Climate

Use this section to find out more about the climate of our district. Learn about rainfall, drought, temperature, frosts, and the variability of our local climate.

For detailed climate information on a location in your area see the climate data in your sub-catchment profile.

What is in this section?

This section contains general information on the climate of the Central Tablelands Landcare district. It outlines the regional climate influences and explains different rainfall measurements and aspects of drought. It explains the aspects of temperature, frosts, wind, evaporation and solar radiation. Summaries of the various aspects of our climate are included for the district.

Climate Snapshot – Central Tablelands

Rainfall

- ***Orange and Sunny Corner both receive more than 920mm of rain per year on average. Bathurst averages less than 650mm and Manildra about 580mm.***
- ***Molong has recorded nearly 200mm falling in a single day. The highest ever daily fall in Orange is 98mm.***
- ***In Manildra's driest ever recorded year only 197mm of rain fell.***
- ***The Central Tablelands has been in drought for about 30% of its recorded history. That equals one year in every three.***
- ***One third of all Molong's droughts have been severe ones with less than 5% of normal rainfall.***
- ***April rainfall is the most unreliable compared to other months in most places in the district.***

Temperature

- ***Molong has an annual average maximum temperature of 22^{o}C. Oberon has one of 16.4^{o}C.***
- ***Blayney has an annual average minimum temperature of 4.4^{o}C which is colder than both Orange and Oberon.***
- ***The hottest ever day recorded at Molong was 42.3^{o}C.***
- ***The coldest day ever recorded at Blayney was –10.6^{o}C.***
- ***On average Molong gets 4 times as many summer days above 30^{o}C as Orange does.***
- ***Blayney gets on average 33 frosts in spring, Molong 27, Orange just 14 and Parkes gets 2.***
- ***Each year Blayney and Molong both get more frosts than Orange and Bathurst do on average.***

Contents

4-1 Our Regional Climate

Our Bioregion

Australia has the highest year to year rainfall variability of all the continents and is the driest except for Antarctica.

Australia's climate is mainly influenced by a belt of mid-latitudinal, **high air pressure systems** passing from west to east across our continent. In winter this belt moves northwards. This allows cold fronts to pass over southern Australia bringing winter rain and storms from the Southern Ocean. In summer the relatively stable air of the high pressure systems pass over southern Australia bringing dry conditions.

Northern Australia is influenced by the **tropical zone** and this brings monsoonal rains and tropical cyclone weather to the north in summer. Large tropical cyclone systems can also bring summer rain to southern Australia as well at times.

The influence of the high pressure systems and the tropical climate systems mean that northern Australia is dominated by summer rainfall and southern Australia is dominated by winter rainfall.

Our district lies in between the summer rainfall zone of northern Australia and the winter rainfall zone of the south. We therefore receive a relatively **uniform distribution of rain** throughout the year. There are some variations in seasonal rainfall patterns between locations within the district however.

The dominance of high pressure systems over much of our continent also means that Australia has the highest year to year variability of rainfall of any of the continents.

This variability has been found to be linked to the **Southern Oscillation** which includes **the El Nino effect.** Heating and cooling of the Pacific Ocean and the air above it changes air-flows across the tropics. Changes in these patterns, and sometimes the prolonged dominance of one type, are linked with drought and flooding events in Australia.

Our district mainly lies in the **South Eastern Highlands Bioregion** of south-eastern Australia. The climate of our area is **temperate with no distinct dry season**. Being in the mid latitudes, between the equator and the poles, it has relatively mild temperature conditions.

In the higher parts we experience **warm or mild summers** while on the western slopes the summer can be hot. This is mainly due to altitude, or height above sea-level, which influences temperatures. The higher the elevation the milder the summers tend to be.

4-2 Rainfall – Central Tablelands

What influences our rainfall?

Large scale influences

At a larger scale the **continental climate systems** that influence Australia impact on our district's rainfall.

In winter the frontal rains formed by the cold fronts passing across southern Australia bring winter rains. In summer the tropical cyclone systems in northern Australia can bring summer rain.

As our district lies in the transitional zone between the summer and winter rainfall areas of Australia we receive relatively reliable rainfall all year around compared with many other regions.

The **Southern Oscillation Index** and the **El Nino effect** are part of the influences on our rainfall over the longer-term.

Long term natural climate cycles also impact on our rainfall. The causes of **global climate change** are still being explored and remain difficult to predict. The balance of greenhouse gases in our atmosphere is changing and will have an impact on our climate – the evidence for this so far is mostly in slightly increased temperatures. Impacts on rainfall are difficult to show, partly because our rainfall records only go back about 150 years. An increase in extreme events (more floods and prolonged drought) is the more likely affect for our region.

Local influences

Altitude or height above sea level influences rainfall. Higher areas tend to receive more rain and further west (the upper western slopes) the amount of rainfall drops off as the elevation does. Manildra, at an elevation of 438m, receives only 584mm per annum compared to Sunny Corner, at 1220m in the Great Divide near Bathurst. It receives 930mm of rain on average per year.

Table 4.2.1
Comparison of altitude and average rainfall for selected locations in our district.

Location	Altitude (metres)	Average annual rainfall (mm)
Sunny Corner	1220	930
Oberon	1190	844
Orange	865	875
Cargo	600	677
Manildra	438	584

Relief or steepness of the land also affects rainfall. Localities with steep sloping landscapes create local rainfall conditions and tend to receive more rainfall compared to relatively flat country.

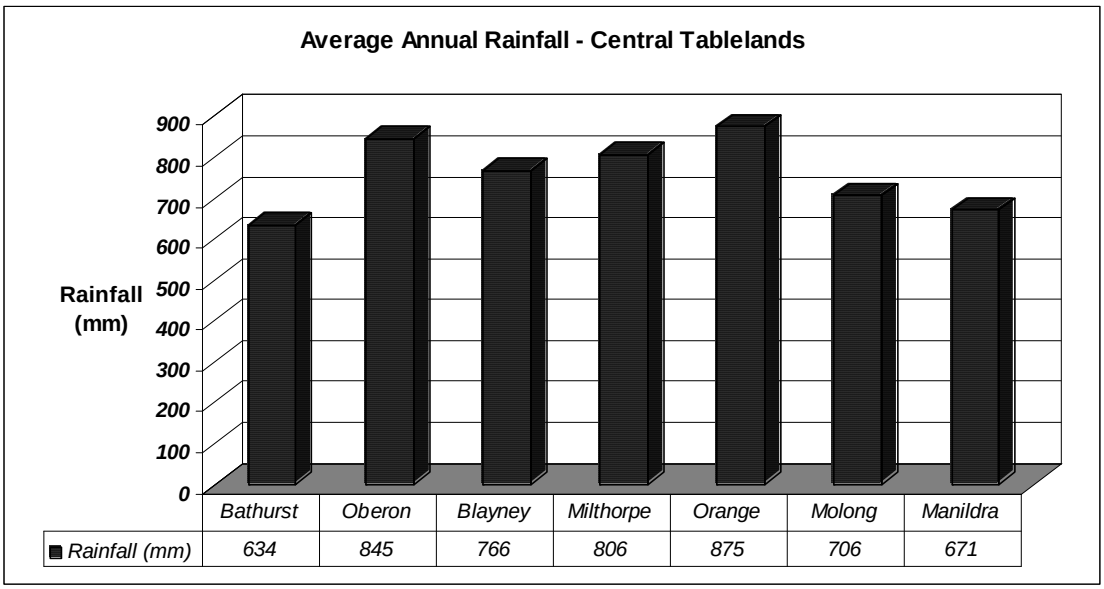
Canobolas at the foot of Mt Canobolas, receives 952mm of rain on average per year. Millthorpe, although at almost the same elevation – around 970m

above sea level – receives 806mm on average. The steep country around the mountain induces local rain which Millthorpe, on gently rolling terrain does not experience.

How much rain? – Central Tablelands

An important measure of rainfall for an area is the **average annual rainfall**. This shows how much rain, on average, a place receives per year. Orange has the highest annual average rainfall with 948mm. Orange is strongly influenced by Mt Canobolas which causes local weather conditions and encourages local rain. Manildra has the lowest with 584mm.

Figure 4.2.1
Average annual rainfall for selected locations in our district. (Bureau of Meteorology)



Average annual rainfall gives a general indication of how much rainfall an area receives but it does not show the variation of rainfall that can occur between years or the time of year rain generally falls.

Maximum and Minimum Rainfalls measure the most extreme years of rainfall for a locality. It can also be used to measure the highest and lowest rainfalls received in any single month for a location.

Table 4.2.2
Highest and lowest annual rainfall for selected Central Tablelands locations.

Location	Lowest annual rainfall (mm)	Highest annual rainfall (mm)	Highest DAILY rainfall (mm)
Bathurst	214	1275	108.7
Oberon	351	1464	122.4
Blayney	261	1328	131.8
Millthorpe	292	1466	119.4
Orange	339	1761	98.6
Molong	302	1614	197.6
Manildra	197	1185	260.1

Another measurement is the **highest daily rainfall** event. This measures the highest amount of rain that has ever fallen in one day in a locality.

Of the selected sites Molong has had the largest recorded amount of rain in a single day. It's heaviest ever day of rain was twice that of Orange even though Orange receives one third more rain on average than Molong.

When does it fall?

Annual patterns

Apart from the amount of rain that falls it is also important to know when during the year it falls and how reliable the rain will be.

Our district lies in between the predominantly summer rainfall area of northern Australia and the winter rainfall areas of the south.
In our district the **seasonal distribution** of rain is, on average, relatively even between summer and winter. The influence of each system shifts from year to year - so some years have more winter rain and others a more predominate summer pattern.

Table 4.2.3
Summer/winter rainfall (mm) for selected localities, compared to Albany –WA- & Cairns. (Bureau of Meteorology)

Location	Summer Rainfall	Winter Rainfall	Winter dominance
Manildra	165	138	0.8
Orange	242	266	1.1
Millthorpe	201	228	1.1
Carcoar	174	242	1.4
Oberon	214	228	1.1
Bathurst	188	144	0.7
Albany	**76**	**405**	**5.3**
Batlow	**208**	**460**	**2.2**
Cairns	**1044**	**153**	**0.2**

Winter dominance is ratio of the sums of the mean rainfall for the 3 winter months compared to the 3 summer ones

Bathurst and Manildra receive slightly more rain in summer than winter on average. This compares with Cairns, in the summer rainfall zone, where nearly seven times as much rain falls in summer than winter. The other sites in our district receive more rain in winter than they do in summer.
Carcoar receives nearly 40% more rain in winter than summer. Albany, in the winter rainfall zone of Australia, receives more than 5 times (500% more) winter rain than it does summer rain.

The **seasonal distribution** of rain throughout the year can be seen below for six sites across our district. Manildra has a relatively even distribution of rain throughout the year. Bathurst has relatively dry autumn and winter and a wet summer. The other four locations have markedly dry autumns and wet winters.

Figure 4.2.2
Annual distribution of rainfall by monthly rainfall medians. (Bureau of Meteorology)

