OCR GCSE (9–1)

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GEOGRAPHY B

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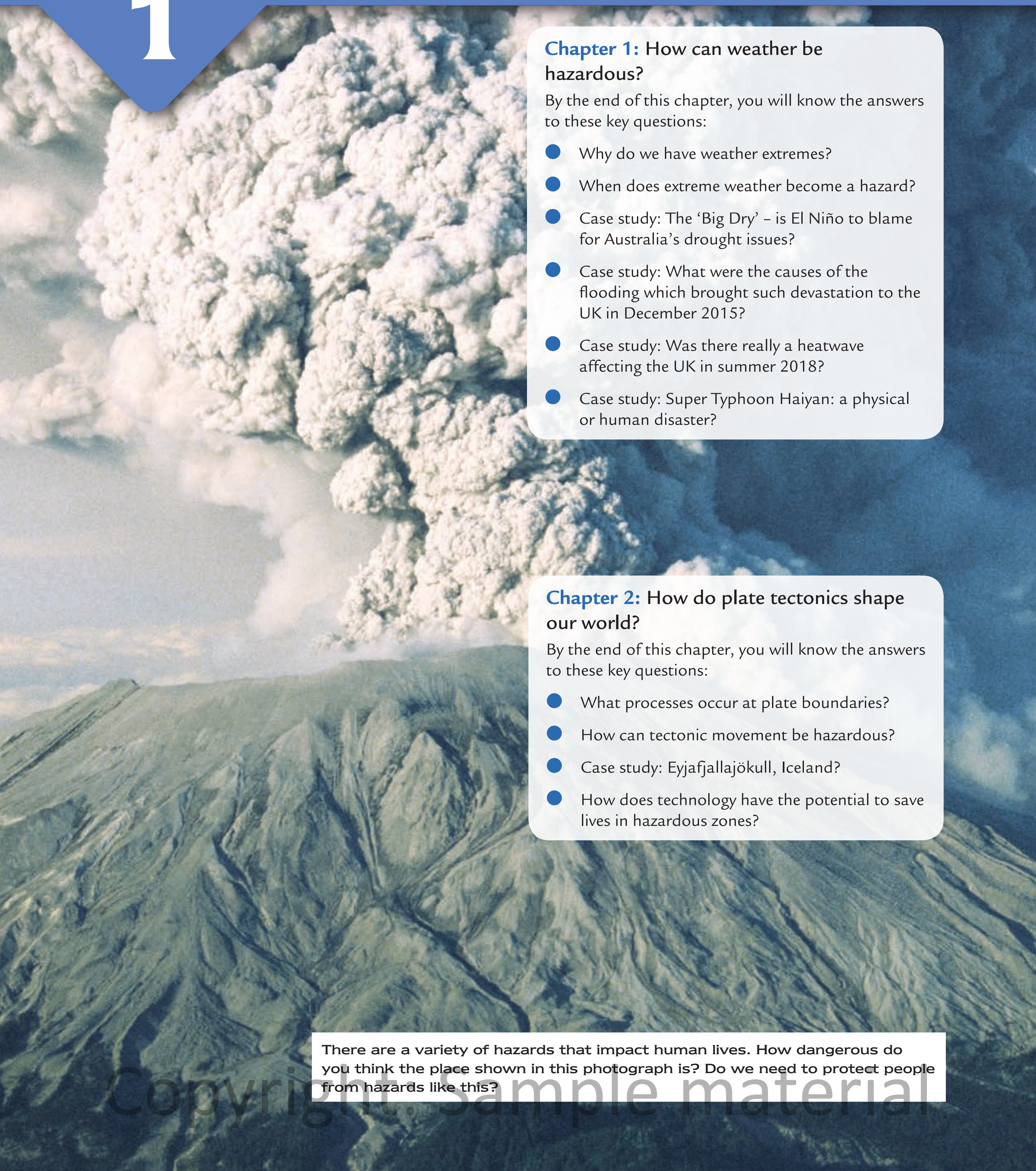
TOPIC 1

Global Hazards



Chapter 1: How can weather be hazardous?

By the end of this chapter, you will know the answers to these key questions:

- Why do we have weather extremes?
- When does extreme weather become a hazard?
- Case study: The ‘Big Dry’ – is El Niño to blame for Australia’s drought issues?
- Case study: What were the causes of the flooding which brought such devastation to the UK in December 2015?
- Case study: Was there really a heatwave affecting the UK in summer 2018?
- Case study: Super Typhoon Haiyan: a physical or human disaster?

Chapter 2: How do plate tectonics shape our world?

By the end of this chapter, you will know the answers to these key questions:

- What processes occur at plate boundaries?
- How can tectonic movement be hazardous?
- Case study: Eyjafjallajökull, Iceland?
- How does technology have the potential to save lives in hazardous zones?

There are a variety of hazards that impact human lives. How dangerous do you think the place shown in this photograph is? Do we need to protect people from hazards like this?

CHAPTER 1

How can weather be hazardous?

Why do we have weather extremes?

