Seasonal climate summary southern hemisphere (summer 1998/99): a weak cold event (La Niña) in the Pacific basin

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Southern Hemisphere circulation patterns for summer 1998/99 (December-February) are reviewed, with emphasis given to the tropical Pacific and the Australian region. The cold event conditions which had been developing through the winter and spring of 1998 ceased intensification during the summer, with some signs of a decline late in the summer. An enhanced Walker circulation remained in place in the western and central equatorial Pacific. Sea-surface temperatures remained cooler than normal in the central equatorial Pacific, and returned to near normal in the eastern Pacific after having been warmer than normal throughout 1998. The resultant pattern, whilst it was best described as a La Niña, differed significantly from the ‘classic’ La Niña situation.

It was a notably wet summer in the northern two-thirds of Western Australia. Over much of the remainder of the country rainfall for the season was close to normal. Mean maximum temperatures were generally above average in southern Australia and below average in northern Australia, with mean minimum temperatures above average over most of the country.

Introduction

Climate patterns across the Pacific Ocean continued the weak cold (La Niña) event that has been in place since winter 1998 (Collins 1999). Most of the indicators of Pacific climate remained fairly stable through the summer of 1998/99, suggesting that this portion of the event is at or near its peak. Trends late in the season suggested a possible return towards near-neutral conditions. The Southern Oscillation Index (SOI) and sea-surface temperature anomalies in the Pacific remained near the levels established during the preceding winter and spring, although the remnant warm anomalies in the eastern Pacific continued to weaken. Subsurface ocean temperatures remained below normal through the central and eastern equatorial Pacific, but the magnitude of anomalies moderated somewhat from those observed in mid-1998.

Wind anomalies in the lower and upper atmosphere indicated an enhanced Walker circulation in the western and central equatorial Pacific, with easterly anomalies at lower levels and westerly anomalies at upper levels. There was also suppressed convection, as indicated by enhanced outgoing long wave radiation, in the central equatorial Pacific. The convection and wind signals are both consistent with the existence of a La Niña. Neither signal was evident in the eastern Pacific.

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The main sources of information were the Climate Monitoring Bulletin (Bureau of Meteorology, Australia) and the Climate Diagnostics Bulletin (Climate Prediction Center, Washington).

Pacific basin climate indices

The Southern Oscillation Index (SOI)
The mean value of the SOI for summer was +12.5, with values for the months of December, January and February of +13.3, +15.6 and +8.6 respectively. This continued the period of positive SOI values which commenced in May 1998, after the rapid transition from a negative to a positive phase between April and June 1998. Figure 1 shows this period of consistently positive SOI values, which followed a prolonged period of negative values associated with the strong El Niño event of 1997/98. This is consistent with the existence of a weak La Niña event; in fact, the signal in the SOI is arguably stronger than that in the ocean temperatures (Fig. 3).

In all three summer months, the mean sea-level pressure was below average at Darwin and above average at Tahiti. In both cases this continued anomalies which had commenced in May or June 1998, giving rise to the persistently positive values of the SOI. The Darwin pressure anomalies in December (-1.5 hPa) and January (-1.4 hPa) were the strongest of this event thus far, whilst the monthly anomalies of 1.1 to 1.8 hPa at Tahiti were comparable with values observed between July and September 1998.

Wind
The Climate Prediction Center’s index of standardised 850 hPa wind anomalies (not shown) shows marked easterly low-level wind anomalies in the western and central Pacific west of 140°W, marking a continuation of the enhanced Walker circulation that has been evident in this region since mid-1998. Low-level winds were near normal in the equatorial eastern Pacific east of 140°W.

Outgoing long wave radiation
A time series of monthly standardised outgoing long wave radiation (OLR) anomalies from January 1994 to February 1999 is shown in Fig. 2. These data were provided by the Climate Prediction Center, Washington (Climate Prediction Center 1999), and are a measure of the amount of outgoing long wave radiation emitted from an equatorial region centred about the date-line. Positive values of this index indicate reduced levels of cloudiness in the region and a decrease in convection. The OLR index was positive throughout summer 1998/99, as it has been since June 1998 (Collins 1999), and the January value was among the highest recorded in the last 20 years. There were, however, some signs of a decline in February. The drop in cloudiness over the central equatorial Pacific, as indicated by this index, are consistent with the observed anomalously cool ocean temperatures in this region.

