

The tropical circulation in the Australian/Asian region - May to October 2005

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A summary of the broadscale tropical circulation from 70°E to 180°, for the six months May to October 2005, is presented. The previous season (Nov 2004 - April 2005) was described as ENSO – neutral, although it did have some of the characteristics that are typical of weak El Niño events. Some of these indicators lingered for a short while into this period, but overall the period May to October 2005 is best described as being in a neutral ENSO phase. Towards the end of the period, there was some evidence of the Maritime Continent region becoming the broad focus of tropical convection. Throughout the season, sea-surface temperatures in the eastern near-equatorial Pacific were near average. The warmest waters of the Pacific were located close to the near-equatorial date-line, rather than the climatological location of the northwest Pacific. Most of the Northwest Pacific and Australian continent mean sea-level pressures were above average, with mostly close to average tropical convection. Outgoing long wave radiation and mean sea-level pressure over India indicate above average convection associated with the monsoon. Several active convective phases of the Madden-Julian Oscillation (MJO) were observed in the region during the season. The periodicity remained close to 45 days. A total of 18 tropical cyclones (13 typhoons) developed during the period, less than the mean (27) for the Darwin Regional Specialised Meteorological Centre (RSMC) area. All of these formed in the northwest Pacific.

Introduction

This summary reviews the broadscale tropical circulation in the Australian/Asian region during the period May to October 2005. 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 Cleland (2005a, 2005b and 2005c). 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) anomaly 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.

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Table 1. Monthly values of Troup's SOI for the period January 2003 to October 2005.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2003	-2	-7	-7	-5	-7	-12	+3	-2	-2	-2	-3	+10
2004	-12	+9	0	-15	+13	-14	-7	-8	-3	-4	-9	-8
2005	+2	-29	0	-11	-15	+3	0	-7	+4	+11		

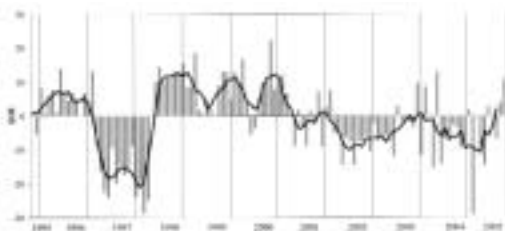
Broadscale seasonal features

The climate system has predominantly been in an ENSO-neutral state since the demise of the 2002-03 El Niño event. This characterisation is drawn from a lack of coherent El Niño or La Niña signals across the Pacific basin during this time. However, at times some strong El Niño-like signals have been present, as discussed in the previous seasonal summary (Shaik and Cleland 2005c). Some of the El Niño-like signals persisted into the early part of this summary period. By the end of the period, there was evidence of a slightly stronger than normal convection branch of the Walker Circulation over the Maritime Continent.

Southern Oscillation

Figure 1 shows the ten-year behaviour of Troup's Southern Oscillation Index (SOI) from November 1995 and its symmetrical five-month running mean. Monthly values of the SOI from January 2003 are given in Table 1. Large oscillations in the SOI were evident during the season, mostly in response to the cycle of active and inactive phases of the Madden-Julian Oscillation (MJO). The monthly SOI values were confined to within one standard deviation between June and September, a higher negative value to start the period and positive value to the end of it. This indicates that the region remained neutral, but being on the El Niño side of the neutral spectrum early in the season and transitioning nearer to some La Niña-like conditions late in the season. The mean northern Australian SOI for the season was -0.6 , higher than the previous dry season of -3.8 (May – Oct. 2004 season).

Fig. 1 SOI time series for ten years to October 2005: 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. For the seasonal mean, convection in the northern hemisphere associated with the monsoon was above average across the longitude range south of about 20°N . However, convection over central Indonesian islands remained less

Fig. 2 Six-month (May to October 2005): (a) mean OLR (W m^{-2}). Above 260 W m^{-2} yellow-red shading, below 240 W m^{-2} blue-purple shading; (b) OLR anomaly (W m^{-2}). More than 5 W m^{-2} yellow shading and below -5 W m^{-2} blue shading.

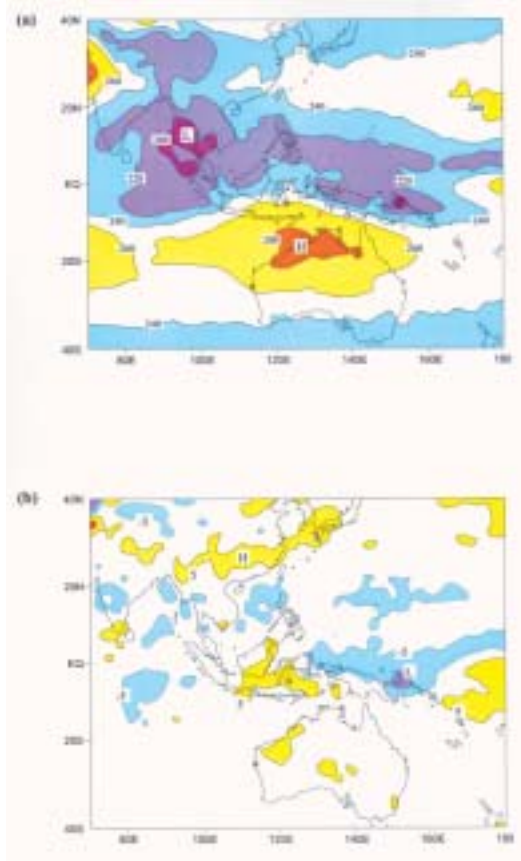


Fig. 3 Monthly mean OLR ($W m^{-2}$). Above $260 W m^{-2}$ yellow-red shading, below $240 W m^{-2}$ blue-purple shading: (a) May 2005; (b) June 2005; (c) July 2005; (d) August 2005; (e) September 2005; (f) October 2005.

