



Australian Government
Bureau of Meteorology

Annual Climate Report 2015





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This document is also available online: www.bom.gov.au/climate/annual_sum/2015/

This edition is based on data available as of 21 January 2016. Some data have not yet been fully quality controlled.

Cover picture: An impressive shelf cloud over Sydney on 25 April. A slow-moving East Coast Low brought severe weather and flooding to much of coastal New South Wales between the 20 and 23 April. Photograph: Daniel Tran.

Picture on this page: SA Country Fire Services volunteers from the Swanport strike team protect assets on Millar Road, Inglewood on 3 January during the Sampson Flat fires. Photograph: Greg Mitchell.

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Two East Coast Lows brought flooding and severe weather to Australia's eastern seaboard in close succession—the first between 20 and 23 April, the second a week later between 1 and 4 May. The image above, from 3 May, shows Moreton Bay and the Brisbane metropolitan area. Plumes of sediment carried by flood waters in the Brisbane and Logan rivers are visible. Image: NASA Earth Observatory by Jesse Allen, using Operational Land Imager (OLI) data from Landsat 8, from the United States Geological Survey.

1. Overview

2015 was Australia's fifth-warmest year on record, with a number of notable heatwaves, and record-breaking temperatures from October to December. Australian mean rainfall was only 4 per cent below average nationally, but it was drier in some parts than others. Long-term drought continued in Queensland and increased in parts of the south. A strong El Niño contributed to the drier and warmer year in 2015.

Another warm year for Australia

The Australian mean temperature for 2015 was 0.83 °C above the 1961–1990 average, making it the fifth-warmest year on record (national observations commence in 1910).¹ Western Australia, Queensland, Victoria, South Australia and New South Wales ranked in the ten warmest years on record.

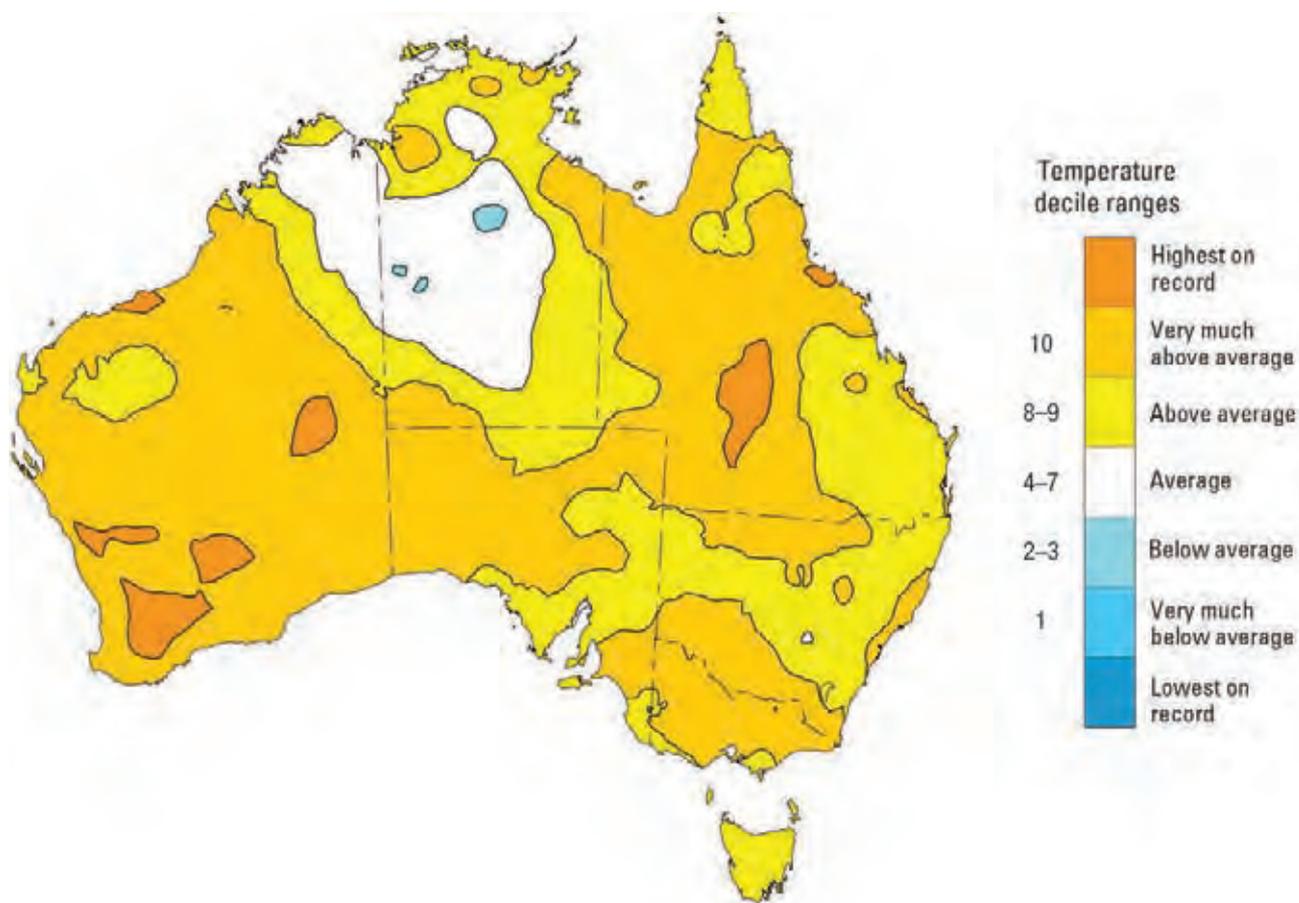
Nationally, maximum temperatures were 0.96 °C above average, and minimum temperatures were 0.69 °C above average; both ranking sixth-warmest on record.

¹ Unless otherwise stated, all climatological averages are calculated over the 30-year period 1961–1990, as defined by the World Meteorological Organization. Anomalies are the difference between an observed value and the corresponding average over the 1961–1990 reference period. Unless otherwise noted, rankings are for the period from 1910 for temperature records and for the period from 1900 for rainfall records.

Mean temperatures, maximum temperatures (maxima) and minimum temperatures (minima) were above average across the majority of Australia.

Mean temperatures were in the highest 10 per cent of historical observations for most of Western Australia, Queensland, Victoria, South Australia, and parts of New South Wales. Areas of the central Northern Territory and northwestern Kimberley in Western Australia observed near-average annual mean temperatures.

Maxima were in the highest 10 per cent of observations for the north of the Northern Territory, most of Queensland, most of Victoria, southeast and western South Australia, and large areas of Western Australia (highest on record for part of southwest Western Australia). Minima were in the highest 10 per cent of observations for most of Western Australia and large parts of Queensland, western South Australia, areas of New South Wales, and far eastern Victoria.



Annual mean temperature deciles 2015 (based on a 105-year climatology of gridded data for 1911–2015). Decile 1 means the lowest 10 per cent of records, decile 2 the next lowest 10 per cent, and so on, up to decile 10, the highest 10 per cent of records.

Minima were cooler than average for some areas of the southeast Top End and between the northern Kimberley and western central Territory. They were near average for most of the Northern Territory, the northeast of Western Australia, other smaller areas in western Tasmania, the northern Cape York Peninsula and near Rockhampton in Queensland, and pockets of agricultural South Australia.

Exceptional warm spells during 2015 included heatwaves across northern and central Australia during March, southern Australia in October, and much of southeast Australia during the third week of December (see page 17).

The end of the year was particularly warm with spring the second-warmest on record for Australia and the three months October–December the warmest on record. October’s mean temperature anomaly (+2.89 °C) was the largest on record for any month.

Following a ‘near miss’ in 2014, the Pacific Ocean warmed rapidly during autumn 2015, with El Niño declared in May. The El Niño contributed to warmer daytime temperatures in much of eastern Australia and continued into 2016.

Eight of Australia’s ten warmest years on record have occurred between 2002 and 2015. The past three years have all been in the top five (ranking first, third and fifth). The 10-year mean temperature for 2005–2015 was 0.53 °C above average, the second highest on record and just behind 2005–2014. Australia has experienced just one cooler than average year (2011) in the last ten years.

Warming in the Australian region is very similar to that seen at the global scale. Temperatures over Australia have warmed by about one degree since 1910, with most of the warming occurring since 1950. The past year emphasises that the warming trend continues.

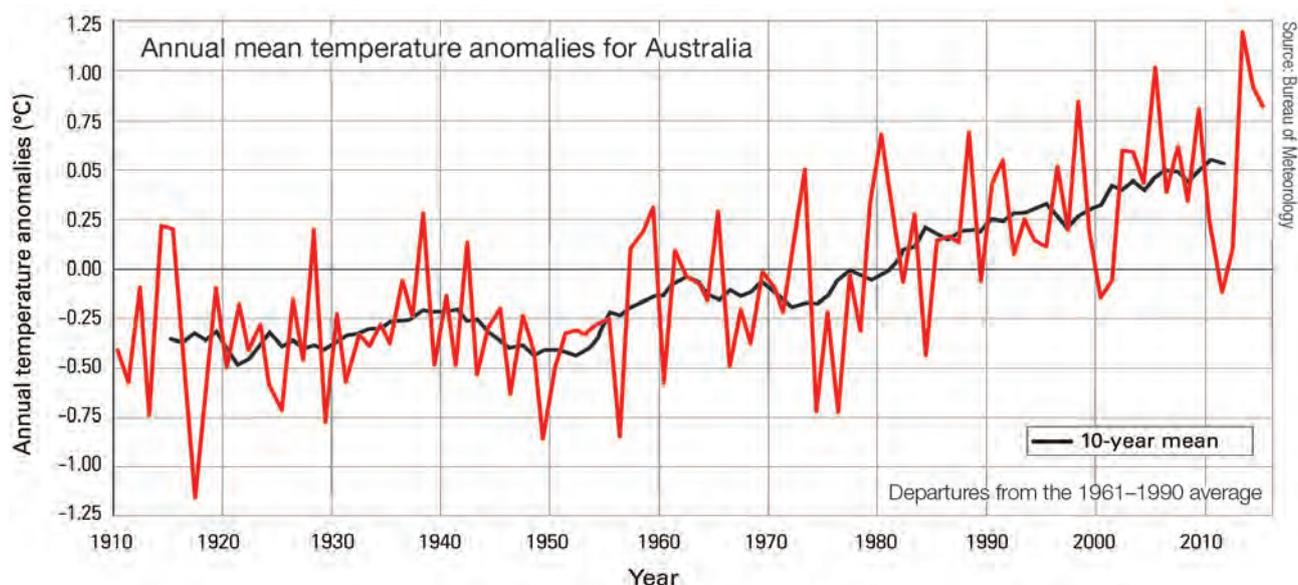
Globally, the warmest year on record again

The World Meteorological Organization combines data from three datasets to calculate global mean temperatures.² The combined sea surface and land air temperature for 2015 was 0.76 °C ± 0.09 °C above the 1961–1990 average. Global observations from these combined datasets commence in 1880.

2015 has beaten the previous record of 0.61 ± 0.09 °C set in 2014 by a substantial margin. The only other time a record has been broken by more than 0.10 °C was when 1998 (+0.53 °C) replaced 1997 (+0.38 °C).

No year since 1985 has recorded a below average global mean temperature and all of the ten warmest years have occurred between 1998 and 2015. The ten-year global average for 2006–2015 was +0.54 °C, the warmest 10-year period on record.

² UK Met Office Hadley Centre (HadCRUT4), the US National Climatic Data Center (MLOST) and the NASA Goddard Institute of Space Studies (GISTEMP).



Annual mean temperature anomalies for Australia (1910–2015). The black line shows the ten-year moving average.

A dry year in parts of the east and southwest

Nationally averaged rainfall was 445.8 mm, 4 per cent below the 1961–1990 average of 465.2 mm, placing 2015 near the median of historical observations.

Annual rainfall was below average across most of Queensland, Victoria and southeast South Australia, Tasmania, the western half of South Australia and the far southwest of the Northern Territory, and the southwest of Western Australia.

Rainfall was above average for the Gascoyne and Pilbara in Western Australia, much of the Northern Territory, northeastern South Australia, northwestern New South Wales, and also small parts of the east coast between southeastern Queensland and East Gippsland in Victoria.

Annual rainfall totals were in decile 1 for southeastern South Australia extending across the southern half of Victoria to South Gippsland, much of Tasmania, most of the South West Land Division in Western Australia, and parts of Queensland—mostly between the North Tropical Coast and central Queensland. For Tasmania it was the eight-driest year on record.

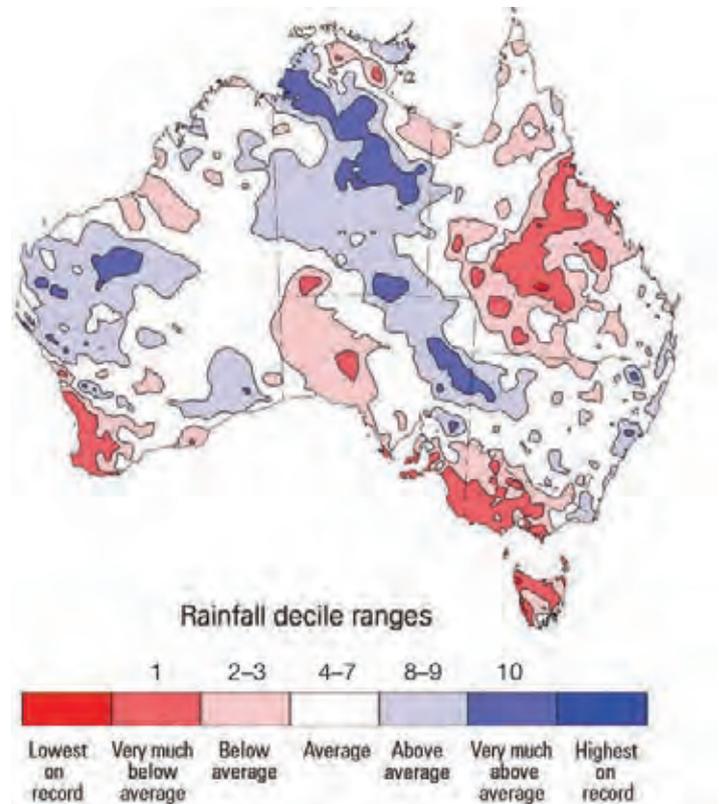
The El Niño declared in May also contributed to below average rainfall over eastern Australia. Record warm sea surface temperatures in the Indian Ocean initially moderated the effect of the El Niño with moisture flowing from the Indian Ocean. However, a positive Indian Ocean Dipole (IOD) developed in late August and had the opposite effect, reinforcing drying over much of Australia. The positive IOD dissipated by mid-November.

A series of drier than average years since the most recent La Niña (ending autumn 2012) has seen long-term drought re-emerge through western Victoria, South Australia and southwest Western Australia.

