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Seasonal climate summary southern hemisphere (spring 2009): rapid intensification of El Niño, drier than average in northern and eastern Australia and warmer than average throughout

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Southern hemisphere circulation patterns and associated anomalies for the austral spring 2009 are reviewed, with emphasis given to the Pacific Basin climate indicates and Australian rainfall and temperature patterns.

Spring 2009 confirmed the indications seen in winter 2009 of an emerging new El Niño event in the tropical Pacific Ocean. Australian rainfall was below to very much below average across much of Queensland and the Northern Territory, and seasonal maximum temperatures were above to very much above average over most of the country. Seasonal minimum temperatures were above to very much above average over most of the southern half of the country.

Introduction

This summary reviews the southern hemisphere and equatorial climate patterns for spring 2009, 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's National Climate Centre and the Centre for Australian Weather and Climate Research (CAWCR).

Pacific Basin climate indices

The Troup Southern Oscillation Index

A new sequence of negative values of the Southern Oscillation Index[1] (SOI) began in October 2009, indicating a new negative phase of the Southern Oscillation. Monthly values for the season were +3.9 (September), –14.7 (October) and –6.7 (November), resulting in a seasonal mean of –5.8 (ranked 38th of 134 across the period 1876-2009). The October value was the most negative monthly value of the SOI since October 2006 (–15.3), during the 2006/07 El Niño (Qi 2007). Darwin's mean sea-level pressure (MSLP) remained fairly close to average during the season, with monthly anomalies of –0.7, +0.7 and +0.1 hPa. In contrast, Tahiti saw persistence of below average MSLP, the monthly anomalies being –0.1, –1.7 and –0.9 hPa. Figure 1 shows the monthly SOI from January 2005 to November 2009, together with a five-month weighted moving average.

A composite monthly ENSO index, calculated as the standardised amplitude of the first principal component[2] of monthly Darwin and Tahiti MSLP[3] and monthly NINO3, NINO3.4 and NINO4 sea-surface temperatures[4] (SSTs) (Kuleshov et al. 2008), continued a sequence of positive values which began in May 2009 (Fig. 2). Two of the three

[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 being provided by Météo France interregional direction for French Polynesia.

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[2] The principal component analysis and standardisation of this ENSO index is performed over the period 1950-1999.

[3] Obtained from http://www.bom.gov.au/climate/current/soihtm1.shtml. As with the SOI calculation, the Tahiti MSLP data are provided by Météo France interregional direction for French Polynesia.

[4] Obtained from ftp://ftp.cpc.ncep.noaa.gov/wd52dg/data/indices/sstoi.indices.

Fig. 1 Southern Oscillation Index, from January 2005 to November 2009, together with a five-month binomially weighted moving average. Means and standard deviations used in the computation of the SOI are based on the period 1933-1992.

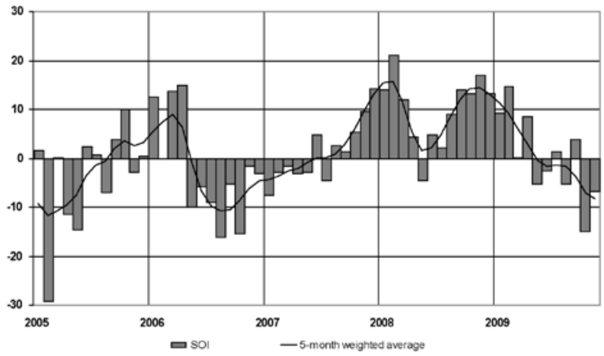
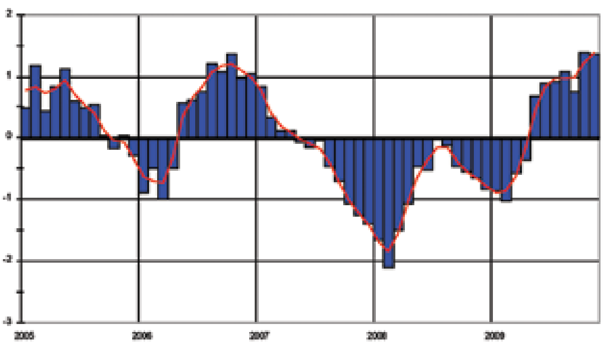


Fig. 2 Composite standardised monthly ENSO index from January 2005 to November 2009, together with a weighted three-month moving average. See text for details.



monthly values in the season exceeded one standard deviation, confirming that the emerging negative phase of the Southern Oscillation had reached El Niño status. Monthly values of this index were +0.75 (September), +1.40 (October) and +1.37 (November). The October value of this index was the most positive monthly value since December 2002 (+1.41) during the 2002/03 El Niño.

The September/October and October/November values of the Climate Diagnostics Center (CDC) bi-monthly Multivariate ENSO index[5] (MEI; Wolter and Timlin 1993, 1998) were +0.999 and +1.039, respectively. The MEI remained consistently positive from the April/May 2009 value of +0.344, the first positive value after a sequence of nine negative values. The October/November value of this index was the most positive value since October/November 2006 (+1.288) during the 2006/07 El Niño. The trends in these three ENSO indices during spring were of sufficient magnitude as to point to the emergence of a new El Niño event.

Outgoing long-wave radiation

The Climate Prediction Center, Washington, computes a standardised monthly anomaly[6] of outgoing long-wave radiation (OLR) for an equatorial region ranging from 5°S to 5°N and 160°E to 160°W (not shown). Tropical deep convection in this region is particularly sensitive to changes in the phase of the Southern Oscillation. During El Niño events, convection is generally more prevalent, resulting in a reduction in OLR. This reduction is due to the lower effective black-body temperature and is associated with increased high cloud and deep convection. The reverse applies in La Niña events, with less convection in the vicinity of the date-line (and consequently, positive anomalous OLR). Monthly values for the season were –0.6 (September), –0.2 (October) and 0.0 (November). These values were comparable with those of the previous El Niño (–0.2, –0.8 and –0.2 in spring 2006), but rather weaker than those of the 1997 (–1.2, –2.5 and 0.0) and 2002 (–1.8, –1.3 and –1.4) El Niño springs.

