MODULE 1 GEOGRAPHICAL KNOWLEDGE

THE ATMOSPHERE

UNIT 1: Composition and structure of the atmosphere

Importance of the atmosphere

The Earth is surrounded by a blanket-like layer of air we call the atmosphere. Without the atmosphere, there would be no life on Earth.

Question
Why is the atmosphere so important?

The atmosphere is important because:	
1	it insulates the Earth
2	it shields plants and animals from the Sun's harmful ultraviolet rays
3	it provides gases that are essential for life
4	it is the source of the Earth's **climate** and weather

Table 1.1 Why the atmosphere is important

Composition of air

Plants need carbon dioxide for photosynthesis. Plants and animals need oxygen for respiration.

The **air** in the atmosphere is an invisible mixture of gases. Air:

- is roughly 99% nitrogen and oxygen
- contains small amounts of carbon dioxide and noble gases such as argon
- contains variable amounts of water vapour, ozone and greenhouse gases (such as methane).

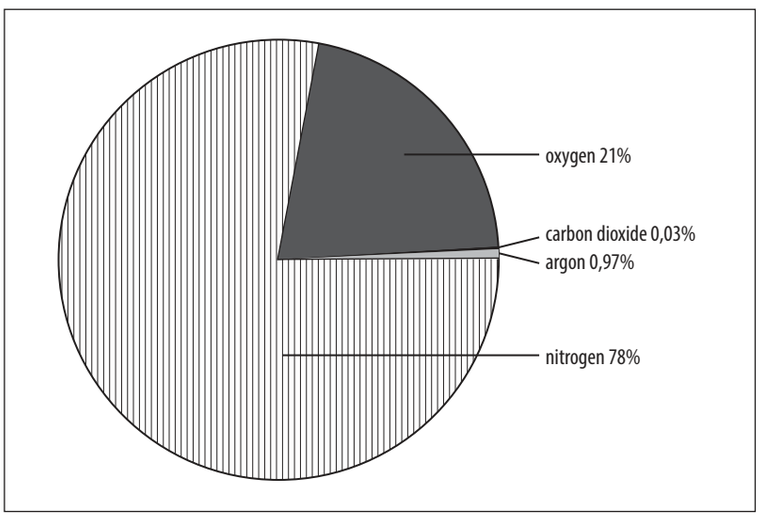

Figure 1.1 The composition of dry air at sea level

Activity 1.1 Identify gases in the air

1. Name the gas that:
   a) makes up most of the air
   b) makes up about one fifth of the air
   c) is essential for plants, but not for animals and humans
   d) is the source of rain
   e) is present in small, constant amounts.
2. Suggest why the amount of water vapour in the air varies.

Layers of the atmosphere

- The atmosphere is about 700 km thick, but it does not have the same air composition all the way through.
- 99% of the air is concentrated in the 30 km closest to the Earth. Air is densest where gravity is highest.
- The atmosphere is divided into four layers – the **troposphere**, **stratosphere**, **mesosphere** and **thermosphere** – according to temperature gradients.
- Temperatures decrease with altitude in the troposphere and mesosphere.
- Temperatures increase with altitude in the stratosphere and thermosphere.