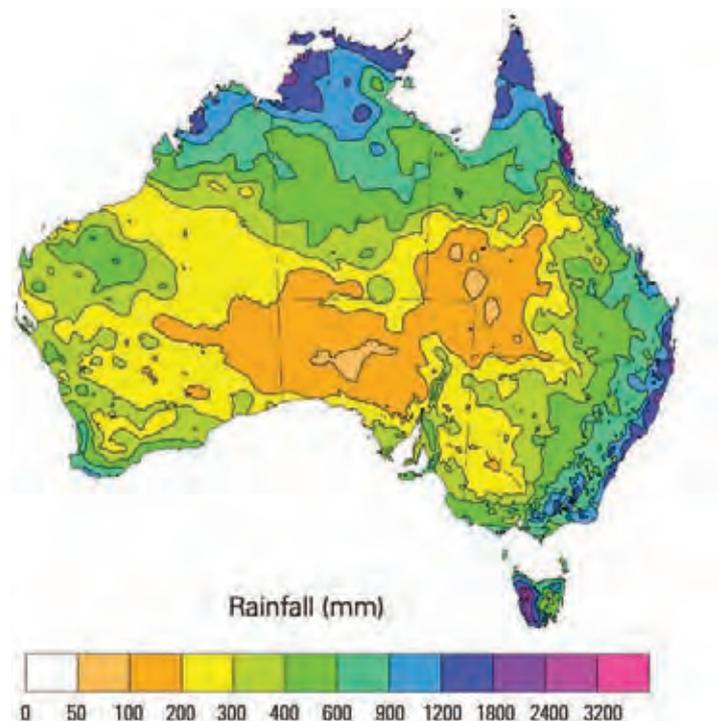
Rainfall patterns in recent years share characteristics of the Millennium Drought and longer-term trends, including a reduction in cool season (April–October) rainfall over southern Australia.

Low rainfall over most of the past two decades in west-facing southern Australia—southwest Western Australia, Tasmania, South Australia and Victoria—reflects a southward shifting ‘storm track’, with high pressure systems displacing cold fronts and lows across southern Australia.

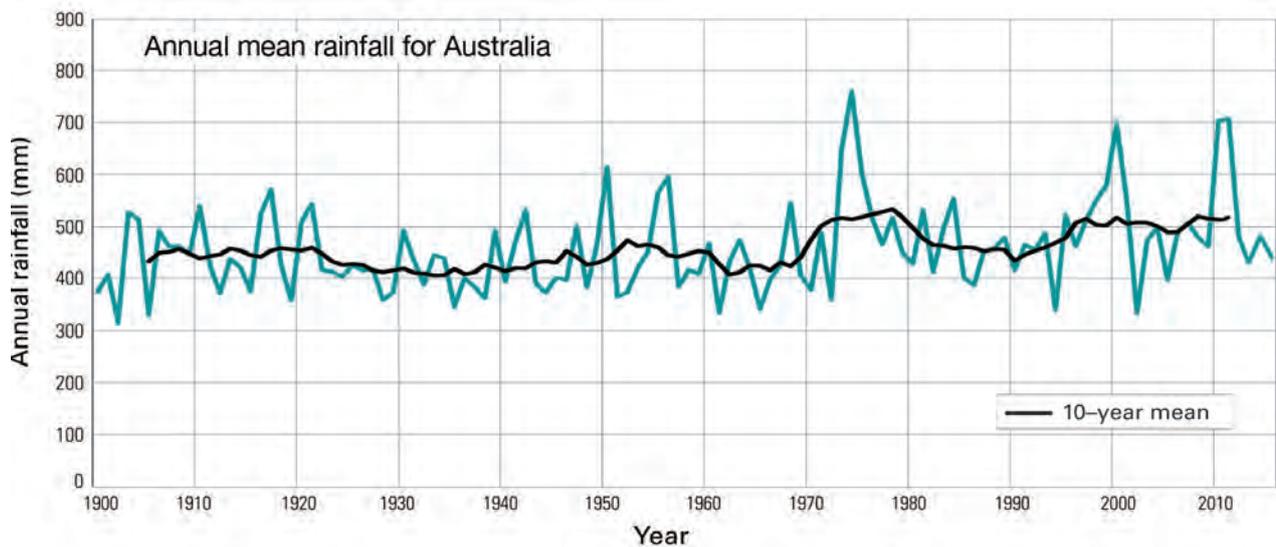
In Queensland, wet-season rainfall was near or below average in 2014–15, the third successive year in which it has been generally below average. This sequence has led to drought over much of that State.



Annual rainfall deciles 2015 (based on a 116-year climatology of gridded data for 1900–2015).



Annual rainfall totals 2015.



Annual mean rainfall for Australia (1900–2015). The black line shows the ten-year moving average.

Capital cities

All capital cities recorded warmer-than-average maximum temperatures (see page 5). For Perth, annual maximum temperatures were the equal warmest on record (tied with 2012 and 2011).

The southeastern capitals also generally experienced a warm year. Sydney's annual mean temperature was the equal third-warmest on record, with maxima fifth warmest and minima equal sixth-warmest. In Canberra maxima were the equal seventh-warmest.

	Rainfall (mm)			Maximum temperature (°C)			Minimum temperature (°C)		
	2015 total	1961–1990 average	Rank (of 116)	2015 anomaly	1961–1990 average	Rank (of 106)	2015 anomaly	1961–1990 average	Rank (of 106)
Australia	445.8	465.2	59	+0.96	28.6	6	+0.69	15.1	6
New South Wales/ACT	450.3	552.8	67	+1.05	23.9	14	+0.94	10.7	6
Northern Territory	639.5	540.3	95	+0.52	31.9	17	0.00	18.5	45
Queensland	495.2	623.4	25	+1.04	29.9	6	+1.01	16.6	5
South Australia	197.2	225.2	52	+0.97	26.7	11	+0.73	12.2	7
Tasmania	1117.1	1390.4	8	+0.28	14.7	24	0.00	6.0	32
Victoria	507.4	660.2	14	+1.00	19.9	7	+0.53	8.3	12
Western Australia	354.5	340.9	70	+1.12	29.3	2	+0.78	15.7	3
Murray–Darling Basin	429.2	488.4	41	+1.11	24.4	11	+0.92	10.9	5

Summary of 2015 mean rainfall and temperatures for Australia, the States, Northern Territory and Murray–Darling Basin. Ranks are for all years since national records began (1900 for rainfall, 1910 for temperature), with 1 indicating the driest/warmest year. Annual mean temperatures can be calculated from the average of the mean maximum and mean minimum temperatures. Area averages are calculated over continental Australia and the main island of Tasmania

Perth's temperature of 44.4 °C on 5 January was the highest daily maximum temperature for a capital city during 2015, closely followed by Adelaide's 44.1 °C on 2 January. Canberra, Melbourne and Hobart recorded their warmest day of the year during the December heatwave. The lowest temperature recorded at a capital city was –7.0 °C in Canberra on both 2 June and 3 July.

Brisbane and Sydney exceeded their annual average rainfall. Perth, Adelaide and Melbourne were much drier than average. The remaining capital cities recorded annual totals closer to the 1961–1990 median. Sydney recorded the highest number of rain days (167), closely followed by Hobart (161). Perth (91) and Canberra (98) recorded the fewest.

Capital city summary

City	Highest temp. (°C) Date	Lowest temp. (°C) Date	Mean maximum Average Anomaly (°C)	Mean minimum Average Anomaly (°C)	Rainfall (mm), no. rain days Average (mm) Decile range (1900–2015)
Perth	44.4	0.8	25.7	13.3	617.8 on 91 days
	5 January	9 July	24.8	12.8	819.4
			+0.9	+0.5	2
Darwin	36.9	14.8	32.6	23.1	1725.2 on 102 days
	8 November	14 July	32.0	23.3	1705.1
			+0.6	–0.2	7
Adelaide	44.1	1.8	23.2	12.5	395.2 on 119 days
	2 January	20 July	22.3	12.2	546.3
			+0.9	+0.3	1
Brisbane	36.7	5.4	26.4	16.6	1445.4 on 139 days
	18 and 25 January	15 July	25.6	16.4	1217.7
			+0.8	+0.2	9
Sydney	40.9	5.0	23.3	15.0	1338.2 on 167 days
	20 November	5 August	22.1	14.2	1302.2
			+1.1	+0.8	8
Canberra	37.0	–7.0	21.1	6.5	545.4 on 98 days
	20 December	2 June and 3 July	19.6	6.5	623.2
			+1.5	0.0	5
Melbourne	41.2	0.6	20.4	11.5	439.2 on 127 days
	19 December	19 July			638.8
					1
Hobart	36.0	0.3	17.7	8.7	528.4 on 161 days
	25 December	22 June and 8 July	17.1	8.7	586.4
			+0.6	0.0	4

Averages are based on the 1961–1990 period, with the exceptions of Adelaide (1981–2010) and Brisbane (1961–1985, temperature only, using site number 40214), and Perth (1994–2015, temperature only). Canberra's average uses site number 70014. No average or anomaly is given for Melbourne temperatures due to the recent site move (Olympic Park opened in 2013).

Data were recorded at Bureau of Meteorology official city observation stations. Averaging periods are calculated based on the availability of historical data from these or other comparable stations.

Decile ranges are calculated from station data for stations with an available long-term record. They are supplemented with gridded monthly analyses based on all available data where suitable station observations are not available (particularly for Darwin and Canberra during 1900–1940).

2. Monthly maximum and minimum temperatures

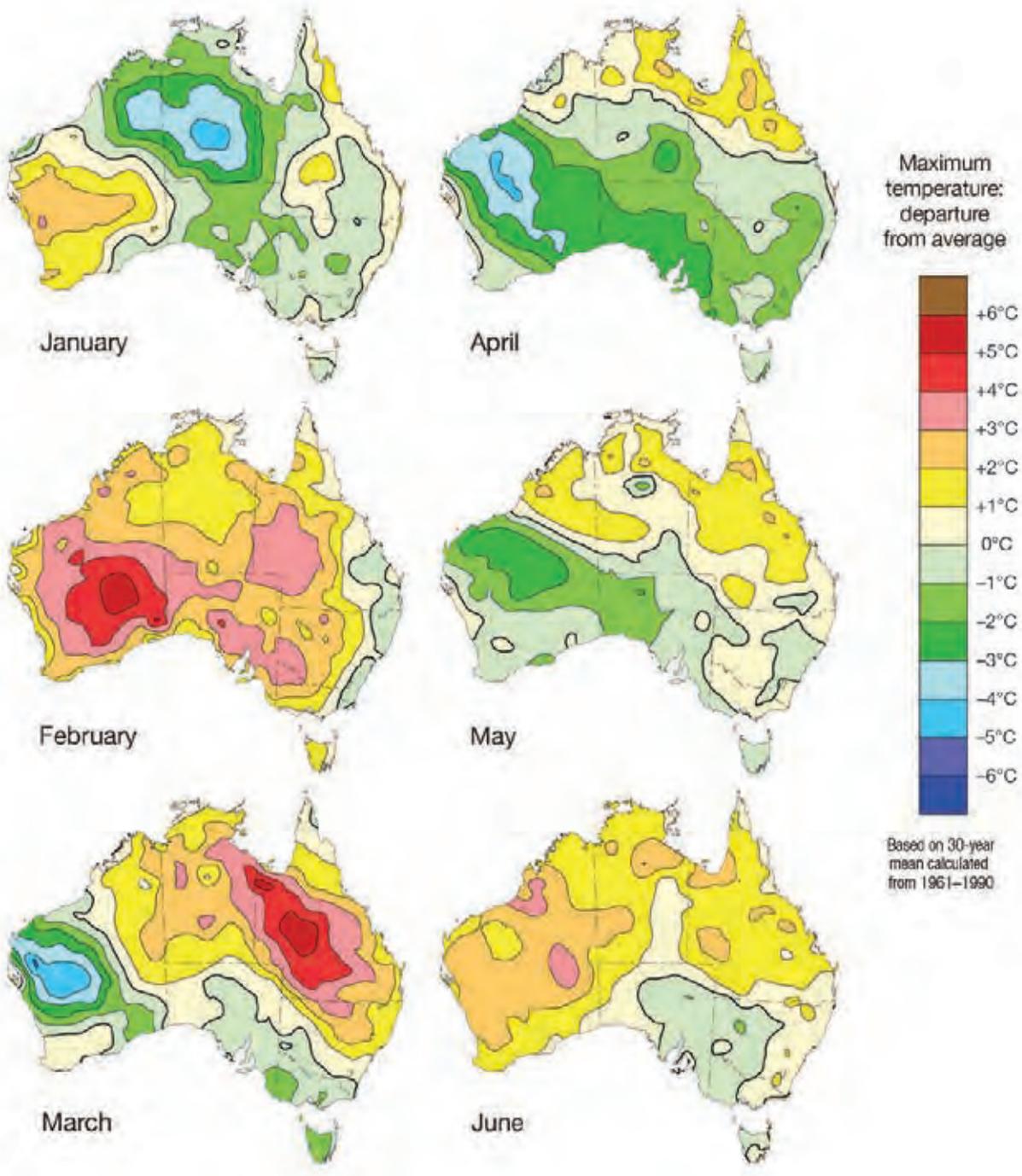
January was warmer than average for both maxima and minima in southern Western Australia. Minima were also above average in the southeast, eastern New South Wales, much of Queensland, and the Top End. Cooler than average maxima extended from the northwest, across the Northern Territory and into central New South Wales, mirroring areas of above average rainfall.

February monthly mean temperatures were the second-warmest on record for Australia and for Western Australia, and in the top ten for Queensland, Victoria and South Australia. Maxima were generally above to very much above average except over the eastern seaboard and central Northern Territory.

Minima were above average in similar areas, and record-warm for central Western Australia.

March, April and May maxima were warmer than average over northern Australia, with the largest spatial extent during March—covering the northeastern half of Australia. A heatwave contributed to Queensland’s warmest March for both maxima and minima, and to Australia’s eighth-warmest March for mean temperatures.

Autumn months were cooler than average for maxima across much of Western Australia and for most areas south of the northern tropics for April.

