Australian Government

Bureau of Meteorology

Darwin Tropical Diagnostic Statement

DARWIN REGIONAL SPECIALISED METEOROLOGICAL CENTRE

December 2002, VOL 21 No 12

ISSN 1321 - 4233

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DARWIN TROPICAL DIAGNOSTIC STATEMENT

December 2002

ISSUED BY DARWIN RSMC

SUMMARY

Atmospheric indicators generally imply continuing moderate El Niño conditions. The SOI increased its negative magnitude, while low level westerly wind anomalies increased and divergent upper level easterlies persisted near the equator to the west of the date-line. The areas of above average tropical active convection were confined generally to eastern and western parts, twin near-equatorial troughs being a feature of the Indian Ocean for much of the month. Three tropical cyclones formed in the RSMC area, about average except for the Australian region, which was below average. An enhanced MJO pulse developed towards the end of December, hastening development of the summer monsoon in the Indonesia /north Australian region.

INDICES

Troup's Southern Oscillation Index (SOI) for December 2002	-11
5-month mean (centred upon October)	-9
Darwin mean MSL pressure for December 2002	1009.1 hPa
Pressure anomaly (1933 – 1992 mean)	+1.7 hPa
Tahiti mean MSL pressure for December 2002	1010.5 hPa
Pressure anomaly (1933 – 1992 mean)	-0.4 hPa

Time series of Troup's SOI:

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2000	+5	+13	+9	+17	+4	-5	-4	+5	+10	+10	+22	+8
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

The above table presents the monthly values of SOI from year 2000. Fig. 1 shows the monthly SOI and its five-month running mean for the past ten years.

After easing a little during the previous three months the SOI once again dropped to more than 1 standard deviation below the mean. However the 5-month running mean remained at –9 for the third successive month, implying little overall change in the broad-scale Walker circulation.

TROPICAL CYCLONES [Figs 2]

Three tropical cyclones were analysed in the Darwin RSMC area during December, one each in the Bay of Bengal, northwest Pacific and southwest Pacific, the last two being very powerful systems. An additional severe TC (Crystal) developed in the south Indian Ocean just west of the

RSMC region and a weak one (Yolande) in the southwest Pacific east of the date-line, while a depression in the central south Indian Ocean late in the month failed to reach TC intensity. Comparative December averages are: northwest Pacific basin 1.3 storms (0.7 typhoons) and north Indian Ocean 0.4 cyclones. For the south Indian Ocean and Pacific Oceans a 21-year mean of 3.4 includes depression with maximum winds of $\geq$ 25 knots.

Typhoon Pongsona

At the beginning of December a monsoon trough remained active in the north Pacific west of the date-line, with a circulation initially analysed near 5°N 165°E. Monsoonal westerlies were supported by cross-equatorial flow from the southern hemisphere. Named overnight on the 3rd, Pongsona was steered first west, then gradually northwest around the mid-level STR, intensifying steadily under divergent upper easterly flow. Maximum intensity was reached on the 8th, the eyewall passing over Guam, where it caused major damage and at least three deaths. By the 9th Pongsona was moving through the ridge axis and began to interact with a mid-latitude frontal system shortly thereafter. It then became caught in the westerly flow and accelerated rapidly to the east-northeast, becoming extra-tropical by the 11th.

Tropical cyclone no name (05B)

Twin NETs were evident across the central and east Indian Ocean for much of the month. With the development of a MJO enhanced phase, convection began to increase in both hemispheres during the second half. A circulation, evident to the south of Sri Lanka, began to intensify from the 22nd, with southern hemisphere twins both east and west of it (the latter becoming STC Crystal after moving across 70°E out of the RSMC region). Located just south of the upper ridge under diffluent easterlies, it attained minimal TC intensity off the southeast coast of Sri Lanka early on the 24th, its movement mostly due to the equatorial westerlies. Shear in this flow prevented further intensification and resulted in an early demise.

Severe Tropical Cyclone Zoe

This system formed initially in a trough east of the date-line, moving into the RSMC area early on the 25th. With a mid-level sub-tropical high cell to its southwest and moderate easterly flow aloft, it continued tracking west and reached TC strength early on the 26th. Greatly improved upper outflow in all quadrants then promoted rapid development. By the 28th it had become a very powerful system as it tracked toward a weakness in the ridge, caused by an approaching mid-level trough. Passing through the ridge during the next 24 hours, it then encountered increasing northwesterly flow and accelerated to the southeast, gradually weakening over the next few days. Zoe crossed several of the outer Solomon Islands while at maximum intensity, causing heavy damage but no known fatalities.

SEA SURFACE TEMPERATURE [Figs. 3, 4]

The El Niño pattern of warm SST anomalies across the equatorial Pacific remained almost unchanged from November apart from small decreases in the east (not shown). Warm anomalies strengthened somewhat over the Indian Ocean, Indonesian and northwest Australian region, and through much of the South and East China Seas. There was some contraction of warm anomalies in the western Pacific between about 5°N and 20°N, anomalies in this region being generally weakly negative in December except in the west where weak positive values persisted.

MSL PRESSURE [Figs. 5, 6]

Through central and eastern longitudes the pressure anomaly pattern in the tropics was similar to that of the previous month, with high pressures in central parts - though negative anomalies near the equatorial date-line were weaker. A strong sub-tropical ridge was evident in the southern hemisphere; the eastern Indian Ocean high cell was located east of its mean position and pushed a strong ridge south of Western Australia, enhancing the pressure gradient to its north. The ridge over the central north Pacific was near its mean latitude and a little stronger than average.

850 hPa FLOW [Figs. 7, 8]

The most striking feature of the flow is the extensive band of easterly wind anomalies through the southern hemisphere tropics, consistent with above average pressures across the broader Australian region. There was little sign of broad-scale monsoon development through the Indonesian/ Australian region. Twin NETs were evident in the Indian Ocean, generally similar to the mean, though the circulation in the south was stronger than average. Twin troughs were also a feature of the western Pacific, resulting in westerly winds along the equator east of 150°E, a region of climatological easterlies. Westerly anomalies in this region were stronger than in November, another indication that El Niño remains a significant factor at this stage.

850 hPa WIND COMPONENTS at DARWIN [Figs. 9(a), (b)]

The diagrams show that light southeasterlies prevailed for most of the first third of the month, moderate easterlies dominating thereafter. Easterly components were above average for the latter period, as might be expected from the broad-scale anomaly pattern. This period also saw some resurgence of rainfall, due generally to land-based diurnal convective activity. However total monthly rainfall was well below the December average.

CROSS-EQUATORIAL INTERACTION [Fig. 10]

With climatological southerly upper flow replaced by northerlies across most of the region there was little sign of any significant Hadley cell except over the central Indian Ocean. The low-level northerly maximum near 100-110°E was weaker than normal. Other northerly maxima at 120°E and 140°E, although a little stonger than average, were confined below 850 hPa and made no significant contribution to development of the monsoon. East of 145°E, a region of climatological northerly flow, weak southerlies extended across the equator in several places. This was due to diffluent flow around the western flank of a trough in the region of the SPCZ - itself partly a result of STC Zoe - which helped maintain the anomalous northern hemisphere trough.

UPPER LEVEL FLOW [Figs 11, 12]

The ridge in the northern hemisphere moved markedly south from November and was south of its climatological latitude. In the southern hemisphere the ridge was near its normal latitude over the Indian Ocean, but generally equatorward of it further to the east. This combination resulted in weaker than average equatorial easterlies except over the central Indian Ocean and to the east of 160°E, where divergent easterly anomalies persisted, typical of El Niño. Flow was also generally into, rather than out of, the summer hemisphere over much of the longitude range. In the southern hemisphere mid latitudes, a ridge over Western Australia displaced the climatological trough westward over the Indian Ocean, with the eastern Australian trough also somewhat west of its mean location.

VELOCITY POTENTIAL [Figs 13, 14]

The diagrams clearly imply strongest up-motion at the eastern and western ends of the longitude range. In the east the axes of low level convergence and upper level divergence are in approximate alignment near the equator. A somewhat similar situation is also seen over the Indian Ocean, where organisation appears strongest south of the equator. Suppressed tropical up-motion is inferred through central longitudes, there being little evidence of broad-scale low-level convergence in particular.

INTRA-SEASONAL VARIATIONS [Figs. 15, 16, 17]

During the last third of the month a pulse was clearly evident in 200 hPa velocity potential and OLR data for all latitude ranges. This was accompanied by increased organisation of the southern monsoon trough over the Indian Ocean, and beginnings of its development further eastward; TCs were spawned in the Indian Ocean on both sides of the equator. This is the second clear MJO pulse in the past two months; it implies an apparent periodicity of about 35-40 days. Despite these two MJO pulses, the majority of the region was dominated by suppressed convective activity for the bulk of December, while persistent convective activity is seen in the east. This is due in part to ongoing El Niño conditions.

RAINFALL [Figs 18, 19]

Gridded Australian rainfall maps provided by the Bureau of Meteorology's National Climate Centre are at Fig. 18; OLR maps, courtesy of the Bureau of Meteorology Research Centre, are shown in Fig. 19 (see Explanatory Notes for details).

