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Seasonal climate summary southern hemisphere (autumn 1993): a second mature ENSO phase

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Southern hemisphere climate patterns for autumn (March–May) 1993 are reviewed, with particular emphasis on Pacific Basin climate indicators, and on temperature and rainfall over Australia. Marked climate anomalies over other southern hemisphere countries are also briefly summarised. The period saw mature El Niño-Southern Oscillation (ENSO) phase conditions develop for the second autumn in a row, with many of the climatic teleconnections typical of past ENSO episodes in evidence. Over Australia, below average rainfall and above average temperatures in the north and east resembled autumn 1992, and were characteristic of the mature phase of an ENSO event.

Introduction

The ENSO event that commenced in 1991 matured as a moderate to strong event in summer 1991–92 and autumn 1992. It waned in the winter/spring months of 1992, accompanied by some spectacular weather anomalies over Australia in the spring months (Plummer 1994), only to undergo a resurgence in summer 1992–93 (Lin 1994). The resurgence continued in autumn 1993, as for the second year in a row conditions typical of the mature phase of an ENSO event developed. This summary reviews southern hemisphere climate patterns in autumn 1993, with particular emphasis on the Pacific Basin region and Australia.

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

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Pacific Basin climate indices

Atmospheric indices and the SOI

The SOI (Fig. 1) remained strongly negative in all three months (monthly values were −8.3, −18.6 and −7.3), reflecting negative sea level pressure anomalies over the tropical and subtropical Pacific east of the date-line, positive anomalies west of the date-line, and weaker than normal easterlies. These atmospheric anomalies have now persisted virtually unbroken since early 1990, and the only periods of negative SOI of comparable length this century were in 1911–15 and 1939–41 (comparisons of other indices over this period are not possible because of the lack of data).

Figure 2, adapted from Climate Analysis Center (May 1993), is a time sequence of anom- the near-equatorial Pacific and Australasian regions between March 1991 and May 1993. Significant negative OLR anomalies – indicative of well above normal convective rainfall – redeveloped over the central and most of the eastern equatorial Pacific (longitudes 180°E to 80°W) in February 1993, and intensified in April and May. This followed a marked decline during the late winter-spring of 1992, when atmosphere and

Fig. 1 Tahiti-Darwin Southern Oscillation Index, January 1988 to May 1993 inclusive.

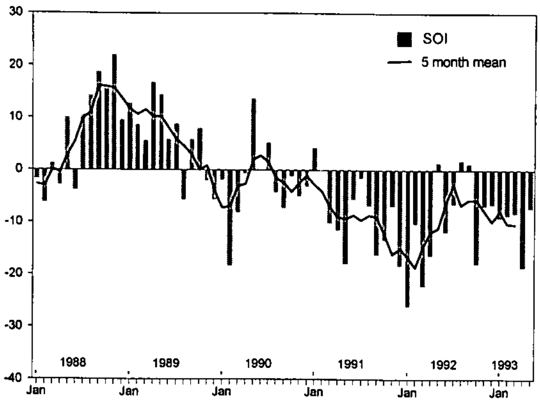
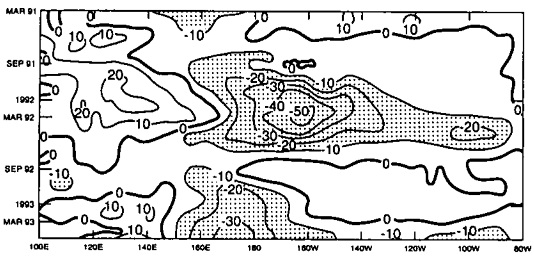


Fig. 2 Time-longitude section of monthly outgoing long wave radiation anomalies for 5°N–5°S, March 1991 (top) — May 1993 (bottom). Contour interval is 10 W m^{-2}. Shading indicates negative anomalies (i.e. enhanced convection and rainfall). Anomalies are based on a 1979–88 base period mean. After Climate Analysis Center (May 1993).



ocean appeared to return towards normal (Plummer 1994). Positive anomalies in OLR are evident thoughout the summer and autumn in the area north of Australia. Note, however, that the intensity of the anomalies is substantially less than at the same time in 1992.

CAC monthly OLR analyses showed a northwest/southeast-oriented belt of significant negative anomalies over western and central Australia in April and May 1993 (not shown). This reflects the extension of some significant cloudbands from the tropical Indian Ocean southeast across these areas.

