Seasonal climate summary southern hemisphere (winter 2015): Mild winter over most of Australia as El Niño strengthens

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The climate is summarised for the austral winter season of 2015 with emphasis on the tropical Pacific region as well as rainfall and temperature over Australia. In the tropical Pacific, winter was dominated by a developing El Niño event; by June the Southern Oscillation Index had already exceeded El Niño thresholds for the second month running and sea surface temperatures had also passed key threshold levels as the tropical Pacific Ocean warmed rapidly. Several composite indices of El Niño such as the 5VAR and Multivariate ENSO Index (MEI) continued to rise as the winter months progressed, indicating an atmosphere and ocean that was building towards a strong event, with index values by August being comparable to the previously strong El Niño events of 1982–83 and 1997–98.

August saw the start of the strongest positive Indian Ocean Dipole event since 2006 while the Southern Annular Mode was consistently positive throughout winter. Australian rainfall was lower than average during winter, most notably over the southern regions, with daytime temperatures above normal in northern and western parts of Australia. Night-time temperatures were overall warmer than normal with the main exception being Tasmania, parts of the southeast and Northern Territory.

1. Introduction

This summary reviews the climate patterns for winter 2015, with particular attention given to the Australasian and Pacific regions. The main sources of information for this report are analyses prepared by the Bureau of Meteorology with other data sourced given below.

2. Pacific and Indian Basin climate indices

2.1 Southern Oscillation Index

The Troup Southern Oscillation Index\(^1\) (SOI; Troup 1965) is based on the mean sea level pressure (MSLP) difference between Tahiti and Darwin (in this case it is the ten times the standardised monthly anomaly of the difference in mean sea level). Sustained negative values below \(-8\) generally indicate El Niño periods, while sustained positive values above \(+8\)

\(^1\) The Troup Southern Oscillation Index (Troup 1965) used in this article is ten times the standardised monthly anomaly of the difference in mean sea level pressure (MSLP) between Tahiti and Darwin. The calculation is based on a sixty-year climatology (1933–1992). The Darwin MSLP is provided by the Bureau of Meteorology, with the Tahiti MSLP provided by Météo France inter-regional direction for French Polynesia.
are associated with La Niña events. The period January 2010 to August 2015 is shown in Figure 1 together with a five-month moving average.

After briefly reaching El Niño levels in the last half of 2014 (Hope et al. 2015, Blockley 2015), SOI values fell further into negative (El Niño) territory during early 2015, with sustained negative values reached through winter. By May, the SOI had dropped significantly to –13.7 its lowest monthly value since February 2010. The SOI value for June was –12.0, July –14.7 and August –19.8. These strong negative SOI values over winter were a combination of positive mean sea level pressure (MSLP) anomalies at Darwin and negative anomalies over Tahiti during this time. Notable departures from normal pressure during August saw Darwin with a +2.0 hPa anomaly and Tahiti with a –1.1 hPa anomaly.

Figure 1 Southern Oscillation Index (SOI), from January 2010 to August 2015, together with a five-month binomially weighted moving average. The means and standard deviations used in the computation of the SOI are based on the period 1933–1992.

2.2 Composite monthly ENSO indices

5VAR² is a composite monthly ENSO index, calculated as the standardised amplitude of the first principal component of monthly Darwin and Tahiti MSLP³ and monthly NINO3, NINO3.4 and NINO4 sea surface temperatures⁴ (SSTs) (Kuleshov et al. 2009). The monthly 5VAR values for the period January 2010 to August 2015 are shown in Figure 2, along with the three-month moving average. Persistently positive (negative) values in excess of one standard deviation typically indicate El Niño (La Niña).

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² ENSO 5VAR was developed by the Bureau of Meteorology and is described in Kuleshov et al. (2009). The principal component analysis and standardisation of this ENSO index is performed over the period 1950–1999.
⁴ SST indices obtained from ftp://ftp.cpc.ncep.noaa.gov/wd52dg/data/indices/sstoi.indices
The near El Niño of 2014 can be seen in Figure 2 with more positive values commencing in autumn of 2015 as El Niño finally arrived (Cook 2015). Values of the 5VAR index rose further as the El Niño strengthened through the winter months with increasingly positive values for June, July and August measuring +2.24, +2.48 and +2.60, respectively. August 2015 had the third highest 5VAR value on record dating back to 1950 behind February and March of 1983, suggesting that the event was among the strongest on records as measured by a coupled ocean-atmosphere index.

