# 2.4 Weather

**Key questions**

- How are weather data collected?
- How can the data be used to describe the weather?
- How do graphs and other diagrams show weather data?

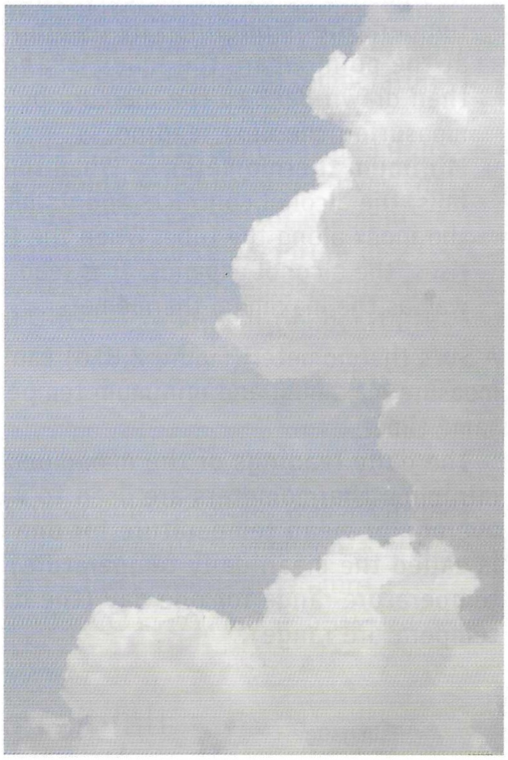


Figure 2.85 ▶ Clouds formed by convectional uplift

## Measuring the weather

### The weather station

A weather station is a place where the elements of **weather**, such as temperature, **rainfall**, **humidity**, **air pressure**, wind direction and velocity, sunshine and cloud cover are measured and recorded as accurately as possible. The weather station is placed on an open piece of land and it contains the following instruments: thermometers (ideally kept in a **Stevenson screen** — see Figure 2.86), a **rain gauge**, barometer, wind vane, anemometer and sunshine recorder.

Whichever instruments are used, ideally they should have good exposure (that is, they should be sited away from buildings, fences, trees and other obstacles). The flat top of a science block is a favoured location in many schools.

- Thermometers should be placed in the shade. Ideally, they should be in a Stevenson screen or slatted box. If this is not available they could be hung on a shaded wall or fence.
- Rain gauges should be away from walls, fences and bushes as these affect the amount of rain caught in the rain gauge.
- Wind instruments should be well clear of walls, fences and houses as these cause eddies that spoil the reading and make the direction difficult to assess.

It is important that readings are taken at the same time each day.

The Stevenson screen is a wooden box standing on four legs at a height of about 120 cm. The screen is built so that the shade temperature of the air can be measured. The sides of the box are slatted to allow free entry of air, and the roof is made of double boarding to prevent the Sun's heat from reaching the inside of the screen. Insulation is further improved by painting the outside of the screen white so as to reflect much of the Sun's energy. The screen is usually placed on a grass-covered surface, thereby reducing the radiation of heat from the ground.

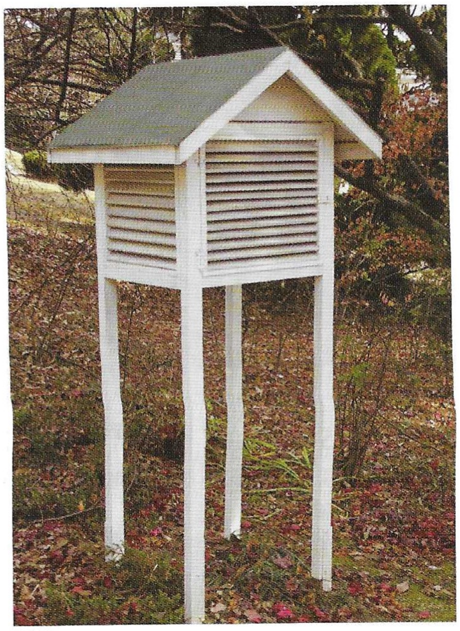


**Figure 2.86** ▶ A Stevenson screen

Instruments kept inside the Stevenson screen include a **maximum-minimum thermometer** (or Six's thermometer) and a wet- and dry-bulb thermometer (also called a hygrometer) — see Figures 2.87 and 2.89.

Instruments kept outside the Stevenson screen include a rain gauge, a wind vane to determine wind direction, and an anemometer to assess wind speed.

