Annual climate statement 2023

Analysis of Australia's temperature, rainfall, water, oceans, sea ice, significant weather and influences during 2023

Issued **Thursday 8 February 2024**

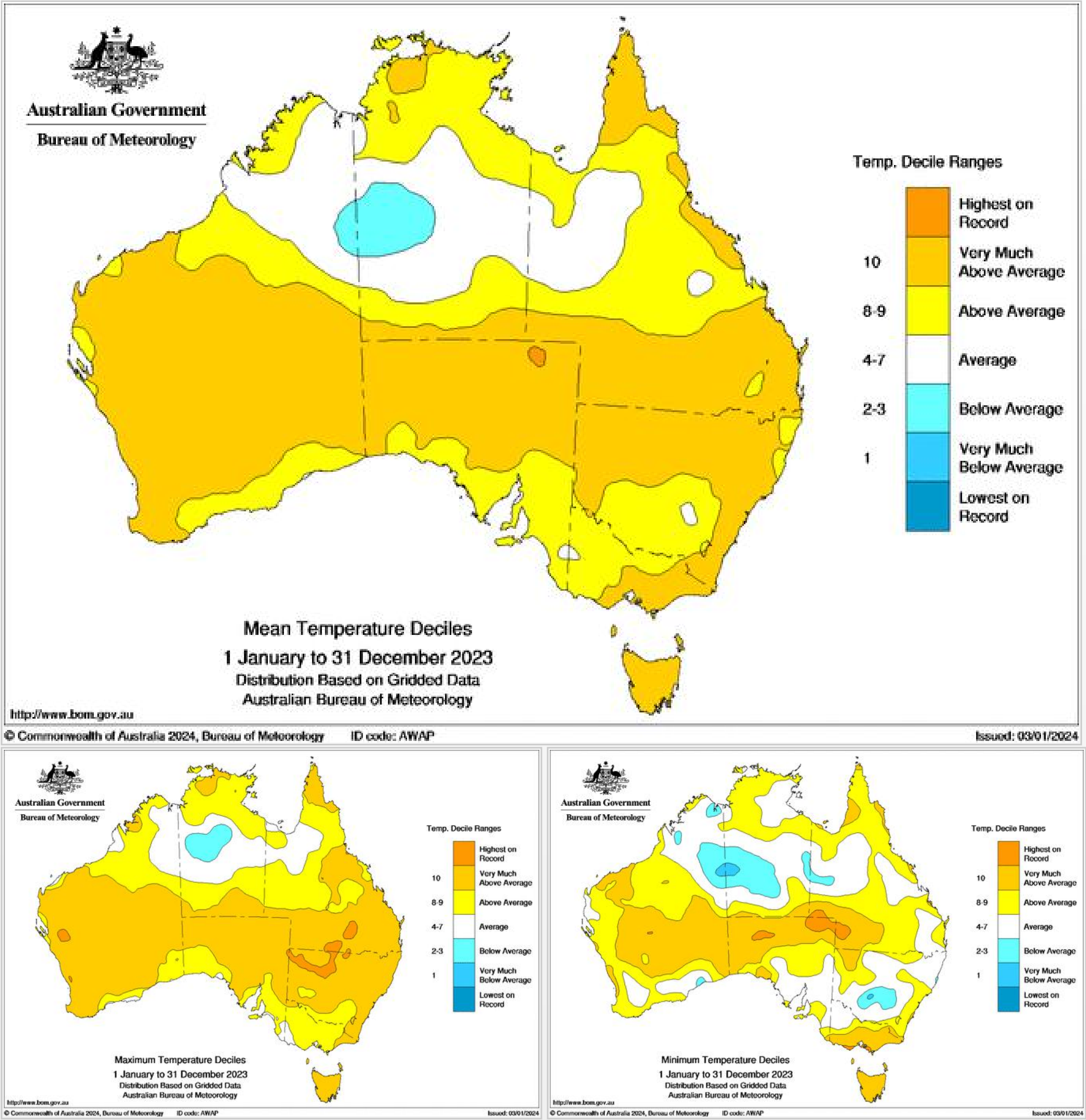
Australia's climate in 2023

- Australia's equal eighth-warmest year on record with the national mean temperature 0.98 °C warmer than the 1961–1990 average.
- Both the mean annual maximum and minimum temperatures were above average for all States and the Northern Territory.
- Winter was Australia's warmest on record, with the national mean temperature 1.53 °C above the 1961–1990 average.
- Widespread warmth throughout the second half of the year. The mean national temperature for June, July, August, September, November and December were among the ten warmest on record.
- Between October to December parts of northern and central Australia were affected by frequent low-to-severe intensity heatwave conditions.
- Nationally-averaged rainfall was 1.6% above the 1961–1990 average at 473.70 mm.
- Rainfall was above the 1961–1990 average for much of northern Australia, but below the 1961–1990 average for Tasmania, much of the south-eastern quarter of Queensland, parts of northern New South Wales, western and southern Western Australia, and parts of southern Victoria, eastern and south-western South Australia.
- In the first quarter, Australia experienced multiple major flood events, mostly across inland and northern regions.
- The August to October period was Australia's driest three month period on record since 1900.
- Surface water storages declined, including those in the Murray–Darling Basin. However, Australia's total surface water storage volume remained high at the end of the year (at 74.1% of its accessible capacity).

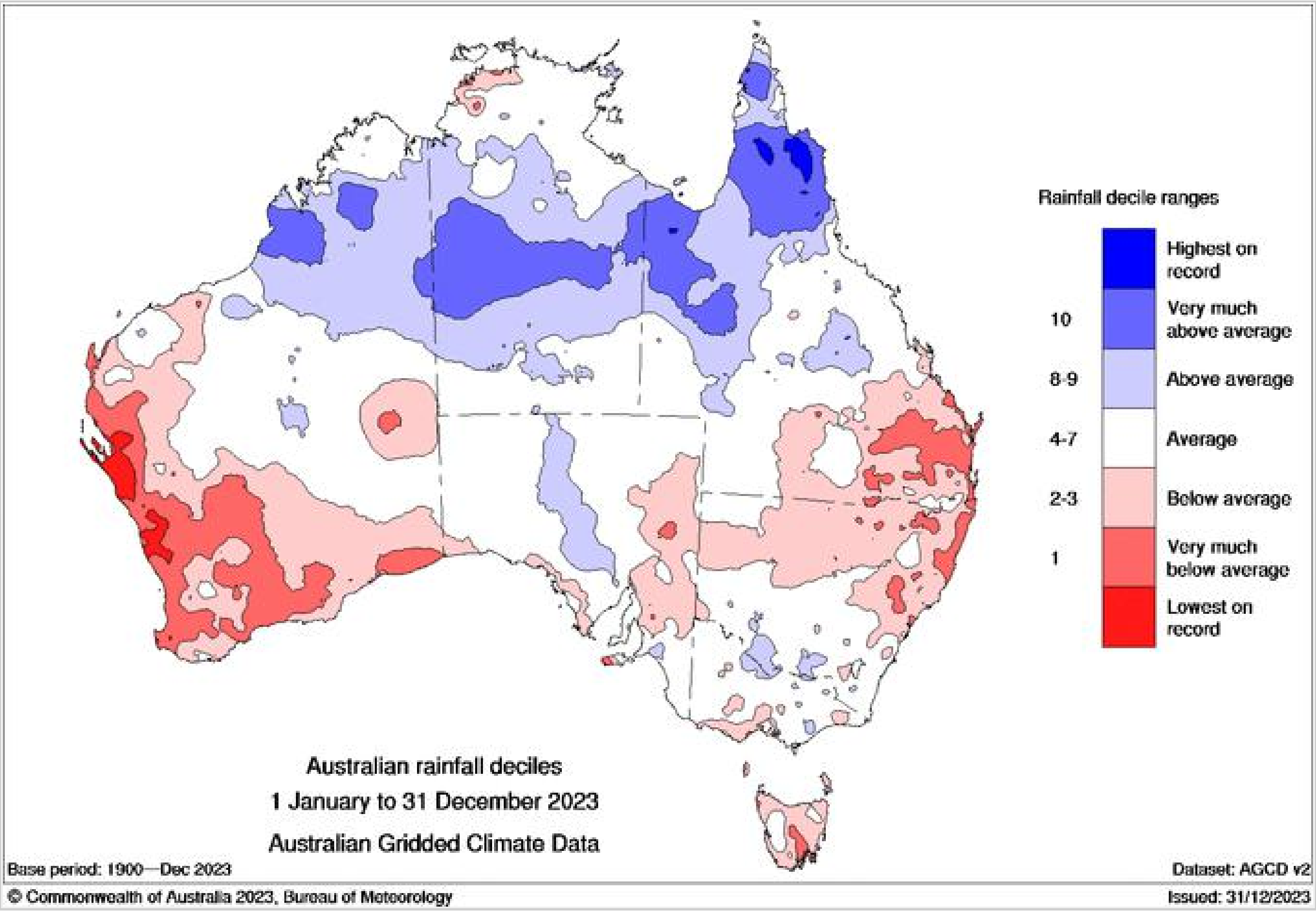
- Major global-scale climate influences on Australian climate in 2023 were La Niña at the start of the year, an El Niño and a strong positive Indian Ocean Dipole which were established in early spring, and a positive phase of the Southern Annular Mode towards the end of the year.

- Globally, it was the warmest year on record, with record warm oceans since April and record low Antarctic sea ice extent for much of the year.

2023 was Australia's equal–eighth warmest year on record, a year of contrasts for rainfall



2023 annual mean temperatures compared to historical temperature observations (top). See also annual mean maximum temperature (left) and annual mean minimum temperature (right). [About deciles.]



2023 annual rainfall compared to historical rainfall observations. [About deciles.]

2023 was Australia's equal-eighth warmest year on record, compared to all years since 1910, and the warmest year since 2020. Australia's area-averaged mean temperature for 2023 was 0.98 °C above the 1961–1990 average. The area-averaged mean maximum temperature was the fifth-warmest on record, at 1.34 °C above the 1961–1990 average, and the mean minimum temperature was 0.61 °C above the 1961–1990 average.

Annual national area-averaged rainfall was 1.6% above average at 473.70 mm (compared to the 1961–1990 average of 466.0 mm) and the lowest since 2019. Rainfall was above average across much of the north, but below average across parts of the east, south and west.

At the start of 2023, surface water storages were generally high across Australia at 77.9% of accessible capacity. With low streamflow for most sites across Australia and dry catchment conditions across much of the south of the country, surface water levels in many storages declined, with lower water storage levels in south-eastern Queensland and the Murray Darling Basin compared to 2022. However, total surface water storage volume remained high at the end of the year, at 74.1% of accessible capacity across Australia.

Sea surface temperatures (SSTs) in the oceans around Australia were 0.54 °C warmer than the 1961–1990 average and the seventh-warmest on record since 1900.

Net Antarctic sea-ice extent was either below the 1991–2020 average or at record lows throughout the year.

Several major global-scale atmospheric and oceanic circulation patterns influenced Australian climate in 2023. These included the weakening 2022–2023 La Niña at the start of the year, the strong positive Indian Dipole (IOD) and an El Niño that developed from the middle of the year, with a positive phase of the Southern Annular Mode (SAM) towards the end of the year.

The positive IOD, El Niño and positive phase SAM occurred in a climate influenced by global warming. Globally, 2023 was the warmest year on record, with the World Meteorological Organization reporting an average global temperature 1.45 ± 0.12 °C above the pre-industrial (1850–1900) baseline. The combination of major climate influences with global warming increased the likelihood of extreme climate events occurring in 2023, for example Australia's warmest winter and winter-spring periods on record.

Capital Cities

The 2023 annual mean maximum temperatures for all capital cities except Melbourne and Adelaide were 0 to 1 °C above their average, when compared with observations in recent decades (see table caption below for details of averaging periods). This placed them all within their 10 warmest years on records, and their warmest since 2019, with temperature observations starting in the 19th century at all capital cities except Canberra and Darwin. Sydney had its equal-second-warmest annual mean maximum temperature on record and Hobart its third-warmest.

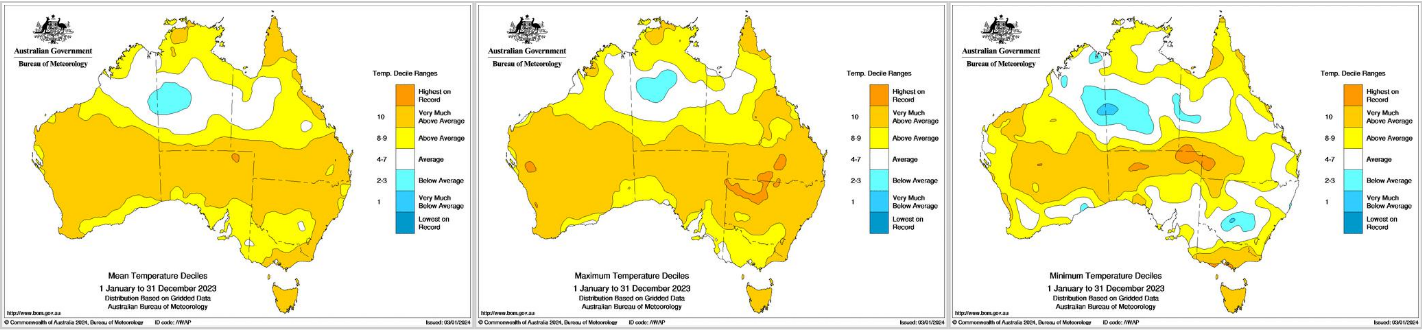
2023 annual mean minimum temperatures were within 0.5 °C of their average, compared to recent decades, for all capital cities. The annual mean minimum temperature for Hobart was the equal-second–warmest on record.

Rainfall was below average in 2023, compared to recent decades, for Sydney, Brisbane, Hobart, Perth and Darwin. Perth and Hobart both had their ninth–driest year on record. Annual rainfall was close to average for Melbourne and wetter than average for Canberra and Adelaide.

	Opened	Maximum temperature			Minimum temperature			Rainfall		
		2023 average (°C)	Anomaly (°C)	Historical rank	2023 average (°C)	Anomaly (°C)	Historical rank	2023 total (mm)	Anomaly (%)	Historical rank
Canberra	1939	21.2	+0.2	equal-8th warmest	6.5	−0.3		711.1	+10%	
Brisbane	1840	27.2	+0.6	equal-4th warmest	16.7	+0.2		777.4	-26%^	driest since 2019
Sydney	1858	23.8	+0.9	equal-2nd warmest	14.6	−0.1		1065*	-7%	
Melbourne	1855	20.2	−0.2		11.9	+0.2		574.4	+1%	
Hobart	1882	18.4	+0.8	3rd warmest	9.5	+0.5	equal-2nd warmest	422.8	-25%	9th driest
Adelaide	1839	22.3	−0.3		12.2	−0.2		587.6	+9%	
Perth	1876	25.5	+0.7	equal-5th warmest	13.4	+0.5	coolest since 2019	596.4	-18%	9th driest
Darwin	1941	32.9	+0.5	equal-5th warmest	23.7	+0.4		1365.0	-26%	driest since 2019

Table of annual rainfall and temperature values and anomalies for the capital cities. The year opened is the first year for which rainfall data is available; temperature data at Brisbane starts in 1887, at Sydney in 1859, at Adelaide in 1887 and at Perth in 1897.
Anomalies are relative to recent decades, usually determined by data availability at the current site. For each city these periods are: Canberra 2008–2023 (current Airport site); Brisbane 2000–2023 (current site); Sydney 1991–2020 (former Observatory Hill site); Melbourne 2013–2023 (current site); Hobart 1991–2020; Adelaide 1991–2020 (former Kent Town site); Perth 1994–2023 (current site); Darwin 1991–2020.
(^) The Brisbane rainfall climatology includes estimated annual totals for 2019, 2021 and 2022. This is due to equipment in those years, requiring an estimate of the rainfall over the period to obtain the annual rainfall total. Due to other equipment faults, the annual rainfall total for Brisbane cannot be reliably estimated for 2003, 2016, 2017 or 2020.
(*) The 2023 Sydney total includes an estimated 176 mm for February. An equipment fault from the 22nd to the 24th meant that the daily totals could not be reliably estimated. However, the estimated monthly total is consistent with nearby rain gauges.

Australia's equal eighth-warmest year on record



2023 annual mean temperatures compared to historical temperature observations (right), annual mean maximum temperature (middle), and annual mean minimum temperature (right). [About deciles.]

2023 was Australia's equal eighth-warmest year on record since 1910. For Australia as a whole, the annual national mean temperature was 0.98 °C above the 1961–1990 average and the warmest since 2020.

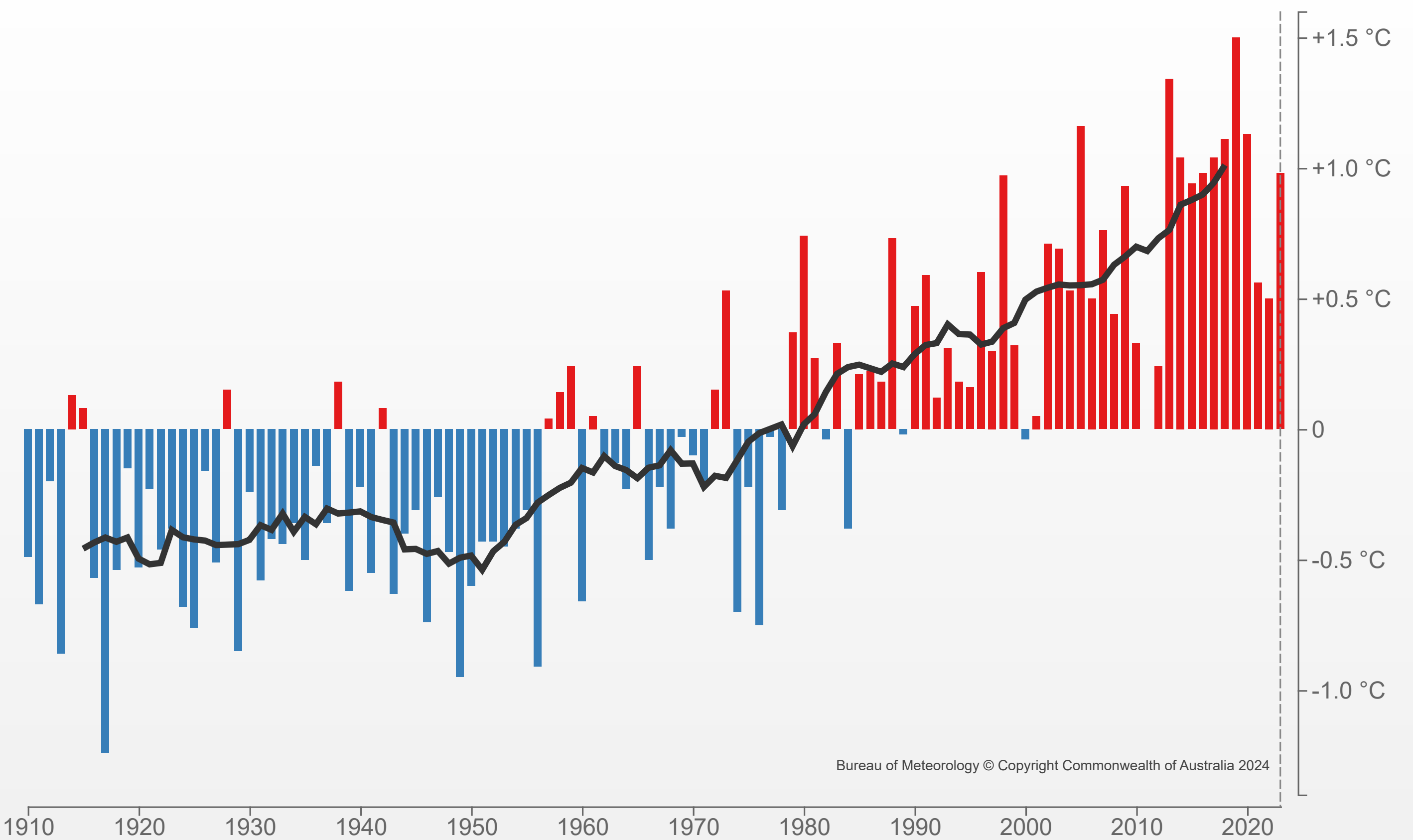
The national mean maximum temperature was 1.34 °C warmer than the 1961–1990 average, the equal fifth-warmest year on record, and the warmest since 2019. The national mean minimum temperature was 0.61 °C warmer than the 1961–1990 average and the coolest since 2021.

