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Seasonal climate summary southern hemisphere (summer 2006-07): the end of the 2006-07 El Niño

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Southern hemisphere circulation patterns and associated anomalies for the austral summer 2006-07 are reviewed, with emphasis given to the Pacific Basin climate indicators and Australian rainfall and temperature patterns.

The summer saw clear signs of weakening of the El Niño event which began earlier in 2006, and according to some of the important indices the event had in fact concluded by the end of the season. Australian summer rainfall patterns showed no strong swings towards either wetter or drier conditions, but the season was characterised by widespread positive temperature anomalies.

Introduction

This summary reviews the southern hemisphere and equatorial climate patterns for summer 2006-07, 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, the Bureau's *Darwin Tropical Diagnostic Statements*, *Australian Seasonal Climate Summary** and *Monthly Significant Weather Summaries***, the Bureau of Meteorology Research Centre (BMRC), and the *Climate Diagnostics Bulletin* (Climate Prediction Center, Washington).

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* See http://www.bom.gov.au/climate/current/season/aus/archive/
** See http://www.bom.gov.au/inside/services_policy/public/sigwxsum/sigwmenu.shtml

Pacific Basin climate indices

The Troup Southern Oscillation Index

The sequence of negative values of the Southern Oscillation Index† (SOI), which began in May 2006, continued through summer 2006-07, with monthly values of −3.0 (December), −7.3 (January) and −2.7 (February). These values confirmed the marked weakening of the atmospheric intensity of the 2006-07 El Niño event seen in the spring 2006 values of the SOI (Qi 2007). They did not, however, mark the end of the negative phase of the Southern Oscillation, as negative values of the SOI persisted through autumn 2007. Figure 1 shows the monthly SOI from January 2003 to February 2007, together with a five-month weighted moving average.

† The Troup Southern Oscillation Index 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 Tahiti MSLP is provided by Météo France interregional direction for French Polynesia.

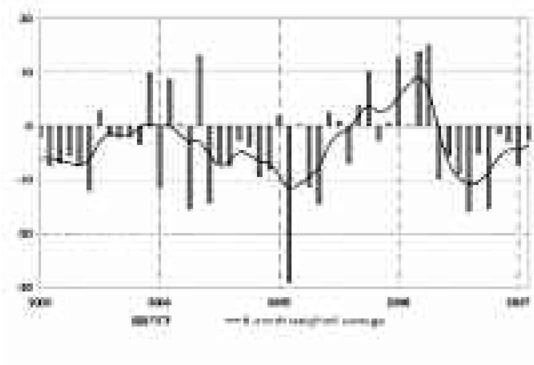


Fig. 1 **Southern Oscillation Index, from January 2003 to February 2007. Means and standard deviations used in the computation of the SOI are based on the period 1933-1992.**

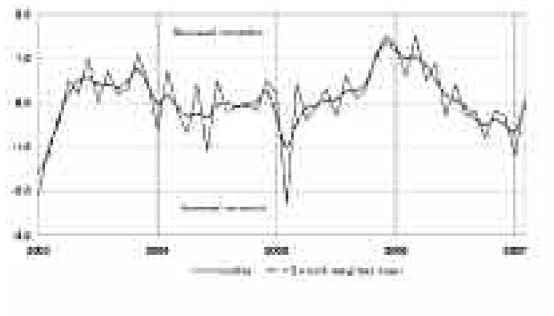


Fig. 2 **Standardised anomaly of monthly OLR averaged over the area 5°S to 5°N and 160°E to 160°W, from January 2003 to February 2007. Negative (positive) anomalies indicate enhanced (reduced) convection and rainfall in the area. Anomalies are based on the 1979-1995 base period. After CPC (2007).**

Daily mean sea-level pressure (MSLP) values at Darwin were above average for most of the season, with two notable exceptions. The first was in late January and the first week of February, while the second was in late February and early March. This second excursion was much stronger than the first, with daily pressure anomalies reaching −6 hPa at the very end of the season. In contrast, Tahiti's daily pressure values were much less consistently below average.

The December-January and January-February values of the Climate Diagnostics Center (CDC) Multivariate El Niño-Southern Oscillation (ENSO) Index (MEI; Wolter and Timlin 1993, 1998) were +1.037 and +0.537, respectively. The first of these values was the second highest bi-monthly value for the 2006-07 El Niño, after the October-November value (+1.293). The February-March and subsequent autumn values of the MEI were much weaker (although still positive), confirming the weakening of the El Niño event as suggested by the SOI values described above.

Outgoing long-wave radiation

Figure 2, adapted from the Climate Prediction Center (CPC), Washington, shows a standardised monthly anomaly of outgoing long-wave radiation (OLR) from January 2003 to February 2007, together with a three-month moving average. These data, compiled by the CPC, are a measure of the amount of long-wave radiation emitted from an equatorial region centred about the date-line (5°S to 5°N and 160°E to 160°W). Tropical deep convection in this region is particularly sensitive to changes in the phase of the Southern Oscillation. During warm (El Niño) ENSO 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 cold (La Niña) events, with less convection expected in the vicinity of the date-line.