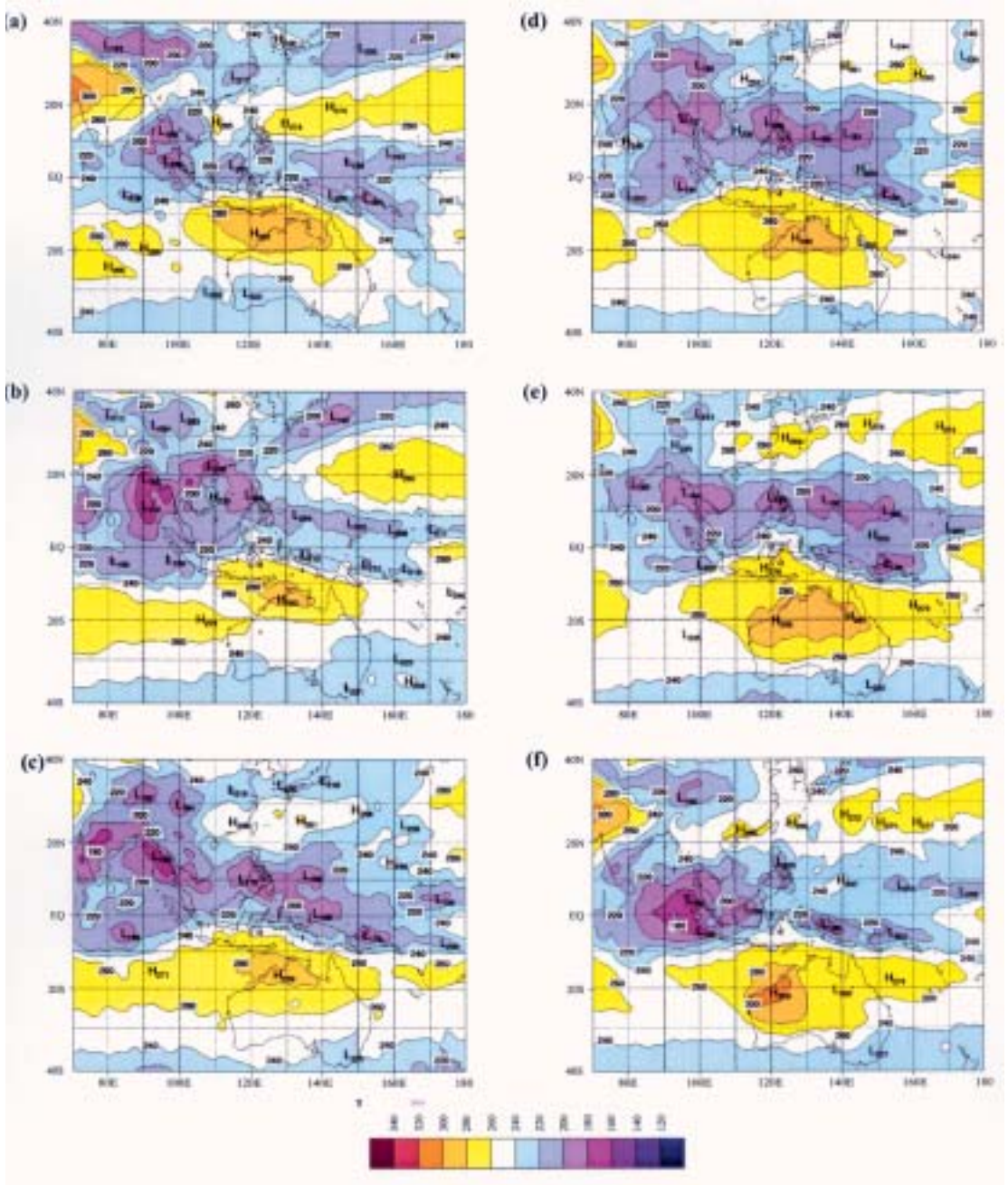
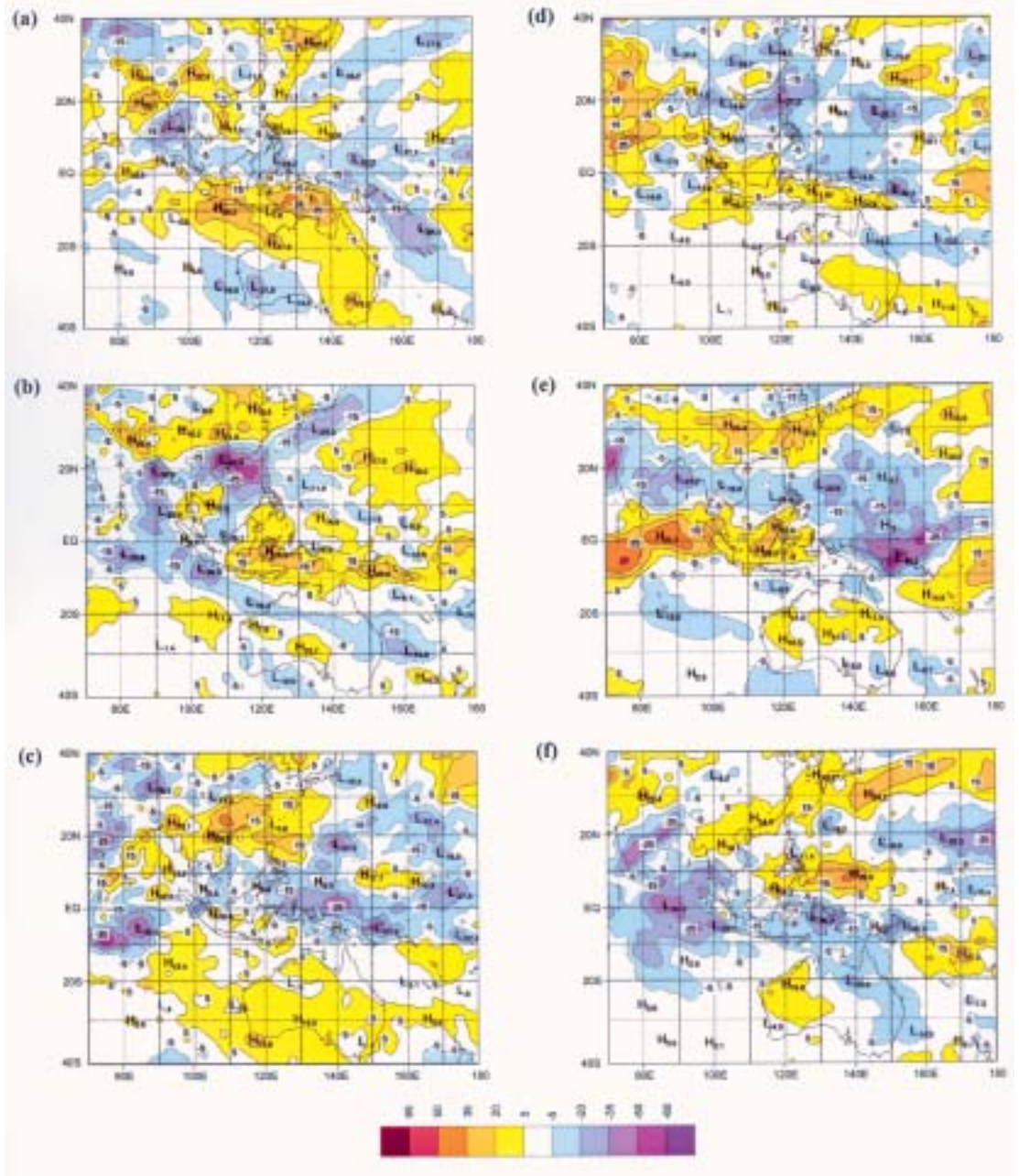


