





ANNUAL CLIMATE SUMMARY 2009

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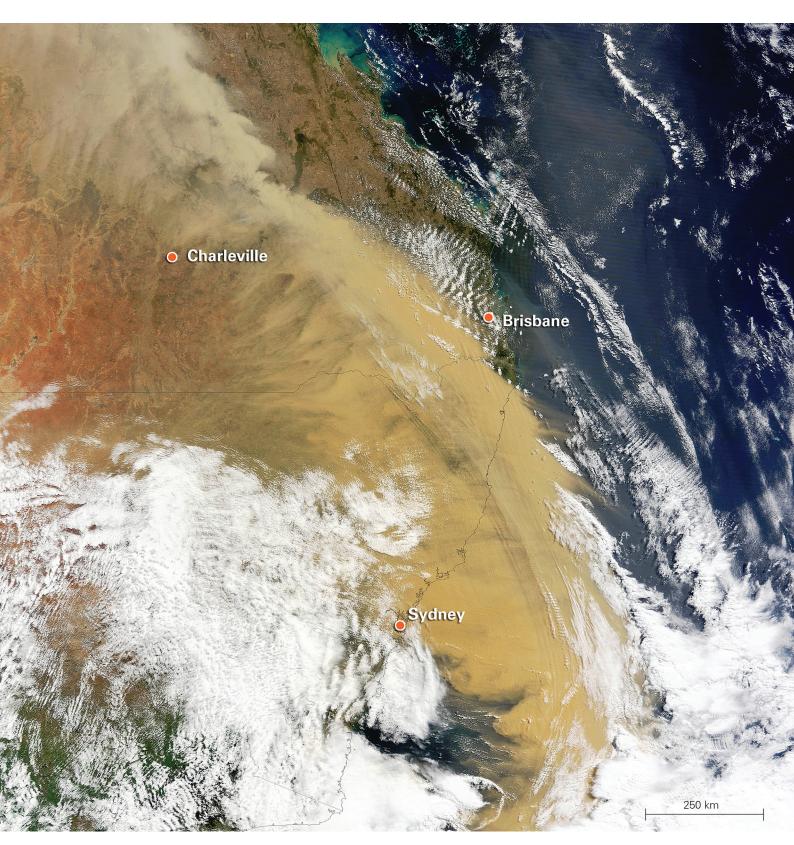
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ISSN 1837-8854

This document is also available online: www.bom.gov.au/climate/annual_sum/annsum.shtml

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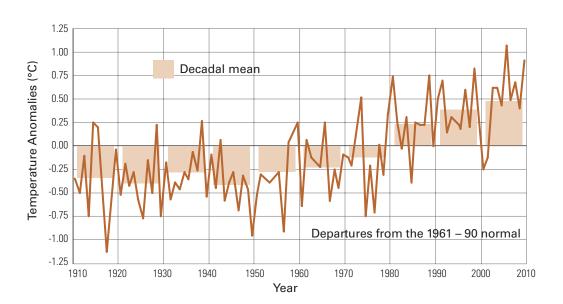
Dust storm across eastern Australia on the morning of 23 September 2009 as observed by the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite. A major dust storm with strong winds hit Sydney during the morning of 23 September, producing a red sky and reducing visibility over much of the city. It was Sydney's worst dust storm since 1942. The dust storm stretched across central and north Queensland by the evening of the same day (see page16).

1. Overview

Second warmest year for Australia

Data collected by the Bureau of Meteorology indicate that Australia's annual mean temperature for 2009 was 0.90°C above the 1961-90 average, making it the nation's second warmest year since high-quality records began in 1910. High temperatures were especially notable in the southeast during the second half of the year, with Australia, Victoria, South Australia and New South Wales all recording their warmest July-December periods on record.

The year also included three exceptional heatwaves – in late January-early February across southeast Australia, in August across Queensland, the Northern Territory and New South Wales, and again across the southeast during November. A range of temperature records during these events were broken by large margins, with, regrettably, major loss of life through both extreme heat and bushfires during the January-February event.



Annual and decadal mean temperature anomalies (1910-2009) for Australia (compared with 1961-90 average).

Warmest decade on record

The year 2009 ends Australia's warmest decade on record (data are available from 1910 onwards), with a decadal mean temperature 0.48°C above the standard 1961-90 average. In Australia, each decade since the 1940s has been warmer than the preceding decade. In contrast, decadal temperature variations during the first few decades of Australia's climate record do not display any clear trend. This suggests an apparent shift in Australia's climate from one characterised by natural variability to one increasingly characterised by a trend to warmer temperatures.

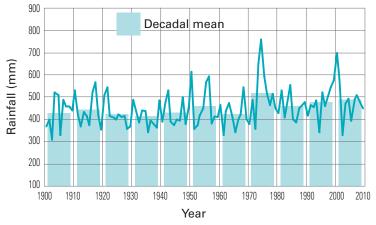
2009 the fifth warmest year globally

The World Meteorological Organization (WMO), using two separate datasets, has stated that 2009 is nominally ranked as the globe's fifth warmest year on record, about 0.45°C above the 1961-90 average of 14°C. A cooler-than-average global mean temperature has not been recorded since 1985, with the last decade also being the globe's warmest on record. Increasing global mean temperatures derived from instrumental measurements are consistent with other independent indicators of climate change, such as reductions in sea-ice and snow cover, and record high global mean sea levels.

Another drier than average year in the southeast mainland

Based on preliminary data, the overall Australian mean rainfall total for 2009 was 458 mm, slightly less than the long-term average (1961-90) of 465 mm. Above-average rainfall in January and February, especially in the northern tropics, was followed by dry conditions from March onwards, with the March-November total being the 11th lowest on record for Australia. A dry year in the southeast and southwest of mainland Australia has prolonged the multi-year meteorological drought in those regions.

During July to October 2009, serious rainfall deficiencies were experienced over large areas of Queensland and isolated parts of New South Wales, consistent with the development of an El Niño event



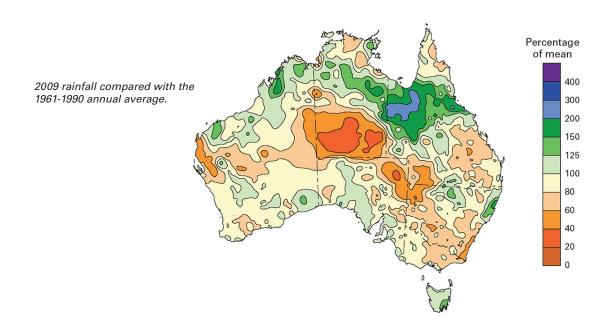
Australian annual and decadal mean rainfall (1900-2009).

during this time. The unusually dry and warm winter was associated with a series of dust storms across eastern New South Wales and southeast Queensland in September and early October.

Despite the long dry, several short-term flood events occurred in eastern Australia in 2009, the most notable in May when daily rainfall totals exceeded previous records for the month at locations across Queensland and New South Wales. Parts of Tasmania were affected by repeated flooding during May to September. Timely rainfall across southern Australia in winter and early spring resulted in record falls in southeast Tasmania and eased water shortages for some agricultural regions and the urban water supplies of Adelaide, Canberra and Melbourne. The year ended with further flooding in parts of New South Wales and Queensland.