The OLR response to the 2006-07 El Niño, as measured by the index plotted in Fig. 2, was much weaker than that of the 2002-03 El Niño (see for example, Fig. 2 in Qi (2007)). In fact it was considerably weaker than the (opposite sign) response a year earlier, which was neither long enough nor intense enough to qualify as a La Niña event. The January 2007 value of −1.2 was the strongest value observed during the El Niño event, and thereafter the values of the index returned to neutral territory.

Figure 3 shows the seasonal OLR anomalies for the tropical Asia-Pacific region. Negative anomalies were observed around and to the west of the date-line (which coincides with the right boundary of the map). This is consistent with the typical OLR response to El Niño events, although the pattern of positive anomalies over the equatorial regions north of Australia is relatively weak.

Oceanic patterns

Sea-surface temperatures

Figure 4 shows summer 2006-07 sea-surface temperature (SST) anomalies in degrees Celsius (°C). These have been obtained from the National Oceanic and Atmospheric (NOAA) Optimum Interpolation analyses (Reynolds et al. 2002).

The pattern of anomalies in Fig. 4 corresponds to an El Niño of weak to moderate intensity, but small-

Fig. 3 Anomalies of OLR for summer 2006-07 (W m^{-2}). Base period 1979 to 1998.

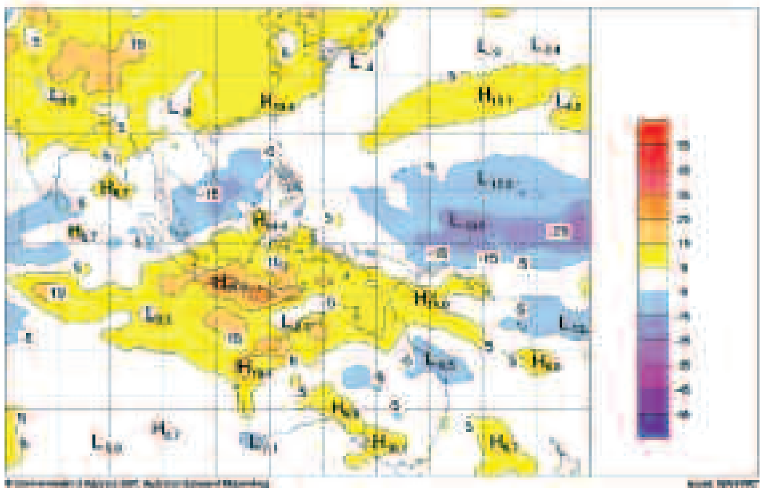
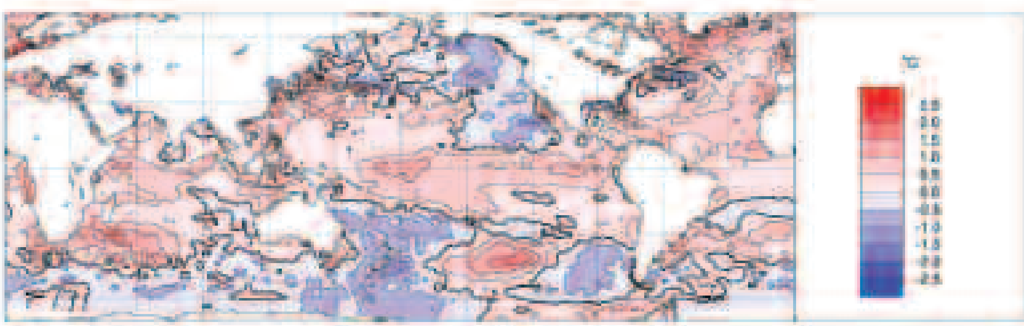


Fig. 4 Anomalies of SST for summer 2006-07 (°C). The contour interval is 0.5°C.



er in amplitude compared to the spring 2006 pattern (Qi 2007). Equatorial Pacific anomalies above +0.5° extended from around 165°E eastward almost to the South American coast, with two main areas of +1°C anomalies. The first of these was located around the date-line, while the second was located between 90°W and 110°W. The tropical Indian Ocean and tropical waters to Australia's north and northwest were likewise warmer than average during the summer.

The NINO3 anomaly indices for the season were +1.28°C (Dec), +0.88°C (Jan.) and +0.09°C (Feb.), while the NINO3.4 indices were +1.29°C (Dec.), +0.74°C (Jan.) and +0.12°C (Feb.). The corresponding NINO4 values were +1.20°C (Dec.), +0.79°C (Jan.) and +0.61°C (Feb.). These values confirm the weakening of the El Niño through the summer season.

Seasonal anomalies around the Australian coast were mostly positive, with two major exceptions. Anomalies were negative along the east coast of Queensland, part of a pattern which extended southeast towards New Zealand, and also along the west coast of Western Australia, part of a pattern which extended northwest out into the central Indian Ocean.

Seasonal anomalies at high latitudes in the southern hemisphere were negative in most areas, the south-central South Pacific being the only notable exception (with peak anomalies exceeding +1.5°C).

Subsurface patterns

The Hovmöller diagram for the 20°C isotherm depth anomaly (obtained from BMRC) across the equator from January 2001 to February 2007 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 subsequent changes at the surface.

