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 from May to October.

Cold fronts bring rain to the Wimmera, particularly in winter, but have less effect on 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.

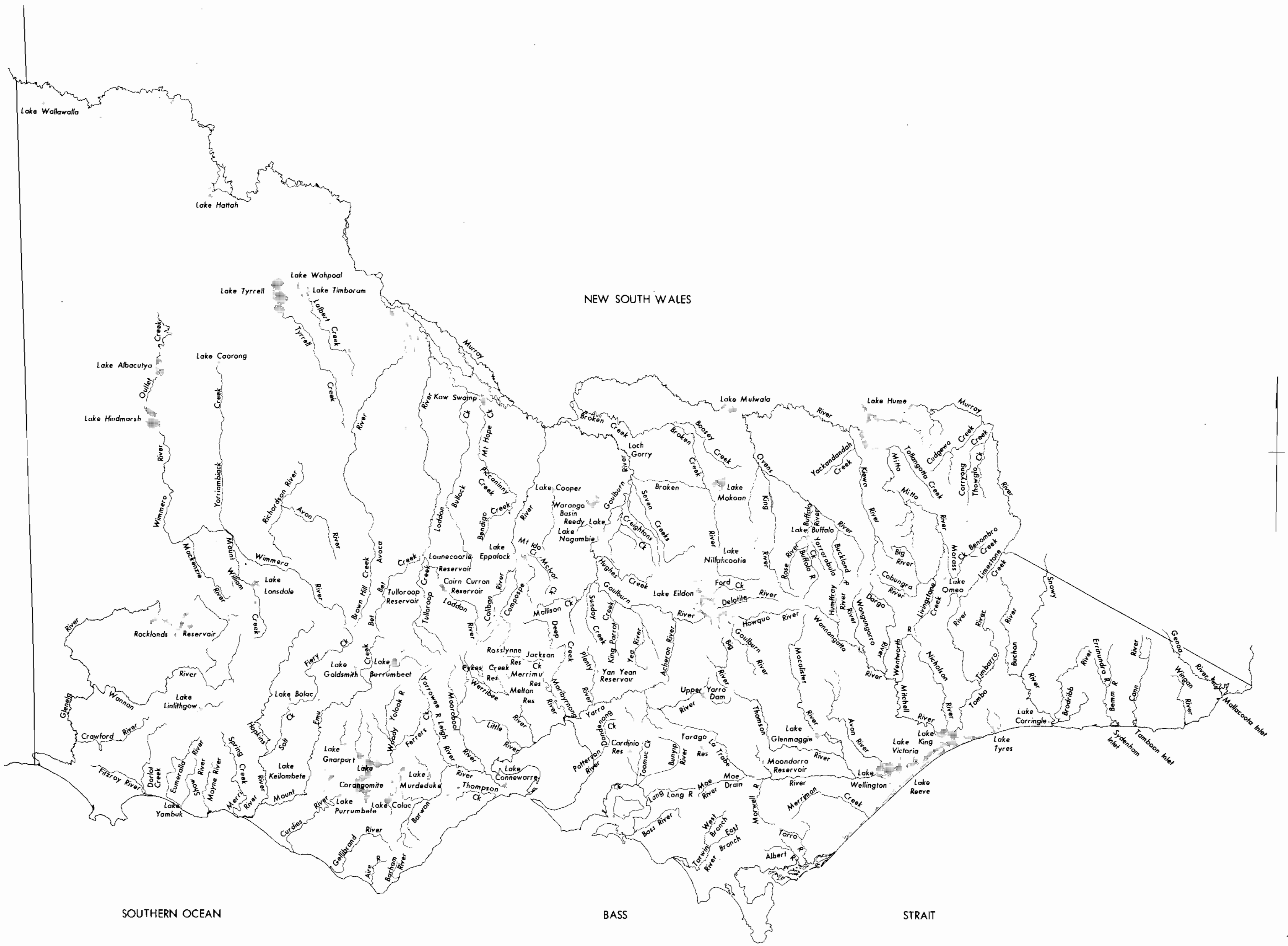
On some winter days, however, the coastal areas of East Gippsland have the highest temperatures in the State, due to the Föhn effect of north-westerly winds descending from the mountains.

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 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 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 for as long as a week.



STREAMS AND LAKES OF VICTORIA

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. 8 on page 84. 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 days of rain (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 86.

