

# The tropical circulation in the Australian/Asian region - May to October 2003

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**A summary of the broadscale tropical circulation from 70°E to 180°, for the six months May to October 2003, is presented. Neutral ENSO conditions persisted during the season, as suggested by weak pressure anomalies over most of the equatorial latitude belt, small values of the Southern Oscillation Index, warm sea-surface temperature anomalies in the northwestern Pacific and weak wind anomalies at lower and upper levels in the equatorial Pacific near the date-line. Convection associated with the northern hemisphere monsoon was weaker than average over the Indian subcontinent. Four active convective phases of the Madden-Julian Oscillation affected the region during the season. The periodicity remained close to the upper limit of the 30 to 60-day intraseasonal oscillation. A total of 20 tropical cyclones (11 typhoons) developed during the period, less than the mean (27) for the RSMC area.**

## Introduction

This summary reviews the broadscale tropical circulation in the Australian/Asian region during the period May to October 2003. The area covered is the Darwin Regional Specialised Meteorological Centre (RSMC) analysis domain, which is 70°E to 180°, 40°N to 40°S. Previous seasons have been described in earlier summaries of this series by Shaik and Jackson (2003) and Shaik and Cleland (2004). The first section of this summary uses mostly six-month average charts to describe the overall seasonal circulation and anomalies. The second section uses time series to portray variations of the tropical circulation within the season. Intraseasonal variability of outgoing long wave radiation (OLR), 200 hPa velocity potential and mean sea-level pressure (MSLP) anom-

aly are analysed in this section. The third section briefly describes the occurrence of tropical cyclones in the six-month period. Data sources used in this study are detailed in the appendix.

## Broadscale seasonal features

### Southern Oscillation

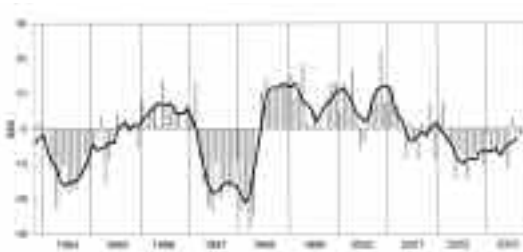
Figure 1 shows the ten-year behaviour of Troup's Southern Oscillation Index (SOI) from November 1993 and its symmetrical five-month running mean. Monthly values of the SOI from January 2001 are given in Table 1. The mean SOI for the season was -3.7, smaller in magnitude than the previous two seasons (-6.3 and -9.7 during November 2002 to April 2003 season and May - October 2002 season respectively). As indicated by the low values of the SOI, neutral ENSO conditions were evident throughout the summary period.

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**Table 1. Monthly values of Troup's SOI for the period January 2001 to October 2003.**

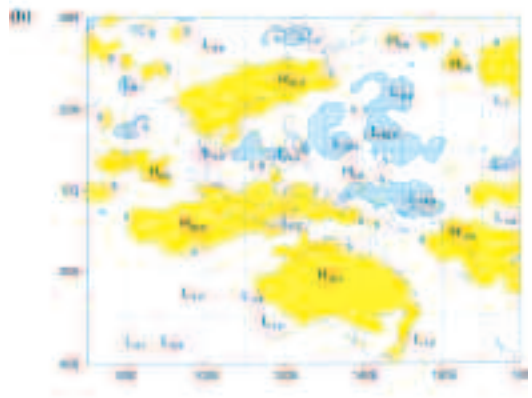
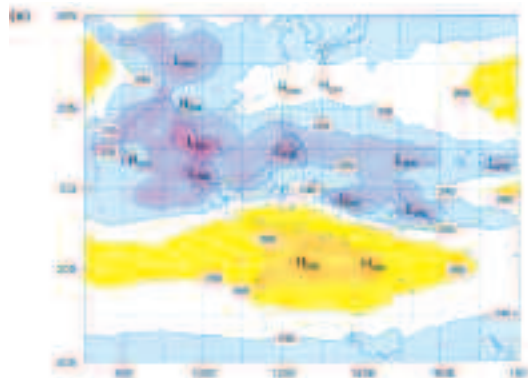
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2001	+9	+12	+7	0	-9	+2	-3	-9	+1	-2	+7	-9
2002	+3	+8	-5	-4	-14	-6	-8	-15	-8	-7	-6	-11
2003	-2	-7	-7	-5	-7	-12	+3	-2	-2	-2		

**Fig. 1 SOI time series for ten years to October 2003: monthly values (bars); five-month centred mean values (black line).**

