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Seasonal climate summary southern hemisphere (spring 1991): a maturing El Niño–Southern Oscillation (ENSO) episode

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A climate analysis is given of the southern hemisphere spring (September to November) 1991, with a greater focus on the Australian region. The season saw the continued development of the El Niño episode which began in autumn 1991. Positive sea-surface temperature anomalies dominated the tropical Pacific, a strong polar trough characterised the Indian Ocean and Australian sectors, and rainfall was below average over most of eastern Australia.

Introduction

This seasonal summary reviews the southern hemisphere climate for spring 1991 (September to November), with greater attention given to the Australian region.

The main information sources were the Climate Monitoring Bulletins issued by the Bureau of Meteorology, Australia, as well as climate bulletins issued by other national meteorological services. Data sources are specified in the Appendix.

Climate indices

Following a brief rally in the Southern Oscillation Index (SOI) during winter, moderately strong negative values were observed during spring. The index averaged −12.2 for the season. After hovering around −15 in September and October, it rose to −7 in November (Fig. 1). The jump in November was due principally to a 2 hPa rise in the Tahiti mean sea level pressure (MSLP) anomaly.

The SOI remained negative since February 1991 and was consistent with a developing ENSO event.

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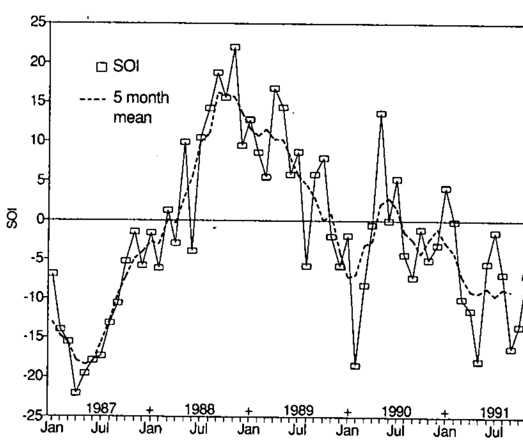
Low-level equatorial easterlies were weaker than normal during the entire period (i.e. anomalous westerlies). Intensification in the low-level westerly anomalies occurred near the dateline during November. Negative outgoing long wave radiation (OLR) anomalies in the vicinity of the equatorial dateline increased in magnitude during the season, particularly in the latter half. These anomalies indicate areas of enhanced convection.

Fig. 1 Southern Oscillation Index, January 1987 to November 1991 inclusive.



The pattern of OLR anomalies evident across the equatorial Pacific at the end of November was consistent with those observed during the mature stages of previous warm (ENSO) episodes (CAC, Washington).

Positive sea-surface temperature (SST) anomalies persisted across the central and eastern equatorial Pacific during spring (Figs 2(a), (b), (c)). Both the intensity and area affected by these anomalies increased as the season progressed. The pattern of SST anomalies across the Pacific basin was typical of a maturing ENSO event (Rasmusson and Wallace 1983).

Sea-surface temperatures

Due to the injection of aerosols into the stratosphere by the June 1991 eruption of Mt Pinatubo (Philippines), satellite-derived SST anomalies cannot be presented. Continuing the practice adopted in the previous seasonal summary (de Hoedt 1992), monthly anomaly charts for September to November adopted from Climate Analysis Center (CAC) Washington are shown in Figs 2(a) to (c).

Persisting during spring was a pattern of warm anomalies in the central/eastern equatorial

Fig. 2(a) September 1991 sea-surface temperature anomaly (°C).

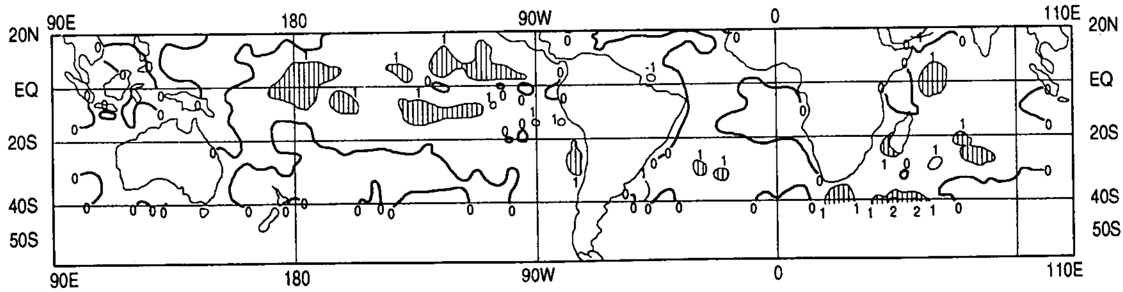


Fig. 2(b) October 1991 sea-surface temperature anomaly (°C).