Fig. 4 Monthly OLR anomaly ($W m^{-2}$). Above $+5 W m^{-2}$ yellow-red shading, below $-5 W m^{-2}$ blue-purple shading; (a) May 2005; (b) June 2005; (c) July 2005; (d) August 2005; (e) September 2005; (f) October 2005.



than average. Convection was above average over areas north of Papua New Guinea (PNG) and parts of the southern tropical Indian Ocean. Most of the Australian continent remained drier than normal.

The monthly OLR anomaly charts indicate above average convection over India during June, July, September and October and over Southeast Asia and southern China during June, August and September. The focus of convection shifted close to the equator during October and extended from the equatorial Indian Ocean to PNG.

The axes of low-level convergence and upper-level divergence, as indicated by 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 previous two May to October 2003 periods (Shaik and Cleland 2004b, 2005b). The good vertical alignment of the centres of low-level convergence and upper-level

divergence in the Bay of Bengal and the western Pacific indicate well-organised upmotion.

Seasonally averaged MSLP and anomalies are shown in Fig. 6. Negative pressure anomalies over India and Indochina reflect the active monsoon over the region. Pressures were mostly higher than normal over much of the central RSMC longitudes, particularly Australia, the Maritime Continent and much of the northwestern Pacific despite some above average convection in the area. The pressures were less than normal in the equatorial western Pacific, close to the date-line.

Vector wind analyses and anomalies at 850 hPa and 200 hPa are shown in Figs 7 and 8 respectively. Low-level westerly anomalies were evident in the equatorial Indian Ocean, with easterly anomalies in the equatorial northwestern Pacific, close to the date-line. Monsoon winds were stronger than normal over the north Indian Ocean, similar to the previous north-

Fig. 5 Six-month mean velocity potential ($10^6 \text{ m}^2 \text{ s}^{-1}$) and divergent winds, May to October 2005. Yellow-red shaded areas positive and blue-purple shaded areas negative: (a) 850 hPa, contour interval 1; (b) 200 hPa, contour interval 2.