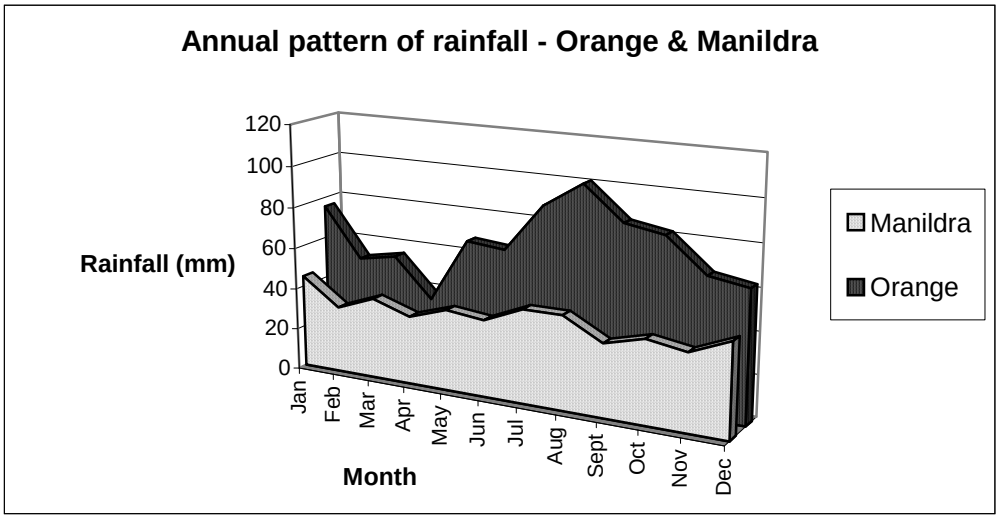


Figure 4.2.3

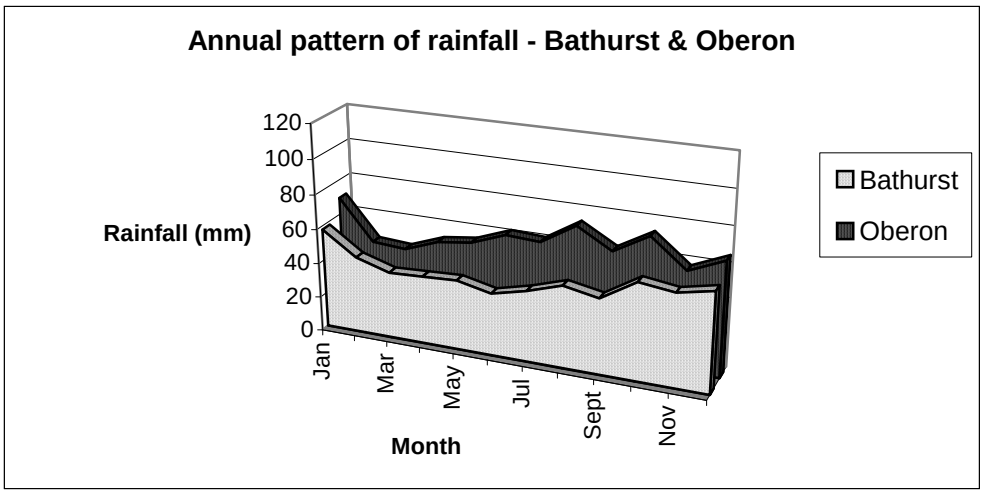
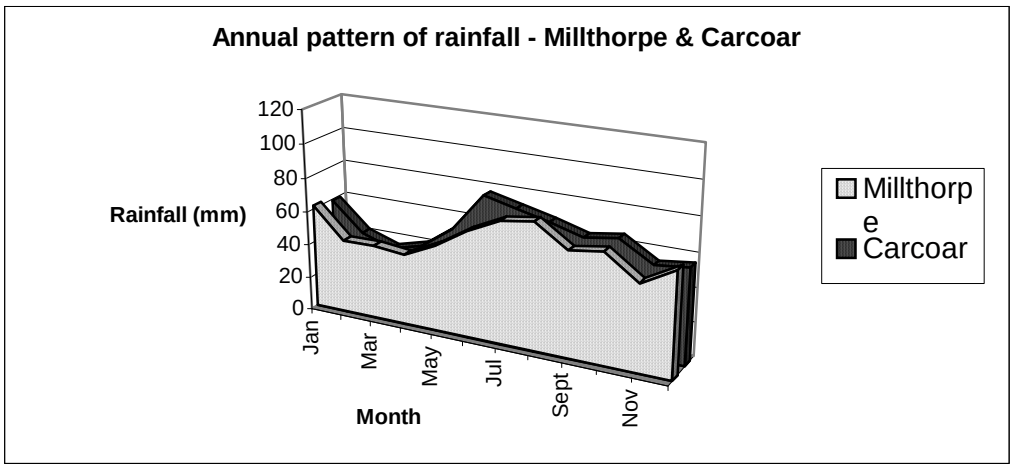
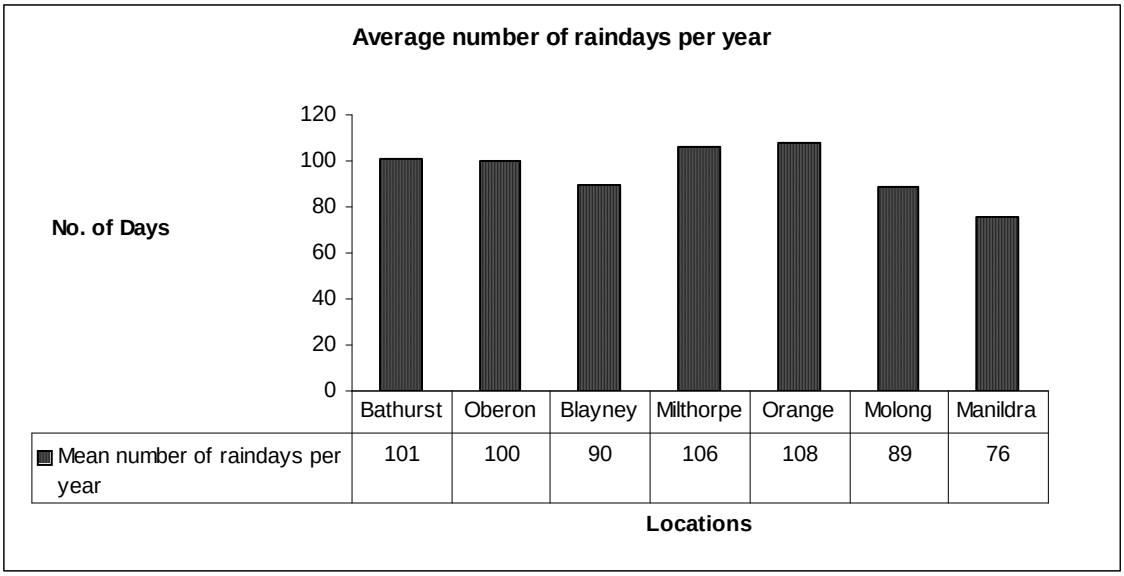


Figure 4.2.4



The **average number of raindays** indicates how many days during a period that rain falls in a locality. It can be measured per month, season or for a year. Of the selected sites in our district Orange has the highest number of wet days every year with 108 days getting rain. Manildra has the least with 76.

Figure 4.2.5
Average number of raindays per year for selected locations in our district.



Intensity

Rain does not fall with the same intensity at all places. Some areas get heavy rain occasionally whilst other places get light showers frequently. The **average rainfall event** measures the relative intensity of rainfall by showing the average amount of rain that falls each rainday.

Table 4.2.4
Average annual rainfall event for locations in our district. Compared to Cairns.

Locality	Average daily rainfall event (mm)
Bathurst	6.3
Oberon	8.5
Blayney	8.5
Millthorpe	7.6
Orange	8.8
Molong	7.9
Manildra	7.7
Cairns	**16.2**

Bathurst has the least intense rainfall on average with just over 6mm of rain falling each day it rains. Orange has nearly 9mm. Cairns annually averages about 16mm of rain per rainday. Its rainfall is twice as intense as that received by Molong.

Reliability

Rainfall in Australia can be highly unreliable with some years and seasons being good ones and others dry. Rainfall variability is measured by an index – **the rainfall variability index (RVI)**. The higher the index number, the greater the variability and the less reliable rainfall is.

Table 4.2.5
The Rainfall Variability Index. (Bureau of Meteorology)

Rainfall Variablity Index	
Extreme	**more than 2**
Very High	**1.5 to 2.0**
High	**1.25 to 1.5**
Moderate to High	**1 to 1.25**
Moderate	**0.75 to 1**
Low to Moderate	**0.5 to 0.75**
Low	**0 to 0.5**

The **variability of annual rainfall** shows how reliable the annual average rainfall is for an area. On an annual basis our district has a **low to moderate** rainfall variability – an index between 0.5 and 0.75. This compares with Alice Springs which has a high and Broome which has moderate annual rainfall variability.

Table 4.2.6
The annual Rainfall Variability Index of selected Central Tablelands locations. Compared to Alice Springs and Broome. (Bureau of Meteorology)

Location	Rainfall Variability Index
Bathurst	0.67
Oberon	0.71
Blayney	0.67
Milthorpe	0.66
Orange	0.68
Molong	0.71
Manildra	0.71
Alice Springs	**1.3**
Broome	**1.0**

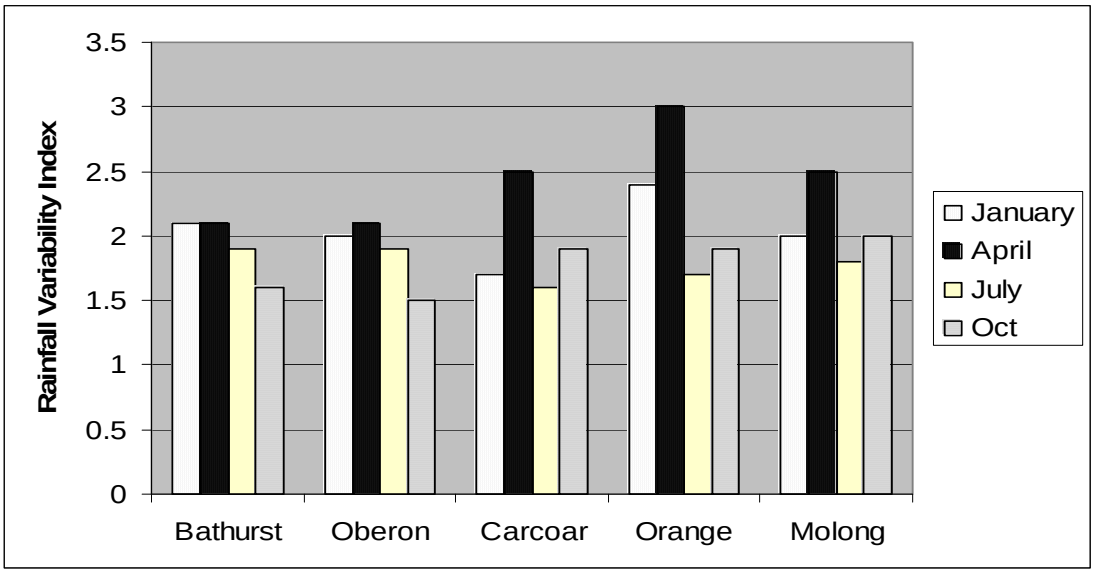
The variability of our rainfall is high within each year however. We have highly variable seasons as far as rainfall goes. In other words we tend to get relatively reliable amounts of rain on an annual basis but our seasonal rains are not so reliable.

Table 4.2.7
Rainfall variability of Central Tablelands locations for selected months.

Location	January	April	July	Oct
Bathurst	2.1	2.1	1.9	1.6
Oberon	2	2.1	1.9	1.5
Carcoar	1.7	2.5	1.6	1.9
Orange	2.4	3	1.7	1.9
Molong	2	2.5	1.8	2

Rainfall in each month is at least highly variable with some places experiencing extreme rainfall variability in some months. April (autumn) rain is extremely variable at all of the sites. Carcoar and Orange's rainfall in particular are noticeably unreliable in autumn (April) compared to the rest of the year.

Figure 4.2.6
Rainfall variability in the months of January, April, July and October for selected sites in our district. (Bureau of Meteorology)



Expressing rainfall as **percentiles** can also give an idea of reliability**.** They are based on our rainfall records to date - generally for the last 110 to 140 years – and give an idea of the chance or probability that a certain amount of rain will fall in that month.

The **median rainfall** – **0.5 percentile** - is the measure of rainfall in which half the years, or 50% of the time, there will be more rain than this amount and half the years there will be less. For example, the median annual rainfall for Orange is 853 mm. In half the years we can expect more rain than this and in the other half we can expect less. (Note that the average annual rainfall for Orange of 875 mm is slightly more than the median, or "middle" value).

The **0.9 percentile** shows the amount that in 90% of years, (or on average, 9 years out of 10), there will be less rain than this. Generally only one year in 10 will be wetter.

The **0.1 percentile** shows that in 1 out of 10 years the location will receive less rain than this amount for a particular period.

These two percentiles show the upper and lower rainfall extremes that can be expected for a location over time.

Figure 4.2.7 and **Table 4.2.8** show the rainfall percentiles for Oberon. In the month of January each year there is a 50% chance of receiving more than 69.5mm of rain and 50% chance of receiving less. This is the median rainfall for the month.

Figure 4.2.7
Rainfall percentiles (mm) for Oberon NSW. (Bureau of Meteorology)

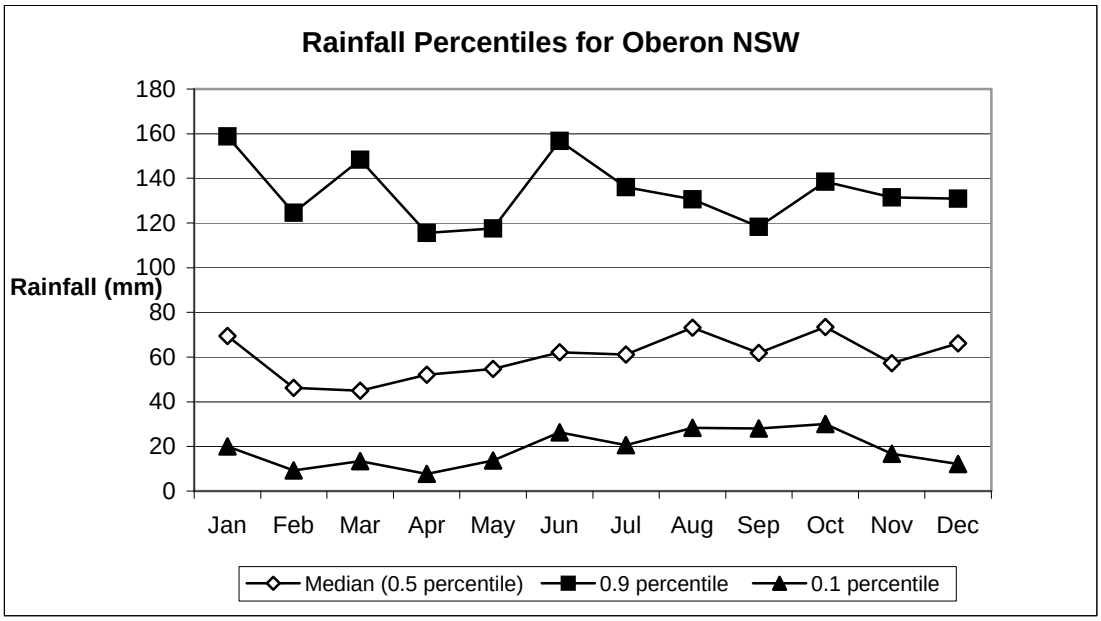


Table 4.2.8
Rainfall percentiles (mm) for Oberon NSW. (Bureau of Meteorology)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
0.1 percentile	20	9.3	13.5	7.7	13.7	26.4	20.6	28.4	28.1	30.1	16.7	12.2	**534**
Median (0.5 percentile)	69.5	46.2	44.9	52.1	54.7	62.2	61.1	73.2	61.9	73.4	57.3	66.1	**824**
0.9 percentile	158.8	124.6	148.3	115.5	117.5	156.8	136	130.6	118.3	138.5	131.5	130.9	**1117**

The 0.9 percentile for January is 158.8mm. In 90% of years, 9 years out of 10, Oberon will receive less than this much rain in January. In 10% of years it will get a greater rainfall amount than this in January, a very wet year. The 0.1 percentile for January is 20mm. One in every 10 years Oberon is expected to get less than this much rain for that month.