Although some rain fell over virtually all of Australia during December, in eastern and northern parts falls were again generally below average and very much below average over large areas. This is consistent with the ongoing El Niño event and, in particular, generally high pressures associated with a strong sub-tropical ridge. Dry and hot conditions contributed to severe bush fires in parts of southeastern Australia. Large parts of Western Australia fared better with average to very much above average falls over large areas, broadly coinciding with enhanced convergence into the inland trough.

The OLR anomaly map (Fig. 19(b)) clearly indicates the persistent negative El Niño-related convection anomalies through the maritime continent, SPCZ region and northwest equatorial Pacific. Strong convection continued across the equator near and east of the date-line. Over the Indian Ocean, activity associated with the twin NET configuration is apparent, strongest activity being evident south of the equator, although anomalies were stronger in the north.

Despite generally suppressed convection, media reports indicate that heavy rainfall in parts of Indonesia, notably Sumatra and Java, has caused widespread dislocation, including a number of deaths, since the monsoon began affecting the region in the latter half of the month.

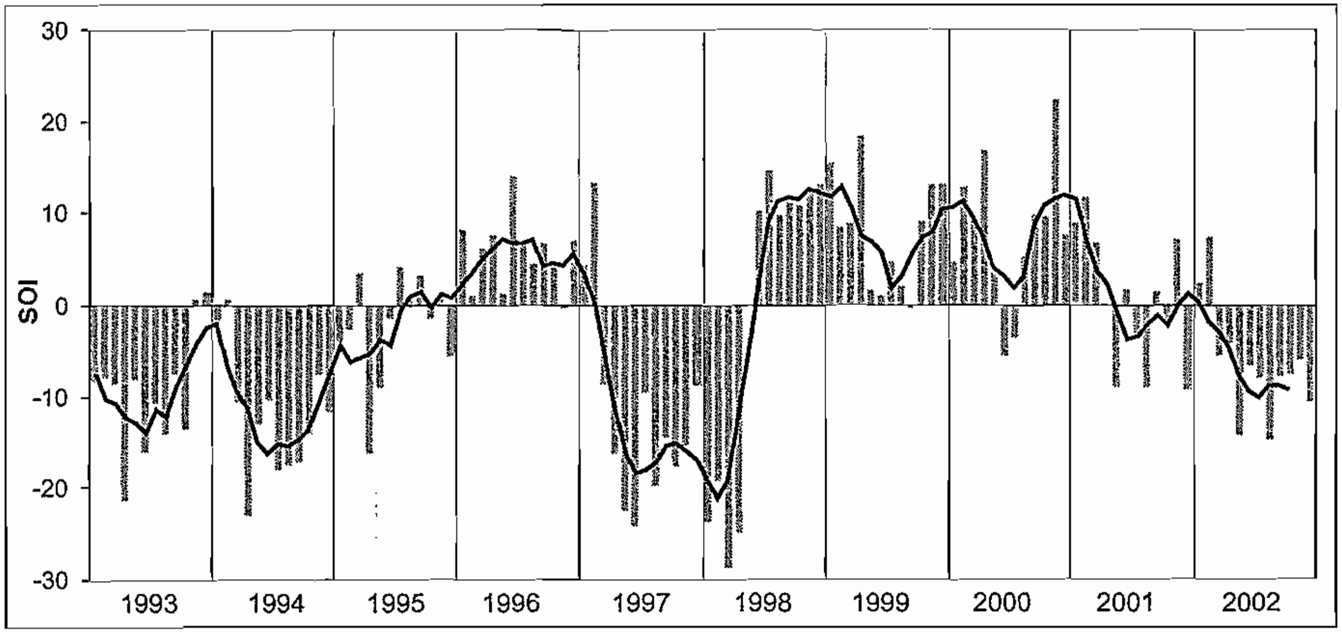

Fig.1 SOUTHERN OSCILLATION INDEX 1993 - 2002
Monthly SOI (bars) and 5-month running mean SOI.

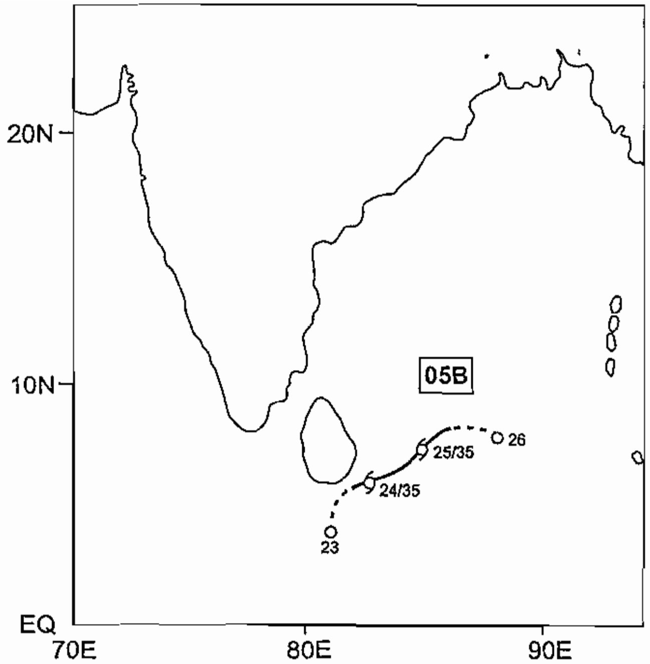

Fig.2(b) OPERATIONAL TRACK OF CYCLONE 05B, DECEMBER 2002.

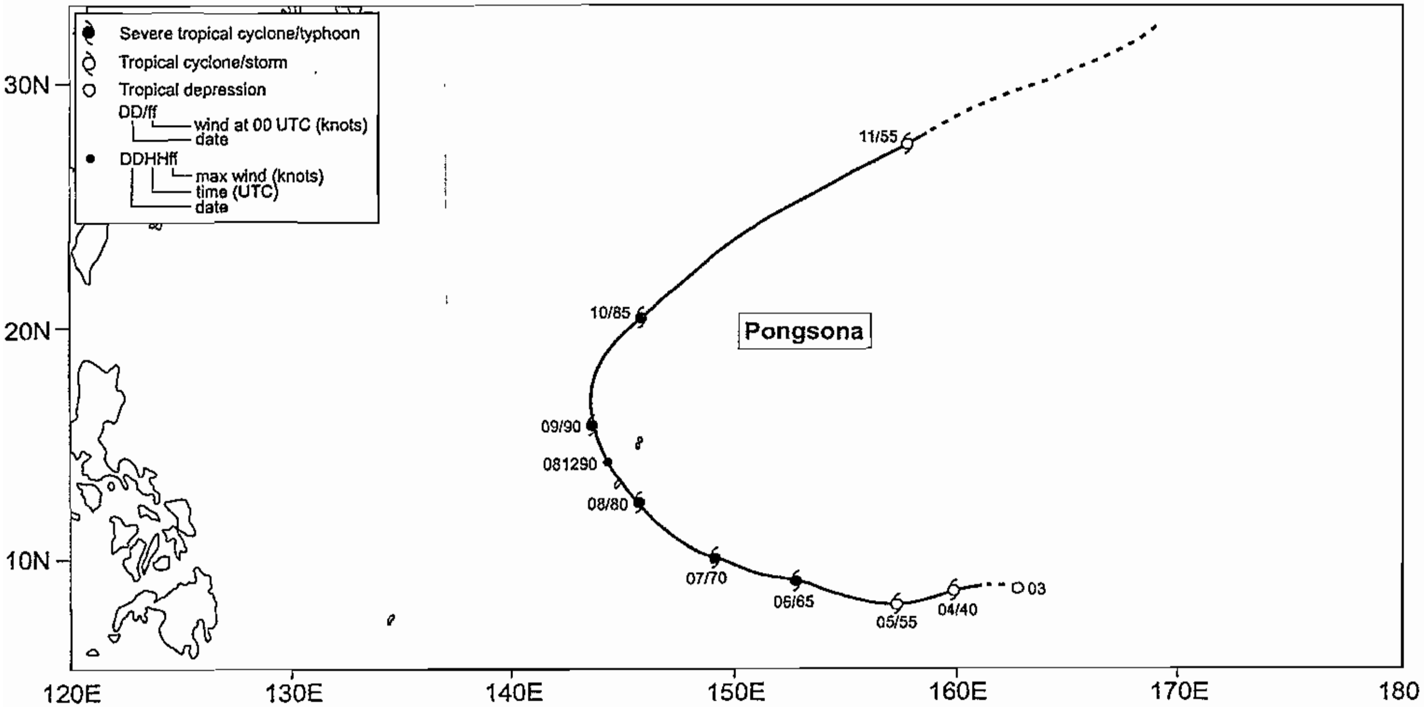

Fig.2(a) OPERATIONAL TRACK OF CYCLONE PONGSONA, DECEMBER 2002.

