

Seasonal climate summary southern hemisphere (summer 1993–94): conditions return to near normal across the tropical Pacific

Leanne Hollis

National Climate Centre, Bureau of Meteorology, Australia
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During summer there was a weakening of the warm episode conditions that have dominated the tropical Pacific over the past three years. Many tropical warm episode indicators showed a return to normal. The Southern Oscillation Index (SOI) was close to zero, and in the tropical Pacific Ocean, low-level easterlies were stronger than normal, there was a cooling of warm sea-surface temperature (SST) anomalies and convection was near normal.

Introduction

Warm SST conditions have dominated the tropical Pacific Ocean for the past three years. A moderate to strong El Niño-Southern Oscillation (ENSO) event began in 1991, peaking in the summer/autumn period of 1991–92. It weakened during the winter and spring of 1992 before warm conditions re-developed during summer 1992–93. For the second consecutive year, the autumn period showed characteristics of a mature ENSO event (Wright 1994). Winter and spring again saw a weakening of ENSO conditions (Beard 1994), and by the end of summer the main ENSO indicators were near normal.

A review of the climate patterns in the southern hemisphere during summer (December–February) 1993–94 is presented in this seasonal summary, with the Australian and Pacific Basin regions receiving greater attention.

Information was primarily obtained from monthly issues of the *Climate Monitoring Bulletin* (Bureau of Meteorology, Australia) and the *Climate Diagnostics Bulletin* (Climate Analysis Center (CAC), Washington). Sources of data are listed in the Appendix.

Pacific Basin climate indicators

Atmospheric circulation indices

December saw the SOI* (Fig. 1) near zero for the second month in a row. It remained close to zero throughout the summer period (monthly values for December, January and February were +1, –2 and 0 respectively), and was one of several indicators suggesting an end to the warm episode conditions that had been dominating the Pacific Ocean region for the previous three years. Other significant features in the equatorial Pacific were:

(a) stronger than normal low-level easterly flow (Figs 2 and 11), the first significant easterly anomalies since April 1991, and westerly wind anomalies at 200 hPa. Figure 2 is a time-longitude plot of anomalous zonal wind at 850 hPa for 5°N–5°S from October 1991.

(b) a decrease in (both magnitude and area of) warm SST anomalies. By the end of summer the warmest water had moved west of the date-line to be near 150°E for the first time in more than three years.

Corresponding author address: Leanne Hollis, National Climate Centre, Bureau of Meteorology, GPO Box 1289K, Melbourne, Vic 3001, Australia.

*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.

Fig. 1 Southern Oscillation Index, January 1989 to February 1994 inclusive.

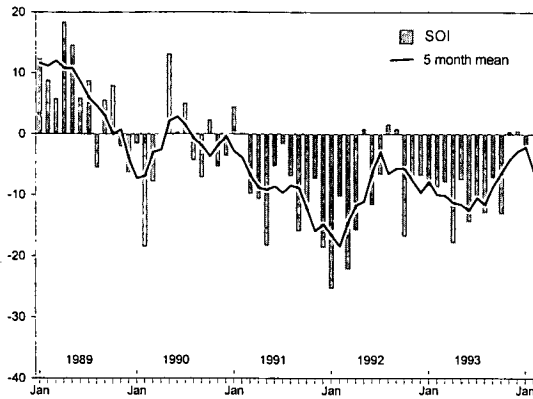


Fig. 2 Time-longitude section of anomalous 850 hPa zonal wind for 5°N–5°S, October 1991 to February 1994 (after CAC 1994). Contour interval is 1 m s⁻¹. Dashed contours indicate easterly anomalies. Anomalies are based on a 1979–1988 base period mean.

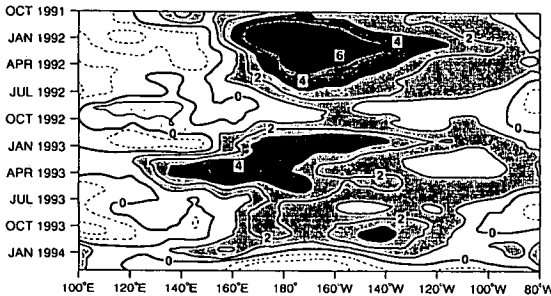


Fig. 3 Time-longitude section of monthly outgoing long wave radiation anomalies for 5°N–5°S, December 1992 to February 1994 (after CAC 1994). Contour interval is 10 W m⁻². Shading indicates negative anomalies. Anomalies are based on a 1979–1988 base period mean.