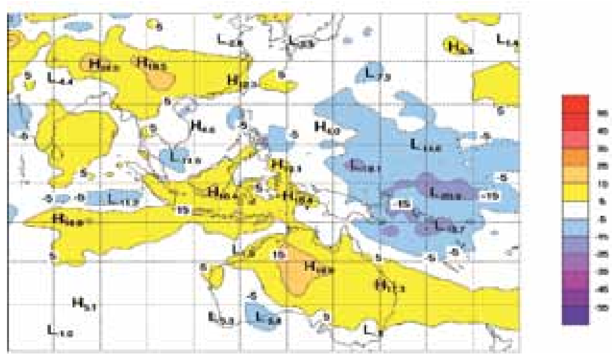
Figure 3 shows the seasonal OLR anomalies for the Asia-Pacific region between 40°S and 40°N. Negative anomalies were observed on the equator immediately west of the date-line, but the strongest negative equatorial anomalies were seen between 150°E and 175°E, rather than on the date-line itself.

Oceanic patterns

Sea-surface temperatures

Figure 4 shows spring 2009 sea-surface temperature (SST) anomalies in degrees Celsius (°C). These have been obtained from the US National Oceanic and Atmospheric Administration (NOAA) Optimum Interpolation analyses (Reynolds et al. 2002). The base period is 1961-1990. Seasonal SSTs were above average across the entire equatorial

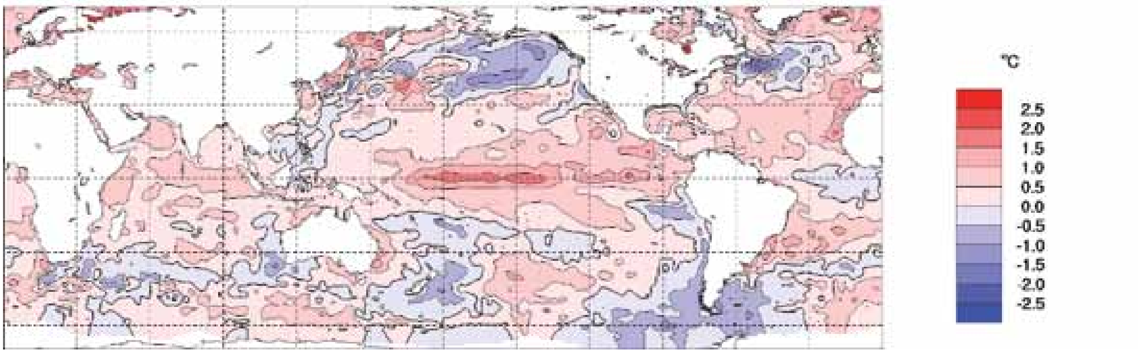
Fig. 3 OLR anomalies for spring 2009 (W m^{-2}). Base period 1979 to 1998. The mapped region extends from 40°S to 40°N and from 70°E to 180°E.



[5] Obtained from http://www.esrl.noaa.gov/psd/people/klaus.wolter/MEI/table.html. The MEI is a standardised anomaly index.

[6] Obtained from http://www.cpc.ncep.noaa.gov/data/indices/olr

Fig. 4 Anomalies of SST for spring 2009 (°C). The contour interval is 0.5°C.



Pacific, with peak anomalies between +1.5°C and +2.0°C centrally located between 170°E and 140°W. The season saw significant warming in the central equatorial Pacific, with November 2009 anomalies being more than 1°C higher in some places than those recorded three months earlier in August 2009.

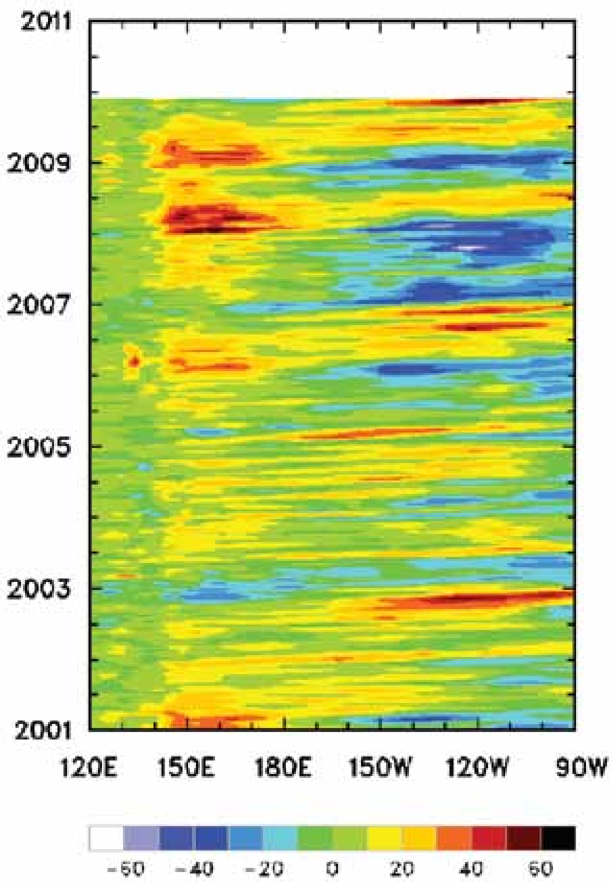
This warming can also be seen in the standard SST indices. The monthly SST anomaly indices[7] for the NINO3 region were +0.92° (September), +0.95° (October) and +1.39°C (November), continuing a sequence of positive values which began in April 2009. Those for the NINO3.4 region were +0.87°C (September), +1.02°C (October) and +1.69°C (November), continuing a sequence of positive values which began in May 2009, while the corresponding values for the NINO4 region were +0.88°C, +1.24°C and +1.50°C, continuing a sequence of positive values which also began in April 2009. These values are consistent with the equatorial pattern of the anomalies shown in Fig. 4, and confirm the establishment of the El Niño event.

SSTs were also above average across almost the entire tropical Indian Ocean, with relatively weak gradients along the equator. In the Australian region, SST anomalies were positive around the northern, eastern and southeastern coasts, while negative anomalies stretched from the North West Cape (WA) around to the top of the Bight.

Subsurface patterns

The Hovmöller diagram for the 20°C isotherm depth anomaly (obtained from CAWCR) across the equator (January 2001 to November 2009) is shown in Fig. 5. The 20°C isotherm is generally situated close to the equatorial thermocline, the region of greatest temperature gradient with depth and the boundary between the warm near-surface and cold deep-ocean waters. Positive anomalies correspond to the 20°C isotherm being deeper than average, and negative anomalies to it being shallower than average. Changes in the thermocline depth may act as a precursor to changes at the surface.

