

# Seasonal climate summary southern hemisphere (spring 1988): the cold episode in the central/eastern tropical Pacific intensifies

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An analysis of the southern hemisphere circulation for the austral spring, September to November 1988, is presented. More detailed treatment is given to the Australian region bounded by the equator, Antarctica, longitude 90°E and the dateline. Tropical and extratropical anomalies in the southern hemisphere circulation are discussed along with their relevance to the cold episode which increased in intensity during this season.

## Introduction

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

The cold episode further intensified in spring with the Southern Oscillation Index reaching its highest value since 1975.

This climate summary reviews the southern hemisphere circulation for the austral spring season. Tropical climatic indicators and southern hemisphere circulation features at upper and lower levels are discussed. A description of Australian rainfall and significant rainfall anomalies in other parts of the hemisphere is also provided along with comments on temperature anomalies in the Australian region. A summary of the main circulation features for the season is also given.

## Data

Many data sources were used in the preparation of this climate summary and these are described below.

Southern Oscillation Index values were calculated from synoptic reports of mean sea level pressure (MSLP) for Darwin and Tahiti. The long-term means used in the derivation of the index were obtained from a data set compiled by

the National Climate Centre, Melbourne.

Anomalies of sea surface temperature, low and upper-level wind and outward long wave radiation in the tropical Pacific region were taken from Climate Analysis Center Climate Diagnostics Bulletins.

Sea surface temperature anomalies for the Australian region were obtained from Darwin Tropical Diagnostics Statements.

The analysis of anomalous sea temperature integrated to 150 m for the Pacific basin was based on bathythermograph messages (submitted under the Integrated Global Ocean Services System and transmitted worldwide using the Global Telecommunications System) and the climatology of Levitus (1982).

Mean and anomaly fields for the southern hemisphere were derived from daily 2300 UTC grid-point operational analysis data archived by the World Meteorological Centre, Melbourne. The base period for the calculation of anomalies was 1977–86. The southern hemisphere daily Blocking Index was derived from 1100 UTC and 2300 UTC southern hemisphere grid-point analysis data.

Australian monthly and seasonal rainfall decile maps were obtained from Monthly Rainfall Reviews produced by the National Climate Centre, Melbourne; the maps were based on district average monthly rainfall data archived by the Centre.

**Table 1. Values of the Southern Oscillation Index for the period January 1986 to November 1988.**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1986	7	-12	0	1	-6	8	2	-7	-5	6	-13	-15
1987	-7	-14	-16	-22	-20	-18	-18	-13	-11	-6	-1	-6
1988	-2	-6	1	-1	10	-4	11	14	20	15	20	

Australian temperature anomaly analyses were produced using monthly means of daily maximum and minimum temperature extracted from synoptic reports, and long-term means published by the Bureau of Meteorology in 1988.

Further information on the data sources can be found in the Appendix.

## Discussion of the spring circulation

### Tropical climatic indicators

Comparison of tropical indicators for winter and spring of 1988 pointed to an intensification of the cold episode during spring. The Southern Oscillation Index\* (SOI) increased in the spring months and values of +20, +15 and +20 were recorded for September, October and November respectively (see Table 1). The figure of +20 was the highest since September 1975. Monthly mean MSLPs for Darwin for September, October and November were, respectively (anomaly in brackets), 1010.6(-1.4), 1009.1(-1.6) and 1007.1(-1.8) whilst those for Tahiti were 1016.1(+1.8), 1014.4(+0.8) and 1013.5(+1.7).

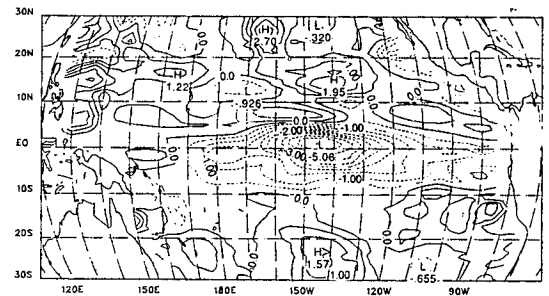
The areal extent of negative sea surface temperature anomalies in the central equatorial Pacific during spring was greater than that during the preceding winter. In October and November, the magnitude of the anomalies in this area also increased with several regions around the equator registering values lower than -3 degrees.

