CHAPTER FIVE

PHYSICAL GEOGRAPHY AND CLIMATE OF AUSTRALIA

This chapter is concerned with the physical geography of Australia and features influencing Australia's climate. Detailed climatic data for each capital city are included. A special article on Australian landforms is below, and an article on Australia's weather service is included at the end of the chapter (*see* page 248).

LANDFORMS AND THEIR HISTORY

(This special article has been contributed by Professor Cliff Ollier, University of New England)

Australia is the lowest, flattest, and, apart from Antarctica, the driest of the continents. Unlike Europe and North America, where much of the landscape dates back to 20,000 years ago when great ice sheets retreated, the age of landforms in Australia is generally measured in many millions of years. This fact gives Australia a very distinctive physical geography.

The continent can be divided into three parts—the Western Plateau, the Central Lowlands and the Eastern Highlands.

The Western Plateau consists of very old rocks (some over 3,000 million years old), and much of it has existed as a landmass for over 500 million years. Several parts have individual 'plateau' names (e.g. Kimberley, Hammersley, Arnhem Land, Yilgarn). In the Perth area, younger rocks along a coastal strip are separated from the rest by the Darling Fault escarpment. The Nullarbor Plain is virtually an uplifted sea floor, a limestone plain of Miocene age (about 25 million years).

The Central Lowlands stretch from the Gulf of Carpentaria through the Great Artesian Basin to the Murray-Darling Plains. The Great Artesian Basin is filled with sedimentary rocks which hold water that enters in the wetter Eastern Highlands.

Much of the centre of Australia is flat, but there are numerous ranges (e.g. Macdonnels, Musgrave) and some individual mountains of which Ayers Rock (Uluru) is the best known. Faulting and folding in this area took place long ago, the area was worn to a plain, the plain uplifted and then eroded to form the modern ranges on today's plain. In looking at Ayers Rock the remarkable thing is not how it got there, but that so much has been eroded from all around, leaving it there.

In the South Australian part of the Central Lowlands fault movements are more recent, and the area can be considered as a number of blocks that have been moved up and down to form a series of 'ranges' (Mt Lofty, Flinders Ranges) and 'hills' (such as the Adelaide Hills), with the downfaulted blocks occupied by sea (e.g. Spencer Gulf) or lowlands including the lower Murray Plains.

The Eastern Highlands rise gently from central Australia towards a series of high plateaus, and even the highest part around Mt Kosciusko (2,230 m) is part of a plateau. There are a few younger faults and folds, such as the Lake George Fault near Canberra, and the Lapstone Monocline near Sydney.

Some plateaus in the Eastern Highlands are dissected by erosion into rugged hills, and the eastern edges of plateaus tend to form high escarpments. Many of these are united to form a Great Escarpment that runs from northern Queensland to the Victorian border. Australia's highest waterfalls (Wollombi on the Macleay, Wallaman Falls on a tributary of the Herbert, Barron Falls near Cairns, and Wentworth Falls in the Blue Mountains) all occur where rivers flow over the Great Escarpment. For most of its length the Great Divide (separating rivers flowing to Central Australia from rivers flowing to the Pacific) runs across remarkably flat country dotted with lakes and airstrips, and there is no 'Great Dividing

Range'. In eastern Victoria, however, the old plateau has been eroded into separate High Plains (such as Dargo High Plain), mostly lying south of the Divide which here runs across rugged country.

The present topography results from a long landscape history which can conveniently be started in the Permian, about 290 million years ago, when much of Australia was glaciated by a huge ice cap. After the ice melted, parts of the continent subsided and were covered with sediment to form sedimentary basins such as the Great Artesian Basin. By early Cretaceous times, about 140 million years ago, Australia was already so flat and low that a major rise in sea level divided it into three landmasses as the shallow Cretaceous sea spread over the land.

In the following Tertiary times Australia can be regarded as a landscape of broad swells varied by a number of sedimentary basins (Murray, Gippsland, Eucla, Carpentaria, Lake Eyre and other basins). These slowly filled up and some are now sources of coal or oil. The Eastern Highlands were uplifted about this time.

Throughout the Tertiary, volcanoes erupted in eastern Australia. Some individual volcanoes were the size of modern Vesuvius, and huge lava plains covered large areas. Volcanic activity continued up to a few thousand years ago in Victoria and Queensland. Australia's youngest volcano is Mt Gambier in South Australia, about 6,000 years old.

Between about 55 and 10 million years ago Australia drifted across the surface of the earth as a plate, moving north from a position once adjacent to Antarctica. There have been many changes in the climate of Australia in the past, but oddly these are not due to changing latitude. Even when Australia was close to the South Pole the climate was warm and wet, and this climate persisted for a long time despite changes in latitude. It was probably under this climate that the deep weathered, iron-rich profiles that characterise much of Australia were formed. Aridity only seems to have set in after Australia reached its present latitude, and the northern part was probably never arid.

Today a large part of Australia is arid or semi-arid. Sand dunes are mostly longitudinal, following the dominant wind directions of a high pressure cell. The dunes are mostly fixed now. Stony deserts or gibber plains (covered with small stones or 'gibbers') are areas without a sand cove and occupy a larger area than the dunefields. Salt lakes occur in many low positions, in places following lines of ancient drainage. They are often associated with lunettes, dunes formed on the downwind side of lakes. Many important finds of Aboriginal pre-history have been made in lunettes. Despite the prevalence of arid conditions today, real aridity seems to be geologically young, with no dunes or salt lakes older than a million years.

The past few million years were notable for the Quarternary ice age. There were many glacial and interglacial periods (over 20) during this time, the last glacial about 20,000 years ago. In Tasmania there is evidence of three different glaciations—the last glaciation, one sometime in the Quaternary, and one in the Tertiary. In mainland Australia there is evidence of only the last glaciation, and the ice then covered only 25 square kilometres, in the vicinity of Mt Kosciusko.

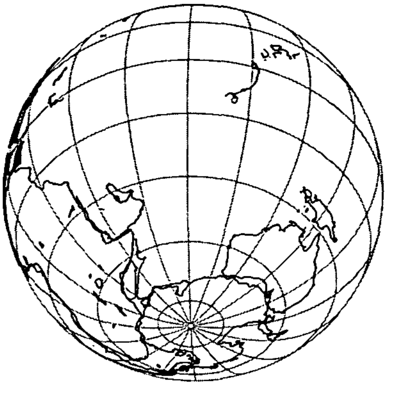
The broad shape of Australia is caused by earth movements, but most of the detail is carved by river erosion. Many of Australia's rivers drain inland, and while they may be eroding their valleys near their highland sources, their lower courses are filling up with alluvium, and the rivers often end in salt lakes which are dry for most of the time. Other rivers reach the sea, and have dissected a broad near-coast region into plateaus, hills and valleys. Many of the features of the drainage pattern of Australia have a very long history, and some individual valleys have maintained their position for hundreds of millions of years. The salt lakes of the Yilgarn Plateau in Western Australia are the remnants of a drainage pattern that was active before continental drift separated Australia from Antarctica.

During the last ice age, sea level was over 100 metres lower than it is today, and rivers cut down to this low level. When sea level rose again the lower valleys were drowned. Some make fine harbours (e.g. Sydney Harbour), whilst others have tended to fill with alluvium, making the typical lowland valleys around the Australian coast.

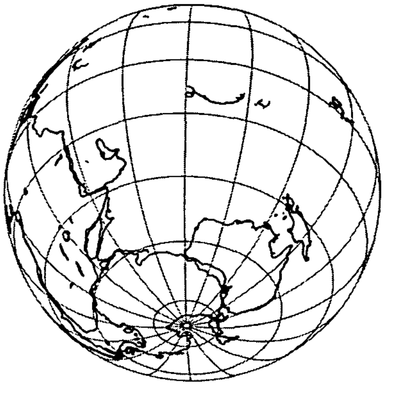
Coastal geomorphology is also largely the result of the accumulation of sediment on drowned coasts. In some areas, such as Ninety Mile Beach (Victoria) or the Coorong (South Australia), there are simple accumulation beaches. In much of the east there is a characteristic alternation of rocky headland and long beach, backed by plains filled with river and marine sediments.

PALAEOGEOGRAPHIC RECONSTRUCTION MAPS: 300 MILLION YEARS AGO TO PRESENT DAY

(*Source:* Bureau of Mineral Resources, Geology and Geophysics)

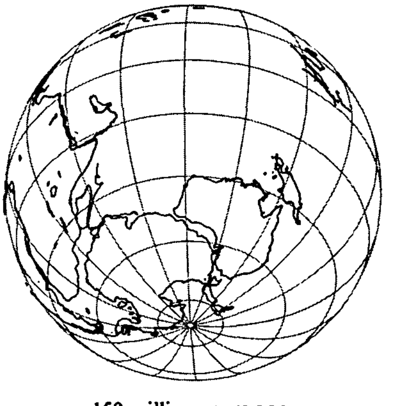


300 million years ago

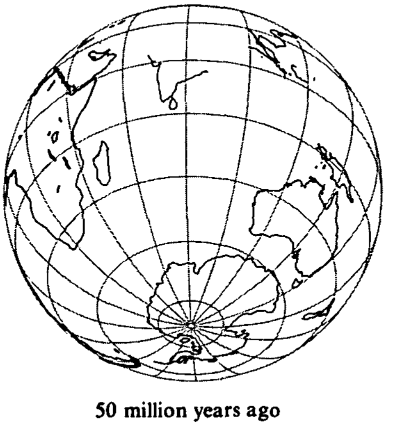


250 million years ago

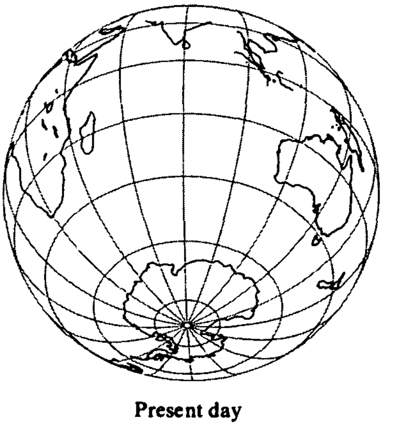
200 million years ago



150 million years ago



50 million years ago



Present day

These maps have been produced on an orthographic projection with a 20 degree graticule spacing. All six maps have a centre of view at a location of 83 degrees East longitude and 45 degrees South latitude.

The offshore shape of Australia, revealed in isobath contours, results mainly from the pattern of break-up of the super-continent of which Australia was once a part. There is a broad continental shelf around most of Australia, bounded by a steeper continental slope, except in New South Wales where the continental shelf is very narrow. The Queensland coast is bounded by a broad plateau on which the Great Barrier Reef has grown in only the last two million years. In South Australia the continental shelf is grooved by submarine canyons.

The Australian landforms of today are thus seen to result from long-continued processes in a unique setting, giving rise to typical Australian landscapes, which in turn provide the physical basis for the distribution and nature of biological and human activity in Australia.

Geography of Australia

Position and area

Position

Australia comprises a land area of 7,682,300 square kilometres. The land lies between latitudes 10°41'S. (Cape York) and 43°39'S. (South Cape, Tasmania) and between longitudes 113°09'E. (Steep Point) and 153°39'E. (Cape Byron). The most southerly point on the mainland is South Point (Wilson's Promontory) 39°08'S. The latitudinal distance between Cape York and South Point is about 3,180 kilometres, while the latitudinal distance between Cape York and South East Cape, Tasmania, is 3,680 kilometres. The longitudinal distance between Steep Point and Cape Byron is about 4,000 kilometres.

Area of Australia compared with other countries

The area of Australia is almost as great as that of the United States of America (excluding Alaska), about 50 per cent greater than Europe (excluding U.S.S.R.) and 32 times greater than the United Kingdom. The following table shows the area of Australia in relation to areas of other continents and selected countries.

AREAS OF CONTINENTS AND SELECTED COUNTRIES

('000 square kilometres)

Country	*Area*	*Country*	*Area*
Continental divisions—		Canada	9,976
Europe (*a*)	4,936	China	9,590
Asia (*a*)	27,532	Germany, Federal Republic of	248
U.S.S.R. (Europe and Asia)	22,402	India	3,288
Africa	30,319	Indonesia	1,919
North and Central America and West Indies	24,247	Japan	372
South America	17,834	Papua New Guinea	462
Oceania	8,504	New Zealand	269
Country—		United Kingdom	244
Australia.	7,682	United States of America (*b*)	9,363
Brazil	8,512	**Total, land mass excluding Arctic and Antarctic continents**	**135,771**

(*a*) Excludes U.S.S.R., shown below. (*b*) Includes Hawaii and Alaska.

Rivers and lakes

The rivers of Australia may be divided into two major classes, those of the coastal margins with moderate rates of fall and those of the central plains with very slight fall. Of the rivers of the east coast, the longest in Queensland are the Burdekin and the Fitzroy, while the Hunter is the largest coastal river of New South Wales. The longest river system in Australia is the Murray-Darling which drains part of Queensland, the major part of New South Wales and a large part of Victoria, finally flowing into the arm of the sea known as Lake Alexandrina, on the eastern side of the South Australian coast. The length of the Murray is about 2,520 kilometres and the Darling and Upper Darling together are also just over 2,500 kilometres long. The rivers of the north-west coast of Australia, e.g. the Murchison, Gascoyne, Ashburton, Fortescue, De Grey, Fitzroy, Drysdale and Ord, are of considerable size. So also are those rivers in the Northern Territory, e.g. the Victoria and Daly, and those on the Queensland side of the Gulf of Carpentaria, such as the Gregory, Leichhardt, Cloncurry, Gilbert and Mitchell. The rivers of Tasmania have short and rapid courses, as might be expected from the configuration of the country.

There are many types of lakes in Australia, the largest being drainage sumps from the internal rivers. In dry seasons these lakes finally become beds of salt and dry mud. The largest are Lake Eyre 9,500 square kilometres, Lake Torrens 5,900 square kilometres and Lake Gairdner 4,300 square kilometres.

Other lake types are glacial, most common in Tasmania; volcanic crater lakes predominantly in Victoria and Queensland; fault angle lakes, of which Lake George near Canberra is a good example and coastal lakes formed by marine damming of valleys.

Area, coastline, tropical and temperate zones, and standard times

The areas of the States and Territories and the length of the coastline were determined in 1973, by the Division of National Mapping, Department of National Resources, by manually digitising these features from the 1:250,000 map series of Australia. This means that only features of measurable size at this scale were considered. About 60,000 points were digitised at an approximate spacing of 0.5 kilometres. These points were joined by chords as the basis for calculation of areas and coastline lengths by computer.

The approximate high water mark coastline was digitised and included all bays, ports and estuaries which are open to the sea. In these cases, the shoreline was assumed to be where the seaward boundary of the title of ownership would be. In mangroves, the shoreline was assumed to be on the landward side. Rivers were considered in a similar manner but the decisions were rather more subjective, the line being across the river where it appeared to take its true form.

AREA, COASTLINE, TROPICAL AND TEMPERATE ZONES, AND STANDARD TIMES: AUSTRALIA

State or Territory	*Estimated area* Total	*Estimated area* Percentage of total area	Length of coastline	*Percentage of total area* Tropical zone	*Percentage of total area* Temperate zone	*Standard times* Meridian selected	*Standard times* Ahead of G.M.T.(a)
	km²		km				hours(b)
New South Wales	801,600	10.43	1,900	..	100	150°E	(b)10.0
Victoria	227,600	2.96	1,800	..	100	150°E	(b)10.0
Queensland	1,727,200	22.48	7,400	54	46	150°E	10.0
South Australia	984,000	12.81	3,700	..	100	142°30'E	(b)9.5
Western Australia	2,525,500	32.87	12,500	37	63	120°E	8.0
Tasmania	67,800	0.88	3,200	..	100	150°E	(b)10.0
Northern Territory	1,346,200	17.52	6,200	81	19	142°30'E	9.5
Australian Capital Territory	2,400	0.03	35	..	100	150°E	(b)10.0
Australia	**7,682,300**	**100.00**	**36,735**	**39**	**61**	..	..

(a) Greenwich Mean Time. (b) For States with 'daylight saving' an hour should be added for this period.

Climate of Australia

The climate of Australia is predominantly continental but the insular nature of the land mass is significant in producing some modification of the continental pattern.

The island continent of Australia is relatively dry, with 80 per cent of the area having a median rainfall of less than 600 millimetres per year and 50 per cent less than 300 millimetres. Extreme minimum temperatures are not as low as those recorded in other continents because of the absence of extensive mountain masses and because of the expanse of the surrounding oceans. However, extreme maxima are comparatively high, reaching 50°C over the inland, mainly due to the great east-west extent of the continent in the vicinity of the Tropic of Capricorn.

Climatic discomfort, particularly heat discomfort, is significant over most of Australia. During summer, prolonged high temperatures and humidity around the northern coasts and high temperatures over the inland cause physical discomfort. In winter, low temperatures and strong cold winds over the interior and southern areas can be severe for relatively short periods.

Climatic controls

The generally low relief of Australia causes little obstruction to the atmospheric systems which control the climate. A notable exception is the eastern uplands which modify the atmospheric flow.

In the winter half of the year (May-October) anticyclones, or high pressure systems, pass from west to east across the continent and often remain almost stationary over the interior for several days. These anticyclones may extend to 4,000 kilometres along their west-east axes. Northern Australia is then influenced by mild, dry south-east trade winds, and southern Australia experiences cool, moist westerly winds. The westerlies and the frontal systems associated with extensive depressions travelling over the Southern Ocean have a controlling influence on the climate of southern Australia during the winter season, causing rainy periods. Cold outbreaks, particularly in south-east Australia, occur when cold air of Southern Ocean origin is directed northwards by intense depressions having diameters up to 2,000 kilometres. Cold fronts associated with the southern depressions, or with secondary depressions over the Tasman Sea, may produce large day-to-day changes in temperature in southern areas, particularly in south-east coastal regions.

In the summer half of the year (November-April) the anticyclones travel from west to east on a more southerly track across the southern fringes of Australia directing easterly winds generally over the continent. Fine, warmer weather predominates in southern Australia with the passage of each anticyclone. Heat waves occur when there is an interruption to the eastward progression of the anticyclone (blocking) and winds back northerly and later north-westerly. Northern Australia comes under the influence of summer disturbances associated with the southward intrusion of warm moist monsoonal air from north of the inter-tropical convergence zone, resulting in a hot rainy season.

Tropical cyclones develop over the seas around northern Australia in summer between November and April. Their frequency of occurrence and the tracks they follow vary greatly from season to season. On average, about three cyclones per season directly affect the Queensland coast, and about three affect the north and north-west coasts. Tropical cyclones approaching the coast usually produce very heavy rain and high winds in coastal areas. Some cyclones move inland, losing intensity but still producing widespread heavy rainfall. Individual cyclonic systems may control the weather over northern Australia for periods extending up to three weeks.

Rainfall

Annual

The annual 10, 50 and 90 percentile* rainfall maps are shown on Figures 1, 2 and 3 respectively. The area of lowest rainfall is in the vicinity of Lake Eyre in South Australia, where the median (50 percentile) rainfall is only about 100 millimetres. Another very low rainfall area is in Western Australia in the Giles-Warburton Range region, which has a median annual rainfall of about 150 millimetres. A vast region, extending from the west coast near Shark Bay across the interior of Western Australia and South Australia to south-west Queensland and north-west New South Wales, has a median annual rainfall of less than 200 millimetres. This region is not normally exposed to moist air masses for extended periods and rainfall is irregular, averaging only one or two days per month. However, in favourable synoptic situations, which occur infrequently over extensive parts of the region, up to 400 millimetres of rain may fall within a few days and cause widespread flooding.

The region with the highest median annual rainfall is the east coast of Queensland between Cairns and Cardwell, where Tully has a median of 4,058 millimetres (61 years to 1985 inclusive). The mountainous region of western Tasmania also has a high annual rainfall, with Lake Margaret having a median of 3,559 millimetres (72 years to 1985 inclusive). In

* The amounts that are not exceeded by 10, 50 and 90 per cent of all recordings are the 10, 50 and 90 percentiles or the first, fifth and ninth deciles respectively. The 50 percentile is usually called the median.

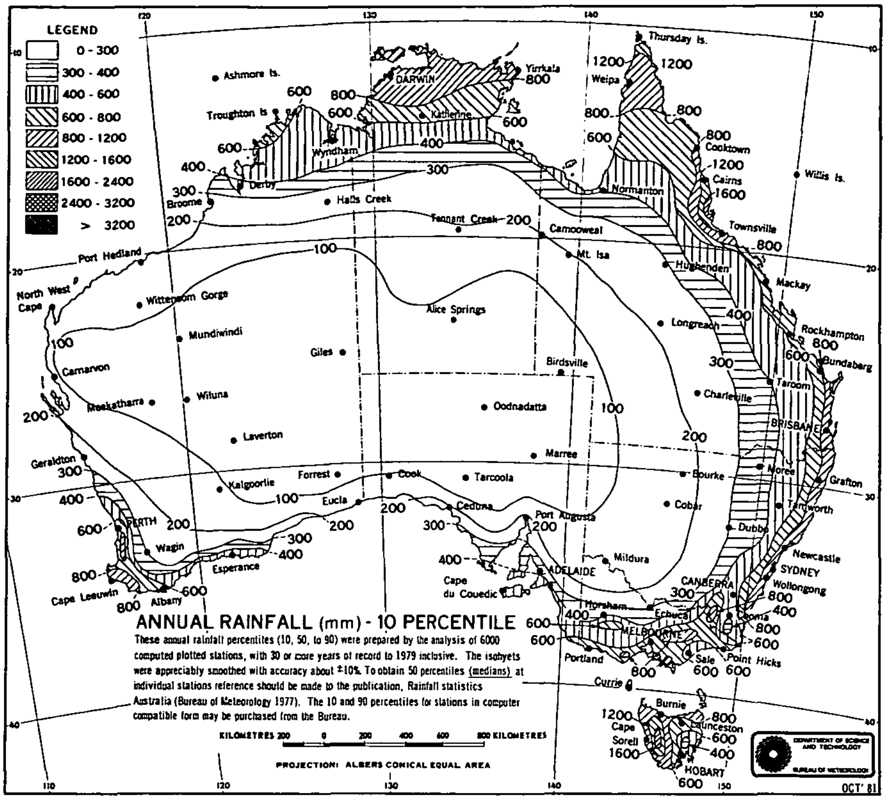


FIGURE 1

the mountainous areas of north-east Victoria and some parts of the east coastal slopes there are small pockets with median annual rainfall greater than 2,500 millimetres, but the map scale is too small for these to be shown.

The Snowy Mountains area in New South Wales also has a particularly high rainfall. The highest median annual rainfall isohyet drawn for this region is 3,200 millimetres, and it is likely that small areas have a median annual rainfall approaching 4,000 millimetres on the western slopes above 2,000 metres elevation.

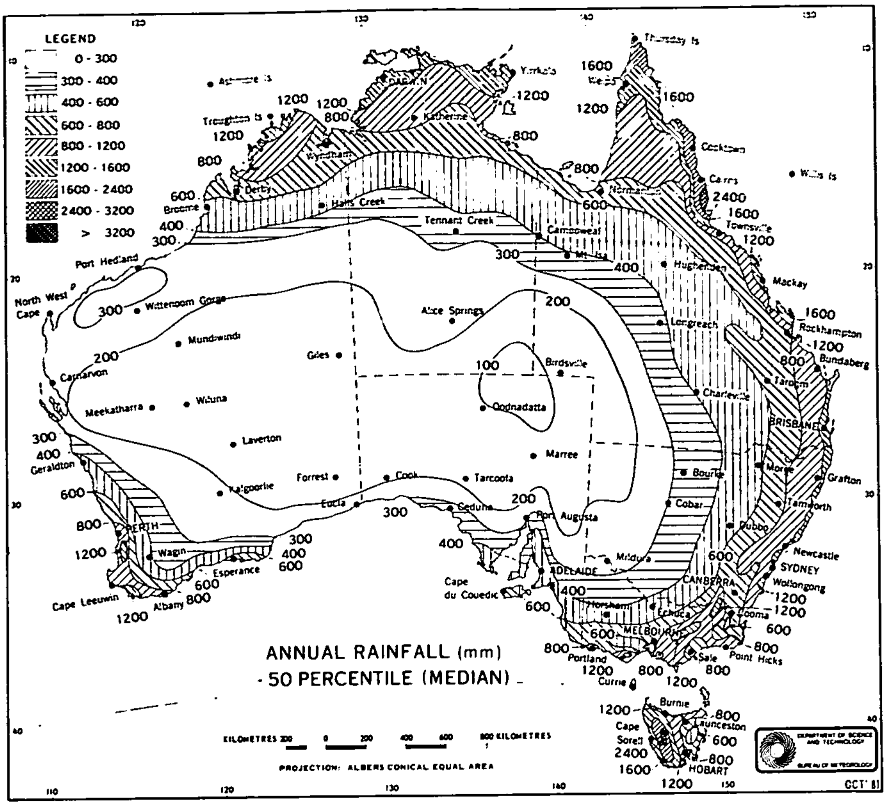
The following table shows the area distribution of the median annual rainfall.

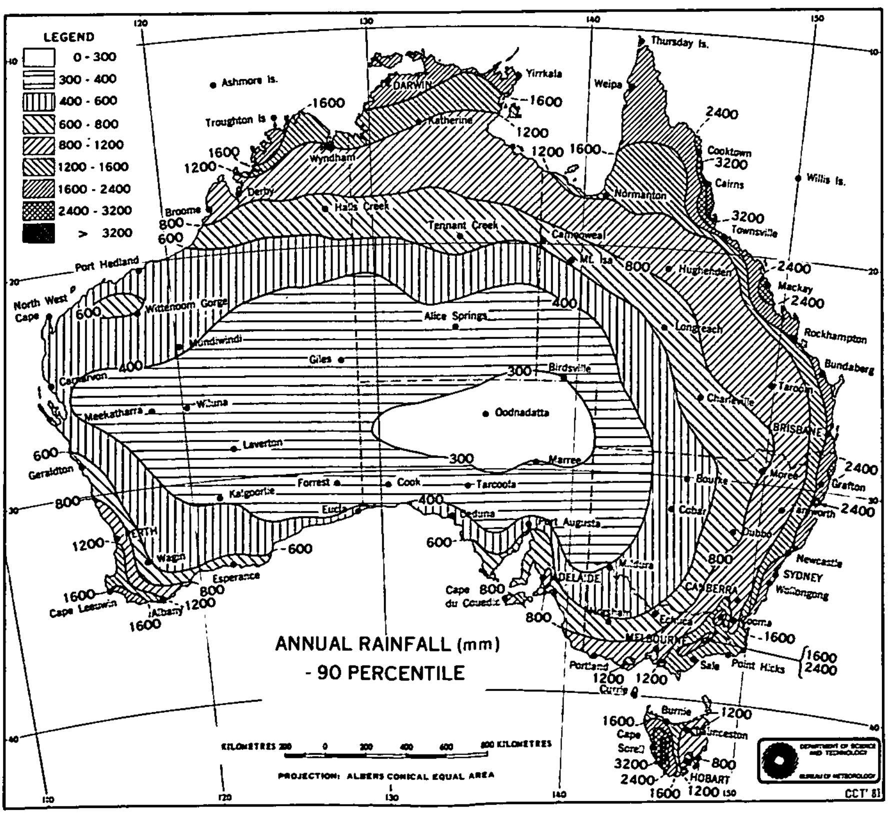
AREA DISTRIBUTION OF MEDIAN ANNUAL RAINFALL: AUSTRALIA

(per cent)

Median annual rainfall	*N.S.W.(a)*	*Vic.*	*Qld*	*S.A.*	*W.A.*	*Tas.*	*N.T.*	*Aust.*
Under 200 mm . . .	8.0	..	10.2	74.2	43.5	..	15.5	29.6
200 to 300 „ . . .	20.3	6.3	13.0	13.5	29.6	..	35.6	22.9
300 „ 400 „ . . .	19.0	19.2	12.3	6.8	10.5	..	9.0	11.2
400 „ 500 „ . . .	12.4	11.8	13.5	3.2	4.3	..	6.6	7.6
500 „ 600 „ . . .	11.3	14.1	11.6	1.8	3.1	12.2	5.8	6.6
600 „ 800 „ . . .	15.1	24.5	20.5	0.5	4.6	18.2	11.6	10.7
800 „ 1,200 „ . . .	11.3	17.7	12.6	..	3.7	25.0	9.6	7.7
Above 1,200 „ . . .	2.6	6.4	6.3	..	0.7	44.6	6.3	3.7
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

(*a*) Includes Australian Capital Territory.