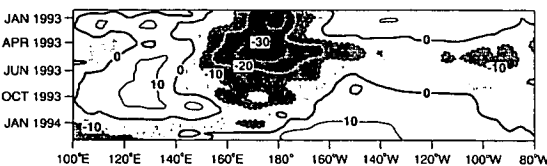


Fig. 4 Summer 1993–94 sea-surface temperature anomaly (°C).

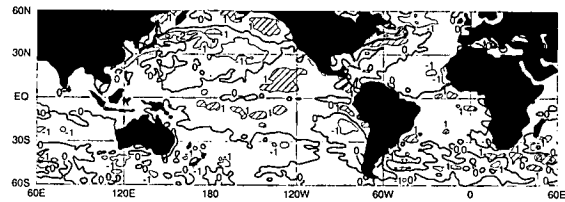
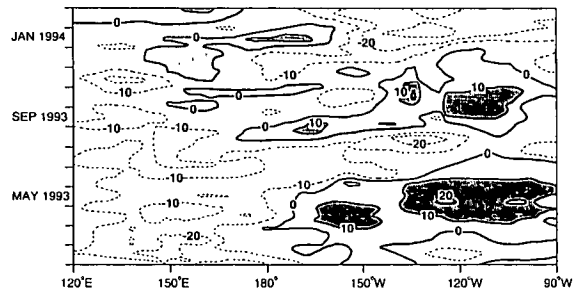


Fig. 5 Time-longitude section of monthly anomalous depth of 20°C isotherm at the equator from February 1993 to February 1994. Contour interval is 10 m.



(c) a return to near-normal convection in the central equatorial Pacific Ocean (CAC). Figure 3, adapted from CAC (1994), shows a time series of anomalous outgoing long wave radiation (OLR) over the near-equatorial Pacific and Australasian regions. Negative anomalies imply above average cloudiness, and hence rainfall.

Ocean indicators

Sea-surface temperatures (SSTs). In December, sea-surface temperatures were warmer than normal across most of the central and eastern tropical Pacific, although there were some cold anomalies along the equator. By the end of February the cold tongue had become more prominent and, in general, there was a weakening of the warm anomalies in the central tropical Pacific. Figure 4 shows SST anomalies over summer.

Subsurface patterns. The depth of the 20°C isotherm along the equator (Fig. 5) was near normal during December. Shoaling of the thermocline (using the depth of the 20°C isotherm as a proxy) in the east was representative of significant cooling in the upper ocean. Cool anomalies dominated to a depth of 200 m during summer (sub-surface temperature profile along the equator not shown).

Surface analyses

Figures 6 and 7 show the summer mean sea-level pressure (MSLP) analysis and anomaly patterns respectively. The southern hemisphere subtropical ridge was near its normal position, but stronger than normal across most of the longitude range. Positive anomalies in the Indian Ocean and just west of South America corresponded to favoured positions of high pressure systems within the subtropical ridge. Southeast of New Zealand pressures were more than 5 hPa above normal and were associated with a high level of blocking activity in the region. At high latitudes, lower than normal pressures dominated.

Upper-level analyses

The mean and anomaly charts at 500 hPa are shown in Figs 8 and 9. The anomaly pattern at 500 hPa in the southern hemisphere very closely resembles that at the surface, with positive anomalies in a band between 30 and 50°S, and negative anomalies at high latitudes.

Fig. 6 Summer 1993–94 (December, January, February) mean sea-level pressure (hPa).

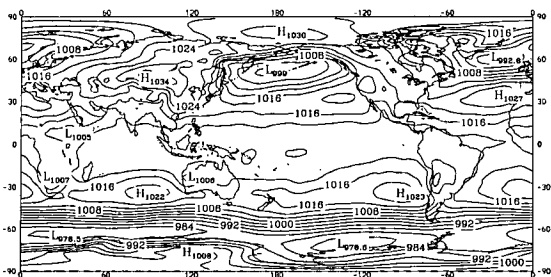
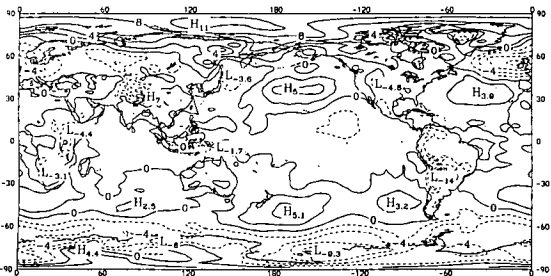


Fig. 7 Summer 1993–94 (December, January, February) mean sea-level pressure anomaly (hPa).



Blocking

Figure 10 shows a time-longitude section of the daily southern hemisphere Blocking Index (BI)*. Positive values of the BI are generally associated with a split in the mid-latitude westerly flow and blocking events.

