Aust. Met. Mag. 54 (2005) 241-252

The tropical circulation in the Australian/Asian region - November 2004 to April 2005

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(Manuscript submitted August 2005)

A summary of the broadscale tropical circulation from 70°E to 180°, for the six months November 2004 to April 2005, is presented. While some El Niño characteristics were seen, some critical elements usually associated with El Niño events were absent. For instance, the SST (sea-surface temperature) pattern in the near-equatorial far eastern Pacific and nearby South American coast was near normal, as was tropical cloudiness in this region. However, within the RSMC region several indicators were of a nature similar to weak El Niño conditions. For instance, higher than normal atmospheric pressure anomalies over most of the RSMC longitude range, five-month averaged values of the Southern Oscillation Index (SOI) that remained between -10 and -4 and higher than average levels of tropical outgoing long wave radiation (OLR) across most of the central longitude range. The low rainfall and low-level easterly wind anomalies over northern Australia were indicative of a poor summer monsoon season over northern Australia. However, the date of onset of the Australian monsoon over northern Australia was close to climatology. The signal of Madden-Julian Oscillation (MJO) showed a regular periodicity at around 30 - 35 days. A total of 23 tropical cyclones (TCs) developed in the RSMC area during the period.

Introduction

This summary is part of a continuing series that reviews the broadscale tropical circulation in the Australian/Asian region, and is for the period November 2004 to April 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. Seasons immediately prior to this were described by Shaik and Cleland (2005b) and Shaik and Cleland (2005a). 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) anomalies 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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Broadscale seasonal features

The seasonally averaged diagnostics generally support a neutral El Niño Southern Oscillation (ENSO) phase. However, there were some mixed indicators with some neutral and some El Niño-like characteristics evident since the previous summary season (Shaik and Cleland 2005b). Some of the El Niño-like features include: less than average convection; higher than normal mean sea-level pressures (MSLP); and below average rainfall over central RSMC longitudes. The critical characteristics normally associated with El Niño events that were absent included the near-normal SST pattern and cloudiness around the South American coast and the near-equatorial far eastern Pacific. The monsoon onset over Darwin occurred on 27 December, close to climatological date of 28 December (Drosdowsky 1996). The low monthly rainfall totals from February to April 2005 were the main contributors to below average seasonal rainfall.

Southern Oscillation

Figure 1 shows the ten-year fluctuation of the SOI from May 1995 to April 2005 and its symmetrical five-month running mean. Monthly values of the SOI from January 2003 are given in Table 1. Large fluctuations in the monthly SOI were evident during the season, with the values oscillating between +2 and -29. This latter value was the lowest since February 1983, seemingly in response to the active convection in the south-west Pacific. The mean SOI for the current season was -9. It was -3.8 in the May to October 2004 season, and -2 in the November 2003 to April 2004 season (Shaik

Fig. 1 **SOI time series for ten years to April 2005: monthly values (bars); five-month centred mean values (black line).**

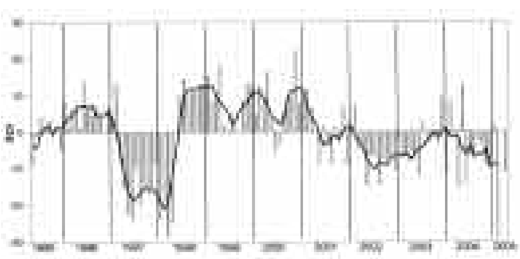


Fig. 2 **Six-month (November 2004 to April 2005): (a) mean OLR (W m^{-2}). 260 W m^{-2} and above yellow shading, 240 W m^{-2} and below blue shading; (b) OLR anomaly (W m^{-2}) > +5 W m^{-2} yellow shading and < -5 W m^{-2} blue shading.**

