Humans, more than any other species, have sought to change and control their environment. We have sent people into outer space and can transfer information around the globe in the blink of an eye.

Yet despite all our accomplishments, we are still at the mercy of the weather and often struggle to understand or predict its various moods. Beaches are ravaged by storm activity, drought results in the heartbreaking loss of crops and livestock, cities are inundated by floods while bushfires race through the countryside destroying all in their path. Few communities are free of the risk of natural hazards. We cannot control weather, but we can try to understand it, predict it and prepare for its extremes when hazards become disasters.

**Geographical knowledge and understanding**
- Use a variety of geographical tools and skills to investigate areas of Australia and the regions surrounding it.
- Explain, with examples, how the interaction of physical processes and human activities create variations within regions.
- Extend knowledge and understanding of physical phenomena (including natural hazards) and the physical processes that produce them.

**Geospatial skills**
- Apply basic mapping skills.
- Use a range of techniques to collect, process, present and analyse data.
- Use a variety of maps and other geographical information as sources of spatial information.
- Identify and gather geographical information from fieldwork, and organise, process and communicate it using a range of forms.

*Firefighters battle to control a raging bushfire in the Simi Valley, California.*
air pressure: the pressure that the weight of air in the atmosphere exerts on the Earth’s surface. Rising air reduces this pressure; falling air increases it.

atmosphere: the band of gases surrounding the Earth

bushfire: a fire burning out of control in the open

climate: the state of the atmosphere, averaged over a long period of time

climatic zone: a group of areas that experience the same type of climate

cumulonimbus cloud: a thundercloud that forms when humidity is very high and the atmosphere is unstable; thunder and lightning are common

drought: an extended period of below-average rainfall that results in a water shortage

evaporate: water is heated by the sun and absorbed into the atmosphere as water vapour

firestorm: an intense fire which may generate strong winds that throw burning embers ahead of the main fire

floodplains: the flat land on either side of a river that is covered with water during times of high run-off and flood

global warming: the warming of the atmosphere that has been attributed to the burning of fossil fuels

hemisphere: one half of the Earth, as divided by the Equator

hurricane: the term used in the United States for tropical cyclones

inundate: cover with water

isobars: the lines on a weather map joining places of equal atmospheric pressure

precipitation: water returning to the Earth in the form of rain, hail, sleet or snow

rain depression: heavy rains and strong winds which result when a cyclone moves over land and loses intensity

relative humidity: the ratio of the amount of water vapour contained in the air, compared to what it can hold at a given temperature

storm surge: a sudden increase in sea level as a result of storm activity, a drop in air pressure and strong winds. Low lying land may be flooded.

synoptic chart: another name for a weather map

tropical cyclone: strong spiralling winds that form over tropical waters. They require a water temperature of 26ºC to form.

troposphere: the layer of the atmosphere that stretches from ground level to 16 km above the Earth. Weather happens in this layer.

typhoon: the term used in South-East Asia for a tropical cyclone

updraft: strong upward air current

weather: the day-to-day condition of the atmosphere
WHAT ARE NATURAL HAZARDS?

There is a difference between natural hazards and natural disasters. A hazard is an event or object that is a potential source of harm to a community. A disaster is an extreme event that causes severe disruption to normal activities. This chapter describes natural hazards related to the weather. Chapter 9: Restless Earth describes volcanoes and earthquakes, which are natural hazards associated with forces deep within the Earth. There are six broad types of hazards:
1. **Atmospheric** — for example, cyclones, hailstorms, blizzards or bushfires
2. **Hydrological** — for example, flooding, wave action or glaciers
3. **Geological** — for example, earthquakes or volcanoes
4. **Biological** — for example, disease epidemics and plagues
5. **Technological** — for example, accidents, explosions or hazardous materials
6. **Human** — for example, war, crowd stampede and terrorism.

**Australia’s worst natural disasters**
- **Cyclone**: Cyclone Tracy, Darwin 1974 — 65 deaths, 10 800 buildings destroyed, $4180 million cost
- **Hailstorm**: Sydney 1999 — 1 death, 24 800 buildings damaged, $2000 million cost
- **Bushfire**: Ash Wednesday, Victoria and South Australia 1983 — 75 deaths, 2500 buildings destroyed, $950 million cost
- **Earthquake**: Newcastle 1989 — 13 deaths, 50 000 buildings damaged, more than $4000 million cost
- **Landslide**: Thredbo, 1997 — 8 deaths, 2 buildings destroyed, $40 million cost.

The first four groupings are generally referred to as natural hazards and the last two as human hazards. It should be noted that some natural hazards are influenced by the actions and locations of people. For example, humans can influence bushfires through carelessness in the use of fire or inadequate preparation of their property.
Activities

Understand
1. List the 10 natural hazards shown in this illustration.
2. Choose three of the hazards shown and briefly describe what type of damage each is likely to cause to the natural and human environment.

Think
3. Where do you think would be the safest place to live in this scene? Why?
4. Do you think people could have contributed to causing any of the hazards shown? Explain.
5. In your notebook, draw up a table with two headings: ‘Hazards caused by weather’ and ‘Hazards caused by forces deep within the Earth’. Use the table to classify each of the hazards shown according to their cause.

6. Would it have been possible to prevent any of the hazards shown? How?

Dig deeper
7. To find out more about natural hazards in Australia, visit the website for this book and click on the Natural Hazards weblink for this chapter (see ‘Weblinks’, page xii).