Compared to 2008, 2009 was most notably wetter through areas directly south of the Gulf of Carpentaria, including large areas of western Queensland and eastern parts of the Northern Territory (which includes northern areas of the Lake Eyre catchment), on the northern New South Wales coast between Coffs Harbour and Port Macquarie, and for virtually all of Tasmania.

In contrast, the Top End of the Northern Territory and Cape York Peninsula experienced an early end to the monsoon and hence were drier in 2009 than 2008. Likewise southeastern Queensland was also drier than the previous year. Average rainfall over the Murray – Darling Basin for 2009 was 416 mm – 36 mm less than the Basin received in 2008.



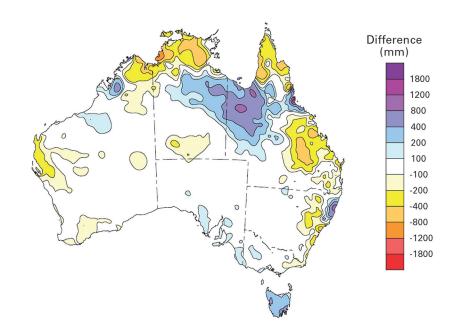
Capital city statistics (page 20) show that all capital cities had both warmer than average days and nights. Melbourne recorded the most extreme maximum temperature of any capital city for the year, with 46.4°C on 7 February, a new record high maximum for Melbourne and also the highest temperature ever recorded at an Australian capital city site (excluding airports). Other records at capital cities included Adelaide and Melbourne recording their longest run of consecutive days over 43°C (4 and 3 respectively), Adelaide recording its hottest night (33.9°C on 29 January), Darwin recording its equal hottest night (29.7°C on 10 December) and highest monthly mean

maximum temperature (34.8°C for October). The lowest temperature recorded for the year was –5.8°C at Canberra on 11 June. Rainfall was below the median at all capital city sites apart from Darwin and Hobart. Hobart was notable, in that it recorded decile 10 rainfall (i.e. rainfall in the highest 10 per cent of recorded totals) following its decile 1 (lowest 10 per cent of recorded totals) rainfall in 2008. Melbourne finally broke its three-year run of decile 1 rainfall, recording decile 2 rainfall in 2009. Hobart recorded the highest number of rain days (175), while Canberra once again received the fewest (93).

	Rainfall (mm)			Maximum temperature (°C)			Minimum temperature (°C)		
	2009 total	Normal	Rank (of 110)	2009 anomaly	Normal	Rank (of 100)	2009 anomaly	Normal	Rank (of 100)
AUSTRALIA	458	465	63 rd	+1.04	28.55	98 th	+0.76	15.07	96 th
New South Wales/ACT	497	553	50 th	+1.48	23.91	97 th	+1.16	10.75	100 th
Northern Territory	508	540	60^{th}	+0.84	31.89	90 th	+0.75	18.45	88 th
Queensland	687	623	80 th	+0.84	29.89	94 th	+0.57	16.57	88 th
South Australia	201	225	55 th	+1.33	26.71	98 th	+1.19	12.20	100 th
Tasmania	1515	1390	80 th	+0.23	14.71	78 th	+0.63	5.99	98 th
Victoria	534	660	17 th	+1.36	19.86	100 th	+0.69	8.34	98 th
Western Australia	329	341	55 th	+1.01	29.27	99 th	+0.60	15.66	95 th

Summary of 2009 mean rainfall and temperatures for Australia and States/Territories. Normal values are calculated using 1961-90 averages. Ranks are from lowest to highest. Annual mean temperatures can be calculated from the average of mean maximum and mean minimum temperatures.

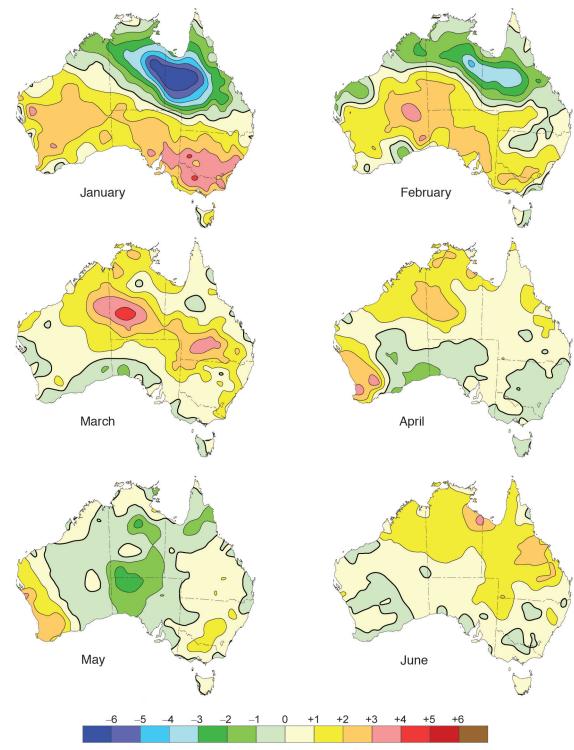
Difference between the 2009 and 2008 annual rainfall totals. The areas shaded blue and purple were wetter in 2009, while those shaded in yellow and orange were drier.



2. Monthly maximum temperatures: January to December 2009

The year commenced with temperatures above normal in southern Australia and below normal in northern Australia, with the north-south contrast especially strong during January. In March and April the focus of warm conditions shifted to the north, while in May this was largely confined to western Western Australia.

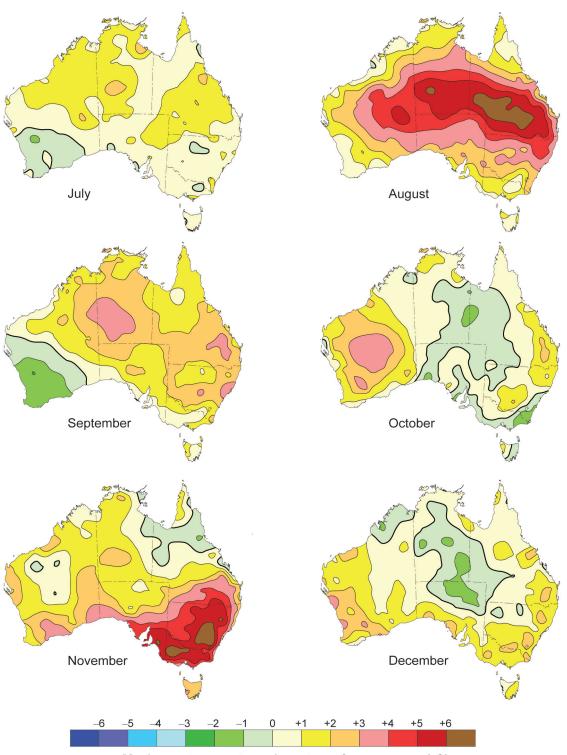
Above-average temperatures became increasingly widespread from June onwards, with only relatively small areas below normal in each month. August and November were especially warm with positive anomalies almost everywhere.



