3

CLIMATE

CLIMATE IN VICTORIA

General conditions

Victoria is situated between latitudes 35°S and 39°S on the south-eastern side of the Australian continent. The major topographical determinant of the climate is the Great Dividing Range, running east-west across the State and varying in elevation from about 500 metres to nearly 2,000 metres. This acts as a barrier to the moist south-east to south-west winds, causing 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 the year the temperature over the State may rise to between 35°C and 40°C, often with a strong northerly wind.

Geographical characteristics

Northern plains

Average annual rainfall ranges from 250 mm in the northern Mallee to 500 mm along the northern fringe of the Dividing Range. Variability of rain from year to year is high and increases towards the north. Sixty per cent of the average rain falls in the grain-growing season of 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

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. The proportion of rain which falls between May and October ranges from 60 per cent in the west to 70 per cent in the east. Pasture growth is limited by cold in winter and the main growth occurs in autumn and spring.

The low valleys are subject to hot summer days but mean 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 winter 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 district. There are, however, a number of days when the temperature exceeds 32°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 District.

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 the State. 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.

Circulation patterns

The general weather of southern Australia is determined primarily by the behaviour of 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 latitude 30°S and 35°S from May to October. Anticyclones are separated by low pressure areas, which usually contain active frontal surfaces separating air masses of different characteristics. These low pressure areas are 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 in 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 through the year.

On occasions, in winter or spring, an anticyclone develops a ridge to 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 southern location of the anticyclone belt frequently brings a light east to north-east 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 northerly and 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 Fig. 7 on page 88. Average annual rainfall ranges between 250 mm for the driest parts of the Mallee to 2,600 mm at Falls Creek in the Alps. There will be other locations in the Alps with similar rainfall, but 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 the State 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 north-east, 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 wet days (0.2 mm or more in 24 hours) is over 150 on the west coast and 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 area, distribution of average annual rainfall, and the actual distribution of rainfall in Victoria as shown by area is given in the following table, and the table at the top of page 90:

VICTORIA—DISTRIBUTION OF AVERAGE AND ANNUAL RAINFALL

Rainfall (mm)	Area ('000 square kilometre) (*a*)					
	Average	1970	1971	1972	1973	1974
Under 300	18.4	8.8	9.6	55.2	..	..
300–400	36.5	36.7	23.6	38.5	..	..
400–500	27.5	29.6	30.0	35.0	..	18.5
500–600	34.9	18.2	24.6	40.7	22.6	23.5
600–800	52.3	35.8	50.0	40.9	76.2	81.7
800–1,000	29.0	38.2	47.1	12.9	65.2	38.1
Over 1,000	29.0	60.3	42.7	4.4	63.6	65.8

