

Seasonal climate summary southern hemisphere (winter 1988): eastern equatorial Pacific cold episode established

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The salient climate features of the southern hemisphere during the winter of 1988 (June, July, August) are reviewed with emphasis given to the Australian region. A dominant feature was the eastern equatorial Pacific cold episode which established rapidly during this winter.

Tropical warming transferred to the Indian Ocean which as an energy source could be linked to planetary wave developments in the extratropics.

Introduction

This climate summary reviews the winter season, June to August 1988, over the southern hemisphere, highlighting the main circulation features. The summary has been prepared in the context of the overall global climate for this season and in this regard attention has been given to Ropelewski (1988). More detailed treatment is given to the Australian region bounded by the equator, Antarctica, longitude 90°E and the dateline.

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

The 1986-87 El Niño-Southern Oscillation warm episode declined in austral summer 1987-88 (Casey 1989) and came to an end in early autumn 1988. Cooling evident in the eastern equatorial Pacific during autumn (Gaffney 1989) accelerated rapidly in winter to establish a cold episode.

In the tropical Indian Ocean positive sea surface temperature (SST) anomalies (1-2°C) persisted, particularly off the coast of Australia. The tropical warming in the Indian Ocean was evidently a main energy source for enhanced wave train developments in the extratropical troposphere, notably in August.

Climate indices

Standard climate indices, designed specifically to monitor the El Niño-Southern Oscillation phenomenon, were indicating a sharp reversal from a warm to a cold episode in the equatorial eastern Pacific with a transfer of tropospheric convection to the Indian Ocean.

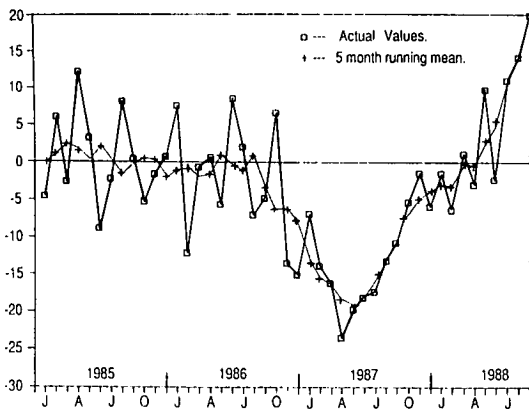
The monthly values of the Southern Oscillation Index (SOI)* since January 1985 are shown in Fig. 1. The SOI rose sharply to +14 in August 1988, the highest value since July 1979 (also +14). This high value was primarily due to the significant positive sea level pressure anomaly (2 hPa) at Tahiti, resulting from enhanced intensification of the southeast Pacific anticyclone.

Sea surface temperatures in the central and eastern equatorial Pacific decreased, with standard indices in the El Niño 1, 2 and 3 Zones† having negative departures around 2°C (Fig. 2). The outgoing long wave radiation index on the equatorial dateline became strongly positive, with convective activity shifting westwards to the Indian Ocean in association with a westwards shift of the Walker circulation. A stronger than average Walker circulation was evident with a generally

*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.

†El Niño zones are used for deriving SST anomaly indices in the equatorial Pacific (CAC Bulletin — see Appendix).

Fig. 1 Southern Oscillation Index, January 1985 — August 1988 inclusive.



above average Indian summer monsoon.

Easterly wind anomalies across the equatorial Pacific basin at 850 hPa and a tendency towards westerly wind anomalies at 200 hPa in the central equatorial Pacific also indicated an above normal Walker circulation.

Sea surface temperatures

As mentioned, SST anomalies in the eastern equatorial Pacific in winter 1988 showed negative departures establishing a cold episode (Fig. 2). In contrast, over the equatorial Pacific west of the dateline and across Indonesia to the South China Sea departures were positive, generally about 1°C.

It is relevant that in the Indonesian region in winter 1988 positive departures were similar to

those for a composite of anomaly analyses derived by Van Loon and Shea (1987) for the period, May to July, in the year immediately before a warm episode. Conditions pertaining to the latter period (i.e. May to July in the year before a warm episode) are generally similar to a cold episode situation, such as in winter 1988.

Positive departures decreased to about zero towards mid-latitudes in the Indian Ocean establishing a significant positive anomaly gradient. This gradient was inductive to upper-tropospheric trough developments in the Australian region associated with above average winter rainfall (Nicholls 1988), particularly over eastern Australia.