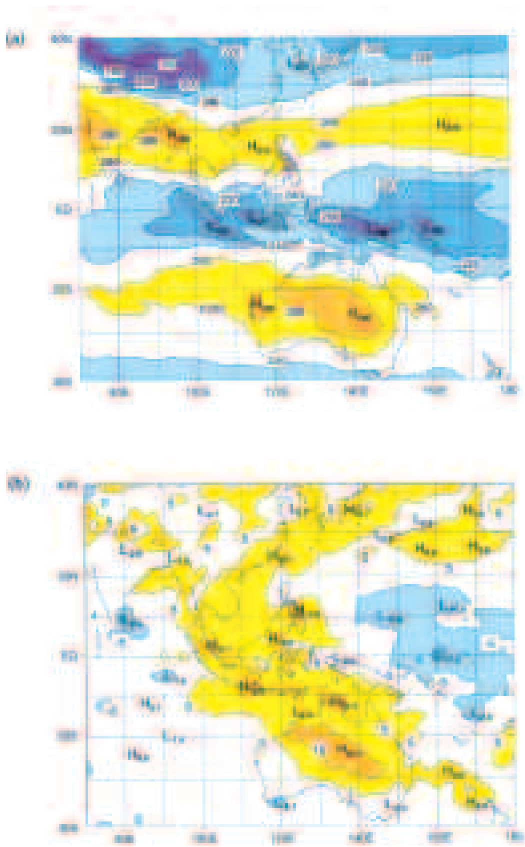
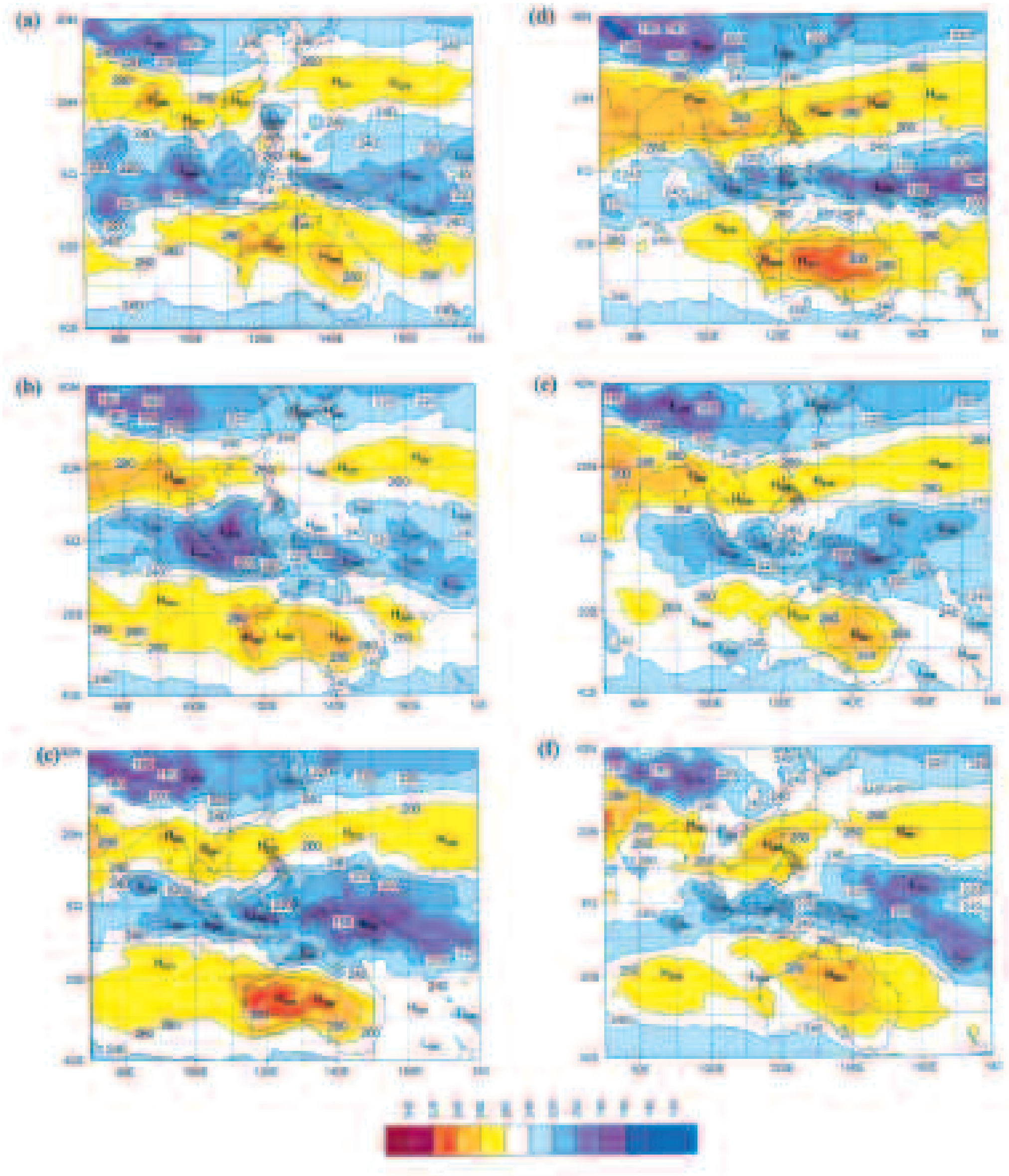


Table 1. Monthly values of Troup's SOI for the period January 2003 to April 2005.

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								

Fig. 3 **Monthly mean OLR (W m^{-2}). 260 W m^{-2} and above yellow-red shading, 240 W m^{-2} and below blue-purple shading: (a) November 2004; (b) December 2004; (c) January 2005; (d) February 2005; (e) March 2005; (f) April 2005.**