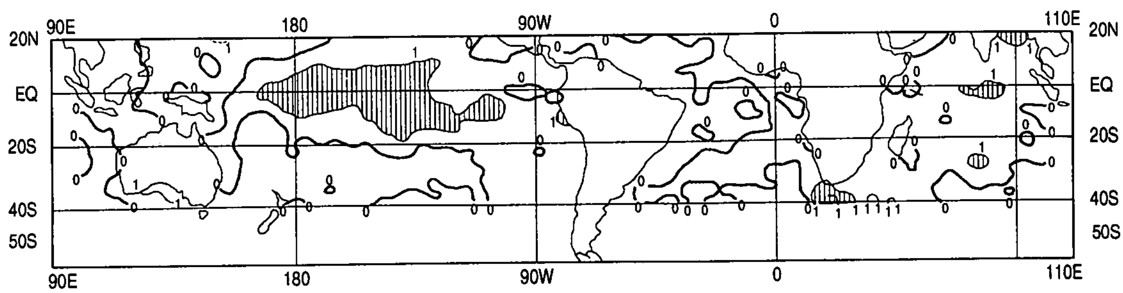
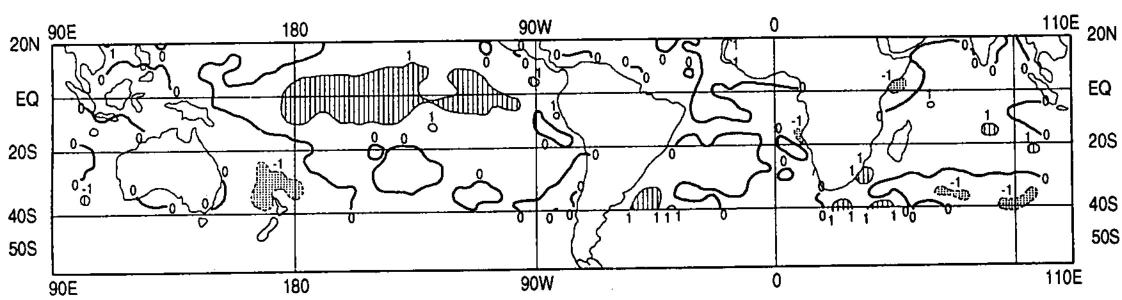


Fig. 2(c) November 1991 sea-surface temperature anomaly (°C).



Pacific surrounded by two bands of cold anomalies stretching to the northeast and southeast from the New Guinea/Philippines region. This is a classic signature of the El Niño phenomenon (Rasmusson and Wallace 1983).

In September (Fig. 2(a)), positive SST anomalies of 1° to 2°C were evident in the equatorial Pacific near the dateline, and along 5°N and 5°S across a large part of the eastern Pacific.

The spatial extent of the warm anomalies in the tropical Pacific expanded during October. In addition, an eastward propagating oceanic Kelvin wave was responsible for an increased thermocline depth in the eastern Pacific, and a corresponding decrease in the west (Wyrtki 1982). This situation had some similarities with that observed during late 1986 as the 1986–87 warm episode developed.

Warming of the equatorial central and eastern Pacific continued in November. For example, some stations along the Peruvian coast registered positive anomalies of 2° to 3°C for the month.

Surface analysis

Figures 3 and 4 show the spring MSLP analysis and anomaly respectively. The pattern in the mean chart showed a four-wave pattern at mid to high latitudes with troughs located in the southeast Pacific, south Atlantic and east Indian Oceans. A pronounced southwest to northeast tilting trough was situated just to the east of New Zealand.

The anomaly pattern (Fig. 4) was dominated by a broad region of negative anomalies stretching east-northeast from the south Indian Ocean across New Zealand to the subtropical Pacific Ocean near the west coast of South America. Higher than normal surface pressure occurred to the north of this area in the Indonesian and Australian regions. This pattern of positive and negative MSLP anomalies has many similarities with the composites of the mature phase of previous warm ENSO events produced by van Loon and Shea (1987).

Another marked feature of the anomaly pattern was the strong positive centre over the southeast Pacific. This is indicative of strong blocking in that region and has been a feature of previous ENSO episodes.

