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Seasonal climate summary southern hemisphere (spring 1993): conditions across the tropical Pacific tend towards normal

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Southern hemisphere circulation patterns and anomalies for spring (September–November) 1993 are reviewed, with emphasis given to Pacific Basin climate indicators, and Australian rainfall and temperature patterns. A rising trend in the Southern Oscillation Index was accompanied by a decrease in the anomalies of other Pacific Basin indicators. Rainfall was above average across a large part of eastern and central Australia, but temperatures over the continent were near normal.

Introduction

The declining phase of El Niño noted in winter 1993 (Nydam 1994) continued through spring with several indicators trending back towards average. This summary reviews the southern hemisphere and equatorial climate patterns of spring 1993, with particular attention given to the Australasian/Pacific region.

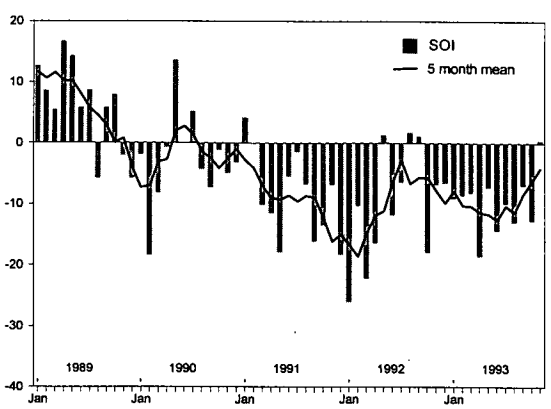
The main sources of information were the *Climate Monitoring Bulletin* (Bureau of Meteorology, Australia), and the *Climate Diagnostics Bulletin* (Climate Analysis Center (CAC), Washington). Data sources are given in the Appendix.

Pacific Basin climate indices

The Southern Oscillation Index (SOI)*

The values of the index for the individual months from September to November were −7.0, −12.8 and +0.4 respectively; the November reading being the first positive value, albeit small, for 1993. The monthly mean sea-level pressure (MSLP) anomaly at Darwin tended towards zero from prior positive values, whilst the anomaly at Tahiti was near zero for the season apart from a −0.9 hPa reading in October. A sustained positive trend in the five-month moving average since August 1993 is clearly evident in Fig. 1.

Fig. 1 Southern Oscillation Index, January 1989 to November 1993 Inclusive.



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*The SOI used here is ten times the monthly anomaly of the difference in mean sea-level pressure between Tahiti and Darwin, divided by the standard deviation of that difference for the relevant month, based on the period 1876–1993.

Atmospheric indices

Low-level equatorial and near-equatorial easterlies were at near-normal strength in the central and western Pacific but weaker in the east, particular south of the equator. These features were generally present each month.

Figure 2, adapted from CAC (1993), displays a time-longitude Hovmoeller plot of anomalous outgoing long wave radiation (OLR) over the near-equatorial Pacific and Australasian regions between September 1992 and November 1993. Negative anomalies, indicative of increased cloudiness and rainfall, were evident just west of the date-line in September 1993, but the situation reverted to near normal by the end of November.

Oceanic indices

Sea-surface temperatures (SSTs). Apart from a strip of negative anomalies along the equator east of 160°W, the tropical Pacific was dominated by positive anomalies (Fig. 3). The most anomalously warm area was near the date-line where departures approached +2°C. Another feature, which had been present for all of 1993, was the band of negative anomalies stretching to the southeast of New Guinea across the Coral Sea to the north of New Zealand. Across the tropical Pacific there was a tendency for anomalies of both signs to decrease in magnitude during the spring season.

Fig. 2 Time-longitude section of monthly outgoing long wave radiation anomalies for 5°N–5°S, September 1992 to November 1993. Contour interval is 10Wm^{-2} Shading indicates negative anomalies (i.e. enhanced convection and rainfall). Anomalies are based on a 1979–88 base period mean. After CAC (1993).