Blocking activity was largely confined to longitudes nearest the date-line. This is reflected on both the MSLP and 500 hPa anomaly charts with strong positive anomalies in this region. A significant blocking event influenced the weather over Australia in the last week of December when a deep low developed southeast of the continent.

The most intense, although short-lived, blocking event occurred at the end of January near the date-line.

Fig. 10 Summer 1993-94 (December, January, February) daily Blocking Index: time-longitude section. Day 1 is 1 December.

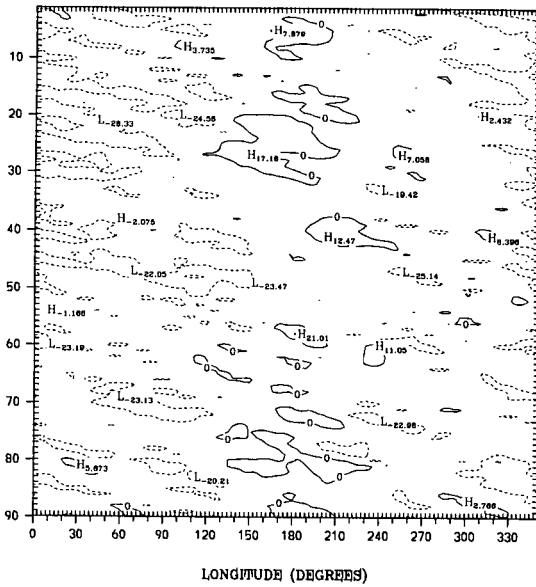


Fig. 11 Summer 1993-94 (December, January, February) 850 hPa vector wind anomalies ($m s^{-1}$).

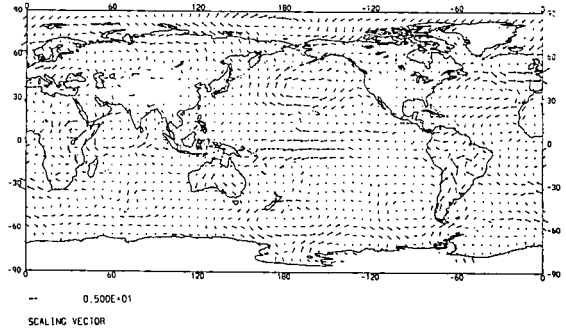
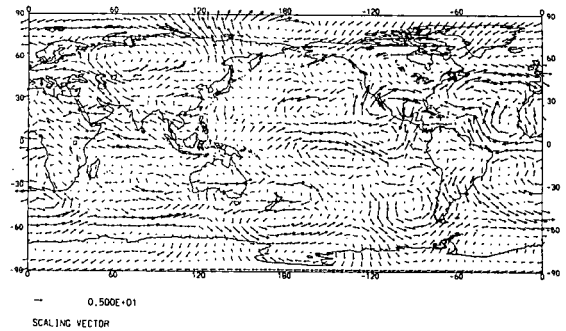


Fig. 12 Summer 1993-94 (December, January, February) 200 hPa vector wind anomalies ($m s^{-1}$).



Winds

Anomalous anticyclonic winds at 850 hPa (Fig. 11) along the subtropical ridge corresponded to those areas where MSLPs were above normal. A band of anomalous easterly winds was evident across the equatorial Pacific Ocean. Figure 2 shows the emergence of easterly anomalies about the date-line in December, strengthening and extending eastwards over summer.

A significant feature of the 200 hPa anomaly chart (Fig. 12) is the cyclonic anomaly couplet straddling the equator in the Pacific Ocean, producing westerly wind anomalies across this region. Also a feature was the band of westerly wind anomalies at around 60°S.

Australian region

Circulation and rainfall

Rainfall was average to above average in a band stretching from northwestern Australia through to the southeast (Fig. 13). Above average summer rainfall over western NSW and Victoria was a

result of frontal activity in December and the intrusion of moist tropical air on several occasions during February. A particularly intense front and associated low in late December caused havoc in the Sydney to Hobart yacht race and flooding in eastern Tasmania. Very much above average rainfall reports in the areas south of Broome and southeast of Carnarvon were due to tropical disturbances making landfall.

Below to very much below average rains were received in northeastern and southwestern parts of the continent. The very much below average summer rains in the northeast exacerbated long-term rainfall deficiencies in that area.

Temperature

Maximum temperatures (Fig. 14) were above average in the northeast, in large part due to temperatures up to five degrees warmer than normal in January. January also brought hot and dry con-

Fig. 13 Summer 1993-94 (December, January, February) rainfall in Australia: decile range values based on district averages and selected stations.