Upper air analysis

The 500 hPa mean spring analysis and anomalies are shown in Figs 5 and 6 respectively. The pattern observed was an asymmetrical four-wave pattern with strong troughs anchored over the east Indian and west Pacific Ocean regions. Weaker troughs can be noted over the eastern Pacific and south Atlantic. The flow is markedly diffluent over the Pacific sector in contrast to the strong zonal regime evident between the south Atlantic Ocean and Australia.

Fig. 3 Spring 1991 (September, October, November) mean sea level pressure (hPa).

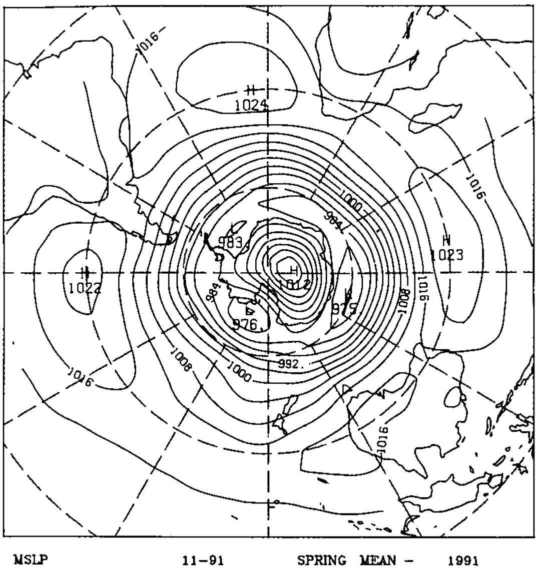
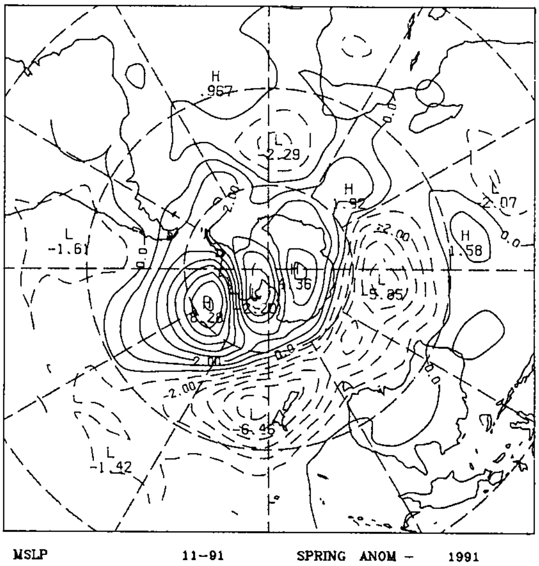


Fig. 4 Spring 1991 (September, October, November) mean sea level pressure anomaly (hPa).



Blocking

The spring season was characterised by a succession of blocking episodes over the central Pacific Ocean, where the degree of blocking activity was

Fig. 5 Spring 1991 (September, October, November) 500 hPa mean geopotential height (dam).

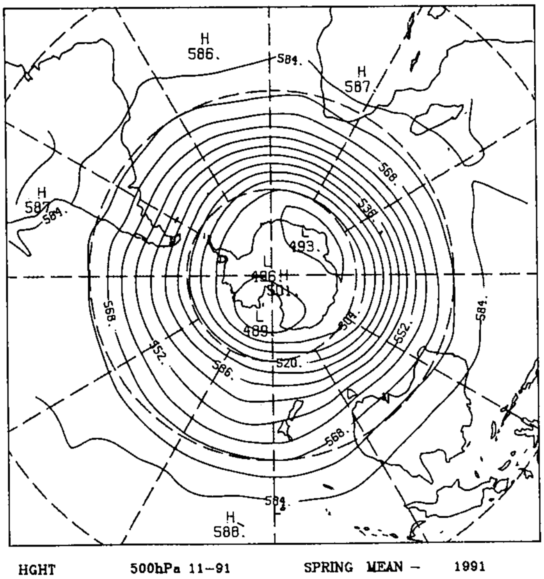


Fig. 6 Spring 1991 (September, October, November) 500 hPa mean geopotential height anomaly (dam).

