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Seasonal climate summary southern hemisphere (autumn 1991): early indications of the formation of El Niño-type conditions

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A climate analysis is given of the southern hemisphere autumn circulation, March to May 1991, with greater attention to the Australian region.
The standard climate indices gave early indications of the formation of El Niño-type conditions. The most significant indicators were the substantial negative Southern Oscillation Index and the gradual warming in the central and eastern equatorial Pacific. A blocking dipole in the South Pacific was another El Niño signature. In the Australian region, record low autumn rainfalls in some eastern areas could be linked to incipient El Niño conditions.

Introduction

This seasonal summary reviews the southern hemisphere climate for autumn 1991 (March to May inclusive) with more detail given to the Australian region.

The main information sources were the routine monitoring bulletins issued by the Bureau of Meteorology, Australia, and reference was also made to climate bulletins issued by other national meteorological services. Data sources are specified in the Appendix.

Climate indices

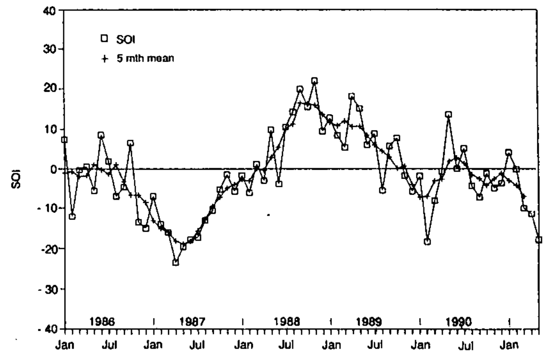
During the transition from summer (Gaffney 1991) to autumn, the tropical climate indices showed signs of gradual change towards El Niño-type values.

The Southern Oscillation Index (SOI)* fell from −10.1 in March to −17.9 in May as depicted in Fig. 1. However these falls seemed to be related more to extratropical controls (Pacific dipole) than to positive sea-surface temperature (SST) anomalies in the tropical Pacific.

In May, 850 hPa westerly wind anomalies in the three standard index regions of the equatorial Pacific were indicative of the formation of El Niño-type conditions.

Consistent with the 850 hPa westerly anomalies, 200 hPa easterly wind anomalies became established across the equatorial Pacific in May.

Fig. 1 Southern Oscillation Index, January 1986 to May 1991 inclusive.



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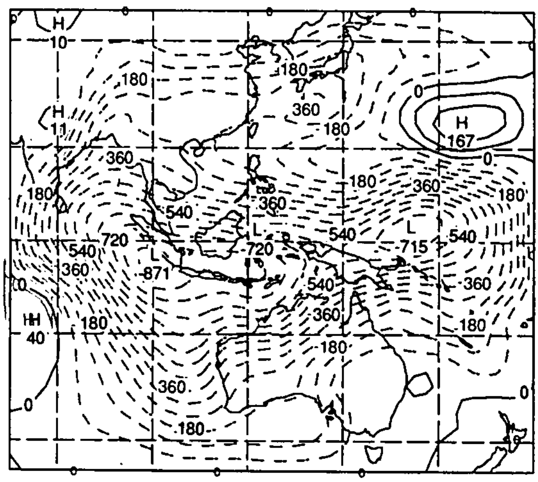
*The Southern Oscillation Index (SOI) used here is 10 times the Tahiti minus Darwin MSL pressure anomaly divided by the standard deviation for the month, based on the period 1882 to 1985.

The SST indices became positive by the month of May in all three of the standard monitoring areas of the equatorial Pacific with the strongest warming in the east.

The 200 hPa velocity potential for April in the Australian-Asian region, typical of the pattern for this autumn, is given in Fig. 2. A centre of upper level divergence was located near Sumatra with an axis extending eastwards to another centre located northeast of New Guinea. The relatively high values of velocity potential in eastern Australia, indicating upper level convergence and tropospheric subsidence, could be linked to record low seasonal rainfall in parts of that region (see Fig. 13).