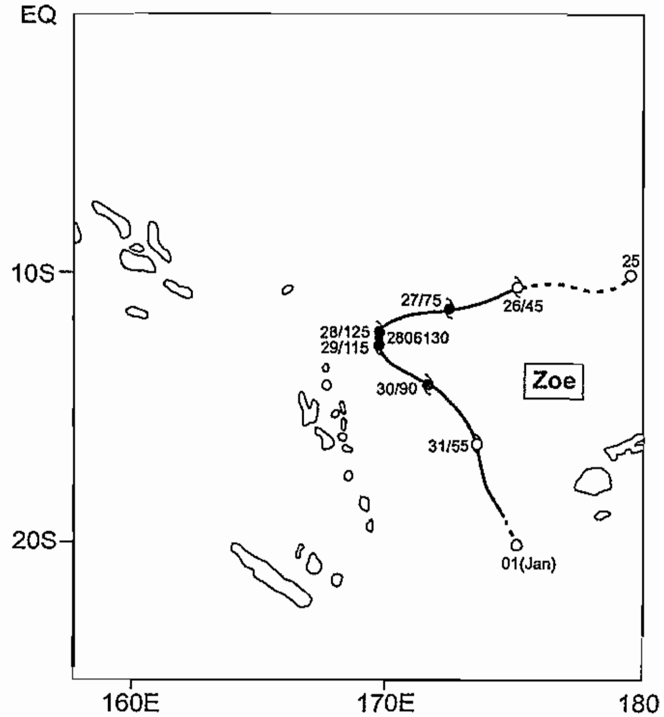

Fig.2(c) OPERATIONAL TRACK OF CYCLONE ZOE, DECEMBER 2002.

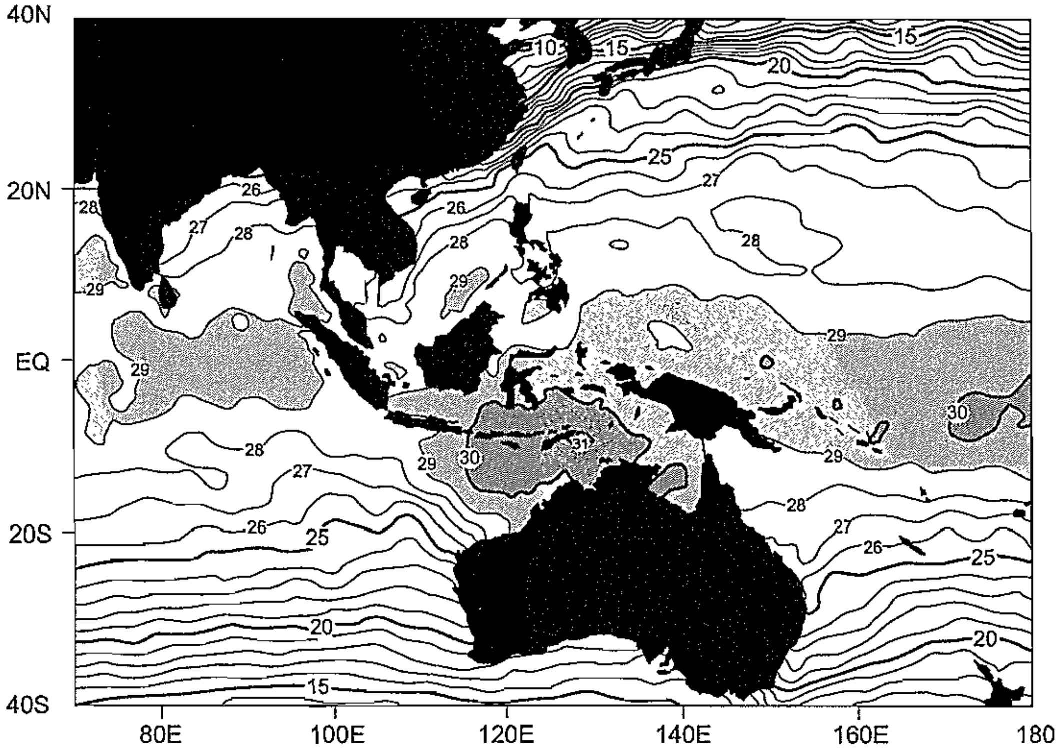

Fig.3 MEAN SEA SURFACE TEMPERATURE, DECEMBER 2002.
Contour interval 1°C, heavy lines every 5°C, >29°C shaded.

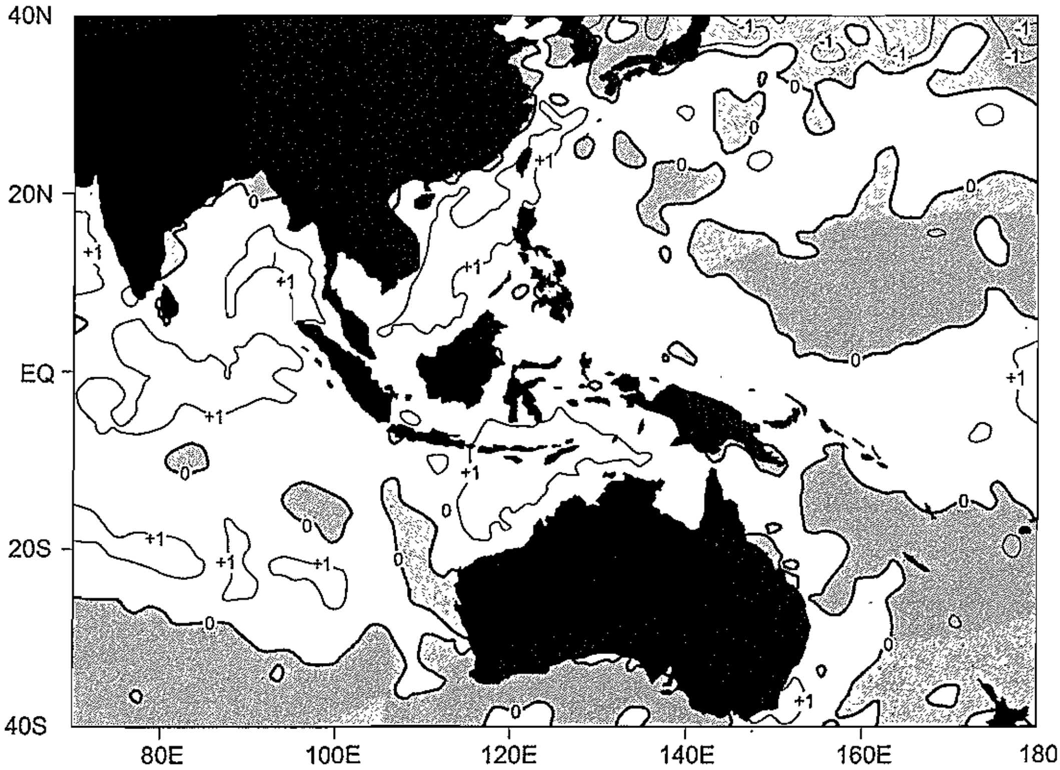

Fig.4 SEA SURFACE TEMPERATURE ANOMALY, DECEMBER 2002.
Contour interval 1°C. Heavy line represents 0°C anomaly, negative anomaly shaded.

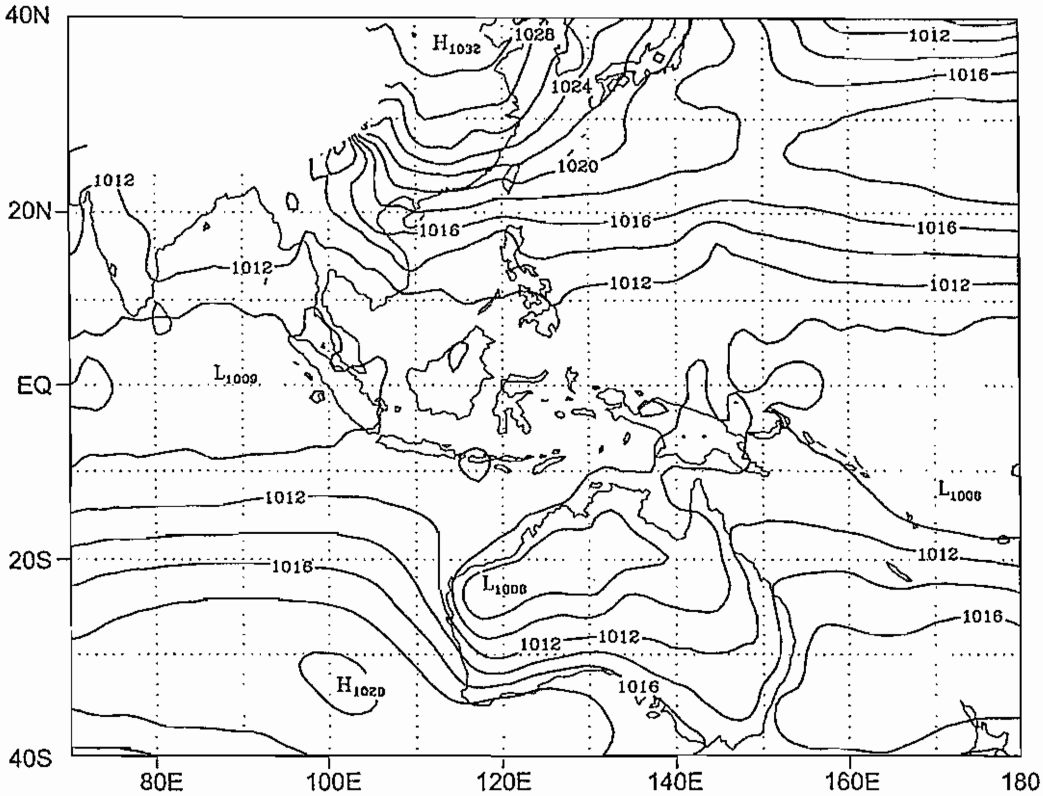

Fig.5 MEAN MSL PRESSURE, DECEMBER 2002.
Isobar interval 2 hPa.