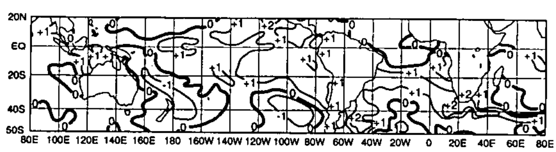
Oceanic

Sea-surface temperatures (SSTs). Satellite-derived SST anomalies (SSTAs) from the National Meteorological Centre, Australian Bureau of Meteorology, are used in this summary. Autumn 1993 SST patterns (Figs. 3(a)–(c)) over the tropical Pacific resembled classic mature ENSO conditions (Rasmusson and Carpenter 1982), with SSTs from 1–3°C above average over an extensive area of the central and eastern tropical Pacific. This pattern was prominent in all months, and anomalies generally increased as the season progressed. The pattern was similar to that of autumn 1992 (Wright 1993), except that the magnitude of the anomalies was slightly less (e.g., Climate Analysis Center (April 1993)).

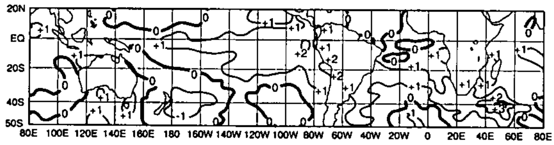
Another feature of interest was the large area of negative SSTAs near and east of New Zealand, which extended northwestward through the Coral Sea. This pattern had persisted since early 1992, and is consistent with continued anomalous south to southwesterly flow across the region.

Fig. 3 Monthly mean sea-surface temperature anomalies (°C): (a) March 1993; (b) April 1993; (c) May 1993.

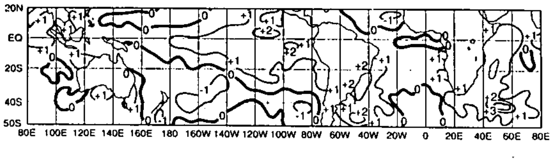
(a)



(b)

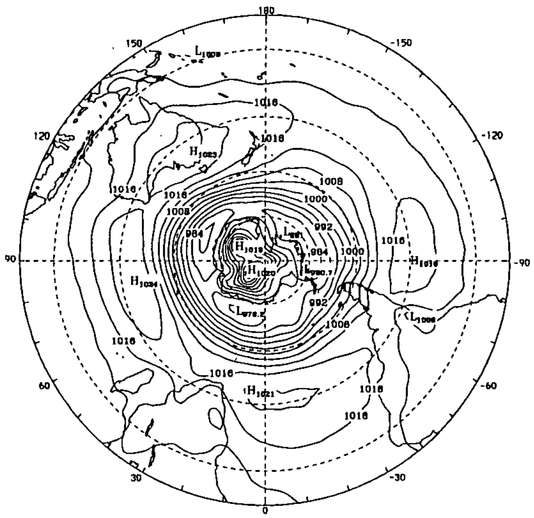


(c)



Subsurface temperature patterns. These patterns (not shown) were characterised by an anomalously deep oceanic thermocline in the central and eastern equatorial Pacific, and a shallower than normal one in the west. This pattern of subsurface anomalies developed in late 1992 and persisted through autumn. Unlike in May 1992, there was little obvious sign in May 1993 that the warm eastern Pacific conditions were coming to an end (Climate Analysis Center, May 1993).

Fig. 4 Autumn 1993 (March, April, May) mean sea level pressure (hPa).