Fig. 2 Velocity potential (200 hPa) for April 1991 ($m^2\ s^{-1}\ 10^{-6}$).



Sea-surface temperatures

In the tropics, SST anomalies were slightly positive, the only exception being an area of negative anomaly in the Atlantic as depicted in Fig. 3. Positive SST anomalies continued to extend eastwards across the central tropical Pacific from summer into autumn.

At mid-latitudes, SST anomalies remained generally positive from summer through autumn (Fig. 3).

Surface analysis

The mean sea level pressure analysis is shown in Fig. 4 with corresponding anomalies in Fig. 5.

The main features of the anomalies (Fig. 5) were:

(a) the continuing intense high pressure centre at mid to high latitudes in the South Pacific;
(b) the low pressure band at 30°S across the Pacific; and
(c) the deep, low pressure centre over western Antarctica.

Upper air analysis

The 500 hPa analysis and anomalies in Figs 6 and 7 showed a four-wave pattern with troughs in the central and eastern Pacific, eastern Atlantic and the eastern Indian Ocean.

Notable aspects of the anomalies (Fig. 7) were:

(a) the strong dipole pattern in the Pacific indicative of El Niño-type conditions (see, for example, Karoly 1989); and
(b) the positive anomalies south of Western Australia and in the Atlantic.

Fig. 3 Autumn 1991 (March, April, May) sea-surface temperature anomaly (°C).

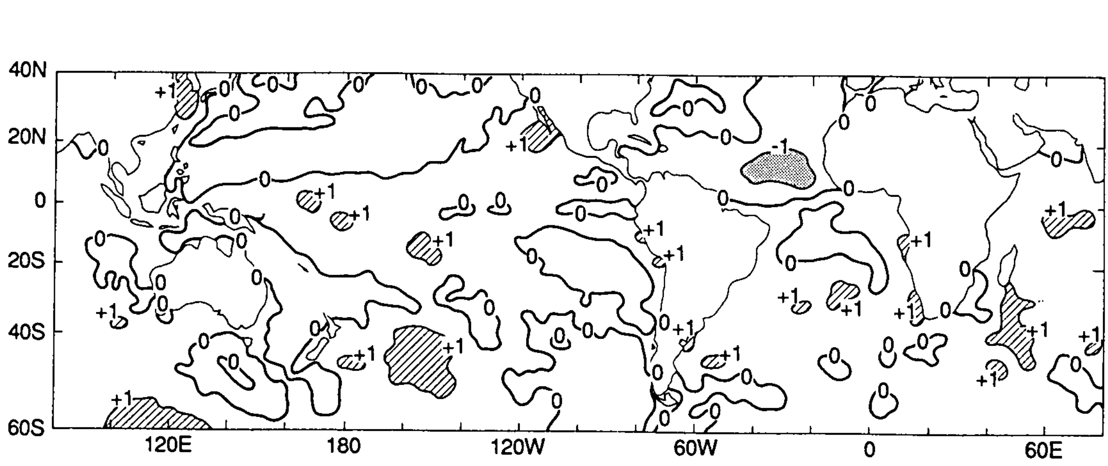


Fig. 4 Autumn 1991 (March, April, May) mean sea level pressure (hPa).

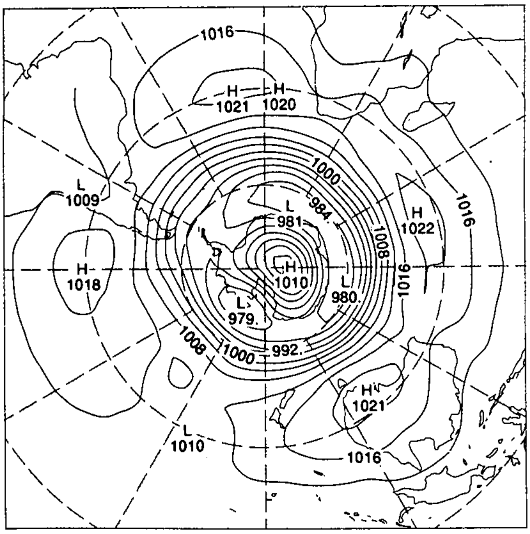


Fig. 6 Autumn 1991 (March, April, May) 500 hPa mean height (dam).