Fig. 5 Time-longitude section of the monthly anomalous depth of the 20°C isotherm at the equator for January 2001 to November 2009. The contour interval is 10 m.



[7] As before, obtained from ftp://ftp.cpc.ncep.noaa.gov/wd52dg/data/indices/sstoi.indices . All anomaly indices in °C and calculated with respect to the base period 1961-1990. The NINO3 region is 5°S to 5°N and 150°W to 90°W. The NINO3.4 region is 5°S to 5°N and 170°W to 120°W. The NINO4 region is 5°S to 5°N and 160°E to 150°W.

A weak downwelling Kelvin wave (positive anomalies in Fig. 5) proceeded across the equatorial Pacific in late winter (Jakob 2010) and early spring, followed by another one in mid to late spring. The latter of these two downwelling Kelvin waves was the strongest one seen in the eastern equatorial Pacific since the 2006/2007 El Niño event, but at the end of the season it was still in progress. Its passage can also be seen in Fig. 6, which shows a vertical cross-section of equatorial subsurface temperature anomalies from August to November 2009. The Kelvin wave clearly played a role in the steady increase of the NINO3 and NINO3.4 SST indices during the season.

Atmospheric patterns

Surface analyses

The spring 2009 mean sea-level pressure (MSLP) pattern, computed by the Bureau of Meteorology's Global Assimilation and Prognosis (GASP) model, is shown in Fig. 7, and the associated anomaly pattern in Fig. 8. These anomalies are the difference from a 1979-2000 climatology obtained from the National Centers for Environmental Prediction (NCEP) II Reanalysis data (Kanamitsu et al. 2002). The MSLP analysis has been computed using data from the 0000 UTC daily analyses of the GASP model. The MSLP anomaly field is not shown over areas of elevated topography (grey shading).

The spring 2009 MSLP pattern (Fig. 7) was fairly zonal in the southern hemisphere mid-latitudes, the principal exception being a trough of low pressure at around 170°W, east of New Zealand. This trough arose from a weak negative

Fig. 6 Four-month August to November 2009 sequence of vertical sea subsurface temperature anomalies at the equator for the Pacific Ocean. The contour interval is 0.5°C.

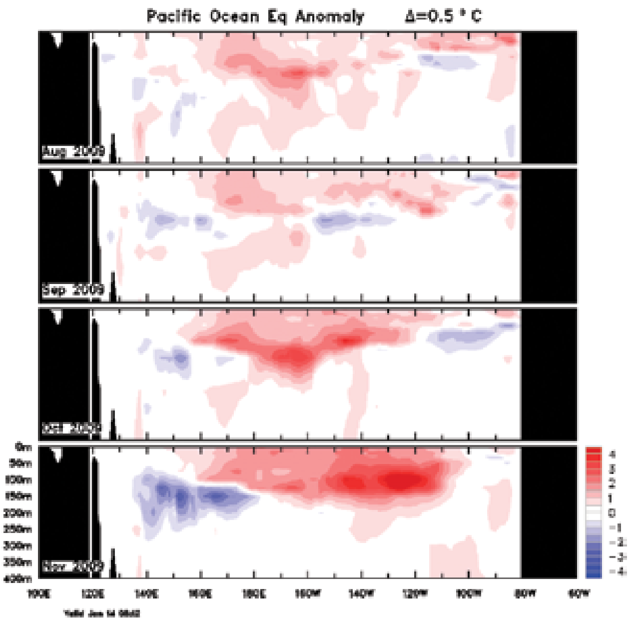


Fig. 7 Spring 2009 MSLP (hPa).

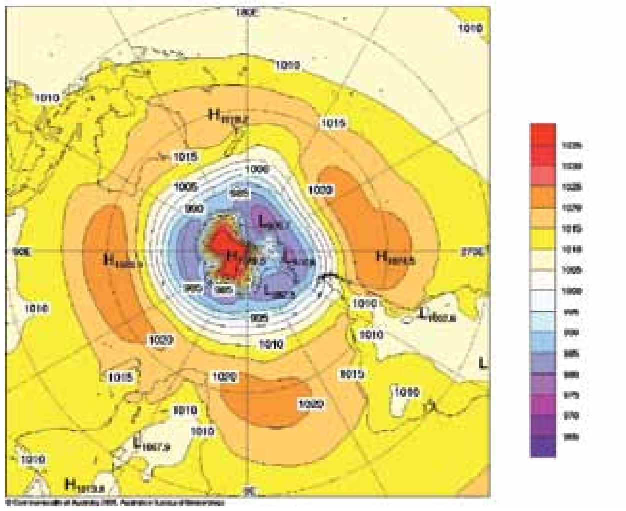
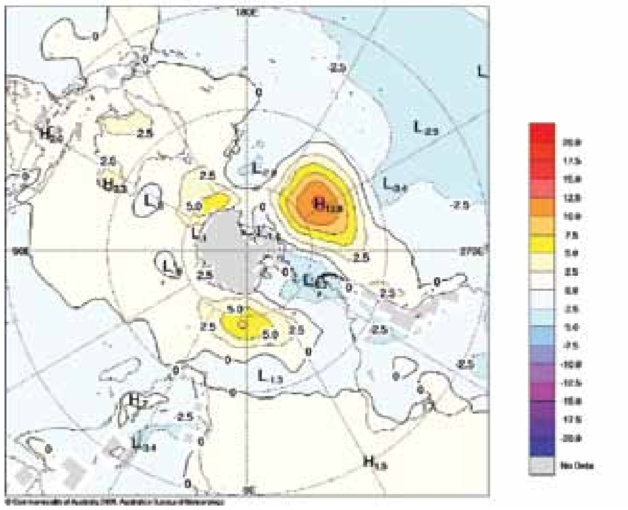


Fig. 8 Spring 2009 MSLP anomalies (hPa).



anomaly (–2.8 hPa) close to the date-line (Fig. 8), together with a much stronger positive anomaly (+12.8 hPa) further east (120°W). (Anomalous ridging in the far south to southeast Pacific has been a feature in previous El Niño events, e.g., summer 2002/2003 (Reid 2003), summer 1997/1998 (Mullen 1998), spring 1997 (Walland 1998), winter 1997 (Fawcett 1998), spring 1994 (Beard 1995).) A weaker positive anomaly of around +8 hPa was located at 0° longitude, but the absence of a positive anomaly of comparable magnitude at around 120°E prevents a clear three-wave pattern in the anomalies. Anomalies between 120°E and 160°E closer to the South Pole reached +5 hPa over a smaller area.

