

You need to know:

- if the UK's weather is becoming more extreme.

Student Book
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Evidence that UK weather is becoming more extreme?

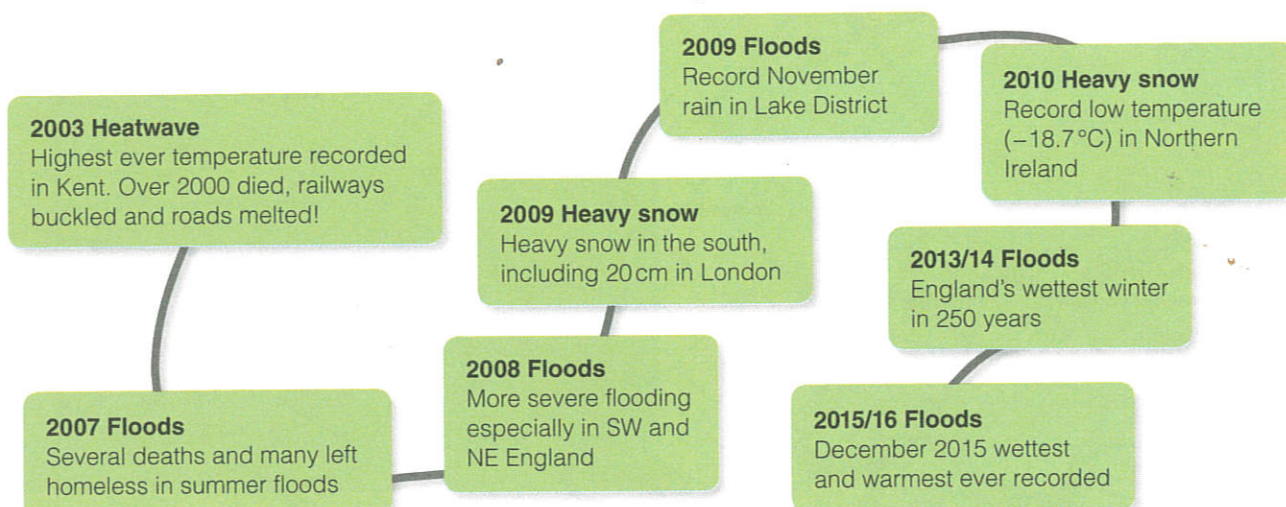


Figure 1 Flow diagram of extreme weather events

Why might extreme weather events be on the increase?

Recent extreme weather events have also occurred elsewhere in the world – such as the severe droughts in western USA (2014). Whilst no single weather event can be blamed on climate change, trends over many years could be linked to global warming, which:

- leads to more energy in the atmosphere, which could lead to more intense storms
- possibly affects atmospheric circulation, bringing floods to normally dry areas and heatwaves to normally cooler areas.

Could UK weather patterns be getting stuck?

UK weather systems, driven by winds from the *jet stream*, usually cross from west to east. The jet stream moves north and south but can 'stick' in one position resulting in prolonged periods of the same type of weather, such as heatwaves.

These 'stuck' periods have become more frequent and could be due to climate change.



Figure 2 Snow causes traffic chaos in 2010



Six Second Summary

- The UK has experienced an increase in the number of extreme weather events in recent years.
- Scientists believe that the global increase in extreme weather events may be linked to climate change and increasing temperatures.
- The jet stream driving UK weather systems may be getting 'stuck' due to climate change.



Over to you

- Describe **three** points about each of **two** examples of extreme weather in the UK.
- TV, social media and newspapers may report individual weather events as evidence of climate change. Why might this be misleading?

What is the evidence for climate change?

You need to know:

- the evidence for climate change from the beginning of the Quaternary period to the present day.

Student Book
See pages 40–1

What is the evidence for climate change?

We know that climates have changed throughout geological time.

For example, scientists using fossil records have found fluctuations in temperature for the last 5.5 million years, and, interestingly, a gradual cooling trend!