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

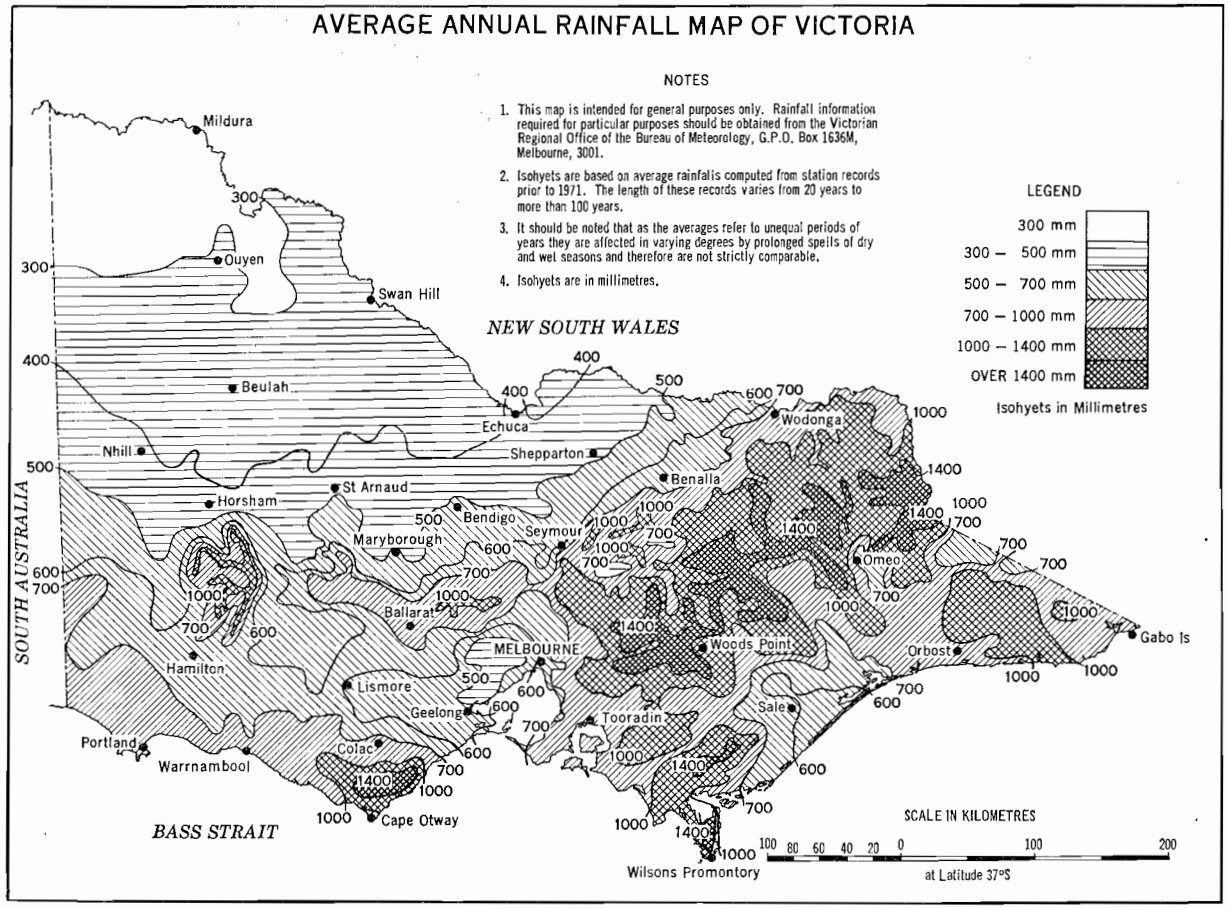

FIGURE 7. Average annual rainfall map of Victoria.

VICTORIA—DISTRICT MONTHLY RAINFALL: AVERAGE AND 1974

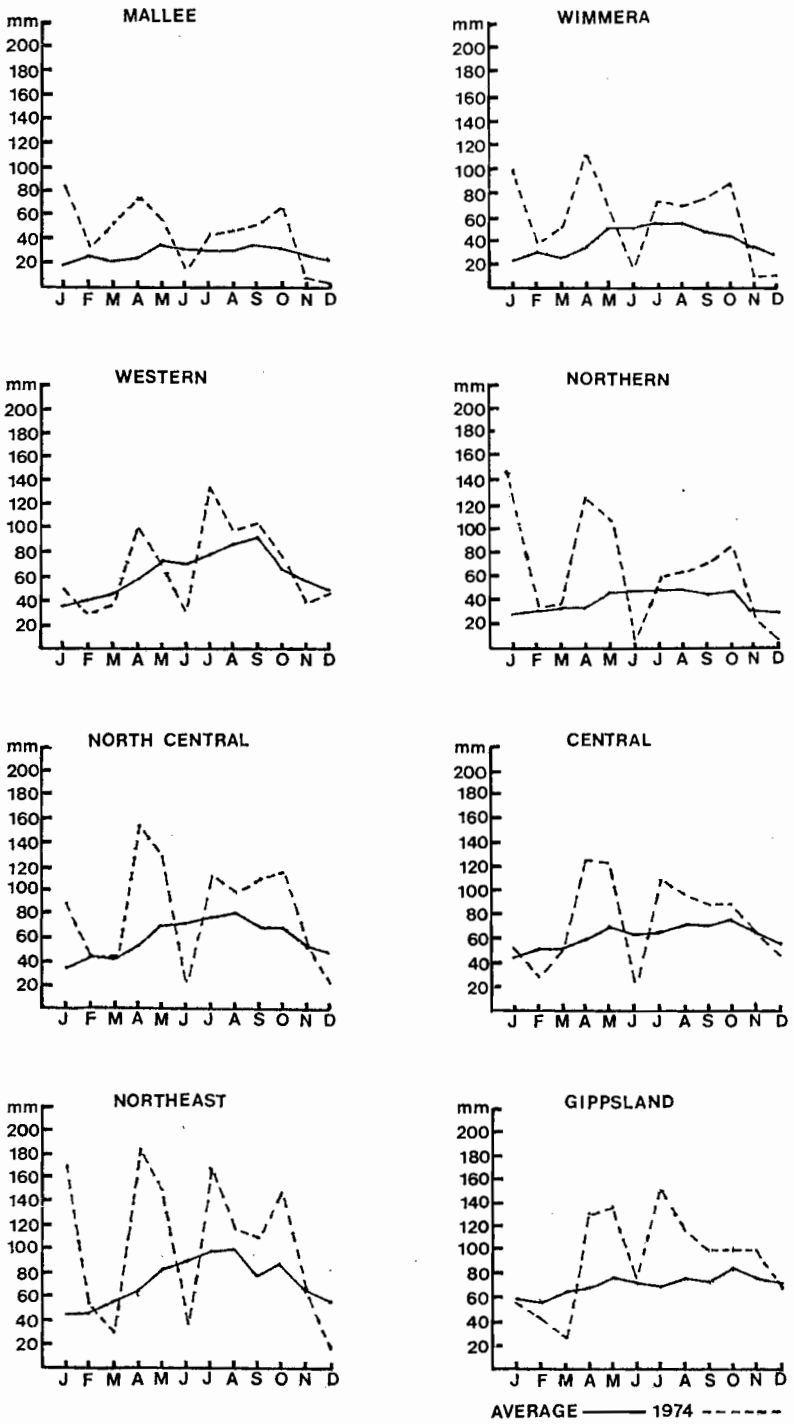

FIGURE 8.

VICTORIA—RAINFALL IN DISTRICTS
(mm)

Year	District							
	Mallee	Wimmera	Northern	North Central	North-Eastern	Western	Central	Gipps-land
1965	299	387	390	656	655	627	637	668
1966	317	418	515	812	1,048	746	815	990
1967	130	221	240	408	448	417	434	593
1968	348	500	532	880	1,004	852	733	865
1969	408	443	481	690	878	679	664	915
1970	367	474	515	843	993	857	937	1,122
1971	384	568	529	891	888	905	849	872
1972	261	365	331	576	522	600	564	601
1973	634	764	905	1,144	1,307	856	933	908
1974	530	692	763	993	1,254	805	895	1,102
Average (*a*)	327	458	468	709	862	724	741	856

(*a*) Average for 60 years 1913 to 1972.