The national temperature dataset, ACORN-SAT, commences in 1910 and spans 114 years of observations.

Compared to the distribution across all years since 1910, annual mean, maximum and minimum temperatures were above average or very much above for most of Australia except for inland Northern Territory and adjacent parts of Western Australia. Minimum temperatures were also below average for an area of western Queensland and areas of inland New South Wales.

Australian mean temperature anomaly

2023 **+0.98 °C**



Mean temperature anomalies averaged over Australia (as calculated from the 1961–1990 average). The black line shows the 11-year moving average.

Summer 2022–23

The year commenced with the January national mean temperature close to average. It was the coldest January since 2002 and large parts of northern and central Australia exhibited cooler than average daytime temperatures consistent with heavy rainfall associated with ex-Tropical Cyclone Ellie and monsoonal rain. Cooler conditions continued across northern parts of the country into February, with below average mean temperatures across much of the central Northern Territory and western and central Queensland.

Autumn

The national mean temperature was close to the 1961–1990 average for autumn. The national mean maximum temperature in April was cooler than average. In Western Australia below average April temperatures were consistent with above average rainfall due to tropical moisture over the state. Conversely, mean maximum temperatures were above average for northern and eastern Queensland, with many sites in Queensland's north-east experiencing their warmest mean maximum temperature on record for April.

In May, the national mean temperature was 1.10 °C below the 1961–1990 average and the lowest since 2011. Minimum temperatures in May were cooler than average for much of the country and in the lowest 10% of historical observations for large parts of central, northern and eastern Australia. This was caused by a combination of clear skies and light winds under a ridge of a high pressure dominating much of the country and strong cold fronts crossing southern and northern parts of the country.

Winter

A persistent ridge of high pressure dominated throughout winter. It was Australia's warmest winter on record (since 1910), with the national mean temperature 1.53 °C above the 1961–1990 average. It was the warmest June on record for much of Queensland and in July most of Tasmania and the eastern parts of southeast Australia had their warmest July on record. The national mean maximum temperature in August was the second-warmest on record and daytime temperatures were in the highest 10% of historical observations for most of the country.

Spring and December

Warmer and drier conditions continued into September. Nationally, September was the third-warmest on record since 1910. Many stations across Tasmania, Victoria, New South Wales and Western Australia had their highest daily September maximum and minimum temperatures on record. The winter to spring mean temperature (July–November) was 1.69 °C above the 1961–1990 average, surpassing the previous record in 2019 at 1.60 °C.

Exceptionally warm conditions persisted throughout November and December, as the mean temperature was the ninth- and fourth-warmest on record respectively. December was among the top 10 warmest on record for every state and territory, except Victoria and South Australia.

Area-average temperatures

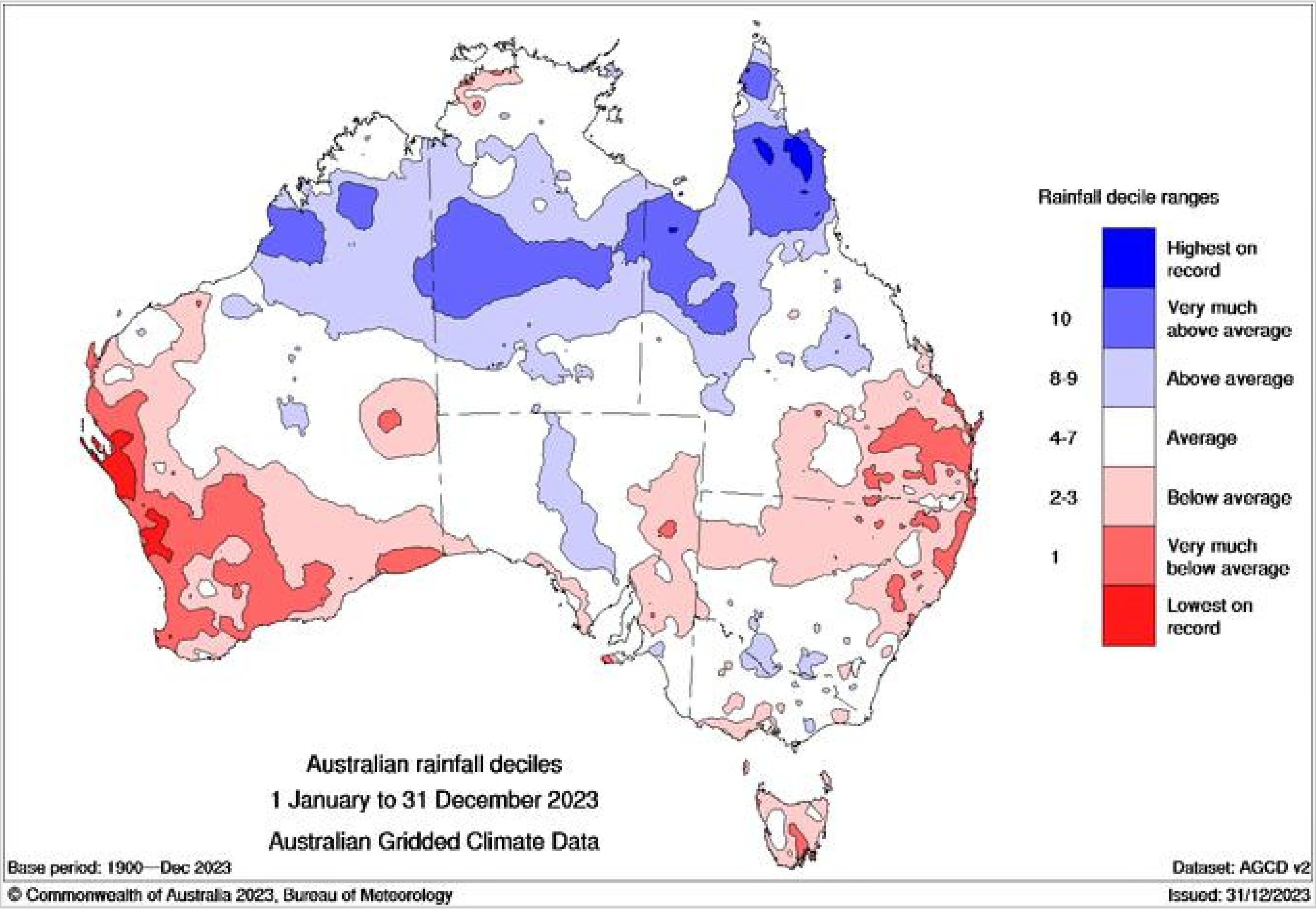
	Maximum Temperature			Minimum Temperature			Mean Temperature		
	Rank (of 114)	Anomaly (°C)	Comment	Rank (of 114)	Anomaly (°C)	Comment	Rank (of 114)	Anomaly (°C)	Comment
Australia	= 109	+1.34	equal 5th highest	= 97	+0.61		= 106	+0.98	equal 8th highest
Queensland	108	+1.34	7th highest	97	+0.99		105	+1.17	10th highest
New South Wales	112	+1.96	3rd highest (record +2.44 °C in 2019)	93	+0.63		109	+1.30	6th highest
Victoria	98	+0.69		= 103	+0.69		104	+0.69	
Tasmania	111	+0.93	4th highest (record +1.06 °C in 2014)	112	+0.68	3rd highest (record +1.03 °C in 2016)	112	+0.81	3rd highest (record +0.86 °C in 1988)

South Australia	109	+1.55	6th highest	= 106	+0.74	equal 8th highest	108	+1.15	7th highest
Western Australia	112	+1.52	3rd highest (record +2.52 °C in 2019)	102	+0.53		109	+1.03	6th highest
Northern Territory	= 91	+0.58		= 64	+0.13		83	+0.36	

*Rank ranges from 1 (lowest value on record) to 114 (highest value on record). The national temperature dataset commences in 1910. A rank marked with '=' indicates that a value is shared by two or more years, resulting in a tie for that rank.
^Anomaly is the departure from the long-term (1961–1990) average.

In climatology a baseline, or long-term average, is required against which to compare changes over time. The Bureau uses the 1961–1990 period as the climate reference period for the Annual Climate Statement and other climate monitoring products. It has no bearing on the calculation of trends over time, or the ranking of one year compared to all other years in a dataset.

Annual rainfall above average for much of the north, and below average other parts of the country



2023 annual rainfall compared to historical rainfall observations. [About deciles.]

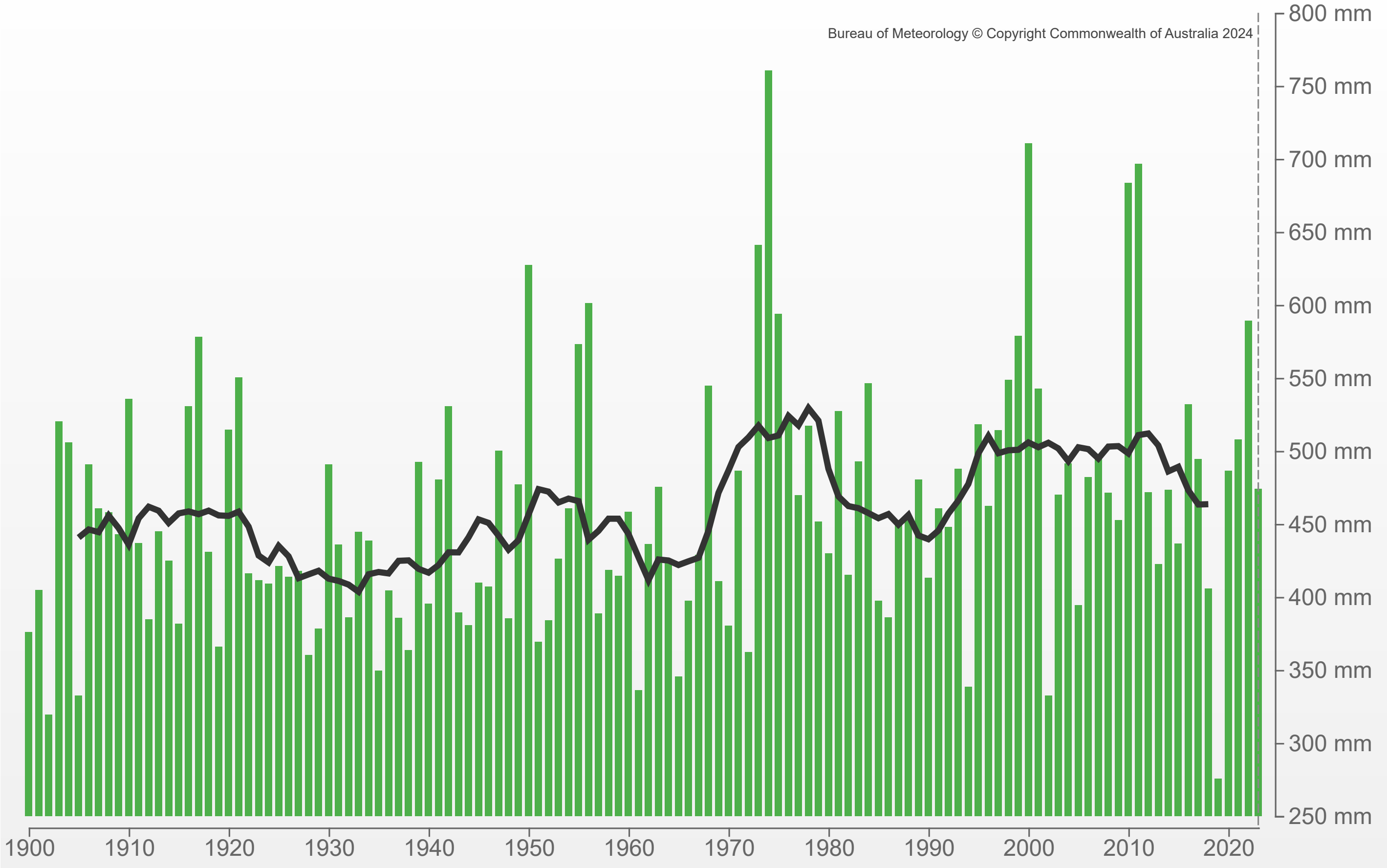
Nationally, the area-average annual rainfall total for Australia was 473.70 mm, 1.6% above the 1961–1990 average of 466.0 mm.

Rainfall was above to very much above average for much of the Northern Territory, western and northern Queensland, Western Australia's Kimberley, Pilbara and interior and parts of central South Australia. Rainfall was very much above average for parts of northern and western Queensland, central parts of the Northern Territory and north-west Western Australia.

Rainfall for the year was below average for most of Tasmania, the south-eastern quarter of Queensland, northern New South Wales, much of western and southern Western Australia, parts of eastern and coastal South Australia, southern Victoria, and the Top End in the Northern Territory. Rainfall was very much below average for large areas in western and southern Western Australia including an area of the Southern Interior district, and parts of south-eastern Queensland, north-eastern New South Wales and south-eastern and central Tasmania. Parts of the Gascoyne and Central West districts in Western Australia had their lowest rainfall on record.

Australian annual mean rainfall

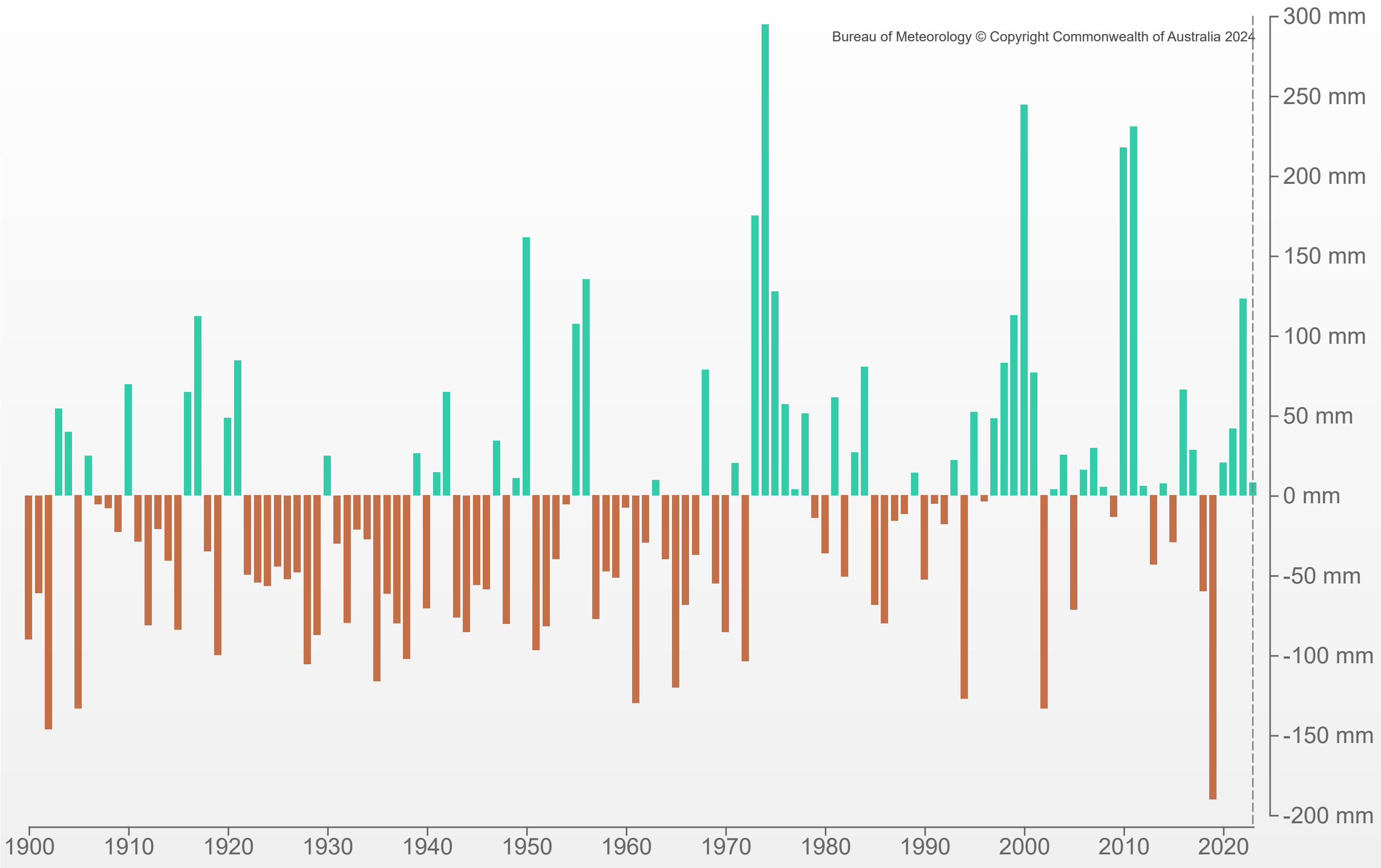
2023 **474.02 mm**



Annual mean rainfall totals for Australia. The black line shows the 11-year moving average.

Australian annual mean rainfall anomaly

2023 **7.99 mm**



Annual mean rainfall anomalies for Australia (as calculated from the 1961–1990 average).

