

CLIMATE

CLIMATE IN VICTORIA

General conditions

Victoria is situated between latitudes 35° S and 39° S in the south-east of the Australian continent. The major topographical determinant of the climate is the Great Dividing Range, running east-west across the State, and rising to nearly 2,000 metres in the eastern half. This acts as a barrier to the moist south-east and south-west winds and together with its proximity to the coast, causes the south of the State to receive more rain than the north.

To the south of Victoria, except for Tasmania and its islands, there is no land for 3,000 kilometres. This vast area of ocean has a moderating influence on Victoria's climate in winter. Snow, which is a common winter occurrence at similar latitudes on the eastern seaboard of the great land masses of the northern hemisphere, is rare in Victoria below elevations of 600 metres. To the north of Victoria, the land mass of Australia becomes very hot in the summer, and on several days at this time of year the temperature over the State may rise to between 35°C and 40°C, often with a strong northerly wind.

Climatic divisions

Northern plains

The mean annual rainfall varies from below 300 mm in the northern Mallee to 500 mm on the northern slopes of the Great Dividing Range. Variability of rain from year to year is high and increases northwards. Average monthly rainfall totals range from 20 to 30 mm in the summer to between 30 and 50 mm during the colder six months – May to October.

Cold fronts bring rain to the Wimmera, particularly in winter, but have less effect in the Mallee and the Northern Country. Rain in these latter districts is usually brought by depressions moving inland from the region of the Great Australian Bight, or from depressions developing over New South Wales or northern Victoria itself.

Summers are hot with many days over 32°C, while winter nights can be very cold with widespread frost.

Highlands

The average annual rainfall depends on elevation, ranging from 500 mm in the foothills in the west to over 1,500 mm on the mountains in the east. The higher mountains are snow covered in the winter months. During the colder part of the year, essentially May to October, monthly rainfall is generally higher than for the remainder of the year. Pasture growth is limited by cold in winter and the main growth occurs in autumn and spring.

The lower valleys are subject to hot summer days but mean maximum temperature decreases by about 1°C per 200 metres elevation. Winter nights are very cold and the valleys are particularly prone to frost and fog.

Western districts

Most rain comes with the westerly winds and cold fronts that predominate in winter and the average rainfall shows a winter maximum which is most marked along the West Coast. Average annual rainfall ranges from less than 600 mm over the plains from Geelong to Lismore to over 1,400 mm on the higher parts of the Otways. Pasture growth is limited by dryness in summer and cold in winter; the main growth occurs in autumn and spring.

Sea breezes near the coast temper the heat on many summer days and on many occasions the sea breeze develops into a weak cold front which extends over most of the area. There are, however, a number of days when the temperature exceeds 31°C.

Gippsland

In West and South Gippsland most rain comes with the westerly winds and cold fronts that predominate in winter, but some rain also falls in summer from depressions over eastern New South Wales. The difference between winter and summer rainfall is not as marked as in the western districts.

Depressions off the east coast bring most rain to East Gippsland and such rainfall can be very heavy. The frequency of a three day rainfall over 75 mm is much greater in this district than elsewhere in Victoria. Rainfall in the east is fairly evenly distributed throughout the year.

Average annual rainfall is less than 600 mm in the Sale-Maffra area, which lies between the influence of western cold fronts and eastern depressions. Over the higher parts of the South Gippsland hills, the average annual rainfall exceeds 1,400 mm. Along the upper valleys of the Mitchell, Tambo, and Snowy Rivers, rainfall is much less than on the surrounding highlands.

Most of the closely settled areas are within reach of the sea breeze on summer days and the frequency of high temperatures is less than in other parts of Victoria of similar elevation.

On some winter days, however, the coastal areas of East Gippsland have the highest temperatures in the State, due to the Föhn effect of north-westerly winds descending from the mountains.

Weather patterns

The general weather of southern Australia is determined primarily by the behaviour of high pressure systems, which move from west to east on a more or less latitudinal track. The mean track is centred south of the continent from November to April, but is located between latitudes 30°S and 35°S from May to October. These anticyclones are separated by low pressure areas, which usually contain active frontal surfaces separating air masses of different characteristics. The low pressure areas are often rain bearing systems and their most northerly influence occurs in winter.

Rainfall in most districts is higher in winter and spring than in other seasons. This effect is most marked in the south-west quarter of the State, where the average rainfall in July is three times that of January. East Gippsland, however, receives little rain from cold fronts and depressions approaching from the west. The heaviest rain in that district is produced by intense depressions to the east of Bass Strait which have usually developed to the east of New South Wales or further north, and moved southwards along the coast. Rainfall in East Gippsland is fairly evenly distributed throughout the year.

On occasions, in late autumn, winter, or spring, an anticyclone develops a ridge of high pressure over southern waters and a depression intensifies east of Tasmania. This causes cold and relatively dry air to be brought rapidly across Victoria, bringing windy, showery weather with some hail and snow. On other occasions, when an anticyclone moves slowly over Victoria or Tasmania, a spell of fine weather with frost or fog results. These spells can last as long as a week.

In summer, the more southerly location of the anticyclone belt frequently brings a light easterly wind flow over Victoria with sea breezes near the coast. When anticyclones move into the Tasman Sea, where they sometimes stagnate for several days, winds tend north-east to northerly and sometimes increase in speed. This situation results in heat wave conditions, which persist until relieved by the west to south-west winds associated with the next oncoming depression. The fall in temperature associated with the wind change can be quite sharp.

The weather over south-eastern Australia in summer is occasionally influenced by the penetration of moist air of tropical origin. Although an infrequent event, this is responsible for some of the heaviest rainfalls over the State.

Rainfall

The distribution of average annual rainfall in Victoria is shown in Figure 17 on page 63. Average rainfall ranges from 250 mm for the driest parts of the Mallee to 2,600 mm at Falls Creek in the Alps. There would be other locations in the Alps with similar rainfall, where the rain is not measured.

Except for East Gippsland, more rain falls in winter than in summer. Summer rainfall is more variable and the higher evaporation of this season greatly reduces the effectiveness of the rainfall.

All parts of Victoria are occasionally subject to heavy rain and monthly totals exceeding three times the average have been recorded. Monthly totals have exceeded 250 mm on several occasions in Gippsland and the Northeast and, rarely, along the West Coast. The highest monthly total recorded in the State is 891 mm at Tanybryn in the Otway district in June 1952.

Intense rainfall of short duration is usually the result of a thunderstorm. On 17 February 1972, 78 mm fell within one hour over an area of about 3.5 square kilometres in central Melbourne. Falls of

similar intensity and duration occur from time to time in Victoria, but because such a small area is affected, not all are officially recorded.

The average annual number of days of rain (0.2 mm or more in 24 hours) is over 150 on the West Coast and in West Gippsland, and exceeds 200 over the Otway Ranges. The average number of wet days a year is reduced to 100 at a distance of approximately 160 kilometres inland from the coast.