Marked fluctuations throughout the last 2.6 million years (the *Quaternary period*) explain *glacial periods* and warmer *inter-glacial periods*. Oxygen trapped in layers of ocean sediments, and water molecules in Antarctic snow, can be analysed to calculate temperature because reliable thermometer records only go back around 100 years.

But these direct measurements indicate a clear warming trend, with most of the increase since the mid-1970s (Figure 1).

This is 'global warming', which has already had significant effects on global ecosystems and on people's lives.

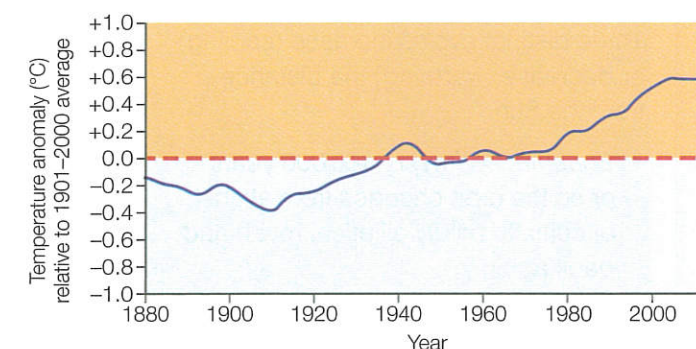
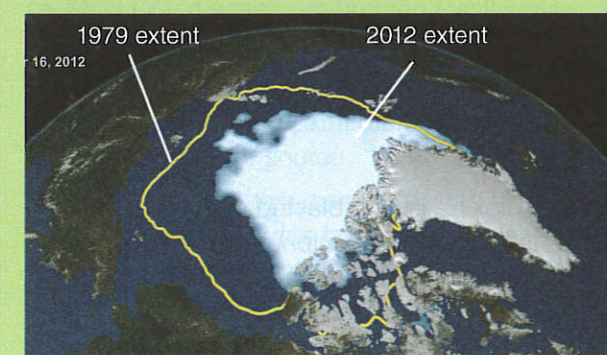


Figure 1 Average global temperatures (1880–2013) based on recorded temperature records

Recent evidence for climate change

Shrinking glaciers and melting ice

Some glaciers may disappear by 2035. The extent of Arctic sea ice reached an all-time low in 2014.



Rising sea level

- Glacier and ice cap melting adds fresh water.
- Thermal expansion – warm ocean waters expand in volume.
- Low-lying islands such as the Maldives, and coastal regions in Bangladesh, India and Vietnam, in danger of flooding.

Seasonal changes

- Tree flowering and bird migration is advancing.
- Bird nesting is earlier than in the 1970s.



Six Second Summary

- Global temperatures have been cooling gradually over 5.5 million years, but increasing in recent decades.
- Many consider contemporary global warming to indicate climate change.
- Melting glaciers, rising sea levels, changing seasons and direct temperature measures give evidence of climate change.
- Climate change is having a significant effect on global ecosystems and on people's lives.



Over to you

Study Figure 1.

- Describe the trend of the average temperature throughout the period of the graph.
- Comment on **how far** this is strong evidence for global warming? (Don't forget you'd need to justify your answer with evidence.)

You need to know:

- the natural causes of climate change – orbital changes, solar activity and volcanic activity.

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The three main natural causes of climate change

1

Orbital changes – the Milankovitch cycles

Three distinct cycles increase (cooling) or decrease (warming) the distance from the Sun:

- Eccentricity** – every 100 000 years or so the orbit changes from almost circular, to mildly elliptical (oval) and back again.
- Axial tilt** – every 41 000 years the tilt of the Earth's axis moves back and forth between 21.5° and 24.5°.
- Precession (or wobble like a spinning top)** – over a period of around 26 000 years the axis wobbles from one extreme to the other.

