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# Seasonal climate summary southern hemisphere (winter 1993): the 1991–93 El Niño–Southern Oscillation (ENSO) episode declines

**P.G. Nydam**
National Climate Centre, Bureau of Meteorology, Australia

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**An analysis is given of Pacific basin tropical climate indicators and the southern hemisphere circulation for the austral winter, 1993. Winter rainfall and temperature are discussed for the Australian region. The season saw a decline in the warm ENSO episode conditions which redeveloped in the tropical Pacific during the austral summer 1992/93 and autumn 1993. Winter rainfall over Australia was generally average to above average, in contrast to the previous season when it was mainly below average.**

## Introduction

This seasonal summary reviews the climate of the Pacific basin tropics and southern hemisphere (SH) during the austral winter 1993. During this period, the unusual 1991–93 ENSO episode entered a second declining phase. Preceding this episode, positive sea-surface temperature (SST) anomalies developed in the western equatorial Pacific towards the end of 1989. By February 1991, the Southern Oscillation Index (SOI) was continuously negative. Significantly negative values of the SOI commenced in autumn 1991 and by mid-1991, an El Niño episode had begun. The episode continued to develop during the austral spring and matured as a moderate to strong event in summer 1991/2 and autumn 1992. It waned in the winter/spring months of 1992, and redeveloped in summer 1992/93 to reach its mature phase in autumn 1993 (Wright 1994).

The sources of information used for this summary were the *Climate Monitoring Bulletin* issued by the Bureau of Meteorology (Australia), and the *Climate Diagnostics Bulletin*, Climate Analysis Center (CAC) Washington. The SH seasonal mean and anomaly analyses presented were produced from daily grid-point data archived by the National Meteorological Centre, Melbourne, Australia. The addresses of the above sources are given in the Appendix.

## Tropical climate indicators

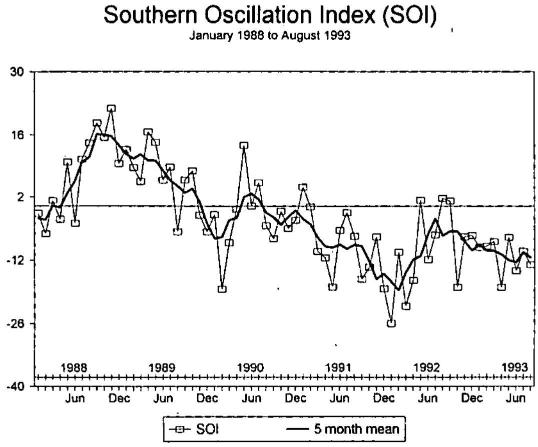
### Atmospheric

During winter 1993, values of the SOI* remained significantly negative (Fig. 1) despite a general cooling trend in the equatorial Pacific. Darwin and Tahiti pressure anomalies during winter were generally less than those during the preceding autumn. Darwin's mean sea-level pressure (MSLP) for June, July and August (anomaly in brackets) was 1013.9 (+1.5), 1013.5 (+0.5) and 1015.1 (+2.3) hPa respectively; those for Tahiti were 1013.1 (−0.6), 1012.8 (−1.2) and 1014.6

*Corresponding author address:* Mr P.G. Nydam, National Climate Centre, Bureau of Meteorology, GPO Box 1289K, Melbourne, Vic 3001, Australia.

*The SOI used here is 10 times the anomaly of the monthly mean Tahiti minus Darwin mean sea-level pressure difference divided by the standard deviation of that difference for the relevant month, based on the period 1882–1985.

**Fig. 1 Southern Oscillation Index (SOI), January 1988 to August 1993 inclusive.**




(+0.1). Tropical MSLPs were generally positive west of the date-line over the Pacific and in the Indian Ocean; east of the date-line in the Pacific they were generally negative.

During winter, weaker than normal low-level equatorial easterlies continued from the previous season while upper level equatorial westerlies strengthened to near-normal values for the season. Figure 2 shows a filtered time series of 200 hPa velocity potential (VP) averaged from 5°N to 5°S and 120°E to 140°E. From June to the end of August, there were several negative dips in the VP, however, it was unclear whether these were associated with the passage of a 40 to 50-day wave.