The subtropical ridge was slightly stronger than normal in the Australian region, with centres of 1023.9 hPa (90°E) and 1019.2 hPa (165°E) in the MSLP field (Fig. 7) and +3.3 hPa over Western Australia in the anomalies (Fig. 8). Anomalies were positive over all of Australia, although a weak negative anomaly (–0.5 hPa) was located to the south of Western Australia.

Mid-tropospheric analyses

The 500 hPa geopotential height (an indicator of the steering of surface synoptic systems across the southern hemisphere) for spring 2009 is shown in Fig. 9, with the associated anomalies in Fig. 10. The seasonal 500 hPa height field in the southern hemisphere was characterised by generally zonal flow, with troughs located at around 100°E, 165°W and 75°W. The strong positive anomaly at the surface at around 120°W (Fig. 8) was also clearly evident at the mid-levels (Fig. 10). The two weaker negative anomalies to the east and west at the surface were also evident at this level. A weak ridge of positive anomalies stretched from the Tasman Sea across Antarctica into the southwest Atlantic Ocean. Anomalies across Australia for the season were uniformly positive, but weak in magnitude.

Fig. 9 Spring 2009 500 hPa mean geopotential height (gpm).

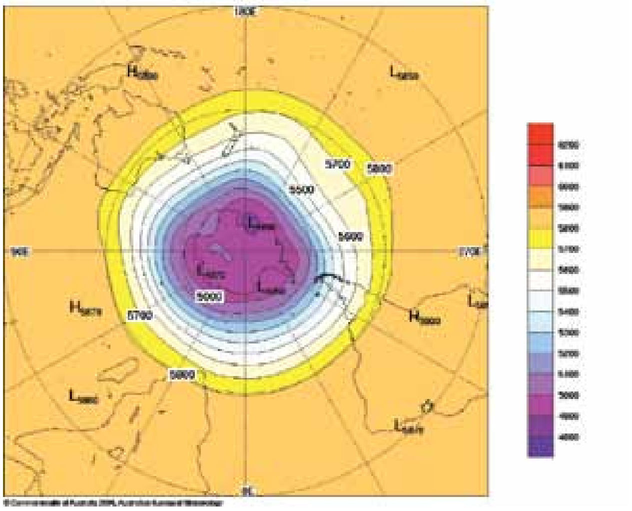
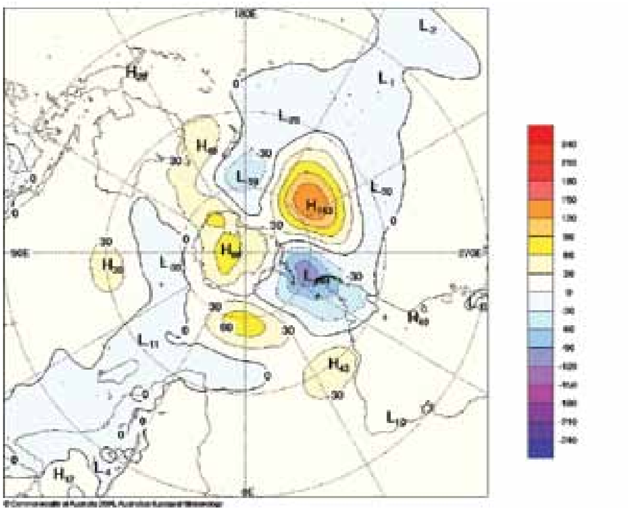


Fig. 10 Spring 2009 500 hPa mean geopotential height anomalies (gpm).



Blocking

The time-longitude section of the daily southern hemisphere blocking index[8] is shown in Fig. 11, with the start of the season at the top of the figure. This index is a measure of the strength of the zonal 500 hPa flow in the mid-latitudes (40°S to 50°S), relative to that of the subtropical (25°S to 30°S) and high (55°S to 60°S) latitudes. Positive values of the index are generally associated with a split in the mid-latitude westerly flow near 45°S and mid-latitude blocking activity. Figure 12 shows the seasonal index for each longitude.

Fig. 11 Spring 2009 daily southern hemisphere blocking index (m s^{-1}) time-longitude section. The horizontal axis shows degrees east of the Greenwich meridian. Day one is 1 September.

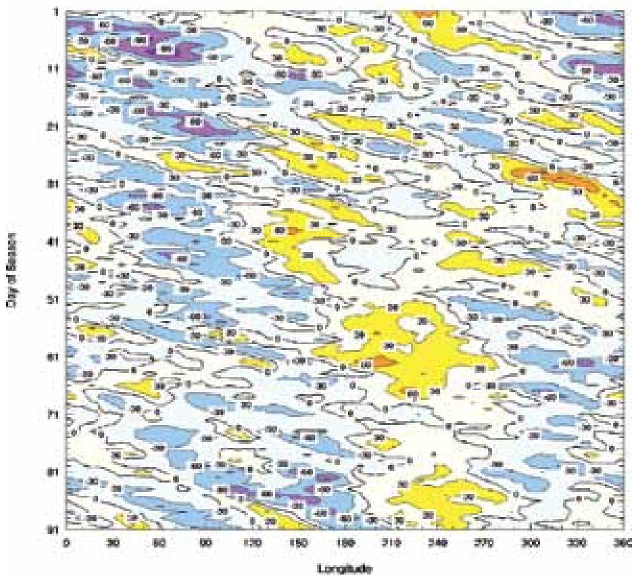
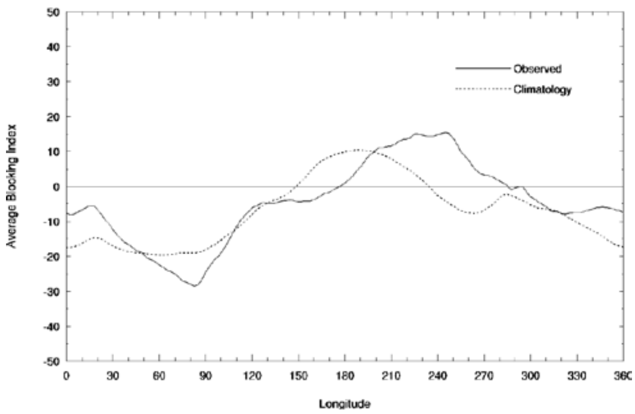


Fig. 12 Mean southern hemisphere blocking index (m s^{-1}) for spring 2009 (solid line). The dashed line shows the corresponding long-term average. The horizontal axis shows degrees east of the Greenwich meridian.



