Australia's climate in 2021

- Australia's national mean temperature was 0.56 °C warmer than the 1961–1990 average, making 2021 the 19th-warmest year on record, and coolest since 2012
- Both mean annual maximum and minimum temperatures were above average for most of northern Australia, Tasmania, and parts of the west coast, but below average for parts of inland New South Wales
- July and August were particularly warm, with the national mean temperature fourth-warmest and sixth-warmest on record for their respective months
- Severe to extreme heatwave conditions affected the Kimberley and Top End during October, and parts of the north in November and December
- Nationally-averaged rainfall was 9% above the 1961–1990 average at 509.7 mm
- Rainfall was above average, compared to the distribution of rainfall across all years since 1900, for eastern Victoria, much of New South Wales, southern and central west Queensland, the Gascoyne and South West Land Division in Western Australia, and much of the far northern tropics, including the Top End of the Northern Territory and Cape York Peninsula in Queensland
- Rainfall was below average, compared to the distribution of rainfall across all years since 1900, for a few areas, such as around the border of South Australia and Victoria
- The year commenced with parts of south-west to central Western Australia, as well as the south-eastern quarter of Queensland, affected by meteorological drought, with rainfall for the period commencing April 2020 in the lowest 10% of historical observations
- Above average rainfall, compared to the distribution of rainfall across all years since 1900, brought relief from drought in Western Australia in March, and in Queensland in November
- While southern Murray–Darling Basin water storages saw significant increases during winter and spring 2021, storage levels remained low in south-east Queensland
- Flooding affected eastern and central Australia during the second half of March, parts of Victoria during June, and across large areas of New South Wales and Queensland from November into December
- La Niña persisted through summer 2020–21, returning to neutral during March, with signs of it emerging again in early spring, and becoming established in late November
- A Negative Indian Ocean Dipole in winter and spring also fuelled above-average winter–spring rainfall over parts of southern Australia, compared to the distribution of rainfall across all years since
A warmer than average year for Australia, despite La Niña in successive summers

Australia's area-averaged mean temperature for 2021 was 0.56 °C above the 1961–1990 average. The mean maximum temperature was 0.65 °C above average and the mean minimum temperature was 0.45 °C above average. The national temperature dataset, ACORN-SAT, commences in 1910 and spans 112 years of observations.

2021 was Australia’s 19th-warmest year on record, and the coolest year since 2012, when the conclusion of the moderately strong 2011–12 La Niña brought cooler and wetter conditions for the first half of the year.

Annual mean temperatures for 2021 were above average for most of northern Australia, Tasmania, and large parts of the Western Australia, but below average for parts of inland New South Wales, compared to the distribution across all years.
since 1910.

Rainfall for Australia was 9% above average for the nation as a whole at 509.7 mm, compared to the 1961–1990 average of 466.0 mm. The national rainfall dataset commences in 1900.

Rainfall for the year was above average for eastern Victoria, much of New South Wales, southern and central west Queensland, the west of Western Australia, and much of the far northern tropics, when compared to the distribution across all years since 1900. Rainfall was below average only for a few small areas, including around the border of South Australia and Victoria.

Rainfall decile ranges

- Highest on record
- Very much above average
- Above average
- Average
- Below average
- Very much below average
- Lowest on record

2021 annual rainfall compared to historical rainfall observations. About deciles.

At the start of 2021 there were significant rainfall deficiencies in place for the period commencing April 2020 in parts of south-west to central Western Australia, and the south-eastern quarter of Queensland, following rainfall in the lowest 10% of historical observations for periods of the same length, commencing in the same month, compared to all observations since 1900 when national records commence. Above or very much above average rainfall (compared to the distribution of rainfall across all years since 1900) brought relief in Western Australia in March, and Queensland in November. After commencing 2021 at 58% of capacity, water storages in the Murray–Darling Basin experienced significant filling over winter and spring. However, storages in south-east Queensland remained low at the end of the year.

After being declared in spring 2020, La Niña persisted in the tropical Pacific through summer 2020–21, with a clearly neutral El Niño–Southern Oscillation (ENSO) state returning during March 2021. Signs of La Niña development again emerged in early spring, with La Niña becoming established in late November.

A negative Indian Ocean Dipole (IOD) contributed to above average rainfall over southern and eastern Australia and warmth in the tropics while it was active between late May and November. The Southern Annular Mode was positive through much of 2021, as often occurs during La Niña. It favoured increased rainfall over eastern Australia during spring to summer, but decreased the chance of rainfall over western Tasmania through much of the year, and south-west and south-east Australia during winter.

The Southern Annular Mode (SAM) was also positive throughout much of the year, with the most notable influence in November (wetter than average for eastern Australia) and December (very much below average rainfall for Tasmania and the southern coast of the mainland).

Most capital cities had mean maximum and minimum temperatures which were within half a degree of average, compared to observations in recent decades (see table caption below for details of averaging periods). Canberra was a notable exception, with daytime temperatures well below average. Rainfall was close to average (within 10% of average) for...
Adelaide and Darwin; above average for Sydney, Hobart, and Perth; and well above average for Brisbane and Canberra. For Canberra it was the wettest year since 2010 and the 5th-wettest year on record.

Table of annual rainfall and temperature values and anomalies for the capital cities. Anomalies are relative to the "recent decades” 1991–2020 where data is available. That is, for Sydney relative to the former Observatory Hill site; for Adelaide relative to the former Kent Town site; for Hobart and Darwin both relative to the current sites. Where observations are only available over a shorter period all available data are used. The current Canberra site opened in 2008, the current Brisbane site opened in 1999, and the current Perth site opened in 1993. *The current Melbourne site has not been open long enough to allow temperature anomalies to be calculated, and anomalies cannot be calculated relative to the former site due to significant differences in exposure. The 2021 Brisbane rainfall total includes about 30 mm missed over a period in December, Hobart about 2 mm missed over a period in May, and Adelaide about 14 mm missed over a period in July—in each case these estimated amounts were missed due to an equipment fault.

<table>
<thead>
<tr>
<th></th>
<th>Maximum temperature</th>
<th>Minimum temperature</th>
<th>Rainfall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average (°C)</td>
<td>Anomaly (°C)</td>
<td>Comment</td>
</tr>
<tr>
<td>Canberra</td>
<td>19.6</td>
<td>−1.5</td>
<td>Coolest since 1996</td>
</tr>
<tr>
<td>Brisbane</td>
<td>26.3</td>
<td>−0.4</td>
<td>16.6</td>
</tr>
<tr>
<td>Sydney</td>
<td>23.2</td>
<td>+0.4</td>
<td>14.1</td>
</tr>
<tr>
<td>Melbourne</td>
<td>19.9</td>
<td>N/A*</td>
<td>Coolest since 1996</td>
</tr>
<tr>
<td>Hobart</td>
<td>17.7</td>
<td>+0.1</td>
<td>9.2</td>
</tr>
<tr>
<td>Adelaide</td>
<td>22.1</td>
<td>−0.5</td>
<td>Coolest since 1997</td>
</tr>
<tr>
<td>Perth</td>
<td>25.0</td>
<td>+0.2</td>
<td>13.2</td>
</tr>
<tr>
<td>Darwin</td>
<td>33.0</td>
<td>+0.6</td>
<td>Equal-4th-warmest</td>
</tr>
</tbody>
</table>

A warmer than average year despite La Niña
Australian annual mean temperature, with years coded by ENSO phase. Years in which La Niña began are blue, orange is El Niño, and years which were neutral or contained both El Niño and La Niña are grey.