In the early part of the summer, positive anomalies were observed east of the date-line, with a moderately strong downwelling Kelvin wave in progress resulting from weaker than normal trade winds across most of the equatorial Pacific in October. This Kelvin wave reached the far eastern Pacific in December. However, the later part of the season saw the replacement of the positive anomalies by negative anomalies, with an upwelling Kelvin wave of similar strength still in progress at the end of the season, effectively bringing the 2006-07 El Niño to an end. This upwelling was associated with a burst of stronger than average trade winds around the date-line between mid-December and early January. (Consistent with the El Niño, trade winds east of 140°W were weaker than average through most of the season.)

The replacement of the warm subsurface anomalies associated with the El Niño event by cool anomalies is shown clearly in Fig. 6, which shows a cross-section of equatorial subsurface temperature anomalies from November 2006 to February 2007, also obtained from BMRC. Red shades indicate positive anomalies, and blue shades negative anomalies. The pattern of positive anomalies for November, indicative of the El Niño event, was progressively undercut by the cool waters of the upwelling Kelvin wave, so that by the end of the season the El Niño signal had disappeared. It also contributed to speculation about a potential 2007-08 La Niña event.

Atmospheric patterns

Surface analyses

The summer 2006-07 mean sea-level pressure (MSLP) pattern, computed from the Bureau of Meteorology's Global Assimilation and Prediction (GASP) model, is shown in Fig. 7, with 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

Fig. 5 **Time-longitude section of the monthly anomalous depth of the 20°C isotherm at the equator from January 2001 to February 2007. The contour interval is 10 m.**

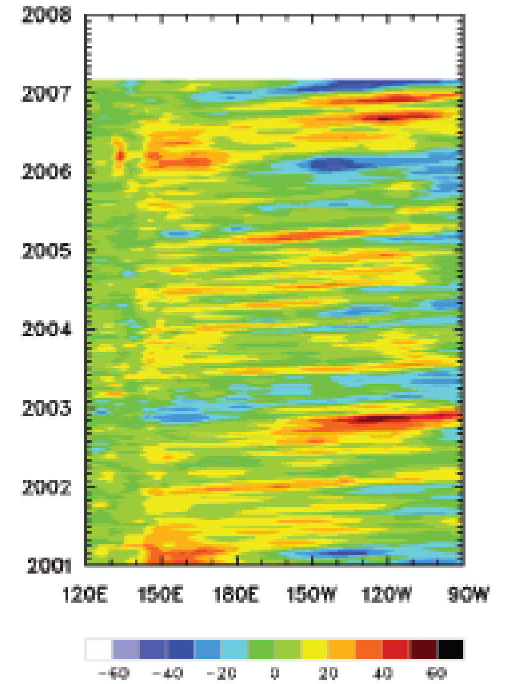


Fig. 6 **Four-month November 2006 to February 2007 sequence of vertical temperature anomalies at the equator for the Pacific Ocean. The contour interval is 0.5°C.**

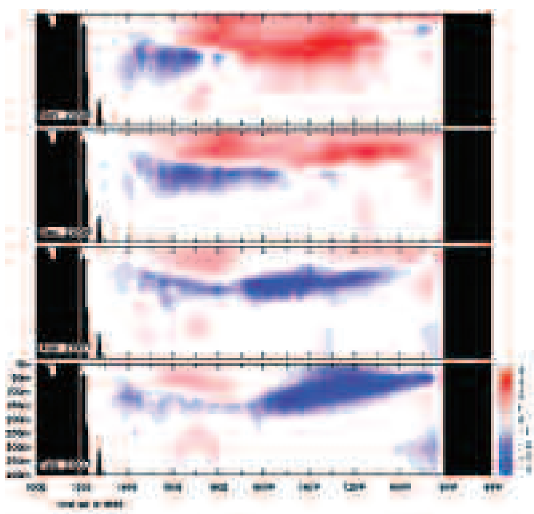


Fig. 7 Summer 2006-07 MSLP (hPa). The contour interval is 5 hPa.

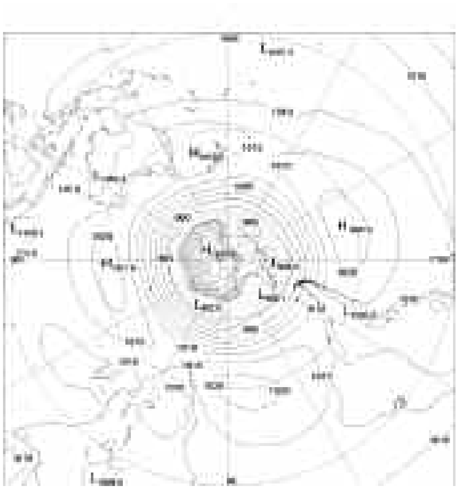
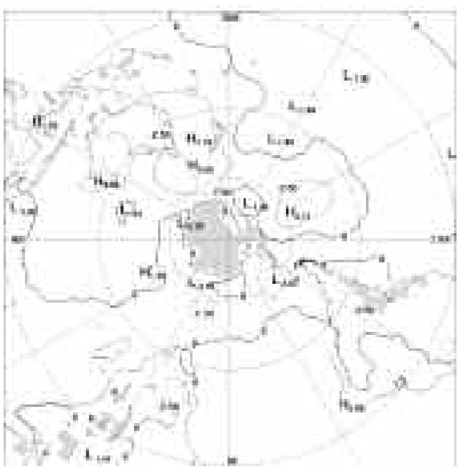


Fig. 8 Summer 2006-07 MSLP anomaly (hPa). The contour interval is 2.5 hPa.