An estimate of the distribution of average annual rainfall, and the actual distribution of rainfall in Victoria by districts are given in the following tables:

DISTRIBUTION OF AVERAGE AND ANNUAL RAINFALL, VICTORIA

Rainfall (mm)	Area ('000 square kilometres) (a)						
	Average	1978	1979	1980	1981	1982	1983
Under 300	18.4	3.3	0.1	24.4	17.3	104.1	2.0
300 and under 400	36.5	15.4	39.7	40.1	28.6	33.4	25.2
400 and under 500	27.5	45.8	63.3	26.4	30.4	33.5	31.1
500 and under 600	34.9	21.6	48.6	37.5	30.5	21.1	19.4
600 and under 800	52.3	43.7	44.1	49.8	58.8	24.4	65.8
800 to 1,000	29.0	38.3	29.5	25.6	29.2	9.2	48.9
Over 1,000	29.0	59.5	2.3	23.8	32.8	3.9	35.2

(a) Total area of Victoria is 227,600 square kilometres.

RAINFALL IN DISTRICTS, VICTORIA
(mm)

District	Year						Average (a)
	1978	1979	1980	1981	1982	1983	
North Mallee	381	385	274	339	112	392	307
South Mallee	441	416	322	378	123	437	354
North Wimmera	432	456	371	449	149	484	414
South Wimmera	531	580	505	556	230	605	501
Lower North	524	435	364	471	172	532	432
Upper North	646	504	459	618	222	630	516
Lower Northeast	955	678	705	1,008	377	935	775
Upper Northeast	1,258	950	1,004	1,278	534	1,124	1,103
East Gippsland	1,171	460	692	753	553	868	775
West Gippsland	1,206	759	939	874	628	988	913
East Central	1,081	752	853	874	647	887	890
West Central	877	499	545	628	349	680	611
North Central	839	717	700	797	403	832	719
Western Plains	729	583	592	607	333	722	630
West Coast	871	723	767	704	495	873	773

(a) Average for 71 years 1913 to 1983.

Rainfall reliability

It is not possible to give a complete description of rainfall at a place or in a district by using a single measurement. The common practice of quoting the annual average rainfall alone is quite inadequate in that it does not convey any idea of the extent of the variability likely to be encountered. Examination of rainfall figures over a period of years for any particular place indicates a wide variation from the average; in fact it is rare for any station to record the average rainfall in any particular year. Thus for a more complete picture of annual rainfall the variability, or likely deviation from the average, should be considered in conjunction with the average.

Rainfall variability assumes major importance in some agricultural areas. Even though the average rainfall may suggest a reasonable margin of safety for the growing of certain crops, this figure may be based on a few years of heavy rainfall combined with a larger number of years having rainfall below minimum requirements. Variability of rainfall is also important for water storage design, as a large number of relatively dry years would not be completely compensated by a few exceptionally wet years when surplus water could not be stored.

Although variability would give some indication of expected departures from normal over a number of years, variability cannot be presented as simply as average rainfall.

Several expressions may be used to measure variability, each of which may have a different magnitude. The simplest measure of variability is the range, i.e. the difference between the highest

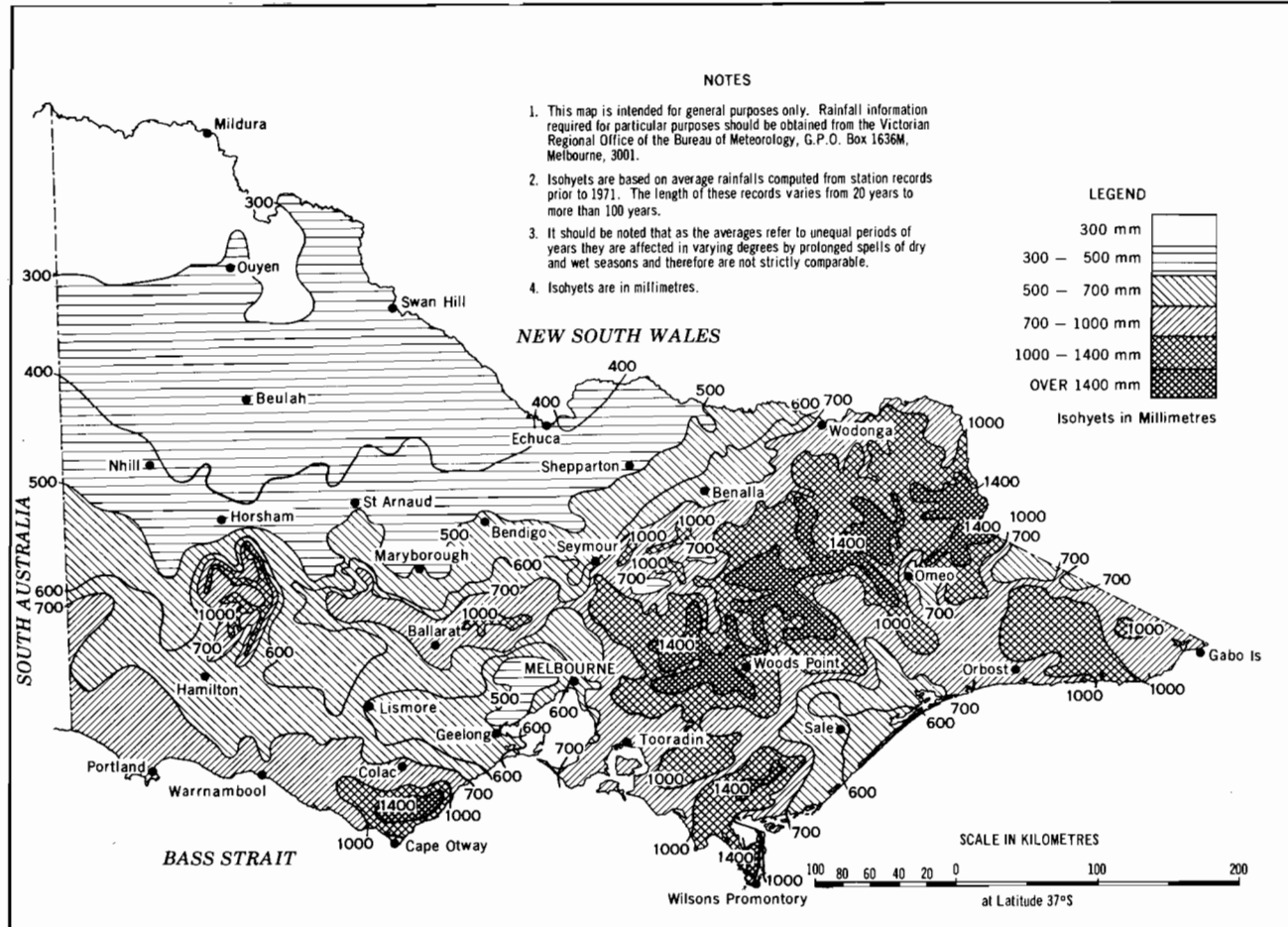


FIGURE 17. Average annual rainfall of Victoria.

