8.1 Weather and Climate

Relative Humidity: The amount of water vapour in the air relative to the maximum amount of water that it is possible for the air to hold at that temperature.

Climate: The average of the weather in a region over a long period of time (based on data gathered over many years)

Weather: Atmospheric conditions including temperature, precipitation, wind, and humidity, atmospheric pressure in a particular location over a short period of time, such as a day or week

Atmospheric pressure: The force exerted on a surface by the weight of the air above it

Predicting the Weather

Methods of collecting data:

- Weather stations
- Aircraft
- Satellites
- Weather balloons

8.2 Classifying Climate

Climate Zones

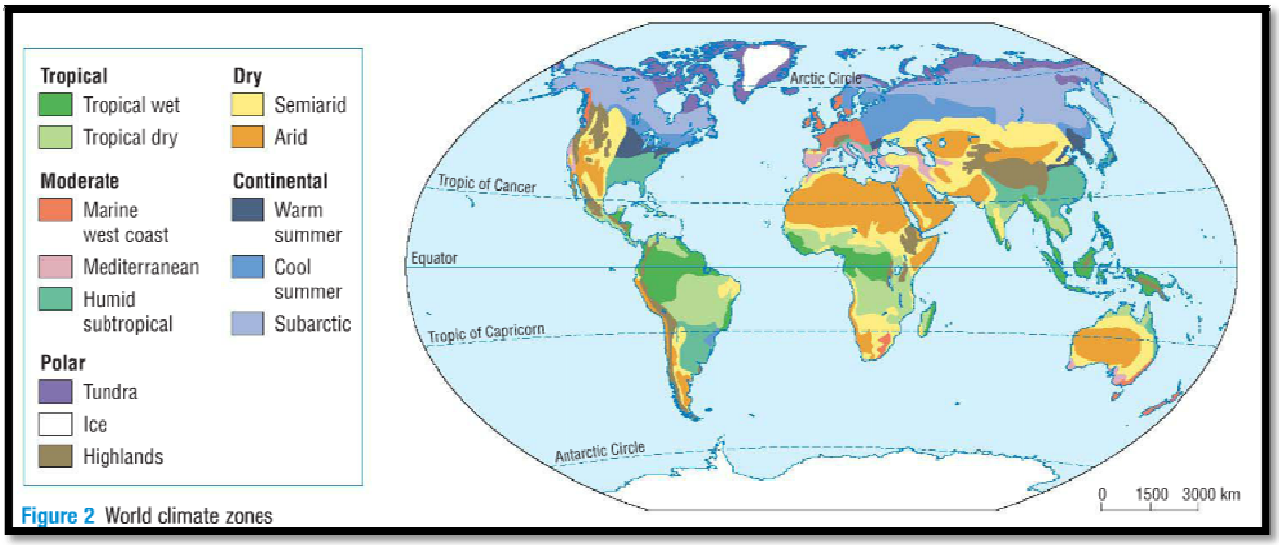


Figure 2 World climate zones

Ecoregions

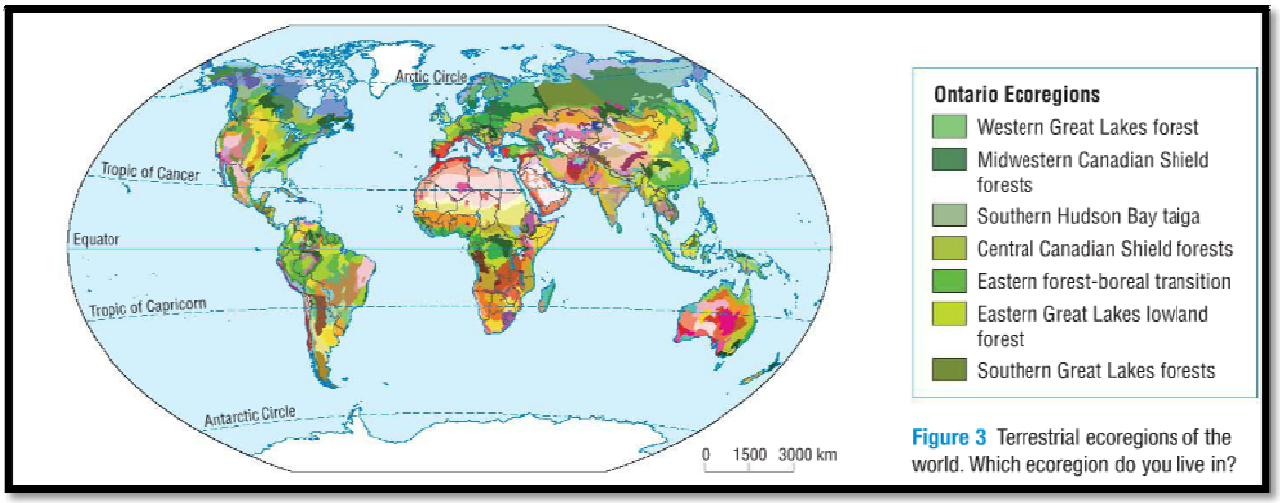


Figure 3 Terrestrial ecoregions of the world. Which ecoregion do you live in?