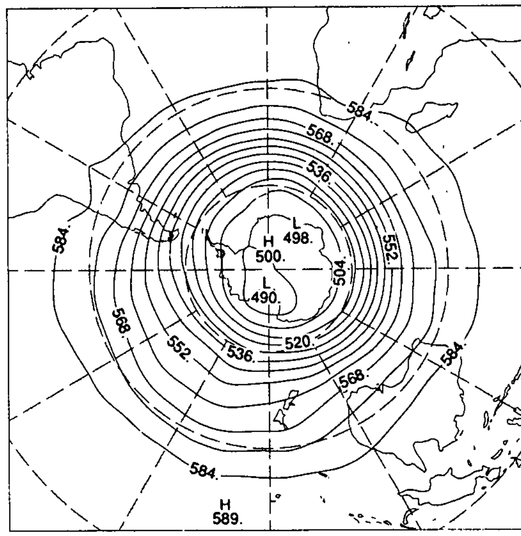


Fig. 5 Autumn 1991 (March, April, May) mean sea level pressure anomaly (hPa).

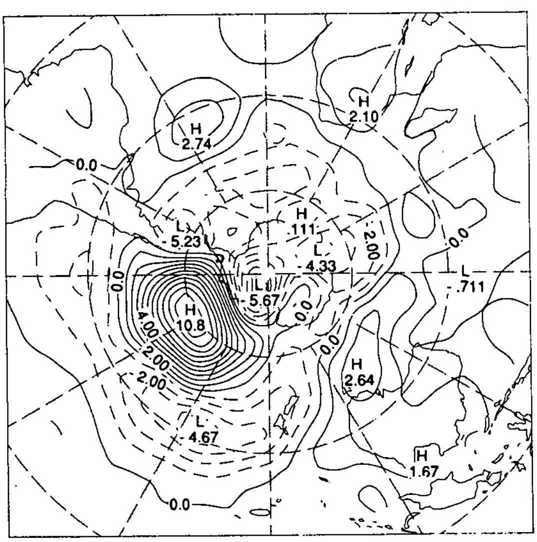
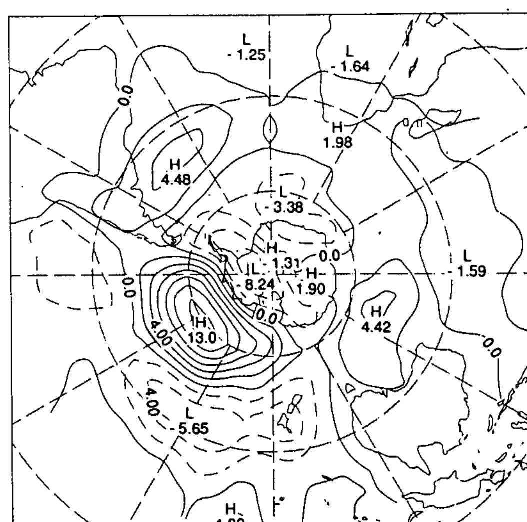


Fig. 7 Autumn 1991 (March, April, May) 500 hPa height anomaly (dam).



At 300 hPa, the four-wave pattern could be distinguished as indicated in Figs 8 and 9. The dipole pattern dominated the Pacific (Fig. 9), as at the 500 hPa level (Fig. 7).

Blocking

Blocking* dipole activity was prominent in the Pacific throughout autumn as can be seen from Fig. 10. Elsewhere around the hemisphere there were only very brief periods of blocking during the season. The mean blocking index graphs (not shown) indicated that blocking was significantly above average in the Pacific during most of autumn, and this was consistent with the dipole pattern (Fig. 7). Elsewhere the wind flow was generally zonal during the season.