Source: Bureau of Meteorology

and lowest annual amounts recorded in a series of years. Annual rainfall in Victoria is assumed to have a 'normal' statistical distribution. These distributions can be described fully by the average and the standard deviation. To compare the variability at one station with that at another, the percentage coefficient of variation ($\frac{\text{standard deviation}}{\text{the average}} \times 100$) has been used. This percentage coefficient has been calculated for the fifteen climatic districts of Victoria (see Figure 18 on page 66.) for the 71 years 1913 to 1983 and the results are tabulated in the following table in order of rainfall reliability:

ANNUAL RAINFALL VARIATION, VICTORIA

District	Average annual rainfall (a)	Standard deviation	Coefficient of variation
	mm	mm	per cent
1 West Coast	773	125	16.2
2 West Gippsland	913	149	16.4
3 East Central	890	147	16.6
4 Western Plains	630	115	18.3
5 West Central	611	124	20.2
6 East Gippsland	775	159	20.6
7 South Wimmera	501	111	22.1
8 North Central	719	164	22.8
9 North Wimmera	414	100	24.2
10 Upper Northeast	1,103	275	24.9
11 Lower Northeast	775	210	27.2
12 South Mallee	354	99	27.9
13 Upper North	516	146	28.2
14 Lower North	432	133	30.7
15 North Mallee	307	95	31.1

(a) Average for 71 years 1913 to 1983.

The higher the value of the percentage coefficient of variation of the rainfall of a district, the greater the possible departure from the average and hence the more unreliable the rainfall.

It should be noted that the above applies to *annual* rainfall. The assumption of a 'normal' statistical distribution is not generally applicable to periods of less than 12 months. Statistically, because of the highly skewed nature of monthly rainfall it is not possible to use the standard deviation as an indicator of variability; instead, decile analyses are preferred.

Droughts

The exact definition of drought is not specific in nature. A general term is 'severe water shortage', but a severe shortage of water for a large consumer, such as a market gardener, may not be of undue concern to a pastoralist.

Rainfall is the best single index of drought, although evaporation losses and storages in reservoirs must also be taken into account when determining the severity of a drought.

One advantage of assessing droughts on the basis of rainfall statistics is that records are available dating back for over 100 years at some locations, thus providing an objective basis for assessing drought severity. Studies based on drought effects on plants and animals, however, would be of a more subjective nature, due to technological advances in drought resistance.

The variability of annual rainfall is closely associated with the incidence of drought. Droughts are rare over areas of low rainfall variability and more common in areas where this index is high.

Since records have been taken, there have been numerous dry spells in various parts of Victoria, most of them of little consequence, but some widespread and long enough to be classified as droughts. The severity of major droughts or dry spells is much lower in Gippsland and the Western District than in northern Victoria.

The earliest references to drought in Victoria appear to date from 1865 when a major drought occurred in northern Victoria, and predominantly dry conditions prevailed in the Central District. Another dry spell of lesser intensity occurred in 1868.

The most severe and widespread drought recorded since European settlement in Australia occurred in the period from 1897 to 1902. Victoria was most affected in the south in 1897-98 and in the north in 1902.

The next major drought commenced about June 1913 and continued until April 1915 in the north and west and until August 1916 in Gippsland. The worst period was from May to October 1914.

DISTRICT MONTHLY RAINFALL,
NORMAL, VICTORIA
(mm)

District	Month												Annual
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
North Mallee —													
Normal	19	24	20	21	31	28	28	30	29	34	24	19	307
1982	17	5	18	15	7	22	3	4	12	3	3	3	112
1983	2	0.9	73	17	27	13	48	47	39	39	27	59	392
South Mallee —													
Normal	21	26	23	25	36	32	34	36	34	38	27	22	354
1982	19	2	24	14	11	21	4	7	6	5	5	5	123
1983	4	4	96	16	37	17	49	53	57	33	29	42	437
North Wimmera —													
Normal	23	26	23	30	42	41	44	45	42	42	31	25	414
1982	25	5	26	17	16	21	7	7	9	6	4	6	149
1983	5	0.1	91	32	49	23	55	58	72	31	45	23	484
South Wimmera —													
Normal	25	29	25	37	53	51	57	58	51	50	37	28	501
1982	30	11	27	21	32	34	18	13	18	12	7	7	230
1983	7	3	83	47	77	34	71	79	87	34	67	16	605
Lower North —													
Normal	28	29	31	31	43	41	42	44	41	45	30	27	432
1982	32	0.2	36	16	20	22	4	6	12	9	6	9	172
1983	7	1	95	44	69	25	78	56	69	27	33	28	532
Upper North —													
Normal	33	34	36	39	50	50	52	54	49	51	36	32	516
1982	40	2	46	17	28	24	10	9	18	11	5	12	222
1983	8	3	66	59	95	35	101	70	89	39	46	19	630
Lower Northeast —													
Normal	44	43	51	56	73	80	85	86	72	78	55	52	775
1982	50	1	74	27	61	39	17	17	51	11	6	23	377
1983	12	24	81	82	134	67	122	120	119	64	68	42	935
Upper Northeast —													
Normal	56	54	66	79	108	115	127	132	106	110	80	70	1,103
1982	82	6	87	35	83	45	27	30	68	24	14	33	534
1983	33	14	81	91	144	85	136	128	169	76	121	46	1,124
East Gippsland —													
Normal	64	54	64	61	67	69	59	59	61	74	72	71	775
1982	80	3	134	27	25	55	61	11	52	46	10	49	553
1983	40	16	85	102	147	31	78	72	76	110	57	54	868
West Gippsland —													
Normal	56	55	68	72	88	82	79	90	84	91	80	68	913
1982	71	9	108	52	87	48	33	23	90	48	24	35	628
1983	46	10	110	80	151	100	63	61	137	108	89	33	988
East Central —													
Normal	51	54	61	74	87	76	80	88	84	92	78	65	890
1982	68	10	66	78	89	60	35	34	79	52	21	55	647
1983	39	3	64	65	102	91	77	89	121	111	96	29	887
West Central —													
Normal	36	45	42	48	55	51	53	60	59	64	53	45	611
1982	44	5	43	28	37	29	16	20	40	26	10	51	349
1983	18	6	67	54	85	44	77	53	90	102	72	12	680
North Central —													
Normal	38	43	42	54	71	71	78	82	71	70	53	46	719
1982	53	3	62	36	47	43	21	22	39	21	18	38	403
1983	16	3	67	62	116	64	125	96	108	69	87	19	832
Western Plains —													
Normal	34	38	37	50	60	55	63	70	64	63	54	42	630
1982	32	6	42	28	44	35	25	15	40	28	13	25	333
1983	18	1	79	55	105	65	71	81	99	65	76	7	722
West Coast —													
Normal	35	37	45	62	78	77	90	94	79	71	60	45	773
1982	36	8	50	43	74	69	44	22	57	45	16	31	495
1983	34	0.7	117	76	103	94	83	88	131	50	83	13	873