The Multivariate ENSO Index\(^5\) (MEI), produced by the Physical Sciences Division of the Earth Systems Research Laboratory (formerly known as the US Climate Diagnostics Center), is derived from a number of atmospheric and oceanic parameters calculated as a two-month mean (Wolter and Timlin 1993, 1998). As with 5VAR, large negative anomalies in the MEI are usually associated with La Niña and large positive anomalies indicate El Niño. The May–June (+2.06), June–July (+1.97) and July–August (+2.37) MEI values are at levels indicative of El Niño with the June–July and July–August values both the second highest on record for their respective months; in both cases behind values set in 1997. This highlights that not only was the 2015 El Niño strong by historical standards, but it started early and strengthened rapidly.

2.3 Outgoing long-wave radiation

Outgoing long-wave radiation (OLR) in the equatorial Pacific Ocean is a good proxy for tropical convection, with decreases (increases) in OLR associated with increased (decreased) cloudiness and hence convection rainfall changes. During El Niño, OLR is often decreased near the Date Line indicating increased convection (and rainfall) as the Walker Circulation weakens and the warm pool an associated tropical rainfall is displaced to the east. The reverse is true during La Niña events.

Standardised monthly anomalies of OLR are computed for an equatorial region from 5°S to 5°N and 160°E to 160°W by NOAA's Climate Prediction Centre. Monthly values for winter were −1.4 Wm\(^{-2}\), −0.3 Wm\(^{-2}\) and −1.4 Wm\(^{-2}\) for June, July and August respectively, indicating that convection was significantly enhanced in that area during winter. The overall winter 2015 mean was −1.0 Wm\(^{-2}\), the most negative seasonal anomaly since the 1997–98 El Niño.

The spatial pattern of seasonal OLR anomalies across the Asia–Pacific region between 40°S and 40°N are shown in Figure 3. Strong positive OLR anomalies are shown over the far western Pacific coinciding with decreased rainfall over the region. This low rainfall in the region had significant impacts with fires widespread in Indonesia and severe drought in New Guinea. Conversely strong negative OLR anomalies can be seen near the Solomon Islands which are largely due to a tropical cyclone in this area during July as well as Madden-Julian Oscillation (MJO) activity during June (see Section 2.5).

![Figure 3 OLR anomalies for winter 2015 (Wm\(^{-2}\)). Base period is 1979–2000.](image)

### 2.4 Indian Ocean Dipole

The Indian Ocean Dipole (IOD) describes the pattern of sea surface temperature anomalies (SSTs) across the equatorial Indian Ocean. A positive phase of the IOD is characterised by cooler than usual water near Indonesia and warmer than usual water in the tropical western Indian Ocean. This pattern is associated with decreased convection, and hence less rainfall in the eastern Indian Ocean and across southern Australia during winter and spring. The opposite is true for a negative IOD.

IOD events can be represented by the Dipole Mode Index (DMI) (Saji et al. 1999), where the difference in SST anomalies is measured between the western (50°E to 70°E and 10°S to 10°N) and eastern (90°E to 110°E and 10°S to 0°S) equatorial Indian Ocean. Sustained values below −0.4 °C indicate a negative IOD event and values above +0.4 °C indicate a positive IOD event. Weekly values of the DMI index are shown in Figure 4. Values of the DMI were neutral through the start of winter before becoming persistently positive at the start of August as a positive IOD event began. In this case, SSTs in the eastern Indian Ocean region were generally close to average or slightly above average during August, however the western tropical Indian Ocean was substantially warmer than normal, with some regions of highest on record.

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6 Obtained from [http://www.cpc.ncep.noaa.gov/data/indices/olr](http://www.cpc.ncep.noaa.gov/data/indices/olr)
2.5 Madden–Julian Oscillation

The Madden–Julian Oscillation (MJO) can be characterised as a burst of tropical cloud and rainfall which develops in the Indian Ocean and propagates eastwards into the Pacific Ocean (Madden and Julian 1971, 1972, and 1994). The MJO typically takes 30 to 60 days to reach the western Pacific, with six to twelve events per year. An active phase of the MJO is associated with increased tropical rainfall and can be detected by negative OLR anomalies. The MJO is monitored by the Real-time Multivariate MJO (RMM) index as described by Wheeler and Hendon (2004).