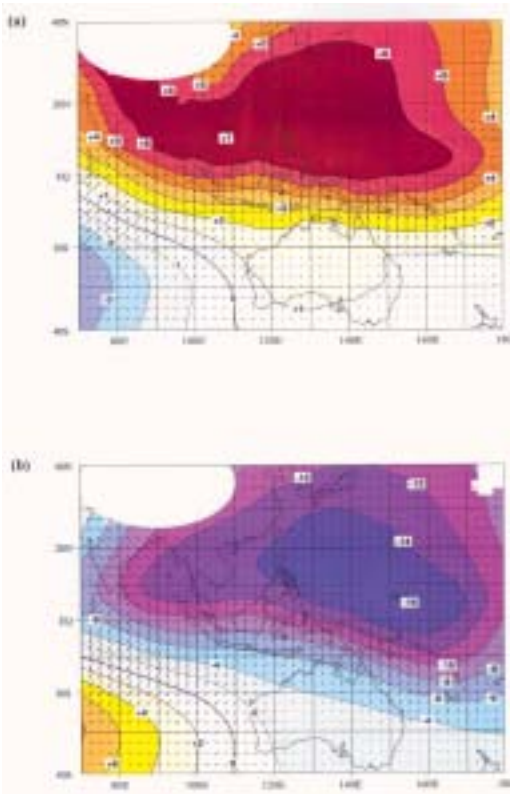


Fig. 6 Six-month MSL pressure (hPa), May to October 2005: (a) mean, isobar interval 2.5 hPa; (b) anomaly, contour interval 1 hPa, blue-shaded areas negative, yellow-shaded areas positive.

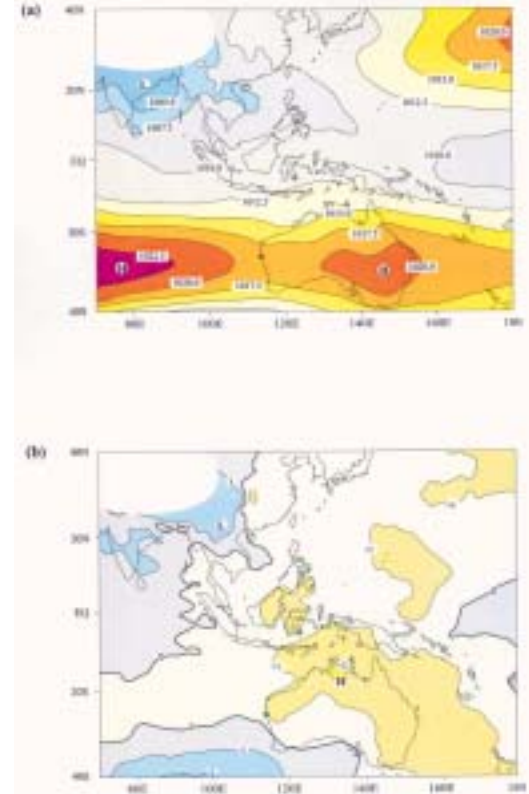


Fig. 7 Six-month 850 hPa vector wind field, May to October 2005, isotach (thin lines) interval 5 m s^{-1} , above 5 m s^{-1} shaded yellow: (a) mean; (b) anomaly.

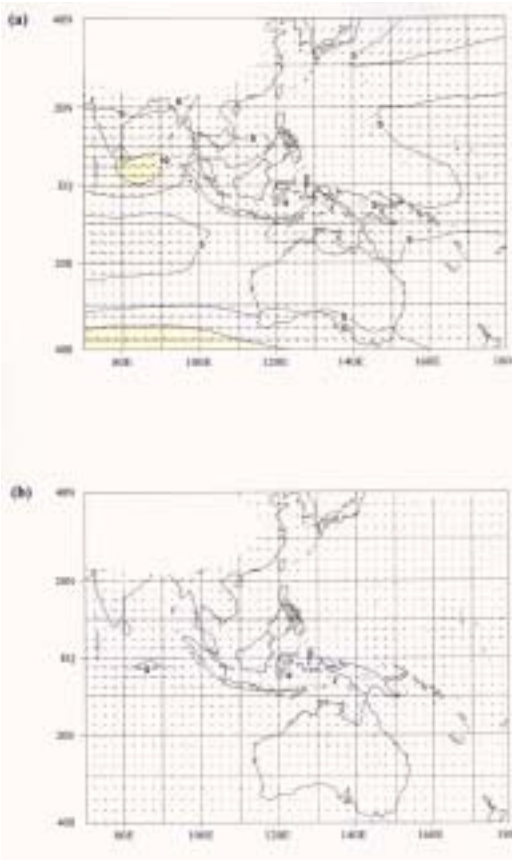
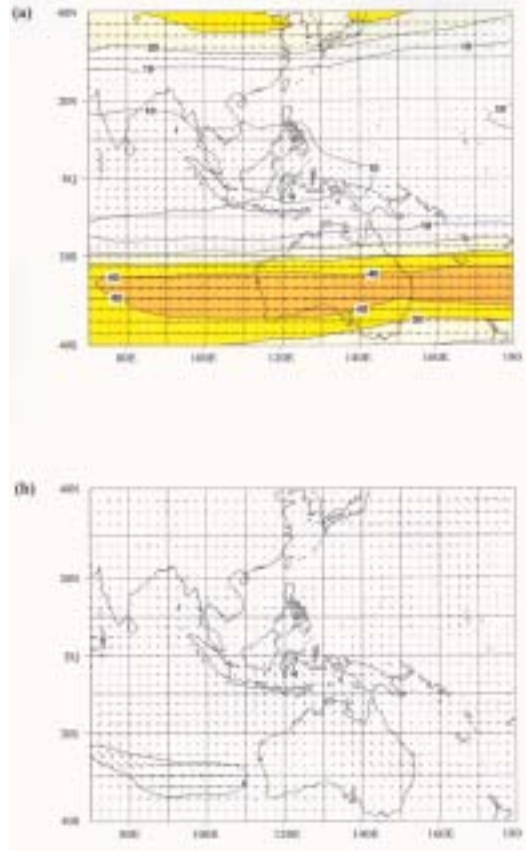