## Measuring temperature

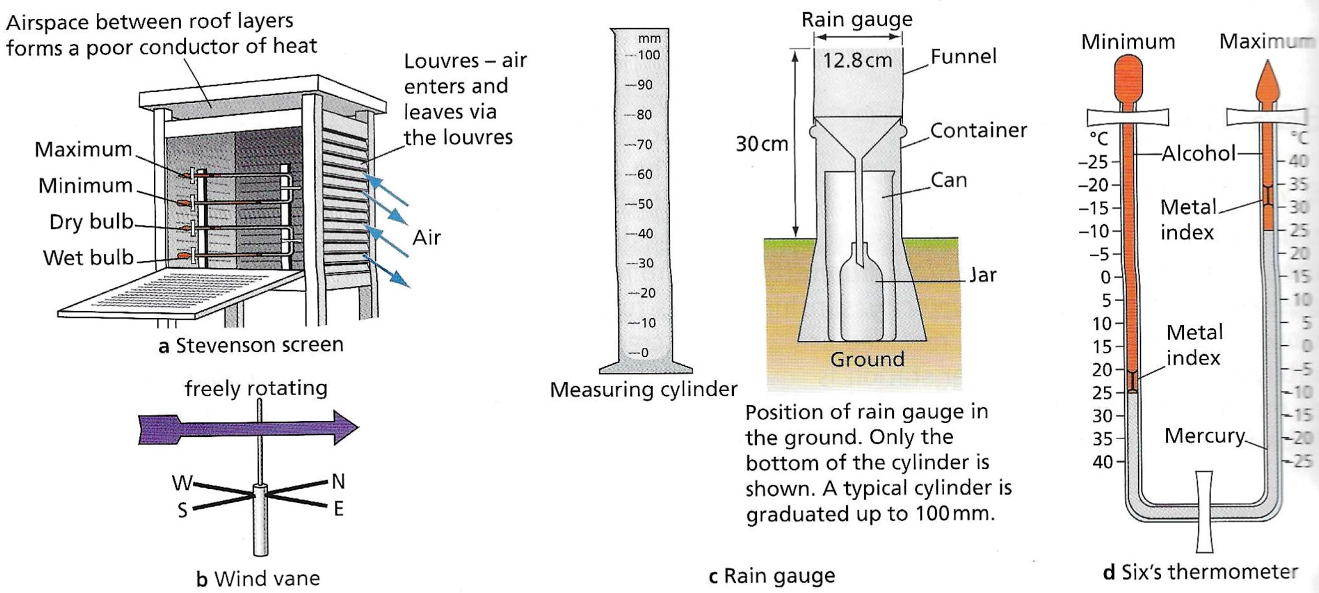
Variations in temperature represent responses to differences in insolation, or the amount of energy received from the Sun at different times.

Meteorologists measure shade temperature. This is less variable than air temperature, which is affected by cloud cover and direct insolation. Temperature is measured using a thermometer. A continuous temperature reading is given by a thermograph.

- **Maximum thermometer** — When the temperature rises, the mercury in the thermometer expands and pushes the index along the tube. When the temperature falls, the mercury contracts but the index stays where it was pushed to by the mercury. The maximum temperature is obtained by reading the scale at the point where the index is. The index is then drawn back to the mercury by a magnet for measuring the next reading.
- **Minimum thermometer** — When the temperature falls, the alcohol contracts and its meniscus pulls the index along the tube. When the temperature rises, the alcohol expands. It is read in the same way as the maximum thermometer.

A Six's thermometer (Figure 2.87d) can be used to measure maximum and minimum temperatures at the same time.

The daily readings of the maximum and minimum thermometers are used to work out the average or mean temperature for one day (this is called the mean daily temperature) and the temperature range for one day (the daily or diurnal temperature range).




▲ **Figure 2.87** Equipment in a weather station

To find the mean daily temperature, the maximum and minimum temperatures for one day are added together and then halved. For example: (maximum temperature, 35°C + minimum temperature, 25°C)/2 = mean daily temperature, 30°C. The sum of the daily mean temperatures for one month divided by the number of days for that month gives the mean monthly temperature. The sum of the mean monthly temperatures divided by 12 gives the mean annual temperature.

The daily or diurnal temperature range is found by subtracting the minimum temperature from the maximum temperature for any one day. For example: maximum temperature, 35°C – minimum temperature 25°C = daily or diurnal temperature range, 10°C.

The highest mean monthly temperature minus the lowest mean monthly temperature gives the mean annual temperature range. For example, Lagos has a mean maximum temperature of 27.5°C (March), and a mean minimum temperature of 24.5°C (August). Its mean annual temperature range is therefore 3°C.