Worksheets
10.1 Extreme weather report

- Large circular clouds indicate that a tropical cyclone is approaching. Strong winds, torrential rain and high waves caused by tropical cyclones or storms can devastate towns and cities on the coast.
- Lightning is a release of electricity from storm clouds to the Earth.
- A bushfire has been started by a natural event—a lightning strike. (Some bushfires, though, are started by arsonists.) Bushfires are a common occurrence not only in Australia but also in parts of the United States and Europe.
- A tsunami is a large wave. Tsunamis are usually created when an earthquake occurs under the ocean.

- Landslides can be triggered by heavy rainfall, earthquakes and volcanic eruptions. Clearing forests from steep hillsides increases the risk of landslides.
- Heavy rain in the mountains can cause Rivers to flood low-lying areas.

- A bushfire has been started by a natural event—a lightning strike. (Some bushfires, though, are started by arsonists.) Bushfires are a common occurrence not only in Australia but also in parts of the United States and Europe.

- Lightning is a release of electricity from storm clouds to the Earth.
WHAT IS WEATHER?

Our Earth is surrounded by a band of gases called the atmosphere. It protects Earth from the extremes of the sun’s heat and the chill of space, making conditions just right to support life. The atmosphere has five different layers. The layer that starts at ground level, and ends about 16 kilometres above Earth, is called the troposphere. It contains most of the water vapour in the atmosphere. Our weather results from constant changes in the air in the troposphere.

Heatwaves, snowfalls, cyclones, floods, droughts, hailstorms — even cloudless days with gentle breezes — all begin with changes in the air in the troposphere.

HOW DOES WEATHER CHANGE?

All weather conditions result from different combinations of three factors: air temperature, air movement, and the amount of water in the air. The sun influences all three.

Firstly, the sun heats the air. It also heats the Earth’s surface which, in turn, heats the air even further. How hot the Earth’s surface becomes depends on the season and the amount of cloud cover.

Secondly, the sun causes air to move. This is because land surfaces are heated more by the sun than oceans are. As the warmer air over land gets even warmer it expands, and as it expands it rises. When hot air rises, colder air moves in to take its place.

Thirdly, the sun creates moisture in the air. The heat of the sun causes water on the Earth’s surface to evaporate, forming water vapour. As this water vapour cools, it forms clouds. It may return to Earth as rain, dew, fog, snow or hail.

WEATHER AND THE SEASONS

Why is it that Melbourne can be experiencing a heatwave, while people in Canada are experiencing blizzards? Melbourne is in the southern hemisphere and Canada is in the northern hemisphere. As the Earth orbits the sun, the tilt of its axis does not change. This means that at certain
times during the Earth’s orbit, one hemisphere or the other is leaning more towards the sun.

When a hemisphere tilts towards the sun, the sun’s rays ‘hit’ it more directly. This means that a larger area is in more intense sunlight for longer. So it heats up faster and days are warmer. This hemisphere experiences summer. When a hemisphere tilts away from the sun, the sun’s rays ‘hit’ it at more of an angle. So heat energy from the sun’s rays is spread out more, and is not as intense. This means it takes longer for that hemisphere to heat up. Days are colder. This hemisphere experiences winter. When neither hemisphere tilts towards the sun, which happens in autumn and spring, each receives the same amount of the sun’s rays.

Weather and climate

Weather is not the same as climate. Weather is the day-to-day short-term change in the atmosphere of a location. It is the condition of the atmosphere at a particular place at a particular time. Weather can change very quickly, so it is often difficult to predict.

However, we can begin to see patterns in the weather if we average out the weather information over a long period of time, say over 30 years. We refer to this average as the climate of a particular place. We can define climate as the long-term variation in the atmosphere for a given area, as determined over the seasons and the years. Places that share the same type of climate are said to lie in the same climatic zone. Because of Australia’s size, the continent’s climate and weather varies considerably from one part to another.

Activities

Understand
1. What is the name of the layer of the atmosphere where all Earth’s weather happens?
2. What role does the sun play in influencing weather patterns?
3. During which season in Australia does the Southern Hemisphere tilt towards the sun?
4. What season are we having in Australia when:
   (a) it is summer in England
   (b) it is autumn in China?

Think
5. Use an example from your local area to explain the difference between weather and climate.
6. Look at the map of Australia’s climatic zones.
   (a) Describe the climate in Perth, Darwin, Brisbane, Adelaide, Hobart.
   (b) Find the description for the climate zone in which you live. Does it describe the weather there today? Explain.

Dig deeper
7. Test the theory that our atmosphere is constantly changing. Use your own observations to collect weather data over a period of 10 days. At the same time each day, record the temperature, wind direction (use a wind vane) and rainfall (use a rain gauge).

   When you have collected all your data, write a carefully worded response to the following statement: ‘Our atmosphere is constantly changing.’
Weather maps, or synoptic charts, can appear rather complicated. But when you know what the lines and symbols mean you will find these maps easy to use.

**PRESSURE SYSTEMS**

One of the most important features of the atmosphere and one that is very frequently measured is air pressure, or the weight of the air. All air has weight. While we can’t feel it because we are constantly surrounded by it, sensitive instruments called barometers can measure the air pressure. Atmospheric air pressure measurements are given in hectopascals (hPa). Several times a day, air pressure is read at various weather stations around the world. Many observers around Australia measure air pressure and other aspects of the weather and send them to the national and regional centres of the Bureau of Meteorology. These observations are combined with others made from satellites, aircraft, ships at sea and in other countries to prepare weather maps.

The main lines that we see on weather maps are called isobars. Isobars are lines joining places of equal pressure.