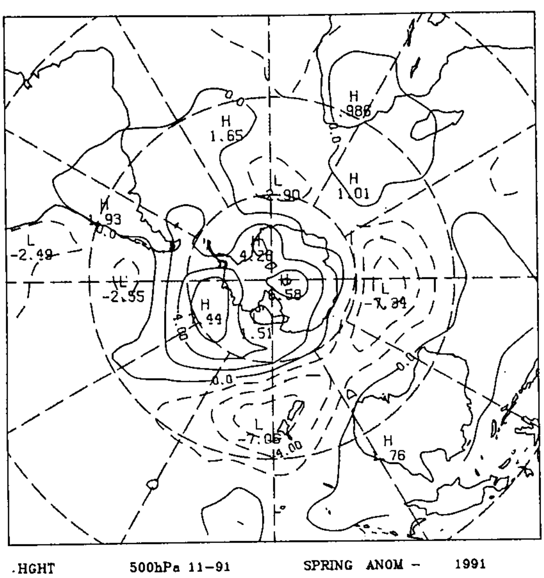


Fig. 7 Spring 1991 (September, October, November) 300 hPa mean geopotential height (dam).

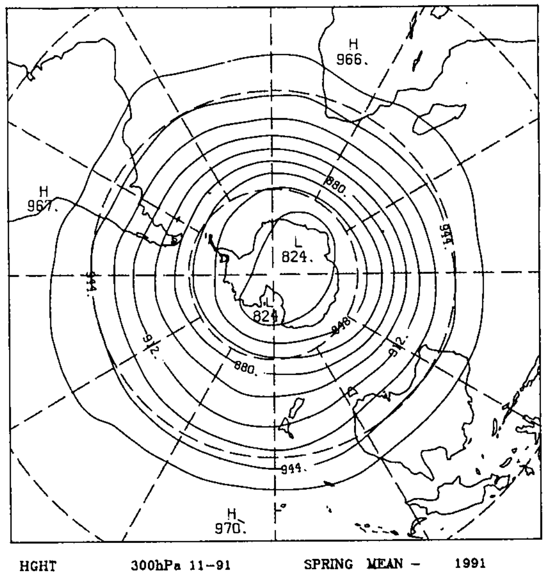
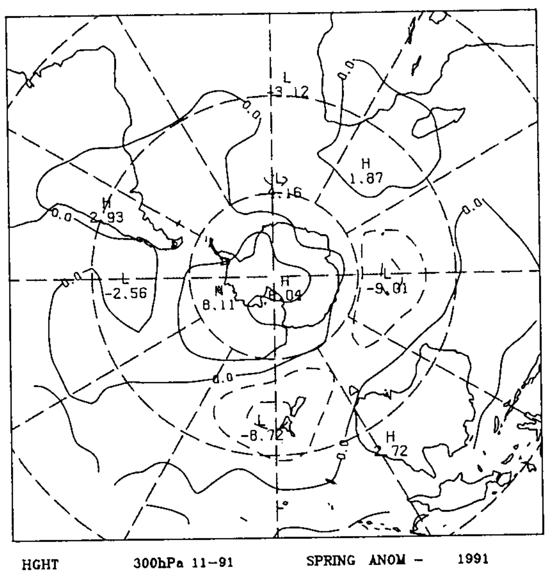


Fig. 8 Spring 1991 (September, October, November) 300 hPa mean geopotential height anomaly (dam).



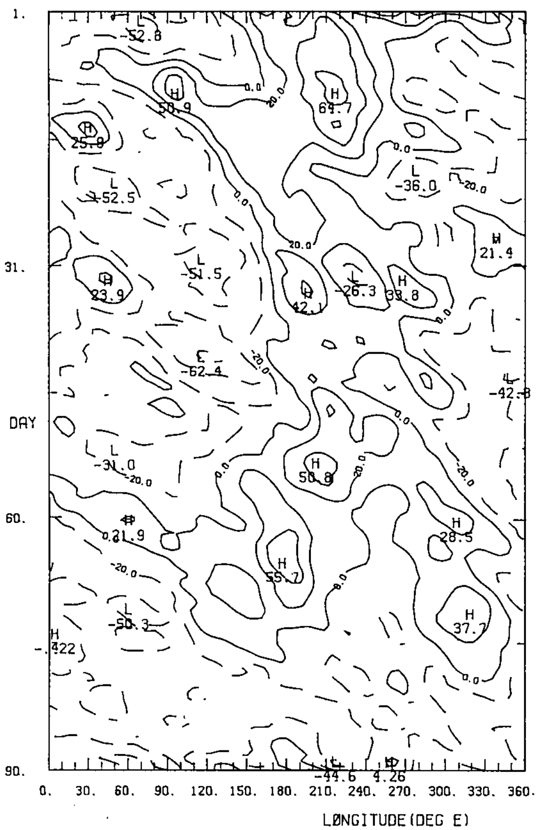
well above normal. Figure 9 shows a time-longitude cross-section of the blocking index* for the season.