The phase-space diagram of the RMM index for winter is shown in Figure 5 and the evolution of tropical convection anomalies along the equator with time is shown in Figure 6. The period from June to August 2015 showed a relatively strong pulse of MJO activity that propagated around the full phase space. The MJO pulse occurred at the start of June in phase 1; it progressed across the Indian Ocean, weakening as it passed through the Maritime Continent before strengthening again into the Pacific to become strong through the early part of July. This pulse was associated with a westerly wind burst which acted to strengthen the El Niño. By late July the MJO signal became weak and was then indiscernible through August.
Figure 5  Phase-space representation of the MJO index for austral winter 2015. Daily values are shown with June in red, July in green, and August in blue.

Figure 6  Time–longitude section of daily-averaged outgoing long-wave radiation (OLR) anomalies, averaged for 15°S to 15°N, for the period April 2015 to October 2015. Anomalies are with respect to a base period of 1979–2010.
3. Oceanic patterns

3.1 Sea surface temperatures

Winter 2015 global SST anomalies, from the US National Oceanic and Atmospheric Administration Optimum Interpolation analyses (Reynolds et al. 2002) are displayed in Figure 7. The base period is 1981–2010. Positive (warm) anomalies are shown in red shades, while negative (cool) anomalies are shown in blue shades.

SST anomalies across the tropical Pacific have been on the positive side since late autumn/early winter 2014 (Pollock 2015), although monthly SST values in the key NINO3.4 region in the central tropical Pacific fell short of El Niño levels for most of last year. By winter 2015 SSTs had warmed significantly, with the NINO3 and NINO3.4 values increasing through each month of winter (Table 1), to be well above the typical El Niño thresholds at the start of June.

Warm winter also covered almost the entire north Pacific, with record warm conditions present off the Americas. This pattern is consistent with a strongly positive Pacific Decadal Oscillation, with values for this index becoming positive since early 2014. The remarkable warmth across the Pacific without compensating cool anomalies elsewhere meant that the oceans during this period were globally the warmest on record.

Warm SST anomalies were also present during winter across most of the Indian Ocean basin, with the warm anomalies extending to cover much of the Australian region, particularly southern Australia. The pattern of basin wide warmth is unprecedented in the historical records, and resulted in the basin having its warmest winter on record by a substantial margin. The Indian Ocean has experienced remarkable warming since the late 2000s (Lee et al. 2015) which means that anomalies such as those associated with the IOD are occurring on top of a particularly warm mean state. The particularly strong anomalies in the western Indian Ocean were responsible for the positive Indian Ocean Dipole event over late winter as discussed previously.
3.2 Equatorial Pacific sub-surface patterns

A cross-section along the equator (2°S to 2°N) of monthly subsurface anomalies from May to August 2015 (from the Bureau of Meteorology) is shown in Figure 8. Red shading indicates positive anomalies and blue shades indicate negative anomalies. Strong warm anomalies have persisted largely unchanged in the top 150 m of the Pacific to the east of the Date Line through late autumn and winter. The cool anomalies below the surface to the west of the Date Line strengthened slightly through each month of winter although their spatial extent did not alter significantly. With central Pacific subsurface anomalies in excess of +6 °C, the El Niño event was comparable to that during winter 1997, but appears to be substantially stronger than the 1972 and 1982 events for the time of year.

Figure 8 Four-month sequence from May to August 2015 of vertical sea subsurface temperature anomalies at the equator for the Pacific Ocean. The contour interval is 0.5 °C. (Plot obtained from the Bureau of Meteorology).