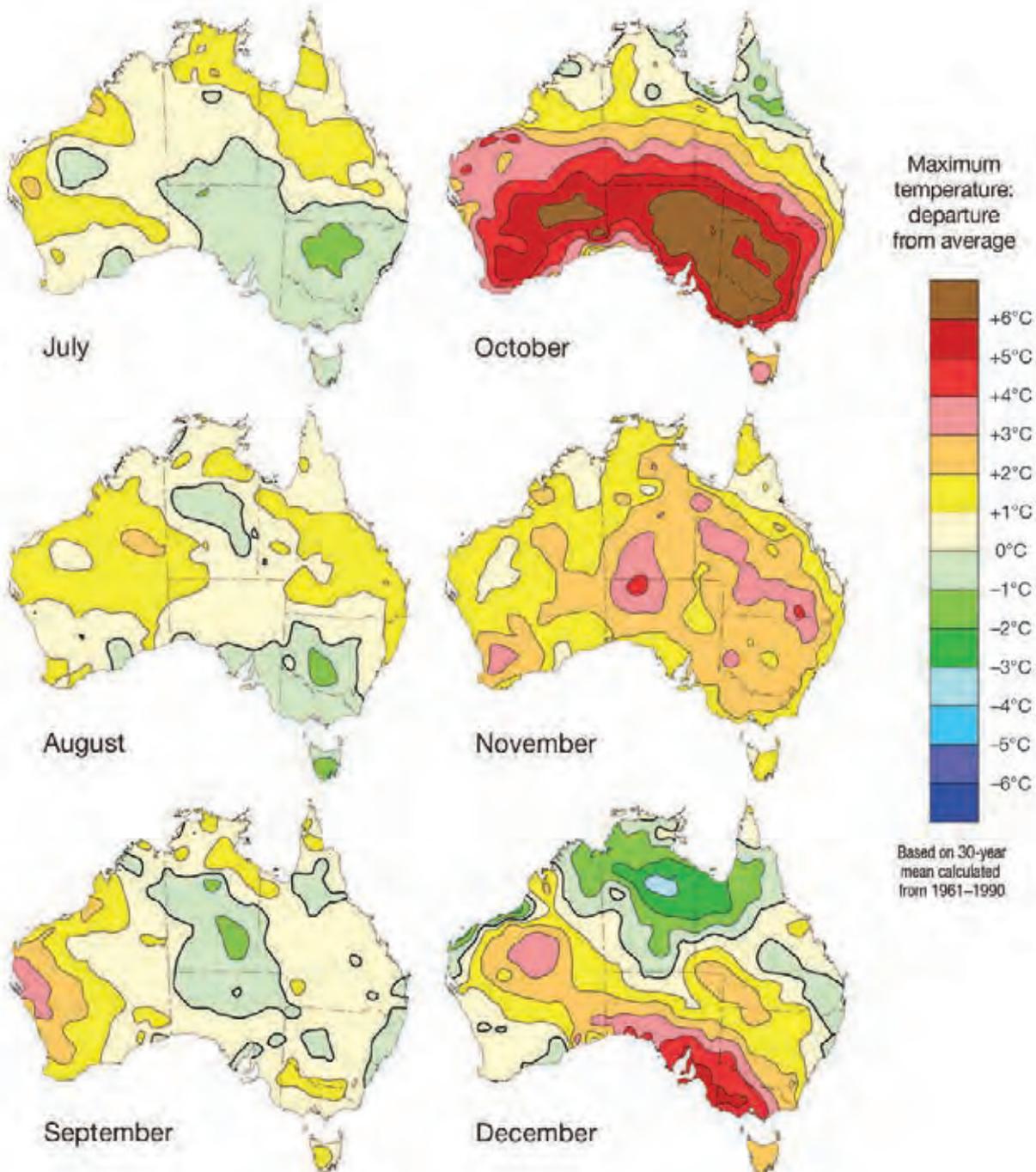


April maxima were the sixth-coolest on record for Western Australia, and in decile 1 (the lowest 10 per cent of historical observations) over much of the State. May minima were in decile 1 in parts of the Top End and Kimberley. April and May were the only months in which national mean temperatures were below average.

June was generally warmer than average for both maxima and minima, but mostly near average to cooler than average over the southeast. June maxima were in decile 10 (the highest 10 per cent of historical observations) over most of Western Australia and coastal northern Australia, and were highest on record for Western Australia as a whole.

Minima were in decile 10 for most of Queensland, with June minima Queensland's third-warmest on record. For Australia as a whole, June mean temperatures were the fifth-warmest on record.

July and August monthly maxima were above average for large parts of Western Australia, the north of the Northern Territory and much of Queensland. Maxima were below average for parts of the southeast. Minima were generally above to very much above average for Western Australia in both months, but were mixed over the eastern States and near average in large areas. For Tasmania, August was the equal third-coolest for mean temperatures, with maxima and minima in decile 1 across the majority of the State.

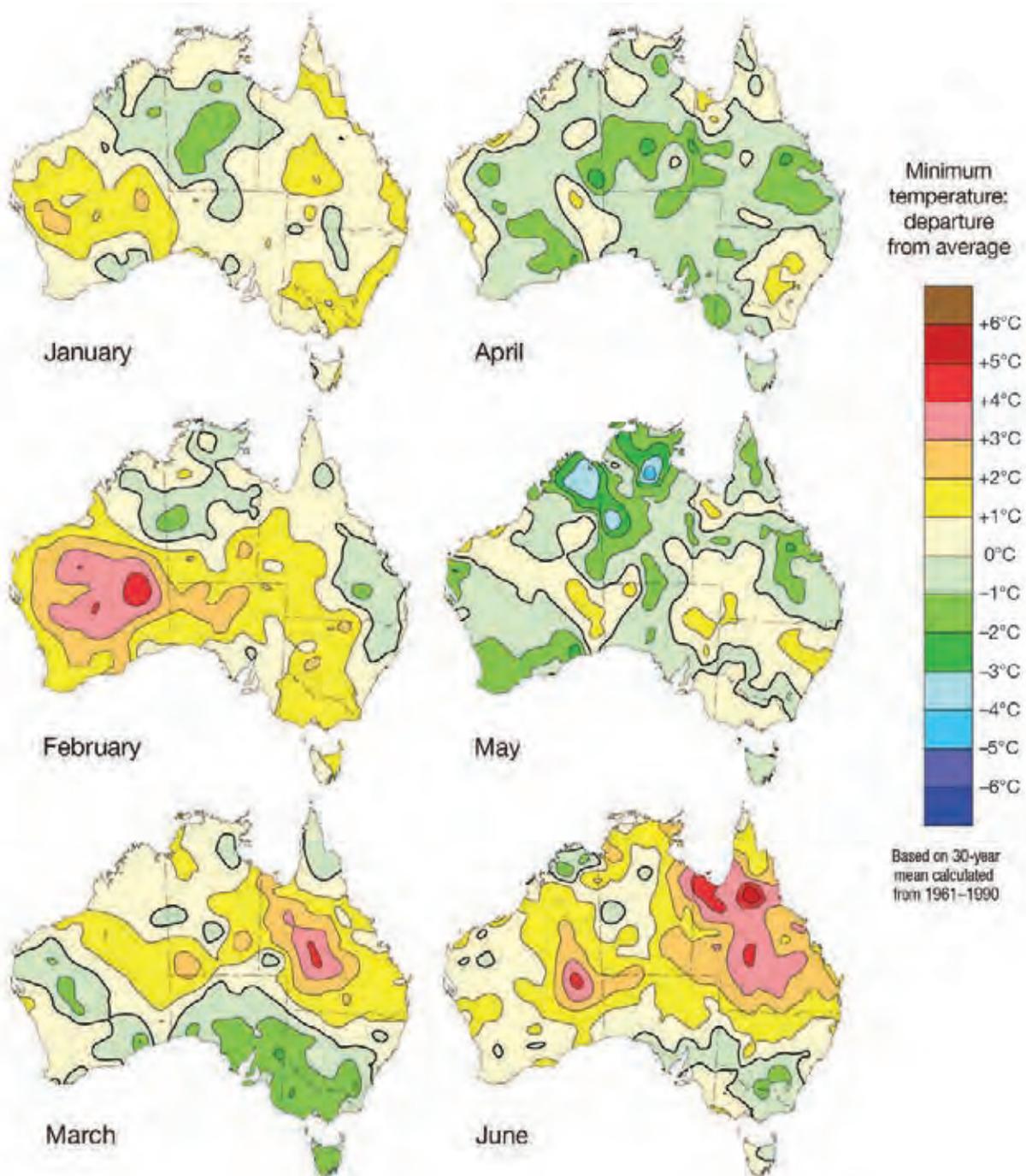


Spring mean temperatures for the past three years have been in the three warmest on record for Australia: 2013 (+1.57 °C), 2014 (+1.67 °C), and 2015 (+1.65 °C). Each was characterised by dry lead-in conditions with below average winter–spring rainfall associated with record warmth. In 2015, the exceptional spring was particularly a result of a record warm October and warm November, with September nearer to average.

September maxima were above to very much above average across the west of Western Australia, parts of the northern coast, and Tasmania. September maxima were the eighth-warmest on record for Western Australia.

Minima were above average for parts of Western Australia, although below average minima stretching from the Kimberley, through central Australia, and across the mainland southeast were more notable.

October–December was the warmest on record for Australia, for both maximum and minimum temperatures. October maxima and minima were warmest on record across most of southern Australia. Maxima were more like typical December temperatures for much of the southeastern quarter of the mainland.



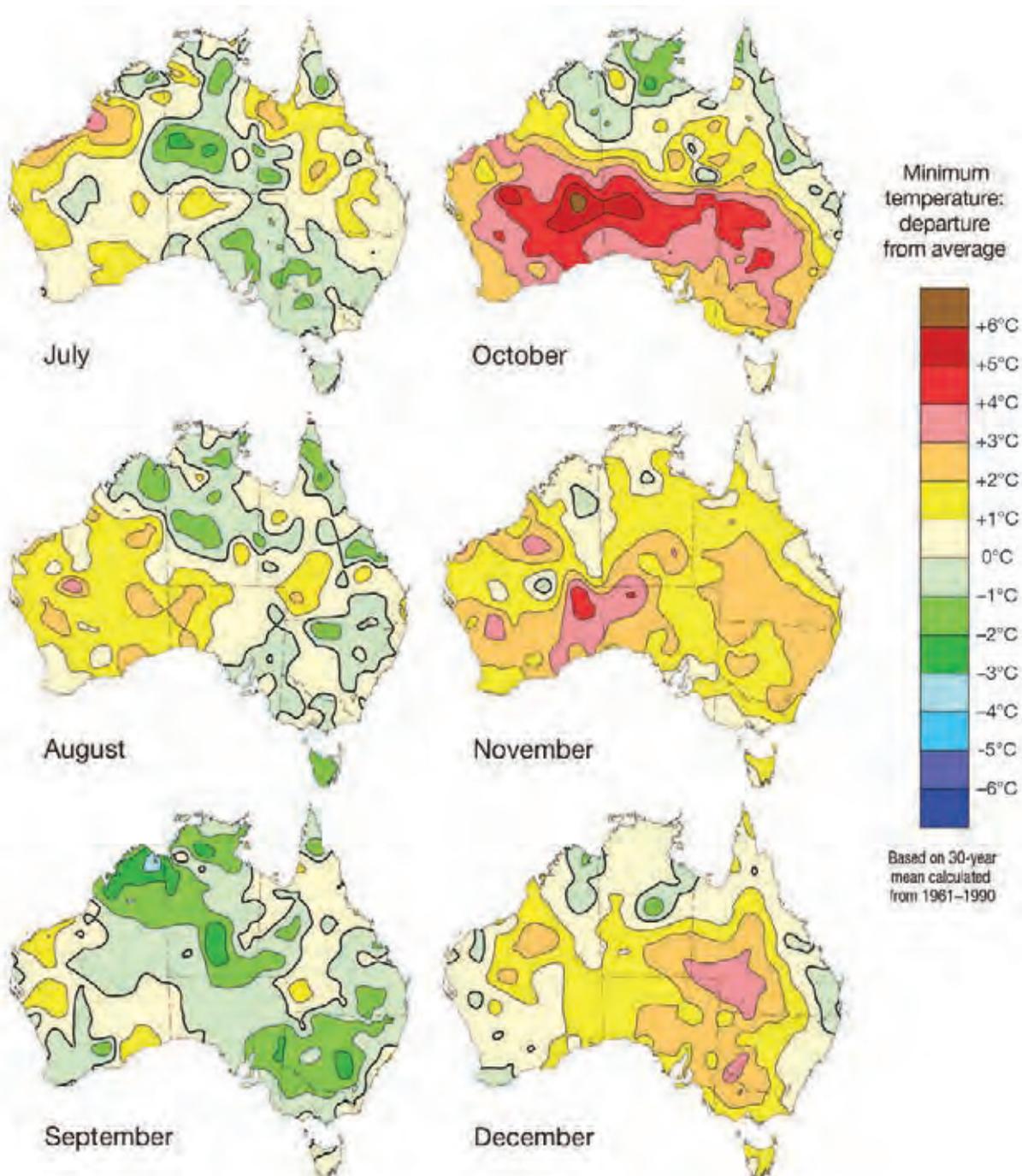
October's mean temperature anomaly was the largest on record for Australia for any month of the year (+2.89 °C; previous record +2.75 °C in September 2013).

November and December maxima and minima were above average to very much above average over most of Australia with some records in each month, most notably December maxima in southern South Australia and Victoria.

November mean temperatures were the second-warmest on record for Australia, while minima were amongst the top ten for all States except Victoria and Tasmania. Maxima were third- or fourth-warmest for Queensland, Western Australia, and the Northern Territory.

December maxima were below average to very much below average in parts of northern Australia accompanying very much above average rainfall.

December's mean temperature was the highest on record for the southeastern States while New South Wales and Queensland placed in the top ten for minima. Western Australia was eighth-warmest for mean temperatures despite maxima and minima both just outside top ten.



3. Monthly rainfall

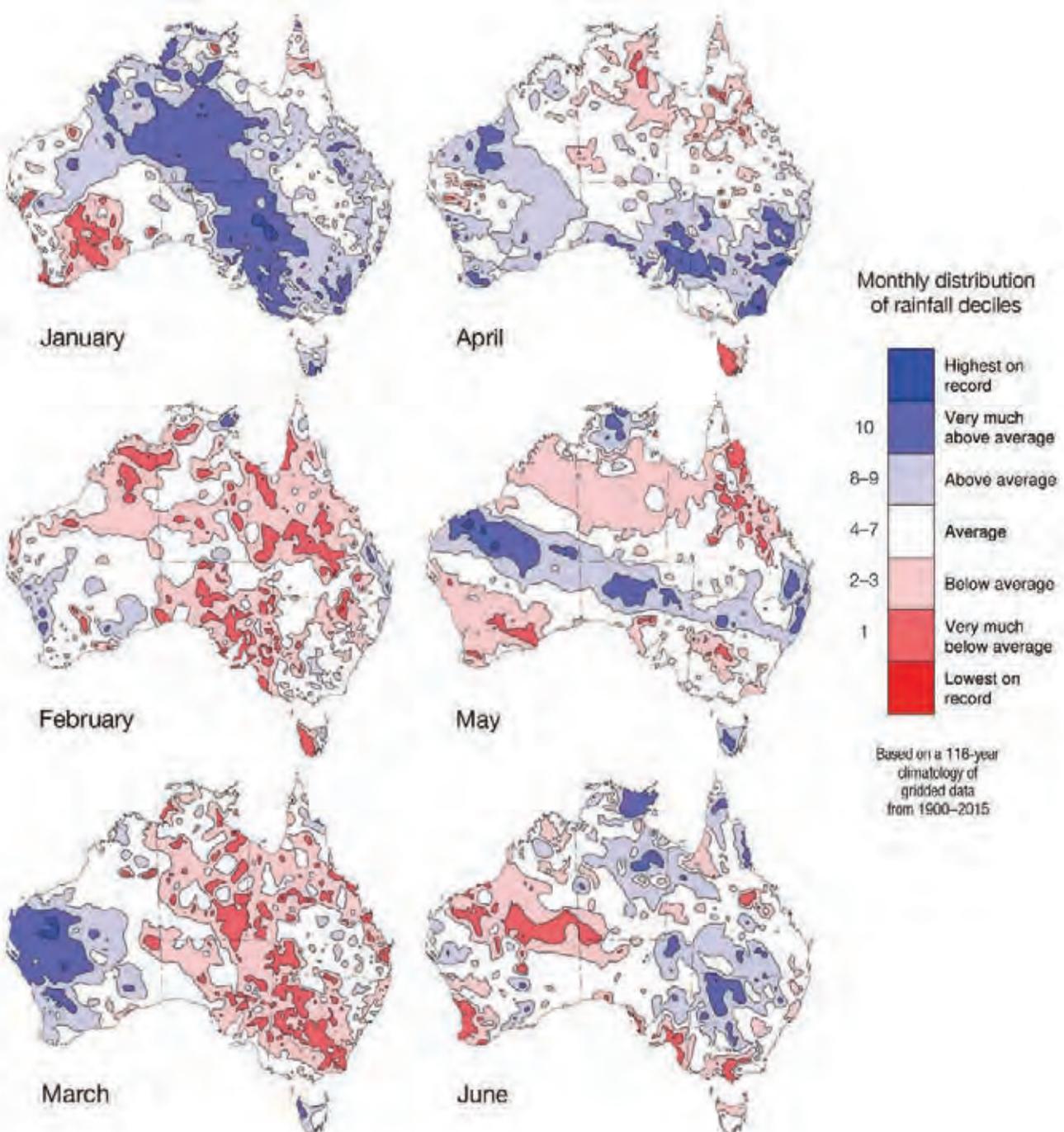
One of the strongest El Niño events on record contributed to below average rainfall in eastern Australia; although a record warm Indian Ocean appears to have contributed to a moderation of El Niño’s impact during the first half of the cool season. Between August and November a positive Indian Ocean Dipole reinforced the shift towards drier conditions.