On an annual basis the median amount is 824mm. In 50% of years Oberon can expect more than this amount and in 50% it can expect less. It is likely to receive less than 534mm only once every ten years. This is the 0.1 percentile. In 8 years out of 10 Oberon will receive between 534mm and 1117mm of rain. This is the range between the 0.1 and 0.9 percentile amounts.

Drought

Droughts are a regular part of the Australian climate cycles. They not only impact on agriculture but also on our wider environment. Soil erosion, dust storms, water restrictions and economic losses due to a downturn in agricultural production all result from drought. Furthermore it causes social stress for families on the land and in towns that are dependant on agriculture for their economies.

There are three types of droughts that can occur: **seasonal**, **major** and **extended** droughts. They can be classed as either **moderate** or **severe** depending upon how little rain falls.

A **moderate drought** occurs when the amount of rain received for a period is in lowest 10% of the recorded rainfall ever for that place. It becomes a **severe drought** when the amount of rain that falls is less than 5% of the recorded ever amount.

The maintenance of ground cover is essential in times of drought. This should become a major goal for landholders. With at least minimal ground cover and the good root mass that accompanies this, recovery of pastures is much quicker when adequate rains do return. Ground cover protects the farmer's major asset – his soil - from wind and water erosion both during and at the end of a drought. Compaction and loss of soil structure make the problem worse if ground cover is not maintained.

Seasonal Droughts

These are of a relatively short-term, lasting just for a season or so. Many parts of Australia do not receive rain in some seasons so this is not a seasonal drought. But when an area usually receives rain in a season and gets rainfall in the lowest 10% then that period can be considered as a seasonal drought.

Major Droughts

When the drought extends beyond a season then it becomes a major drought. These are the droughts of a year or more. They can be moderate, severe or go through periods of being both severe and moderate.

Table 4.2.9
Major drought information for selected locations in our district. (Rainman v3)

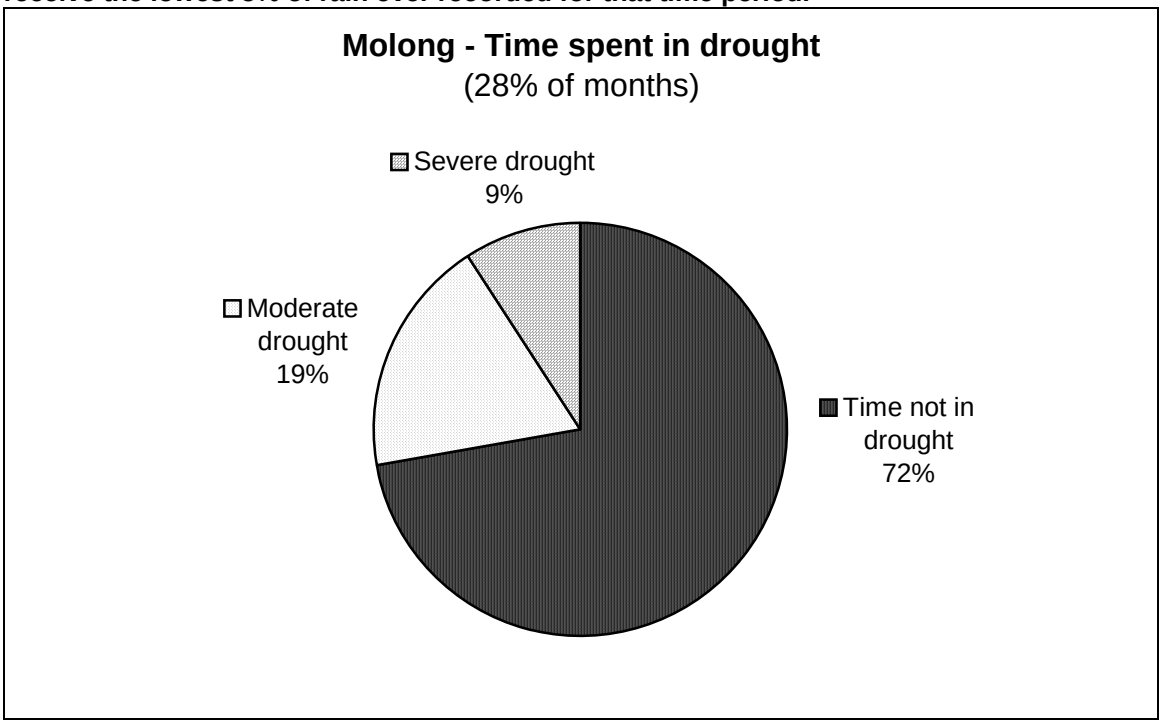
Location	Number of major droughts	Total months in major drought	% of time in drought	% of drought that is severe
Bathurst	19	351	32%	25%
Oberon	20	404	31%	25%
Orange	22	394	29%	27%
Molong	21	384	28%	33%
Manildra	20	375	28%	24%

* Starting year of records varies between locations but 2000 is last year of record for all locations.

All of the selected locations have spent around 30% of the time in a major drought. Molong has experienced the most severe major droughts with a third

of its time in major droughts being severe. Bathurst and Oberon have been in severe drought for about a quarter of their drought periods.

Figure 4.2.8
The proportion of time that Molong has experienced drought. Severe drought periods receive the lowest 5% of rain ever recorded for that time period.



Extended droughts

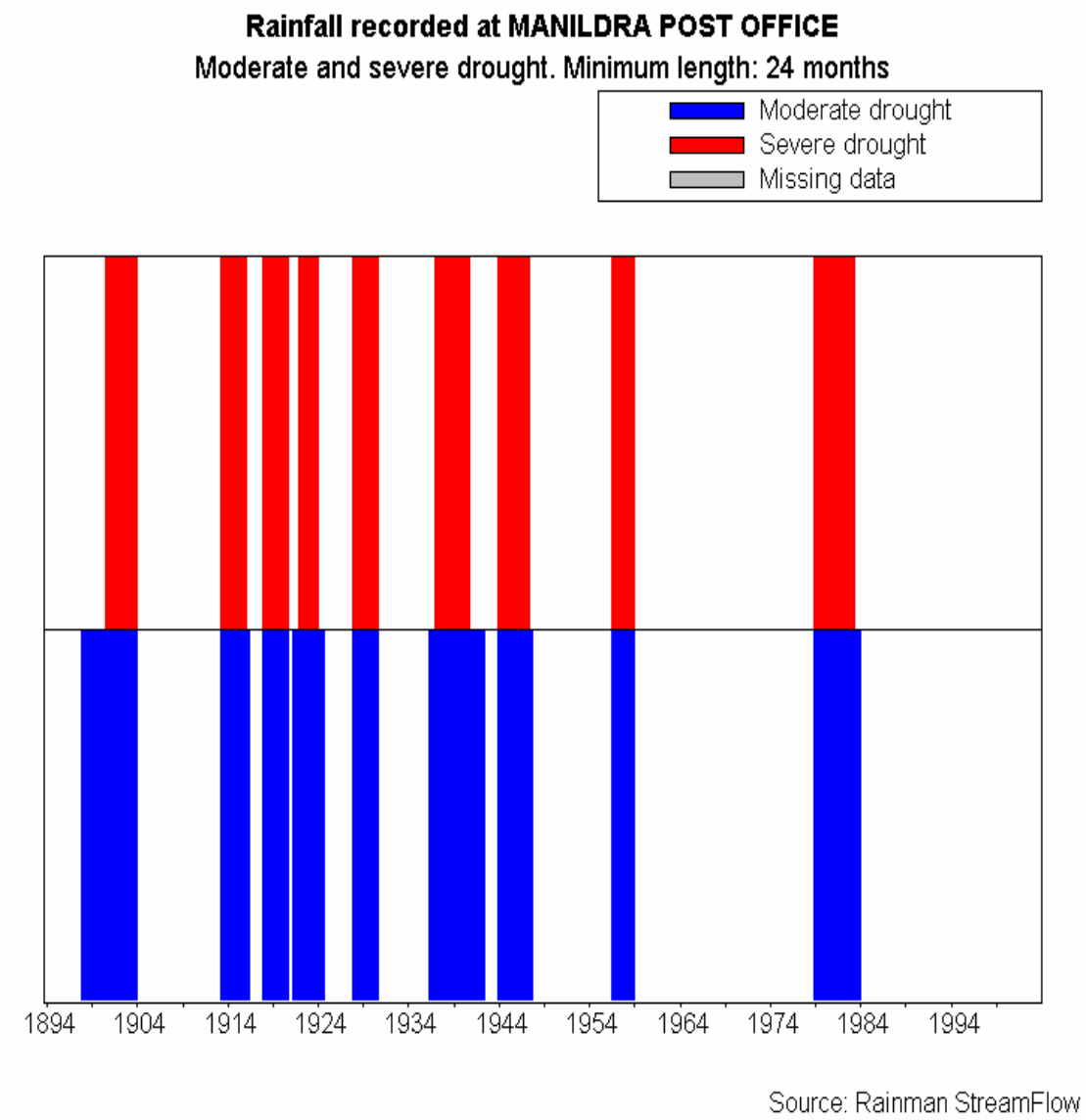
Some droughts in our history have been exceptionally long. These are periods of at least 24 months when there has been the lowest 10% of ever rainfall recorded. Some of these extended droughts are a number of major droughts that occurred close together. The effect of this is to create an extended, exceptional drought period.

In Australia's recent history there have been a number of these extended droughts. Some of the more serious ones are

- **The Federation Drought** 1895-1902. So serious that February the 26th 1902 was declared a "humiliation and prayer day" for rain by the NSW government.
- **The 1914-1915 Drought**. In October 1914 there was a total failure of Australia's wheat crop.
- **The World War II Drought**. During this drought the Hunter River ceased to flow in many parts.
- **The 1982-83 Drought**. Although not long it was perhaps the driest drought period in our history. Parts of the Central Tablelands received the lowest ever rainfall on record.
-