## Oceanic

In the equatorial Pacific, there was a general cooling trend during the season. During June, a fairly large area of positive SST anomaly exceeding 1°C was evident in the central Pacific (Fig. 3(a)). In July this region contracted and moved to the west;

**Fig. 2 Time series plot of 5-day running mean 200 hPa velocity potential averaged from 5°N to 5°S and 120°E to 140°E. Units are $m^2s^{-1}$.**

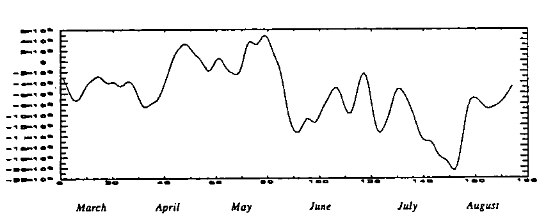



**Fig. 3(a) June 1993 sea-surface temperature anomaly (°C).**

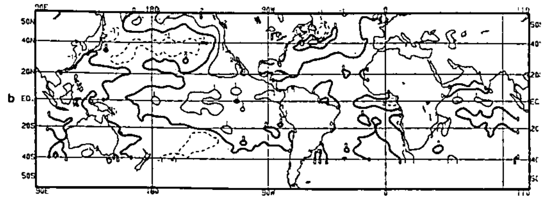


**Fig. 3(b) July 1993 sea-surface temperature anomaly (°C).**

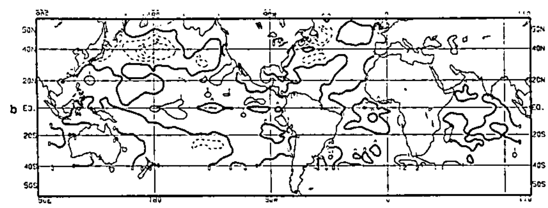
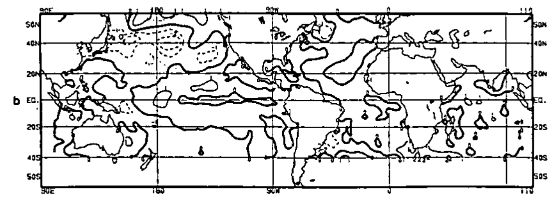


**Fig. 3(c) August 1993 sea-surface temperature anomaly (°C).**



it was replaced by a small area of cooler than normal water; cool anomalies also developed in parts of the eastern equatorial Pacific (Fig. 3(b)). In August, the region of positive anomaly moved further to the west to a position near the date-line and contracted in size; the area of negative anomaly expanded longitudinally to occupy most of the central and eastern equatorial Pacific (Fig. 3(c)).

Subsurface temperature anomalies in the equatorial Pacific are shown for June, July and August in Figs 4(a), 4(b) and 4(c) respectively. These analyses show a progressive cooling of the mixed layer east of about 160°E, consistent with the development of negative surface anomalies along the equator during the season.