VICTORIA—DISTRIBUTION OF AVERAGE AND ANNUAL RAINFALL

Rainfall (mm)	Area ('000 square kilometres) (*a*)					
	Average	1971	1972	1973	1974	1975
Under 300	18.4	9.6	55.2	..	..	1.4
300–400	36.5	23.6	38.5	..	..	29.7
400–500	27.5	30.0	35.0	..	18.5	25.1
500–600	34.9	24.6	40.7	22.6	23.5	22.1
600–800	52.3	50.0	40.9	76.2	81.7	64.2
800–1,000	29.0	47.1	12.9	65.2	38.1	35.8
Over 1,000	29.0	42.7	4.4	63.6	65.8	49.3

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

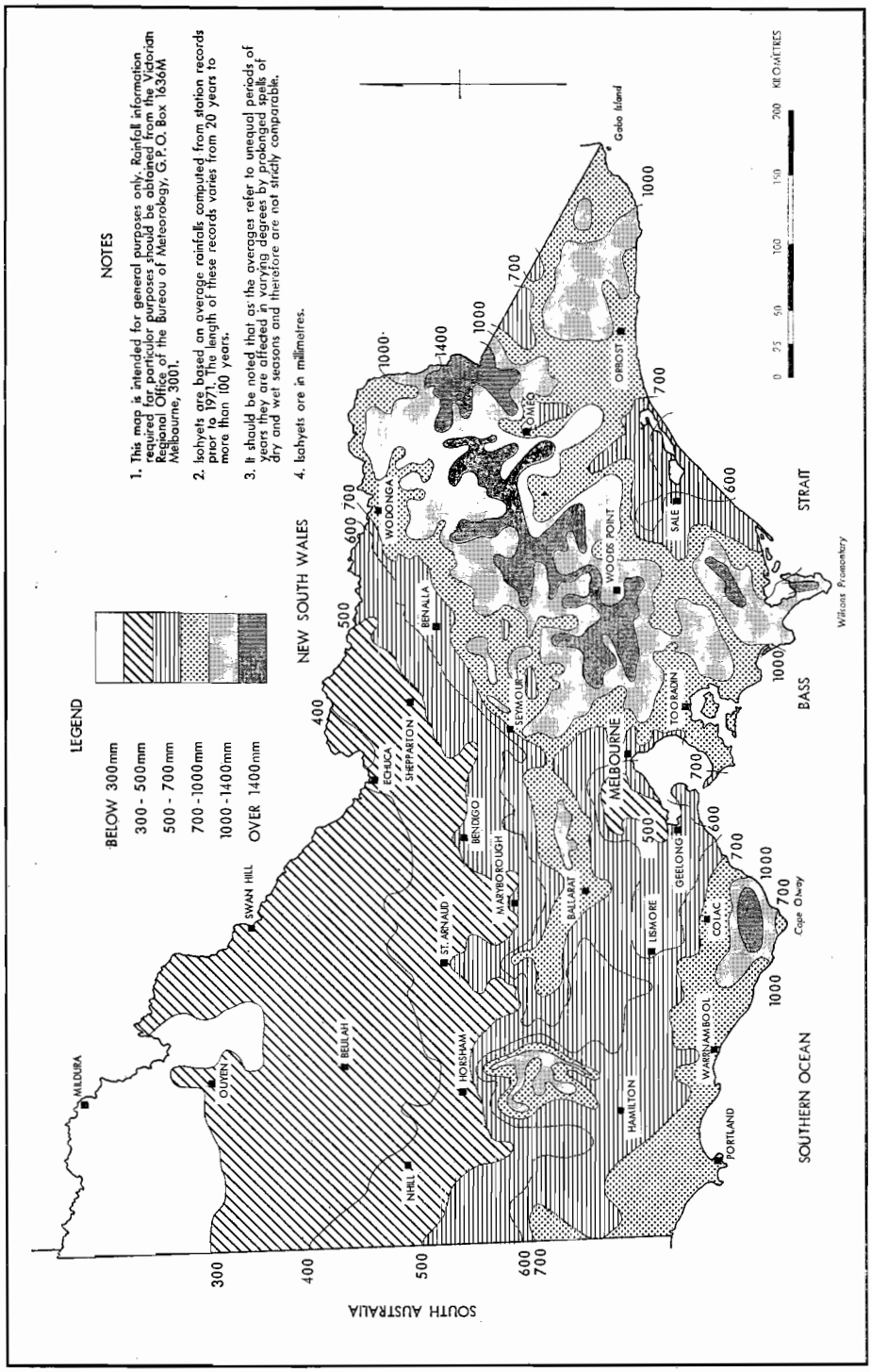


FIGURE 8. Average annual rainfall map of Victoria.