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 summer 2006-07 MSLP pattern (Fig. 7) showed something of a weak four-wave pattern in the mid to high latitudes, with troughs located at approximately 40°E, 110°E, 170°W and 100°W, although overall the pattern was quite zonal. There were three principal centres in the polar trough around the Antarctic continent. These were located at 90°W, 150°W and 30°E, the last of these being the deepest. A lesser centre in the polar trough was located at around 45°W.

The main feature in the anomalies was the broad region of positive anomalies covering the western Pacific, Australia, the eastern Indian Ocean and the south-central Pacific. Elsewhere, high-latitude negative anomalies were located at around 45°E and 50°W. The seasonal anomalies in the polar trough were the weakest for many seasons. MSLP values were similarly close to average over most of the rest of the southern hemisphere, although over Australia and the Tasman Sea, the anomalies were everywhere positive.

Tropical cyclones

The Australian coast experienced a quiet tropical cyclone season in summer, with only one tropical cyclone crossing the coast. Tropical cyclone *Nelson* started life as a tropical low within the monsoon trough in the Gulf of Carpentaria in early February, intensifying to tropical cyclone status on 6 February and moving east-southeast to make landfall on Cape York Peninsula on 7 February. It dissipated soon after and widespread flooding was reported.

Mid-tropospheric analyses

The 500 hPa geopotential height (an indicator of the steering of surface synoptic systems) across the southern hemisphere is shown in Fig. 9, with the associated anomalies shown in Fig. 10. The four-wave pattern of Fig. 7 is also evident in Fig. 9, although in this season, the often-seen divergence in the seasonal flow west of New Zealand is much more evident at the 500 hPa level than at the surface.

In the southern Indian Ocean, the stronger than average polar trough shows a stronger signal at the 500 hPa level than at the surface, whereas the mid-level anomalies over Australia are somewhat weaker than their surface counterparts.

Blocking

The time-longitude section of the daily southern hemisphere blocking index (BI) 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 at subtropical (25°S to 30°S) and high (55°S to 60°S) latitudes. Positive values of the blocking index are generally associated with a split in the mid-latitude westerly flow centred near 45°S and mid-latitude blocking activity.

Fig. 9 **Summer 2006-07 500 hPa mean geopotential height (gpm). The contour interval is 100 gpm.**

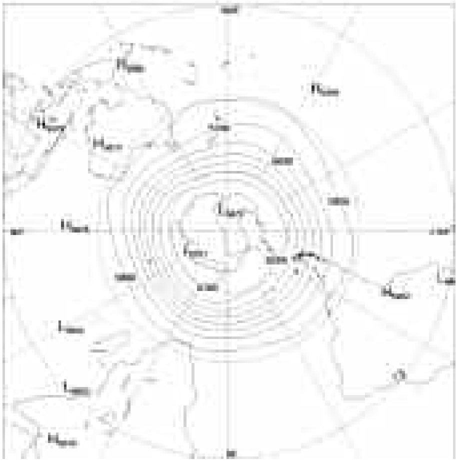


Fig. 10 **Summer 2006-07 500 hPa mean geopotential height anomaly (gpm). The contour interval is 30 gpm.**

Averaged over the entire season (Fig. 12), blocking was close to average for most longitudes, although slightly above average between 90°E and 70°W and slightly below average between 10°W and 90°E. Strong positive values of the blocking index (BI > 30 m s^{-1}) were mostly restricted to the first 40 days and last 30 days of the season, with most of the activity occurring in Pacific longitudes.

Fig. 11 **Summer 2006-07 daily blocking index (m s^{-1}) time-longitude section. The horizontal axis shows degrees east of the Greenwich meridian. Day one is 1 December.**

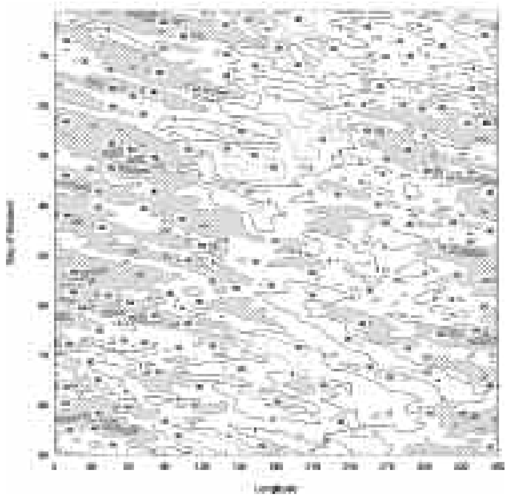
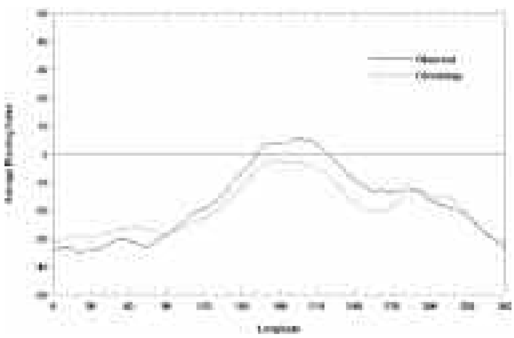