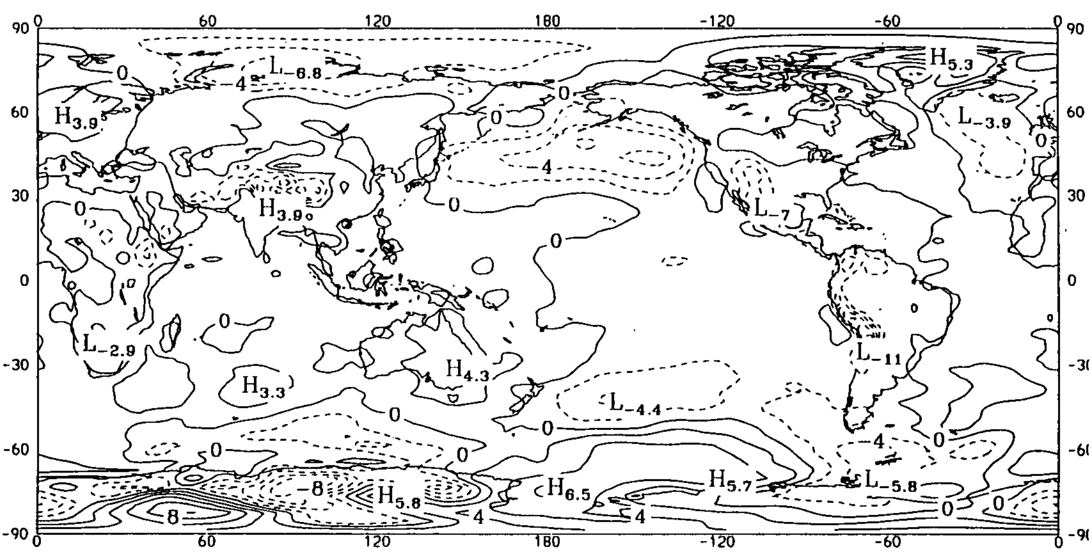
Surface analyses

Figures 4 and 5 show the autumn 1993 mean sea level pressure (MSLP) analysis and anomaly patterns respectively. Anomalies are deviations from an 11-year (1979–89) climatology of southern hemisphere analyses, compiled by the European Centre for Medium-range Weather Forecasting. The tendency for below normal pressures over the middle and low latitudes of the central and eastern Pacific is clearly evident in Fig. 5, with a substantial negative anomaly centre east of New Zealand. The latter feature mainly reflected conditions in March, which was very cold over New Zealand (only March 1992 was colder in the past 50 years). In contrast, pressures were higher than normal over Australia and Indonesia, and over most of the Indian Ocean apart from the higher latitudes. Ridging was prominent over the high latitude central-eastern Pacific.

Upper level analyses

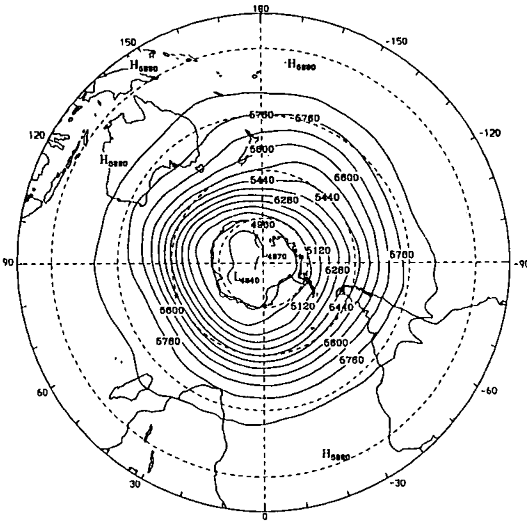
The mean 500 hPa analysis (Fig. 6) shows longwave troughs located over the eastern sides of the three southern hemisphere ocean basins, but anomalies (Fig. 7) over mid-latitudes were small, indicating that trough amplitudes were not greatly different from normal. A prominent feature was the strong blocking dipole over the central Pacific (Fig. 7), with marked anomalous ridging at 50°–60°S and troughing near 40°S. Other features evident on Fig. 7 include:

Fig. 5 Autumn 1993 (March, April, May) mean sea level pressure anomaly (hPa).



(a) Higher than normal heights throughout the season over Australia, associated with above average temperatures. Strong ridging was also apparent over the southwestern Atlantic and Indian Oceans.
(b) Lower than normal heights over the Antarctic continent and immediately adjacent areas. This was associated with a strong circumpolar vortex.

Fig. 6 Autumn 1993 (March, April, May) 500 hPa mean geopotential height (dam).



Analysis of individual months (not shown) suggested that there was a general southeastward progression of anomalies through the season.

Blocking

Figure 8 is a time-longitude section of the daily southern hemisphere Blocking Index, measuring the strength of the mid-latitude 500 hPa flow relative to that at subtropical and high latitudes over the period 1 March 1993 (day 1) through 31 May 1993. The index is defined as:

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

where U^x is the daily mean 500 hPa zonal wind at latitude x. Positive values of the index correspond to a split in the mid-latitude westerlies, and are therefore an indicator of blocking. Strong and persistent blocking is clearly evident throughout the period over the central and eastern Pacific (longs 160°–260° on Fig. 8, i.e., 160°E–100°W). By contrast, a predominantly zonal flow regime prevailed over the remainder of the eastern hemisphere (0°–150° on Fig. 8). There was little significant month-to-month variation in these patterns.