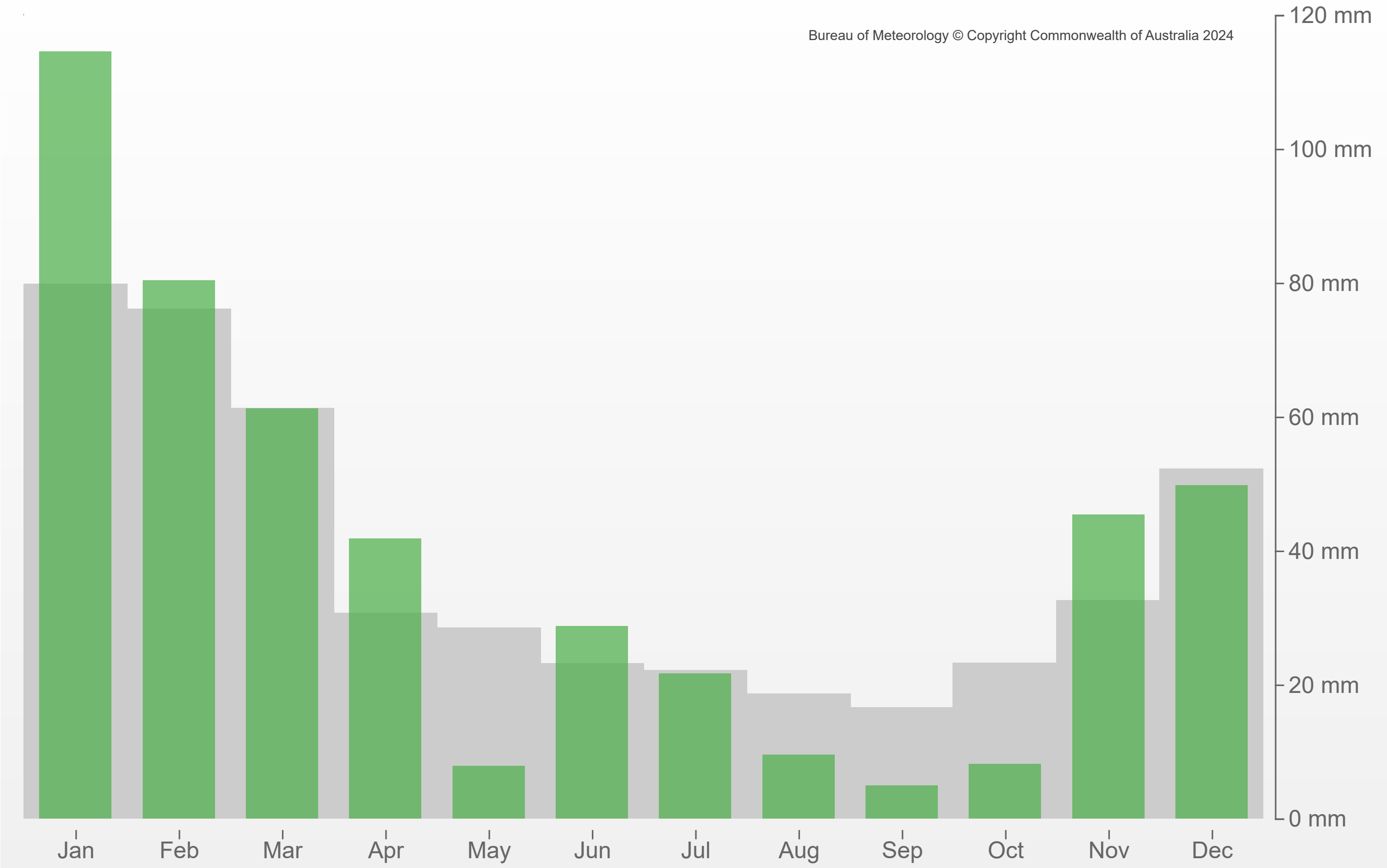
Monthly rainfall

The year started with Australia's ninth-wettest January on record (since 1900). April was also a wet month nationwide.

In contrast, May, August, September and October were all in the ten driest for their respective months. For Australia as a whole, August–October 2023 was the driest three month period on record since national observations began in 1900. September was also the second-driest on record for any month, behind April 1902.

In November, rainfall totals were above the 1961–1990 average for most of Australia as large areas of central, northern and eastern Australia were impacted by widespread and at times heavy rainfall and isolated thunderstorms.

Australian mean monthly rainfall



Monthly mean rainfall totals for Australia. The grey bars show the monthly mean for 1961–1990.

Northern Australia

Over January to April, the latter part of the 2022–23 northern wet season, northern Australia rainfall totals were generally above average. Rainfall was in the highest 10% of all years since 1900 for large parts of north-west Western Australia, central Northern Territory, and north-western and northern Queensland. The above average rainfall was mostly related to tropical systems that brought heavy rainfall to northern Australia at the beginning of January, late in February and early March. In mid-April, heavy rainfall in northern Western Australia was associated with severe Tropical Cyclone Ilsa which made landfall on the Pilbara coast of Western Australia.

At the start of the 2023–24 northern wet season (October–December), rainfall was close to average to below average for most of northern Australia, and above to very much above average for parts of north-eastern and eastern Queensland. Rainfall was the highest on record for most of the North Tropical Coast and Tablelands district of Queensland as a result of heavy rainfall from ex-Tropical Cyclone Jasper in mid-December.

Southern Australia

Rainfall across southern Australia was below the 1961–1990 average from May to October. High pressure systems over much of the country brought settled weather and cloudless skies, with fewer rain-bearing systems and cold fronts affecting southern Australia. Persistent thunderstorms and heavy rainfall during November and December resulted in above average rainfall in the east and south-east of Australia.

Rainfall deficiencies

Summer rainfall (December 2022 to February 2023) was below to very much below average for much of the southern half of Western Australia, northern and eastern New South Wales and Victoria, and most of Tasmania and south-eastern Queensland. As a result, serious or severe rainfall deficiencies (totals in the lowest 10% or 5% of historical observation since 1900) emerged in summer across south-western and south-eastern Western Australia, western Victoria, western Tasmania, north-eastern New South Wales and south-eastern Queensland.

The following months (May to August 2023) were dry for large parts of the country, resulting in the intensification of existing rainfall deficiencies and their development in new areas particularly across western and southern parts of Western Australia.

For Australia as a whole, August to October 2023 was the driest three month period on record since national observations began in 1900. During that period, areas of severe or serious rainfall deficiencies developed across most of the Northern Territory, into South Australia along the south-west and southern coast, northern Tasmania and much of eastern Australia.

Extensive rainfall over parts of eastern and southern Australia in November and December, reduced or removed areas with serious or severe rainfall deficiencies in eastern parts of the country. By December 2023, the most significant rainfall deficiencies were for the eight month period (May to December) across most of the west of Western Australia, parts of the Southern Interior district and much of the Eucla district, and to a lesser extent, in north-eastern New South Wales.

For more information on rainfall deficiencies during 2023 see the monthly Drought Statements.

Area-average rainfall

Area-average rainfall

	Rank (of 124)	Average (mm)	Departure from mean	Comment
Australia	78	474.0	+2%	
Queensland	92	699.1	+12%	
New South Wales	24	425.9	−23%	
Victoria	55	624.5	−6%	
Tasmania	25	1200.5	−12%	
South Australia	55	196.6	−12%	
Western Australia	58	332.3	−3%	
Northern Territory	99	624.3	+14%	
Murray-Darling Basin	33	396.2	−20%	

*Rank ranges from 1 (lowest value on record) to 123 (highest value on record). The national rainfall dataset commences in 1900. A rank marked with '=' indicates that a value is shared by two or more years, resulting in a tie for that rank.
^Departure from mean is relative to the long-term (1961–1990) average.

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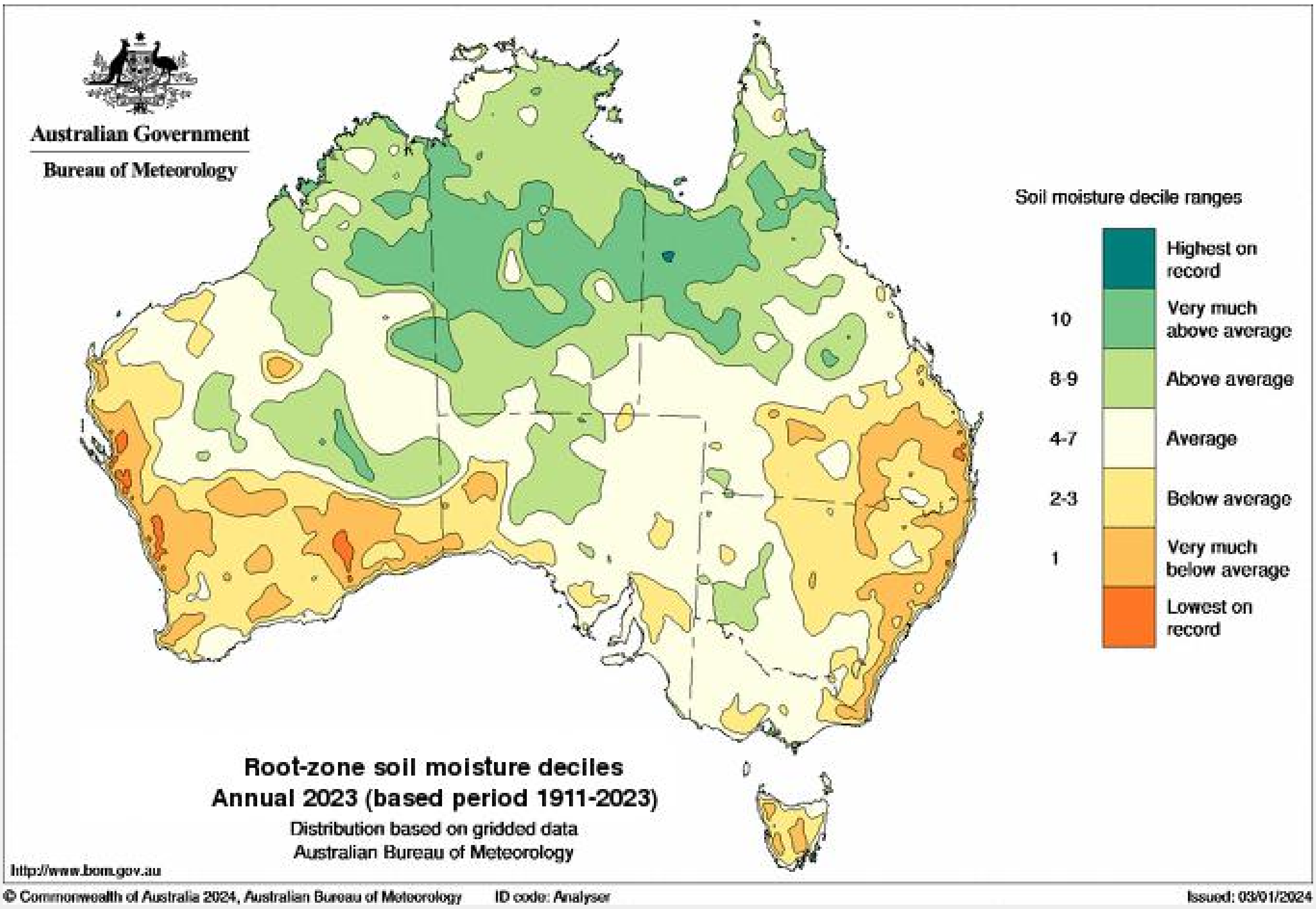
Water resources influenced by wet conditions in the north and dry conditions in the south

Australia's water resources were influenced by wet conditions in the north at the beginning of the year, and dry conditions in the south during winter.

- Soil moisture in the root zone (in the top 100 cm) was above to very much above average for parts of north-eastern Western Australia, central Northern Territory, and north-western Queensland due to above average rainfall during the northern wet season (October 2022 to April 2023).
- Soil moisture was below to very much below average for much of the south-eastern quarter of Queensland and large parts of eastern New South Wales, Tasmania, and southern parts of South Australia and Western Australia due to dry conditions from May to October across much of southern Australia.
- Significant flooding occurred in the first quarter of 2023 in northern Australia, particularly in the Kimberley, Western Australia (in January) due to ex-Tropical Cyclone Ellie, and north-eastern Northern Territory and north-western Queensland (in late March and early April). In late January, some flash flooding was also observed across parts of New South Wales and southern Victoria, while major flooding from 2022 continued along the Murray–Darling River system.
- Damaging major floods affected northern Queensland in December as a result of ex-Tropical Cyclone Jasper.
- Following the rainfall patterns and catchment conditions, high streamflows were observed across northern Australia, including in the Kimberley (Western Australia), the Northern Territory and the northern wet tropics of Queensland. In contrast, low streamflows were observed across southern parts of the country.
- With low inflows in the southern parts of the country, levels in many surface water storages decreased in 2023, including for those in the Murray–Darling Basin. Storages in south-eastern Queensland continued to decline. However, total surface water storage volume remained high at the end of the year (74.1% of accessible capacity) despite decreasing from the volume at the beginning of the year (77.9% of accessible capacity).
- No significant change was observed in groundwater levels during 2023 from the previous year. This means groundwater levels continued to recover to pre-drought conditions in the northern Murray–Darling Basin and southern Queensland following periods of heavy rain and flooding, while

groundwater levels continued to decline in the Victoria–South Australia border region and south-west Western Australia.

Above average soil moisture in the north and below average in the south-east and south-west of the country



Root-zone soil moisture deciles map from the Australian Water Resources Assessment Landscape model (AWRA-L) 7.0 for the 2023 calendar year. Based on all years since 1911. [About deciles.]

Annual

In 2023, root zone soil moisture (in the top 100 cm) was above average for much of northern Australia, and very much above average (in the highest 10% of all years since 1911) for parts of the north-east of Western Australia, central Northern Territory, and north-west Queensland. This was largely due to above average rainfall in much of northern Australia from January to April and during November and December. In contrast, soil moisture was below to very much below average for much of the south-eastern quarter of Queensland and large parts of eastern New South Wales, Tasmania, and southern parts of South Australia and Western Australia. This was due to very much below average rainfall (in the lowest 10% of all years since 1900) from May to October across much of southern Australia.

Early 2023

At the start of the year, soil moisture was above to very much above average for much of northern Australia and central New South Wales, largely due to above average northern wet season (October 2022 to April 2023) rainfall and Australia's second-wettest spring on record (since 1900) in 2022. During March and April, tropical moisture from Tropical Cyclones Herman and Ilsa resulted in heavy rainfall and thunderstorms mainly in western and northern Australia.

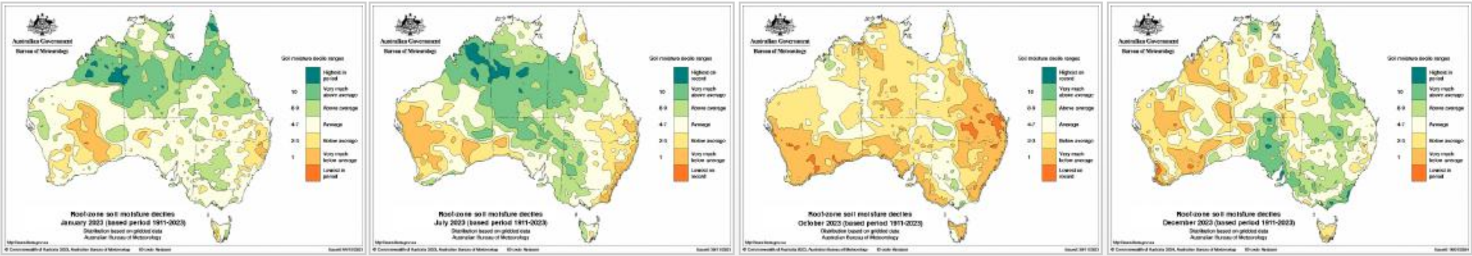
Mid 2023

Unseasonable rainfall events in parts of northern Australia at the end of June and in early July caused soil moisture to remain very much above average until July across much of the north of Western Australia, the north-western quadrant of Queensland, all of the Northern Territory except the Top End, and parts of northern South Australia.

Average to below average rainfall and above average temperatures in winter caused a decline in soil moisture for most of Australia, notably in the eastern and south-western parts of the country.

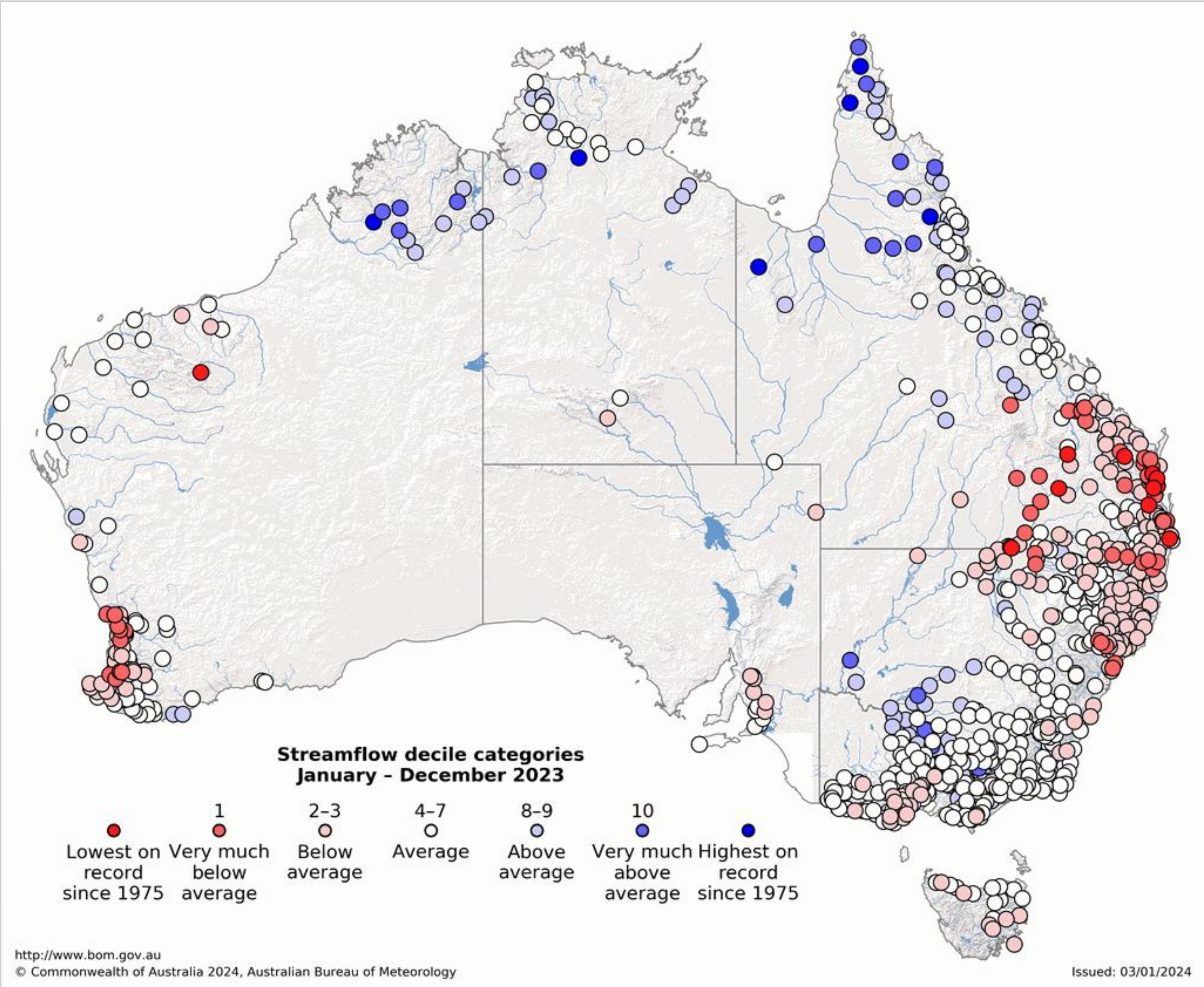
Late 2023

Following Australia's driest 3-month period on record (since 1900) from August to October, soil moisture decreased by end of October to very much below average (lowest 10% of all years since 1911) across much of southern, eastern and parts of central Australia. In contrast, above average rainfall in November and December helped in soil moisture recovery, with average to very much above average soil moisture conditions across much of Australia except in Western Australia and Tasmania.