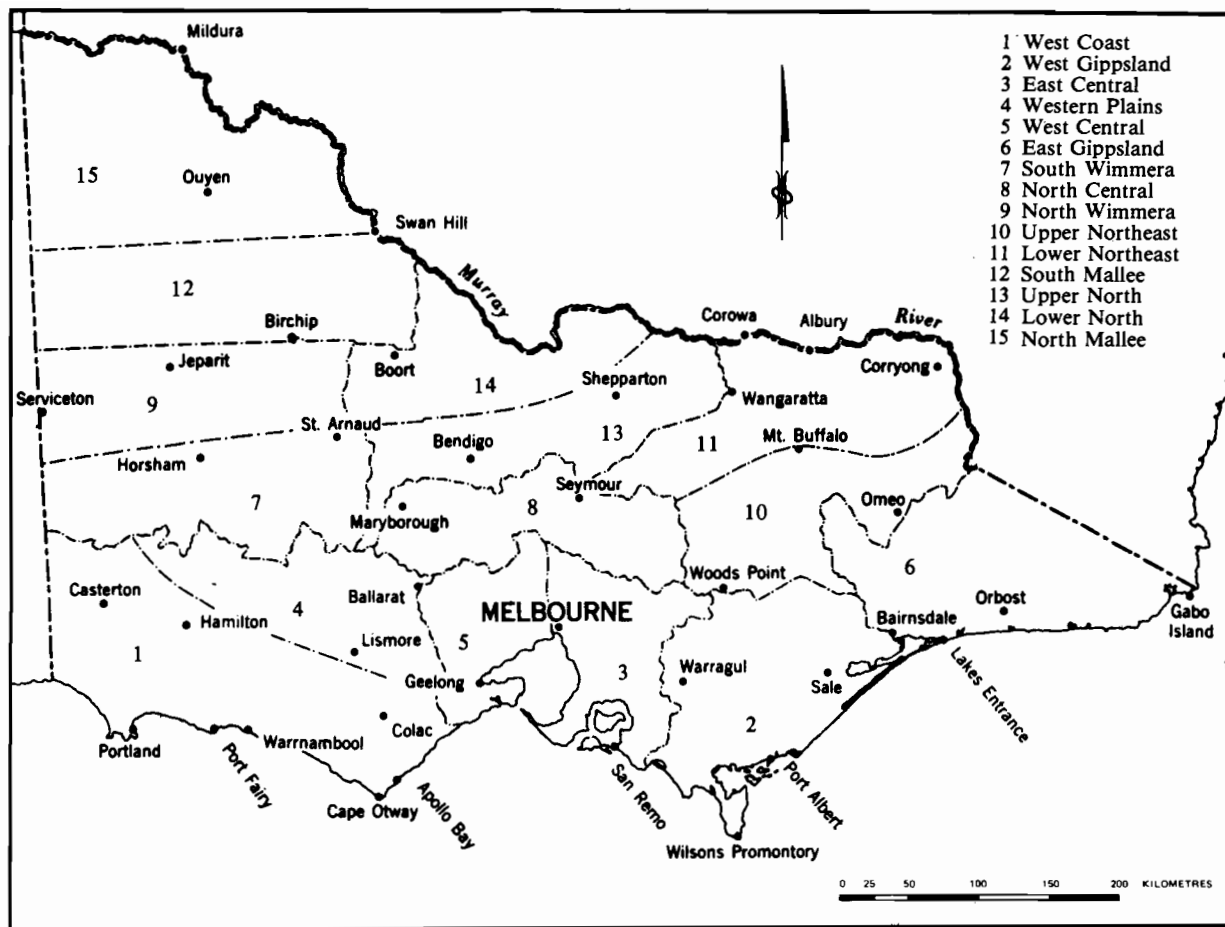


FIGURE 18. Rainfall districts, Victoria.

Source: Bureau of Meteorology

Droughts of shorter duration and lower intensity occurred in 1877, 1888, in 1907-08 in Gippsland, and in the 1920s, particularly in 1925, 1927, and 1929.

The period from 1937 to 1945 was marked by three major droughts. The first commenced in February 1937 and continued with a break in the succeeding spring and summer until January 1939, the effects being felt much more severely in northern districts than elsewhere. Good rains in 1939 were followed by another dry period from December 1939 to December 1940. The third drought of the period extended from 1943 to 1945 in which the worst period was from June to October 1944. The drought from 1967 to 1968 is described on pages 53 and 67 of the *Victorian Year Book* 1969 and other effects noted on pages 309-12 of the *Victorian Year Book* 1970.

Drought prevailed in East Gippsland in 1971. In 1972, this drought extended westwards to affect most parts of the State by the end of the year, before ending after heavy rain in February 1973.

Northern Victoria experienced drought conditions for about ten months until September 1975, while in 1976 the failure of summer and early autumn rains in the south led to severe rainfall deficiencies, particularly in South Gippsland. The drought had extended to most of Victoria before ending with good rains in September and October. Large sections of Victoria experienced serious to severe deficiencies during the latter half of 1977 and the first five months of 1978. Drought conditions prevailed in north-east Victoria in the latter half of 1979. However, good rainfall in January 1980 provided some relief from these rainfall deficiencies. Rain in the latter half of April was sufficient to break the five month drought in most of Victoria, but not in Gippsland. It was not until good rain was received in October that the eight month drought was broken in East Gippsland.

Drought conditions were experienced throughout Victoria during the period commencing April 1982 and continuing into 1983. The drought was extremely severe in all districts north of the Great Dividing Range where rainfall totals for the eleven months from April 1982 to February 1983 were the lowest ever recorded. Southern Victoria fared only slightly better with serious to severe rainfall deficiencies occurring generally. Rainfall during March 1983 significantly reduced the extent of the drought, particularly in western Victoria. During April, the drought area contracted in the north-east, but much of central and eastern Victoria was still rainfall deficient. By the end of May, the only drought areas remaining were in central Victoria and in the far north-west. This situation persisted until September 1983.

Floods

Lands bordering rivers, lakes, and coastal regions have historically attracted settlement and development. These areas, known as 'flood-plains', are susceptible to occasional inundation, and depending on their extent of development, extensive damage to property and even loss of life may result. The realisation of this danger has led man to attempt to reduce the effect of flood damage by means such as the construction of dams and discouragement of development in certain areas. However, it should be recognised that as floods are a natural phenomenon, they have major beneficial as well as detrimental effects. The very existence of fertile flood plains depends on the occurrence of floods.

Flooding occurs in all districts but is most frequent in the Northeast and in Gippsland. The occurrence of flooding in place and time is highly variable since it depends on the location and intensity of rainfall. In general, in Victoria, flooding is most likely in late winter or early spring, since this is the time of maximum rainfall and maximum catchment wetness, but floods can occur at any time of the year. On many streams, particularly in East Gippsland, some of the most severe floods have been in January or February.

The extent and effect of flooding is dependent not only on rainfall but also on topography, land-use, water control structures, and the location of towns.