Maximum temperature: departures from average (°C) (Based on a 30-year mean calculated from 1961-1990)

The year's largest positive anomalies were in August and November, exceeding $+6^{\circ}\text{C}$ over much of southern inland Queensland in August, and the Victorian Wimmera and southern inland New South Wales (where they approached $+8^{\circ}\text{C}$) in November. In contrast, departures of -6 to -7°C occurred over parts

of northwest Queensland and the adjacent eastern Northern Territory in January. All twelve months recorded above-normal Australia-wide averages, with anomalies ranging from +0.01°C in May to an all-time record monthly anomaly of +3.20°C in August.

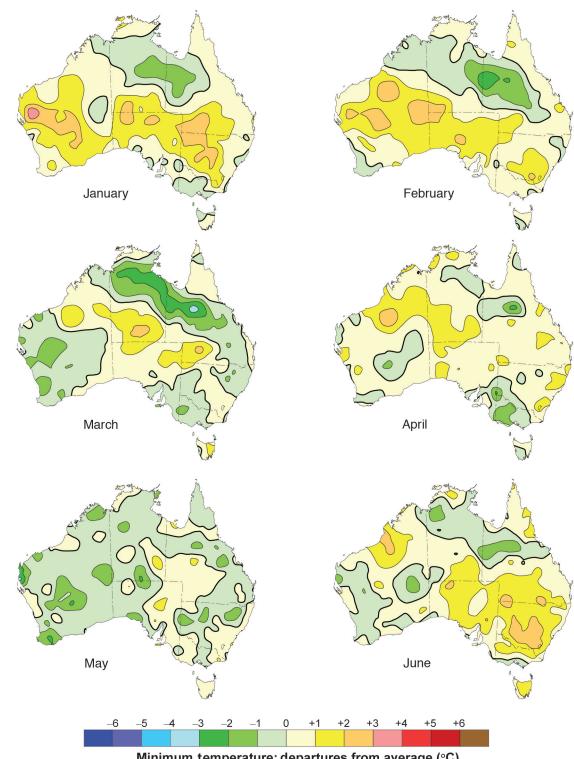


Maximum temperature: departures from average (°C) (Based on a 30-year mean calculated from 1961-1990)

3. Monthly minimum temperatures: January to December 2009

Minimum temperatures during January and February were well above average across much of southern Australia, while in contrast they were below normal in the north. During the autumn months, temperatures were generally close to normal, although central areas and Tasmania were warm, while the tropics were somewhat cool, during March. Warm conditions

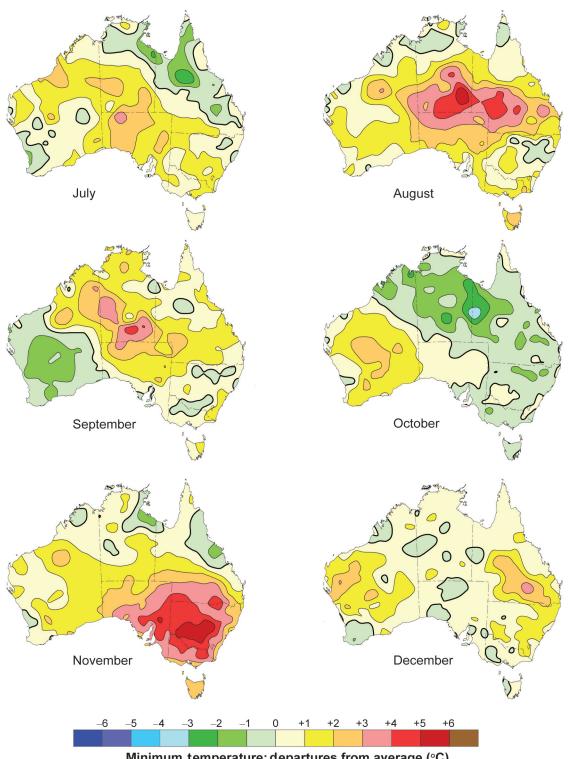
dominated from June onwards, especially in South Australia and the inland southeast, although there were some cool areas (notably the northeast in July and the northwest in October). Central Australia was very warm in August and September, as was the southeast in November.



Minimum temperature: departures from average (°C) (Based on a 30-year mean calculated from 1961-1990)

The strongest positive anomalies were recorded during November, when minima were 5 to 6°C above average across most of southern inland New South Wales. Similar anomalies occurred more locally in the southern Northern Territory in August. The

largest negative departures, around -3° C, occurred in north-central Queensland in March, and near the Queensland-Northern Territory border in October. Australia-wide average anomalies ranged from +1.75°C in August to -0.33° C in May.

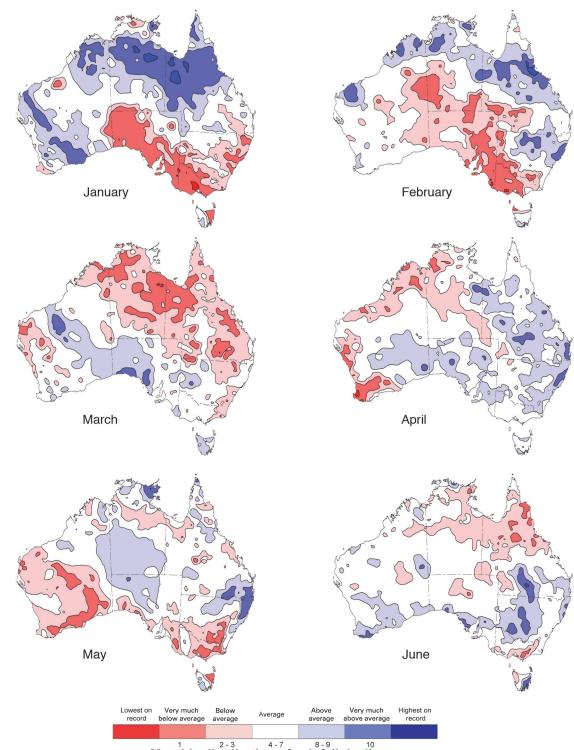


Minimum temperature: departures from average (°C) (Based on a 30-year mean calculated from 1961-1990)

4. Monthly distribution of rainfall deciles: January to December 2009

Associated with lingering La Niña conditions, January and February brought heavy rainfall to much of tropical Australia, especially Queensland and the Northern Territory, with widespread decile 8-10 totals in both months. Monthly records were set in northwest Queensland and the central Northern Territory (January)

