

Seasonal climate summary southern hemisphere (summer 1990–91): a strong Australian monsoon with record rainfall

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A climate analysis is given of the southern hemisphere summer circulation, December 1990 to February 1991, with more detailed treatment of the Australian region.

A strong monsoon occurred in the Australian region with record high summer rainfall over extensive areas of northern Australia and major floods. Positive sea-surface temperature anomalies expanded in the western equatorial Pacific and in the equatorial Indian Ocean, whereas negative anomalies were noted in an area off the coast of Peru. An extensive area of positive sea-surface temperature anomalies formed at mid-latitudes in the South Pacific. A four-wave planetary pattern was evident in the upper troposphere with an anomalously deep trough in the western Pacific and relatively weak troughs in the eastern Pacific, eastern Atlantic and Indian Oceans.

Introduction

This seasonal summary reviews the southern hemisphere climate for summer 1990–91 (December 1990 to February 1991 inclusive), with more detail relating to the Australian region. The main information source was the routine monitoring bulletins issued by the Bureau of Meteorology, Australia, and reference was also made to climate bulletins issued by other national meteorological services. Data sources are specified in the Appendix.

Climate indices

The transition from spring 1990 (see Gaffney 1991) to summer 1990–91 saw only minor changes in the main tropical climate indices. The Southern Oscillation Index (SOI)* was near zero as shown in Fig. 1, and the index had been close to zero during the latter half of 1990.

As in the case of the SOI, the other climate indices used for monitoring the El Niño — Southern Oscillation phenomenon remained chiefly near average. Broadly, the climate indices were not showing any persistent trends at the end of summer. In particular, the sea-surface temperatures (SST) were not giving any clear signals in this regard, even though nearly four years had elapsed since the previous substantial El Niño episode in 1987 (see, for example, Philander (1990)).

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*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. 1 Southern Oscillation Index, January 1986 to February 1991 inclusive.

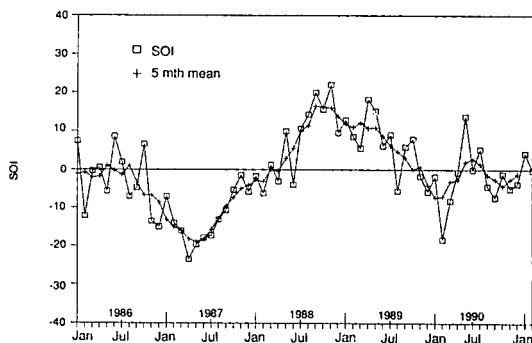
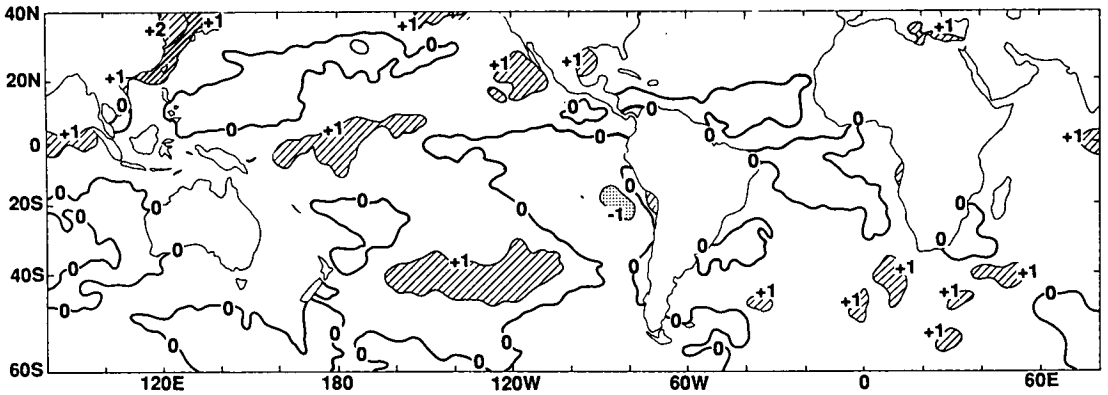


Fig. 2 Summer 1990–91 (December, January, February) sea-surface temperature anomaly (°C).