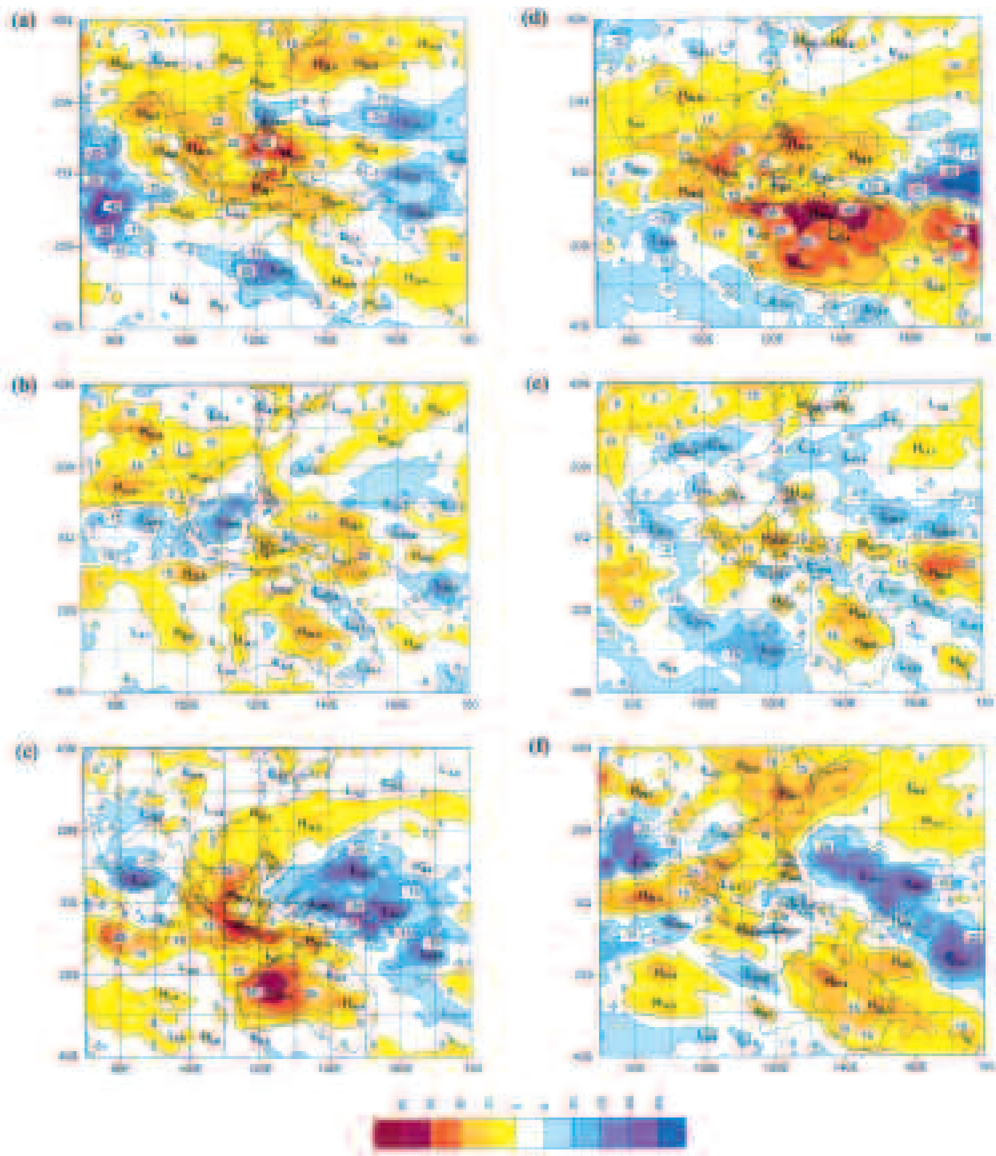


and Cleland 2005b, 2005a). The five-month centred mean during the season remained between -4 and -10. Overall, the SOI values over the past few seasons have predominantly been within one standard deviation of the long-term mean, consistent with the neutral ENSO conditions.

Convection and tropospheric circulation

The mean and anomaly of OLR – used as a proxy for convection – averaged for the six-month period are shown in Fig. 2(a) and (b) and for each individual month shown in Figs 3(a) to (f) and 4(a) to (f) respectively. The maritime continent and Australia experienced mostly below average cloudiness (above average OLR) for the season. Though the monsoon trough was well defined in the southern hemisphere wind analysis, the active areas of convection were mainly focussed in the tropical Indian Ocean and southwest-

Fig. 4 Monthly OLR anomaly (W m^{-2}). > +5 W m^{-2} yellow-red shading, < -5 W m^{-2} blue-purple shading: (a) November 2004; (b) December 2004; (c) January 2005; (d) February 2005; (e) March 2005; (f) April 2005.



ern Pacific. The OLR anomalies (Fig. 4) for individual months show above average convection during November 2004, January, February and April 2005 over the tropical western Pacific.

Velocity potential analyses at 850 hPa and 200 hPa levels (Fig. 5) show good vertical alignment of axes of maximum low-level convergence and upper-level divergence, indicating a well-organised upmotion of a vigorous Hadley circulation in the western Pacific. The poor vertical alignment over the Indian subcontinent represents the below average convection over that area. The positions of both lower and upper-level axes were close to their respective climatological mean latitudes. However, the centres of maximum low-level convergence and upper-level divergence were displaced well to the east of their climatological locations, consistent with the areas of active convection and similar to the pattern that appeared during the November 2003 to April 2004 season (Shaik and Cleland 2005a).

Fig. 5 **Six-month mean velocity potential (10^6 m^2s^{-1}) and vector winds, November 2004 to April 2005. > 0 yellow-red shading and < 0 blue-purple shading: (a) 850 hPa, contour interval 1; (b) 200 hPa, contour interval 2.**

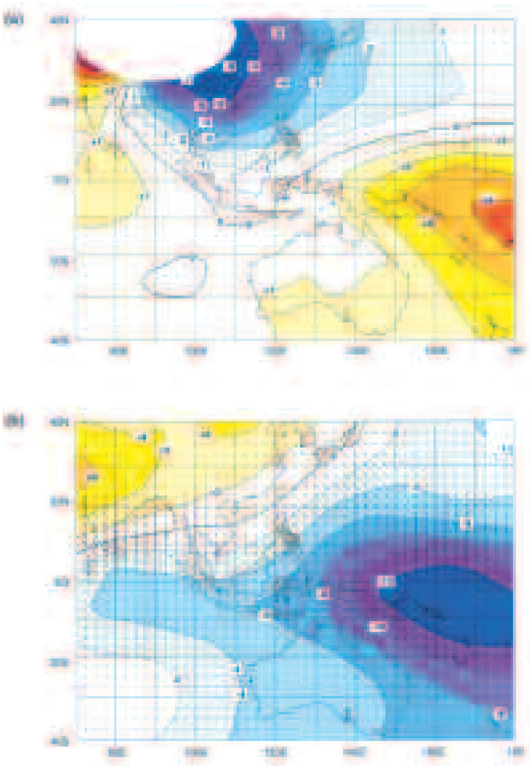
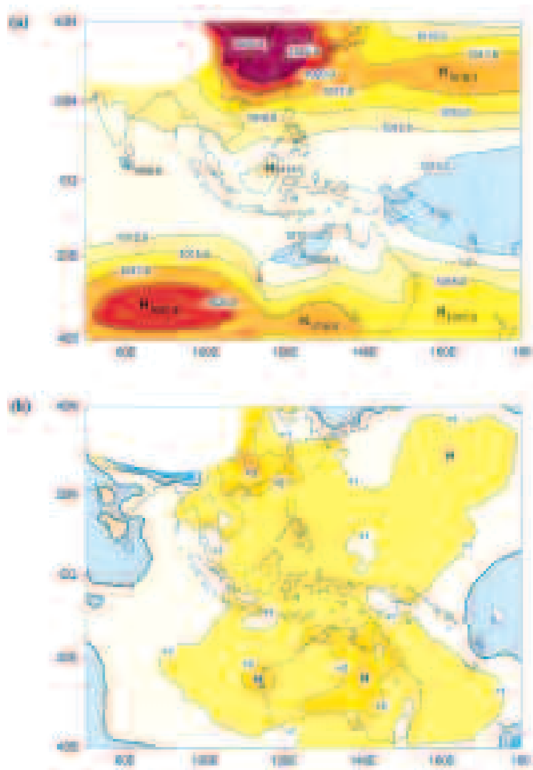