**Interesting note**

The highest temperature recorded was at Furnace Creek, California, USA in 1913 when it reached 56.7°C. In contrast, the lowest temperature recorded was −89.2°C in Antarctica in 1983.

## Measuring rainfall

A rain gauge is used to measure rainfall. It consists of a cylinder in which there is a collecting can containing a glass or plastic jar, and a funnel that fits in the top of the container. The gauge is placed in an open space so that only raindrops enter the funnel of the gauge, and no runoff from trees, buildings or other objects can get into the funnel. The gauge is sunk into the ground so that the top of the funnel is about 30 cm above ground level (Figures 2.87c and 2.88). This is to prevent the Sun's heat from evaporating any water collected and to ensure no rain splashes up from the ground into the funnel.

▲ **Figure 2.88** Rain gauge

Rain falling over the funnel collects in the jar. This is emptied, usually every 24 hours, and measured in a tapered glass measure, graduated in millimetres. The tapered end of the jar enables very small amounts of rain to be measured accurately.

The rainfall recorded for a place, either for a day, week, month or year, can be shown on a map. This is done using lines called isohyets. An isohyet is a line on a map that joins places of equal rainfall.

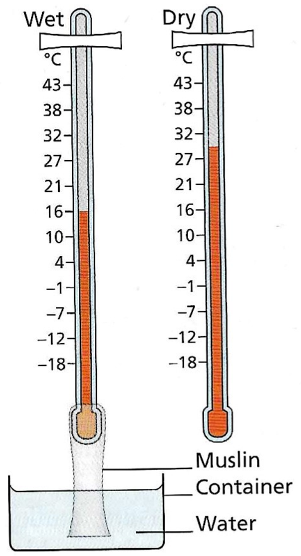
It is important to check the rain gauge every day, preferably at the same time, even if there has not been any rainfall. This is because small amounts of dew may accumulate in the gauge, leading to false readings when it does rain.

**Interesting note**

The highest rainfall over a 24-hour period was in Foc-Foc, Réunion, when 1.825 m of rain fell. The largest 1-minute burst of rainfall was 31.2 mm in Unionville, Maryland, USA in 1956.

## Measuring relative humidity

Wet- and dry-bulb thermometers are used to measure relative humidity. The dry-bulb is a glass thermometer that records the actual air temperature. The wet-bulb is a similar thermometer, but with the bulb enclosed in a muslin bag which is dipped into a bottle of water (Figure 2.89). This thermometer measures the wet-bulb temperature, which, unless the relative humidity is close to 100 per cent, is generally lower than the dry-bulb temperature.



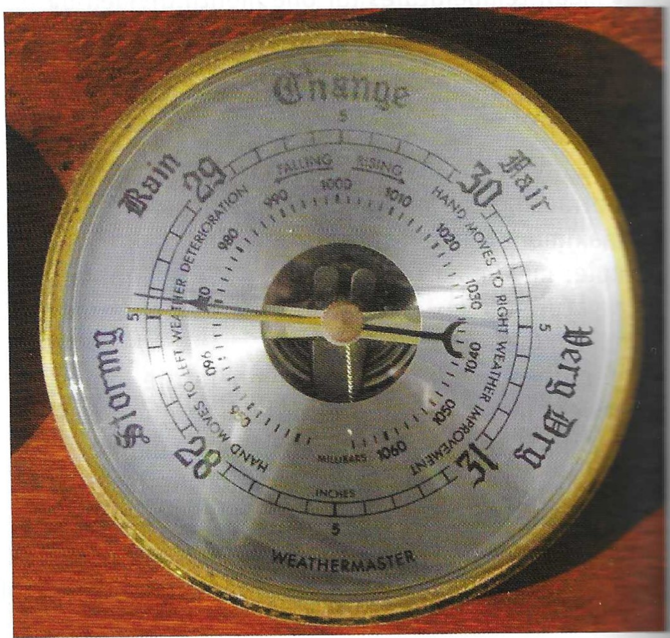

▶ **Figure 2.89** Wet- and dry-bulb thermometer

## Measuring air pressure, wind speed and direction

Because air has weight it exerts a pressure on the Earth's surface. At sea level the pressure is about 1.03 kg/cm². Pressure varies with temperature and altitude, and is usually measured in millibars. The instrument that measures pressure is called a barometer (Figure 2.90)

A mercury barometer is a hollow tube from which the air is extracted before the open end is placed in a bath of mercury. Mercury is forced up the tube by the pressure of the atmosphere on the mercury in the bath. When the pressure of the mercury in the tube balances the pressure of the air on the exposed mercury, the mercury in the tube stops rising. The height of the column of mercury changes as air pressure changes: it rises when air pressure increases and falls when air pressure decreases.