Sea-surface temperatures

In the western equatorial Pacific there was an extension of positive SST anomalies from spring into summer. The summer SST anomalies are depicted in Fig. 2 and indicate an extensive area of positive SST anomaly stretching across the equatorial dateline towards the central Pacific. An area of negative SST anomaly was seen in the eastern South Pacific to the southwest of Peru, with a positive anomaly along the coast of that country.

Similarly in the equatorial Indian Ocean, there was an expansion of positive SST anomalies from spring into summer. As seen in Fig. 2, a band of positive anomalies extended along the equator from south of India to Sumatra.

At mid-latitudes in the South Pacific, a relatively wide band of positive SST anomalies emerged in summer (Fig. 2). Across the Atlantic to the western Indian Ocean there were also positive anomalies.

Surface analysis

The mean sea level pressure analysis is shown in Fig. 3 and the corresponding anomalies are in Fig. 4. As seen in Fig. 3, the subtropical oceanic high pressure systems were along latitude 30°S, slightly south of normal.

Notable features of the anomalies in Fig. 4 were:

- (a) the continuing intense high pressure centre at mid-latitudes in the southeast Pacific;
- (b) the deep low pressure centre at high latitudes in the western Pacific; and
- (c) the mainly low pressure centres in Antarctica.

Upper air analysis

The 500 hPa analysis and anomalies in Figs 5 and 6 showed a four-wave pattern with a deep tilting trough in the western Pacific. Weak troughs occurred in the eastern Pacific, eastern Atlantic and the central Indian Oceans.

Features of the anomalies in Fig. 6 were:

- (a) the strong positive height departures in the eastern Pacific and the strong negative departures in the western Pacific corresponding to the surface anomalies (Fig. 4); and
- (b) the relatively small height departures elsewhere.

At 300 hPa (Figs 7 and 8), a corresponding four-wave pattern could be seen. The west Pacific trough remained strong while the other three troughs were weak.

Fig. 3 Summer 1990–91 (December, January, February) mean sea level pressure (hPa).

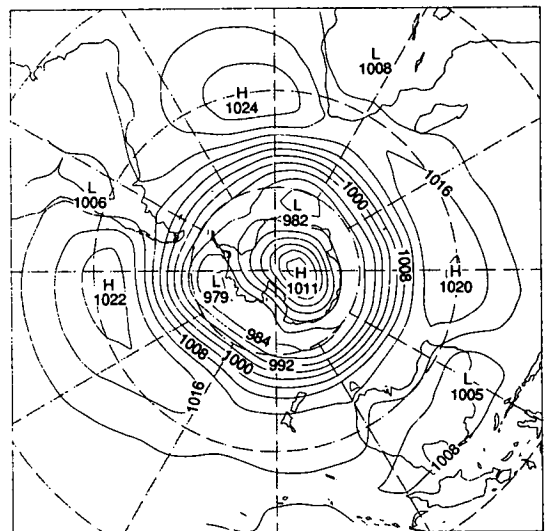


Fig. 4 Summer 1990-91 (December, January, February) mean sea level pressure anomaly (hPa). Dashed lines are negative.

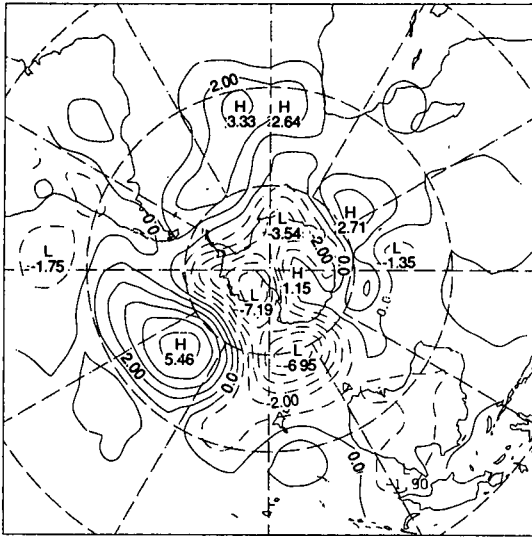


Fig. 6 Summer 1990-91 (December, January, February) 500 hPa height anomaly (dam). Dashed lines are negative.