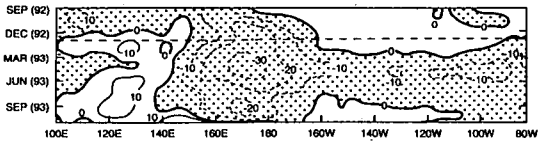


Fig. 3 Spring 1993 sea-surface temperature anomaly (°C).

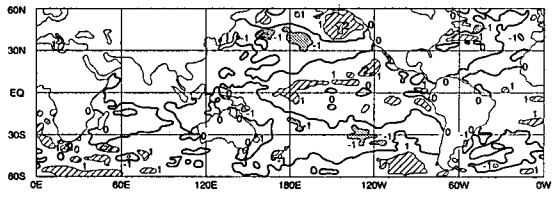
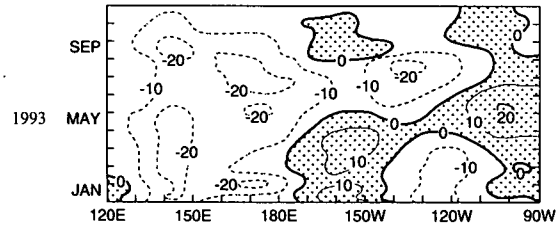


Fig. 4 Time-longitude section of monthly anomalous depth of 20°C isotherm at the equator from January to November 1993. Contour interval is 10m.



Subsurface patterns. Figure 4 shows the anomaly of the depth of the 20°C isotherm along the equatorial Pacific between January and November 1993. This isotherm is generally situated very close to the equatorial ocean thermocline, the region of greatest temperature gradient with depth, or the boundary between the upper ocean warm water and the deep ocean cold water. During spring the equatorial Pacific Ocean showed a mostly shallower than normal thermocline in the west (negative anomalies in the depth of the 20°C isotherm), and a slightly deeper than average thermocline in the east. As with the SSTs, there was a movement towards normal during the season, but most particularly in the west where there was a decrease in the strength of the negative anomaly. The anomalies present at the end of November were certainly less pronounced than those evident around the middle of the year.

Surface analyses

Figures 5 and 6 show the mean and anomalous spring 1993 MSLP patterns respectively. Anomalies are deviations from an eleven-year (1979–1989) global climatology from the European Centre for Medium Range Weather Forecasts (ECMWF), Bracknell, England. A wave-3 pattern was evident on the individual monthly analyses (not shown) as well as the seasonal mean. Long wave troughs at middle to high latitudes were located over the central Pacific and Atlantic, and east Indian Oceans. The trough over the Pacific was quite broad with two peaks, one near New Zealand and the other near 130°W. The circumpolar vortex was considerably stronger than nor-

Fig. 5 Spring 1993 (September, October, November) mean sea-level pressure (hPa).

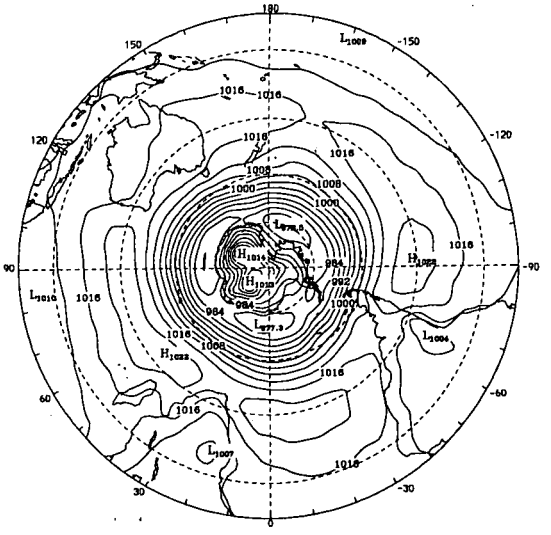


Fig. 6 Spring 1993 (September, October, November) mean sea-level pressure anomaly (hPa).