### Convection and tropospheric circulation

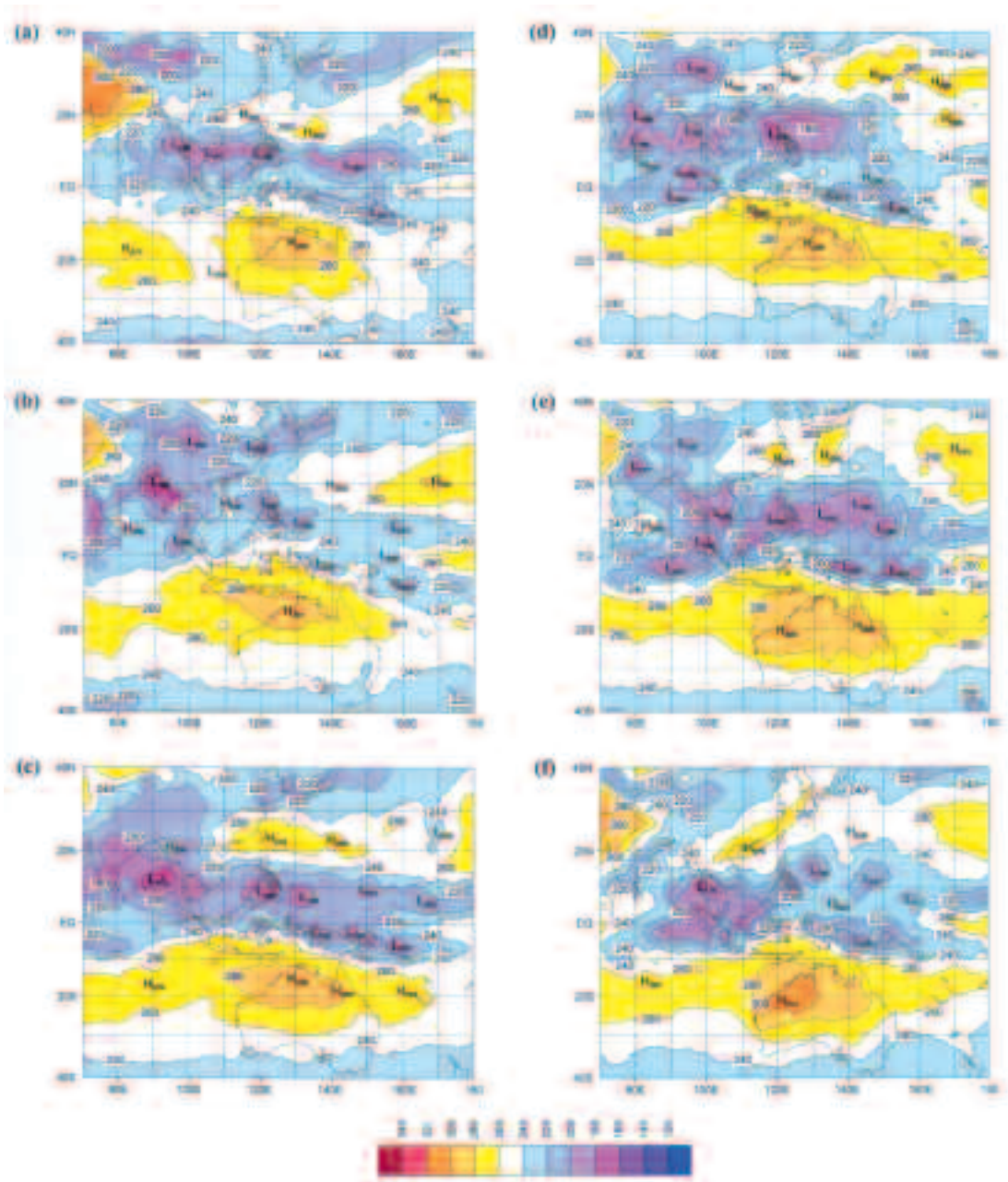
The outgoing long wave radiation (OLR) mean and anomaly – used as a proxy for convection – for the six-month period are shown in Fig. 2(a) and 2(b) and for each individual month are shown in Figs 3(a) to (f) and 4(a) to (f) respectively. Convection over the equatorial regions in the RSMC area was near or below average, except a small area east of Papua New Guinea. Convection associated with the northern monsoon was above average in the northwestern Pacific and about average elsewhere. OLR anomalies for individual months indicate an active northern hemisphere monsoon and south Pacific convergence zone (SPCZ) during May and July, and a relatively weak monsoon during June and August. However, convection was above average in the South China Sea area during August due to active cyclones. In the southern hemisphere, most of the Australian continent was drier than normal.

The axes of low-level convergence and upper-level divergence as indicated in the velocity potential analyses at 850 hPa and 200 hPa levels respectively (Fig. 5) remained close to their respective climatological mean latitudes, similar to the May to October 2002 season (Shaik and Jackson 2003). However, the centres of strong low-level convergence and upper-level divergence were positioned east of their respective mean location (means not shown). The good vertical align-

**Fig. 2 Six-month (May to October 2003) (a) mean OLR ( $W m^{-2}$ ),  $260 W m^{-2}$  and above yellow shading,  $240 W m^{-2}$  and below, blue shading; (b) OLR anomaly ( $W m^{-2}$ ),  $> +5 W m^{-2}$  yellow shading,  $< -5 W m^{-2}$ , blue shading.**

ment of the centres of low-level convergence and upper-level divergence in the western Pacific indicate well organised upmotion of a vigorous Hadley circulation in the area, whereas the poor vertical alignment over the Indian subcontinent indicates the below average monsoon circulation over that area.

**Fig. 3** Monthly mean OLR ( $\text{W m}^{-2}$ ),  $260 \text{ W m}^{-2}$  and above yellow-red shading,  $240 \text{ W m}^{-2}$  and below, blue shading: (a) May 2003; (b) June 2003; (c) July 2003; (d) August 2003; (e) September 2003; (f) October 2003.

