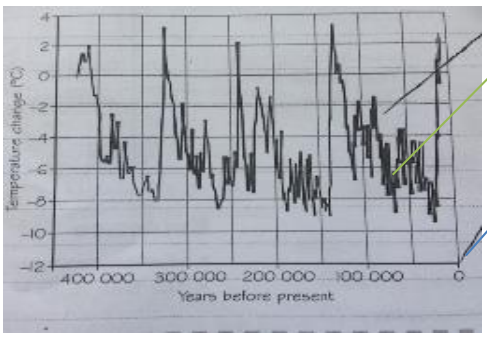
Environmental Threats to our Planet 1

The climate has changed from the start of the Quaternary period.

Term	Definition
climate change	Changes in the long-term temperature and precipitation patterns that can either be natural or linked to human activities.
quaternary geological period	The most recent geological period covering the last 2.6 million years, during which time there were several cold and warm periods.
glacial period	Historic cold periods associated with the build up of snow and the growth of ice sheets and glaciers.
inter-glacial period	Historic warm periods in between glacial periods when conditions were like they are today.
global warming	A trend associated with climate change involving a warming trend in temperature.

How has climate changed over time?

The graph shows how the Earth's temperature has cooled and warmed over 450,000 years. It demonstrates long-term temperature changes due to natural causes.



When the temperature is cooler for longer periods, more of the Earth is covered in ice. This is called an Ice Age or **glacial.**

This is now! We are in a warmer period called an **interglacial.**

The Little Ice Age
A colder period in Northern Europe starting in the 15th Century, lasting till the 19th Century.
The winters were very cold and the summers short. Crops did not grow well which meant less productivity and less food for people.

Evidence for Climate Change

Global temperature data
There is a warming trend for most of the world. Temperatures near the North Pole have risen the most.

Paintings and diaries
Historical records, such as paintings and diaries, can provide additional evidence of climate change. Several painters at the time of the Little Ice Age captured the winter landscapes of ice fairs and markets on the River Thames.

Tree Rings
Every year the growth of a tree is shown by a single ring. The narrower the ring the cooler and drier the year. If it is thicker the temperature was warmer and it was wetter.

Ice cores
Buried layers of snow are compressed and gradually turned into ice. The water molecules in the ice can be tested and the scientists can work out the global temperature at the time the snow fell. This gives us a temperature record of over 400,000 years.

Example of an impact of this climate change: Tuvalu
Tuvalu is a collection of 9 tiny islands that could all flood due to climate change. Water supply is an issue as droughts occur. The people of Tuvalu are responding by moving to New Zealand as environmental refugees and trying to restore damaged coral.

Consequences of Climate Change

Social impacts	Economic impacts	Environmental impacts
Sea level rise will lead to: - Vulnerable people having to move home due to risk of flooding and storm damage. - People losing their jobs in fishing and tourism. - Increase in number of refugees.	Sea level rise will lead to: - Cities like Venice and London being flooded. - Agricultural land being flooded or polluted by sea water. - Transport systems disrupted. - Beaches eroded and hotels forced to close.	Sea level rise will lead to: - Fresh water being contaminated by sea water. - Damage to mangrove swamps and coral reefs (eg bleaching). - Harbours being blocked by sediment.

Environmental Threats to our Planet 2

There are a number of possible causes of climate change.

Term	Definition
volcanic winter	Cooling trend caused by volcanic particles in the atmosphere blocking out some of the Sun's radiation.
greenhouse effect	Natural warming of the atmosphere as heat given off from the Earth is absorbed by liquids and gases, such as carbon dioxide.
enhanced greenhouse effect	The exaggerated warming of the atmosphere caused by the emission of gases from human activities resulting in the natural greenhouse effect becoming more effective.

Natural causes of climate change

Volcanic eruptions
- Large eruptions emit vast quantities of dust and gases such as sulphur dioxide into the atmosphere.
- This blocks out or absorbs solar radiation so the Earth cools.
- Eg Mount Pinatubo in 1991, Laki eruption in 1783 and Mount Toba 70,000 years ago.