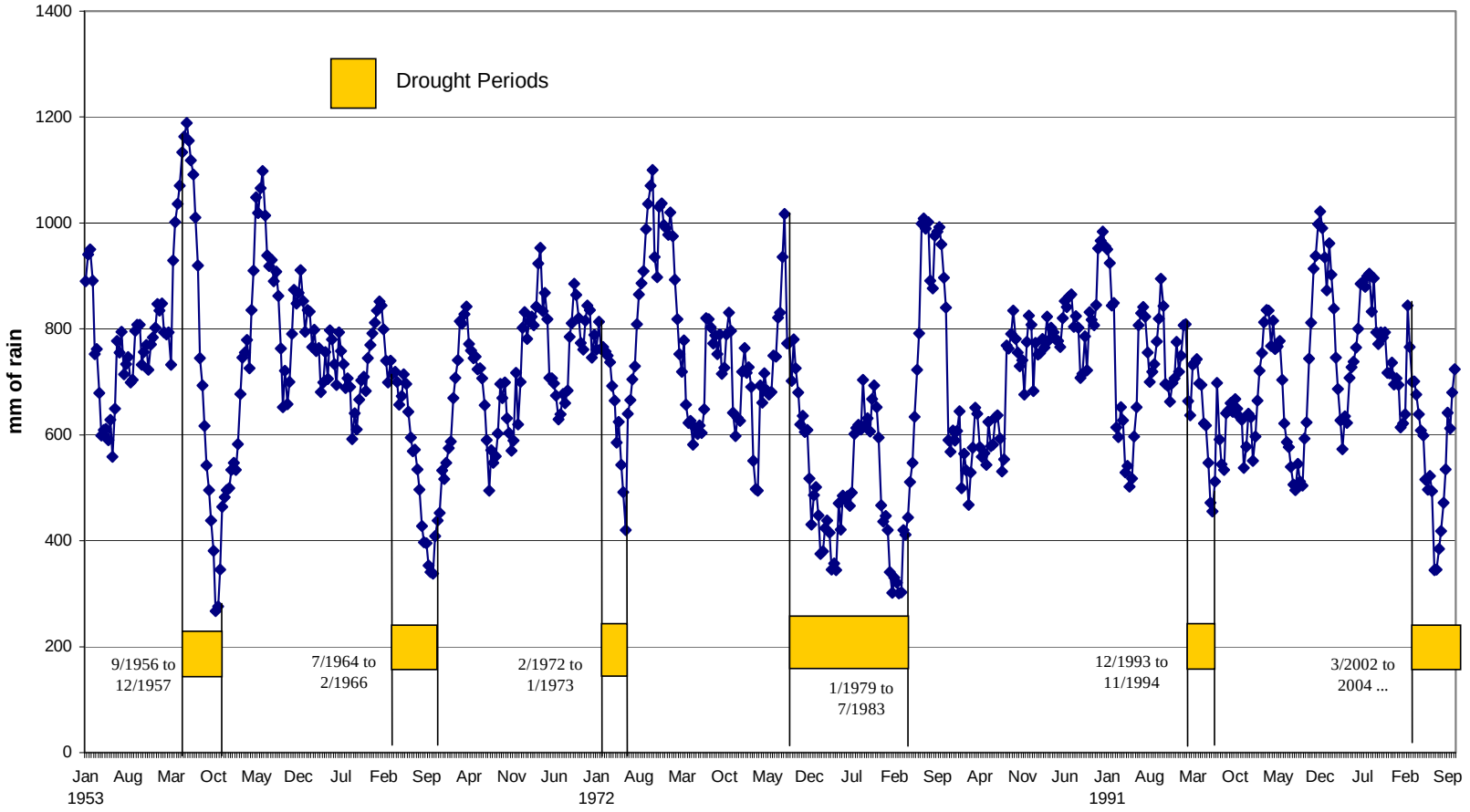
You can pick these droughts out in Figure 4.2.9

Figure 4.2.9
Moderate and severe drought based on Manildra rainfall records. Severe drought is the direst 5% of years, and moderate drought the second driest 5%.



Source: Rainman StreamFlow

Running 12 month Rainfall - Molong: 1953 to 2003



Evaporation & effective rainfall

Due to the heat of the sun water gets lost to the atmosphere from dams, creeks and other open water sources. This is known as **evaporation.** The **average evaporation rate** measures how much water is lost to the air from open water (pan evaporation) for a location.

Table 4.2.10
Average evaporation for selected months for the Central Tablelands. Compared to Alice Springs. (Bureau of Meteorology)

	Average evaporation - mm	
Month	**Central Tablelands area**	**Alice Springs**
January	175-250mm	350-400mm
April	80-100mm	200-250mm
July	30-60mm	100-125mm
October	100-150mm	300-350mm

Evaporation rates change through the year with the hotter summer months recording the highest amounts. In our district evaporation in July – the midwinter month – is about 3 times less than in January – the hottest summer month. Alice Springs has around double the evaporation rate of our district, with an average of around 3,000 mm. The annual rainfall of Alice Springs is 279 mm; - one reason why permanent surface water rarely exists in more arid areas.

Water is also lost from soil and plants in a process known as **evapo-transpiration.** In many parts of Australia the potential loss of water from evapo-transpiration is greater than the amount of rain that falls. It is also generally more than pan evaporation, as plants actively transpire water.

Evapo-transpiration depends upon a number of factors including the amount and type of ground cover and the vegetation type, in particular its root depth. It also depends upon wind, cloud cover and air temperatures. Winds and hot weather can increase both evaporation and evapo-transpiration, whilst cloud cover can reduce them.

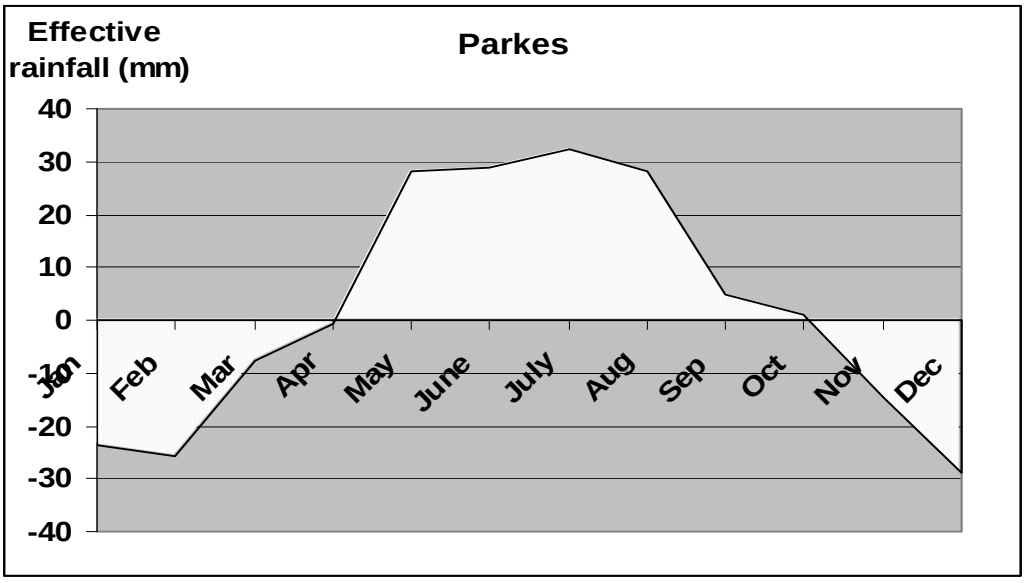
Much rain that falls enters the soil and is not lost directly to the air by evapo-transpiration. This is the soil moisture that feeds plants during dry periods and refills surface and underground water systems. Rain may be lost from run-off, drainage below the root zone, as well as evapo-transpiration. **Effective rainfall** is an estimate of the amount of rainfall which remains for plant growth. Because of this, light showery weather with rainfall less than 5 mm is widely considered as non-effective for most crops.

A surplus of rainfall remaining after soil evapo-transpiration results in a **positive effective rainfall**. Conversely if evaporation is high then an effective

rainfall deficit can occur. If there is not enough soil moisture stored from surplus periods then plants can be at risk of moisture stress during high evaporation periods.

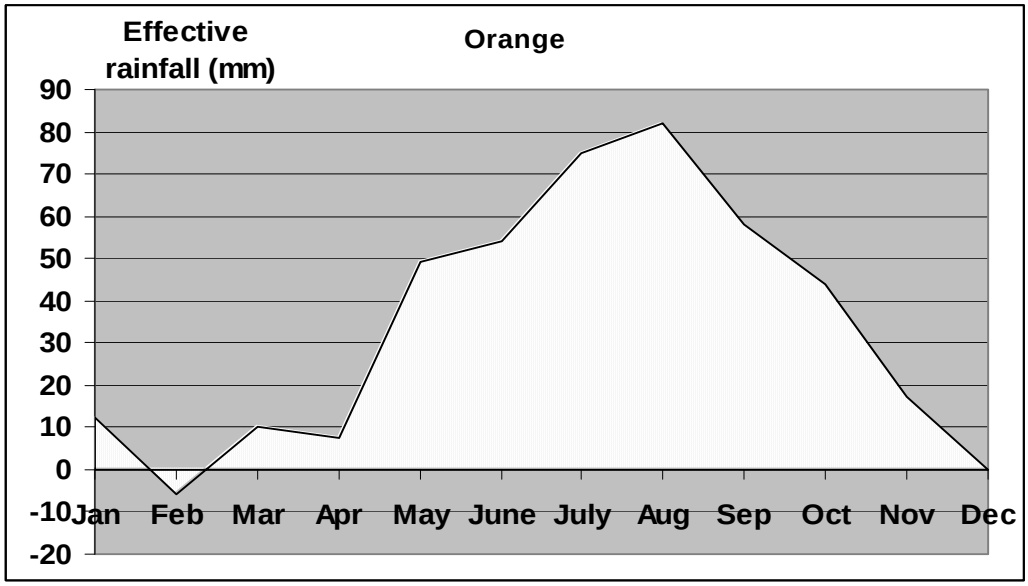
The following three figures show the average effective rainfall for Parkes, Orange and Bathurst – the balance of plant available moisture in each month will of course depend on surface run-off and deep drainage as well. Again, seasonal variation means that each year is different, and the graphs provide a guide only – and an interesting comparison of different locations.

Figure 4.2.10
Effective rainfall (mm) - Parkes.



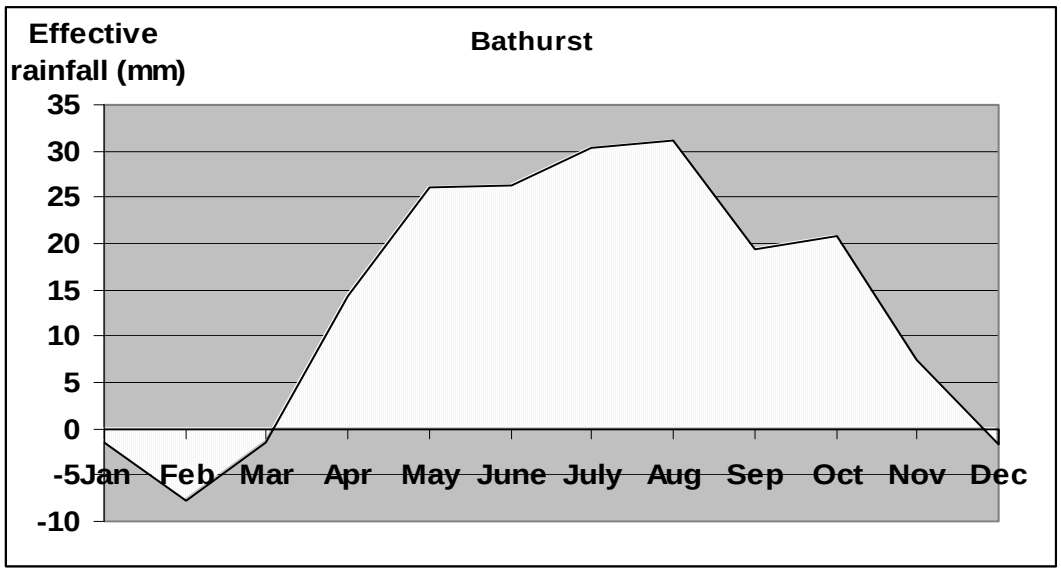
The westerns slopes of our district, represented by Parkes, typically have no effective rainfall in late spring, summer and early autumn. This is when soil evaporation exceeds rainfall. During the late autumn and winter period Parkes receives a positive effective rainfall as rainfall exceeds soil evaporation. Unless there is good soil moisture stored in the soil over this period plants may suffer water stress during the high evaporation periods. The role of irrigation is to maintain the plant available soil water in times when the plant would otherwise experience water stress.

Figure 4.2.11
Effective rainfall - Orange



Orange generally receives a surplus of effective rain most of the year with a minor deficit in February. Evaporation rates are relatively low compared to rainfall. It shows why irrigation is more supplementary in the Orange district – but again in some years, and particularly with young plantings, it can be critical for crop yields and fruit quality.

Figure 4.2.12
Effective rainfall - Bathurst



Bathurst also receives a positive effective rainfall most of the year with a slightly higher deficit in February than Orange does.

4-3 Temperature – Central Tablelands

What influences our temperatures?

Large scale influences

The temperature of our environment comes originally from the **solar radiation** of the sun. The heat of the sun changes through the seasons as it moves between the northern and southern hemispheres. When it is above the southern hemisphere we receive more solar radiation and so it is hotter. This is our summer. Conversely when the sun is in the northern hemisphere we receive less solar radiation and this is our winter period.

The differences in summer and winter temperatures are large for our district. For Orange the average top temperature each day in January is 16^{o}C higher than it is in July. In Molong the top daily temperature is 18^{o}C warmer in January. In winter the average daily minimum is around 13^{o}C less in winter than it is in summer for both Bathurst and Molong.

Temperature decreases with distance from the equator – **latitude**. As a general rule with every 1^{o} of latitude change the temperature reduces by approximately1^{o}C.

Local influences

At a local and regional scale temperature is influenced by aspects of the local topography. Generally the higher the **altitude** (height above sea level) the cooler a location is. For every 100m in elevation the temperature decreases by about 1^{o}C. This is why mountain areas are cooler than valleys and plains.

Aspect and local landforms influence local temperatures. Sites on the southern side of hills and mountains receive less sunshine than those on the north and may be cooler. Places that are situated in a valley may experience a greater number of frosts than places higher up and so be colder. This is because cold air drains at night down slopes and hillsides. This may help explain why Blayney is colder than Oberon and Orange.

Weather factors such as **wind** can also affects temperature. A cold windy place can be cooler than neighbouring calmer sites. **Clouds** reduce the occurrence of frost by trapping heat at night. Places with cloudy nights generally have milder nights with less frosts occurring. Cloudy days however, can reduce incoming sunlight and reduce daytime temperatures.