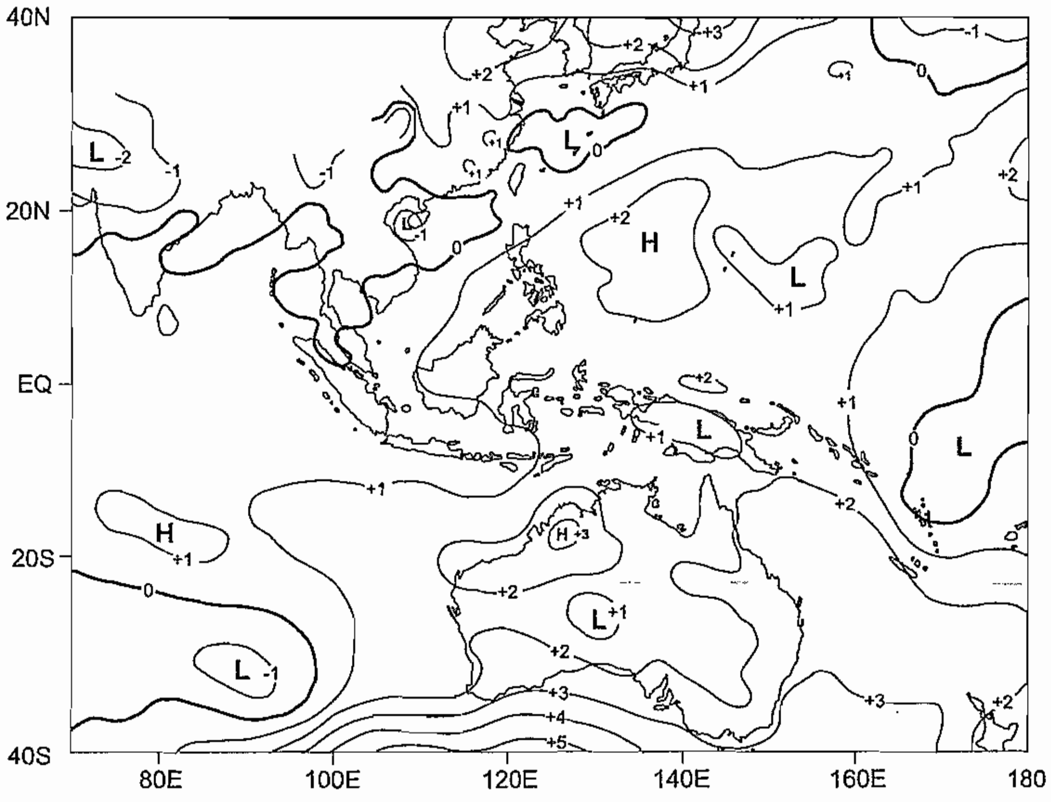

Fig.6 MSL PRESSURE ANOMALY, DECEMBER 2002.
Contour interval 1 hPa. Heavy line represents zero anomaly.

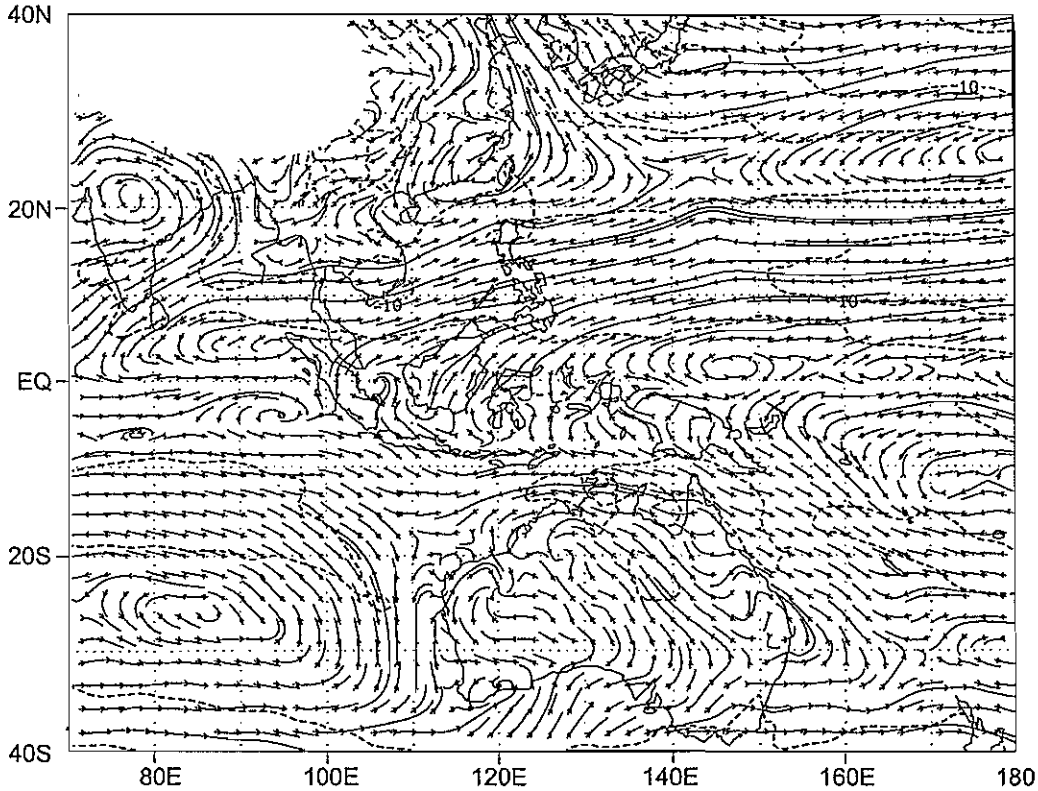

Fig.7 850 hPa MEAN STREAMLINE ANALYSIS, DECEMBER 2002.
Isotachs at 5 ms^{-1} intervals.

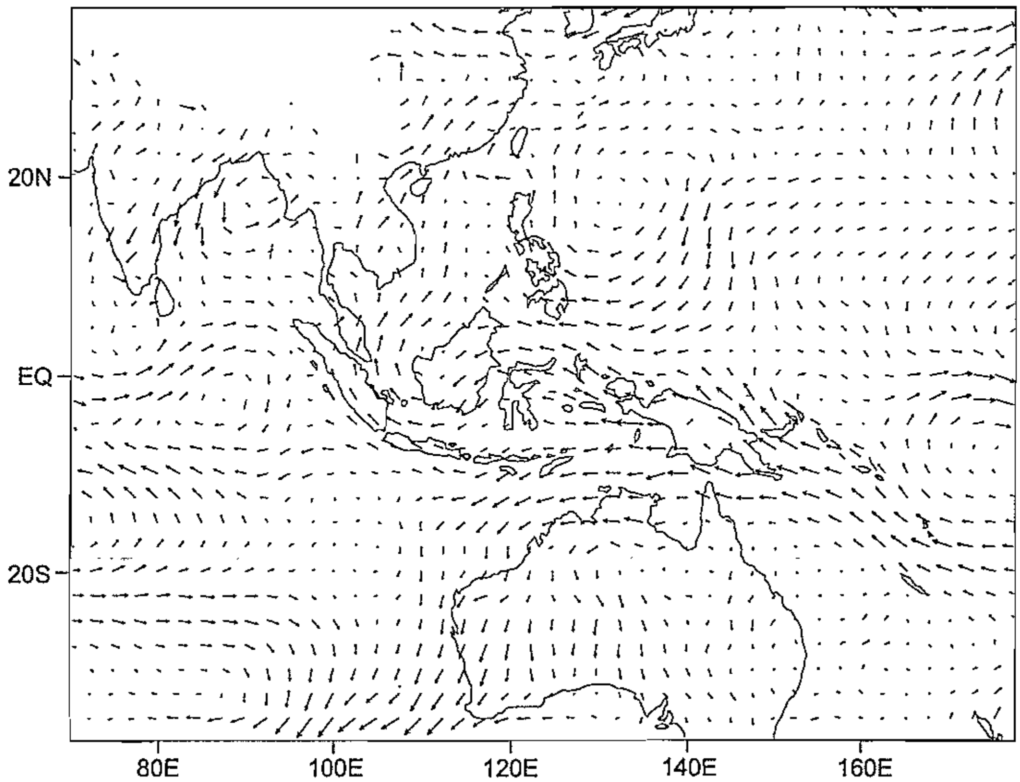

Fig.8 850 hPa WIND ANOMALY, DECEMBER 2002.
Arrow length indicates relative magnitude.