While La Niña tends to result in cooler annual mean temperature for Australia, the greatest effect on Australian mean temperature is observed over financial years (July–June), rather than calendar years, as this more closely matches the typical autumn to autumn life cycle of ENSO events.

For Australia as a whole, the annual national mean temperature for 2021 was 0.56 °C above the 1961–1990 average. The mean maximum temperature was 0.65 °C above average and the mean minimum temperature was 0.45 °C above average. The national temperature dataset, ACORN-SAT, commences in 1910, spanning 112 years.

2021 was Australia’s 19th-warmest year on record, and the coolest year since 2012. The record-breaking La Niña events of 2010–11 and 2011–12 led to each of 2010, 2011, and 2012 being cooler than both the eight years before and the eight years after this period.

2021 is also the first year since 2013 which wasn’t amongst the ten warmest years on record for Australia. Despite 2021 being cooler than recent years, the mean temperature for the 10 years from 2012 to 2021 was the highest on record, at 0.99 °C above the 1961–1990 average, and 0.38 °C warmer than the ten years 2001–2010. Only five years prior to 2000 were warmer than 2021.

Based on the ACORN-SAT dataset, Australia’s climate has warmed on average by 1.47 ± 0.24 °C between when national records began in 1910 and 2020. Most of this warming has occurred since 1950.
Compared to the distribution across all years since 1910, annual mean temperatures for 2021 were above or very much above average for most of northern Australia, Tasmania, and in Western Australia along the coast, the interior, and the south-east of that state. They were in the highest 10% of historical observations for most of the northern tropics. Much of central New South Wales west of the ranges had mean temperatures that were cooler than average.

Maximum temperatures for the year were above or very much above average across Queensland, most of the Northern Territory, parts of northern, central, and west coast Western Australia, and for Tasmania, compared to the distribution across all years since 1910. The mean maximum temperature was below average for some parts of inland New South Wales, extending into north-eastern Victoria.

January brought heatwaves to the north of Western Australia and to south-east Australia, though the monthly mean for maximum temperature was very much warmer than average compared to the distribution across all years since 1910 only along the north-west coast.

March days were cooler than average across the mainland south-east, while clear skies and cold fronts bringing widespread cool spells during April brought cooler than average nights across the inland south-east.

Both days and nights were warmer or very much warmer than average for much of the southern half of Western Australia in March, April, and May.

The northern tropics were warmer than average throughout winter. July and August were particularly warm, with the national mean temperature fourth-warmest and sixth-warmest on record respectively. July days were warmest on record.
for large parts of northern Australia, while some areas along the northern coasts, including Darwin and Broome, had their highest mean August maximum temperature on record.

Warmth continued across the north into spring, with severe to extreme heatwave conditions in the Kimberley and Top End during October. A number of stations observed record runs of consecutive days of high temperatures and large areas of the northern tropics observed their warmest October on record.

A record-wet November brought cooler than average temperatures for most of Australia away from the tropical northern coasts.

Heatwave conditions returned to parts of the north and west in December. While the month was cooler than average for some parts of the east, both days and nights were warmest on record for parts of north-west Western Australia.

### Area-average temperatures

<table>
<thead>
<tr>
<th></th>
<th>Maximum Temperature</th>
<th>Minimum Temperature</th>
<th>Mean Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rank^* (of 112)</td>
<td>Anomaly^ (°C)</td>
<td>Comment</td>
</tr>
<tr>
<td>Australia</td>
<td>= 93</td>
<td>+0.65</td>
<td></td>
</tr>
<tr>
<td>Queensland</td>
<td>= 96</td>
<td>+0.88</td>
<td></td>
</tr>
<tr>
<td>New South Wales</td>
<td>= 58</td>
<td>+0.13</td>
<td></td>
</tr>
<tr>
<td>Victoria</td>
<td>71</td>
<td>+0.23</td>
<td></td>
</tr>
<tr>
<td>Tasmania</td>
<td>= 92</td>
<td>+0.42</td>
<td></td>
</tr>
<tr>
<td>South Australia</td>
<td>= 83</td>
<td>+0.53</td>
<td></td>
</tr>
<tr>
<td>Western Australia</td>
<td>= 90</td>
<td>+0.67</td>
<td></td>
</tr>
<tr>
<td>Northern Territory</td>
<td>= 98</td>
<td>+0.84</td>
<td></td>
</tr>
</tbody>
</table>

*Rank ranges from 1 (lowest value on record) to 112 (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.

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**Annual rainfall above average; boosted by the wettest November on record**
Rainfall for the year was above average for Australia as a whole. The national total rainfall for 2021 was 9% above the 1961–1990 average at 509.7 mm (the 1961–1990 average is 466.0 mm).

Compared to the distribution of rainfall across all years since 1900, rainfall was above average for eastern Victoria, much of New South Wales, southern and central west Queensland, the South West Land Division in Western Australia, and parts of the far northern tropics in the Kimberley, Top End, and Queensland's Cape York Peninsula. Annual rainfall totals were in the highest 10% of historical observations since 1900 for parts of the west of Western Australia and for much of the eastern half of New South Wales, extending into eastern Victoria and southern Queensland.

Rainfall was below average for a few areas, such as around the border of South Australia and Victoria and in the central Northern Territory.
Very much above average rainfall (compared to the distribution of rainfall across all years since 1900) in eastern Australia was largely a result of an exceptionally wet March and November, months both marked by flooding across large areas.
Above average rainfall in the west of Western Australia was a result of contributions spread across more of the year, mostly during February, March, May, and July.

January rainfall was above average for much of the mainland south-east and parts of the tropical north. February was wetter than average for large areas, through Western Australia, the Top End, central to eastern New South Wales, and much of Tasmania. January and February were both drier than average for areas of eastern Queensland.

March rainfall was above or very much above average for much of eastern, central, and north-western Australia, as well as the west of Western Australia. Rainfall for New South Wales was more than double the March average, coming in as the second-wettest March on record for the state. Flooding affected eastern and central Australia during the second half of March following a major rain event. The week ending 24 March 2021 was the wettest week for coastal New South Wales since national daily records began in 1900. For more details see Special Climate Statement 74, Extreme rainfall and flooding in eastern and central Australia in March 2021.

April and May were drier than average for Australia as a whole, despite above average rainfall along the west coast in both months and across Cape York Peninsula in April. Rainfall during April 2021 was very low for the south-eastern mainland. For New South Wales it was the ninth-driest April on record and for South Australia it was the seventh-driest.