On the other hand, in the 1987 winter, SST anomalies were slightly negative in the Indonesian region with positive departures (1°C) towards mid-latitudes in the Indian Ocean. The resulting negative SST anomaly gradient could be related to below average rainfall over the Australian winter rainfall zone in 1987.

Mean sea level pressure analysis

The mean sea level pressure analysis for winter is shown in Fig. 3 with the corresponding anomalies in Fig. 4. The mean analysis (Fig. 3) depicts three major waves with deep long wave troughs in the Indian and Pacific Oceans and a moderate trough in the Atlantic. The anomalies (Fig. 4) show a distinctive wave train beginning at mid-latitudes in the Indian Ocean and extending east-southeast at high latitudes across the South Pacific to the Antarctic coastline, then to the south Atlantic. Over Antarctica the high pressure system was generally weaker than normal.

The marked planetary wave train shown in Figs 3 and 4 was in contrast to the extratropical cir-

Fig. 2 Winter 1988 (June, July, August) sea surface temperature anomaly (source: CAC Washington).

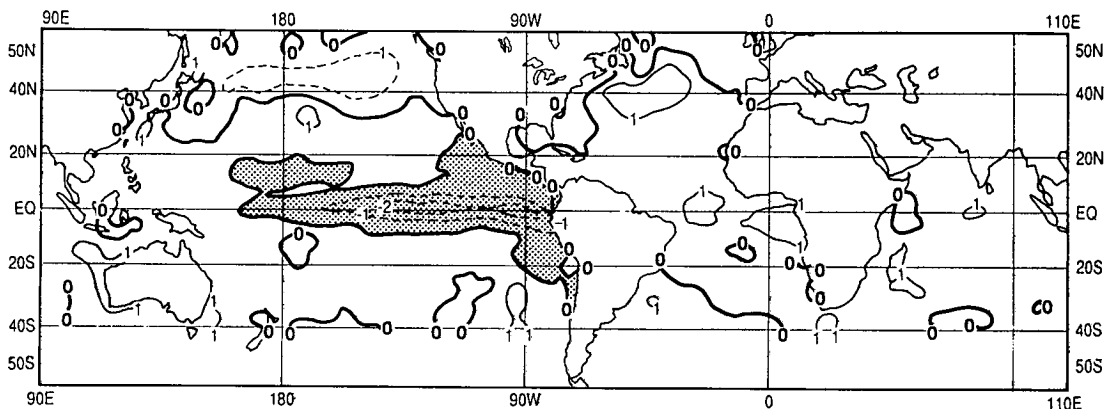


Fig. 3 Winter 1988 (June, July, August) mean sea level pressure (hPa).

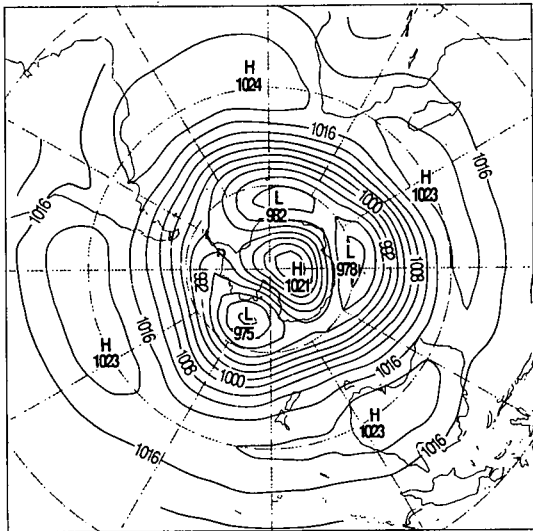
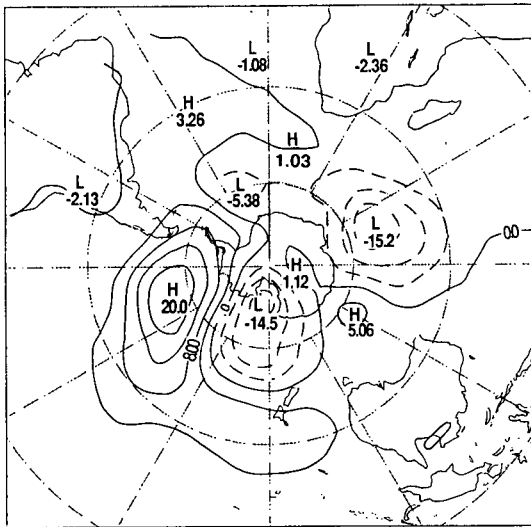


Fig. 4 Winter 1988 (June, July, August) mean sea level pressure anomaly (hPa).