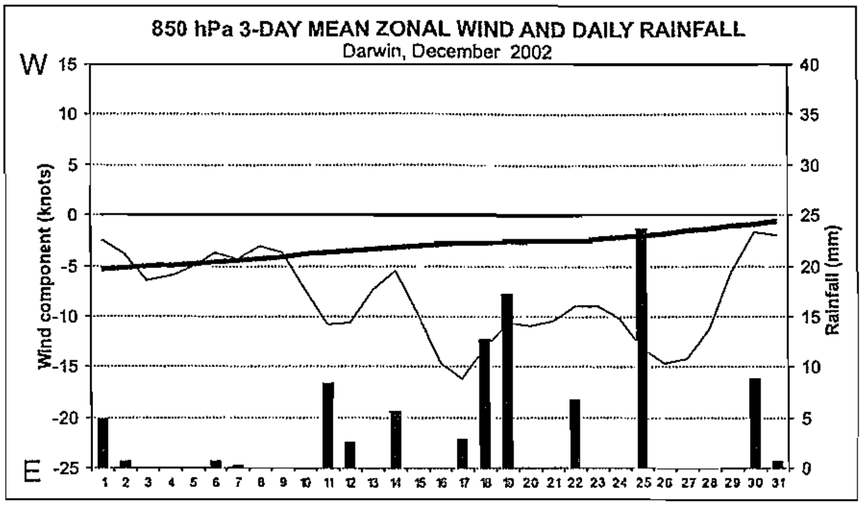

Fig.(9a) DARWIN 850 hPa MEAN ZONAL WIND AND DAILY RAINFALL (bars), DECEMBER 2002.
Thin line represents 3-day running mean. Solid line represents the mean seasonal wind cycle.

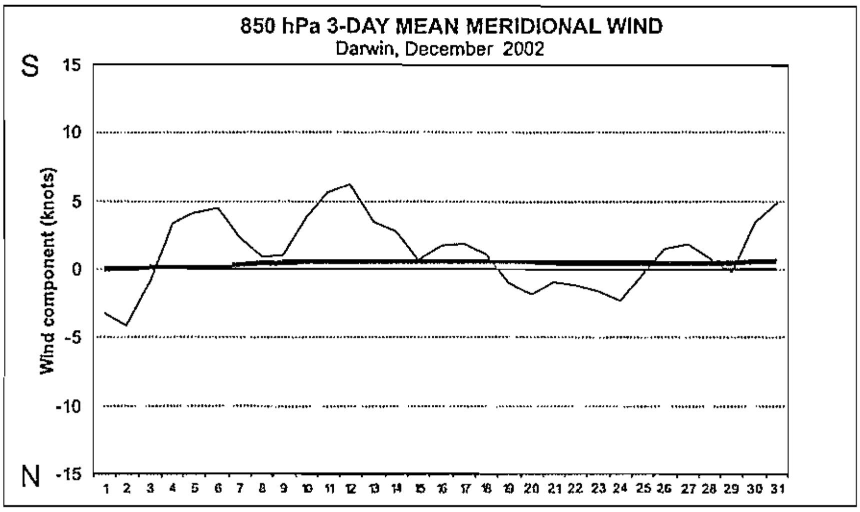

Fig.(9b) DARWIN 850 hPa MEAN MERIDIONAL WIND, DECEMBER 2002.
Thin line represents 3-day running mean. Solid line represents the mean seasonal wind cycle.

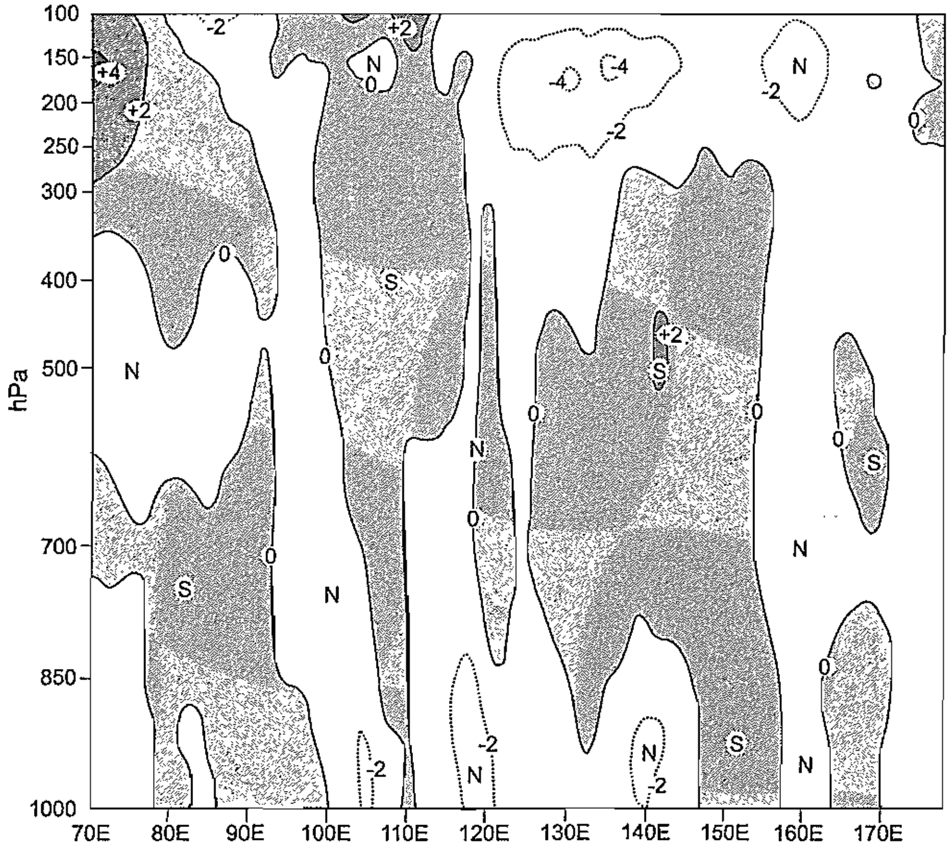

Fig.10 EQUATORIAL CROSS-SECTION OF MERIDIONAL WIND, DECEMBER 2002.
Isotachs at 2 ms^{-1} intervals, southerly shaded.

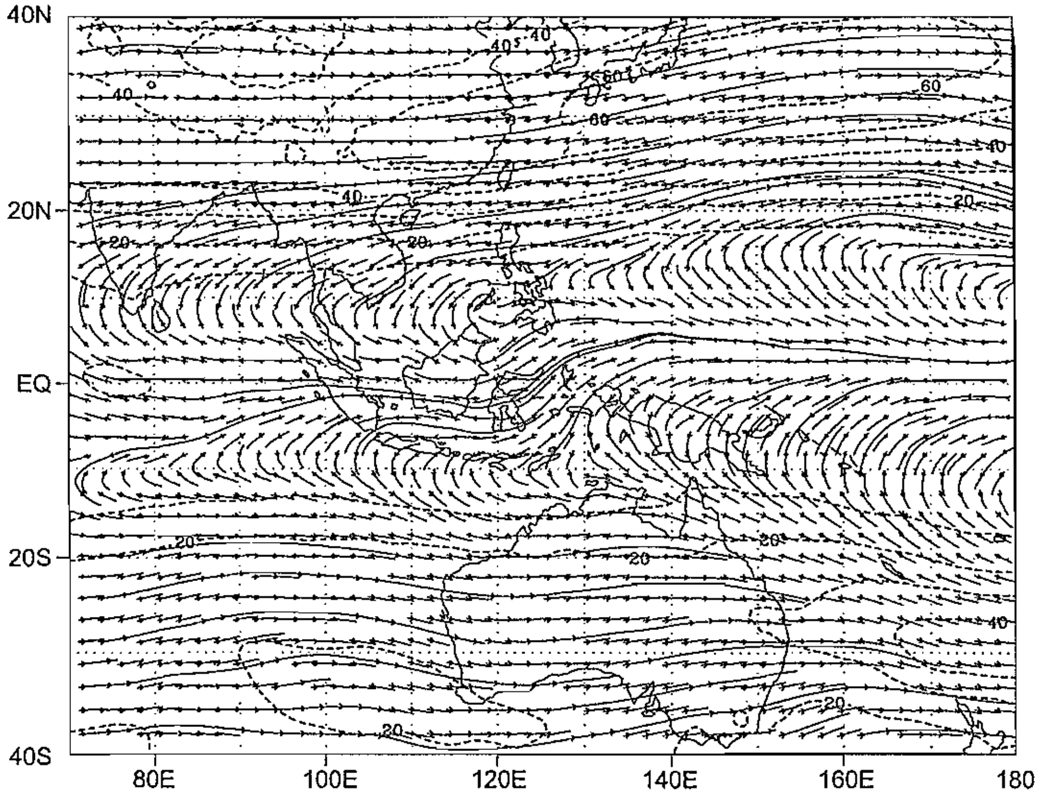

Fig.11 200 hPa MEAN STREAMLINE ANALYSIS, DECEMBER 2002.
Isotachs at 10 ms^{-1} intervals.