All districts of Victoria have experienced disastrous flooding, although it is relatively unusual for major floods to occur on several catchments at once. East Gippsland suffered major flooding in 1971. In 1973, 1974, 1975, 1981, and 1983, widespread flooding, varying from moderate to major, occurred throughout Victoria, particularly in the Northern, Northeast, West Central, and East Gippsland Districts. In 1978, major flooding occurred on most rivers in East Gippsland.

Snow

Snow in Victoria is confined usually to the Great Dividing Range and the alpine massif, which at intervals during the winter and early spring months may be covered to a considerable extent, especially over the more elevated eastern section. Falls elsewhere are usually light and infrequent. Snow has been recorded in all districts except the Mallee. The heaviest falls in Victoria are confined to

sparsely populated areas and hence general community disorganisation is kept to a minimum. Snow has been recorded in all months on the higher Alps, but the main falls occur during the winter. The average duration of the snow season in the alpine area is from three to five months.

Temperatures

January and February are the hottest months of the year. Average maximum temperatures are under 20°C on the higher mountains and under 24°C along the coast, but exceed 32°C in parts of the Mallee.

Average maximum temperatures are lowest in July, when they are below 10°C over most of the Great Dividing Range, and less than 3°C on the higher mountains. Over the lower country there is little variation across the State, ranging from 13°C near the coast to 16°C in the northern Mallee.

In summer, high temperatures may be experienced throughout the State except over the alpine area. Most inland places have recorded maxima over 43°C with an all time extreme for the State of 50.8°C at Mildura on 6 January 1906. Usually such days are the culmination of a period during which temperatures gradually rise, and relief comes sharply in the form of a cool change when the temperature may fall as much as 17°C in an hour. However, such relief does not always arrive so soon and periods of two or three days or even longer have been experienced when the maximum temperature has exceeded 38°C. On rare occasions, extreme heat may continue for as long as a week with little relief.

Night temperatures, as gauged by the average minimum temperature, are, like the maximum, highest in January and February. They are below 9°C over the higher mountains, but otherwise the range is chiefly 13°C to 15°C. The highest night temperatures are recorded along the Murray River and on the East Gippsland coast. Average July minima exceed 6°C along parts of the coast, but are below 0°C in the Alps. Although three or four stations have been set up at different times in the mountains, none has a very long or satisfactory record. The lowest temperature on record to date is -12.8°C at Hotham Heights (station height 1,760 metres) at an exposed location near a mountain. However, a minimum of -22.2°C has been recorded at Charlotte Pass (station height 1,840 metres) — a high valley near Mt Kosciusko in New South Wales — and it is reasonable to expect that similar locations in Victoria would experience similar temperatures, although none has been recorded due to lack of observing stations.

Frosts

Frosts may occur at any time of the year over the ranges of Victoria, whereas along the exposed coasts frosts are rare and severe frosts (air temperature 0°C or less) do not occur. Frost, however, can be a very localised phenomenon, dependent on local topography. Hollows may experience frost, while the surrounding area is free of frost.

The average frost-free period is less than 50 days over the higher ranges of the Northeast while it exceeds 200 days within 80 kilometres of the coast and north of the Divide. The average number of severe frosts (air temperature 0°C or less) exceeds 20 per year over the ranges. The average number of light frosts (air temperature between 0°C and 2°C) varies from less than 10 per year near the coast to 50 per year in the highlands of the Northeast.

The first frosts of the season may be expected in April in most of the Mallee and Northern Country and in March in the Wimmera. Over the highlands of the Northeast, frosts may be severe from March to November. Severe frosts on the northern side of the Divide are twice as frequent as on the southern side at the same elevation.

Humidity

Generally, humidity in the lower atmosphere is much less over Victoria than over other eastern States. This is because the extreme south-east of the continent is mostly beyond the reach of tropical and sub-tropical air masses. The most humid weather in Victoria occurs when light north-easterly winds persist for several days in summer, bringing moist air from the Tasman Sea or from further north. On these occasions the dew point can rise to 20°C.

When northerly winds blow over Victoria in summer and dry air arrives from central Australia, the dew point can fall to 0°C or lower. When combined with high temperatures, the relative humidity can fall below 10 per cent. The cold air which arrives over the State from the far south from time to time in winter can also be very dry, with a dew point of about 3°C.

Evaporation

Since 1967, the Class A Pan has been the standard evaporimeter used by the Bureau of Meteorology. This type is now used exclusively at evaporation recording stations in Victoria; there were 72 at

the end of 1983, 48 of which were owned by the Bureau of Meteorology, compared with 73 and 48, respectively, for 1982.

Measurements of evaporation have been made in the past with the Australian tank at about 30 stations, about half of which were owned by the Bureau of Meteorology. Results from these stations show that evaporation exceeds the average annual rainfall in inland areas, especially in the north and north-west, by about 1,000 mm. In all the highland areas and the Western District the discrepancy is much less marked, and in the Central District and the lowlands of East Gippsland annual evaporation exceeds annual rainfall by 200 mm to 400 mm. Evaporation is greatest in the summer months in all districts. In the three winter months rainfall exceeds evaporation in many parts of Victoria, but not in the north and north-west.

Winds

The predominant wind stream over Victoria is of a general westerly direction, although it may arrive over the State from the north-west or south-west. Easterly winds are least frequent over Victoria, but are often associated with widespread rain in Gippsland. There are, however, wide variations from this general description. For example, Melbourne has a predominance of northerlies and southerlies, while Sale has an easterly sea breeze on most summer afternoons.

The wind is usually strongest during the day, when the air in the lower atmosphere is well mixed. As the ground cools after sunset, stratification of the air above it takes place, and the wind near the surface dies down. In valleys, however, the cooler air near the ground begins to flow down the slope, and the valley or katabatic breeze may blow through the night, to die down after sunrise.

At the surface of the earth the wind is rarely steady, particularly over land where there are obstructions to its flow. In the central areas of large cities, where there are tall buildings, there are many gusts and eddies. The mean wind speed for meteorological purposes is taken as the average over a period of ten minutes. In this time the actual speed can vary considerably, reaching much higher levels in gusts which last for only a few seconds.

The sensitive equipment required to measure extreme wind gusts has been installed at only a few places in Victoria and the highest gust recorded to date is 164 km/h at Point Henry near Geelong in 1962, although here the anemometer is 23 metres above ground level compared to the standard 10 metres for meteorological anemometers. It is considered that any place in Victoria could feasibly experience at some time a local gust of 160 km/h or more. Two diagrams of wind roses for Victoria at 9 a.m. and 3 p.m., respectively, are shown on pages 78 and 79 of the *Victorian Year Book* 1980.

Thunderstorms

Thunderstorms occur far less frequently in Victoria and Tasmania than in the other two eastern States. They occur mainly in the summer months when there is adequate surface heating to provide energy for convection. Between ten and twenty storms occur each year in most of Victoria, but the annual average is about thirty in the north-eastern ranges. Isolated severe wind squalls and tornadoes sometimes occur in conjunction with thunderstorm conditions, but these destructive phenomena are comparatively rare. Hailstorms affect small areas in the summer months, and showers of small hail are not uncommon during cold outbreaks in the winter and spring.