Fig. 12 **Mean southern hemisphere blocking index (m s^{-1}) for summer 2006-07 (solid line). The dashed line shows the corresponding long-term average. The horizontal axis shows degrees east of the Greenwich meridian.**



Winds

Summer 2006-07 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 grey. The low-level wind anomalies (Fig. 13) generally reflected the MSLP anomalies (Fig. 8). Along the equatorial Pacific, anomalies

Fig. 13 Summer 2006-07 850 hPa vector wind anomalies (m s^{-1}).

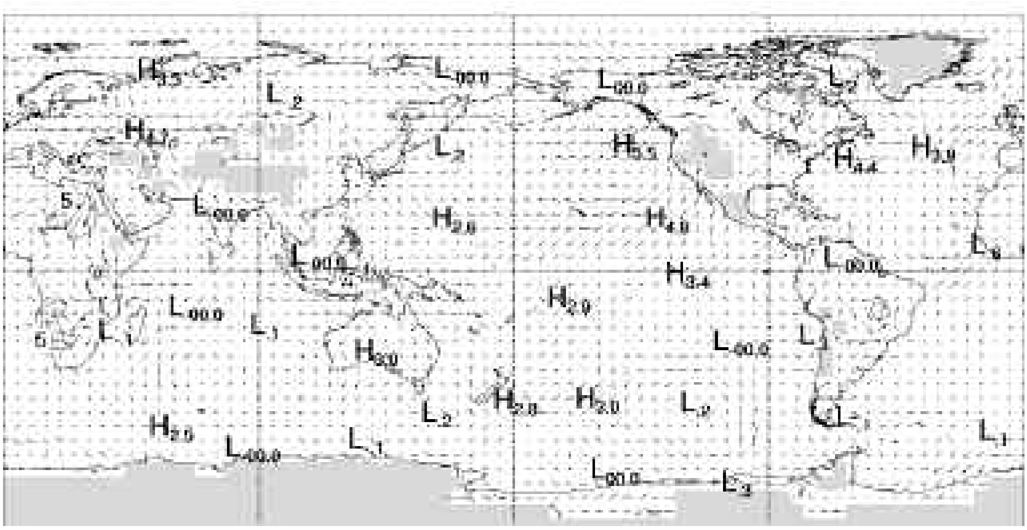
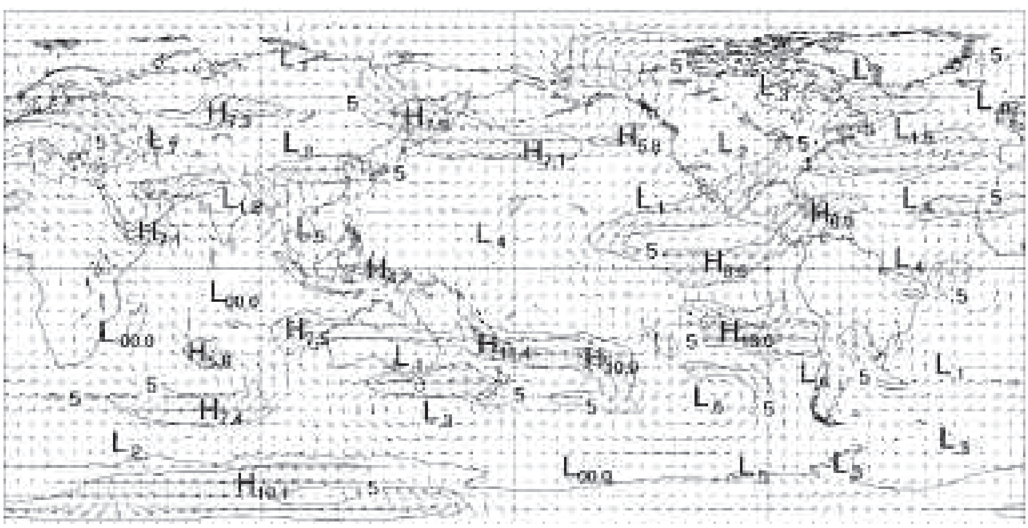


Fig. 14 Summer 2006-07 200 hPa vector wind anomalies (m s^{-1}).



were very weak in the west, but slightly stronger in the east where a cross-equatorial anomalous southwesterly flow was observed. In the eastern South Pacific, a weak anticyclonic anomaly pattern was observed, while off the southwest coast of Australia a weak cyclonic anomaly pattern was evident. Anomalies over Australia itself were also weak, consistent with the positive pressure anomalies. The easterly anomalies in the Australian tropics indicated a weaker than normal monsoon.

In the upper levels there was some cross-equatorial northeasterly return flow in the eastern equatorial Pacific, while in the western equatorial Pacific the anomalies were quite weak. Across central Australia, there was a band of anomalous westerlies around 5 m s^{-1} in strength. Anomalous easterlies of comparable strength were observed over the southeast of the country, associated with an anomalous anticyclonic circulation pattern (also evident in the mid-levels (see Fig. 10)).