FIGURES 2 AND 3

Seasonal

As outlined above, the rainfall pattern of Australia is strongly seasonal in character with a winter rainfall regime in the south and a summer regime in the north.

The dominance of rainfall over other climatic elements in determining the growth of specific plants in Australia has led to the development of a climatic classification based on two main parameters. The parameters are median annual rainfall and seasonal rainfall incidence. Figure 4 is a reduced version of the seasonal rainfall zones arising from this classification (*see* Bureau of Meteorology publication *Climatic Atlas of Australia, Map Set 5, Rainfall, 1977*).

Evaporation and the concept of rainfall effectiveness are taken into account to some extent in this classification by assigning higher median annual rainfall limits to the summer zones than the corresponding uniform and winter zones. The main features of the seasonal rainfall are:

- marked wet summer and dry winter of northern Australia;
- wet summer and relatively dry winter of south-eastern Queensland and north-eastern New South Wales;
- uniform rainfall in south-eastern Australia—much of New South Wales, parts of eastern Victoria and in southern Tasmania;
- marked wet winter and dry summer of south-west Western Australia and, to a lesser extent, of much of the remainder of southern Australia directly influenced by westerly circulation;
- arid area comprising about half the continent extending from the north-west coast of Western Australia across the interior and reaching the south coast at the head of the Great Australian Bight.

The seasonal rainfall classification (*Climatic Atlas, Map Set 5*) can be further reduced to provide a simplified distribution of seven climatic zones as shown in Figure 5.

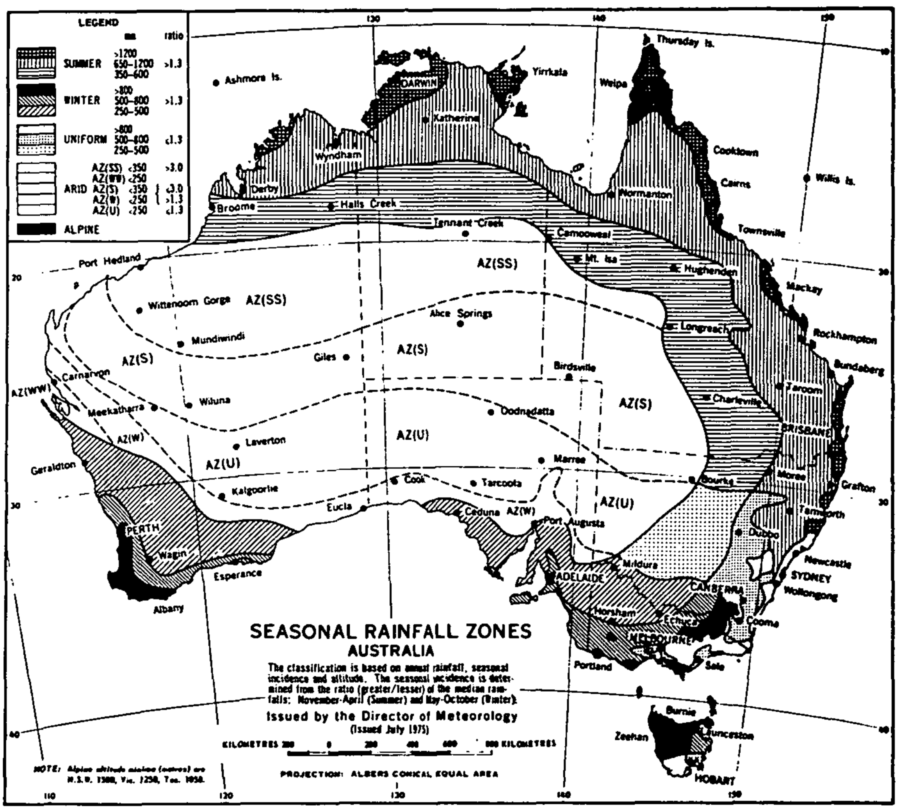
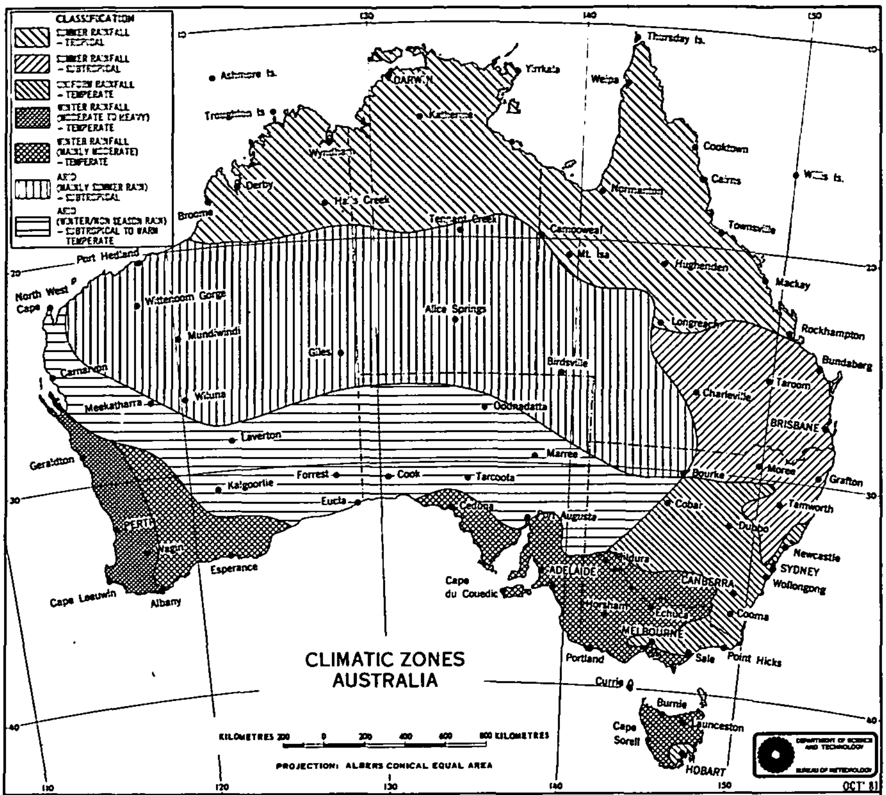


FIGURE 4



CLASSIFICATION	SEASONAL CHARACTERISTICS SUMMER	WINTER
Summer Rainfall - Tropical	Heavy periodic rains (heavier in coastal & highland areas) Hot generally Humid in coastal areas	Generally rainless Mild to warm Dry
Summer Rainfall - Subtropical	Heavy periodic rains (heavier in coastal & highland areas) Mainly hot Humid in highlands & coastal areas	Some significant rain Mild
Uniform Rainfall - Temperate	Mainly reliable rain Warm to hot	Mainly reliable rain Cool to cold
Winter Rainfall (moderate to heavy) - Temperate	Irregular rain, mostly light Warm to hot	Reliable rain (moderate to heavy) Cool to cold
Winter Rainfall (mainly moderate) - Temperate	Mostly light irregular rain Warm to hot	Reliable rain (mainly moderate) Cool to cold
Arid (mainly summer rain) - Subtropical	Variably rain Hot to extreme Very dry	Mainly irregular light rain Mild to warm Dry
Arid (winter or non-seasonal rain) - Warm Temperate to Subtropical	Very irregular rain Hot to extreme Very dry	Variable rain, mainly light Cool to cold Dry

[Reference:- Climatic Atlas of Australia, Map set 5, Bureau of Meteorology 1975]

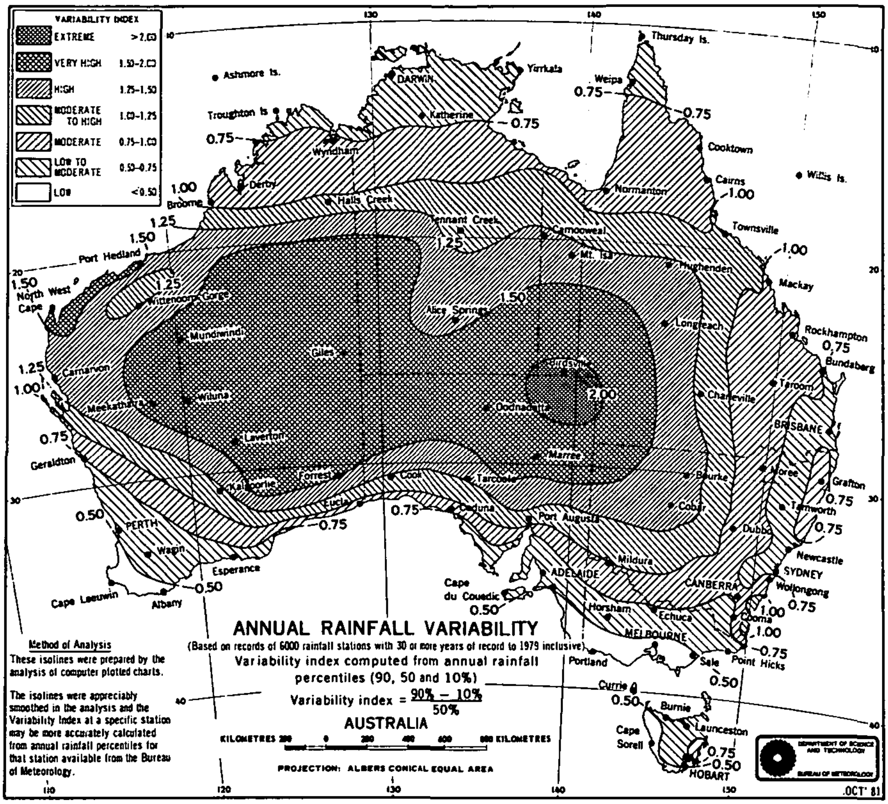
FIGURE 5

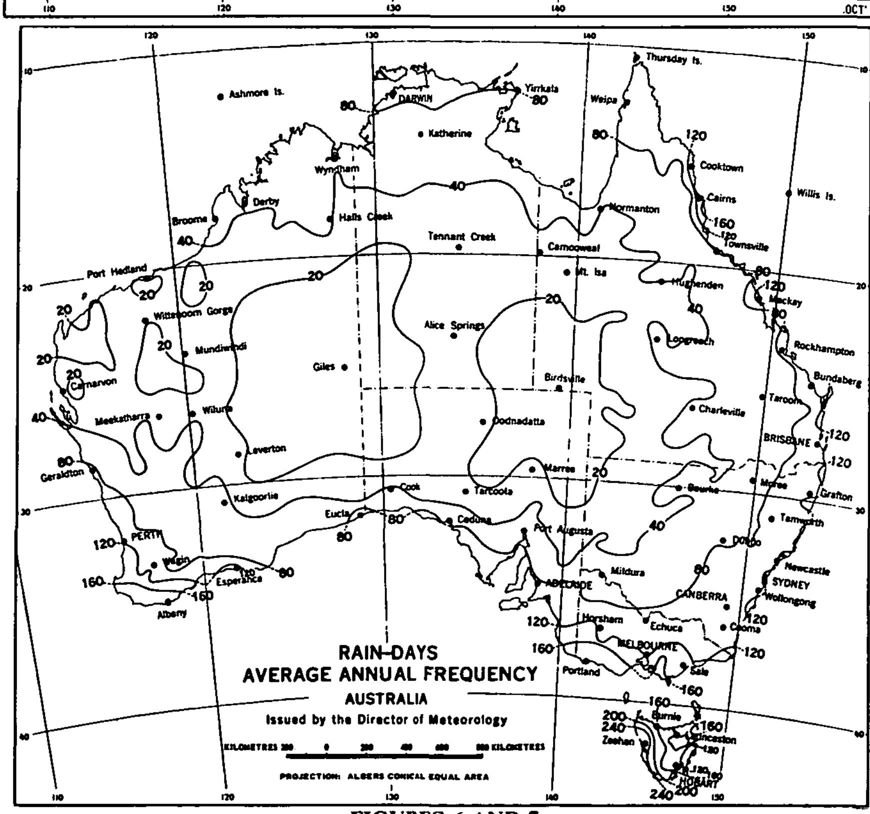
Variability

The adequate presentation of rainfall variability over an extensive geographical area is difficult. Probably the best measures are found in tables compiled for a number of individual stations in some of the Climatic Survey districts. These tables show the percentage chances of receiving specified amounts of rainfall in monthly, seasonal or annual time spans. Statistical indexes of rainfall variation based on several techniques have been used to compile maps showing main features of the variability of annual rainfall over Australia.

One index for assessing the variability of annual rainfall is given by the ratio of the 90—10 percentile range to the 50 percentile (median value):

$$\text{i.e. Variability Index} = \left\{ \frac{90-10}{50} \right\} \text{percentiles.}$$





FIGURES 6 AND 7

Variability based on this relationship (Gaffney 1975) is shown in Figure 6. The region of high to extreme variability shown in Figure 6 lies mostly in the arid zone with summer rainfall incidence, AZ(S) defined on Figure 4. In the winter rainfall zones, the variability is generally low to moderate as exemplified by the south-west of Western Australia. In the tropics, random cyclone visitations cause extreme variations in rainfall from year to year: at Onslow (Western Australia), annual totals varied from 15 millimetres in 1912 to 1,085 millimetres in 1961 and, in the four consecutive years 1921 to 1924, the annual totals were 566, 69, 682 and 55 millimetres respectively. At Whim Creek (Western Australia), where 747 millimetres have been recorded in a single day, only 4 millimetres were received in the whole of 1924. Great variability can also occur in the heavy rainfall areas: at Tully (Queensland), the annual rainfalls have varied from 7,898 millimetres in 1950 to 2,486 millimetres in 1961.

For more information on variability, *see Year Book* No. 68.

Rainday frequency

The average number of days per year with rainfall of 0.2 millimetres or more is shown in Figure 7.

The frequency of rain-days exceeds 150 per year in Tasmania (with a maximum of over 200 in western Tasmania), southern Victoria, parts of the north Queensland coast and in the extreme south-west of Western Australia. Over most of the continent the frequency is less than 50 rain-days per year. The area of low rainfall with high variability, extending from the north-west coast of Western Australia through the interior of the continent, has less than 25 rain-days per year. In the high rainfall areas of northern Australia the number of rain-days is about 80 per year, but heavier falls occur in this region than in southern regions.

Intensity

The highest rainfall intensities for some localities are shown in the table below.

HIGHEST RAINFALL INTENSITIES IN SPECIFIED PERIODS

(millimetres)

(*Source:* Pluviograph records in Bureau of Meteorology archives)

Station	*Period of record*	*Years of complete records*	*Period in hours* 1	3	6	12	24
			mm	mm	mm	mm	mm
Adelaide	1897–1980	80	69	133	141	141	141
Alice Springs	1951–1980	28	75	77	87	108	150
Brisbane	1911–1986	76	88	142	182	266	465
Broome	1948–1979	32	112	157	185	313	351
Canberra	1932–1979	44	51	68	71	89	139
Carnarvon	1956–1979	24	32	63	83	95	108
Charleville	1953–1980	28	42	66	75	111	142
Cloncurry	1953–1975	20	59	118	164	173	204
Darwin (Airport)	1953–1980	25	88	138	214	260	277
Esperance	1963–1979	15	23	45	62	68	79
Hobart	1911–1980	67	28	56	87	117	168
Meekatharra	1953–1979	25	33	67	81	99	112
Melbourne	1878–1980	90	79	83	86	97	130
Mildura	1953–1977	23	49	60	65	65	91
Perth	1946–1980	33	32	38	47	64	93
Sydney	1913–1979	73	121	190	198	233	328
Townsville	1953–1980	26	88	158	235	296	319

These figures represent intensities over only small areas around the recording points because turbulence and exposure characteristics of the measuring gauge may vary over a distance of a few metres. The highest rainfall measured for one hour is 330 millimetres at Deeral, Queensland, 13 March 1936. The highest 24-hour (9 a.m. to 9 a.m.) falls are listed below. Most of the very high 24-hour falls (above 700 millimetres) have occurred in the coastal strip of Queensland, where a tropical cyclone moving close to mountainous terrain provides ideal conditions for spectacular falls. The highest 24-hour fall (1,140 millimetres) occurred at Bellenden Ker (Top Station) on 4 January 1979. Bellenden Ker (Top Station) has also recorded the highest monthly rainfall in Australia (5,387 millimetres in January 1979).

HIGHEST DAILY RAINFALLS

State	*Station*	*Date*	*Amount*
			mm
New South Wales . .	Dorrigo.	21.2.1954	809
	Cordeaux River	14.2.1898	574
Victoria	Tanybryn	22.3.1983	315
	Baloak	18.2.1951	275
Queensland	Bellenden Ker (Top Station) .	4.1.1979	1,140
	Crohamhurst	3.2.1893	907
	Finch Hatton	18.2.1958	878
	Mount Dangar	20.1.1970	869
South Australia . . .	Stansbury	18.2.1946	222
	Stirling	17.4.1889	208
Western Australia . .	Whim Creek	3.4.1898	747
	Kilto	4.12.1970	635
	Fortescue	3.5.1890	593
Tasmania.	Cullenswood	22.3.1974	352
	Mathinna	5.4.1929	337
Northern Territory . .	Roper Valley	15.4.1963	545
	Groote Eylandt	28.3.1953	513

The highest annual rainfalls are listed by State in the following table.

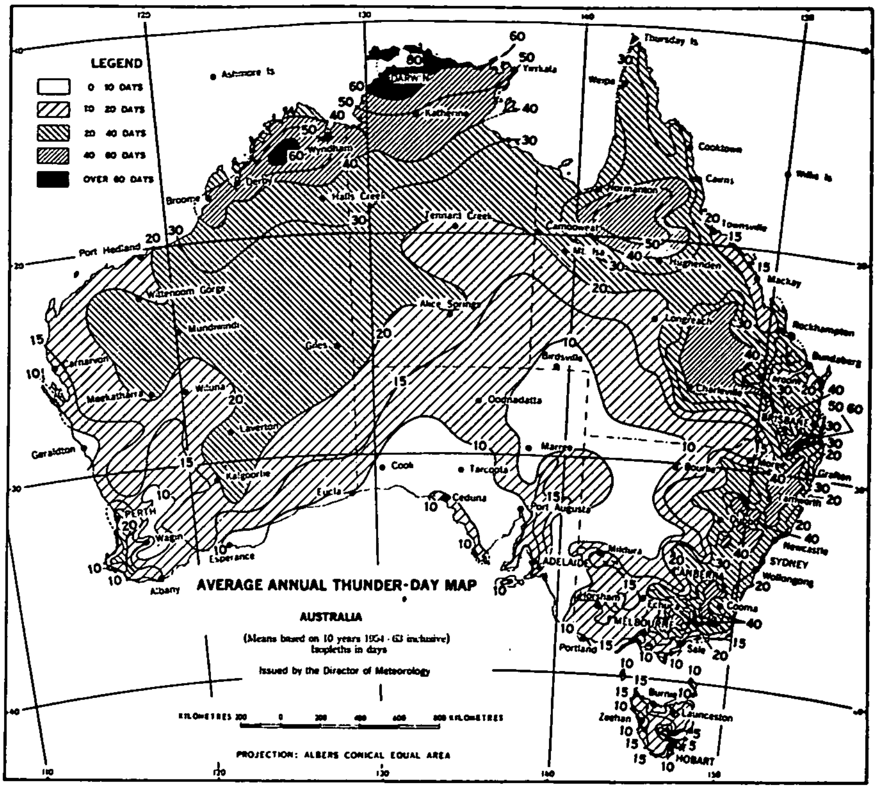
HIGHEST ANNUAL RAINFALLS
(All years to 1980 inclusive)

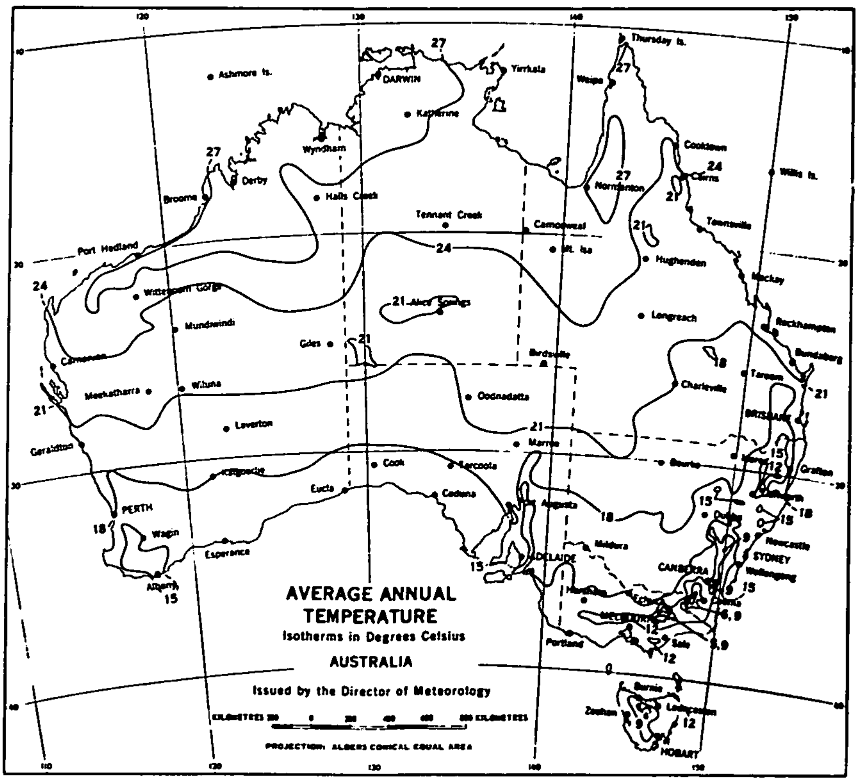
State	*Station*	*Year*	*Amount*
			mm
New South Wales.	Tallowwood Point	1950	4,540
Victoria.	Mount Buffalo Chalet	1917	3,342
Queensland.	Bellenden Ker (Top Station)	1979	11,251
South Australia	Aldgate State School	1917	1,851
Western Australia.	Mitchell Plateau.	1973	2,154
Tasmania	Lake Margaret	1948	4,505
Northern Territory	Elizabeth Downs.	1973	2,966

Thunderstorms and hail

A thunder-day at a given location is a calendar day on which thunder is heard at least once. Figure 8 shows isopleths (isobronts) of the average annual number of thuder-days which varies from 80 per year near Darwin to less than 10 per year over parts of the southern regions. Convectional processes during the summer wet season cause high thunderstorm incidence in northern Australia. The generally high incidence (40–60 annually) over the eastern upland areas is produced mainly by orographic uplift of moist air streams.

Hail, mostly of small size (less than 10 millimetres diameter), occurs with winter/spring cold frontal activity in southern Australia. Summer thunderstorms, particularly over the uplands of eastern Australia, sometimes produce large hail (greater than 10 millimetres diameter). Hail capable of piercing light gauge galvanised iron occurs at irregular intervals and sometimes causes widespread damage.





FIGURES 8 AND 9

Snow

Generally, snow covers much of the Australian Alps above 1,500 metres for varying periods from late autumn to early spring. Similarly, in Tasmania the mountains are covered fairly frequently above 1,000 metres in these seasons. The area, depth and duration are highly variable. No snow falls in the altitude range of 500–1,000 metres in some years. Snowfalls at levels below 500 metres are occasionally experienced in southern Australia, particularly in the foothill areas of Tasmania and Victoria, but falls are usually light and short lived. In some seasons, parts of the eastern uplands above 1,000 metres from Victoria to south-eastern Queensland have been covered with snow for several weeks. In ravines around Mount Kosciusko (2,228 metres) small areas of snow may persist through summer but there are no permanent snowfields.

Temperature

Average temperatures

Average annual air temperatures, as shown in Figure 9, range from 28°C along the Kimberley coast in the extreme north of Western Australia to 4°C in the alpine areas of south-eastern Australia. Although annual temperature may be used for broad comparisons, monthly temperatures are required for detailed analyses.

July is the month with the lowest average temperature in all parts of the continent. The months with the highest average temperature are January or February in the south and December in the north (except in the extreme north and north-west where it is November). The slightly lower temperatures of mid-summer in the north are due to the increase in cloud during the wet season.

Average monthly maxima

Maps of average maximum and minimum temperature for the month of January and July are shown in Figures 10 to 13 inclusive.

In January, average maximum temperatures exceed 35°C over a vast area of the interior and exceed 40°C over appreciable areas of the north-west. The consistently hottest part of Australia in terms of summer maxima is around Marble Bar in Western Australia (150 kilometres south-east of Port Hedland) where the average is 41°C and daily maxima during summer may exceed 40°C consecutively for several weeks at a time.

The marked gradients of isotherms of maximum temperature in summer in coastal areas, particularly along the south and west coasts, are due to the penetration inland of fresh sea breezes initiated by the sharp temperature discontinuities between the land and sea surfaces. There are also gradients of a complex nature in south-east coastal areas caused primarily by the uplands.

In July, a more regular latitudinal distribution of average maxima is evident. Maxima range from 30°C near the north coast to 5°C in the alpine areas of the south-east.