Fig. 6 **Six-month MSL pressure (hPa), November 2004 to April 2005: (a) mean, isobar interval 2.5 hPa; (b) anomaly, contour interval 1 hPa, blue-shaded areas negative, yellow-shaded areas positive.**



Seasonally averaged mean sea-level pressure (MSLP) and anomalies are shown in Fig. 6. Positive pressure anomalies dominated the RSMC region except for a few areas near the western and eastern boundaries. The positive anomalies over Australia were consistent with the persistent dry conditions over much of the continent. The subtropical ridges in both hemispheres were close to their respective mean locations. The pattern of MSLP anomalies over this region was similar to the November 2003 to April 2004 season (Shaik and Cleland 2005a), and to what could be expected in a weak El Niño event. MSLP was relatively high over most of the RSMC area but low over most of the tropical eastern Pacific. Note though, the magnitude of the anomalies in the RSMC area was relatively small, which is more consistent with neutral ENSO conditions.

Vector wind analyses and anomalies at 850 hPa and 200 hPa levels are shown in Figs 7 and 8 respectively. Low-level westerly anomalies were evident across most of the near-equatorial Pacific leading to seasonally averaged westerlies around Papua New Guinea (PNG). This gave rise in the anomaly fields to an apparent divergence over Indonesia and convergence over northern tropical Pacific around 160°E. Low-level winds over northern Australia showed easterly anomalies of nearly 5 m s^{-1} over large areas, indicative of the poor monsoon season over the region. At the upper levels, the flow gave a divergence effect northeast of PNG and convergent effect north of Indonesia. This is consistent with above average convection east of 160°E and below average convection over the Maritime Continent. The seasonal mean flow showed a strong long-wave trough focussed west of Western Australia.

Fig. 7 **Six-month 850 hPa vector wind field, November 2004 to April 2005, isotach (thin lines) interval 5 m s^{-1}, > 5 m s^{-1} shaded yellow: (a) mean; (b) anomaly.**

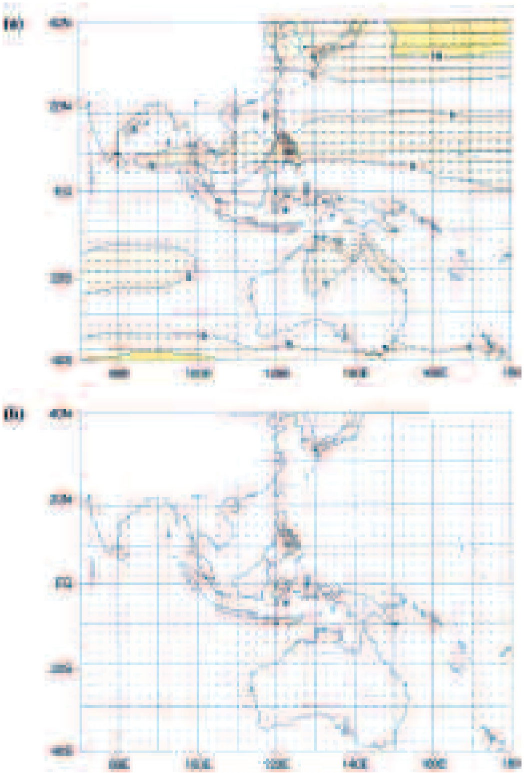
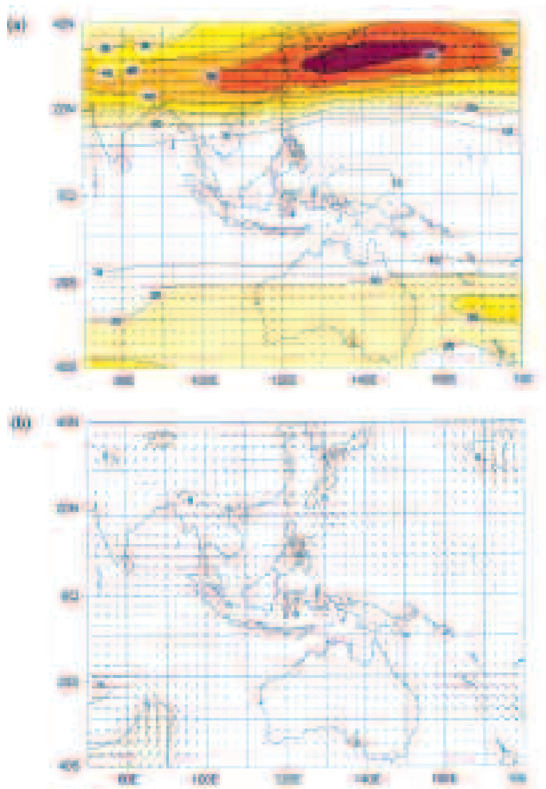


Fig. 8 **Six-month 200 hPa vector wind field, November 2004 to April 2005: (a) mean, isotach (thin lines) interval 10 m s^{-1}, > 10 m s^{-1} shaded yellow; (b) anomaly, isotach (thin lines) interval 5 m s^{-1}, > 5 m s^{-1} shaded yellow.**



Diagrams depicting the cross-equatorial component of the flow and its anomalies are shown in Fig. 9. Despite the poor monsoon flow, these indicate a pattern close to the mean with anomalies more or less close to zero. The exception to this is the presence of southerlies at lower levels between 80°E and 90°E, replacing climatological northerlies. Cross-equatorial flow for the individual months (*Darwin Tropical Diagnostic Statement* (DTDS) – see Appendix) also indicate this flow pattern of the southern monsoon was close to climatology.