Each place is affected by all of these factors in different ways and so temperature can vary widely between different locations even those located close to each other. Each location is unique and so it is important to get local knowledge for effective land management.

How hot and how cold?

Two measurements of temperature for a location are the **mean annual maximum** and the **mean annual minimum temperatures.**

These mean temperatures give an overall indication of how hot or cold it is. They do not however reveal the variations in temperature a place may receive through the seasons and the change in temperature a location may experience between day and night.

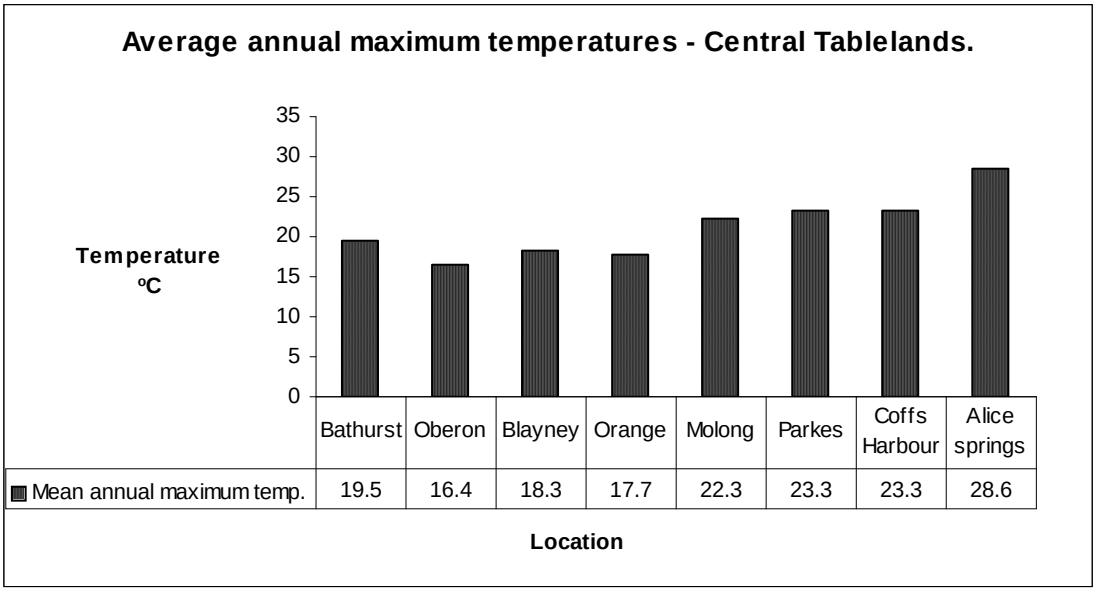
Heat

The **mean annual maximum temperature** measures the average maximum daily temperature of a place for the whole year. Of the selected sites in our district Molong has the highest average annual maximum temperature with 22.3 ^{o}C. Oberon has the lowest with 16.4 ^{o}C.

There are few temperature records for the western slopes section of our district. Parkes has been included to give an indication of the temperature in the Manildra, Cudal and Mandagery districts.

The influence of altitude is reflected in the maximum average temperatures for the district. Bathurst has a relatively warm annual maximum average as it is located in a basin. Oberon, at a higher altitude, has a cooler one.

Figure 4.3.1
Mean annual maximum temperatures for selected locations in our district. Compared with Coffs Harbour and Alice Springs. (Bureau of Meteorology)

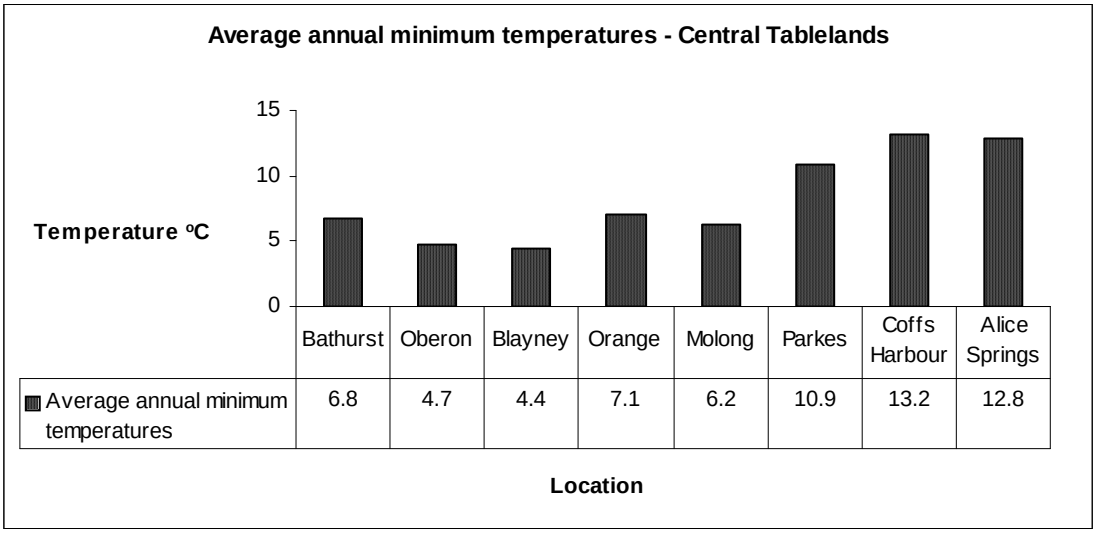


Coffs Harbour, which is thought to have the most ideal climate in Australia, has about the same maximum average annual temperature as Parkes and Molong. Alice Springs, in the hot arid interior of Australia, has almost double the maximum annual average as Oberon.

Cold

The **mean annual minimum temperature** measures the average mimimum daily temperature of a place for the whole year. Of the selected sites in our district Blayney has the coolest average annual minimum temperature with 4.4 ^{o}C. Molong and Parkes have the warmest minimum with 6.2 and 10.9 ^{o}C respectively.

Figure 4.3.2
Mean annual minimum temperatures for selected locations in our district. Compared to Coffs Harbour & Alice Springs. (Bureau of Meteorology)



Influences on cold

Minimum temperatures are influenced by various factors including **altitude.** Higher areas tend to be cooler. Oberon at an elevation of 1190metres has an annual average minimum temperature of 4.7 ^{o}C. Bathurst, with an elevation of 713 metres averages 6.8 ^{o}C.

Topography and **aspect** can also influence minimum temperatures. Local hills, local winds and being located on a southerly aspect, away from winter sun, can cause a place to be cooler than surrounding areas.

Blayney has an average annual minimum temperature of 4.4 ^{o}C which is cooler than Oberon. This is despite the fact that Oberon is at a much higher elevation than Blayney, 1190 metres compared to 863 metres. Local topography influences Blayney's temperature. It experiences frosts over forty more days a year than Oberon does on average. This caused in part by local air patterns shaped by the local topography.

Extremes

Extremes of temperature can be measured by the **maximum and minimum temperatures**. These measure the highest and lowest ever recorded temperatures for a location. The highest and lowest temperatures can be measured for a year, by season or for each month.

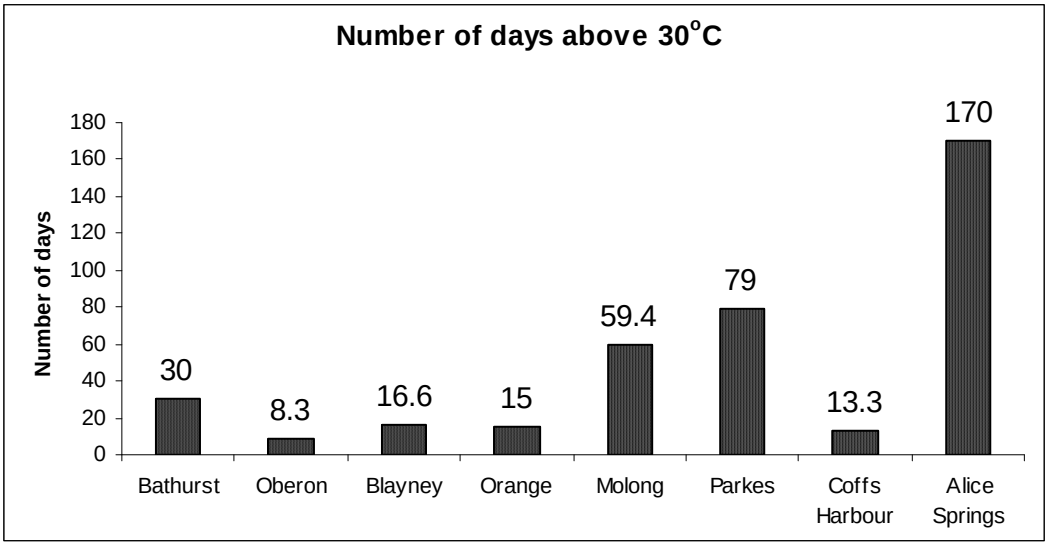
Table 4.3.1
Highest and lowest temperatures ever recorded for selected sites in our districts. (Bureau of Meteorology)

Location	Highest ever temp °C	Lowest ever temp °C
Bathurst	38.3	-8.9
Oberon	35.9	-8.7
Blayney	37.5	-10.6
Orange	36.7	-5.6
Molong	42.3	-8.8
Parkes	45.2	-4.2
Coffs Harbour	43.3	-3.2
Alice Springs	47.5	-7.2

The areas of the western slopes have experienced the hottest days for our district. Parkes has recorded over 45°C compared to Oberon with about 36°C. Blayney has the coldest ever recorded temperature in the district with –10.6 °C. Interestingly Molong has a colder recorded extreme than Orange.

The **average number of days above 30°C** a location gets each year also measures how hot a region is. In our area this measurement helps indicate how hot the summers get. Oberon has the mildest summers with an average of only 8.3 days per year above 30°C. Parkes and Molong have the hottest with 79 and 59 days respectively. Places with low elevations and those further inland tend to have hotter summers. Compare our district with Alice Springs.

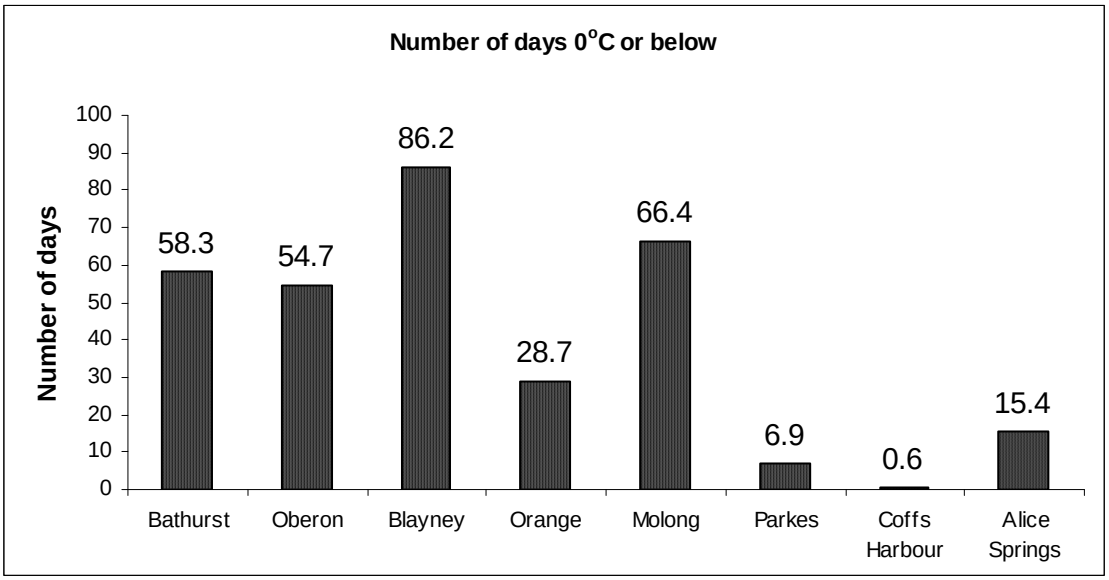
Figure 4.3.3
Average number of days per year the temperature exceeds 30°C for selected locations in our district. Compared to Alice Springs & Coffs Harbour. (Bureau of Meteorology)



The **average number of days per year below 0°C** that a location gets is another measure of how cold it is. This is the temperature at which heavy frosts occur. So places with a high number of frosts every year tend to experience colder winter extremes than those with a low number of frost days.

Of the selected sites in our district Blayney has the highest number of severe frost days per year with an average of 86. Parkes has the least with about 7 days a year below zero. Coffs Harbour, with reputedly Australia's most ideal climate, has less than one heavy frost day per year on average.

Figure 4.3.4
Average number of days per year the temperature is at or below 0°C for selected sights in our district. Compared to Alice Springs and Coffs Harbour. (Bureau of Meteorology)



Temperature variability

Temperature varies throughout the year changing with each of the seasons. Temperature also changes daily between night and day. Temperature variations, like rainfall patterns, have an important effect on plant growth and animal production.