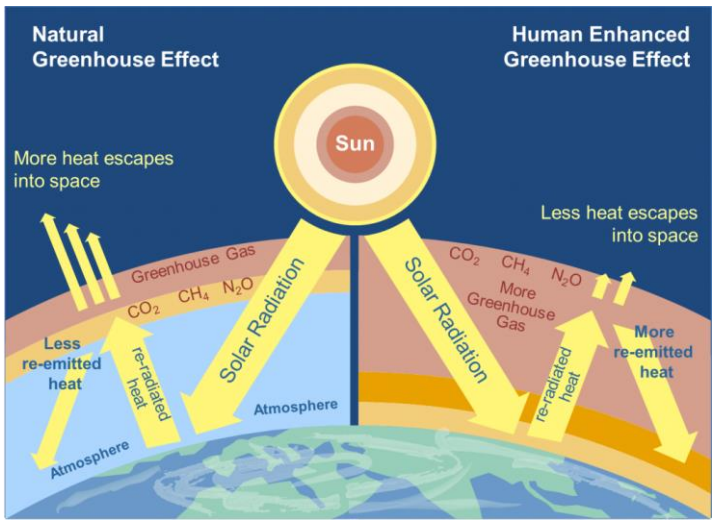
Asteroid collisions
- Large asteroid collisions can cause cooling as material blocks out the Sun.
- Asteroids hitting the Earth can cause huge fires which release massive amounts of CO2 which subsequently has a warming affect.

Sunspot activity
- Sunspots are darker areas on the Sun's surface – they are a sign of greater solar activity.
- They come and go in cycles of about 11 years.
- Between 1645-1715 there were few sunspots = the Little Ice Age.

Milankovitch cycles
- The shape of the Earth's orbit changes from elliptical to circular over 100,000 years. It appears that colder periods occur when the Earth's orbit is more circular and warmer periods when it is more elliptical.
- The Earth wobbles on its axis every 26,000 years. This can affect how long days and nights are so can make temperatures more extreme.
- The tilt of the axis varies every 40,000 years. The greater the degree of tilt is associated with the world having a higher average temperature.
- Taken together these effects change the amount of solar energy received at the Earth's surface.

Ocean currents
- Ocean current changes can cause cooling and warming.
- In the UK, we have a warm and wet climate because of warm Atlantic current. Sometimes the current shifts and we get a cooler climate for a short period of time.

Human causes of climate change



Greenhouse gas levels in the atmosphere are increasing by burning fossil fuels, deforestation and emissions from vehicles.

Many scientists believe human activities are at least partly to blame for the rapid rise in temperatures (global warming) since the 1970s.

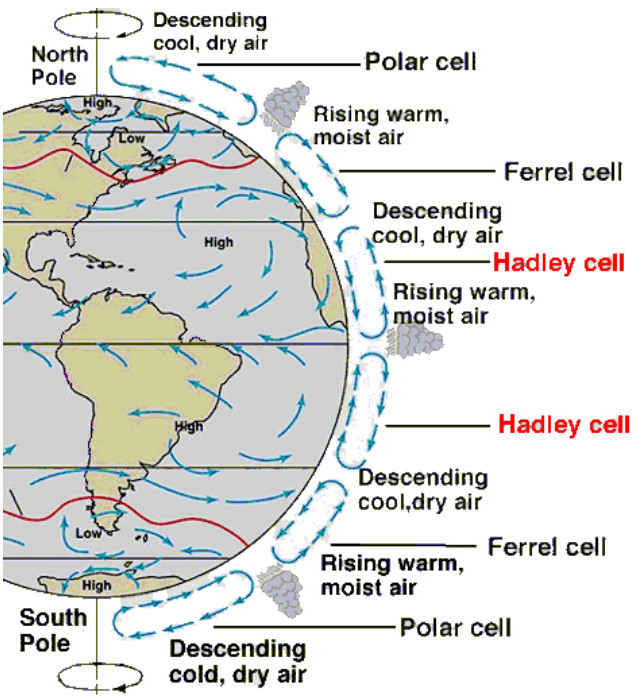
The Earth's atmosphere behaves like a greenhouse:
- Heat as short-wave solar radiation travels to reach the outer atmosphere.
- As it passed through the atmosphere some is reflected back into the atmosphere. The rest reaches the Earth's surface and is absorbed.
- This warmth is then released in the form of long-wave infrared radiation.
- Some of this is absorbed by liquids and greenhouse gases in the atmosphere and some escapes to space.
- The more greenhouse gases (carbon dioxide, methane, nitrous oxides) there are in the atmosphere, the more infrared radiation is absorbed and the warmer it gets.