Fig. 7 Autumn 1993 (March, April, May) 500 hPa mean geopotential height anomaly (dam).

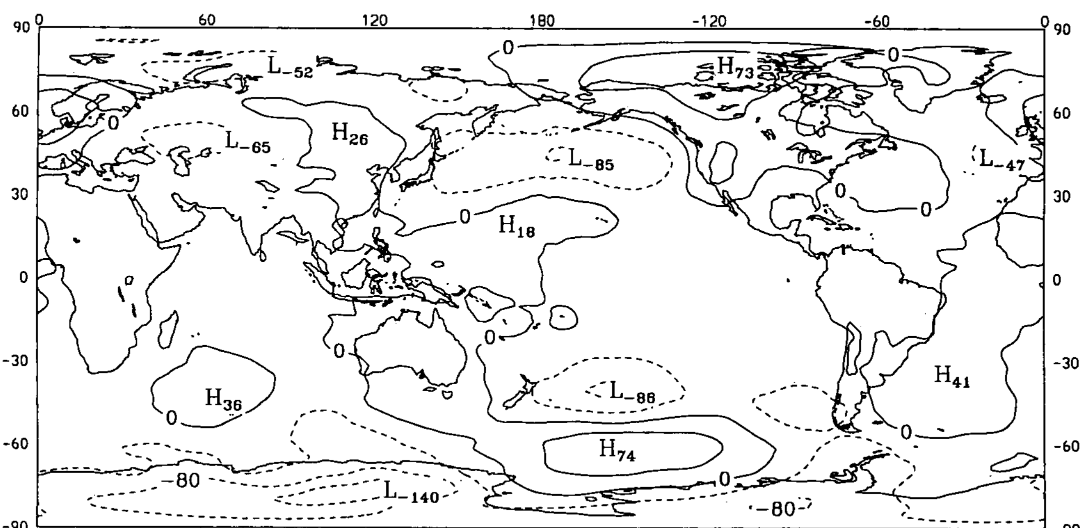
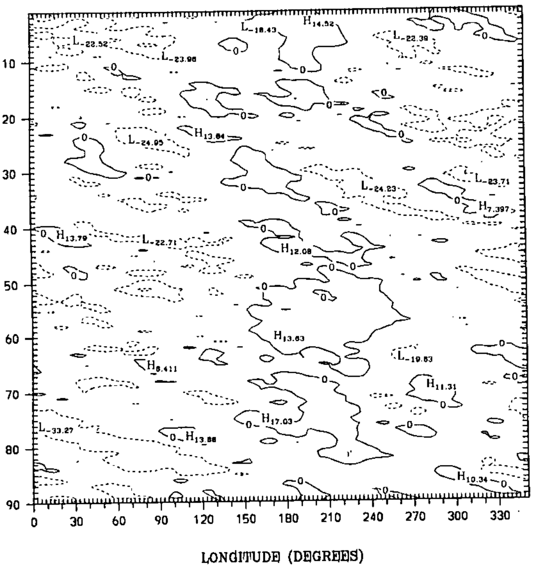


Fig. 8 Time-longitude section of daily Blocking Index, Autumn 1993 (March, April, May). Day 1 is 1 March 1993.



Winds

Wind anomalies at 850 hPa (representing low-level flow) and 200 hPa (upper flow) are shown in Figs 9 and 10 respectively. Notable features at low levels include:

(a) Pronounced easterly flow anomalies over northern Australia and adjacent Indonesia. These were particularly prominent in March and April, and reflected an early end to the monsoon season over northern Australia.

(b) Prominent northerly anomalies across extra-tropical Australia (associated with unusually warm conditions), and anomalous southerly flow across New Zealand and the Tasman Sea.

(c) The substantially weaker than normal westerlies at higher mid-latitudes (45°–60°S) over most of the South Pacific basin.

(d) Northerly flow anomalies over the far eastern Pacific.

A striking feature of the 200 hPa flow anomaly analysis was the well-defined anticyclonic anomaly couplet over the Pacific, with circulations centred near 20° north and south. This feature is typical of the mature phase of warm Pacific (i.e. ENSO) events (Rasmusson and Carpenter 1982). A powerful subtropical jetstream immediately poleward of the circulations in both hemispheres was evident; over the South Pacific, this belt of enhanced upper level westerly winds at about 30°–35°S extended eastwards to the South American coast.