Bioclimate profile:A graphical representation of current and future climate data from a specific location

Factors Affecting Climate:

- Presence of ocean or air currents
- Land formations
- Distance from the equator (latitude)
- Presence of large bodies of water
- Height above sea level (altitude)

8.3 The Sun Powers Earth's Climate System

Climate System: Complex set of components that interact with each other to produce Earth's climate

Almost all of the energy on Earth comes directly from the Sun. The sun emits a variety of radiation including:

- Ultraviolet (invisible higher-energy radiation)
- Infrared (invisible lower-energy radiation)

When radiation contacts a particle of matter, one of three things happens:

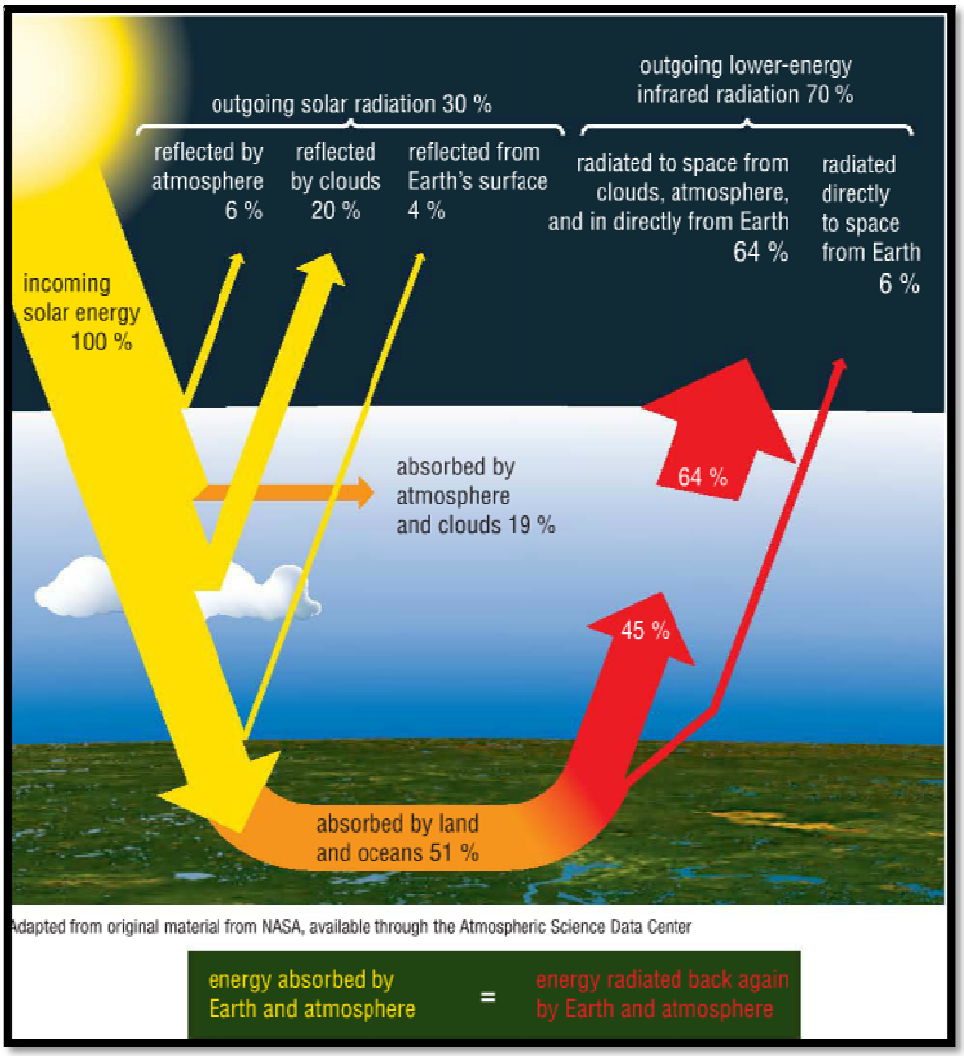
1. The radiation may be reflected off the particle
2. The radiation may be transmitted through the particle
3. The radiation may be absorbed by the particle, causing the particle to gain energy.

What happens to radiation from the sun once it reaches the Earth:

- 70% is absorbed by Earth's surface, clouds and certain gases
  - Plants trap some of the energy (<1%) for photosynthesis
  - Rocks and water absorb the energy causing them to heat up and heat the air around them.

- 30% is reflected back to space by clouds, Earth's surface as well as, particles in the atmosphere.