*Blocking Index (BI):

$$BI = U_{27.5} + U_{57.5} - (U_{42.5} + U_{47.5})$$

where U is the 500 hPa mean zonal wind and the subscript is the corresponding latitude.

Fig. 8 Autumn 1991 (March, April, May) 300 hPa mean height (dam).

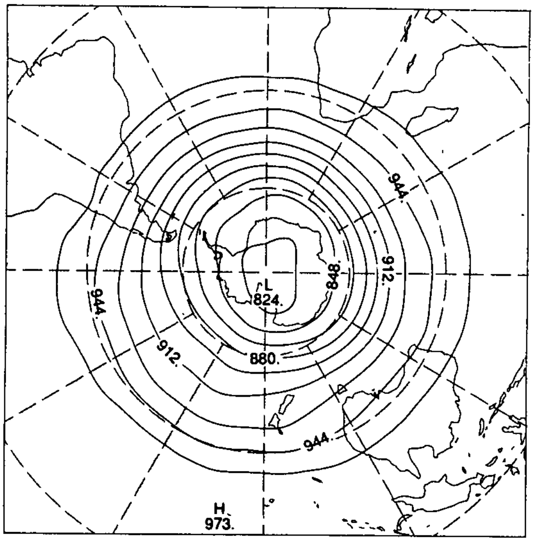


Fig. 9 Autumn 1991 (March, April, May) 300 hPa height anomaly (dam).

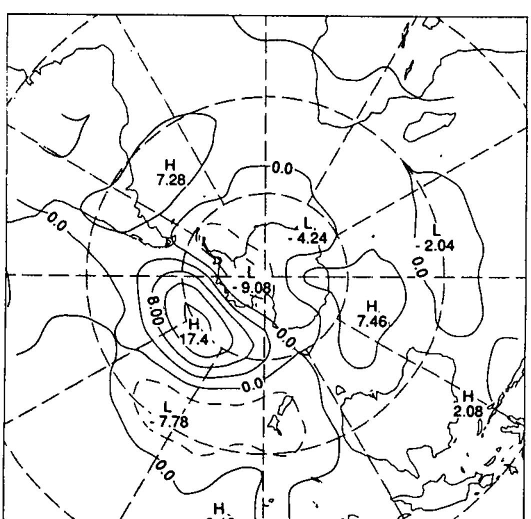
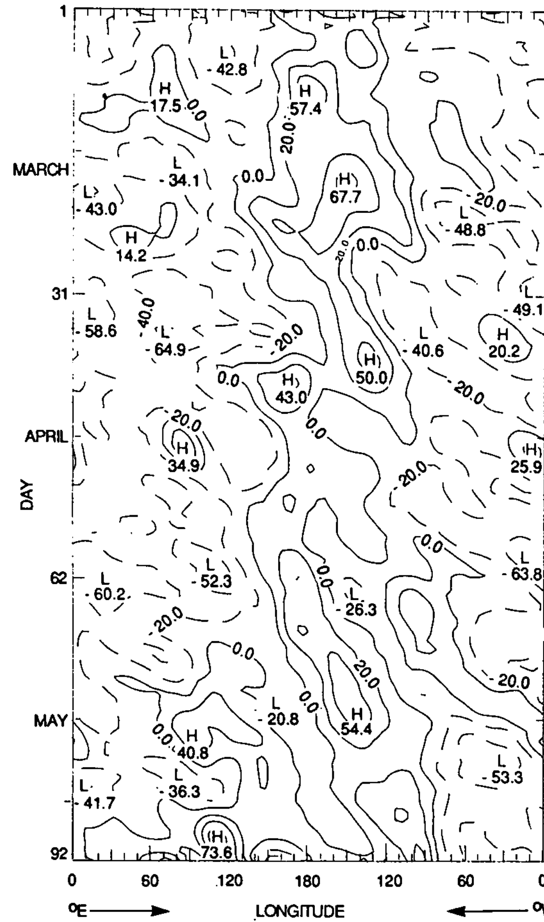


Fig. 10 Autumn 1991 (March, April, May) daily Blocking Index: time-longitude section. Day 1 is 1 March.