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 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 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 one distribution with the other, the coefficient of variation

$$\left(\frac{\text{standard deviation}}{\text{the average}} \times 100 \right)$$

has been used. The coefficient of variation has been calculated for the fifteen climatic districts of Victoria (see Fig. 9) for the 60 years 1913 to 1972 and the results are tabulated in the following table in order of rainfall reliability :

VICTORIA—ANNUAL RAINFALL VARIATION

District	Average annual rainfall (*a*)	Standard deviation	Coefficient of variation
	mm	mm	per cent
1 West Gippsland	915	144	15.7
2 West Coast	773	127	16.4
3 East Central	885	150	16.9
4 Western Plains	630	113	17.9
5 East Gippsland	767	144	18.8
6 West Central	607	119	19.6
7 Wimmera South	493	99	20.1
8 Wimmera North	407	88	21.6
9 North Central	709	157	22.1
10 Upper North	508	119	23.4
11 Upper North-east	1,106	268	24.2
12 Lower North-east	766	187	24.4
13 Mallee South	348	89	25.6
14 Lower North	423	116	27.4
15 Mallee North	299	85	28.4

(*a*) Average for 60 years 1913 to 1972.

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

Droughts

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.

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.

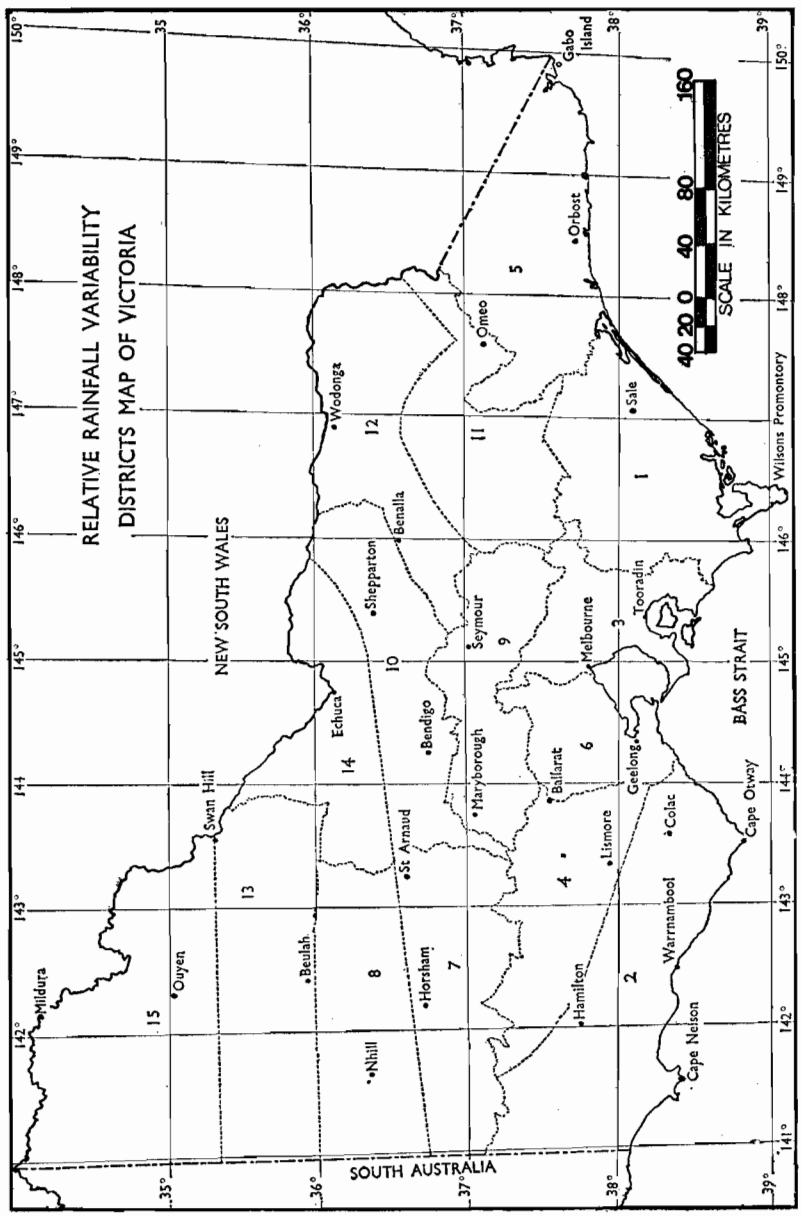

FIGURE 9. Relative rainfall variability by districts. Names of climatic districts are shown in the table on page 91.

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 breaking with heavy rain in February 1973.

Readers should refer to the publication *Droughts in Australia,* Bulletin No. 43 of the Bureau of Meteorology, published in 1957, for a definitive treatment of the subject of droughts in Victoria.

Floods

Floods have occurred in all districts, but they are more frequent in the wetter parts of the State such as the north-east and Gippsland. However, although a rarer event over the north-west lowlands, they may result from less intense rainfall and continue longer because of the poor drainage in this section of the State. In many instances the frequency of flooding is increased by valley contours and damage is often greater because of the higher density of adjacent property and crops.