➜ In this section you will:

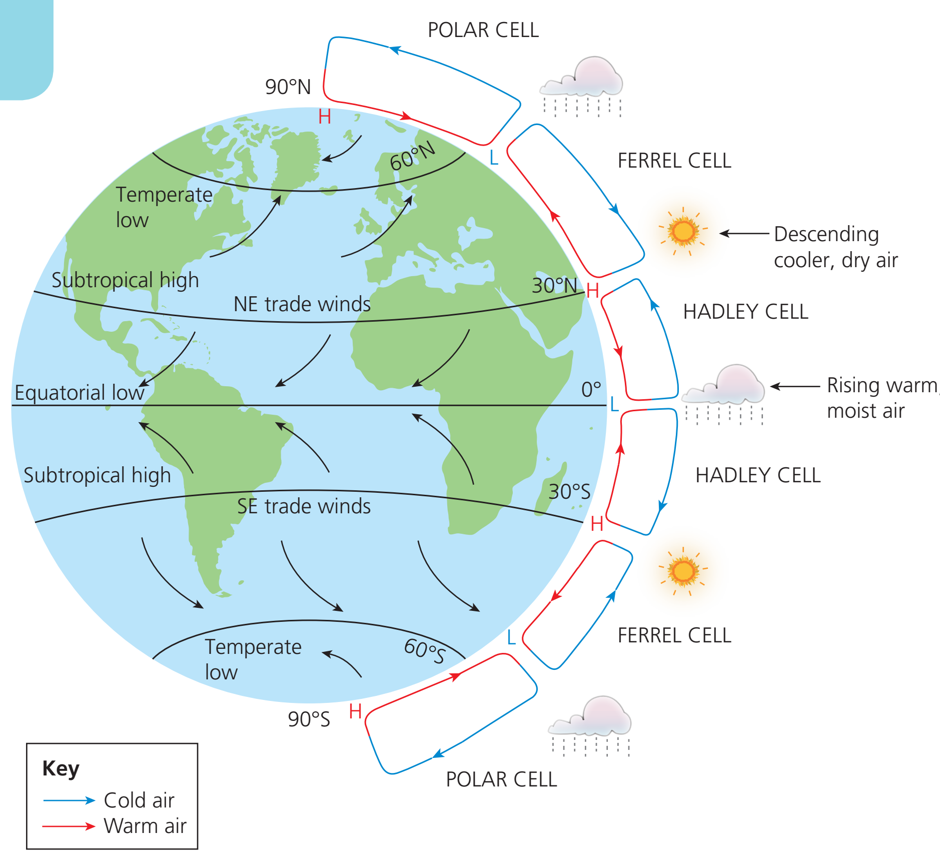
- examine the global circulation system, including the effects of high and low pressure belts in creating climatic zones
- explore the extremes in weather conditions associated with wind, temperature and precipitation in contrasting countries
- consider the causes, distribution and frequency of tropical storms and drought, and whether these have changed over time.

What is the global pattern of air circulation?

There are large-scale, circular movements of air over the Earth's surface. These circulations of air transport heat from the tropical regions at the Equator, where the Earth gets more heat from the Sun, to the polar regions at the poles.

The imaginary lines that surround the Earth are known as lines of **latitude**. The Equator is at the 0° latitude line and the region spanning it is known as the 'low' latitudes. The polar regions are towards 90° north and south of the Equator line and are known as the 'high' latitudes.

The world is divided into two at the Equator line to create the northern and southern **hemispheres**. In each hemisphere there are three specific 'cells' of air called Hadley, Ferrel and Polar (Figures 1 and 2). Within these cells, air circulates within the **troposphere**, an area of the atmosphere from the Earth's surface up to 10–15 km high. The troposphere is the part of the atmosphere where the Earth's weather takes place. The three cells of air play an important role in creating the distinct **climate zones** that we experience on Earth.



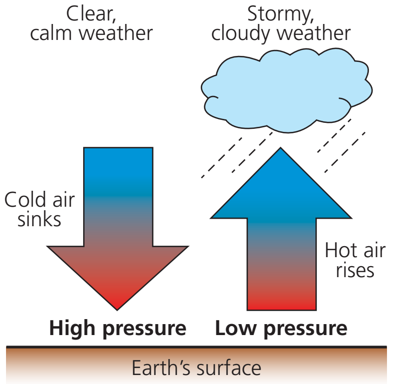
▲ **Figure 1:** Global circulation system

	Where is it?	What happens?
Hadley cell	The largest cell which extends from the Equator to between 30° and 40° north and south.	• Trade winds are winds that blow from the tropical regions towards the Equator. They usually travel from an easterly direction. • Near the Equator, the trade winds meet and the warm air rises and forms thunderstorms. • From the top of these storms air flows towards higher latitudes where it becomes cooler and sinks over subtropical regions.
Ferrel cell	The middle cell, which generally occurs from the edge of the Hadley cell to between 60° and 70°.	• This is the most complicated cell as it moves in the opposite direction from the Hadley and Polar cells, similar to a cog in a machine. • Air in this cell joins the sinking air of the Hadley cell and travels at low heights to mid-latitudes where it rises along the border with the cold air of the Polar cell. • This occurs around the latitude of the UK and accounts for the frequently unsettled weather. • Air then flows back towards the low latitudes, in the direction of the Equator.
Polar cell	The smallest and weakest cell, which extends from the edge of the Ferrel cell to the poles at 90°.	• Air in this cell sinks over the highest latitudes, at the poles, and flows out towards the lower latitudes.