This and other analyses available from http://www.bom.gov.au/oceanography/oceantemp/pastanal.shtml
The equatorial thermocline is a region below the surface where the temperature gradient between warm near surface water and cold deep-ocean waters is greatest. The 20 °C isotherm depth is generally located close to this equatorial thermocline. Therefore, measurements of the 20 °C isotherm make a good proxy for the thermocline depth. Positive anomalies correspond to a deeper-than-average thermocline and vice versa, where shifts in the depth of the 20 °C isotherm provide an indication of subsequent temperature changes in SSTs; a deeper thermocline results in less cold water available for upwelling, and therefore warming of surface temperatures. The time-longitude (Hovmöller) diagram for the 20 °C isotherm depth anomaly along the equator for January 2013 to August 2015, obtained from the TAO Project Office, is shown in Figure 9.

A downwelling Kelvin (wave) wave crossed the Pacific during autumn, the effect of which was to lower the 20 °C isotherm by more than 20m as it propagated east. By August the 20 °C isotherm was approaching 40m lower than normal in the far eastern Pacific and subsurface temperatures were well above average.

Figure 9  Time-longitude section of the monthly anomalous depth of the 20 °C isotherm at the equator (2°S to 2°N) for January 2013 to August 2015. (Plot obtained from the TAO Project Office)
4. Atmospheric patterns

4.1 Surface analyses

The mean sea level pressure (MSLP) pattern for winter 2015 is shown in Figure 10, computed using data from the 0000 UTC daily analyses of the Bureau of Meteorology’s Australian Community Climate and Earth System Simulator (ACCESS) model. The MSLP anomalies are shown in Figure 11, relative to the 1979–2000 climatology obtained from the National Centers for Environmental Prediction (NCEP) II Reanalysis data (Kanamitsu et al. 2002). The MSLP anomaly field is not shown over areas of elevated topography (grey shading) as the extrapolation to sea level can result in unrealistic structures.

The winter 2015 MSLP pattern shows the subtropical ridge lay over southern Australia with a local maximum of 1025.7 hPa over South Australia (Figure 10), and anomaly of +8.6 hPa off the southwest Australian coast (Figure 11). The pressure anomalies to the south of Australia are remarkable for both their intensity and extent. As a result, westerly winds were greatly reduced and frontal passages and associated rainfall was significantly reduced. Further south, the circumpolar trough was deeper than normal, with strongest anomalies of −9.6 hPa around the Antarctic. This pattern is consistent with a strong positive phase on the SAM.

Other notable areas of anomalous high pressure were recorded across the south Pacific Ocean, with anomalies of +6.1 hPa to the east of the Date Line, and +5 hPa to the southwest of the South African coast. Negative MSLP anomalies extend around the Antarctic coastline and out to Chile and Argentina.

Figure 10 Winter 2015 mean sea level pressure (MSLP; hPa). The contour interval is 5 hPa.

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9 For more information on the Bureau of Meteorology’s ACCESS model, see http://www.bom.gov.au/nwp/doc/access/NWPData.shtml
4.2 Mid-tropospheric analyses

The 500 hPa geopotential height is a good indicator of the steering of surface synoptic systems across the southern hemisphere. The mean for winter 2015 is shown in Figure 12, with the corresponding anomalies in Figure 13. The winter anomaly pattern for the 500 hPa geopotential height shows good alignment with the MSLP anomaly pattern in the previous section. The regions of strongest local minimum occur over the Antarctic Peninsula with Figure 13 showing a minimum in 500 hPa height of −88 gpm, with a maximum off the southwest Australian coast of +94.8 gpm. The anomalies to the southwest of Australia reveal that the anticyclonic conditions in this region stretch through the entire troposphere.

4.3 Southern Annular Mode

The Southern Annular Mode (SAM), also known as the Antarctic Oscillation (AAO), describes the north–south shift in the belt of strong westerly winds in the middle to higher latitudes of the southern hemisphere. A positive phase of SAM is associated with negative MSLP anomalies near Antarctica and positive anomalies in the mid-latitudes as the belt of westerly winds (and hence cold fronts) shifts polewards. A negative SAM is associated with lower pressure over the mid-latitudes and higher pressure over the Antarctic region, as westerly winds shift northwards. In winter, a positive SAM tends to decrease rainfall across southern Victoria, northern Tasmania and southwest Western Australia, and increase rainfall in inland New South Wales (Hendon et al. 2007). It is typical for the Southern Hemisphere to have positive values of the SAM during El Niño events.