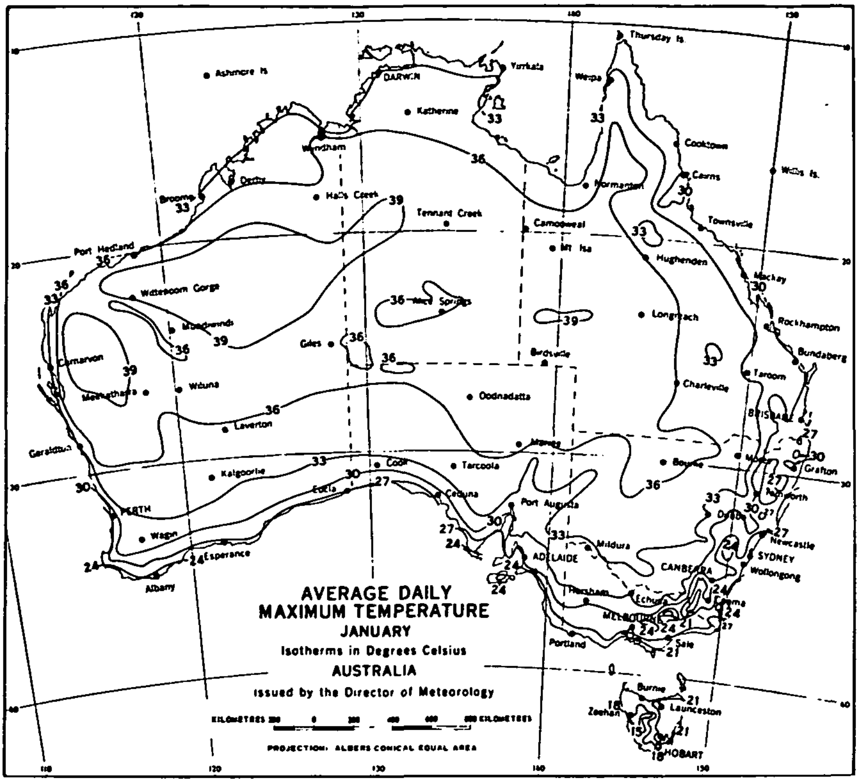
Average monthly minima

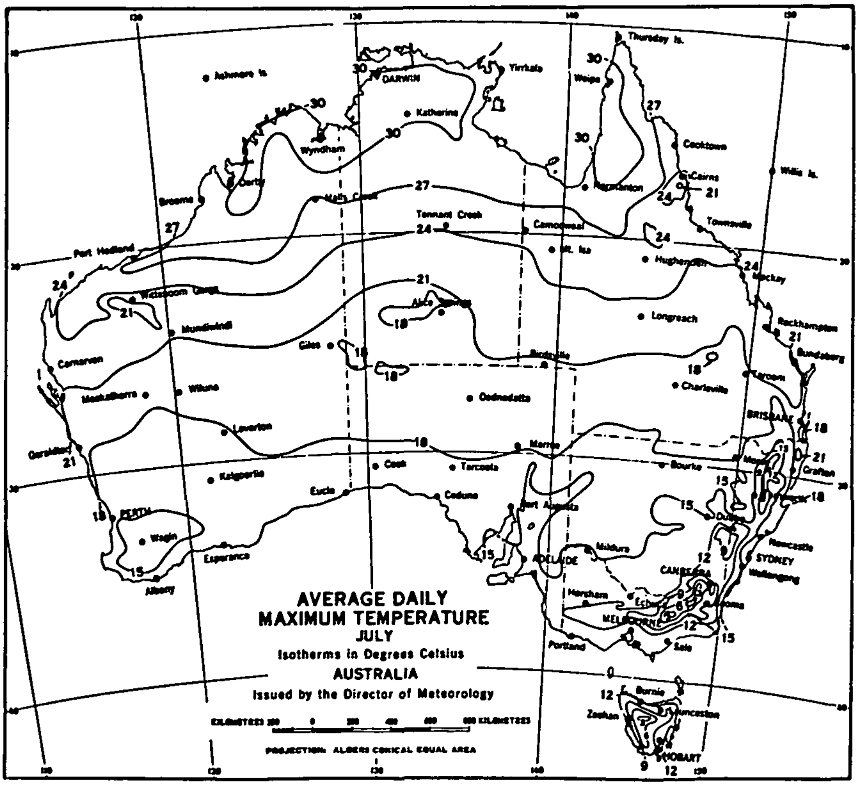
In January, average minima range from 27°C on the north-west coast to 5°C in the alpine areas of the south-east. In July, average minima fall below 5°C in areas south of the tropics (away from the coasts). Alpine areas record the lowest temperatures; the July average is as low as -5°C.

Extreme maxima

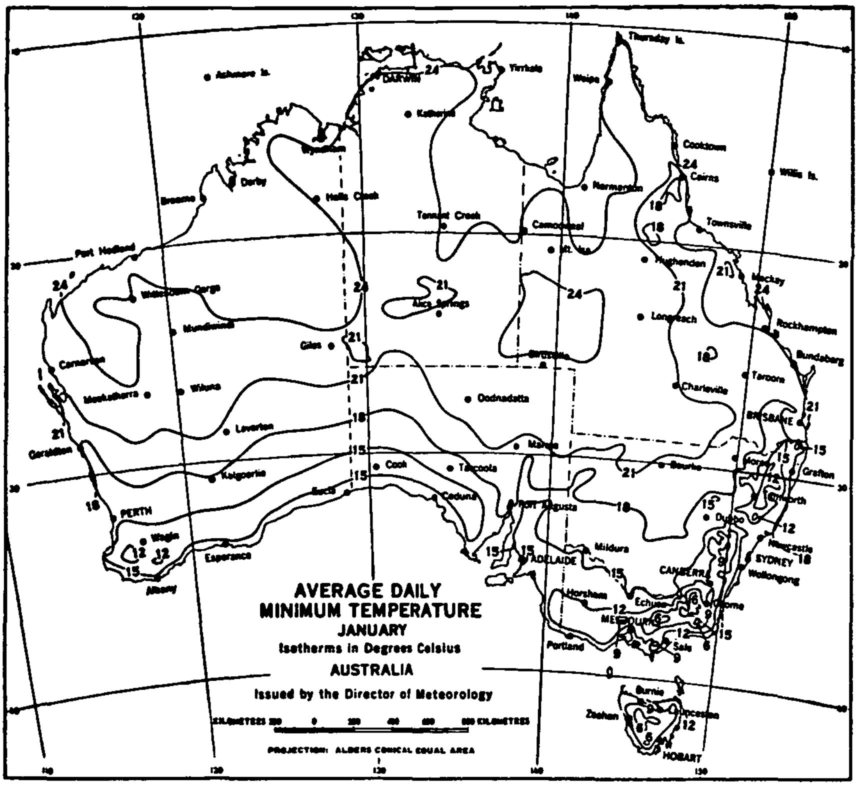
Temperatures have exceeded 45°C at nearly all inland stations more than 150 kilometres from the coast and at many places on the north-west and south coasts. Temperatures have exceeded 50°C at some inland stations and at a few near the coast. It is noteworthy that Eucla on the south coast has recorded 50.7°C, the highest temperature in Western Australia. This is due to the long trajectory over land of hot north-west winds from the Marble Bar area. Although the highest temperature recorded in Australia was 53.1°C at Cloncurry (Queensland), more stations have exceeded 50°C in western New South Wales than in other areas due to the long land trajectory of hot winds from the north-west interior of the continent.

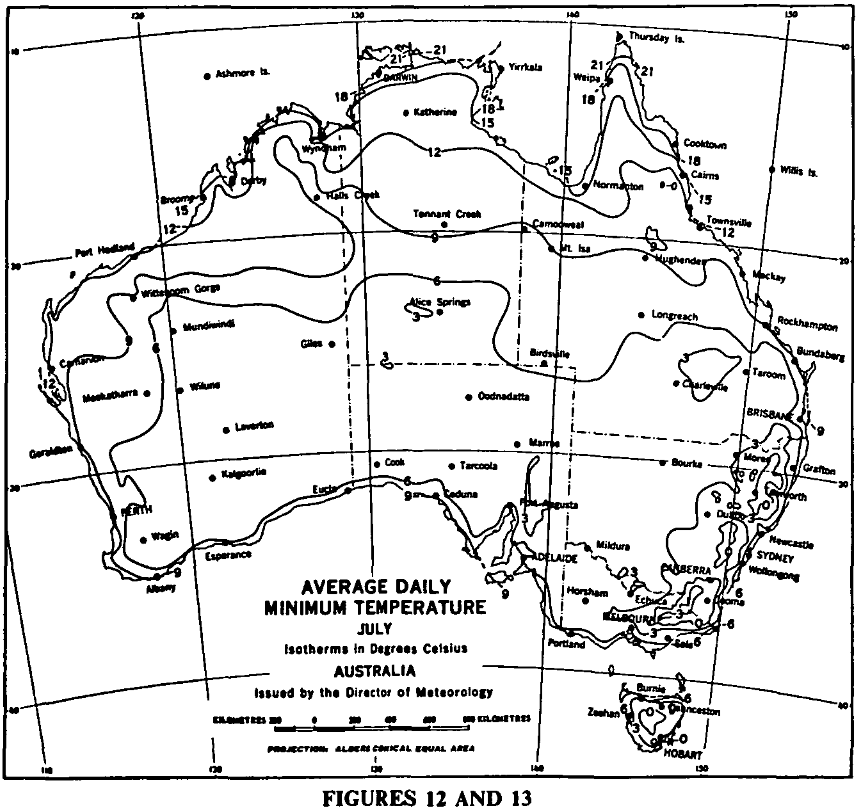
Extreme maximum temperatures recorded at selected stations, including the highest recorded in each State, are shown in the table below.





FIGURES 10 AND 11





FIGURES 12 AND 13

EXTREME MAXIMUM TEMPERATURES
(All years to September 1985)

Station	°C	Date	Station	°C	Date
New South Wales—			Western Australia—		
Bourke	52.8	17.1.1877	Eucla	50.7	22.1.1906
Walgett	50.1	2.1.1903	Mundrabilla	49.8	3.1.1979
Wilcannia	50.0	11.1.1939	Forrest	49.8	13.1.1979
Victoria—			Madura	49.4	7.1.1971
Mildura	50.8	6.1.1906	Tasmania—		
Swan Hill	49.4	18.1.1906	Bushby Park	40.8	26.12.1945
Queensland—			Hobart	40.8	4.1.1976
Cloncurry	53.1	16.1.1889	Northern Territory—		
Winton	50.7	14.12.1888	Finke	48.3	2.1.1960
Birdsville	50.0	24.12.1972	Jervois	47.5	3.1.1978
South Australia—			Australian Capital Territory—		
Oodnadatta	50.7	2.1.1960	Canberra (Acton)	42.8	11.1.1939
Marree	49.4	2.1.1960			
Whyalla	49.4	2.1.1960			

Extreme minima

The lowest temperatures in Australia have been recorded in the Snowy Mountains, where Charlotte Pass (elevation 1,760 metres) has recorded −22.2°C on 14 July 1945 and 22 August 1947. Temperatures have fallen below −5°C at most inland places south of the tropics and at some places within a few kilometres of southern coasts. At Eyre, on the south coast of Western Australia, a minimum temperature of −4.3°C has been recorded, and at Swansea, on the east coast of Tasmania, the temperature has fallen as low as −5.0°C.

In the tropics, extreme minima below 0°C have been recorded at many places away from the coasts—as far north as Herberton, Queensland (−5.0°C). Even very close to the tropical coastline, temperatures have fallen to 0°C, a low recording being −0.8°C for Mackay.

The next table shows extreme minimum temperatures recorded at specified stations, including the lowest recorded in each State.

EXTREME MINIMUM TEMPERATURES

Station	°C	Date	Station	°C	Date
New South Wales—			Western Australia—		
Charlotte Pass	−22.2	14.7.1945 22.8.1947	Booylgoo	−6.7	12.7.1969
			Wandering	−5.7	1.6.1964
Kiandra	−20.6	2.8.1929	Tasmania—		
Kosciusko Hotel	−14.4	3.7.1929 6.7.1939	Shannon	−13.0	30.6.1983
			Buitlers Gorge	−13.0	30.6.1983
Cooma	−11.4	16.7.1979	Tarraleah	−13.0	30.6.1983
Victoria—			Northern Territory		
Mount Hotham	−12.8	13.8.1947	Alice Springs	−7.5	12.7.1976
Omeo	−11.7	15.6.1965	Tempe Downs	−6.9	24.7.1971
Bairnsdale	−7.2	16.8.1896	Australian Capital Territory—		
Queensland—			Gugdenby	−14.6	11.7.1971
Stanthorpe	−11.0	4.7.1895			
Mitchell	−9.4	15.8.1979			
Nanango	−9.3	16.7.1918			
South Australia—					
Yongala	−8.2	20.7.1976			
Kyancutta	−7.0	9.7.1959			
Mt. Crawford	−7.0	8.6.1982 20.7.1982			

Heat waves

Periods with a number of successive days having a temperature higher than 40°C are relatively common in summer over parts of Australia. With the exception of the north-west coast of Western Australia, however, most coastal areas rarely experience more than three successive days of such conditions. The frequency increases inland, and periods of up to ten successive days have been recorded at many inland stations. This figure increases in western Queensland and north-western Western Australia to more than twenty days in places. The central part of the Northern Territory and the Marble Bar-Nullagine area of Western Australia have recorded the most prolonged heat waves. Marble Bar is the only station in the world where temperatures of more than 37.8°C (100°F) have been recorded on as many as 161 consecutive days (30 October 1923–7 April 1924).

Heat waves are experienced in the coastal areas from time to time. During 11–14 January 1939, for example, a severe heat wave affected south eastern Australia: Adelaide had a record of 47.6°C on the 12th, Melbourne a record of 45.6°C on the 13th and Sydney a record of 45.3°C on the 14th.

The Kimberley district of Western Australia is the consistently hottest part of Australia in terms of annual average maximum temperature. Wyndham, for example, has an annual average maximum of 35.6°C.

Frost

Frost can cause serious losses in agricultural crops, and numerous climatic studies have been made in Australia relating to specific crops cultivated in local areas.

Under calm conditions, overnight temperatures at ground level are often as much as 5°C lower than those measured in the instrument screen (base height 1.1 metre) and differences of 10°C have been recorded. Only a small number of stations measure minima at ground level, the lowest recordings being −15.1°C at Canberra and −11.0°C at Stanthorpe (Queensland). Lower readings may be recorded in alpine areas.

Frost frequency depends on location and orography, and even on minor variations in the contour of the land. The parts of Australia which are most subject to frost are the eastern uplands from north-eastern Victoria to the western Darling Downs in southern Queensland. Most stations in this region experience more than ten nights a month with readings of 0°C (or under) for three to five months of the year. On Tasmania's Central Plateau similar conditions occur for three to six months of the year. Frosts may occur within a few miles of the coasts except in the Northern Territory and most of the north Queensland coasts.

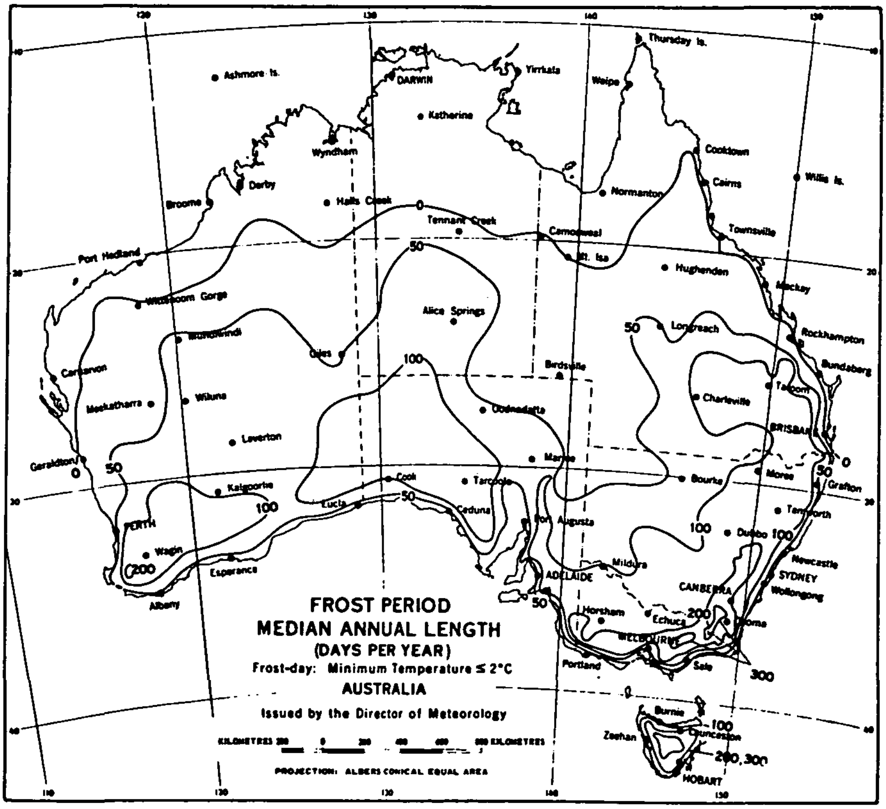


FIGURE 14

Regions in which frosts may occur at any time of the year comprise most of Tasmania, large areas of the tablelands of New South Wales, much of inland Victoria, particularly the north-east, and a small part of the extreme south-west of Western Australia. Over most of the interior of the continent, and on the highlands of Queensland as far north as the Atherton Plateau, frosts commence in April and end in September. Minimum temperatures below 0°C are experienced in most of the subtropical interior in June and July.

The length of the frost period for the year is taken as the number of days between the first and last recording of an air temperature of 2°C or less. The median duration of the frost period in days per year is shown in Figure 14.

The median frost period over the continent varies from over 200 days per year in the south-eastern uplands areas south of the Hunter Valley to zero days in northern Australia. In the southern regions of the continent, the annual frost period generally decreases from about 100 days inland to below 50 days towards the coast. However, there are appreciable spatial variations depending mainly on local orography. In Tasmania the frost period exceeds 300 days on the uplands and decreases to 100 days near the coast.

More strictly, a frost is taken as corresponding to a minimum screen temperature of 2.2°C or less. A light frost is said to occur when the screen minimum temperature is greater than 0°C but less than or equal to 2.2°C. A heavy frost corresponds to a minimum temperature of 0°C or less.

The table below includes the average annual frequency of minima of 2.2°C or less for a wide selection of stations, particularly those prone to frosts. These data show the high spatial variability of frost frequency across Australia. The south-eastern alpine areas, as represented by Kiandra (elevation 1,400 metres), have a frequency exceeding 200. At Kalgoorlie the average annual frequency is 20.4 days, at Alice Springs 32.7, Charleville 32.3, Canberra 101.1 and Essendon Airport (Melbourne) 14.2.

FROST FREQUENCY

Average annual number of frosty nights (screen minimum <=2.2°C) and heavy frosts (<=0°C)

Station	*Period of record*	*Altitude (metres)*	*Average number of frosty nights <=2.2°C*	*Average number of heavy frosts <=0°C*
Adelaide Airport	1956–85	6.0	6.2	0.9
Alice Springs	1942–85	545.0	32.7	11.9
Ballan	1957–68	442.0	62.3	20.5
Birdsville	1957–83	43.0	4.7	0.4
Brisbane Airport	1950–85	6.0	0.2	0.0
Canberra Airport	1940–85	571.0	101.1	63.6
Ceduna Airport	1943–85	24.0	18.4	4.2
Charleville Airport	1943–85	306.0	32.3	12.9
Essendon Airport (Melbourne)	1940–70	86.0	14.2	2.6
Hobart	1949–85	55.2	17.1	1.7
Kalgoorlie Airport	1943–84	360.0	20.4	4.6
Kiandra	1957–68	1,395.4	228.3	176.7
Mount Gambier Airport	1943–85	63.0	26.0	6.9
Perth Airport	1945–86	20.0	2.8	0.1
Walgett	1957–84	131.0	23.3	5.7

NOTE: '< =' denoted less than or equal to

The regions of mainland Australia most prone to heavy frosts are the eastern uplands and adjacent areas extending from Victoria through New South Wales to south-eastern Queensland. Stations above 1,000 metres in altitude in the southern parts of these uplands have more than 100 heavy frosts annually, and in the upland areas below 1,000 metres the annual frequency ranges from 100 to about 20. Over the remainder of southern Queensland, New South Wales and Victoria, although there are great spatial variations, the average annual frequency of heavy frosts typically ranges from about 20 inland to 10 towards the coast.

In Tasmania, uplands above 1,000 metres have more than 100 heavy frosts annually and, in neighbouring areas, the frequency is about 100 decreasing to 20 towards the coasts. Even some coastal stations have a relatively high frequency (Swansea, for example, has 15.7).

The southern half of Western Australia, the whole of South Australia, and the Alice Springs district of the Northern Territory experience heavy frosts. Differences in annual frequencies between places are great but in general the frequency is about 10 inland, decreasing towards the coasts. Some places average more than 20 heavy frosts annually, notably Wandering, Western Australia (21.5) and Yongala, South Australia (41.8). At Alice Springs the annual average frequency is 11.9.

Humidity

Australia is a dry continent in terms of the water vapour content or humidity of the air and this element may be compared with evaporation to which it is related. Humidity is measured at Bureau of Meteorology observational stations by a pair of dry and wet bulb thermometers mounted in a standard instrument screen. These measurements enable moisture content to be expressed by a number of parameters, the most commonly known being relative humidity.

Relative humidity at a given temperature is the ratio (expressed as a percentage) of actual vapour pressure to the saturated vapour pressure at that temperature. As a single measure of human discomfort, relative humidity is of limited value because it must be related to the temperature at the time.

Since the temperature at 9 a.m. approximates the mean temperature for the day (24 hours), the relative humidity at 9 a.m. may be taken as an estimate of the mean relative humidity for the day. Relative humidity at 3 p.m. occurs around the warmest part of the day on the average and is representative of the lowest daily values. Relative humidity on the average is at a maximum in the early morning when air temperature is minimal.

The main features of the relative humidity pattern are:

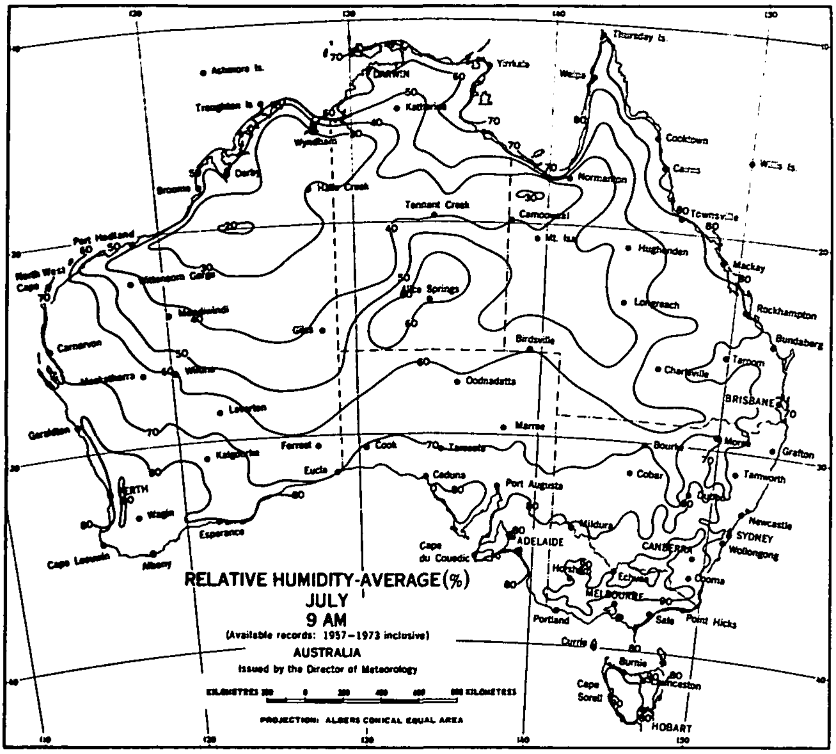
- over the interior of the continent there is a marked dryness during most of the year, notably towards the northern coats in the dry season (May-October);
- the coastal fringes are comparatively moist, although this is less evident along the north-west coast of Western Australia where continental effects are marked;
- in northern Australia, the highest values occur during the summer wet season (December-February) and the lowest during the winter dry season (June-August);
- in most of southern Australia the highest values are experienced in the winter rainy season (June-August) and the lowest in summer (December-February).

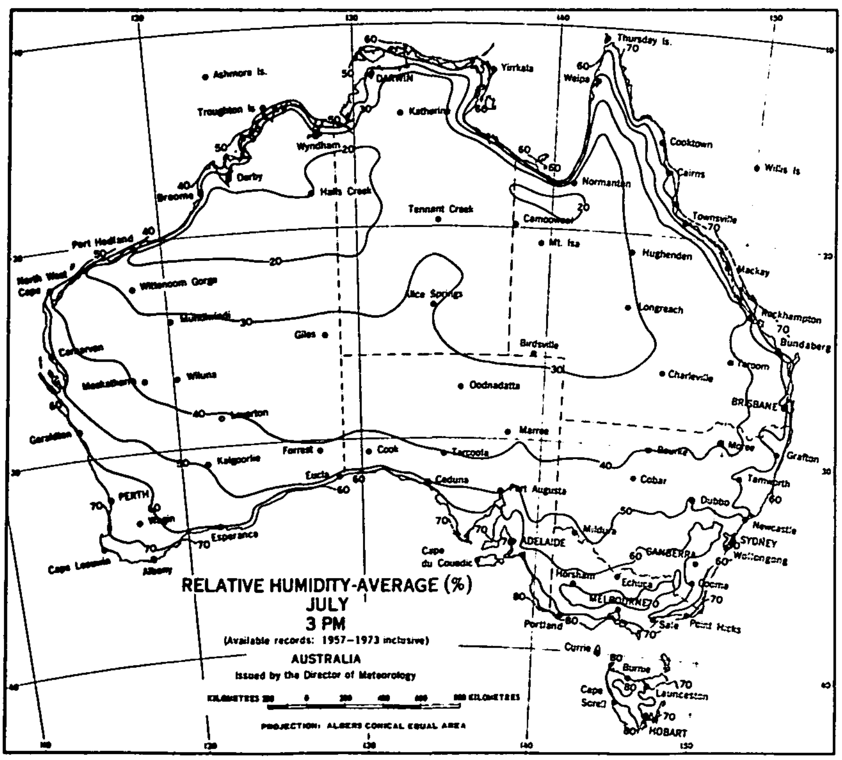
The table below contains average relative humidity at 9 a.m. for the year and for each month for selected stations. Humidity values for the capital cities are contained in the capital city detailed statistical tables found further on. Average annual figures on the table range from 35 per cent at Mundiwindi, to 80 per cent at Thursday Island illustrating the range of average relative humidity over Australia. Adelaide has the lowest value for a capital city with an annual average of 58 per cent, compared with Melbourne (69 per cent) and Darwin (73 per cent).

AVERAGE RELATIVE HUMIDITY AT 9 A.M.