Daily variations

A daily variation in temperature occurs between night and day and is caused by the warming and cooling of the air and ground and the sun's radiation. This is known as the **diurnal temperature fluctuation** for a location. In some locations high daytime temperatures are followed by very cold nights. In other places the difference is small.

The **average monthly diurnal temperature fluctuation** indicates the variation in temperature between night and day for a location. Of the selected sites in our district Orange has the smallest fluctuation between day and night time temperatures with 10.7^{o}C. Molong has the greatest with 15.9^{o}C. Molong can experience greater extremes in cold and heat in one day as the temperature varies between cold nights and warm days.

Table 4.3.2
Average monthly diurnal temperature fluctuation* for selected locations in our district. Compared to Coffs Harbour and Alice Springs. (Bureau of Meteorology)

Location	Temperature ^{o}C
Bathurst	12.9
Oberon	11.6
Blayney	13.6
Orange	10.7
Molong	15.9
Parkes	12.6
Coffs Harbour	10.1
Alice Springs	15.8

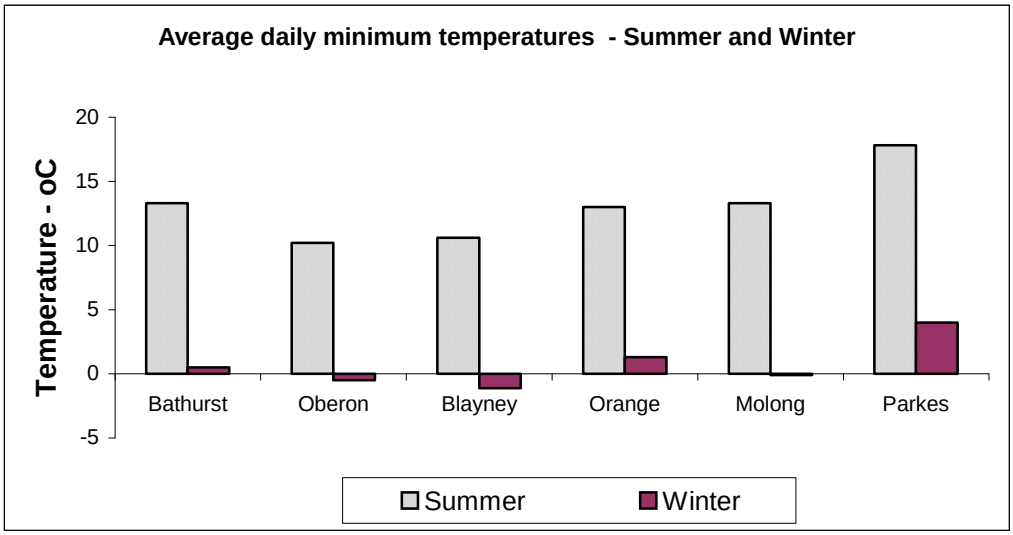
*Calculated as the annual mean of the differences in average monthly maximum and daily minimums.

Seasonal variations

The most obvious variation in temperature is the change between the seasons. Between the seasonal extremes of summer and winter there are significant changes in the **average daily maximum and minimum temperatures**.

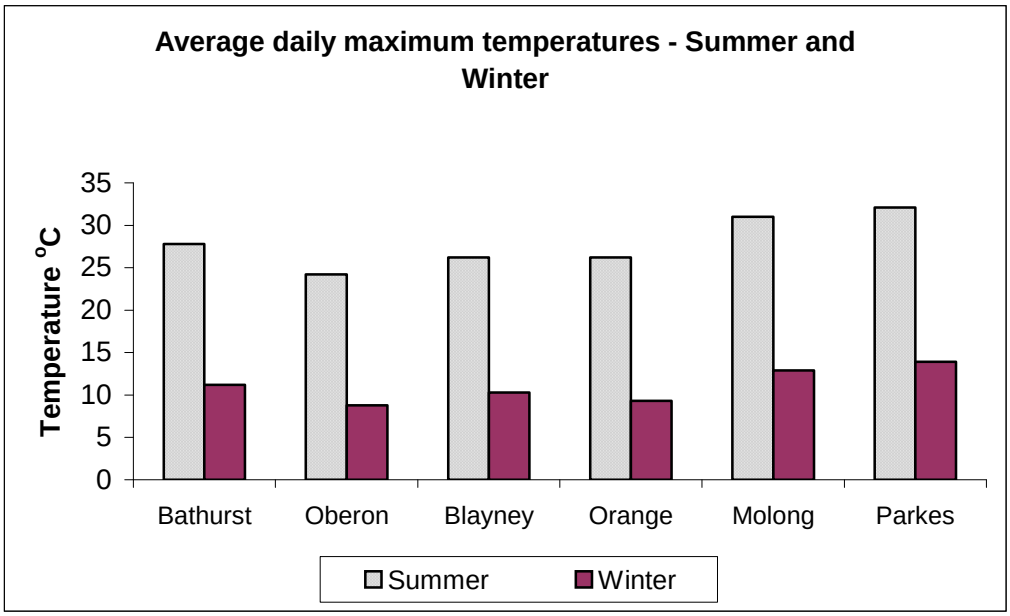
The average daily minimum temperature is much higher in summer than it is in winter. For Orange the minimum average daily temperature is 11.7^{o}C warmer in summer than winter. In Bathurst it is 12.8^{o}C warmer and in Molong the minimum daily temperatures, on average, are 13.2^{o}C warmer in summer than they are in winter.

Figure 4.3.5
Comparison between the average daily minimum temperatures in summer and winter for selected locations in our district. (Bureau of Meteorology)



Differences also occur in the average daily maximum temperatures between summer and winter. For Orange and Bathurst the daily top temperatures are, on average, 16^{o}C warmer in summer than they are in winter. Molong daily maximums are 18^{o}C warmer in summer than in winter.

Figure 4.3.6
Comparison between the average daily maximum temperatures in summer and winter for selected locations in our district. (Bureau of Meteorology)



The transitional seasons of Spring and Autumn have very similar maximum and minimum daily average temperatures to each other. In Oberon the average daily maximum is the same in Spring as it is in Autumn – 16.7^{o}C. The minimum daily average in Autumn for Bathurst is 6.7^{o}C, in Spring it is 6.2^{o}C.

Table 4.3.3
Average daily maximum and minimum temperatures in each season for selected locations in our district. (°C) (Bureau of Meteorology)

	Summer		Autumn		Winter		Spring	
Location	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**
Bathurst	27.8	13.3	20	6.7	11.2	0.5	19.7	6.2
Oberon	24.2	10.2	16.7	5.2	8.8	-0.5	16.7	4.6
Blayney	26.2	10.6	19.2	4	10.3	-1.1	18.1	4.6
Orange	26.2	13	18.2	7.2	9.3	1.3	17.3	6.5
Molong	31	13.3	22.5	6	12.9	-0.1	22.6	5.4
Parkes	32.1	17.8	23.4	11	13.9	4	23.5	10.4

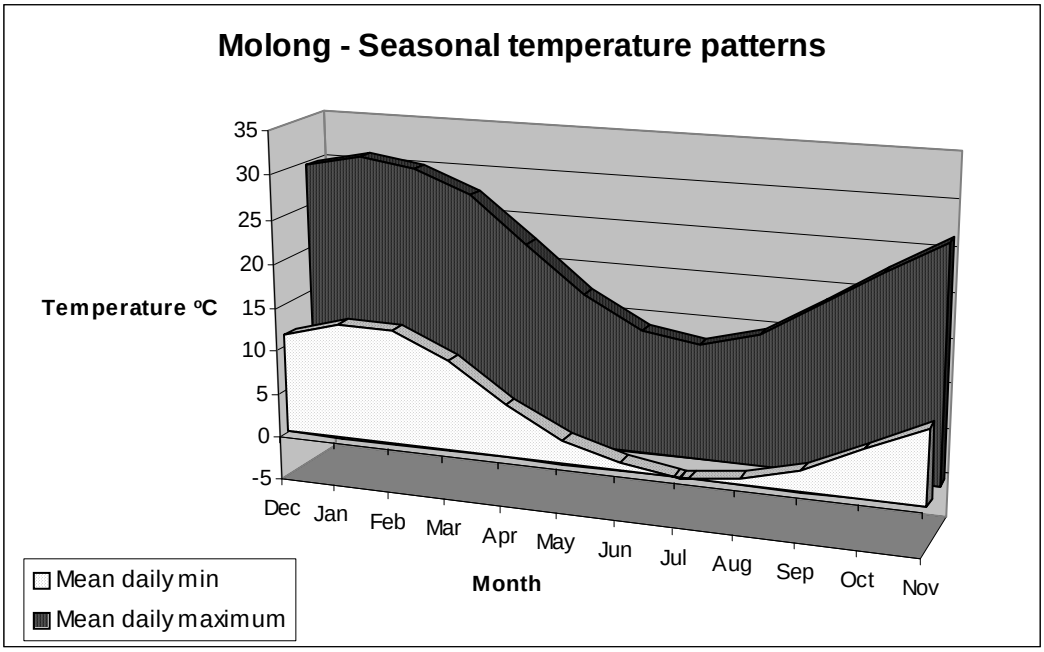
*Using the average daily means for the months Jan, April, July and Oct.

Seasonal patterns

The seasonal changes in temperature for locations in our district follow a pattern of four seasons. The warm summer is followed by falling temperatures in autumn, then the coldest period of winter and finally the rising temperatures of spring as the year moves onto the next summer.

This pattern, typical for all places in our district, can be seen in the example of the Molong temperature graph below.

Figure 4.3.7
The seasonal temperature patterns of Molong showing average daily maximum and minimum temperatures for each month. (Bureau of Meteorology)



Frosts

Frosts occur **when heat is lost from the ground rapidly in the night** leading to freezing temperatures at or near the surface. Their occurrence is influenced by altitude, latitude – distance from the equator – and nearness to the sea. Local topography – cold air drains down into valleys at night - and the daily weather conditions in a location also play an important part in frosts occurring. Cloudy skies reduce the chance of frost occurring.

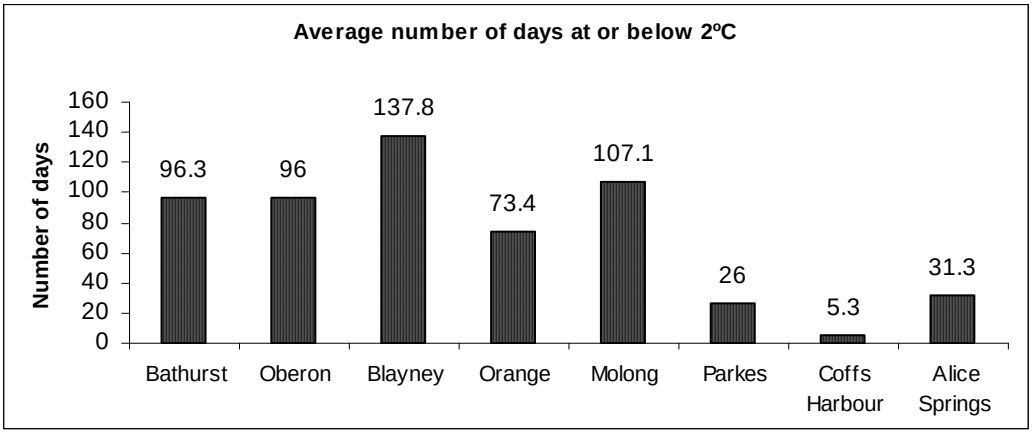
There are two types of frosts. **Light frosts** occur when the temperature reaches 2^{o}C or less. **Heavy frosts** occur when the temperature reaches 0^{o}C or less. Both types impact directly on plants and indirectly on animal production. Vegetation in an area can often be determined by the frost activity in that area.

Frosts typically occur in the cooler months of the year being most common over winter. In some places they also occur in summer as well. These locations are usually more restricted in the types of agricultural activities that can be done as frosts kill many actively growing plants.

Frostiness in an area

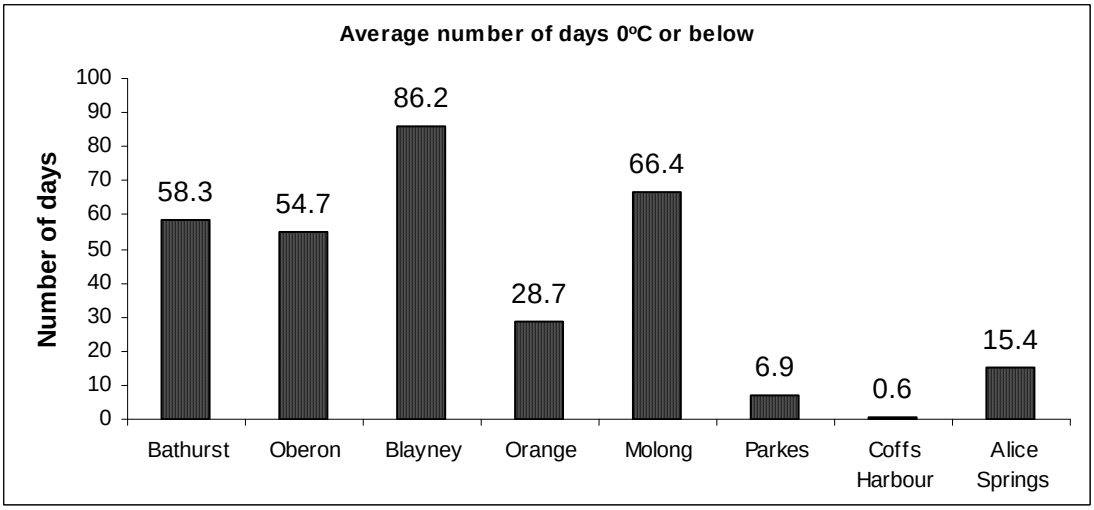
The **average number of days per year at or below 2^{o}C** measures how many days a year a place gets frosts – light and heavy – on average. Of the selected sites in our district Blayney gets the most frosts each year on average. With nearly 138 frost days a year it experiences nearly twice as many frosts as Orange does. It also gets about one third more frosts each year than Oberon and Bathurst.