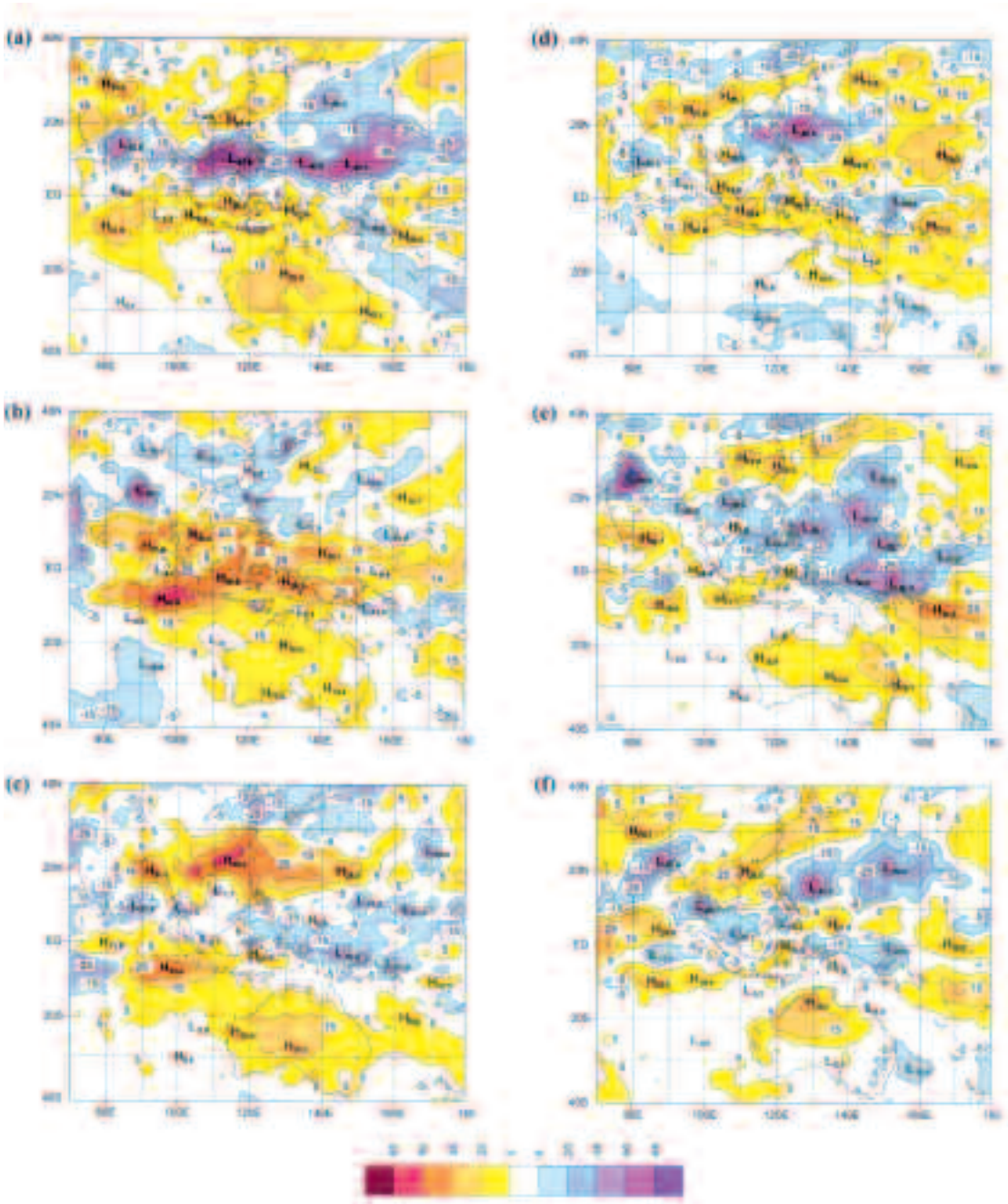


Seasonally averaged mean sea-level pressure (MSLP) and anomalies are shown in Fig. 6. Weak pressure anomalies over the equatorial belt are consistent with the near neutral ENSO conditions during the season. Positive anomalies persisted over most of the northwestern Pacific and equatorial belt between

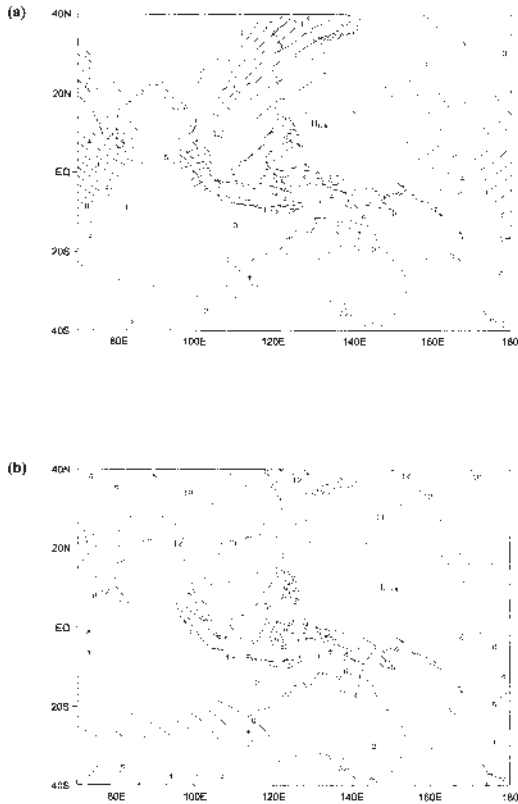
$100^{\circ}\text{E}$  and  $150^{\circ}\text{E}$ . In the southern hemisphere, positive anomalies over northern Australia are consistent with the relatively dry conditions, especially over eastern Australia.

Vector wind analyses and anomalies at 850 hPa and 200 hPa are shown in Figs 7 and 8 respectively.