Fig. 8 Six-month 200 hPa vector wind field, May to October 2005: (a) mean, isotach (thin lines) interval 10 m s^{-1} , above 10 m s^{-1} shaded yellow; (b) anomaly, isotach (thin lines) interval 5 m s^{-1} , above 5 m s^{-1} shaded yellow.



ern hemisphere seasons of 2003 and 2004. However the low level southerly component of the cross-equatorial flow over the Indian Ocean was stronger than the previous two seasons (Shaik and Cleland 2004b, 2005b). The cross-equatorial flow over the equatorial northwestern Pacific was close to the mean. The upper level subtropical jet in the southern hemisphere was located south of climatological location in the southern Indian Ocean. The jet in the northern hemisphere was also poleward of its climatological location and contributed to the easterly anomalies in the northwestern Pacific.

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 May to October 2004 season (Shaik and Cleland 2005b). Stronger than average low-level southerlies

and upper-level northerlies 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 western tropical Pacific shares some similarities with the previous seasons May to October 2004 and November 2004 to April 2005 (Shaik and Cleland 2005b, 2005c). Anomalies over the tropical waters remained mostly above 0.5°C with close to normal SSTs over the Maritime Continent. Most of northwest Pacific and Australian continent mean sea-level pressures were above average, with mostly close to average tropical convection.

Fig. 9 Equatorial cross-section of six-month meridional wind, May to October 2005, contour interval 2 m s^{-1} , northerlies (negative values) shaded blue, southerlies (positive values) shaded pink-red: (a) mean; (b) anomaly.

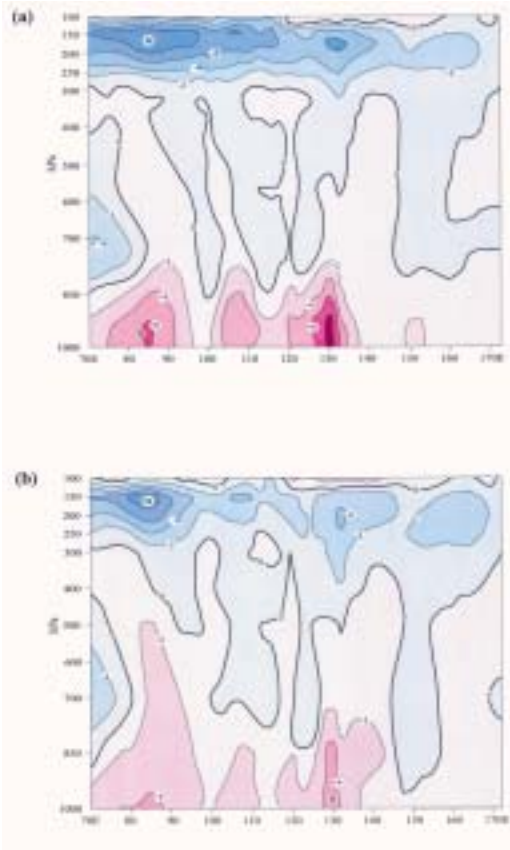
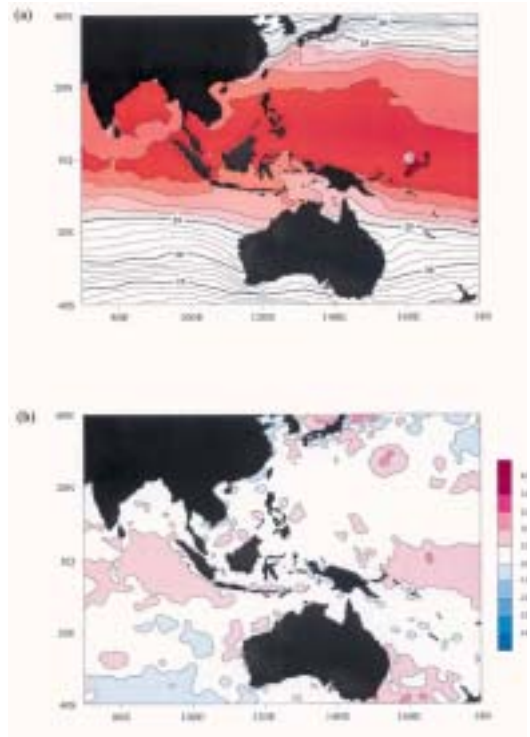


Fig. 10 Six-month SST ($^{\circ}\text{C}$), May to October 2005: (a) mean, isotherm interval 1°C , more than 25°C red shading; (b) anomaly, contours -0.5°C to 0.5°C green shade; above 0.5°C pink - red shade; below -0.5°C blue shade.