CLIMATE IN MELBOURNE

General conditions

Temperature

The proximity of Port Phillip Bay bears a direct influence on the climate of the metropolitan area. The hottest months in Melbourne are normally January and February, when the average maximum temperature is 26°C. Inland, Watsonia has an average of 27°C, while along the Bay, Aspendale and Black Rock, subject to any sea breeze, have an average of 25°C. This difference does not persist throughout the year, however, and in July average maxima at most stations are within 1°C of one another at approximately 13°C. The hottest day on record in Melbourne was 13 January 1939, when the temperature reached 45.6°C. This is the second highest temperature ever recorded in an Australian capital city. In Melbourne, the average number of days per year with maxima over 38°C is about four, but there were fifteen in the summer of 1897-98 and there have been a few years with no occurrences. The average annual number of days over 32°C is approximately nineteen.

Nights are coldest at places a considerable distance from the sea, and away from the city where heat retention by buildings, roads, and pavements may maintain the air at a slightly higher temperature.

MEANS OF CLIMATIC ELEMENTS, SELECTED VICTORIAN TOWNS

	Locality	Legend (a)	Years of record	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
MALLEE	Mildura	1	37	19	23	22	22	28	23	26	27	27	33	25	20	295
		2	37	32.1	31.2	28.1	23.3	18.8	15.8	15.3	17.2	20.2	23.5	27.1	30.0	23.5
		3	37	16.7	16.5	14.0	10.2	7.5	5.1	4.3	5.4	7.3	9.8	12.2	14.7	10.3
	Swan Hill	1	99	22	23	24	25	34	36	32	35	32	35	26	24	348
		2	83	31.5	31.3	27.8	22.8	18.3	14.8	14.5	16.3	19.4	22.9	26.9	30.0	23.0
		3	81	15.4	15.4	12.9	9.7	6.9	4.7	4.0	4.9	6.6	8.9	11.6	13.8	9.6
WIMMERA	Horsham	1	109	22	26	25	34	48	50	46	48	46	44	34	27	450
		2	77	29.9	29.8	26.5	21.4	17.1	13.9	13.3	15.0	17.7	20.9	24.8	27.8	21.5
		3	76	13.4	13.6	11.5	8.6	6.3	4.5	3.7	4.5	5.7	7.5	9.7	11.9	8.4
	Nhill	1	97	22	23	23	31	41	47	46	47	43	41	31	27	422
		2	79	29.7	29.4	26.3	21.5	17.3	14.2	13.6	15.1	17.8	21.0	24.8	27.9	21.6
		3	80	12.9	13.3	11.0	8.4	6.2	4.2	3.4	4.1	5.4	7.2	9.4	11.6	8.1
WESTERN	Ballarat	1	75	37	46	46	54	70	64	68	77	73	71	57	50	713
		2	74	25.0	24.9	22.0	17.4	13.4	10.6	9.9	11.3	13.8	16.5	19.4	22.4	17.2
		3	75	10.9	11.8	10.1	7.6	5.9	4.1	3.4	3.9	5.0	6.4	7.8	9.6	7.2
	Hamilton	1	109	33	32	43	55	69	72	74	77	73	66	52	45	691
		2	93	25.7	25.7	23.0	18.8	15.3	12.7	12.0	13.2	15.4	17.7	20.6	23.3	18.6
		3	93	11.4	12.0	10.6	8.6	6.9	5.2	4.5	5.0	6.1	7.2	8.5	10.1	8.0
NORTHERN	Warrnambool	1	85	33	34	48	60	78	77	88	86	74	67	55	44	744
		2	82	22.2	22.3	21.1	18.6	16.1	13.9	13.3	14.1	15.7	17.4	19.0	20.7	17.8
		3	82	12.8	13.3	12.3	10.4	8.7	6.9	6.2	6.7	7.7	9.0	10.1	11.6	9.6
	Bendigo	1	122	33	33	37	41	54	61	56	57	55	53	38	32	550
		2	119	29.4	29.1	25.9	20.9	16.1	12.9	12.1	13.9	16.7	20.3	24.1	27.3	20.7
		3	116	14.1	14.4	12.4	9.1	6.5	4.7	3.7	4.4	6.0	8.1	10.4	12.4	8.8
	Echuca	1	104	27	27	34	34	42	44	40	43	40	43	32	28	434
		2	101	30.8	30.5	27.2	22.1	17.5	14.1	13.4	15.2	18.3	22.0	26.0	29.0	22.2
		3	101	15.2	15.3	13.1	9.5	6.8	4.9	4.0	5.0	6.5	8.9	11.3	13.6	9.5

MEANS OF CLIMATIC ELEMENTS, SELECTED VICTORIAN TOWNS — *continued*

	Locality	Legend (a)	Years of record	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
NORTH CENTRAL	Alexandra	1	104	41	37	51	53	65	72	71	75	67	70	57	48	707
		2	48	29.3	29.3	26.0	20.5	15.8	12.0	11.7	13.8	17.0	20.3	23.8	27.3	20.6
		3	48	11.2	11.7	9.4	6.3	4.3	2.9	2.5	2.9	4.4	6.0	8.0	9.9	6.6
	Kyneton	1	95	37	39	47	54	75	90	82	84	74	69	52	50	753
		2	78	27.0	26.6	23.5	18.2	13.8	10.7	9.9	11.6	14.7	17.9	21.4	24.9	18.2
		3	71	9.9	10.3	8.5	5.7	3.6	2.3	1.6	2.0	3.4	4.9	6.6	8.6	5.6
CENTRAL	Geelong	1	99	31	37	41	45	50	49	46	48	51	52	48	40	538
		2	77	25.1	25.0	23.2	19.9	16.7	14.1	13.6	14.9	16.9	19.1	21.3	23.4	19.4
		3	78	13.3	13.9	12.5	10.2	8.0	6.0	5.1	5.7	6.9	8.4	10.1	11.9	9.3
	Mornington	1	97	45	43	52	63	71	70	69	71	71	71	58	52	736
		2	43	25.0	25.0	23.3	19.4	16.2	13.5	12.8	13.8	15.9	18.1	20.3	23.1	18.9
		3	40	13.4	13.9	12.9	10.9	9.1	7.1	6.5	6.8	8.1	9.5	10.7	12.1	10.1
NORTHEAST	Omeo	1	104	52	52	55	47	54	57	52	56	61	72	63	61	682
		2	102	26.2	25.9	23.1	18.6	14.1	10.7	10.1	12.1	15.2	18.5	21.7	24.4	18.4
		3	102	9.5	9.6	7.9	4.9	2.2	0.8	-0.2	0.6	2.7	4.7	6.4	8.3	4.8
	Wangaratta	1	106	37	39	47	47	56	71	64	64	61	63	46	42	637
		2	81	31.0	30.7	27.3	22.0	17.3	13.6	12.7	14.5	17.7	21.1	25.3	28.9	21.8
		3	81	15.0	15.1	12.3	8.3	5.5	3.8	3.3	4.1	5.9	8.2	10.7	13.3	8.8
EAST GIPPSLAND WEST GIPPSLAND	Yallourn	1	34	51	52	60	62	94	77	80	92	90	86	82	66	892
		2	34	24.8	24.7	22.5	18.7	14.8	12.5	11.8	13.1	15.3	17.7	19.7	22.3	18.1
		3	33	12.7	13.3	12.2	9.6	7.5	5.7	4.7	5.4	6.6	8.3	9.7	11.2	8.9
	Sale	1	40	48	41	57	45	61	48	39	53	51	64	61	57	625
		2	38	25.3	25.2	23.4	20.1	16.5	14.0	13.6	14.8	16.8	19.0	21.0	23.2	19.4
		3	38	12.6	13.2	11.6	8.6	6.2	4.2	3.1	4.1	5.5	7.6	9.3	11.2	8.1
	Bairnsdale	1	65	60	50	67	50	54	58	50	49	57	70	64	68	697
		2	65	24.6	24.7	23.0	20.3	17.0	14.3	13.8	15.3	17.4	19.6	21.7	23.4	19.6
		3	64	12.3	12.6	11.2	8.5	6.0	4.2	3.4	4.1	5.9	7.7	9.4	11.2	8.0
	Orbost	1	100	70	58	69	73	75	85	66	60	69	78	68	77	848
		2	44	25.3	25.2	23.7	20.8	17.5	15.0	14.7	15.7	17.7	19.7	21.3	23.6	20.0
		3	45	13.0	13.5	12.0	9.3	6.9	5.1	4.0	4.7	6.1	8.3	10.1	11.7	8.7