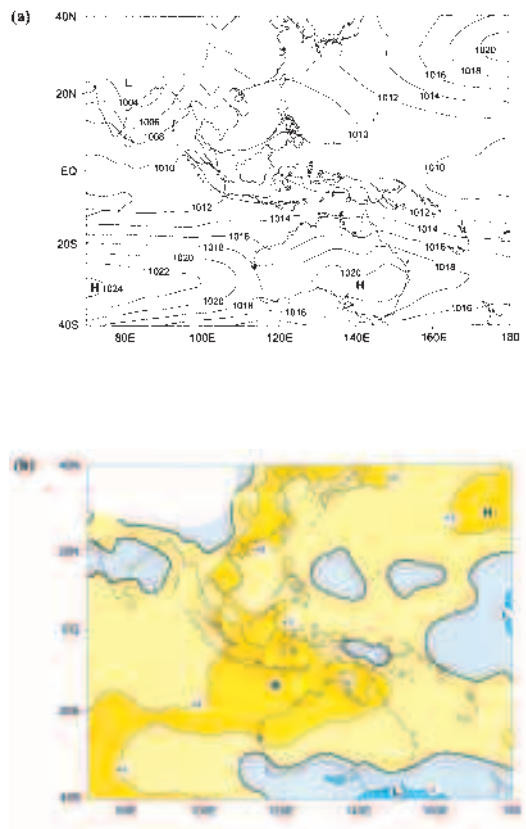
Fig. 4 Monthly OLR anomaly ( $W m^{-2}$ ),  $> +5 W m^{-2}$  yellow-red shading,  $< -5 W m^{-2}$ , blue-purple shading: (a) May 2003; (b) June 2003; (c) July 2003; (d) August 2003; (e) September 2003; (f) October 2003.



**Fig. 5** Six-month mean velocity potential ( $10^6 \text{ m}^2 \text{ s}^{-1}$ ), May to October 2003, negative contours dashed: (a) 850 hPa; (b) 200 hPa.



**Fig. 6** Six-month MSL pressure (hPa), May to October 2003: (a) mean, isobar interval 2 hPa; (b) anomaly, contour interval 1 hPa, blue-shaded areas negative, yellow-shaded areas positive.



Greater than average cross-equatorial flow was evident in the Indian Ocean and over the maritime continent into the low-level monsoon flow and out of the upper return flow. Western Pacific trade winds remained stronger than normal during the season. The wind anomalies were weaker than last dry season (Shaik and Jackson 2003) over the equatorial western Pacific near the date-line, consistent with the neutral ENSO conditions. In the extratropical southern hemisphere, the subtropical jet was stronger than normal over southeastern Australia, consistent with the enhanced cross-equatorial return flow.

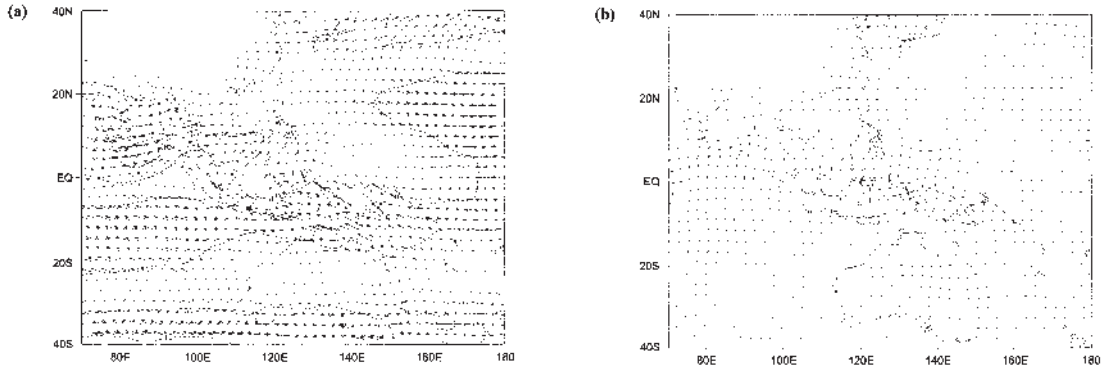
The cross-equatorial components of the flow and anomalies are shown in Fig. 9. These diagrams indicate that the flow pattern is similar to the previous season in 2002 (Shaik and Jackson 2003). Stronger than average low-level southerlies and upper-level norther-

lies prevailed west of 140°E. The cross-equatorial component to the east of 140°E was close to normal.