January was a wet month for most of Australia, but below average over most of the south of Western Australia. A tropical low and associated cloudbands contributed to decile 10 rainfall (the highest 10 per cent of historical records) for large areas of the Northern Territory, eastern South Australia, and adjacent parts of other States.

Following an early finish to the north Australian monsoon conditions turned drier from mid-February. Monthly rainfall was below average for Australia as a whole for each month from February to October.

February rainfall was generally below average, but above average in areas of Western Australia’s central west coast, coastal southeast Queensland and northeastern New South Wales, the Arnhem District of the Northern Territory and small parts of the mainland southeast.

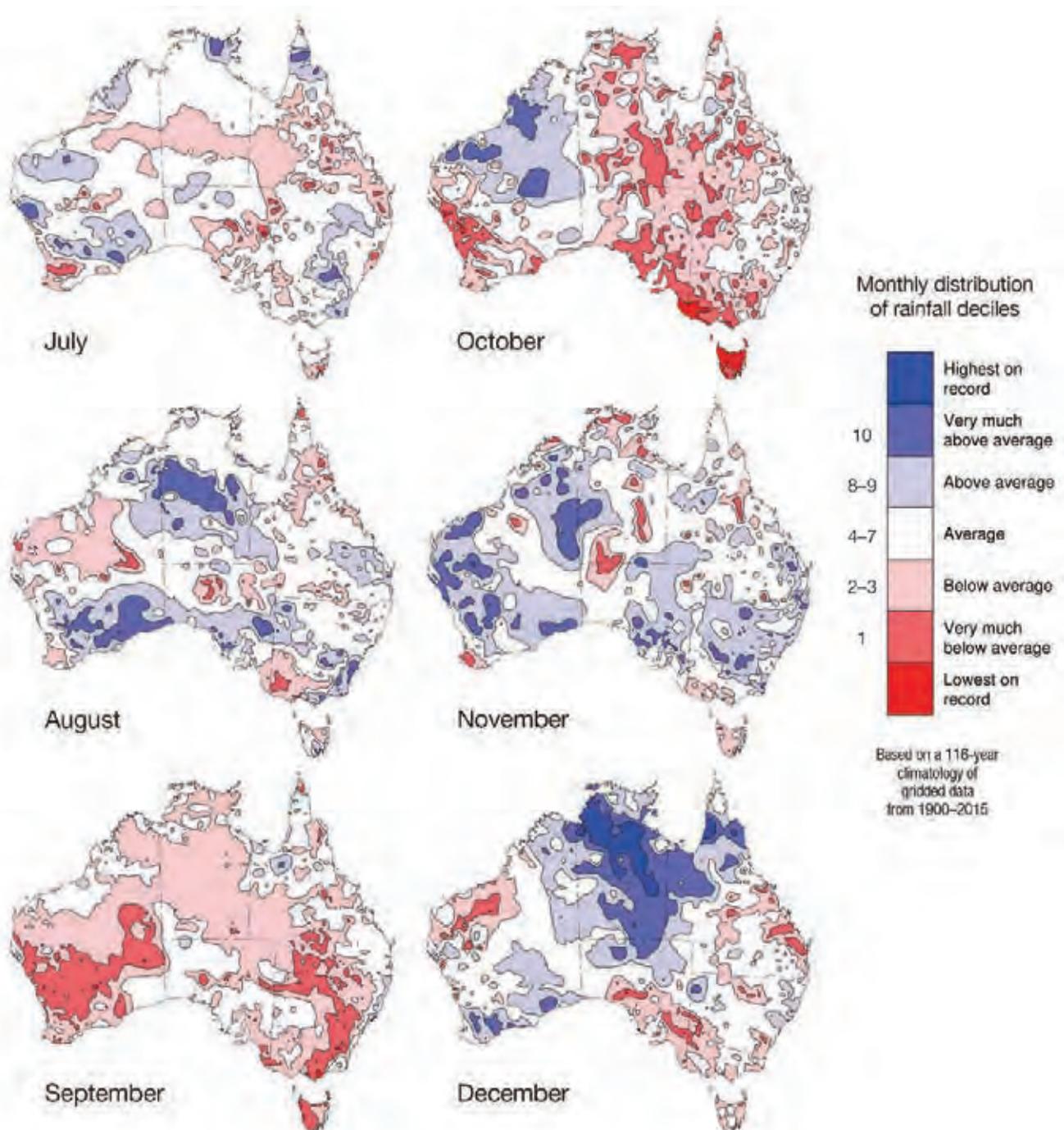
March rainfall was generally below average for Australia, but above average for large parts of the west and interior of Western Australia—and in decile 10 for a large area—



resulting from heavy rain early in the month and severe tropical cyclone *Olwyn* around mid-month. Rainfall was also above average for western Tasmania.

April was wetter than average for large parts of Western Australia, much of South Australia, New South Wales and eastern Victoria. An East Coast Low late in the month contributed to New South Wales' seventh-wettest April on record. It was particularly dry for Tasmania—decile 1 over much of the State, and the sixth-driest April on record. Below average rainfall also occurred in parts of northern Australia.

In early May, another East Coast Low contributed to above average monthly rainfall for southeast Queensland and northern coastal New South Wales. In the west severe tropical cyclone *Quang* and broad cloudbands later in the month contributed to above average totals between the Pilbara and northern South Australia. Rainfall was also above average for Tasmania, the central Top End and northern New South Wales. Rainfall was below average for southern Western Australia, much of northern Australia, southwestern New South Wales and parts of Victoria.

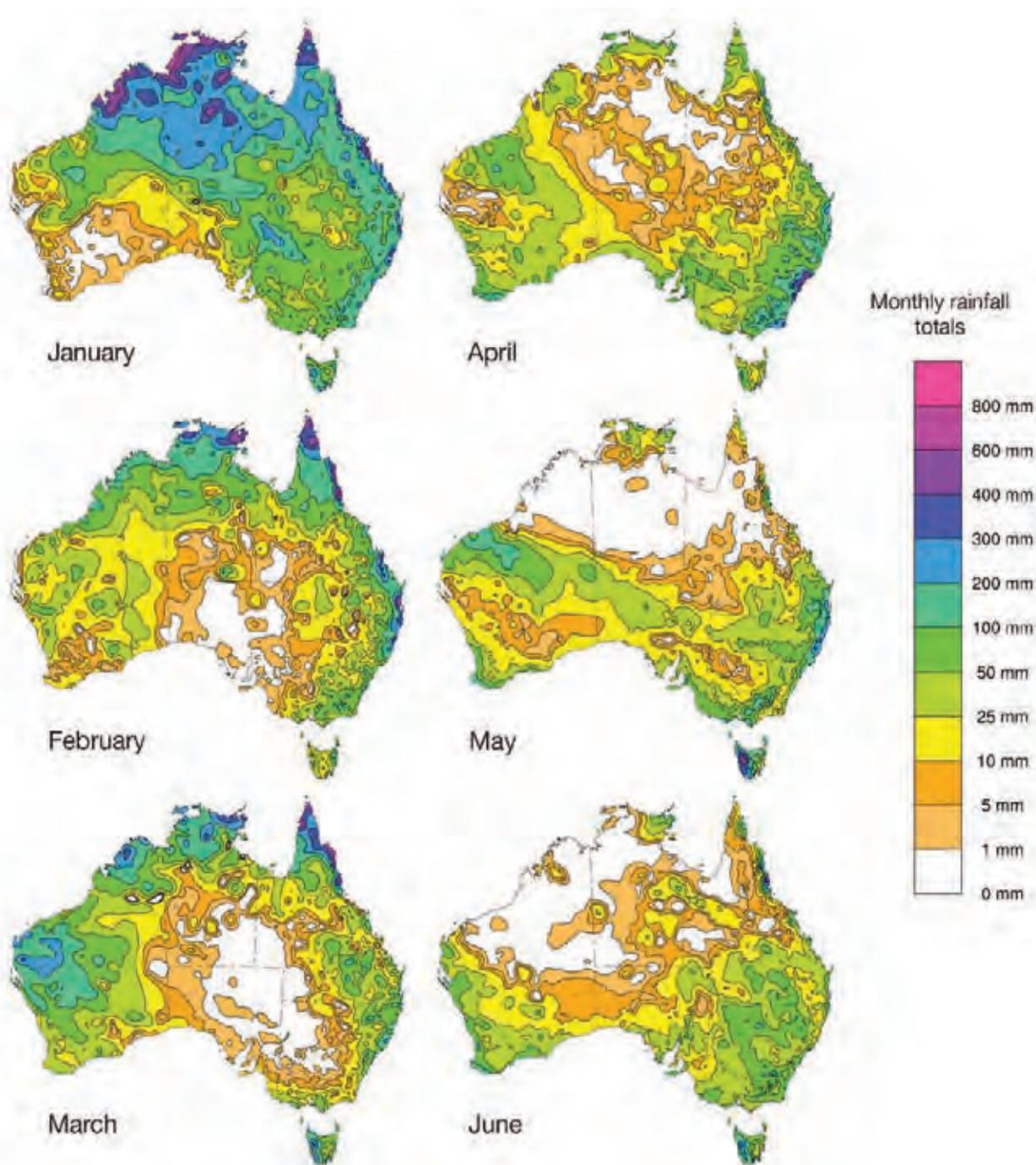


June rainfall was mixed—below average for large parts of Western Australia, agricultural South Australia, Victoria and northern Tasmania, but above average for much of New South Wales, adjacent South Australia, southern and northern Queensland, and much of the Northern Territory.

July rainfall was near average over most of the country but above average for parts of Western Australia, far eastern Victoria, inland New South Wales, and inland southeastern Queensland. Rainfall was below average for southwestern Western Australia and parts of South Australia, Tasmania, and Queensland.

August was drier than average for most of Victoria and southeastern South Australia, northern Tasmania, southwest Western Australia and the Pilbara. Rainfall was above average for the south of Western Australia (due to very heavy rainfall early in the month), parts of the central Northern Territory, southern South Australia and eastern Victoria and southeastern New South Wales (where an East Coast Low contributed).

September rainfall was below average for most of Australia, with particularly large anomalies in western Tasmania and along the Great Dividing Range in the southeast.



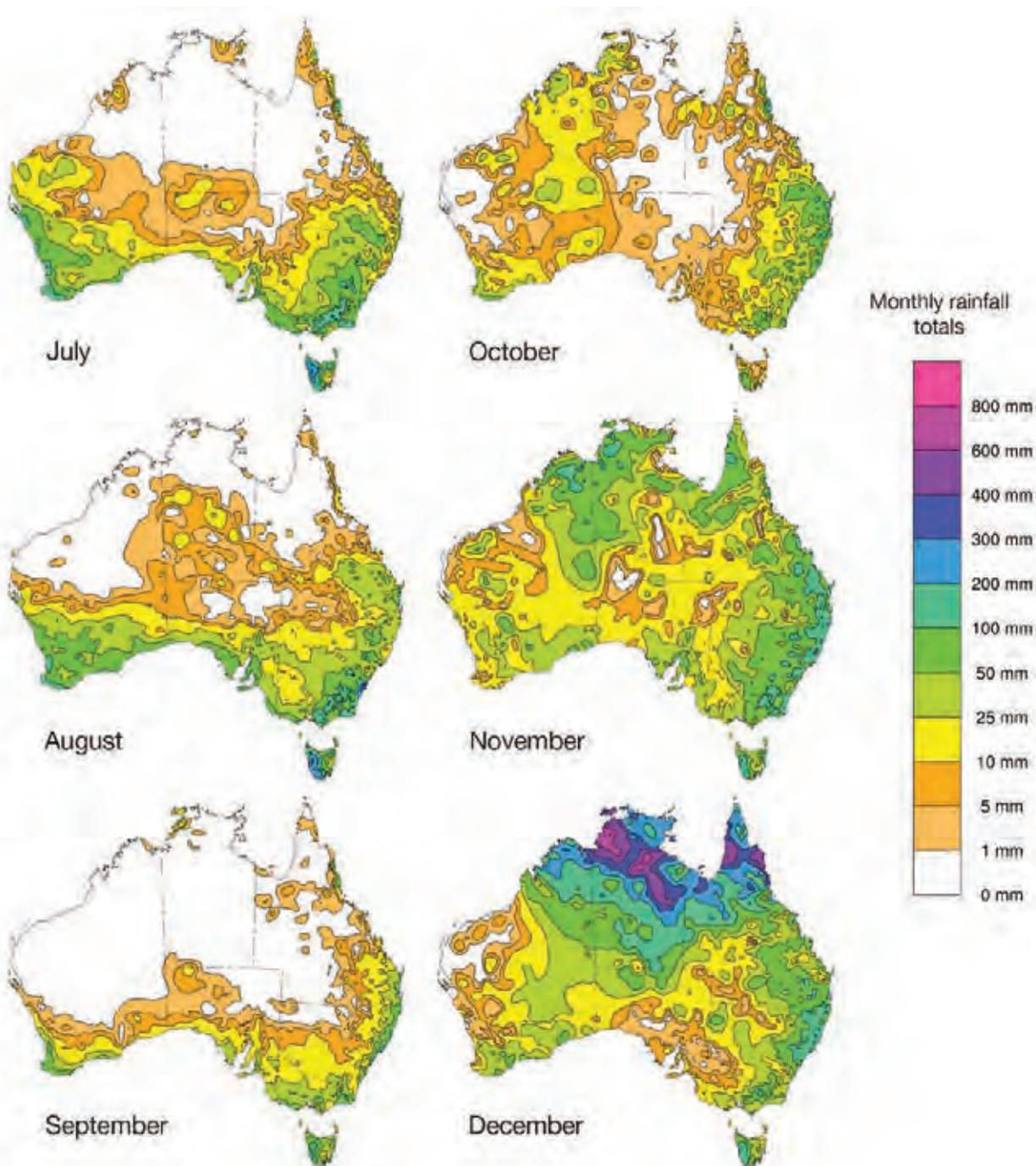
For Australia as a whole September was the third-driest on record—Western Australia was third-driest on record, Tasmania fifth-driest, and Victoria ninth-driest.