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, Wimmera, and northern country. 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. They are below 10°C over most of the 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–15°C. The highest night temperatures are recorded along the Murray and on the far eastern 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 so far is −12.8°C at Hotham Heights

VICTORIA—MEANS OF CLIMATIC ELEMENTS : SELECTED VICTORIAN TOWNS

	Locality	Legend (a)	Years of record	January	February	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Annual
MALLEE	Mildura	1	28	19	25	25	22	29	23	26	29	27	31	25	20	301
		2	27	32.1	30.8	28.1	23.4	18.7	16.0	15.2	17.0	20.2	23.6	26.9	29.7	23.5
		3	27	16.7	16.3	13.8	10.3	7.4	5.3	4.4	5.3	7.3	9.8	12.1	14.6	10.3
	Swan Hill	1	90	21	24	24	25	34	36	31	35	32	34	26	24	346
		2	73	31.5	31.1	27.8	22.8	18.2	14.8	14.3	16.2	19.4	22.9	26.8	29.9	22.9
		3	67	15.3	15.3	12.8	9.6	6.7	4.7	4.0	4.8	6.5	8.8	11.5	13.8	9.6
WIMMERA	Horsham	1	101	22	27	25	34	47	50	46	48	45	43	34	28	449
		2	65	30.0	29.8	26.5	21.5	17.1	13.9	13.3	15.0	17.8	21.0	24.9	27.8	21.5
		3	66	13.4	13.6	11.4	8.6	6.3	4.6	3.8	4.6	5.7	7.5	9.8	11.9	8.4
	Nhill	1	88	22	25	23	31	41	48	46	48	43	41	30	28	426
		2	69	29.6	29.3	26.2	21.5	17.2	14.3	13.6	15.1	17.9	21.1	24.8	27.8	21.5
		3	70	12.9	13.2	10.9	8.3	6.0	4.2	3.4	4.1	5.4	7.2	9.3	11.6	8.0
WESTERN	Ballarat	1	65	38	50	47	57	70	63	69	77	73	68	56	52	720
		2	64	25.0	24.7	21.9	17.3	13.3	10.6	9.9	11.3	13.9	16.6	19.4	22.3	17.2
		3	63	10.7	11.7	10.0	7.6	5.8	4.1	3.4	3.9	5.0	6.4	7.7	9.5	7.2
	Hamilton	1	104	33	33	43	56	69	73	74	77	72	66	51	46	693
		2	86	25.6	25.5	22.9	18.8	15.2	12.7	12.0	13.1	15.3	17.7	20.5	23.3	18.5
		3	87	11.3	11.9	10.5	8.5	6.8	5.2	4.5	5.0	6.0	7.1	8.4	10.0	7.9
	Warrnambool	1	77	32	36	47	61	77	75	86	83	72	65	53	45	732
		2	69	22.0	22.0	20.9	18.5	15.9	13.8	13.2	13.9	15.6	17.2	18.8	20.5	17.7
		3	69	12.7	13.2	12.1	10.3	8.5	6.8	6.1	6.6	7.6	8.9	10.0	11.5	9.5
NORTHERN	Bendigo	1	113	33	35	37	41	54	61	55	56	53	52	37	33	547
		2	108	29.4	29.0	25.9	20.9	16.1	12.9	12.2	13.8	16.7	20.3	24.2	27.3	20.7
		3	106	14.1	14.3	12.3	9.1	6.4	4.8	3.7	4.4	6.0	8.1	10.3	12.5	8.8
	Echuca	1	96	27	29	34	35	43	45	40	43	39	43	32	29	439
		2	91	30.8	30.4	27.1	22.1	17.4	14.1	13.3	15.1	18.3	22.0	26.0	29.0	22.1
		3	90	15.3	15.3	13.0	9.6	6.7	4.9	4.0	5.0	6.5	8.9	11.3	13.7	9.5