VICTORIA—DISTRICT MONTHLY RAINFALL: AVERAGE AND 1975

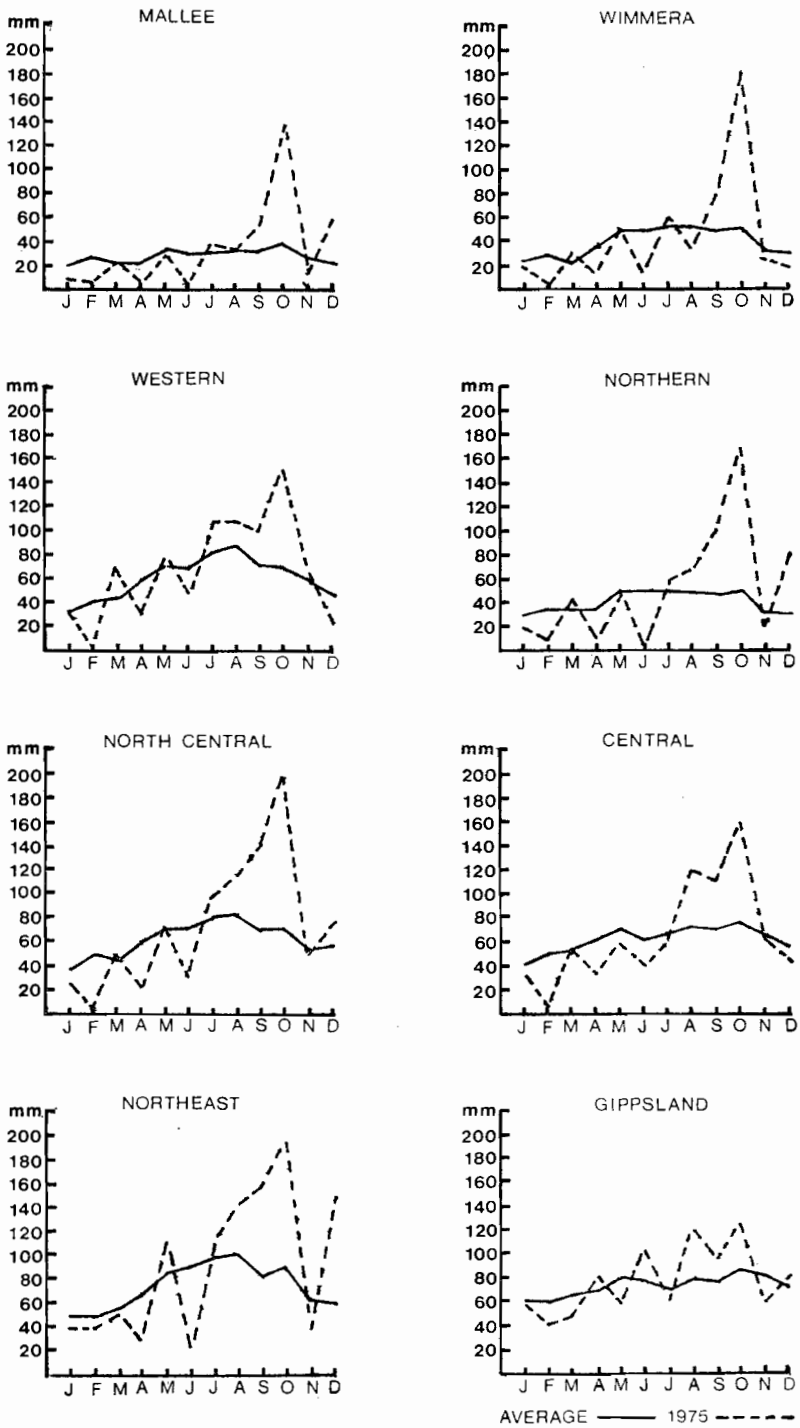


FIGURE 9.

VICTORIA—RAINFALL IN DISTRICTS
(mm)

Year	District							
	Mallee	Wimmera	Northern	North Central	North-Eastern	Western	Central	Gippsland
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
1975	406	531	618	885	1,081	818	787	920
Average (*a*)	338	470	481	725	879	730	742	861

(*a*) Average for 63 years 1913 to 1975.

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. 10) for the 63 years 1913 to 1975 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	919	147	16.0
2 West Coast	778	126	16.2
3 East Central	895	150	16.8
4 Western Plains	635	114	18.0
5 East Gippsland	779	153	19.6
6 West Central	614	121	19.7
7 South Wimmera	506	109	21.5
8 North Central	725	168	23.2
9 North Wimmera	418	98	23.4
10 Upper North-east	1,119	273	24.4
11 Lower North-east	784	209	26.7
12 South Mallee	357	99	27.7
13 Upper North	522	145	27.8
14 Lower North	439	133	30.3
15 North Mallee	310	96	31.0

(*a*) Average for 63 years 1913 to 1975.

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.