For most of Australia October rainfall was below average, but above average for most of the northern half of Western Australia. Monthly rainfall was the lowest on record for parts of the southeast. For Tasmania it was the driest October on record, Victoria was the seventh-driest and South Australia the sixth-driest.

November rainfall was above average for much of Western Australia, eastern South Australia and New South Wales.

Areas of the Top End, southwest Western Australia, Victoria, Tasmania and Central Australia were drier than average.

An active monsoon trough brought record-high December rainfall to northern parts of the Northern Territory and a pocket of the western Cape York Peninsula, and a record-wet December for the Territory as a whole. Rainfall was above average across the Territory, the northwestern half of Queensland and eastern and southern Western Australia. Rainfall was below average in the Pilbara, parts of eastern Australia, and southern South Australia.



4. Rainfall and temperature extremes

NEW SOUTH WALES

Highest daily maximum temperature	45.6 °C at Menindee Post Office on 7 December
Lowest daily minimum temperature	-12.8 °C at Perisher Valley AWS on 4 August
Highest average maximum temperature	29.2 °C at Mungindi Post Office
Lowest average minimum temperature	1.2 °C at Perisher Valley AWS and Thredbo AWS
Highest daily rainfall	307.5 mm at Maitland Belmore Bridge (Hunter River) on 22 April
Highest annual rainfall	2927.4 mm at Yarras (Mount Seaview)

NORTHERN TERRITORY

Highest daily maximum temperature	44.1 °C at Yulara Airport on 5 December
Lowest daily minimum temperature	-5.0 °C at Alice Springs Airport and Arltunga on 20 July
Highest average maximum temperature	35.9 °C at Bradshaw
Lowest average minimum temperature	12.7 °C at Alice Springs Airport
Highest daily rainfall	283.8 mm at Bradshaw on 26 December
Highest annual rainfall	2194.8 mm at Territory Wildlife Park

QUEENSLAND

Highest daily maximum temperature	46.7 °C at Birdsville Airport on 6 December
Lowest daily minimum temperature	-5.1 °C at Stanthorpe Leslie Parade on 7 August
Highest average maximum temperature	35.3 °C at Century Mine
Lowest average minimum temperature	9.2 °C at Applethorpe
Highest daily rainfall	329.4 mm at Elimbah on 2 May
Highest annual rainfall	3539.5 mm at Babinda Post Office

SOUTH AUSTRALIA

Highest daily maximum temperature	47.2 °C at Port Augusta Aero on 19 December
Lowest daily minimum temperature	-5.7 °C at Gluepot Reserve (Gluepot) on 20 July
Highest average maximum temperature	29.8 °C at Oodnadatta Airport
Lowest average minimum temperature	7.8 °C at Naracoorte Aerodrome
Highest daily rainfall	156.0 mm at Gammon Ranges (Moolawatana) on 10 January
Highest annual rainfall	939.4 mm at Uraidla

TASMANIA

Highest daily maximum temperature	39.8 °C at Friendly Beaches on 20 December
Lowest daily minimum temperature	-11.1 °C at Liawenee on 8 August
Highest average maximum temperature	18.9 °C at Launceston (Ti Tree Bend)
Lowest average minimum temperature	1.3 °C at Liawenee and kunanyi (Mount Wellington Pinnacle)
Highest daily rainfall	153.4 mm at kunanyi (Mount Wellington Pinnacle) on 14 January
Highest annual rainfall	3306.2 mm at Mount Read [#]

VICTORIA

Highest daily maximum temperature	45.0 °C at Avalon Airport on 19 December
Lowest daily minimum temperature	-8.6 °C at Falls Creek on 4 August
Highest average maximum temperature	25.2 °C at Mildura Airport
Lowest average minimum temperature	3.0 °C at Falls Creek
Highest daily rainfall	149.2 mm at Snowy River at McKillops Bridge on 18 February
Highest annual rainfall	1889.9 mm at Haines Junction (Mount Sabine)

WESTERN AUSTRALIA

Highest daily maximum temperature	49.2 °C at Roebourne Aero on 21 February
Lowest daily minimum temperature	-4.0 °C at Norseman Aero on 22 July
Highest average maximum temperature	36.5 °C at Fitzroy Crossing Aero
Lowest average minimum temperature	8.6 °C at Wandering
Highest daily rainfall	400 mm at Cape Leveque on 8 January*
Highest annual rainfall	1274.4 mm at Theda

AUSTRALIA

Highest mean temperature	29.3 °C at Wyndham Aero (WA)
Lowest mean temperature	4.7 °C at kunanyi (Mount Wellington Pinnacle) (Tas.)

Temperatures are in degrees Celsius (°C), rainfall totals are in millimetres (mm). Daily temperatures and daily rainfalls are for 24 hours ending 9:00 am on the date shown. The mean temperature is the average of maximum and minimum temperature.

[#]Mount Read's true total is unknown but likely higher, as the gauge was affected by snow and equipment failure several times during the year.

*The true daily total is unknown but likely higher, as the gauge overflowed in heavy rainfall.

5. Annual review and significant events

January and February: bushfires, storms, two cyclones

Hot and windy conditions developed over the south and west of South Australia ahead of a trough during the first few days of 2015. On 2 January, severe fire danger was observed in all but one of the fifteen South Australian forecast districts, and was extreme or catastrophic in eight. On the following day twelve districts observed at least severe fire danger.

Several fires started during 2 January, the most significant at Sampson Flat in the Mount Lofty Ranges. The Sampson Flat fire burned 20 000 hectares and 27 houses before widespread rain on 9 and 10 January helped bring the fire under control.

Fire weather was also significant across Victoria. Bushfires started on 3 January in the Little Desert National Park and Black Range State Park in western Victoria, burning around 4000 hectares by 5 January. Another fire at Moyston, west of Ararat, destroyed two homes, damaged around 90 other properties, and burnt 5000 hectares before being brought under control on 4 January.

Lightning ignited numerous fires in South West Western Australia on the afternoon of 28 January. The Boddington fire burnt approximately 52 000 hectares of forest and farmland over seven days and the Northcliffe fire burnt close to 100 000 hectares and two houses after escalating on 4 February in hot northerly winds. The Northcliffe fire was one of the most significant on record for the region.

A tropical low brought significant rain over Central Australia and western Queensland during the first half of January. Large areas received totals about equal to the annual average between 4 and 11 January, causing some flooding. Kati Thanda-Lake Eyre experienced significant inflows, mostly resulting from local rainfall, which is unusual as the lake typically receives water flowing from rainfall over inland and western Queensland.

Periods of strong winds, heavy rain and storms also occurred during January and February, including:

- thunderstorms in Melbourne on 7 January with gusts up to 100 km/h, widespread power outages, wind damage and fallen branches, and over 1000 State Emergency Service (SES) callouts
- flash flooding in South Australia and Bendigo (where 100 mm of rain fell in one hour) on 8 January as a tropical disturbance crossed the southeast, with 156 SES callouts across Victoria
- heavy rain across the central and northern coast of New South Wales on 26 and 27 January, causing flash flooding in Sydney, the Port Macquarie region and around Coffs Harbour



Several large bushfires in South West Western Australia on 4 February. The more southerly of the fires, near Northcliffe, was one of the most significant on record for the region. Image: NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) on the Terra satellite.

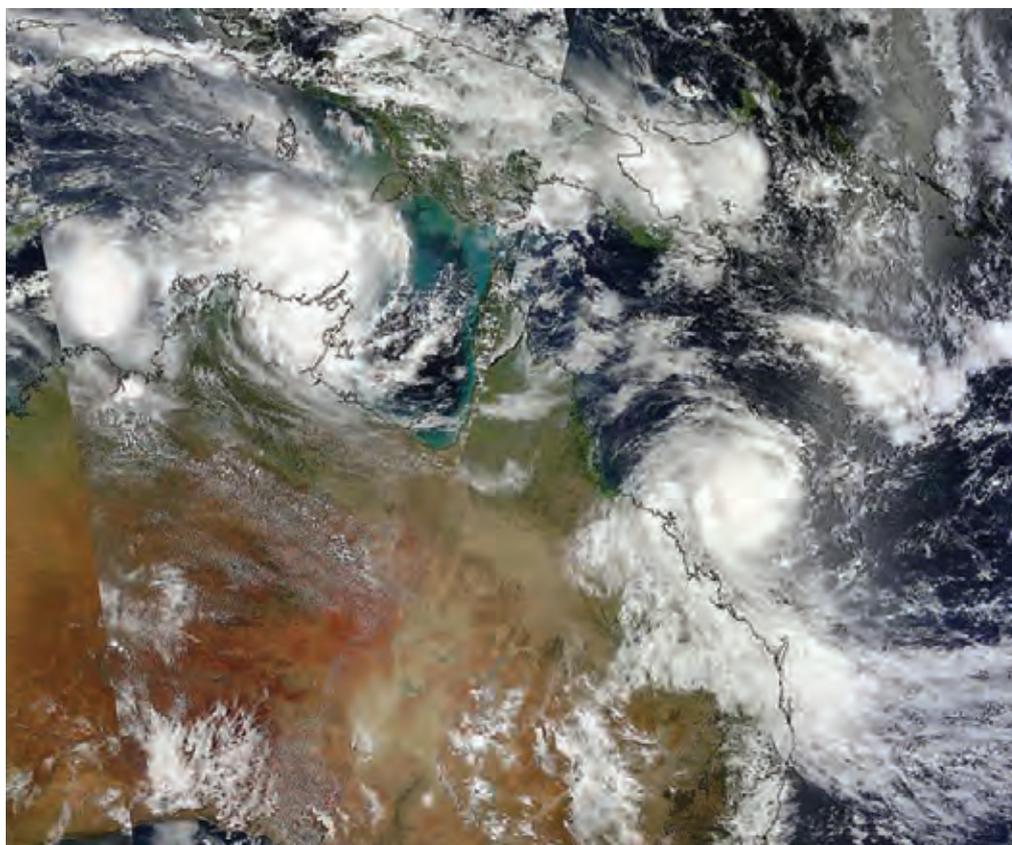
- storms in Melbourne and the eastern suburbs on the evening of 28 January, with wind gusts to 130 km/h, extensive power outages, felled trees, structural damage, and 1700 SES callouts. There was one fatality and one seriously injured when a tree fell onto a Dandenong Ranges home.

A number of other less damaging storms also occurred. For more details see the Monthly Weather Reviews for specific months.³

Severe tropical cyclone *Marcia* was the most intense cyclone to make landfall during 2015, and the most intense landfall recorded so far south on the east coast.⁴ *Marcia* intensified rapidly, going from tropical low to category 5 strength during the two days prior to landfall at around 8:00 am on 20 February at Shoalwater Bay, north-northwest of Yeppoon.

³ Monthly Weather Reviews www.bom.gov.au/climate/mwvr/

⁴ Tropical cyclone summary www.bom.gov.au/announcements/sevwx/qld/qldtc20150218.shtml



Two tropical cyclones—*Marcia* and *Lam*—approaching the coast of Queensland and the Northern Territory respectively on 19 February. Image: NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) on the Terra satellite.

Marcia caused extensive damage in Yeppoon, Byfield, Rockhampton and Biloela, before weakening steadily as it tracked southward. Heavy rain and some areas of flooding occurred along the east coast as far south as Lismore in New South Wales. The SES received almost 3000 requests for assistance, mostly from central Queensland. Reported damages totalled at least \$750 million.

Severe tropical cyclone *Lam* also made landfall on 20 February, the first time in recorded history that two severe tropical cyclones made landfall in Australia on the same day.⁵

Lam formed early on 17 February in the Gulf of Carpentaria and crossed the Top End coast early on 20 February as a category 4 storm, but weakened rapidly over land. *Lam* caused heavy rainfall in parts of the Top End and the Cape York Peninsula and extensive structural damage and disruptions to power supply and communications on Elcho Island and at Milingimbi and Ramingining.

March: cyclones, storms and a heatwave

Severe tropical cyclone *Nathan* was a very long-lived system.⁶ It reached category 2 strength over the Coral Sea on 11 March and lingered east of the Cape York Peninsula before making landfall north of Cooktown as a category 4 storm early on 20 March. *Nathan* then made landfall on the Arnhem coastline south of Nhulunbuy at category 2 strength on the morning of 22 March, crossed Elcho Island, and made landfall again west of Maningrida at category 1 strength early on 24 March. Heavy rain resulted in parts of Far North Queensland around mid-March and again later in the month over northeastern Queensland and the north of the Northern Territory. There was little further damage to areas affected by *Lam* a month earlier.

Severe tropical cyclone *Olwyn* reached category 3 strength as it approached the Pilbara coast on 12 March.⁷ *Olwyn* passed west of Exmouth during 13 March and tracked southwards along and over the coast before moving over land south of Carnarvon.

5 Tropical cyclone summary www.bom.gov.au/announcements/sevwx/nt/nttc20150217.shtml

6 Tropical cyclone summary www.bom.gov.au/announcements/sevwx/qld/qldtc20150310.shtml

7 Tropical cyclone summary www.bom.gov.au/announcements/sevwx/wa/watc20150308.shtml

Olwyn weakened to tropical low strength near Geraldton on 14 March after bringing heavy rain and damaging winds over coastal areas, with significant damage in the Carnarvon area.

Areas of rain extended further inland and southwards over following days. Minor flooding resulted in the Gascoyne, Greenough and Irwin catchments with several towns and communities declared natural disaster zones.

Thunderstorms were common in New South Wales during March, with significant storms affecting:

- Sydney on 1 March, with 500 calls for assistance to the SES for roof damage and downed trees and powerlines
- the central coast and Blue Mountains on 12 March, with some reports suggesting hail of up to 10 cm in diameter in Faulconbridge
- the Narrabri region on 21 March, with hail of more than 7 cm in diameter causing widespread damage to crops, roofs, cars and windows.

An exceptional hot spell affected large parts of northern and central Australia during March.⁸ At the start of the month warmth occurred over the Top End, Gulf Country

⁸ *Special Climate Statement 51: an exceptional autumn hot spell in northern and central Australia*, Bureau of Meteorology, 1 April 2015: www.bom.gov.au/climate/current/statements/scs51.pdf

and northwestern Queensland.

From mid-month, unusual heat spread to a much larger area, with records set in large parts of the Northern Territory, Queensland, outback South Australia and northern New South Wales during 19 and 20 March. Records were also set for area-averaged temperatures, runs of warm days, and late-season heat.