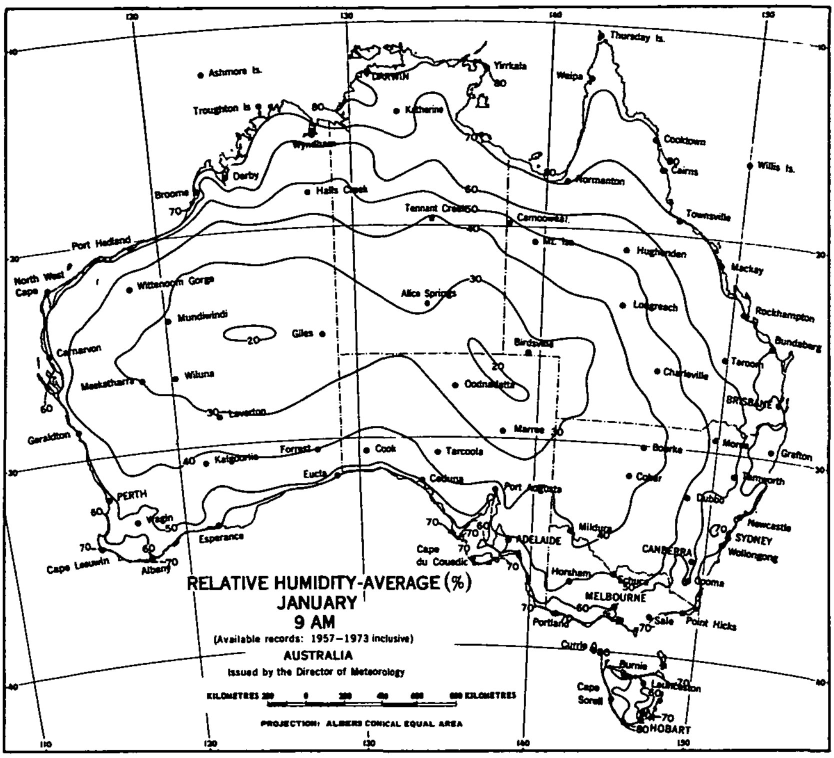
(per cent)

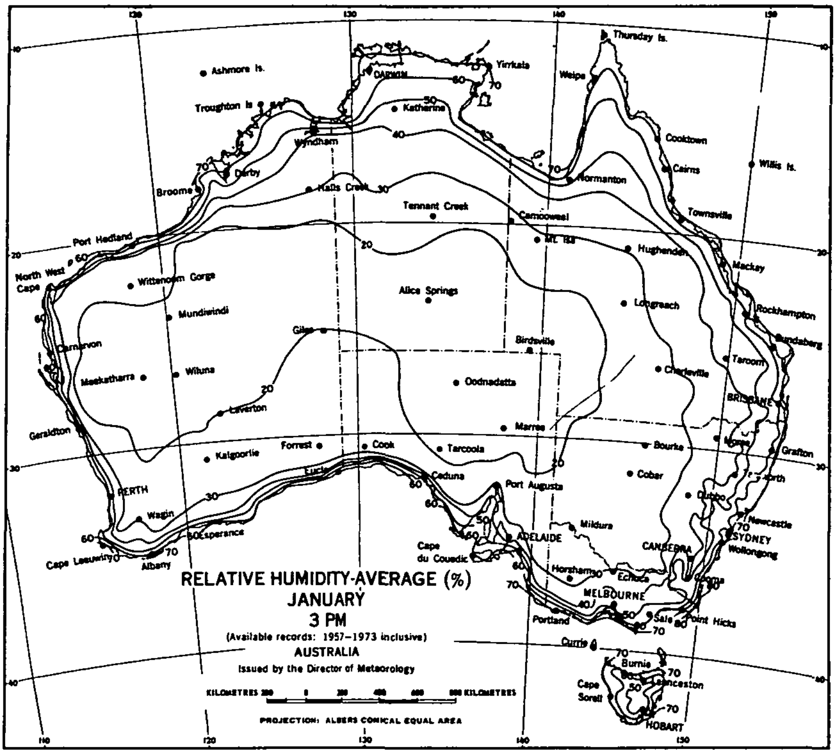
Station	*Period of record*	*Jan.*	*Feb.*	*Mar.*	*Apr.*	*May*	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*Year*
Alice Springs . .	1941-86	34	39	40	46	57	65	59	47	35	31	29	29	43
Armidale . . .	1907-85	63	69	71	73	78	80	77	71	62	57	56	57	68
Broome	1939-86	71	74	69	56	49	49	47	45	48	53	58	64	57
Carnarvon . . .	1945-86	58	58	57	57	60	69	69	64	54	51	54	57	59
Ceduna	1939-86	52	59	61	66	76	81	80	75	64	54	51	51	64
Charleville . . .	1942-86	47	53	53	53	63	71	66	56	44	41	37	39	52
Cloncurry . . .	1939-75	52	60	52	45	47	51	45	37	31	31	31	40	44
Esperance . . .	1969-86	58	61	64	70	74	77	77	75	68	61	60	57	67
Halls Creek . .	1944-86	51	55	44	34	35	34	31	25	22	25	30	39	35
Kalgoorlie . . .	1938-53	43	48	51	57	63	68	72	61	48	45	40	39	53
Katanning . . .	1957-86	57	64	67	76	83	88	89	87	81	69	60	56	73
Kiandra. . . .	1907-74	61	66	72	79	84	89	90	87	76	67	62	62	75
Marble Bar. . .	1937-86	44	47	40	34	39	42	39	33	27	26	26	33	36
Mildura. . . .	1946-86	50	56	59	70	82	88	86	79	67	57	52	48	66
Mundiwindi . .	1938-81	31	35	34	37	44	53	49	39	28	23	22	23	35
Thursday Island	1950-86	84	86	85	82	82	81	80	78	75	73	73	78	80
Townsville . . .	1940-86	72	75	74	69	68	66	67	64	60	61	63	66	67



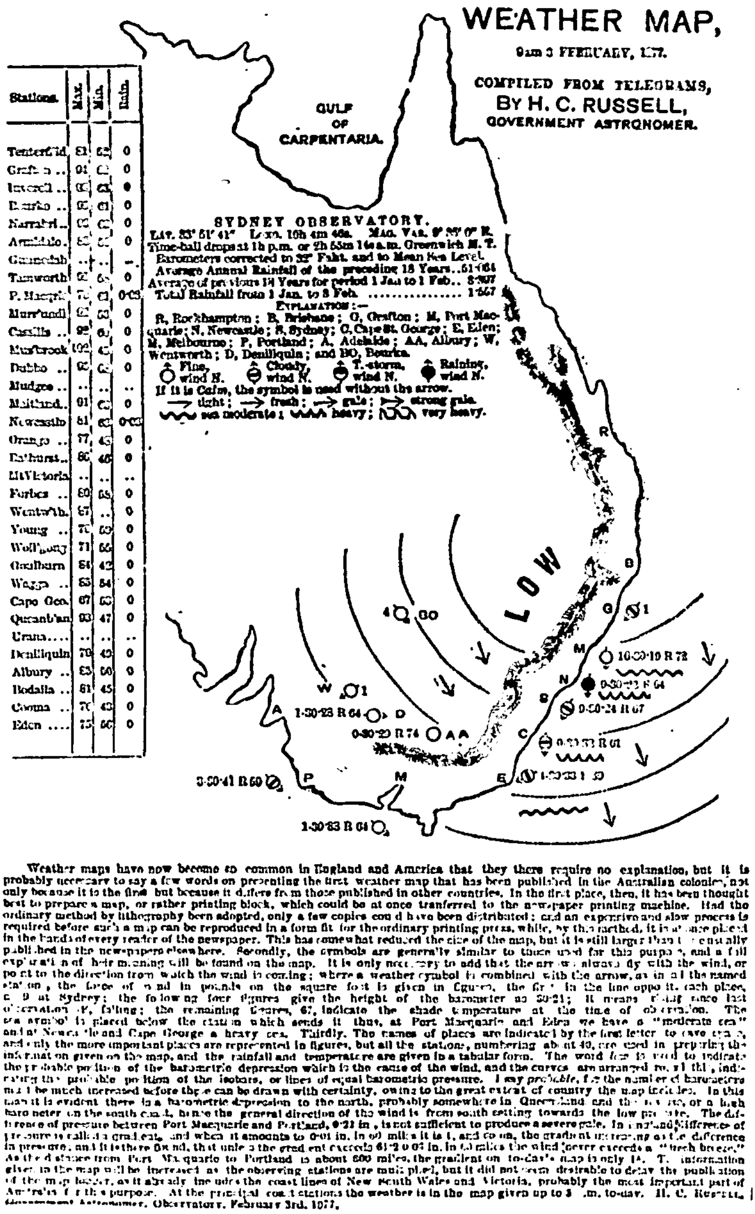


FIGURES 15 AND 16





FIGURES 17 AND 18



WEATHER MAP,

9am 3 FEBRUARY, 1877.

COMPILED FROM TELEGRAMS,
BY H. C. RUSSELL,
GOVERNMENT ASTRONOMER.

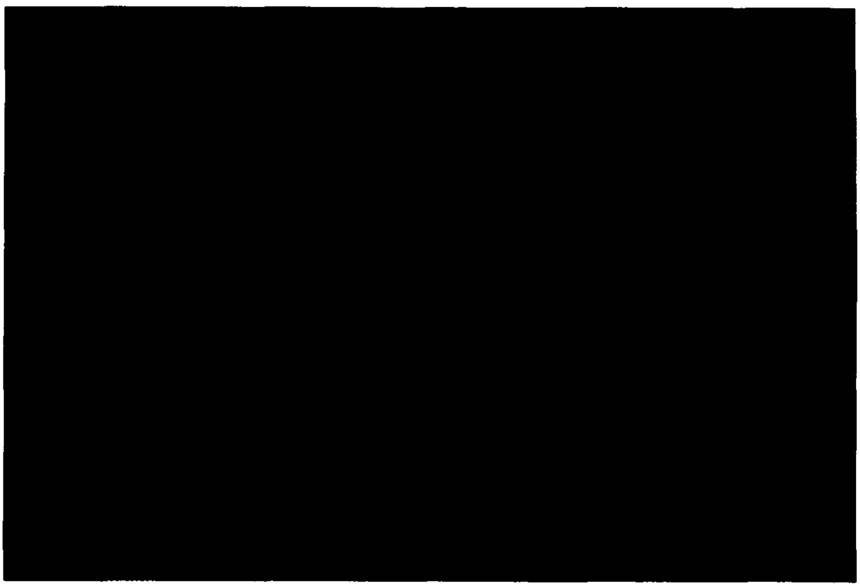
Stations.	Max.	Min.	Rain.
Tenterf'ld	81	62	0
Graft n ..	91	[illegible]	0
Inverell ..	[illegible]	63	●
Bourke ..	[illegible]	61	0
Narrabri ..	[illegible]	[illegible]	0
Armidale ..	82	[illegible]	0
Gunnedah	..	..	..
Tamworth	[illegible]	65	0
P. Macqrie	70	61	0·03
Murr'undi	[illegible]	63	0
Cassilis ..	92	60	0
Musw'brook	102	45	0
Dubbo ..	[illegible]	65	0
Mudgee ..	..	..	..
Maitland ..	91	63	0
Newcastle	81	63	0·03
Orange ..	77	43	0
Bathurst ..	86	46	0
MtVictoria	..	..	..
Forbes ..	80	58	0
Wentw'th.	67	..	0
Young ..	70	60	0
Woll'gong	71	66	0
Goulburn	84	42	0
Wagga ..	83	64	0
Cape Geo.	67	60	0
Queanb'an	93	47	0
Urana	..	..	..
Deniliquin	79	40	0
Albury ..	83	60	0
Bodalla ..	81	45	0
Cooma ..	70	43	0
Eden	75	60	0

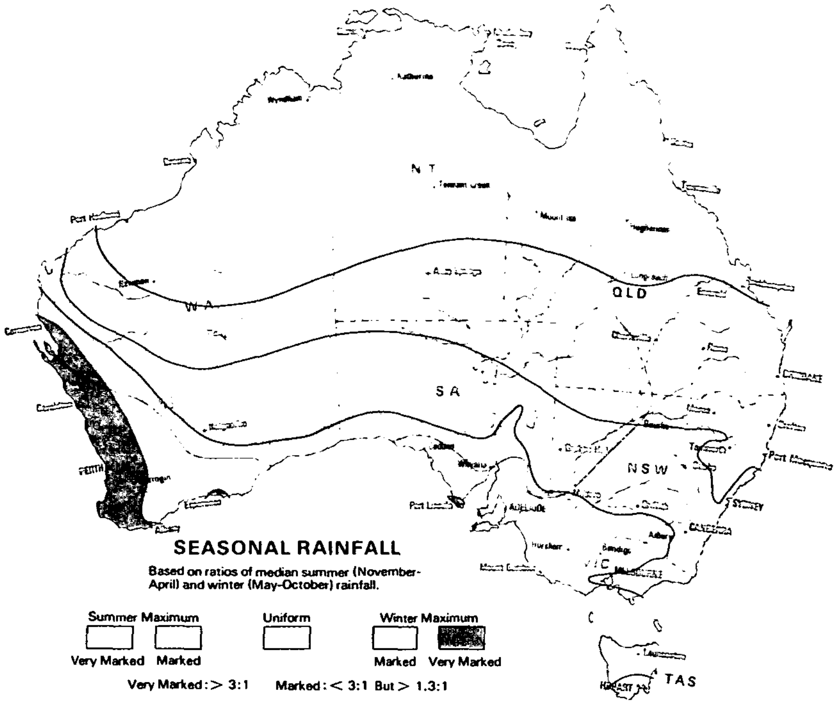
SYDNEY OBSERVATORY.
LAT. 33° 51' 41" LONG. 10h 4m 46s. MAG. VAR. 9° 55' 0" E.
Time-ball drops at 1h p.m. or 2h 55m 14s a.m. Greenwich M. T.
Barometers corrected to 32° Faht. and to Mean Sea Level.
Average Annual Rainfall of the preceding 18 Years..51·664
Average of previous 18 Years for period 1 Jan to 1 Feb.. 8·507
Total Rainfall from 1 Jan. to 3 Feb. .... 1·667

EXPLANATION :—
R, Rockhampton ; B, Brisbane ; G, Grafton ; M, Port Macquarie ; N, Newcastle ; S, Sydney ; C, Cape St. George ; E, Eden ; M, Melbourne ; P, Portland ; A, Adelaide ; AA, Albury ; W, Wentworth ; D, Deniliquin ; and BO, Bourke.
Fine, wind N. Cloudy, wind N. T.-storm, wind N. Raining, wind N.
If it is Calm, the symbol is used without the arrow.
light ; fresh ; gale ; strong gale.
sea moderate ; heavy ; very heavy.

Weather maps have now become so common in England and America that they there require no explanation, but it is probably necessary to say a few words on presenting the first weather map that has been published in the Australian colonies, not only because it is the first but because it differs from those published in other countries. In the first place, then, it has been thought best to prepare a map, or rather printing block, which could be at once tranferred to the newspaper printing machine. Had the ordinary method by lithography been adopted, only a few copies could have been distributed ; and an expensive and slow process is required before such a map can be reproduced in a form fit for the ordinary printing press, while, by this method, it is at once placed in the hands of every reader of the newspaper. This has somewhat reduced the size of the map, but it is still larger than those usually published in the newspapers elsewhere. Secondly, the symbols are generally similar to those used for this purpose, and a full explanation of their meaning will be found on the map. It is only necessary to add that the arrows always fly with the wind, or point to the direction from which the wind is coming ; where a weather symbol is combined with the arrow, as in all the named stations, the force of wind in pounds on the square foot is given in figures, the first in the line opposite each place, e. g. 9 at Sydney ; the following four figures give the height of the barometer as 30·21 ; R means rising since last observation, F, falling ; the remaining figures, 67, indicate the shade temperature at the time of observation. The sea symbol is placed below the station which sends it thus, at Port Macquarie and Eden we have a "moderate sea" and at Newcastle and Cape George a heavy sea. Thirdly. The names of places are indicated by the first letter to save space, and only the more important places are represented in figures, but all the stations, numbering about 40, are used in preparing the information given on the map, and the rainfall and temperature are given in a tabular form. The word *low* is used to indicate the probable position of the barometric depression which is the cause of the wind, and the curves are arranged round this, indicating the probable position of the isobars, or lines of equal barometric pressure. I say *probable*, for the number of barometers must be much increased before these can be drawn with certainty, owing to the great extent of country the map includes. In this map it is evident there is a barometric depression to the north, probably somewhere in Queensland and the [illegible], or a high barometer on the south coast, hence the general direction of the wind is from south setting towards the low pressure. The difference of pressure between Port Macquarie and Portland, 0·21 in., is not sufficient to produce a severe gale. In England difference of pressure is called a gradient, and when it amounts to 0·01 in. in 60 miles it is 1, and so on, the gradient increasing as the difference in pressure ; and it is there found, that unless the gradient exceeds 6, or 0·06 in. in 60 miles the wind never exceeds a "fresh breeze." As the distance from Port Macquarie to Portland is about 600 miles, the gradient on to-day's map is only 1·4. The information given in the map will be increased as the observing stations are multiplied, but it did not seem desirable to delay the publication of the map longer, as it already includes the coast lines of New South Wales and Victoria, probably the most important part of Australia for this purpose. At the principal coast stations the weather is in the map given up to 9 a.m. to-day. H. C. RUSSELL, Government Astronomer, Observatory, February 3rd, 1877.

Photographs— Bureau of Meteorology





SEASONAL RAINFALL

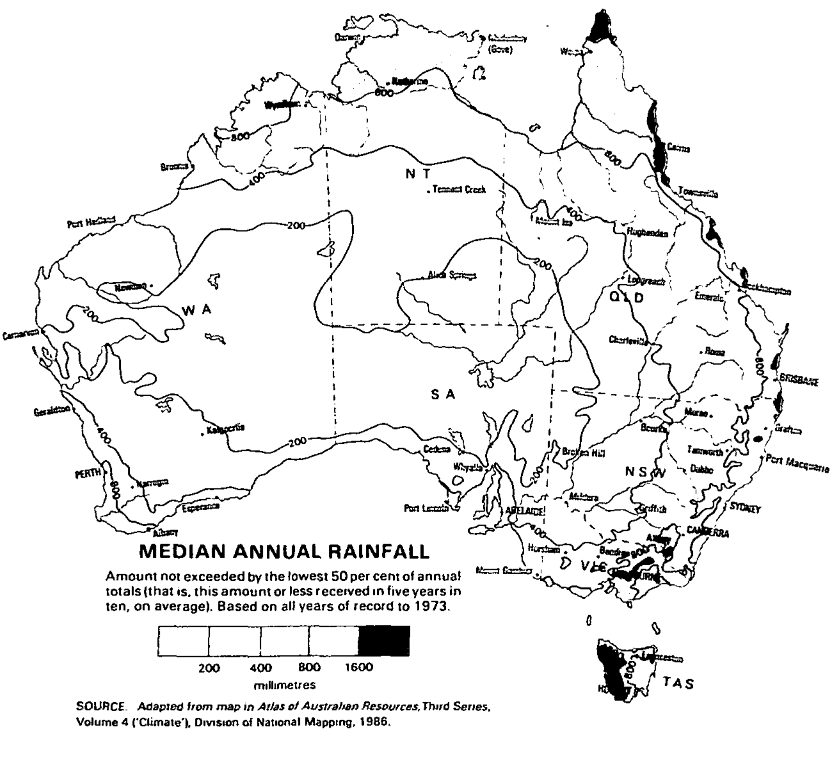
Based on ratios of median summer (November-April) and winter (May-October) rainfall.

Summer Maximum		Uniform	Winter Maximum	
Very Marked	Marked		Marked	Very Marked

Very Marked: > 3:1 Marked: < 3:1 But > 1.3:1

Arid Zone (annual median < 350 mm for summer maximum and < 250 mm for uniform and winter maximum)

SOURCE. Adapted from map in Bureau of Meteorology, *Climatic Atlas of Australia*, Map Set 5



MEDIAN ANNUAL RAINFALL

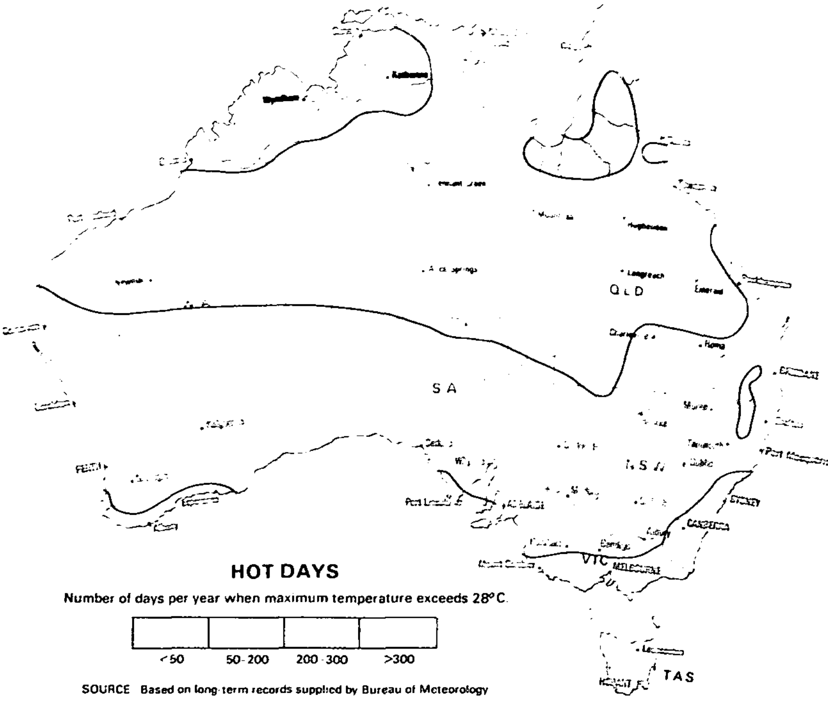
Amount not exceeded by the lowest 50 per cent of annual totals (that is, this amount or less received in five years in ten, on average). Based on all years of record to 1973.

200 400 800 1600

millimetres

SOURCE. Adapted from map in *Atlas of Australian Resources*, Third Series, Volume 4 ('Climate'), Division of National Mapping, 1986.

NMP 86/008.11

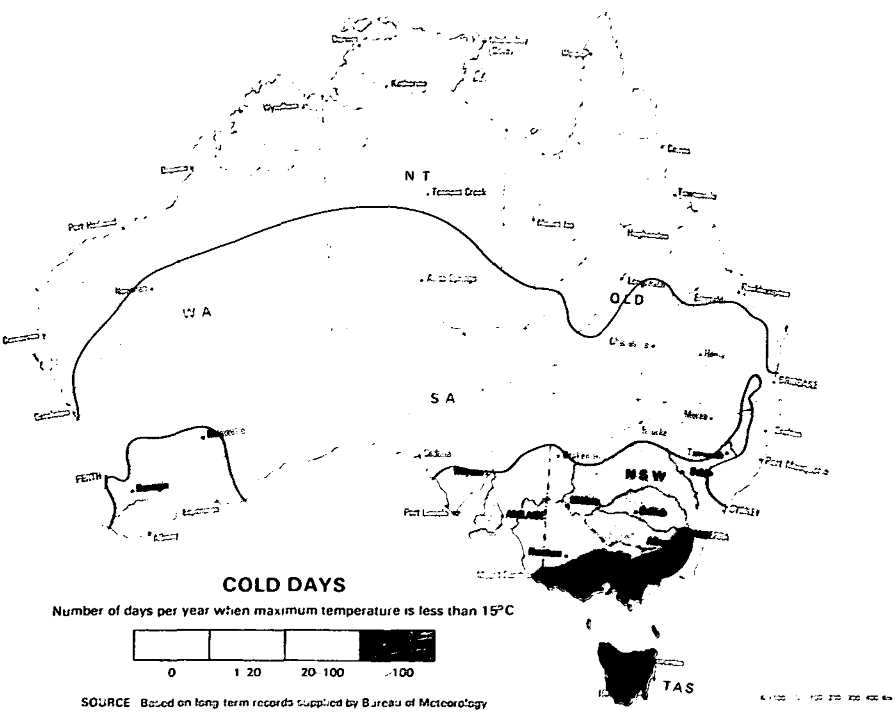


HOT DAYS

Number of days per year when maximum temperature exceeds 28°C.

<50	50-200	200-300	>300

SOURCE Based on long-term records supplied by Bureau of Meteorology

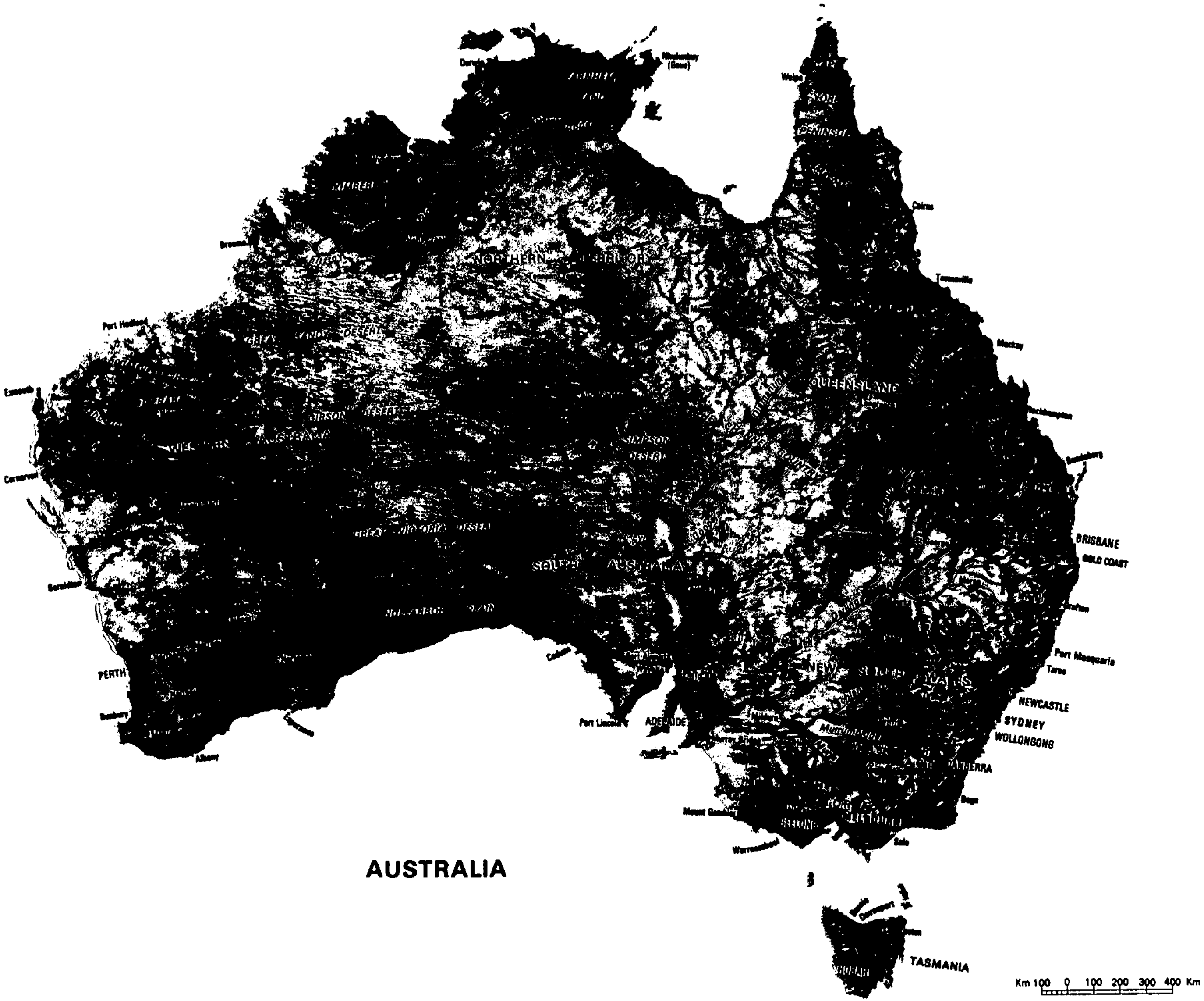


COLD DAYS

Number of days per year when maximum temperature is less than 15°C

0	1-20	20-100	>100

SOURCE Based on long term records supplied by Bureau of Meteorology



AUSTRALIA

NMP 86/008.11

Monthly averages shown in the table range from 22 per cent at Halls Creek in September and Mundiwindi in November, to 90 per cent at Kiandra in July. At Alice Springs monthly averages vary from 29 per cent in November and December to 65 per cent in the winter month of June when low temperatures have the effect of raising relative humidity over the interior. Broome varies from 45 per cent in August to 74 per cent in February, which is a marked seasonal change for a coastal station.