Figure 4.3.8
Average number of frost days per year for selected locations in our district. Compared to Alice Springs and Coffs Harbour. (Bureau of Meteorology)



The **average number of days per year at or below 0°C** measures how many heavy frosts a location gets on average every year. Of the selected sites in our district Blayney also has the highest number of severe frost days per year with an average of 86.2. Molong, with 66, gets more the double the number of heavy frosts as Orange and Oberon, both towns which have a reputation for being really cold. Parkes has only about 7 days a year below zero. Coffs Harbour, with reputedly Australia's most ideal climate, has less than one heavy frost day per year on average.

Figure 4.3.9
Average number of days per year with heavy frost for selected sites in our district. Compared to Alice Springs and Coffs Harbour. (Bureau of Meteorology)



Heavy frost areas

Some places tend to get more severe frosts than others which experience mainly light frosts. In our district Blayney not only gets the most frosts but about 60% of these are heavy. Bathurst, Oberon and Molong also get around 60% of their frosts being heavy ones.

Surprisingly Orange, which experiences about half as many frosts as Blayney and one third less than Molong, gets less than 40% of its frosts as heavy. It

gets a greater percentage of light frosts than the other locations in our district except for Parkes. Coffs Harbour not only gets very few frosts but most of them are light ones with only one in ten frosts being, on average, heavy.

Table 4.3.4
Percentage of all frosts that are heavy for selected locations in our district compared with Coffs Harbour and Alice Springs. (Bureau of Meteorology)

Location	Percentage of frosts that are heavy
Bathurst	60%
Oberon	57%
Blayney	62%
Orange	39%
Molong	62%
Parkes	26%
Coffs Harbour	11%
Alice Springs	49%

Seasonal frost occurrences

The measure of the average number of frost days per year does not tell when the frosts occur. This is important because frosts occurring in spring, summer and autumn can restrict pasture growth on sheep and cattle properties and affect horticulture crops and revegetation activities by damaging seedlings in spring or blossoms and fruits later in the year.

The risk of frost to agriculture and land management can be seen by measuring the average **number of frosts that can occur in each season** for a location. Apart from Parkes, all the sites in our region are more prone to frosts in the spring and summer seasons. It is rare, but possible, that Parkes will experience frosts which cause significant damage to crops in spring and summer

Table 4.3.5
Average number of frost days per year in each season for selected locations in our district. (Bureau of Meteorology)

Location	Number of frost days			
	Spring	Summer	Autumn	Winter
Bathurst	19.9	0.2	17.9	58.3
Oberon	22.2	0.4	17.5	56
Blayney	33	3.7	34.6	66.6
Orange	13.9	0.1	8.4	51.1
Molong	26.9	0.4	20.3	59.6
Parkes	1.9	0	2.2	21.9

4-4 Wind, solar radiation and sunshine

Wind

Wind is an important element of our climate. It can increase evaporation and water use by plants, impact on livestock health and modify local temperatures. Cold winter winds can reduce temperatures even further and windy nights can prevent frosts forming.

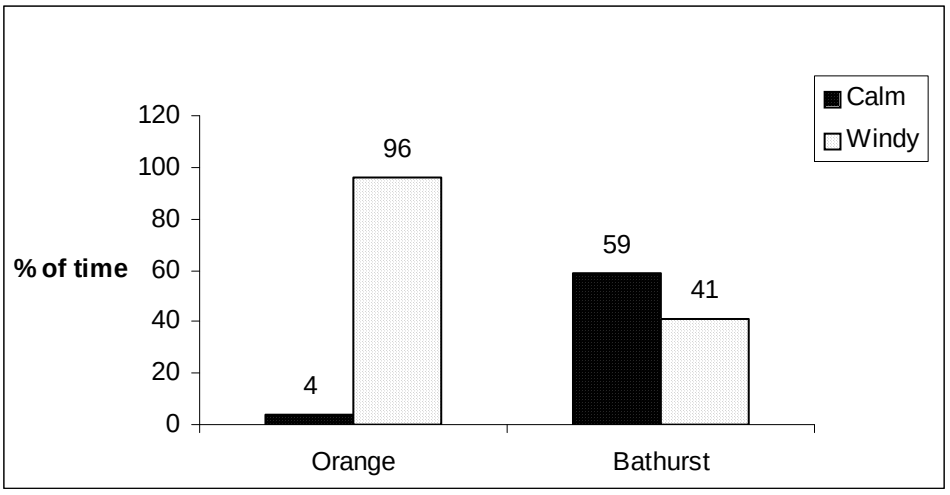
Three important aspects of wind are **wind frequency**, **wind direction** and the **wind speed** in an area. These are all influenced by large scale climate factors such as the continental pressure systems as well as local conditions.

Wind Frequency

Recorded data on the frequency of winds is available for only a few sites in our district.

Although similar overall wind patterns prevail in our region each location varies significantly from one to another due to local conditions. Bathurst is significantly calmer than Orange. 59% of the time is being recorded as calm compared to only 4% for Orange.

Figure 4.4.1
Percentage of time with wind and calm conditions for Orange and Bathurst. (SCS Technical manuals – Orange & Bathurst)



Wind direction

In our district **wind direction** is influenced by the large wind systems caused by the high and low air pressure systems that dominate our weather through the seasons. The **summer highs generally bring northerly to easterly winds** to the area. In **winter the dominant winds are the south-westerlies** that come through with the cold fronts.

Locally wind direction is strongly influenced by the landscape. Hills and valleys can tunnel wind and bend it so that locally the winter wind may come in from the north-west rather than the south. Behind steep hills wind may be very turbulent and not come from any particular direction. Other areas may receive very little wind as they are sheltered by the local topography from the prevailing winds.

Both Orange and Bathurst mainly experience westerly winds. In summer there is an even spread between easterly and westerly winds with a slight dominance of westerlies. In winter and spring it is obvious that westerly winds significantly dominate our district.

In both places the highest proportion of easterly winds occurs in summer and the lowest proportion occurs in winter.

Figure 4.4.2
Percentage of winds coming from an easterly and westerly direction for Orange in each season. (SCS Technical manual - Orange)

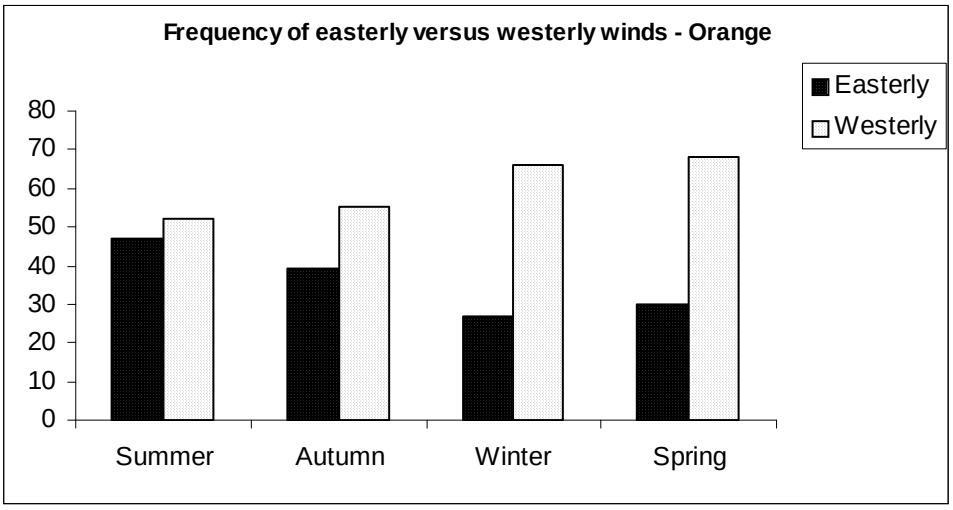
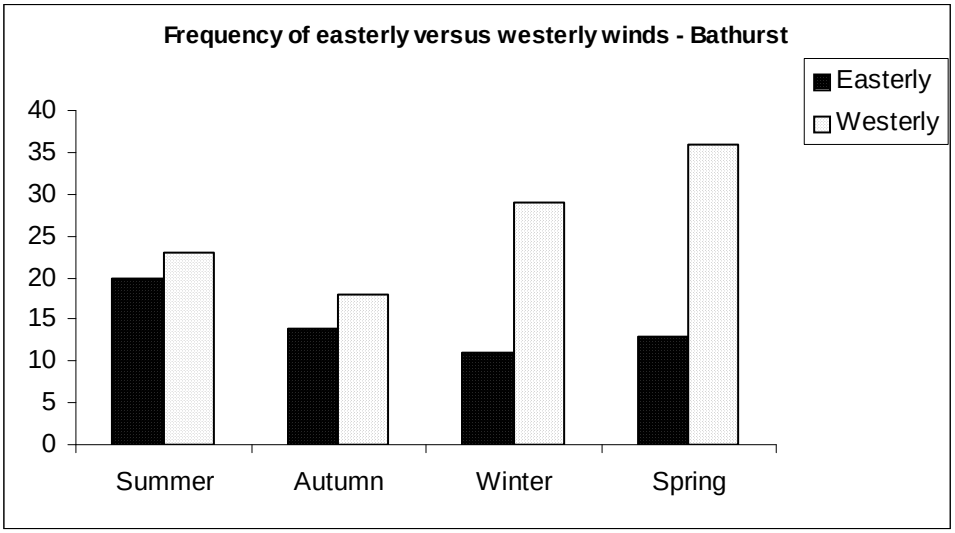
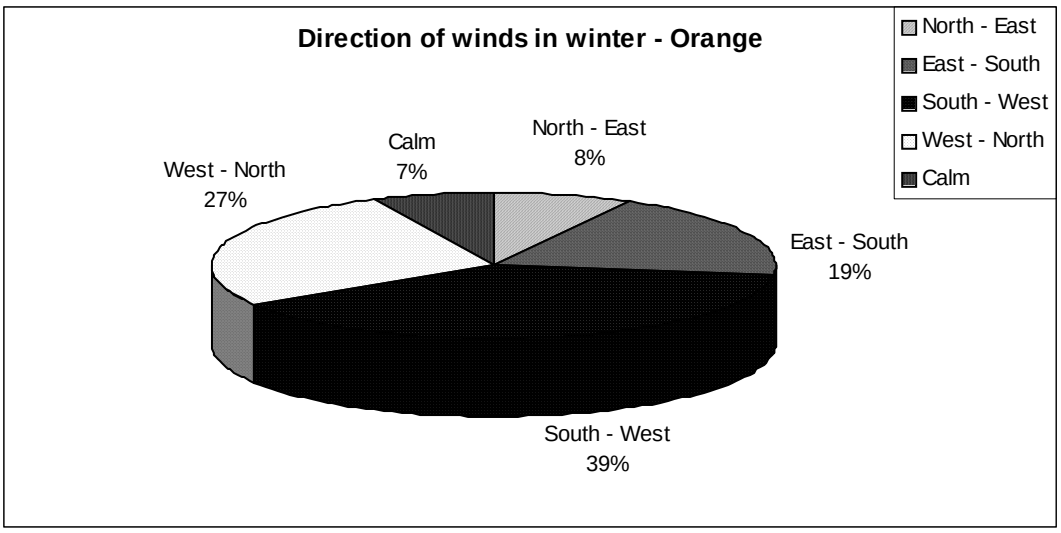


Figure 4.4.3
Percentage of winds coming from an easterly and westerly direction for Bathurst in each season. (SCS Technical manual - Bathurst)



Looking at the winter season in Orange it is clear the largest proportion of wind blows from the south-west. These are the winds associated with the cold fronts that pass across our district every winter, bringing cold weather and sometimes snow.