An aneroid barometer is a vacuum chamber in the form of a small metal cylinder. Inside, a strong metal spring prevents the chamber from collapsing. The spring contracts and expands with changes in atmospheric pressure. These changes are magnified by a series of levers and the movements are conveyed to a pointer, which moves across a calibrated scale. A barograph is a tracing from an aneroid barometer,




▲ **Figure 2.90** A simple barometer

which records continuously for one week. Changes in pressure are recorded by a flexible arm, which traces an ink line on a rotating paper-covered drum. The paper is divided by vertical lines at 2-hour intervals.

The atmospheric pressure is recorded at numerous weather stations for a region and these are plotted on a map of the region. First, though, the pressures are 'reduced' to sea level — that is, they are adjusted to what they would be if the stations were at sea level. The pressures are plotted on a map. Lines are then drawn through points where pressure is the same. These lines are called isobars.

The wind vane is used to indicate wind direction. It consists of a horizontal rotating arm pivoted on a vertical shaft. The rotating arm has a tail at one end and a pointer at the other. When the wind blows, the arm swings until the pointer faces the wind. The directions north, east, south and west are marked on the arms, which are rigidly fixed to the shaft.

The speed of the wind is measured by an anemometer (Figure 2.91), which consists of three or four metal cups fixed to metal arms that rotate freely on a vertical shaft. When there is a wind, the cups rotate. The stronger the wind, the faster the rotation.

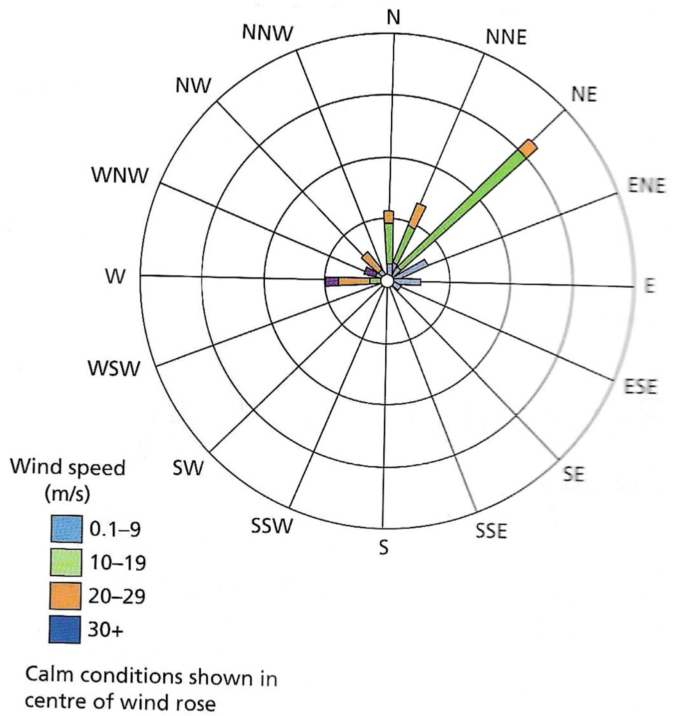
The number of rotations is recorded on a meter to give the speed of the wind in km/hr.

The wind vane and anemometer are placed well away from any buildings or trees that may interfere with the free movement of air. Buildings may channel air through narrow passages between two buildings, or decrease the flow of air by blocking its path. Trees have a similar effect.

▲ Figure 2.91 An anemometer

Winds are shown by arrows on a weather map. The shaft of the arrow shows wind direction and the feathers on the shaft indicate wind velocity. The tip of the arrow, at the opposite end from the feathers, points to the direction in which the wind is blowing.

Wind direction for a specific place can be shown on a wind rose (Figure 2.92). It is made up of a circle from which rectangles radiate. The directions of the rectangles represent the points of the compass. The lengths of the rectangles are determined by the number of days/times the wind blows from that direction. The number of days/times (hours) when there is no wind is recorded in the centre of the rose.