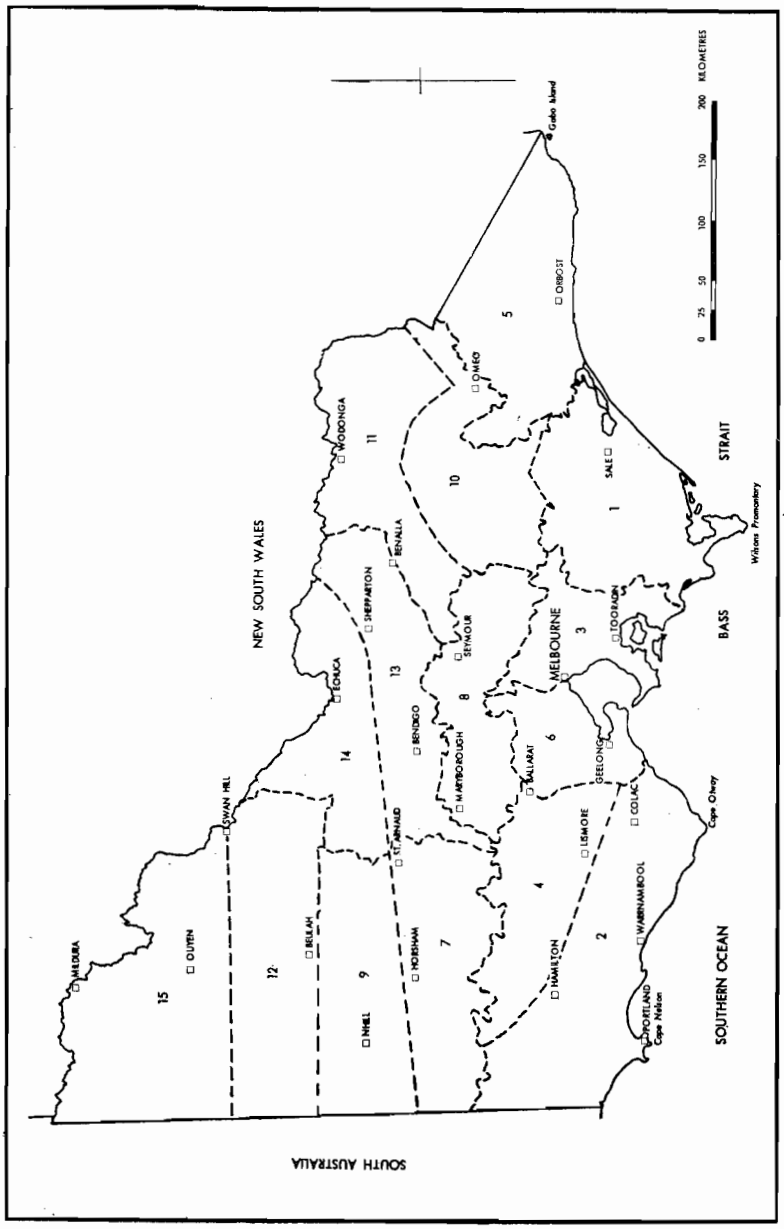


FIGURE 10. Relative rainfall variability by districts. Names of climatic districts are shown in the table on page 87,

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.

The publication *Droughts in Australia,* Bulletin No. 43 of the Bureau of Meteorology, published in 1957, gives 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 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

VICTORIA—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	28	19	25	25	22	29	23	26	29	27	31	25	20	301
		2	28	32.1	30.8	28.2	23.4	18.7	16.0	15.2	17.0	20.1	23.6	26.8	29.7	23.5
		3	28	16.8	16.3	13.9	10.4	7.4	5.2	4.4	5.3	7.2	9.8	12.0	14.6	10.3
	Swan Hill	1	90	21	24	24	25	34	36	31	35	32	34	26	24	346
		2	74	31.4	29.7	27.8	22.8	18.2	14.8	14.3	16.1	19.3	22.9	26.7	29.9	22.9
		3	68	15.4	15.3	12.9	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	66	30.0	29.8	26.1	21.5	17.1	13.9	13.3	15.0	17.7	21.0	24.9	27.7	21.5
		3	67	13.4	13.6	11.5	8.7	6.3	4.6	3.8	4.6	5.7	7.5	9.8	11.9	8.5
	Nhill	1	88	22	25	23	31	41	48	46	48	43	41	30	28	426
		2	70	29.6	29.3	26.3	21.5	17.3	14.3	13.6	15.1	17.8	21.1	24.8	27.7	21.5
		3	71	12.7	13.2	11.0	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	65	25.0	24.7	22.0	17.3	13.3	10.6	9.9	11.3	13.8	16.6	19.4	22.3	17.2
		3	64	10.8	11.7	10.0	7.7	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	87	25.7	25.5	23.0	18.8	15.2	12.7	12.0	13.2	15.3	17.7	20.5	23.3	18.5
		3	88	11.4	11.9	10.5	8.6	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	70	22.0	22.1	21.0	18.5	15.9	13.8	13.2	14.0	15.6	17.3	18.8	20.5	17.7
		3	70	12.7	13.2	12.2	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	109	29.4	29.0	25.9	20.9	16.1	12.9	12.2	13.8	16.7	20.3	24.1	27.3	20.7
		3	107	14.1	14.3	12.3	9.2	6.5	4.8	3.7	4.4	6.0	8.1	10.3	12.4	8.8
	Echuca	1	96	27	29	34	35	43	45	40	43	39	43	32	29	439
		2	92	30.8	30.4	27.1	22.1	17.4	14.1	13.3	15.1	18.2	22.0	26.0	29.0	22.1
		3	90	15.3	15.3	13.1	9.6	6.7	4.9	4.1	5.0	6.6	8.9	11.3	13.6	9.6