Rainfall during June was below average for Western Australia's South West Land Division, but above average for the south-west during July. For south-west Western Australia it was the wettest July since 1996. June rainfall was generally above average for the mainland south-east following a series of wintry cold outbreaks. A complex low pressure system early in the month brought flooding rains to parts of West Gippsland in Victoria, and caused areas of widespread damage from strong winds. July rainfall was also above average for parts of the eastern mainland.

August rainfall was below average over much of Australia outside the tropics, and September rainfall was below average for the southern half of Western Australia and much of South Australia. However, September was wetter than average for the central Northern Territory and northern Queensland, and from inland southern Queensland to eastern Victoria.

The developing La Niña saw above average rainfall becoming more widespread as spring progressed. October rainfall was above or very much above average for much of the west of Western Australia and the inland Kimberley, and much of the Northern Territory and western Queensland, along parts of coastal southern and eastern Australia, and across most of Tasmania.

Rainfall was above average for most of Australia during November, and it was the wettest November on record for New South Wales and South Australia, the seventh-wettest November on record for Queensland, the eighth-wettest for the Northern Territory, and the ninth-wettest for Western Australia. Large areas of mainland Australia received very much above average November (decile 10, i.e. the highest 10% of historical observations) rainfall and flooding occurred in numerous rivers in New South Wales and Queensland. However, rainfall was below average for west-facing coastal areas of Tasmania, far south-west Victoria and south-east South Australia, and south-west Western Australia.

December rainfall was above average for parts of the east coast of the mainland, and or the Top End of the Northern Territory and Cape York Peninsula in Queensland, but was below average for most of Australia, and very much below average (decile 1, i.e. the lowest 10% of historical observations) for parts of the south coast and most of Tasmania. For Tasmania it was the sixth-driest December on record. The national rainfall dataset commences in 1900.
Rainfall deficiencies
For the period commencing April 2020, rainfall had been in the lowest 10% of historical observations (decile 1) over large parts of south-west to central Western Australia, though generally not extending to the coast, and also across the south-eastern quarter of Queensland.

These serious rainfall deficiencies, indicated by decile 1 rainfall for the period commenting April 2020, had built over the preceding year, and peaked in the west over summer 2020–21.

Above average rainfall during February resulted in a substantial lessening of deficiencies across much of Western Australia, with follow-up rain during March raising rainfall totals for the period commencing April 2020 out of the lowest 10% of historical observations and leaving only a few small pockets of deficiencies in the state.

While deficiencies in Queensland contracted over the year across the Maranoa and Darling Downs in the inland south, closer to the coast serious or severe rainfall deficiencies persisted (despite above average rainfall in March, July, and October) until November. Very much above average to highest on record rainfall for November lifted totals across the Capricornia and Wide Bay and Burnett districts out of the lowest 10% of historical observations for the period commencing April 2020, although in some areas close to the coast, rainfall totals for the period were still below average.

Rainfall deficiency maps for Australia for, from right to left:
- April 2020–January 2021,
- April 2020–April 2021,
- April 2020–July 2021,
- April 2020–September 2021,

Serious deficiency corresponds to decile 1 rainfall, based on all years since 1900.

About deciles.

Tropical cyclones
Eight tropical cyclones were recorded in the broader Australian region during the 2020–21 tropical cyclone season, below the long-term average of eleven (average for all seasons since 1969–70).

Three tropical cyclones reached severe (category 3) and two tropical cyclones crossed the coast (Imogen and Seroja). Severe tropical cyclone Seroja brought heavy rains and damaging winds to areas around Kalbarri and Geraldton in Western Australia during April — the furthest south a tropical cyclone has crossed the Western Australian coast since the 1950s.

As of 31 December 2021, the 2021–22 tropical cyclone season had recorded four tropical cyclones (Paddy, Teratai, Ruby, and Seth), none of them reaching severe.

The tropical cyclone season typically runs from 1 November to 30 April, although tropical cyclones can and do form outside of those bounds. All tropical cyclones existing between 1 July and 30 June the following year count towards the season total. The broader Australian region covers the area south of the Equator and between 90°E and 160°E, and includes Australian, Papua New Guinea, and Indonesian areas of responsibility.

For more information on tropical cyclones, see the Tropical Cyclone Knowledge Centre.

<table>
<thead>
<tr>
<th>Area-average rainfall</th>
<th>Rank* (of 122)</th>
<th>Average (mm)</th>
<th>Departure from mean^</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>95</td>
<td>509.7</td>
<td>+9%</td>
<td></td>
</tr>
<tr>
<td>Queensland</td>
<td>87</td>
<td>676.1</td>
<td>+9%</td>
<td></td>
</tr>
<tr>
<td>New South Wales</td>
<td>117</td>
<td>720.6</td>
<td>+30%</td>
<td>6th highest; highest since 2010</td>
</tr>
<tr>
<td>Victoria</td>
<td>85</td>
<td>699.2</td>
<td>+5%</td>
<td></td>
</tr>
<tr>
<td>Tasmania</td>
<td>69</td>
<td>1378.0</td>
<td>+1%</td>
<td></td>
</tr>
<tr>
<td>South Australia</td>
<td>74</td>
<td>220.7</td>
<td>−1%</td>
<td></td>
</tr>
<tr>
<td>Western Australia</td>
<td>82</td>
<td>371.2</td>
<td>+9%</td>
<td></td>
</tr>
<tr>
<td>Northern Territory</td>
<td>80</td>
<td>565.0</td>
<td>+4%</td>
<td></td>
</tr>
<tr>
<td>Murray-Darling Basin</td>
<td>111</td>
<td>611.7</td>
<td>+24%</td>
<td></td>
</tr>
</tbody>
</table>

*Rank ranges from 1 (lowest value on record) to 122 (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.

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.

**Water resources**

- Above average rainfall during 2021 compared to the distribution of rainfall across all years since 1900 saw significant increases in storages across the Murray–Darling Basin with many reaching full capacity
- The increase in surface water availability saw a decrease in the dependence on groundwater and desalinated water in many parts of Australia
- Storages in south-east Queensland remained low and in northern Australia, Argyle dam did not fill for the fourth consecutive year
- Despite increased rainfall and reduction in groundwater extractions, groundwater levels continued to be low, although there were some signs of recovery
- Increased water availability resulted in many irrigators receiving their full allocation and continued the reduction in prices paid for water trades
- Streamflows in eastern New South Wales registered highest on record and very much above average flows compared to all years since 1975, however, many other parts of Australia did not observe such high streamflows, with South Australia in particular recording below average flows

The year commenced with parts of south-west to central Western Australia, and the south-eastern quarter of Queensland affected by meteorological drought conditions that began in April 2020. There was relief from these deficiencies in Western
Australia in March, and Queensland in November.