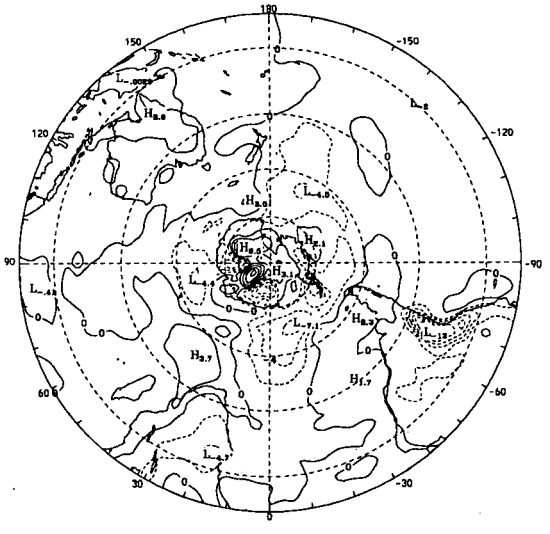


Fig. 7 Spring 1993 (September, October, November) 500hPa mean geopotential height (m).

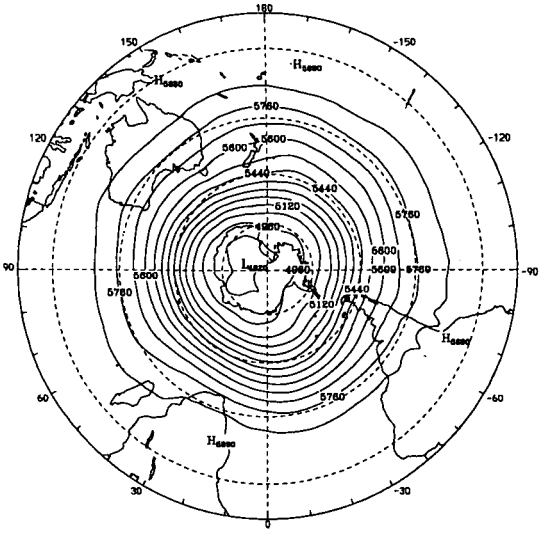
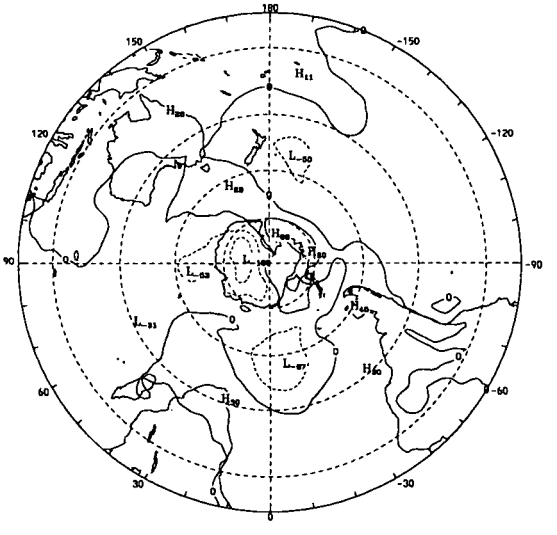


Fig. 8 Spring 1993 (September, October, November) 500hPa mean geopotential height anomaly (m).

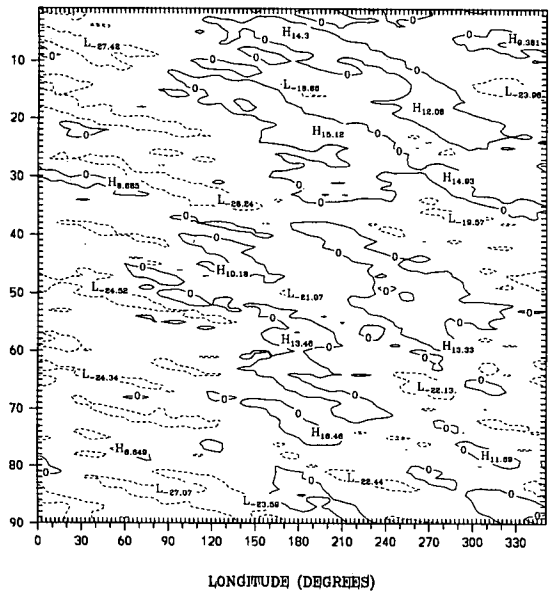


mal, as indicated by the belt of negative anomalies south of 50°S, a feature evident since March 1993 (CAC 1993). Higher than usual MSLP was a feature of the Australian region, although the magnitudes of the anomalies were generally less than 2 hPa. Persistently higher than normal pressure to the southeast of Africa, with anomalously low pressure anchored to the northeast over that continent, was evident throughout the season.