(a) Legend: 1. Average monthly rainfall in mm (for all available years of record to 1983).
 2. Average daily maximum temperature (°C) (for all available years of record to 1983).
 3. Average daily minimum temperature (°C) (for all available years of record to 1983).

The lowest temperature ever recorded in the city was -2.8°C on 21 July 1869, and the highest minimum ever recorded was 30.6°C on 1 February 1902.

In Melbourne the overnight temperature remains above 20°C on about four nights per year. During the early years of record, temperatures below 0°C were recorded during most winters. However, over more recent years, the urban 'heat island' effect has resulted in such low temperatures occurring only once in two years on average. Minima below -1°C have been experienced during the months of May to August, while even as late as October extremes have been down to 0°C . During the summer, minima have never been below 4°C .

Wide variations in the frequencies of occurrences of low air temperatures are noted across the Melbourne metropolitan area. For example, there are approximately ten annual occurrences of 2°C or less around the Bay, but frequencies increase to over twenty in the outer suburbs and probably to over thirty a year in the more frost susceptible areas. The average frost-free period is about 200 days in the outer northern and eastern suburbs, gradually increasing to over 250 days towards the city, and approaching 300 days along parts of the bayside.

The means of the climatic elements for the seasons in Melbourne, computed from all available official records, are given in the following table:

MEANS OF CLIMATIC ELEMENTS, MELBOURNE

Meteorological element	Spring	Summer	Autumn	Winter
Mean atmospheric pressure (millibar)	1,014.9	1,013.2	1,018.3	1,018.4
Mean temperature of air in shade ($^{\circ}\text{C}$)	14.4	19.4	15.4	10.2
Mean daily range of temperature of air in shade ($^{\circ}\text{C}$)	10.2	11.5	9.5	7.7
Mean relative humidity at 9 a.m. (saturation = 100)	64	62	72	79
Mean rainfall (mm)	186	154	169	148
Mean number of days of rain	40	25	34	44
Mean amount of evaporation (mm) (a)	371	590	293	145
Mean daily amount of cloudiness (scale 0 to 8) (b)	4.9	4.2	4.8	5.1
Mean daily hours of sunshine (c)	6.5	8.4	5.5	4.6
Mean number of days of fog	1.4	0.6	5.9	10.7

(a) Measured by Class A Pan (records commenced 1967).

(b) Scale: 0 = clear, 8 = overcast.

(c) Measured at Laverton (records commenced 1968).

In the following table the yearly means of the climatic elements in Melbourne for each of the years 1978 to 1983 are shown. The extreme values of temperature in each year are also included.

YEARLY MEANS AND EXTREMES OF CLIMATIC ELEMENTS, MELBOURNE

Meteorological element	1978	1979	1980	1981	1982	1983
Mean atmospheric pressure (millibar)	1,016.4	1,016.9	1,016.4	1,015.1	1,018.8	1,017.7
Mean temperature of air in shade ($^{\circ}\text{C}$) —						
Mean	15.0	15.8	15.9	16.1	15.7	15.4
Mean daily maximum	19.2	20.3	20.4	20.6	20.5	19.6
Mean daily minimum	11.0	11.3	11.3	11.6	10.8	11.2
Absolute maximum	38.1	41.3	41.4	41.8	43.3	43.2
Absolute minimum	2.6	1.2	1.5	2.1	-0.8	0.0
Mean terrestrial minimum temperature ($^{\circ}\text{C}$)	9.1	9.4	9.4	9.4	8.6	9.2
Number of days maximum 35°C and over	5	10	14	16	19	15
Number of days minimum 2°C and under	0	2	1	0	8	3
Rainfall (mm)	867	543	644	602	422	612
Number of days of rain	148	151	149	138	101	143
Total amount of evaporation (mm) (a)	1,254	1,320	1,352	1,341	1,379	1,167
Mean relative humidity at 9 a.m. (saturation = 100)	72	69	67	69	69	72
Mean daily amount of cloudiness (scale 0 to 8) (b)	5.2	5.1	4.8	4.7	4.4	4.9
Mean daily hours of sunshine (c)	5.8	6.1	6.5	6.8	6.9	6.0
Mean daily wind speed (km/h)	8.1	7.7	(d)	(e)	9.0	9.0
Number of days of wind gusts 63 km/h and over	32	42	(d) 59	(e) 48	39	40
Number of days of fog	7	8	10	3	11	9
Number of days of thunder	15	10	6	12	10	6

(a) Evaporation measured by Class A Pan.

(b) Scale: 0 = clear, 8 = overcast.

(c) Sunshine measured at Laverton.

(d) Incomplete, records for June not available.

(e) Incomplete, records for October not available.

Rainfall

The average annual rainfall in the city is 657 mm over 143 days. The average monthly rainfall varies from 48 mm in January and July to 68 mm in October. Rainfall is relatively steady during the winter

months, and observed totals have ranged from 8 mm to 180 mm, but variability increases towards the warmer months. In the latter period, monthly totals have ranged between practically zero and over 230 mm.

Over 75 mm of rain has been recorded in 24 hours on several occasions, but these have been restricted to the warmer months – December to April. Only three times has over 50 mm during 24 hours been recorded in the cooler months of May to August.

The average rainfall varies considerably over the Melbourne metropolitan area. The western suburbs are relatively dry and Deer Park has an average annual rainfall of only 500 mm. Rainfall increases towards the east, and at Mitcham averages 900 mm a year. The rainfall is greater still on the Dandenong Ranges, and at Sassafras the annual average is over 1,300 mm.

