Seasonal climate summary southern hemisphere (spring 1996): characteristics of a weak positive phase of the Southern Oscillation persist

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Southern hemisphere circulation patterns and anomalies for spring (September to November) 1996 are reviewed, with emphasis given to the Pacific Basin climate indicators, and Australian rainfall and temperature patterns. In winter, characteristics associated with a weak positive phase of the Southern Oscillation were observed. These conditions persisted in spring and were reflected in the anomalous surface and subsurface temperature distribution and associated convective patterns across the equatorial Pacific Ocean. A change in the rainfall pattern over southern parts of the country during the spring months was associated with a significant increase in mean sea-level pressure anomalies over Australia between early and mid-spring.

Introduction

Ocean and atmospheric indicators were consistent with a weak positive phase of the Southern Oscillation; a continuation of the conditions observed in winter. Cooling in the subsurface waters of the eastern equatorial Pacific strengthened and surface waters to the north and west of Australia remained warmer than normal. Convection was enhanced in the western equatorial Pacific and suppressed in the central equatorial Pacific. Trade winds were stronger than normal in the western Pacific and enhanced upper-level winds through the western half of the equatorial Pacific were associated with an enhanced Walker circulation. In mid-spring, widespread thunderstorm activity was associated with an early start to the northern Australian rainy season.

This summary reviews the southern hemisphere and equatorial climate patterns of spring 1996, with particular attention given to the Australasian/Pacific region. The main sources of information were the Climate Monitoring Bulletin (Bureau of Meteorology, Australia), and the Climate Diagnostics Bulletin (Climate Prediction Center, Washington D.C., USA). Data sources are given in the Appendix.

Pacific basin climate indices

The Southern Oscillation Index (SOI)*
The SOI generally maintained a positive trend from summer 1995/96 through autumn and winter 1996

*The SOI used here 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.
(Fig. 1). In contrast, spring shows the start of a downward (negative) trend in the values of the SOI. The positive values in September (+6.9) and October (+4.2) were followed by a value of -0.1 in November, the lowest value since December 1995.

The change to near-zero values in the SOI was mainly associated with anomalous mean sea-level pressure (MSLP) variations at Darwin. At Tahiti, MSLPs were slightly lower than the long-term average with MSLP anomalies varying less than 0.5 hPa. However, Darwin recorded a change of 1.3 hPa in MSLP anomalies during spring. Darwin’s MSLP anomaly changed from -1.7 hPa in September to -0.4 hPa in November.

**Atmospheric indices**

Towards the end of autumn 1996, tropical wind strengths were close to their climatological values (Jones 1996), but a resurgence in the Pacific trade winds was observed during the early part of winter 1996 (Collins 1997). The stronger than normal low-level easterly winds were maintained across the western equatorial Pacific Ocean during spring, however weak westerly anomalies developed in the eastern equatorial Pacific during October and November.

The monthly standardised outgoing long wave radiation (OLR) anomaly is shown in Fig. 2. These data are provided by the Climate Prediction Center, Washington (CPC 1996), and are a measure of the amount of long wave radiation emitted from an equatorial region close to the date-line. Positive values of the index are evident since early 1995 and the positive trend in OLR index values, which began in winter, continued during spring. These positive values were associated with suppressed convection over the central equatorial Pacific, during the spring period, and increased strength of the equatorial Walker circulation. According to CPC, convection was enhanced over the western equatorial Pacific during spring.

**Oceanic indices**

*Sea-surface temperatures (SSTs).* The SST anomaly pattern through the tropical Pacific Ocean (Fig. 3) was generally similar for the three seasons; autumn (Jones 1996), winter (Collins 1997) and spring. The SST anomaly pattern for spring shows cool anomalies in the far eastern tropical Pacific which become patchy (a combination of warm and cool anomalies), as they extend westward into the central tropical Pacific Ocean. The warmer areas to the north and west of Australia which were a persistent feature since winter increased in magnitude during the middle of the spring period.

*Subsurface patterns.* Figure 4 shows the anomaly of the depth of the 20°C isotherm along the equatorial Pacific between January 1994 and November 1996. 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 relatively warm surface water and cold deep ocean water.

During the latter part of winter, cool anomalies propagated eastward from the central equatorial Pacific. This cooling in the eastern Pacific, which appears to be an amplification of the normal seasonal cycle, strengthened (uplifted isotherms) and persisted during spring. In the western equatorial Pacific, isotherms were gradually depressed (warmer than average conditions) during spring. Conditions in the central equatorial Pacific were near-average. However, in the latter part of spring, warm anomalies appeared to propagate eastward from the western equatorial Pacific.
Upper-level analyses

Figures 7 and 8 show the mean and anomalous spring 1996 500 hPa patterns respectively. Long wave troughs at middle to higher latitudes were most prominent in the eastern Pacific and eastern Atlantic oceans and an area of weak diffuence is located near New Zealand longitudes. A stronger zonal component is evident through the higher latitudes of the Indian Ocean and Australian region.
Fig. 3  Spring 1996 sea-surface temperature anomaly (°C).