**Highs and lows**

The average weight of air at sea level is 1013 hPa. If air pressure measures more than 1013 hPa, it is usually an area of sinking air and is generally an area of high pressure. High pressure systems are often called anticyclones. You can see from the table opposite what a high pressure system looks like and the anticlockwise direction the air travels in a high pressure system. The moving air, known as wind, always moves out of a high and into a low pressure system.

If air pressure measures below 1013 hPa, it is usually an area of rising air, and is generally an area of low pressure. Low pressure systems are often called cyclones. You can see in our table what a low pressure system looks like and the clockwise direction the air travels in a low pressure system.

Pressure systems generally move from west to east as they move across Australia and around the world. As they move, they change in shape and often change their latitudinal position.

**AIR MASSES AND FRONTS**

Sometimes people confuse pressure systems with air masses. An air mass is a large section of the atmosphere containing air with a similar temperature and moisture content. A line drawn on a weather map to show where two different air masses meet is called a front. There are two main types of fronts: cold fronts and warm fronts.

**WINDS AND TEMPERATURE**

When we look at the direction of winds on a weather map we can work out if temperatures are warmer, cooler or about normal for the time of year. In Australia, a northerly wind (coming from the north) means warmer than normal temperatures and a southerly wind, cooler than normal temperatures. Easterlies and westerlies mean temperatures that are around normal.

**SAMPLE STUDY**

**Snowfalls to the south and central ranges of south-eastern Australia**

The weather map below for 30 July 2003 shows a cold front moving into the Tasman Sea that has brought a ‘cold snap’ to south-eastern Australia. Cold and moist air from the ocean to the south of Australia moved across Tasmania, Victoria and New South Wales, bringing extensive snowfalls to the higher parts of the tablelands and ranges. Over 40 centimetres of snow fell in the Snowy Mountains, and there were falls of up to 20 centimetres over the Central Tablelands. While such snowfalls are welcome news for skiers during the winter months, they often create difficult conditions for graziers who must take early precautions to protect their sheep from the very cold weather.
1. What is another name for a weather map?
2. List three differences between a low and a high pressure system.
3. What does a weather map indicate when:
   (a) isobars are close together
   (b) isobars are well apart?
4. What do we call the lines that are drawn on weather maps to separate different air masses?
5. Observe the weather map below.
   (a) Estimate the wind direction in Adelaide. Is it windy or calm?
   (b) Identify the pressure systems at A, B and C.
   (c) Identify the types of fronts at D and E.
   (d) Describe the temperatures at Brisbane, Sydney, Melbourne, Adelaide and Perth, using the terms ‘warmer’, ‘cooler’, ‘about normal for the time of the year’.
   (e) Name any of these cities in which you think it could be raining and give reasons for your answer.
   (f) Which capital city is about to experience a cool change?

6. Read the sample study.
   (a) What is the central pressure of the high pressure system over South Australia?
   (b) What separates this high and the low further west to the south of Western Australia?
   (c) Describe the weather being experienced over south-eastern Australia. Mention wind strength and direction, cloud cover, precipitation, including snowfall, and the temperature.
   (d) Why did the weather situation bring widespread snowfalls?
7. Visit the website for this book and click on the Weather Satellite weblink for this chapter (see ‘Weblinks’, page xii). Select one satellite image and describe the pattern of cloud over Australia.

**Worksheets**
10.2 Watch the weather

To learn more about weather maps, visit the website for this book and click on the Bureau of Meteorology weblink for this chapter (see ‘Weblinks’, page xii).

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### Interpreting synoptic charts

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Name</th>
<th>Description</th>
<th>Associated weather</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Isobars" /></td>
<td>Isobars</td>
<td>Lines joining places of equal pressure</td>
<td>The closer the isobars are, the stronger the winds.</td>
</tr>
<tr>
<td><img src="image" alt="High pressure system" /></td>
<td>High pressure system</td>
<td>Area of sinking air</td>
<td>Generally fine weather. Winds rotate around these systems in an anticlockwise direction.</td>
</tr>
<tr>
<td><img src="image" alt="Low pressure system" /></td>
<td>Low pressure system</td>
<td>Area of rising air</td>
<td>Generally cloudy weather and a good chance of rain. Winds rotate around these systems in a clockwise direction.</td>
</tr>
<tr>
<td><img src="image" alt="Tropical cyclone" /></td>
<td>Tropical cyclone</td>
<td>Area of rapidly rising air</td>
<td>Torrential rain, very strong and destructive winds in a clockwise direction. Given a name (e.g. Tropical Cyclone Pamela)</td>
</tr>
<tr>
<td><img src="image" alt="Cold front" /></td>
<td>Cold front</td>
<td>Separates warm and cold air, with the cold air behind the front</td>
<td>Fall in temperature, may bring rain and storms. Front moves in the direction of the arrowheads.</td>
</tr>
<tr>
<td><img src="image" alt="Warm front" /></td>
<td>Warm front</td>
<td>Separates warm and cold air, with the warm air behind the front</td>
<td>Increase in temperature; may bring light showers. Uncommon in Australia.</td>
</tr>
</tbody>
</table>
Clouds can provide a useful indication of weather conditions. Weather observers around Australia send regular reports to Bureau of Meteorology forecasters on cloud types, height, and the amount of sky covered. The official unit of cloud cover is eighths of the sky. When the sky is completely covered by cloud (overcast), the cloud cover is eight-eighths. When the sky is clear, the reading is zero-eighths.

Some cloud types form only at certain altitudes. Others, such as cumulonimbus clouds, may extend right up through the troposphere. Clouds can be roughly described as being one of three main types. The meanings of their Latin names give us some idea of their appearance:

- ‘strato’ means smooth, flat layer
- ‘cumulo’ means pile or heap
- ‘cirro’ means curl.