Relative humidity is dependent on temperature and if the water content of the air remains constant, relative humidity decreases with increasing temperature. For instance Perth, for January, has a mean 9 a.m. relative humidity of 50 per cent, but for 3 p.m., when the mean temperature is higher, the mean relative humidity is 41 per cent.

Relative humidity isopleths for January and July at 9 a.m. and 3 p.m. shown in Figures 15–18 are extracted from the *Climatic Atlas of Australia, Map Set 6, Relative Humidity,* 1978.

Global radiation

Global (short wave) radiation includes that radiation energy reaching the ground directly from the sun and that received indirectly from the sky, scattered downwards by clouds, dust particles, etc.

Figures 19 and 20 show the average global radiation for the months of January and July.

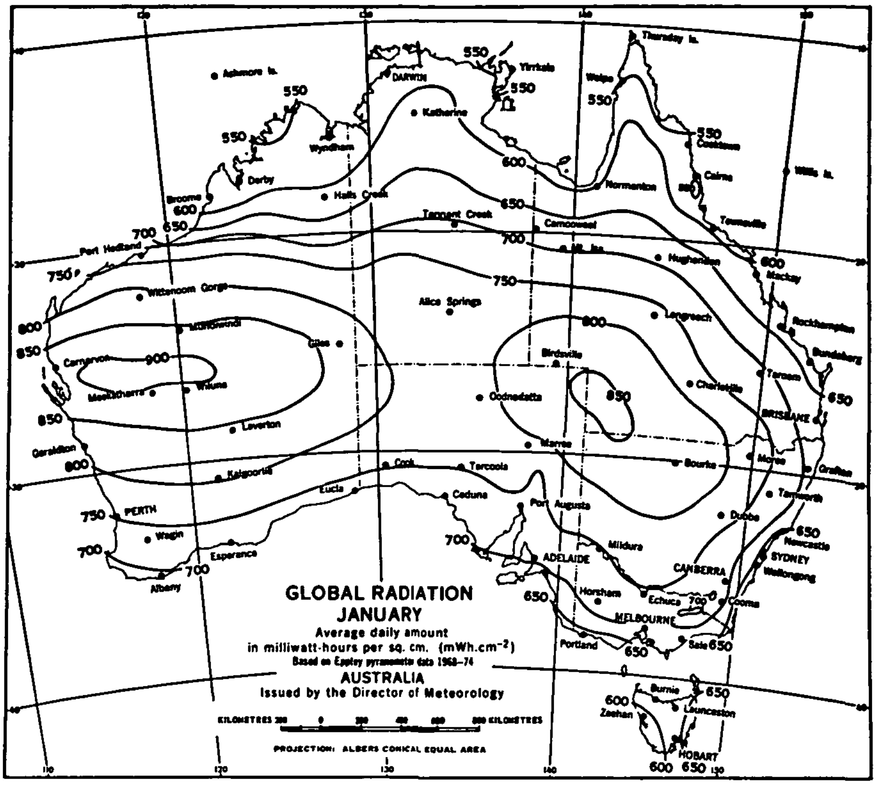
A high correlation exists between daily global radiation (Figures 19 and 20) and daily hours of sunshine (Figures 21 and 22). On the north-west coast around Port Hedland, where average daily global radiation is the highest for Australia (640 milliwatt hours), average daily sunshine is also highest, being approximately 10 hours. Sunshine is more dependent on variations in cloud coverage than is global radiation, since the latter includes diffuse radiation from the sky as well as direct radiation from the sun. An example is Darwin where, in the dry month of July, sunshine approaches twice that of the wet (cloudy) month of January but global radiation figures for the two months are comparable.

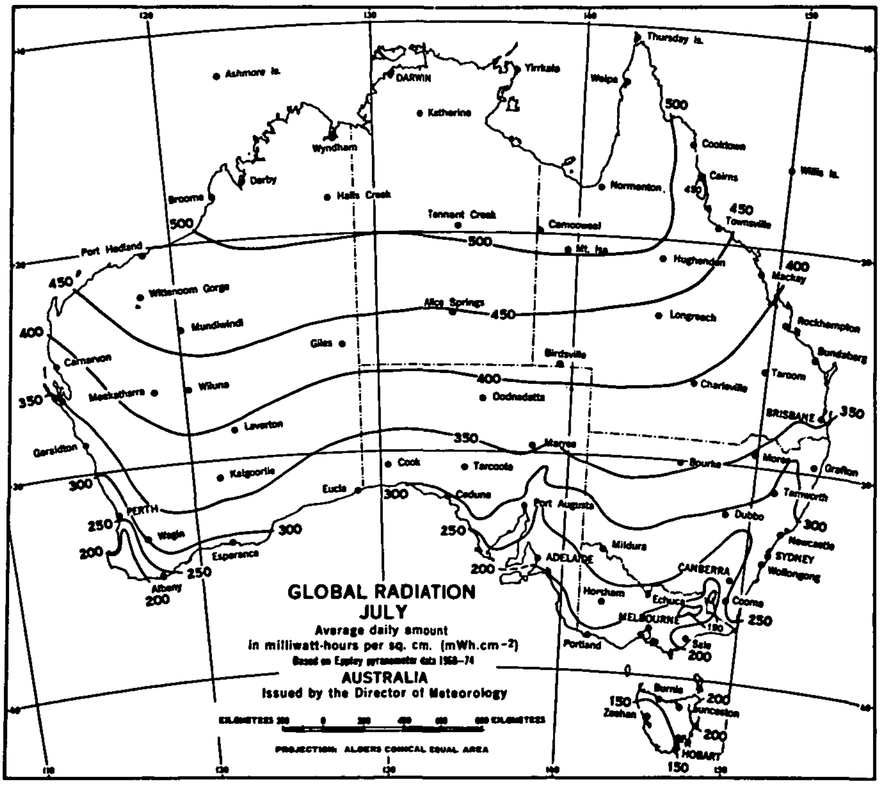
Sunshine

Sunshine as treated here refers to bright or direct sunshine. Australia receives relatively large amounts of sunshine although seasonal cloud formations have a notable effect on its spatial and temporal distribution. Cloud cover reduces both incoming and outgoing radiation and thus affects sunshine, air temperature and other climatic elements at the earth's surface. Sunshine amounts at Australian capitals are included in the climatic tables (*see* pages 236 to 247).

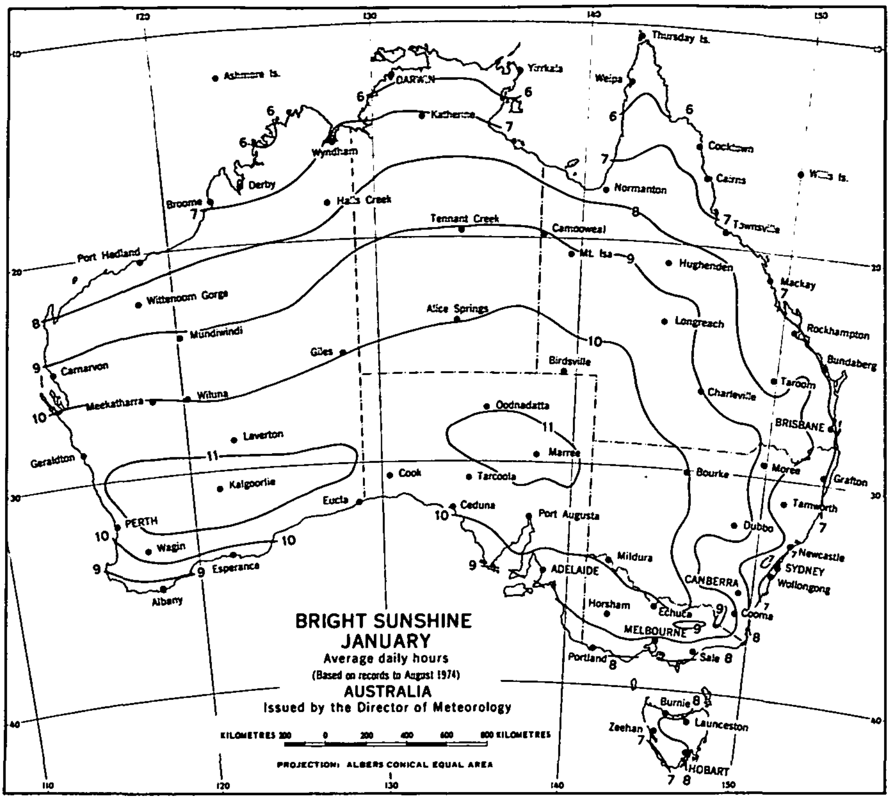
Average daily sunshine (hours) in January and July based on all available data to August 1974 is shown in Figures 21 and 22. Sunshine for April and October and annual amounts are included in the *Climatic Atlas, Map Set 4.* In areas where there is a sparsity of data, estimates of sunshine derived from cloud data are used. Most of the continent receives more than 3,000 hours of sunshine a year, or nearly 70 per cent of the total possible. In central Australia and the mid-west coast of Western Australia totals slightly in excess of 3,500 hours occur. Totals of less than 1,750 hours occur on the west coast and highlands of Tasmania; this amount is only 40 per cent of the total possible per year (about 4,380 hours).

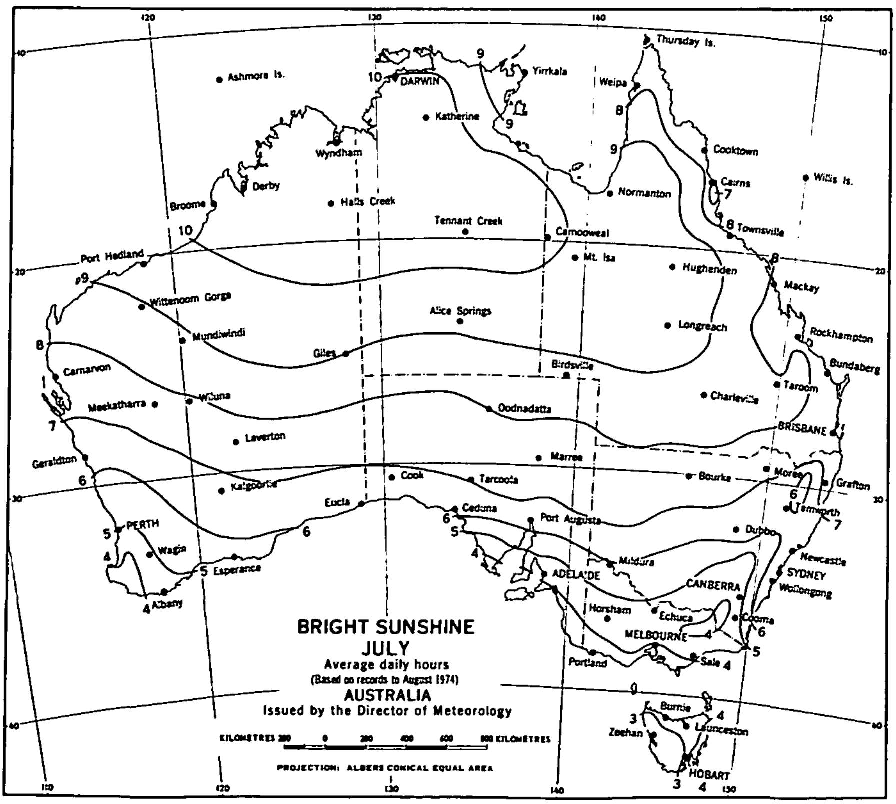
In southern Australia the duration of sunshine is greatest about December when the sun is at its highest elevation, and lowest in June when the sun is lowest. In northern Australia sunshine is generally greatest about August-October prior to the wet season, and least about January-March during the wet season. The table below gives the 20, 50 and 80 percentiles of daily bright sunshine for the months of January and July at selected stations. These values give an indication of the variability of daily sunshine hours. Perth, for example, has a high variability of daily sunshine hours in the wet month of July and a low variability in the dry month of January. Darwin has a low variability in the dry season month of July and a high variability in the wet season month of January.





FIGURES 19 AND 20





FIGURES 21 AND 22

BRIGHT SUNSHINE, VARIABILITY OF DAILY HOURS
(20, 50 and 80 percentile values)

Station	Period of record	January Percentile 20	January Percentile 50	January Percentile 80	July Percentile 20	July Percentile 50	July Percentile 80
Adelaide	1955–1986	6.8	11.9	13.3	1.1	4.0	7.3
Alice Springs. . . .	1954–1986	7.8	11.8	13.0	7.6	10.4	10.7
Brisbane	1951–1985	2.6	8.4	11.5	4.5	9.0	9.9
Canberra	1978–1986	7.0	11.3	12.7	2.4	6.4	8.3
Darwin	1951–1986	1.5	5.9	9.4	9.8	10.6	10.9
Hobart	1950–1986	4.3	8.7	12.1	1.5	4.4	7.2
Melbourne	1955–1986	5.5	9.9	12.6	0.8	3.6	6.3
Perth	1942–1986	9.2	12.0	12.7	2.5	5.4	8.6
Sydney	1955–1986	1.9	8.1	11.6	3.2	7.5	9.3
Townsville	1943–1986	3.0	9.0	11.3	6.7	10.0	10.6

Evaporation

Evaporation is determined by measuring the amount of water evaporated from a free water surface exposed in a pan. Evaporation from a free water surface depends on a number of climatic elements, mainly temperature, humidity and wind. Evaporation data are useful in water conservation studies and in estimating potential evapotranspiration for irrigation and plant growth studies. In Australia. where surface water storage is vital over large areas, evaporation is a highly significant element.

Average January, July and annual (Class A) pan evaporation is mapped in Figures 23, 24 and 25 respectively.

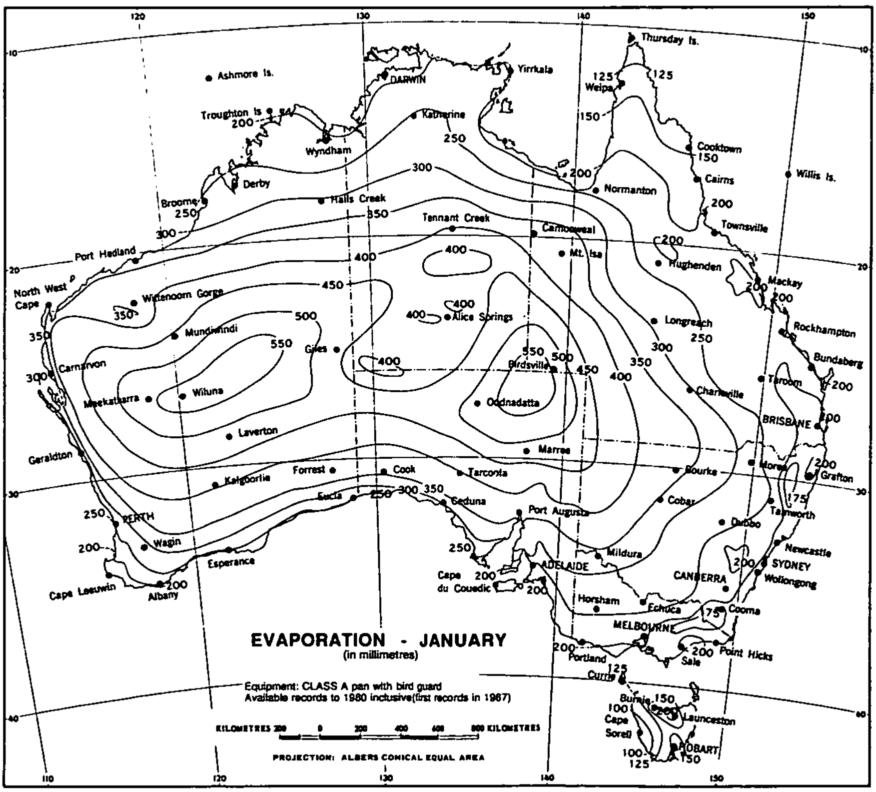
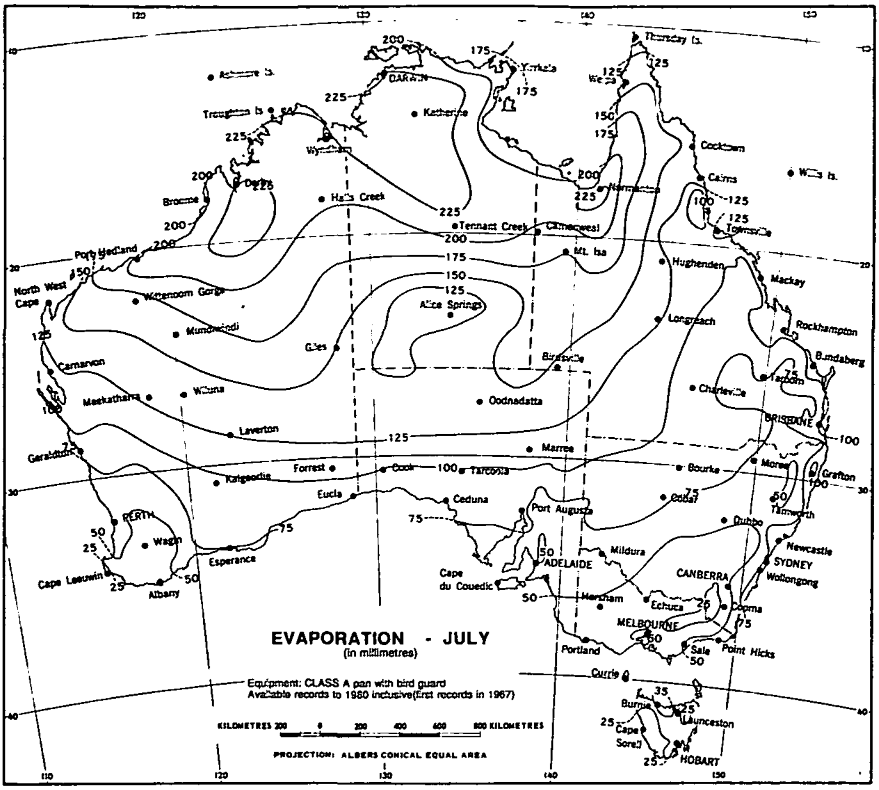
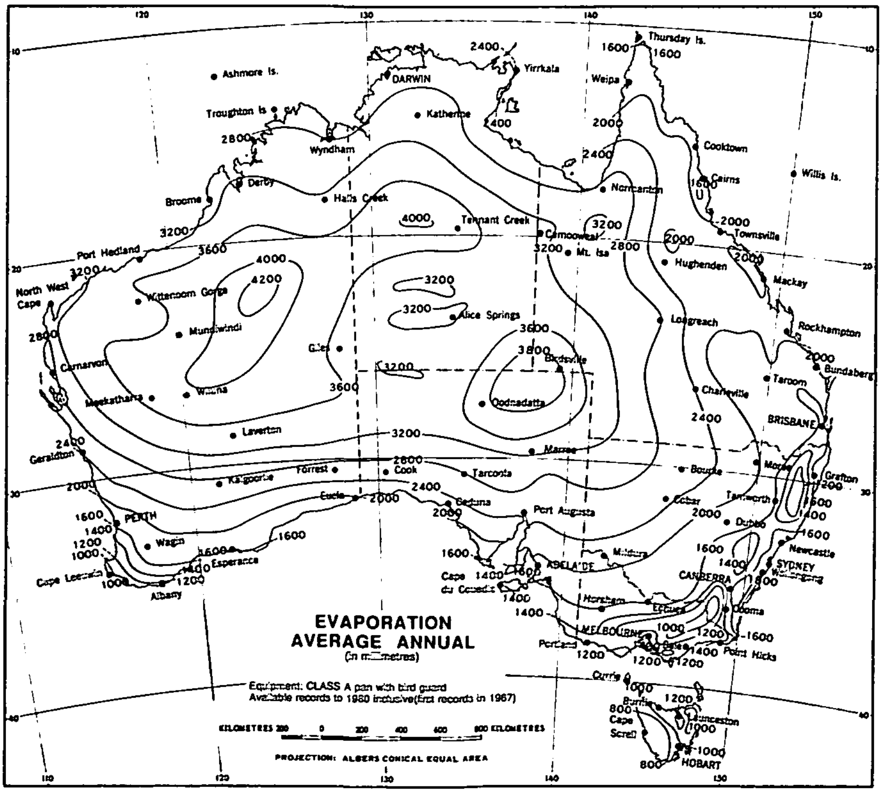


FIGURE 23





FIGURES 24 AND 25

Due to the relatively short records at some stations, the maps may not be representative of climate averages in some areas. Dashed isopleths on the maps over some coastal fringes to aid interpolation do not represent evaporation from ocean surfaces or expanses of water.

Evaporation varies markedly with exposure of the instrument. Sheltering from wind and shading of pans cause local variations in measured evaporation of as much as 25 per cent. Instruments near expanses of water such as coastal inlets, rivers, reservoirs or irrigation systems may record lower evaporation than the surrounding country due to local effects on meteorological elements, notably humidity. Such reductions are about five to ten per cent.

The Class A pan instruments have a wire mesh bird guard, which reduces the measured evaporation. An estimate of the unguarded average Class A pan evaporation for any locality may be derived by applying a seven per cent increase to the value interpolated from the maps.

Average annual Class A pan evaporation ranges from more than 4,000 mm over central Western Australia to less than 1,000 mm in alpine areas of south-east Australia and in much of Tasmania.

In areas south of the tropics, average monthly evaporation follows seasonal changes in solar radiation, giving highest evaporation in December and January, and lowest in June and July. In the tropics, onset of summer brings increasing cloudiness and higher humidity, causing reduced evaporation in these months and a secondary minimum in February. Maximum evaporation in tropical areas occurs around November on average, but high evaporation is sustained when summer rains are delayed or are persistently below average.

Cloud and fog

Cloud

Seasonal changes in cloudiness vary with the distribution of rainfall. In the southern parts of the continent, particularly in the coastal and low lying areas, the winter months are generally more cloudy than the summer months. This is due to the formation of extensive areas of stratiform cloud and fog during the colder months, when the structure of the lower layers of the atmosphere favours the physical processes resulting in this type of cloud. Particularly strong seasonal variability of cloud cover exists in northern Australia where skies are clouded during the summer wet season and mainly cloudless during the winter dry season. Cloud coverage is greater near coasts and on the windward slopes of the eastern uplands of Australia and less over the dry interior.

The average monthly and annual number of cloudy days (days when the cloud coverage was greater than or equal to seven-eighths of the sky) and clear days (less than or equal to one-eighth) is included for the capital cities in the detailed capital city statistical tables.

Fog

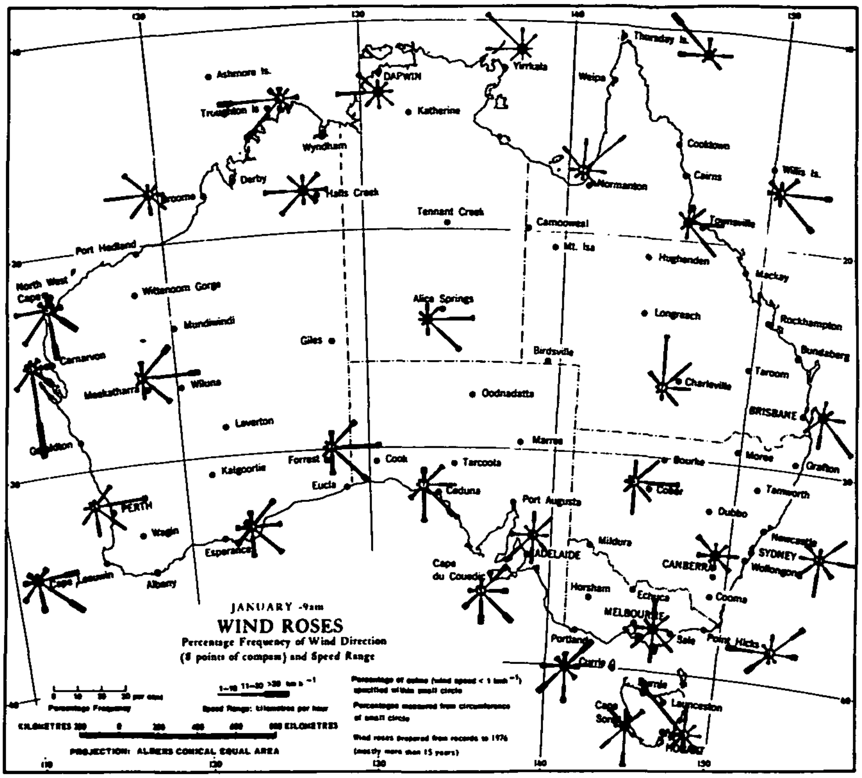
The formation of fog depends on the occurrence of favourable meteorological elements—mainly temperature, humidity, wind and cloud cover. The nature of the local terrain is important for the development of fog and there is a tendency for this phenomenon to persist in valleys and hollows. The incidence of fog may vary significantly over distances as short as one kilometre.