The above average rainfall during 2021 compared to the distribution of rainfall across all years since 1900 saw significant increases in the water available in the soil, storages, rivers, and groundwater, especially during March and November. In the Murray–Darling Basin, the heavy rainfall in March saw some recovery in the northern part with the November rainfall filling the storages. However, major flooding was also associated with both these rainfall events. Despite the improved rainfall during 2021, some areas of Australia saw only limited improvement in water availability.

After commencing 2021 at 58% of capacity, water storages in the Murray–Darling Basin experienced significant filling over winter and spring with a number of storages spilling or being operated to avoid spilling. However, storages in south-east Queensland remained low with the largest storage, Wivenhoe, only increasing from 39% to 47% during 2021. In northern Australia, the volume of water in Argyle dam increased during 2021 but did not fill for the fourth consecutive year.

**Soil moisture**

In response to above average rainfall towards the end of the year, the amount of soil moisture in the root zone improved significantly across most of Australia during 2021 with eastern and northern Australia experiencing above or very much above average soil moisture for the year as a whole (compared to all years from 1911 to 2021). Average to very much below average soil moisture in many parts of Australia during August was followed by very wet soils across most of the country during November. At the end of 2021, soil moisture in the east of the country, including the Murray–Darling Basin, and South Australia was above average to highest on record.

Some areas, like western Victoria and eastern South Australia, and central Western Australia experienced below average soil moisture for 2021 as a whole. Western Tasmania, western Victoria and eastern South Australia, and south-west Western Australia ended the year with below to very much below average soil moisture.
Mostly above average streamflows
Streamflow deciles for 2021 calendar year, relative to all years since 1975.

In response to the above average rainfall and wet soils, streamflows across much of Australia were above average. In particular, north-eastern and south-eastern New South Wales saw many rivers observe their highest on record flows, associated with the floods which occurred in March and November. Streamflow averages are calculated compared to observations for all years since 1975.

The heavy rainfall in late March in eastern New South Wales, south-eastern Queensland, and large inland areas across both states, resulted in significant coastal and inland riverine flooding. Some areas experienced their worst floods in more than 30 years (see Special Climate Statement 74 for more information). The high flows during this event contributed to the well above average annual streamflows in many catchments along Australia’s south-east coast.

The flood waters resulting from the above average rainfall in the northern Murray–Darling Basin in March, travelled down the Darling–Barka River resulting in the highest levels in the Menindee Lakes system since 2012. At the end of 2021, releases were being made from the Lakes in order to reduce the storage to accommodate the flood waters from the Namoi, Border Rivers, and southern Queensland tributaries that resulted from the above average rainfall in November.

The heavy rainfall in November resulted in widespread flooding. The most significant flooding was in the rivers of the Murray–Darling Basin, particularly from the Lachlan River northwards, but there was also flooding in a number of catchments which drain to the east coast. Major flooding was observed in November and early December at locations in catchments including the Macintyre–Weir, Condamine–Balonne, Barwon, Namoi, Macquarie, Lachlan, Dawson, Logan–Albert, and Hunter.

Other parts of Australia recorded average or above average streamflows with the exceptions of South Australia, which only observed above average flows in November and December; central and south-east Queensland which recorded below average flows in some rivers every month except November and December; and south-west Western Australia which recorded very much below average streamflows in some rivers in four out of the first six months of 2021.

**Streamflow salinity**

In 2021, 68% of Australia's river and stream sites were on average high quality and suitable for drinking while 10% of sites were fresh to marginal. The remaining 22% of the sites were brackish or saline.
The sites with high quality median water salinities were mostly located in areas with high rainfall, along the east coast. In the Murray–Darling Basin, median streamflow salinities were mostly high quality but tended to be higher in the lower reaches of the Murray River. In contrast, most flows at the analysed monitoring sites in Western Australia continued to be saline in 2021. In South Australia about a quarter of the sites recorded brackish or saline flows.

Despite the improved rainfall conditions, streamflow salinity increased along the River Murray and in some sites within South Australia but decreased in other parts of the Murray–Darling Basin and in many Western Australia sites. Around 40% of the 440 gauging sites had an increase in median streamflow salinity in 2021.

Data used for the comparison were from 440 gauging stations that had reliable data for 2020 and 2021.

### Table of water salinity categories and primary suitability for use

<table>
<thead>
<tr>
<th>Salinity category</th>
<th>TDS concentration (mg/L)</th>
<th>Suitability for use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh</td>
<td>0–500</td>
<td>Good-quality water suitable for drinking and all irrigation</td>
</tr>
<tr>
<td>Marginal</td>
<td>500–1,000</td>
<td>Fair- to poor-quality drinking water; most irrigation; adverse effects on ecosystems may become apparent</td>
</tr>
<tr>
<td>Brackish</td>
<td>1,000–3,000</td>
<td>Unacceptable drinking water quality; useful for most livestock; irrigation limited to certain crops</td>
</tr>
<tr>
<td>Saline</td>
<td>3,000–35,000</td>
<td>Unacceptable drinking water quality; use may be limited for certain livestock</td>
</tr>
<tr>
<td>Hyper-saline</td>
<td>&gt;35,000</td>
<td>Seawater salinity or greater; undrinkable; some mining and industrial uses</td>
</tr>
</tbody>
</table>

mg/L = milligrams per litre; TDS = total dissolved solids

### Increasing surface water availability

The improved rainfall and streamflow conditions saw an improvement in the amount of water stored with the capacity in Australia’s storages increasing from 52.2% to 71.5% during 2021.

In the Murray–Darling Basin, the major water storages saw significant recovery in 2021, increasing to 90.7% at the end of the year with some storages spilling or being operated to prevent spilling. Compared to the end of 2020 when the total storage volume was only 57.0% the storages are in a significantly better position.

In the northern Murray–Darling Basin, where storages fell to 5.0% in January 2020 and had only risen to 24.5% at the end of 2020, the above average rainfall and increased inflows, especially during March and November 2021, saw storages reach 96.5% by the end of the year — the highest level since May 2012. In the southern Basin, where 80% of the total storage volume in the Basin is located, the total storage volume reached 89.4% by the end of the year, compared to the same time last year when it was only 64.5%.
The above average rainfall in the northern Basin, particularly during March, had a significant impact on the storage volume in the Menindee Lakes system reaching 114.0% storage capacity in October, the highest level since 2012. The levels started to decrease in November and December as releases were made to reduce the storages to accommodate flows from the upstream tributaries resulting from the flooding in November. At the end of December, the system was at 93.5% compared to 20.9% at the end of 2020.

In the urban centres, the storages that supply Sydney, Canberra, and Hobart all maintained the full storage volumes that had been achieved during 2020, and ended 2021 at 95.0%, 100.0%, and 98.0% respectively. However, despite above average rainfall across Australia, storages in northern Australia and south-east and central Queensland did not experience the same recovery during 2021. In northern Australia, Argyle dam, the largest water supply dam in Australia, saw some recovery during 2021 reaching 82.4% in March, but did not fill for the fourth consecutive year.