Upper level analyses

Figures 7 and 8 show the mean and anomalous spring 1993 500 hPa patterns respectively. These show a similar wave-3 pattern to the MSLP, with the same double-peak nature to the Pacific trough. A difference from the MSLP analyses is that negative anomalies extended from the Indian Ocean across most of southern Australia, almost linking with negative anomalies in the Tasman Sea/New Zealand region.

Fig. 9 Spring 1993 (September, October, November) daily Blocking Index: time-longitude section. Day 1 is 1 Sept.



Blocking

Figure 9 is a time-longitude section of the daily southern hemisphere Blocking Index (BI)(Wright 1993), measuring the strength of the 500 hPa flow at mid-latitudes relative to that at subtropical and high latitudes. The focus of blocking (positive index values) during the season was located over the west/central Pacific Ocean (150°–240° in Fig. 9). A departure from this pattern occurred around the middle of October when blocking activity became centred over the eastern sides of the Indian and Pacific Basins. Zonal flow (negative index values) predominated over the Atlantic and Indian Ocean sectors.

Winds

Low level (850 hPa) and upper level (200 hPa) wind anomalies are shown in Figs 10 and 11 respectively. At low levels the significant features were (a) enhanced polar easterlies south of 60°S over most of the hemisphere; (b) westerly anomalies over the eastern equatorial Pacific; (c) anomalous cyclonic circulations over the central Indian Ocean and to the east of New Zealand related to the enhanced troughing noted to the east of New Zealand in Fig. 6; and (d) northerly or northwesterly anomalies over the northern two-thirds of mainland Australia.

At upper levels an enhanced subtropical jet stream is evident over the eastern Indian Ocean and also over Australia, whilst a cyclonic circulation anomaly was apparent over the Great Australian Bight.

Fig. 10 Spring 1993 (September, October, November) 850 hPa vector wind anomalies (ms^{-1}).

