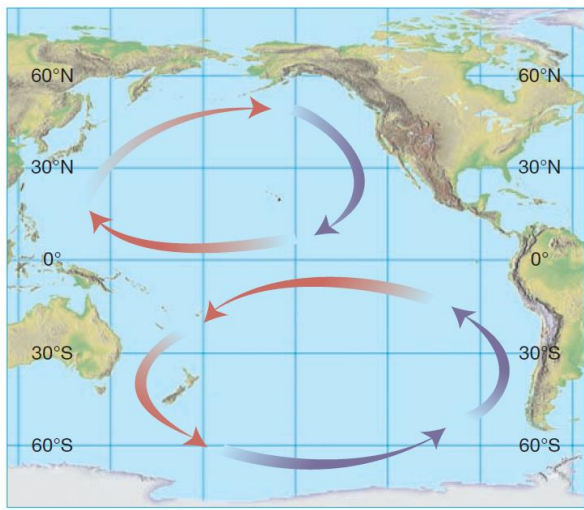
3. General circulation of the atmosphere



Hess, 2014

Controls of weather and climate

4. General circulation of the oceans



- warm water (red arrows)
- cool water (blue arrows)

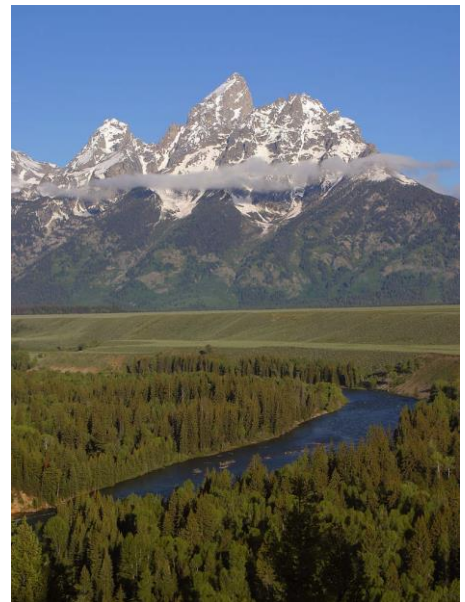
Hess, 2014

Controls of weather and climate

5. Altitude

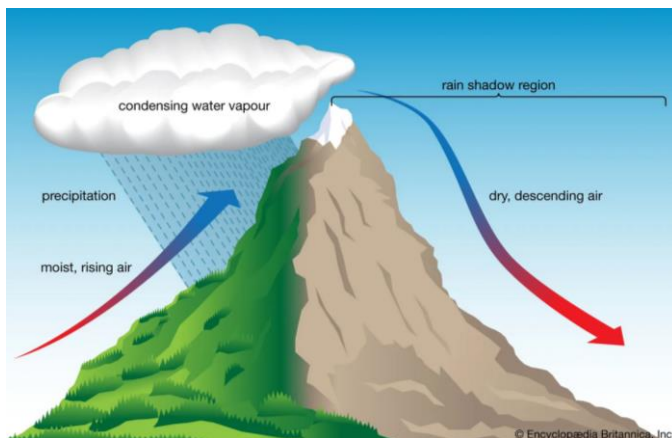
Atmospheric temperature **drops with increasing altitude** by about **0.5 to 0.6 °C per 100 metres** (0.9 to 1.1 °F per 328 feet) – **normal (temperature) lapse rate**