Stratus are low, greyish clouds whose base can be anywhere between ground level and about two kilometres above sea level. Any rain is often drizzle.

Cumulus clouds form fluffy, white piles that often evaporate. They can, however, turn into cumulonimbus clouds. Cumulus clouds lie between about one and 2.5 kilometres above the ground.

Altocumulus clouds are found between about 2.5 and six kilometres above the ground. These are rippled clouds that may produce light showers.

Stratocumulus clouds are broad and flat at the bottom and puffy on the top. These clouds (whose base lies between about one and 2.5 kilometres above the Earth’s surface) produce drizzling rain.

Smog (a mixture of fog and air pollution) hangs on the horizons of large cities. It becomes worse when a layer of warm air moves over a layer of cold air, preventing it from rising and spreading the pollutants. This is known as a temperature inversion.

Rainbows appear when sunlight passes through raindrops. As sunlight enters a raindrop, the rays of light are bent at different angles and the colours of light are separated. Rainbows have seven colours. From outside to inside they are: red, orange, yellow, green, blue, indigo and violet.

Tornadoes may form from the meeting of air underneath a developing cumulonimbus cloud. The swirling air is then tilted upwards to form the tornado. Tornadoes range in size from a few metres across to about a kilometre wide.

On clear, still nights the ground temperature can fall to below 0°Celsius. When this happens, water vapour can turn into solid crystals of frost. Frost occurs more often in valleys than higher areas because colder and heavier air sinks.
Think

1. Look carefully at the illustration opposite.
   (a) Describe what cumulus clouds look like.
   (b) Clouds are categorised as low (from the Earth’s surface to about two kilometres), middle (about two to six kilometres), or high (above six kilometres). Give one example for each category.
   (c) Which clouds are made of ice crystals? Why do you think this is so?
   (d) What are the similarities and differences between fog and clouds?
   (e) What types of clouds can you see today? Will they produce rain? Explain.

2. Identify the type of cloud shown below.
   (a) Where is it usually found in the sky?
   (b) What type of rain do these clouds bring?

Teamwork

3. Work in small groups for this activity. Observe the clouds you can see in the sky above your schoolyard over a two-week period. Do not look directly at the sun.
   • On each day, measure the temperature using a thermometer. The thermometer should be placed in a shady location about a metre above the ground and well away from buildings.
   • Estimate the percentage of the sky covered by cloud.
   • Identify the type of cloud using the illustration on these pages.
   • Draw up a table like the following one, and record your results in it.

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Temp.</th>
<th>Cloud type</th>
<th>Cloud cover</th>
<th>Rain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

   (a) Is there a relationship between the percentage of cloud cover and temperature?
   (b) Is there a relationship between the type of cloud and temperature?
   (c) Did any rain fall during your trial? If so, which clouds produced rain?

Worksheets

10.3 Children’s cloud book
FLOODS: TOO MUCH WATER

Flooding occurs when water inundates normally dry land. Causes of floods include heavy rainfall, storm surges along the coast or a river overflowing its banks. Even though Australia is the driest inhabited continent, high-intensity rains may occur as a result of:

- storms — thunderstorms, tropical cyclones or rain depressions (the remains of tropical cyclones after they have moved inland)
- low pressure systems, including those associated with cold fronts and east coast depressions.

In Australia, floods cause damage to property and loss of livestock. When people are killed by floods in Australia, it is usually because they have tried to drive, walk or swim through floodwaters. Others have been trapped by flash floods. Such floods often occur in dry riverbeds, when there is heavy rainfall many kilometres away.

Flood disasters in other countries can be responsible for the loss of thousands of lives. Flooding in countries such as Bangladesh, where many thousands of people live on floodplains, has resulted in very high death tolls as well as the loss of homes, land and crops, and increased disease from polluted floodwaters.

On 3 February 2005, Melbourne experienced its biggest downpour since records began in 1856. The city recorded 23 per cent of its annual rainfall in just one day. An intense low pressure system dumped a record 120.2 millimetres of rain in just 24 hours, closing roads, railways and airports. Winds of more than 100 kilometres per hour brought down trees and power lines, cutting off power to 120,000 homes. The storm put great pressure on the State Emergency Service, police, ambulance and fire services, who received a record number of calls for help.
The next day people were warned to stay away from beaches as huge amounts of debris were washed into Port Phillip Bay from rivers and stormwater drains, decreasing water quality and posing health risks. The storm also brought unseasonable snow to some alpine areas.

Activities

Understand
1. What is a flood? What causes floods?
2. List the problems caused by the floods and winds that hit Melbourne on 3 February 2005.
3. Why was the flooding in Melbourne considered unusual?

Think
4. Examine the satellite image and synoptic chart.
   (a) Was the air over Melbourne rising or sinking?
   (b) Describe the areas of Australia where rain had fallen in the past 24 hours.
   (c) How is the line of clouds that runs from Melbourne to Brisbane shown on the weather map?
   (d) In which direction was the cold front heading?

Skills essentials

Using aerial photographs

Aerial photograph of Wangaratta, October 1993. The flood was the largest in the town’s history. It is estimated that 180 homes in the town and 40 on surrounding farms were flooded.

Emergency services study flooding rivers from the air so they can see the extent of the problem. Aerial photographs are also used to prepare maps to help plan for future floods. The photograph above is a vertical aerial photograph (camera lens points straight down) of the floodwaters that hit the town of Wangaratta in 1993. Oblique aerial photographs (camera lens is at an angle) cannot be used to prepare maps, as the scale varies from the foreground to the background.