April and May: East Coast Lows, a cyclone

A slow-moving East Coast Low developed off the Hunter coast on the evening of 20 April, producing severe weather across much of coastal New South Wales before decaying during 23 April. Two-day totals as high as 436 mm were recorded at Tocal and Maitland, and hourly totals as high as 112 mm in Tocal on the morning of 21 April.

Twelve regions were declared natural disaster areas, with major flooding in the Williams and Patersons rivers, and flash flooding across the Sydney, Hunter and Central Coast regions. Almost 80 homes were badly damaged in Dungog in severe flash flooding on the morning of 21 April, resulting in several fatalities. Strong winds and high seas also contributed to substantial coastal erosion, with sand blown well beyond the immediate beachfront. There were more than 20 000 SES callouts and 169 flood rescues, the largest response operation in the history of the service. It was the most severe East Coast Low since at least June 2007.



Severe tropical cyclone *Marcia* caused areas of flooding between Yeppoon and Biloela. Evacuations were ordered in the town of Jambin, near Biloela south of Rockhampton, when heavy rains led to flooding on the Callide River. Photograph: Sue Wilkie.

Another East Coast Low, which developed in a coastal surface trough during 1 and 2 May, brought widespread moderate to heavy rainfall, powerful surf and damaging winds to southeast Queensland and parts of New South Wales.

Localised flash flooding resulted around Brisbane and the Gold Coast, with flood warnings in southeast Queensland and northeast New South Wales. Heavy rain continued in coastal New South Wales until 4 May as the low tracked southward. Four lives were lost north of Brisbane when two vehicles were swept from flooded roadways. There were a number of flood rescues in New South Wales, and one fatality was associated with dangerous surf.

Severe tropical cyclone *Quang* produced widespread moderate rainfall in the Pilbara and adjacent areas of Western Australia at the start of May, having formed during the last days of April.⁹ *Quang* reached category 4 strength while well offshore, but was below cyclone strength by the time it made landfall between Exmouth and Onslow just after 6:00 pm on 1 May. Damage was reported at Exmouth in the hours before the cyclone reached the coast.

A strong westerly airstream with embedded lows and cold fronts affected the southeast between 5 and 14 May. The winds raised the sea level in and around Port Phillip in Victoria by about half a metre, causing minor coastal inundation. Some wind damage was reported about parts of the Yorke Peninsula and the southern Mount Lofty Ranges in South Australia on the afternoon of 4 and into 5 May, with the SES responding to 240 callouts.

9 Tropical cyclone summary www.bom.gov.au/announcements/sevwx/wa/watc20150427.shtml

A dust storm crossed western Victoria and southwestern New South Wales in south to southwesterly winds behind one of the fronts on 5 May, reaching Sydney and the Illawarra by 6 May. In Tasmania, wind and locally heavy rain on 5 and 6 May blocked roads with fallen trees and caused widespread power outages and some damage, with 45 SES callouts from the northwest.

Winter: a cold outbreak, a warm spell, an East Coast Low

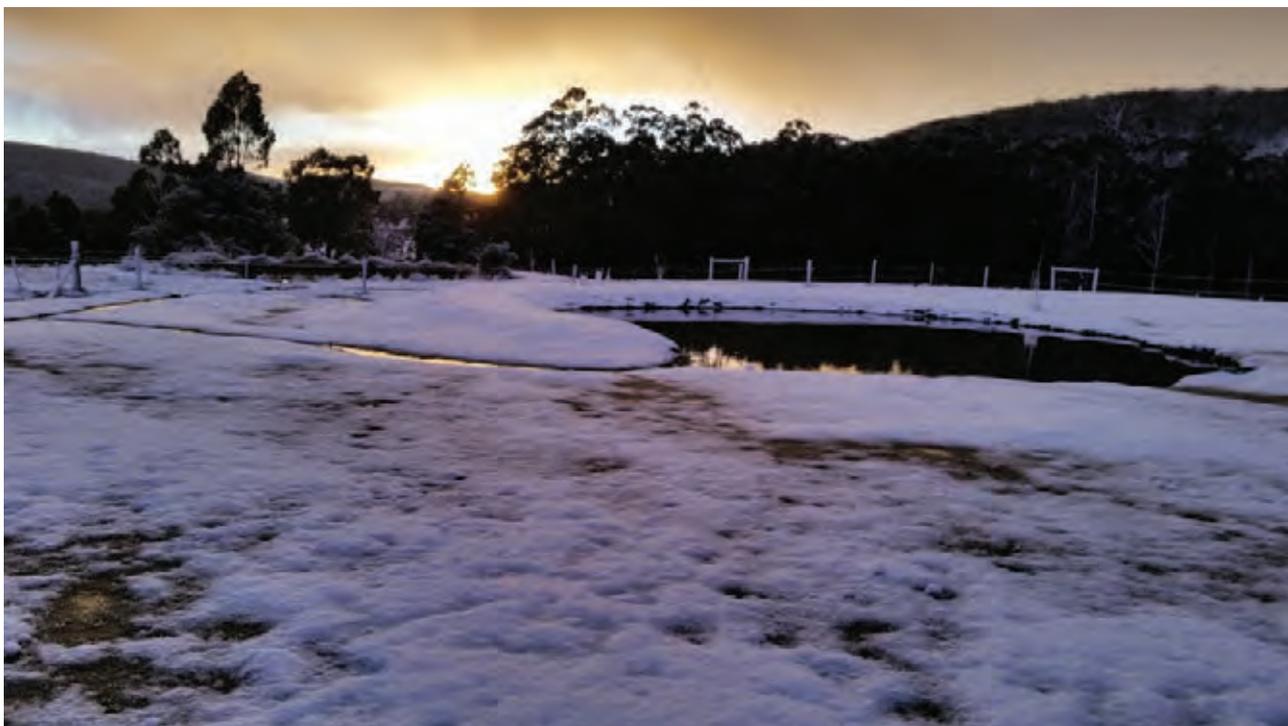
A strong cold front crossed Tasmania late on 7 June, causing power outages but relatively little damage. Many sites recorded gusts in excess of 100 km/h on 8 June, including some June records: Maatsuyker Island's 185 km/h gust was a new Australian record for June.

Between 11 and 17 July a significant cold outbreak occurred as a sequence of strong cold fronts crossed eastern Australia.¹⁰ Snow was recorded along the Great Dividing Range from east of Melbourne to the Granite Belt in southern Queensland, with settling snow to levels as low as 400 metres across the central west of New South Wales. For locations in elevated areas of southeast Queensland it was the heaviest snowfall since 1984. Light falls were recorded in the ranges east of Melbourne early in the sequence, becoming more widespread in elevated parts of the State on 14–15 July; however, these snowfalls were not particularly unusual. Roads were closed in multiple areas, while high winds caused some damage and disruption to power supplies.

10 A significant low-level snow event across eastern Australia, Bureau of Meteorology, July 2015: www.bom.gov.au/climate/updates/articles/a011-eastern-snow-event.shtml



An East Coast Low brought severe weather to parts of coastal New South Wales between 20 and 23 April. Strong winds, coastal erosion and significant flooding resulted. Large volumes of sand were also moved by wind, as seen here at Bondi Beach on 21 April. Photograph: Newspix.



Snow fell to near sea level several times during August. Some roads and schools were closed at times, causing disruptions. Snow blankets the ground at Allens Rivulet, southwest of Hobart, at around 150 m elevation on 3 August 2015. Photograph: Paul Fox-Hughes.

Snow also fell to low levels in Tasmania several times between May and August. The most notable event was during the first week of August as strong cold fronts crossed Tasmania. Roads and school closures occurred between 1 and 3 August, including Hobart's most significant snow event since July 1986. On 5 August snow again fell down to 100 metres in the south and west, with associated road closures. See the Monthly Weather Review for details of other events.¹¹

Northern Australia experienced a warm spell late in July. A strengthening high pressure system over southern Australia extended a dry air mass into southern and western Queensland, which then reached into central parts of the Northern Territory and the Kimberley, before spreading to more inland parts of Western Australia.

Several locations in central and western Queensland, the Top End, and the northwest of Western Australia experienced their warmest July day or night on record between 26 and 30 July.

A low pressure system crossed New South Wales during 23 and 24 August, triggering thunderstorms in northern and eastern New South Wales and parts of the Darling Downs and Granite Belt in Queensland. A tornado damaged at least 12 properties in Dubbo and flash flooding occurred in the Sydney CBD.

The low developed into an East Coast Low, which produced high winds and 48-hour rainfall totals to 9:00 am on 26 August in excess of 300 mm in parts of the Illawarra and South Coast districts of New South Wales. Heavy rain continued in Victoria on the back side of the low, including some August daily rainfall records.

Flooding occurred in the Illawarra and South Coast areas, and Warragamba Dam spilled for the first time since June 2013, causing minor flooding in the Hawkesbury–Nepean River. The New South Wales SES received more than 1800 callouts during the event and preceding thunderstorms, with 95 flood rescues.

September storms

Slow-moving thunderstorms over Adelaide on the afternoon of 16 September produced large accumulations of small hail and heavy rainfall in the eastern suburbs. The SES received around 190 callouts.

On 17 September, the depression merged with a surface trough inland of the Great Dividing Range in Queensland and northeastern New South Wales, producing storms in parts of the Hunter Valley and Central Coast districts of New South Wales with hailstones up to golf-ball size, localised flash flooding, power outages and traffic disruptions. The New South Wales SES received close to 500 calls for assistance, mostly from northeast of Gosford.

¹¹ Monthly Weather Reviews www.bom.gov.au/climate/mwr/

October: the warmest on record

A heatwave developed over parts of the South West Land Division in Western Australia from 1 October, before extending into the mainland southeast.¹² Early season records were set across large parts of southern Australia between 4 and 6 October, with further extreme high temperatures in the south of Western Australia between 8 and 13 October, and on 22 October.

The early October heat, and preceding low rainfall, also saw an early start to the fire season with extreme fire danger declared over much of Victoria and parts of Tasmania on 6 October. More than 70 fires burnt during early October in Victoria, with around another 55 in Tasmania.

The Lancefield fire, north-northwest of Melbourne, was a control burn that escaped control lines on 3 October. A strong wind change crossed the southeast, causing wind damage which resulted in 315 SES callouts in Victoria and challenging firefighting conditions as the fire rapidly spread. 4000 hectares were burnt and four houses and about two dozen sheds destroyed before it was contained on 11 October.

¹² *Special Climate Statement 52: Australia's warmest October on record*, Bureau of Meteorology, 3 December 2015: www.bom.gov.au/climate/current/statements/scs52.pdf

Other fires occurred on 5 October: near Tallarook north of Melbourne, at Wensleydale near Geelong, near Port Lincoln in South Australia and on the northern outskirts of Hobart; and south of Geeveston in Tasmania later in the month, when a number of new fires and re-ignitions were reported in a burst of hot and windy weather on 15 October.

Areas of very heavy rain and thunderstorms occurred across many areas of Australia during October, including:

- intense but patchy storms across Victoria during 11 and 12 October causing heavy rain, fallen trees, and power outages across the city and eastern suburbs, as well as ending Melbourne's run of 19 dry days; a run which equalled the record for September and October
- thunderstorms in parts of the South West Land Division and Goldfields district in Western Australia overnight on 17 to 18 and on 25 October, with hail causing extensive crop losses in some areas
- severe thunderstorms and large hail in inland southeastern Queensland and around the northeast of Brisbane between 27 and 29 October, with widespread structural damage at Fernvale and Chinchilla.



A number of large fires burnt around the Esperance region of Western Australia in mid-November. Cropping land provided abundant fuel, generating an intense fire and vast plumes of smoke, such as seen here in Scaddan on 17 November. Photograph: AAP.



A water bombing helicopter works above the Lancefield fire, which burnt during the first two weeks of October. Photograph: CFA Victoria, courtesy of Wayne Rigg.

November and December: bushfires, heat, and a tropical low

Lightning contributed to the ignition of a number of fires around Esperance in Western Australia on 15 November, which became uncontained on 17 November in catastrophic fire weather conditions followed by a southerly wind change. Four people perished in the fires, which collectively burnt 145 000 hectares, including vast areas of cropping land.

Large bushfires burnt in South Australia as hot, windy and very dry conditions ahead of a strong change led to catastrophic fire danger ratings in the Mid North and Murraylands districts on 25 November. The Pinery fire north of Adelaide travelled more than 50 km in the first four hours, running southeastwards along a narrow front before spreading from the eastern flank when the wind turned. About 90 000 hectares of mainly agricultural land was burnt before containment on 27 November, most during the first day. Two people perished and several more were seriously burned. At least 87 houses were destroyed or severely damaged, along with thousands of livestock.

Thunderstorms were again numerous over eastern Australia during November, with notable storms including:

- on 1 November across northern Victoria and southern New South Wales, causing mostly minor damage, but with a tornado at Strathmerton west of Cobram removing roofs from several houses
- heavy rain on 5 November leading to flash flooding in northwest Victoria and around Melbourne, with funnel clouds also spotted over the northern metropolitan area
- heavy rain and hail in Sydney and the central coast on 13 November, with 160 SES callouts, power outages, and some localised flash flooding.

Severe thunderstorms crossed the Sydney region on 16 December, producing heavy rain, localised flash flooding, hail larger than 3 cm in diameter at several locations in southeastern suburbs.

A category F2 tornado was observed, which damaged several properties and the desalination plant in Kurnell. A wind gust of 213 km/h was recorded at Kurnell, the strongest on record for New South Wales.

Extreme heat affected much of southeastern Australia in the third week of December following a warm first half of the month.¹³ Heat became established over South Australia from 13 December, intensifying on 16 December as an area of high pressure over the Tasman Sea directed northeasterly winds over South Australia. Heat peaked on 19 December before a cool change passed through the southeast on 20 December. December daily maximum temperature records were broken in South Australia, Victoria and Tasmania, while exceptionally warm minima on the night of 19–20 December set records over large parts of Victoria and Tasmania and some parts of eastern South Australia and southern New South Wales.

A bushfire west of Lorne, in Victoria, ignited by lightning on 19 December, flared up in hot, windy conditions on 25 December, destroying 98 homes and holiday houses at Wye River and a further 18 at Separation Creek. The fire continued to burn for a number of weeks, and had burnt somewhat more than 2500 hectares of steep, difficult and heavily treed terrain by the end of 2015.

Significant rainfall over areas of the western Top End between 24 and 27 December was associated with an active monsoon trough, with many locations recording cumulative totals of 400 mm to 500 mm, exceeding 600 mm in isolated areas. The low tracked east then south, bringing significant rainfall over the east of the Northern Territory and adjacent areas in the last days of 2015, including some record December daily rainfall totals. Flooding resulted in some areas, with many roads cut, and Kati Thanda-Lake Eyre experienced significant inflows from local rainfall, as it had at the start of the year.