**Fig. 4(a) June 1993 Pacific Ocean equatorial subsurface anomaly (contour interval 2°C).**

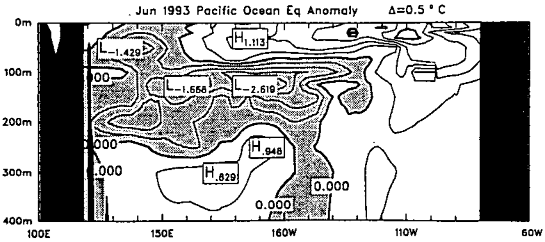



**Fig. 4(b) July 1993 Pacific Ocean equatorial subsurface anomaly (contour interval 2°C).**

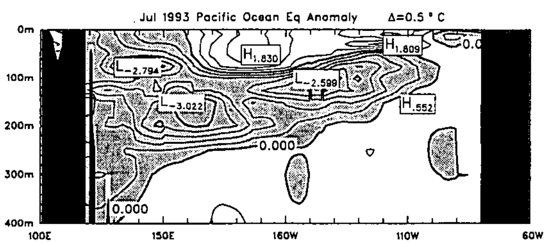
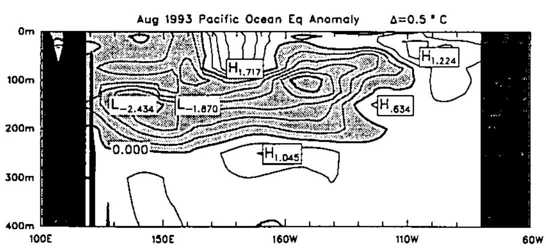



**Fig. 4(c) August 1993 Pacific Ocean equatorial subsurface anomaly (contour interval 2°C).**




## Southern hemisphere circulation

### Surface analyses

Figures 5 and 6 show the winter 1993 MSLP analysis and anomaly patterns respectively for the SH. Anomalies are based on an 11-year (1979–1989) climatology of SH analyses, compiled by the European Centre for Medium Range Weather Forecasts.

Features of the MSLP analysis were the enhanced Pacific and Atlantic troughs. On the anomaly analysis, negative anomalies were evident over most of the hemisphere south of 50°S. Over the Antarctic continent, these negative anomalies were quite strong. Significant positive anomalies affected Australia along with an adjacent broad belt occupying tropical to mid-latitudes of the western to central Pacific.