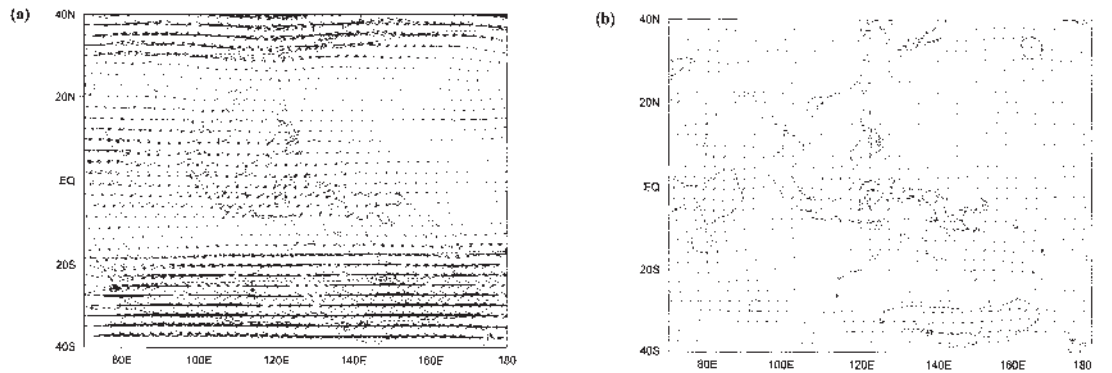
### Sea-surface temperature

Six-month mean and anomalous sea-surface temperatures (SST) are shown in Fig. 10. The SST configuration in the tropics reflects a warming trend as compared with the previous seasons May - October 2002 and November 2002 - April 2003 (Shaik and Jackson and Shaik and Cleland 2004). The features include, up to +2°C warm anomalies in the tropical Indian Ocean, strengthening of warm anomalies in the northwest Pacific, spreading of warm anomalies in the equatorial Pacific all the way from Papua New Guinea to the date-line. The warmest waters in the equatorial Pacific remained west of the date-line, a pattern consistent with neutral ENSO.

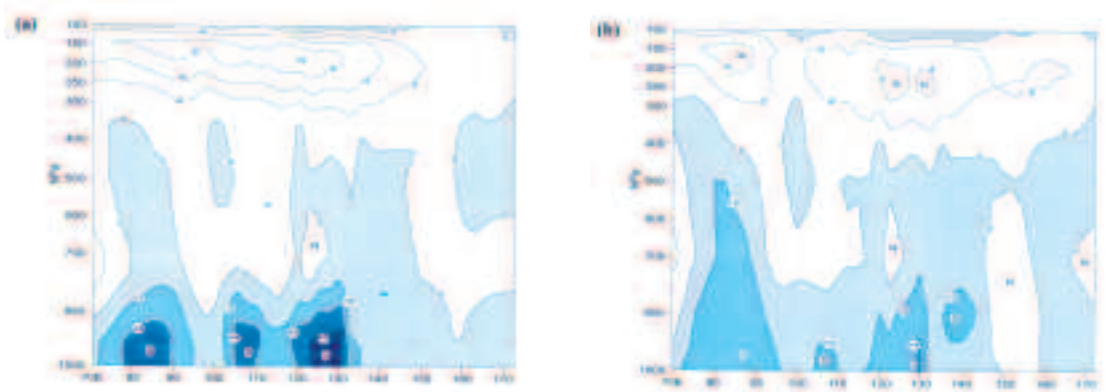
**Fig. 7** Six-month 850 hPa vector wind field, May to October 2003, isotach (dashed) interval  $5 \text{ m s}^{-1}$ : (a) mean; (b) anomaly.



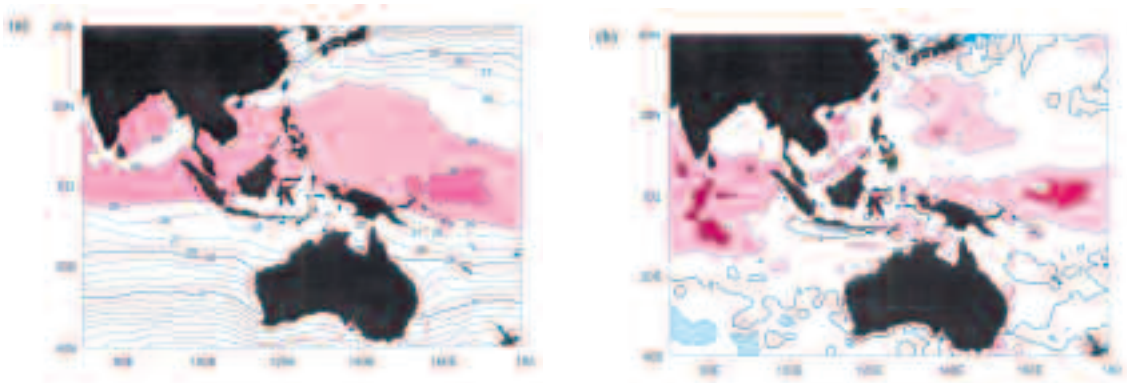
**Fig. 8** Six-month 200 hPa vector wind field, May to October 2003: (a) mean, isotach (dashed) interval  $20 \text{ m s}^{-1}$ ; (b) anomaly, isotach (dashed) interval  $5 \text{ m s}^{-1}$ .



**Fig. 9** Equatorial cross-section of six-month meridional wind, May to October 2003; contour interval  $2 \text{ m s}^{-1}$ , negative (northerly) contours dashed, positive (southerly) shaded: (a) mean; (b) anomaly.



**Fig. 10** Six-month SST (°C), May to October 2003: (a) mean, isotherm interval 1°C, >29 °C pink shading; (b) anomaly, contour interval 0.5°C, < -0.5°C blue shading, > +0.5°C, pink shading.