Intraseasonal variability

Figures 11 to 13 show time/longitude plots of (a) 200hPa 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 tropical cyclone genesis events.

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

These series show a coherent picture of minimum mean sea-level pressure, implying active phases of the MJO at their peak over central RSMC longitudes around middle June, late July, early September and mid October. There is good agreement with the time-longitude plots shown in Figs 11 to 13.

Tropical cyclones

Tropical cyclones (TCs) are defined here as systems having maximum ten-minute mean winds greater than 17 m s^{-1} , or having been named. Operational tracks are shown in Fig. 15, while Table 2 lists TCs in order

Fig. 11 Time-longitude sections, latitude band 5°S-15°S (southern series), 1 May to 31 October 2005 of five-day backward running mean: (a) 200 hPa velocity potential ($10^6 \text{ m}^2 \text{ s}^{-1}$); (b) OLR (W m^{-2}); (c) MSLP anomaly (hPa).

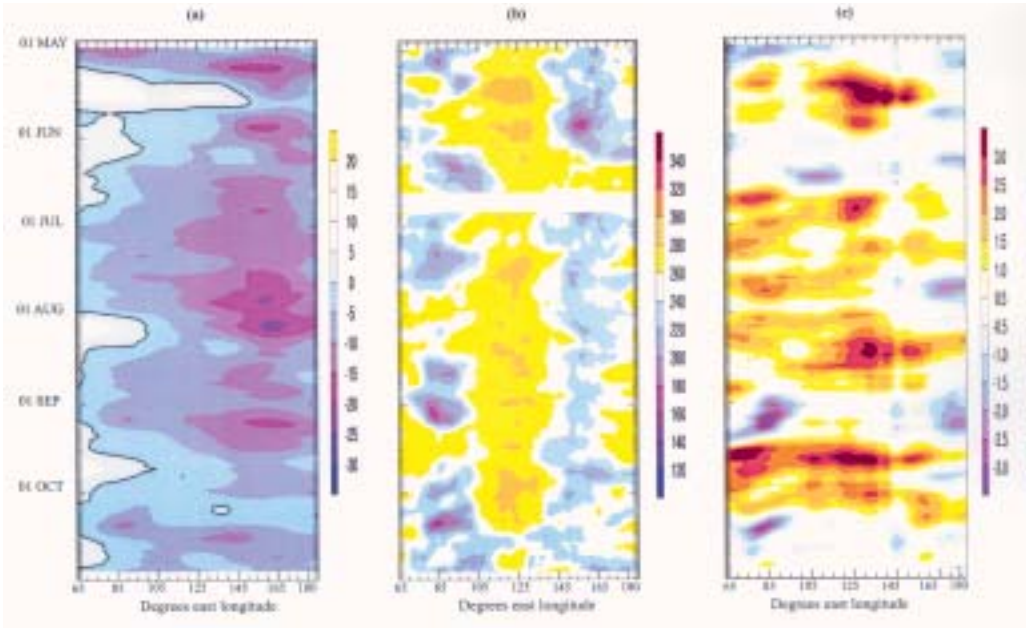


Fig. 12 Time-longitude sections, latitude band 5°N-5°S (equatorial series), 1 May to 31 October 2005 of five-day backward running mean: (a) 200 hPa velocity potential ($10^6 \text{ m}^2 \text{ s}^{-1}$); (b) OLR (W m^{-2}); (c) MSLP anomaly (hPa).