Other notable periods of blocking occurred over the southwest Atlantic between late October and early November, and briefly over the Indian Ocean in early September. This latter event was the only significant block to affect the Indian Ocean sector for the season.

Systems were very progressive in the second half of November as no blocks occurred at all during this period.

*Blocking Index (BI) = $U_{27.5} + U_{57.5} - (U_{42.5} + U_{47.5})$ where U is the westerly wind component at 500 hPa. The subscripts refer to the latitude.

Fig. 9 Spring 1991 (September, October, November) daily Blocking Index: time-longitude section. Day 1 is 1 September.



Winds

Lower tropospheric (850 hPa) wind vector anomalies are shown in Fig. 10, and show strong correlation with the MSLP anomalies (Fig. 4).

Anomalous polar easterlies are prominent over the Pacific Ocean and to the southwest of Australia. These were associated with a cyclonic circulation near 40°S170°W and an anticyclonic circulation near 60°S120°W. An anomalous cyclonic centre is also evident over the southeastern Indian Ocean.

Figure 11 shows the wind anomalies in the upper troposphere (300 hPa) which can be related to the 300 hPa geopotential height anomalies (Fig. 8). The main features of the upper tropospheric wind anomalies were:

(a) cyclonic circulations near New Zealand and over the south Indian Ocean associated with negative geopotential height anomalies;
(b) an anticyclonic centre over the western tropical Pacific; and
(c) marked easterly anomalies over the south Pacific.

Fig. 10 Spring 1991 (September, October, November) 850 hPa wind anomalies (m s^{-1}). (The figures near the H and L are vector values at respective locations.)

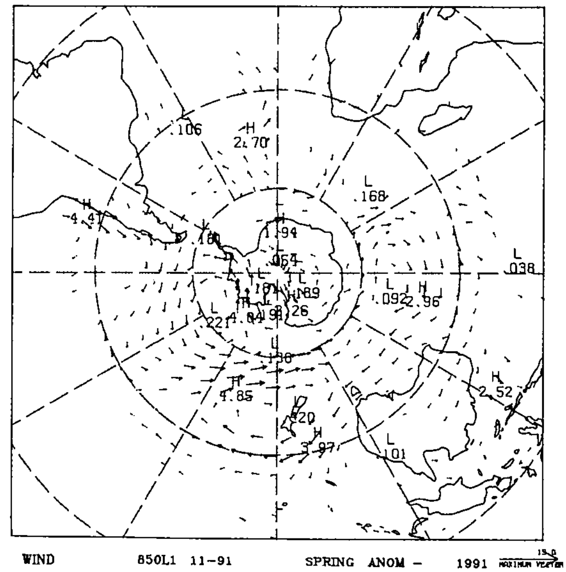
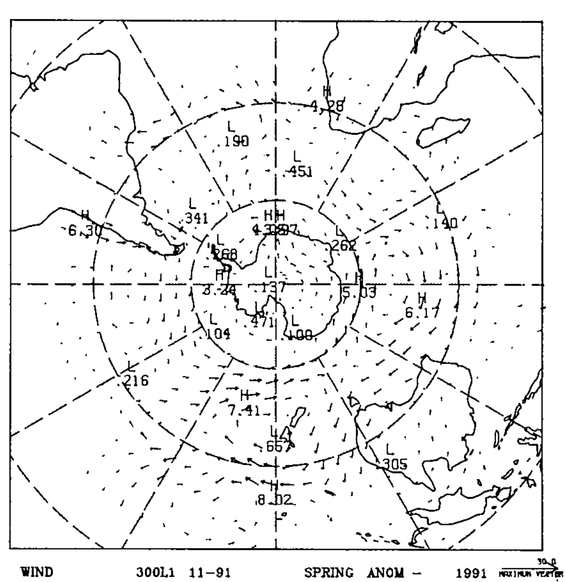


Fig. 11 Spring 1991 (September, October, November) 300 hPa wind anomalies (m s^{-1}). (The figures near the H and L are vector values at respective locations.)