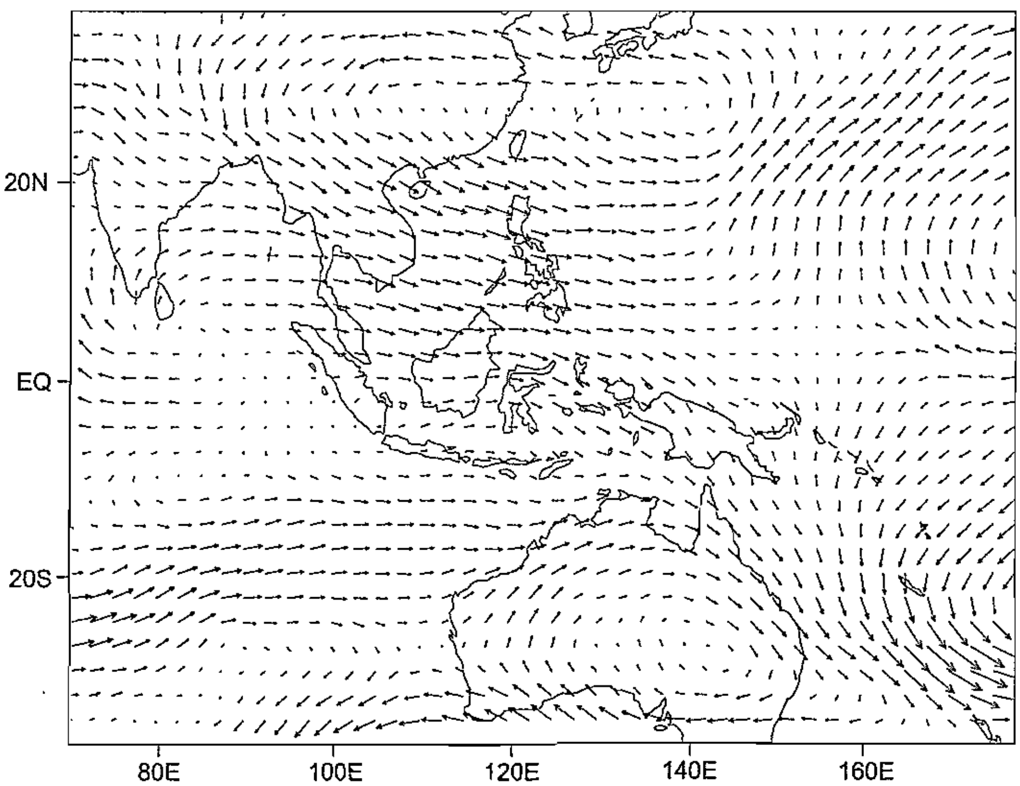

Fig.12 200 hPa WIND ANOMALY, DECEMBER 2002.
Arrow length indicates relative magnitude.

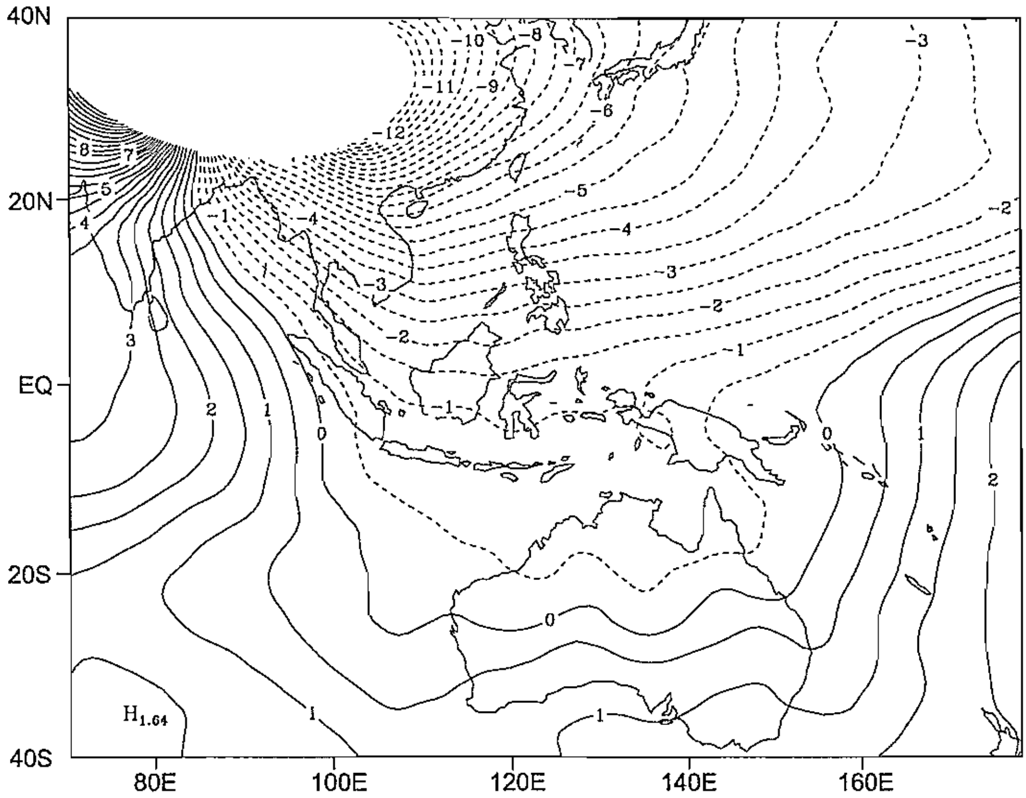

Fig.13 850 hPa VELOCITY POTENTIAL, DECEMBER 2002, (x 10^6 m^2 s^{-1}).

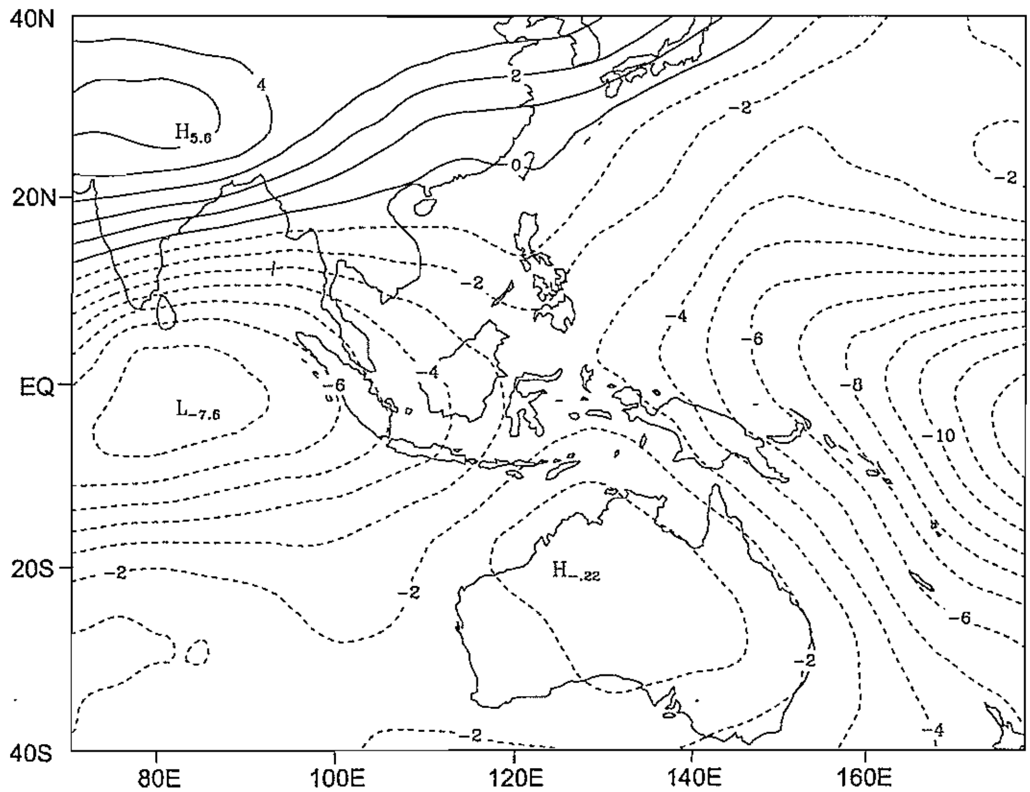

Fig.14 200 hPa VELOCITY POTENTIAL, DECEMBER 2002, (x 10^6 m^2 s^{-1}).

Time/longitude cross section, southern series.

5 day running mean, averaged over 5°S - 15°S.

