Seasonal climate summary southern hemisphere (autumn 1989): a second peak in the Southern Oscillation Index

D. Gaffney
National Climate Centre, Bureau of Meteorology, Melbourne, Australia
(Manuscript received September 1989; revised December 1989)

The climate of the southern hemisphere autumn 1989 is summarised with emphasis on the Australian region.
After rising to a peak in early summer 1988–89 the Southern Oscillation Index peaked again in autumn. Although sea-surface temperature indices in the eastern equatorial Pacific continued to rise towards normal levels, some other climate indices were maintaining values characteristic of a cold episode. Temperatures remained above normal along mid-latitudes with significant warming southwards from Australia. High latitude patterns of this cold episode autumn were in significant contrast to respective patterns of the 1987 warm episode autumn. Australia received extensive record rains in autumn and useful rains in northern Argentina and Uruguay terminated an abnormal dry spell in that region.

Introduction

This seasonal climate summary reviews the southern hemisphere climate features for autumn 1989 (March to May inclusive). Features reviewed include climate indices, sea-surface temperatures and tropospheric pressure patterns. Circulation, rainfall and temperature in the Australian region are given more detailed attention.

The data sources were the Climate Monitoring Bulletin — Southern Hemisphere and the Darwin Tropical Diagnostic Statement issued monthly by the Bureau of Meteorology, Australia, along with monthly climate bulletins issued routinely by other national weather services. Data sources are listed in the Appendix.

Climate indices

After reaching a maximum in December 1988, the cold episode in the Pacific had shown early signs of weakening during summer as the Southern Oscillation Index (SOI)*, shown in Fig. 1, began to fall and negative sea-surface temperature anomalies began to weaken in the central and eastern equatorial Pacific (Mo 1989; Gaffney 1990; R. Keith, personal communication). However, the SOI rose again to a second peak in April before declining in May. Not since the 1975–76 period have such strong positive SOI anomalies occurred so persistently.

Fig. 1 Southern Oscillation Index, January 1986–May 1989 inclusive.

*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.
Fig. 2 Autumn 1989 (March, April, May) sea-surface temperature anomaly (°C).

Other standard indices continued to reflect a persisting cold episode. For example, equatorial convective activity was continuing much westward of the dateline and the outgoing long wave radiation index near the dateline retained an appreciable positive anomaly, although smaller in May. Similarly the Pacific trade winds were unabated as determined by a continuing positive 850 hPa zonal wind index. Likewise the upper tropospheric equatorial westerlies were unabated as shown by the 200 hPa zonal wind index remaining positive.

In the eastern Australian region the subtropical ridge of high pressure was further south than normal, particularly in March and April, being displaced about 5 degrees south of normal latitudes in those months. This was consistent with the positive SOI and lower than normal surface pressures in the Australian region.

Sea-surface temperatures

Sea-surface temperature (SST) anomalies for autumn, based on satellite measurements, are shown in Fig. 2. Negative anomalies in the central equatorial Pacific continued to weaken from summer (−2°C) through autumn (−1°C) as the cold episode weakened, while a tongue of positive SST anomaly spread westwards from the coast of Peru. In the Atlantic, SSTs were positive south of the equator and negative to the north.

Continuing the summer 1988–89 pattern at mid-latitudes, positive departures were generally prominent around the hemisphere. This feature was marked in the Australian region and in the South Pacific where there were extensive areas with positive anomalies (1–2°C).

Surface analyses

The autumn mean sea level pressure distribution and anomalies are given in Figs 3 and 4 respectively. Continuing the summer pattern, subtropical high pressure cells were chiefly further south than normal, a notable exception being over South America. As in summer, negative anomalies occurred at high latitudes, particularly over Antarctica. The negative anomalies over Antarctica were a distinctive feature of this cold episode autumn. They contrasted sharply with the

Fig. 3 Autumn 1989 (March, April, May) mean sea level pressure (hPa).
positive anomalies located over Antarctica in each month of the 1987 warm episode autumn. It is noted also that Karoly (1989) obtained positive anomalies over Antarctica in composite analyses of three warm Pacific episodes.

**Upper air analyses**

The 500 hPa analyses showed a planetary mean four-wave pattern (Figs 5 and 6) with long wave troughs in the eastern Atlantic, eastern Indian, western Pacific and eastern Pacific Oceans. The troughs in the eastern Indian and eastern Pacific Oceans extended well northwards into the tropics. Planetary five-wave patterns were prominent in the first half of March and also in April.

The 500 hPa anomaly analysis for autumn 1989, during a Pacific cold episode (Fig. 6), differs markedly from the corresponding analysis for autumn 1987 during a warm episode, as shown in Fig. 7 from Gaffney and Casey (1987) (see also Karoly 1989). The main differences are:

(a) that the anomaly centres at mid-latitudes in 1989 are generally 60–90° east of their 1987 positions (e.g. high over Australia in 1987 is east of New Zealand in 1989);

(b) that positive anomalies are located to the southwest of Western Australia in 1987, whereas they are negative in 1989;

(c) that anomalies over Antarctica in 1987 are positive, whereas in 1989 they are strongly negative.