Winds

Wind anomalies at 850 hPa in Fig. 11 may be related to the surface pressure anomalies in Fig. 5. As in the preceding summer, there were strong wind anomalies associated with the dipole in the South Pacific. Wind anomalies in the Indian Ocean were generally weak at this level and also relatively weak in the Atlantic.

The upper tropospheric (300 hPa) wind anomalies shown in Fig. 12 relate to the corresponding height anomalies in Fig. 9. Outstanding features of the upper level wind anomalies were:

(a) the strong anomalies associated with the Pacific dipole; and

(b) the strong subtropical jet across the western and central Pacific (El Niño signature).

Australian region

Circulation

A velocity potential ridge extended from the east coast across eastern Australia (Fig. 2), and the subtropical surface ridge was also prominent in that region (Fig. 5). This pattern induced a strong suppression of rainfall over most of eastern Australia.

Rainfall

Autumn rainfall was the lowest on record in parts of eastern Australia and extensive areas registered very much below average rainfall (in decile range one) as seen in Fig. 13. Rainfall in most central and western parts of Australia was also below average. This abnormally low rainfall across the continent resulted from the circulation described above.

Fig. 11 Autumn 1991 (March, April, May) 850 hPa wind anomalies (m s^{-1}). (The figures near the H and L are vector values at respective locations.)

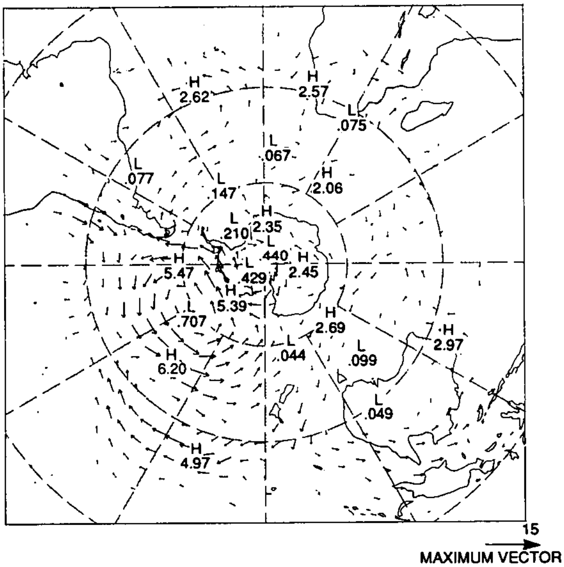


Fig. 12 Autumn 1991 (March, April, May) 300 hPa wind anomalies (m s^{-1}). (The figures near the H and L are vector values at respective locations.)

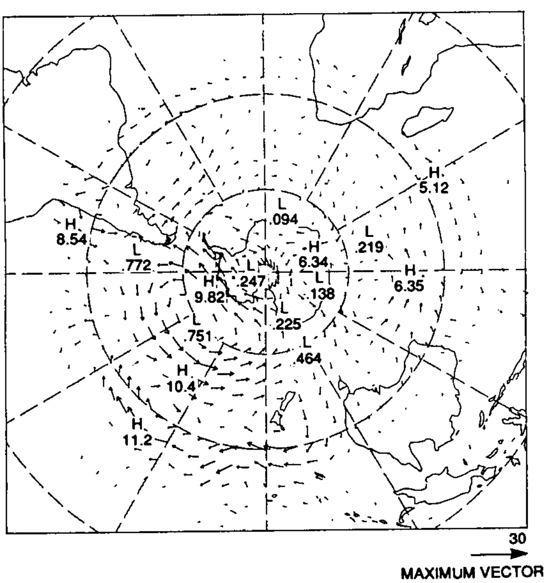


Fig. 13 Autumn 1991 (March, April, May) rainfall in Australia: decile range values based on district averages.