▲ **Figure 2:** Differences between the three circulatory cells

What happens in areas of high pressure and low pressure?

What we know as wind is air moving from high to low pressure. Atmospheric air pressure is the force exerted on the Earth's surface by the weight of the air. It is measured in millibars. The normal range of air pressure is 980 millibars (low pressure) to 1050 millibars (high pressure). Where the air in the Hadley cells rises at the Equator, low pressure is created. However, where the Hadley and Ferrel cells meet at 30° north and south of the Equator, air descends, creating high pressure on the ground below (see Figure 3). The contrasts in air pressure associated with the different cells, combined with distance from the Equator, creates climate regions with distinctive average temperature and rainfall patterns (see pages 4–5).



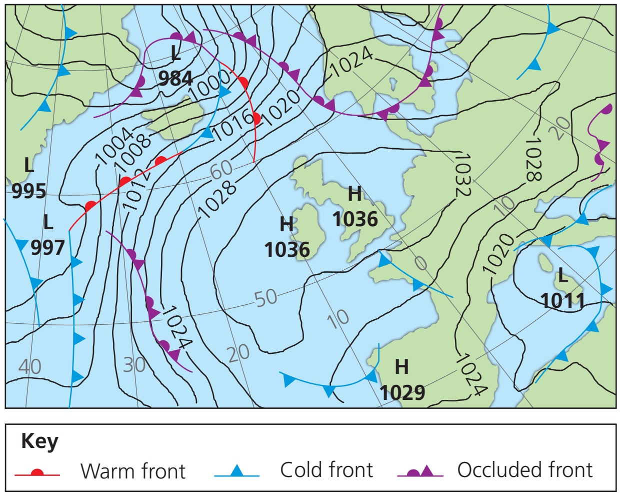
▲ **Figure 3:** The difference between high and low pressure

What happens in areas of low pressure?

A low-pressure system occurs when the atmospheric pressure is lower than that of the surrounding area. It is usually associated with high winds and warm, rising air. As the warm air cools and condenses as it rises, it forms clouds. Condensation is the process whereby this rising vapour turns into a liquid. Eventually, moisture falls from the atmosphere as rain, sleet, snow or hail, collectively known as precipitation. In the UK, for example, daily ranges of temperatures are unlikely to be large, as the cloud cover reflects solar radiation during the day and traps heat during the night.

What happens in areas of high pressure?

When air cools it becomes denser and starts to fall towards the ground, increasing the air pressure. This cool air is subjected to warming, which causes any clouds to evaporate. Also, heavy rain at the Equator means that most of the moisture in the atmosphere is removed before the air reaches the sub-tropics. At 30° north and south of the equator high pressure systems are usually associated with clear skies and dry (possibly hot), calm weather.

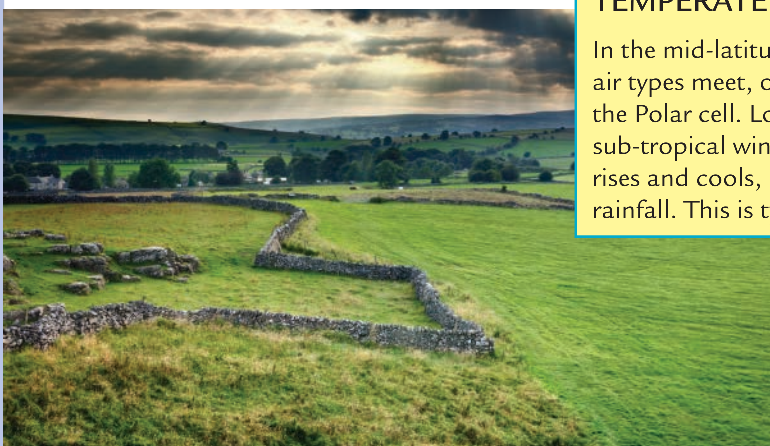


▲ **Figure 4:** A synoptic weather chart

What is the relationship between the global circulation system and the major climate zones of the world?