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	76	27.1	26.6	23.5	18.2	13.8	10.7	9.9	11.5	14.8	17.9	21.6	24.9	18.4
		3	70	10.0	10.3	8.5	5.7	3.6	2.3	1.6	2.0	3.3	4.9	6.6	8.5	5.6
CENTRAL	Geelong	1	104	32	39	42	45	50	49	46	48	51	51	47	40	540
		2	64	25.1	24.9	23.2	19.9	16.6	13.9	13.6	14.8	16.9	19.2	21.2	23.3	19.4
		3	65	13.3	13.8	12.5	10.3	8.0	6.0	5.2	5.7	6.9	8.4	10.0	11.9	9.4
	Mornington	1	85	45	45	52	64	71	71	69	70	70	69	58	53	737
		2	41	25.0	24.3	23.2	19.4	16.1	13.5	12.8	13.8	15.9	18.1	20.3	23.1	18.8
		3	39	13.4	13.8	12.9	10.9	9.1	7.2	6.5	6.8	8.5	9.4	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	89	25.2	25.1	23.6	20.7	17.4	14.9	14.6	15.6	17.6	19.5	21.1	23.5	19.9
		3	90	12.8	13.3	11.8	9.2	6.8	5.0	4.0	4.5	5.9	8.1	9.8	11.6	8.6
	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	25	24.8	24.3	22.6	18.3	14.7	12.6	11.8	12.9	15.2	17.6	19.5	22.1	18.7
		3	25	12.7	13.3	12.1	9.7	7.5	5.9	4.8	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	29	25.1	24.9	23.2	20.1	16.3	14.0	13.5	14.6	16.7	18.9	20.7	23.0	19.2
		3	29	12.5	13.2	11.4	8.6	6.1	4.2	3.4	4.2	5.4	7.6	9.6	11.1	8.1
EAST GIPPSLAND	Bairnsdale	1	70	61	52	64	51	55	57	50	51	57	69	66	69	702
		2	68	24.6	24.7	23.1	20.4	17.1	14.4	13.5	15.3	17.5	19.6	21.6	23.5	19.6
		3	67	12.4	12.7	11.2	8.6	6.1	4.2	3.4	4.2	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	33	25.2	25.1	23.6	20.7	17.4	14.9	14.6	15.6	17.6	19.5	21.1	23.5	19.9
		3	31	12.8	13.3	11.8	9.2	6.8	5.0	4.0	4.5	5.9	8.1	9.8	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 1974).
3. Average daily minimum temperature (°C) (for all years of record to 1974).

(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 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 north-westerly 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 being progressively installed at evaporation recording stations in Victoria; there were 64 in mid-1974, 62 of which were owned by the Bureau of Meteorology.

Measurements of evaporation have been made with the Australian tank at about 30 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 this general description, however, and this is shown by the wind roses for selected towns, which are shown in Figs. 11 and 12 on pages 93–4. For example, Melbourne has a predominance of northerlies and southerlies, while Sale has an easterly sea breeze on most summer afternoons.