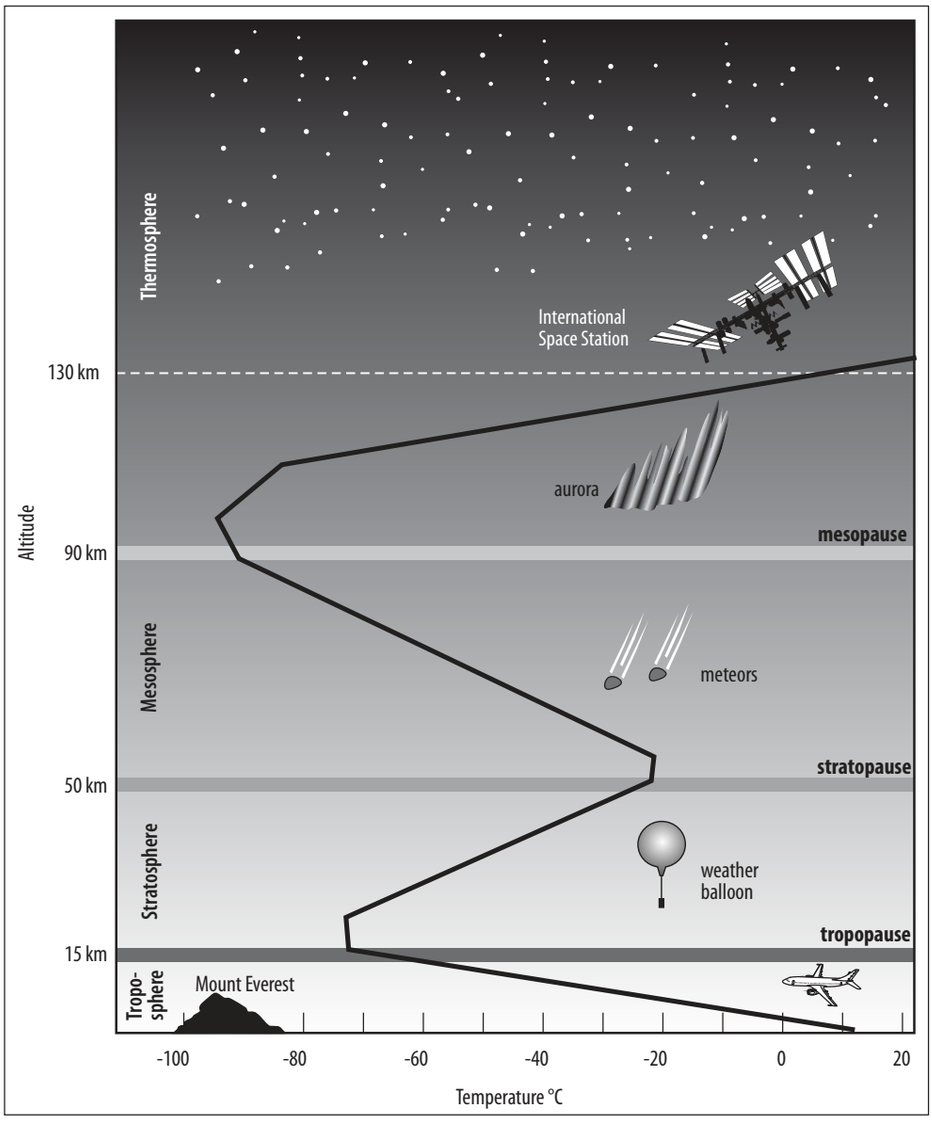

Figure 1.2 The four layers of the atmosphere

Activity 1.2 Identify different layers of the atmosphere

1. Name the atmosphere layer/s:
   a) that are thinnest and contain 75% of the air (all weather takes place here)
   b) in which auroras form (these lights are sometimes seen near the poles)
   c) with temperature inversion, i.e. their temperature increases with altitude
2. Name the boundary between the troposphere and stratosphere.

Question
What is the ozone layer and why is it important?

The ozone layer of the stratosphere

- The lower part of the stratosphere is rich in ozone.
- **Ozone** is a gas made up of three atoms of oxygen (O_3). It is formed when the Sun's ultraviolet (UV) light reacts with oxygen (O_2).
- The **ozone layer** filters most of the Sun's harmful UV rays, forming a natural sunscreen. Ozone depletion is therefore a problem.

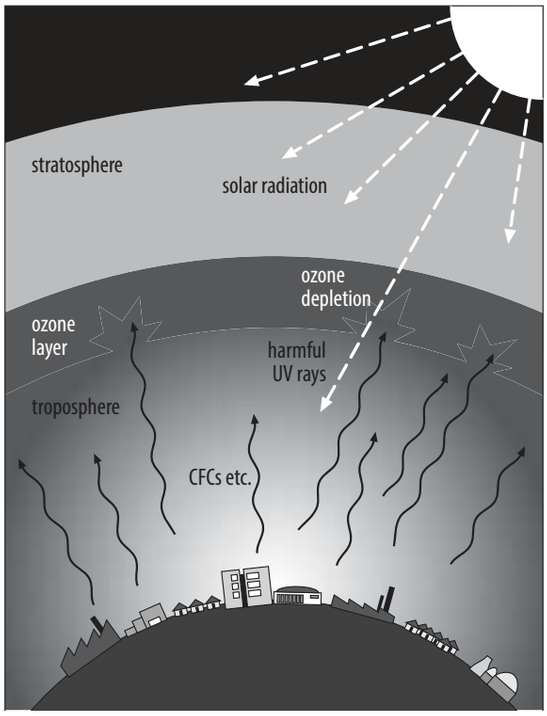

Figure 1.3 Thinning of the protective ozone layer means more UV rays penetrate the atmosphere.