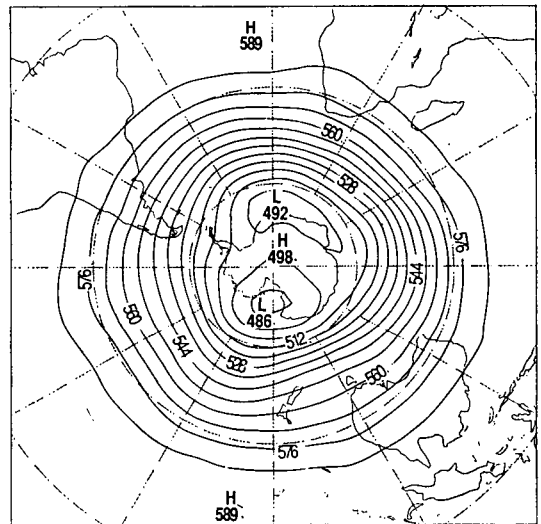
lation of the 1987 winter when anomalies were zonally orientated and weaker, with the Antarctic high having a strong positive departure.

Van Loon and Shea (1987) have derived three-monthly composite anomalies of sea level pressures over the southern hemisphere for the year before, and during a warm episode. It is noteworthy that for the year before a warm episode their composite anomalies for the three-month period, May to July, had similarities to a cold episode pattern and resembled the June to August pattern shown in Fig. 4.

500 hPa analysis

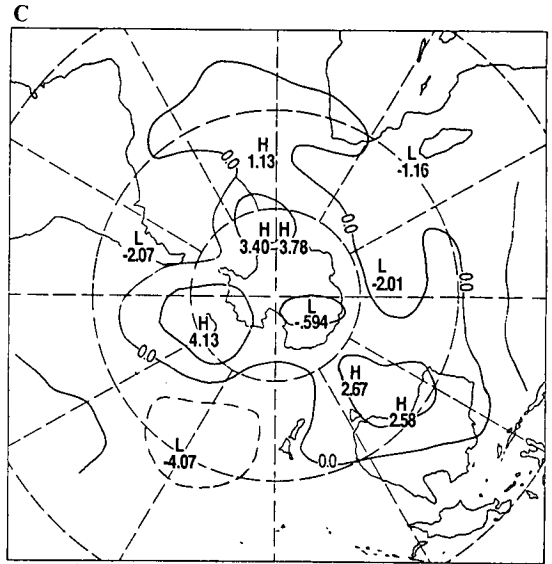
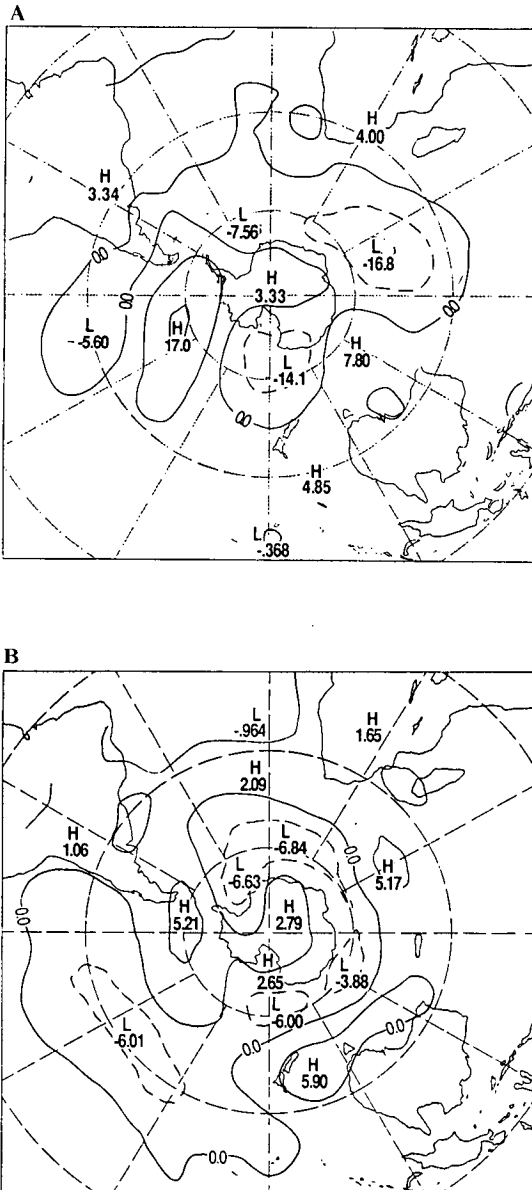
The winter 500 hPa height analysis presented in Fig. 5 displays a typical three-wave pattern similar to Fig. 3, with major long waves in the Pacific, Atlantic and Indian Oceans.