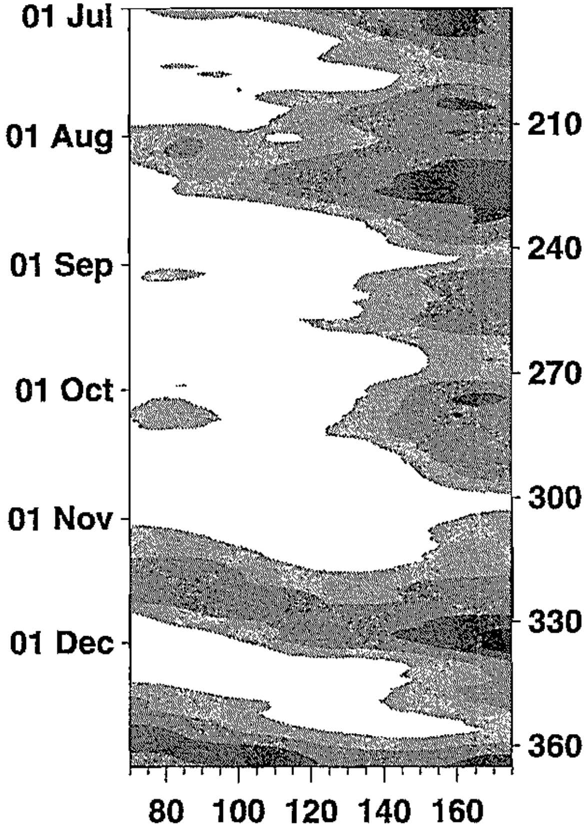

Fig. 15(a) 200hPa velocity potential based on GASP output ($10^5 m^2 s^{-1}$).

- < -250
- -250 to -200
- -200 to -150
- -150 to -80
- -80 to -30
- > -30

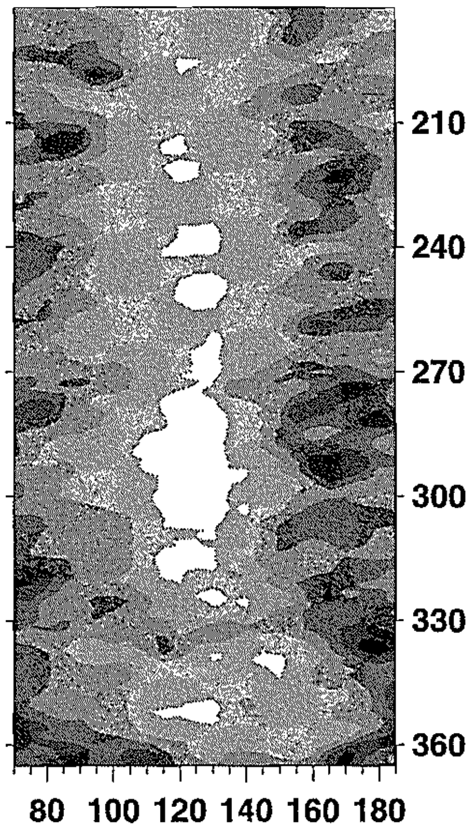

Fig. 15(b) Outgoing long wave radiation. (watt m^{-2}).

- < 210
- 210 to 270
- 270 to 320
- 320 to 370
- 370 to 420
- > 420

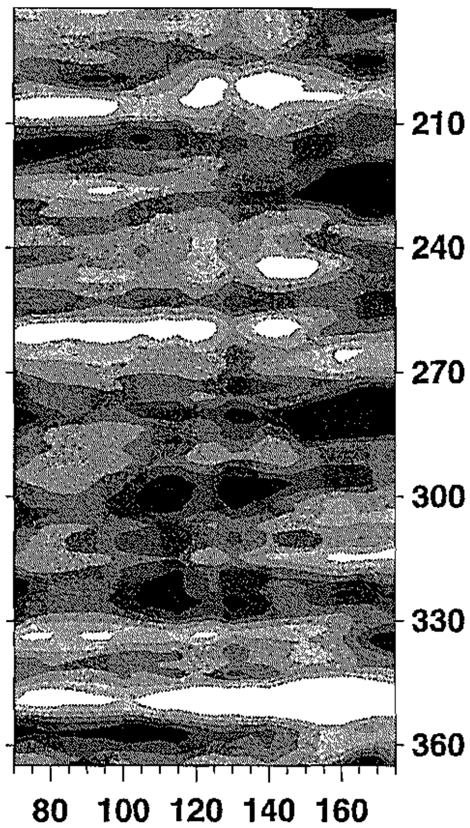

Fig. 15(c) Mean sea-level pressure anomaly based on TLAPS output (hPa).

- < -1.6
- -1.6 to -0.8
- -0.8 to 0.0
- 0.0 to 0.8
- 0.8 to 1.6
- > 1.6

Time/longitude cross section, equatorial series.

5 day running mean, averaged over 5°N - 5°S.

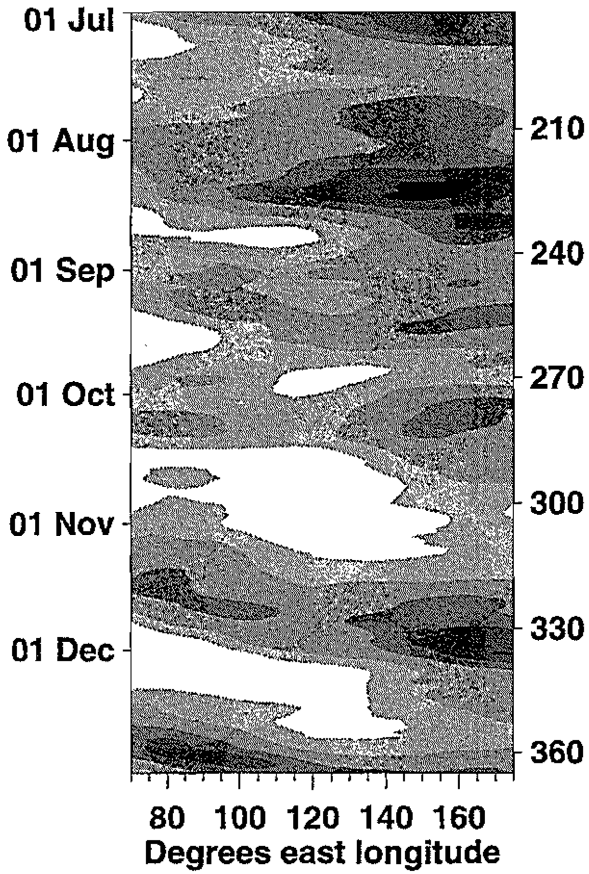

Fig. 16(a) 200hPa velocity potential based on GASP output ($10^5 m^2 s^{-1}$).

< -250; -250 to -200; -200 to -150; -150 to -80; -80 to -30; > -30

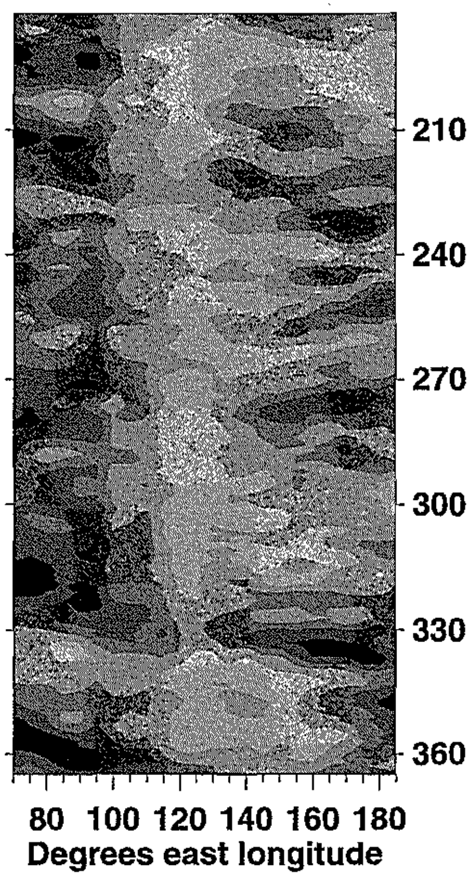

Fig. 16(b) Outgoing long wave radiation. (watt m^{-2}).

< 210; 210 to 270; 270 to 320; 320 to 370; 370 to 420; > 420

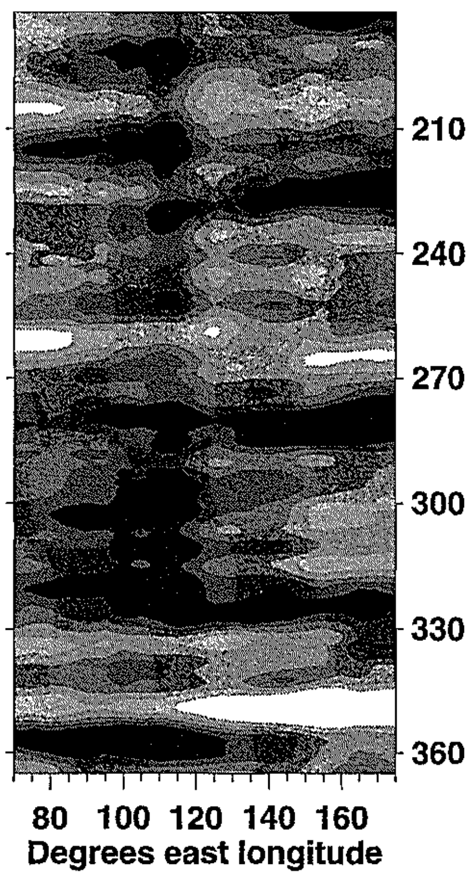

Fig. 16(c) Mean sea-level pressure anomaly based on TLAPS output (hPa).