Case study

The hole in the ozone

Since 1979, satellite data has shown that there is a thinning or 'hole' in the ozone layer. At first the measurements were so unexpected that scientists ignored them and called them errors. They also knew that after each winter, a natural ozone hole developed over the Antarctic. But by 1985, scientists reported that there was a sudden and large increase in the size of the 'hole'. They identified chlorofluorocarbons (CFCs) as the cause.

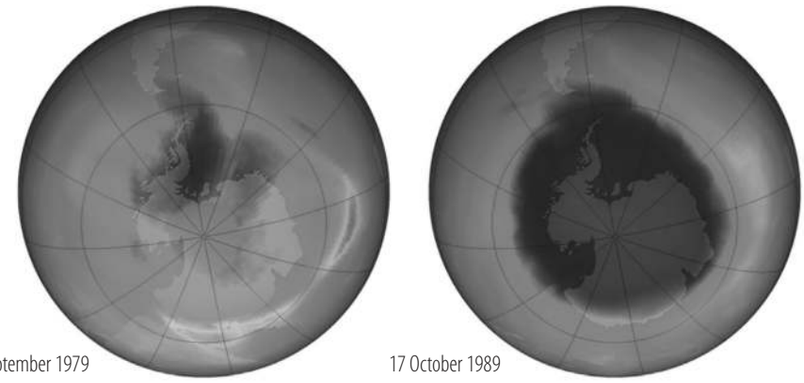

Figure 1.4 The growing ozone hole over the Antarctic. With an international ban on CFC production since 1989, the hole is now closing up.

CFCs contain chlorine, fluorine and carbon. Halons contain bromine, fluorine and carbon.

Causes and effects of ozone depletion

- Manufactured chemicals such as **chlorofluorocarbons (CFCs)** and halons are the culprits of ozone depletion.
- These chemicals are liquids or gases used as cooling and foaming agents.
- These chemicals or their breakdown products can easily survive for 100 years in the atmosphere.

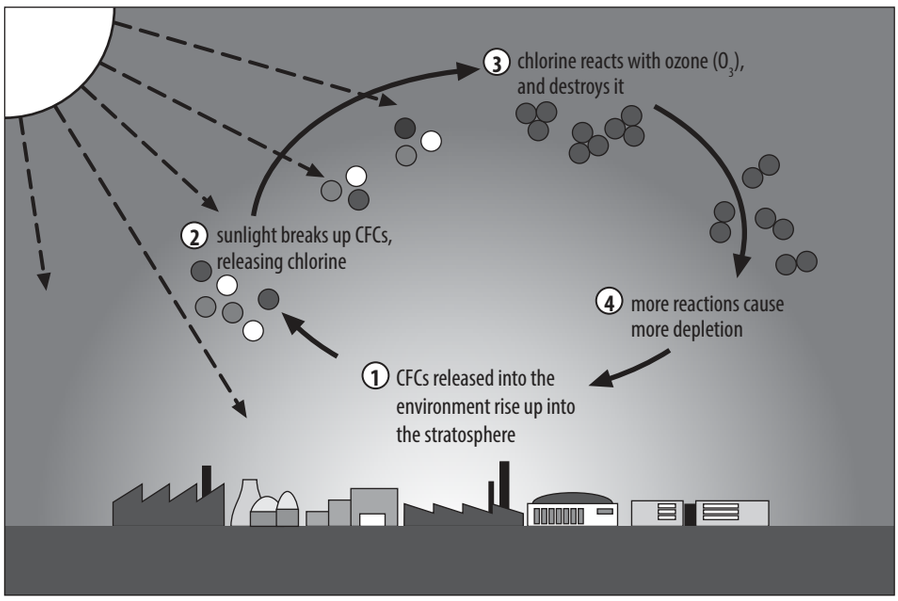

Figure 1.5 How CFCs destroy ozone

Causes of ozone depletion		Effects of increased UV exposure	
1	CFSs – used as propellants in aerosol sprays and coolants in refrigerators and air conditioning	1	skin cancer and premature skin aging
2	halons – in fire extinguishers	2	eye cataracts
3	methyl bromide – in agricultural pesticides	3	damage to phytoplankton and marine ecosystems
4	nitrous oxygen – in car exhaust fumes and fertilisers	4	negative effects on photosynthesis in plants