Root-zone soil moisture deciles map from the Australian Water Resources Assessment Landscape model (AWRA-L) 7.0 for January, July, October and December. Based on all years since 1911. [About deciles.]

Above average streamflows in the far north and below average for the rest of Australia



Streamflow deciles for 2023, relative to all years since 1975. The analysis includes, in total, 838 sites which had at least 80% of daily observations available during 2023.

Streamflow conditions in 2023 mostly followed rainfall patterns throughout the seasons.

As a result of near average annual rainfall and dry catchment conditions in the later part of the year, streamflows were average to below average across much of Australia (compared to all records since 1975). Streamflows were very much below average in the north-eastern parts of the Murray—Darling Basin, south-eastern Queensland, and south-west of Western Australia.

In contrast, above to very much above average streamflows were observed in northern Australia, including the Kimberley (Western Australia), Northern Territory and across the northern wet tropics of Queensland. This was due to the above average rainfall and wet catchment conditions in much of northern Australia.

Highest on record streamflows were observed only at 1% of the 838 sites where streamflow is measured and analysed. Higher than average streamflows were measured at 17% of sites, mostly in the Kimberly region, northern parts of the Northern Territory and Queensland, southern New South Wales, and northern Victoria. 52% of sites experienced average streamflows, mainly across the east and south-east coasts. Below average or very much below average streamflows were recorded at 31% of sites, mostly in the east and south-west coasts.

Streamflow decile category	Number of sites	Percentage of sites (%)
Highest on record	5	1
Very much above average	21	3
Above average	120	14
Average	434	52
Below average	199	24
Very much below average	47	6
Lowest on record	12	1

Table of the number of streamflow sites in each decile category for 2023. Observations from 838 sites where streamflow is measured and which had at least 80% of daily observations available during 2023.

Early-year floods across northern Australia

Despite average to below average streamflow conditions in 2023, some rivers observed their highest on record flows, associated with different flood levels. In the first quarter of 2023, Australia experienced multiple major flood events mostly in inland and across the northern regions.

Early 2023

Saturated soil condition across the country at the beginning of 2023 was a significant contributor to the severity of flooding and increased inflows into inland water storages. In early January, heavy rainfall associated with ex-Tropical Cyclone Ellie in northern Australia led to major flooding on the Fitzroy River, with significant damage to transport infrastructure. In late January, heavy rainfall and thunderstorms in south-eastern Australia caused localised flash flooding across parts of New South Wales (Sydney), as well as southern Victoria (Geelong). Major flooding continued along the Murray-Darling River system in January.

A monsoon trough and the slow-moving tropical low activity in late February and early March, caused minor to moderate flooding in some areas of eastern the Kimberley in Western Australia, through the Northern Territory Top End and the Cape York Peninsula in Queensland. Major flooding also occurred along several rivers across the eastern Northern Territory and north-western Queensland.

In mid-April, Ex-Tropical Cyclone Ilsa caused severe thunderstorms and heavy to locally intense rainfall with some flooding in northern Kimberley (Western Australia) and north-western Northern Territory.

Mid 2023

In June 2023 there were minor to moderate floods in some catchments in north-eastern Victoria, the Tarra River and north-eastern Tasmania due to high daily rainfall totals.

Across winter 2023, there was only some minor flooding in the Murray–Darling River in Victoria and New South Wales, north-western Tasmania and central-western Queensland, with below average rainfall in the southern states.

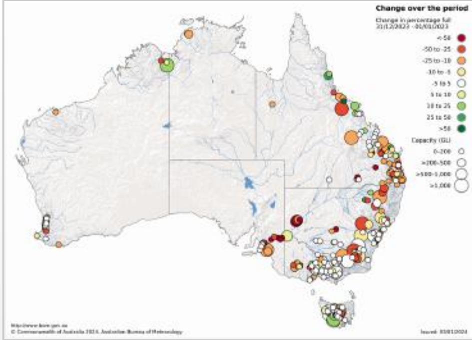
Late 2023

Heavy rainfall in early October brought some moderate flooding into Victoria and south-western New South Wales. Prolonged moderate to heavy rainfall in November resulted in minor to major flooding in south-western Queensland, south-eastern New South Wales and parts of Victoria's Gippsland.

In early December, northern Queensland was affected by damaging major flooding due to Ex-Tropical Cyclone Jasper. Outbreak thunderstorms also affected parts of New South Wales and south-eastern Queensland on the last days of 2023 with flash flooding.

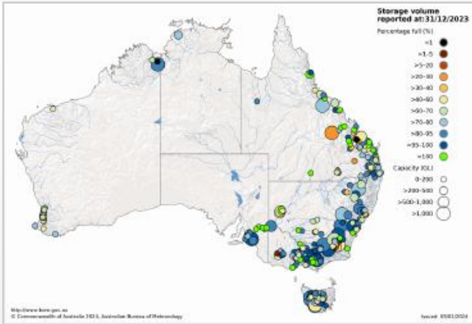
Decreased surface water volumes across most of the water storages

Due to dry catchment conditions across much of the southern parts of Australia, water levels in many surface storages decreased in 2023. However, total surface water storage volume remained high and finished 2023 at 74.1% of accessible capacity.



Map showing percentage change in storage system volume during 2023

Surface water storages supplying major capital cities started 2023 with over 80% of accessible capacity in all capitals except Perth (55.5%). Due to dry conditions in the second half of 2023, storages experienced significant water level declines in Darwin, Brisbane, Adelaide and Perth but remained similar to 2022 by the end of the year in the other capital cities. Perth's surface water storages remained lowest (46.5%) due to long-term decreases in its surface water inflows into storages.



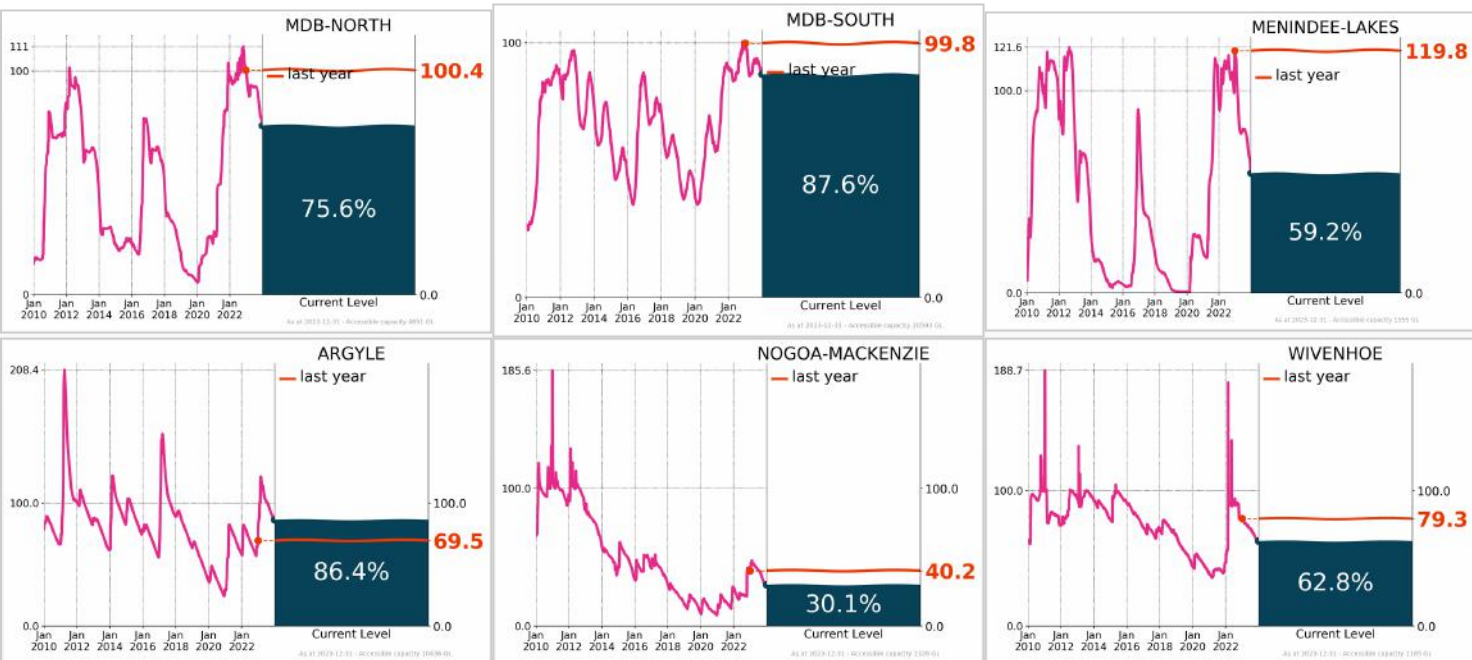
Map showing percentage full of storage system at the end of 2023

In January, major water storages in the Murray–Darling Basin were almost at their full capacity. Combined dry catchment conditions with irrigation season demand during the later months of 2023 resulted in a storage volume decrease in the Murray–Darling Basin by 14.5% from 2022. At the end of the year, major storages across the Murray–Darling Basin were at 85.4% of accessible capacity (compared to 99.9% full at the end of 2022). Many storages decreased in the northern Basin from 100.4% to 75.6%, and in the southern Basin from 99.8% to 87.6% throughout the year.

Below average rainfall and lower inflows from the Darling River caused water level decreases in the Menindee Lakes throughout the year and ended at 59.2%, significantly lower than its level at the end of 2022 (119.8%).

In northern Australia, above to very much above average rainfall during the wet season (October 2022 to April 2023) resulted in high soil moisture and inflows to Lake Argyle, the largest water supply storage in Australia. In March, storage volume in Lake Argyle reached to 121.4% of its accessible capacity – the highest level since 2017. However, its storage volume steadily declined from mid-March in response to dry season catchment conditions and finished the year at 86.4%, remaining at a higher level than the end of 2022 (69.5%).

Below average rainfall in south-eastern Queensland resulted in low inflows to the water storages in those areas. Therefore, storage volume in the Nogoa Mackenzie rural system continued to decline from mid-March and remained below 50% of its accessible capacity throughout the year, finishing 2023 at 30.1%, lower than 40.2% at the end of 2022. Wivenhoe, the largest storage in south-eastern Queensland, started at 79.3% of its accessible capacity and decreased throughout the year, reaching 62.8% by end of 2023 – a significant decline of 21% from the same time in 2022.

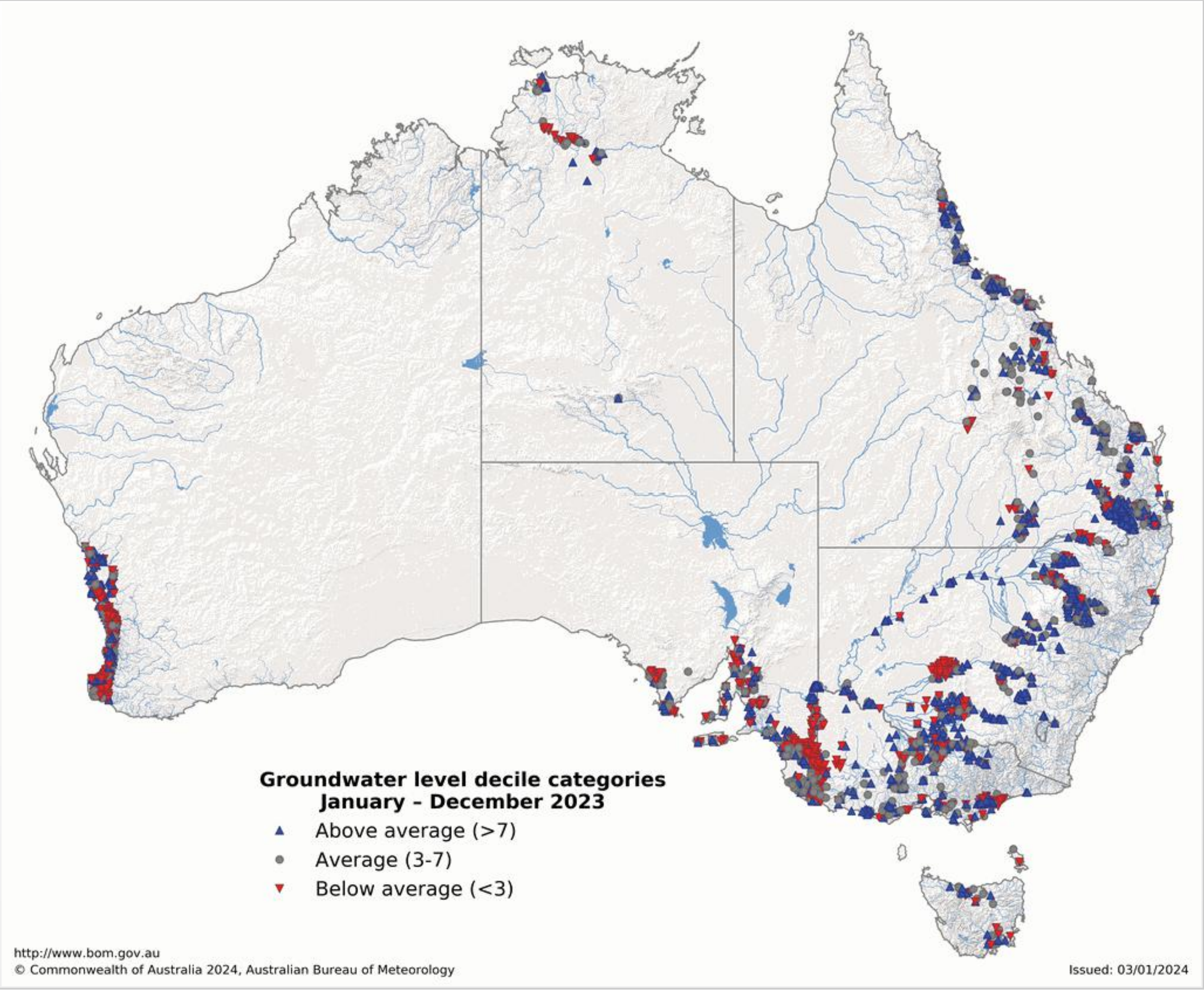


Percentage full (accessible capacity) at the end of 2023 compared to 2022 for Murray–Darling North and South, Menindee Lakes, Lake Argyle, Nogoa Mackenzie and Wivenhoe.

Individual storages

Australia has over 500 major storages, several thousand small storages, and in excess of two million farm dams. More detailed water information for eleven nationally significant water management regions is provided in the National Water Account. Individual timeseries of storage volume as a percentage of capacity for major storages are available from Water Data Online. Further details on individual storages in the Murray–Darling Basin can be found in the Murray–Darling Basin Water Information Portal.

Groundwater continues to recover in the east while declining in the Victoria–South Australia border and south-west Western Australia



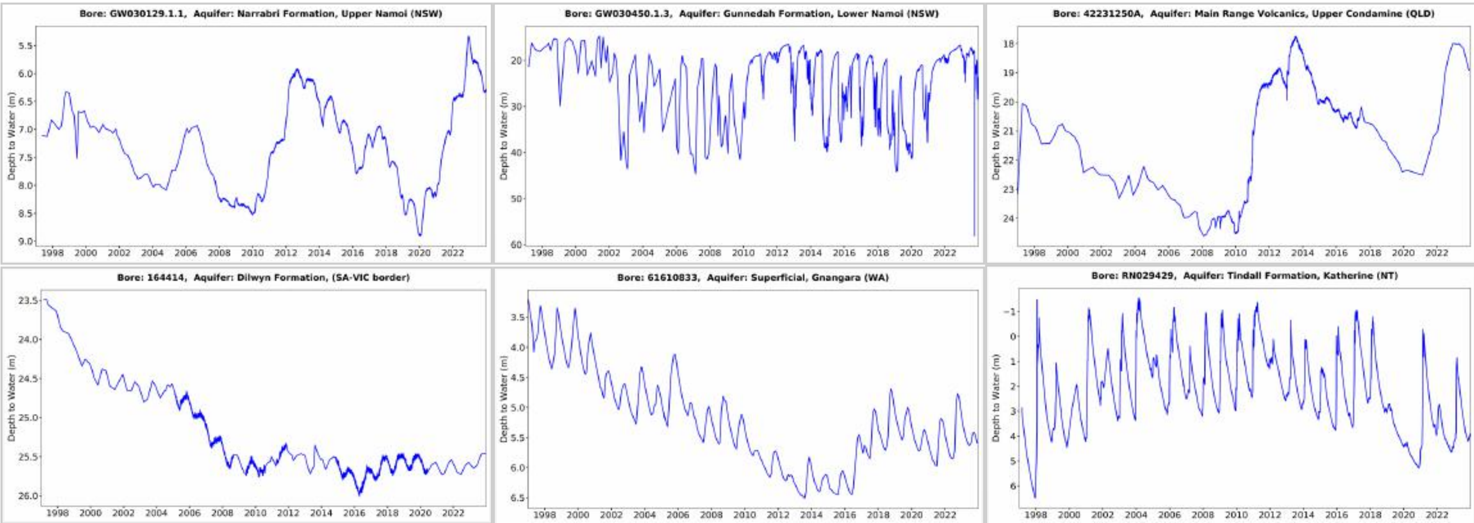
Groundwater level status map for Australia in 2023 (based on data records from 1997, except for Tasmania where records commence in 2008).

Groundwater level conditions in 2023 did not change significantly from 2022. There was still a lot of variation across Australia in 2023, with 26% of bores experiencing below average conditions, 31% experiencing average conditions and 43% observing above average conditions. More markedly, the groundwater level trends over the recent 5-year period (2019–2023) show the impact of three years of high rainfall with 49% of bores rising, 41% being stable, and only 10% declining.

In the northern Murray–Darling Basin and south-eastern Queensland, groundwater levels continued to recover, following periods of heavy rainfall and flooding since 2021. Further high rainfall and flooding in 2022 and into 2023 affected the whole Murray–Darling Basin and returned groundwater levels to the pre-drought conditions in many areas, including the aquifers of the Namoi and Condamine basins. In contrast, many of the bores in the Victoria–South Australia border region remained average to below average, reflecting both low rainfalls throughout recent years and long-term consequences of groundwater extraction.

In south-west Western Australia, groundwater levels have generally been in decline over the past 40 years due to the decreasing rainfall and increasing groundwater demands. Below average winter rainfall in 2023 resulted in less recharge to surficial aquifers of the Gnangara Mound.

In the top end of the Northern Territory, where groundwater recharge is reliant on wet season rainfall and streamflow, groundwater levels have shown some improvement since 2021. However, groundwater levels were average to below average at around 70% of bores in 2023 in this region.



Groundwater levels in the monitoring bores in the Narrabri and Gunnedah Formations in the Namoi catchment in the northern Murray–Darling Basin, Main Range Volcanics in Upper Condamine in Queensland, Dilwyn Formation in the Victoria–South Australia border, Gnangara Mound in Western Australia, and Tindall aquifer in the Katherine region, Northern Territory.

Australian climate influences in 2023

- Australian climate is influenced, or driven, by global-scale patterns in the atmospheric and ocean circulation. These patterns, or mode of variability, arise from physical processes in the global climate system, such as the Earth's rotation and the transfer of heat from warmer to colder regions. They can vary on a monthly, seasonal or annual basis.