[8] The blocking index is defined as $BI = 0.5 [(u_{25} + u_{30}) - (u_{40} + 2 u_{45} + u_{50}) + (u_{55} + u_{60})]$, where u_x is the westerly component of the 500 hPa wind at latitude x.

Southern hemisphere blocking during spring 2009 was below average across the South Indian Ocean (50°E to 110°E) and Australian longitudes (130°E to 160°W), but above average in the central and eastern Pacific (eastward of 160°W). This latter feature was consistent with the anomalous high-latitude ridging as seen in Fig. 8 and Fig. 10. Peak values of the blocking index were seen over the central Pacific in early November and over the South Atlantic Ocean in late September/early October.

Winds

Spring 2009 low-level (850 hPa) and upper-level (200 hPa) wind anomalies (from the 22-year NCEP II climatology) are shown in Figs 13 and 14 respectively. Isotach contours are at 5 m s^{-1} intervals, and in Fig. 13 regions where the surface rises above the 850 hPa level are shaded. In spite of the falling SOI, the wind anomalies along the equatorial Pacific show little indication of a weakened Walker circulation – the equatorial anomalies are very weak, although they are westerly in character as expected in an El Niño.

In the upper levels (Fig. 14), an anticyclonic anomaly pattern covered much of the South Indian Ocean. This pattern can be seen in the 500 hPa height anomalies (Fig. 10), although there was little reflection of this feature at the surface (Fig. 8). A neighbouring feature in the upper levels was a cyclonic circulation over the western half of Australia, which may have been associated with the average to above average rainfall seen over much of Western Australia (see below).

Australian region

Rainfall

Figure 15 shows the spring rainfall totals for Australia, while Fig. 16 shows the spring rainfall deciles, where the deciles are calculated with respect to gridded rainfall data for all springs from 1900 to 2009.

Spring rainfall averaged over Australia was 22 per cent below the 1961-1990 normal (37th lowest in a record of 110 years – see Table 1). Spring rainfall was below to very much

Fig. 13 Spring 2009 850 hPa vector wind anomalies (m s^{-1}). The anomaly field is not shown over areas of elevated topography.

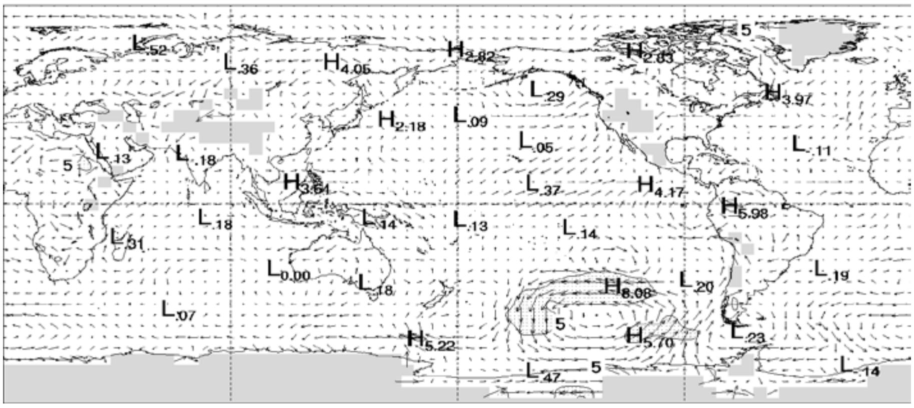


Fig. 14 Spring 2009 200 hPa vector wind anomalies (m s^{-1}).

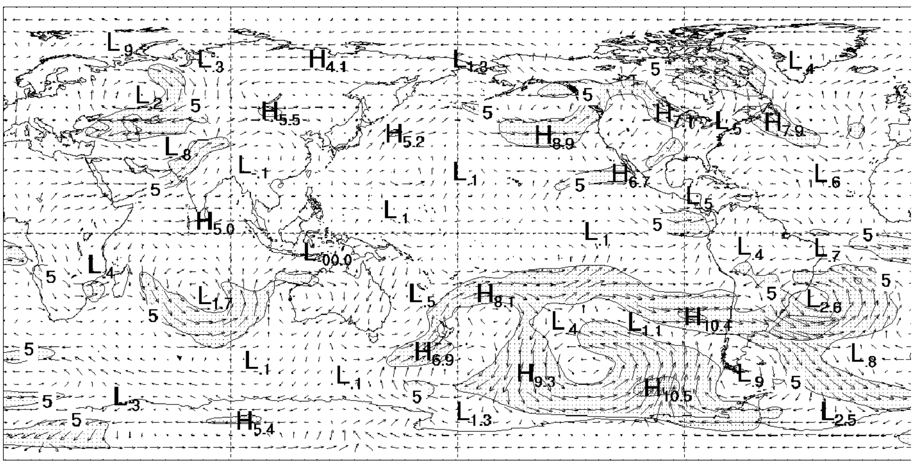


Fig. 15 Spring 2009 rainfall totals (mm) for Australia.

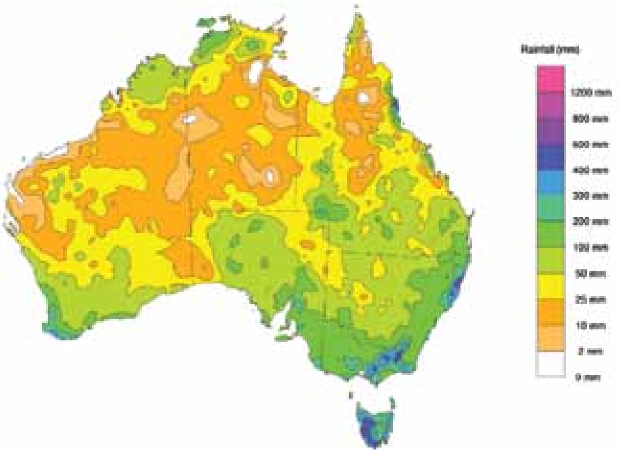


Fig. 16 Spring 2009 rainfall deciles for Australia: decile ranges based on grid-point values over the springs 1900 to 2009.

