Seasonal climate summary southern hemisphere (summer 1996/97) : a weak positive phase of the Southern Oscillation (La Niña) reaches its peak

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Southern hemisphere circulation patterns and anomalies for summer (December-February) 1996/97 are reviewed, with emphasis given to Pacific basin climate indicators and Australian rainfall and temperature patterns. Weak positive phase conditions which had persisted during winter and spring reached a peak in terms of Pacific basin indicators during the summer period, and average to above average rainfall across much of Australia was associated with an active monsoon. Temperatures tended to be below normal across the north of the country and above normal in southern areas, particularly in the second half of the season which was abnormally hot.

Introduction

There had been some waxing and waning of weak La Niña conditions across the Pacific basin during much of 1996, but there was somewhat of a resurgence during summer (DJF). The Troup Southern Oscillation Index (SOI)* hovered near +10, the tropical Pacific Walker Circulation was enhanced, and sea-surface temperatures (SSTs) in the central and eastern equatorial Pacific were weakly cooler than normal. This summary reviews the southern hemisphere and equatorial climate patterns of summer 1996/97, with particular attention given to the Australasian and Pacific region.

The main sources of information were the Climate Monitoring Bulletin (Bureau of Meteorology, Australia), and the Climate Diagnostics Bulletin (Climate Prediction Center (CPC), Washington). Data sources are given in the Appendix.

Pacific basin climate indices

The Troup Southern Oscillation Index (SOI)
The downward trend in the SOI during spring (de Hoedt 1997) was arrested during summer to a near neutral or slightly positive trend (Fig. 1). The individual monthly values of the SOI during the season were +7.2 (Dec), +4.1 (Jan), and +13.3 (Feb) which was the highest

*The Troup SOI 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 1933-1992.
Outgoing long wave radiation

Figure 2, adapted from CPC (1997), shows the monthly standardised anomaly of outgoing long wave radiation (OLR) from January 1993 to February 1997. These data are compiled by the CPC in Washington, and are an indication of the amount of long wave radiation emitted from an equatorial region centred about the date-line. Tropical convection in this region is particularly sensitive to changes in the phase of the Southern Oscillation; during warm (El Niño) events convection is generally more prevalent resulting in a reduction in the intensity of the OLR due to the lower effective black-body temperature, and the reverse applies in cold (La Niña) events. Most of the period since the beginning of 1995 has been characterised by positive values of the index and weak to moderate La Niña conditions. During the summer 1996/97 period a slight falling trend was observed although the values of the index were close to neutral.

Oceanic patterns

Sea-surface temperatures (SSTs). Negative anomalies of the order of 0°C to -1°C were analysed in the eastern equatorial Pacific, consistent with a weak La Niña pattern (Fig. 3). There was only slight variation of this pattern between the individual months, although the anomalies appeared to lose intensity during February following a peak in magnitude around January. Positive anomalies of similar magnitude covered the western tropical Pacific as well as waters immediately north of Australia.
and around Indonesia. An interesting feature was the persistence of positive anomalies of +1°C to +2°C along latitude 30°S, possibly associated with a stronger than normal subtropical ridge. Monthly charts appear to show propagation of these anomalies eastwards towards, and then northwards along the west coast of South America.

**Subsurface patterns.** Figure 4 shows the anomaly in metres of the depth of the 20°C isotherm along the equatorial Pacific between January 1994 and February 1997. This isotherm is generally situated very close to the equatorial ocean thermocline, the region of greatest temperature gradient with depth, or the boundary between the upper ocean warm water and the deep ocean cold water. During summer, the eastern equatorial Pacific Ocean was characterised by negative anomalies indicating a shallower than normal thermocline and generally cooler than normal water — a situation consistent with a Pacific cool (La Niña) episode. The negative anomaly close to the South American coast reached its peak magnitude in early to mid-January in line with the variation of SST anomalies. Positive anomalies dominated much of the western Pacific and there appears to be an eastwards propagation of a positive anomaly from a peak near 160°E in early January. This wave had reached the eastern Pacific by the end of February.

**Fig. 4** Time-longitude section of monthly anomalous depth of 20°C isotherm at the equator from January 1994 to February 1997. Contour interval is 10 m.

**Surface analyses**

Figures 5 and 6 show the mean and anomalous summer 1996/97 MSLP patterns respectively. Anomalies are deviations from an eleven-year (1979-1989) global climatology from the European Centre for Medium-range Weather Forecasts.

**Fig. 5** Summer 1996/97 (December, January, February) mean sea-level pressure (hPa).

**Fig. 6** Summer 1996/97 (December, January, February) mean sea-level pressure anomaly (hPa).
Weather Forecasts (ECMWF). A three-wave pattern was evident in the seasonal mean with long wave troughs at middle to high latitudes being located over the eastern sides of the major ocean basins. Pressures were generally higher than average over much of the hemisphere south of around 30°S indicating an enhanced subtropical ridge and weakened circumpolar vortex. MSLP was marginally above normal across eastern Australia, and a little lower than average in the west. However, there was some significant monthly variability within the season with marked positive anomalies predominating in January, and conversely, widespread negative anomalies over much of the continent in February.

Upper-level analyses

500 hPa analyses
Figures 7 and 8 show the mean and anomalous summer 1996/97 500 hPa patterns respectively. The mean flow shows a three-wave pattern, similar to the MSLP, and the pattern of anomalies, though rather diffuse, indicates a generally stronger than normal subtropical ridge.