Sea-surface temperature

Six-month SST mean and anomalies are shown in Fig. 10. The area shaded light green in Fig. 10(b) represent a near-climatology anomaly range of between +0.5°C and -0.5°C. Most of the equatorial Indian Ocean and seas to the northwest of Australia remained warmer than normal. SSTs in the equatorial western Pacific east of PNG and Northwestern Pacific also remained warmer than normal. These warm temperature anomalies have been more or less a feature of the past three seasons. The warmest waters in the equatorial Pacific remained mostly west of the dateline while the SST pattern near the South American coast was close to climatology.

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 RSMC longitude range. The southern and northern OLR plots (Fig. 11(b) and Fig. 13(b)) also indicate the date and longitude of tropical cyclone genesis events

Fig. 9 **Equatorial cross-section of six-month meridional wind, November 2004 to April 2005, contour interval 2 m s^{-1}, northerlies (negative values) shaded blue, southerlies (positive values) shaded pink-red: (a) mean; (b) anomaly.**

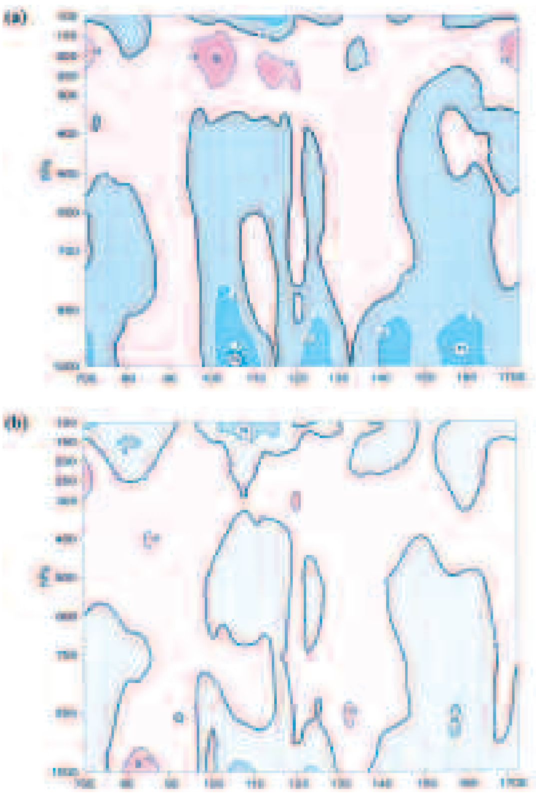
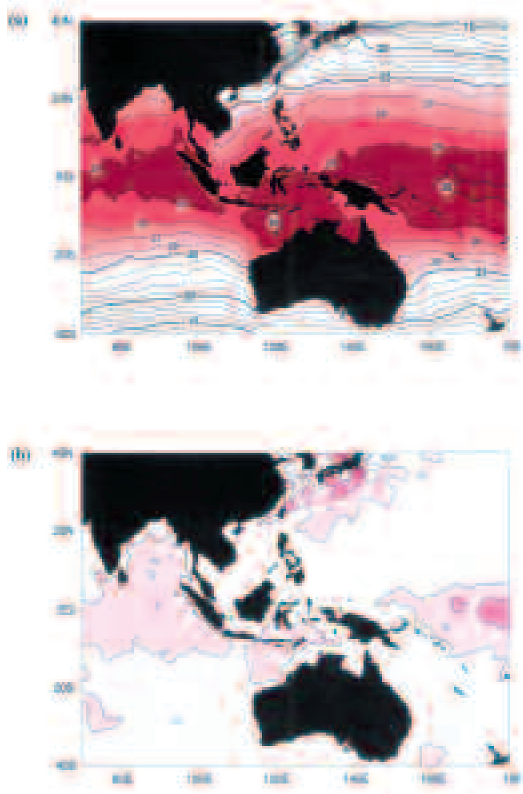


Fig. 10 **Six-month SST (°C), November 2004 to April 2005: (a) mean, isotherm interval 1°C, >25 °C red shading; (b) anomaly, contours -0.5°C to 0.5°C green shade; > +0.5°C pink - red shade; < - 0.5°C blue shade.**



during the season. The time-longitude plots indicate that broadscale areas of active convection formed over the near-equatorial central Indian Ocean during the latter half of each month since July 2004, which could be attributed to MJO active phases. The periodicity of these active events remained around 30 - 35 days for the season. In addition to these major events, there were several weak convective pulses, which occurred in the eastern half of the region and may well be related to the progress of near-equatorial Rossby waves through the region.

Figure 14 shows filtered mean sea-level pressure anomaly series for four stations, two in each hemisphere (see Appendix). 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 to enhance the portrayal of eastward propagating signals. The combined filtered series (Fig. 14(c)) indicate a good phase agreement between the combined pressure signals from mid-December, consistent with the structure of the southern monsoon trough. The individual pressure series have shown good phase agreement during the season until February. The late February event in the Indian Ocean, despite having a strong signal in the upper velocity potential time-longitude plot, showed little evidence in either OLR or MSLP. The pressure series are more or less consistent with the time-longitude plots, suggesting distinct active phases of the MJO during each month throughout the season.

Tropical cyclones

Cyclone definition and details of cyclone data and analysis are presented in the Appendix.

Fig. 11 Time-longitude sections, latitude band 5°S-15°S (southern series), 1 November 2004 to 31 April 2005 of five-day backward running mean: (a) 200 hPa velocity potential (10^6 m^2 s^{-2}); (b) OLR (W m-2); 'X' denote time and longitude of TC genesis events in the latitude band; '0' denote events pole ward, outside of the latitude band; (c) MSLP anomaly (hPa).