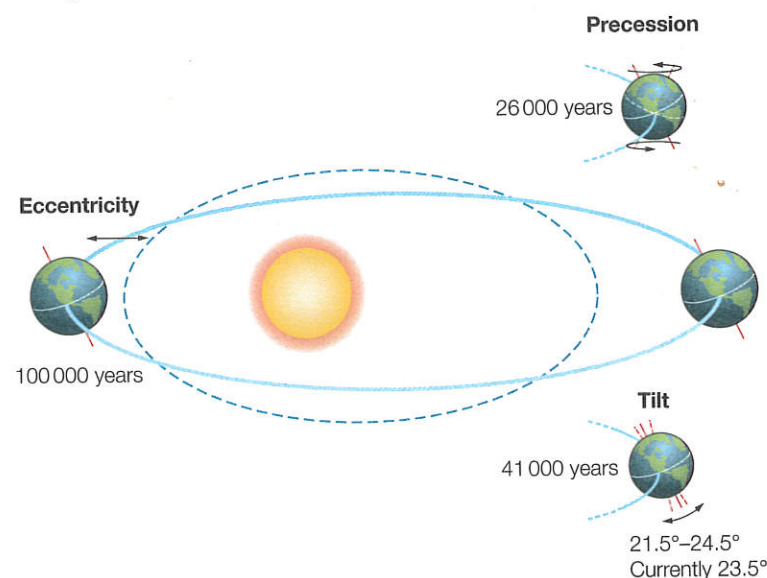


Figure 1 The Milankovitch cycles

2

Solar activity

The surface of the Sun has dark patches called sunspots which mark short-term regions of reduced surface temperature. They are usually accompanied by explosive, high-energy solar flares increasing heat output.

Over a period of around 11 years, sunspots increase from a minimum to a maximum, and back again.

3

Volcanic activity

Volcanic ash can block out the Sun, reducing temperatures on the Earth. This is a short-term impact.

Sulphur dioxide is also blasted out which converts to droplets of sulphuric acid, and acts like mirrors to reflect solar radiation back into space. This longer-term impact (over many years) also reduces temperatures.



Six Second Summary

- Milankovitch cycles (orbital changes) constantly change the Earth's distance from the Sun.
- Solar activity varies with the number of sunspots and high-energy solar flares.
- Volcanic activity produces ash and sulphuric acid droplets which reduce temperature.



Over to you

- Make a mnemonic (see page 11) from the **three** natural ways in which climate can change.
- Practise summarising **each** reason why climate can change naturally over time.

You need to know:

- what the greenhouse effect is
- how human activities can enhance it.

Student Book
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What is the natural greenhouse effect?

The greenhouse effect keeps the Earth naturally warm enough to support life (Figure 1). It works like a glass greenhouse by:

- greenhouse gases (e.g. water vapour, carbon dioxide (CO₂), methane (CH₄) and nitrous oxides) trapping heat that would otherwise escape into space
- allowing short-wave radiation (light) from the Sun through to the Earth
- trapping some of the longer wavelength radiation (heat) that would otherwise be radiated back into the atmosphere.

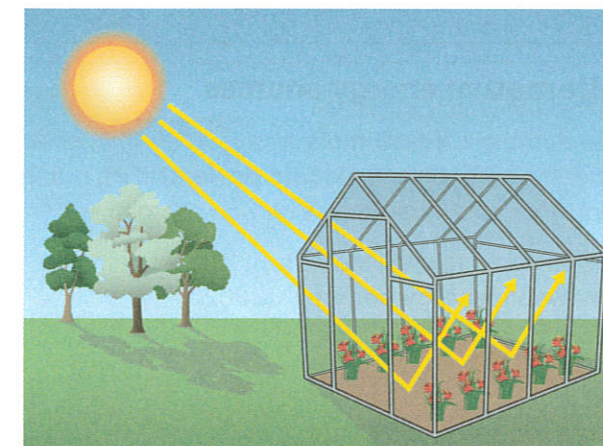


Figure 1 How the greenhouse effect works

Human impact and the enhanced greenhouse effect

In recent years the amounts of greenhouse gases in the atmosphere have increased (Figure 2). Scientists believe that this *enhanced greenhouse effect* is due to human activities.