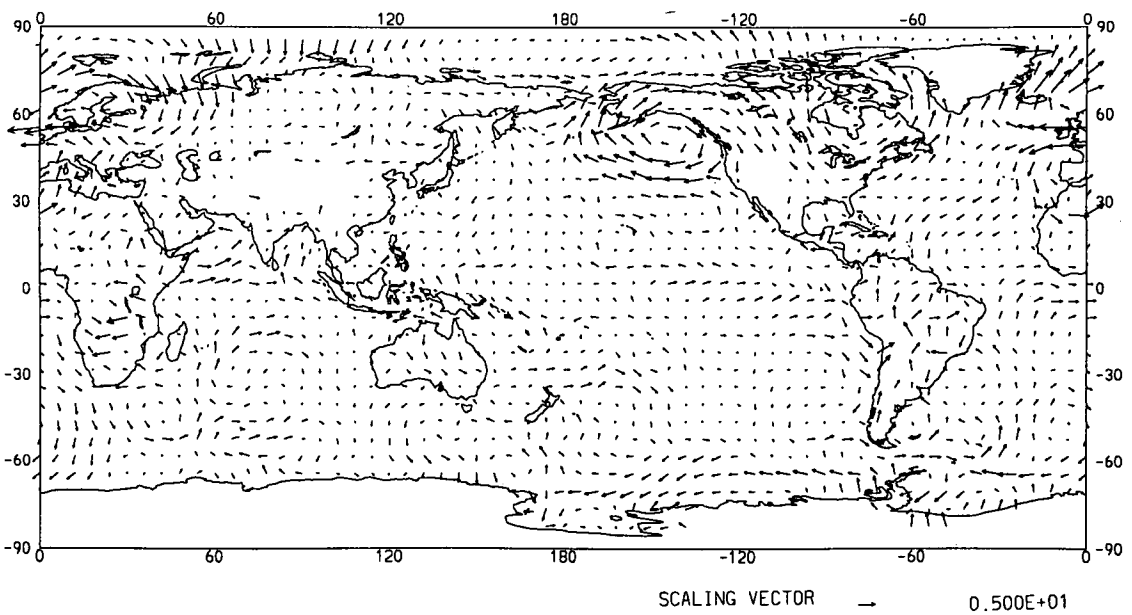
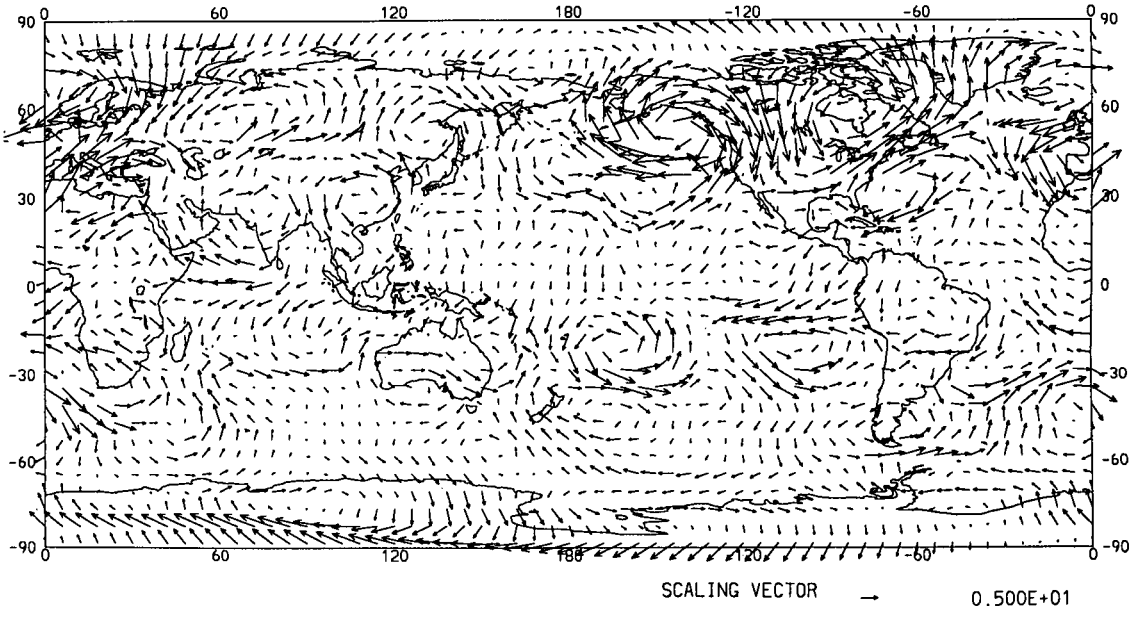


Fig. 11 Spring 1993 (September, October, November) 200 hPa vector wind anomalies (ms^{-1}).



Australian region

Circulation and rainfall

The upper level cut-off and low-level northerly anomalies mentioned in the previous section provided favourable conditions for tropical moisture incursions and interactions to develop over Australia. During September and October most of the rainfall from such systems fell in eastern and southern Australia. One particularly noteworthy cloudband affected central and southeastern Australia in the first week of October; torrential rain fell over Victoria and southern New South Wales with mountainous regions registering over 200 mm in as little as four hours. Disastrous flooding resulted, particularly in Victoria where river catchments were already saturated. Further interactions between tropical moisture and cyclonic developments over the continent occurred in November, but this time the focus was over southern Western Australia and north-central Australia. Sporadic thunderstorms produced some heavy falls over Queensland. The overall distribution of seasonal precipitation for spring is shown in Fig. 12. Most of the country recorded average to above average totals, particularly in the southeast, with only isolated areas recording accumulations below the spring average.

Temperatures

Mean maximum and minimum temperatures for spring 1993 are shown in Figs 13 and 14 respectively. Maximum temperatures were a little below normal over most of the continent. Part of western Western Australia recorded departures of −1 to −2°C, probably as a result of increased cloud in relation to the stronger than normal subtropical jet. An area of north-central Victoria and southern New South Wales registered similar anomalies of maximum temperature.