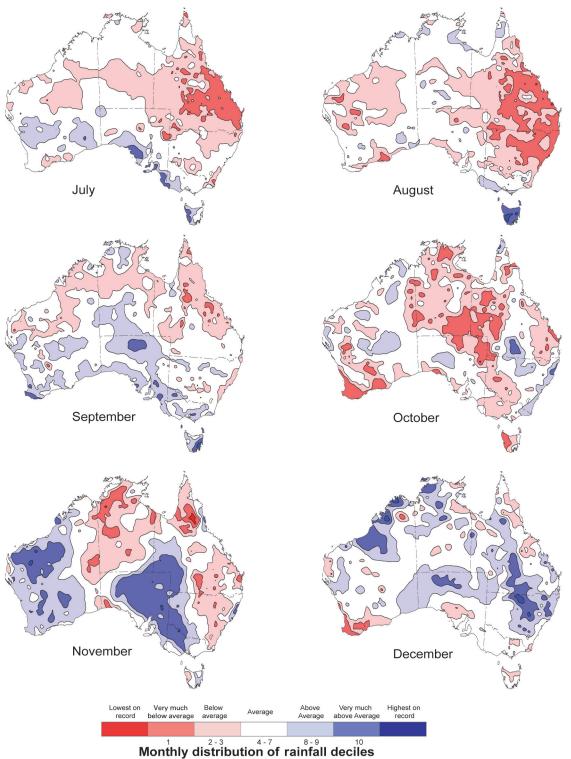
and around Townsville (February). In contrast it was very dry in South Australia and Victoria during both months. From March to November, rainfall was below normal across much of northern Australia, extending over much of New South Wales during July and August, as El Niño conditions developed in the Pacific.



Monthly distribution of rainfall deciles
(Based on a 110-year climatology of gridded fields from 1900-2009)

The northern coast of New South Wales (and southeast Queensland) received localised aboveaverage rainfall at times, especially in April/May and October/November. Many southern areas remained relatively dry in autumn, but from June to September rainfall was near or above average across much of southern mainland Australia, and well above normal in Tasmania with numerous records broken. November

was wet across parts of central Australia, South Australia and Victoria, while December had aboveaverage rainfall in those areas influenced by tropical cyclone Laurence, including the Northern Territory Top End, Western Australia Kimberley, northern South Australia, and inland areas near the Queensland-New South Wales border.

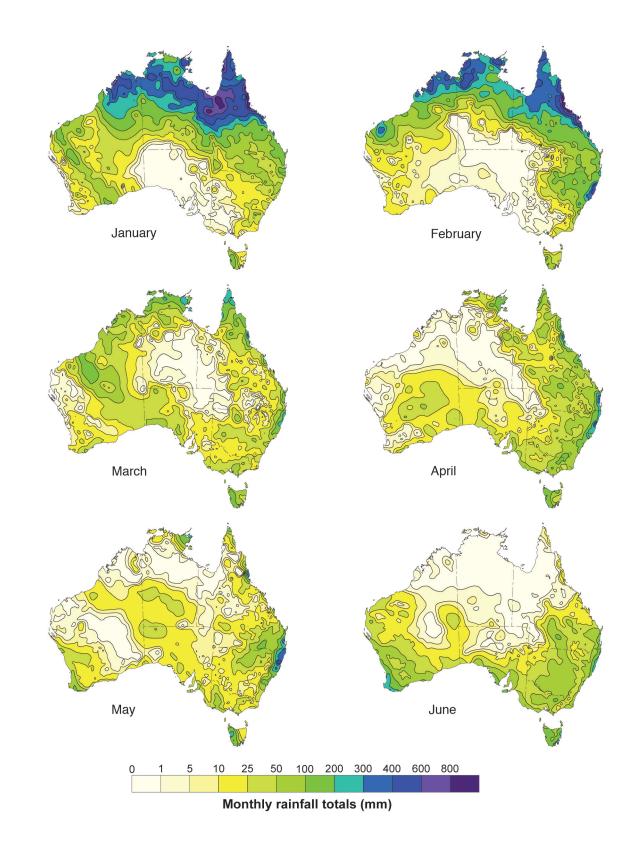


(Based on a 110-year climatology of gridded fields from 1900-2009)

5. Monthly rainfall totals: January to December 2009

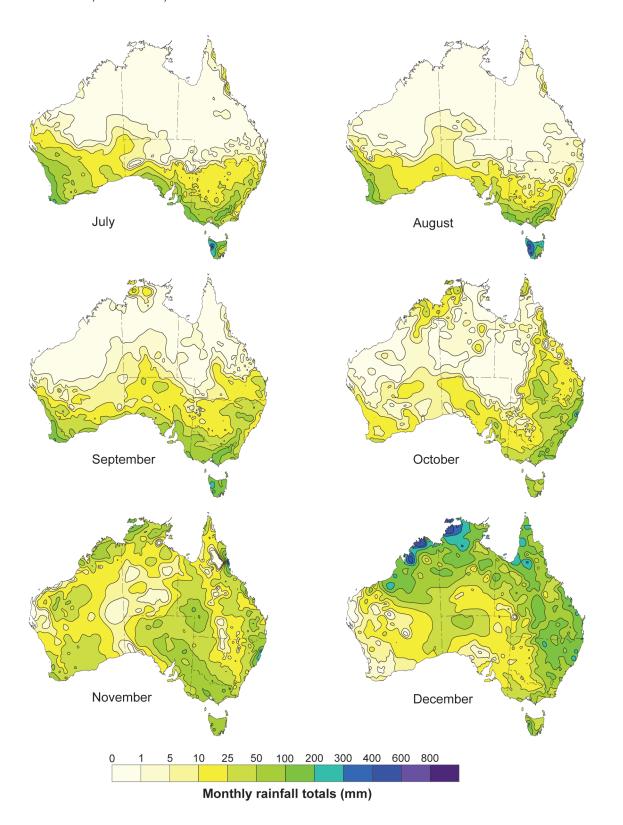
Heavy monthly falls were widespread across northern Australia in January, with widespread totals exceeding 400 mm, including over 800 mm in parts of northwest and coastal Queensland. Such falls also occurred in parts of these regions during February, especially on the north Queensland coast. Heavy tropical rains of around 300-600 mm did not return until December,

when numerous locations were affected by tropical cyclone *Laurence* in the Northern Territory Top End and Western Australia Kimberley. Heavy falls were a regular occurrence on the northern New South Wales coast, sometimes extending into southeast Queensland, with totals in excess of 400 mm recorded during February, April, May, October and November.