▲ Figure 2.92 A wind rose

## Measuring sunshine hours

The number of hours and minutes of sunshine received at a place can be measured and recorded by a sunshine recorder. This is a glass sphere partly surrounded by a metal frame (Figure 2.93). A strip of special card, divided up into hours and minutes, is placed below the sphere. When the sun shines, the sphere focuses the Sun's rays on the card. As the Sun moves, the rays burn a trace on the card. At the end of the day, the card is removed and replaced. The length of the trace represents the amount of sunshine that the location received.

▲ Figure 2.93 Campbell-Stokes sunshine recorder

## Activities

1. Describe and explain the main characteristics of a Stevenson screen.
2. What information does a Six's thermometer show?
3. Why are weather readings taken at the same time each day?
4. Where is the best place to locate a rain gauge? Briefly explain why.
5. How are wind speed and wind direction measured?

# Recording the weather

## Clouds

The ten main types of **cloud** can be separated into three broad categories according to the height of their base above the ground: high clouds, medium clouds and low clouds (Figure 2.94).

High clouds are usually composed solely of ice crystals and have a base between 5500 and 14,000 m. These are described as:

- cirrus — white filaments
- cirrocumulus — small, rippled elements
- cirrostratus — a transparent sheet, often with a halo.

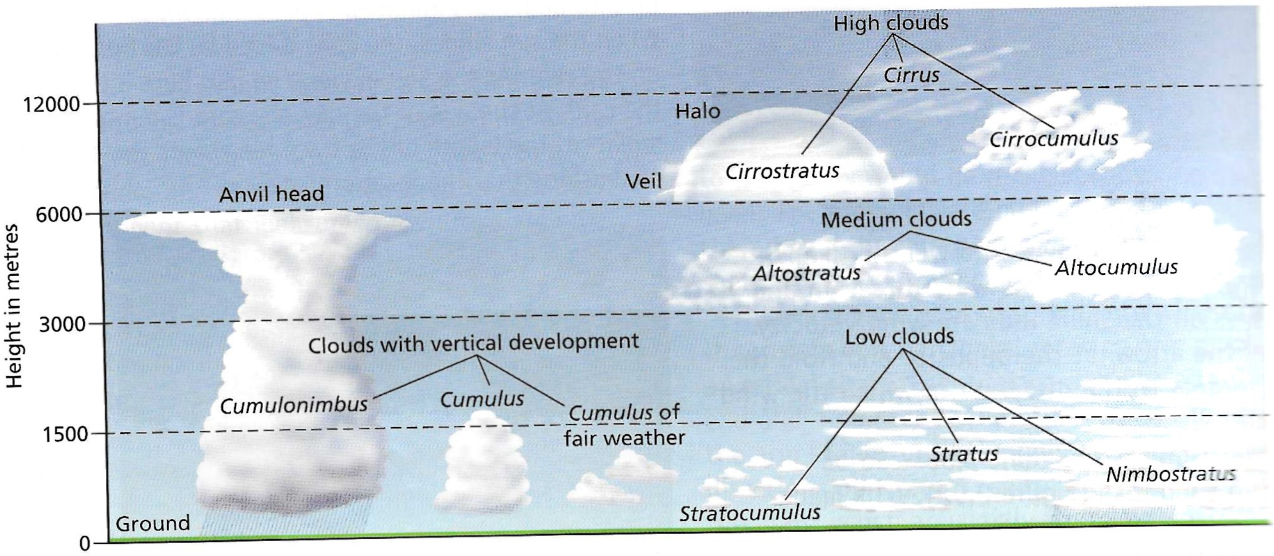
Medium clouds are usually composed of water droplets or a mixture of water droplets and ice crystals, and have a base between 2000 m and 7000 m. These are decribed as:

- altocumulus — layered, rippled elements, generally white with some shading
- altostratus — a thin, grey layer that allows sunshine to appear as if through ground glass.

Low clouds are usually composed of water droplets, although cumulonimbus clouds include ice crystals, and have a base below 2000 m. These are decribed as:

- stratocumulus — layered in a series of rounded rolls; generally white with some shading
- stratus — layered, uniform base, grey
- nimbostratus — a thick, dark layer with a low base; rain or snow may fall from it
- cumulus — individual cells; vertical rolls or towers with a flat base
- cumulonimbus — large, cauliflower-shaped towers, often with 'anvil tops'; sometimes giving thunderstorms or showers of rain or snow.

Cloud cover is measured in oktas (eighths). This is made by a visual assessment of how much of the sky is covered by cloud. For example, in Figure [illegible] on page 149 the sky has approximately 4/8 cloud cover.