Altitudinal zonation



Controls of weather and climate

6. Topographic barriers



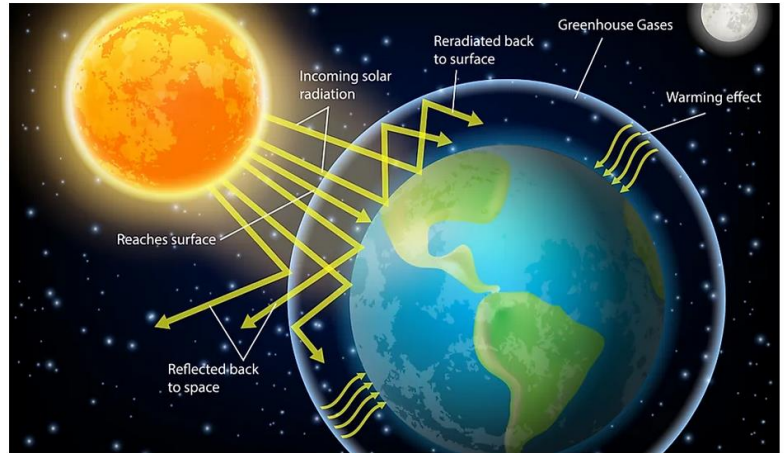
<https://www.britannica.com/science/orographic-precipitation>

Föhn winds

- warm and dry, gusty wind on the leeward side of cross mountain wind (rain shadow region)
- e.g. Alps in Europe, Rockies in the United States (*chينوок*), Abdes (*zonda*) Tianshan and Qinling in China

Energy transfers

- **solar energy** – primary energy source for most processes in the atmosphere, hydrosphere, and biosphere
- processes leading to the **warming and cooling of the atmosphere**



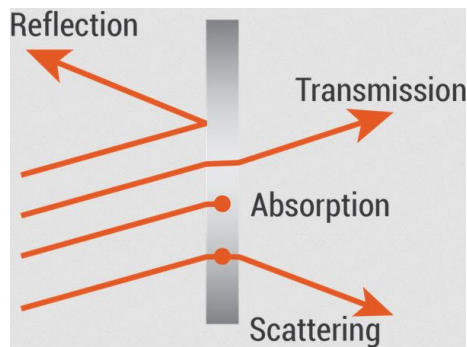
Earth's energy balance depends on the incoming and outgoing energy from the sun.

<https://www.worldatlas.com/articles/what-is-the-earth-s-energy-budget.html>

Energy transfers

Radiation (emission, W/m^2)

- emission of electromagnetic radiation from an object (e.g. Sun)
- hotter object = more intense radiation

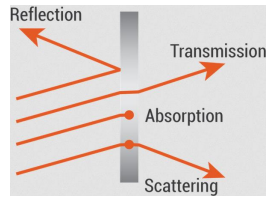


<https://www.quora.com>

Energy transfers

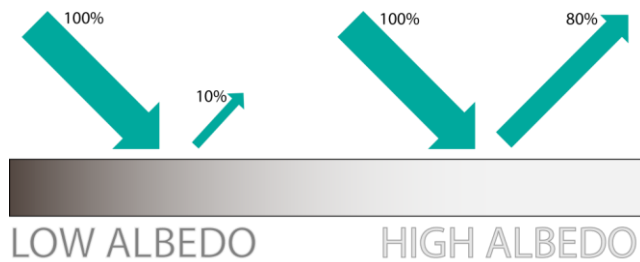
Reflection

- ability of an object to repel/return electromagnetic waves that strike it
- different reflection based on wavelength angle



Albedo (%)

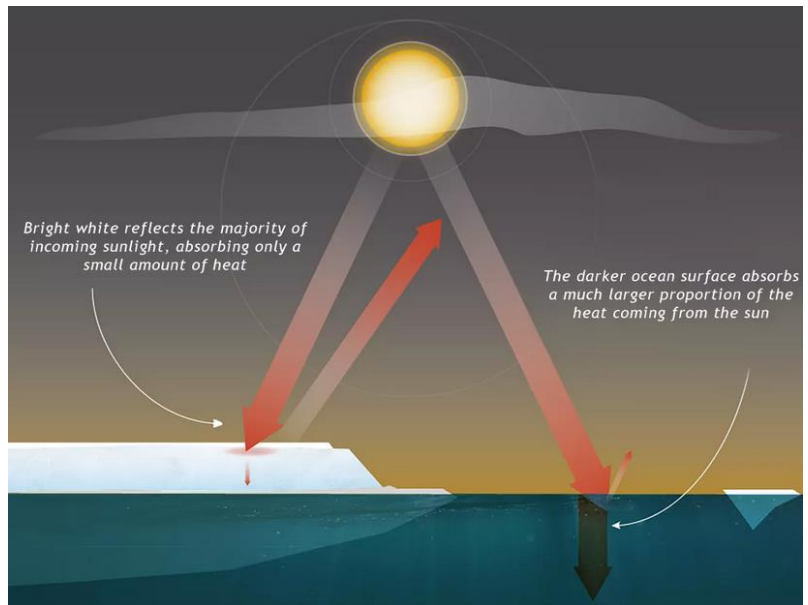
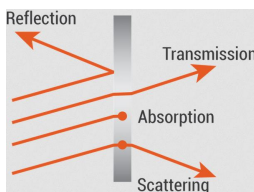
overall reflectivity of an object or surface