Wivenhoe, the largest storage in south-east Queensland, started the year at 39.0%, however, despite the above average rainfall observed in neighbouring areas during November, had only increased to 46.7% by the end of 2021. In central Queensland, although the Bundaberg system, which includes Fred Haigh and Paradise storages, saw some increase in storage volume at the end of December they were only at 51.7% compared to 40.6% in December 2020. Similarly, the Nogoa Mackenzie, which includes Fairbairn storage, system only increased to 27.8% from 8.8% at the same time last year.

Percentage full storage at the end of 2021 compared to 2020, for Murray–Darling North, Murray–Darling South, Menindee Lakes, Argyle, and Wivenhoe.
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 showing signs of recovery

While availability of surface water generally increased during 2021, the situation for groundwater levels was more varied. Overall groundwater levels ranged from below average (42% of bores analysed) to average (31%) and above average (27%) in 2021. This was an improvement from the largely below average (57% of bores analysed) to average (29%) conditions in 2020.

Groundwater anomalies (i.e. above or below average levels) are calculated compared to observations for all years since 1997 for the mainland, and since 2008 for Tasmania.

High rainfall and flooding in some areas started to restore groundwater levels that were low due to reduced or no recharge, and increased pumping associated with the prolonged drought conditions from 2017 to 2020. However, groundwater levels have remained low in some parts of the country due to a lack of recovery from earlier drought or dry conditions in 2021.

Regionally, groundwater levels were average to above average in north-east Queensland and the Top End of the Northern Territory due to high rainfall driven by La Niña and a good wet season in early 2021. For example, groundwater in the Oolloo Dolostone and Tindall Limestone aquifers near Katherine recovered to average levels from historically low levels during 2018 to 2020.

The northern Murray–Darling Basin and south-east Queensland saw some recovery of groundwater levels due to increased recharge and reduced pumping associated with heavy rainfall and flooding in March and again in November. In contrast, many bores in the western and southern Murray–Darling Basin remain below average and require follow up rainfall to return groundwater levels to pre-drought conditions. In addition, below average rainfall during 2021 in the Victoria – South Australia border region has further affected groundwater levels in this area.

In Western Australia, groundwater levels in the Gnangara Mound near Perth generally remained low but started to show signs of recovery due to average to above average rainfall in 2021. Prior to this, the Perth region experienced two consecutive years of low winter rainfall resulting in low groundwater recharge and low groundwater levels.
Groundwater level status map for Australia in 2021 (based on data records from 1997, except for Tasmania where records are from 2008).

Groundwater levels in monitoring bores in the Lower Namoi catchment in the Murray–Darling Basin (left), Tindall aquifer in Katherine region (middle) and Gnangara Mound, Western Australia (right).

Water Markets

During 2021, increased rainfall led to improved water availability resulting in record high volumes of water allocations traded for a calendar year (8,300 GL) but a significant decrease in prices paid compared to the previous year.

In the Murray–Darling Basin, the high volumes of water in storage and the likelihood of above average rainfall resulted in all high reliability entitlement holders being at 100% of their allocation at the end of December 2021. In addition, most major general reliability entitlements also received full allocations, with only a few exceptions such as Lower Namoi at 70.7%.

As a consequence, the average water allocation prices in the southern Murray–Darling Basin, Australia's largest water market accounting for over 90% of total allocation trades by volume, have been around $100 per ML during 2021. This is a significant decline from $700 per ML being paid in January 2020, when average storage levels were at 32% for the southern Murray–Darling Basin.

Further information on water markets is in the Australian Water Markets Report.
Major climate influences during 2021: La Niña, negative IOD, and positive SAM

A combination of drivers influenced Australia during 2021. A La Niña was in place at the start of the year and declined as summer continued; the middle of the year was dominated by a negative Indian Ocean Dipole (IOD); and La Niña again emerged over spring. The Southern Annular Mode (SAM) was also positive throughout much of the year.

After being declared in spring 2020, La Niña persisted in the tropical Pacific through summer 2020–21, with a clearly neutral El Niño–Southern Oscillation (ENSO) state returning during March 2021.

In late May 2021 a negative Indian Ocean Dipole (IOD) pattern developed. Although the event weakened temporarily during August and September, the negative phase of the IOD persisted into early December with residual atmospheric patterns continuing for several weeks after weekly values of the IOD had returned to neutral in late spring.

A negative IOD increases the chances of above average winter–spring rainfall for much of southern and eastern Australia, and likely contributed to the above average rainfall observed across much of Australia during June and July, and parts of eastern Australia during September and October. Maximum temperatures are also more likely to be below average across southern Australia during a negative IOD, while across northern Australia warmer than average temperatures are more likely during a negative IOD. It is likely some of the maximum temperature pattern seen through May to November had an IOD influence, with temperatures well above average across the north, and near-average to below average across the south.

ENSO remained neutral through winter, before signs of possible La Niña development were again detected in early spring. Cooler than average sea surface temperatures were observed in the tropical Pacific Ocean from late October and values of the Southern Oscillation Index (SOI) remained close to La Niña levels. La Niña becoming established in late November as indicators in the ocean and atmosphere consolidated. La Niña typically brings above average rainfall to much of northern and eastern Australia when it is active.

A stronger than average polar vortex around Antarctica, and the associated larger than average Antarctic ozone hole, drove a strongly positive Southern Annular Mode (SAM) from towards the end of 2020 until late January 2021, with values of SAM remaining weakly positive through the first half of February. SAM was also positive for four weeks around June. The stratospheric polar vortex was again stronger, and the associated ozone hole larger, than their climatological averages from spring onwards, with SAM again positive from late August, and remaining mostly positive throughout spring and December.

Positive SAM can also be promoted by La Niña in the spring and summer, which would have contributed to the extraordinarily persistent positive SAM during October to December 2021. Positive SAM typically enhances chances of above average rainfall over much of New South Wales during spring, and increases the chance of rainfall in much of eastern Australia during late spring and summer. However, western Tasmania is typically drier as positive SAM shifts weather systems further south than their average path. During winter positive SAM also has a drying influence on south-west and south-east Australia in addition to Tasmania. The positive SAM during June may have influenced below average rainfall for parts of southern Western Australia and western Tasmania. It also likely influenced some of the below average rainfall seen during October to December for south-east South Australia, western Victoria and western Tasmania, and the above average rainfall along the east coast of Australia.

Climate change

In addition to the influence of natural drivers, Australia’s climate is increasingly affected by global warming and natural variability takes place on top of this background trend. Based on the temperature dataset ACORN-SAT, Australia’s climate has warmed on average by 1.47 ± 0.24 °C between when national records began in 1910 and 2020, with most of the warming occurring since 1950. The ocean waters around Australia have also warmed significantly over the past century, and have been very warm consistently across the past two decades. The background warming trend can only be explained by human influence on the global climate. The role of climate change is further discussed in State of the Climate 2020.

There has been a significant decline in April to October rainfall observed over south-east and south-west Australia in recent decades, including in higher rainfall parts of the Murray–Darling Basin. In the south-east of Australia April–October rainfall has declined by around 12% since the late 1990s. There has been a decline of around 16% in April–October rainfall over the south-west of Australia. The drying trend is particularly strong for May–July across south-west Western Australia; this region has seen May–July rainfall decrease by around 20% since 1970.