Fig. 9 Autumn 1993 (March, April, May) 850 hPa vector wind anomalies (m s^{-1}).

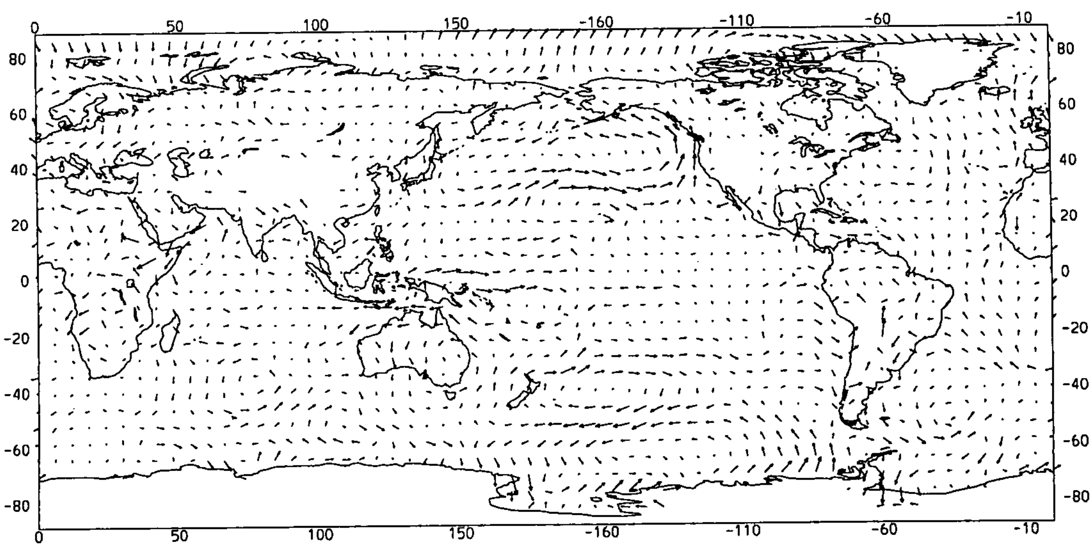


Fig. 10 **As for Fig. 9, but for 200 hPa wind anomalies.**

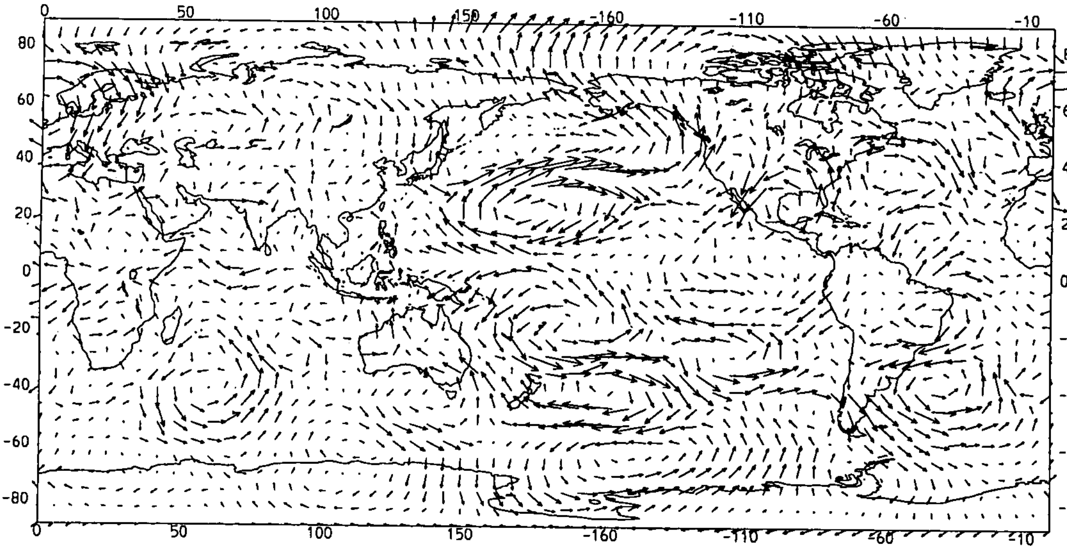
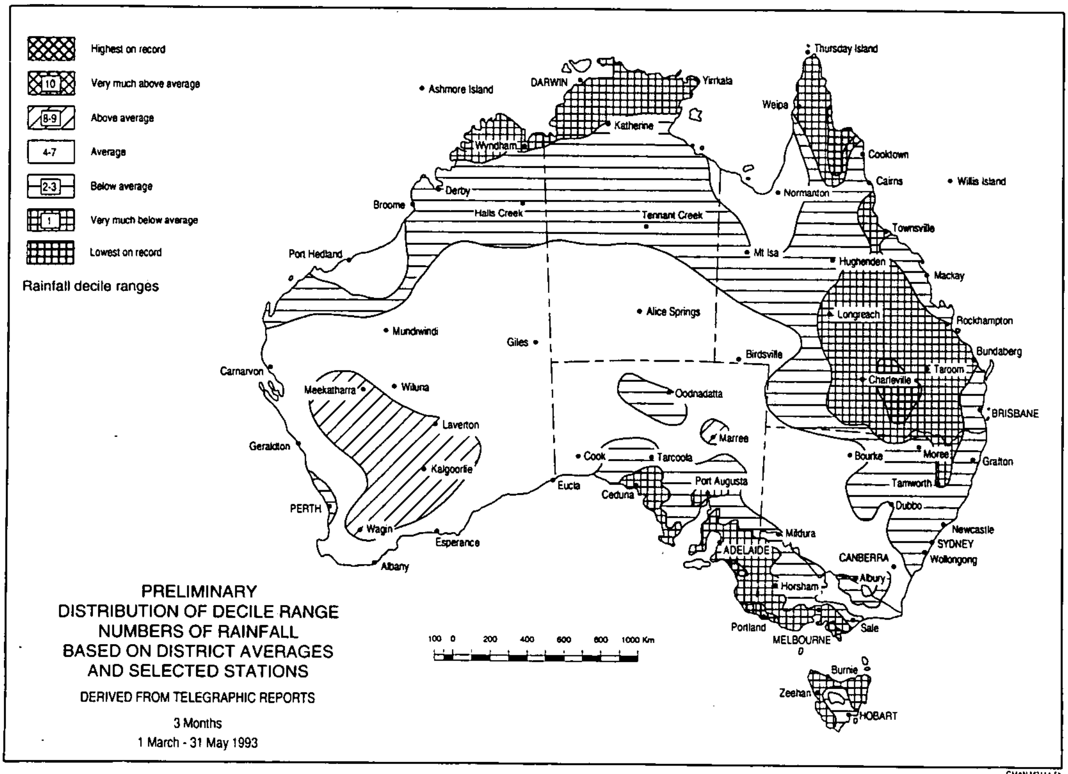


Fig. 11 **Autumn 1993 (March, April, May) rainfall in Australia, expressed as decile ranges. Values based on district averages.**



Australian region

Circulation and rainfall

Autumn 1993 rainfall deciles for Australia are shown in Fig. 11. The northern Australian wet season failed to extend beyond February, resulting in well below normal rainfall in March and April throughout the tropics. Consequently, autumn as a whole was very dry over northern parts of Western Australia and the Northern Territory (and also over adjacent areas of eastern Indonesia), and over central and eastern Queensland; parts of the latter State had record low totals. The wet season failed for the second year in a row in central/eastern Queensland, with the drought situation there becoming very serious. Tropical cyclone *Roger* brought local relief (75–150 mm) to coastal areas of northeastern New South Wales and southern Queensland in March.

Outside the tropics, continual high pressure over Australia and the adjacent western Pacific/Tasman Sea areas (Fig. 5) resulted in well below normal autumn rainfall over most of eastern Australia. The unusually dry conditions were particularly marked in southern South Australia and western Victoria, where again some areas had record low amounts. In contrast, northwest cloudbands (Tapp and Barrell 1984) produced slightly above normal rains over inland Western Australia in April, and well above normal rains in Western and central Australia in May.