Energy transfers

Absorption

- assimilation of electromagnetic waves by an object
- different absorptive capabilities of various materials and colours

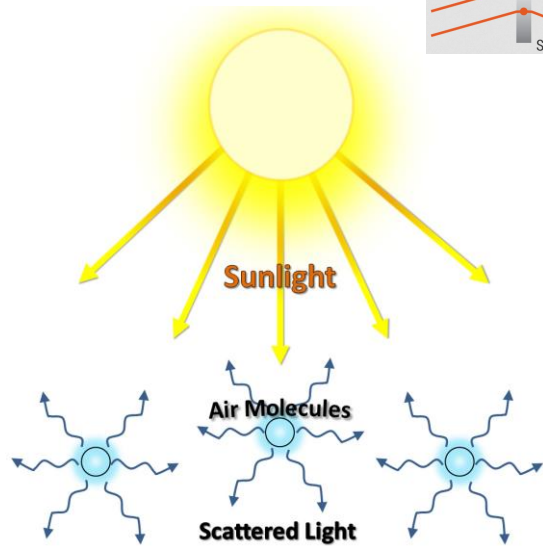


<https://nsidc.org/learn/parts-cryosphere/sea-ice/quick-facts-about-sea-ice>

Energy transfers

- **Scattering**

- deflecting and redirecting of light waves by molecules and particles in the atmosphere
- recently increased scattering and diminished intensity of solar radiation striking the surface as a result of recent climate change



<https://www.ces.fau.edu/nasa/module-2/earth-energy-balance.php>

Energy transfers

- **Transmission**

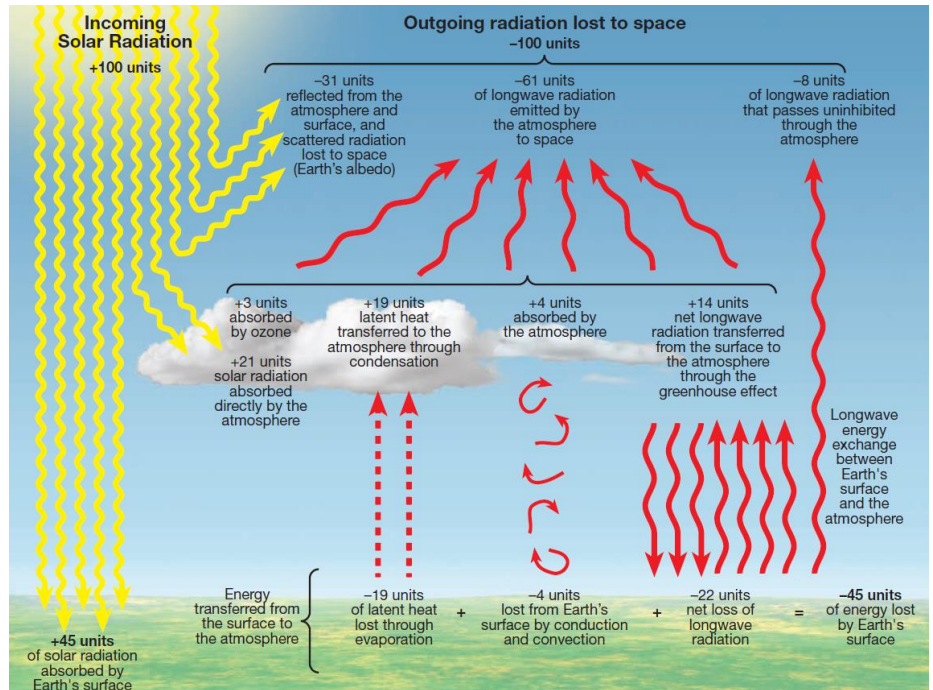
- complete pass of electromagnetic waves through a medium (Earth materials vs. water)
- dependence of medium transmission ability on the wavelength radiation (e.g. glass)