Conversely to the drying trend in the south, rainfall across northern Australia has increased during the northern wet season (October–April) since the 1970s, with more high intensity and short duration rain events.
Climate projections, described in State of the Climate 2020, indicate that Australia will likely spend more time in drought and that temperatures will continue to rise.

The World Meteorological Organization (WMO) released a statement on the State of the Global Climate in 2021, finding that 2021 was one of the seven warmest years on record with an average global temperature for 2021 of 1.11 ± 0.13 °C above the pre-industrial (1850–1900) baseline. 2021 is the seventh consecutive year (2015–2021) where the global temperature has been more than 1 °C above pre-industrial levels.

Greenhouse gases

Concentrations of all the major long-lived greenhouse gases in the atmosphere rose again in 2021. Measurements are made at the Cape Grim Baseline Air Pollution Station (CGBAPS), at Kennaook / Cape Grim, on Tasmania's north-west coast. The air measured there has passed from the Southern Ocean, free of local pollutants, and is representative of the well-mixed southern hemisphere atmosphere. Measurements taken in these circumstances are referred to as baseline (background) and have been made at Kennaook / Cape Grim since 1976. These gases are the principle driving force of global temperature increases. Carbon dioxide is the single most important anthropogenic greenhouse gas, accounting for approximately 66% of the radiative forcing by the long-lived greenhouse gases.

By December the baseline concentration of carbon dioxide (CO₂) was 413.1 parts per million in dry air (ppm). One year earlier, in December 2020, the concentration was 410.8 ppm. A decade earlier, in December 2011, the concentration was 388.9 ppm. The December 2021 value marks a 49% increase from the pre-industrial concentration of 278 ppm in 1750.

The baseline methane (CH₄) concentration in December 2021 was 1847 parts per billion in dry air (ppb). This represents an increase of 17 ppb over 12 months and is 156% higher than the pre-industrial level of 722 ppb. Methane accounts for about 16% of the radiative forcing of the long-lived greenhouse gases. The baseline nitrous oxide (N₂O) concentration in December 2021 was 334.0 ppb, 1.2 ppb higher than the same time in 2020, and 24% higher than the pre-industrial concentration of 270 ppb. Nitrous oxide accounts for about 7% of the radiative forcing by long-lived greenhouse gases.

The relative radiative forcings of CO₂, CH₄, and N₂O, as well as their pre-industrial concentrations, are consistent with (and referenced in) the WMO Greenhouse Gas Bulletin No. 17 of 25 October 2021.

CGBAPS 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 Cape Grim greenhouse gas data
- About Cape Grim Baseline Air Pollution Station

See State of the Climate 2020 for further information about greenhouse gases.
Baseline gas carbon dioxide (CO2)

Baseline concentration of carbon dioxide (CO2) measured at Cape Grim Baseline Air Pollution Station. Select each year to view the value.

Baseline gas methane (CH4)

Baseline concentration of methane (CH4) measured at Cape Grim Baseline Air Pollution Station. Monthly data are available from August 1984. Select each year to view the value.
The Antarctic ozone hole in 2021 closely resembled that of 2020, being both relatively large and deep, as well as very long-lasting. According to NASA satellite measurements, the ozone hole reached its maximum area of 24.8 million km² on 7 October 2021. The minimum measured value of total ozone was 92 Dobson Units (DU), also on 7 October. Unusually, the 2021 ozone hole persisted until very late in December.

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 approximately 80% over springtime, with the lowest observed value being 32.9 DU recorded on the flight of 8 October. This value is the seventh-lowest annual minimum in the Davis record, which began in 2003 (19 years of data). Ozone values in late November were among the lowest recorded at Davis for this time of year, due to the long-lasting ozone hole.

The year-to-year variability in the severity of the Antarctic ozone hole is determined primarily by meteorological conditions in the Antarctic stratosphere. In 2021 the stratospheric polar vortex was remarkably stable leading to cold temperatures lasting well into spring and hence a long-lasting ozone hole. Due to actions taken under the Montreal Protocol to end the use of ozone depleting substances, an underlying slow recovery in Antarctic ozone since the year 2000 is now detectable.

A long-lasting and larger than average ozone hole is known to promote positive Southern Annular Mode (SAM) at the surface during late spring to summer, due to the enhanced tropics-to-pole temperature gradient. Thus, the significantly larger than average ozone hole in 2021 could have been an additional forcing to the extraordinarily persistent and strong positive SAM in the last quarter of 2021.
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 2003–2020, and red crosses the 2021 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 sixth-warmest on record for the Australian region as a whole
2021 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 annual 2021 sea surface temperature (SST) anomaly for the Australian region was the sixth-highest on record; 0.52 °C above the 1961–1990 average based on data from the NOAA Extended Reconstructed Sea Surface Temperature dataset, ERSST v5. SSTs around Australia have warmed by over one degree since 1900. Above average annual SSTs have been observed for the Australian region for every year since 1995, and have been persistently high for the past decade. See State of the Climate 2020 for further information on long-term change in SSTs.

Sea surface temperatures were very much warmer than average (i.e. in the highest 10% of historical observations, compared to all years since 1900) across much of the waters around the northern tropics of Australia, and across waters around the north-west of Western Australia, extending into the Indian Ocean. Mean SSTs for the year were the fifth-warmest on record for the Northern Australian region, at 0.52 °C above average. Waters were also much warmer than average for an area around south-east South Australia, western Victoria, and the west of Bass Strait.

Farther away from Australia, SSTs were very much warmer than average to highest on record across much of the Maritime Continent, and very much warmer than average for the western Pacific Ocean, areas of the Tasman Sea around New Zealand and between Australia and New Zealand, and an area extending from the southern Indian Ocean to the coastline of eastern Antarctica.

SSTs remained high throughout the year, with large areas in the highest 10% of historical observations in each month. January and each month from June to December was amongst the ten warmest on record for the Northern Australian region and also for the Australian region as a whole.

Very much warmer than average SSTs were prominent over the Maritime Continent and to the north-east of Australia during January, and decreased into early autumn as the 2020–21 La Niña faded. The re-development of La Niña during spring was associated with very much warmer than average SSTs returning to the western Pacific and the Maritime Continent in October and November, with areas of cooler than average SSTs seen in the eastern Pacific Ocean. During November and December SSTs reached highest on record for their respective months across large areas of water to the east of Australia. Each of the Coral Sea region, Great Barrier Reef region, and Northern Australian region as a whole observed their warmest December on record. For the Coral Sea, December SSTs were the warmest on record for any month of the year, while November had been the warmest November on record, and October had been the second-warmest October on record.