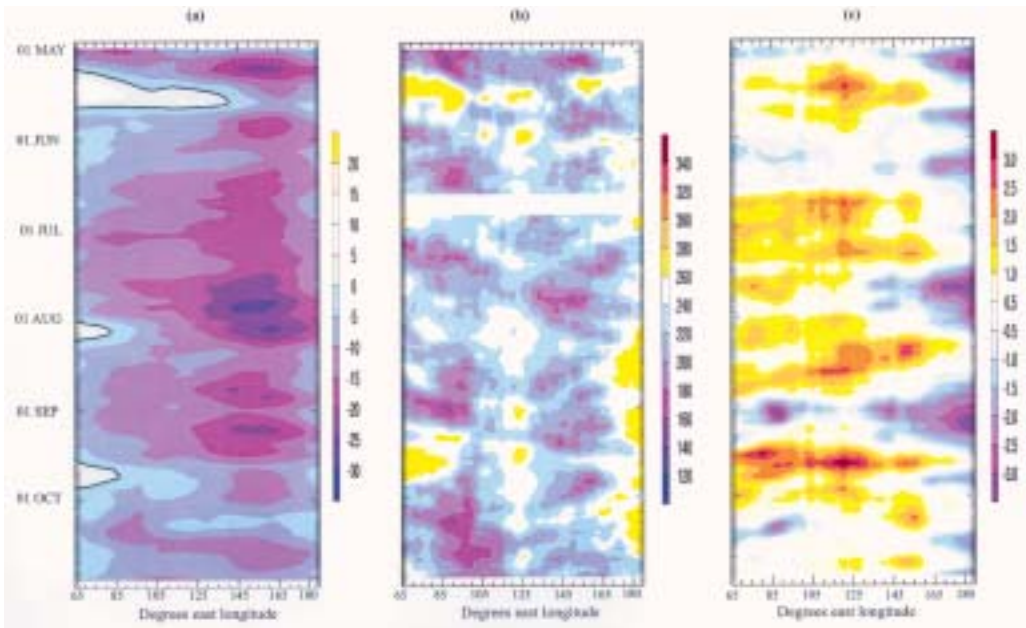


Fig. 13 Time-longitude sections, latitude band 5°N-15°N (northern series), 1 May to 31 October 2005 of five-day backward running mean: (a) 200 hPa velocity potential ($10^6 \text{ m}^2 \text{ s}^{-1}$); (b) OLR (W m^{-2}), 'X' denote time and longitude of TC genesis events in the latitude band, '0' denote events poleward, outside of the latitude band; (c) MSLP anomaly (hPa).

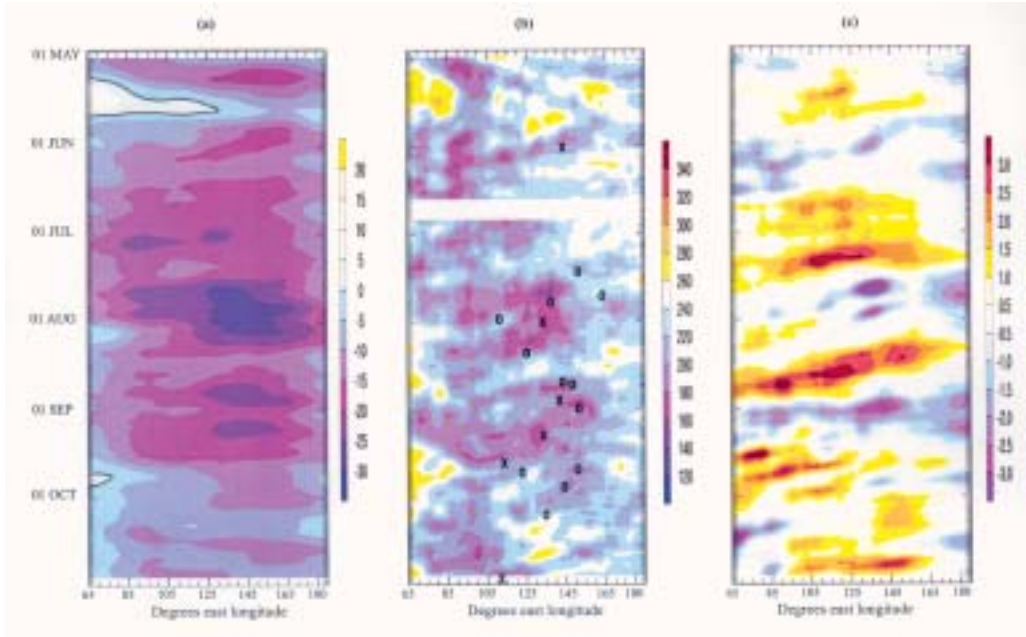
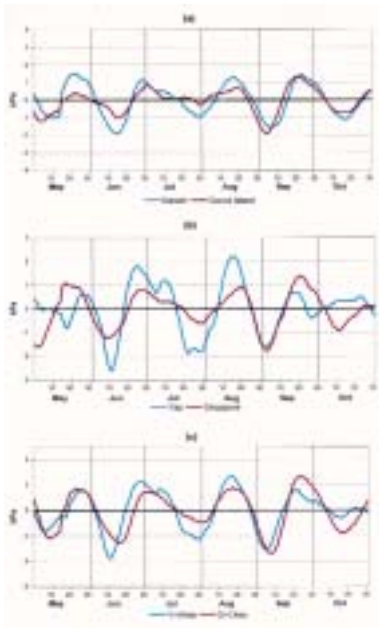


Fig. 14 Filtered MSLP anomalies for two tropical stations in each hemisphere: (a) southern hemisphere, Darwin (blue) and Cocos Island (red); (b) northern hemisphere, Yap (blue) and Singapore (red); (c) Yap plus Singapore four days earlier (blue) and Darwin plus Cocos I. four days earlier (red).



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 18 TCs were analysed in the Darwin RSMC area during the summary period; of these twelve reached severe tropical cyclone or typhoon intensity. All of them formed in the northwestern Pacific (20.5 average). No cyclones formed in the Bay of Bengal or north Indian Ocean (3.6 average). Also no cyclones developed in the south Indian Ocean and none in the south Pacific (average 2.7 for the south Indian and south Pacific Oceans combined). In addition, at least 15 cyclones formed east of the RSMC area in the north Pacific, most of them being close to the American coast (Metcalfe 2005). Seventeen cyclones formed in the northwestern Pacific east of the RSMC area during May October 2004 season (Shaik and Cleland 2005b). On average 27 TCs form in the RSMC region between May and October.