1. Draw a map of the 1993 Wangaratta flood to include the town of Wangaratta; major transport routes; the usual course of the King River, the Ovens River and One Mile Creek; the two levee banks; and floodwaters as shown in the aerial photograph above.
2. Most damage was caused by the flooding of One Mile Creek. Why might this be the case?
3. On your map, overlay an action plan to prevent future flooding.
THUNDERSTORMS

WHAT IS A THUNDERSTORM?

Thunderstorms occur when cumulonimbus clouds build up enough static electricity to produce lightning. Lightning instantly heats the air through which it travels to about 20 000°C Celsius — more than three times as hot as the surface of the sun. This causes the air to expand so quickly that it causes an explosion (thunder). The time between a lightning flash and the crash of thunder tells you how far away the lightning is (5 seconds = 1.6 kilometres).

Each year in Australia, there are between five and ten deaths from lightning strikes.

Thunderstorms form in unstable, moist atmospheres when powerful updrafts occur. Strong updrafts can occur, for example, when a cold front approaches, or when warm, moist air rises and condenses into large clouds as the sun’s rays heat the Earth’s surface. Thunderstorms are most likely to occur during the afternoon.

SEVERE THUNDERSTORMS

According to the Bureau of Meteorology, a thunderstorm can be classified as severe if it has one or more of the following features:

- Some 1000 years or so ago, the Vikings thought thunder was the rumbling of Thor’s chariot. (He was their god of thunder and lightning.) Lightning marked the path of his mighty hammer, Mjölnir, when he threw it across the sky at his enemies.
- An average of about 100 severe thunderstorms are reported in Australia each year.
• hailstones that are two centimetres or more in diameter
• wind gusts of 90 kilometres per hour or more. Cold blasts of wind hurtle out of thunderclouds, dragged down by falling rain or hail. When the drafts hit the ground, they gust outwards in all directions.
• flash flooding. A thunderstorm often moves slowly, dropping a lot of precipitation in one area. The rain or hail may thus be too heavy and prolonged for the ground to absorb the moisture. The water runs off, quickly flooding local areas.
• tornadoes. These are rapidly spinning updrafts of air. Although severe tornadoes are not common in Australia, around 400 tornadoes have been recorded.

**SYDNEY HAILSTORM, 1999**

At about 7.30 pm on 14 April 1999, a freak hailstorm hit Sydney. In the space of only 45 minutes, about half a million tonnes of hailstones — some the size of cricket balls — smashed through roof tiles, windows and car windscreens. One person was killed. More than 24 000 buildings and 60 000 cars were damaged. It was one of the worst natural disasters in Australia’s history in terms of economic cost and property damage. The hailstorm was the result of a very powerful thunderstorm — known as a supercell. The much stronger updraft of air in a supercell storm keeps hailstones suspended inside the cloud for a longer time, allowing smaller hailstones to join together and grow before falling to the ground.

**Activities**

**Understand**

1. During which part of the day are thunderstorms most likely to occur? Why?
2. Name two features of a severe thunderstorm.
3. List the types of damage caused by the Sydney hailstorm. Why was it rated as one of Australia’s worst disasters?

**Communicate**

4. Study the diagram of the development of a supercell storm. Write a paragraph explaining why the hailstones that fell during the Sydney hailstorm were larger than normal.
5. Create an illustrated booklet or web page for young children about how lightning and thunder occur.
6. Suggest reasons why weather events were often assumed by people in ancient civilisations to be the action of the gods.

**Use ICT**

7. Visit the website for this book and click on the Thunderstorm weblink for this chapter (see ‘Weblinks’, page xii). Describe the ideal conditions for a severe thunderstorm.
8. Find out how to protect yourself, your property and your pets during a thunderstorm. Visit the website for this book and click on the Storm Protection weblink for this chapter (see ‘Weblinks’, page xii).

**Worksheets**

10.4 Storm sounds
TROPICAL CYCLONES

Tropical cyclones (called hurricanes in the Americas and typhoons in Asia) can cause great damage to property and significant loss of life.

Some 80 to 100 tropical cyclones occur around the world every year in tropical coastal areas located north and south of the Equator. These areas include the Caribbean Sea (Central America), the north-west Pacific and north-east Australia.

Cyclones form when a cold air mass meets a warm, moist air mass lying over tropical seas with a surface temperature of at least 27°C. Cold air currents race in to replace rapidly rising, warm, moist air currents, creating an intense low pressure system.

Cyclones in the southern hemisphere rotate in a clockwise direction. In the northern hemisphere they rotate in an anticlockwise direction.

Around the edges of the eye, rain and winds are at their fiercest. However, in the eye itself, the air is still, and the sky above may be cloudless.

As a tropical cyclone passes, the calm conditions of the eye often tempt people to venture out to assess the damage or attempt repairs. However, the other side of the cyclone soon hits and the winds come from the opposite direction.

At first, the winds spin around an area about 200 to 300 kilometres wide. As the winds gather energy by sucking in more warm, moist air, they get faster. In severe cyclones, winds may reach speeds of 360 kilometres per hour. The faster the winds blow, the smaller becomes the area around which they spin — called the ‘eye’. It might end up being only 30 kilometres wide.

Satellite image showing Hurricane Katrina which caused massive damage in New Orleans and surrounding areas of the United States in 2005

World distribution of tropical cyclones, by names given in different regions
Tropical cyclones can cause extensive damage if they cross land. Gale-force winds can blow buildings to bits and uproot massive trees. Torrential rain can cause flooding, as can *storm surges*. If a storm surge hits a coastline during high tide, it can cause serious flooding.