In the equatorial Pacific, low-level easterly and upper-level westerly wind anomalies which were present in winter, increased in magnitude during spring.

Anomalous outgoing long wave radiation (OLR) over the maritime continent and equatorial Pacific was consistent with other tropical climatic indicators. Over the maritime continent, there was a general increase in the magnitude of negative OLR anomalies from winter to spring indicating an enhancement of convection, whilst in the equatorial Pacific to the east of the maritime continent, the opposite occurred.

Figure 1 shows Pacific basin sea temperature anomalies integrated from the surface to 150 metres depth. A typical cold event pattern is exhibited with a cold anomaly in the central equatorial Pacific flanked by warm anomalies to the north and south, and a slight warm anomaly in the western Pacific. The magnitude of the maximum cold anomaly of 5°C seems too large and could be partially due to the climatology used in the analysis scheme.

**Fig. 1 Pacific basin sea temperature anomaly (°C) integrated from the surface to 150 metres depth, averaged for October and November.**



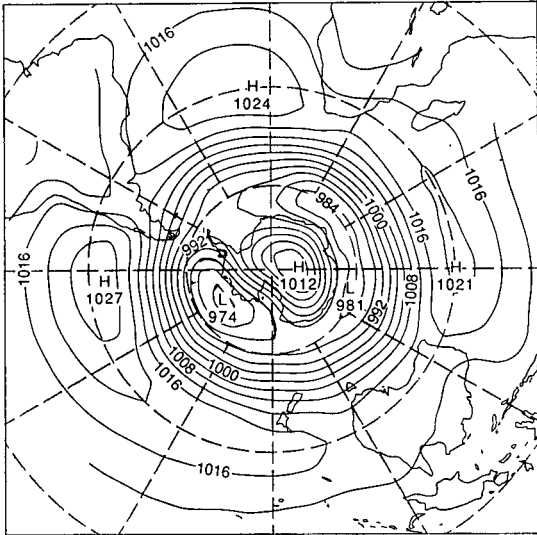
### MSLP and MSLP anomaly

Whereas the winter 1988 mean sea level pressure (MSLP) pattern exhibited a pronounced 3-wave pattern at mid-latitudes, the analysis for spring (Fig. 2) showed a 5-wave pattern with troughs located in the western and central Pacific, just to the east of the South American peninsula, south of South Africa and to the south of Western Australia. These troughs had relatively small amplitudes and the flow at mid to high latitudes was generally more zonal than normal.

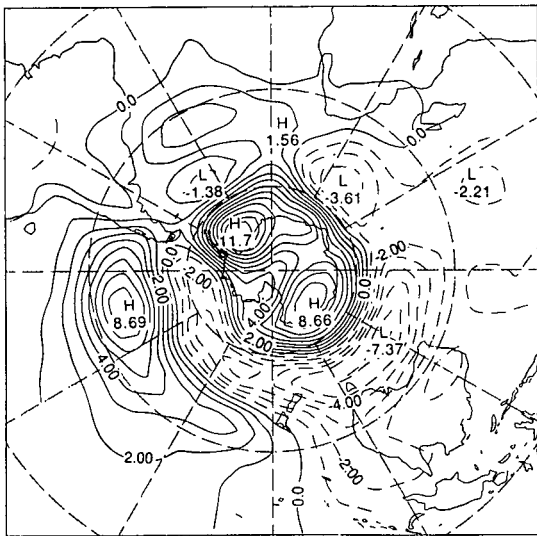
The MSLP anomaly pattern (Fig. 3) was dominated by a positive anomaly in the eastern South Pacific reflecting an intensified South Pacific anticyclone, and negative anomalies from about 40-60°S and extending eastwards from about 60°W eastwards to 150°W. The composite MSLP anomaly map of Van Loon and Shea (1987), for August to October in the year preceding a warm event, showed a similar distribution of pressure in

\*The SOI used here is 10 times the Tahiti minus Darwin monthly mean difference anomaly divided by the standard deviation of that difference for the relevant month, based on the period 1882-1985.