**Fig. 5 Winter 1993 (June, July, August) mean sea-level pressure (hPa).**

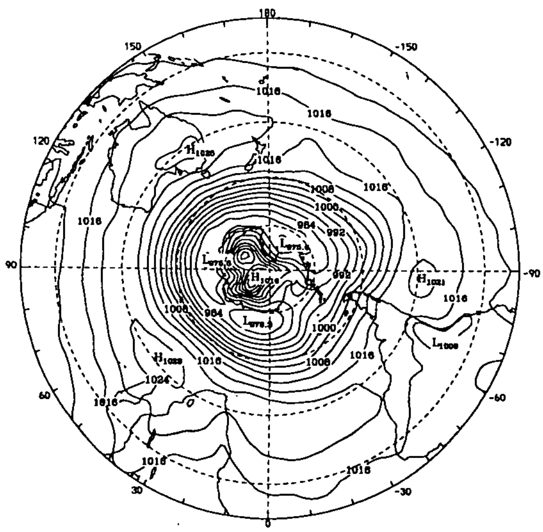


**Fig. 6 Winter 1993 (June, July, August) mean sea-level pressure anomaly (hPa).**

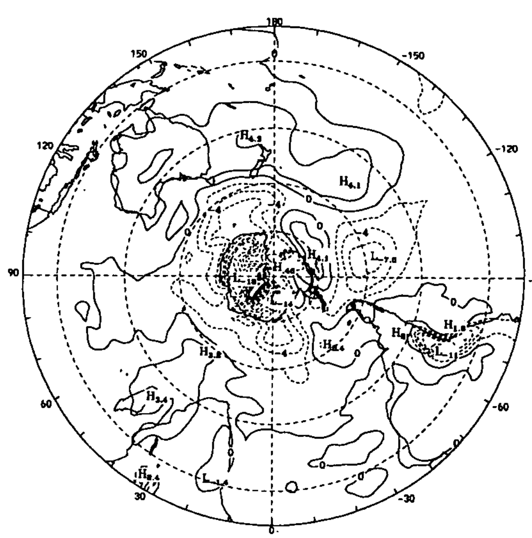


**Fig. 7 Winter 1993 (June, July, August) 500 hPa mean geopotential height (dam).**

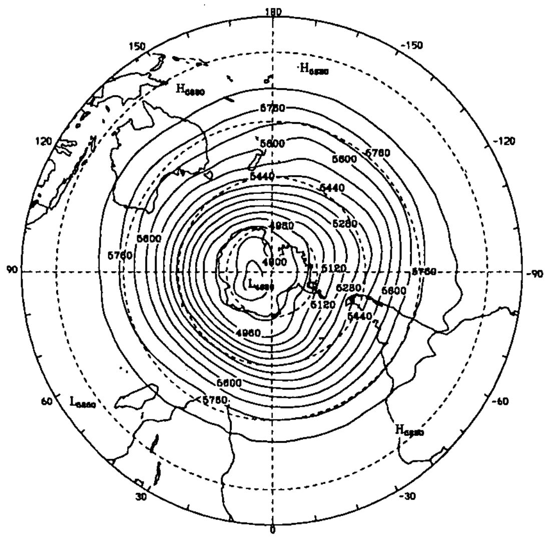
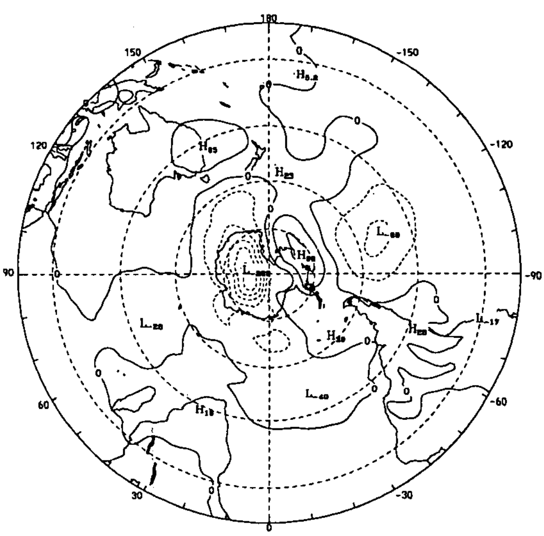


**Fig. 8 Winter 1993 (June, July, August) 500 hPa mean geopotential height anomaly (dam).**

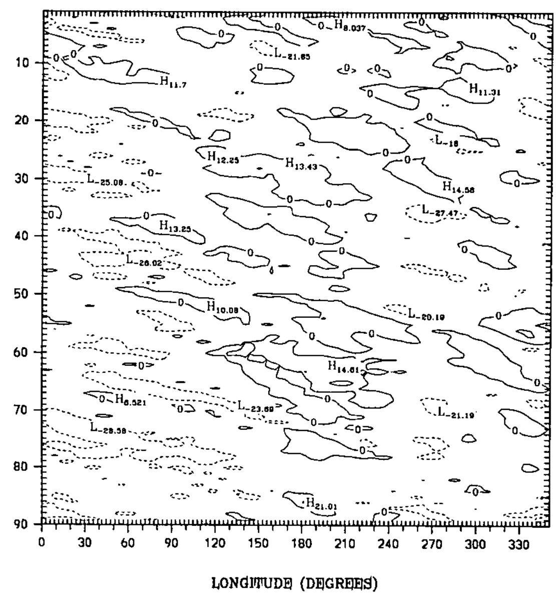


## Upper level analyses

Figures 7 and 8 show the winter 500 hPa heights and height anomalies respectively. Zonal flow at mid-latitudes was fairly close to normal. Notable features of the anomaly map are the anomaly dipole over Antarctica and negative anomalies over the eastern Pacific at mid-latitudes.

A time-longitude section of the daily SH Blocking Index (BI) is shown in Figure 9. This index is defined by the following relation:

**Fig. 9 Winter 1993 (June, July, August) time-longitude cross-section of the daily southern hemisphere Blocking Index. Day 1 is June 1.**




$$BI = 0.5(U_{25} + U_{30} + U_{55} + U_{60} - U_{40} - U_{50} - 2U_{45})$$

where U is the 500 hPa daily zonal wind for 1100 and 2300 UTC and the subscript is the corresponding latitude in degrees south.

The index measures the difference in strength between the westerlies at low/high latitudes and those at mid-latitudes. The split in the mid-latitude westerlies caused by blocking activity tends to produce positive values of the index.