Monthly values of SAM over winter 2015 were +2.41, +2.00 and +1.86 for June, July and August respectively. These strong positive values of SAM indicates the contraction of the belt of strong westerly winds towards the pole has played a part towards the drier than normal winter across southwest Western Australia, southeast South Australia, Victoria and Tasmania (see Section 5.1).
Figure 12  Winter 2015 500 hPa mean geopotential height (gpm).

Figure 13  Winter 2015 500 hPa mean geopotential height anomalies (gpm), from a 1979–2000 climatology.
4.4 Winds

Winter 2015 low-level (850 hPa) and upper-level (200 hPa) wind anomalies are shown in Figure 14 and Figure 15, respectively. Isotach contours are at 5 ms$^{-1}$ intervals.

At 850 hPa anomalies for winter were generally within 5 ms$^{-1}$ of the long-term average, with easterly wind anomalies tending to dominate. Over Australia, weak southeasterly low-level wind anomalies can be seen feeding across southern parts of Australia, with more easterly flow in the central and northern parts of the country. In the central tropical Pacific there was enhanced westerly flow across the north of the equator, consistent with El Niño conditions in place. The easterly wind anomalies near and southwest of Western Australia were associated with weakened mid latitude storm activity.

Upper-level 200 hPa anomalies show anticlockwise gyres in the southern Pacific Ocean to the northeast and east of New Zealand. A clockwise gyre sat over Australia’s northwest, which caused flow to the southeast over the northern half of Australia and flow to the west over the southern half of the mainland. The subtropical jet was substantially stronger than average in the South Pacific, with some extension into the Australian region.

Figure 14 Winter 2015 850 hPa vector wind anomalies (ms$^{-1}$).

Figure 15 Winter 2015 200 hPa vector wind anomalies (ms$^{-1}$).
5. Australian region

5.1 Rainfall

Australian rainfall totals for winter 2015 are shown in Figure 16, with corresponding rainfall deciles shown in Figure 17. The deciles are calculated using rainfall data for all winter periods between 1900 and 2015 (i.e., 116 winters). Winter rainfall for Australia was overall below normal, with an area-average of 54.5 mm, 15% below the 1961–90 average. Nationally the total ranked 40th, just outside of the lowest third (tercile; see Table 2). Winter rainfall was low over Australia as a whole in June, July and August; with July being a standout with below normal rainfall in each of Australia’s states. Overall, winter rainfall has been below normal since 2010.

Notable areas of above-average winter rainfall in 2015 were generally located in isolated patches in central New South Wales, southeastern Western Australia and parts of the Northern Territory. New South Wales was the only State to record higher than normal winter rainfall (see Table 2), which is rather unusual given the presence of a strong El Niño event. The heavy rainfall in parts of inland and southern Western Australia largely came from a major low pressure system which developed in August. Large parts of Victoria, Tasmania, and central and southwest Western Australia all recorded below normal rainfall over winter 2015 with particularly poor rainfall in areas with good exposure to the westerlies. These same regions have all experienced long-term rainfall declines over recent decades and the poor rainfall during winter 2015 adds to the drying trend. Both Queensland and the Northern Territory recorded rainfall that was near 25% below the long-term mean, consistent with the El Niño event and weakened Walker Circulation.

Figure 16 Winter 2015 rainfall totals (mm) for Australia.
### Table 2
Summary of the seasonal rainfall ranks and extremes on a national and State basis for winter 2015. The ranking in the last column goes from 1 (lowest) to 116 (highest) and is calculated over the years 1900 to 2015 inclusive.