- In 2023, the major climate influences on Australian climate were the El Niño–South Oscillation (ENSO) in the Pacific Ocean, which began the year in a La Niña state and finished the year as El Niño, a positive phase of the Indian Ocean Dipole (IOD) and a positive phase of the Southern Annular Mode (SAM).

- A relatively cool and wet start to the year, consistent with the weakening 2022-23 La Niña.

- August to October was Australia's driest three-month period on record (since 1900), during the development of a strong positive IOD and an El Niño in the tropical Pacific.

- Warmer than average temperatures across southern Australia in winter and spring, also consistent with a strong positive IOD and developing El Niño.

- Above average rainfall, with thunderstorms, across eastern Australia in November and December, consistent with a positive SAM at those times.

- The current global climate is also influenced by global warming attributable to increasing greenhouse gas concentrations. The World Meteorological Organization has reported that that 2023 was warmest year on record. Modes of variability such as ENSO, the IOD and SAM, are occurring in addition to this record global warmth. The combination of influences can lead to an increased likelihood of extreme climate events occurring.

- 2023 saw Australia's warmest winter and winter-spring periods on record, with national records starting in 1910.

- An analysis has found that the chances of Western Australia's record warm spring in 2023 occurring in the current climate, compared to one without global warming, was at least 50 times greater.

- Below average rainfall in across southern Australian in the cool season (April to October), consistent with atmosphere circulation changes attributable to global warming.

- Extreme rainfall totals in tropical north Queensland in December following Tropical Cyclone Jasper are consistent with a globally warmer atmosphere capable of holding more moisture.

Major climate influences during 2023: Warm sea temperatures, El Niño, positive IOD, positive SAM

El Niño-Southern Oscillation (ENSO)

After three consecutive years of La Niña (2020–2021, 2021–2202 and 2022–2023), oceanic and atmospheric indicators weakened towards neutral El Niño-Southern Oscillation (ENSO) values during summer 2022–23.

During early autumn in the southern hemisphere, the tropical Pacific Ocean began showing early signs of a developing El Niño. Sea surface temperatures (SSTs) in the central and eastern tropical Pacific Ocean warmed and by early June exceeded El Niño thresholds (+0.8 °C in the NINO3.4 region, a key indicator of equatorial central Pacific SSTs). However, it was not until early spring that the Bureau's El Niño criteria were met including sustained changes in the Pacific Ocean and atmospheric indicators including cloudiness, trade winds and the Southern Oscillation Index (SOI, a measure of the tropical Pacific pressure pattern).

The monthly NINO3.4 index reached a peak of 1.76 °C above the 1961–1990 average in November, before cooling slightly in December. El Niño atmospheric indicators of cloudiness and trade winds started returning to ENSO-neutral values from December and into January 2024. The SOI also returned to ENSO-neutral values from December, although values were also impacted by transient tropical systems during this period.

The 2023–2024 El Niño is notable for its concurrence with record warm ocean temperatures globally, which were sustained from April 2023 onward. Warm SSTs were also present in the western Pacific and in the Coral Sea (see the Oceans Section). The impact of these locally warm SSTs, and of global warming on the ENSO lifecycle, is the subject of ongoing research.

Indian Ocean Dipole (IOD)

A positive Indian Ocean Dipole (IOD) pattern developed in mid-August, with cooler than average waters off Java, and warmer than average waters off the Horn of Africa (see the Oceans Section). From mid-August, the Bureau's weekly IOD index was exceeding positive IOD thresholds (+0.40 °C) and peaked at +1.92 °C in the week ending 15 October. This was the second-highest peak on record in the Bureau weekly SST dataset, which began in 2001, behind only 2019, which saw a peak of +2.15 °C. IOD events typically break down late in the year as the monsoon trough shifts south into the southern hemisphere. Due to the strength of the positive IOD in 2023, the decay of the event was later than usual. The positive IOD eased through December, as the SST temperature gradient weakened, with the weekly IOD index returning to neutral in early 2024.

A positive IOD, alone or in conjunction with an El Niño, can influence Australian climate through their association with dry and warm conditions over much of the country during winter and spring, particularly in the south. Consistent with the developing strong positive IOD and the El Niño, August to October 2023 was Australia's driest three-month period on record (since 1900) and the national mean temperature was in the top 10 warmest on record (since 1910) for each month between June and December with the exception of October.

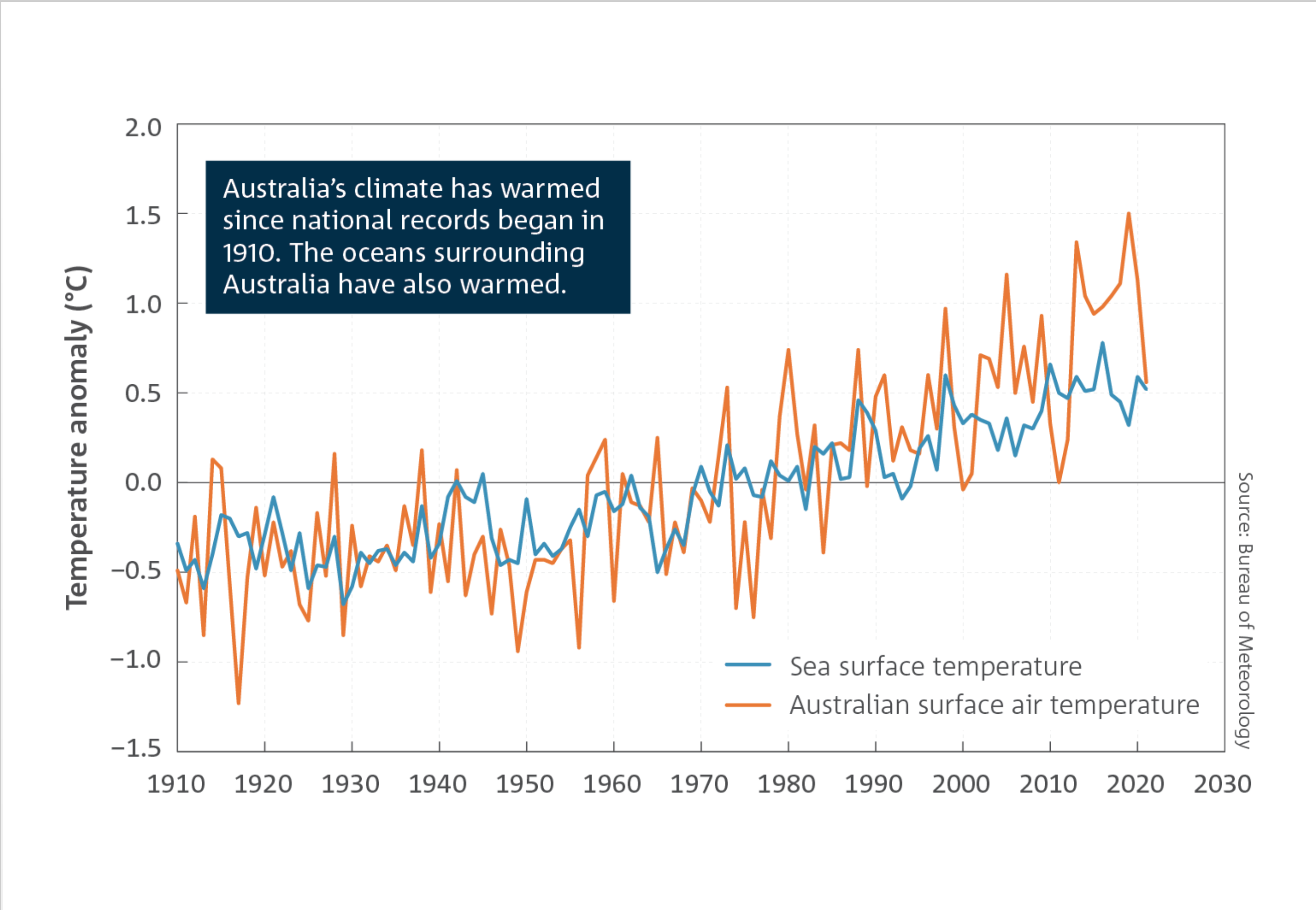
Southern Hemisphere mid-latitudes

In 2023, the Southern Annular Mode (SAM) was positive during January and for much of the period between September and December.

In spring and summer, a positive phase of SAM is defined by mid-latitude high pressure systems being located further south (further toward the pole), including in the Australian region. This hemispheric pattern is associated with winds over southern Australia that are more easterly than usual in spring and summer. This was particularly the case in November and December. In late November, slow moving high pressure systems to the south of Western Australia directed hot air in an easterly flow over south-west West Australia, causing prolonged heatwave conditions. Onshore easterly flow brought moist air over eastern and south-eastern Australia during November and December resulting in above average rainfall, with frequent heavy rainfall, thunderstorms and flash and riverine flooding.

The combination of El Niño and positive SAM in the latter part of 2023 is not common. Typically, an El Niño event induces a negative phase of SAM. While this forcing occurred at times in Pacific sector from September, the dominant influence elsewhere in the southern hemisphere midlatitudes was a stronger than usual polar vortex over Antarctica, particularly in November and December (see Ozone hole section).

Climate change



Anomalies in annual mean sea surface temperature, and temperature over land, in the Australian region. Anomalies are the departures from the 1961–90 standard averaging period. Sea surface temperature values (data source: ERSST v5, www.esrl.noaa.gov/psd/) are provided for a region around Australia (4–46 °S and 94–174 °E).

Australia

Based on the temperature dataset ACORN-SAT, Australia's climate has warmed on average by 1.50 ± 0.23 °C between 1910 when national records began and 2023, with most of the warming occurring since 1950. The ocean waters around Australia have also warmed significantly over the past century — rising by 1.05 °C since 1900, with 9 of the 10 warmest years on record (since 1900) occurring since 2010.

There has been a significant decline in cool season (April to October) rainfall observed over south-east and south-west Australia in recent decades. In 2023 cool season rainfall was 21% and 22% respectively below the 1961–1990 average for south-east and south-west Australia. In the south-east of Australia, there has been around a 9% decrease in cool season rainfall since the late 1990s. In the south-west of Australia, cool season rainfall has declined by around 16% since 1970.

The role of climate change and climate projections is further discussed in State of the Climate 2022.

Global

Based on data from 6 leading international datasets, the World Meteorological Organization (WMO) found that 2023 was the warmest year on record, with an average global temperature 1.45 ± 0.12 °C above the pre-industrial (1850–1900) baseline. The previous warmest years on record were 2016 and 2020, with 1.29 ± 0.12 °C and 1.27 ± 0.12 °C above the 1850–1900 average respectively. Global monthly temperatures between June and December also set new monthly records, with July and August the two hottest months on record. The WMO statement on the State of the Global Climate in 2023 also found that 2023 was the ninth consecutive year that the global annual mean temperature has reached at least 1 °C above pre-industrial levels, and that the past nine years (up to and including 2023) were the warmest on record for the globe as a whole. Global ocean temperatures were also at warmest-on-record levels for each month from April to December 2023 (see Oceans section).

An increase in greenhouse gas concentrations

Greenhouse

Concentrations of all the major long-lived greenhouse gases in the atmosphere rose again in 2023. Greenhouse gases are the principle driving force of global temperature increases. Carbon dioxide is the single most important anthropogenic greenhouse gas, accounting for approximately 64% of the radiative forcing by the long-lived greenhouse gases.

Greenhouse gas concentrations are based on air sampled at the Kennaook / Cape Grim Baseline Air Pollution Station in north-west Tasmania. Air masses sampled at the Kennaook / Cape Grim travel thousands of kilometres across the Southern Ocean, free of pollutants due to human and terrestrial influence, before arriving at the station. The air is well-mixed, making it representative of the background or 'baseline' composition of the atmosphere in the southern hemisphere. These baseline air samples have been measured at Kennaook / Cape Grim since 1976.

By December, the baseline concentration of carbon dioxide (CO_2) was 417.8 parts per million in dry air (ppm), an increase from 415.2 ppm in December 2022. A decade earlier, in December 2013, the concentration was 393.9 ppm. The December value marks a 50% increase from the pre-industrial concentration of 278 ppm in 1750. Pre-industrial concentrations are based on measurements of air trapped in ice and compacted snow collected at Law Dome, Antarctica.

The baseline methane (CH_4) concentration in December 2023 was 1874 parts per billion in dry air (ppb). This represents an increase of 10 ppb over 12 months and is 157% higher than the pre-industrial level of 729 ppb. Methane accounts for about 19% of the radiative forcing by long-lived greenhouse gases.

The baseline nitrous oxide (N_2O) concentration in October 2023 was 336.4 ppb, 1.1 ppb higher than the same time in 2022, and 25% higher than the pre-industrial concentration of 270 ppb. Nitrous oxide accounts for about 6% of the radiative forcing by long-lived greenhouse gases.

The relative radiative forcings and pre-industrial concentrations of carbon dioxide, methane and nitrous oxide are consistent with (and referenced in) the WMO Greenhouse Gas Bulletin No. 19 of 15 November 2023.

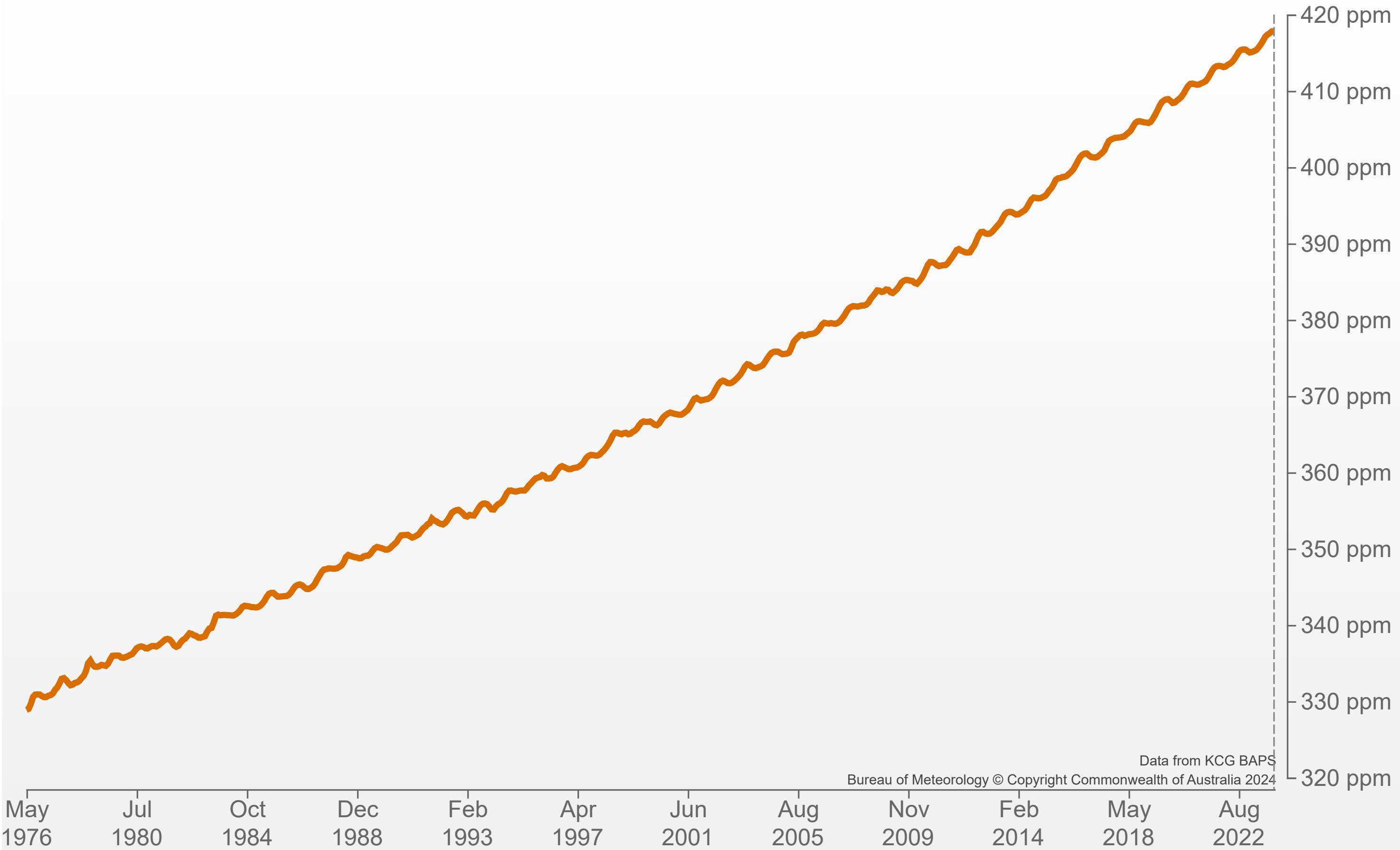
KCG BAPS is funded and managed by the Australian Bureau of Meteorology, and the scientific program is jointly supervised with CSIRO Oceans & Atmosphere. For more information on CGBAPS please see:

- CSIRO Kennaook / Cape Grim greenhouse gas data
- About the Kennaook / Cape Grim Baseline Air Pollution Station

See State of the Climate 2022 for further information about greenhouse gases.

Baseline gas carbon dioxide (CO_2)

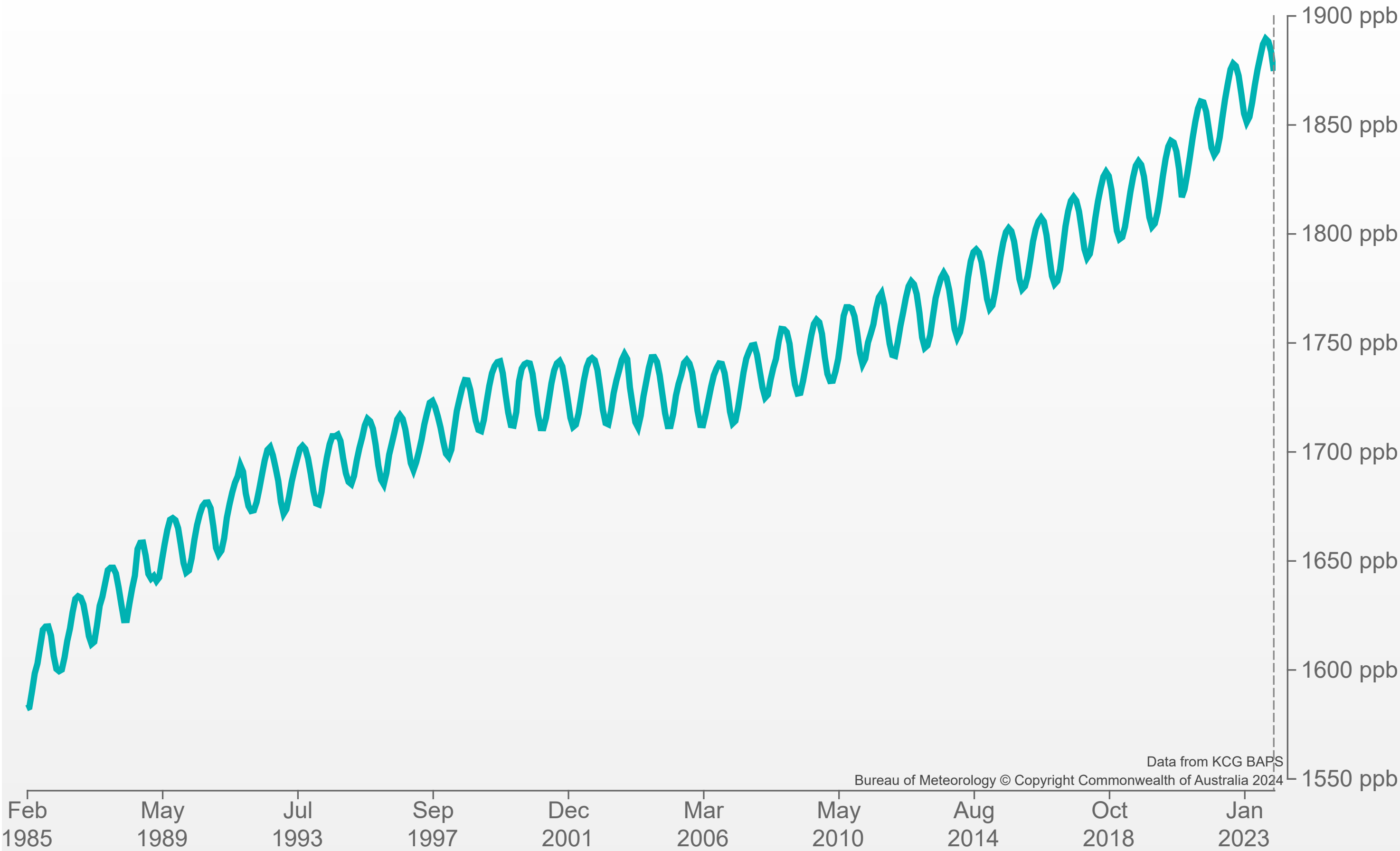
Dec 2023 **417.78 ppm**



Baseline concentration of carbon dioxide (CO_2) measured at Kennaook / Cape Grim Baseline Air Pollution Station.