While SSTs remained above or very much above average across waters to the north-west of Australia throughout the year, in the west of the Indian Ocean basin SSTs declined as the negative Indian Ocean Dipole emerged during May. From late autumn into winter SSTs were close to average in areas near the Horn of Africa and the Arabian Peninsula. The temporary weakening of the IOD event during August to September was associated with SSTs close to north-west Australia and
Indonesia moving to above average, rather than very much above average. The dissipation of the event in late spring favoured a return to near-average SSTs close to Australia and above average SSTs near the Horn of Africa.

For the globe as a whole, SSTs were the highest on record for each month from June to November. Globally, the average annual sea surface temperature for 2021 was 0.57 °C above the 1961–1990 average, the fourth-warmest on record in the ERSST v5 dataset which commences in 1854. The warmest through third-warmest year on record were 2019 (+0.64 °C), 2016 (+0.63 °C), and 2020 (+0.59 °C) respectively, and eight of the last ten years have been amongst the ten warmest on record.

### Notable events

See also the [Monthly Weather Review](#) for extra details, including events affecting smaller geographical regions or causing limited damage.

**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

Tropical cyclone *Imogen* made landfall near Karumba in Queensland's Gulf Country on 3 January, with the remnants then combining with a coastal trough and low. Widespread moderate rainfall resulted across northern Queensland in early January.

The coastal trough and another trough located further inland combined with an upper-level disturbance, producing areas of thunderstorms and widespread moderate falls across most of eastern Queensland. Heavy falls were localised around the north tropical to central coasts, with major flooding on the Herbert and Lower Burdekin rivers, and moderate flooding in some Gulf and western catchments on the 10th and the 11th.
On 11 January, a grassfire started in South Australia’s Lower South East region and travelled in an easterly direction towards the town of Lucindale. The fire burnt through 16,800 hectares of land, with some properties damaged or destroyed, and significant losses to livestock and fencing. Electricity was also cut to over 3,000 homes.

A low-intensity to severe-intensity heatwave occurred in Western Australia’s north between 12 and 15 January, including 47.1 °C at Roebourne Aero on the 15th. For the month as a whole a number of stations in coastal Western Australia observed their warmest January mean maximum temperature on record.

A low-intensity to severe-intensity heatwave affected most of mainland south-east Australia in the days leading up to 26 January. The hottest day was the 24th, with 45.3 °C at Port Augusta Aero in South Australia, 43.9 °C at Ouyen in Victoria, and 43.6 °C at Hay Airport in New South Wales. Sydney Observatory Hill recorded 5 consecutive days over 30 °C from the 22nd to the 26th; only the ninth instance since records began of 5 or more such days, but now the third year in a row that this has occurred.

An ignition in the Perth Hills suburb of Wooroloo around midday on 1 February became an out-of-control bushfire due to persistent easterly winds, threatening homes in the shire of Mundaring and the City of Swans. The fire burnt over 10,000 hectares of land with 98 homes and more than 100 other structures destroyed or damaged. Rainfall associated with a slow-moving tropical low moving down the south-west coast assisted in extinguishing the fires on the 7th.

Tropical low (12U) tracked south-west through the inland Kimberly, Pilbara, and northern Gascoyne in late January and the start of February. It moved offshore near Carnarvon on 5 February before tracking southward along the west coast and south-west of Western Australia until the 8th. The low brought significant rainfall to the state’s north and west, and caused extensive flooding and damage in the north-west, including in and around Carnarvon. A number of stations observed their highest February daily rainfall on record between the 5th and the 8th, with a number of stations recording their highest total February rainfall on record.

A tropical low pressure system (17U) off the Cairns coast developed into tropical cyclone Niran on 1 March. The system stayed off the Cairns coast but caused extensive damage to banana crops in Queensland. The system generated widespread moderate to heavy rainfall along the north tropical coast, with major flooding on the Herbert River on the 1st and 2nd. The system intensified as it moved away from the Australian coast, peaking as a category 5 storm on 5 March.

A deep surface trough extended from north-west Queensland to the inland south of the state from 14 March, and produced widespread moderate falls in north-west, central, and southern parts of the state. On the 17th, an isolated, extremely heavy daily rainfall total of 550 mm was recorded at Byfield Childs Road in the Capricornia District in Queensland, with further falls over 100 mm the following day.

A major rain event affected many parts of eastern and central Australia in the second half of March when a coastal trough deepened into a coastal low as it moved south along the New South Wales Coast, bringing very heavy rainfall and damaging winds. The highest rainfall totals occurred in coastal New South Wales, with the week ending 24 March the wettest week for the region since national daily records began in 1900.

Extensive heavy rainfall also occurred over large inland areas, particularly much of inland New South Wales and northern South Australia. Widespread significant flooding resulted in coastal New South Wales, and some adjacent parts of south-east Queensland and eastern Victoria. There was also significant flooding on some inland rivers in northern New South Wales and southern Queensland, as well as in eastern Tasmania. For more details see Special Climate Statement 74 Extreme rainfall and flooding in eastern and central Australia in March 2021.
On 4 April, a tropical low formed well off the north-west of Australia, in the vicinity of the monsoon trough, and later developed into severe tropical cyclone Seroja on the 5th while north of Kimberley in Western Australia. On the 9th, Seroja interacted with a tropical low, which later became the shorted-lived tropical cyclone Odette, and intensified to category 3 strength system before tracking south-east towards the west coast of Western Australia. Severe tropical cyclone Seroja crossed the coast of Western Australia between Kalbarri and Geraldton during the evening of the 11th, bringing heavy rainfall and damaging winds to a broad area. Several sites in South West Western Australia had their highest April daily rainfall on record.

Strong north to north-westerly winds affected Victoria on 7 and 8 June, ahead of a complex low pressure system crossing the state on the 9th and 10th. Low temperatures, heavy rainfall, and damaging winds were observed across Victoria. Damaging winds also brought down trees and unroofed houses, with more than 9,000 calls to the Victorian State Emergency Service for assistance as power was cut to more than 200,000 people on the 9th. Repairs to the electrical supply network took several weeks in some locations due to the severity of damage and very large number of fallen trees. There were significant telecommunications outages, with damage to over 400 NBN sites and over 200 mobile base stations. A number of roads were closed due to flooding, particularly through Gippsland, while some road closures elsewhere due to fallen powerlines and trees.

On 9 June, in Tasmania heavy rain and severe winds left more than 2,000 homes without power and a few sites with their highest June daily rainfall on record. Persistent rain during the second week of the month resulted in moderate flooding from the 10th to the 12th along the South Esk and Macquarie rivers, with flood warnings and flood watches in place for catchments across northern and eastern Tasmania.

On 20 July, a cold front brought damaging winds to central and eastern agricultural districts, with gusts over 80 km/h recorded at several locations. A tornado damaged homes in Adelaide’s north-east.

On the 24th, multiple fast-moving tornadoes brought down trees and damaged property south of Adelaide. Small hail fell across the Adelaide Hills, covering the ground in ice.

Severe thunderstorms also affected parts of New South Wales at the end of September, with damaging winds, heavy rain, and hail on the 29th and 30th. Giant hail (5 to 7 cm in diameter) was reported 40 km north of Bourke, with large hail also reported at Cunnamulla and Eulo on the 29th, while on the 30th a tornado was observed at Clear Creek, near Bathurst. The tornado caused damage to houses, powerlines, and trees along a 25 to 30 km line.