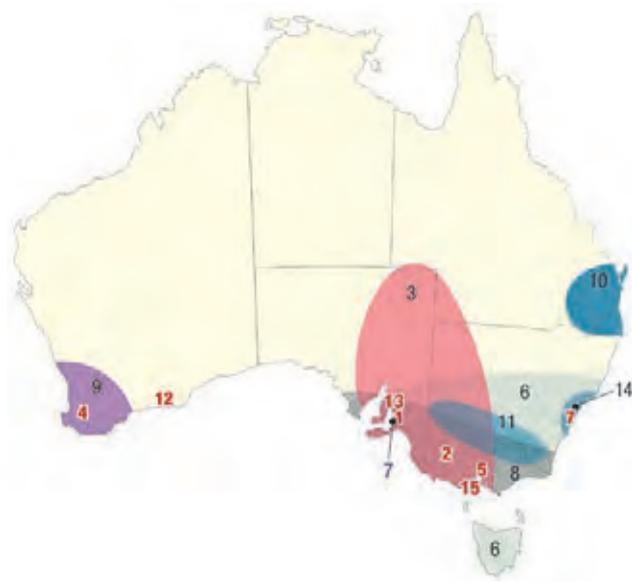
¹³ *Special Climate Statement 53: widespread record December temperatures in southeast Australia*, Bureau of Meteorology, 7 January 2016: www.bom.gov.au/climate/current/statements/scs53.pdf



Plumes of smoke from the Wye River fire near Lorne in Victoria. The fire caused extensive damage on 25 December and continued to burn for several weeks in difficult terrain. Photograph: Christine Shaw, CFA.

Severe weather and bushfires

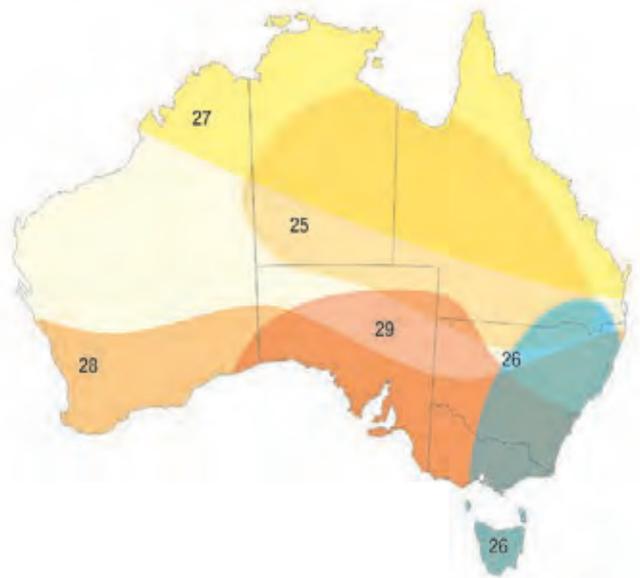
1. Significant bushfire in early January at Sampson Flat in South Australia's Mount Lofty Ranges, destroying 27 houses.
2. Significant bushfire in Victoria and at Moyston, west of Ararat at the start of January, damaging 90 properties and destroying two houses.
3. Severe thunderstorms in the southeast between 7 and 9 January caused widespread power outages and wind damage in Melbourne, flash flooding and some wind damage in northeastern and southeast South Australia, and very heavy rain over parts of New South Wales and western Victoria, with flash flooding in Bendigo.
4. Very large bushfires in South West Western Australia in early February, the largest and most significant in many decades.
5. Severe thunderstorms in Melbourne on 28 February, causing structural damage and one death.
6. Strong winds in the southeast between 5 and 12 May, causing exceptionally high tides around Port Phillip and nearby coastal waters in Victoria, wind damage in areas around Adelaide and Tasmania, and a dust storm which travelled from northwest Victoria to Sydney.
7. Thunderstorms caused damage and flooding in Adelaide on 16 September, followed by localised flash flooding and damage in parts of the Hunter Valley and Central Coast districts of New South Wales on 17 September.
8. A strong wind change passed through the southeast on 6 October, causing widespread wind damage to trees and some structures in Victoria, and hastening the spread of bushfires.
9. Thunderstorms caused extensive damage to crops in parts of southern Western Australia on the night of 17 October and on 25 October.
10. Severe thunderstorms in parts of southeastern Queensland between 27 and 29 October, with widespread structural damage at Fernvale and Chinchilla.
11. Notable thunderstorms in November, including those across northern Victoria and southern New South Wales on 1 November, which spawned a tornado at Strathmerton.
12. Significant and very large fires around Esperance in Western Australia between 15 and 21 November following catastrophic fire weather on 17 November.
13. Large bushfires in South Australia's Mid North between 25 and 27 November, where the Pinery fire destroyed or severely damaged at least 87 houses.
14. Severe thunderstorms in the Sydney region on 16 December, including a category F2 tornado which damaged several properties and the desalination plant in Kurnell, and areas of heavy rain and localised flash flooding.
15. Bushfire near Lorne in Victoria destroyed 116 homes and holiday houses at Wye River and Separation Creek on 25 December.



Rainfall and floods

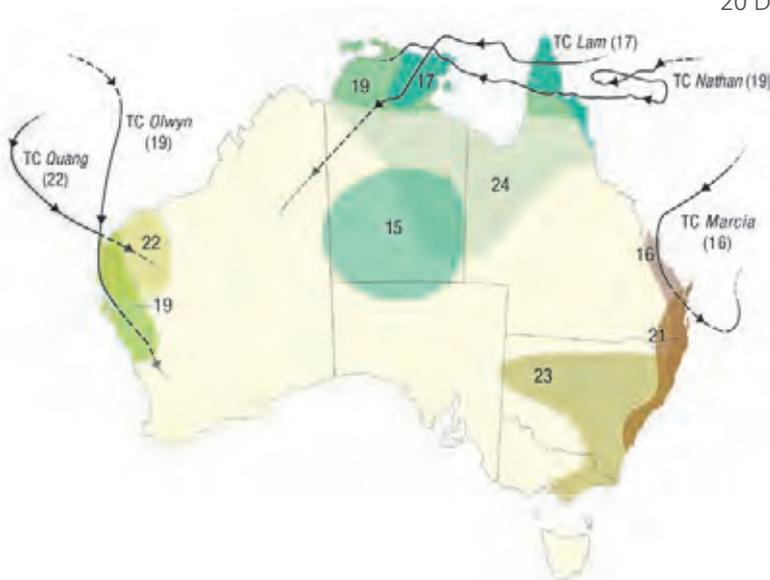
16. Tropical low brought heavy rain over parts of Central Australia in the first half of January, equalling the annual average in places, and causing areas of flooding.
17. Severe tropical cyclone *Marcia* made landfall on 20 February north of Yeppoon in Queensland, causing damage along a path from Yeppoon to Bundaberg, with heavy rain and areas of flooding as far south as Lismore in New South Wales.
18. Severe tropical cyclone *Lam* made landfall in the Top End, also on 20 February, causing heavy rain in parts of the Top End and Cape York Peninsula, with extensive damage in some remote communities.
19. Severe tropical cyclone *Olwyn* tracked along the Pilbara and Gascoyne coast between 12 and 14 March, producing heavy rain and damaging winds with minor flooding in some areas.

- 20. Severe tropical cyclone *Nathan* brought heavy rain to areas of northern Queensland and the Northern Territory between 11 and 27 March. The system made landfall on 20 March between Cape Melville and Cape Flattery, with subsequent landfalls south of Nhulunbuy, on Elcho Island, and between Goulburn Island and Maningrida as it tracked westward.
- 21. East Coast Low produced severe weather across coastal New South Wales between 20 and 23 April, with twelve regions declared natural disaster areas due to storm damage and flooding. Another East Coast Low produced heavy rain and damaging winds over southeast Queensland and parts of northern and coastal New South Wales between 1 and 4 May.
- 22. Severe tropical cyclone *Quang* produced widespread moderate rainfall in the Pilbara and adjacent areas of Western Australia on 1 May. It was below cyclone strength when it made landfall between Exmouth and Onslow, although wind damage occurred prior to landfall.
- 23. Thunderstorms occurred in northern and eastern New South Wales and southeast Queensland during 23 and 24 August, including a tornado that damaged properties at Dubbo. Associated low developed into an East Coast Low, producing high winds, heavy rain, and widespread flooding in the Illawarra and South Coast districts of New South Wales between 24 and 26 August. Heavy rain continued in Victoria on 27 August.
- 24. Tropical low brought several days of heavy rain over areas of the Top End, the east of Northern Territory, and parts of northern and western Queensland during the last week of December. Flooding resulted in some areas, with numerous roads cut.



Temperature

- 25. Record autumn hot spell across large parts of northern and central Australia during March, with prolonged heat peaking on 19 and 20 March.
- 26. A significant cold outbreak occurred across the southeast between 11 and 17 July, with widespread snow along the Great Dividing Range extending into southern Queensland.
- 27. A very warm spell affected northern Australia during late July.
- 28. A heatwave affected southern Australia in early October, contributing to Australia's warmest October on record.
- 29. Extreme heat affected much of southeastern Australia in the third week of December, peaking on 19 and 20 December.



New site records

New site records set in 2015, for selected stations with at least 45 years of record are shown below.

Record high daily rainfall (mm)

Station name	State	Highest daily rainfall	Previous record	Years of record
Tannymorel	Qld	165.0 on 21 Feb	125.8 on 2 Mar 1982	63
Tecoma	Qld	155.0 on 21 Feb	148.8 on 7 Feb 1956	73
Wingfield	Qld	130.0 on 21 Feb	115.0 on 26 Feb 2013	61
Dungog Post Office	NSW	233.4 on 21 Apr	223.5 on 19 Apr 1946	116
Elderslie	NSW	175.0 on 21 Apr	135.9 on 10 Jun 1964	76
Glendon Brook (Lilyvale)	NSW	200.0 on 21 Apr	128.0 on 10 Jun 1964	56
Paterson (Tocal AWS)	NSW	242.6 on 21 Apr	200.2 on 9 Jun 2007	49
Paterson Post Office	NSW	236.8 on 21 Apr	214.6 on 18 Nov 2013	115
Sedgefield (Bundajon)	NSW	207.2 on 21 Apr	146.8 on 24 Feb 1955	113
Branxton (Dalwood Vineyard)	NSW	199.4 on 22 Apr	193.4 on 9 Jun 2007	128
Douglas River	NT	244.4 on 26 Dec	212.0 on 1 Feb 2014	47
Huddleston (Willow Ponds)	SA	72.8 on 10 Jan	71.0 on 31 Dec 1979	59
Sturt Vale	SA	100.0 on 17 Apr	74.0 on 24 Oct 2007	54
Mount Wedge	SA	77.0 on 4 Nov	74.4 on 21 Feb 1938	128
Jamestown	SA	88.4 on 5 Nov	74.7 on 5 Feb 1890	135
Jamestown PIRSA	SA	81.2 on 5 Nov	70.2 on 31 Oct 1997	65
Taroona (Taroona Crescent)	Tas.	102.4 on 14 Jan	97.2 on 13 Apr 2011	54
Eneabba	WA	95.2 on 31 Jul	78.4 on 7 Feb 2008	50
Miling	WA	98.0 on 31 Jul	73.7 on 14 Apr 1961	88
Wongan Hills	WA	86.2 on 31 Jul	81.3 on 19 Mar 1942	109
Spring Valley	WA	123.4 on 7 Nov	80.2 on 29 Jan 1990	57

Record low total annual rainfall (mm)

Station name	State	2015 total	Previous record	Years of record	Annual average
Townsville Aero	Qld	397.2	464.2 in 1969	74	1144.7
Yankalilla	SA	350.0	361.4 in 1982	119	572.1
Albany	WA	596.3	628.5 in 1972	136	931.5
Denmark	WA	762.2	763.0 in 1940	107	1090.6

Record high annual mean temperature (°C)

Station name	State	Annual mean	Previous record	Years of record	Annual average
Brookton	WA	18.1	17.9 in 2011	46	17.0
Narrogin	WA	17.3	17.2 in 2014	81	15.9
Kalgoorlie–Boulder Airport	WA	19.7	19.5 in 2007	72	18.5
Port Hedland Airport	WA	27.7	27.6 in 2010	66	26.4

Record high annual mean maximum temperature (°C)

Station name	State	Annual mean maxima	Previous record	Years of record	Annual average
Corrigin	WA	25.5	25.3 in 2014	63	23.8
Dwellingup	WA	23.7	23.6 in 2010	75	21.9
Manjimup	WA	22.3	22.1 in 2012	74	20.4
Narrogin	WA	24.2	23.8 in 2014	84	22.4
Pearce RAAF	WA	26.8	26.5 in 2013	51	25.2

Record high annual mean minimum temperature (°C)

Station name	State	Annual mean minima	Previous record	Years of record	Annual average
Kalgoorlie–Boulder Airport	WA	12.9	12.7 in 2013	72	11.7
Mardie	WA	20.3	20.2 in 2010	55	18.8

Record high daily minimum temperature (°C)

Station name	State	Highest daily minima	Previous record	Years of record	Annual average
Mildura Airport	Vic.	31.9 on 20 Dec	30.9 on 24 Jan 2001	70	10.3
Ouyen (Post Office)	Vic.	31.1 on 20 Dec	30.3 on 28 Jan 1957	59	9.7

6. Oceans: sea level and sea surface temperatures

A strong El Niño and a positive Indian Ocean Dipole

Global sea surface temperatures (SSTs) set a new record for the calendar year, at 0.60 °C above average (previous record +0.50 °C in 2014)¹⁴, influenced by record warmth in both the Pacific and Indian oceans.

Remnant warmth in the eastern Pacific from 2014's 'near miss' El Niño persisted until the Pacific Ocean warmed rapidly during autumn 2015, with El Niño declared in May as atmospheric indicators consolidated. SSTs in the central to eastern Pacific (NINO3.4 and NINO3) peaked in late November. Values were comparable to the strong El Niño events of 1997–98 and 1982–83, but short of records set in 1997–98 for other indicators. El Niño persisted into 2016, declining slowly.

Despite record warm SSTs across the Indian Ocean throughout the year, between late August and mid-November, a positive Indian Ocean Dipole (IOD) developed, peaking at values not seen since the very strong positive IOD of late 2006.

From May 2015 onwards the monthly SST anomalies in the southern Indian Ocean were the highest on record. In the Pacific Ocean SST anomalies for every month in 2015 were the highest on record. The October SST anomaly was the largest on record for any month for the southern Indian Ocean, while November took that honour for the Pacific Ocean.