Table 1.2 Causes and effects of ozone depletion

Activity 1.3 Examine ozone depletion

Read the case study on page 4.

1. What is ozone?
2. In which layer of the atmosphere is ozone concentrated?
3. What role does ozone play in protecting the Earth?
4. Which countries do you think were most affected by the spreading hole in the ozone layer over the Antarctic?
5. What are CFCs?

The problem is that HFCs are greenhouse gases.

Ways to reduce ozone depletion

- Thanks to the Montreal Protocol of 1987, CFCs were banned in 1989 and are no longer used. They have been replaced by **hydrofluorocarbons (HFCs)**.

- Additional ways to reduce ozone depletion include the following.

1	Use environmentally friendly products and materials (paints, adhesives and cleaning products).
2	Limit travelling by car to reduce smog.
3	Avoid using pesticides and fertilisers.

Table 1.3 Things you can do to limit ozone depletion

Case study **Patching the hole in the ozone**

According to the Montreal Protocol, all CFCs were to be replaced with HFCs by 1996. Ozone levels are slowly recovering and scientists predict that by 2065 the hole in the ozone layer will have closed up.

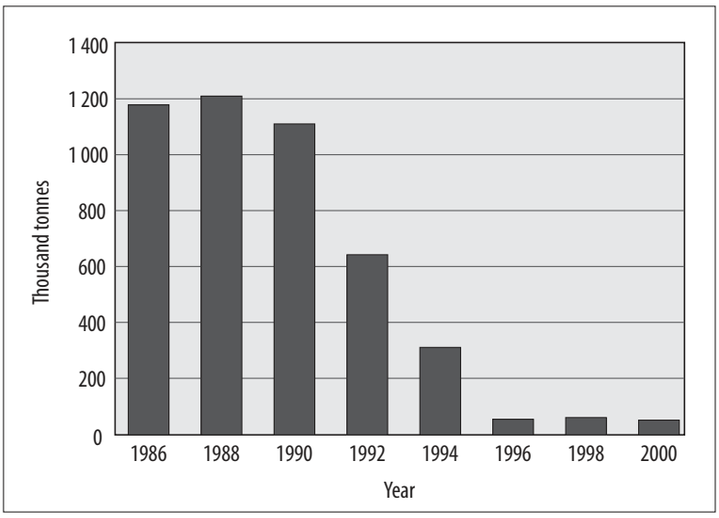

Figure 1.6 World production of CFCs

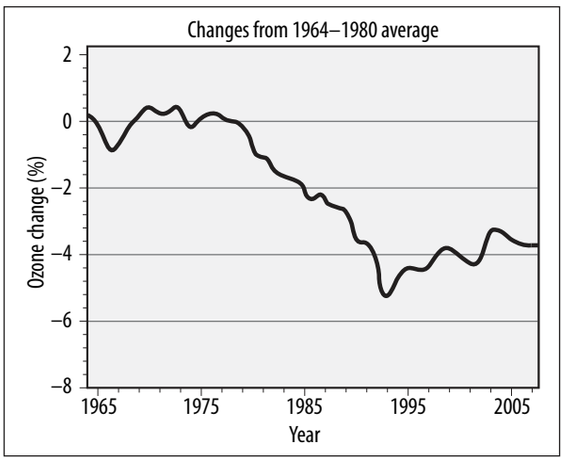

Figure 1.7 Change in ozone concentrations

Activity 1.4 Analyse changes in ozone concentrations

Read the case study above and refer to Figures 1.6 and 1.7.

1. Did the Montreal Protocol achieve its 1996 target? Justify your answer.
2. When did ozone concentrations reach their lowest level?
3. Why are ozone concentrations slow to recover?