Australian region

Rainfall

Figure 15 shows the summer rainfall totals for Australia, while Fig. 16 shows the summer rainfall deciles, where the deciles are calculated with respect to gridded rainfall data for all summers from 1900-01 to 2006-07.

The summer rainfall, unlike the previous spring (Qi 2007), showed a fairly neutral pattern (Fig. 16). Areas of above average (deciles 8 to 10) rainfall were observed in southern WA, central SA and southern NT/southwestern Queensland. Areas of below average (deciles 1 to 3) rainfall were observed in western WA, southeastern Queensland/northeastern NSW and central Victoria/south-central NSW.

In terms of the monthly outcomes (not shown), December rainfall was somewhat like the seasonal pattern, being composed of moderately sized areas of below average (deciles 1 to 3) and above average (deciles 8 to 10) rainfall. January rainfall, in contrast, was characterised by widespread above to very much above average rainfall across the southwest, centre (SA and the NT), and western parts of the eastern States. There were many small areas with highest on record January totals (based on gridded rainfall totals from 1900 to 2007). Areas of below to very much below average January rainfall were mostly confined to the western and eastern margins of the continent. February rainfall showed an opposite pattern, with a broad area of below to very much below average rainfall extending from the tropical northwest across the middle NT down into northern SA, southwestern Queensland and northwestern NSW.

Table 1 summarises the seasonal rainfall ranks and extremes, on a national and State basis. Averaged across the entire country, the summer rainfall was 203 mm, its rank 52 out of 107 placing it slightly below the median. The area averages for Queensland, South Australia and the Northern Territory were a little above the median, while the averages for the other States were a little below the median.

Fig. 15 **Summer 2006-07 rainfall totals (mm) in Australia.**

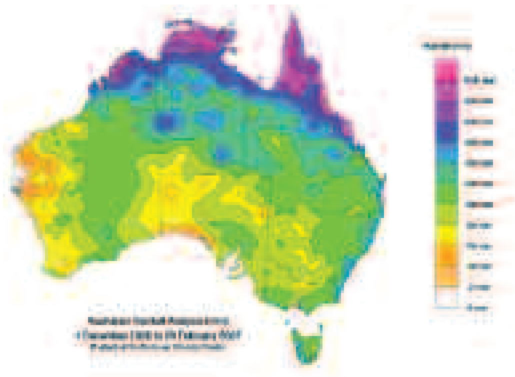
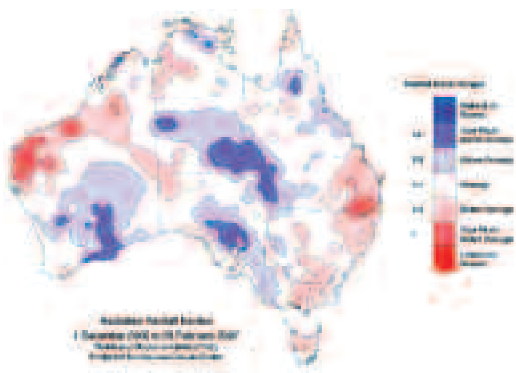


Fig. 16 **Summer 2006-07 rainfall for Australia: decile ranges based on grid-point values over the summers 1900-01 to 2006-07.**



Drought

At the end of summer, 19.7% of Australia was in serious rainfall deficiency (decile 1) for the 10 months ending February 2007. This area comprised the southwest coast of Western Australia (21.7%), the central and southeast coast of South Australia (20.9%), most of Victoria (85.4%), the northern two-thirds of Tasmania (73.3%), south-central New South Wales west of and including the ACT (31.6%) and southeast Queensland. For shorter or longer drought assessment periods the total national area in serious rainfall deficiency was less than this local temporal maximum, with another local temporal maximum at a period length of 63 months (5.25 years) for periods ending February 2007 in which 23.2% of Australia was in serious deficiency. For this longer period, the main region affected is the Murray-Darling Basin and adjacent areas (representing 43.1% of Queensland, 61.4% of New South Wales, 84.3% of Victoria, 34.5% of Tasmania and 16.8% of South Australia).

The very dry conditions were a major contributing factor to numerous major and long-lived bushfires, especially in the mountains of eastern Victoria, where lightning on 1 December ignited fires which merged into a single blaze which remained uncontained until early February; approximately 11 000 square kilometres were burned.

Table1. Summary of the seasonal rainfall ranks and extremes on a national and State basis.