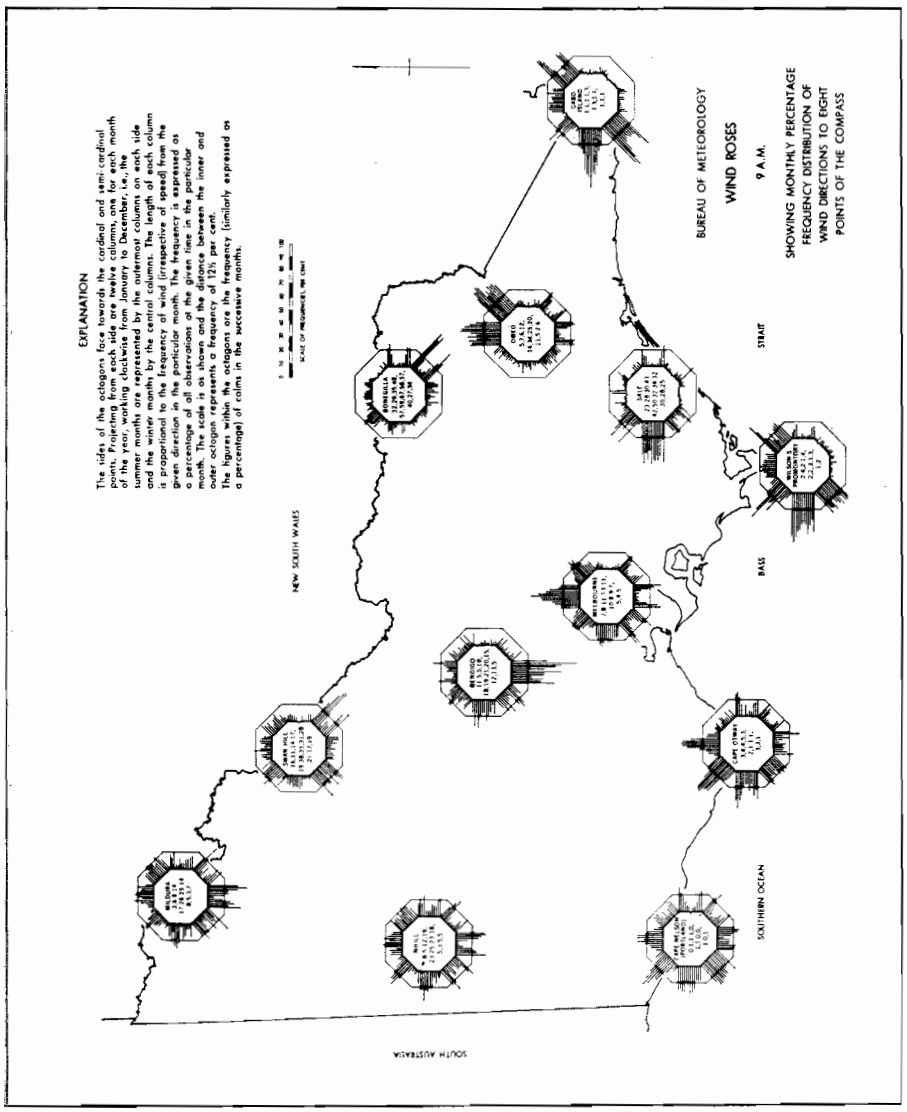


FIGURE 11. Victoria—wind roses for 9 a.m.

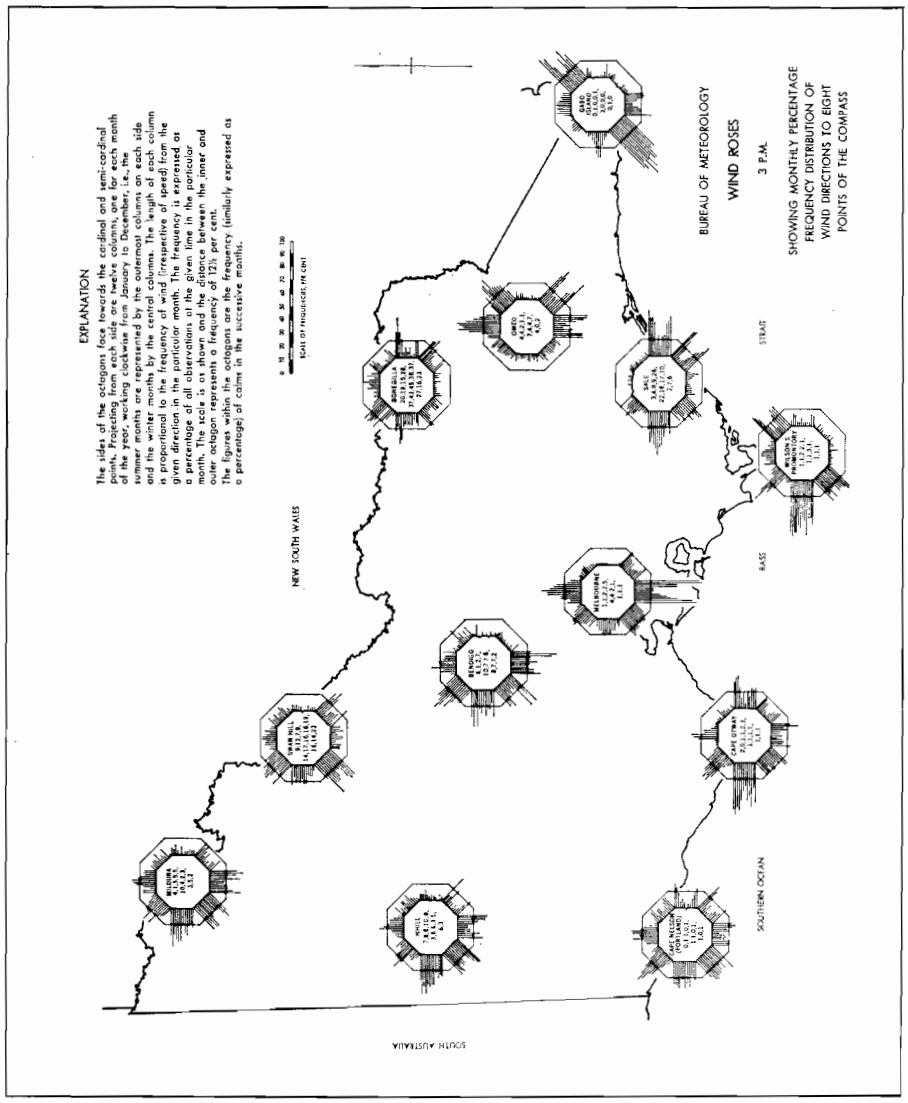


FIGURE 12. Victoria—wind roses for 3 p.m.

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.

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.