NORTH CENTRAL	Alexandra	1	95	41	40	52	53	65	72	71	74	66	70	56	48	708
		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	100	39	42	47	56	76	89	82	84	75	70	52	50	762
		2	75	27.1	26.7	23.5	18.3	13.8	10.7	9.9	11.5	14.8	18.0	21.7	24.9	18.4
		3	69	9.9	10.3	8.4	5.7	3.6	2.3	1.6	1.9	3.3	4.8	6.6	8.6	5.6
CENTRAL	Geelong	1	104	32	39	42	45	50	49	46	48	51	51	47	40	540
		2	64	25.0	24.9	23.2	19.9	16.6	14.1	13.6	14.8	16.9	19.2	21.2	23.3	19.4
		3	64	13.3	13.8	12.5	10.3	8.0	6.0	5.2	5.7	6.9	8.4	10.1	11.9	9.4
	Mornington	1	85	45	45	52	64	71	71	69	70	70	69	58	53	737
		2	40	24.9	24.9	23.1	19.4	16.0	13.4	12.7	13.7	15.9	18.1	20.3	23.0	18.8
		3	38	13.3	13.8	12.8	10.9	9.0	7.1	6.4	6.8	8.0	9.5	10.7	12.1	10.0
NORTH-EASTERN	Omeo	1	95	51	54	54	47	55	57	52	56	62	72	63	62	685
		2	88	26.2	25.8	23.1	18.7	14.1	10.8	10.1	12.1	15.3	18.5	21.8	24.5	18.4
		3	89	9.4	9.5	7.8	4.8	2.1	0.8	-0.2	0.7	2.6	4.7	6.4	8.3	4.7
	Wangaratta	1	95	38	40	48	49	56	72	64	64	59	63	47	42	642
		2	71	31.0	30.6	27.3	22.0	17.3	13.6	12.7	14.5	17.6	21.1	25.3	28.9	21.8
		3	70	15.0	14.9	12.2	8.4	5.5	3.8	3.3	4.1	5.8	8.2	10.7	13.3	8.7
WEST GIPPSLAND	Yallourn	1	25	50	61	56	66	97	76	81	97	88	87	85	68	912
		2	24	24.8	24.2	22.4	18.8	14.6	12.6	11.8	13.0	15.3	17.6	19.5	22.1	18.0
		3	24	12.7	13.3	12.0	9.7	7.5	5.9	4.7	5.3	6.5	8.3	9.5	11.1	8.9
	Sale	1	31	47	46	55	47	59	46	42	55	50	66	66	58	637
		2	28	25.1	24.8	23.1	20.1	16.3	14.0	13.5	14.7	16.7	18.9	20.7	23.1	19.2
		3	28	12.5	13.2	11.3	8.5	6.1	4.2	3.3	4.1	5.4	7.6	9.2	11.1	8.0
EAST GIPPSLAND	Bairnsdale	1	70	61	52	64	51	55	57	50	51	57	69	66	69	702
		2	67	24.6	24.7	23.0	20.4	17.1	14.4	13.9	15.3	17.5	19.6	21.6	23.5	19.6
		3	66	12.3	12.7	11.2	8.5	6.0	4.2	3.4	4.1	5.9	7.8	9.4	11.2	8.1
	Orbost	1	91	70	61	68	71	73	82	67	60	68	79	70	76	845
		2	32	25.1	25.0	23.6	20.7	17.3	14.9	14.5	15.6	17.6	19.5	21.1	23.5	19.9
		3	30	12.7	13.3	11.8	9.1	6.7	4.9	3.9	4.6	5.9	8.1	9.9	11.6	8.6

(*a*) Legend : 1. Average monthly rainfall in mm (for all available years of record to 1974).
2. Average daily maximum temperature (°C) (for all years of record to 1973).
3. Average daily minimum temperature (°C) (for all years of record to 1973).

(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 north-east 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 north-east.

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 north-east 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 in 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. For several periods in the summer, however, air from the Tasman Sea has a trajectory over Bass Strait and parts of the State, and it is then that the moisture content rises to show wet bulb temperatures above 18°C. The incidence of high humidity is important to the vine and fruit industry, tobacco growers, and wheat farmers.

Evaporation

Since 1967 the Class A Pan has been the standard evaporimeter used by the Bureau of Meteorology. This type is being progressively installed at evaporation recording stations in Victoria; there were sixty-four in mid-1974, sixty-two of which were owned by the Bureau of Meteorology.

Measurements of evaporation have been made with the Australian tank at about thirty stations, about half of which are 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 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 wide variations from

Cliffed sector in the Otway Ranges with dipping sandstone rocks and a shore platform above low water mark.

Neville Rosengren

Mud flats, mangrove, and saltmarsh at The Inlets, Western Port.
Neville Rosengren

The mouth of the Glenelg River showing the estuarine lagoon and the entrance constricted by sand spits.
Neville Rosengren

Cliffed coast in limestones near Peterborough.

Neville Rosengren

Steeply plunging granite cliffs at Wilsons Promontory. Note the absence of a platform.

Neville Rosengren

Typical mountain terrain in north-eastern Victoria, showing Mount Cobbler in the foreground.