**Fig. 2 Spring (SON) mean sea level pressure (hPa) analysis.**



**Fig. 3 Spring (SON) mean sea level pressure anomaly (hPa) analysis.**



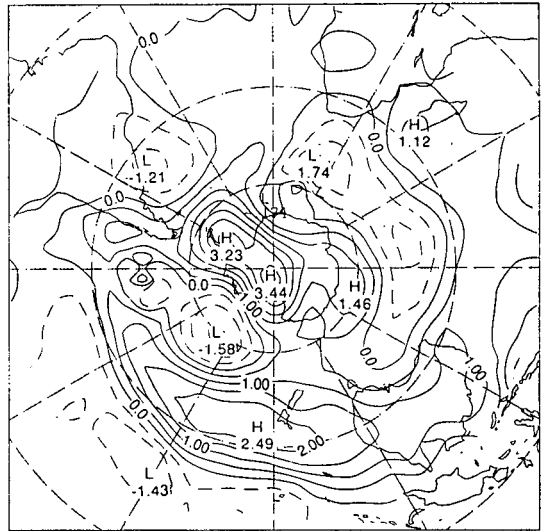
the Pacific and Indian Oceans at mid-latitudes. This is not surprising as the year preceding a warm event generally has mild cold episode characteristics with small negative SST anomalies in the equatorial Pacific (Van Loon and Shea 1987).

**Upper-level analysis**

**700 hPa temperature anomaly.** In the 700 hPa temperature anomaly analysis (Fig. 4), negative anomalies to  $-1.4^{\circ}\text{C}$  extended over much of the tropical Pacific. The anomalies were probably due

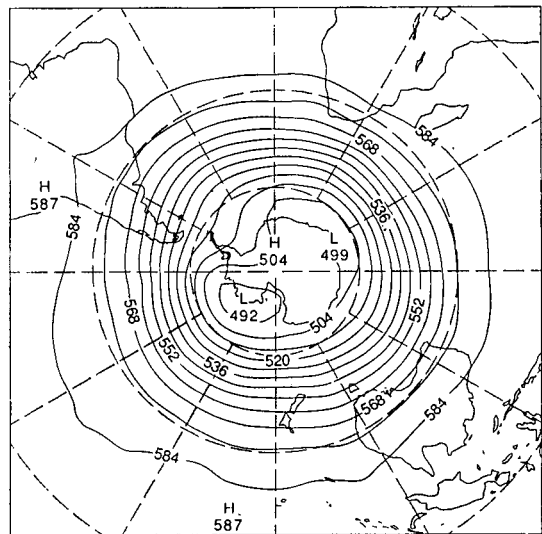
to the large region of negative sea surface temperature anomaly present during spring in the central equatorial Pacific. Widespread tropospheric cooling in the tropics associated with cold events was also found by Horel and Wallace (1981).

**Fig. 4 Spring (SON) 700 hPa temperature anomaly ( $^{\circ}\text{C}$ ) analysis.**



**500 hPa height.** The 500 hPa height analysis (Fig. 5) at subtropical to high latitudes, showed a high degree of zonality when compared with the preceding winter (Gaffney 1989) and the long-term pattern for spring.

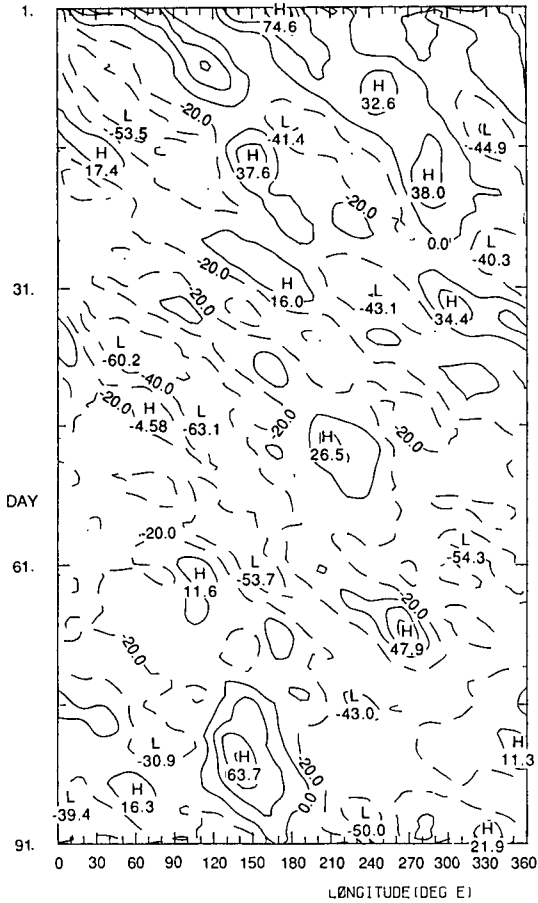
**Fig. 5 Spring (SON) 500 hPa height analysis (dam).**