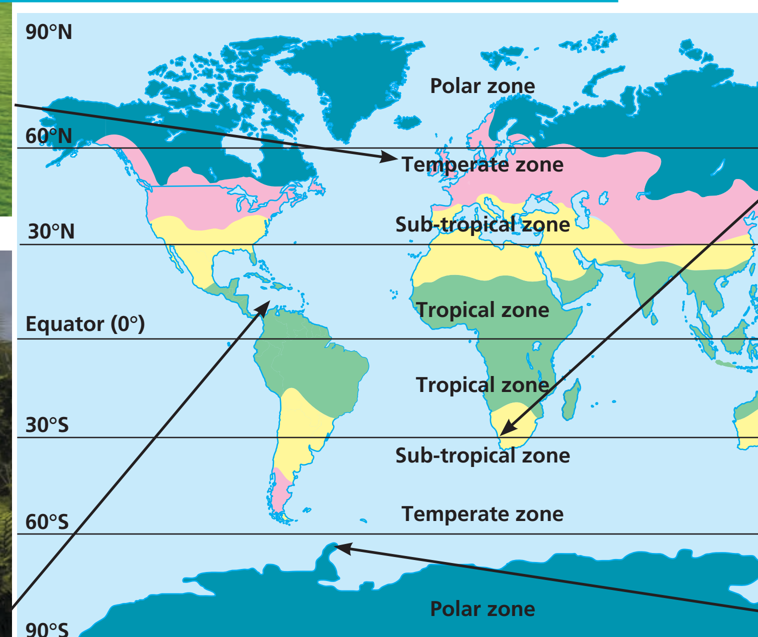
A number of climate zones, or belts, can be traced between the Equator and the pole in each hemisphere as a result of the global movements of air and the atmospheric pressure that this generates.

▼ **Figure 6:** Peak District, Derbyshire, England



TEMPERATE CLIMATE

In the mid-latitudes, 50°–60° north and south of the Equator, two air types meet, one warm from the Ferrel cell and one cold from the Polar cell. Low pressure is created from the rising of the warm, sub-tropical winds over the cold, polar winds at a front. As this air rises and cools, it condenses to form clouds and ultimately frequent rainfall. This is typical of the UK.



▲ **Figure 5:** Map of the four common climate zones

▲ **Figure 7:** Windward Islands, Dominica, Caribbean

TROPICAL CLIMATE

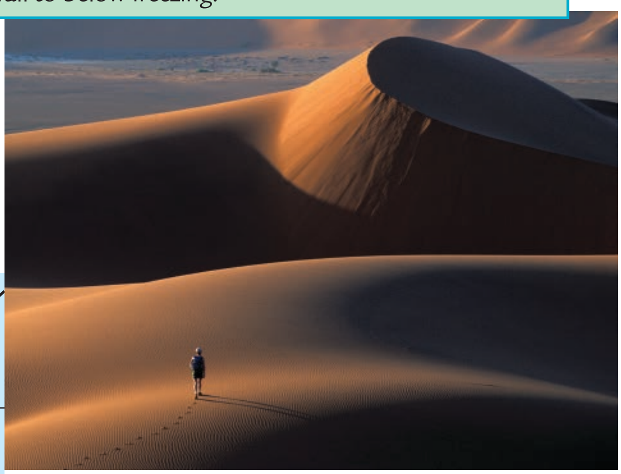
This is a belt of relatively low pressure, heavy rainfall and thunderstorms as a result of rising air in the Hadley cell. Places such as northern Brazil in South America and Malaysia in Southeast Asia experience this climate.

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Average temp (°C)	12.4	15.4	19.3	25.1	29.0	31.7	31.5	30.8	29.0	23.8	17.7	13.1
Rainfall (mm)	3.2	2.9	2.2	1.6	2.5	1.1	0.0	0.7	2.1	1.4	1.8	1.6

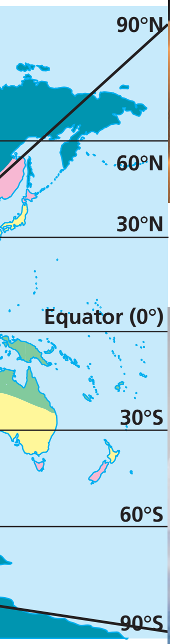
▲ **Figure 8:** Climate data for Djanet, Algeria

SUB-TROPICAL (DESERT) CLIMATE

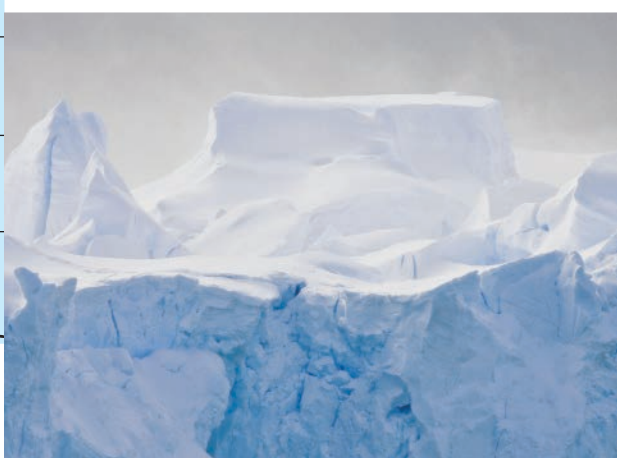
At 30° north and south of the Equator there is high pressure as a result of sinking, dry air as the Hadley and Ferrel cells meet. This creates a belt of desert regions. These include the Sahara in northern Africa and the Namib desert in Namibia, southern Africa. Daytime temperatures can exceed 40 °C, while at night, due to a lack of cloud cover, temperatures can fall to below freezing.