Robert Marshall

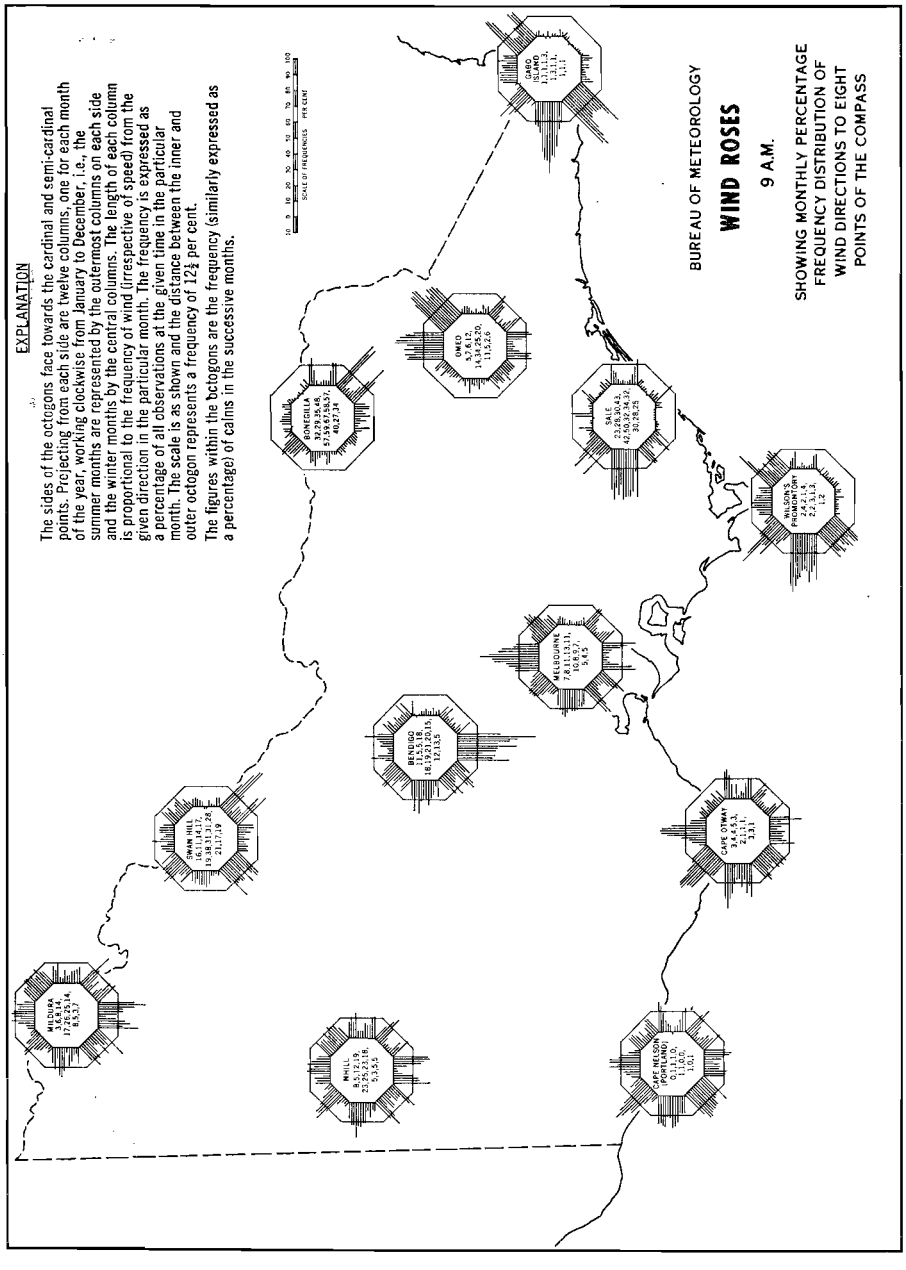

FIGURE 10. Victoria—wind roses for 9 a.m.

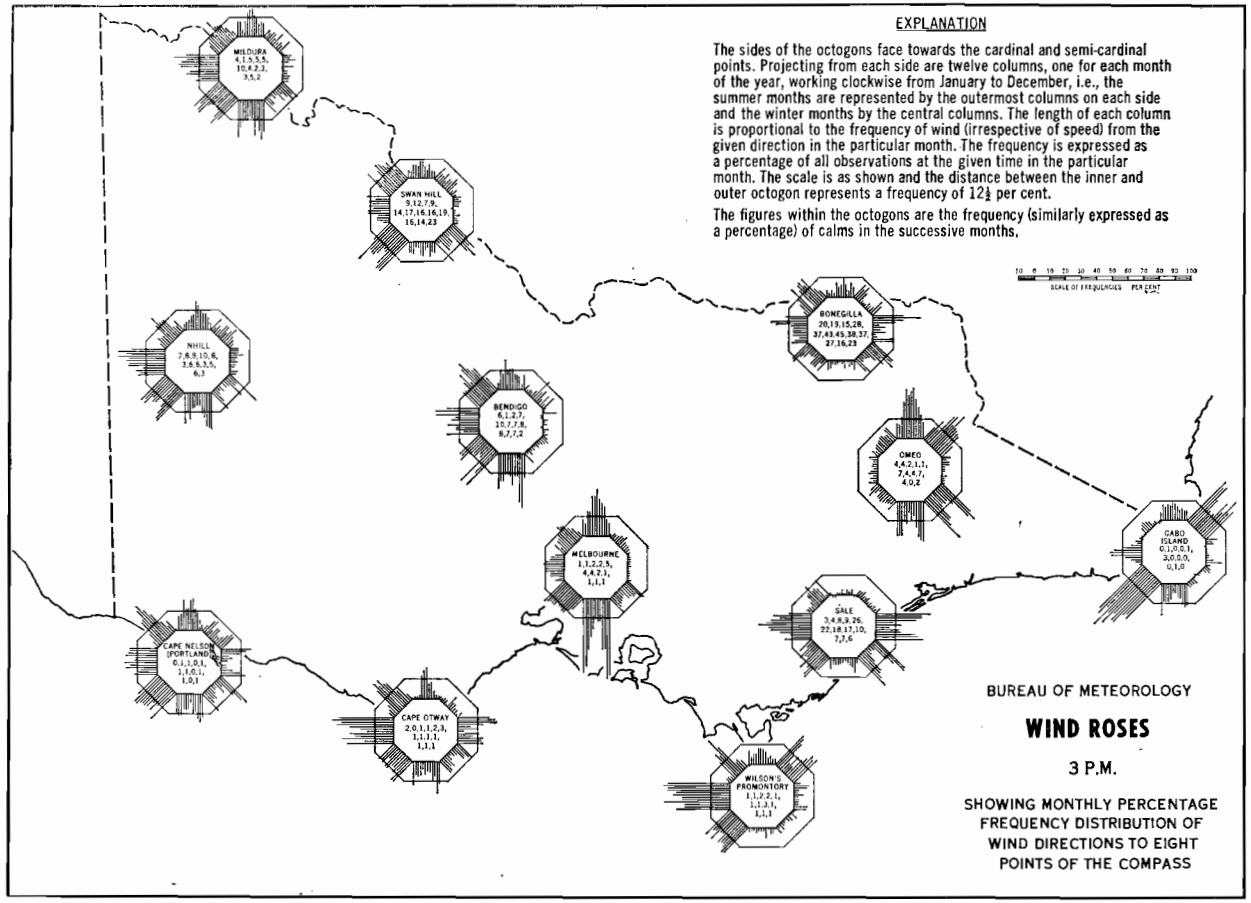

FIGURE 11. Victoria—wind roses for 3 p.m.

this general description, however, and this is shown by the wind roses for selected towns, which are shown in Figs 10 and 11 on pages 97–8. 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 the 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 values 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 the State and to date the highest gust recorded 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.