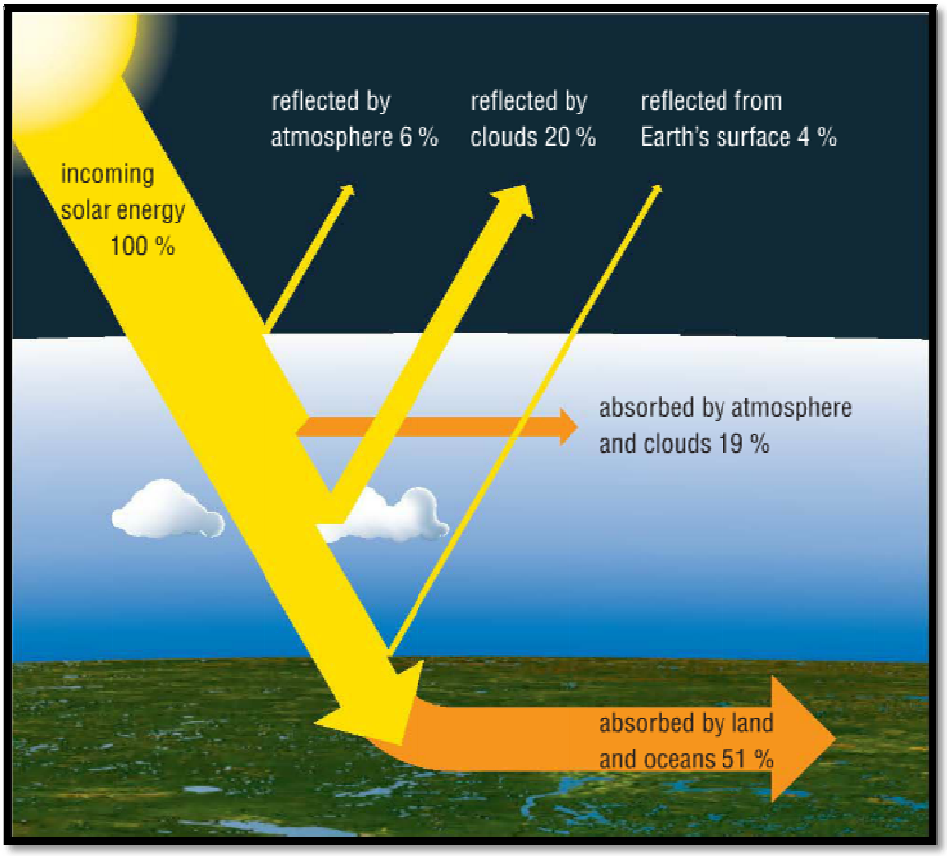
Thermal energy: Energy present in the motion of particles at a particular temperature.



Temperature:

- If energy absorbed is greater than energy radiated —> Earth heats up
- If energy absorbed is less than energy radiated —> Earth cools down
- The earth must maintain an energy balance

Climate Change with Latitude



8.4 Components of Earth's Climate System

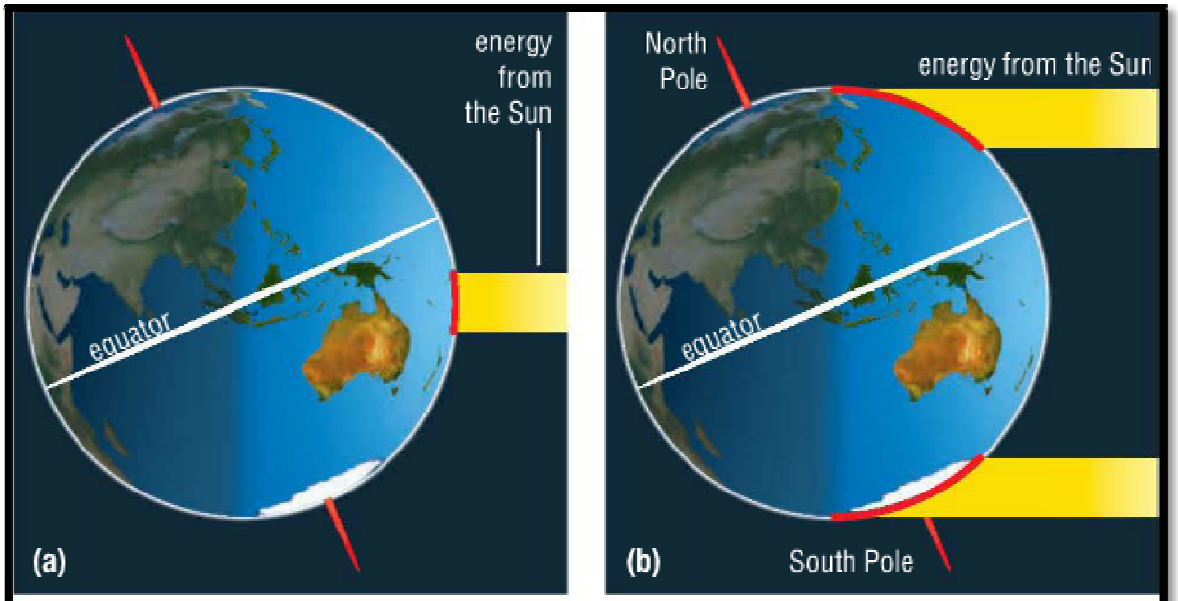
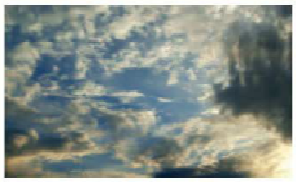
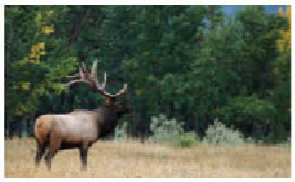


Figure 7 (a) The energy from the Sun is more intense near Earth's equator since it hits Earth's surface directly. (b) Energy from the Sun is less intense near the two poles since energy hits Earth's surface at an angle and spreads over a larger area.

Table 1 Components of Earth's Climate System

Atmosphere	Hydrosphere	Lithosphere	Living Things
			
The atmosphere is made of layers of gases surrounding Earth.	The hydrosphere includes liquid water in lakes and oceans, water vapour in the atmosphere, and ice in glaciers and at the poles.	The lithosphere is Earth's rock crust, including land surfaces.	All living things on Earth are part of the climate system.