When a tropical cyclone approaches or crosses a coastline, the very low atmospheric pressure and the stress of strong winds on the sea surface produce a rise in sea level (see the diagram below). Among the destructive and death-dealing features of tropical cyclones, sea action and floods are ranked as more significant than winds.

Cyclones need warm sea water to maintain the upward movement of air. When a cyclone moves over land, it loses intensity and eventually becomes a rain depression. Cyclones usually die out when they move inland away from the water vapour, or if they move out of the tropics away from the warmth.

Tropical cyclones occur in northern Australia between December and April, with the greatest activity usually occurring between January and March. The number of cyclones varies considerably from year to year, the frequency usually determined by the temperature of the oceans in the tropical waters around northern Australia.

**Activities**

**Understand**

1. What conditions do tropical cyclones need to develop?
2. Why do tropical cyclones die out if they move inland?
3. List and rank the types of damage caused by cyclones.

**Think**

4. Refer to the map showing the world distribution of tropical cyclones.
   (a) When do most cyclones occur north of the Equator? When do most occur south of the Equator? How do you explain the differences?
   (b) Which Australian states and territories appear to be most at risk from cyclones?

**Dig deeper**

5. Prepare a desktop published document about Tropical Cyclone Tracy. Search the Internet or visit the website for this book and click on the Tropical Cyclone Tracy weblink for this chapter (see ‘Weblinks’, page xii). Choose one of the following topics for your presentation:
   - Explain why Tropical Cyclone Tracy was so destructive when it hit Darwin.
   - Describe the impacts of Tropical Cyclone Tracy.
   - Imagine you are a rescue worker and it is just on dawn following the passage of Tropical Cyclone Tracy. Describe the tasks ahead of you. What would you do first?
   - Choose your own topic.

**Worksheet**

10.5 Use cyclone data
Fire has always been a part of the Australian environment. Aborigines used it to encourage new growth, which attracted the animals they hunted. Early European settlers used fire to clear land for settlement and agriculture. A bushfire, however, is uncontrolled and causes immense damage to natural and human environments, and may result in loss of life.

Many bushfires occur naturally as a result of lightning strikes. Most, however, result from the careless activities of people — sparks from machinery, burning off and discarded cigarettes and matches. Some bushfires are started by arsonists.

Activities

Understand
1. How has fire been used successfully in the Australian environment?
2. List some causes of bushfires.
3. List the firefighting techniques shown in the illustration.
4. Why do many animals die in bushfires?
5. Why do bushfires often occur in times of drought?
6. How do eucalypt trees help bushfires spread?
7. Imagine a small fire front with a long flank. The fire is being pushed by winds from the north. Suddenly the wind changes and starts blowing from the west. Will the people on the west or on the east of the original fire now be in danger?

Design and create
8. Write a news report of the scene shown on these pages. Outline the effects on people and wildlife. Include interviews and describe the fire.
9. Design a poster outlining one way people could make their home or community safer in a bushfire. To get started, visit the website for this book and click on the Fire Prevention weblink for this chapter (see ‘Weblinks’, page xii).

Worksheets
10.6 Firewatch
Australia’s eucalypt forests not only tolerate fire but also need it in order to survive! The seeds of some eucalypts need the heat of a bushfire to be able to open and grow. The low moisture content of eucalypts means they ignite and burn easily. Their fibrous bark is highly combustible.

What was the flank or side of a bushfire can become the new fire front if there is a wind change.

Special helicopters can scoop up to 9500 litres of water in 45 seconds and dump the whole lot in just 3 seconds.

Dry forests provide plenty of fuel. Surface bushfires quickly ignite dry, flammable grass, twigs and branches on the ground.

By using the wrong building materials, planting eucalypts close to the house and stacking firewood against the house, people can actively contribute to the spread of a bushfire.

A firebrand is burning fuel that is pushed ahead of the fire front by the wind. Firebrands have been known to travel kilometres from their original source. A spot fire is a new bushfire started by firebrands.

Properties are more likely to survive if gutters are clear of leaves, lawns and shrubs are trimmed, and there is access to water and hoses. People who defend their house must cover up with cotton or woollen clothing.
CANBERRA FIRESTORM 2003

HOW DID IT HAPPEN?
On 18 January 2003, Canberra was hit by the most devastating bushfire in its history. Canberra’s firestorm had its beginnings on 8 January, when lightning strikes in adjacent national parks ignited a number of bushfires. Shifting winds widened the fire fronts of these fires, joining some together. Eight days later, strong south-westerly winds drove the bushfire towards the national capital.

The fierce winds blew burning embers ahead of the fire front, igniting spot fires in and around houses on the capital’s south-western edge. At times, the shower of embers blew horizontally. There was little the 500 firefighters and 100 police could do to stop such a massive blaze. Their work was made more difficult by the billowing black smoke (which reduced visibility), by power and water-pressure failures, and by the rapid spread of the fires.

PERFECT FIRESTORM CONDITIONS
The conditions in and around Canberra on 18 January were perfect for a firestorm. There was a huge supply of fuel. (Canberra is sometimes called the ‘bush capital’, as it is virtually surrounded by bushland and pine plantations and has a number of bush/pine corridors.) This fuel was tinder dry due to the prolonged drought. On the day of the fire, very high temperatures, strong winds and extremely low relative humidity turned the advancing bushfire into a fireball.