Hess, 2014

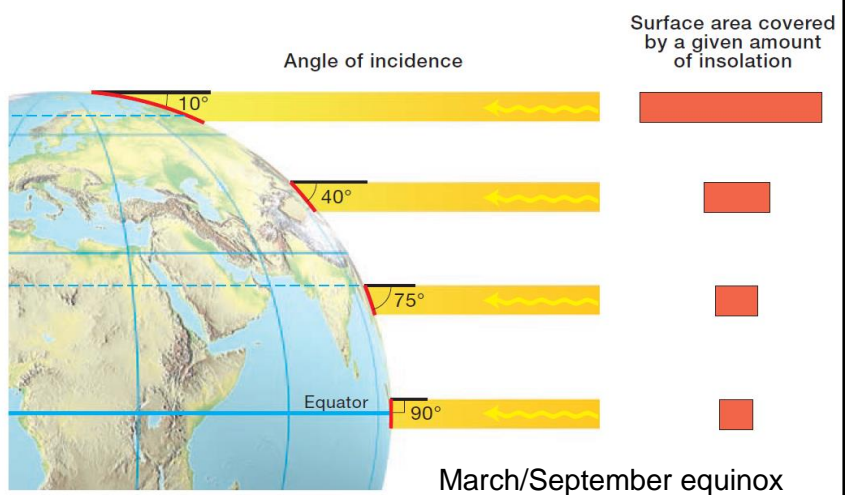
Earth's energy budget

- Annual balance between incoming and outgoing radiation



Earth's energy budget

- Latitudinal energy transport**
 - balanced energy input and output for the Earth in the long term