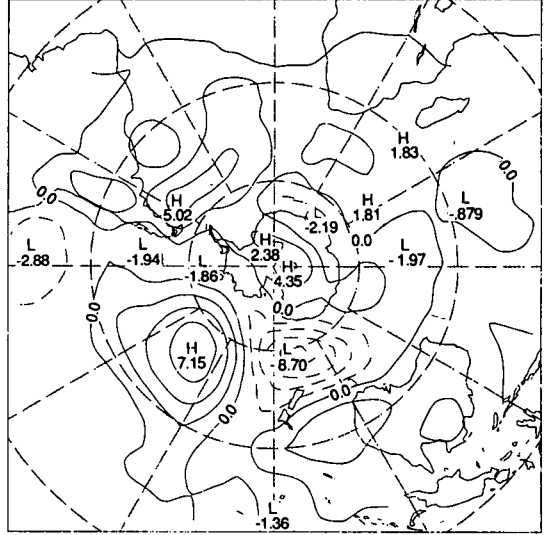


Fig. 5 Summer 1990-91 (December, January, February) 500 hPa mean height (dam).

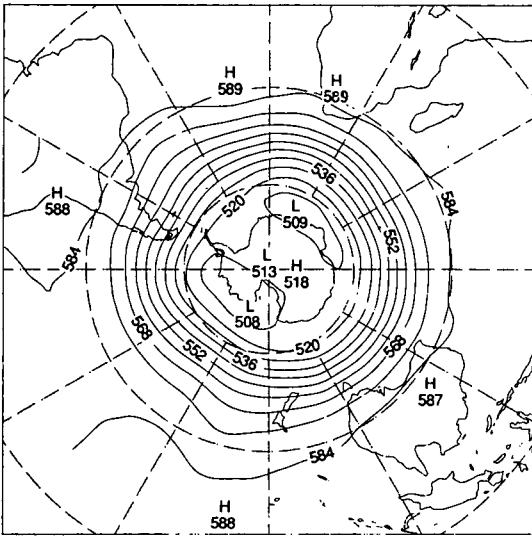
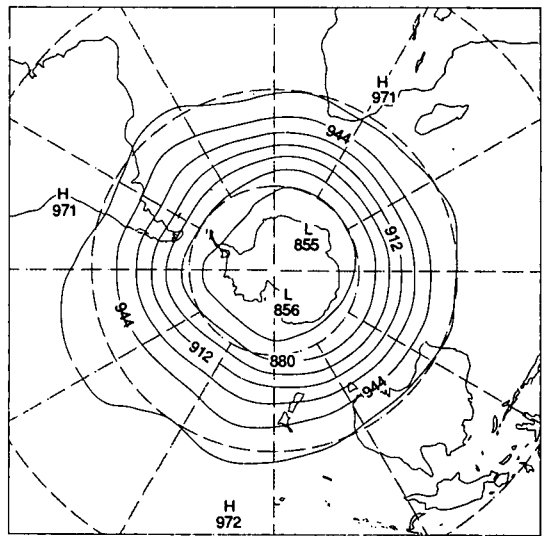


Fig. 7 Summer 1990-91 (December, January, February) 300 hPa mean height (dam).



Blocking

Blocking activity around the hemisphere, as measured by the daily Blocking Index (BI)*, is given in Fig. 9.

*Blocking Index (BI):

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

where U is the 500 hPa mean zonal wind and the subscript is the corresponding latitude.

In December, blocking was generally weak with zonal circulation prominent during most of the month (Fig. 9).