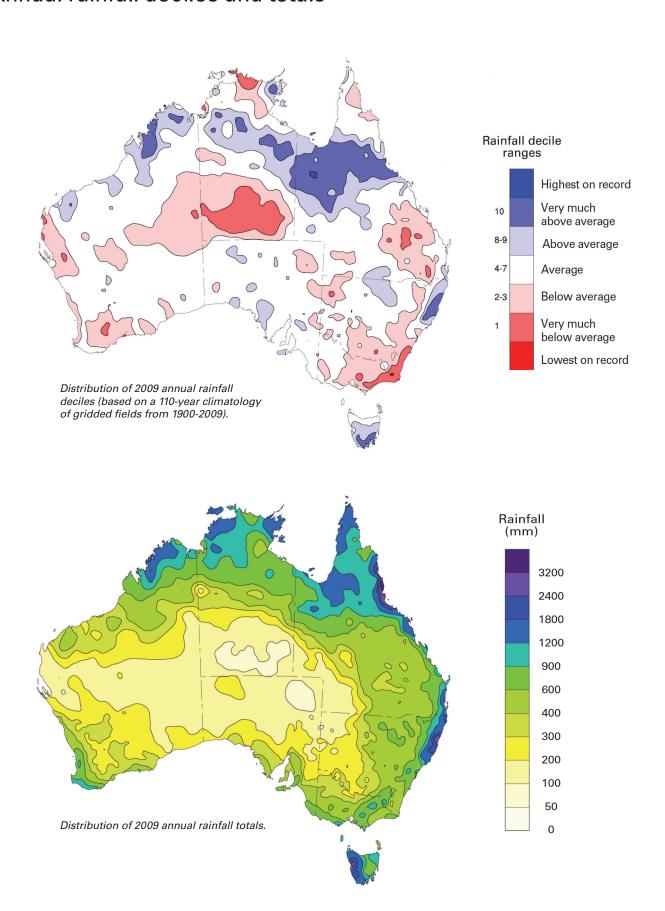


Similar totals also fell in western Tasmania during August, and to a lesser extent in July. The far southwest of Western Australia received 200-300 mm in June, July and September. South Australia and Victoria (with the exception of Gippsland) received little or no rainfall during January and February. Similarly, much of coastal western Western Australia remained dry until late May. Most of the northern

half of Australia, with the exception of the east coast, received very limited rainfall between March and November, with the dry conditions extending across much of New South Wales from July to September. Extremes of the Australia-wide average rainfall were 126.2 mm in January and 11.3 mm in August, with all months from March to November below normal.



6. Annual rainfall deciles and totals



7. Annual review and significant events

January-February: hot and dry in the south, cool and wet in the north – La Niña fades

A marked contrast between northern and southern Australia was evident during the first two months of 2009. Across much of northern Australia, and most notably in Queensland, rainfall was well above normal. Temperatures (particularly daytime maximum temperatures) were well below normal in association with a decaying La Niña event in the Pacific Ocean. The January-February period proved to be the thirdwettest on record for Queensland, which had a Statewide average total for the first two months of 2009 of 438 mm, 80 per cent above normal, only behind 1974 (607 mm) and 1991 (519 mm). Queensland maximum temperatures for the same period were 1.73°C below average (seventh lowest on record), with areas in the State's northwest between 6 and 7°C below average during January.

In contrast, temperatures were above average during January-February across much of southern Australia, with temperatures 2 to 3°C above average in northern Victoria and southern New South Wales. These warm conditions were largely a product of a heatwave in late January and early February, when much of southeast Australia was affected by extreme temperatures. All-time State records were set in Tasmania (42.2°C at Scamander on 30 January) and Victoria (48.8°C at Hopetoun on 7 February), while the associated and devastating Black Saturday bushfires of 7 February claimed 173 lives in Victoria. In contrast, temperatures during the remainder of the summer were fairly close to normal. For southern Australia the start to the year was also very dry, especially in Victoria. The Statewide average of only 12 mm was the second lowest since State records began in 1900. Most areas north and west of Melbourne had their driest January-February on record, with two-month totals below 5 mm in many places.

Autumn (March-May): tropics turn dry, temperatures close to normal

Heavy tropical rainfall eased after mid-February as the monsoon rains came to an early end across northern Australia. Except for a small area of the eastern Pilbara in Western Australia, autumn rainfall was below normal throughout the tropics, and was in the lowest ten per cent of recorded totals in many northern areas. Daytime maximum temperatures also returned to warmer than average levels, particularly in March and April, although overnight minima were closer to normal as a result of the generally dry conditions and reduced cloud cover.

In those areas of eastern Australia south of the tropics, rainfall and temperatures were mostly close to normal, although rainfall remained below normal in Victoria. It was, however, very wet on the east coast between Sydney and Brisbane, largely as a result of major rain events in March and again in May. The May event was the most extensive, affecting areas from Kempsey (NSW) to Brisbane. Yamba was isolated for nine days, and sadly, there was one death in the Coffs Harbour region.

It was a very dry start to the winter rainfall season in western areas of Western Australia. Some areas south of Perth had their driest autumn on record, while Kalbarri did not record its first measurable rain for 2009 until 21 May. April and May were also very warm along the west coast, with maximum temperatures 2 to 3°C above average, sufficient for some local records to be set for May.

June-September: very warm and dry except along the southern fringe, with an exceptionally warm August – El Niño develops

Australian temperatures were generally above average from June onwards, most notably in the north and east of the continent. Maximum temperatures were consistently above normal everywhere except in the southwest of Western Australia. Maxima for the four-month period were more than 2°C above average across vast areas of the central and eastern inland. Overnight minimum temperatures were also above normal over most of the continent, although areas which were more than 2°C above normal were largely confined to central Australia; Alice Springs had its first year since 1973 with no nights below 0°C.

August in particular was an exceptional month. Maximum temperatures were above normal across virtually the entire continent, with areas 6 to 7°C above average across parts of southern inland Queensland. The Australia-wide maximum temperature was 3.2°C above average, the largest anomaly ever recorded for any month, while the anomalies for Queensland (+4.24°C) and the Northern Territory (+3.91°C) also set all-month records. The national mean temperature (i.e. the average of the maximum and minimum temperature) was 2.47°C above normal, the second largest difference from climatology after April 2005. Record high monthly-mean maximum temperatures covered 49 per cent of Australia, including most of Queensland (89 per cent) and the Northern Territory (92 per cent).

The extremely warm August, when combined with above-normal temperatures in June and July, gave Australia its warmest winter maximum temperature on record (1.64°C above average), and the mean temperature anomaly of +1.33°C fell just 0.01°C short of the 1996 record. September, while not as extreme as August, was still warmer than normal over most areas, particularly in Queensland. Rockhampton broke monthly records for high mean maximum temperatures in four successive months from June to September.

It was also a generally dry period over most of the continent, particularly from July onwards. Queensland had its second driest July to September period on record, with eastern areas of the State particularly affected. However, rainfall for the period was near or above normal over much of the southern fringe of the continent, with the Eyre Peninsula (South Australia) receiving over 150 per cent of normal rainfall in places. In marked contrast with the mainland, it was extremely wet in Tasmania, with the four-month total setting a new record for the June to September period of 836 mm.

October: milder in the east, but a dry month

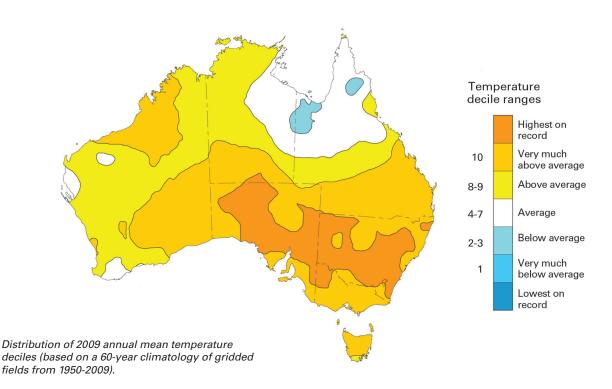
After the exceptionally warm conditions which prevailed during the preceding four months, temperatures in the eastern half of Australia were mainly close to normal in October, although maximum temperatures in Queensland were still generally above normal. The southeast was particularly cool in the first half of the month due to a succession of cold outbreaks, resulting

in the somewhat unusual substantial growth of the mountain snowpack at a time when it is normally melting rapidly. At Spencers Creek snow depths increased from 91 cm in late September to 140 cm in mid-October, just short of the earlier seasonal peak of 148 cm. This cool, dry air filtered northwards, resulting in widespread below-normal monthly mean minima in the inland tropics and subtropics. In contrast, it was very warm in Western Australia with maximum temperatures 3 to 4°C above the October average over parts of the Goldfields region. It was also very warm in the Top End of the Northern Territory, where Darwin had its highest mean maximum temperature (34.8°C) since records began in 1941.