Atmosphere: The layers of gases surrounding the Earth:

- 78% nitrogen
- 21% oxygen
- Remaining 1% includes argon, Carbon dioxide, traces of helium, hydrogen and ozone as well as water vapour and dust.
    - Ozone, O_3, protects us from some of the damaging energy from the sun. Most common in the stratosphere.

Hydrosphere: The part of the climate system that includes all water on and around Earth (water cycle)(Large bodies of water affect climate, stores more thermal energy)

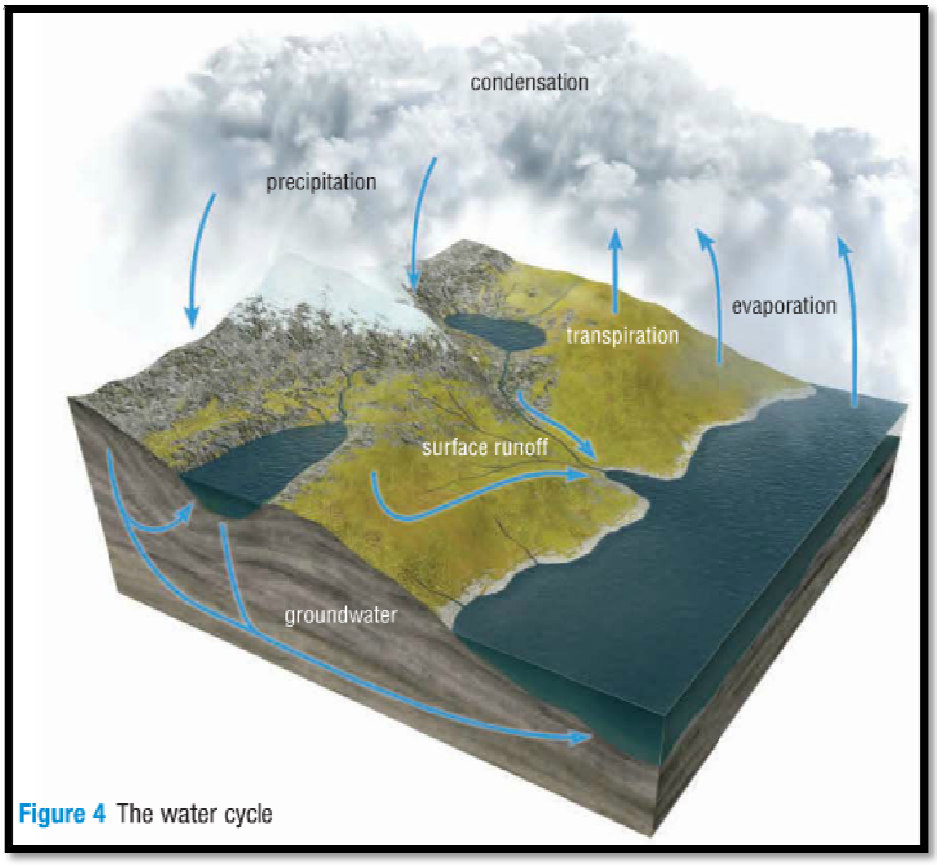


Figure 4 The water cycle

- Energy is absorbed when water evaporates from oceans and lakes
    - This process has the effect of cooling its surroundings
- Energy is given off when water vapour condenses into clouds in the atmosphere
    - This process warms the surroundings

Large Bodies of Water

- Water absorbs and stores more thermal energy than land.
- Consequently, water heats up and cools down more slowly than land.
    - Regions near an ocean or large lake tend to be cooler in the summer than inland locations because water takes a long time to warm up as it absorbs thermal energy.
- These regions also tend to be warmer in the fall as the water slowly emits stored thermal energy.
- Regions that are downwind from a large body of water have more snowfall in the winter.
    - If the water is not covered with ice, air passing over the water can absorb water vapour. Once the air reaches the colder land, the water vapour condenses as snow.

Lithosphere: The part of the climate system made up of the solid rock, soil and minerals of Earth's crust