<table>
<thead>
<tr>
<th>Region</th>
<th>Highest seasonal total (mm)</th>
<th>Lowest seasonal total (mm)</th>
<th>Highest daily total (mm)</th>
<th>Area-averaged rainfall (mm)</th>
<th>Rank of area-averaged rainfall</th>
<th>% difference from mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>857.8 at Tree House Creek (Qld)</td>
<td>Zero at several locations</td>
<td>320.0 at Bellenden Ker Top Station on 30/06 (Qld)</td>
<td>53.6</td>
<td>37</td>
<td>−16%</td>
</tr>
<tr>
<td>Queensland</td>
<td>857.8 at Tree House Creek</td>
<td>Zero at several locations</td>
<td>320.0 at Bellenden Ker Top Station on 30/06</td>
<td>38.1</td>
<td>44</td>
<td>−26%</td>
</tr>
<tr>
<td>New South Wales</td>
<td>704.6 at Blackbutt</td>
<td>29.8 at Lake Victoria Storage</td>
<td>297.6 at Jamberoo on 26/08</td>
<td>125.2</td>
<td>71</td>
<td>+8%</td>
</tr>
<tr>
<td>Victoria</td>
<td>679.8 at Haines Junction</td>
<td>47.6 at Charlton</td>
<td>84.0 at Goongerah on 13/07</td>
<td>152.8</td>
<td>21</td>
<td>−25%</td>
</tr>
<tr>
<td>Tasmania</td>
<td>982.2 at Mount Read(^{10})</td>
<td>59.5 at Premaydena Hatchery</td>
<td>81.0 at Strathgordon on 09/06</td>
<td>369.0</td>
<td>27</td>
<td>−16%</td>
</tr>
<tr>
<td>South Australia</td>
<td>367.7 at Uraidla</td>
<td>3.7 at Moonaree</td>
<td>62.6 at Wudinna Aero on 18/06</td>
<td>44.4</td>
<td>37</td>
<td>−20%</td>
</tr>
<tr>
<td>Western Australia</td>
<td>543.3 at Northcliffe</td>
<td>Zero at several locations</td>
<td>132.0 at Murchison on 17/06</td>
<td>48.4</td>
<td>36</td>
<td>−20%</td>
</tr>
<tr>
<td>Northern Territory</td>
<td>159.4 at Yirrkala Tropical Gardens</td>
<td>Zero at several locations</td>
<td>125.0 at Maningrida Airport on 01/06</td>
<td>13.6</td>
<td>66</td>
<td>−26%</td>
</tr>
</tbody>
</table>

5.2 Drought

Rainfall over the previous three years has been very much below average across much of central and western Queensland, extending into parts of northern New South Wales along with the western half of Victoria extending into southeast South Australia. A way in which the Bureau of Meteorology assesses drought is by considering the extent of areas of the country which contain accumulated rainfall in the lowest 10% of records for varying timescales.

For a 35-month period October 2012 to August 2015 (Figure 18), 16% of Australia was experiencing at least serious rainfall deficiencies (lowest 10% of records), with 9.3% experiencing severe deficiencies (lowest 5% of records). Much of the serious rainfall deficiencies covered large parts of Queensland and the western half of Victoria.

Over the shorter term, for 3-month and 20-month periods (not shown), less than 6% of Australia had recorded rainfall in the lowest 10% of records. In both cases, regions that were most affected included western Victoria into South Australia, coastal parts of Tasmania, southwestern Western Australia and parts of central Queensland. On the 20-month timescale severe deficiencies covered 18% of Victoria and 14% of Tasmania.

\(^{10}\) The true value is unknown, but likely higher as some snow was lost
Figure 17  Winter 2015 rainfall deciles for Australia: decile ranges based on grid-point values over all winters from 1900 to 2015.

Figure 18  Rainfall deficiencies for the 35-month period 1 October 2012 to 31 August 2015.
5.3 Temperature

Australian maximum and minimum temperature anomalies are shown in Figure 19 and Figure 21. Seasonal anomalies are calculated with respect to the 1961–1990 period, and use all stations for which an elevation is available (Jones et al. 2009). Figure 20 and Figure 21 shows the equivalent maximum and minimum temperature deciles, calculated using gridded temperature data for all winter periods between 1911 and 2015.

Mean maximum temperatures for winter were mainly above average for Australia, with the main exception being in the southeast, including; Tasmania, Victoria, southeast South Australia and inland New South Wales. While cooler than normal, anomalies in this region were within 1 °C of normal. There were widespread positive anomalies through the western and northern parts of the mainland of up to 2°C. Anomalies in excess of +2.0 °C were recorded across the Pilbara/Kimberley and Gascoyne regions of Western Australia. Nearly half (49%) of Western Australia experienced maximum temperatures in the highest decile, with winter 2015 the second warmest on record behind 2002. Western Australia has experienced a remarkable run of milder than average winters, with the last cooler than average season occurring back in 2000. One third of Queensland was in decile 10, with a seasonal anomaly of +0.96 °C. Overall, the Australian area average anomaly was +0.83 °C for winter, ranking the three months as equal eighth-warmest from the 106 years of record. See Table 3 for a full summary.