	Highest seasonal total (mm)	*Lowest seasonal total (mm)*	*Highest 24-hour fall (mm)*	*Area-averaged rainfall (AAR) (mm)*	*Rank of AAR**
Australia	3939 at Bellenden Ker Top Station (QLD)	Zero at several WA locations	461 at Wilson Beach (QLD), 2 February	203.0	52
WA	1029 at Kuri Bay	Zero at several locations	211 at Kimberley Coastal Camp, 16 January	134.1	48
NT	1422 at Pinelands	40 at Mount Ebenezer	195 at Wildman Rangers, 28 February	338.6	68
SA	274 at Yednalue	4 at Smoky Bay	149 at Yednalue, 20 January	63.2	71
QLD	3939 at Bellenden Ker Top Station	59 at Hungerford	461 at Wilson Beach, 2 February	332.2	56
NSW	627 at Beaumont	16 at Weethalle	286 at East Kangaloon, 12 February	122.0	32
VIC	365 at Wyelangta	29 at Echuca	138 at Dergholm, 20 January	101.8	39
TAS	571 at Mount Read	56 at Tunbridge	96 at Glenorchy, 22 January	173.6	28

* The rank goes from 1 (lowest) to 107 (highest) and is calculated using the summers 1900-01 to 2006-07 inclusive.

Temperatures

Figures 17 and 18 show the maximum and minimum temperature anomalies, respectively, for summer 2006-07. The anomalies have been calculated with respect to the 1961-1990 period, and use all temperature-observing stations for which a 1961-1990 normal is available. A high-quality subset of the network is used to calculate the spatial averages and rankings shown in Tables 2 and 3. These averages are available from 1950 to the present. All ranking of the summer 2006-07 temperatures against the historical record is done in terms of this high-quality subset.

Seasonal maximum temperatures (Fig. 17) were above average over most of the south and west of the country, the most significant area of negative anomalies covering central Queensland and eastern parts of the Northern Territory. A widespread area of +1°C anomalies covered much of WA and adjacent parts of western SA and southwest NT, while another area of similar size covered southeastern SA, Victoria and most of NSW. Most of Tasmania likewise recorded +1°C anomalies. Scattered smaller areas of +2°C anomalies were observed in both the east and west. Seasonal anomalies in the −1 to −2°C range were observed on the Qld/NT border and in parts of east-central Queensland.

Fig. 17 Summer 2006-07 maximum temperature anomalies (°C) for Australia, based on a 1961-1990 mean.

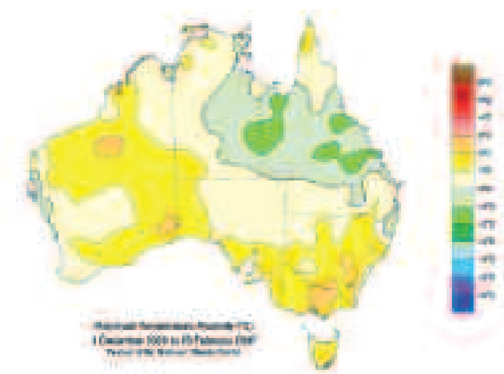


Fig. 18 Summer 2006-07 minimum temperature anomalies (°C) for Australia, based on a 1961-1990 mean.

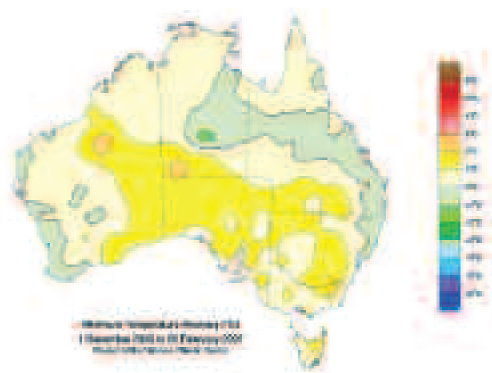


Table 2. Summary of the seasonal maximum temperature ranks and extremes on a national and State basis.

	Highest seasonal mean (°C)	*Lowest seasonal mean (°C)*	*Highest daily recording (°C)*	*Lowest daily recording (°C)*	*Anomaly of area-averaged mean (°C) (AAM)*	*Rank of AAM**
Australia	43.0 at Marble Bar (WA)	14.1 at Mt Wellington (TAS)	48.6 at Hyden (WA), 3 February	–0.8 at Mount Buller (VIC), 25 December ##	+0.57	48
WA	43.0 at Marble Bar	22.2 at Albany	48.6 at Hyden, 3 February	14.5 at Ravensthorpe and Newdegate, 4 January	+0.91	51
NT	38.0 at Yulara	31.4 at McCluer Island	45.5 at Wulungurru, 9 February	19.1 at Arltunga, 24 December	–0.06	29
SA	38.0 at Marree	22.2 at Cape Willoughby	47.6 at Nullarbor, 17 February	10.2 at Mt Lofty, 25 December	+1.15	49
QLD	38.1 at Birdsville Airport	25.3 at Maleny	46.9 at Cloncurry and Winton, 1 December	16.4 at Injune, 26 December	–0.33	24
NSW	36.4 at Ivanhoe	16.7 at Thredbo Top Station	46.0 at Ivanhoe, 11 January	0.1 at Thredbo Top Station, 25 December #	+1.38	49
VIC	32.6 at Yarrawonga	16.5 at Mt Baw Baw	42.9 at Kerang and Viewbank, 10 December	–0.8 at Mount Buller, 25 December	+1.61	54
TAS	25.4 at Cressy	14.1 at Mt Wellington	37.0 at Fingal, 10 December	1.7 at Mt Wellington, 25 December	+1.58	53

* The temperature ranks go from 1 (lowest) to 57 (highest) and are calculated using the summers 1950-51 to 2006-07 inclusive.
# State record for summer.
Australian record for summer.