Environmental Threats to our Planet 3

The global circulation of the atmosphere controls weather and climate.

Term	Definition
latitude	The imaginary lines that surround the Earth ranging from 0◦ at the Equator to 90◦ at the poles.
Hemisphere	A half of the Earth; usually divided into northern and southern halves by the equator.
troposphere	An area of the atmosphere, from the Earth's surface to a height of 10-15km, in which the weather takes place.
climate zones	Divisions of the Earth's climates into belts, or zones, according to average temperatures and average rainfall. The three major zones are polar, temperate and tropical.
atmospheric air pressure	The force exerted on the Earth's surface by the weight of the air, measured in millibars.
high pressure	When there is more air pressing down on the ground, caused by air sinking; air descends as it cools leading to high pressure at the surface.
low pressure	Caused when the air is rising, so less air is pressing down on the ground; air rises as it warms, leading to low pressure at the surface.
condensation	The process whereby rising water vapour becomes a liquid.
precipitation	The collective term for moisture that falls from the atmosphere; this could be in the form of rain, sleet, snow or hail.

Global atmospheric circulation



There are large-scale circular movements of air all over the Earth's surface. They transport heat from the tropical regions at the Equator (where the Earth gets more heat from the sun) to the poles.

The Earth is divided by the Equator into the Northern Hemisphere and the Southern Hemisphere. In each hemisphere there are 3 circular movements of air called 'cells': the Hadley call, the Ferrel cell and the Polar cell.

The 3 cells play an important told in creating distinct climate zones.

Hadley cell – extends from the Equator to 30-40°N/S.	Strong trade winds blow towards the Equator. Where they meet the warm air rises and causes thunderstorms.
Ferrel cell – occurs from the edge of the Hadley cell to between 60-70°N/S.	This cell moves air between the Hadley and Polar cells. Where the warmer air from the Ferrel cell meets the cold Polar air, the air rises and gives unsettled wet weather.
Polar cell – links the Ferrel cell to the poles.	Air sinks at the poles to give dry conditions and then flows towards the lower latitudes.

What happens in areas of high pressure and low pressure?

High Pressure: Cold air sinks and gives clear, dry and calm weather.

Low Pressure: Hot air rises. As the warm air cools and condenses to give stormy, cloudy weather.

Environmental Threats to our Planet 4

The global circulation of the atmosphere controls weather and climate.

Term	Definition
katabatic wind	movements of cold dense air that flow downhill and along valley floors; in Antarctica, most winds blow towards the coast from the centre.
monsoon	heavy rainfall that arrives as a result of a seasonal wind, notably in southern Asia and India between May and September.

Weather extremes: where are the coldest, hottest, driest, wettest and windiest places in the world?

Dry Place: Death Valley
Average annual rainfall of 500mm. Any clouds coming from the Pacific have been forced over the mountains first so cooled and rained.

Wet Place: Mawsynram, India
Annual rainfall is 11m! 80% falls in the seasonal monsoon between June and September when the Inter-tropical convergence zone passes of the land.

Wet Place: Mount Waialeale, Hawaii
Average annual rainfall of 9763 mm.

Dry Place: Atacama Desert
Prevailing wind from the southeast brings rain to the mountain ranges but this air is dry by the time it reaches the flat land on the other side. This area is what we call a rain shadow.

Cold Place: Vostok, Antarctica
World's coldest temperature recorded was -89.2C.

Windy Place: Commonwealth Bay, Antarctica
Windiest place on Earth with winds exceeding 240km/h. Storms are caused by katabatic winds which are winds that carry air from high ground down a slope due to gravity.