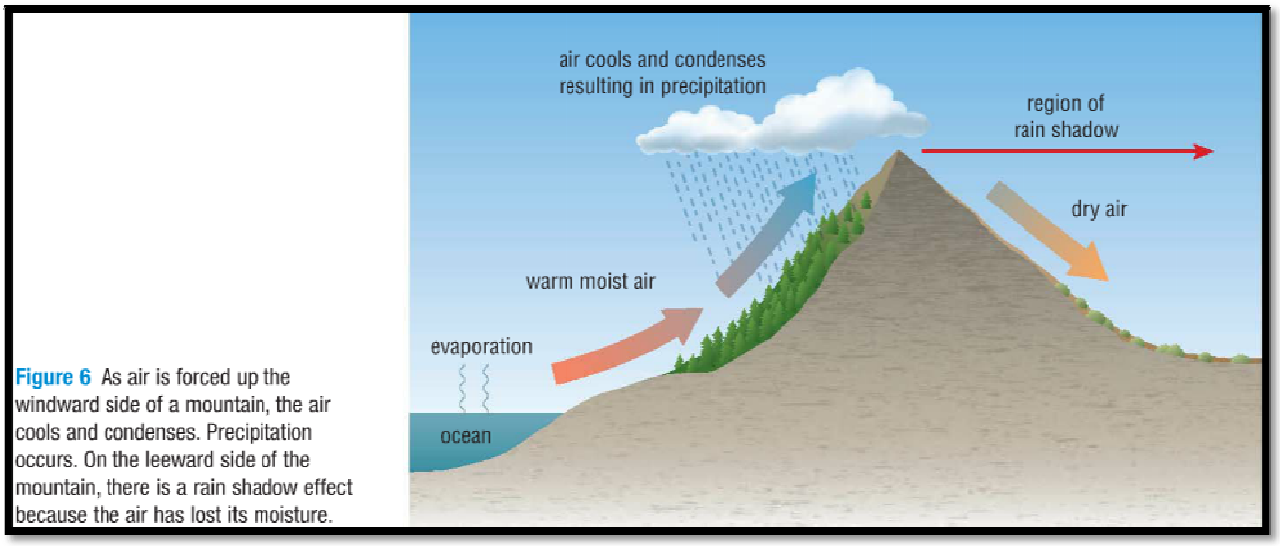
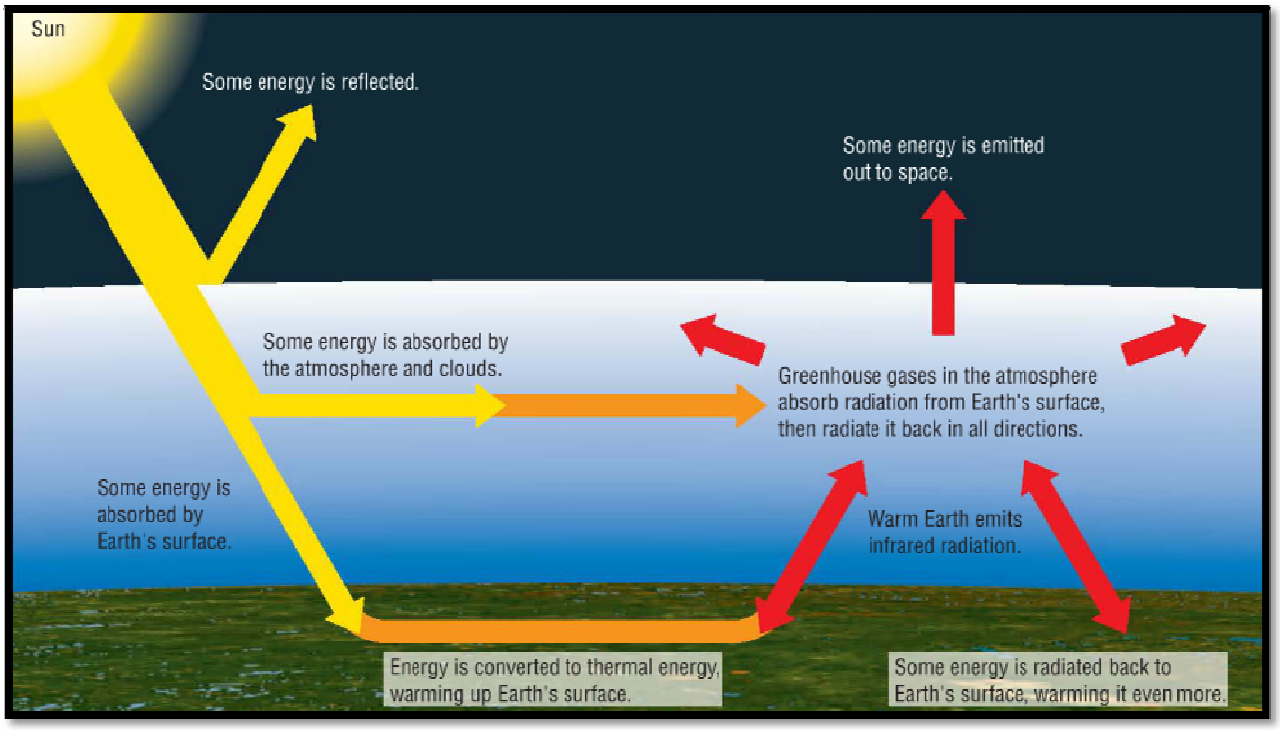


Figure 6 As air is forced up the windward side of a mountain, the air cools and condenses. Precipitation occurs. On the leeward side of the mountain, there is a rain shadow effect because the air has lost its moisture.

- At high altitudes, atmospheric pressure is lower because there is less air above pushing down.
    - This means air from lower altitudes rises to higher altitudes, expands and cools down. Therefore, higher altitudes are cooler than lower altitudes.

8.6 The Greenhouse Effect

Greenhouse effect:A natural process whereby gases and clouds absorb infrared radiation emitted from Earth's surface and radiate it, heating the atmosphere and Earth's surface.



- **Greenhouse gas:**Any gas in the atmosphere (such as water vapour, carbon dioxide, and methane) that absorbs lower-energy infrared radiation.