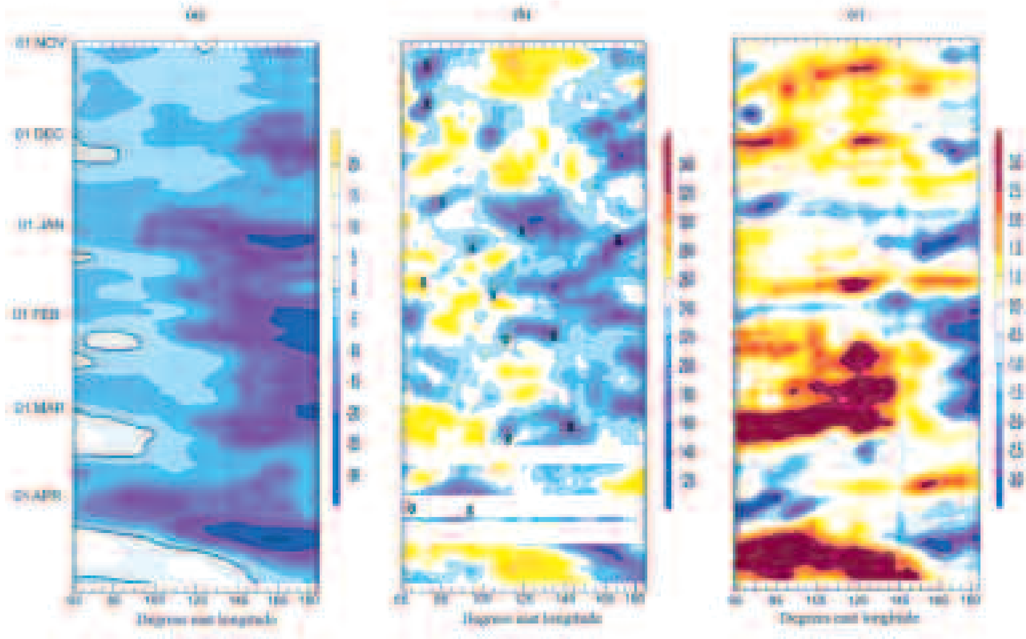


Fig. 12 Time-longitude sections, latitude band 5°N-5°S (equatorial series), 1 November 2004 to 30 April 2005 of five-day backward running mean: (a) 200 hPa velocity potential; (b) OLR; (c) MSLP anomaly.