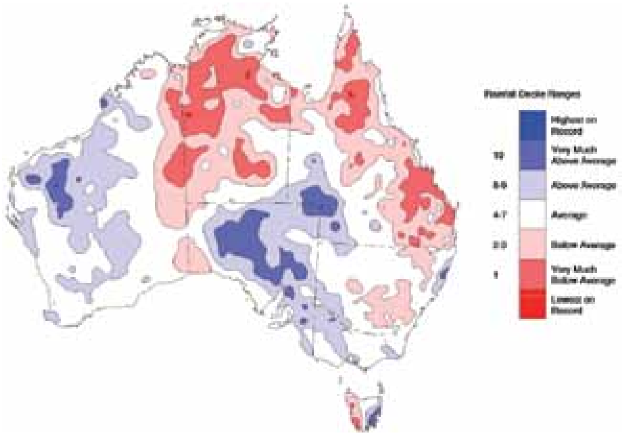


Table 1. Summary of the seasonal rainfall ranks and extremes on a national and State basis for spring 2009. The ranking in the last column goes from 1 (lowest) to 110 (highest) and is calculated over the years 1900 to 2009.

Region	*Highest seasonal total (mm)*	*Lowest seasonal total (mm)*	*Highest daily total (mm)*	*Area-averaged rainfall (mm)*	*Rank of area-averaged rainfall*
Australia	1522 at Bellenden Ker Top Station (Qld)	Zero at several locations	411 at Promised Land (NSW), 27 October	57	37
Queensland	1522 at Bellenden Ker Top Station	Zero at several locations	229 at Tree House Creek, 12 November	48	23
New South Wales	967 at Promised Land	20 at Corona Homestead	411 at Promised Land, 27 October	100	44
Victoria	664 at Rocky Valley	84 at Kotta	103 at Trentham, 22 November	195	69
Tasmania	599 at Lake Margaret Dam	132 at Ouse	150 at Maria Island, 29 November	335	41
South Australia	318 at Piccadilly	15 at Cook	96 at Ki Ki, 27 November	73	96
Western Australia	394 at Pemberton	Zero at several locations	104 at Kilto Station, 6 November	38	62
Northern Territory	325 at Pirlangimpi	Zero at several locations	94 at Bulman, 24 November	26	11

below average across most of the Northern Territory (the Territorial area average of 26 mm was 62 per cent below mean) and coastal Queensland (the State area average of 48 mm was 43 per cent below mean), together with the far east of Western Australia, western Tasmania and inland New South Wales. In contrast, the seasonal rainfall was above to very much above average across much of the remainder of Western Australia and a large area comprising most of South Australia and adjacent parts of southwest Queensland and western Victoria. Rainfall was also above normal on parts of the northern New South Wales coast, reaching the highest decile around Coffs Harbour, which saw significant floods in October and November.

Table 2 shows percentage areas of spring rainfall being in various categories. Spring rainfall was at or below the 10th percentile for 10.9 per cent of Australia, while 4.6 per cent of the country had spring rainfall at or below the 5th percentile (severe deficiency). Much of the affected area was in the tropical north – below to very much below average rainfalls were widespread across northern Queensland and the

Table 2. Percentage areas in different categories for spring 2009 rainfall. 'Severe deficiency' denotes rainfall at or below the 5th percentile. Areas in 'decile 1' include those in 'severe deficiency', which in turn include those which are 'lowest on record'. Areas in 'decile 10' include those which are 'highest on record'. Percentage areas of highest and lowest on record are given to two decimal places because of the small quantities involved; other percentage areas to one decimal place.

Region	*Lowest on record*	*Severe deficiency*	*Decile 1*	*Decile 10*	*Highest on record*
Australia	0.27	4.6	10.9	5.5	0.06
Queensland	0.50	7.7	17.5	3.6	0.12
New South Wales	0.00	0.0	0.2	0.7	0.00
Victoria	0.00	0.0	0.0	1.4	0.00
Tasmania	0.89	6.2	13.4	12.5	0.00
South Australia	0.00	0.0	0.0	25.0	0.00
Western Australia	0.00	1.0	3.2	3.6	0.11
Northern Territory	0.84	14.7	33.2	0.0	0.00

Northern Territory. Spring rainfall is negatively correlated with spring seasonal means of the monthly ENSO index shown in Fig. 2 across much of the tropical north of the country, and the areas of below to very much below average rainfall in Fig. 16 are reasonably consistent with those parts of the continent showing a negative correlation of –0.45 or stronger over the last 50 years.

Drought

At the end of November 2009, 17.4 per cent of Australia had experienced rainfall at or below the 10th percentile (serious deficiency) for the six months of winter and spring, with 8.6 per cent of the country experiencing severe deficiency (rainfall at or below the 5th percentile) for the period. The areas affected were principally Queensland (37.6 per cent, with 18.4 per cent in severe deficiency) and the Northern Territory (44.1 per cent, with 23.5 per cent in severe deficiency).

Over the slightly longer period of the nine months ending November 2009, 22.7 per cent of the country was in serious deficiency in rainfall (12.2 per cent in severe deficiency), comprising 34.4 per cent of Queensland (15.2 per cent in severe deficiency) and 60.1 per cent of the Northern Territory (39.3 per cent in severe deficiency). For this period 12.3 per cent of Western Australia was in serious deficiency. (It should be noted, in relation to these outcomes, that much of the region affected is seasonally dry in parts of the nominated periods.)

The national figure of 17.4 per cent for the six months ending November 2009 is rather larger than the corresponding figure of 11.0 per cent for the three months ending August 2009, while the figure of 22.7 per cent for the nine months ending November 2009 is slightly larger than the corresponding figure of 18.0 per cent for the six months ending August 2009. Together these suggest a slight intensification of the drought.

Temperatures

The spring maximum and minimum temperature anomalies are shown in Fig. 17 and Fig. 19, respectively, for spring 2009. The anomalies have been calculated with respect to the 1961-1990 period, and use all stations for which an elevation is available. Station normals have been estimated using gridded climatologies for those stations with insufficient data to calculate a station normal directly (Jones et al. 2009). Figure 18 and Fig. 20 show spring maximum and minimum temperature deciles, respectively, calculated using monthly temperature analyses from 1911 to 2009.