- The most important are water vapour, H_2O, carbon dioxide, CO_2. Others include methane, CH_4, tropospheric ozone, O_3, nitrous oxide, N_2O.
    - Their contribution is determined by their concentration in the atmosphere and by how much thermal energy each molecule of the

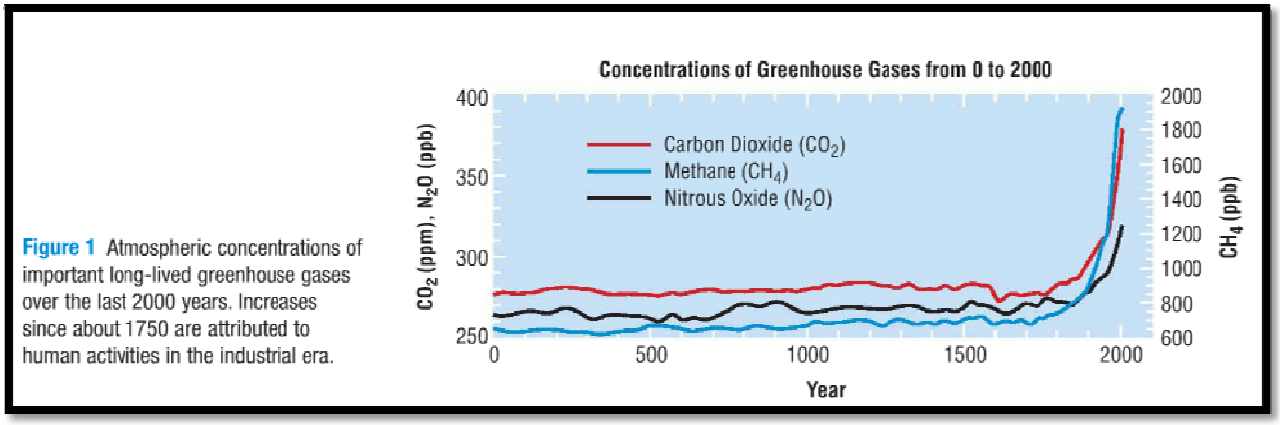


Figure 1 Atmospheric concentrations of important long-lived greenhouse gases over the last 2000 years. Increases since about 1750 are attributed to human activities in the industrial era.

gas can absorb.

Carbon Dioxide

- Earth's atmosphere contains only 385 ppm CO_2 but before the industrial age it was 280 ppm.

- Natural Sources include: volcanic eruptions, the burning of organic matter, and cellular respiration of plants and animals.

Carbon sink: Areservoir, such as an ocean or a forest, that absorbs carbon dioxide from the atmosphere and stores the carbon in another form. When these decompose or burn, the carbon is released back into the atmosphere.

Water Vapour

- Water evaporates more when it heated.
- Warmer air can hold more water vapour.
    - Thus, as Earth's temperature increases, more liquid water becomes water vapour.
    - Because water vapour traps energy, the more water vapour there is in the atmosphere, the warmer Earth becomes.

Feedback loop: A process in which the result acts to influence the original process

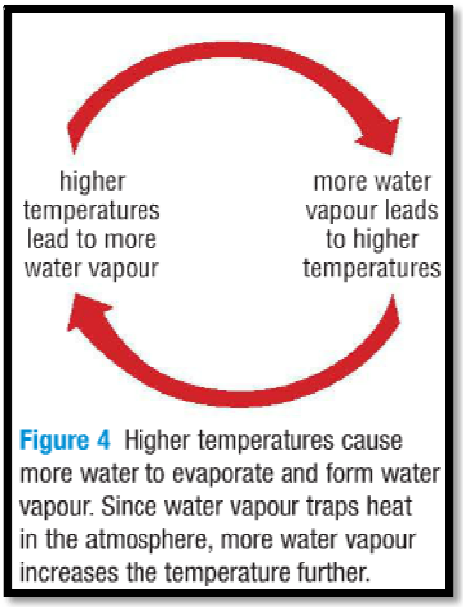


Figure 4 Higher temperatures cause more water to evaporate and form water vapour. Since water vapour traps heat in the atmosphere, more water vapour increases the temperature further.

Methane

- Molecule of methane is about 23 times more powerful as a greenhouse gas than carbon dioxide
- Went from 0.7ppm to 1.785 ppm
- There is less methane than carbon dioxide in the atmosphere

Ozone

- Lower in the troposphere, ozone acts like a greenhouse gas.

Nitrous Oxide

- There is less nitrous oxide than carbon dioxide in the atmosphere
- Went from 0.270 ppm to 0.321 ppm
- Molecule of nitrous oxide is about 300 times more powerful as a greenhouse gas than carbon dioxide

How Do Gases Trap Infrared Radiation

- Since nitrogen and oxygen gas are composed of two identical atoms, they only vibrate one way. This limits the type of energy it can absorb

- Water, carbon dioxide and methane consist of two or three atoms and have different types of atoms.

- The atoms in these molecules vibrate in many ways and can absorb different types of energy. Thus, when infrared radiation reaches these molecules they trap energy and radiate it out in every direction

8.8 Energy Transfer within the Climate System: Air and Ocean Circulation

- Water and land absorb energy at different rates, Earth is unevenly heated.

- The climate system transports thermal energy from areas that receive a lot of radiation to areas that receive less radiation.

Heat sinks: A reservoir, such as the ocean, that absorbs and stores thermal energy

- Warm water is less dense than cold water. A current forms when water is unevenly heated. Colder water falls, pushes warm water up.

- Near the equator, the sun's rays reach the surface with great intensity. Air heats up and becomes less dense, colder air falls. It creates an area of lower pressure under it.