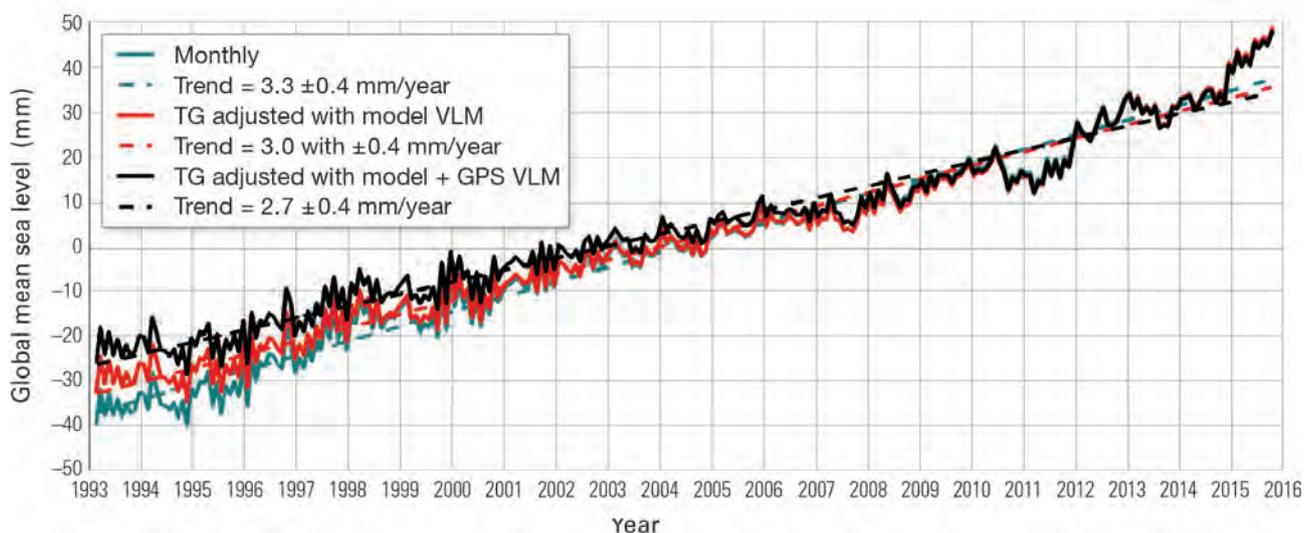
¹⁴ SST values quoted use the NOAA Extended Reconstructed Sea Surface Temperature Version 4 (ERSSTv4) dataset, which commences in 1854.

Sea level and sub-surface ocean temperatures continue to increase

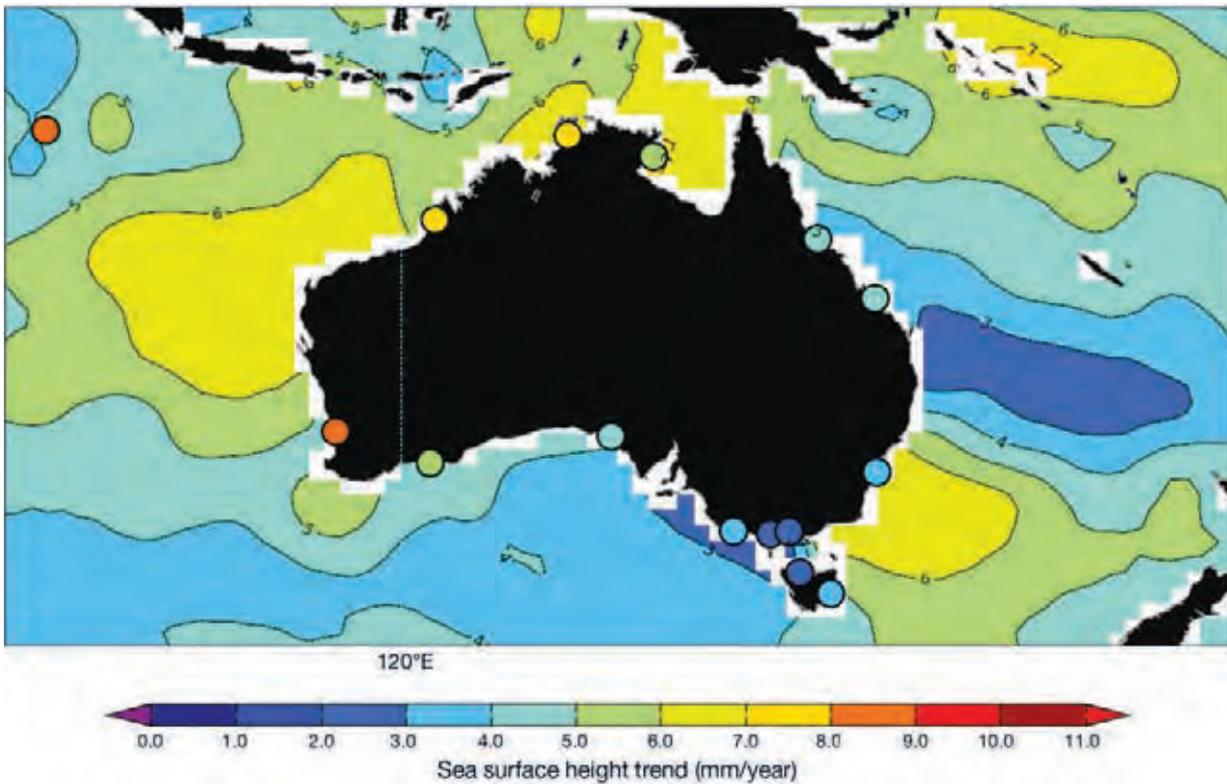
Global sea-level measurements from satellite altimetry over the period January 1993 to October 2015 show sea level rose at a rate of 3.3 ± 0.4 mm/year. A recent reanalysis of the altimeter and in situ sea level data by CSIRO and the University of Tasmania, using Global Isostatic Adjustment (GIA) models and Global Positioning System (GPS) data (where available) to estimate the vertical movement of tide gauges, indicates a small uncertainty of about 1 cm in the first decade of the altimeter record. If further results confirm this reanalysis, the new rate of rise would be in the range of 2.7 ± 0.4 to 3.0 ± 0.4 mm/yr; about 15 per cent below earlier estimates. Global mean sea level for 2015 was the highest level since the start of the instrumental record in the 19th century.

Global average sea level rise is the result of thermal expansion of the oceans as they warm, the addition of fresh water to the ocean from glaciers and the ice sheets of Greenland and Antarctica, and exchange of freshwater with terrestrial water storages.

Sea level, and changes in sea level, are not uniform around the globe and are influenced by natural climate variability such as the El Niño–Southern Oscillation (ENSO) and the Interdecadal Pacific Oscillation (on different timescales) and associated changes in winds and currents.



Monthly global mean sea level from satellite altimeter data (January 1993 to October 2015). The seasonal signal has been removed. The solid blue line shows the nominal monthly time series. The solid red line shows the version with the small satellites biases estimated using a Global Isostatic Adjustment (GIA) model to estimate the vertical land movement of tide gauges (TG). The solid black line shows the version where the satellites biases are estimated using Global Positioning System (GPS) to estimate vertical land movement (VLM) of tide gauges. The dashed line shows the linear trend for each timeseries. Source: CSIRO and University of Tasmania.



1993 to 2015 rate of sea surface height rise measured relative to the land by coastal tide gauges (coloured dots, to November 2015) and relative to the centre of the Earth by satellites (to October 2015). Note: satellite observations have had the seasonal signal removed and small corrections applied for changes in atmospheric pressure. Source: Australian Baseline Sea Level Monitoring Project and CSIRO.

This means that over decades the local and regional sea level rise can be above or below the global mean rate. As a result of this natural variability, rates of sea level rise to the north and northwest of Australia over the satellite measurement period have been between 5 and 7 mm/year, well above the global average.

These large-scale drivers also have a global effect. ENSO has been a large driver of sea level trends in recent decades. The strong La Niña of 2011 resulted in high rainfall over areas including Australia, with the resultant above-average water storage on land producing a notable dip in global sea level before global sea levels returned to trend or above by mid-2012. The development of El Niño in early 2015 propelled the rate of global sea level to well above trend.

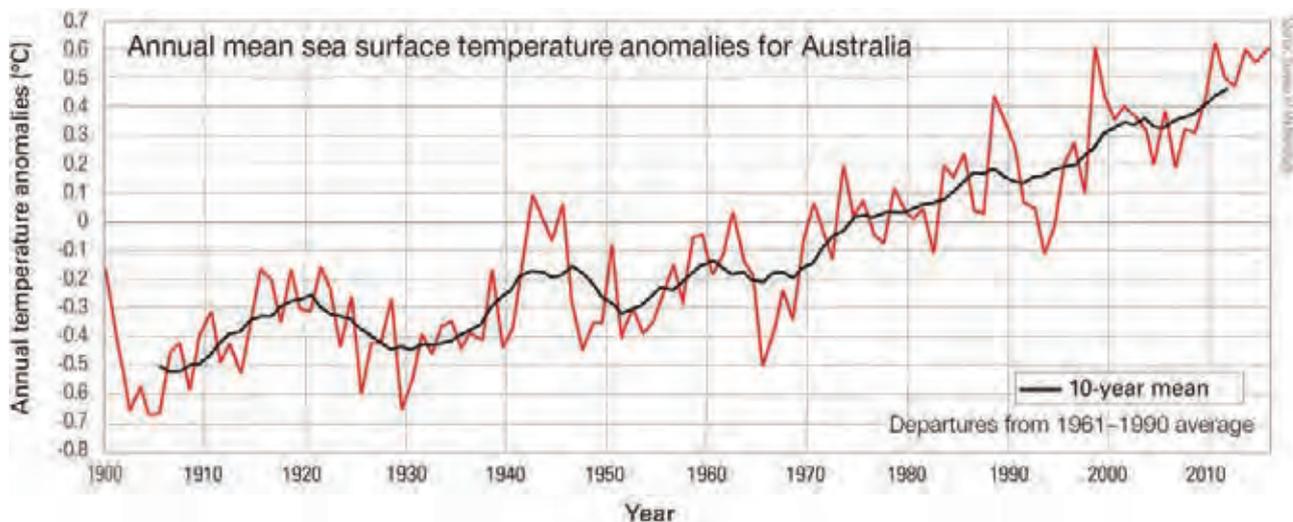
Care must be taken when interpreting sea level trends from individual tide gauges. For instance, the greater apparent sea level rise compared to satellite measurements at Hillarys, near Perth, and in the Cocos Islands is thought to be associated with sinking of the coastal tide gauge, possibly due to compaction and/or ground water extraction. The local sea level rise relative to the land affects the coastal environment, but may not be directly comparable with satellite measurements of sea level relative to the centre of the Earth.

Due to the oceans' large heat capacity, they play a major role in the global climate system by absorbing heat energy. The global ocean has absorbed 93 per cent of the extra heat trapped by the Earth since 1970, reducing the rate of atmospheric warming.

Since 2006, the average global ocean temperature between the surface and a depth of 2000 m (current limit of the Argo observational sampling) has shown a consistent warming trend.

As the surface to 100 m depth of the ocean warms and cools in synchronisation with ENSO events, this shallow heat storage in the tropical Pacific is largely balanced by temperatures oscillations between 100 m and 250 m. Below 300 m, the ocean has shown a more consistent warming trend which extends down to the current limit of observational sampling.

Warming over these depths features an intensifying hemispheric asymmetry, with over 70 per cent of the heat accumulating south of the equator, predominately in the mid-latitudes.



Annual mean sea surface temperature anomalies in the Australian region for 1900–2015 (compared with 1961–1990 average). The Australian region is defined by a box from 4°S to 46°S and from 94°E to 174°E. The black line shows the 10-year moving average. Values are from the National Oceanographic and Atmospheric Association Extended Reconstructed Sea-Surface Temperature (NOAA_ERSST_v4 dataset).

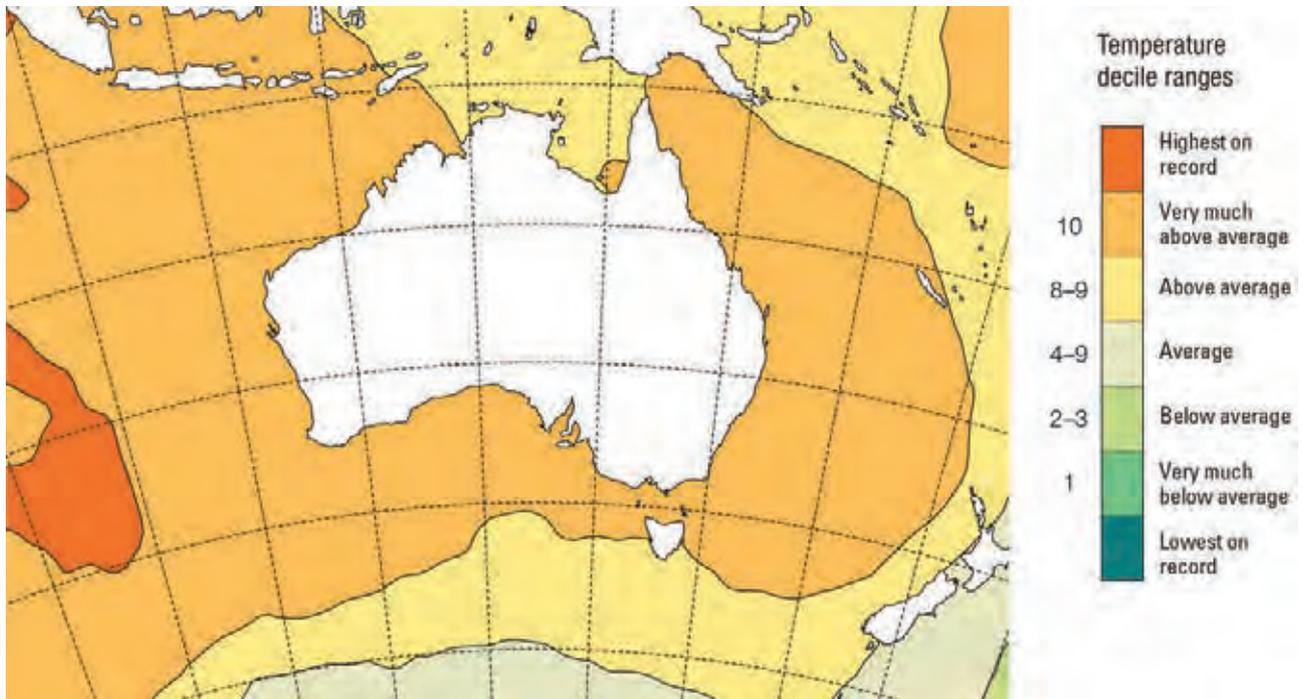
Sea surface temperatures in the Australian region remain above average

SSTs have remained high around Australia in recent years. The 2015 anomaly for the Australian region was the fourth-highest since 1900, 0.59 °C above the 1961–1990 average. The five warmest years on record have been 2010 (+0.63 °C), 1998 (+0.61 °C), 2013 (+0.60 °C), 2015 and 2014 (+0.55 °C).

SSTs across the Australian region were unusually warm throughout 2015; anomalies for all months except June and August were amongst the six warmest on record for their respective months. The March anomaly was the fourth-largest on record for any month. SSTs were very much warmer than average (in the warmest 10 per cent of historical observations) around nearly all of Australia for the year. Record warmth was also observed across the southern Indian Ocean.

From May to November large areas of the Indian Ocean to Australia’s west were warmest on record in each respective month, with record warmth extending across the Bight and waters around the southern coastline in October and November. For December, record warmth was observed across the waters around the southeast and Tasman Sea.

Below average annual SSTs have not been observed for the Australian region since 1994. Australian-region SSTs have increased approximately 1 °C since 1910, very similar to the increase in temperature observed over land. It is common for Australia SSTs to warm in the year following an El Niño; this suggests that the next 12 months will likely see well above average ocean temperatures in the Australian region.



Annual sea surface temperature deciles for 2015, based on a 116-year climatology of gridded data for 1900–2015 from NOAA_ERSST_v4.

For further information

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