**Atmosphere and Change**

* Describe the functioning of the atmospheric system in terms of the energy balance between solar and long wave radiation. Explain the changes in this balance due to external forces (changes in solar radiation, changes in the albedo of the atmosphere and changes in the long wave radiation returned to space). Discuss the causes and environmental consequences of global climate change.

Energy balance between solar and terrestrial radiation:

* There is a natural energy balance (budget) between inputs (insolation) and outputs (radiation from earth).
* The sun emits radiant energy (insolation) from nuclear reactions in its core. It is transmitted in short waves. 45% perceived as light, rest ultraviolet & infrared. The amount of insolation received is known as solar constant.
* The earth emits long waves (infrared or thermal radiation)

The earth receives about 340W solar energy per m2.

Clouds, dust particles and the Earth’s surface directly reflect 32%.

**The natural greenhouse effect** occurs because of several gases in the atmosphere, which absorb and emit infrared radiation. Main gases are water vapor, CO2, methane, nitrous oxides and ozone. They allow insolation to pass, but trap long wave infrared radiation from the Earth.

**Energy transfer processes occurring:** Important for an energy balance

* **Sensible heat** transfer: The energy transferred between surface and air. Heat is transferred through conduction and as warm molecules rise, convection.
* **Latent heat:** Energy needed for a change in state in the atmosphere (breaking bonds).
* **Condensation:** Gas to liquid. Latent heat released.
* **Ground heat:** Warming of Earth’s subsurface. Heat transferred through conduction.

The energy balance varies across the globe. Low latitudes (equators) receive surplus energy, while higher ones (north and south) have deficits, due to the decreased angle, which spreads the heat. This heat difference is mainly balanced through winds (80%) and ocean currents (20%), which transfer heat.

Changes in the energy balance:

* **Changes in solar radiation:** Affected by sunspots. The sun undergoes an 11-year cycle of solar activity variation.
* **Global brightening/dimming:** Increasing and declining intensities of sunlight.
* **Composition of the atmosphere and greenhouse gases**.
* **Albedo effect:** The earth reflecting radiation. If the surface has a higher albedo, more solar radiation is reflected back. Dark surfaces (rainforest 7-15%) have lower albedos, while light surfaces (snow 80-90%) have low albedos. The melting of snow into water (low albedo) means that less solar radiation is reflected and more absorbed. The earth’s albedo has decreased compared to 1997. Changes in albedo occur in:
	+ Areas with desertification (sand has higher albedo than soil)
	+ Areas with deforestation
	+ Melting of ice
	+ Changes in cloud cover

Causes and environmental consequences of global climate change:

Global temperatures are rising fast, largely due to increased human air pollution. China (21%) and the USA (20%) are the largest polluters. Increasing greenhouse gases lets ice melt (lower albedo) and increases water vapour, causing more heat.

**Causes:**

* Carbon dioxide: Released from fossil fuels and deforestation. Grew by 3.1% a year between 2000 and 2006.
* Methane: Released from cattle, rice fields and methane trapped in permafrost. Annual growth of 1%.
* Nitrous oxides: Power stations, vehicle emissions, fertilizers and burning biomass. Could be reduced through catalytic converters.
* Chlorofluorocarbons (CFC’s): Synthetic materials that destroy ozone.

**Consequences:**

IPCC is an international body to assess information on climate change.

* **Global temperature variations and heat waves**
* **Rising sea levels:** 3mm per year, with acceleration in recent years. Will rise due to thermal expansion and melting of ice.
* **Increasing acidity in oceans:** Due to increased dissolved CO2. Negative impacts on ecosystem and e.g. corals (calcium shells).
* **Melting icecaps and glaciers:** Arctic sea ice has decreased by 15% since 1960. Also permafrost may release methane.
* **El Nino:** Changes in wind and ocean currents may intensify natural hazards.
* **Growth of tropical belt**
* **Changing patterns in rainfall**: May cause declining crop yields.
* **Impact on wildlife**: Many species may fail to adapt quickly

Solutions to global climate change:

More investment into researching renewables, increasing social pressure and government legislation.