- Once the warm air is high in the troposphere, it spreads out toward the poles and cools down, it sinks over the poles and results in higher pressure

Convection current:A circular current in air and other fluids caused by the rising of warm fluid as cold fluid sinks

- They move energy from the equator towards the north and south poles
- Air moves from areas of high pressure to low pressure, causing air currents (wind)
- Since Earth has permanent bands of high and low pressure, there are prevailing winds that blow in the same direction.

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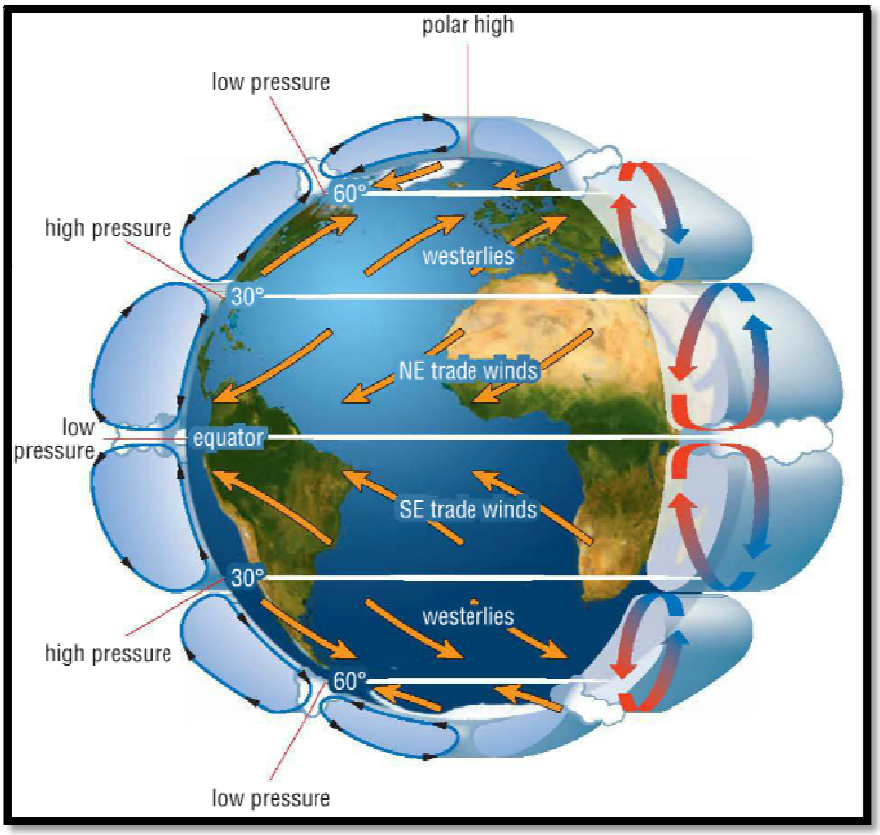
- Prevailing winds impact climate. They pass over oceans picking up water vapour and then as it reaches land the vapour condenses, bringing rain.



Energy Transfer in the Oceans

- As water travels toward the poles, it gets colder. It also becomes more salty as surface water evaporates and sea ice forms.
    - Sea ice is mostly fresh water because it rejects the salt when it freezes. Both of these factors—the low temperature and the saltiness of the water—make water at the poles more dense causing it to sink

- Warmer surface water from the equator flows to the poles to take its place.

Thermohaline circulation: The continuous flow of water around the world's oceans driven
by differences in water temperature and salinity.

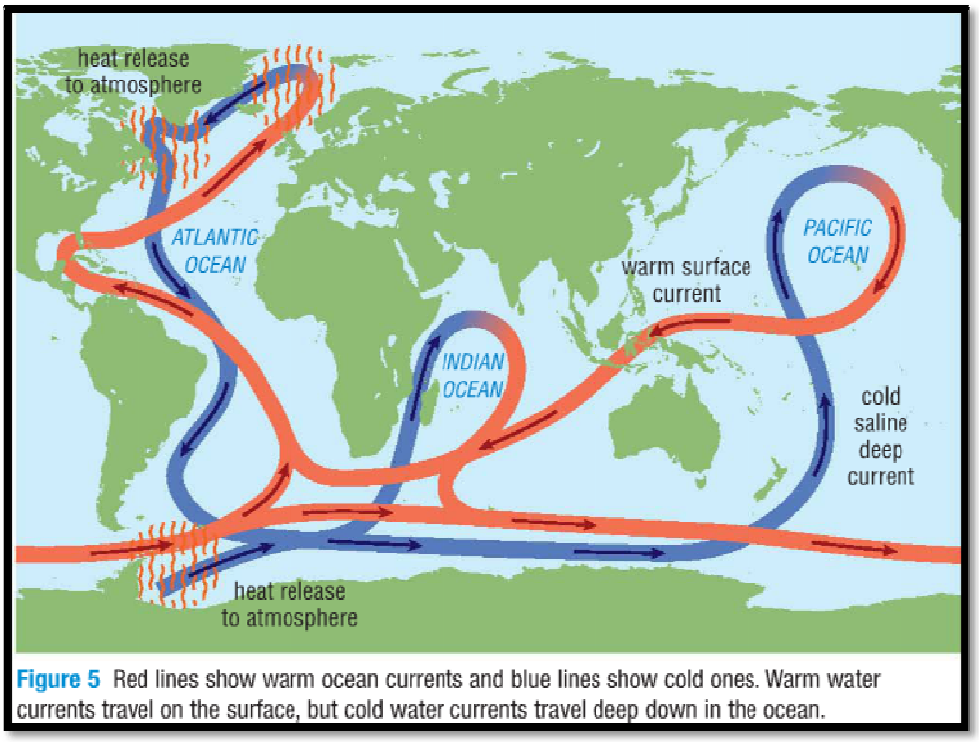


Figure 5 Red lines show warm ocean currents and blue lines show cold ones. Warm water currents travel on the surface, but cold water currents travel deep down in the ocean.