Baseline gas methane (CH_4)

Dec 2023 **1874 ppb**



Baseline concentration of methane (CH_4) measured at Kennaook / Cape Grim Baseline Air Pollution Station. Monthly data are available from August 1984. Select each year to view the value.

Baseline gas nitrous oxide (N2O)

Oct 2023 **336 ppb**

Baseline concentration of nitrous oxide (N2O) measured at Kennaook / Cape Grim Baseline Air Pollution Station. Monthly data are available from August 1992.

A relatively large and long-lasting Antarctic ozone hole

The Antarctic ozone hole in 2023 was relatively large and long-lasting for the fourth consecutive year.

According to NASA satellite measurements, the ozone hole reached a maximum area of 26.0 million km2 on 21 September. The minimum value of total column ozone (a measurement of the total amount of atmospheric ozone in a given column) was 99 Dobson Units (DU), on 3 October. These values are comparable to those from the years 2020–2022. However, the 2023 ozone hole developed notably more rapidly than in the preceding 3 years.

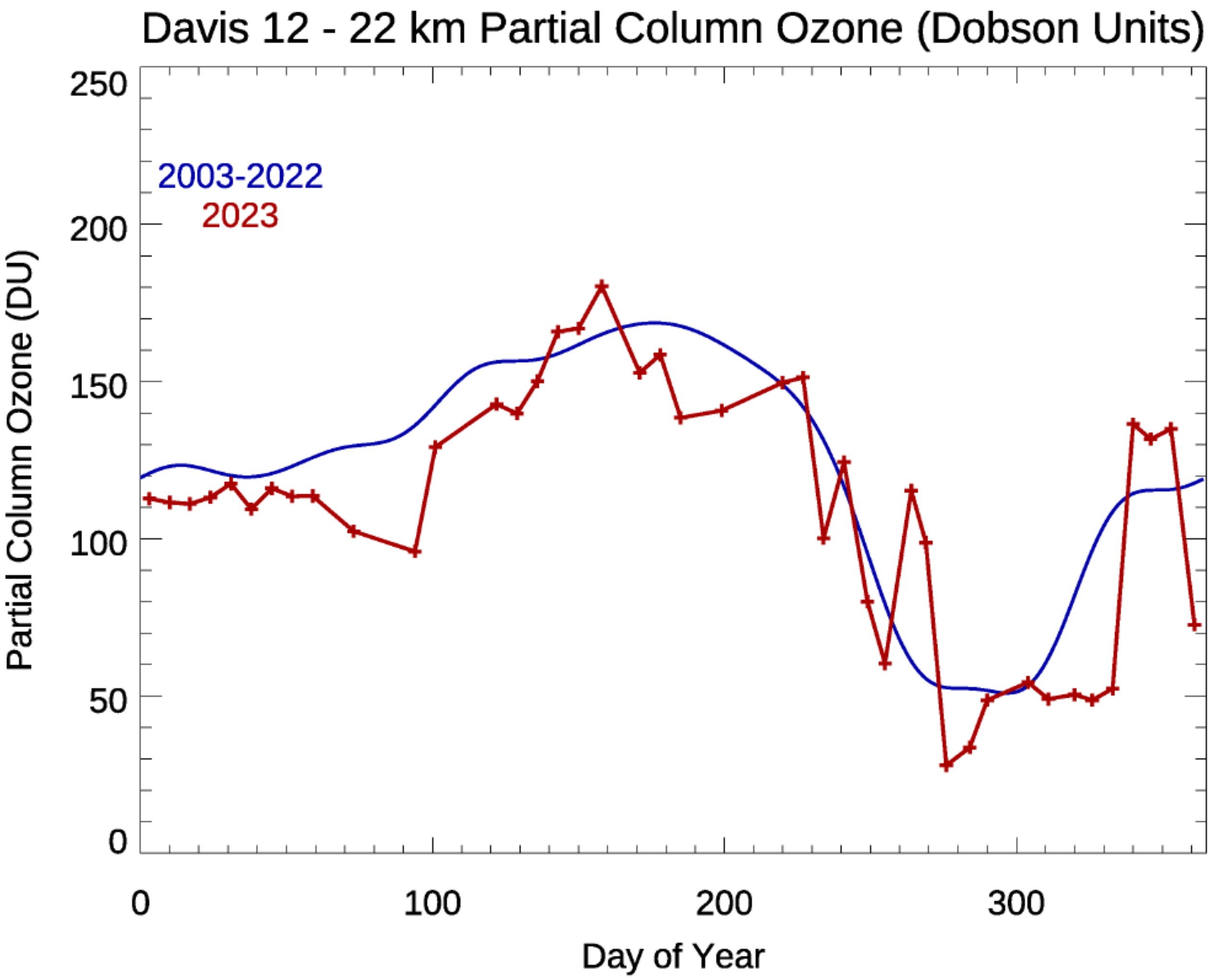
Weekly measurements made by the Bureau's balloon ozonesonde program at Davis station in Antarctica show ozone in the 12–22 km altitude range decreased by more than 80% from the middle of August to the beginning of October. The lowest observed value (partial column ozone between 12–22 km altitude) during 2023 was 27.97 DU, recorded on 3 October. Ozone observations at Davis commenced in 2003 (21 years of data). Compared to the lowest value observed since 2003, the 2023 minimum was the sixth-lowest annual minimum in the Davis record. Ozone values within this height range were also well below the 2003–2022 November average, consistent with the long-lasting ozone hole.

Although actions taken under the Montreal Protocol to end the use of ozone-depleting substances have been leading to a slow underlying recovery in Antarctic ozone since the year 2000, the year-to-year variability in the severity of the Antarctic ozone hole is determined primarily by meteorological conditions in the Antarctic stratosphere.

In 2023, significantly lower ozone was observed over the Antarctic region from mid-April to July and accompanied by a stronger-than-normal winter polar vortex in the mid-stratosphere. This was suggestive of an influence of the January 2022 eruption of the Hunga-Tonga-Hunga Ha'apai volcano. This eruption injected an unprecedented amount of water vapour directly into the stratosphere, which by early 2023 had been transported to the Antarctic polar vortex. The increased water vapour led to cooling in the lower stratosphere, increased formation of polar stratospheric clouds and increased reaction rates of heterogeneous chemical reactions leading to increased chemical loss of ozone.

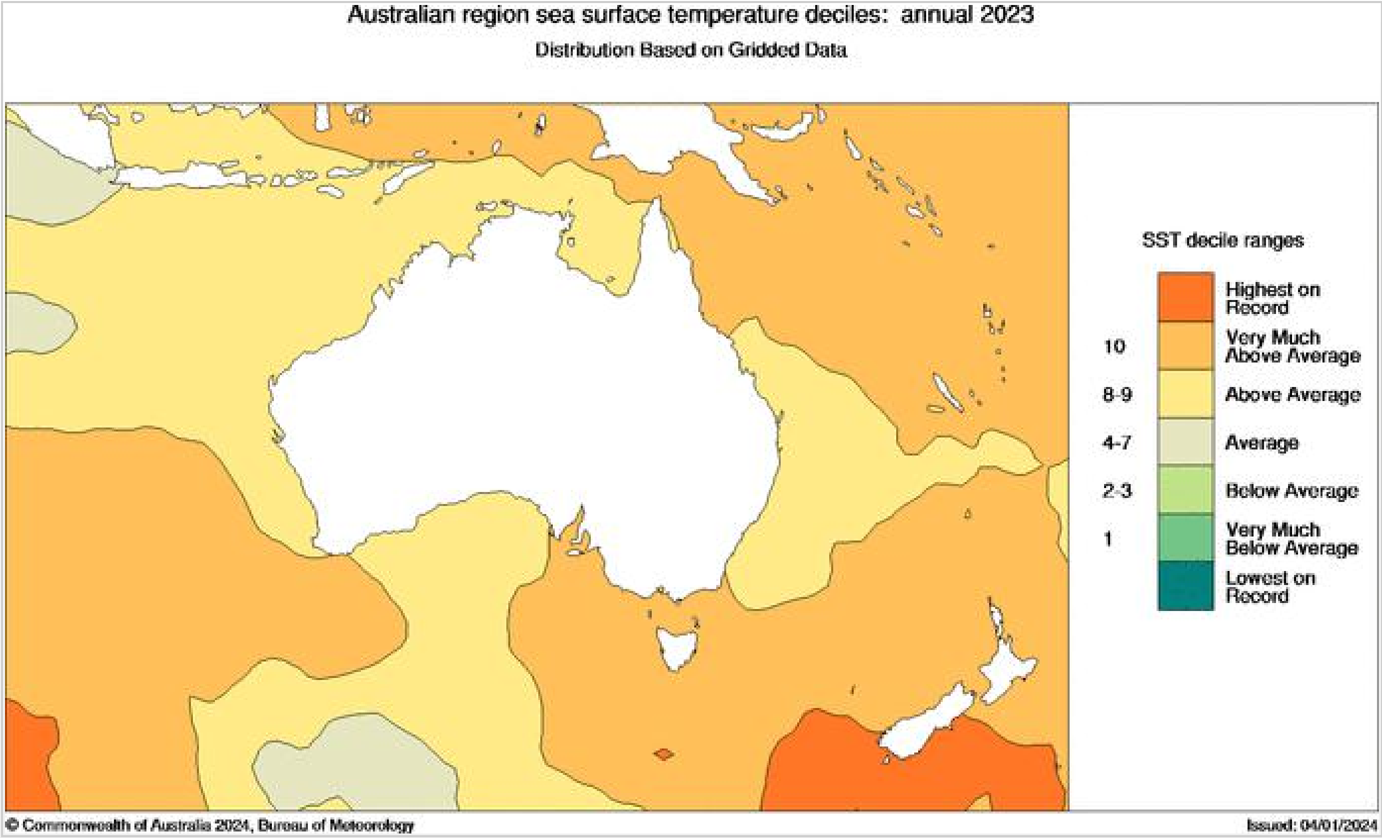
Concurrent with Antarctic ozone remaining lower than average for most of the spring of 2023, the polar vortex also maintained its strength for a longer period through December. These anomalously strong and cold polar vortex and low ozone conditions reinforced each other and pulled the southern hemisphere tropospheric midlatitude jet towards the pole in December. This resulted in a positive phase of the Southern Annular Mode (SAM).

See also: A review of Antarctic stratospheric ozone trends and variability and their impacts on surface climate



12–22 km partial column ozone measured by ozonesondes at Davis in Antarctica; sonde launches are weekly, listed by day of year. The blue crosses show values from all successful flights from 2003–2022, and (connected) red crosses the 2023 values. The light blue curve is a smoothed running mean, calculated using a 2-week span average of daily values, followed by a 45-day running mean. The program is operated in collaboration with the Australian Antarctic Division.

Sea surface temperatures seventh-warmest on record for the Australian region



2023 sea surface temperatures compared to historical records.
(From the NOAA Extended Reconstructed Sea Surface Temperature dataset, ERSST v5). About sea surface temperature regions and deciles.

The 2023 annual sea surface temperature (SST) anomaly for the Australian region (4°S to 46°S and 94°E to 174°E) was the seventh-warmest on record since 1900 and 0.54 °C above the 1961–1990 average based on data from the NOAA Extended Reconstructed Sea Surface Temperature (ERSSTv5) dataset. Above average annual SSTs have been observed for the Australian region every year since 1995.

Australian region

SSTs were warmer than average in waters around nearly all of Australia during 2023 and very much above average (in the highest 10% of all years since 1900) in waters off the north-east and south-east coast of the mainland and the south-west of Western Australia. Area-averaged SSTs for March, May, June, July, October, November and December, were in their top 10 warmest for their respective month (since 1900), with December being the second-warmest on record.

Monthly SSTs were in the highest 10% of historical observations in waters to the north of Australia between March to July, areas of the Coral and Tasman Seas from March to December, and waters to the south of Australia between August to December. SSTs were the warmest on record off the coast of southern Western Australia in October and December.

Moderate to strong marine heatwave conditions were also observed off the east coast of Tasmania from August to December. Peak anomalies (departures from the climatological average) of 2 to 3 °C warmer than the 1961–1990 average occurred during August to October and noticeably warmer anomalies occurred in November and December at 3 to 4 °C warmer than the 1961–1990 average.

The 2023 annual SST for the Coral Sea was the seventh-warmest on record at 0.61 °C above average. The Tasman Sea also had its seventh-warmest year on record, at 0.77 °C above average.

Pacific and Indian oceans

The development of El Niño in the equatorial Pacific during the southern hemisphere autumn and winter resulted in monthly SSTs in the central and eastern equatorial Pacific Ocean 1 to 3 °C above the 1961–1990 average from August to November. SSTs in the equatorial Pacific Ocean cooled slightly in December as the El Niño reached its peak.

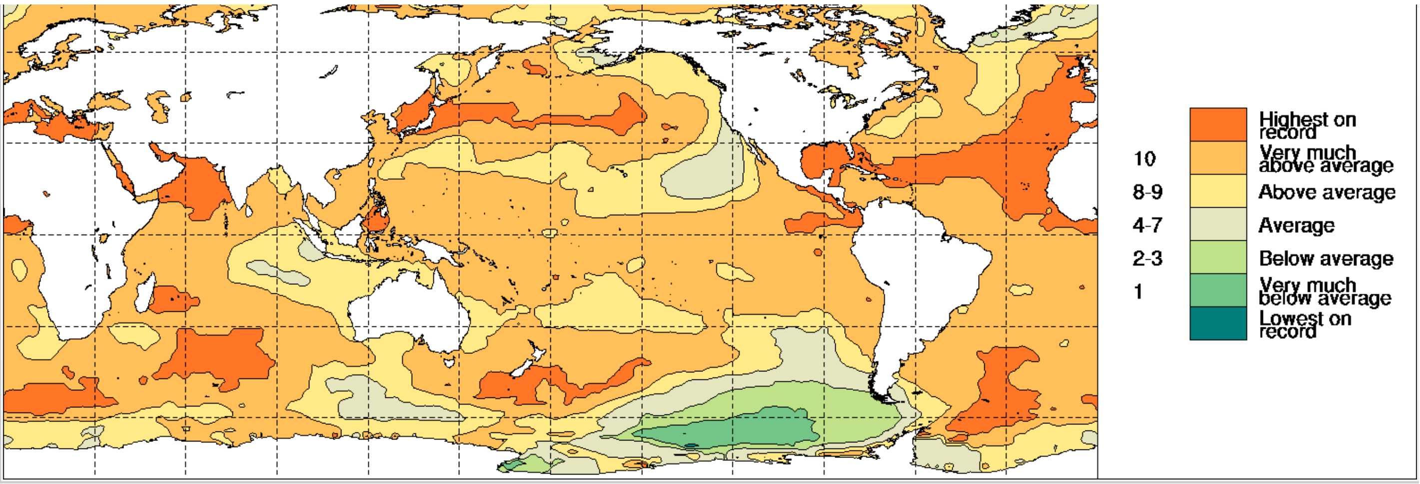
SSTs in the tropical western Pacific Ocean were up to 2 °C above average in some areas for much of the year since April. The persistence of warm SSTs in this region during the development of an El Niño is unprecedented in the observational record.

In the Indian Ocean, warmer than average waters developed across large regions from March. From July, cooler than average SSTs developed off the south–west coast of Java and expanded across most of the eastern tropical Indian Ocean, while the west Indian Ocean remained warm. The temperature difference, or gradient, between the western and eastern tropical Indian Oceans resulted in a strong positive Indian Ocean Dipole (IOD) from September, which persisted until December. The temperature gradient began to weaken in December with the movement south of the monsoon trough into the southern hemisphere.