and upper-level westerlies normally increase over central/southern Australia. However in October 1988, this increase occurred much further to the south.

**Fig. 9** Time-longitude section of the southern hemisphere daily Blocking Index. Day 1 is 1 September 1988.

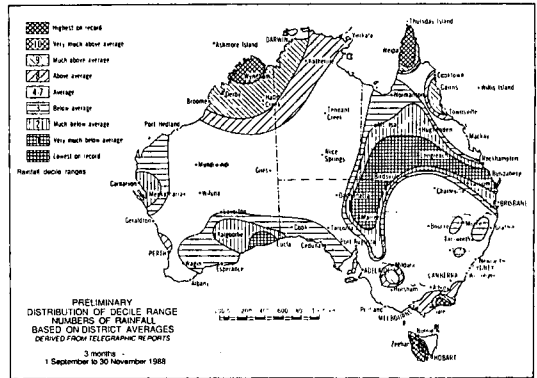


**Rainfall**

**Australian rainfall**

Well above average spring rainfall (Fig. 10) was received over northern west Australia and the Peninsula district of Queensland. This was consistent with the simultaneous SOI/rainfall correlation pattern found by McBride and Nicholls (1983). Southeastern Victoria and the south-western half of Tasmania also received significantly above average totals. Below average totals were registered over much of the southern half of Queensland, parts of eastern South Australia and

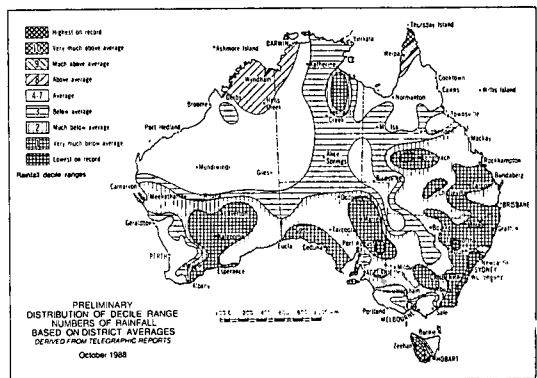
**Fig. 10** Spring (SON) rainfall in Australia: decile range values based on district averages.



southern Western Australia; the below average rainfall in the former two regions was not consistent with the above correlation pattern.

During October, rainfall (Fig. 11) was significantly below average over most of Australia. Below normal rainfall in the southern half of the continent may have been due to the fact that the strong westerlies did not penetrate as far north across Australia as normal for a cold event. The fronts appeared to stay well south bringing above average rainfall to the western half of Tasmania but not to more northern regions of the continent. Another contributing factor may have been the well below average blocking activity which was evident throughout the southern hemisphere during the month. The major subtropical land masses of the southern hemisphere receive a substantial portion of their winter and spring rainfall from cut-off lows associated with blocking high pressure systems, and below normal blocking may have produced a reduction in cut-off low activity in the Australian region.