Fig. 4  Time longitude section of monthly anomalous depth of the 20°C isotherm at the equator from January 1994 to the end of 1996. Contour interval is 10 m.

Surface analyses

In the monthly analyses (not shown) MSLPs were well below average over most of the continent in September. These negative anomalies which had dominated the Australian region for several months prior to and including September, and were associated with wet conditions and enhanced westerly flow in southern Australia in early spring, contracted to a region south of the continent in mid-spring. Consequently, MSLP was close to average over Australia in October and November but remained below average over most of the Southern Ocean.

Figures 5 and 6 show the mean and anomalous spring 1996 MSLP patterns respectively. Anomalies are deviations from an eleven-year (1979-1989) global climatology from the European Centre for Medium Range Weather Forecasts (ECMWF), Bracknell England. The negative MSLP anomalies to the south of Australia, which were a feature of the monthly analyses, are shown on the anomalous MSLP pattern for spring (Fig. 6). Negative anomalies of similar magnitude but lesser extent were located to the southwest of South America. To the west of these negative anomalies, a broad region of above average pressure extended through the mid to higher latitudes of the central Pacific Ocean.
Spring 1996 daily Blocking Index: time longitude section. Day 1 is 1 September 1996.

The anomaly pattern at 500 hPa shows a marked positive anomaly over the higher latitudes of the western Atlantic ocean and a weaker positive anomaly over the mid-latitudes of the far eastern Indian Ocean. The positive height anomalies near and to the east of the date-line, associated with blocking in this region, are also evident. Significant negative anomalies were located southwest of South America and over a broad area to the south and southwest of Australia.

**Blocking**

Figure 9 is a time-longitude section of the daily southern hemisphere Blocking Index (BI) (Wright 1993) for spring 1996. BI is a measure of the strength of the 500 hPa flow at mid-latitudes relative to that at subtropical and high latitudes. Positive values in the BI are generally associated with a split in the mid-latitude westerly flow and blocking events.

In early spring, periods of moderate blocking activity occurred in the eastern Indian Ocean and in the vicinity of the date-line. A period of blocking, in the latter part of spring occurred near and to the east of the date-line. Blocking activity tended to be suppressed, particularly through the Indian Ocean and Australian region during October and November.

**Winds**

Low-level (850 hPa) and upper-level (200 hPa) wind anomalies are shown in Figs 10 and 11 respectively. In the lower levels of the near equatorial region, easterly anomalies extended eastward from Papua New Guinea to 140°W and weak westerly anomalies extended from 120°W to the South American coast. The western half of the tropical Pacific has been dominated by enhanced
Fig. 11  200 hPa vector wind anomalies (m s\(^{-1}\)) – Spring 1996.

Fig. 12  Spring 1996 rainfall in Australia: decile range values based on grid-point averages for the period 1900-1995.
easterly winds since early 1995 (CPC 1996). In the higher latitudes, westerly anomalies over southern Australia reflect the cyclonic pressure anomalies through that area.

The upper-level wind anomaly pattern (Fig. 11) shows the strong westerly anomalies through the equatorial western and central Pacific. The westerly anomalies, which redeveloped in autumn (Jones 1996) and persisted through winter (Collins 1997) and spring were associated with an enhanced Walker circulation. The strong northwesterly anomalies in the tropical eastern Pacific and associated anomalous anticyclone west of South America were also observed in winter.

**Australian region**

**Circulation and rainfall**

Figure 12 shows the rainfall deciles over Australia for spring 1996. Apart from central Australia, which generally experienced drier conditions throughout spring, rainfall varied throughout Australia during each of the three spring months. In early spring, westerly flow with embedded cold fronts provided regular falls to southern Australia, particularly the southwest and far southeast. Middle-level cloud associated with a deep trough brought heavy rainfall to areas of eastern Australia, and a very deep cut-off low pressure system, at the end of September, generated further significant rainfall through southern areas of the continent.

In contrast to September, most of southern Australia received below average rainfall in October. Thunderstorm activity which affected the 'top end' of the continent was associated with an early onset of the rainy season in northern Australia. Some areas of the tropical Australia received in excess of 100 mm and isolated areas recorded their highest falls on record for the month.

Little or no rain was reported throughout much of central Australia during the latter part of spring, and wet season activity was somewhat suppressed during this period. However, frontal systems and a low pressure trough brought significant falls to the southwest. In addition, a strong onshore flow resulted in heavy falls along parts of the east coast of Australia; falls of more than 300 mm were recorded with localised severe flooding.

**Temperatures**

Maximum and minimum temperature anomalies for spring 1996 are shown in Figs 13 and 14 respectively. The general patterns of the maximum and minimum anomaly analyses were similar, with warmer temperatures through central Australia and western Australia and cooler conditions in the southeast and over parts of eastern and northern Australia.

**References**


**Appendix**

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

*National Climate Centre, Bureau of Meteorology, GPO Box 1289K, Melbourne, Vic 3001, Australia.
+ Climate Prediction Center, W/NP52, NOAA/NWS/NCEP, NOAA Science Center, Room 605, 5200 Auth Road, Washington D.C., 20233, USA.