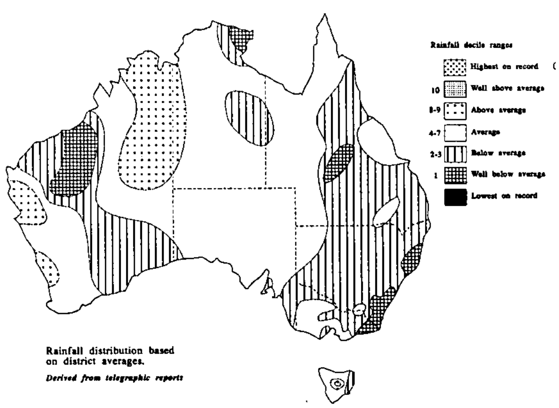
Australian region

Circulation and rainfall

Surface pressures were slightly below normal over the southern half of the continent, reflecting the enhanced polar trough (Fig. 4). Rapidly moving frontal systems were a regular feature over southern Australia during spring but seldom produced heavy rainfall. The more significant rain events occurred when there was interaction between a cold front and tropical moisture associated with continental heat lows.

Most of the continent received average to below average rainfall for the season (Fig. 12). In particular, rainfall was suppressed over most of eastern Australia in keeping with the maturing ENSO event. Higher rainfall over parts of Western Australia (W.A.) was mostly associated with the development of low pressure systems during November.

Fig. 12 Spring 1991 (September, October, November) rainfall in Australia: decile range values based on district averages.



Temperatures

Maximum temperatures for spring were above average over most of the continent (Fig. 13(a)). The largest departures from normal of + 2°C to + 3°C occurred over the central interior and parts of eastern Queensland. The only regions which experienced negative anomalies were over the west coast of W.A. and western Tasmania.

A similar pattern was evident in the spring minimum temperature anomalies (Fig. 13(b)), although the areal extent of the positive departures was not as great. In addition to the western parts of W.A. and Tasmania, negative anomalies also prevailed over the southeast of the continent.

Fig. 13(a) Spring 1991 (September, October, November) maximum temperature anomalies (°C).

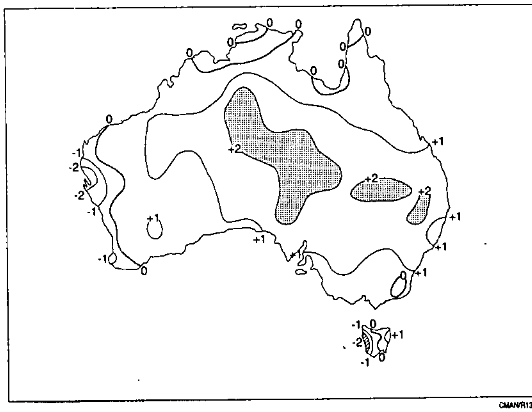
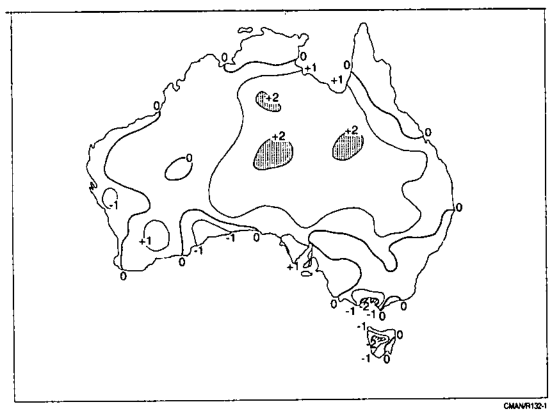


Fig. 13(b) Spring 1991 (September, October, November) minimum temperature anomalies (°C).



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Rasmusson, E.M. and Wallace, J.M. 1983. Meteorological Aspects of the El Niño/Southern Oscillation. *Science*, *222*, 1195–202.

Wyrtki, K. 1982. El-Niño — The dynamic response of the equatorial Pacific Ocean to atmospheric forcing. *J. Phys. Oceanogr.*, *5*, 572–84.

Appendix

Data sources used for this review were:

Climate Analysis Center — Climate Diagnostics Bulletin.*

National Climate Centre — Climate Monitoring Bulletin — Southern Hemisphere.†

Obtainable from:

*Climate Analysis Center (CAC), National Weather Service, Washington D.C. 20233, USA.

†National Climate Centre, Bureau of Meteorology, GPO Box 1289K, Melbourne, Vic 3001, Australia.