UNIT 2: Heating of the atmosphere

Processes associated with the heating of the atmosphere

The Sun heats up the Earth, and the Earth, in turn, heats up the atmosphere. The following four points explain why.

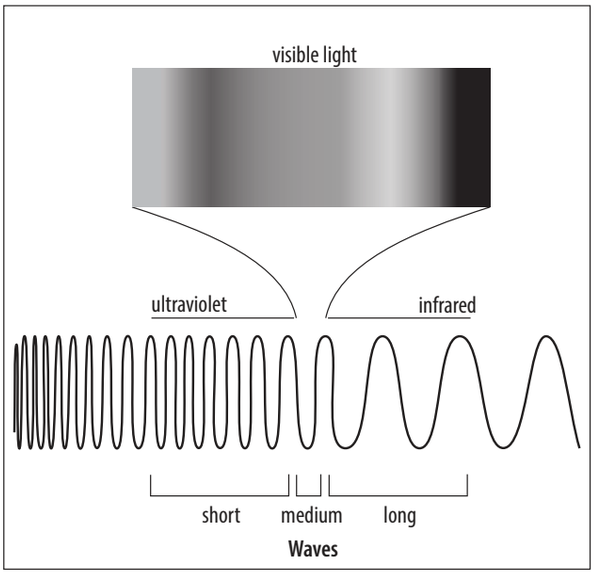

Figure 1.8 Solar radiation consists of short, medium and long electromagnetic waves.

Insolation and terrestrial radiation

1. **Solar radiation** that enters the Earth's atmosphere is called **insolation**. Insolation is short for *in*cident or *in*coming *sol*ar radi*ation*.
2. Solar radiation consists of three types of wave:
   - ultraviolet (UV) light – short waves
   - visible light – medium waves
   - infrared heat – long waves.
3. The gases in the atmosphere are transparent to UV and visible light. UV and visible light pass through the gases and are absorbed by the Earth's surface.
4. The Earth heats up and radiates infrared heat (long waves) into the atmosphere. This is called terrestrial radiation.

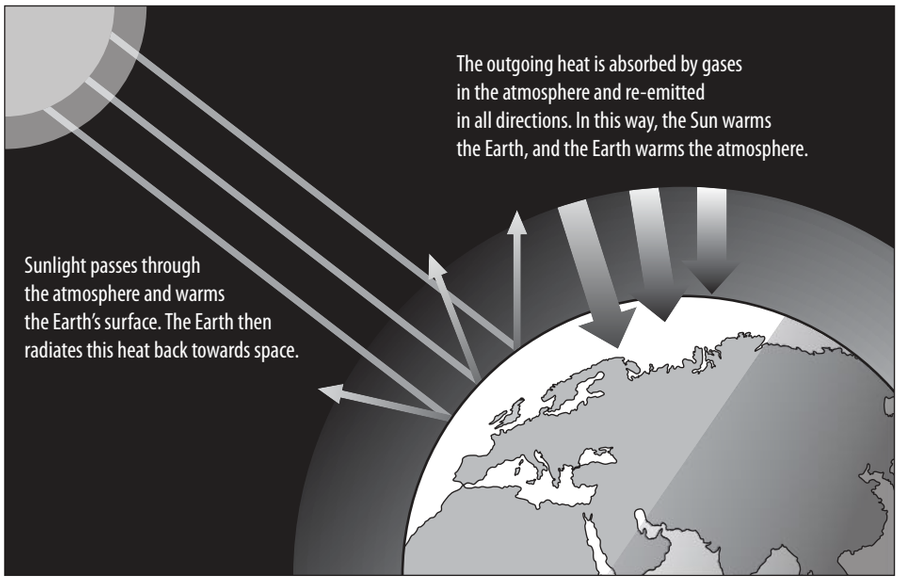

Figure 1.9 The Sun heats the Earth, the Earth heats the atmosphere, and the atmosphere retains much of this heat and keeps the Earth warm.

Absorption, scattering and reflection

Not all insolation reaches or is absorbed by the Earth's surface. In the atmosphere some is:

- **absorbed** (taken up) by water vapour, ozone, carbon dioxide and **clouds**
- **scattered** (sent in all directions) by dust particles or aerosols
- **reflected** (sent back at the same angle) off clouds.