Table 2. Tropical cyclones within the Darwin RSMC area May to October 2005. TS = tropical 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) $m s^{-1}$ (knots)</i>	<i>Estimated minimum MSLP (hPa)</i>	<i>Warning Agency*</i>
Bay of Bengal /North Indian Ocean	Nil			
South Indian Ocean	Nil			
South Pacific	Nil			
Northwest Pacific/South China Sea				
Nesat (Ty)	1 - 11 Jun	49 (95)	930	JMA
Haitang (Ty)	12 -20 Jul	54 (105)	915	JMA
Nalgae (TS)	20 - 24 Jul	23 (45)	990	JMA
Banyan (TS) ¹	21 -28 Jul	28 (55)	980	JMA
Washi (TS)	29 -31 Jul	23 (45)	984	Hong Kong
Matsa (Ty)	31 Jul -7 Aug	40 (78)	963	PAGASA
Sanvu (TS)	11 - 14 Aug	28 (55)	985	JMA
Mawar (Ty)	20 - 28 Aug	49 (95)	930	JMA
Guchol (TS) ¹	21- 25 Aug	28 (55)	980	JMA
Talim (Ty)	27 Aug - 2 Sep	49 (95)	925	JMA
Nabi (Ty) ¹	29 Aug - 7 Sep	49 (95)	930	JMA
Khanun (Ty)	7 -13 Sep	40 (78)	963	PAGASA
Vicente (TS)	16 -18 Sep	23 (45)	988	Hong Kong
Saola (Ty) ¹	20 - 26 Sep	41 (80)	950	JMA
Damrey (Ty)	21 - 27 Sep	41 (80)	955	JMA
Longwang (Ty)	26 Sep - 3 Oct	49 (95)	930	JMA
Kirogi (Ty)	10 - 19 Oct	43 (84)	944	PAGASA
Kai-Tak (Ty)	29 Oct - 2 Nov	41 (80)	952	Hong Kong

* JMA= Japan Meteorological Agency, Tokyo; Hong Kong = Hong Kong Observatory, Hong Kong; PAGASA = Philippine Atmospheric, Geophysical and Astronomical Services Administration, Manila.

Notes

¹ This system moved north eastward out of the RSMC area (40°N) and merged into the extratropical flow.

Where central pressures are not available from the warning centres such as JTWC warnings, only the wind has been obtained from the warnings and pressures are estimated from the relationship described in Atkinson and Holliday (1977).

OLR six-monthly and monthly map figures and time longitude plots for the period May to October 2005 are derived from the data generated by NOAA, Climate Prediction Center, W/NP52, Room 605, WWBG, 5200 Auth Road, Camp Springs, Maryland, 20746-4304 USA. OLR anomalies are derived using 1979-95 climatology dataset.

Sea-surface temperature analysis derived from the operational global analysis of National Meteorological and Oceanographic Centre, Bureau of Meteorology, Melbourne. Includes blended *in situ* and satellite data, 1°C resolution. The 1°x1° global SST climatology from the US National Centers for Environment Prediction (Reynolds and Smith 1995) was used to calculate anomalies.

Darwin Tropical Diagnostic Statement (DTDS), May to October 2005 (issued monthly), and *Weekly Tropical Climate Note* (website: <http://www.bom.gov.au/climate/tropnote/tropnote.shtml>) for the period 3 May 2005 to 1 November 2005 obtainable from the Bureau of Meteorology, PO Box 40050, Casuarina, NT 0811, Australia, were used for reference.

Tropical cyclones

Tropical cyclones (TC) are defined as having maximum ten-minute mean winds greater than 17 m s⁻¹, or named systems. Operational tracks shown in Fig. 15 are from the near real-time publication *Darwin Tropical Diagnostic Statement*, and are based on

RSMC operational manual analyses, with limited post-analysis in a few cases.

Following WMO guidelines (Neumann 1993), winds are assumed to be averaged over ten minutes except those from the JTWC, which uses one-minute means. A conversion factor of 0.88 to relate one-minute to ten-minute means was applied to advices issued from the JTWC. Minimum pressures were also obtained from advices, except for those issued by the JTWC. In these cases minimum pressures were estimated using the relationship of Atkinson and Holliday (1977). Since most agencies use the unit of knots (kn) in warnings, wind speeds are shown in Table 2 in knots as well as m s^{-1} . Climatological numbers are from Atangan and Preble (2005) for the northwest Pacific and southern hemisphere and Mandal (1991) for the Bay of Bengal. A brief discussion and further details of each cyclone can be found in the DTDS for the relevant month.

Tropical storms data for the season was obtained from the University of Hawaii website: <http://www.solar.ifa.hawaii.edu/Tropical/tropical.html> (Metcalf 2005). The data were compiled with the advisories from the National Hurricane Center, the Central Pacific Hurricane Center and the Joint Typhoon Warning Center. The data are near real-time, may not be accurate and have no official status.

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