Temperatures

Mean minimum and maximum temperature anomalies for autumn 1993 are shown in Figs 12 and 13 respectively. Temperatures in southwestern Australia were slightly below normal, and minima in southeastern Australia were up to one degree below normal, probably because clearer than normal skies would have allowed substantial overnight cooling. In general, however, autumn temperatures were mostly well above normal, particularly in April/May where anomalies reached two to three degrees over extensive areas of central and eastern Australia. This unusual warmth mainly reflected the marked northerly flow anomalies over the continent (Fig. 9), although the general lack of cloud and rain over eastern Australia may have been a factor in the maximum temperature anomalies there. In particular, April maxima over southeastern Australia set new records at many places, including Melbourne with 138 years of record.

Fig. 12 Autumn 1993 mean minimum temperature anomalies (°C) over Australia. Values based on station data.

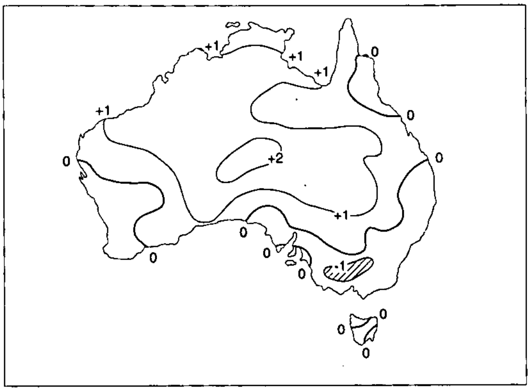
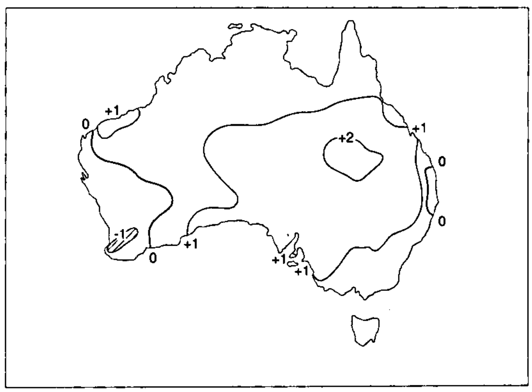


Fig. 13 As for Fig. 12, but for maximum temperature anomalies.



Climate anomalies elsewhere in the southern hemisphere

South Pacific and New Zealand

Rainfall patterns over the South Pacific islands were typical of mature-phase ENSO events, and continued a trend that has more or less persisted since the start of the current warm Pacific conditions in 1991. Well above average rains (200–400 per cent of normal) drenched much of the tropical Pacific near to and east of the date-line. For instance, Apia (western Samoa) with 890 mm (in five days), and Christmas Island (417 mm) in the eastern Kiribati group — an area highly sensitive to ENSO events (Bjerknes 1969) — had record March totals; in April, Fanning Island (Kiribati group) had a record 529 mm. However, convective rainfall was still less than in the previous autumn (refer Fig. 2), and the Society Islands area had well below normal rains. The southwest Pacific/Coral Sea region had relatively cool conditions with well below normal rainfall, except over the Tasman and southern Coral Seas area in March. Papua New Guinea was also very dry.

New Zealand was cool in March and April, with generally average to below average rainfall. May was a generally dry month.

Southern Africa

Unusually warm, dry conditions were widespread over southern Africa in March, associated with strong ridging south of the continent. Many regions had less than half their normal March rainfall. Heavy rains fell in southwestern South Africa in April/May, while the dry spell in southeastern South Africa/southern Mozambique was temporarily relieved in April. Northern areas of Zimbabwe and Mozambique, and parts of adjoining countries, also experienced heavy April rains. Generally drier conditions returned in May, although heavy rains drenched Kenya. In general, the areas worst affected by the 'drought of the Century' in 1991–92 received reasonable rains in summer 1992–93 and autumn 1993.

South America

Dry, warm conditions persisted in northeastern Brazil. A dry spell continued over Brazil, Argentina, part of Paraguay, and southern Bolivia in March, aggravated in Argentina by a heat wave in the second half of the month. At the same time, very wet conditions developed over southern South America as anomalous ridging collapsed. Extremely wet conditions occurred in south central Chile, Uruguay, northeastern Argentina and southeastern Paraguay during April/May, with up to 400 mm in three weeks. These rains are consistent with the mature phase of an ENSO event (Ropelewski and Halpert 1987). Similarly, Ecuador and Peru were much warmer than normal, and unusual heavy rains in the coastal areas were a noteworthy, ENSO-related feature.

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Appendix

Data sources used for this review were:

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

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

World Meteorological Organization — *Climate System Monitoring Monthly Bulletin.#*

Obtained from:

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

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