Fig. 5 Winter 1988 (June, July, August) 500 hPa height anomaly (dam).



ference in the intensity of the wave trains between Fig. 6(a) (deep) and Fig. 6(c) (shallow) is marked. Comparing warm episode analyses, Figs 6(b) and 6(c), the 1987 winter pattern (Fig. 6(b)) was evidently not typical, being zonally symmetrical.

Fig. 6 Winter 1988 (June, July, August) 500 hPa height anomaly (dam) for (a) 1988 (b) 1987 (c) composite 1972, 1976-77, 1982.



Blocking activity

The winter daily Blocking Index* was high at mid-latitudes in the Pacific with intense blocks in the southeast towards Cape Horn as evident in Fig. 7. In July and August the mean Blocking Index (not shown) was markedly above average in the eastern Pacific to the western Atlantic.

In the western Pacific winter blocking was chiefly below average, although in the Australian region blocking was above average in August. Except for short periods in June, the Indian Ocean was free of blocking (Fig. 7).

Comparing the 1987 and 1988 winters, blocking in the eastern Pacific was significantly more frequent and intense in the latter year than the former. The 1988 blocks formed a dipole pattern as seen in Fig. 6(a).

Winds

The wind anomalies in the extratropics for the 850 hPa and 300 hPa levels are shown in Figs 8 and 9; these can be compared with wave trains in the mean sea level pressure in Fig. 4 and the 500 hPa height anomalies in Fig. 6(a) respectively. The wind anomalies were characterised by strong meridional patterns contrasting with the more zonal patterns prevailing in the 1987 warm episode winter. At the 850 hPa level (Fig. 8) a strong anomalous cyclonic pattern extending across the south Indian Ocean was a major feature.

*The Blocking Index (BI) values shown in Fig. 7 are derived from:

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

where U is the zonal wind component ($m\ s^{-1}$) and the subscript refers to latitude.

Fig. 7 Daily Blocking Index: time-longitude section at 55°S. Day 1 is 1 June 1988.

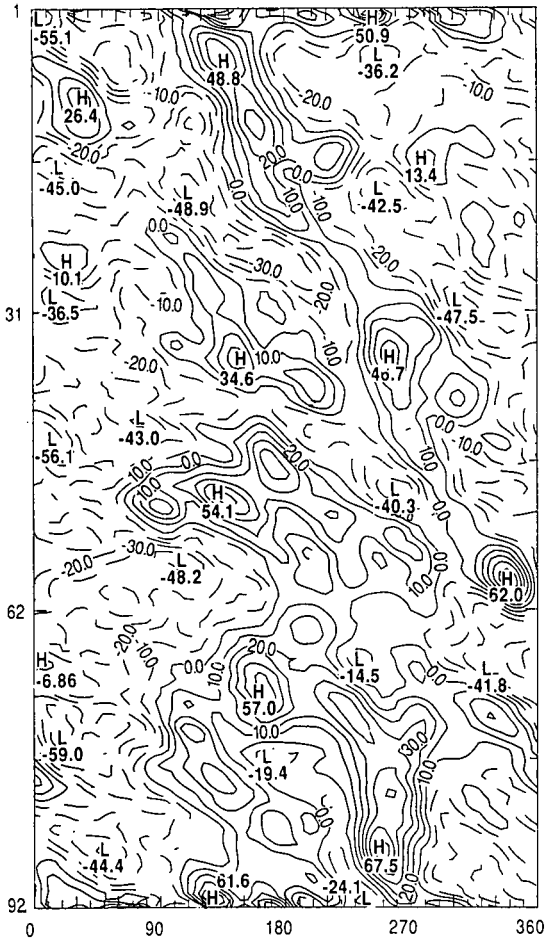


Fig. 8 Winter 1988 (June, July, August) 850 hPa wind anomalies ($m s^{-1}$).