▲ **Figure 9:** Namib desert, Namibia, Africa



▼ **Figure 10:** Antarctic Peninsula



POLAR CLIMATE

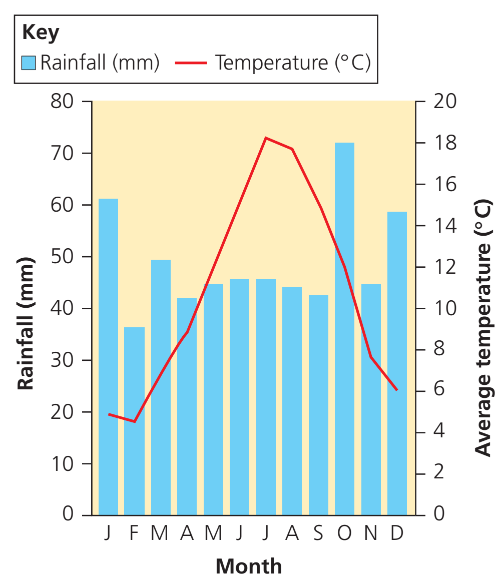
At the highest latitudes, cold air from the Polar cell sinks, producing high pressure. This is characterised by dry, icy winds caused by the spin of the Earth. In some places in Antarctica, the average annual wind speed is nearly 80 miles per hour!

Activities

1. Multiple choice:
   Which two cells meet to bring high pressure to the sub-tropical region?
   a. Hadley and Hadley
   b. Hadley and Ferrel
   c. Polar and Ferrel
2. Describe the difference between high and low pressure.
3. Study Figure 4. What pressure is shown over the British Isles – high or low?
4. Use the climate data in Figure 8 to draw a climate graph for Djanet, Algeria.
5. In which climate zone is Djanet located? How do you know this?
6. With the help of Figure 1 on page 2 which shows the global circulation of air, and pages 4 to 5, explain why the rainfall in Djanet is so low.

Geographical skills

A climate graph (Figure 11) shows the average temperature and rainfall for a place during a year. It is measured using months of the year on the *x* axis and both *y* axes are used to plot the rainfall in bars and the temperature as a line.



▲ **Figure 11:** Climate graph for London, UK

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

DEATH VALLEY: Driest place in North America with an average rainfall of 500 mm. Storms coming from the Pacific Ocean must travel over a series of mountain ranges on their journey eastwards. This means that many of the clouds have already cooled, condensed and fallen as rain before they reach Death Valley.

MOUNT WAIALEALE: Located on the island of Kauai in Hawaii, this is the wettest place in America with an annual average rainfall of 9763 mm.

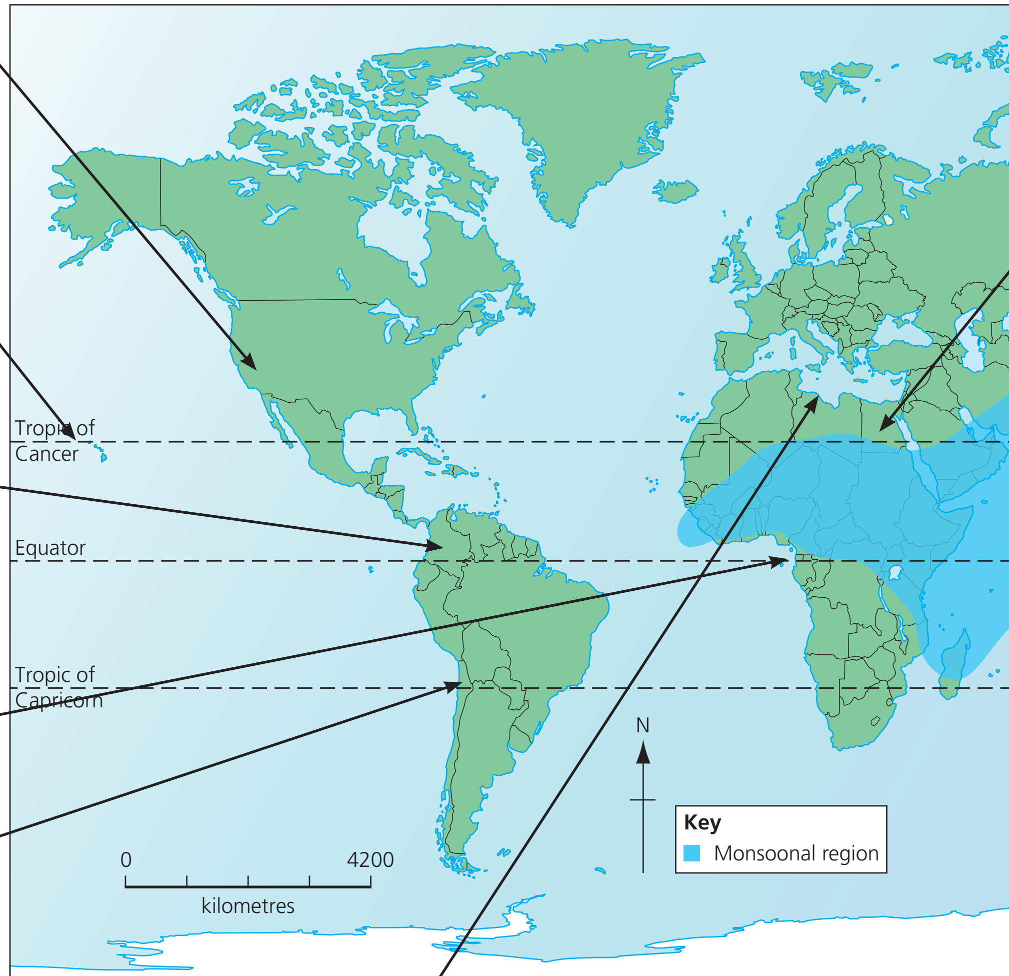
PUERTO LÓPEZ: A small fishing village in Colombia is one of the wettest places on Earth. It has an annual rainfall of 12,892 mm. In the mid-1980s, it rained every single day for two years!