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1. **Tuesday, January 8:** Brindabella — a moderate fire is started by lightning strikes in bushland on January 8. A normal bushfire fuelled by warm conditions, low humidity and drought conditions, with 2–3 m flames spotting 100 m ahead. It is contained by firefighters.
2. **Fires open up on three fronts north, west and south of Canberra. Fire crews are stretched and fire builds.**
3. **Firefighters build containment lines to stop fire along a 35 km front. Bulldozers unable to enter rugged terrain.**
4. **Firefront catches up to spot fires ahead and creates massive fireball.**
5. **Saturday, January 18:** Wind gusts of up to 100 km/h turn fire into an inferno. At this stage it becomes almost unstoppable.
6. **Cumulus clouds of smoke up to 6000 m high, carrying embers and fuel.**
7. **100 km/h winds pick up on January 18 and change the fire’s behaviour.**
8. **Humidity drops to 10%**
9. **Temperature rises to 48°C**
10. **Wind gusts of 60–100 km/h**
11. **Fire temperatures reach 1000°C**
12. **Crowning 60 m into the air 3 times higher than the trees.**
13. **Embers spotting 2 km ahead of main fire.**
14. **Embers spotting in and around houses on the capital’s south-western edge.**
15. **Grasslands and paddocks**

**Anatomy of a Fire**

The difference between January 8 and January 18 was a few percentage points in humidity and slightly warmer temperatures plus ‘cyclonic’ winds.

Humidity at 20%
Warm conditions of 30–35°C
Moderate intensity bushfire started by lightning strike
100 km/h winds pick up on January 18 and change the fire’s behaviour.
Cumulus clouds of smoke up to 6000 m high, carrying embers and fuel.
Crowning fires up to 60 m high
Embers spotting 2 km ahead of main fire.
Grasslands and paddocks
The firestorm destroyed 530 homes — some in little more than 10 minutes — and about 30 farms. Four people lost their lives, as did hundreds of cattle, thousands of sheep and many thousands of native animals. About 12 million trees were destroyed by the fire. Powerlines exploded and the famous Mount Stromlo Observatory was burnt down. As well as destroying lives, homes and livelihoods, the damage bill was expected to top $280 million.

Activities

Think
1. What started the Canberra bushfires?
2. From which direction was the wind blowing when the firestorm reached Canberra’s urban edge?
3. Describe how spot fires played a role in the growth of this disaster.
4. Explain why conditions in Canberra on 18 January 2003 were perfect for a firestorm. Use examples and refer to the diagram.
5. Describe the spread of the fire from 8 January to 18 January. What action did the firefighters take?
6. List the main impacts of the bushfire.

Communicate
7. Imagine that you are a news reporter for a Canberra television station. Write (and be prepared to deliver to the class) a three-minute news segment on the Canberra bushfire disaster.
   To find out more about the Canberra bushfires of January 2003, visit the website for this book and click on the Canberra Bushfire weblink for this chapter (see ‘Weblinks’, page xii).
8. Discuss as a class what actions you think should be taken by Canberra government bodies and private citizens to ensure a disaster such as this never happens again.
DROUGHT: NOT ENOUGH WATER

Australia is the driest inhabited continent, yet there are large variations in the amount of rainfall in different parts of the continent. Cairns, for example, has an average annual rainfall of 2150 mm, Melbourne, 659, and Coober Pedy only 157 mm.

The average pressure pattern in the Asia–Pacific region for August is a good example of how Australia is dominated by high pressure systems. The low pressure region to the north of Australia has moist rising air that produces clouds and rain. As the air moves south to Australia, it cools and sinks, forming high pressure zones with dry conditions.

Low average rainfall and extended dry spells are a normal part of life throughout most of Australia. The continent is located in a zone dominated by high pressure for most of the year. High pressure systems drift from west to east across Australia, bringing dry, stable, sinking air. These atmospheric conditions are not favourable for rainfall. Drought conditions occur when the high pressure systems are more extensive than usual. Many areas of Australia experience drought — a prolonged period of below average rainfall, when there is not enough water to supply our normal needs.

This should not be confused with low rainfall. Broken Hill experiences low rainfall, at around 250 mm per year, but this is not the same as a drought.

DROUGHT AND EL NIÑO

Many droughts in Australia are caused by El Niño events. In summer during a normal year, cold water on the west coast of South America moves north towards the Equator. As the water moves north, it turns towards the western Pacific due to the influence of the trade winds. As it moves along the Equator, the water is warmed by the sun. The air is also heated by the sun. It rises high above the western Pacific, carrying evaporated moisture from the warm waters, and forms huge clouds. These clouds then cool and drop this moisture as rain over Australia. On the other side of the Pacific, South America experiences drought.

When there is an El Niño event, these winds and surface ocean currents reverse their direction. The warmer water moves towards South America. This produces rain in South America and drought in Australia.

Conditions during a normal and an El Niño year
THE IMPACT OF DROUGHT

The impact of drought is usually first felt in rural communities:

- Crops fail or the harvest is greatly reduced in both quality and quantity.
- Grasses die and farmers must buy feed for livestock. In times of severe drought, farmers may have to kill animals because they are unable to sell them for a reasonable price, either as a result of a surplus as other farmers try to sell too, or because of the state of the animals.
- Farmers may have to borrow to keep their farms operating, successive poor years result in more debt and in some instances the farmer has no choice other than to leave the land.
- Rural communities suffer as there is less money available and businesses fail. People leave the area in search of work and do not return.
- Millions of tonnes of valuable topsoil are blown away as there is no vegetation to hold it in place. This further reduces the productivity of the soil. Much of this topsoil is blown into towns and waterways.