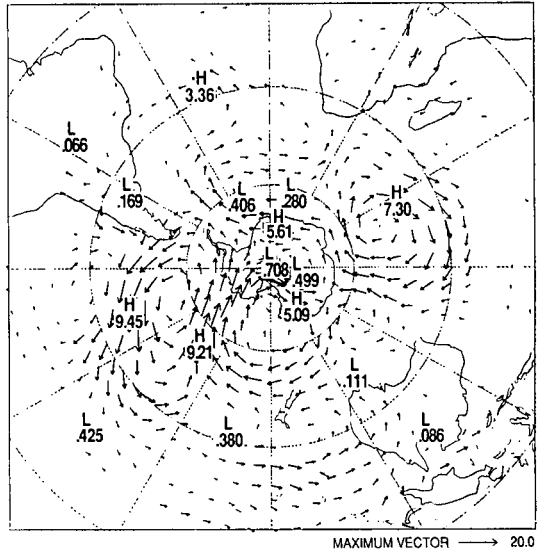
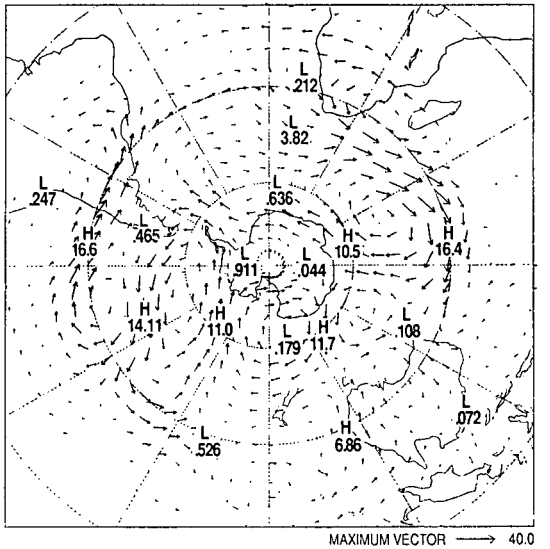


Fig. 9 Winter 1988 (June, July, August) 300 hPa wind anomalies ($m s^{-1}$).



In the Pacific at 850 hPa another strong cyclonic wind circulation extended meridionally from New Zealand southwards along the dateline over the Ross Sea to the South Pole (Fig. 8). To the east of this circulation was an intense anticyclonic circulation. These anomalies were generated by the anomalous systems depicted in Fig. 4.

Similar wind anomaly patterns were evident at 300 hPa (Fig. 9). Westerly wind anomalies were significantly strong in the southern Indian Ocean from South Africa to southwest Australia across the northern flank of the deep low height anomaly (Fig. 6(a)). The circulation around the involuted trough extending from the Pacific to the Atlantic (Fig. 6(a)) was also strong.

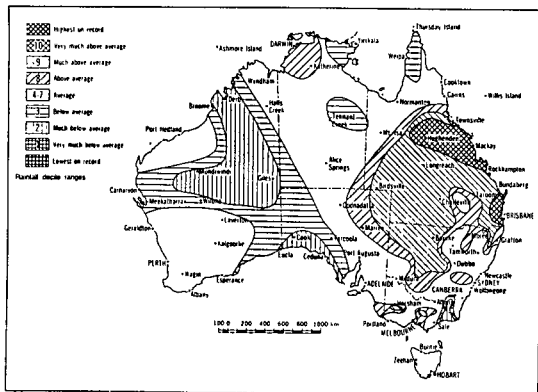
These patterns showed that marked meridional wind anomalies associated with deep planetary waves were a major feature of this cold episode winter. It appears that vigorous interaction between tropical and polar regions is characteristic of cold episode winters.

Australian conditions

Rainfall

In eastern Australia winter rainfall was chiefly above average with extensive areas of Queensland and New South Wales receiving totals in deciles 9–10 (Fig. 10) and this pattern was broadly consistent with a cold episode in the Pacific (Ropelewski and Halpert 1989). In August the

Fig. 10 Winter 1988 (June, July, August) rainfall in Australia: decile range values based on district averages.



South Coast district of Queensland received record district rainfall with many stations registering record totals for that month.