These differences in circulation patterns between the 1987 and 1989 autumns appear to be related to the westward location and enhance-
Blocking

The occurrence of blocking at mid-latitudes during autumn, as measured by the Blocking Index (BI)*, is given in Fig. 10. In March, a tendency towards blocking activity in the Indian Ocean between longitudes 30°-100°E (Fig. 10) was generally associated with the southward displacement of the subtropical ridge and the mid-latitude jet stream. In terms of the March mean (1973-82) Blocking Index (not shown) this blocking tendency in the Indian Ocean was significantly above average.

In April, only brief blocking episodes occurred in the eastern Australian — western Pacific region between longitudes 140°E-180°E (Fig. 10), and around the remainder of the hemisphere the circulation was zonal. Relative to the mean April (1973-82) Blocking Index, blocking activity around the hemisphere was generally below average for that month.

During May there was some brief blocking in the Pacific Ocean, 150°E-120°W, and in the Indian Ocean (Fig. 10), between 30°E-90°E, and mean monthly analyses indicated this was above average.

Winds

In the lower troposphere (850 hPa) during autumn, strong westerly wind anomalies prevailed in the circumpolar trough (Fig. 11). A strong anticyclonic anomaly was notable at mid to high latitudes in the South Pacific.

At 300 hPa (Fig. 12) anomalous westerlies at high latitudes were strong, particularly around Antarctica. These anomalous westerlies were linked to the deep circumpolar trough (Fig. 9). Another band of anomalous westerlies across the eastern Indian Ocean and Australia were related to negative height anomalies in this region (Fig. 9).
Fig. 10 Autumn 1989 (March, April, May) daily Blocking Index: time-longitude section. Day 1 is 1 March.

Fig. 11 Autumn 1989 (March, April, May) 850 hPa wind anomalies (m s⁻¹). (The figures near the H and L symbols are vector values at respective locations.)

Fig. 12 Autumn 1989 (March, April, May) 300 hPa wind anomalies (m s⁻¹). (The figures near the H and L symbols are vector values at respective locations.)

General climatic conditions

A substantial area of northern Argentina and Uruguay had been abnormally dry for about nine months to February 1989. In March, beneficial rains eased the situation in some areas, and further rains in May ended this long dry spell. Elsewhere in South America autumn rains were chiefly average. In April unusually heavy rain fell in many parts of southern South Africa, but this was followed by a dry period in the first half of May. The record autumn rains in Australia are discussed below.

Australian region

Circulation

The first peak in the active phase of the 30 to 60-day oscillation within the northern Australian monsoon (1988–89) occurred at the end of November 1988 and the second peak in late January 1989 (R. Keith, personal communication). The third active peak in the oscillation occurred towards mid-March and the fourth about mid-April, both of which evidently induced rain periods over Australia.

As mentioned previously, the subtropical ridge was displaced about 5° south of normal latitudes in March and April but returned towards normal in May (Figs 3 and 4). Sea-surface temperatures in the eastern Indian Ocean and south of Australia were 1–2°C above average (Fig. 2) providing a significant source of moisture for transient systems in the westerlies.
Rainfall
Record autumn rainfall occurred over extensive areas of the interior and northern Australia with most of the eastern and northern portions of the continent receiving seasonal totals in decile range 10 (Fig. 13).

The abundant rainfall was associated with the high index phase of the Southern Oscillation (Ropelewski and Halpert 1989). Linked to the high SOI were the southward displacement of the subtropical high pressure ridge and positive SST anomalies in the Australian region. As indicated above, the wet periods could also be related to the third and fourth active phases of the 30 to 60-day oscillation.

The only districts to record below average autumn rainfall were the Upper Southeast of South Australia and the West Coast of Tasmania. In this regard it was noteworthy that Australia had been free of rainfall deficiencies since the end of 1988 (an unusually lengthy period correlating with the persistence of the cold episode). This was the first occasion since February 1984 when there were no rainfall deficiencies over Australia.

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

Fig. 14 Autumn 1989 (March, April, May) temperature anomalies (°C) for Australia: (a) maximum; (b) minimum.

Temperatures
Mean maximum temperatures in autumn were 2°C below normal over the interior of Australia (Fig. 14(a)) which can be attributed to the widespread cloud and record rainfall during the season. Elsewhere over the continent, maxima were generally about average, except for above average recordings near the west coast.

Minimum temperatures for autumn were above average over most of Australia, having positive anomalies of 2–3°C in the eastern part (Fig. 14(b)). The well above average cloud and rainfall were also the main causes of relatively warm nights during the season.

Acknowledgment
Appreciation is expressed to Dr M.J. Coughlan (Bureau of Meteorology, Australia) for discussions and advice during the preparation of the paper.

References
Appendix

Data sources used for this review were:
Climate Analysis Center Climate Diagnostics
Bulletins, March, April, May 1989 and seasonal
analyses.*
Darwin Tropical Diagnostic Statement, March,
April, May 1989.†
Monthly report on Climate System, March, April,
May 1989.§
National Climate Centre Climate Monitoring
Bulletin — Southern Hemisphere, March,
April, May 1989.¶

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

* Obtainable from the Climate Analysis Center, National
Weather Service, Washington D.C. 20233, USA.
† Obtainable from the Northern Territory Regional Office,
Bureau of Meteorology, PO Box 735, Darwin 0801, Aus-
tralia.
§ Obtainable from the Japan Meteorological Agency, 1-3-4, Ote-
machi chiyoda-ku, Tokyo, Japan.
¶ Obtainable from the National Climate Centre, Bureau of
Meteorology, GPO Box 1289K, Melbourne 3001, Australia.