During January the western Pacific showed strong blocking activity. A little blocking occurred in the Atlantic in January, but in the Indian Ocean the flow was zonal throughout the month.

In February, apart from one blocking episode in the Atlantic during mid-month, flow was chiefly zonal around the hemisphere (Fig.9).

Fig. 8 Summer 1990-91 (December, January, February) 300 hPa height anomaly (dam). Dashed lines are negative.

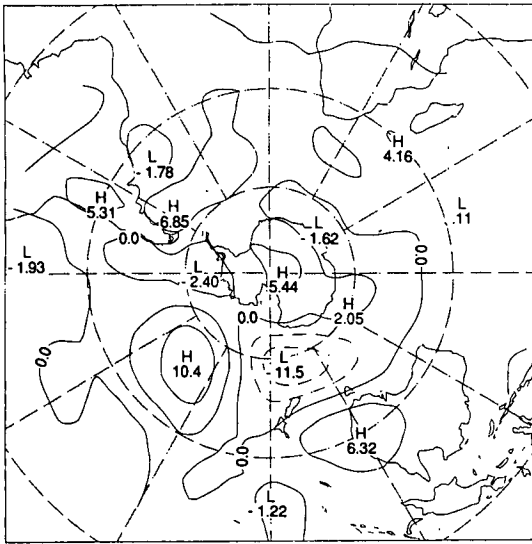


Fig. 9 Summer 1990-91 daily Blocking Index; time-longitude section. Day 1 is 1 December 1990.

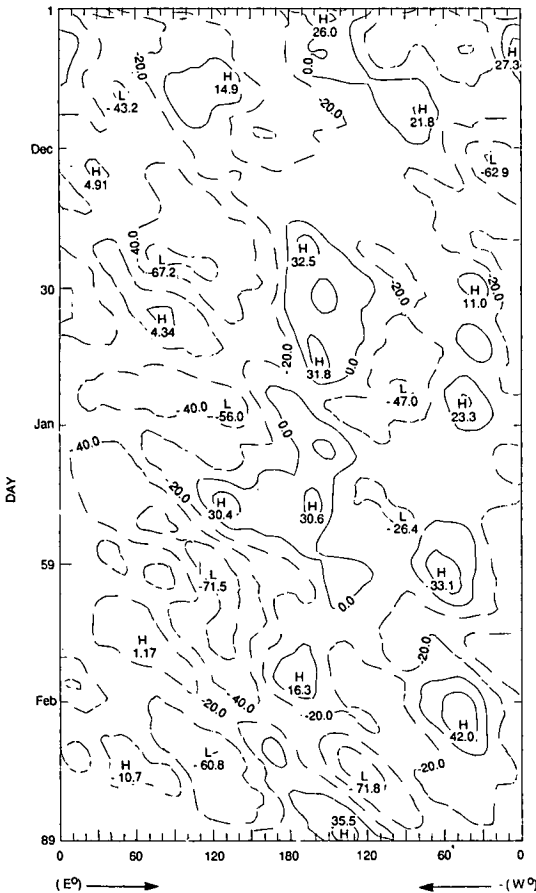


Fig. 10 Summer 1990-91 (December, January, February) 850 hPa wind anomalies ($m s^{-1}$). (The figures near the H and L are values at respective locations.)