Drought: Causes what, where and when?
Droughts develop slowly and it can take weeks, months or even years for the full effect to appear. In some places a drought might be declared after 15 days. A drought occurs when a region experiences below average precipitation. It is a period of time with abnormally dry weather leading to a shortage of water, which can have a negative effect on vegetation, animals and people over a large area.

Droughts occur around the world in countries including Australia, Brazil, India, China, parts of the USA and Mexico, as well as the Sahel region of Africa. Large parts of these countries and regions already have a dry climate and receive low amounts of rainfall per year, so a period of time with less rainfall than usual can places, such as the tropical Amazon basin, can also experience drought if they receive significantly less rainfall than usual over a long period of time.

Causes of drought:
Physical causes: Most droughts occur when the regular weather patterns have been disturbed. There might be an above average presence of dry, high-pressure systems.
El Nino brings descending air and high pressure over Indonesia and Australia, leading to drought.
As global temperatures increase, more water is needed to grow crops and more water is lost through evaporation.
The intertropical convergence zone (ITCZ) has been linked to occurrence of drought particularly in Africa.

Environmental Threats to our Planet 5

Extreme weather conditions cause different natural weather hazards.

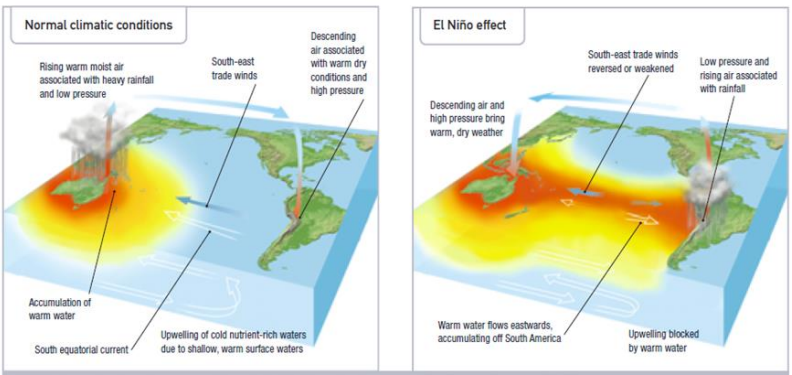
Term	Definition
Thermocline	The point at which the temperature changes from warmer surface waters
Drought	A prolonged period of time with unusually low rainfall; droughts occur when there is not enough rainfall to support people or crops.
Tropical storm	Hurricane, cyclone, typhoon: an area of lowland pressure with winds moving in a spiral around the calm central point called the 'eye' of the storm. Winds are powerful and rainfall is heavy.
Intertropical convergence zone	A low- pressure belt that encircle the globe around the Equator; it is where the trade winds from the northeast and southeast meet; the Earth is tilted on its orbit around the Sun, causing the ITCZ to migrate between the Tropic of Cancer and Capricorn with the seasons.

How does El Nino and La Nina in the Pacific Ocean cause extreme weather?

El Nino was the term used for the appearance of warm surface water around the coasts of Peru and Ecuador.

What causes El Nino and Al Nina?
Scientists continue to study the exact causes of El Nino. There is a strong interaction between ocean and atmosphere in the pacific, so even small changes can be enough to have a large-scale impact across the region and cause global changes to weather and climate.

For a brief time, seafloor heating as a result of volcanic activity became a popular theory. It was noted that two separate eruptions in the region were followed closely by El Nino events. For example, Mount Pinatubo erupted in 1991, the same year in which an El Nino events began. However, this is not a likely theory.



3.7.09 Atmospheric and ocean conditions in the Pacific region in normal climatic conditions and El Niño years

Tropical storms: What, where and when?

What is a tropical storm
Tropical storms begin as a low-pressure system originating in the tropics, known as a tropical depression, and can develop into a tropical cyclone (also known as a hurricane or typhoon). Characterised by high winds maximum wind speed ranging from 63km/h to 118km/h and heavy rain. When wind speeds are in excess of 119km/h the storms become a tropical cyclone.

Tropical storms are found:
Over tropical and subtropical waters between 5 and 30 north and south of the equator.
Where temperature of the surface layer of ocean water is in excess of 26.5C and at a depth of at least 50-60m.
500km away from the equator where the Coriolis effect, or force, is strong enough to make the weather system spin.