Maritime meteorology

The Bureau of Meteorology provides a comprehensive operational forecasting service for all shipping and small craft. Maritime bulletins for shipping, issued by the Bureau, consist of (i) any warnings which are current for the area; (ii) a brief description of the synoptic situation, expected development, and any significant weather; and (iii) a forecast of wind direction and speed and the associated state of the sea.

The Victorian Regional Forecasting Centre issues forecasts twice daily for the high seas area between 30°S and 50°S and between 130°E and 170°E. These forecasts are broadcast on multi-wave by the Sydney long distance ship-shore radio station. A current weather chart and a forecast of the chart for the following 24 hours is broadcast in an international code, to enable ships' captains to plot their own weather charts. Ships equipped with radio-facsimile receivers receive broadcasts of weather charts by facsimile and clear reproductions are received at considerable distances. Forecasts are also issued twice daily by the Victorian Regional Forecasting Centre and broadcast by Melbourne Radio VIM, for the ocean area between 38°S and 50°S and 141°E and 160°E, and, separately, for Bass Strait.

For fishing craft, forecasts are issued twice daily for coastal waters, extending 100 kilometres to seaward. The Victorian coast is divided into five sections, namely, from the South Australian border to Port Campbell, from Port Campbell to Queenscliffe, from Queenscliffe to Wilsons Promontory, from Wilsons Promontory to Lakes Entrance, and from Lakes Entrance to Gabo Island. These forecasts are broadcast by commercial and national radio stations near the coast.

Forecasts of wind speed and direction and the associated state of sea for Port Phillip and Western Port Bays are issued four times daily with the Official

Weather Reports and are broadcast by Melbourne metropolitan radio and television stations and published in the metropolitan press. Forecasts for Port Phillip Bay are also included in the automatic telephone forecast for the Melbourne metropolitan area.

The provision of warnings is by far the most important shipping requirement of a meteorological service, since its purpose is the protection of human life and property. Storm warnings are issued whenever the mean wind is expected to exceed 48 knots or force 10 on the Beaufort scale. Any storm warning received from an adjoining area (Adelaide or Sydney) that is likely to affect shipping proceeding through that area is rebroadcast by Melbourne radio. If the mean wind is expected to be between 34 and 47 knots (Beaufort force 7 to 9), a gale warning is issued, while if it is expected to be between 27 and 33 knots (Beaufort force 6), a strong wind warning is issued. The latter was designed specifically for the benefit of smaller craft.

To supplement the data of its established observational network, the Bureau receives regular weather reports from a selected number of ships every six hours and special weather reports are made by ships when weather conditions become extreme, e.g., during tropical cyclones. Data received from ships are most valuable, but are sparse away from regular shipping routes, such as over the ocean far south of Australia. Port meteorological agents maintain contact with the reporting officers on ships, inspect meteorological equipment, and instruct, enlist, and equip ships with the instruments needed to provide regular reports.

With the introduction of container ships and faster services, the number of observations received has been considerably reduced in recent years. However, satellites orbiting the earth provide photographs of the ocean areas and these help in the detection and location of cyclones and storms. In the future it is hoped that automatic weather stations on buoys either moored or drifting, and interrogated by satellite, will add to our knowledge of weather conditions over the oceans.

A special maritime service is provided by the Victorian Regional Forecasting Centre for the offshore oil and gas field in the Gippsland waters. The service includes special forecasts of winds, waves, and swell several times a day, as well as routine forecasts of general weather and warnings of likely extreme weather.

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 Melbourne metropolitan area. For example, there are approximately ten annual occurrences of 2°C or under 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 Bay side.

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

MELBOURNE—MEANS OF CLIMATIC ELEMENTS

Meteorological element	Spring	Summer	Autumn	Winter
Mean atmospheric pressure (millibar)	1,014.8	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)	186	156	170	149
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	7.7	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 of the years 1971 to 1975 are shown. The extreme values of temperature in each year are also included.

MELBOURNE—YEARLY MEANS AND EXTREMES OF CLIMATIC ELEMENTS

Meteorological element	1971	1972	1973	1974	1975
Mean atmospheric pressure (millibar)	1,014.2	1,018.2	1,017.0	1,015.7	1,015.8
Temperature of air in shade (°C)—					
Mean	15.5	15.5	15.5	15.6	15.6
Mean daily maximum	19.8	20.3	19.8	19.7	19.8
Mean daily minimum	11.0	10.8	11.2	11.4	11.4
Absolute maximum	38.7	39.9	40.5	36.5	39.6
Absolute minimum	−0.1	0.0	−0.5	0.6	0.9
Mean terrestrial minimum temperature (°C)	9.4	8.9	9.6	9.7	9.7
Number of days maximum 35°C and over	8	6	11	3	7
Number of days minimum 2°C and under	4	7	10	5	3
Rainfall (mm)	779	566	817	804	710
Number of days of rain	154	119	150	164	169
Total amount of evaporation (mm) (*a*)	1,503	1,587	1,496	1,418	1,393
Mean relative humidity at 9 a.m. (saturation=100)	70	69	69	73	71
Mean daily amount of cloudiness (scale 0 to 8) (*b*)	4.9	4.3	5.1	5.1	4.9
Mean daily hours of sunshine (*c*)	5.9	6.7	6.3	6.1	6.1
Mean daily wind speed (km/h)	12.2	12.7	9.7	9.4	10.3
Number of days of wind gusts 63 km/h and over	69	58	78	58	43
Number of days of fog	7	9	8	5	13
Number of days of thunder	13	10	7	11	10