The mean BI for the three-month period was notably above average over the Tasman Sea/New Zealand region.

Figures 10 and 11 show SH vector wind anomalies for winter at 850 and 200 hPa respectively. Features of the 850 hPa anomaly analysis were the stronger than normal westerlies in the Southern Ocean to the south of Australia and New Zealand, the stronger than normal trades along the Queensland and northern New South Wales coasts of Australia. On the 200 hPa anomaly analysis, the subtropical jet was stronger than normal over much of the eastern half of the South Pacific Ocean; in contrast, it was weaker than normal over Australia.

**Fig. 10** **Winter 1993 (June, July, August) 850 hPa vector wind anomalies (m $s^{-1}$).**

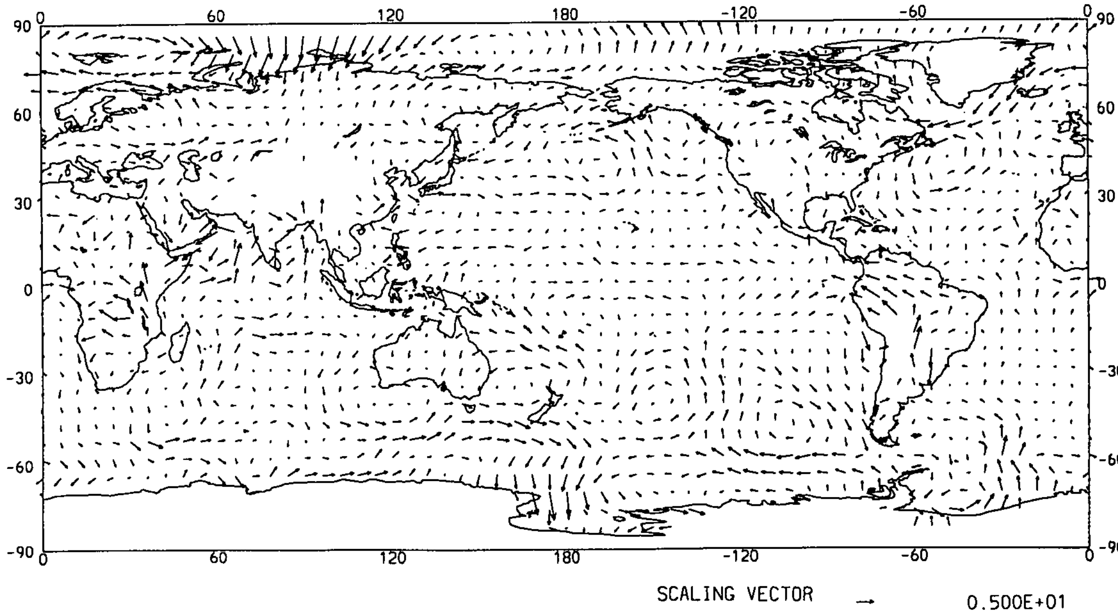
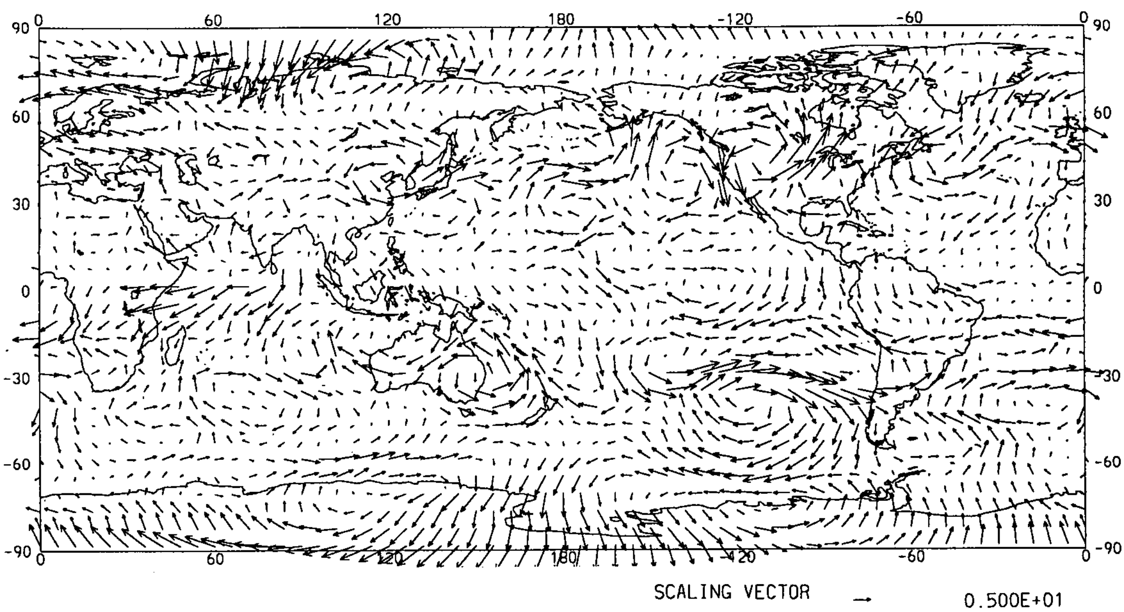