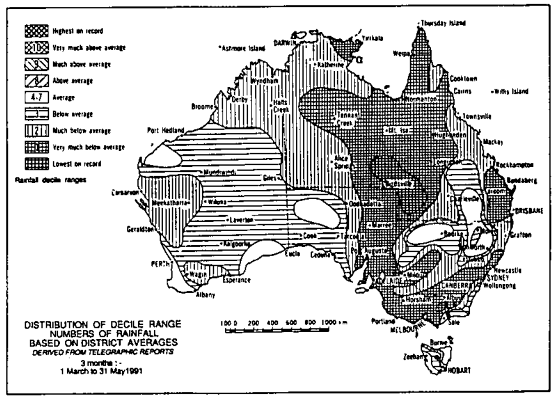
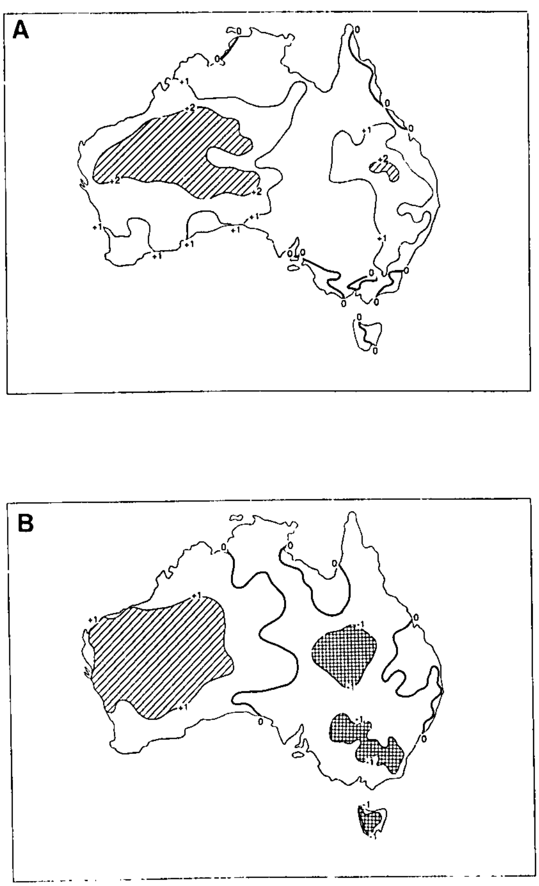


Fig. 14 Autumn 1991 (March, April, May) temperature anomalies (°C) Australia: (a) maximum; (b) minimum.



Temperatures

In autumn, maximum temperatures were generally above average in Australia as seen in Fig. 14(a). This pattern could be attributed to the increased insolation resulting from the markedly below average rainfall and cloudiness.

Minimum temperatures were below average in the eastern parts of the continent, where outgoing long wave radiation was above average at night. In the western part, chiefly above average minimum temperatures could be related to reduction in outgoing long wave radiation by clouds associated with inland heat troughs.

References

Gaffney, D. 1991. Seasonal climate summary southern hemisphere (summer 1990–91): a strong Australian monsoon with record rainfall. *Aust. Met. Mag.*, *39*, 267–72.

Karoly, D.J. 1989. Southern hemisphere circulation features associated with El Niño–Southern Oscillation events. *Jnl climate*, *2*, 1239–52.

Appendix

Data sources used for this review were:

Climate Analysis Center — Climate Diagnostics Bulletin.*

Darwin Tropical Diagnostic Statement.†

Monthly report on Climate System.§

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

Southern hemisphere grid-point analysis data archived by the World Meteorological Centre, Melbourne.‡

Obtainable from:

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

†Northern Territory Regional Office, Bureau of Meteorology, PO Box 735, Darwin 0801, Australia.

§Japan Meteorological Agency, 1-3-4, Ote-machi chiyoda-ku, Tokyo, Japan.

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