Severe thunderstorms also brought giant hail to parts of southern and south-east Queensland on 30 September, with 6 cm hail reported on the western Darling Downs.

Warmth was persistent across the north during October, with severe to extreme heatwave conditions affecting the Kimberley and Top End during the month. A large number of stations in the Northern Territory and western Queensland set early season temperature records for the warmest day so early after mid-winter, while others observed record runs of consecutive days of high temperatures, including 23 consecutive days of 40.0 °C or above at Argyle Aerodrome in the Kimberley. Three consecutive days of at least 42.0 °C were observed at Tennant Creek Airport, each exceeding the previous highest October maximum temperature record of 41.9 °C.
On 14 October, a tornado was observed at Armidale in New South Wales, with reports of damage to buildings and cars. Large hail, up to 5 cm in diameter, was reported at multiple locations including Tenterfield, Lalor Park, Ropes Crossing, and the Blue Mountains.

On the 20th a severe thunderstorm moved through Coffs Harbour and Sawtell, resulting in extensive damage to homes and the Toormina shopping centre, and leaving hail in drifts up to 30 cm deep on the ground.

Severe thunderstorms in Queensland brought giant hail and other damaging phenomena at times during October, including:
- giant hail in areas near the Sunshine Coast on the 14th
- golf ball sized hail south-east of Rockhampton on the 18th
- a funnel cloud and possible tornado at Bracewell near Gladstone on the 18th
- giant hail, up to 16 cm in diameter, at Yalboroo (between Mackay and Proserpine) on the 19th; including the largest hailstone with a verified measurement in Australia
- giant hail up to 11 cm in diameter in the Mackay area on the 20th, and a wind gust of up to 120 km/h at Mackay Airport with sightings of a weak tornado
- heavy rain and severe winds, leading to localised flash flooding at Brisbane Airport, and a weak tornado which damaged buildings around the Port of Brisbane and Brisbane Airport on the 21st

Australia's wettest November on record brought record-high November total rainfall to numerous sites in New South Wales and Queensland. During the month periods of heavy rainfall contributed to areas of flash flooding and riverine flooding across eastern and south-east Australia. Significant impacts included:
- Flooding occurred across large areas of inland New South Wales and large areas of Queensland from the 11th, before renewed rainfall from the 21st to the end of the month caused further flooding.
- At St Arnaud, in Victoria's Wimmera, a storm cell dumped two month's average rainfall in just a couple of hours on 4 November, resulting in significant flooding and evacuations.
- Heavy rain and hail resulted in damaged crops and in flooding in South Australia's Riverland on 6 November, while storms in Melbourne brought heavy rainfall to northern and eastern suburbs, and caused flash flooding in some south-eastern suburbs.
- In Queensland on 9 November storms caused damage to the North Coast rail line north of Rockhampton.
- Alice Springs Airport, in the southern Northern Territory, recorded its wettest November day on record on the 10th, with the Todd River bursting its banks.

At the start of December, Western Australia experienced heatwave conditions, continuing from late November. The north of Western Australia would go on to experience severe heatwave conditions a number of times during the month, with a number of sites in the Pilbara observing their hottest December on record for either mean maximum temperature or mean minimum temperature.

Marble Bar recorded a total of 16 days with maximum temperatures of 45 °C or above in December, the highest count for December on record and the second-highest count for any month. Marble Bar also recorded 29 consecutive days of at least 42 °C, exceeding the site's December record of 25 days in 1986.

A severe to extreme heatwave affected the west coast of Western Australia in late December, with daytime and overnight temperatures peaking on Christmas Day (25th) and Boxing Day (26th). Several sites observed their highest December temperature on record or warmest December night on record. Some sites observed daily records for any time of the year. During the event Perth observed 4 consecutive days with maximum temperatures reaching at least 40 °C, a first for December (4 consecutive days also occurred in February 2016 and 1933).

Geraldton Airport recorded 6 consecutive days with maximum temperatures at 40 °C or above between the 24th and 29th, which was its longest such run in December and the equal second-longest run for any month at Geraldton Airport (combining observations from the current site and observations from the old site, extending back to 1941).
Severe winds affected broad areas of eastern Australia on 19 December as a cold front crossed south-eastern Australia, with gusts over 100 km/h recorded at a number of locations in Victoria, New South Wales, and Tasmania. In Sydney’s northern beaches, the State Emergency Service received almost 600 requests for assistance, with damage to trees and structures reported across parts of New South Wales and Victoria.

A tropical low pressure system brought heavy rainfall to parts of the Northern Territory and Queensland towards the end of December, generating widespread moderate to locally heavy falls across the Top End for several days. Daily rainfall records for December were set at numerous sites in the Top End of the Northern Territory between the 25th and 28th. Extreme rainfall continued in northern Queensland until the end of the month, including 345 mm at Kowanyama over two days.

### 2021 monthly and annual rainfall, temperature and sea surface temperature deciles maps

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<th>Minimum temperature deciles</th>
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<tr>
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<td><img src="image21" alt="Map" /></td>
<td><img src="image22" alt="Map" /></td>
<td><img src="image23" alt="Map" /></td>
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<td><img src="image37" alt="Map" /></td>
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<tr>
<td></td>
<td>Rainfall deciles</td>
<td>Maximum temperature deciles</td>
<td>Minimum temperature deciles</td>
<td>Mean temperature deciles</td>
<td>Sea surface temperature deciles</td>
</tr>
<tr>
<td>---------</td>
<td>------------------</td>
<td>-----------------------------</td>
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<td>-------------------------</td>
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<td><img src="image3" alt="Min Temp Map" /></td>
<td><img src="image4" alt="Mean Temp Map" /></td>
<td><img src="image5" alt="Sea Temp Map" /></td>
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<td><img src="image9" alt="Mean Temp Map" /></td>
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<td><img src="image11" alt="Rainfall Map" /></td>
<td><img src="image12" alt="Max Temp Map" /></td>
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<td><img src="image14" alt="Mean Temp Map" /></td>
<td><img src="image15" alt="Sea Temp Map" /></td>
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<tr>
<td>December</td>
<td><img src="image16" alt="Rainfall Map" /></td>
<td><img src="image17" alt="Max Temp Map" /></td>
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<tr>
<td>Year</td>
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<td><img src="image24" alt="Mean Temp Map" /></td>
<td><img src="image25" alt="Sea Temp Map" /></td>
</tr>
</tbody>
</table>

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.

This statement has been prepared using the homogenised Australian temperature dataset (ACORN-SAT) for area-averaged temperature values and the observational datasets. Mapped analysis uses AWAP temperature data and AWAP rainfall data up to 2019. From 2020 area-averaged rainfall values and mapped analyses use the new AGCD dataset.

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 Cape Grim Baseline Air Pollution Station (CGBAPS)

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.