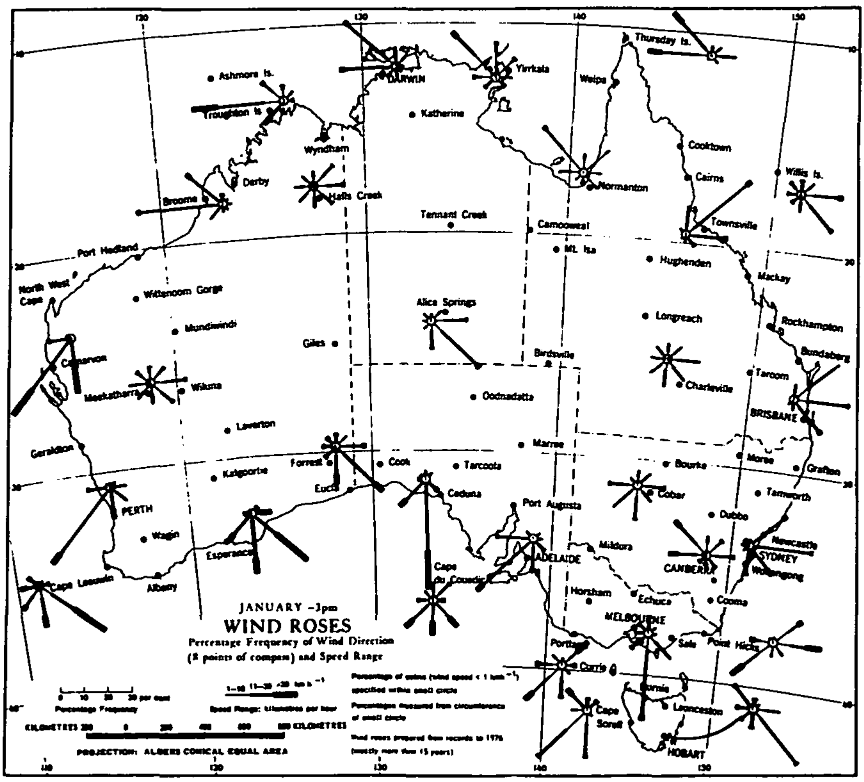
Fog in Australia tends to be greater in the south than the north, although parts of the east coastal areas are relatively fog prone even in the tropics. Incidence is much greater in the colder months, particularly in the eastern uplands. Fog may persist during the day but rarely until the afternoon over the interior. The highest fog incidence at a capital city is at Canberra which has an average of 47 days per year on which fog occurs, 26 of which are in the period May to August. Brisbane averages 20 days of fog per year. Darwin averages only 2 days per year, in the months of July and August.

Winds

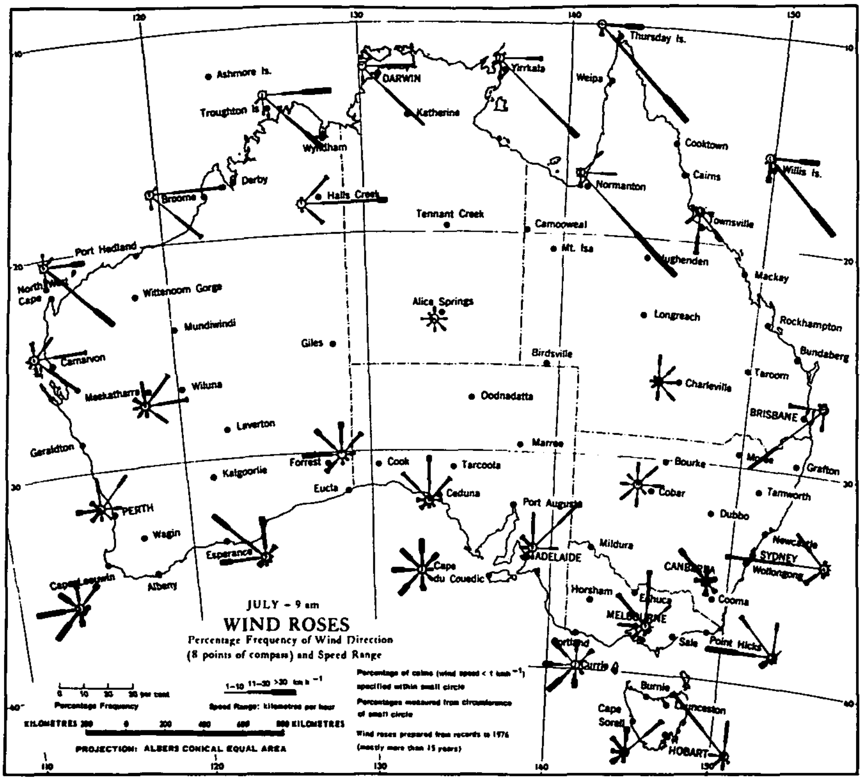
The mid-latitude anticyclones are the chief determinants of Australia's two main prevailing wind streams. In relation to the west-east axes of the anticyclones these streams are easterly to the north and westerly to the south. The cycles of development, motion and decay of low pressure systems to the north and south of the anticyclones result in diversity of wind flow patterns. Wind variations are greatest around the coasts where diurnal land and sea breeze effects are important.

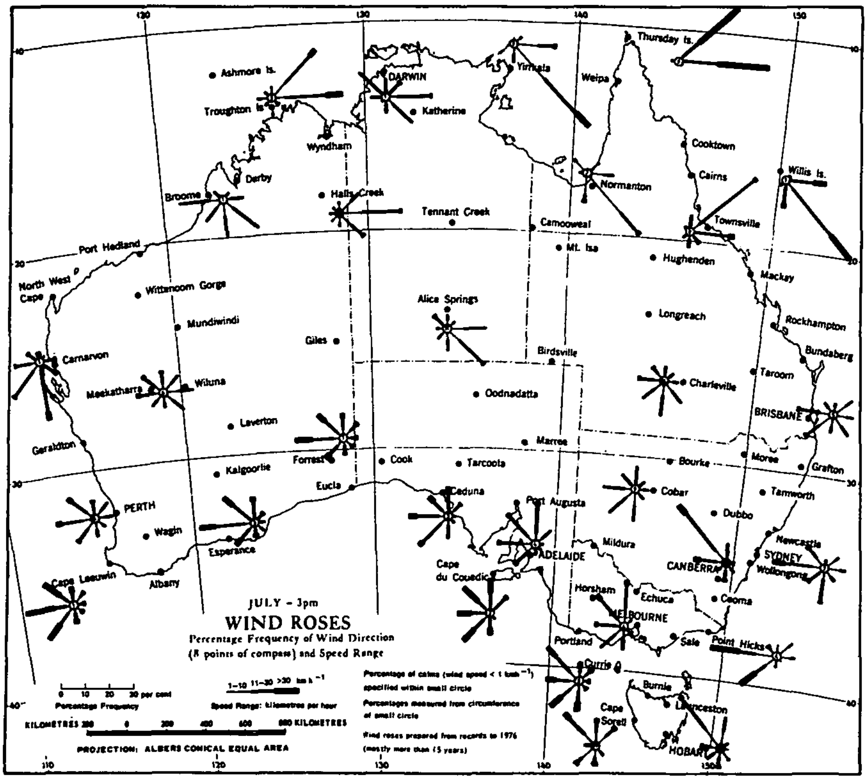
Wind roses for the months of January and July at 9 a.m. and 3 p.m. at selected stations are shown in Figures 26 to 29 inclusive, extracted from *Climatic Atlas of Australia, Map Set 8*, 1979. The wind roses show the percentage frequency of direction (eight points of compass) and speed ranges of winds.





FIGURES 26 AND 27





FIGURES 28 AND 29

Orography affects the prevailing wind pattern in various ways such as the channelling of winds through valleys, deflection by mountains and cold air drainage from highland areas. An example of this channelling is the high frequency of north-west winds at Hobart caused by the north-west south-east orientation of the Derwent River Valley.

Average wind speeds and prevailing directions at Australian capitals are included in the detailed climatic tables. Perth is the windiest capital with an average wind speed of 15.6 kilometres per hour; Canberra is the least windy with an average speed of 5.4 kilometres per hour.

The highest wind speeds and wind gusts recorded in Australia have been associated with tropical cyclones. The highest recorded gust was 259 kilometres per hour at Mardie (near Onslow), Western Australia on 19 February 1975, and gusts reaching 200 kilometres per hour have been recorded on several occasions in northern Australia with cyclone visitations. The highest gusts recorded at Australian capitals were 217 kilometres per hour at Darwin and 156 kilometres per hour at Perth.

Floods

Widespread flood rainfall may occur anywhere in Australia but it has a higher incidence in the north and in the eastern coastal areas. It is most economically damaging along the shorter streams flowing from the eastern uplands eastward to the seaboard of Queensland and New South Wales. These flood rains are notably destructive in the more densely populated coastal river valleys of New South Wales; the Tweed, Richmond, Clarence, Macleay, Hunter and Nepean-Hawkesbury; all of which experience relatively frequent flooding. Although chiefly caused by summer rains, they may occur in any season.

The great Fitzroy and Burdekin river basins of Queensland receive flood rains during the summer wet season. Much of the run-off due to heavy rain in north Queensland west of the eastern uplands flows southward through the normally dry channels of the network of rivers draining the interior lowlands into Lake Eyre. This widespread rain may cause floods over an extensive area, but it soon seeps away or evaporates, occasionally reaching the lake in quantity. The Condamine and other northern tributaries of the Darling also carry large volumes of water from flood rains south through western New South Wales to the Murray and flooding occurs along their courses at times.

Flood rains occur at irregular intervals in the Murray-Murrumbidgee system of New South Wales and Victoria, the coastal streams of southern Victoria and the north coast streams of Tasmania.

Droughts

Drought, in general terms, refers to an acute water shortage. This is normally due to rainfall deficiency but with other parameters contributing to the actual water availability. The best single measure of water availability in Australia is rainfall; although parameters such as evaporation and soil moisture are significant or even dominant in some situations.

An article on the incidence of drought in Australia is included in Chapter 16, Water Resources.

Climatic discomfort

In Australia climatic discomfort is significant in most areas. During the summer half of the year (November–April), prolonged high temperatures and humidity around the northern coasts and high temperatures over the inland cause physical stress. In winter, low temperatures and strong cold winds over the interior and southern areas can be severe for relatively short periods. However, cold stress does not cause prolonged physical hardship in Australia at altitudes lower than 1,000 metres, that is, over more than 99 per cent of the continent.

The climatic variables determining physical discomfort are primarily air temperature, vapour pressure and wind. The complete assessment of physical discomfort also requires analyses of such parameters as thermal conductivity of clothing, vapour pressure at the skin and the metabolic heat rate arising from activity of the human body. The cooling system of the human body depends on evaporation of moisture to keep body temperature from rising to lethal levels as air temperature rises. Defining criteria of discomfort is difficult because personal reactions to the weather differ greatly according to a number of variables including health, age, clothing, occupation and acclimatisation (Ashton, 1964). However, climatic strain has been measured experimentally and discomfort indexes based on the average response of subjects under specified conditions have been derived. One of the most commonly used indexes is the relative strain index. The index, derived by Lee and Henschel (1963), has been applied in Australia to measure heat discomfort. The results obtained with Australian data are useful for purposes of comparison but interpretation of the actual results is tentative until empirical environmental studies are carried out in this region. In addition to temperature, humidity and air movement, the relative strain index has facilities for the incorporation of metabolic heat rate, net radiation and insulation of clothing. It has the advantage of being applicable to manual workers under shelter and expending energy at various metabolic heat rates.

The discomfort map, Figure 30, shows the average number of days per year when the relative strain index exceeds 0.3 discomfort level at 3 p.m. assuming standard conditions as defined (*see* following table). Maximum discomfort generally occurs around 3 p.m. on days of high temperature.

A notable feature is the lower frequency of days of discomfort in Queensland coastal areas in comparison with the northern coastal areas of Western Australia. This is due to the onshore winds prevailing on the Queensland coast and the cooling effect of the adjacent eastern uplands. Lower frequencies on the Atherton Plateau in the tropics near Cairns show the advantage of altitude. Relatively low heat discomfort frequencies are evident in upland and coast areas of south-east Australia. Tasmania is entirely in the zone of least discomfort, experiencing on the average less than one day of heat discomfort per year. In Western Australia most of the Kimberley region in the north lies in the highest discomfort zone with the frequencies decreasing southwards to a strip of lowest discomfort towards the south-west coast. A steep gradient of discomfort frequency on the west coast shows the moderating effect of sea breezes.

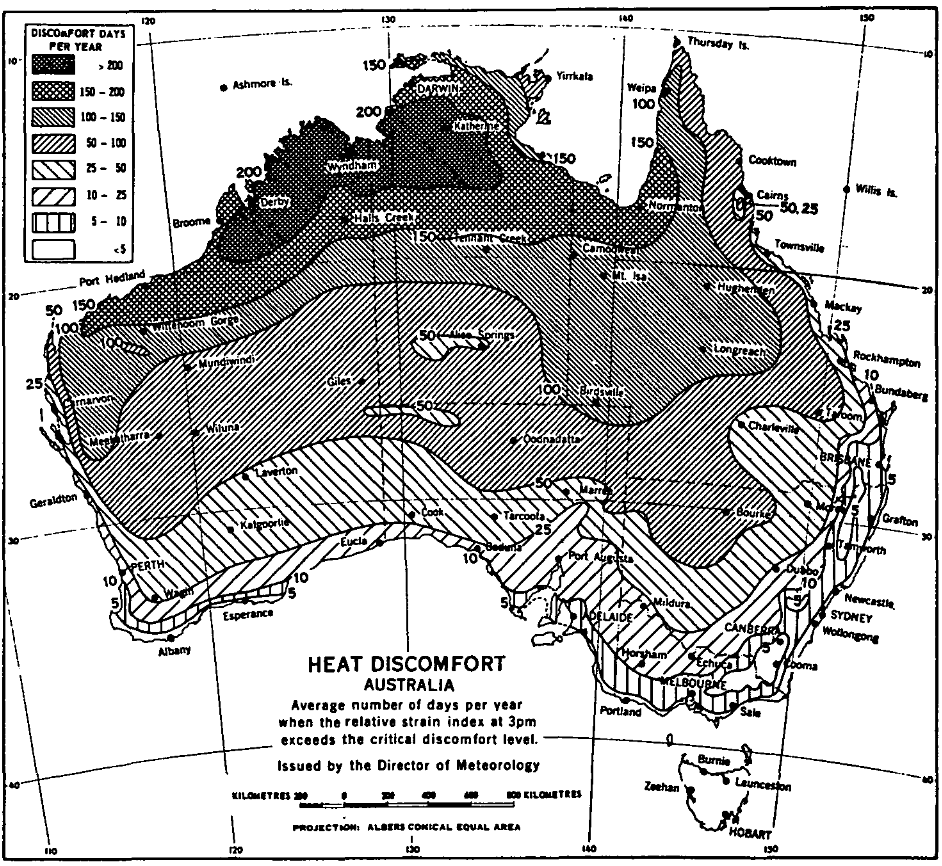


FIGURE 30

The average annual frequency of days when the relative strain index at 3 p.m. exceeds specified discomfort levels is shown in the table below. The Sydney frequencies were derived from observations at the regional office of the Bureau of Meteorology, which is representative of eastern coastal suburbs; frequencies are higher in western suburbs. The Melbourne frequencies were derived from observations at the Bureau's regional office, which may be taken as fairly representative of inner northern and eastern suburbs; frequencies are lower in bayside suburbs. Similarly, in other capital city areas significant variations occur with distance from the coast.

HEAT DISCOMFORT(*a*)

Station	*Period of record*	*Greater than*	
		0.3 RSI	*0.4 RSI*
Adelaide	1955–72	7	1
Albury	1962–71	8	1
Alice Springs	1955–67	50	4
Brisbane	1951–69	6	<1
Broome	1940–72	155	48
Canberra	1940–72	2	<1
Carnarvon	1945–72	23	3
Ceduna	1955–71	16	3
Charleville	1942–72	42	3
Cloncurry	1940–72	126	28
Darwin	1955–69	165	23
Hobart	1944–67	<1	<1
Kalgoorlie	1939–72	30	5
Marble Bar	1957–71	173	69
Melbourne	1955–71	6	1
Mildura	1946–72	19	3
Perth	1944–72	12	1
Rockhampton	1940–72	33	5
Sydney	1955–72	2	<1
Townsville	1941–69	36	4
Woomera	1954–72	25	3

(*a*) Average number of days per year when relative strain index (RSI) at 3 p.m. exceeds 0.3 (discomfort) and 0.4 (high discomfort) under standard conditions (indoors, manual activities, light clothing, air movement 60 metres per minute).

At inland places, relatively low night temperatures have recuperative effects after hot days.

Acclimatised people would suffer discomfort less frequently than shown by the relative strain index figures. For example, Australians living in the north evidently experience less discomfort at high air temperatures than those in the south, if humidities are comparable.

Both direction and speed of prevailing winds are significant for the ventilation of buildings. In the tropics, for instance, windward slopes allow optimal air movement enabling more comfortable ventilation to be obtained. Regular sea breezes such as those experienced at Perth reduce discomfort although on some days their full benefit may not be experienced until after 3 p.m.

Climatic data for capital cities

The averages for a number of elements determined from long-period observations at the Australian capitals (generally available years to 1986 inclusive) are given in the following pages. Extremes generally cover all available data to July 1986 inclusive, whereas averages may only refer to present sites.

CLIMATIC DATA: SYDNEY, NEW SOUTH WALES

(Lat. 33° 52' S., Long. 151° 12' E. Height above mean sea level (M.S.L.) 42 metres)

BAROMETER, WIND, EVAPORATION, THUNDER, CLOUDS AND CLEAR DAYS

Month	*Mean of 9 a.m. and 3 p.m. atmospheric pressure reduced to mean sea level (hPa)*	*Wind (height of anemometer 22 metres)* Average (km/h)	Highest gust speed (km/h)	Prevailing direction 9 a.m.	Prevailing direction 3 p.m.	*Mean amount evaporation (mm)*	*Mean No. days thunder*	*Mean No. cloudy days (a)*	*Mean No. clear days (b)*
No. of years of record	72	(c)25	62	(c)25	(c)25	(d)7	67	31	76
January	1,012.7	12.3	150	NE	NE	220	3.2	12	5.1
February	1,014.3	11.6	111	NE	ENE	178	2.5	11	4.6
March	1,016.4	10.5	96	WNW	ENE	164	1.6	10	5.9
April	1,018.3	10.2	116	W	ENE	123	1.2	8	7.7
May	1,018.9	10.5	135	W	ENE	93	0.8	8	7.9
June	1,018.8	11.6	135	W	WSW	78	0.8	9	8.2
July	1,018.6	11.5	109	W	WSW	90	0.7	6	10.7
August	1,017.9	12.1	113	WNW	WNW	115	1.3	6	10.9
September	1,017.0	11.6	131	WNW	NE	141	1.8	7	9.0
October	1,015.3	12.3	153	WNW	ENE	171	2.6	10	6.5
November	1,013.6	12.4	118	WNW	ENE	192	3.5	10	5.3
December	1,012.0	12.3	121	NE	ENE	239	3.6	10	5.0
Year Totals	..	..	..	..	..	**1,804**	**23.7**	**107**	**86.8**
Year Averages	**1,016.1**	**11.6**	..	**WNW**	**ENE**	..	..	..	..
Year Extremes	..	..	**153**	..	..	..	..	..	..

(*a*) Mean number of days when cloud cover equalled or exceeded seven-eighths. (*b*) Mean number of days when cloud cover was less than or equal to one-eighth. (*c*) Years 1938-1962 inclusive. (*d*) Sydney Airport, Class—A Pan (1974-80)

TEMPERATURE AND SUNSHINE

Month	*Air temperature daily readings (°Celsius)* Mean max.	Mean min.	Mean	*Extreme air temperature (°Celsius)* Highest		Lowest		Lowest on grass		*Mean daily hours sunshine*
No. of years of record	123	123	123		123		123		124	61
January	25.8	18.4	22.1	45.3	14/39	10.6	18/49	6.5	6/25	7.2
February	25.5	18.5	22.0	42.1	8/26	9.6	28/63*	6.0	22/33	6.8
March	24.6	17.4	21.0	39.2	3/69*	9.3	14/86*	4.4	17/13	6.3
April	22.2	14.6	18.4	33.9	5/86	7.0	27/64*	0.7	24/09	6.3
May	19.7	11.3	15.5	30.0	1/19	4.4	30/62*	−1.5	25/17	5.8
June	16.7	9.2	12.9	26.9	11/31	2.1	22/32	−2.2	22/32	5.3
July	15.9	7.9	11.9	25.7	22/26	2.2	12/90*	−4.4	4/93*	6.3
August	17.5	8.9	13.2	30.4	24/54	2.7	3/72*	−3.3	4/09	6.9
September	19.7	10.9	15.3	34.6	26/65	4.9	2/45	−1.1	17/05	7.2
October	21.9	13.4	17.7	37.4	4/42	5.7	6/27	0.4	9/05	7.3
November	23.5	15.5	19.5	40.3	6/46	7.7	1/05	1.9	21/67	7.6
December	25.0	17.3	21.1	42.2	20/57	9.1	3/24	5.2	3/24	7.5
Year Averages	**21.5**	**13.6**	**17.4**	..	..	..	..	..	..	**6.7**
Year Extremes	..	..	..	**45.3**	**14/1/39**	**2.1**	**22/6/32**	**−4.4**	**4/7/1893**	..

CLIMATIC DATA: SYDNEY, NEW SOUTH WALES—*continued*

(Lat. 33° 52′ S., Long. 151° 12′ E. Height above mean sea level (M.S.L.) 42 metres)

HUMIDITY, RAINFALL AND FOG

	Rel. hum. (%)		*Rainfall (millimetres)*						
Month	*9 a.m. mean*	*3 p.m. mean*	*Mean monthly*	*Mean No. of days of rain*	*Greatest monthly*	*Least monthly*	*Greatest in one day*		*Fog mean No. days*
No. of years of record . . .	31	31	123	123	123	123		123	61
January . . .	69	62	102	13	388 (1911)	6 (1932)	180	13/11	0.3
February . . .	72	64	113	13	564 (1954)	3 (1939)	226	25/73*	0.6
March	72	62	135	14	521 (1942)	8 (1965)	281	28/42	1.3
April	71	58	124	13	622 (1861)	2 (1868)	191	29/60*	1.9
May	72	55	121	13	585 (1919)	4 (1957)	212	28/89*	3.0
June	74	57	131	12	643 (1950)	4 (1962)	131	16/84*	2.4
July	69	50	101	11	336 (1950)	2 (1970)	198	7/31	1.9
August . . .	66	49	80	11	471 (1986)	1 (1885)	328	6/86	1.5
September . .	62	51	69	11	357 (1879)	2 (1882)	145	10/79*	0.9
October . . .	61	56	78	12	283 (*a*)	2 (1971)	162	13/02	0.6
November . .	63	57	81	12	517 (1961)	2 (1915)	235	9/84	0.5
December . .	65	59	77	12	402 (1920)	3 (1979)	126	9/70	0.4
Totals .	..	..	**1,214**	**148**	..	..	..	..	**15.2**
Year Averages	**68**	**57**	..	..	..	..	..	..	..
Extremes	..	..	..	..	**643 (6/1950)**	**1 (8/1885)**	**281**	**28/3/1942**	..

(*a*) 1916 and 1959.

NOTE: Figures such as 10/49, 28/63, etc. indicate, in respect of the month of reference, the day and year of the occurrence. Dates marked with an asterisk(*) relate to nineteenth century. Bracketed figures indicate year of occurrence.

CLIMATIC DATA: MELBOURNE, VICTORIA

(Lat. 37° 49′ S., Long. 144° 58′ E. Height above M.S.L. 35 metres)

BAROMETER, WIND, EVAPORATION, THUNDER, CLOUDS AND CLEAR DAYS

	Mean of 9 a.m. and 3 p.m. atmospheric pressure reduced to mean sea level (hPa)	*Wind (height of anemometer 28 metres)*							
Month		*Average (km/h)*	*Highest gust speed (km/h)*	*Prevailing direction 9 a.m.*	*Prevailing direction 3 p.m.*	*Mean amount evaporation (mm)*	*Mean No. days thunder*	*Mean No. cloudy days(a)*	*Mean No. clear days(b)*
No. of years of record	130	(*c*)47	77	68	68	(*d*)20	79	31	79
January	1,012.9	11.9	106	S	S	204	1.6	7	6.5
February	1,014.4	11.5	119	S	S	179	1.7	7	6.2
March	1,016.8	10.5	106	N	S	135	1.3	10	5.4
April	1,019.0	10.1	108	N	S	91	0.7	11	4.2
May	1,019.2	10.6	116	N	N	57	0.4	14	2.9
June	1,019.0	10.8	103	N	N	36	0.2	13	2.7
July	1,018.6	12.1	109	N	N	43	0.2	12	2.6
August	1,017.6	12.1	108	N	N	61	0.6	13	2.7
September	1,016.0	12.4	120	N	S	85	0.7	11	3.6
October	1,014.8	12.2	111	N	S	125	1.5	12	3.6
November	1,014.0	12.5	114	SW	S	151	1.9	12	3.2
December	1,012.4	12.3	104	S	S	187	2.1	10	4.2
Totals . . .	..	..	..	..	..	**1,356**	**12.8**	**132**	**48.0**
Year Averages . .	**1,016.2**	**11.7**	..	N	S	..	..		..
Extremes . .	..	..	**120**	..	..	..	..		..

(*a*) Mean number of days when cloud cover equalled or exceeded seven-eighths. (*b*) Mean number of days when cloud cover was less than or equal to one-eighth. (*c*) Early records not comparable. (*d*) Class-A Pan.

CLIMATIC DATA: MELBOURNE, VICTORIA—*continued*
(Lat. 37° 49′ S., Long. 144° 58′ E. Height above M.S.L. 35 metres)

TEMPERATURE AND SUNSHINE

Month	Air temperature daily readings (°Celsius) Mean max.	Mean min.	Mean	Extreme air temperature (°Celsius) Highest		Lowest		Extreme temperature (°Celsius) Lowest on grass		Mean daily hours sunshine
No. of years of record	131	131	131		131		131		122	(a)52
January	25.8	14.0	19.9	45.6	13/39	5.6	28/85*	−1.0	28/85*	8.1
February	25.7	14.3	20.0	43.2	8/83	4.6	24/24	−0.6	6/91*	7.5
March	23.8	13.0	18.4	41.7	11/40	2.8	17/84*	−1.7	(b)	6.6
April	20.1	10.6	15.3	34.9	5/38	1.6	24/88*	−3.9	23/97*	5.1
May	16.5	8.5	12.5	28.7	7/05	−1.2	29/16	−6.1	26/16	3.9
June	13.9	6.7	10.3	22.4	2/57	−2.2	11/66*	−6.7	30/29	3.4
July	13.3	5.7	9.5	23.1	30/75	−2.8	21/69*	−6.4	12/03	3.7
August	14.8	6.5	10.7	26.5	29/82	−2.1	11/63*	−5.9	14/02	4.6
September	17.1	7.7	12.4	31.4	28/28	−0.6	3/40	−5.1	8/18	5.5
October	19.5	9.3	14.4	36.9	24/14	0.1	3/71*	−4.0	22/18	5.9
November	21.8	10.9	16.4	40.9	27/94*	2.4	2/96*	−4.1	2/96*	6.5
December	24.1	12.7	18.4	43.7	15/76	4.4	4/70*	0.7	1/04	7.3
Year Averages	**19.7**	**10.0**	**14.9**	..	..	..	..	..	..	**5.7**
Year Extremes	..	..	..	**45.6**	**13/1/39**	**−2.8**	**21/7/69***	**−6.7**	**30/6/29**	..