Like maximum temperatures, minimum temperatures for winter were warmer than average except in a pocket of the Northern Territory, southeast South Australia, southern New South Wales, Victoria and Tasmania. The overall Australian anomaly was +0.76 °C, placing it as the 13th warmest winter on record (Table 4). The largest anomalies over the three months were +2 °C to +3 °C occurring in isolated patches across central and northern Queensland as well as parts of Western Australia (see Figure 21). 53% of Western Australia and 37% of Queensland were in decile 10 when compared to the historic record and Western Australia came in as the seventh warmest on record. Conversely, 28% of Tasmania was in decile 1, recording the coolest winter nights since 1995, the lowest mean temperature since 1966, and for the State as a whole, the 10th lowest on record.

Figure 19 Winter 2015 maximum temperature anomalies (°C).
Figure 20  Winter 2015 maximum temperature deciles: decile ranges based on grid-point values for all winters from 1911 to 2015.

Figure 21  Winter 2015 minimum temperature anomalies (°C).
Figure 22  Winter 2015 minimum temperature deciles: decile ranges based on grid-point values for all autumns from 1911 to 2015.
<table>
<thead>
<tr>
<th>Region</th>
<th>Highest seasonal mean maximum (°C)</th>
<th>Lowest seasonal mean maximum (°C)</th>
<th>Highest daily temperature (°C)</th>
<th>Lowest daily maximum temperature (°C)</th>
<th>Area-averaged temperature anomaly (°C)</th>
<th>Rank of area-averaged temperature anomaly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>33.6 at Middle Point (NT)</td>
<td>1.8 at Mount Buller (Vic)</td>
<td>37.6 at Wyndham (WA) on 31/08 and Warmun on 25/08</td>
<td>-5.4 at Mount Hotham (Vic) 01/06</td>
<td>+0.83</td>
<td>98.5 (tied)</td>
</tr>
<tr>
<td>Queensland</td>
<td>32.6 at Kowanyama</td>
<td>15.2 at Applethorpe</td>
<td>37.7 at Century Mine on 24/08</td>
<td>4.8 at Applethorpe on 17/07</td>
<td>+0.96</td>
<td>94</td>
</tr>
<tr>
<td>New South Wales</td>
<td>21.6 at Casino Airport</td>
<td>1.4 at Thredbo</td>
<td>31.1 at Tiboolburra Airport on 22/08</td>
<td>-4.7 at Thredbo on 01/06</td>
<td>+0.03</td>
<td>52</td>
</tr>
<tr>
<td>Victoria</td>
<td>15.8 at Mildura</td>
<td>1.8 at Mount Buller</td>
<td>24.5 at Mallacoota</td>
<td>-5.4 at Mount Hotham 01/06</td>
<td>-0.37</td>
<td>28.5 (tied)</td>
</tr>
<tr>
<td>Tasmania</td>
<td>13.9 at Bicheno</td>
<td>2.2 at kunanyi (Mount Wellington)</td>
<td>20.0 at Swansea on 21/08 and Campania on 07/06</td>
<td>-3.7 at kunanyi (Mount Wellington) on 05/08</td>
<td>-0.62</td>
<td>10</td>
</tr>
<tr>
<td>South Australia</td>
<td>20.5 at Oodnadatta</td>
<td>9.5 at Mount Lofty</td>
<td>34.8 at Moomba on 23/8</td>
<td>5.3 at Mount Lofty on 11/07</td>
<td>+0.26</td>
<td>57</td>
</tr>
<tr>
<td>Western Australia</td>
<td>33.1 at Wyndham Aero</td>
<td>15.8 at Shannon</td>
<td>37.6 at Wyndham on 31/08 and Warmun on 25/08</td>
<td>9.5 at Ravens-thorpe on 08/07</td>
<td>+1.44</td>
<td>105</td>
</tr>
<tr>
<td>Northern Territory</td>
<td>33.6 at Middle Point</td>
<td>20.4 at Arltunga</td>
<td>37.5 at Bulman on 25/08</td>
<td>13.2 at Kulgera on 25/07</td>
<td>+0.68</td>
<td>85</td>
</tr>
</tbody>
</table>