**Fig. 11** **Winter 1993 (June, July, August) 200 hPa vector wind anomalies (m $s^{-1}$).**




# Australian region

### Circulation and rainfall

The winter rainfall decile analysis based on district-averaged totals is shown in Fig. 12. Winter rainfall over the continent was generally average to above average. Over eastern Australia, enhanced trade winds, particularly during July and August, provided moisture for synoptic-scale rainfall-producing systems affecting that part of the continent. During the first half of June and again in August, 'northwest cloudbands', or interactions with these, were mainly responsible for the above average rainfall which was recorded in Western Australia and central parts of the continent during winter.

**Fig. 12 Winter rainfall 1993 (June, July, August) over Australia: decile range values based on district average rainfall.**

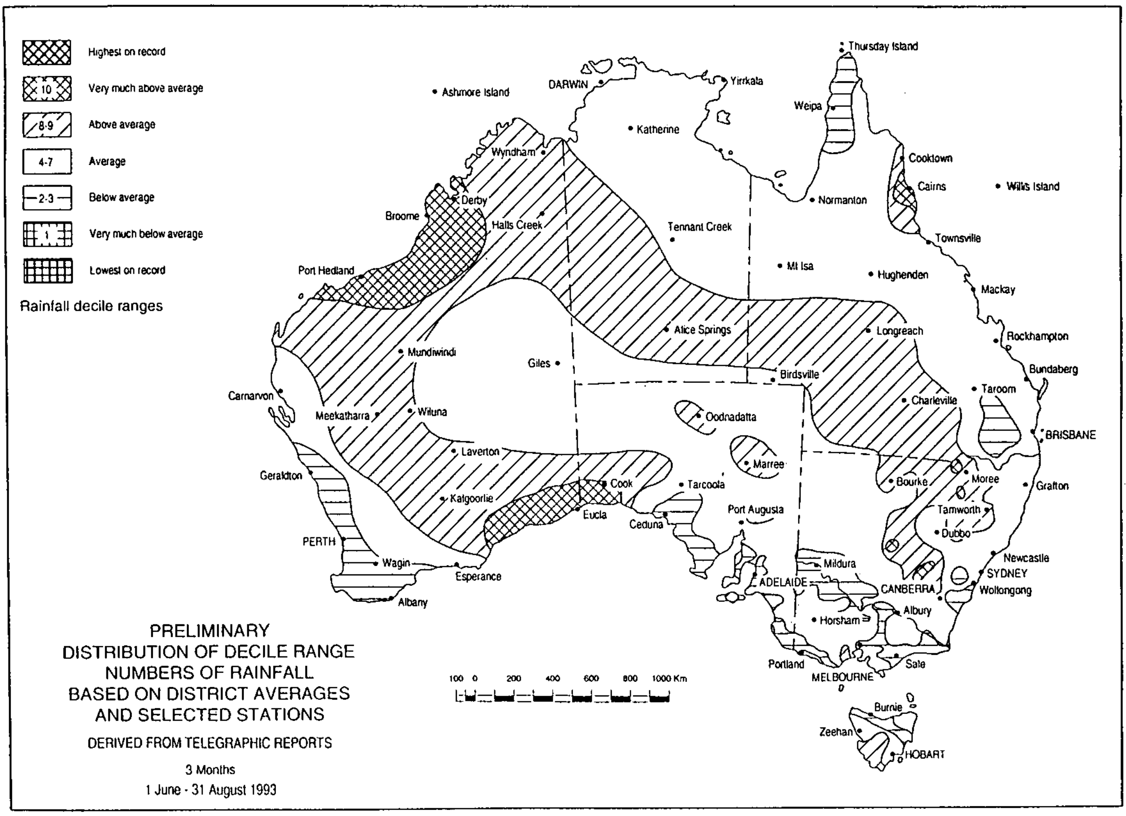



**Fig. 13(a) Winter 1993 (June, July, August) maximum temperature anomalies (°C) for Australia.**

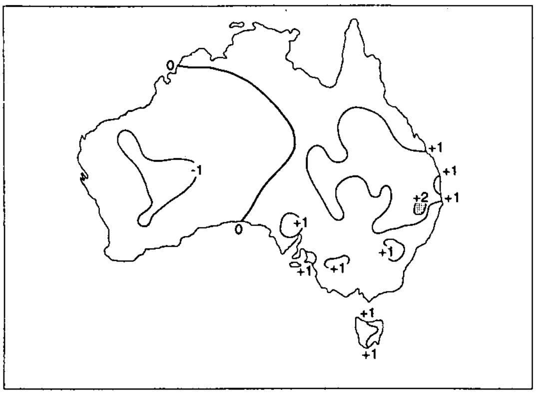
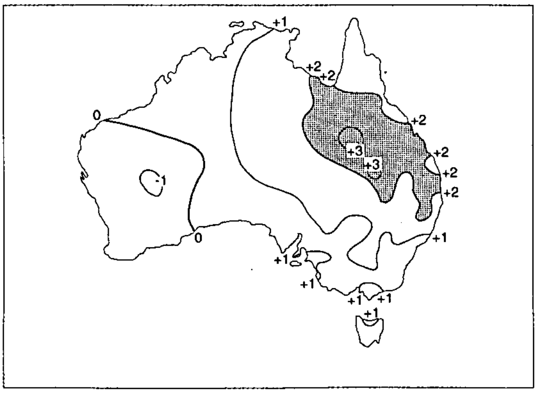