- Ocean currents can also be caused by winds. Winds are the main cause of the Gulf Stream that transports warm water from the tropics up the eastern coast of North America and across to Europe.

8.10 Feedback Loops and Climate

- Positive feedback loop: The effect increases original cause

- Negative feedback loop: The effect decreases the original cause

Low clouds create positive feedback loop:

- Warmer temperatures mean more (low) clouds —> even warmer temperatures

High clouds create negative feedback loops:

- Warmer temperatures mean more (high) clouds —> cooler temperatures

Albedo: Measure of how much of the Sun's radiation is reflected by a surface

- Ice and snow have high albedos because they reflect more radiation than grass or trees.

Albedo Effect: The positive feedback loop in which an increase in Earth's temperature causes ice to melt, so more radiation is absorbed by the Earth's surface, leading to further increases in temperature.

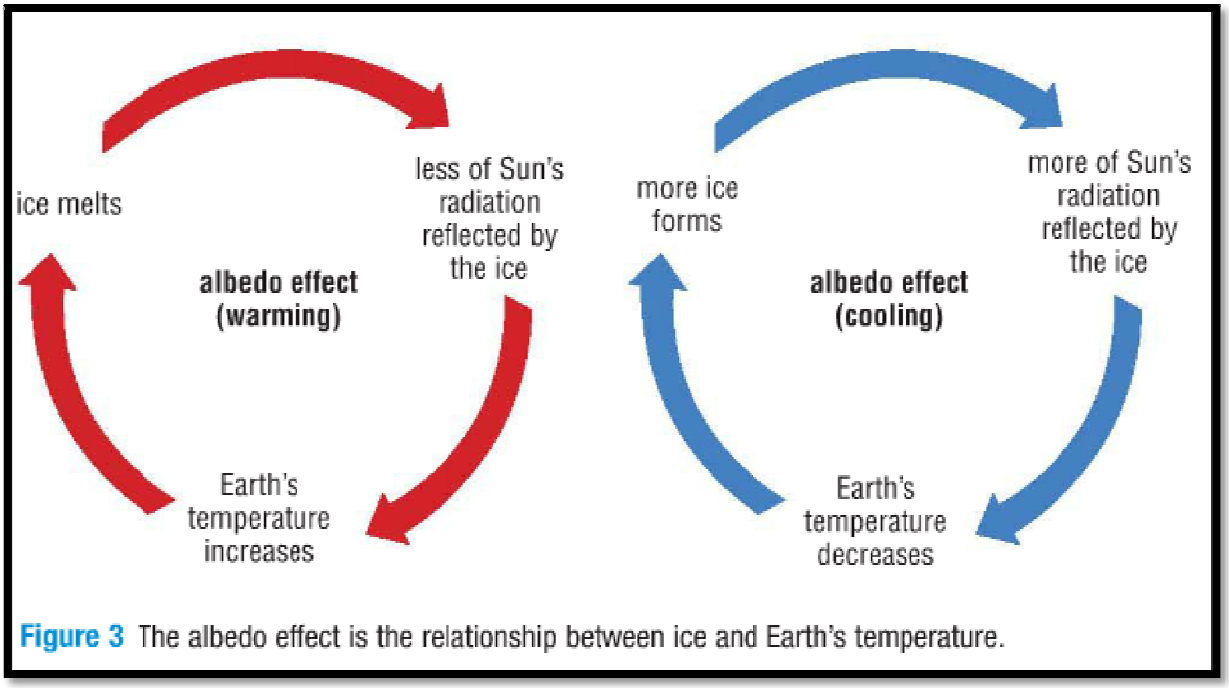


Figure 3 The albedo effect is the relationship between ice and Earth's temperature.

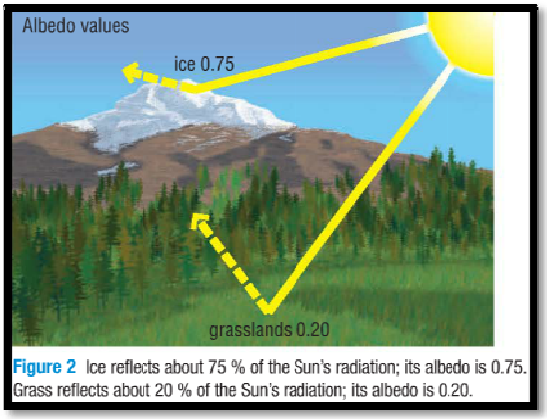


Figure 2 Ice reflects about 75 % of the Sun's radiation; its albedo is 0.75. Grass reflects about 20 % of the Sun's radiation; its albedo is 0.20.