Table 3 Summary of the seasonal maximum temperature ranks and extremes on a national and State basis for winter 2015. The ranking in the last column goes from 1 (lowest) to 106 (highest) and is calculated over the years 1910 to 2015 inclusive.¹¹

¹¹ A subset of the full temperature network is used to calculate the spatial averages and rankings shown in Table 3 (maximum temperature) and Table 4 (minimum temperature); this dataset is known as ACORN-SAT (see http://www.bom.gov.au/climate/change/acorn-sat/ for details). These averages are available from 1910 to the present. As the anomaly averages in the tables are only retained to two decimal places, tied rankings are possible. Rankings marked with "=" denote tied rankings.
### Table 4 Summary of the seasonal minimum temperature ranks and extremes on a national and State basis for winter 2015.

The ranking in the last column goes from 1 (lowest) to 106 (highest) and is calculated over the years 1910 to 2015 inclusive.

<table>
<thead>
<tr>
<th>Region</th>
<th>Highest seasonal mean minimum (°C)</th>
<th>Lowest seasonal mean minimum (°C)</th>
<th>Highest daily minimum temperature (°C)</th>
<th>Lowest daily temperature (°C)</th>
<th>Area-averaged temperature anomaly (°C)</th>
<th>Rank of area-averaged temperature anomaly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>25.2 at Browse Island (WA)</td>
<td>-4.3 at Thredbo (NSW)</td>
<td>27.2 at Browse Island (WA) on 01/06</td>
<td>-12.8 at Perisher (NSW) on 04/08</td>
<td>+0.76</td>
<td>93</td>
</tr>
<tr>
<td>Queensland</td>
<td>23.8 at Coconut Island</td>
<td>2.6 at Stanthorpe</td>
<td>25.8 at Coconut Island on 19/06</td>
<td>-5.1 at Stanthorpe on 07/08</td>
<td>+1.46</td>
<td>98</td>
</tr>
<tr>
<td>New South Wales</td>
<td>12.8 at Byron Bay</td>
<td>-4.3 at Thredbo</td>
<td>18.9 at Murwillumbah on 24/08</td>
<td>-12.8 at Perisher Valley on 04/08</td>
<td>0.40</td>
<td>72</td>
</tr>
<tr>
<td>Victoria</td>
<td>8.9 at Wilsons Promontory</td>
<td>-2.9 at Falls Creek</td>
<td>13.2 at Cape Otway on 08/06</td>
<td>-8.6 at Falls Creek on 04/08</td>
<td>-0.16</td>
<td>43</td>
</tr>
<tr>
<td>Tasmania</td>
<td>8.4 at Hogan Island</td>
<td>-2.5 at Liawenee</td>
<td>13.6 at Low Head on 07/06</td>
<td>-11.1 at Liawenee on 08/08</td>
<td>-0.63</td>
<td>10</td>
</tr>
<tr>
<td>South Australia</td>
<td>11.6 at Neptune Island</td>
<td>2.8 at Yongala</td>
<td>17.6 at Tarcoola on 20/08 and Leigh Creek on 21/08</td>
<td>-5.7 at Gluepot Reserve on 20/07</td>
<td>+0.40</td>
<td>74</td>
</tr>
<tr>
<td>Western Australia</td>
<td>25.2 at Browse Island</td>
<td>5.2 at Yeelirrie</td>
<td>27.2 at Browse Island on 01/06</td>
<td>-4.0 at Norseman on 22/07</td>
<td>+0.95</td>
<td>100</td>
</tr>
<tr>
<td>Northern Territory</td>
<td>23.7 at Mccluer Island</td>
<td>4.3 at Alice Springs</td>
<td>25.4 at Mccluer Island on 25/06</td>
<td>-5.0 at Alice Springs on 20/07 and Arltunga on 20/07</td>
<td>+0.18</td>
<td>66</td>
</tr>
</tbody>
</table>
References