Negative OLR anomalies were widely observed in equatorial regions between 100°E and 160°E, indicating enhanced convection in the Indonesian region and the adjacent Indian Ocean. This is further evidence of an enhanced Walker circulation in the western Pacific.

Fig. 1 Monthly values and 5-month weighted average of the Southern Oscillation Index (SOI) from January 1994 to February 1999.

Fig. 2 Standardised anomalies of outgoing long wave radiation (OLR) from the 1979-1995 base period means, averaged over the area 5°N-5°S, 160°E-160°W.
Ocean patterns

Sea-surface temperatures (SSTs)
Figure 3 shows global sea-surface temperature anomalies for summer 1998/99. The most notable feature in the Pacific was the large area of negative anomalies near and north of the Equator, with the pattern being particularly marked in equatorial latitudes of the central Pacific between 160°E and 130°W. Anomalies in this area were generally in the -1°C to -2°C range with -2°C being exceeded locally. This pattern remained essentially unchanged through the three summer months. It is worth noting that central Pacific SSTs have a particularly strong influence on Australian seasonal mean temperatures (Jones 1998).

The SST anomaly pattern, whilst best described as a weak La Niña pattern, continued to differ from a ‘typical’ La Niña in several respects, as they had in spring (Beard 1999), although some of the ‘atypical’ features weakened somewhat from spring. Weak negative anomalies began to appear in the eastern Pacific north of the Equator, although they were still of lesser magnitude than those in the central Pacific. The asymmetry of the tropical Pacific pattern also continued, with warm anomalies south of the Equator and cool anomalies north of the Equator, although the warm anomalies weakened somewhat and were in the 0-1°C range, compared with 1-2°C in spring, reflecting a weakening of the residual warm waters remaining from the 1997-98 El Niño.

In other regions, notable features included the large area of warm waters off eastern Asia, and extensive cool anomalies in both the North and South Pacific between latitudes 40° and 60°. The Indian Ocean was anomalously cool in a belt stretching from Madagascar to near southern Western Australia, but warm north of this. Australian coastal waters were generally warmer than normal, with anomalies exceeding 1°C off southern New South Wales.

Subsurface patterns
Figure 4 shows the anomaly of the depth of the 20°C isotherm in the equatorial Pacific Ocean from January 1994 to February 1999. This isotherm is essentially the core of the equatorial ocean thermocline which defines the boundary between the warm surface water and cold deep ocean. A raising of the isotherm (negative anomalies) indicates a shallower mixed surface layer, and hence anomalously cool subsurface waters.

Subsurface waters in the eastern half of the Pacific remained cooler than normal during summer 1998/99. The penetration of negative anomalies to the South American coast which occurred during spring 1998 continued, reaching its maximum in January. The negative anomalies had their largest amplitude around 130°W, as they had in preceding months, but their intensity continued to weaken from their July 1998 peak. These observations are consistent with stable or gradually weakening La Niña conditions.

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Fig. 3  Global sea-surface temperature anomalies for summer 1998/99.
Fig. 4  Anomaly of depth of the 20°C isotherm along
the Equator in the Pacific Ocean, from

In the western Pacific, the subsurface waters
warmed substantially during the course of the sum-
mer. Whilst the eastern boundary of positive anom-
alies was located in the vicinity of 150°E in
December, by February, positive anomalies were
occurring in most areas west of the date-line, and
were particularly marked in the vicinity of 160°E.

Atmospheric patterns
Surface analyses
Southern hemisphere mean sea-level pressure
(MSLP) and its associated anomaly are shown in Figs
5 and 6 respectively. Anomalies are deviations from
an eleven-year (1979-1989) global climatology from
the European Centre for Medium-range Weather
Forecasts (ECMWF). The most notable feature of
the pressure field is that the subtropical ridge was located
further south than usual in most longitudes, leading to
widespread positive anomalies in the region normally
associated with the northern boundary of mid-latitude
westerly flow, between 40° and 50°S. The anomalies
were particularly strong in January, and were at their
strongest through the summer near and east of New
Zealand. One exception occurred in the southern
Indian Ocean, where a region of strong negative
anomalies was centred on 40°S in February, although
this was offset by positive anomalies in the same
region in December and January.