URECA: Located on the southern tip of Bioko Island in Equatorial Guinea, this is the wettest location in Africa with an average annual rainfall of 10,450 mm.

ATACAMA DESERT: Coastal mountains to the west block moist air from the Pacific and the Andes block rain from the Amazon in the east (see Figure 13). The prevailing wind (most frequent wind direction) comes from the southeast and carries moist air from the Atlantic.

As the air is forced to rise to cross the Andes it cools, condenses and turns to rain on the eastern side of the Andes. This leaves the Atacama in the rain shadow, which means that it receives little rainfall as high land shelters it from rain-producing weather systems. This creates a 'shadow' of dry conditions on the western side of the Andes.

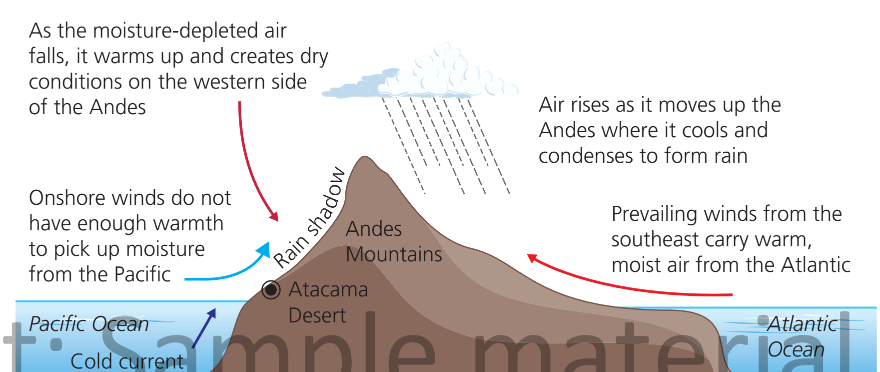
On its western side, the Atacama lies close to the ocean where a cold current flows northwards along the coastline. As it is cold, onshore winds do not have enough warmth to pick up moisture from the ocean surface. This lack of rising air prevents precipitation from forming.



▲ **Figure 12:** Location of the world's weather extremes

AL–AZIZIYAH, LIBYA: The hottest place on Earth is Al-Aziziyah in Libya. 40 km south of Tripoli, Al-Aziziyah is where, on 13 September 1922, the world experienced its hottest air temperature ever recorded at 57.8 ° C.

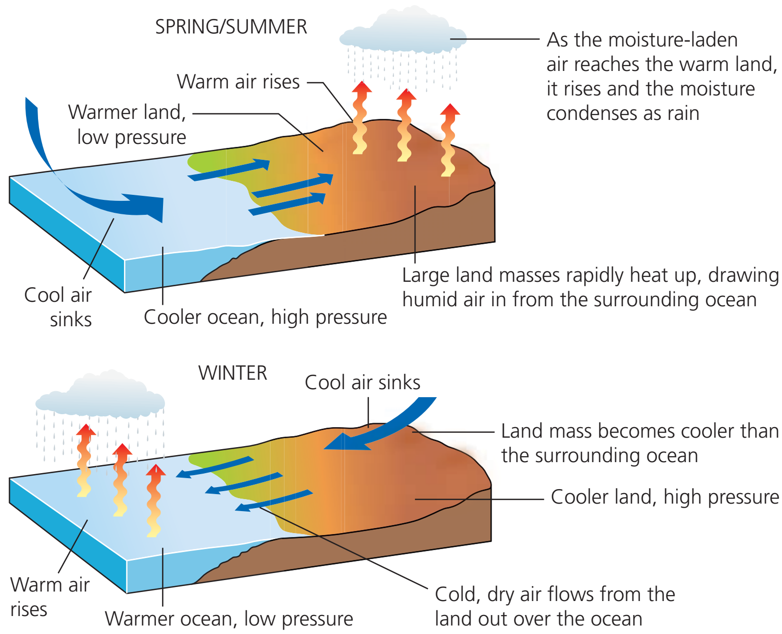
VOSTOK, ANTARCTICA: The coldest place on Earth is Vostok in Antarctica. At a height of around 3500 m above sea level, the Russian research station at Vostok is always cold. On 21 July 1983, the coldest air temperature on the planet was recorded here at –89.2 ° C.