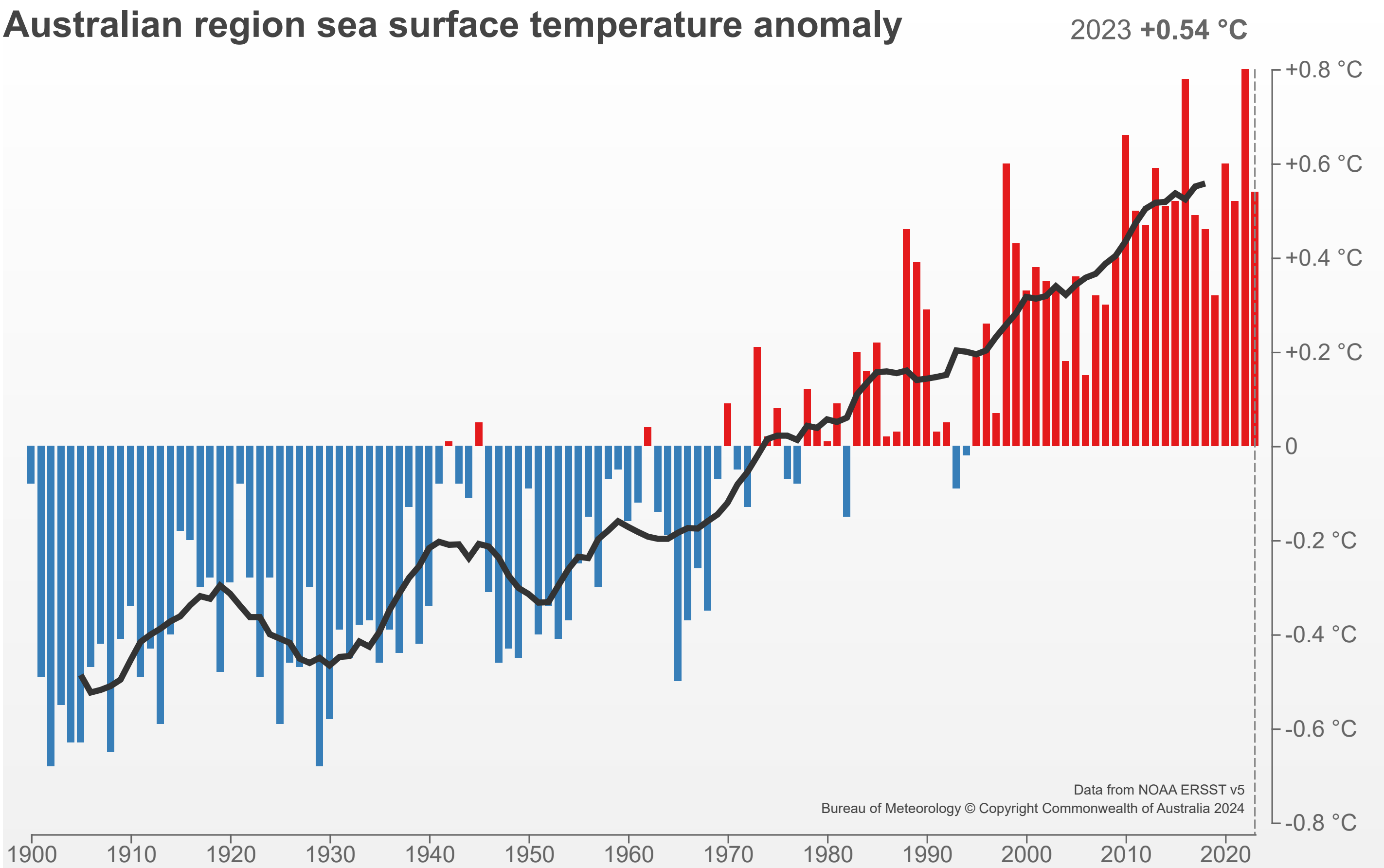
Global oceans

In 2023, global (from 60°S to 60°N) SSTs were the warmest on record (since 1900). The annual global SST was 0.74 °C above the 1961–1990 average in the ERSST v5 dataset. The second-warmest and third-warmest years on record in ERSSTv5 were 2016 (+0.61 °C) and 2019 at (+0.58 °C). The past 10 years have been the 10 warmest on record. From April to December 2023, monthly SSTs have been the warmest on record for their respective months and among the top 10 warmest on record for any month. August 2023 was the warmest globally for any month since 1854 in the ERSSTv5 dataset.

Annual SSTs were above average across the globe, except for an area in the Southern Ocean between 160°E and Cape Horn off the coast of South America, where SSTs were below average based on 1900.

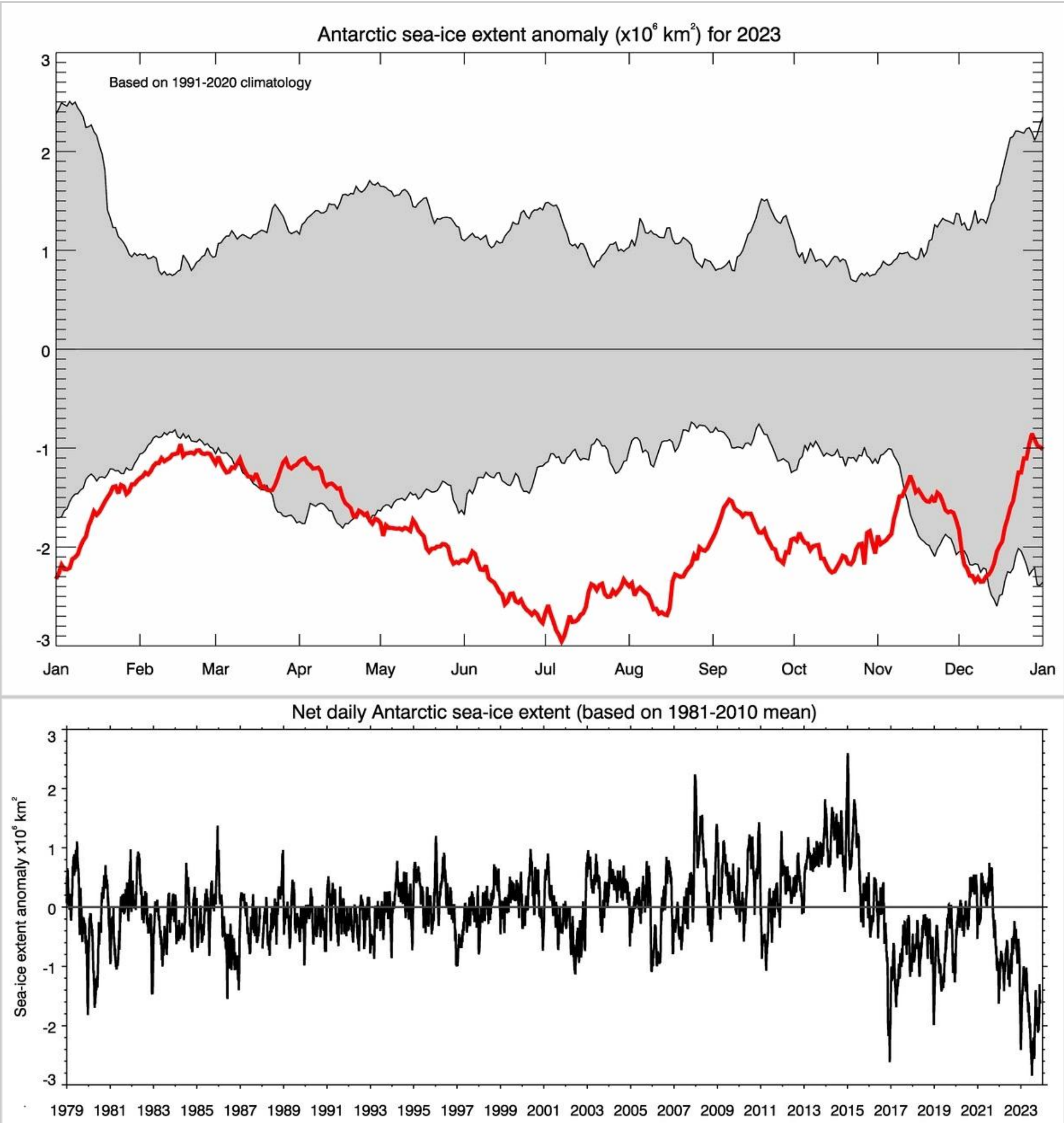


2023 global sea surface temperatures compared to historical records.
(From the [NOAA Extended Reconstructed Sea Surface Temperature dataset, ERSST v5](). About [sea surface temperature regions]() and [deciles]().



Annual mean sea surface temperature anomalies in the Australian region (as calculated from the 1961–1990 average), derived from the NOAA Extended Reconstructed Sea Surface Temperature Version 5 (ERSST v5) dataset. The black line shows the 11-year moving average.

Record low sea-ice extent for much of the year



The first graph shows the daily values of net (total) Antarctic sea-ice extent. Grey area = historical values (1979–2021). Red line = record low values recorded in 2023. The second graph shows changes in net daily Antarctic sea-ice extent since 1979 to 2023 (based on 1981–2010 mean).

Antarctic sea ice (defined as the area of ocean where at least 15% of the surface is frozen) is an important component of the Earth's climate and ecology. It reflects incoming solar radiation, influences interactions between the ocean and atmosphere, contributes to the global ocean circulation, protects ice-shelves from ocean processes, and provides a habitat for polar species.

Antarctic sea-ice extent experiences large seasonal variations, with net summer sea ice extent being approximately 2–4 million km2 and expanding to around 18–20 million km2 in winter. In the last decade (2013–2023) there has been a notable increase in variability of sea-ice extent, with record high winter extents observed in 2012–2014 followed by record lows in the years since 2016.

Throughout 2023, net Antarctic sea-ice extent was either at record lows or well below the 1991–2020 average. Eight months saw record low net sea-ice extent for that month. On 21 February, the daily sea-ice extent was observed at 1.85 million km2, the lowest ever recorded, based on near continuous daily satellite data since 1979. The previous record low was observed on 25 February 2022 at 1.96 million km2. 2023 also recorded the lowest annual daily maximum sea-ice extent of 17.0 million km2 on 7 September, breaking the previous lowest annual daily maximum record set in 1986 by more than 1 million km2. During late December the sea ice retreated somewhat slower than usual, so that by the end of the year net sea-ice extent was the 6th-lowest on record.

Sea-ice extent values are calculated from sea-ice concentrations based on satellite passive-microwave ice concentration data from the National Snow and Ice Data Center dataset (Version 1 for 1979–2021 and Version 2 since 2022).

Notable events

Regions

☑ All ☐ None ☑ NSW & ACT ☑ VIC ☑ QLD ☑ WA ☑ SA ☑ TAS ☑ NT

Event types

☑ All ☐ None ☑ Heat ☑ Cold ☑ Snow ☑ Rainfall ☑ Flood ☑ Storms ☑ Wind ☑ Tropical cyclones

☑ East Coast Lows ☑ Bushfire ☑ Coast ☑ Sea surface temperature

January

Heavy rainfall from ex-Tropical Cyclone Ellie at the start of January caused significant flooding of the Fitzroy River in Western Australia, isolating the Fitzroy Crossing community and damaging the Great Northern Highway bridge. The Fitzroy River reached its highest levels on record, peaking at 15.81 m in the afternoon of 4 January.

January

Moderate to major flooding that started in spring 2022 continued along the Murray–Darling River system, with major flooding along the Darling River throughout most of January.

January

Several days of localised heavy rainfall and thunderstorms affected many areas of Queensland in early January. This included the Gulf Country and Peninsula districts, the northern interior and the tropical east coast, which recorded daily rainfall totals between 20 to 70 mm, and southern Cape York Peninsula where isolated rainfall totals were greater than 100 mm. As a result of these high rainfall total, levels in the Nicholson/Gregory and Leichhardt river systems were high, leading to the isolation of towns in the north-west, including Burketown, Doomadgee and Gregory, into mid-January.

February

Severe thunderstorms moved through south-eastern Queensland and north-eastern New South Wales on 13 February, bringing heavy rainfall to the area. Large hail, of 2 to 5 cm in diameter, was observed near Highfields in New South Wales, and Stanthorpe and Kingsthorpe in Queensland. Flash flooding was observed in several areas in Queensland, including parts of Brisbane and Maroochydore on the Sunshine Coast.

February

Many areas of Australia were affected by heatwave conditions in mid-February, including low-intensity heatwaves in northern and southern areas of South Australia, and severe-intensity heatwaves in southern Victoria and across Western Australia's north-west and central and southern areas.

February

From the last week of February through to early March, areas of the northern tropics were impacted by storms and heavy rain associated with a monsoon trough and a tropical low (16U). Ten-day totals of 400 to 800 mm were recorded in an area of the Carpentaria and Barkly districts in the Northern Territory and in Queensland's Gulf Country and North-West districts. Alexandria, in eastern Northern Territory, received 262.0 mm of rainfall in the 24 hours to 9 am on 3 March, making it the highest daily rainfall in March and the highest daily rainfall at the station for all months. The rainfall event in Alexandria resulted in major flooding of several rivers across eastern Northern Territory and north-western Queensland, leading to the evacuation of some communities and the closure of many transport routes.

March

A series of cold fronts crossed south-eastern Australia between 6 and 10 March, bringing gusty winds and daily maximum temperatures up to 10 °C below the 1961-1990 average. Thunderstorms produced rain and showers across most of Tasmania, Victoria and south-western New South Wales, and in western Tasmania, rainfall totals of 50 and 100 mm were recorded, and snow falls reported at Mount Mawson in southern Tasmania.

March

A heatwave affected much of Australia in mid-March. In the Pilbara district of Western Australia, heatwave conditions reached severe intensity. On the 18 and 19 March, many sites across South Australia, Victoria and New South Wales set warmest March day records.

April

On 14 April, Tropical Cyclone Ilsa, a Category 5 system, made landfall on the Pilbara Coast of Western Australia, causing extensive damage in the area. The highest daily rainfall total was 194.8 mm at Bamboo Creek (near Marble Bar) in the 24 hours to 9 am on 14 April. Prior to making landfall on the mainland, Ilsa passed directly over Bedout Island on 13 April, about 50 km offshore from the coastal crossing site, with a sustained wind speed (10-minute mean) of 219 km/h, the highest on record across the Bureau's observation network, and a maximum wind-gust speed (3-second mean) of 289 km/h, also the highest on record.

April

On 15 April, a cold front moved eastwards across southern Australia drawing moisture from ex-Tropical Cyclone Ilsa. This brought widespread heavy rain, strong winds and thunderstorms to southern and inland Western Australia, southern Northern Territory and South Australia, Victoria, Tasmania and New South Wales. Several long record stations in Western Australia and South Australia had their highest daily rainfall for April in the 24 hours to 9 am on the 14 and 15 April and large parts of Victoria, Tasmania and New South Wales received 20 to 40 mm in the 24 hours to 9 am on the 16 April.

May

On 5 May, a cold front brought gusty winds, isolated thunderstorms and polar air to the south-east states. On 7 May, Cooma Airport (New South Wales) had its lowest maximum temperature for May on record, at 2.7 °C. In south-east New South Wales and north-east Victoria, alpine areas recorded 10 to 20 cm of snow. On 7 May, heavy hail was reported in parts of the Australian Capital Territory and Victoria.

May

A cold front between 20th and 21 May brought damaging to destructive winds exceeding 100 km/h to much of Victoria, Tasmania and southern New South Wales. The strongest wind gusts observed were 137 km/h at Wilsons Promontory Lighthouse (Victoria) and 126 km/h at Tasman Island (Tasmania). Strong winds caused disruptions to electricity supplies and widespread power outages affected various parts of Tasmania.

May

Severe thunderstorms across the Hunter coast and Newcastle area in the afternoon of the 26 May brought heavy rainfall, with local falls exceeding 50 mm in one hour, flash flooding, large to giant hail and reports of a waterspout near Williamstown RAAF. More than 2,000 customers in the suburbs of Newcastle West, The Junction, Bar Beach and Merewether were without power.

June

A cold front dragged in tropical moisture and brought thunderstorms and heavy rain to parts of eastern South Australia, Victoria, southern New South Wales and northern Tasmania on the 7 June. Numerous sites in Victoria's north-east recorded daily rainfall totals of more than 100 mm, while large areas of northern Tasmania recorded rainfall totals of 50 to 100 mm. Minor to Moderate flood warnings were issued for catchments in north-east Victoria.

June

Multiple cold fronts brought storms, strong winds, high daily rainfall totals and snow to the south of the country. Many sites in south-eastern South Australia had their highest daily rainfall total for June on record in the 24 hours to 9 am on the 23 June, including some sites with more than 100 years of data. Daily rainfall totals in the Adelaide Hills were generally 50 to 80 mm and caused flash flooding across the area.

June

From the last 10 days of June until early July, a trough in the upper atmosphere dragged in tropical moisture from the Indian Ocean, north-west of the continent, bringing unseasonable rainfall to large parts of northern Australia. These regions are generally drier at this time of the year, receiving winter totals of less than 50 mm. During this period daily rainfall totals across the region ranged from 10 to 70 mm. Many stations with more than 30 years of records had their highest June or July daily rainfall on record. Cloudy skies and rainfall were also associated with daily maximum temperatures of more than 10 °C below the 1961-1990 average in parts of northern Western Australia, most of the Northern Territory and parts of western Queensland. Many stations had their lowest daily maximum temperature for July on record on 1st and 2nd.

July

Northerly airflow brought warmer than average daytime temperatures across Tasmania between 1 and 3 July and on the 13th. Some stations had their highest July maximum and minimum temperatures on record. Hobart had its highest July mean minimum temperature on record at 13.0 °C (137 years of record).

July

On 7 and 8 July, south-east Australia was impacted by a strong cold front and deep low pressure system, producing damaging winds, widespread rainfall, below average temperatures, hazardous surf, and snow on elevated areas. More than 20 mm of snowfall was recorded in alpine areas in Victoria, Tasmania and New South Wales. Daily rainfall totals of more than 40 mm were recorded at many stations across western and central Tasmania and northern and eastern Victoria to 9 am on 8 and 9 July, with Minor to Moderate flood warning issued for catchments in north-east Victoria and north-west Tasmania.

July

Throughout July, frequent high pressure systems brought settled and dry conditions to most of the country. Clear skies and light winds resulted in low daily minimum temperatures across southern and eastern parts of the country, and many stations in southern Queensland, eastern New South Wales, south-eastern South Australia and Victoria recorded their lowest minimum temperature for July on record. Glen Innes Airport (New South Wales) set a minimum temperature record of -10.8 °C on 20 July. This was Australia's lowest temperature recorded in 2023, and the lowest temperature outside the south-east alpine regions since 2019. For the first time since 1994, Canberra experienced 12 consecutive days (16 to 27 July) of sub-zero minimum (nighttime) temperatures.

July

From 23 July, a surface low near the south-eastern Queensland coast slowly drifted northwards, and a cut-off low in the upper atmosphere generated showers around parts of the east coast and adjacent inland areas. On 27 July, many stations around Queensland's Capricornia, Central and North Tropical Coast and Tablelands districts recorded four-day rainfall totals to 9 am of more than 100 mm, greatly exceeding their July average rainfall of between 25 and 50 mm.

July

Very strong north-westerly winds associated with a cold front impacted southern Tasmania over several days at the end of the month. Many sites recorded wind gusts of more than 100 km/hr that caused extensive power outages. The strongest wind gusts were recorded across south-western Tasmania. Several sites had their highest daily wind gust on record for July or for any month. This included 200 km/hr at Maatsuyker Island, 169 km/hr at Scotts Peak Dam and 146 km/hr at Low Rocky Point.

August

A strong cold front crossed south-west Western Australia on 2 August and brought strong winds and heavy rainfall. The Busselton coast was impacted with heavy rainfall and isolated thunderstorms. In the 24 hours to 9 am on 3 August, falls of 40 to 80 mm were recorded around Bunbury and a daily rainfall total of 73.0 mm at Busselton Shire set an August record for the station. The Carbunup River at Lennox Vineyard and the Wellesley River at Juegenup reached minor flood levels.

August

Warm conditions and strong winds on 18 August resulted in more than 70 grass and bushfires across New South Wales, including two in the Clarence Valley that reached the Watch and Act alert level.

August

On 22 August, severe thunderstorms impacted parts of New South Wales and the Australian Capital Territory, with hail hitting parts of Gunghalin (ACT) and storms lashing Canberra in the early evening. Severe thunderstorms hit areas of the Riverina district of New South Wales, bringing hail and strong winds. There were reports of small hailstones of around 3 cm in diameter in the June and Tumut areas of New South Wales, and marble sized hail at Lake Albert in New South Wales.

September

It was an early and severe start to the bushfire season, as the dry landscape from several months of below average rainfall and warmer than average winter temperatures contributed to extreme to catastrophic fire danger conditions for parts of the country between September to December and significant fires burned across the Northern Territory, New South Wales, Queensland and Western Australia.

September

From early September to mid-October, extreme fire danger warnings were issued for much of the Northern Territory as dry, fresh and gusty south-easterly winds combined with high grass fuel loads. Bushfires burned for weeks in the Northern Territory with an estimated 1 million hectares burned by a large bushfire east of Tennant Creek, 2.8 million hectares burned in the Barkly region and millions of hectares burned across the Tanami and central Australia. On 11 September the fire in the Tanami region was upgraded to a Watch and Act, as strong winds pushed the fire front 60 km closer to Tennant Creek.