The number of days of rain, defined as days on which 0.2 mm or more of rain falls, exhibits marked seasonal variation ranging between a minimum of seven in February and a maximum of fifteen each in July and August. This is in spite of approximately the same total rainfall during each month and indicates the higher intensity of the summer rains. The relatively high number of days of rain in winter gives a superficial impression of a wet winter in Melbourne which is not borne out by an examination of total rainfall.

The highest number of wet days ever recorded in any one month in the city is twenty-seven, in August 1939. On the other hand, there has been only one rainless month in the history of Melbourne's records – April 1923. On occasions, each month from November to May has recorded three wet days or less. The longest wet spell ever recorded was eighteen days and the longest dry spell forty days.

Fogs

Fogs occur on an average of four mornings each month in May, June, and July, and average nineteen days for the year. The highest number ever recorded in a month was twenty in June 1937.

Cloud and sunshine

Cloudiness varies between a minimum in the summer months and a maximum in the winter, but the range, like the rainfall, is not great compared with many other parts of Australia. The number of clear days or nearly clear days averages two to three each month from May to August, but increases to a maximum of six to seven in January and February. The total number for the year averages forty-eight. The high winter cloudiness and shorter days have a depressing effect on sunshine in winter and average daily totals of four to five hours during this period are the lowest of all capital cities except Hobart which is marginally less. There is a steady rise towards the warmer months as the days become longer and cloudiness decreases. An average of more than eight and a half hours a day is received in January; however, the decreasing length of the day is apparent in February, since the sunshine is then less despite a fractional decrease in cloudiness. The total possible monthly sunshine hours at Melbourne range between 465 hours in December and 289 in June under cloudless conditions. The average monthly hours, expressed as a percentage of possible hours, range between 60 per cent for January and February and 40 per cent in June.

Wind

Wind exhibits a wide degree of variation, both diurnally, such as results from a sea breeze, and as a result of the incidence of storms. The speed is usually lowest during the night and early hours of the morning just prior to sunrise, but increases during the day, especially when strong surface heating induces turbulence into the wind stream, and usually reaches a maximum during the afternoon. The greatest mean wind speed at Melbourne for a 24 hour period was 36.9 km/h, while means exceeding 30 km/h are on record for each month except March. These are mean values; the wind is never steady. Continual oscillations take place ranging from lulls, during which the speed may drop to or near zero, to strong surges which may contain an extreme gust, lasting for a period of only a few seconds up to or even over 95 km/h. At the Melbourne observing site, gusts exceeding 95 km/h have been registered during every month with a few near or over 110 km/h, and an extreme of 119 km/h on 18 February 1951. At Essendon, a wind gust of 143 km/h has been measured.

Thunder, hail, and snow

Thunder is heard in Melbourne on an average of 13 days per year, the greatest frequency being in the summer months. On rare occasions thunderstorms are severe, with damaging wind squalls. Hail can fall at any time of the year, but the most probable time of occurrence is from August to November.

Most hail is small and accompanies cold squally weather in winter and spring, but large hailstones may fall during thunderstorms in summer.

Snow has occasionally fallen in the city and suburbs; the heaviest snowstorm on record occurred on 31 August 1849. Streets and house-tops were covered with several centimetres of snow, reported to be 30 centimetres deep at some places. When thawing set in, floods in Elizabeth and Swanston Streets stopped traffic and caused accidents, some of which were fatal.

VICTORIAN WEATHER SUMMARY, 1982 AND 1983

Temperature

Average monthly maximum temperatures show that all districts were close to normal or above normal for 1982, with January, August, and November accounting for most of the warmer readings. August was particularly warm, with a maximum temperature generally two to three degrees above normal. In Melbourne, the temperature reached, or exceeded, 35°C on 19 days and the only years with a greater number of days were 1898 (26 days), and 1940 and 1968 (20 days).

Monthly mean temperatures throughout Victoria were normal to below normal over 1983, apart from a small area in the Northeast recording above normal conditions. February was much above normal with mean maximum departures of two to four degrees and in a few places exceeding five degrees. This was largely offset by generally below normal temperatures in April. Melbourne experienced its hottest February day on record with a temperature of 43.2°C on 8 February. During 1983, there were 31 days when the temperature in Melbourne reached 30°C, the highest number of days since 1978 (21 days).

Rainfall

The year 1982 was the driest or second driest on record in all districts in the north and west of Victoria. The Mallee and North Wimmera received only about one-third of their normal rainfall for the year. The nine months April to December were the lowest on record in all districts, except East Gippsland and East Central, where there have been three drier April to December periods. The only districts to receive more than two-thirds of the normal were Gippsland and East Central, but even in these areas totals were less than 75 per cent of the long-term average.

Melbourne's rainfall total for 1982 of 422 mm was the fourth driest since records commenced in 1855 and the second driest this century.

District averages for 1983 were normal or slightly above normal in all districts. The year was the wettest since 1974 in the North Wimmera and the wettest since 1975 in the North Mallee, South Wimmera, Lower North, and West Coast. In the remainder of Victoria, rainfall was the highest since 1978, except in the Northeast where 1981 was a wetter year. Rainfall during the summer (December 1982 to February 1983) was among the lowest ever recorded for most districts. South Wimmera, Upper Northeast, and Western Plains have recorded only one drier summer. Above average rainfall for Melbourne in July ended a record 15 month period of below normal rainfall.

Severe weather

Thunderstorm activity occurred in each of the 12 months of 1982. Most occurrences were scattered. On 3 September, extremely strong winds, with a record gust of 120 km/h brought down power lines in Melbourne and damaged trees and houses in the Melbourne and Geelong areas. On 15 November, severe wind squalls associated with thunderstorms caused extensive damage to buildings, trees, and power lines. A wind gust of 139 km/h was registered at Melbourne Airport on that day, the strongest ever recorded at that location.

Thunderstorms occurred during each of the twelve months of 1983. Lightning associated with thunderstorms in the Western District in April resulted in the death of a hockey player in Hamilton. Severe wind gusts associated with thunderstorms in the Central District in May caused extensive damage to approximately 200 buildings in the Kilor/Taylor's Lakes area.

In November, lightning caused local power blackouts and a teenage girl was severely injured when struck by lightning. Thunderstorms caused damage to roofs, buildings, power-lines, trees, and orchards. A severe hailstorm in November in Silvan, Seville, Wandin North, and Monbulk devastated fruit and vegetable crops, with damage to property estimated at \$10m. The area also suffered from extensive soil erosion. At the peak of the storm, hail was 50 cm deep in places.

The 'Ash Wednesday' bushfires (16 to 22 February 1983) devastated in excess of 210,000 hectares, causing 48 fatalities, the loss of 1,761 houses, and burning of stock, feed, fencing, and bridges.

Further references: Agricultural meteorology, *Victorian Year Book* 1964, pp.33-4; Aeronautical Meteorology 1967, pp. 53-55; Meteorology in fire prevention, 1968, pp.55-8; Meteorological services for commerce and industry, 1969, pp.61-2;

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