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.

Forecasting for aviation

As forecasts of wind, turbulence, and temperature are vital to the safety of flight, forecasting for aviation comprises a significant part of the work of the Bureau of Meteorology, and the comprehensive service provided has contributed to the excellent safety record of Australian aviation.

The Victorian Regional Forecasting Centre, located in Melbourne, is responsible for forecasts within the Melbourne Flight Information Region (FIR), which extends from Bass Strait to southern New South Wales. Forecasts originating in Regional Forecasting Centres throughout Australia are exchanged through the automatic fixed telegraphic network, operated by the Australian Department of Transport. Hourly meteorological observations at major airports are transmitted by means of this network. Forecasts and observations are exchanged with neighbouring countries such as New Zealand, Fiji, and Singapore.

Route forecasts for major air routes are issued at routine times for periods up to 12 to 18 hours. These include forecasts of winds and temperature up to an altitude of 13 kilometres, and of significant weather, particularly thunderstorms and turbulence. Flight forecasts are provided for flights away from the major routes and particularly to military aircraft, long range travel flights, and all operations to New Zealand. Terminal forecasts for a large

number of airports are issued every 6 hours and are valid for 12 to 18 hours. These include forecasts of wind, visibility, temperature, cloud height, and type of significant weather, particularly thunderstorms and fog.

For light aircraft, forecasts are prepared for four areas of the Melbourne FIR, giving similar information to route forecasts. A 'genmet' service is on trial whereby the FIR is divided into 44 areas, and each area described as open, marginal, or closed for light aircraft operations. This service, as well as providing terminal forecasts for eleven airports in the FIR, is available as an automatic telephone answering service.

Warnings of severe weather are given special prominence. These include dangerous flying conditions of severe icing, severe turbulence, and gale-force surface winds which are a danger to parked aircraft.

Aviation forecasts are available at weather service offices at major airports. In Victoria these are located at Melbourne, Moorabbin, and Essendon Airports. At these offices, pilots are personally provided with forecasts and the latest weather charts. There were over 60,000 such briefings in 1974.

Meteorologists are stationed at the RAAF bases at East Sale and Laverton to provide forecasts as required for RAAF operations. Lectures in meteorology are given to the RAAF training school at East Sale.

In addition to the routine service to civil aviation, special forecasts are provided for search and rescue operations, and for gliding and parachuting championships.

CLIMATE IN MELBOURNE

General conditions

Temperature

The proximity of Port Phillip Bay bears a direct influence on the local climate of the metropolis. 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 buildings may maintain the air at a slightly higher temperature. 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 only about two nights a year and this frequency is the same for nights on which the air temperature falls below 0°C. 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 metropolitan area. For example, there are approximately ten annual occurrences of 2°C or under around the bayside, 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:

MELBOURNE—MEANS OF CLIMATIC ELEMENTS

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 (°C)	14.4	19.4	15.3	10.1
Mean daily range of temperature of air in shade (°C)	10.3	11.6	9.6	7.7
Mean relative humidity at 9 a.m. (saturation=100)	64	61	72	80
Mean rainfall (mm)	185	156	171	148
Mean number of days of rain	40	25	34	44
Mean amount of evaporation (mm) (*a*)	261	441	208	97
Mean daily amount of cloudiness (scale 0 to 8) (*b*)	4.8	4.2	4.7	5.2
Mean daily hours of sunshine (*c*)	6.0	8.0	5.2	3.9
Mean number of days of fog	1.4	0.6	6.1	11.2

(*a*) Measured by Australian Sunken Tank (prior to 1967).
(*b*) Scale : 0 = clear, 8 = overcast.
(*c*) Measured at Melbourne (prior to 1968).

In the following table the yearly means of the climatic elements in Melbourne for each year 1970 to 1974 are shown. The extreme values of temperature in each year are also included.

MELBOURNE—YEARLY MEANS AND EXTREMES OF CLIMATIC ELEMENTS

Meteorological element	1970	1971	1972	1973	1974
Mean atmospheric pressure (millibar)	1,015.8	1,014.2	1,018.2	1,017.0	1,015.7
Temperature of air in shade (°C)—					
Mean	15.1	15.5	15.5	15.5	15.6
Mean daily maximum	19.4	19.8	20.3	19.8	19.7
Mean daily minimum	10.7	11.0	10.8	11.2	11.4
Absolute maximum	37.3	38.7	39.9	40.5	36.5
Absolute minimum	0.6	−0.1	0.0	−0.5	0.6
Mean terrestrial minimum temperature (°C)	9.2	9.4	8.9	9.6	9.7
Number of days maximum 38°C and over	..	1	2	4	3
Number of days minimum 2°C and under	3	4	7	10	5
Rainfall (mm)	803	779	566	817	804
Number of wet days	153	154	120	150	165
Total amount of evaporation (mm) (*a*)	1,465	1,503	1,587	1,496	1,421
Mean relative humidity at 9 a.m. (saturation=100)	71	70	69	69	65
Mean daily amount of cloudiness (scale 0 to 8) (*b*)	4.5	4.9	4.3	5.1	5.1
Mean daily hours of sunshine (*c*)	6.3	5.9	6.7	6.3	6.2
Mean daily wind speed (km/h)	11.4	12.2	12.7	9.7	9.4
Number of days of wind gusts 63 km/h and over	61	69	58	79	59
Number of days of fog	9	7	9	8	5
Number of days of thunder	12	13	11	7	11

(*a*) Evaporation measured by Class A Pan.
(*b*) Scale : 0 = clear, 8 = overcast.
(*c*) Sunshine measured at Laverton.