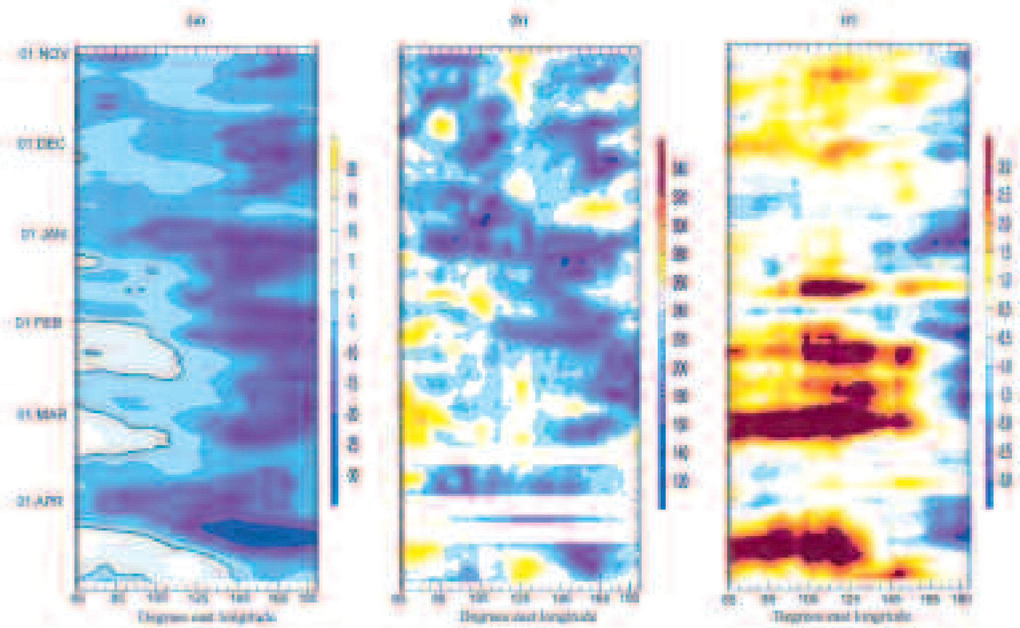


Fig. 13 **As for Fig. 11, except latitude band 5°N-15°N (northern series).**

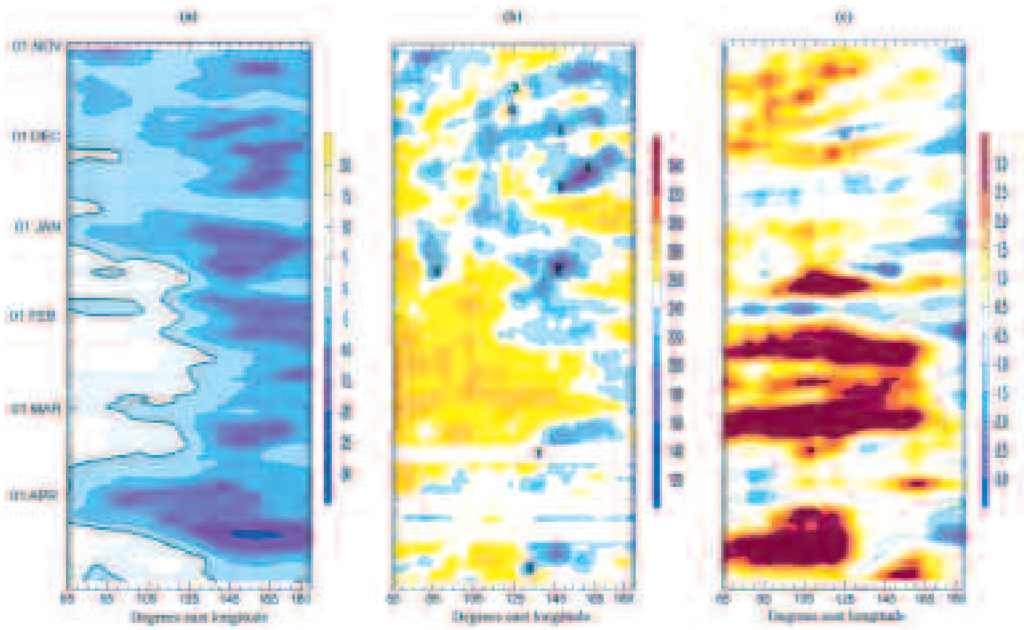
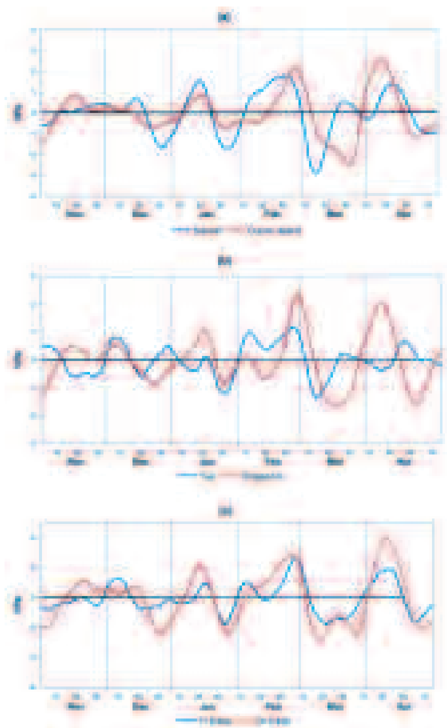


Fig. 14 **Normalised MSLP anomalies for two tropical stations in each hemisphere: (a) southern hemisphere, Darwin (blue) and Cocos Island (red); (b) northern hemisphere, Yap (blue) and Singapore (red); (c) Yap plus Singapore 4 days earlier (blue) and Darwin plus Cocos I. 4 days earlier (red).**



Operational cyclone 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.

A total of 23 TCs were analysed in the RSMC area during the summary period. Of these, ten reached severe tropical cyclone or typhoon intensity whilst within RSMC boundaries. Nineteen cyclones formed at the same time during 2003-04, where neutral ENSO conditions also prevailed (Shaik and Cleland 2004). During the 2002-03 season – which was a transition from warm ENSO to near-neutral conditions – a total of 25 TCs were analysed (Shaik and Cleland 2004), whereas nineteen cyclones formed in the 2001-02 season during a period of transition from near-neutral ENSO to developing El Niño conditions (Shaik and Bate 2003). The distribution during the current season among the different Ocean basins was similar to the 2003-04 season except for the northwestern Pacific basin where there were twice as many cyclones. At least eleven more cyclones formed outside the RSMC region in the Indian and the Pacific Oceans (Tropical Storms data on University of Hawaii website – see Appendix). A total of 23 cyclones developed in the southern hemisphere, out of which fourteen were in the RSMC area and five in the southwestern Pacific. The total of 23 cyclones in the combined south Indian and Pacific oceans is slightly below the mean of 25.3 (Atangan and Amanda 2005). Note though, that the mean includes significant tropical depressions of below gale-force intensity, with maximum mean winds of 13

Table 2. Tropical cyclones within the RSMC area, November 2004 – April 2005. TC = tropical cyclone, STC = severe tropical cyclone, TS = tropical storm, CS = cyclonic storm, Ty = typhoon.

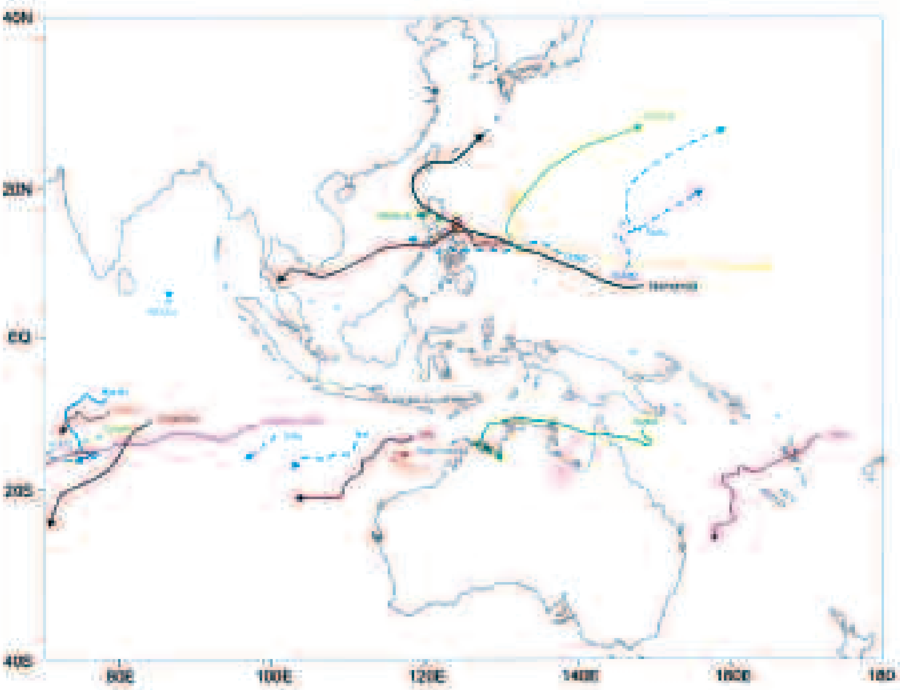
Name	*Dates*[1]	*Mean wind*[2] *m s^{-1} (knots)*	*Estimated minimum MSLP (hPa)*	*Warning Agency**
Bay of Bengal / North Indian Ocean				
Hibaru (CS)	15 - 16 Jan	18 (35)	1000	IMD
Northwest Pacific / South China Sea				
Muifa(Ty)	15 -25 Nov	41 (80)	955	JMA
Merbok (TS)	22 -23 Nov	18 (35)	998	JMA
Nanmadol (Ty)	29 Nov-5 Dec	46 (90)	935	JMA
Talas (TS)	11 -19 Dec	21 (40)	992	JMA
Noru (TS)	18 -22 Dec	23 (45)	990	JMA
Kulap (TS)	15 -19 Jan	26 (50)	985	JMA
Roke (TS)	15 -17 Mar	28 (55)	980	JMA
Sonca (Ty)	23-27 Apr	44 (85)	940	JMA
South Indian Ocean (70°E - 105°E)				
Arola (CS)	8 -12 Nov	31 (60)	976	La RéUnion
Bento (STC)	21 -29 Nov	62 (120)	905	La RéUnion
Chambo (STC)	24 -30 Dec	44 (85)	945	La RéUnion
Sally (TC)	8 -10 Jan	23 (45)	988	Perth
Daren (TC)	19 -20 Jan	21 (40)	988	La RéUnion
Isang (TC)[3]	3-4 Apr	21 (40)	993	La RéUnion
Adeline/Juliet (STC)[4]	3-9 Apr	62 (120)	910	Perth/La RéUnion
Australian (105°E - 165°E)				
Raymond (TC)	2 -2 Jan	21 (40)	990	Perth
Tim (TC)	23 -25 Jan	23 (45)	988	Perth
Harvey (STC)	6 -7 Feb	44 (85)	965	Darwin
Vivienne (TC)	8 -8 Feb	23 (45)	990	Perth
Ingrid (STC)	6 - 16 Mar	62 (120)	925	Brisbane
Willy (STC)	10-14 Mar	39 (75)	960	Perth
South Pacific Ocean (165°E - 180°)				
Kerry (STC)	5 -14 Jan	39 (75)	960	NTCC