For seasonal maximum temperature, spring 2009 was warmer than average across almost the entire country (Fig. 17), the largest exception being a small area in the far south of Western Australia. Anomalies in excess of +1°C were seen in all States and the Northern Territory (in fact covering 69.1 per cent of the country), and Tasmania was the only State not to see +2°C anomalies somewhere. A large band of +2°C anomalies stretched from Adelaide in South Australia across northern Victoria and central New South Wales into southeast Queensland. Peak anomalies in this band exceeded +3°C in central New South Wales. Likewise, all States (apart from South Australia[9]) and the Northern Territory saw local areas of highest on record spring maximum temperatures, according to the archive of gridded monthly temperature analyses from 1911 to 2009. Table 3 shows percentage areas in 'decile 10' (i.e. at or above the 90th percentile) for spring seasonal maximum temperature for each State and Territory. Nearly three per cent of the country saw a record spring maximum temperature, and all of Victoria experienced a decile 10 spring maximum temperature. A significant heat wave in November contributed to the seasonal temperature outcome – see Bureau of Meteorology (2009) for more information.

Fig. 17 Spring 2009 maximum temperature anomalies (°C).

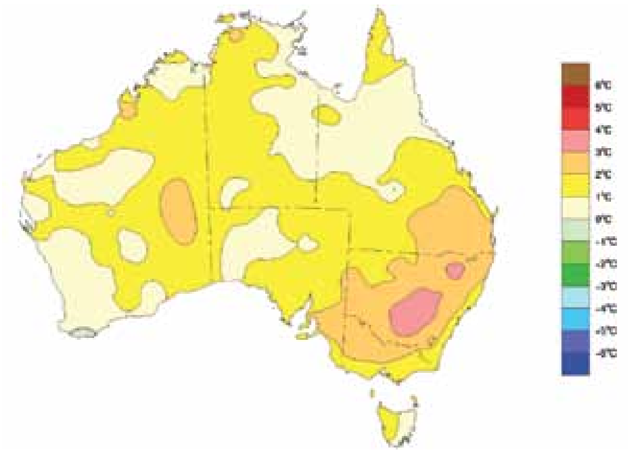
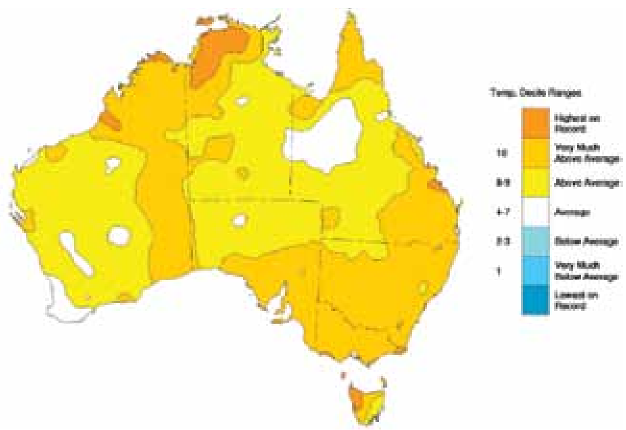


Fig. 18 Spring 2009 maximum temperature deciles: decile ranges based on grid-point values over the springs 1911 to 2009.



[9] This statement and the tables that follow refer just to continental South Australia. Likewise the area averages concerning Tasmania exclude the Bass Strait islands (King and Flinders). In Fig. 18, approximately half of Kangaroo Island (but none of continental South Australia) is shown as having recorded highest on record seasonal maximum temperatures in spring 2009.

Fig. 19 Spring 2009 minimum temperature anomalies (°C).

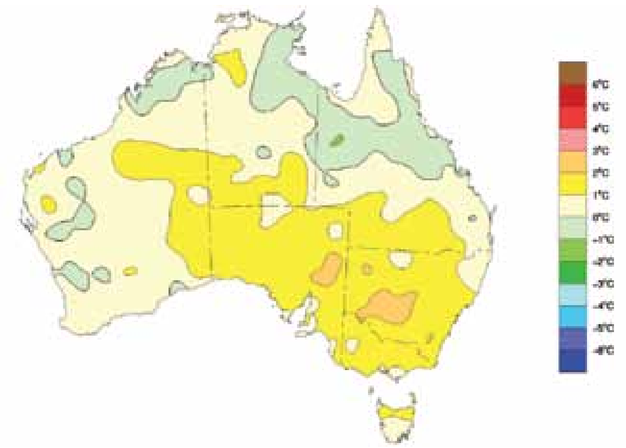
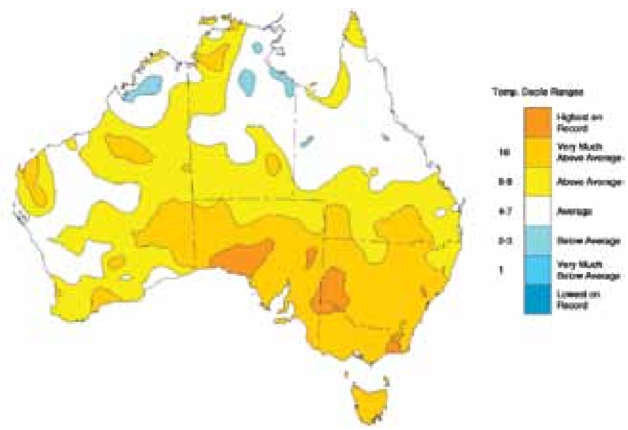


Fig. 20 Spring 2009 minimum temperature deciles: decile ranges based on grid-point values over the springs 1911 to 2009.



The pattern of spring seasonal minimum temperatures anomalies (Fig. 19) was not as strong as that for maximum temperature, but even so a band of +1°C anomalies stretched across 39.2 per cent of the country from northwest Western Australia down across South Australia and southern parts of the Northern Territory, into Victoria, New South Wales and southern Queensland. Small areas of +2°C anomalies were seen in western New South Wales and eastern South Australia. Areas of highest on record seasonal minimum temperature (Fig. 20) were confined to the southern half of the country, specifically South Australia, New South Wales and Victoria, but not Tasmania, even though the entire State experienced decile 10 seasonal temperatures (Table 3).