Fig. 5  Analysis of global mean sea-level pressure for summer 1998/99.
For the summer as a whole, most of mainland Australia experienced negative pressure anomalies, with positive anomalies, consistent with the general hemispheric pattern, to the south and over Tasmania. This pattern is characteristic of a period with positive values of the SOI (Jones and Simmonds 1994). The overall summer pattern was closely matched by that observed for the individual months January and February, with the strongest negative anomalies over northern Western Australia in both months. In December, however, the negative anomalies were confined to the far north, with most of the country experiencing positive anomalies, at their strongest in the south.

Upper-level analyses
The mean 500 hPa geopotential height during summer 1998/99 is shown in Fig. 7, with anomalies from the climatological mean shown in Fig. 8. The anomalies showed a similar pattern to those at the surface. There were positive anomalies over most of the southern hemisphere between 30°S and 50°S, with the strongest anomalies over the South Island of New Zealand. Negative anomalies covered most of Australia, much of the Indian Ocean north of 30°S, and the equatorial Pacific. There were also negative anomalies near the Antarctic coast. As was observed for MSLP, the 500 hPa anomalies displayed considerable persistence from month to month, with the exception of the South Indian Ocean where positive anomalies in January were replaced by negative anomalies in February.

Blocking
Figure 9 shows values of the Blocking Index (BI) for summer 1998/99. The BI is a measure of the strength of the zonal 500 hPa flow at mid-latitudes relative to that at sub-tropical and high latitudes. Blocking was most frequent near the dateline. Whilst this is the most climatologically favoured region for blocking, there was an abnormally high incidence of blocking, particularly in January and February. The South Indian Ocean experienced an anomalously high value of the BI during December. In other regions blocking activity was near normal.

Winds
Figures 10 and 11 show the low-level (850 hPa) and upper-level (200 hPa) wind anomalies, respectively, for summer 1998/99. The enhanced trade winds in the western and central equatorial Pacific that have been present since winter 1998 continued, as shown by the summer mean low-level wind anomalies. The pattern was similar in all three summer months, with some evidence of weakening during February. Anomalies were generally weak in the eastern equatorial Pacific, with slight westerly anomalies near the South American coast. Extratropical anomalies are consis-
Fig. 7  Mean 500 hPa geopotential height for summer 1998/99.

Fig. 8  Anomalies of mean 500 hPa geopotential height from 1979-1989 ECMWF climatology, for summer 1998/99.

tent with the analysed MSLP field, with marked anticyclonic anomalies in the south-eastern and north-eastern Pacific, and near New Zealand. The westerly anomalies near 45°S which had been a feature of winter and spring (Collins 1999; Beard 1999) were largely absent in summer.

The upper-level (200 hPa) field showed a region of marked westerly anomalies through the central equatorial Pacific. This was a further reflection of the enhanced Walker circulation in that region. The belt of anomalies was broadly similar to that observed in spring, but had moved slightly further east and was
Fig. 9  Blocking Index for southern hemisphere for day 0 (December 1) to 90 (February 28) in summer 1998/99. The Blocking Index is defined as 0.5 \((U_{25} + U_{30} + U_{50} + U_{60} - U_{40} - U_{50} - 2U_{45})\), where \(U_p\) is the westerly component of the 500 hPa wind at latitude \(p\)°S. Note that the longitude scale defines the western hemisphere as extending from 180° to 360°.

Concentrated between the dateline and 120°W. This pattern was consistent with the existence of La Niña conditions. As with the low-level field, there were anticyclonic anomalies near New Zealand and in the southeast (but not northeast) Pacific, and there was also a belt of westerly anomalies between 50° and 60°S through most southern hemisphere longitudes.

Over the Australian landmass, there were weak northerly anomalies at lower levels – most pronounced over Western Australia – and somewhat stronger southerly anomalies at upper levels, tending easterly in the northern tropics. Enhanced easterly winds at upper levels in the tropics are associated with an enhanced monsoon (Drosdowsky 1996).