September

Severe winds affected broad areas of south-east Australia on 7 and 8 September, as a strong cold front and low pressure trough crossed southern and south-eastern Australia. Maximum daily wind gusts greater than 100 km were recorded across elevated and coastal areas of Victoria and New South Wales and a few stations across South Australia, Victoria and New South Wales recorded their highest daily wind gust on record for September. There were reports of swells of more than 9 meters at Port Fairy (Victoria) and 8 meters at Portland (Victoria).

September

A strong cold front and low pressure trough moved over southern Western Australia with damaging to locally destructive winds, severe thunderstorms and heavy rain that resulted in flash flooding. Wind gusts exceeded 80 km/h at many locations and damage was reported across Perth and the south-west. Rottnest Island recorded a maximum daily wind gust of 128 km/h, this was the strongest wind gust on record in September. In the Busselton region rainfall totals in the 24 hours to 9 am on the 13th were 30 to 60 mm, with the highest total of 91.4 mm at Busselton Aero. Some stations had their record highest September daily rainfall in the 24 hours to 9 am on 13th or 14th.

September

Unusually warm conditions developed across southern Australia during September. On the 14th many sites in elevated and alpine areas of Tasmania, Victoria and southern New South Wales set records for their highest maximum temperature for September. From the 15th to the 20th, very warm to hot conditions persisted over New South Wales and far eastern Victoria.

September

A low-to-severe intensity heatwave warning was issued for the South Coast district of New South Wales along with Greater Sydney's first Total Fire Ban since November 2020 from the 17th to the 20th.

October

A low pressure system and associated cold front moved over south-east Australia early in October and brought heavy rainfall, damaging winds, severe thunderstorms and showers. In the 24 hours to 9 am on the 4th, many stations in Victoria had their highest October daily rainfall on record including Mount Hotham which received 198.8 mm. Heavy rainfall led to flash flooding and widespread minor and moderate riverine flooding across north-eastern and eastern Victoria.

October

In the last week of October more than 700 vegetation fires were burning across Queensland. On the 31st, dry and very warm weather with maximum temperatures close to 40 °C and gusty north-westerly winds ahead of a southerly change elevated fire danger to extreme through the southeast interior of Queensland and eastern and northern parts of New South Wales. Smoke from ongoing fires led to periods of poor air quality across Queensland and New South Wales, including Brisbane, the Sunshine Coast and Sydney.

October

Dozens of fires burnt across New South Wales during October and into the first week of November. Multiple fires in the Tenterfield region burnt through at least 31,000 hectares of land.

November

Showers and thunderstorms were widespread across large parts of Australia during November and a large number of daily rainfall records were set. On the 15th, thunderstorms across central Australia brought lightning, strong winds and rain with Coober Pedy Airport recording a maximum daily wind gust of 119 km/h, the site's strongest wind gust on record. On the same day, a storm hit Western Australia's wheatbelt with large quantities of hail covering the ground around Hyden and damaging crops in the middle of the harvest. Between the 21st and 29th more than 100 mm of rain was recorded at many locations in southern Queensland and northern New South Wales with persistent showers and thunderstorms leading to localised river rises across the southern interior of Queensland. Between the 27th and 30th, heavy rain, hail and lightning impacted South Australia, Victoria, New South Wales and Queensland as an upper level low pressure system collided with warm and moist air from the north. There was flash flooding in many Adelaide suburbs with more than 50 mm of rain falling in a few hours.

November

A low pressure system that developed over New South Wales on 28 November moved eastwards and brought heavy and locally intense rainfall to Victoria and New South Wales. The highest rainfall totals in the 24 hours to 9 am on the 29th was recorded in the Illawarra and South Coast districts (New South Wales) with 226.8 mm at Jervis Bay (Point Perpendicular AWS), 225.0 mm at Moruya (Burra Creek) and 196.4 mm at Ulladulla AWS, while to 9 am on the 30th some stations in eastern Victoria had daily rainfall totals of more than 100 mm.

November

Between 20 and 27 November, the west coast of Western Australia including Greater Perth was affected by a low to severe intensity heatwave, as a near stationary surface low pressure trough close to the Western Australian coast directed heat from the interior of the continent towards the west coast. Perth set a new record for 10 consecutive days with temperatures equal or above 30 °C, and a number of other stations in south-west Western Australia also set November records for consecutive days above a threshold. Hot, dry conditions and strong winds across Western Australia resulted in high to extreme fire dangers and at least 10 homes were lost after a bushfire tore through a number of northern Perth Suburbs on the 23rd.For more information see Special Climate Statement 78.

December

On December 5, tropical low 02U formed near the Solomon Islands and developed into Tropical Cyclone Jasper. Tropical Cyclone Jasper tracked towards the Queensland east coast and made landfall near Wajul Wajul, just north of Cape Tribulation, as a Category 2 system on the 13th (around 8 pm EST). Significant widespread and heavy rainfall accompanied ex-Tropical Cyclone Jasper as it moved inland and weakened, stalling over the Cape York Peninsula. From the 13th to the 18th daily rainfall totals ranged between 100 to 600 mm with many sites across northern Queensland recording their highest daily rainfall for December. Many sites recorded more the 1000 mm of rainfall over the 5-day period. The highest 5-day total (at the Bureau's station) was 1933.8 mm at Whyanbeel Valley.

The highest daily rainfall total during this event of 714.0 mm was recorded at Mossman South Alchera Drive to 9 am on the 18th (Australia's highest December daily rainfall total). After several days of heavy and persistent rainfall major flood warnings were issued for parts of the Daintree, Barron, Murray and Herbert rivers. The persistent and heavy rainfall resulted in a large number of impacts including widespread flooding, landslides, road closures, mass evacuations of communities, inundation to business and properties and damage to crops.

December

Storms moved across southern parts of South Australia on the evening of 12 December. There were reports of a tornado during a storm impacting the town of Millicent in south-east South Australia which caused damage to properties, uprooted trees and tore down power lines.

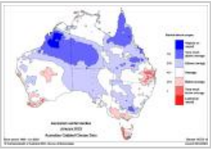
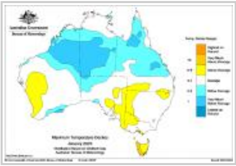
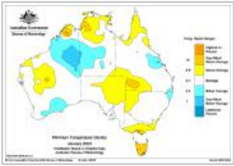
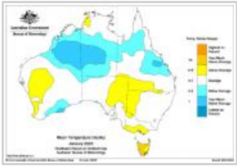
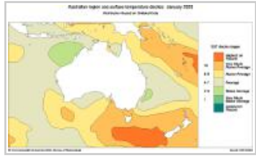
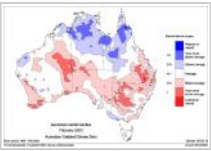
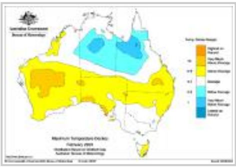
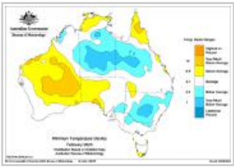
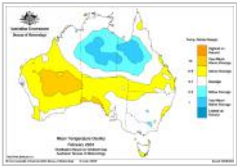
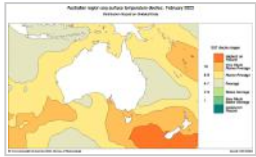
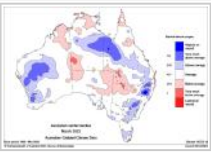
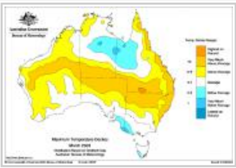
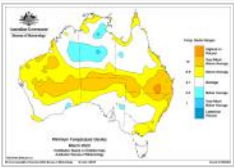
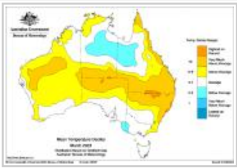
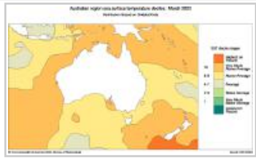
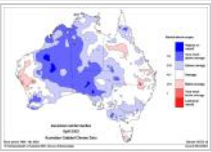
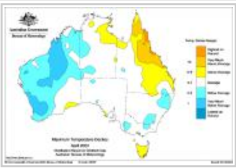
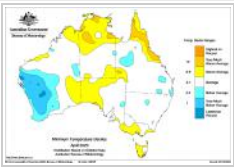
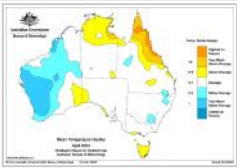
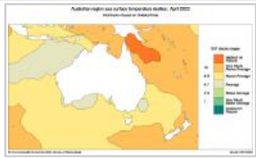
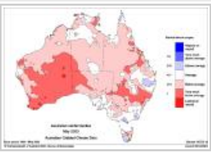
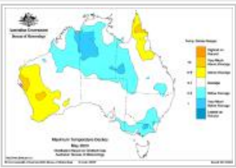
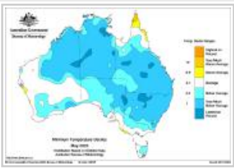
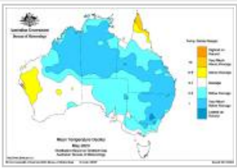
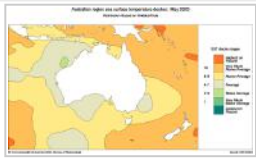
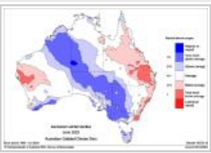
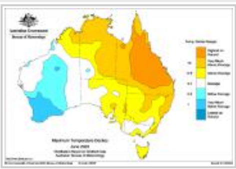
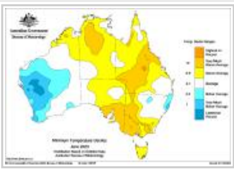
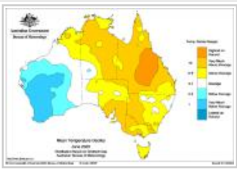
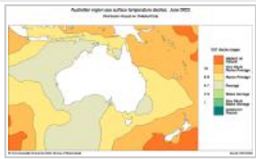
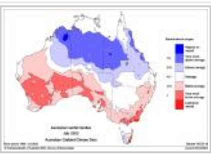
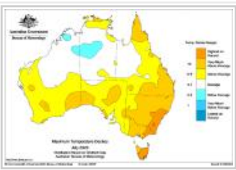
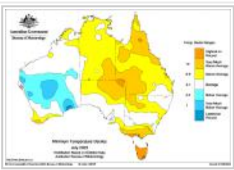
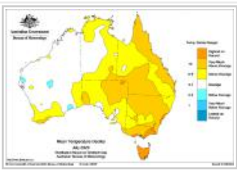
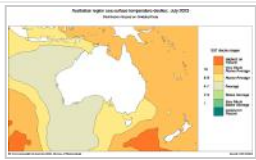
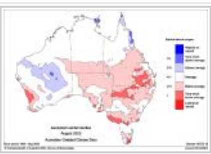
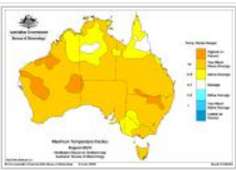
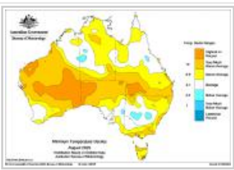
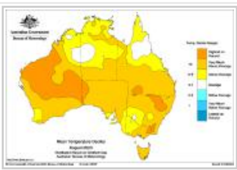
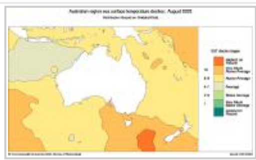
December

During the second half of the month a series low pressure troughs brought widespread rainfall to eastern and south-eastern parts of Australia with also frequent episodes of localised daily thunderstorms particularly across south-eastern Queensland and north-eastern New South Wales. Daily rainfall totals of 50 to 100 mm were recorded in the 24 hours to 9 am between the 25 and 27 December across parts of Victoria with minor to moderate flooding across catchments in north-western, central and eastern Victoria. In the 24 hours to 9 am on the 26th the New South Wales's South Coast recorded rainfall totals between 50 to 100 mm resulting in minor flooding. Severe thunderstorms impacted areas of southern and central Queensland between the 24th and 31st. Impacts from the thunderstorms included: reported hail up to 15 cm in diameter in Burpengary (north of Brisbane) on the 24th, reports of a tornado moving across parts of the Gold Coast and Scenic Rim in the evening of the 25th, damaging winds with Gold Coast Seaway weather station reporting a maximum wind gust of 106 km/h on the evening of the 25th and minor flooding of catchments in southern and central Queensland. On the 30th thunderstorms developed in areas north of Brisbane, with reports of flash flooding, large hail and damaging winds.

December

Much of northern and central Australia were affected by low-to-severe intensity heatwaves during the last week of December including extreme heatwave conditions in north-west Western Australia. Several stations in northern Australia had their highest daily maximum temperature on record for December on the last two days. Roebourne Aero, in north-west Western Australia, had the warmest temperature recorded in Australia in 2023 at 49.5 °C on 31 December.

2023 monthly and annual rainfall, temperature and sea surface temperature deciles maps

	Rainfall deciles	Maximum temperature deciles	Minimum temperature deciles	Mean temperature deciles	Sea surface temperature deciles
January					
February					
March					
April					
May					
June					
July					
August					

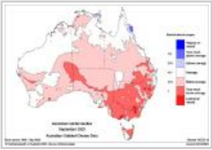
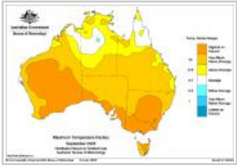
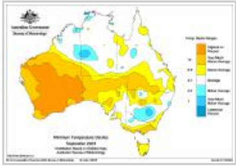
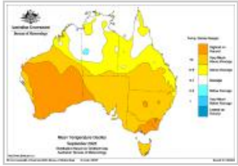
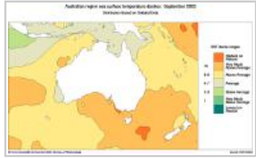
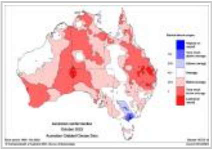
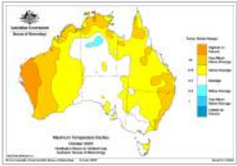
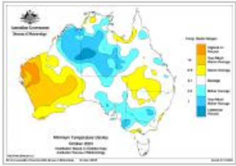
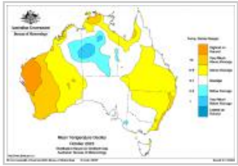
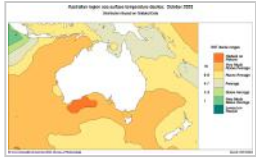
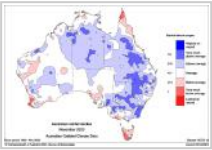
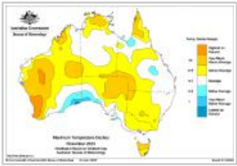
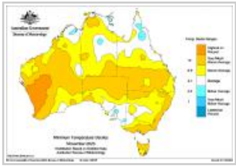
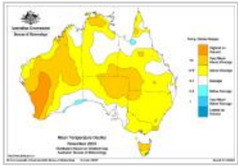
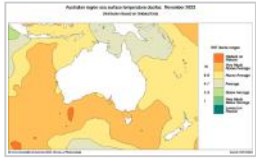
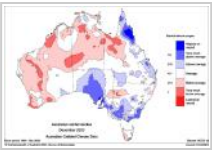
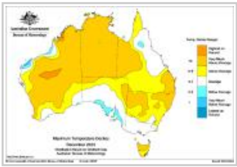
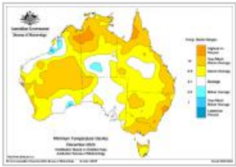
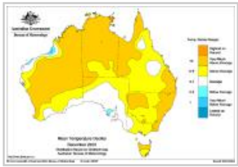
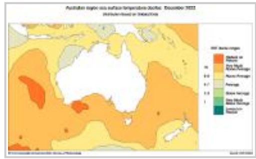
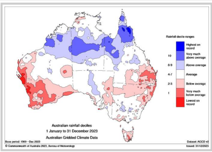
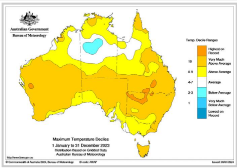
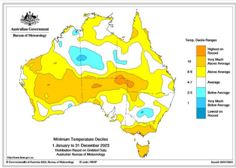
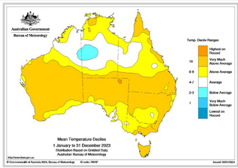
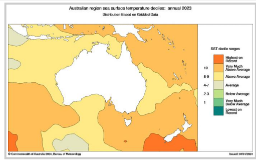
	Rainfall deciles	Maximum temperature deciles	Minimum temperature deciles	Mean temperature deciles	Sea surface temperature deciles
September					
October					
November					
December					
Year					

Table of rainfall, temperature and sea surface temperature maps for each month and the year

Data currency

All values in this statement were compiled from data available on the issue date. Subsequent quality control and the availability of additional data may later result in minor changes to values published elsewhere in the underlying datasets as compared to the values published in this statement.

Accessing datasets

The Bureau collects, manages and safeguards Australia's climate data archive. Several datasets have been developed from this archive to identify, monitor, and attribute changes in the Australian climate. You can access these datasets on our website. The datasets used in the preparation of this statement are outlined below.

Area-averaged temperature values are from the homogenised Australian temperature dataset (ACORN-SAT)

Mapped temperature analyses use AWAP temperature data.

Area-averaged rainfall values and mapped monthly analyses use the AGCD dataset (replacing the AWAP dataset used in Annual Climate Statements for 2019 and earlier years).

Sea surface temperature data are from the NOAA Extended Reconstructed Sea Surface Temperature dataset, ERSST

Soil moisture analysis uses Australian Water Resources Assessment Landscape model (AWRA-L) data

Atmospheric gas charts use data from CSIRO Kennaook / Cape Grim Baseline Air Pollution Station (KCG BAPS)

Sea-ice extent values use data from the National Snow and Ice Data Center, University of Colorado, Boulder – Nimbus-7 SMMR and DMSP SSM/I-SSMIS Passive Microwave Data for 1979 to the year before last, and Near-Real-Time DMSP SSM/I-SSMIS Daily Polar Gridded Sea Ice Concentrations for observations during the most recent year

A note on base periods

In climatology a baseline, or long-term average, is required against which to compare changes in climate over time. The Bureau uses the 1961–1990 period as the climate reference period for the Annual Climate Statement and other climate monitoring products.

A minimum 30 years of data is required to form a robust climatological average, accounting for decadal variability. In general, baseline climatological periods try to make use of the period with the best data coverage. The 1961–1990 period is comparable to the first 30-year period where there is good global coverage of climate data, and is thus used as a benchmark for reporting climate change allowing consistent comparison of national temperature observations across countries. However alternate averaging periods are also used for other purposes, such as facilitating comparison to a more recent period for climate outlooks, or to the pre-industrial period for long-term climate change.

The choice of base period is a convention. It has no bearing on the calculation of trends over time, or the ranking of one year compared to all other years in a dataset.

More information:

- Annual summaries for states, territories, and capital cities

Product code: IDCKGC5AR0

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