- CO₂ is most important, contributing approximately 60% to the net warming by greenhouse gases.
- Most CO₂ comes from burning fossil fuels in industry and power stations. Transport and farming also contribute.
- Deforestation of tropical rainforests by burning is another major source.
- CH₄ emissions from ever-increasing numbers of farm livestock, rice farming, sewage treatment, and emissions from landfill sites, coal mines and natural gas pipelines are growing even faster than CO₂.

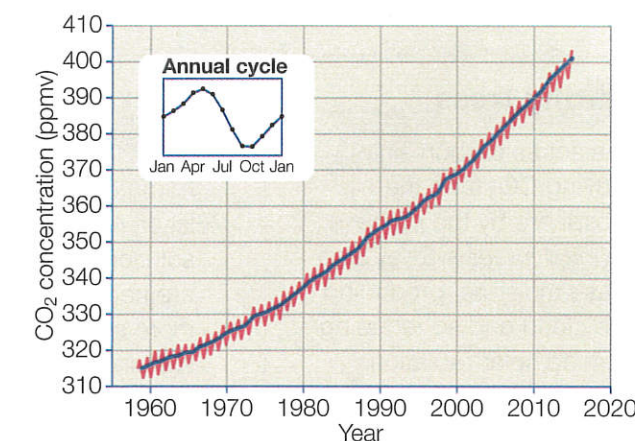


Figure 2 Increase in CO₂ obtained from direct readings at the Mauna Loa Observatory, Hawaii



Six Second Summary

- The natural greenhouse effect keeps the Earth warm enough to support life.
- In recent years greenhouse gases produced by human activities have increased.
- This enhanced greenhouse effect is changing climates, weather patterns and sea levels.



Over to you

- Make a mnemonic of the **four** human activities thought to cause an enhanced greenhouse effect.
- The trend of Figure 2 is identical to that of average global temperatures. So does this support the suggestion that human activities may contribute to global warming? You must be able to explain your answer.

You need to know:

- different ways in which the causes of climate change can be managed (mitigated).

Student Book
See pages 46–7

How can climate change be managed?

Alternative energy sources

The burning of **fossil fuels** accounts for 87% of all CO₂ emissions. Alternative sources of energy such as **hydroelectric power (HEP)**, **nuclear power**, **solar**, **wind** and **tides** represent **sustainable**, low carbon alternatives.

The UK aims to produce 15% of its energy from **renewable energy sources** by 2020.

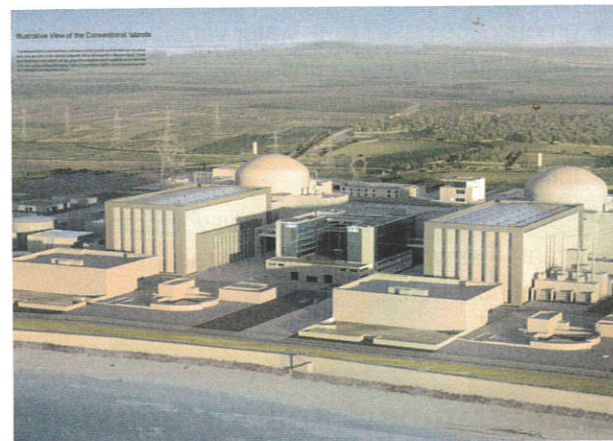


Figure 1 Artist's impression of the Hinkley Point nuclear reactor being built in Somerset

Carbon capture

Although not yet economically viable, *carbon capture and storage (CCS)* uses technology to capture CO₂ that is produced by burning fossil fuels in electricity generation and industrial processes. Once captured, the CO₂ is compressed, piped and injected underground for long-term storage in suitable geological reservoirs, such as depleted oil and gas wells.

Planting trees

Trees act as carbon sinks, removing CO₂ from the atmosphere by the process of *photosynthesis*. They also release moisture, producing more cloud and so reducing incoming solar radiation.

Tree planting is well established in many parts of the world. In fact, plantations are more efficient at absorbing CO₂ than natural forests.