**Fig. 13(b) Winter 1993 (June, July, August) minimum temperature anomalies (°C) for Australia.**



**Temperatures**

Maximum temperatures were, in general, above average over the eastern half and north of the continent; elsewhere, they were generally below average (Fig. 13(a)). The most notable region of positive anomaly was the southern half of Queensland were anomalies in the range 1–2°C were recorded. Negative anomalies exceeding 1°C in magnitude were registered over parts of inland Western Australia.

Minimum temperatures were generally above average over the continent with the exception of the southern half of Western Australia, where they were below average (Fig. 13(b)). The most notable region of positive anomaly was Queensland where many stations recorded minima 2–3°C above normal.

## References

Wright, W.J. 1994. Seasonal climate summary southern hemisphere (autumn 1993): a second mature ENSO phase. *Aust. Met. Mag.*, *43*, 205–12.

## Appendix

Data sources used for this review were:
Climate Analysis Center Diagnostics Bulletin.*
National Climate Centre — *Climate Monitoring Bulletin — Southern Hemisphere.*+
Southern Hemisphere grid-point analysis data.+

Obtainable from:
*Climate Analysis Center, National Weather Service, Washington D.C. 20233, USA.
+National Climate Centre, Bureau of Meteorology, GPO Box 1289K, Melbourne 3001, Australia.