Where in the world do tropical storms occur?
Tropical storms are found in very specific parts of the world. From the Gulf Coast of North America to the northwest of Australia, the Indian Ocean island of Mauritius to Bangladesh.

What causes a tropical storm?
Conditions need to be perfect for a tropical storm to form. There needs to be a movement in the air near the surface of the water. In the troposphere, the temperature needs to cool quickly enough for tall clouds to form through condensation. The wind speeds need to change slowly with height. If the speeds are greater in the upper atmosphere, the storm could be sliced in two. Fuelled by the warm ocean, water vapour is evaporated. As warm, moist air rises it expands, cools and condenses to form the clouds. It maintains its strength as long as it remains over warm water.

Winds speeds increase towards the centre of the storm, around the eyewall. This typically 15-30km from the centre of the storm. Deep clouds rise from the Earths surface up to a height of 15,000m. This with heavy rainfall, the eyewall is the most destructive and dangerous part of the storm. When the vertical winds reach the top of troposphere at 16km the air flows outwards, deflected by the Coriolis effect. The eye of the storm is calm as speeds decrease. There is a central area of clear skies, warm temperatures and low pressure (typically 960 milibars).

Environmental Threats to our Planet 6

Drought can be devastating for people and the environment.

Case Study: a drought event caused by El Niño - THE BIG DRY AUSTRALIA

Distribution

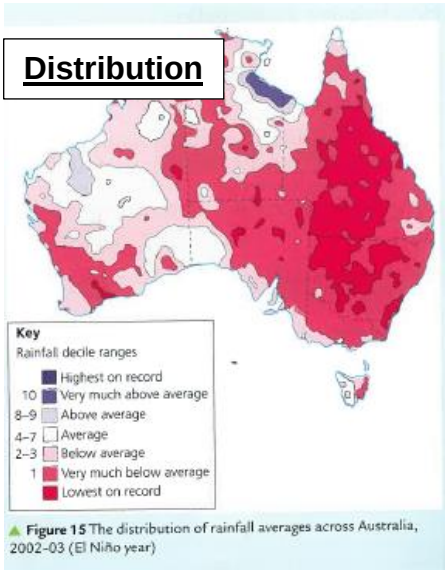


Figure 15 The distribution of rainfall averages across Australia, 2002–03 (El Niño year)

Period of drought 2002 – 2009. In 2006 there was 40-60% less rainfall than average.

CAUSES

Human	Physical
▪ High population growth in relation to access of water (even though low population density). ▪ Main water source – Murray Darling. ▪ River Drainage Basin covers area size of France and Spain. Area is populated by two million (New South Wales/Victoria/Queensland and South Australia). ▪ Water pressures – Agriculture water supply. ▪ 70% of all irrigated land is in this area for agriculture.	**El Nino** caused Australia to become drier. **Key points:** ▪ Weak or reverse trade winds. ▪ Changes position/ cools normally warm waters over Pacific ▪ Creates high pressure and sinking air ▪ Clouds can't form ▪ Rainfall diminishes

CONSEQUENCES:

Social	Economic	Environmental
▪ People in rural areas left due to a lack of water, putting greater pressure on the population of cities. ▪ Rural suicide rates soared.	▪ Farmers had to sell cattle as they could not afford to feed them. ▪ Food prices rose as Australia became more dependent on imports. ▪ Water bills rose 20% in 2008. ▪ Tourism was negatively affected. ▪ Agricultural production was severely affected. ▪ 10,000 people directly employed by the cotton-growing industry were affected. ▪ The number of dairy farms reduced by more than half.	▪ Loss of vegetation, wildlife and biodiversity as well as soil erosion. As the soil dries out, it becomes looser and it is easier for the wind to blow it away. ▪ Grassland turned to scrubland. ▪ Energy from HEP was reduced leading to more pollution as Australia resorted to the use of fossil fuels. ▪ Water quality reduced as toxic algal outbreaks occurred in depleted rivers, dams and lakes.

How have different stakeholders RESPONDED to the drought problems of Australia?