▲ **Figure 13:** Why is the Atacama Desert so dry?

ASWAN: Located in the driest region of Egypt, it has a rainfall of only 0.861 mm per year! Its proximity to the Tropic of Cancer contributes to the high temperatures and dry weather.

MAWSYNRAM: The 10,000 villagers of Mawsynram cope with 11 metres of rain per year. That's 20 times the average rainfall for London! 80 per cent of all of India's rain arrives in the seasonal monsoon deluge from June to September. During this time, more heat from the Sun (solar radiation) is hitting the northern hemisphere. The monsoon is powered by the difference between land and sea and the ways that they respond to the Sun. The sea is cooler than the land as there is both more of it to be heated and it is always on the move due to the winds. The land therefore heats quicker than the sea. As the Sun bakes the land in India, the warm air above it rises and draws in cooler air from the sea. With the triangular shape of India and the long coastline, there is a powerful and sustained current of air moving northwards through India, which bring rains known as the monsoon.



▲ **Figure 14:** The formation of monsoons

	Location	Rainfall (mm per year)
	London, UK	558
1	Mawsynram, India	11,871
2	Cherrapunji, India	11,777
3	Tutendo, Columbia	11,770
4	River Cropp waterfall, New Zealand	11,516
5	Ureca, Bioko Island in Equatorial Guinea, Africa	10,450
6	Debundscha, Cameroon, Africa	10,229
7	Big Bog in Maui, Hawaii	10,272
8	Mount Waialeale in Kauai, Hawaii	9,763
9	Kukui in Maui, Hawaii	9,293
10	Mount Emei, Sichuan Province in China	8,169

▲ **Figure 15:** Top ten wettest places in the world

COMMONWEALTH BAY, ANTARCTICA: This is the windiest place on Earth with winds regularly exceeding 240 km/h, with an average annual wind speed of 80 km/h. Storms are causes by katabatic winds, which are winds that carry air from high ground down a slope due to gravity.

WELLINGTON, NEW ZEALAND: The highest gust of wind ever recorded in Wellington was 248 km/h and the average annual wind speed is 29 km/h. Gusts of wind exceed gale force (75 km/h) on 175 days of the year. The mountainous landscape either side of Wellington acts as a funnel for the winds, increasing their speed.

Activities

1. Choose three of the locations of weather extremes in the world. **Analyse** the reasons why the weather is so extreme. Use the information from other areas of this chapter to help you, including Figure 1.

Take it further

2. To what extent would you agree that Antarctica is the 'most extreme' place in the world? Use evidence from pages 6–7.

Geographical skills

Create a bar graph of the data in Figure 15. Colour code the bars according to the continent. Label the axes and give your graph a title.

What is El Niño?

El Niño was the term first used for the appearance of warm surface water around the coast of Peru and Ecuador. It was originally spotted by a group of Peruvian fishermen who relied on the usually colder waters swelling up from beneath the sea surface to bring up nutrient-rich waters from the deep ocean. This in turn improved their catch of small fish called anchovies. They noticed the unusually high sea surface temperatures occurring about every two or three years around Christmas.

Activities

1. Suggest one cause of El Niño.
2. How was this weather phenomenon first discovered?
3. How might scientists determine an El Niño event is taking place?

How do El Niño and La Niña in the Pacific Ocean cause extreme weather?

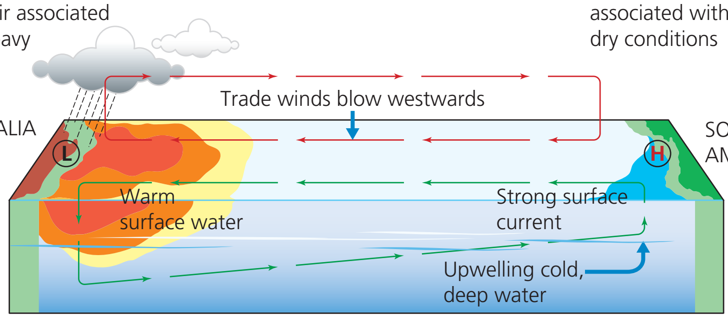
What causes El Niño?

Scientists continue to study the exact causes of El Niño. 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 Niño events. For example, Mount Pinatubo erupted in 1991, the same year in which an El Niño event began. However, this is not a likely theory.

A more probable cause is small changes in sea surface temperatures. This could be caused, for instance, by tropical storms in the western region of the Pacific. If they are violent enough, or last long enough, they could start the movement of warm water eastwards across the Pacific.