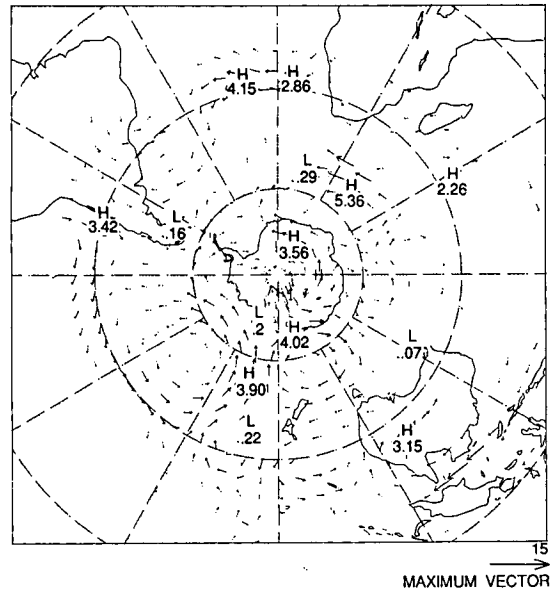
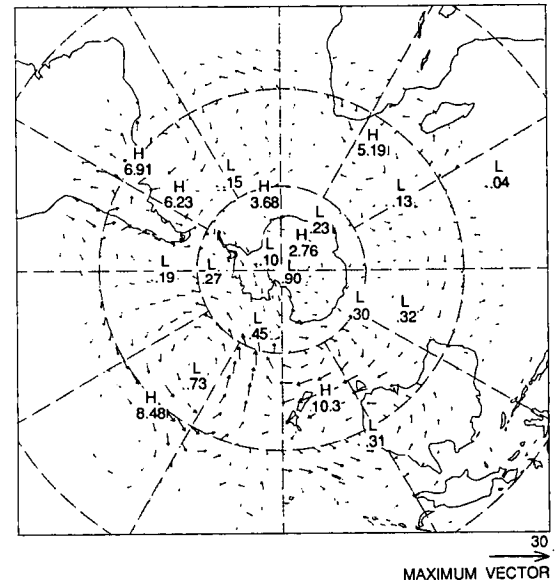


Fig. 11 Summer 1990-91 (December, January, February) 300 hPa wind anomalies ($m s^{-1}$). (The figures near the H and L are vector values at respective locations.)



Winds

Wind anomalies in the lower troposphere at 850 hPa, shown in Fig. 10, may be related to the surface pressure anomalies in Fig. 4. The strong wind anomalies in the Pacific indicate the intensity of the systems over that ocean. Elsewhere wind anomalies at this level were chiefly light.

Fig. 12 200 hPa velocity potential for February 1991 ($m^2 s^{-1} 10^{-6}$).

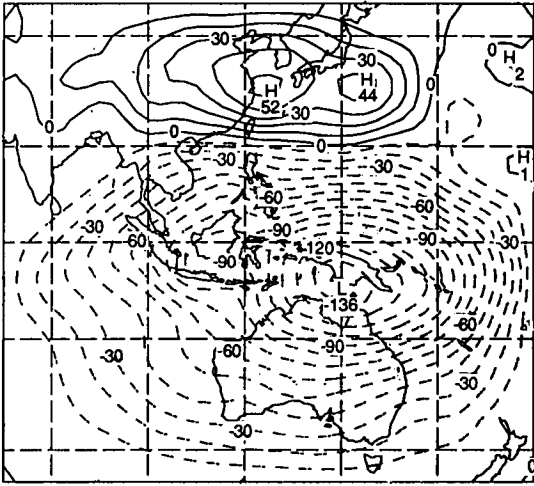


Fig. 13 Summer 1990-91 (December, January, February) rainfall in Australia: decile range values based on district averages.