Table 3. Summary of the seasonal minimum temperature ranks and extremes on a national and State basis.

	Highest seasonal mean (°C)	*Lowest seasonal mean (°C)*	*Highest daily recording (°C)*	*Lowest daily recording (°C)*	*Anomaly of area-averaged mean (°C) (AAM)*	*Rank of AAM**
Australia	27.2 at Marble Bar (WA) and Centre Island (NT)	4.9 at Mt Wellington (TAS)	33.8 at Wittenoom (WA), 27 January	–5.7 at Thredbo Top Station (NSW), 26 December	+0.56	48
WA	27.2 at Marble Bar	11.7 at Shannon	33.8 at Wittenoom, 27 January	0.5 at Eyre, 3 December	+0.56	51
NT	27.2 at Centre Island	20.8 at Territory Grape Farm	32.0 at Yulara, 18 February	10.5 at Kulgera, 27 December and at Arltunga, 28 December	+0.27	36
SA	23.5 at Moomba	11.9 at Naracoorte	32.7 at Oodnadatta Airport, 5 January	1.0 at Robe, 7 December and at Naracoorte, 7, 12 and 16 December	+1.26	51
QLD	26.3 at Sweers Island	14.2 at Applethorpe	33.3 at Birdsville Airport, 12 January	7.6 at Applethorpe, 29 December and at Stanthorpe, 29 January	+0.08	33
NSW	22.7 at Tibooburra	6.4 at Thredbo Village	30.2 at Tibooburra, 20 December	–5.7 at Thredbo Top Station, 26 December	+1.05	49
VIC	17.0 at Mildura	7.4 at Mt Hotham	29.1 at Charlton, 17 January	–5.0 at Mt Hotham, 26 December	+0.98	50
TAS	14.8 at Swan Island	4.9 at Mt Wellington	21.4 at Flinders Island, 18 February	–2.8 at Mt Wellington on 12 December	+0.86	51

* The temperature ranks go from 1 (lowest) to 57 (highest) and are calculated using the summers 1950-51 to 2006-07 inclusive.

The seasonal maximum temperatures ranked as above average (deciles 8 to 10) in a broad band (not shown) from northwest WA, across SA and into the southeast (NSW, Vic, Tas), with very much above average areas (decile 10) in all these named States. Seasonal highest on record outcomes were observed on the southern WA/SA border and in northeast Tasmania. Most notable amongst the monthly outcomes was the exceptionally hot February in much of southern and western Australia. A large area of central Australia extending northwest from the Bight recorded its warmest February for maximum temperatures (based on gridded data from 1950 to the present), and in large parts of Western Australia, the anomalies exceeded +5°C. Marble Bar (Pilbara, WA) recorded a mean maximum temperature of 44.9°C, the highest monthly mean maximum temperature recorded in Australia for any month.

Seasonal minimum temperature anomalies (Fig. 18) showed a somewhat similar pattern, although with a slightly reduced amplitude. A large band across the middle of the country recorded summer anomalies above +1°C, peaking at +2°C in a few places. The eastern half of Western Australia and the northern half of Tasmania recorded their warmest February for minimum temperatures (again based on gridded data from 1950 to the present).

Table 2 summarises the seasonal maximum temperature ranks and extremes, on a national and State basis, and Table 3 shows a corresponding analysis for the seasonal minimum temperatures. As previously indicated, the anomalies and ranks given in Tables 2 and 3 are based on the analyses of the high-quality subset of the temperature network. The area-averaged anomalies are calculated relative to the period 1961-1990, but the ranks are calculated with respect to the full time series in each case. In area-averaged terms, Victoria recorded its fourth warmest summer for maximum temperature, with Tasmania its fifth warmest. For minimum temperature, all the area-averaged anomalies were positive and above median, but none was particularly extreme. For mean temperature (not shown; the average of maximum and minimum temperature, in area-averaged terms) Victoria recorded its equal-fourth warmest summer, while Tasmania recorded its third warmest summer.

References

Climate Prediction Center 2007. *Climate Diagnostics Bulletin*, Climate Prediction Center, National Weather Service, Washington D.C., U.S.A, 20233.

Kanamitsu, M., Ebisuzaki, W., Woollen, J., Yang, S.-K, Hnilo, J.J., Fiorino, M. and Potter, G.L. 2002. NCEP-DOE AMIP-II Reanalysis (R-2). *Bull. Am. Met. Soc., 83*, 1631-43.

Qi, L. 2007. Seasonal climate summary southern hemisphere (spring 2006): weak El Niño in the tropical Pacific – warm and dry conditions in eastern and southern Australia. *Aust. Met. Mag., 56,* 203-14.

Wolter, K. and Timlin, M.S. 1993. Monitoring ENSO in COADS with a seasonally adjusted principal component index. *Proc. of the 17th Climate Diagnostics Workshop,* Norman, OK, NOAA/NMC/CAC, NSSL, Oklahoma Clim. Survey, CIMMS and the School of Meteorology, Univ. of Oklahoma, 52-7.

Wolter, K. and Timlin, M.S. 1998. Measuring the strength of ENSO – how does 1997/98 rank? *Weather, 53*, 315-24.