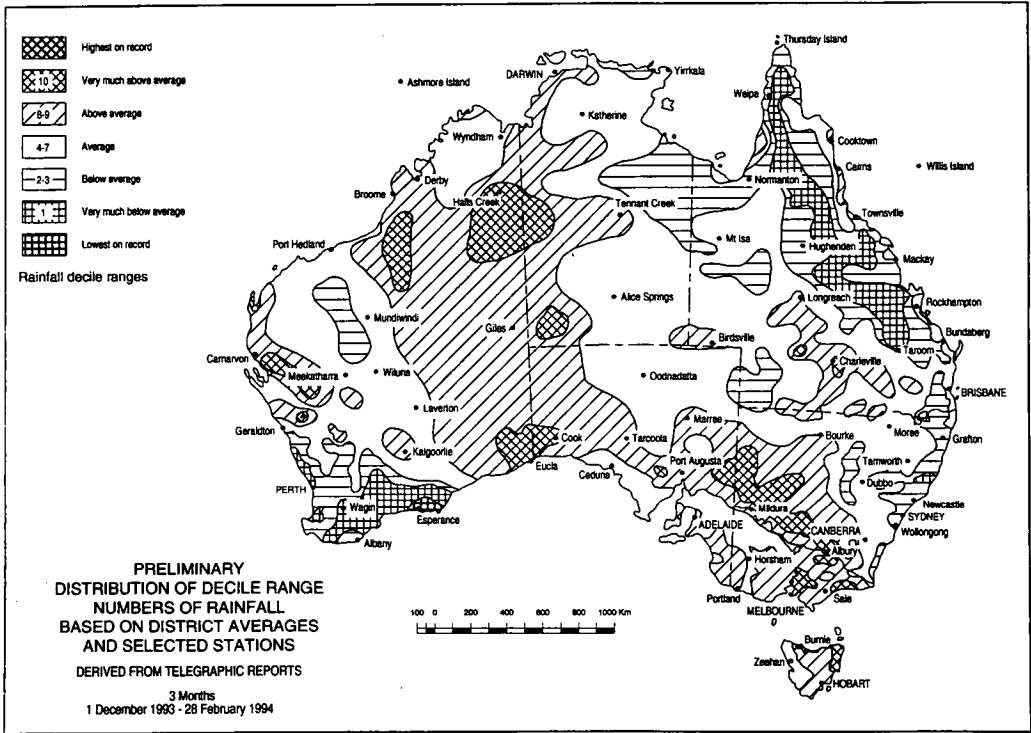


Fig. 14 Summer 1993-94 (December, January, February) maximum temperature anomalies (°C) for Australia.

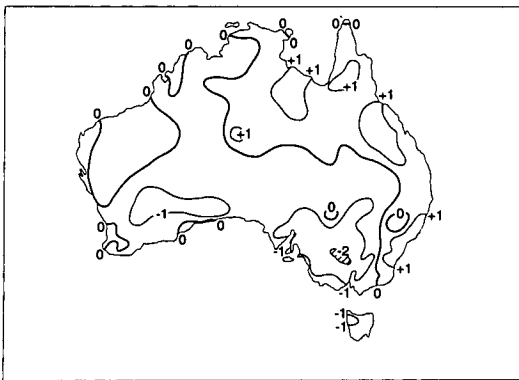
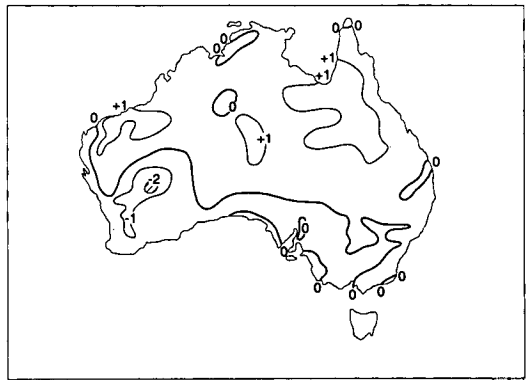


Fig. 15 Summer 1993-94 (December, January, February) minimum temperature anomalies (°C) for Australia.



ditions to NSW. During the first two weeks bushfires raged about the coast and ranges and several stations recorded their hottest day ever. Below average maximum temperatures were recorded in the south.

Minimum temperatures (Fig. 15) were warmer than normal over much of the continent. Overnight temperatures were 1 to 2 degrees warmer over inland Queensland. Cooler than normal temperatures were observed across southern parts of Australia.

References

- Beard, G.S. 1994. Seasonal climate summary southern hemisphere (spring 1993): conditions across the tropical Pacific tend towards normal. *Aust. Met. Mag.*, 43, 291-7.
- Climate Analysis Center 1993, 1994. *Climate Diagnostics Bulletin*, December 1993, January 1994, February 1994. US Dept of Commerce, National Oceanic and Atmospheric Administration, Washington D.C.

- 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:
 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.