Rainfall

The average annual rainfall in the city is 660 mm over 143 days. The average monthly rainfall varies from 48 mm in January to 67 mm in October. Rainfall is relatively steady during the winter months, when the extreme range is from 7 mm to 180 mm, but variability increases towards the warmer months.

In the latter period totals range between practically zero and over 230 mm.

Over 75 mm of rain have been recorded in 24 hours on several occasions, but these have been restricted to the warmer months—September to April. Only twice has a fall above 50 mm during 24 hours been recorded in the cooler months.

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 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 1,376 mm.

The number of wet days, 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 wet days 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 January 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 or five mornings each month in May, June, and July, and average twenty 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 three to four hours during this period are the lowest of all capital cities. There is a steady rise towards the warmer months as the days become longer and cloudiness decreases. An average of over eight hours a day is received in January; however, the decreasing length of the day is again apparent in February, since the sunshine is then less in spite of 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 55 per cent for January and February and 35 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 36.7 km/h, while means exceeding 30 km/h are on record for each winter month. 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 a few seconds only, up to or even over 95 km/h. At Melbourne, 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 14 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 housetops were covered with several centimetres of snow, reported to be 30 centimetres deep at places. When thawing set in, floods in Elizabeth and Swanston Streets stopped traffic, causing accidents, some of which were fatal. One report of the event indicates that the terrified state of the Aboriginals suggested they had never seen snow before.

VICTORIAN WEATHER SUMMARY 1974

Following high rainfall in 1973, Victoria experienced another wet year in 1974. Rainfall was above average almost throughout the State, and the Bairnsdale–Omeo area had a record rainfall.

January rainfall was the highest on record at many places in the southern Mallee, the northern Wimmera, and the north-east. Humidity was well above normal in January, but there was a lack of extremely high temperatures.

On 3–4 January very heavy rain fell in the north-east, over 100 mm being recorded in 48 hours at several places. Flash flooding cut the Hume Highway between Chiltern and Wodonga. Similar rain fell in the north-east on 10–11 January, and some homes in Albury were flooded. On 13–14 January heavy rain fell over the western half of the State. Nhill recorded 140 mm, with severe flooding of the town, while houses were evacuated in Jeparit and Dimboola. The Western Highway was covered, and ballast undermined on the Melbourne–Adelaide railway line.

Widespread, though not so heavy rain fell on several occasions from mid-January to mid-March, followed by thunderstorms and local heavy falls in the last ten days of March. Streets were flooded in the south-eastern suburbs of Melbourne on 21, 24, and 28 March. Gippsland, however, missed out on most of the heavy rain in the first three months of the year, and rainfall there was below average.

March was a very warm month, mean temperatures being the highest for many years. At Melbourne and Ballarat the mean minimum temperature for the month was the highest on record.

Rain was frequent and widespread in April and early May. Gales and rain on the night of 29–30 April caused structural damage in bayside suburbs of Melbourne, while the first snow for the year fell on the Alps. April rainfall was the highest on record at some places in the Wimmera, northern, and north-eastern districts.

Then came one of the heaviest rainstorms to affect Victoria. In three days in mid-May, a large area in the centre of the State received more than 100 mm, causing record floods on the Ovens, Kiewa, and Goulburn rivers. Serious flooding also occurred on the Broken, Campaspe, Loddon, and Maribyrnong

rivers. Many homes along the Maribyrnong River had to be evacuated on the night of 15 May. In Melbourne on 15 May, 82.6 mm fell in 24 hours, the highest fall on record for this period in May.

Heavy rain fell in East Gippsland at the end of May and again on 9–11 June, causing major floods on the Snowy River, but elsewhere in the State rain was light from mid-May to the end of June.

Between July and October, rainfall was above average throughout the State and flooding was frequent on rivers in eastern and northern Victoria. The Maffra–Bairnsdale area experienced its wettest July on record and heavy rain fell in Gippsland at the end of August.

Gales caused power failures in Melbourne suburbs on two occasions in July, and on 4 August the first snow for the year fell on the Dandenong Ranges. On the evening of 25 September a hailstorm occurred in the central city area of Melbourne, and snow fell at Macedon and Woodend.

Heavy rain in the north-east on 3–5 October and 16–17 October led to serious flooding on the Murray and Goulburn systems. On the latter occasion, the Murray at Albury reached its third highest level in 104 years.

The mean maximum temperature was below normal at most places in each of the last five months of the year. At Mildura, the mean maximum temperature in October was the lowest for 18 years.

The last flood-producing rain occurred on 31 October, and apart from isolated thunderstorms, and some heavy rain in the eastern half in late November, rain for the remainder of the year was light and showery. The last two months were very dry in the Mallee and Wimmera and several places had a rainless December.

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