**Australian region**

**Rainfall**

Rainfall totals over Australia for the summer of 1998/99 are shown in Fig. 12, with decile range values based on the post-1900 period shown in Fig. 13.

Widespread areas of significantly above average rainfall in the northern two-thirds of Western Australia were observed in each of the three summer months, whilst a single major rain event in early January resulted in areas around Esperance experiencing their wettest summer on record. Over much of

Fig. 10  Anomalies of vector winds at 850 hPa level for summer 1998/99.
Fig. 11  Anomalies of vector winds at 200 hPa level for summer 1998/99.

Fig. 12  Rainfall totals over Australia for summer 1998/99.

Fig. 13  Deciles of rainfall for Australia for summer 1998/99.

central and eastern Australia, rainfall for the summer was close to average, although there were areas of significantly below average rainfall in a region centred on Birdsville, southeastern South Australia and the western slopes of New South Wales. Some stations in the Birdsville area recorded no rain in the three-month period. Significantly above-average rainfall occurred locally over small areas in eastern Australia.

Most of the northern half of Western Australia experienced summer rainfalls in the highest 10 per cent of records. Although part of this was attributable to the local impacts of cyclones Billy and Thelma in December, all three months were significantly wetter than normal in this region, and the greatest rainfall anomalies arose from non-cyclonic monsoonal influences in February. Marble Bar had one spell in which rain was recorded on 21 out of 23 days. The far north of the Northern Territory experienced heavy rain in early December from cyclone Thelma, with 432 mm in 48 hours at Darwin. Two other major individual rain events occurred in Queensland. Cyclone Rona brought substantial flooding to the coast and adjacent ranges between Cooktown and Townsville in mid-February, with Bellenden Ker recording 1870 mm in a 48-hour period. A substantial flood event in a moist easterly flow occurred on the Queensland Sunshine Coast in the second week of February, with Nambour recording 756 mm in a 10-day period.
The Birdsville region and southeastern South Australia were significantly drier than average in all three summer months. Much of New South Wales was dry in December, and the far southwest of Western Australia had little rain in February. Tasmania was very dry in January, with most of the state having falls in the lowest 10 per cent on record, but in sharp contrast these regions experienced falls in the highest 10 per cent on record in February. The contrast was greatest in the far south, where Cape Bruny had its driest January and wettest February on record.

**Temperature**

Mean maximum and minimum temperature anomalies for the summer of 1998/99, calculated with respect to a 1984-1998 reference period, are shown in Figs 14 and 15 respectively.

Mean maximum temperatures in summer 1998/99 were above average over most of the southern half of Australia, and below average over most of the northern half. Mean minimum temperatures were above average over most of the country, except for some small areas scattered through northern Australia. The most anomalously warm region was northern Victoria and adjacent southern New South Wales, where anomalies exceeded 2°C for both maximum and minimum temperature. The most striking negative anomalies were for maximum temperatures in the northern half of Western Australia, where persistent cloud cover led to a relatively cool summer, in marked contrast with 1997/98. Some parts of the Pilbara had mean maximum temperatures more than 3°C below normal for the summer.

The broad pattern of temperature anomalies was quite similar in all three summer months, although warm anomalies were relatively more widespread in January and less widespread in February. The cool maximum temperature anomalies in the Pilbara were most striking in December and February, and exceeded -5°C locally near Marble Bar in February (which failed to exceed its average maximum of 40.0°C on any day during the month). January was a particularly hot month in much of the south-east, with maximum temperature anomalies exceeding +4°C over northern Victoria (+5°C at Nhill) and adjacent areas of New South Wales and South Australia, and minima more than 4°C above normal locally in southern New South Wales. A number of stations in this region experienced their hottest January on record. Tasmania experienced very warm minima in February, with anomalies in the +2-3°C range throughout the State.

Based on quality-controlled station data, the all-Australia mean maximum temperature for the summer was 0.04°C above the 1961-90 normal, and the mean minimum temperature 0.52°C above normal.

The mean maximum (+1.16°C) and minimum (+1.25°C) temperature anomalies for January were the highest observed since national records commenced in 1950. Whilst the summer as a whole was warmer than normal, it was substantially cooler than 1997/98, when a strong El Niño was in progress.

**References**