In Western Australia average winter seasonal rains were received, although in extensive areas of the east and north of that State winter rainfall was below average.

The abundant rains in Queensland and New South Wales were received in two wet periods: the first week in July and the third week in August. In each period a cut-off surface low was associated with a deep upper trough.

It is notable that the MSL subtropical high pressure ridge was generally further north than normal on the east coast. Nicholls (1988), in noting the increase in rainfall with a more northerly position of the ridge, indicated that its movement north of normal latitude may be determined, to some extent at least, by the magnitude of the sea surface temperature gradient off the northwest coast of the continent. This gradient was seen to be above average during the 1988 winter, and could be linked to the above average rainfall received in eastern Australia.

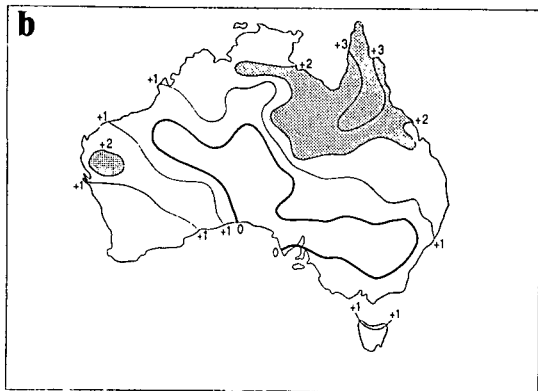
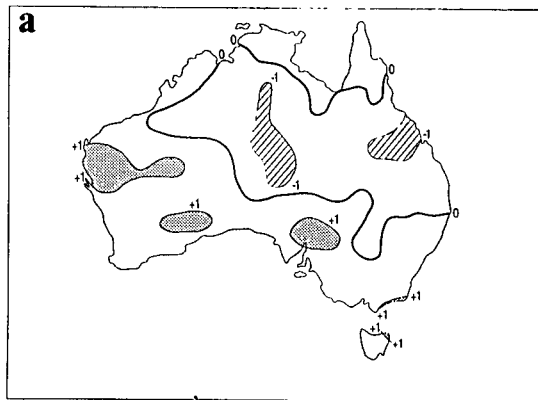
Temperatures

Winter mean temperatures were chiefly above average over Australia. This was consistent with above normal sea surface temperatures in the Indian Ocean and around the coast of the continent where positive anomalies (up to 2°C) were common.

Maximum temperatures were above average (+1°C) in parts of Western Australia and in south-eastern areas of the continent (Fig. 11(a)). Highest July mean monthly maxima on record occurred at many places in Tasmania as well as near record means at places on the southeast mainland. Parts of the interior and northeast had below average maxima (-1°C), resulting from greater cloud coverage and rainfall.

Minimum temperatures were above average throughout the continent (Fig. 11(b)). Positive anomalies of 3°C occurred in the northeast where some places in Queensland and the Northern Territory recorded highest ever August mean monthly minima. These positive anomalies could be related to above normal cloud coverage and humidity at night accompanied by higher than normal rainfall.

Fig. 11 Winter 1988 (June, July, August) temperature anomalies (°C) for Australia (a) maximum (b) minimum.



Concluding remarks

The establishment of an anomalous cold episode in the eastern equatorial Pacific occurred in conjunction with anomalous warming in the tropical Indian Ocean. This indicated that the main source of tropical energy had transferred from the Pacific to the Indian Ocean; and the process could be linked to above normal planetary wave trains in the extratropics.

The extratropical patterns characterising the 1988 winter cold episode featured deep planetary wave developments. These 1988 winter patterns could be distinguished from the zonally symmetrical 1987 winter warm episode. A characteristic feature of the 1988 winter was the anomalously intense southeast Pacific anticyclone accompanied by enhanced blocking activity.

In the Australian region systems were generally active, and the mainly average to above average rainfall and temperatures were related to anomalous meridional tropospheric circulations.

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Appendix

Data sources for this review were:

Climate Analysis Center (CAC) Climate Diagnostics Bulletins, June, July, August 1988 and seasonal analyses.*

Darwin Tropical Diagnostic Statement, June, July, August 1988.†

Monthly Report on Climate System, June, July, August 1988.§

National Climate Centre Climate Monitoring Bulletin — Southern Hemisphere, June, July, August 1988.‡

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, Australia.

§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.