(*a*) Discontinued 1967. (*b*) 17/1884 and 20/1897.

HUMIDITY, RAINFALL AND FOG

Month	Rel. hum. (%) 9 a.m. mean	3 p.m. mean	Rainfall (millimetres) Mean mthly	Mean No. of days of rain	Greatest monthly	Least monthly	Greatest in one day		Fog mean No. days
No. of years of record	78	78	131	131	131	131		128	129
January	59	46	47	8	176 (1963)	(a) (1932)	108	29/63	0.1
February	63	48	48	7	238 (1972)	(a) (1965)	87	26/46	0.3
March	65	50	53	9	191 (1911)	4 (1934)	90	5/19	0.7
April	72	54	58	11	195 (1960)	Nil (1923)	80	23/60	1.7
May	78	61	58	14	142 (1942)	4 (1934)	51	15/74	3.4
June	82	65	49	14	115 (1859)	8 (1858)	44	22/04	4.3
July	81	63	48	15	178 (1891)	9 (1979)	74	12/91*	4.1
August	75	58	51	15	111 (1939)	12 (1903)	54	17/81*	2.2
September	68	54	59	14	201 (1916)	13 (1907)	59	23/16	0.8
October	62	52	68	14	193 (1869)	7 (1914)	61	21/53	0.4
November	61	50	59	12	206 (1954)	6 (1895)	73	21/54	0.2
December	59	47	58	10	182 (1863)	1 (1972)	100	4/54	0.2
Year Totals	..	..	**655**	**143**	..	..	..	..	**18.2**
Year Averages	**69**	**54**	..	..	..	..	..	..	..
Year Extremes	..	..	..	..	**238 (2/72)**	**Nil (4/23)**	**108**	**29/1/63**	..

(*a*) Less than 1 mm.
NOTE: Figures such as 27/41, 28/85, etc. indicate, in respect of the month of reference, the day and year of the concurrence. Dates marked with an asterisk (*) relate to nineteenth century. Bracketed figures indicate year of occurrence.

CLIMATIC DATA: BRISBANE, QUEENSLAND
(Lat. 27° 28′ S., Long. 153° 2′ E. Height above M.S.L. 41 metres)

BAROMETER, WIND, EVAPORATION, THUNDER, CLOUDS AND CLEAR DAYS

Month	*Mean of 9 a.m. and 3 p.m. atmospheric pressure reduced to mean sea level (hPa)*	*Wind (height of anemometer 32 metres)* Average (km/h)				*Mean amount evaporation (mm)*	*Mean No. days thunder*	*Mean No. cloudy days(a)*	*Mean No. clear days(b)*
			Highest gust speed (km/h)	*Prevailing direction 9 a.m.*	*Prevailing direction 3 p.m.*				
No. of years of record	99	70	71	(c)36	(c)36	(d)19	99	99	78
January	1,011.7	11.7	145	SE	NE	176	4.4	4	3.2
February	1,012.5	11.5	108	S	E	142	3.5	4	2.5
March	1,014.5	11.1	106	SW	E	140	2.2	4	5.5
April	1,017.1	10.1	104	SW	SE	114	1.4	2	7.7
May	1,018.5	9.5	87	SW	SE	81	0.5	3	9.5
June	1,018.4	9.8	95	SW	W	64	0.5	2	10.5
July	1,018.9	9.6	111	SW	W	70	0.3	2	13.3
August	1,018.9	9.7	100	SW	NE	98	1.3	2	13.5
September	1,017.8	10.1	102	SW	NE	128	2.7	2	12.4
October	1,016.1	10.6	100	SW	NE	152	4.1	3	8.3
November	1,014.2	11.1	111	SE	NE	168	5.6	3	5.8
December	1,012.1	11.4	127	SE	NE	193	6.5	3	4.5
Totals	..	..	..	..	..	**1,526**	**33.0**	**34**	**96.7**
Year Averages	**1,015.9**	**10.5**	..	**SW**	**ENE**	..	..		..
Extremes	..	..	**145**	..	..	..	..	..	

(a) Mean number of days when cloud cover equalled or exceeded seven-eighths. (b) Mean number of days when cloud cover was less than or equal to one eighth. (c) 1951-87. (d) Class-A Pan.

TEMPERATURE AND SUNSHINE

Month	*Air temperature daily readings (°Celsius)* Mean max.	Mean min.	Mean	*Extreme air temperature (°Celsius)* Highest		Lowest		*Extreme temperature (°Celsius)* Lowest on grass		*Mean daily hours sunshine*
No. of years of record	99		99		99		99		98	77
January	29.4	20.8	25.0	43.2	26/40	14.9	4/93*	9.9	4/93*	7.6
February	29.0	20.6	24.8	40.9	21/25	14.7	23/31	9.5	22/31	7.0
March	28.0	19.4	23.7	38.8	13/65	11.3	29/13	7.4	29/13	6.8
April	26.1	16.7	21.3	36.1	19/73	6.9	25/25	2.6	24/25	7.2
May	23.2	13.4	18.3	32.4	21/23	4.8	30/51	−1.2	8/97*	6.8
June	20.8	10.9	15.9	31.6	19/18	2.4	29/08	−3.7	23/88*	6.7
July	20.4	9.6	15.0	29.1	23/46	2.3	(a)	−4.5	11/90*	7.0
August	21.8	10.3	16.1	32.8	14/46	2.7	13/64	−2.7	9/99*	8.0
September	24.0	12.9	18.5	38.3	22/43	4.8	1/96*	−0.9	1/89*	8.3
October	26.1	15.9	20.9	40.7	30/58	6.3	3/99*	1.6	8/89*	8.2
November	27.8	18.2	22.9	41.2	18/13	9.2	2/05	3.8	1/05	8.2
December	29.1	19.9	24.5	41.2	7/81	13.5	5/55	9.5	3/94*	8.2
Year Averages	**25.5**	**15.7**	**20.6**	..	..	..	..	..	..	**7.5**
Year Extremes	..	..	..	**43.2**	**26/1/1940**	**2.3**	**(a)**	**−4.5**	**11/7/1890**	..

(a) 12/1894 and 2/1896.

CLIMATIC DATA: BRISBANE, QUEENSLAND—*continued*

(Lat.27° 28′ S., Long. 153° 2′ E. Height above M.S.L. 41 metres)

HUMIDITY, RAINFALL AND FOG

Month	*Rel. hum. (%)* 9 a.m. mean	3 p.m. mean	*Rainfall (millimetres)* Mean mthly	Mean No. of days of rain	Greatest monthly	Least monthly	Greatest in one day	Fog mean No. days
No. of years of record	47	44	135	126	135	135	135	99
January	66	58	164	13	872 (1974)	8 (1919)	465 21/87*	0.5
February	70	60	161	14	1,026 (1893)	15 (1849)	270 6/31	0.5
March	71	59	143	15	865 (1870)	Nil (1849)	284 14/08	1.1
April	69	54	87	11	388 (1867)	1 (1944)	178 3/72	2.1
May	70	52	73	10	410 (1980)	Nil (1846)	149 9/80	2.9
June	70	51	68	8	647 (1967)	Nil (1847)	283 12/67	2.7
July	68	47	57	7	330 (1973)	Nil (*a*)	193 20/65	2.7
August	64	44	46	7	373 (1879)	Nil (*b*)	124 12/87*	3.3
September	61	46	47	8	138 (1886)	(*c*) (1979, 80)	80 12/65	2.3
October	60	52	76	9	456 (1972)	(*c*) (1948)	136 25/49	1.2
November	60	55	99	10	413 (1981)	Nil (1842)	143 8/66*	0.5
December	62	57	130	12	441 (1942)	9 (1865)	168 28/71*	0.3
Totals			**1,151**	**123**	..	..	.. ..	**20.0**
Year Averages	**66**	**53**	..	..	..	..	.. ..	
Extremes			..	..	**1,026 (2/1983)**	**Nil (Various)**	**465 21/1/1887**	..

(*a*) 1841 and 1951. (*b*) 1862, 1869, 1880 and 1977. (*c*) Less than 1 mm.
NOTE: Figures such as 23/47, 4/93, etc. indicate, in respect of the month of reference, the day and year of the occurrence. Dates marked with an asterisk (*) relate to nineteenth century. Bracketed figures indicate year of occurrence.

CLIMATIC DATA: ADELAIDE, SOUTH AUSTRALIA

(Lat. 34° 46′ S., Long. 138° 35′ E. Height above M.S.L. 43 metres)

BAROMETER, WIND, EVAPORATION, THUNDER, CLOUDS AND CLEAR DAYS

Month	Mean of 9 a.m. and 3 p.m. atmospheric pressure reduced to mean sea level (hPa)	*Wind (height of anemometer 22 metres)* Average (km/h)	Highest gust speed (km/h)	Prevailing direction 9 a.m.	Prevailing direction 3 p.m.	Mean amount evaporation (mm)	Mean No. days thunder	Mean No. cloudy days(a)	Mean No. clear days(b)
No. of years of record	121	(*c*)20	(*d*)63	(*d*)24	(*d*)24	(*e*)12	105	45	62
January	1,013.2	12.8	116	SW	SW	254	1.5	3	11.9
February	1,014.3	12.1	106	SSW	SW	216	1.1	3	10.8
March	1,017.2	11.4	126	NE	SW	180	0.8	4	10.7
April	1,019.9	11.4	130	NE	WSW	120	1.0	6	6.7
May	1,020.1	11.3	113	NE	WSW	79	1.0	7	4.5
June	1,019.9	11.6	108	NE	NW	56	0.9	7	3.8
July	1,020.8	11.8	148	NE	N	60	0.8	8	3.5
August	1,019.0	12.8	121	NE	W	78	1.1	6	4.6
September	1,017.7	13.2	111	NE	W	110	1.3	6	5.5
October	1,016.0	13.6	121	NE	WSW	164	1.9	6	5.6
November	1,015.0	13.9	130	SW	SW	196	2.0	5	6.5
December	1,013.3	13.5	121	WSW	SW	242	1.5	4	8.7
Totals	..	..	..	..	..	**1,751**	**14.9**	**65**	**82.6**
Year Averages	**1,017.1**	..	..	**NE**	**SW**	..	..		..
Extremes	..	..	**148**	..	..	..	..		..

(*a*) Mean number of days when cloud cover equalled or exceeded seven-eighths. (*b*) Mean number of days when cloud cover was less than or equal to one-eighth. (*c*) Records of cup anemometer. (*d*) 1955–1978. (*e*) Class-A Pan.

CLIMATIC DATA: ADELAIDE, SOUTH AUSTRALIA—*continued*

(Lat. 34° 46′ S., Long. 138° 35′ E. Height above M.S.L. 43 metres)

TEMPERATURE AND SUNSHINE

Month	*Air temperature daily readings (°Celsius)* Mean max.	Mean min.	Mean	*Extreme air temperature (°Celsius)* Highest		Lowest		*Extreme temperature (°Celsius)* Lowest on grass		*Mean daily hours sunshine*
No. of years of record	122	122	122		125		125		119	95
January	29.5	16.4	23.0	47.6	12/39	7.3	21/84*	1.8	3/77	10.0
February	29.3	16.6	23.0	45.3	12/99*	7.5	23/18	2.1	23/26	9.3
March	26.8	15.1	21.0	43.6	9/34	6.6	21/33	0.1	21/33	7.9
April	22.7	12.6	17.7	37.0	5/38	4.2	15/59*	−3.5	30/77	6.0
May	18.7	10.3	14.5	31.9	4/21	(*a*)1.5	22/85	−3.6	19/28	4.8
June	15.8	8.3	12.1	25.6	4/57	(*a*)−0.4	8/82	−6.1	24/44	4.2
July	15.0	7.3	11.1	26.6	29/75	0.0	24/08	−5.5	30/29	4.3
August	16.4	7.8	12.1	29.4	31/11	0.2	17/59*	−5.1	11/29	5.3
September	18.9	9.0	13.9	35.1	30/61	0.4	4/58*	−3.9	25/27	6.2
October	22.0	10.9	16.5	39.4	21/22	2.3	20/58*	−3.0	22/66	7.2
November	25.1	12.9	19.1	45.3	21/65*	4.9	2/09	−0.6	17/76	8.6
December	27.7	15.0	21.3	45.9	29/31	6.1	(*b*)	−1.0	19/76	9.4
Year **Averages**	**22.3**	**11.9**	**17.1**	..	..	..	..	..	..	**6.9**
Year **Extremes**	..	..	..	**47.6**	**12/1/39**	**−0.4**	**24/7/08**	**−6.1**	**24/6/44**	

(*a*) Recorded at Kent Town (*b*) 16/1861 and 4/06.

HUMIDITY, RAINFALL AND FOG

Month	*Rel. hum. (%)* 9 a.m. mean	3 p.m. mean	*Rainfall (millimetres)* Mean mthly	Mean No. of days of rain	Greatest monthly	Least monthly	Greatest in one day		Fog mean No. days
No. of years of record	122	111	140	140	140	140		140	77
January	42	34	20	4	84(1941)	Nil(*a*)	58	2/89*	0.0
February	45	35	21	4	155(1925)	Nil(*a*)	141	7/25	0.0
March	49	39	24	5	117(1878)	Nil(*a*)	89	5/78*	0.0
April	58	47	44	9	154(1971)	Nil(1945)	80	5/60*	0.0
May	69	57	68	13	197(1875)	3(1934)	70	1/53*	0.4
June	76	64	72	15	218(1916)	6(1958)	54	1/20	1.1
July	77	64	66	16	(*b*)160(1890)	10(1899)	44	10/65*	1.3
August	71	58	61	15	157(1852)	8(1944)	57	19/51*	0.6
September	62	52	51	13	148(1923)	7(1951)	40	20/23	0.2
October	53	45	44	11	133(1949)	1(1969)	57	16/08	0.0
November	46	39	31	8	113(1839)	1(1967)	75	12/60	0.0
December	43	36	26	6	101(1861)	Nil(1904)	61	23/13	0.0
Totals	..	..	**528**	**119**	..	..	..	..	**3.6**
Year Averages	**58**	**48**	..	..	..	..	..	..	..
Extremes			..	..	**218(6/1916)**	Nil(*c*)	**141**	**7/2/25**	

(*a*) Various years. (*b*) Kent Town. (*c*) December to April, various years.

NOTE: Figures such as 3/55, 21/84, etc. indicate, in respect of the month of reference, the day and year of the occurrence. Dates marked with an asterisk(*) relate to nineteenth century.

In February, 1977, the Adelaide Regional Office of the Bureau of Meteorology moved from West Terrace to Kent Town. Averages presented in this table are calculated from the observations recorded at West Terrace. Extremes recorded at Kent Town are marked. Bracketed figures indicate year of occurrence.

CLIMATIC DATA: PERTH, WESTERN AUSTRALIA

(Lat. 31° 57′ S., Long. 115° 51′ E. Height above M.S.L. 19.5 metres)

BAROMETER, WIND, EVAPORATION, THUNDER, CLOUDS AND CLEAR DAYS

Month	*Mean of 9 a.m. and 3 p.m. atmospheric pressure reduced to mean sea level (hPa)*	*Wind (height of anemometer 22 metres)*				*Mean amount evaporation (mm)*	*Mean No. days thunder*	*Mean No. cloudy days(a)*	*Mean No. clear days(b)*
		Average (km/h)	*Highest gust speed (km/h)*	*Prevailing direction 9 a.m.*	*Prevailing direction 3 p.m.*				
No. of years of record	94	(*c*)30	68	(*c*)30	(*c*)30	(*d*)12	82	45	(*c*)30
January	1,012.6	17.5	81	E	SSW	285	0.9	2	14
February	1,013.0	17.2	113	ENE	SSW	242	0.7	2	13
March	1,015.2	16.2	113	E	SSW	213	0.7	2	12
April	1,017.9	13.7	130	ENE	SSW	132	0.9	5	9
May	1,017.9	13.5	119	NE	WSW	94	1.7	6	6
June	1,017.6	13.5	129	N	NW	69	1.8	7	5
July	1,018.8	14.2	137	NNE	W	75	1.5	6	5
August	1,018.8	15.1	156	N	WNW	87	1.3	5	6
September	1,018.4	15.1	109	ENE	SSW	118	0.7	4	8
October	1,017.0	16.1	105	SE	SW	173	0.7	3	8
November	1,015.5	17.2	101	E	SW	216	0.8	3	9
December	1,013.4	17.7	103	E	SSW	275	0.9	2	13
Year Totals	..	..	..	..	..	**1,979**	**12.6**	**47**	**108**
Year Averages	**1,016.4**	**15.6**	..	**E**	**SSW**	..	..		..
Year Extremes	..	..	**156**	..	..	..	..		..

(*a*) Mean number of days when cloud cover equalled or exceeded seven-eighths. (*b*) Mean number of days when cloud cover was less than or equal to one eighth. (*c*) Standard thirty years normal (1911-1940). (*d*) Class-A Pan.

TEMPERATURE AND SUNSHINE

Month	*Air temperature daily readings (°Celsius)*			*Extreme air temperature (°Celsius)*				*Extreme temperature (°Celsius)*		*Mean daily hours sunshine*
	Mean max.	*Mean min.*	*Mean*	*Highest*		*Lowest*		*Lowest on grass*		
No. of years of record	85	85	85		85		85		84	81
January	29.6	17.7	23.5	44.7	12/78	9.2	20/25	4.2	20/25	10.5
February	29.9	17.9	23.7	44.6	8/33	8.7	1/02	4.3	1/13	10.1
March	27.8	16.6	22.2	41.3	14/22	7.7	8/03	2.6	(*a*)	9.0
April	24.5	14.1	19.2	37.6	9/10	4.1	20/14	−0.7	26/60	7.4
May	20.7	11.6	16.1	32.4	2/07	1.3	11/14	−3.9	31/64	5.9
June	18.2	9.9	14.1	28.1	5/75	1.6	22/55	−3.4	27/46	4.9
July	17.3	9.0	13.2	26.3	17/76	1.2	7/16	−3.8	30/20	5.3
August	17.9	9.1	13.5	27.8	21/40	1.9	31/08	−3.0	18/66	6.2
September	19.4	10.1	14.8	32.7	30/18	2.6	6/56	−2.7	(*b*)	7.2
October	21.2	11.5	16.3	37.3	29/67	4.2	6/68	−1.2	16/31	8.3
November	24.6	14.0	19.2	40.3	24/13	5.6	1/04	−1.1	6/71	9.7
December	27.3	16.2	21.7	42.3	31/68	8.6	29/57	3.3	29/57	10.6
Year Averages	**23.2**	**13.1**	**18.2**	..	..	..	..	..	..	**7.9**
Year Extremes	..	..	..	**44.7**	**12/1/78**	**1.2**	**7/7/16**	**−3.9**	**31/5/64**	..

(*a*) 8/1903 and 16/1967. (*b*) 8/1952 and 6/1956.

CLIMATIC DATA: PERTH, WESTERN AUSTRALIA—*continued*
(Lat. 31° 57′ S., Long. 115° 51′ E. Height above M.S.L. 19.5 metres)

HUMIDITY, RAINFALL AND FOG

Month	*Rel. hum. (%)* 9 a.m. mean	*Rel. hum. (%)* 3 p.m. mean	*Rainfall (millimetres)* Mean mthly	Mean No. of days of rain	Greatest monthly	Least monthly	Greatest in one day	Fog mean No. days
No. of years of record	44	44	106	102	106	106	102	79
January	50	41	8	3	55(1879)	Nil(*a*)	44 27/79*	0.2
February	53	40	12	3	166(1955)	Nil(*a*)	87 17/55	0.3
March	57	42	20	4	145(1934)	Nil(*a*)	77 9/34	0.6
April	65	49	45	8	149(1926)	Nil(1920)	67 30/04	0.9
May	72	53	124	14	308(1879)	14(1964)	76 17/42	1.3
June	78	60	183	17	476(1945)	55(1877)	99 10/20	1.4
July	78	60	174	18	425(1958)	61(1876)	76 4/91*	1.6
August	74	57	137	17	318(1945)	12(1902)	74 14/45	1.0
September	68	54	80	14	199(1923)	9(1916)	47 18/66	0.3
October	59	49	55	11	200(1890)	1(1969)	55 1/75	0.4
November	54	46	21	6	71(1916)	Nil1891	39 29/56	0.2
December	51	44	14	4	81(1951)	Nil(*a*)	47 3/51	0.2
Totals			**873**	**119**	..	..	.. ..	**8.1**
Year Averages	**63**	**50**	..	..	..	..	.. ..	..
Extremes			..	..	**476(6/1945)**	Nil(*a*)	**99** 10/6/20	

(*a*) Various years.
NOTE: Figures such as 26/76, 29/56, etc. indicate, in respect of the month of reference, the day and year of the occurrence. Dates marked with an asterisk(*) relate to nineteenth century. Bracketed figures indicate year of occurrence.

CLIMATIC DATA: HOBART, TASMANIA
(Lat. 42°53′S., Long. 147°20′E. Height above M.S.L. 54 metres)

BAROMETER, WIND, EVAPORATION, THUNDER, CLOUDS AND CLEAR DAYS

Month	*Mean of 9 a.m. and 3 p.m. atmospheric pressure reduced to mean sea level (hPa)*	*Wind (height of anemometer 12 metres)* Average (km/h)	Highest gust speed (km/h)	Prevailing direction 9 a.m.	Prevailing direction 3 p.m.	*Mean amount evaporation (mm)*	*Mean No. days thunder*	*Mean No. cloudy days(a)*	*Mean No. clear days(b)*
No. of years of record	99	76	96	(*c*)30	(*c*)30	(*d*)11	75	42	(*c*)30
January	1,010.6	12.7	130	NNW	SSE	142	1.0	10	1.9
February	1,012.9	11.7	121	NNW	SSE	123	0.9	9	2.3
March	1,014.3	11.1	127	NW	SSE	92	0.8	11	2.4
April	1,015.5	11.0	141	NW	W	59	0.3	11	1.7
May	1,015.5	10.8	135	NNW	NW	36	Nil	13	2.4
June	1,015.4	10.2	132	NW	NW	20	Nil	11	2.4
July	1,014.1	10.9	129	NNW	NNW	24	Nil	10	2.0
August	1,012.8	11.1	140	NNW	NW	43	Nil	11	2.1
September	1,011.4	12.5	150	NNW	NW	59	0.1	10	1.5
October	1,010.5	12.6	140	NNW	SW	90	0.4	12	1.0
November	1,009.9	12.8	135	NNW	S	121	0.6	12	1.3
December	1,009.4	12.5	122	NNW	SSE	144	0.8	12	1.1
Totals	..	..	..	..	..	**953**	**4.9**	**132**	**22.1**
Year Averages	**1,012.7**	**11.7**	..	NNW	W	..	..		..
Extremes	..	..	**150**	..	..	..	..	..	

(*a*) Mean numbers of days when cloud equalled or exceeded seven-eighths. (*b*) Mean number of days when cloud cover was less than or equal to one-eighth. (*c*) Standard thirty years normal (1911-1940). (*d*) Class-A Pan with Bird Guard.

CLIMATIC DATA: HOBART, TASMANIA—*continued*
(Lat. 42°53′S., Long. 147°20′E. Height above M.S.L. 54 metres)

TEMPERATURE AND SUNSHINE

Month	*Air temperature daily readings (°Celsius)* Mean max.	Mean min.	Mean	*Extreme air temperature (°Celsius)* Highest		Lowest		*Extreme temperature (°Celsius)* Lowest on grass		*Mean daily hours sunshine*
No. of years of record	101	101	101		101		101		99	75
January	21.5	11.7	16.5	40.8	4/76	4.5	9/37	−0.8	19/97*	7.7
February	21.6	11.9	16.7	40.2	12/99*	3.4	10/80*	−2.0	−/87*	6.9
March	20.0	10.7	15.2	37.3	13/40	1.8	31/26	−2.5	30/02	6.2
April	17.1	8.8	12.9	30.6	1/41	0.6	14/63	−3.9	—/86*	5.0
May	14.9	6.8	10.5	25.5	5/21	−1.6	30/02	−6.7	19/02	4.2
June	11.8	5.1	8.5	20.6	1/07	−2.8	25/72	−7.7	24/63	3.8
July	11.5	4.4	7.9	21.0	30/75	−2.8	11/81	−7.5	1/78	4.2
August	12.9	5.1	9.1	24.5	26/77	−1.8	5/62	−6.6	7/09	4.9
September	14.9	6.3	10.6	28.2	29/73	−0.6	16/97*	−7.6	16/26	5.7
October	16.9	7.6	12.2	33.4	24/14	0.0	12/89*	−4.6	(*a*)	6.3
November	18.5	9.1	13.8	36.8	26/37	1.6	16/41	−3.4	1/08	6.9
December	20.2	10.6	15.4	40.7	30/97*	3.3	3/06	−2.6	−/86*	7.2
Year Averages	**16.8**	**8.2**	**12.4**	..	..	..	..	..	..	**5.8**
Year Extremes	..	..	..	**40.8**	**4/1/1976**	**−2.8**	**11/7/81 and 25/6/72**	**−7.7**	**24/6/1963**	..

(*a*) 1/1886 and 1/1899.

HUMIDITY, RAINFALL AND FOG

Month	*Rel. hum. (%)* 9 a.m. mean	3 p.m. mean	*Rainfall (millimetres)* Mean mthly	Mean No. of days of rain	Greatest monthly	Least monthly	Greatest in one day		Fog mean No. days
No. of years of record	86	86	105	105	101	101		101	73
January	59	53	48	11	150(1893)	4(1958)	75	30/16	0.1
February	63	55	40	10	171(1964)	3(1914)	56	1/54	Nil
March	66	55	47	11	255(1946)	7(1943)	88	17/46	0.2
April	70	59	53	12	248(1960)	2(1904)	132	23/60	0.3
May	76	63	49	14	214(1958)	4(1913)	47	3/73	1.2
June	79	68	57	14	238(1954)	2(1979)	147	7/54	1.6
July	78	66	53	15	157(1974)	4(1950)	64	18/22	1.3
August	74	60	52	15	161(1946)	8(1892)	65	2/76	0.6
September	66	56	53	15	201(1957)	10(*a*)	156	15/57	0.2
October	62	56	63	16	193(1947)	9(1982)	66	4/06	0.1
November	60	55	56	14	188(1885)	9(*b*)	94	30/85*	0.1
December	59	58	57	13	206(1985)	5(*c*)	85	5/41	0.1
Year Totals			**628**	**160**	..	..	..	..	**5.8**
Year Averages	**68**	**59**	..	..	..	..	..	..	..
Year Extremes			..	..	**255(3/1946)**	**2(*d*)**	**156**	**15/9/57**	..