**Fig. 11** October rainfall in Australia: decile range values based on district averages.



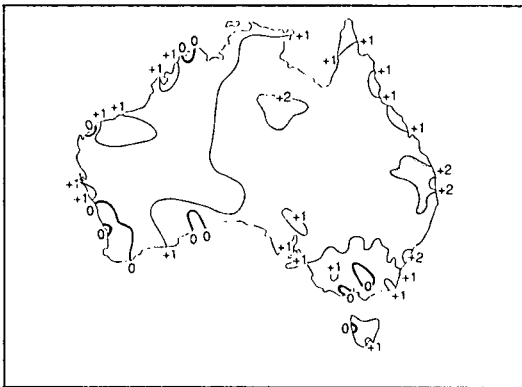
### Significant rainfall anomalies in other parts of the southern hemisphere

Rainfall anomalies within the lowest ten per cent on record were registered in parts of the central equatorial Pacific and northern Argentina. The rainfall in the former region was consistent with the precipitation pattern associated with the high index phase of the Southern Oscillation found by Ropelewski and Halpert (1989). Above normal seasonal rainfall in the Indonesian region inferred from OLR anomalies was also consistent with the high index precipitation pattern.

### Australian temperatures

Maximum temperature anomalies for spring (Fig. 12) were generally in the range +1 to +2°C over the eastern two-thirds of the continent. This could be related to the well below average spring rainfall which was recorded over much of this region. In the remainder of the continent, maximum temperature anomalies were also positive but mainly in the range of 0 to 1°C.

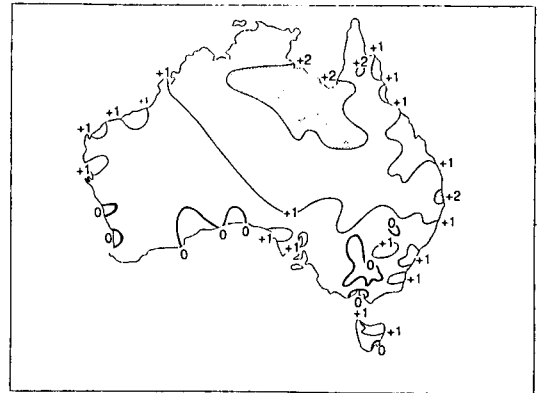
Fig. 12 Spring (SON) maximum temperature anomalies for Australia (°C).



Minimum temperatures were generally above normal over the continent (Fig. 13). Anomalies of magnitude 1 to 2°C affected the majority of Queensland and the Northern Territory, and parts of adjacent Western Australia and South Australia. In remaining areas, anomalies were generally in the range 0 to 1°C.

Above average SSTs (up to 2°C), which were present in the Australian region during spring, may have been partly responsible for the above normal maximum and minimum temperatures which affected most of the continent.

Fig. 13 Spring (SON) minimum temperature anomalies for Australia (°C).



### Summary

The negative sea surface temperature (SST) anomalies which were present over much of the equatorial Pacific during the southern winter, increased in both magnitude and extent during the following spring. This led to a more vigorous Walker circulation with strong low-level easterly and upper-level westerly wind anomalies in the central equatorial Pacific. The upper-level cyclonic couplet, straddling the equator in the central Pacific, which was evident in the southern winter, strengthened during spring and was associated with a weaker than normal subtropical jet over the South Pacific. The SOI during spring reached its highest value (+20 in September and November) since 1975. A feature of this season was the above normal zonality of the height anomalies at mid to high latitudes. Spring rainfall was significantly below average over parts of the southern half of Queensland, eastern South Australia and southern Western Australia, whilst well above average totals were recorded in western Tasmania, northern Western Australia and northern Queensland. Maximum and minimum temperatures were generally above normal over Australia during the season.

### References

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- Climate Analysis Center Climate Diagnostics Bulletin, June, July, August, September, October and November 1988.†
- Climate Analysis Center Weekly Climate Bulletin, 5 November 1988.†
- Darwin Tropical Diagnostics Statement, September, October and November 1988.§
- National Climate Centre Climate Monitoring Bulletin — Southern Hemisphere, September, October and November 1987; June, July, August, September, October and November 1988.‡
- Southern hemisphere grid-point analysis archived by the World Meteorological Centre, Melbourne.‡

## Appendix

### Further information on data sources

The data sources used for this review were:

- Bureau of Meteorology. 1988. *Monthly Rainfall Review*. (October and November 1988 issues.) Bur. Met., Australia.\*

\*Obtainable from the Bureau of Meteorology, GPO Box 1289K, Melbourne 3001, Australia.

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