After the useful rains of the winter and early spring across southern Australia, October turned dry once again for these areas. Monthly rainfall was below normal over most regions, most notably in Tasmania and the southwest of Western Australia, where rainfall was widely in the lowest 10 per cent of historically recorded totals. Most of the tropics and subtropical inland also remained dry, although there was some thunderstorm activity in parts of western Queensland and interior Western Australia.

November: an exceptionally warm month in the south and east

November was exceptionally warm in the southeastern quarter of Australia, mainly as a result of a prolonged heatwave through the middle two weeks of the month which was notable for its duration rather



than its intensity. For instance, Adelaide experienced eight consecutive days above 35°C, doubling its previous November record and equalling its pre-2008 record (surpassed in both March 2008 and January-February 2009) for any time of year. Maximum temperatures for the month were more than 6°C above average over much of northern Victoria and southern and central inland New South Wales, with overnight minimum temperatures being only slightly less extreme. Cowra's monthly maximum anomaly of +7.9°C was the largest departure from normal recorded at any Australian station in any month since +8.1°C at Rutherglen in October 1914. New South Wales maximum temperatures averaged 4.99°C above normal, the largest anomaly ever recorded for any Australian State, breaking the record of +4.38°C set in South Australia in August 1982, whilst Victoria (+4.92°C) and Tasmania (+3.18°C) also set allmonths records for their States. The mean (+4.61°C) temperature anomaly for New South Wales was also the largest ever recorded for any State. Mean monthly maxima were the highest on record over most of the southeast quarter of Australia, with records broken by up to 4°C at some long-term stations. While the exceptionally warm conditions were not as extensive as they were in August, it was still Australia's warmest November ever recorded, with Australia-wide temperatures 1.87°C above average.

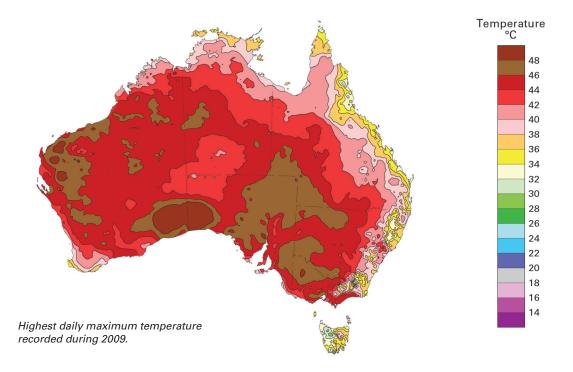
A major rain event affected a wide area during the last 10 days of the month, with totals of 40-100 mm widespread over most of South Australia, Victoria north and west from Melbourne, far western New

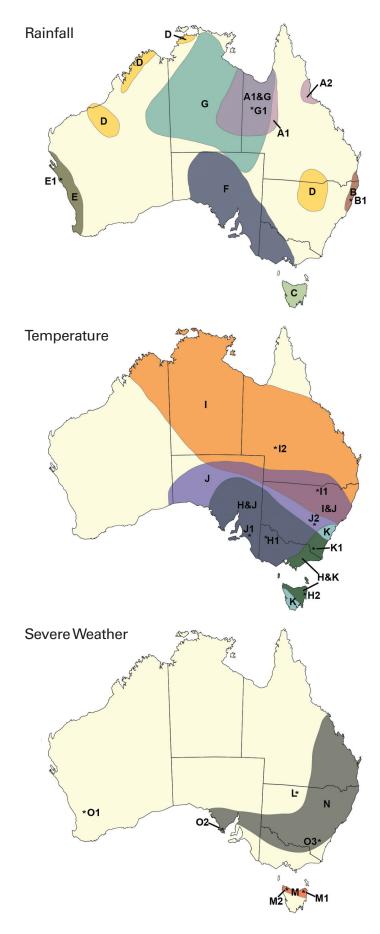
South Wales and southwestern Queensland. This was sufficient to give South Australia its fourth wettest November on record. It was also wetter than normal across much of Western Australia, although the Northern Territory and the eastern halves of Queensland and New South Wales (with the exception of the New South Wales mid-north coast) remained dry.

December: rains return to many parts of Australia

December saw a return to above-average rainfall for Australia, with national monthly rainfall 30 per cent above normal. This largely reflected the direct and indirect effects of tropical cyclone Laurence. Laurence brought heavy rain to the regions along its path, principally the Top End of the Northern Territory and the north and west Kimberley region and interior of Western Australia. It then fed moisture into an inland trough which provided substantial rainfall for northern South Australia, and in many inland areas of northern New South Wales and Queensland. Most of these areas had above-average rainfall for the month, and records were set locally. In areas not affected by Laurence, including Tasmania, Victoria and the southwest of Western Australia, December rainfall was generally below normal.

Temperatures were mostly above normal although, with the exception of Western Australia, not to the extent seen in some months during the winter and spring. Australia-wide mean temperatures for the month were 0.72°C above normal.





- A. Widespread flooding during January and early February in northeast Australia, especially northwest Queensland and eastern NT (A1) and coastal areas around Ingham and Townsville (A2).
- **B.** Flooding on numerous occasions on the coast of northern NSW and southeast Queensland, particularly around Coffs Harbour-Bellingen (B1). Floods in February, April, May (most widespread), October and November.
- **C.** Wettest June-September on record for Tasmania; regular but mostly minor flooding on various rivers.
- **D.** 11–27 December tropical cyclone *Laurence* reached category 5 twice and made two separate landfalls in WA before remnants crossed the continent. Floods in several regions along its track, including NT Top End, north and west Kimberley, Great Sandy Desert and northern inland NSW/ southern Queensland.
- **E.** January-May very dry in coastal WA. First rain for 2009 at Kalbarri (E1) not recorded until 21 May.
- **F.** January-February very dry in much of SA and western Victoria, driest start to year on record in many areas, including Melbourne.
- **G.** April-November very dry in many tropical areas. No rain at Urandangi (G1) between 12 April and 23 November.
- **H**. Severe heatwave 26 Jan 7 Feb. Record run of days above 43°C at Adelaide and Melbourne. All-time record highs for Melbourne (46.4°C), and for Victoria (48.8°C, Hopetoun, H1) and Tasmania (42.2°C, Scamander, H2). On 7 February, strong, dry northwesterly winds fanned bushfires which claimed 173 lives, mostly in areas northeast of Melbourne.
- **I.** Extended heatwave over northern and eastern Australia. Hottest August on record over 49% of Australia. Collarenebri (I1) broke its August record by 5.4°C, Windorah (I2) broke its record 6 times during the month.
- J. Severe heatwave 7-20 November over much of southeast Australia. Record 6 consecutive days over 40°C at Murray Bridge (J1). Cowra (J2) monthly average maximum 7.9°C above normal, largest anomaly in Australia since 1914.
- **K.** 24-30 April persistent cold in southeastern Australia, with early-season snow and Australian record low April minimum of –13.0°C at Charlotte Pass on the 29th (K1).
- f L. 13 February long-lived severe thunderstorm hits Bourke (NSW) with 198 mm rain in 12 hours.
- **M.** 15 April severe thunderstorms in northern Tasmania with widespread damage around Scottsdale (M1) and Wynyard (M2). 194 km/h wind gust recorded in suspected tornado at Scottsdale.
- N. 22-23 September most extensive dust storm since at least the 1940s affects a large area of eastern Australia. Visibility reduced to below 200 metres at Sydney and Brisbane.
- O. Numerous bushfires in southern Australia during December, with property losses at Toodyay, WA (01), Port Lincoln, SA (02), and a number of southern NSW locations (03).