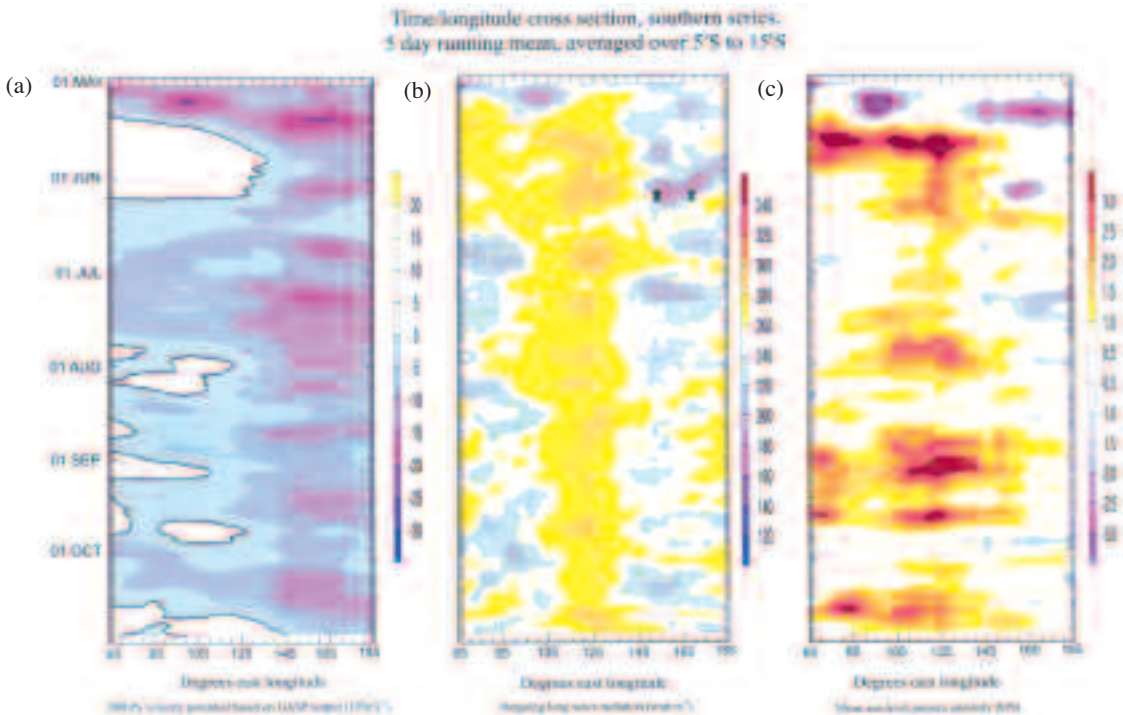
**Intraseasonal variability**

Figures 11 to 13 show time/longitude plots of (a) 200 hPa velocity potential, (b) OLR and (c) MSLP anomaly, averaged over 10° latitude bands, across the Darwin RSMC longitude range. The southern and northern OLR plots (Figs 11(b) and 13(b)) also indicate the date and longitude of tropical cyclone genesis events.

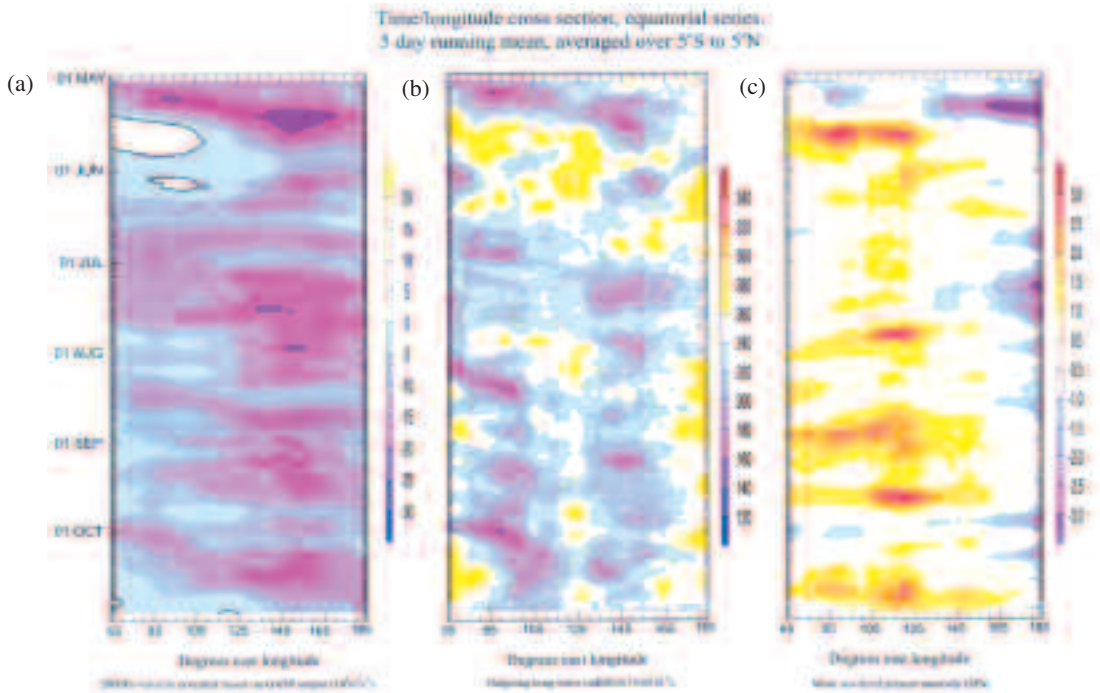
The 200 hPa velocity potential series for the three latitude bands suggest four active MJO events initiated in the western parts of the RSMC area about early May, early July, mid August and early October. The west to east propagation was generally evident in these events.