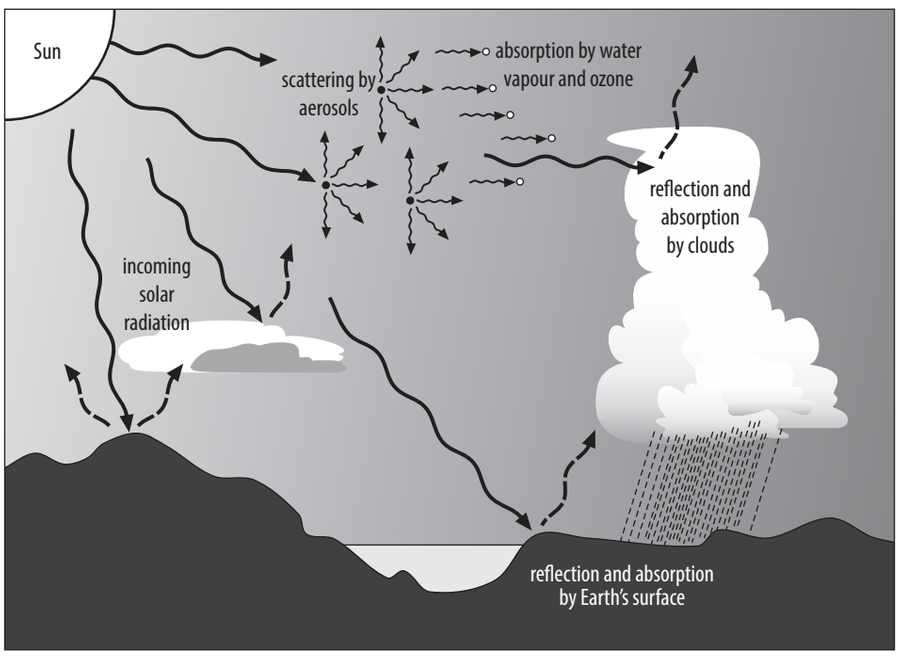

Figure 1.10 Absorption, scattering and reflection

Question
How does the Earth heat the atmosphere?

Conduction and convection

The Earth would get hotter and hotter if it did not lose heat to the atmosphere. The Earth heats the atmosphere mainly by terrestrial radiation, but also in other ways.

1	terrestrial radiation	The Earth radiates heat into the atmosphere.
2	**conduction**	The lowest parts of the atmosphere are warmed because they are in close contact with the warm Earth.
3	**convection**	Heated air expands and rises. In this way, heat is transferred higher into the atmosphere.
4	**evaporation**	When water evaporates, heat is stored in the water vapour as **latent heat**. This heat is released when water condenses.

Table 1.4 Four ways in which the Earth heats up the atmosphere

Activity 1.5 Compare insolation and terrestrial radiation

Copy and complete the following table.

Insolation	Terrestrial radiation
heats up the Earth's surface	
consists of short, medium and long waves	
	takes place during the day and at night

Question
What is the greenhouse effect and how do we contribute to it?

The greenhouse effect

- Heat that is lost by terrestrial radiation is trapped by gases in the atmosphere – this is the **greenhouse effect**.
- **Greenhouse gases** absorb and emit infrared heat.
- Examples of greenhouse gases are the following.

You don't need to know the % contribution.

Greenhouse gas	% contribution
water vapour and clouds	36 – 72%
carbon dioxide (CO_2)	9 – 26%
methane (CH_4)	4 – 9%
ozone (O_3)	3 – 7%

Table 1.5 Four greenhouse gases and their contribution to the greenhouse effect

- The greenhouse effect is a natural phenomenon. Without it, the Earth's average temperatures would be 30°C lower than they are.
- The problem is that since the Industrial Revolution of the 1800s and the agricultural Green Revolution of the 1900s, greenhouse gas emissions such as carbon dioxide and methane have increased significantly.
- The build-up of greenhouse gases in the atmosphere contributes to global warming.