8. Rainfall and temperature extremes by State: 2009

(Temperatures in degrees Celsius, rainfall in millimetres)

(Daily minimum temperatures and daily rainfall are for the 24 hours ending at 9 am on the date shown, daily maximum temperatures are 24 hours beginning at 9 am on the date shown)

WESTERN AUSTRALIA

Highest daily maximum temperature Lowest daily minimum temperature Highest average maximum temperature Lowest average minimum temperature Highest daily rainfall Highest yearly rainfall

NORTHERN TERRITORY

Highest daily maximum temperature Lowest daily minimum temperature Highest average maximum temperature Lowest average minimum temperature Highest daily rainfall Highest yearly rainfall

SOUTH AUSTRALIA

Highest daily maximum temperature Lowest daily minimum temperature Highest average maximum temperature Lowest average minimum temperature Highest daily rainfall Highest yearly rainfall

QUEENSLAND

Highest daily maximum temperature Lowest daily minimum temperature Highest average maximum temperature Lowest average minimum temperature Highest daily rainfall Highest yearly rainfall

NEW SOUTH WALES

Highest daily maximum temperature Lowest daily minimum temperature Highest average maximum temperature Lowest average minimum temperature Highest daily rainfall Highest yearly rainfall

VICTORIA

Highest daily maximum temperature Lowest daily minimum temperature Highest average maximum temperature Lowest average minimum temperature Highest daily rainfall Highest yearly rainfall

TASMANIA

Highest daily maximum temperature Lowest daily minimum temperature Highest average maximum temperature Lowest average minimum temperature Highest daily rainfall Highest yearly rainfall

AUSTRALIA

Highest mean temperature**
Lowest mean temperature**

49.0 at Emu Creek Station on 11 January -4.3 at Eyre on 9 September 36.7 at Fitzroy Crossing 8.2 at Collie East 402 at Napier Downs on 18 December 1963 at Kuri Bay

46.0 at Rabbit Flat on 8 December
–1.7 at Arltunga on 5 August
35.8 at Timber Creek and Bradshaw
14.3 at Alice Springs
290 at Channel Island on 13 December
2053 at Channel Island

48.2 at Kyancutta on 28 January and Renmark on 7 February -4.7 at Yunta on 7 July 30.1 at Marree 8.2 at Munkora and Narracoorte 96 at Ki Ki on 27 November 1252 at Mount Lofty Botanic Garden

46.6 at Birdsville on 18 November
–5.2 at Oakey on 12 June
34.0 at Century Mine
9.3 at Stanthorpe
497 at Hawkins Creek on 4 February
7440 at Bellenden Ker Top Station

47.0 at Ivanhoe on 2 February
–14.9 at Charlotte Pass on 16 July
29.4 at Mungindi
0.2 at Charlotte Pass
510 at Urunga on 1 April
3710 at Mount Seaview

48.8 at Hopetoun on 7 February#

-8.2 at Mount Hotham on 29 April
25.2 at Mildura
2.1 at Mount Hotham
103 at Trentham on 22 November
2130 at Rocky Valley

42.2 at Scamander on 30 January#

-8.6 at Liawenee on 17 July
18.9 at Launceston
1.5 at Mount Wellington
150 at Maria Island on 29 November
over 3152 at Lake Margaret Power Station*

29.4 at Wyndham (Western Australia) 4.9 at Mount Wellington (Tasmania)

^{*}Some missing data so true total is higher

^{**}The mean temperature is the average of all maximum and minimum temperatures.

[#] All-time State records.

9. Oceans and sea level

Sea level at record levels in 2009

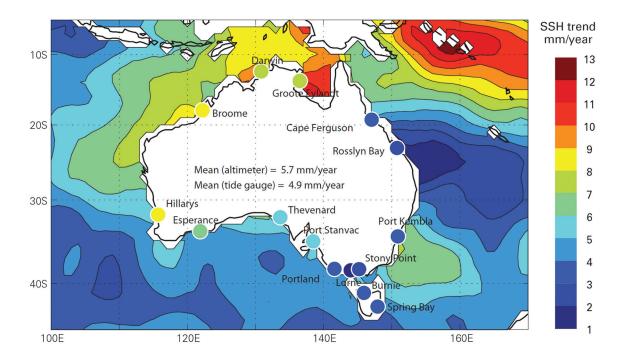
Globally averaged mean sea level for 2009 was 227 \pm 25 mm above the 1870 level. This ranks the 2009 global mean sea level as the highest since quality global records began in 1870.

Geological and archaeological data indicate that there was little net change in global sea level for at least the 2000 years prior to the 19th century. From about 1700, sea levels have been measured by coastal and island tide gauges. Analysis of this sea-level data indicates that the rate of rise of global average sea level increased from the 19th to the 20th century, and accelerated during the 20th century. From the early 1990s until the present, these tide gauges show an average rise of over 3 mm per year, in excess of the 20th century average annual increase of about 1.7 mm.

Since 1993, high quality global sea-level measurements have also become available from satellites. These satellite data indicate that sea level has risen over the period from 1993 to 2009 at an average annual increase of around 3.2 mm, in close agreement with estimates of global sea level from the coastal and island tide gauges.

Since 1961, most of the observed sea-level rise has been the result of expansion of the oceans as they warm and the melting of glaciers. Observations over the same period also show an increasing contribution to rising sea level from the Greenland Ice Sheet, while data since 2003 also indicate an accelerating contribution from Antarctica.