International agreements

Climate change is a global issue requiring global solutions. Governments are negotiating towards a more sustainable future. For example, the Paris Agreement (2015) was the first legally binding global climate deal. It aims to limit global temperature increases to 1.5°C above pre-industrial levels.

Global impacts of climate change

- Reduced crop yields and water supplies
- More heat-related illness and disease
- Low-lying coastal areas threatened by flooding
- Changing ecosystems and animal habitats
- More extreme weather events, such as droughts and floods
- Stronger tropical storms
- Desertification

Six Second Summary

- Alternative energy sources represent sustainable alternatives to fossil fuels.
- Tree planting is established; CCS is not yet economically viable.
- International agreements seek global solutions to issues of climate change.

Over to you

- Learn two points about **each** way in which climate change could be managed.
- How might you argue the importance of international agreements in helping to solve the problems associated with climate change? Think of **three** things to say.

You need to know:

- how climate change can be managed by adapting to changes.

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How can we adapt to climate change?

Agricultural adaptation

Scientists believe that climate change will have a huge impact on agricultural systems across the world, particularly in low latitudes. To adapt farmers will need to:

- cope with extreme weather such as floods, heatwaves and drought
- manage water supply by storing water, use efficient irrigation systems, grow drought-resistant crops, and adapt to seasonal changes
- plant trees to shade seedlings
- change crops and livestock to suit the new climatic conditions.

Introducing drought-resistant strains of crops

Educating farmers in water harvesting techniques

New irrigation systems

Shade trees can be planted to protect seedlings from strong sunshine

New cropping patterns can be introduced, e.g. changing planting/sowing dates



Figure 1 Adapting to climate change – irrigating crops in the Gambia

Reducing risk from rising sea levels

Having already risen 20 cm since 1900, average sea level rises of up to 1 m by 2100 are possible. This will:

- threaten important agricultural land in countries such as Bangladesh, India and Vietnam
- increase rates of coastal erosion and damage from storm surges
- contaminate freshwater supplies with saltwater.

The low-lying Indian Ocean islands of the Maldives are already tackling this change by adopting practical management strategies (Figure 2).

Construction of sea walls – a 3 m sea wall is being constructed around the capital Male with sandbags used elsewhere (as in this photo)

Restoration of coastal mangrove forests – their tangled roots trap sediment and offer protection from storm waves

Building houses that are raised off the ground on stilts

Ultimately the entire population could be relocated to Sri Lanka or India

Construction of artificial islands up to 3 m high so that people most at risk could be relocated

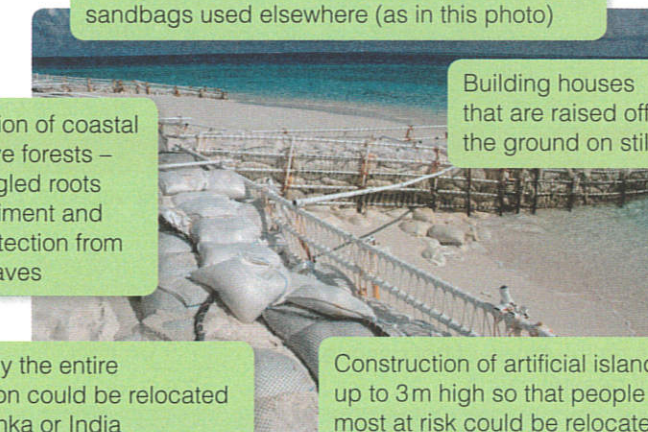


Figure 2 How can the Maldives manage sea-level rise?

Six Second Summary

- Climate change will have a huge impact on agricultural systems, particularly in low latitudes.
- Farmers will have to adapt by changing crops, livestock and techniques, and manage water supplies.
- Sea-level rise will require management of coastal areas.

Over to you

- Learn **three** threats to farmers posed by climate change.
- Which of the sea-level rise management strategies adopted in the Maldives are immediately relevant, and which are longer-term?