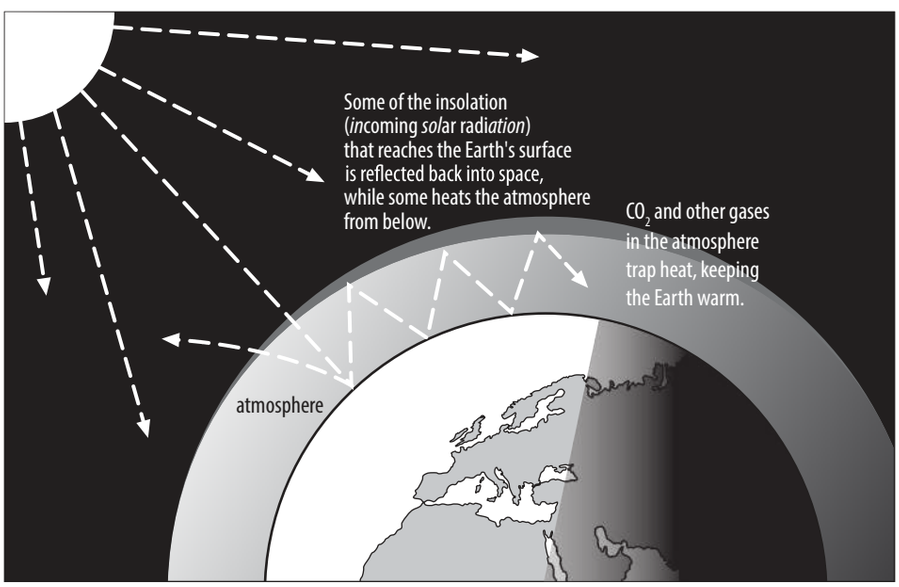

Figure 1.11 The greenhouse effect

Factors that affect the temperature of different places around the world

The Earth and the atmosphere are unevenly heated. There are several reasons for this.

Factor	Explanation
Latitude	The equator is hotter than the poles because the Sun's rays are more direct and therefore more concentrated (see Figure 1.12)
Altitude	Air temperature decreases with altitude. Mountains and high-lying areas are therefore colder than low-lying areas. For every 100 m increase in altitude, the temperature decreases by 0,65°C – this is called the **lapse rate**.
Ocean currents	Warm water circulates from the equator to the poles via **ocean currents**. Warm ocean currents raise water and air temperatures. Cold ocean currents lower water and air temperatures.
Distance from oceans	Oceans heat up and cool down more slowly than land. Oceans therefore have a **moderating effect** on coastal areas. The coast is cooler than inland during the day and warmer than inland during the night.
Albedo	Different surfaces reflect different amounts of light. Snow and ice have high albedo; forests and water have low albedo. **Albedo** is a measure of a particular surface's ability to reflect insolation, thereby returning this insolation to the atmosphere.

Table 1.6 Factors responsible for the Earth's temperature differences

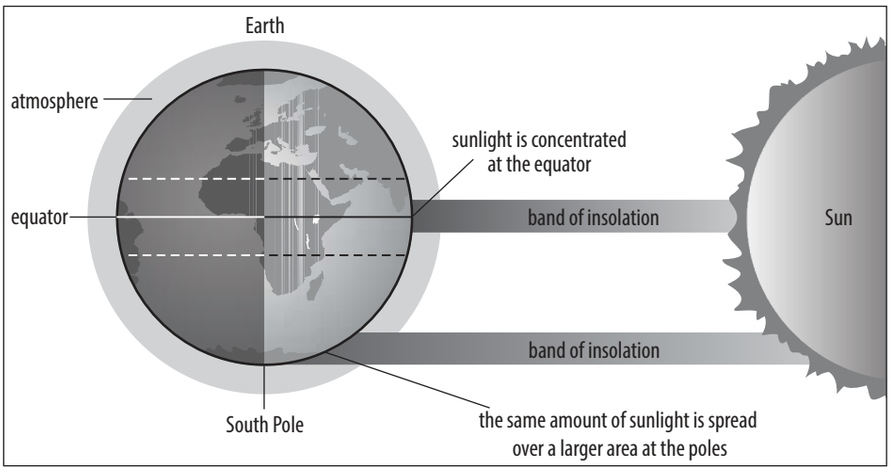

Figure 1.12 Why the equator is hotter than the poles

Activity 1.6 Explore factors that affect temperature differences

Match the processes of insolation, reflection, conduction and convection to each of the factors listed in Table 1.6.