A high-quality subset of the temperature network is used to calculate the spatial averages and rankings shown in Table 4 (maximum temperature) and Table 5 (minimum temperature). These averages are available from 1950 to the present. As the anomaly averages in the tables are only retained to two decimal places, tied rankings are possible.

Table 3. Percentage areas in different temperature categories for spring 2009. Areas in 'decile 10' include those which are 'highest on record'. Grid-point deciles calculated with respect to 1911-2009. No State or Territory experienced areas of 'decile 1' seasonal maximum or minimum temperature.

Region	*Maximum temperature*		*Minimum temperature*	
	Decile 10	*Highest on record*	*Decile 10*	*Highest on record*
Australia	44.2	2.99	31.1	3.32
Queensland	35.6	0.65	10.3	0.00
New South Wales	87.1	0.23	86.1	9.96
Victoria	100.0	3.19	98.9	12.84
Tasmania	65.9	28.12	100.0	0.00
South Australia	40.5	0.00	78.9	14.45
Western Australia	38.5	1.39	14.2	0.00
Northern Territory	31.3	11.82	5.3	0.00

In area-averaged terms with respect to maximum temperature, the spring was nationally the equal third warmest since 1950, the warmest for Tasmania, the second warmest for Victoria, the third warmest for New South Wales and the Murray-Darling Basin, and the fourth warmest for South Australia. November contributed strongly to these outcomes, with the month being nationally the second warmest since 1950 (with an anomaly of +2.12°C, behind the +2.17°C of November 2006), the warmest for New South Wales (+4.99°C), Victoria (+4.92°C), Tasmania (+3.18°C) and the Murray-Darling Basin (+4.87°C), the second warmest for South Australia (+3.05°C) and the fourth warmest for Western Australia (+1.71°C). The New South Wales and Victoria anomalies for November 2009 exceeded the previous highest State/Territory monthly maximum temperature anomaly by a substantial margin (+4.38°C for South Australia in August 1982).

In area-averaged terms with respect to minimum temperature, the spring was nationally the eighth warmest since 1950, and the warmest for New South Wales, Victoria, Tasmania and the Murray-Darling Basin. As with maximum temperature, November contributed strongly to these outcomes, with the month being nationally the warmest (+1.61°C) since 1950, the warmest for New South Wales (+4.22°C), Victoria (+3.81°C), South Australia (+3.36°C) and the Murray-Darling Basin (+4.11°C), and the second warmest for Tasmania (+1.68°C).

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Table 4. Summary of the seasonal maximum temperature ranks and extremes on a national and State basis for spring 2009. The ranking in the last column goes from 1 (lowest) to 60 (highest) and is calculated over the years 1950 to 2009.

	Highest seasonal mean (°C)	*Lowest seasonal mean (°C)*	*Highest daily temperature (°C)*	*Lowest daily temperature (°C)*	*Area-averaged temperature anomaly (°C)*	*Rank of area-averaged temperature anomaly*
Australia	40.0 at Fitzroy Crossing (WA)	8.3 at Mount Hotham (Vic.), and Mount Wellington (Tas.)	47.4 at Marree (SA) 18 November	–3.8 at Thredbo Top Station (NSW), 26 September	+1.44	57.5
Queensland	37.0 at Century Mine	24.3 at Applethorpe	46.6 at Birdsville, 18 November	13.4 at Stanthorpe, 11 October	+1.18	54
New South Wales	31.2 at Mungindi	8.6 at Thredbo Top Station	46.8 at Wanaaring, 20 November	–3.8 at Thredbo Top Station, 26 September	+2.59	58
Victoria	26.3 at Mildura	8.3 at Mount Hotham	42.1 at Mildura, 18 November	–3.4 at Mount Hotham, 26 September	+2.19	59
Tasmania	18.6 at Bushy Park	8.3 at Mount Wellington	35.1 at Bicheno, 20 November	–1.2 at Mount Wellington, 6 & 7 October	+1.38	60
South Australia	31.2 at Moomba	17.9 at Mount Lofty	47.4 at Marree, 18 November	7.2 at Mount Lofty, 25 September	+1.72	57
Western Australia	40.0 at Fitzroy Crossing	18.4 at Shannon	45.6 at Mandora, 29 October	9.8 at Mount Barker, 29 September, and Rocky Gully, 5 September	+1.20	55
Northern Territory	39.1 at Bradshaw	30.6 at Mccluer Island	44.8 at Walungurru, 17 November	18.8 at Kulgera, 26 September	+1.15	53.5

Table 5. Summary of the seasonal minimum temperature ranks and extremes on a national and State basis for spring 2009. The ranking in the last column goes from 1 (lowest) to 60 (highest) and is calculated over the years 1950 to 2009.

	Highest seasonal mean (°C)	*Lowest seasonal mean (°C)*	*Highest daily temperature (°C)*	*Lowest daily temperature (°C)*	*Area-averaged temperature anomaly (°C)*	*Rank of area-averaged temperature anomaly*
Australia	27.0 at Troughton Island (WA)	0.9 at Charlotte Pass (NSW)	33.3 at White Cliffs Airport (NSW), 19 November	–10.4 at Thredbo Top Station (NSW), 2 September	+0.80	53
Queensland	25.0 at Horn Island	9.0 at Stanthorpe	32.8 at Thargomindah, 19 November	–2.4 at Stanthorpe, 1 September	+0.31	35
New South Wales	17.3 at Cape Byron	0.9 at Charlotte Pass	33.3 at White Cliffs Airport, 19 November	–10.4 at Thredbo Top Station, 2 September	+1.56	60
Victoria	12.3 at Gabo Island	2.0 at Mount Hotham	26.9 at Mildura, 20 November	–6.2 at Mount Hotham, 27 September	+1.39	60
Tasmania	11.2 at Hogan Island	1.0 at Mount Wellington	17.8 at Luncheon Hill, 10 November	–5.7 at Liawenee, 29 September	+0.70	55
South Australia	16.3 at Oodnadatta	7.4 at Keith West	31.1 at Moomba, 20 November	–2.3 at Yongala, 14 September	+1.74	60
Western Australia	27.0 at Troughton Island	7.4 at Wandering	31.4 at Wittenoom, 30 October	–4.3 at Eyre, 9 September	+0.61	50.5
Northern Territory	26.2 at McCluer Island	15.2 at Curtin Springs	31.8 at Lajamanu, 22 November	3.1 at Yulara, 6 September	+0.51	39.5

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