When there is no longer natural feed available for cattle, farmers have to buy it — often at great expense.

Eventually, city dwellers also feel the effects of drought — reduced production means less goods are available, leading to higher prices. Water levels in dams and lakes fall. In the summer of 2004–2005, Melbourne’s water storage levels dropped below fifty per cent, and stage two water restrictions were imposed. Although water levels rose to around fifty-two per cent by mid 2005, the State Government passed laws to ensure the permanent conservation of water. In some parts of Australia, much harsher water restrictions are in place. An extended period of above-average rainfall is needed, but scientists have warned that this is unlikely due to the effects of global warming.

Activities

Understand

1. What is a drought?
2. If Melbourne received 200 mm less rainfall per year over the next two years, and Coober Pedy received its current rainfall, would both places be experiencing drought? Explain.
3. What type of pressure system most influences Australia’s climate? How does this affect Australia’s climate?
4. Why do countries to the north of Australia receive more rain than we do?
5. What happens in Australia when an El Niño event occurs? Which continent receives the opposite of Australia’s weather conditions during an El Niño event?

Communicate

6. Study the diagram showing normal and El Niño years.
   (a) Classify the following statements according to whether they occur in a normal year or an El Niño year:
      - Warmer surface water in eastern Pacific Ocean.
      - Low annual rainfall over northern Australia.
      - Warmer surface water in western Pacific Ocean.
      - Ample winter and spring rains in Australia.
   (b) Write a paragraph, including a description of air and ocean currents, that compares a normal year with an El Niño year.
7. Explain the impact of drought on:
   (a) rural communities
   (b) urban communities.

Use ICT

8. Use the Internet to research water restrictions and conservation strategies.
   (a) What are stage 2 water restrictions? Identify one location in Australia that has more severe restrictions and list what these are.
   (b) Design a poster to educate the general public about how to conserve water — your poster should be eye-catching and informative.

Dig deeper

**TEST YOURSELF**

1. Explain the difference between weather and climate.
2. Identify the factors that influence the climate of a particular region.
3. If temperature averages rise due to global warming, explain the effect this could have on weather hazards such as floods, storms, cyclones, bushfires and droughts.
4. Complete the following table to show the impact weather hazards have on the human and natural environment. An example has been provided.

<table>
<thead>
<tr>
<th>Natural environment</th>
<th>Human environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Drought results in the death of wildlife as there is not enough food.</td>
<td>• Crops fail as a result of drought; food shortages could result in famine.</td>
</tr>
</tbody>
</table>

5. Look back over your table and put an L for long-term and S for short-term impact next to each item in your lists.

6. Study the map of Australia above.
   (a) Use your atlas to work out which capital cities are more likely to have severe thunderstorms.
   (b) Which parts of Australia are least likely to have severe thunderstorms?

**WHAT WILL THE WEATHER BE?**

1. Trace the following weather map (for 11 November, 2002).
   - Colour the high pressure systems (pressure above 1013 millibars) red and low pressure systems (pressure below 1013 millibars) dark blue. Shade with light blue any areas that have had rain in the last 24 hours.
   - Use your map to help you explain what the weather was like on 11 November.

![Weather Map]

2. The map below, produced on 11 November, predicts what the weather will be like on 12 November. Make a list of what is different from the previous day’s weather map.

![Weather Forecast Map]

3. The map below shows what the weather was actually like on 12 November.
   - Compare the actual weather conditions with those predicted 24 hours earlier. How accurate was the predicted weather map? Where was it different? Describe what the weather was like in Melbourne on 12 November.

![Actual Weather Map]
TORNADOES

A tornado (or twister) is a wildly spinning column of air that drops down from under a cumulonimbus cloud and moves across the ground or the water. Some tornadoes can suck up objects as heavy as 300 tonnes and create winds of 320 kilometres per hour.

The funnel of a tornado is called the vortex. When it drops down, it hisses. This sound becomes a roar when the funnel hits the ground, especially if the tornado is large.

Tornadoes can occur anywhere, but most occur during spring and summer in a part of the United States known as Tornado Alley. Between 1950 and 1998, 39,011 tornadoes were recorded in the United States, causing 4354 deaths. The worst on record occurred in Missouri in March 1925. It destroyed four towns and killed 689 people.

1. What is a tornado?
2. What do you think you might see, hear and feel if you were watching a severe tornado move through both built-up and open environments?
3. Study the graph and answer the following:
   (a) What is the average number of reported tornadoes in the month of November?
   (b) What is the average number of deaths in the month of November?
   (c) What months have the greatest average number of:
       • tornadoes
       • deaths caused by tornadoes?
4. Use the map and an atlas to work out which American states are most at risk of being hit by a tornado. List ten American cities or towns that lie in the highest risk zones.
5. Visit the website for this book and click on the Tornadoes weblink for this chapter (see ‘Weblinks’, page xii). Describe the impact of one of the top ten US tornadoes. List ways that someone could survive a tornado.

GROUP RESEARCH

1. Working in small groups, research a major bushfire that affected populations near an Australian capital city. Use the questions below to help you to research the topic. Draw up a chart that includes the questions and enough columns to cover each of the bushfires investigated by different groups.
   • When and where did the bushfire occur?
   • What were the weather conditions prior to and during the bushfire?
   • How did the bushfire spread?
   • What was the impact of the bushfire on the natural and human environments?
   • How did people respond to the bushfire?
   • What lessons were learned from this bushfire event?
2. Report your group’s findings in an oral presentation, and record other groups’ findings on your chart.