▲ **Figure 2.94** Cloud types

## Activities

Table 2.18 Daily weather observations at Frankston, Victoria (Australia), 1–7 August 2007

| Date | Day | Temperature | | Rainfall (mm) | Wind direction | Wind speed (km/hr) | Air pressure (mb) |
|---|---|---|---|---|---|---|---|
| | | Max. (°C) | Min. (°C) | | | | |
| 1 August | W | 14.2 | 9.7 | 4.0 | N | 22 | 1006 |
| 2 | Th | 13.4 | 11.5 | 0 | N | 37 | 1004 |
| 3 | F | 9.9 | 8.1 | 0 | WNW | 33 | 1011 |
| 4 | S | 11.5 | 7.2 | 0 | WNW | 31 | 1016 |
| 5 | S | 11.6 | 8.2 | 0 | W | 28 | 1019 |
| 6 | M | 12.7 | 9.5 | 20.2 | W | 20 | 1023 |
| 7 | T | 14.5 | 9.2 | 0 | N | 30 | 1019 |

Table 2.19 Daily weather observations at Frankston, Victoria (Australia), 1–7 February 2008

| Date | Day | Temperature | | Rainfall (mm) | Wind direction | Wind speed (km/hr) | Air pressure (mb) |
|---|---|---|---|---|---|---|---|
| | | Max. (°C) | Min. (°C) | | | | |
| 1 February | F | 25.6 | 11.7 | 6.8 | SSE | 15 | 1020 |
| 2 | S | 25.7 | 16.9 | 0 | NNW | 9 | 1016 |
| 3 | S | 27.6 | 17.9 | 0 | SE | 9 | 1016 |
| 4 | M | 29.1 | 19.9 | 0 | ENE | 11 | 1013 |
| 5 | T | 23.2 | 19.7 | 0 | SW | 13 | 1012 |
| 6 | W | 23.1 | 19.2 | 0 | SW | 19 | 1004 |
| 7 | Th | 17.9 | 15.7 | 8.4 | SW | 19 | 1005 |

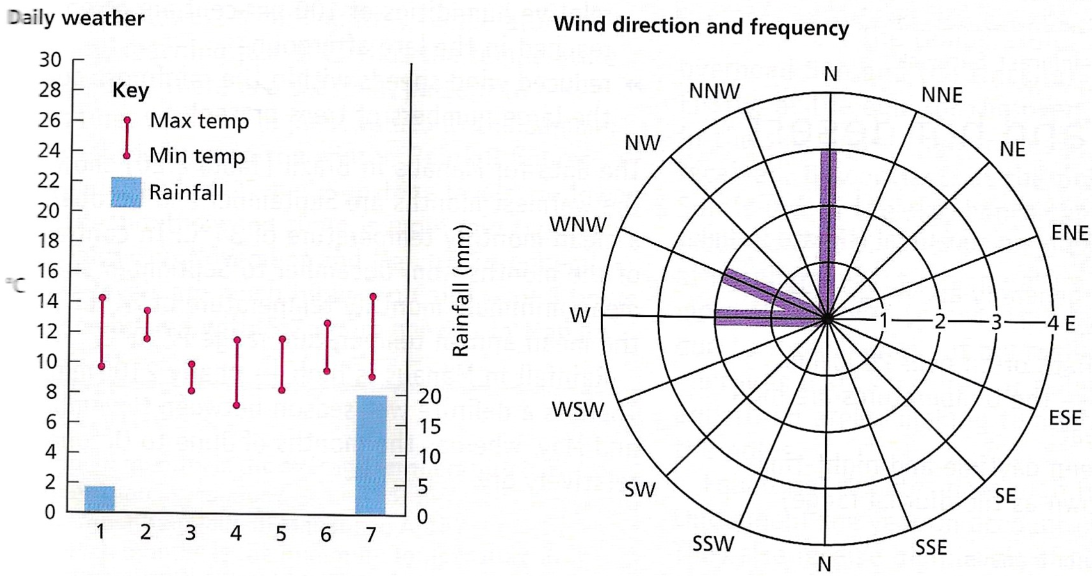



Figure 2.95 Daily weather, wind direction and frequency at Frankston, August 2007

The results recorded by a school in Victoria are shown in Tables 2.18 and 2.19. The data for the first week (August) are plotted in Figure 2.95.

1 Plot the data for February using the same methods as in Figure 2.95.
2 State the maximum and minimum temperatures of the 7-day period in February.
3 Work out the mean minimum temperature and the mean maximum temperature for the 7 days.
4 How much rain fell during the 7 days?
5 Compare the weather in February with that in August.