Notes:
1 Dates (UTC) at TC intensity in Darwin RSMC area
2 Maximum 10-min. Mean wind (while in RSMC area)
3 TC *Isang* remained close to the RSMC western boundary between 60°E and 70°E before merging in an extratropical frontal system.
4 STC *Adeline/Juliet* moved out of RSMC western boundary while intensifying. It reached maximum wind speed of 62 m s^{-1} (120 knots) west of RSMC area.

* Warning Agencies: NTCC = Nadi Tropical Cyclone Centre, Fiji Meteorological Service, Nadi; BoM = Bureau of Meteorology, Australia; Brisbane = BoM, Queensland Regional Office, Brisbane; Darwin = BoM, Northern Territory Regional Office, Darwin; Perth = BoM, Western Australia Regional Office, Perth; JMA = Japan Meteorological Agency, Tokyo; La RéUnion = Météo France, Le Centre Régional de la Réunion, LE CHAUDRON, B.P. 4, La RéUnion; IMD = India Meteorological Department, New Delhi.

Note that where the central pressures are not available from the warnings, the wind has been obtained from the warnings and pressures are estimated from the relationship of Atkinson and Holliday (1977).

Fig. 15 **Tropical cyclone tracks, November 2004 to April 2005. Solid line denotes system reached severe tropical cyclone (typhoon/hurricane) intensity; dashed line denotes system reached only tropical cyclone/storm intensity.**



to 16 m s^{-1}. Eight tropical systems including three of typhoon intensity developed in the northwestern Pacific and one tropical cyclone in the north Indian Ocean, including the Bay of Bengal. This compares with climatology of 5.7 (3.4 typhoons) and 2.2 (0.5 severe tropical cyclones) respectively.

Acknowledgments

The authors would like to express their sincere thanks to Thomas Delfatti for his help in the drafting of figures. Thanks also to Dr Andrew Watkins of the National Climate Centre, Australian Bureau of Meteorology, for generating OLR 6-monthly and monthly maps using data collected from the NOAA-16 satellite through the Climate Prediction Center, Maryland, USA. Thanks are also due to Joan Fernon, Darwin Regional Office and staff, National Climate Centre for their generous help in archiving and providing numerical weather prediction data used in producing various maps. Thanks are also expressed to the United States Climate Prediction Center and the Australian Bureau of Meteorology Research Centre for permission to use OLR figures and data.

Appendix

Data sources used in this summary include:
Construction of MSLP, upper wind, velocity potential six-month seasonal charts, MSLP and velocity potential time-longitude plots are based on the data from the Bureau of Meteorology's Global Assimilation and Prediction system (GASP – Bourke et al. 1990, Bur. Met. 1998); anomalies derived from the ECMWF 22-year climatology. Data for cross-equatorial flow diagrams were obtained from Bureau of Meteorology's Tropical region Extended Limited Area Prediction System (TXLAPS - Bur. Met.2005).

Filtered mean sea-level pressure anomaly series (Fig. 14) for two tropical stations in each hemisphere, normalised then passed through a 40-day Butterworth filter, 50 per cent response at 23 and 70 days: southern hemisphere, Cocos Island, (12.2°S, 96.8°E) and Darwin (12.4°S, 130.9°E); northern hemisphere, Singapore (1.4°N, 104.0°E) and Yap (9.5°N, 138.1°E).

OLR six-monthly and monthly map figures and time longitude plots for the period November 2004 to April 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, November 2004 to April 2005 (issued monthly), and *Weekly Tropical Climate Note,* 2 November 2004 to 3 May 2005 (current issue on web at http://www.bom.gov.au/climate/tropnote/tropnote.shtml). Bureau of Meteorology, PO Box 40050, Casuarina, NT 0811, Australia.

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 and PAGASA Manila. 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 Amanda (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/. The data was compiled with the advisories from the National Hurricane Center, the Central Pacific Hurricane Center and the Joint Typhoon Warning Center. The data is near real time, may not be accurate and has no official status.

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