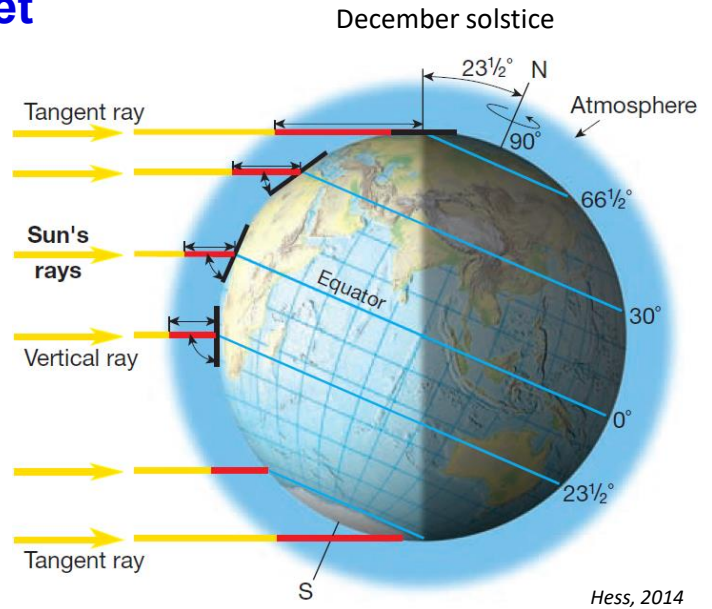
Hess, 2014

Earth's energy budget

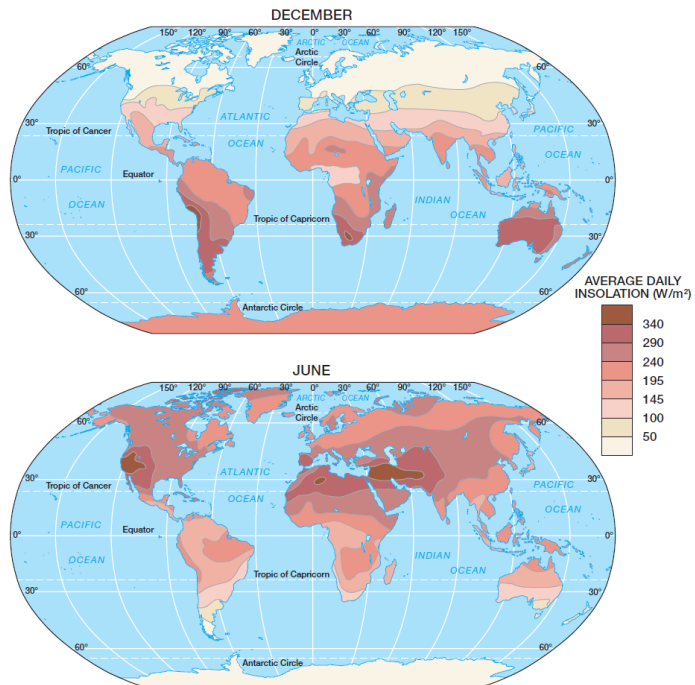
Latitudinal energy transport

Main reasons for the unequal warming:

1. angle of incidence
2. atmospheric obstruction
3. day length



Earth's energy budget

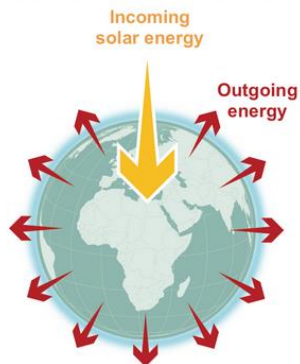


Anthropogenic influences on Earth's energy budget

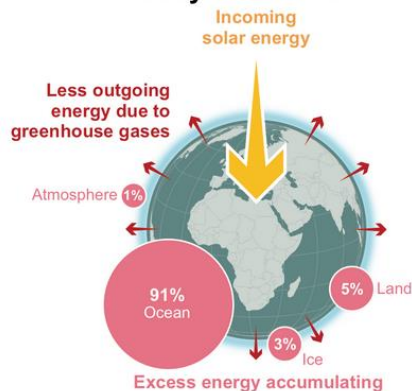
FAQ 7.1: The Earth's energy budget and climate change

Since at least 1970, there has been a persistent imbalance in the energy flows that has led to **excess energy being absorbed by different components of the climate system**.

Stable climate: in balance



Today: imbalanced



(IPCC AR6: FAQ 7.1, Figure 1)

Anthropogenic influences on Earth's energy budget

- **Enhanced greenhouse effect**

- increased concentration of greenhouse gases (GHGs) as the result of human activities and the main cause of recent global warming

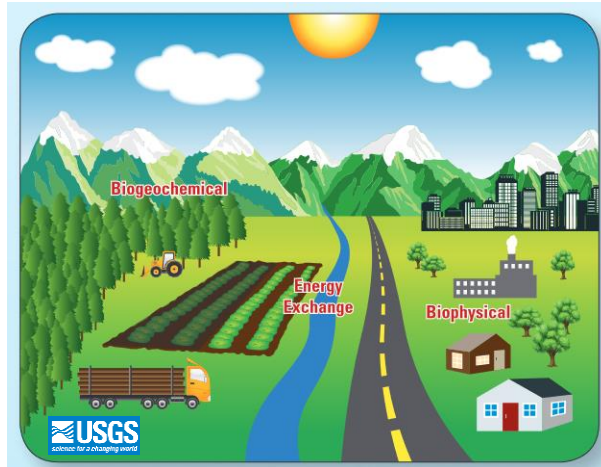
- **Pollution of the atmosphere by aerosols**

- **upper layers:** increased radiation scattering – decreased shortwave radiation (wasted energy)
- **lower layers:** increased absorption of longwave radiation (additional energy)
- global dimming

<https://www.metoffice.gov.uk/weather/climate-change/organisations-and-reports/earths-energy-budget-and-climate-sensitivity>

Anthropogenic influences on Earth's energy budget

- Changes in land-use and land cover



Thank you for your attention