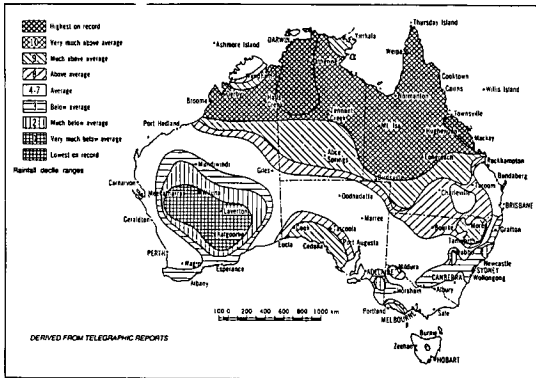
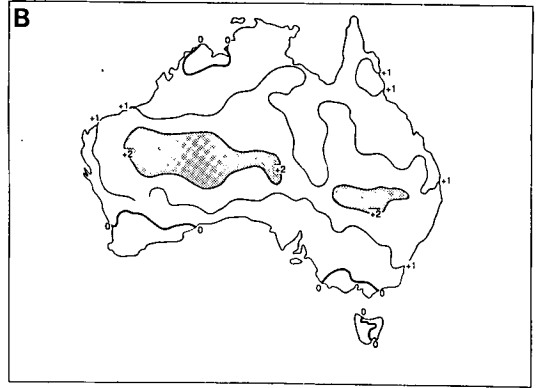
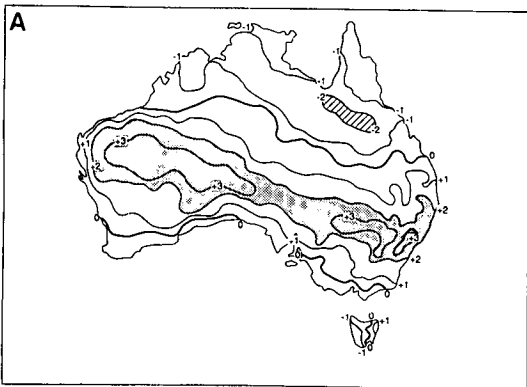


Fig. 14 Summer 1990-91 (December, January, February) temperature anomalies ($^{\circ}C$) Australia: (a) maximum; (b) minimum.



Likewise the upper troposphere (300 hPa) wind anomalies in Fig. 11 relate to Fig. 8. The main features of the upper level wind anomalies were:

- (a) the strong anomalies in the Pacific; and
- (b) the chiefly weak anomalies elsewhere.

Australian region

Circulation

During January and February the ascending arm of the Walker Circulation was well developed in tropical northeastern Australian longitudes, as a velocity potential minimum centre moved southwards from the equator towards northeast Australia. The velocity potential for February, shown in Fig. 12, illustrates this pattern. Positive equatorial SST anomalies to the northwest and northeast of Australia were inductive to convection. Enhanced monsoonal activity occurred, resulting in record heavy February rains in areas of northern Australia.

Rainfall

Summer rainfall was significantly above normal over northern Australia with a vast expanse in decile range ten (Fig. 13), including large areas with highest on record seasonal rainfall. As indicated above, these rains were related to the strong ascending arm of the Walker Circulation linked to the strong negative velocity potential (Fig. 12). In contrast, much of the southern half of Western Australia was in decile range one.

Temperatures

Maximum temperature positive anomalies stretched in a wide band from the northwest coast across the interior to the southeast coast, as shown in Fig. 14(a). This reflected the generally dry conditions across this region. Negative anomalies in the north of the continent were consistent with the strong monsoon.

Minimum temperature anomalies were positive from the west coast across the interior to the east coast, depicted in Fig. 14(b). These positive anomalies were evidently linked to the above normal maxima across the region.

References

- Gaffney, D. 1991. Seasonal climate summary southern hemisphere (spring 1990); chiefly warm anomalies in the tropics and mid-latitudes. *Aust. Met. Mag.*, 39, 191–6.
- Philander, S.G. 1990. *El Nino, La Nina, and the Southern Oscillation*. Academic Press, Inc. San Diego.

Appendix

Data sources used for this review were:
 Climate Analysis Center—Climate Diagnostics
 Bulletin*
 Darwin Tropical Diagnostic Statement†

Monthly report on Climate System§
 National Climate Centre—Climate Monitoring
 Bulletin—Southern Hemisphere‡
 Southern hemisphere grid-point analysis data archived by the World Meteorological Centre, Melbourne‡

Obtainable from:

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

†Northern Territory Regional Office, Bureau of Meteorology, PO Box 735, Darwin 0801, Australia.

§Japan Meteorological Agency, 1–3–4, Ote-machi chiyoda-ku, Tokyo, Japan.

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