Figure 14 shows filtered station pressure anomaly series for four stations, two in each hemisphere. In

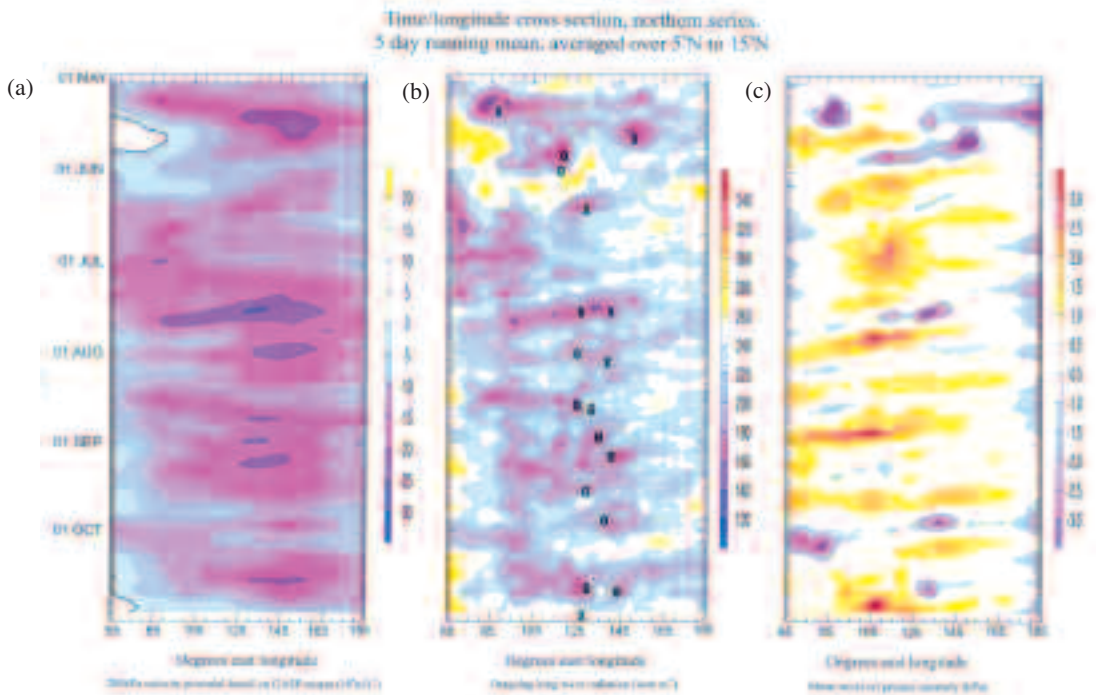
**Fig. 11** Time-longitude sections, latitude band 5°S-15°S, 1 May to 31 October 2003 of five-day backward running mean: (a) 200 hPa velocity potential; (b) OLR. Black crosses denote time and longitude of TC genesis events; circles denote events poleward of the latitude band; (c) MSLP anomaly.



**Fig. 12** Time-longitude sections, latitude band 5°N-5°S, 1 May to 31 October 2003 of five-day backward running mean: (a) 200 hPa velocity potential; (b) OLR; (c) MSLP anomaly.



**Fig. 13** As for Fig. 11, except latitude band 5°N-15°N.



**Fig. 14** MSLP anomalies for two tropical stations in each hemisphere, normalised then passed through a 40-day Butterworth filter, 50% response at 23 and 70 days: (a) southern hemisphere, green line Cocos Island, (12.2°S, 96.8°E) blue line Darwin (12.4°S, 130.9°E); (b) northern hemisphere, green line Singapore (1.4°N, 104.0°E), blue line Yap (9.5°N, 138.1°E); (c) Darwin plus Cocos I. four days earlier (green line) and Yap plus Singapore four days earlier (blue line).

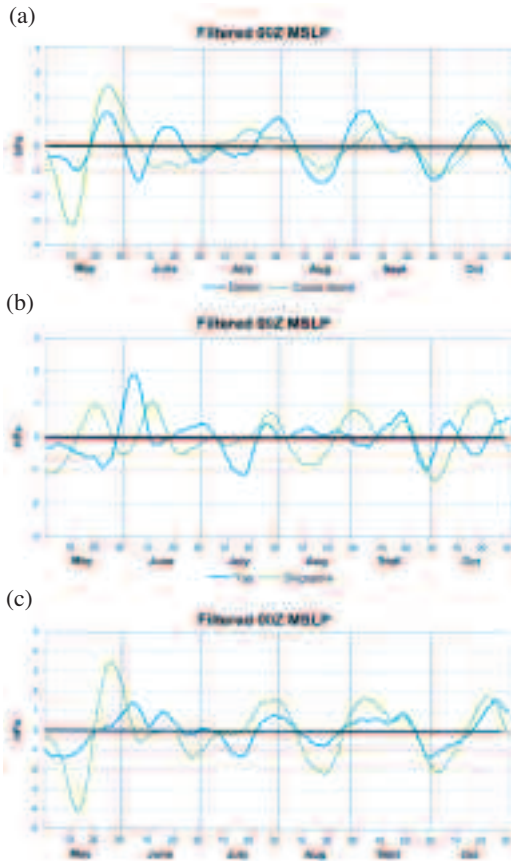


Fig. 14(c) the signal for the eastern station in each hemisphere has been added to that for the western station four days earlier. A four-day period was chosen, as this is approximately the time that an eastward-moving global wave with a period of 45 days will take to travel over this longitude range.

Individual pressure series for each of the four stations could pick up the May, mid-August and early October MJO events. The July pulse was detected by

the Yap pressure series and the combined pressure series with a time lag (Fig. 14(c)). This is consistent with the convection associated with the July pulse being more enhanced to the east of 145°E.