Figure 4.4.4
Frequency of wind directions in winter for Orange. (SCS Technical manual - Orange)

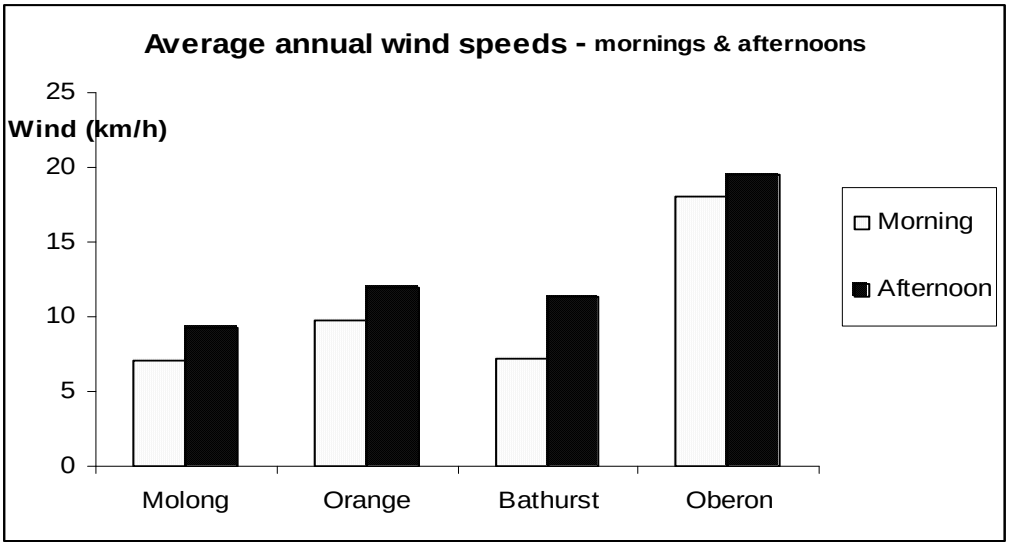


Wind speeds

Wind speed varies from place to place and depends upon many factors. Wind speed increases with height above the ground. Wind speed also tends to increase in the afternoon. Local valleys and hills can increase or reduce wind speed depending upon the landscape and wind direction in each situation.

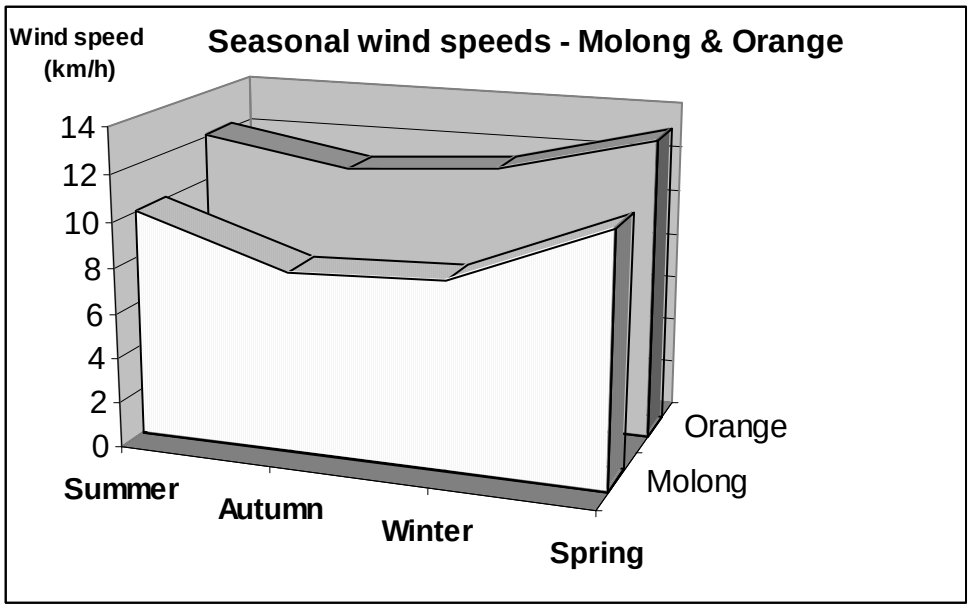
In our district Oberon has the highest **annual average wind speeds** both in the morning and afternoon. Molong winds are about half as strong as Oberon's. At each site wind is stronger in the afternoon than in the mornings.

Figure 4.4.5
Average annual wind speeds for four locations in the district. (Bureau of Meteorology)



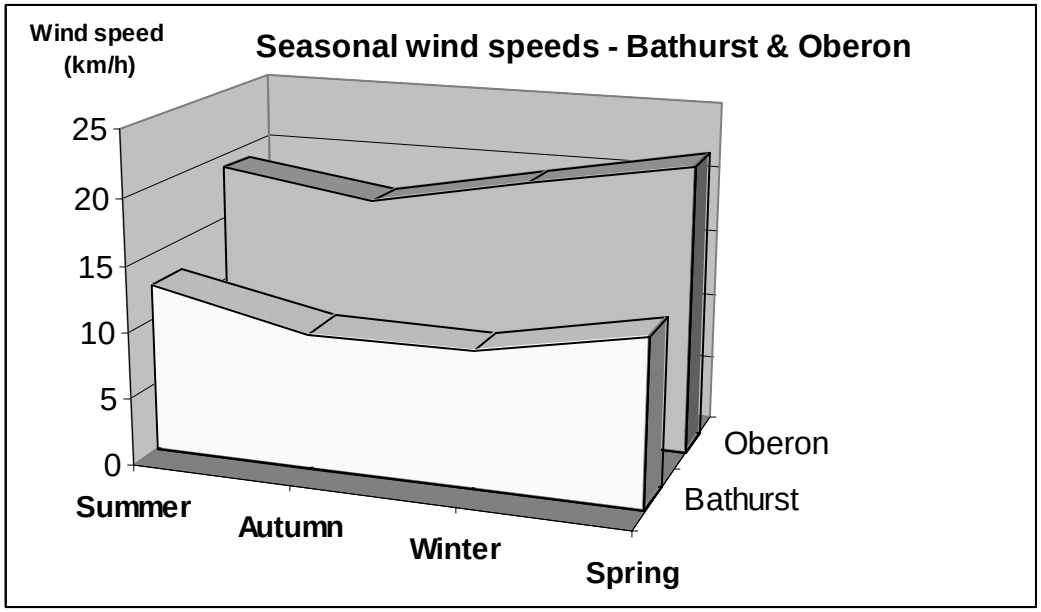
The wind strength changes at a location in different seasons as it is influenced by the climate and sun. In our district **the strongest winds occur mainly in spring followed by summer.**

Figure 4.4.6
Average afternoon wind speeds in the different seasons for Molong & Orange.
(Bureau of Meteorology)



The strength of the afternoon winds in Orange are greater than in Molong but they both experience the strongest winds in the Spring and Summer months.

Figure 4.4.7
Average afternoon wind speeds in the different seasons for Bathurst & Oberon.
(Bureau of Meteorology)



Oberon experiences much stronger winds than Bathurst with spring the season with the highest average afternoon wind speeds.

Solar radiation & sunshine

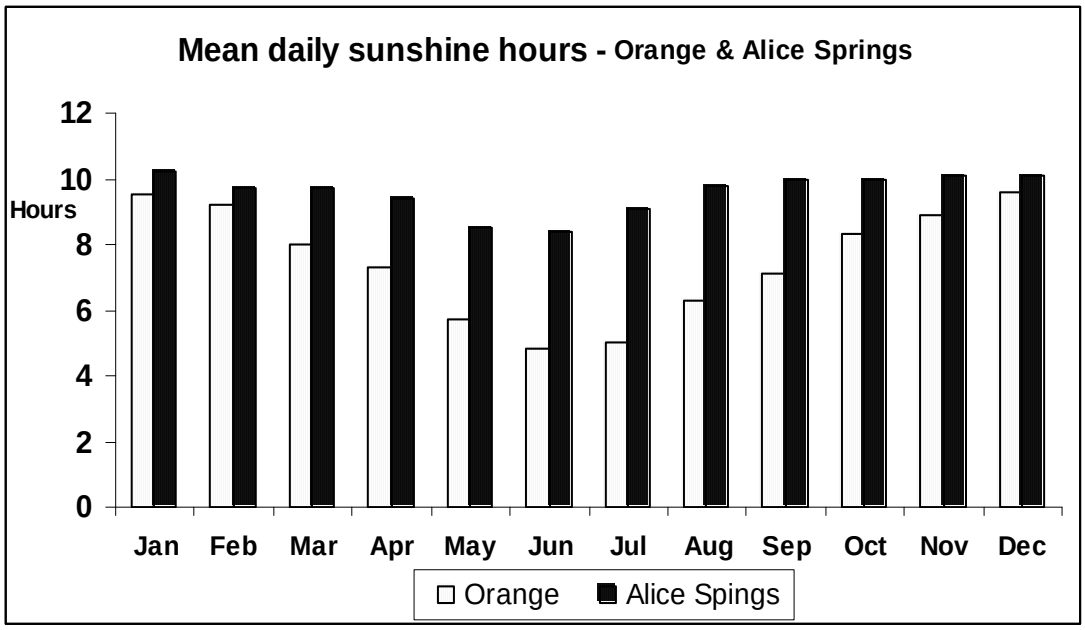
The solar radiation from the sun provides energy for our environment in a number of forms including as **heat** and as **light**. The heat of the sun provides temperatures we experience. It also provides warmth for biological processes such as germination, fruiting and seed setting in plants.

Light is also important as it provides the energy for photosynthesis – the process by which plants grow. Light is also important as it signals for plants to flower and for germination in some.

Light intensity and solar energy levels change through the year. As the sun moves closer in the summer time the day lengthens and we receive more light and heat. Solar radiation is reduced as we move back into winter when the sun is furthest from us.

Mean daily sunshine hours are a measure of the direct solar radiation received by a location. Cloudiness and shade can reduce this direct radiation.

Figure 4.4.8
Mean daily sunshine hours for Orange and compared to Alice Springs. (Bureau of Meteorology)

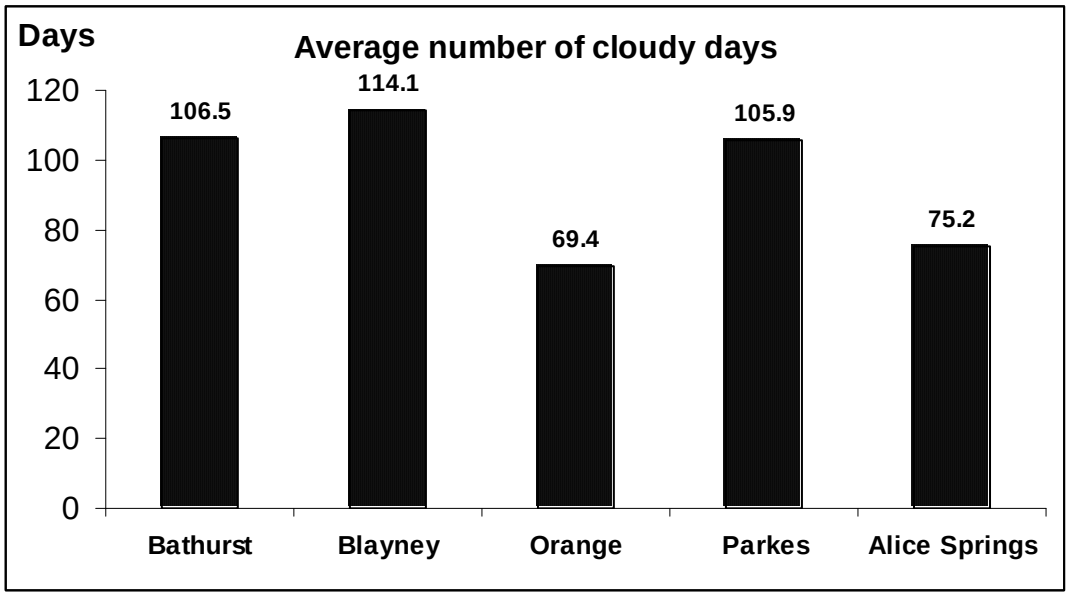


In summer Orange gets slightly less sunshine than Alice Springs but in winter the level of sunshine in Orange are considerably lower. This means Orange has reduced temperatures and less available light for plant photosynthesis than Alice Springs in winter. It also means less evaporation during this period.

Direct solar radiation is reduced by cloud cover. Different locations have different amounts of cloud cover which affects the amount of solar energy received. Cloudiness during daytime can reduce temperatures which can in turn slow plant growth and reduce evaporation. Conversely night time cloudiness can keep the environment warmer and so reduce the incidence of frost.

	Average Number of cloudy days
Bathurst	107
Blayney	114
Orange	69
Parkes	106
Alice Springs	75

Figure 4.4.9
Average number of cloudy days for selected sites in the district. (Bureau of Meteorology)



Of the selected locations in our district Blayney is the cloudiest followed by Bathurst and Parkes. Orange has on average less cloudy days than Alice Springs despite having more than three times the average annual rainfall.

Bibliography

- Bureau of Meteorology - Australia
  www.bom.gov.au
- NSW Wind Atlas – NSW Government
  www.seda.nsw.gov.au
- Soil Conservation Service of NSW Technical manuals (Orange & Bathurst)
- Permaculture: A designers manual. Bill Mollison.
- Agricultural Climatology: Tafe NSW learning guide.
- Australian Rainman: version 3.
- Plants in Agriculture; learning guide. University of Sydney- Orange.