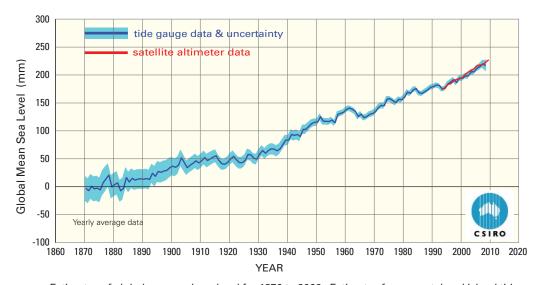
The rate of sea-level rise is neither uniform around the globe nor even from one year to the next, but rather is strongly influenced by fluctuations in the climate, such as El Niño. Thus, local and regional trends can potentially be above or below the global mean for substantial lengths of time. Both satellite and coastal sea-level data indicate that from the early 1990s to the end of 2009, sea level was rising as much as two to three times the global average (i.e. 7 to 10 mm/year) to the north and northwest of Australia. This larger rate of rise than the global mean is at least partly associated with the sequence of El Niño and La Niña events over this period. Lower rates of sea-level rise offshore from southern Queensland and faster rates of rise offshore from southern New South Wales are the result of changes in the East Australian Current, particularly its greater southward penetration in recent years. In



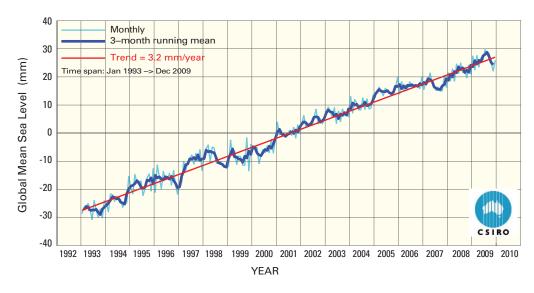
The rate of sea surface height (SSH) rise measured by coastal tide gauges (coloured dots) and satellite observations from the early 1990s to 2009.

the southeast of Australia, coastal measurements indicate sea level has been rising at slightly less than the global average over this period. Note that these local-scale variations remain superimposed on the underlying long-term increase in global mean sea level, and short term trends at individual sites should be viewed cautiously.

Generally, the coastal and offshore measurements of sea-level rise show the same spatial pattern. However there are some exceptions in the Australian region. For instance, the greater apparent rise at Hillarys in Western Australia is associated in part with sediment compaction and sinking of the coastal tide gauge, possibly due to ground water extraction.



Estimates of global averaged sea level for 1870 to 2009. Estimates from coastal and island tide gauges are shown by the solid blue line, with the shading indicating the uncertainty of these estimates. The red line for January 1993 to December 2009 is the direct measurement of global average sea level by satellite altimeters.



Measurements of global mean sea level from satellites for January 1993 to December 2009. The seasonal signal has been removed from the data and corrections applied for changes in atmospheric pressure and land motion. The light blue line shows the monthly data and the dark blue line shows an average of three months of data.

10. Capital city summary

City	Highest temperature Date (°C)	Lowest temperature Date (°C)	Average maximum Long-term average Anomaly (°C)	Average minimum Long-term average Anomaly (°C)	Rainfall (mm) & no. rain days Long-term average (mm) Decile range
Perth	41.8 16 January	1.5 14 July	25.0 24.4 +0.6	12.7 12.6 +0.1	608.2 on 108 days 819.4 1
Darwin	38.0 18 October	14.9 20 June	32.7 32.0 +0.7	23.4 23.3 +0.1	1742.4 on 118 days 1705.1 6
Adelaide	45.7 28 January	2.9 7 July	23.5 22.3 +1.2	13.2 12.2 +1.0	518.2 on 120 days 550.2 3
Brisbane	36.1 9 February	5.5 12 June	26.9 25.6 +1.3	16.6 16.4 +0.2	1072.4 on 123 days 1217.7 3
Sydney	40.9 24 January	5.9 9 August	22.9 22.1 +0.8	15.2 14.2 +1.0	956.2 on 122 days 1302.2 3
Canberra	40.0 8 February	−5.8 11 June	21.4 19.6 +1.8	8.0 6.5 +1.5	442.4 on 93 days 623.2 2
Melbourne	46.4 7 February	2.9 30 April	21.6 20.0 +1.6	12.0 11.0 +1.0	459.6 on 121 days 638.8 2
Hobart	38.3 31 December	0.5 8 July	17.6 17.1 +0.5	9.1 8.7 +0.4	865.0 on 175 days 586.4 10

Notes:

- 1. The long term averages are based on the 1961 to 1990 period, with the exceptions of Perth temperatures (1994-2008), Adelaide (1978-2008) and Brisbane (1961-1985).
- 2. Decile ranges: 1 Lowest 10% of records, 2 next lowest 10% of records, ..., 10 highest 10% of records. Based on all available records.
- 3. Data may not yet have been quality-controlled.

Climate Service Centres

New South Wales Climate Service Centre

Bureau of Meteorology

PO Box 413, Darlinghurst NSW 1300 (Level 16, 300 Elizabeth Street) Contact Hours: 10 am-12 pm and 2-4 pm

Email: climate.nsw@bom.gov.au Telephone: (02) 9296 1500 Facsimile: (02) 9296 1567

Victorian Climate Service Centre

Bureau of Meteorology, PO Box 1636, Melbourne VIC 3001

(6th Floor, 1010 Latrobe Street, Docklands) Contact Hours: 10 am-12 pm and 2-4 pm

Email: climate.vic@bom.gov.au Telephone: (03) 9669 4956 Facsimile: (03) 9669 4977

Queensland Climate Service Centre

Bureau of Meteorology

GPO Box 413, Brisbane QLD 4001

(Level 22, 69 Ann Street)

Contact Hours: 10 am-12 pm and 2-4 pm

Email: climate.qld@bom.gov.au Telephone: (07) 3239 8700 Facsimile: (07) 3239 8679

Western Australian Climate Service Centre

Bureau of Meteorology

PO Box 1370, West Perth WA 6872

(5th Floor, 1100 Hay Street)

Contact Hours: 9.30-11.30 am and 1.30-3.30 pm

Email: climate.wa@bom.gov.au Telephone: (08) 9263 2222 Facsimile: (08) 9263 2233

Northern Territory Climate Service Centre

Bureau of Meteorology

PO Box 40050, Casuarina NT 0811 (3rd Floor, 13 Scaturchio Street)

Contact Hours: 9.30-11.30 am and 1.30-3.30 pm

Email: climatedata.nt@bom.gov.au Telephone: (08) 8920 3800 Facsimile: (08) 8920 3832

South Australian Climate Service Centre

Bureau of Meteorology

PO Box 421, Kent Town SA 5071

(25 College Road)

Contact Hours: 10 am-12 pm and 2-4 pm

Email: climate.sa@bom.gov.au Telephone: (08) 8366 2600 Facsimile: (08) 8366 2693

Tasmania & Antarctica Climate Service Centre

Bureau of Meteorology

GPO Box 727

Hobart TAS 7001

(Level 5, 111 Macquarie Street)

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Email: climate.tas@bom.gov.au Telephone: (03) 6221 2043 Facsimile: (03) 6221 2045

National Climate Centre

Bureau of Meteorology

PO Box 1636, Melbourne VIC 3001, Australia Contact Hours: 10 am-12 pm and 2-4 pm

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