## Tropical cyclones

Tropical cyclones (TCs) are defined here as systems having maximum ten-minute mean winds greater than  $17 \text{ m s}^{-1}$ , or having been named. Operational tracks are shown in Fig. 15, while Table 2 lists TCs in order of occurrence within the various basins, showing duration and estimated maximum intensity details. Tracks are from the near real-time publication Darwin Tropical Diagnostic Statement (DTDS), and are based on Darwin RSMC operational manual analyses, with limited post-analysis in a few cases. A brief discussion and more information of each cyclone can be found in the DTDS for the relevant month. Other details about the cyclone data analysis are presented in the appendix.

A total of 20 TCs were analysed in the Darwin RSMC area during the summary period; of these eleven reached severe tropical cyclone or typhoon intensity. One TC formed in the Bay of Bengal (3.6 average), two developed in the South Pacific Ocean (average 2.7 for the south Indian and Southern Pacific Oceans combined) and the remaining seventeen formed in the northwest Pacific (20.5 average). In addition two TCs formed in the southern Indian Ocean west of the RSMC area and fifteen cyclones formed in the north Pacific east of the date-line (Metcalf 2004). On average 27 TCs form in the RSMC region between May and October.

## Acknowledgments

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**Table 2. Tropical cyclones within the Darwin RSMC area, May – October 2003. TC = tropical cyclone, STC= severe tropical cyclone, TS = tropical storm, VSCS= very severe cyclonic storm, Ty = typhoon.**

<i>Name</i>	<i>Dates(UTC) at TC intensity in Darwin RSMC area</i>	<i>Maximum 10-min. mean wind (while in Darwin RSMC area) m s<sup>-1</sup> (knots)</i>	<i>Estimated minimum MSLP (hPa)</i>	<i>Warning Agency*</i>
<b>Bay of Bengal /North Indian Ocean</b>				
Unnamed 01B (VSCS)	11 - 19 May	34 (65)	975	JTWC
<b>South Indian Ocean</b>				
Nil				
<b>South Pacific</b>				
<i>Gina</i> (STC)	6 - 9 June	41 (80)	950	NTCC
<i>Epi</i> (TC)	5 - 5 June	21 (40)	985	NTCC
<b>Northwest Pacific/South China Sea</b>				
<i>Chan-Hom</i> (Ty)	20 - 27 May	44 (85)	940	JMA
<i>Linfa</i> (TS)	26 - 30 May	28 (55)	980	JMA
<i>Nangka</i> (TS)	1 - 4 June	28 (55)	985	JMA
<i>Soudelor</i> (Ty)	13 - 19 June	41 (80)	955	JMA
<i>Koni</i> (TS)	16 - 22 July	28 (55)	980	Hong Kong
<i>Imbudo</i> (Ty)	17 - 24 July	52 (100)	941	PAGASA
<i>Morakot</i> (TS)	2 - 4 Aug	23(45)	990	Hong Kong
<i>Etau</i> (Ty) <sup>1</sup>	3 - 9 Aug	41 (80)	945	JMA
<i>Vamco</i> (TS)	19 - 20 Aug	18 (35)	994	JMA
<i>Krovanh</i> (Ty)	20 - 26 Aug	39 (75)	960	Hong Kong
<i>Dujan</i> (Ty)	29 Aug - 3 Sep	49 (95)	940	Hong Kong
<i>Maemi</i> (Ty) <sup>2</sup>	6 - 13 Sept	54 (105)	910	JMA
<i>Choi-Wan</i> (Ty) <sup>3</sup>	17 - 22 Sept	36 (70)	965	JMA
<i>Koppu</i> (Ty)	26 - 30 Sept	36 (70)	960	JMA
<i>Ketsana</i> (Ty)	20 - 26 Oct	44 (85)	940	JMA
<i>Parma</i> (Ty) <sup>4</sup>	21 - 31 Oct	49 (95)	930	JMA
<i>Melor</i> (TS)	30 Oct- 3 Nov	31 (60)	975	JMA

\* PAGASA = Philippine Atmospheric, Geophysical and Astronomical Services Administration, Manila; NTCC = Nadi Tropical Cyclone Centre, Fiji Meteorological Service, Nadi; JTWC = Joint Typhoon Warning Center, Pearl Harbor, Hawaii; JMA= Japan Meteorological Agency, Tokyo; Hong Kong = Hong Kong Observatory, Hong Kong.

#### Notes

1 *Etau* weakened, moved northeastward out of the RSMC area (40°N) and merged in the extratropical flow.

2 *Maemi* weakened, moved northeastward out of the RSMC area (40°N) and merged in the extratropical flow.

3 *Choi-Wan* moved northeastward out of the RSMC area (40°N) and merged in the extratropical flow.

4 *Parma* made a full circular movement path in the northwestern Pacific area (40°N) while still intensifying.

Note that central pressures are not available from PAGASA Manila and JTWC warnings; in these cases only the wind has been obtained from the warnings and pressures are estimated from the relationship of Atkinson and Holliday (1977).



Table 2 in knots as well as  $m s^{-1}$ . Climatological numbers are from Furze and Preble (2004) for the north-west Pacific and southern hemisphere and Mandal (1991) for the north Indian Ocean. The cyclone information for the regions outside RSMC area is derived from a web site maintained by Metcalf, T.R.: <http://www.solar.ifa.hawaii.edu/Tropical/tropical.html>.

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