With the exception of western Western Australia, minimum temperatures tended to be a little above normal for spring. A large part of Queensland, together with the eastern Northern Territory, registered minima 1 to 2°C above normal.

Pacific Islands area

Rainfall patterns in September and October resembled those of a warm Pacific episode with above average rains over the area from the equator to 10°S, east of 160°E. Some anomalies reached 200–400 per cent and more. However it was very dry in a belt extending from Papua-New Guinea southeast through Vanuatu, New Caledonia and Fiji-Tonga. The rainfall pattern reflected an eastward shift of the South Pacific convergence zone (SPCZ), a characteristic of warm Pacific episodes and a feature for much of the last two years. In keeping with the below average SSTs in the southwest Pacific, record coolness

Fig. 12 Spring 1993 (September, October, November) rainfall in Australia: decile range values based on district averages and selected stations.

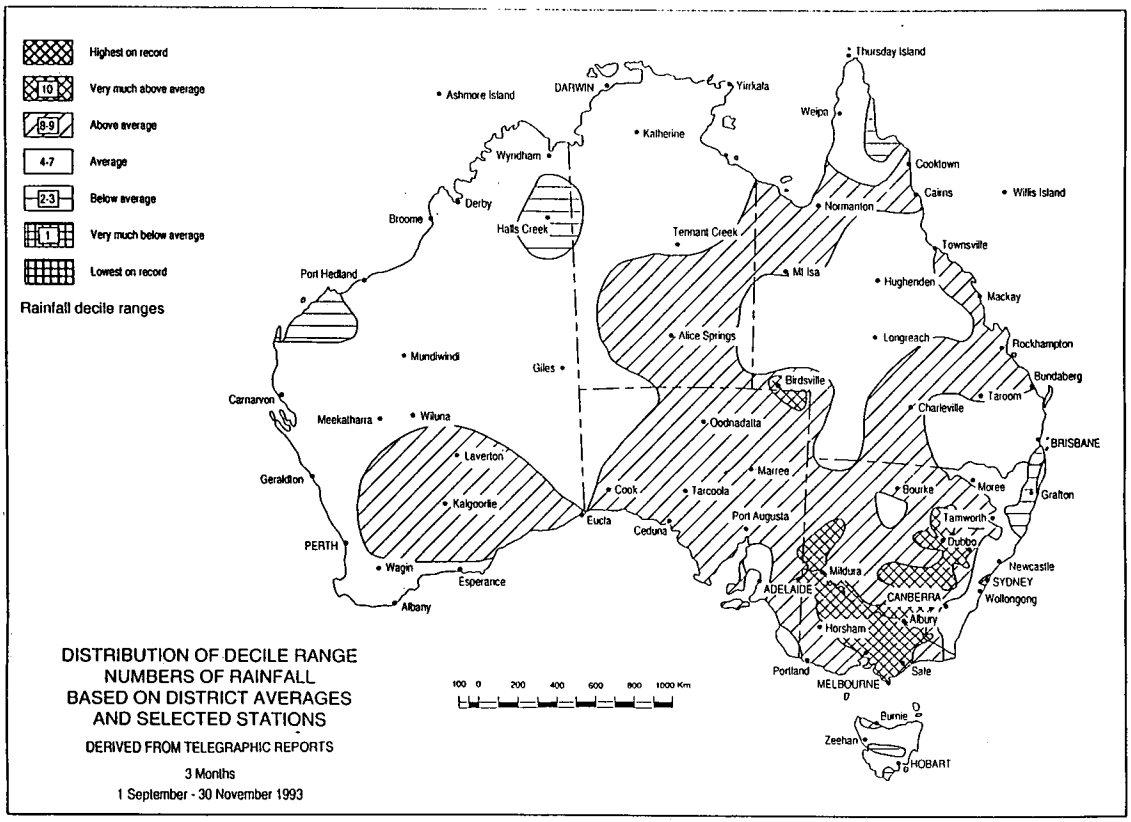


Fig. 13 Spring 1993 (September, October, November) maximum temperature anomalies (°C) for Australia.