Blocking
Figure 9 is a time-longitude section of the daily southern hemisphere Blocking Index (BI) (Wright 1993), measuring the strength of the 500 hPa flow at mid-latitudes relative to that at subtropical and high latitudes. There was little in the way of significant blocking (positive index values) around the hemisphere during summer, a situation typical for the season as shown by the individual monthly analyses. The most significant event in the period occurred in Tasman Sea longitudes during...
the first half of January and another event of shorter duration occurred in the same region later in the month and into February. Blocking Index values were significantly higher than normal in January between 130°E and 170°W, and markedly less than usual, i.e. more zonal, between 110°W and 60°W.

**Winds**

Low-level (850 hPa) and upper-level (200 hPa) wind anomalies are shown in Figs 10 and 11 respectively. Low-level tropical easterlies were stronger than normal across the central and western Pacific – a feature consistent with an enhanced Walker circulation and weak La Niña event. The eastern Pacific was characterised by near neutral or very weak westerly anomalies. Upper-level analyses also imply a stronger than normal Walker circulation with westerly anomalies being analysed across much of the equatorial Pacific. These patterns of anomalies were stable throughout the summer season with only slight month-to-month variations.

Other features at 850 hPa generally reflect the MSLP anomalies shown in Fig. 6, the most noteworthy features being flow from the northerly quarter across much of Australia, and the strong monsoon westerlies or northwesterlies south of Indonesia and northwest of Australia. The most significant feature in the upper atmosphere near Australia was the strong anticyclonic anomaly located near the southwest of Western Australia. Significant easterly anomalies on the northern flank of this circulation affected much of tropical Australia and were associated with the well-developed monsoon.

**Australian region**

**Circulation and rainfall**

A well-developed monsoon circulation was responsible for average to above average summer rainfall totals across much of northern and central Australia. Record high summer totals were established in parts of Western Australia, Northern Territory, Queensland, and South Australia. Tropical moisture penetrated southern latitudes on occasions resulting in heavy rainfall and above normal seasonal totals over parts of Western and South Australia, as well as New South Wales. Below average totals were confined to relatively small areas, the most significant being parts of southern Victoria which experienced one of the driest summers for the past 50 years. A below normal summer total was also registered across other parts of the southeast including northern Tasmania, some areas of eastern and northern Queensland, and over the Nullarbor border region of Western Australia and South Australia. The national distribution of summer rainfall totals is shown in Fig.12, and the distribution of summer rainfall decile ranges is shown in Fig. 13.

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Fig. 10 Summer 1996/97 (December, January, February) 850 hPa vector wind anomalies (m s⁻¹).
Fig. 11  Summer 1996/97 (December, January, February) 200 hPa vector wind anomalies (m s$^{-1}$).

Floodling was quite common during the summer, particularly in northern areas which were influenced by tropical cyclones. Record December rainfall in the north Kimberley was largely due to the passage of tropical cyclone Phil which moved on a westerly trajectory after genesis over the Gulf of Carpentaria. Much of tropical Australia recorded over 400 mm of rain in January, and Western Australia was affected by tropical cyclone Rachel which caused flooding on the coast and in the interior. Severe flooding occurred in and around Broome when 400 mm fell in less than 24 hours towards the end of the month. In early February three States were simultaneously affected by serious to severe flooding: within the first eight days of the month more than 300 mm fell in the Pilbara in Western Australia, 200 to 300 mm was recorded near Charleville in Queensland, and 150 to 200 mm was reported near Clare in South Australia. Also in February, tropical cyclones Gillian and Ita produced heavy rain and flooding along the Queensland coast.

Fig. 12  Summer 1996/97 (December, January, February) rainfall totals (mm) in Australia.

Fig. 13  Summer 1996/97 (December, January, February) rainfall in Australia: decile range values based on grid-point values over the period 1900 to 1997.
Fig. 14 Summer 1996/97 (December, January, February) maximum temperature anomalies (°C) for Australia based on a 1982-1996 mean.

Fig. 15 Summer 1996/97 (December, January, February) minimum temperature anomalies (°C) for Australia based on a 1982-1996 mean.

Temperatures
Mean maximum and minimum temperature anomalies for summer 1996/97 are shown in Figs 14 and 15 respectively. Persistent cloudiness in association with the active monsoon, caused significant negative maximum temperature anomalies over the northern half to two-thirds of the continent. The greatest departures, generally of the order of -2°C to -3°C occurred in Western Australia, the Northern Territory, and far northeast Queensland. Anomalies approaching -4°C were recorded in parts of the Pilbara. In contrast, low-level northerly quarter wind anomalies resulted in positive departures in many southern areas. These were mostly in the range +1°C to +2°C over most of Victoria, and in the south of both New South Wales and South Australia.

Anomalies in this region would have been even higher had it not been for a relatively cool December. In fact departures increased during the season in southern areas, and were generally near +4°C during February which saw heat-wave conditions during the first half of the month.

Minimum temperatures were above normal in most areas with the exception of central and northern Western Australia, the north of the Northern Territory, and along much of the east coast. Anomalies in the +1°C to +2°C range were widely observed over central and southeastern Australia.

References


Appendix
Data sources used for this review were:
National Climate Centre, Climate Monitoring Bulletin - Australia.*
Climate Prediction Center (CPC), Climate Diagnostics Bulletin. †

Obtainable from:
*National Climate Centre, Bureau of Meteorology, GPO Box 1289K, Melbourne Vic. 3001, Australia.
†Climate Prediction Center (CPC), National Weather Service, Washington D.C., 20233, USA.