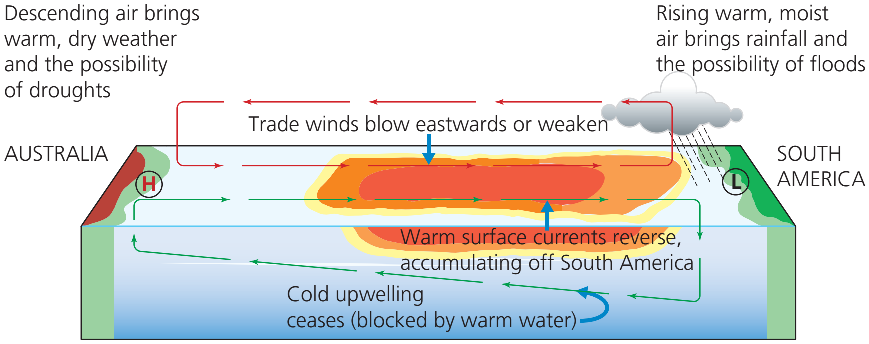
What are the normal conditions in the Pacific Ocean?



▲ **Figure 16:** A normal year

- The surface winds over the Pacific Ocean, known as the trade winds, blow towards the warm water of the western Pacific, off the coasts of Australia and Indonesia.
- Rising air occurs at this location as a result of water heating up the atmosphere. The trade winds across the surface of the Pacific push the warm water westwards from Peru to Australia.
- In the eastern Pacific, off the coast of Peru, the shallow position of the **thermocline** allows winds to pull up water from below. The thermocline is the point at which the temperature changes from warmer surface waters to deeper, colder water. It is this that creates those optimum conditions for fishing, which have already been mentioned, as there is an abundance of phytoplankton within the cold water, supplying the fish with food.
- As a result of the pressure of the trade winds pushing the water westwards, the sea levels in Australasia are about half a metre higher than Peru, with sea temperatures 8 °C warmer.

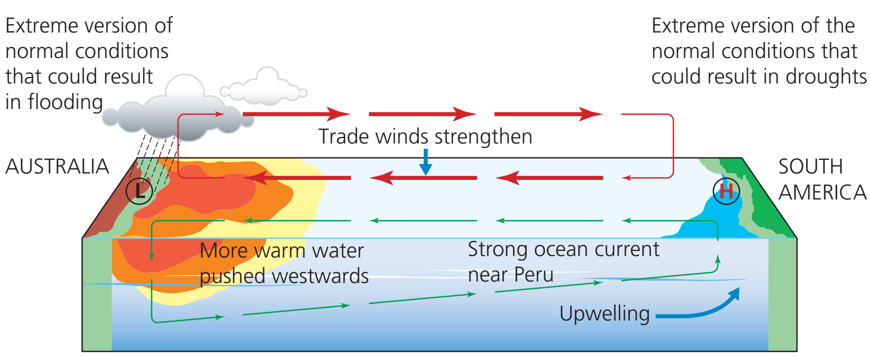
What happens during El Niño?



▲ **Figure 17:** El Niño

- During El Niño, the trade winds weaken, stop or even reverse in the western Pacific.
- The piled up warmer water around Australasia makes its way back eastwards across the Pacific, leading to a 30 cm rise in sea level around Peru, preventing the usual cold upwelling.
- As a result, there is more warm water over the coast of Peru leading to rising air and low pressure. The water becomes 6–8 °C warmer in the eastern Pacific.
- Peru would therefore experience more rainfall than normal.
- In Australasia, however, the water becomes cooler and there is less air rising resulting in high pressure and stable, dry conditions.

What happens during La Niña?



▲ **Figure 18:** La Niña

A La Niña event may, but does not always, follow an El Niño event. La Niña refers to unusually cold sea surface temperatures (3–5 °C colder) found in the eastern tropical Pacific. Broadly speaking, the impacts of La Niña are the opposite of El Niño, where Australia would experience droughts during El Niño, there could be increased risk of flooding during La Niña. Likewise, Peru could experience droughts during La Niña. La Niña could also be described as a more exaggerated version of a normal year in the Pacific Ocean.

El Niño and La Niña are among the most powerful phenomena on Earth, affecting climate across more than half of the planet. Their consequences can, in fact, be global.

How do we know if it is an El Niño year?

Many techniques have been used to identify and predict the occurrence of El Niño.

- Better satellite coverage looking for oceanic patterns.
- Design of buoys has improved. They can now measure sea surface temperatures, surface winds, air temperature and humidity.
- Buoys can be used in mid-ocean or in shallow water and can remain active for one year.
- Buoys transmit to weather forecasting systems, sometimes every hour.
- Sea levels around the world can be measured and recorded.
- Biological recordings. For example, during El Niño, phytoplankton does not grow as there is no upwelling of cold water in the eastern Pacific.

Activity

1. Spot the difference! What are the key differences between the three weather patterns? Use the following table design to help to structure your notes.

	Normal Year	El Niño	La Niña
High pressure			
Low pressure			
Rainfall			
Flooding			
Droughts			
Trade winds			