(*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 of monthly rainfall is from 7 mm to 180 mm, but variability increases towards the warmer months. In the latter period, monthly 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 over 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 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 1,376 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 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 more than 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 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 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 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 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 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 1975

The first six months of 1975 were mostly dry in Victoria, while the second half of the year was generally wet. Yearly rainfall was above average at most places.

January and February were dry months, the latter particularly so in the western half of the State. Following a rapid change in the weather on 24 January, the maximum temperature in Melbourne on 25 January (17.6°C) was the lowest in January for ten years. The only significant heatwave occurred between 5 and 8 February when the temperature exceeded 40°C in the north-west.

Rainfall was above average in several districts in March and there was a flood on the Snowy River on 13 and 14 March. On 9 March a thunderstorm moved over the eastern suburbs of Melbourne from Ringwood to Prahran bringing 50 mm of rain in half an hour at some places. Cold weather prevailed on 20 March, when the first snow fell on the Alps, and there was further cold showery weather with hail and snow on Easter Monday, 31 March.

April was dry except in east Gippsland, where there was a minor flood on the Snowy River on 20 April. There was a prolonged period of westerly winds and showers from 11 to 19 May, with heavy rain in the north-east, but the month was again dry in the north and north-west. On the evening of 13 May a severe squall caused damage to buildings at Carrum. The temperature reached 29.6°C at Mildura on 6 May, the highest May reading since 1938, while 26.7°C at Melbourne on 21 May was the highest ever recorded in the second half of the month.

Cold weather prevailed on several occasions in June. Snow fell on Mt Macedon on 5 June and on the Calder Highway between Woodend and Gisborne, as well as on the Dandenong Ranges, on the evening of 11 June. On 18 June, when mist and fog continued all day, the maximum temperature in Melbourne of 7.2°C was the lowest for June since 1950. At Melbourne Airport the temperature had risen to only 4°C by 3 p.m.

A storm east of Bass Strait on 21–22 June caused heavy rain and floods in east Gippsland, while heavy swells caused damage to oil platforms off the Gippsland coast. Apart from Gippsland, rainfall in June was below average, particularly in the north; at most places along the Murray valley it was the driest June on record. The total rainfall for the eight months from November

1974 to June 1975 was the lowest on record at several places in the north of the State.

The first worthwhile rain for the year in the north-west fell on 12 July and July rainfall was close to or above average in all districts except east Gippsland. Remarkably warm weather occurred in the last half of July. The temperature in Melbourne exceeded 15°C on each of eleven consecutive days; the previous record was broken with 22.7°C on 28 July and broken again with 23.1°C on 30 July. In the Mallee the temperature exceeded 27°C. At practically all places in Victoria the temperature was the highest ever recorded in July. In Melbourne the minimum temperature of 16.4°C on 30 July was the highest recorded in any winter month.

The three months from early August to early November were very wet throughout Victoria with frequent, widespread rain. August in Melbourne was the second wettest on record and minor flooding occurred on most rivers in eastern Victoria. Following heavy rain on 17 September, with locally intense falls on the ranges, serious flooding occurred on most northern rivers. Several railways and main roads were cut.

October was the wettest on record over much of northern and western Victoria. In the southern Wimmera, rainfall in this month was the highest on record for any month. In Melbourne rain fell on sixteen consecutive days, the highest number recorded in spring. On 20 October, thunderstorms with hail and strong winds occurred at Quambatook, Bright, and other places in northern Victoria. On 24 October, a violent thunderstorm caused damage at Beaumaris, and golfers were struck by lightning. There was further flooding of northern rivers on 9 and 21 October and in the last week of the month. The Murray River was above flood level for most of the spring, cutting the Hume Highway at Albury on 26 October and reaching very high levels at Cobram on 29 October and Echuca on 1 November. There was no further flooding of Victorian rivers after the end of October, but the flood on the Murray River continued to move downstream, the level at Mildura only falling below flood level after the end of the year.

Mean temperatures in November were well above average throughout the State, while rainfall was generally below average. However, thunderstorms occurred on several days during the month; on 9 November streets were flooded in the centre of Melbourne. On 24–25 November there were severe gales along the coast.

Hot weather prevailed throughout Victoria on 11 December, the temperature exceeding 40°C in the north. In mid-December, heavy rain fell in the north-east and along the Murray valley. December rainfall was the highest on record in the Mildura–Robinvale area. On 29 December, large hail fell with thunderstorms at Box Hill, Laverton, and other places in the Central District.

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