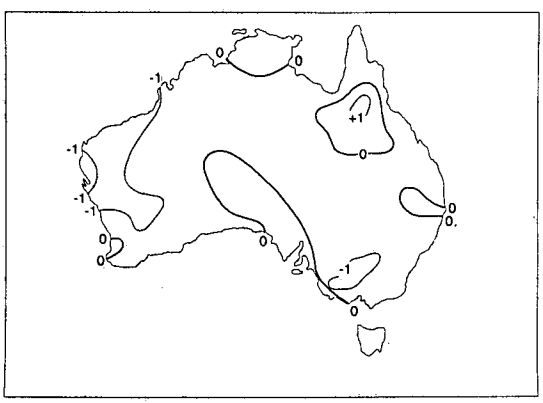
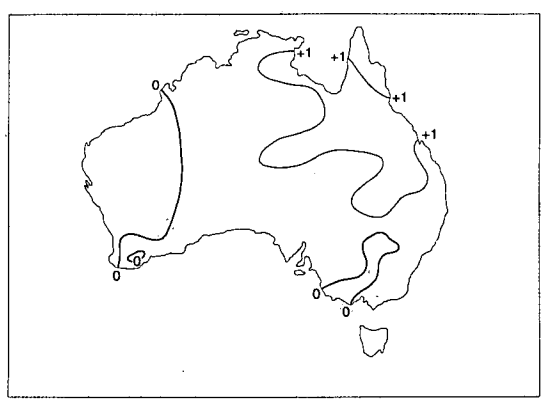


Fig. 14 Spring 1993 (September, October, November) minimum temperature anomalies (°C) for Australia.



was reported in Fiji through the period September-October. In November, the heavy rains around the date-line disappeared, though the SPCZ remained displaced to the east, with heavy rains (200–500 mm; 200–300 per cent of normal) over the northern Cook and Marquesas Islands. It was very dry again over the southwest Pacific and Papua-New Guinea. New Zealand was mostly cold and wet in September (associated with anomalous southerly flow), and generally very dry in October (dominant ridging). November was cool and dry in the west, but wet in the east, associated with pronounced troughing east of the country and anomalous southeasterly flow.

Southern Africa

Most areas had a warmer than normal spring, particularly in September and October. Following predominantly dry weather early in the season, heavy rains developed in late September or early October over large portions of southern Africa (up to 500 per cent of normal). October was then mostly dry (especially over Zimbabwe, Zambia and far southern Africa), though a rain event in the second half of the month brought good falls in the western half and southeastward through western Botswana and northern South Africa. Further heavy rains fell in many areas in the second half of November.

South America

The trend of well above normal temperatures in Peru and Ecuador continued, but while September was dry in this region, heavy rains fell in northern and central Peru during October and November. Conditions were also warm in far southern Chile and Argentina, particularly during the first half of spring. Elsewhere, September and November were unseasonably cool months, due to anomalous southerly flow over much of southern South America in both months. September was mostly dry (exceptions were Bolivia and southeast Brazil, which had 200–400 per cent of their normal September rain), while in November, Uruguay and adjacent areas of Brazil and Argentina, and Bolivia, were wet. Parts of Uruguay had up to 180 mm of rain in the last week of November. Strong ridging over the southwest Atlantic in October produced an anomalous east to northeasterly air-flow, and predominantly warm, wet conditions.

References

Climate Analysis Center 1993. *Climate Diagnostics Bulletin*, November 1993. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Washington D.C., 74 pp.

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World Meteorological Organization (WMO) 1993. *Climate System Monitoring (CSM) Monthly Bulletin*, September, October, November 1993.

Wright, W.J. 1993. Seasonal climate summary southern hemisphere (autumn 1992); signs of a weakening ENSO event. *Aust. Met. Mag.*, *42*, 191–198.

Appendix

Data sources used for this review were:

National Climate Centre, *Climate Monitoring Bulletin* — Australia.+

Climate Analysis Center (CAC), *Climate Diagnostics Bulletin.**

Obtainable from:

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

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