(*a*) 1891 and 1951. (*b*) 1919 and 1921. (*c*) 1897, 1915 and 1931. (*d*) 4/1904 and 6/1979.

NOTE: Figures such as 30/16, 12/99, etc. indicate, in respect of the month of reference, the day and year of the occurrence. Dates marked with an asterisk(*) relate to nineteenth century. Bracketed figures indicate year of occurrence.

CLIMATIC DATA: DARWIN AIRPORT, NORTHERN TERRITORY
(Lat. 12°25'S., Long. 130°52'E. Height above M.S.L. 31 metres)

BAROMETER, WIND, EVAPORATION, THUNDER, CLOUDS AND CLEAR DAYS

Month	*Mean of 9 a.m. and 3 p.m. atmospheric pressure reduced to mean sea level (hPa)*	*Wind (height of anemometer 36 metres)* Average (km/h)	Highest gust speed (km/h)	Prevailing direction 9 a.m.	Prevailing direction 3 p.m.	*Mean amount evaporation (mm)*	*Mean No. days thunder*	*Mean No. cloudy days(a)*	*Mean No. clear days(b)*
No. of years of record	95	45	(c)29			(d)13	45	45	45
January	1,006.4	9.7	100	W	NW	185	15	21	0
February	1,006.4	11.1	96	W	NW	162	11	19	0
March	1,007.6	9.3	107	W	NW	172	11	16	1
April	1,009.6	9.7	117	SE	NW	189	4	9	4
May	1,010.9	10.5	63	SE	E	200	0	5	9
June	1,012.6	10.7	67	SE	E	189	0	3	13
July	1,013.1	9.7	61	SE	E	201	0	3	16
August	1,012.6	9.7	65	SE	NW	203	0	2	15
September	1,012.1	11.0	67	ENE	NW	232	1	2	11
October	1,010.6	10.9	96	NE	NW	254	5	4	6
November	1,008.7	9.1	117	NW	NW	230	12	8	2
December	1,007.4	9.7	217	NW	NW	205	15	15	0
Totals	..	..	..	..	..	**2,422**	**74**	**105**	**77**
Year Averages	**1,009.8**	**10.1**	..	**SE**	**NW**	..	..	..	..
Extremes	..	..	**217**	..	..	..	..	..	

(*a*) Mean number of days when cloud cover equalled or exceeded seven-eighths. (*b*) Mean number of days when cloud cover was less than or equal to one-eighth. (*c*) Several incomplete years. (*d*) Class-A Pan.

TEMPERATURE AND SUNSHINE

Month	*Air temperature daily readings (°Celsius)* Mean max.	Mean max.	Mean	*Extreme air temperature (°Celsius)* Highest		Lowest		*Extreme temperature (°Celsius)* Lowest on grass	*Mean daily hours sunshine*
No. of years of record	45	45	45		(a)100		(a)100		31
January	31.7	24.7	28.2	37.8	2/82*	20.0	20/92*	..	5.6
February	31.4	24.6	28.0	38.3	20/87*	17.2	25/49	..	5.9
March	31.8	24.4	28.1	38.9	(b)	19.2	31/45	..	6.6
April	32.6	23.9	28.3	40.0	7/83*	16.0	11/43	..	8.7
May	31.9	21.9	26.9	39.1	8/84*	14.2	28/67	..	9.5
June	30.4	19.8	25.1	39.0	17/37	12.1	23/63	..	9.9
July	30.3	19.2	24.8	36.7	17/88*	10.4	29/42	..	10.1
August	31.2	20.6	25.9	37.0	30/71*	13.6	11/63	..	10.2
September	32.4	23.0	27.7	38.9	20/82*	16.7	9/63	..	9.8
October	33.0	24.9	29.0	40.5	17/92*	19.4	8/66	..	9.4
November	33.1	25.2	29.2	39.6	9/84*	19.3	4/50	..	8.4
December	32.5	25.2	28.9	38.9	20/82*	18.3	4/60	..	7.2
Year Averages	**31.9**	**23.1**	**27.5**	..	..	..	..	..	**8.4**
Year Extremes	..	..	..	**40.5** 17/10/1892		**10.4** 29/7/1942			..

(*a*) Years 1882-1941 at Post Office; 1942-1981 at Aerodrome; 1967-1973 at Regional office; sites not strictly comparable. (*b*) 26/1883 and 27/1883.

CLIMATIC DATA: DARWIN AIRPORT, NORTHERN TERRITORY—*continued*
(Lat. 12°25'S., Long. 130°52'E. Height above M.S.L. 31 metres)

HUMIDITY, RAINFALL AND FOG

Month	Rel. hum. (%) 9 a.m. mean	Rel. hum. (%) 3 p.m. mean	Rainfall (millimetres) Mean mthly	Mean No. of days of rain	Greatest monthly	Least monthly	Greatest in one day		Fog mean No. days
No. of years of record	41	41	45	45	116(*a*)	45		116(*a*)	45
January	82	70	409	21	906(1981)	136(1965)	296	7/97*	Nil
February	84	72	355	20	815(1969)	103(1959)	250	18/55	Nil
March	83	67	316	19	1,014(1977)	88(1978)	241	16/77	Nil
April	75	52	99	9	357(1953)	1(1946)	143	4/59	Nil
May	67	43	17	2	299(1968)	Nil(*b*)	58	23/79	Nil
June	63	39	2	Nil	41(1973)	Nil(*b*)	36	10/02	Nil
July	64	38	1	Nil	10(1955)	Nil(*b*)	43	12/00	1
August	68	41	6	1	84(1947)	Nil(*b*)	80	2/47	1
September	71	48	18	2	130(1981)	Nil(*b*)	71	21/42	Nil
October	71	53	72	6	339(1954)	Nil(1953)	95	28/56	Nil
November	74	59	142	12	371(1964)	17(1976)	120	19/51	Nil
December	77	65	224	16	665(1974)	56(1961)	277	25/74	Nil
Year Totals			**1,661**	**108**	..	..	..	..	**2**
Year Averages	**73**	**54**	..	..	..	..	..	..	..
Year Extremes			..	..	**1,014(3/77)**	**Nil(*c*)**	**296**	7/1/1897	..

(*a*) Highest or lowest at either Post Office, Aerodrome or Regional Office Sites. Regional Office (1964-1973). (*b*) Various years. (*c*) April to October. Various years.

NOTE: Figures such as 2/82, 26/42, etc, indicate, in respect of the month of reference, the day and year of occurrence. Dates marked with an asterisk (*) relate to nineteenth century. Bracketed figures indicate year of occurrence.

CLIMATIC DATA: CANBERRA, AUSTRALIAN CAPITAL TERRITORY
(Lat. 35° 19' S., Long. 149° 11' E. Height above M.S.L. 577 metres)

BAROMETER, WIND, EVAPORATION, THUNDER, CLOUDS AND CLEAR DAYS

Month	Mean of 9 a.m. and 3 p.m. atmospheric pressure reduced to mean sea level (hPa)	Wind (height of anemometer 10 metres) Average (km/h)	Highest gust speed (km/h)	Prevailing direction 9 a.m.	Prevailing direction 3 p.m.	Mean amount evaporation (mm)	Mean No. days thunder	Mean No. cloudy days(*a*)	Mean No. clear days(*b*)
No. of years of record	35	(*c*)23	47	43	43	(*d*)20	47	47	47
January	1,012.1	6.1	121	NW	NW	259	3.9	8	7.3
February	1,013.8	5.3	104	SE	NW	205	3.5	8	6.1
March	1,016.1	4.7	111	SE	NW	172	1.9	9	6.8
April	1,018.9	4.2	106	NW	NW	109	1.1	7	6.7
May	1,019.9	4.5	104	NW	NW	70	0.5	9	6.6
June	1,020.9	4.2	96	NW	NW	48	0.2	10	6.2
July	1,020.4	4.9	102	NW	NW	53	0.1	8	7.1
August	1,018.5	5.6	113	NW	NW	79	0.8	8	6.7
September	1,017.4	6.0	107	NW	NW	110	1.5	8	7.6
October	1,015.1	6.4	121	NW	NW	157	2.5	9	5.9
November	1,012.7	6.6	128	NW	NW	195	3.5	9	5.1
December	1,011.0	6.8	106	NW	NW	261	3.7	8	6.7
Year Totals	..	..	..	..	..	**1,718**	**23.2**	**101**	**78.8**
Year Averages	**1,016.4**	**5.4**	..	**NW**	**NW**	..	..	..	**6.6**
Year Extremes	..	..	**128**	..	..	..	..	..	..

(*a*) Mean number of days when cloud cover equalled or exceeded seven-eighths. (*b*) Mean number of days when cloud cover was less than or equal to one-eighth. (*c*) Recorded at Yarralumla, where a cup anemometer was installed up to 1980. (*d*) Class-A Pan.

CLIMATIC DATA: CANBERRA, AUSTRALIAN CAPITAL TERRITORY—*continued*

(Lat. 35° 19′ S., Long. 149° 11′ E. Height above M.S.L. 577 metres)

TEMPERATURE AND SUNSHINE

Month	*Air temperature daily readings (°Celsius)* Mean max.	Mean min.	Mean	*Extreme air temperature (°Celsius)* Highest		Lowest		*Extreme temperature (°Celsius)* Lowest on grass		*Mean daily hours sunshine*
No. of years of record	47	47	47		47		47		36	12(*a*)
January	27.7	12.9	20.3	41.4	31/68	1.8	1/56	−0.4	1/56	9.7
February	26.9	12.9	19.9	42.2	1/68	3.0	16/62	−0.5	9/80	9.3
March	24.4	10.7	17.5	36.5	8/83	−1.1	24/67	−4.0	(*b*)	7.8
April	19.6	6.5	13.1	32.6	(*c*)	−3.6	(*d*)	−8.3	24/69	7.3
May	15.1	2.9	9.0	24.5	10/67	−7.5	30/76	−11.0	17/79	5.5
June	12.0	0.8	6.4	20.1	3/57	−8.5	8/57	−13.4	25/71	5.4
July	11.1	−0.3	5.4	19.7	29/75	−10.0	11/71	−15.1	11/71	5.7
August	12.8	0.8	6.8	24.0	30/82	−7.8	6/74	−13.0	3/79	6.7
September	15.9	2.9	9.4	28.6	26/65	−6.4	10/82	−10.7	10/82	7.3
October	19.1	5.9	12.5	32.7	13/46	−3.3	4/57	−7.0	1/82	8.3
November	22.5	8.4	15.5	38.8	19/44	−1.8	28/67	−6.3	28/67	8.9
December	26.0	11.1	18.5	38.8	21/53	1.1	18/64	−3.9	18/64	9.3
Year Averages	**19.4**	**6.3**	**12.9**	..	..	..	..	..	..	**7.6**
Year Extremes	..	..	..	**(*e*)42.2**	**1/2/68**	**−10.0**	**11/7/71**	**−15.1**	**11/7/71**	..

(*a*) Composite of Airport and city. (*b*) 30/58 and 24/67. (*c*) 12/68 and 4/86. (*d*) 27 and 28/78. (*e*) Acton 42.8 on 11/1/39.

HUMIDITY, RAINFALL AND FOG

Month	*Rel. hum. (%)* 9 a.m. mean	3 p.m. mean	*Rainfall (millimetres)* Mean mthly	Mean No. of days of rain	Greatest monthly	Least monthly	Greatest in one day		Fog mean No. days
No. of years of record	47	47	47	47	47	47		47	47
January	60	34	60	8	185(1984)	1(1947)	95	12/45	1.0
February	66	39	57	7	148(1977)	Nil(1968)	69	20/74	1.0
March	68	41	54	7	312(1950)	1(1954)	92	21/78	2.7
April	75	46	50	8	164(1974)	1(1980)	75	2/59	4.1
May	81	55	48	9	150(1953)	Nil(1982)	96	3/48	7.8
June	84	60	37	9	126(1956)	4(1979)	45	25/56	8.1
July	84	58	39	10	104(1960)	4(*a*)	35	10/57	7.8
August	78	53	49	12	156(1974)	7(1944)	48	29/74	5.2
September	72	49	52	11	151(1978)	6(1946)	43	8/78	3.9
October	65	47	69	11	161(1976)	2(1977)	105	21/59	3.0
November	60	40	62	9	135(1961)	Nil(1982)	68	19/86	1.3
December	57	34	49	8	215(1947)	Nil(1967)	87	30/48	0.7
Year Totals			**626**	**109**	.. ..	.. ..	..	..	**46.6**
Year Averages	**71**	**46**	..	..	.. ..	.. ..	..	..	..
Year Extremes	..	..	..	..	**312(3/50)**	**Nil(b)**	**105 21/10/59**		..

(*a*) 1970 and 1982 (*b*) 12/67, 2/68, 5/82 and 11/82.

NOTE: Data shown in the above tables relate to the Canberra Airport Meteorological Office, except where otherwise indicated, and cover years up to 1987.

Figures such as 24/33, 31/68, etc. indicate, in respect of the month of reference, the day and year of the occurrence. Bracketed figures indicate year of occurrence.

METEOROLOGY IN AUSTRALIA

(This special article has been contributed by the Bureau of Meteorology)

In our present complex civilisation, when interests are so inter-involved and world-wide, the discovery and formulation of laws governing the weather are of first importance. To obtain an accurate meteorological system throughout Australia, the Government would be justified in incurring almost any expenditure. To all sections of the community the matter is of great importance—to those interested in commerce, in transportation, navigation, agriculture and trade of all descriptions. In short, it concerns everybody whose living and comfort depend on the weather.

(*Hansard*, House of Representatives, 1 August 1906)

These prophetic words were spoken during the debate on the Meteorology Bill in the Australian Parliament, itself only five years old. The Bill led to the establishment of the Commonwealth Bureau of Meteorology, which began operations as Australia's national meteorological authority on 1 January 1908.

Our first weathermen

The first observations of weather conditions around Australia by Europeans were made by Cook, Dampier and other early navigators. However, the first land-based observations were made by William Dawes, a lieutenant in the Royal Marines who arrived with the First Fleet in 1788. Dawes built an observatory at Sydney Cove and for the next three years kept daily records of wind, temperature, pressure and rainfall.

From 1800 onwards the expansion of weather information was directly related to the exploration of Australia. Men like Mitchell, Oxley, Blaxland, Lawson and Wentworth all compiled valuable weather records as they pushed back the frontiers of settlement.

Official observations in Sydney began in 1859. Activities flourished under the guidance of H. C. Russell, Government Astronomer from 1879 to 1905 who prepared Australia's first newspaper weather map, published in 1877, and initiated the publication of daily weather maps from 1879.

Melbourne's first observatory was built at Williamstown in 1854. Two years later a Bavarian scientist, Georg von Neumayer, established an observatory at Flagstaff Hill and organised a number of observing stations throughout Victoria.

Impetus to the South Australian meteorological service was given by the appointment in 1855 of Sir Charles Todd as the Director of the Adelaide Observatory. Todd was responsible for the construction of the Adelaide-Darwin overland telegraph, and a duty of all his telegraph operators was to observe and dispatch weather reports.

Perhaps the most colourful of the early Australian meteorologists was Clement Wragge, Queensland Government Meteorologist from 1887 to 1903. A man of great energy and enthusiasm, Wragge established a network of observing stations throughout Queensland and pioneered the practice of naming cyclones.

Few countries in the world, therefore, can claim as rich a heritage of foresight, wisdom and dedication on the part of their early meteorologists as can Australia. In just over 100 years after the first European settlements, an observing network over an area larger than Europe had been established, a system of preparing daily weather charts and issuing forecasts had been initiated, and a significant bank of meteorological data had been accumulated.

The Bureau of Meteorology

Victoria and Tasmania: Generally fine with rising temperatures . . . . . .
New South Wales: Isolated thunderstorms on the coast, chiefly north of Sydney . . . . . .
Queensland: Showers and thunder over northern parts . . . . . .
South Australia: Generally fine and warm to hot with northerly winds . . . . . .
Western Australia: Generally fine, hot in the north, cooler on the SW Coast . . . . . .
Ocean: Gales, heavy rains and rough seas off the Queensland coast . . . . . .

These forecasts for 1 January 1908 were prepared by the first Commonwealth Meteorologist, H. A. Hunt. They were published in the press, transmitted by morse code to various country centres, and indicated by a system of flags on tall buildings in metropolitan areas.

Early services consisted of one daily forecast for the States, metropolitan areas and oceans. Although it operated Australia-wide the Bureau for many years worked with very limited staff and resources. Despite this, there were several notable achievements in its early history:

1913—staffing of Macquarie Island meteorological station as a base for Mawson's Antarctic expedition;

1921—establishment of an observing station on remote Willis Island in the Coral Sea;

1924—introduction of radio weather forecasts;

1934—establishment of a meteorological office in Darwin, initially for the London to Melbourne Centenary Air Race.

The threat of war in the late 1930s saw a marked increase in the requirements for meteorological services. Staff numbers jumped dramatically, and training courses for meteorologists and observers were introduced. In 1941 the Bureau was incorporated in the Royal Australian Air Force for the duration of the War.

The post-war period was one of great expansion in the Bureau. It was an era that saw the first use of radar for upper wind measurement (1948), Australia become one of the first members of the World Meteorological Organization (WMO) (1950), the start of continuous meteorological observations at Mawson Station in Antarctica (1954), the first television weather broadcast (1956), the first automatic weather station (1962), reception of the first TIROS satellite picture (1964), introduction of computers (1968), the beginning of regular transmissions from the Japanese geostationary satellite (1978), and introduction of a computerised communications system (1979).

Today the Bureau issues some 3,000 forecasts and warnings each day to the general community and a wide range of special users. Weather information is provided to the public through 136 radio stations and 50 television stations, and all metropolitan and many country newspapers. In addition, about 12 million calls are made each year by the public to recorded weather information services. Forecasts and other weather information are also provided on a daily basis to the aviation industry, defence services, shipping, primary producers, offshore oil rigs, and a range of other commercial interests.

In all, the Bureau issues more than one million forecasts and warnings each year, provides more than one million aviation briefing and documentation services, and handles about half a million queries and consultations on weather forecasts and current information.

The Bureau maintains Regional Forecasting Centres in each capital city and briefing offices at most major airports and RAAF bases throughout Australia. In preparing their forecasts and warnings the Regional Forecasting Centres are supported by analyses and prognoses of the larger-scale weather patterns over the Southern Hemisphere and the tropics, produced by the Bureau's National Meteorological Centre in Melbourne, and a tropical centre in Darwin. The National Meteorological Centre also serves as one of three World Meteorological Centres (the other two are in Washington and Moscow) of the WMO World Weather Watch system.

One of the most important tasks of the Bureau is to provide warnings of dangerous weather conditions. These include tropical cyclones, floods, gales, thunderstorms, cold snaps and fire weather.

Tropical Cyclone Warning Centres are maintained in Brisbane, Darwin and Perth to locate and track tropical cyclones threatening the Australian region. The Centres are supported by a network of radar-equipped observing stations, offshore automatic weather stations, and ship and aircraft reports. In addition, the ability of meteorological satellites to pinpoint the tell-tale spiral of a cyclone means that no cyclone now goes undetected.

The Bureau operates similar specially manned centres in times of floods and bushfires to warn the public and emergency organisations.

Observations

Since its establishment the Bureau has been faced with the problem of obtaining adequate observations over a vast continent—equal in area to Europe or the USA—only thinly populated and surrounded by data-sparse oceans.

Over the years it has built up a network of more than 60 Bureau-staffed stations, covering the continent and including the Antarctic and islands in the Pacific and Indian Oceans. Radar or radio-tracked balloons are used to measure wind, temperature and humidity at various levels into the stratosphere.

In addition to regular pictures of cloud imagery, polar-orbiting satellites have the capacity to sound the atmosphere, thereby providing data on temperature, moisture content and wind values at various levels above the earth's surface.

Australia's national satellite system holds great promise for meteorology through improvements in the dissemination of forecasts and collection of data from remote outback areas and unmanned weather stations. Consideration is being given to inclusion of meteorological sensors to provide forecasts with additional weather data to complement regular cloud imagery.

The Bureau-staffed network is augmented by over 400 part-time observers who provide surface weather reports several times a day, and an army of 6,000 volunteers who provide the Bureau with monthly rainfall totals. A fleet of more than 80 selected ships also radio valuable weather data to the Bureau when they are operating in Australian waters.

Technological advances of recent years have done much to overcome the long-standing problems posed by Australia's physical size and location. In addition to the Japanese Geostationary Meteorological Satellite (GMS), which provides three-hourly pictures day and night from its vantage point 36,000 kilometres above the equator, there are American and Russian satellites in polar orbit which transmit more detailed but less frequent pictures as they pass over the Australian region. The satellites' electronics also enable them to receive and transmit weather data from remote automatic weather stations, drifting ocean buoys, and from wide-bodied jet aircraft fitted with instruments to record and transmit weather data automatically during flight.

Climatological data service

'An important national asset . . . '—that's the description frequently applied to the Bureau's climatological information service. The ever-growing bank of weather data, coupled with powerful computers, enables the Bureau to provide a speedy, comprehensive climatological service to many sectors of the community—researchers in government, private industry and research institutions, atmospheric scientists, and the general public. The data include surface observations, radiation, rainfall, evaporation and upper-air measurements. Rainfall records, which form part of the data bank, have been collected for more than 100 years at some locations.

Climatological data have many applications in today's world. These include:

- urban and regional planning, such as siting of factories to minimise pollution;
- design and construction of mining townships in remote areas;
- dam construction and other water resource projects;
- assessing the need for air-conditioning;
- planning, siting and construction of airports;
- analysis of results of research projects in which weather is a factor;
- climate monitoring, including assessment of drought;
- meteorological research;
- certification of records for legal purposes.

International activities

Australia has played a leading part in the activities of the WMO since its formation in 1950. Bureau officers are members of many of the WMO bodies responsible for fostering the application of meteorology to aviation, shipping and agriculture, and encouraging world-wide co-operation in the establishment and maintenance of observing networks, standardisation of observational methods and the international exchange of data.

The Bureau's observations and telecommunications programs form part of the global system of the WMO World Weather Watch, and the World Meteorological Centre in Melbourne—together with centres in Washington and Moscow—provides a wide range of products for international users.

Australia also has a number of co-operative arrangements in meteorology with other countries. Training courses are provided for overseas students, and the Bureau participates in the programs of the Australian Development Assistance Bureau. One such project involves the secondment of a number of Bureau officers to Saudi Arabia under government to government agreement, to provide management and supervisory assistance in developing the Saudi meteorological service. Another involves assistance to the Solomon Islands service through new and upgraded equipment, consumables, staff training and general scientific and technical support.

Research

The Bureau has been responsible for meteorological research since its establishment in 1908. One of the first products of this research was a landmark publication in 1913 titled *Climate and Weather of Australia*, compiled by the then Commonwealth Meteorologist, H. A. Hunt, and two other distinguished meteorologists, Griffith Taylor and E. T. Quale.

In the following years, the Bureau's research was aimed largely at meeting the needs of operating a daily weather service. This research received a major boost during the period following World War II, when more highly qualified staff and a much improved data base became available.

The 1950s saw the establishment of a special Research and Development Division in the Bureau, and in 1965 in collaboration with the Academy of Science, the Bureau established the International Antarctic Meteorological Research Centre in Melbourne. Much research, however, was still undertaken by meteorologists engaged in operational forecasting, and related to their needs of servicing agricultural and maritime users, and issuing flood warnings and fire-weather information.

It was not until the advent of computers and the development of numerical modelling in the 1960s that research activities adopted a more specialised approach. In 1969 the Bureau joined with the CSIRO to form the Commonwealth Meteorology Research Centre (later Australian Numerical Meteorology Research Centre) which made a major contribution to the development of numerical meteorology at the international level, particularly in connection with the Global Weather Experiments of 1979.

The Bureau of Meteorology Research Centre was established in 1985 following a rationalisation of meteorological research in CSIRO and the Bureau. Its main objectives are to advance the science of meteorology, with particular emphasis on the Southern Hemisphere and the Australian region, and to support the Bureau's services by the development of operational techniques and the provision of scientific advice for other units in the Bureau.

Present and proposed research activities include:

- the development of forecasting systems for short-range (0–36 hours), medium-range (1–10 days) and long-range (1–3 months) forecasting;
- a study of weather features relevant to Australian tropical regions including research to improve predictions of formation, tracking and intensity of cyclones;
- a major collaborative effort involving the Bureau, CSIRO and universities, designed to enhance knowledge of the structure and evolution of summertime cold fronts in southern Australia;
- establishment of a program to improve the understanding of atmospheric systems that effect aviation services in Australia and development of techniques and instrumentation for identifying and forecasting those systems;
- development of a system to enable optimum use of meteorological information from satellite data and improvement of techniques for the incorporation of this data into forecasting systems.

The future

The pioneer meteorologists who issued the Bureau's first forecasts could never have envisaged the sophisticated technology available to the forecaster today.

However, there will be even more exciting developments in meteorology by the year 2000. More advanced satellites, faster and more powerful computers, improved radar equipment, and other sophisticated technological aids will all contribute to more effective and efficient meteorological services.

These improvements will be seen in:

- more timely and accurate forecasts of short-term weather situations such as thunderstorms and cool changes;
- computer-produced graphics that will make the weather come alive on television;
- more detailed forecasts for aviation, resulting in increased economy for airlines;

- more accuracy and precision in warnings of cyclones, dangerous fire days and flood situations;
- computer-produced forecasts of sea conditions, such as waves and swell, that will benefit shipping, offshore operations and the fishing industry.

Long-range forecasting is an extremely complex problem, but there are several promising lines of research that, within the next decade or so, should result in a capability for useful seasonal and longer-range predictions that will be of great benefit to farmers and others whose livelihood depends on seasonal weather conditions. Significant progress already has been made in identifying the factors that have to be monitored, with particular attention being given to the study of the variations in sea surface temperatures, atmospheric circulations and ocean currents.

BIBLIOGRAPHY

ASHTON, H. T. *Meteorological Data for Air Conditioning in Australia.* Melbourne, Bureau of Meteorology, Bulletin No. 32, 1964.

FOLEY, J. C. *Droughts in Australia.* Melbourne, Bureau of Meteorology, Bulletin No. 43, 1957.

GIBBS, W. J. AND MAHER, J. V. *Rainfall Deciles as Drought Indicators.* Melbourne, Bureau of Meteorology, Bulletin No. 48, 1967.

LEE, D. H. K. AND HENSCHEL, A. *Evaluation of Environment in Shelters.* Cincinnati, U.S. Department of Health, Education and Welfare, 1963.

METEOROLOGY, BUREAU OF. *Climatic Atlas of Australia.* Melbourne, Series of Maps 1-8, 1974-79.