< -1.6; -1.6 to -0.8; -0.8 to 0.0; 0.0 to 0.8; 0.8 to 1.6; > 1.6

Time/longitude cross section, northern series.

5 day running mean, averaged over 15°N - 5°N.

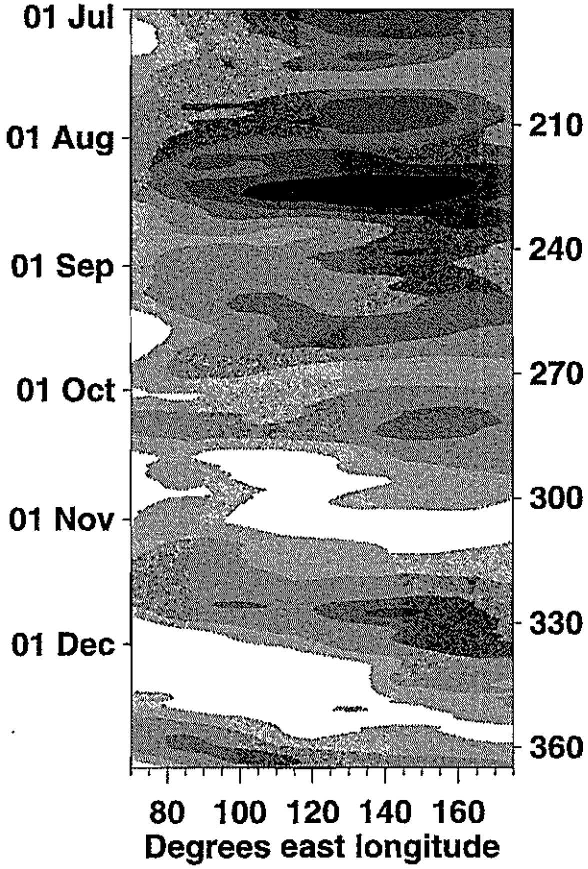

Fig. 17(a) 200hPa velocity potential based on GASP output ($10^5 m^2 s^{-1}$).

< -250 | -250 to -200 | -200 to -150 | -150 to -80 | -80 to -30 | > -30

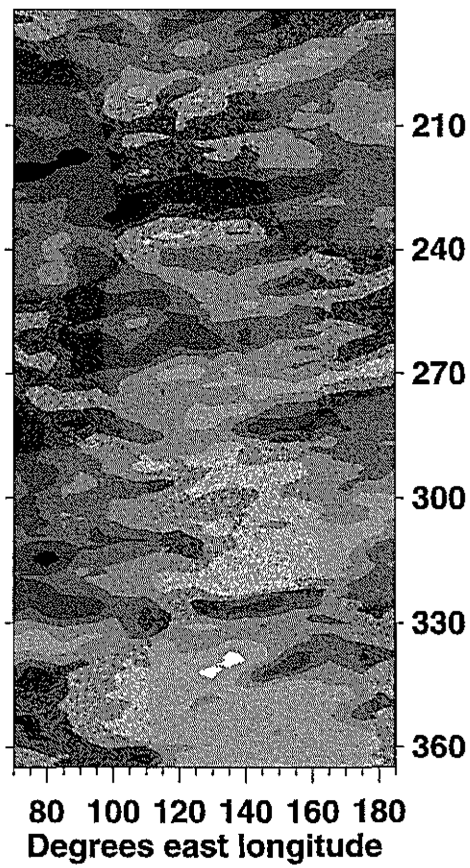

Fig. 17(b) Outgoing long wave radiation. (watt m^{-2}).

< 210 | 210 to 270 | 270 to 320 | 320 to 370 | 370 to 420 | > 420

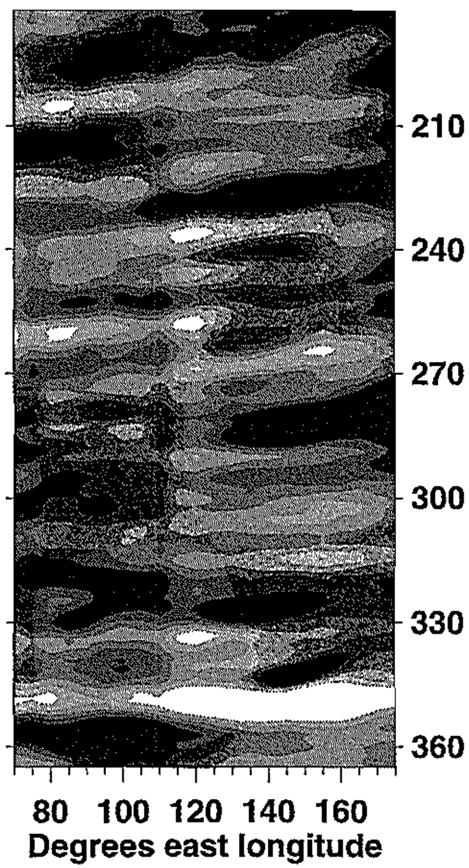

Fig. 17(c) Mean sea-level pressure anomaly based on TLAPS output (hPa).

< -1.6 | -1.6 to -0.8 | -0.8 to 0.0 | 0.0 to 0.8 | 0.8 to 1.6 | > 1.6

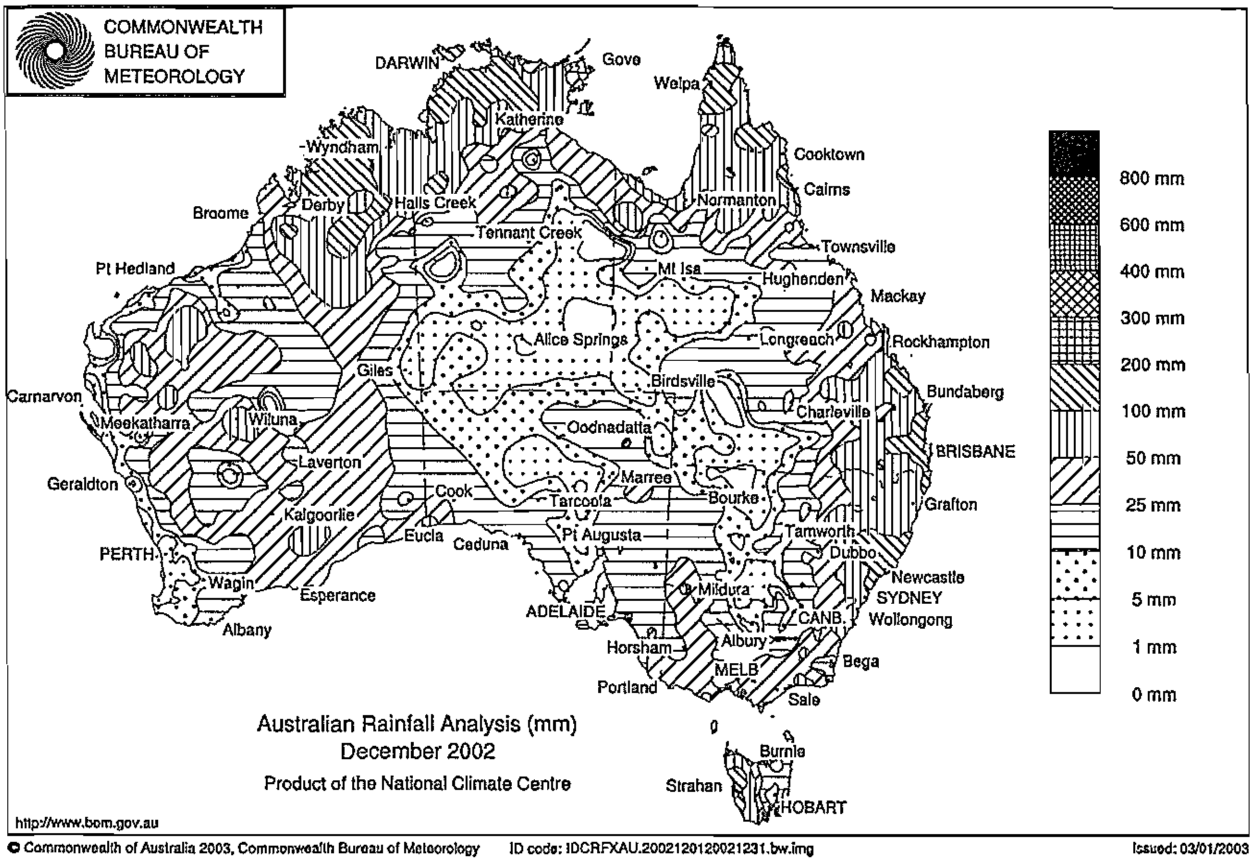

Fig.18 (a) AUSTRALIAN RAINFALL ANALYSIS (mm), DECEMBER 2002.

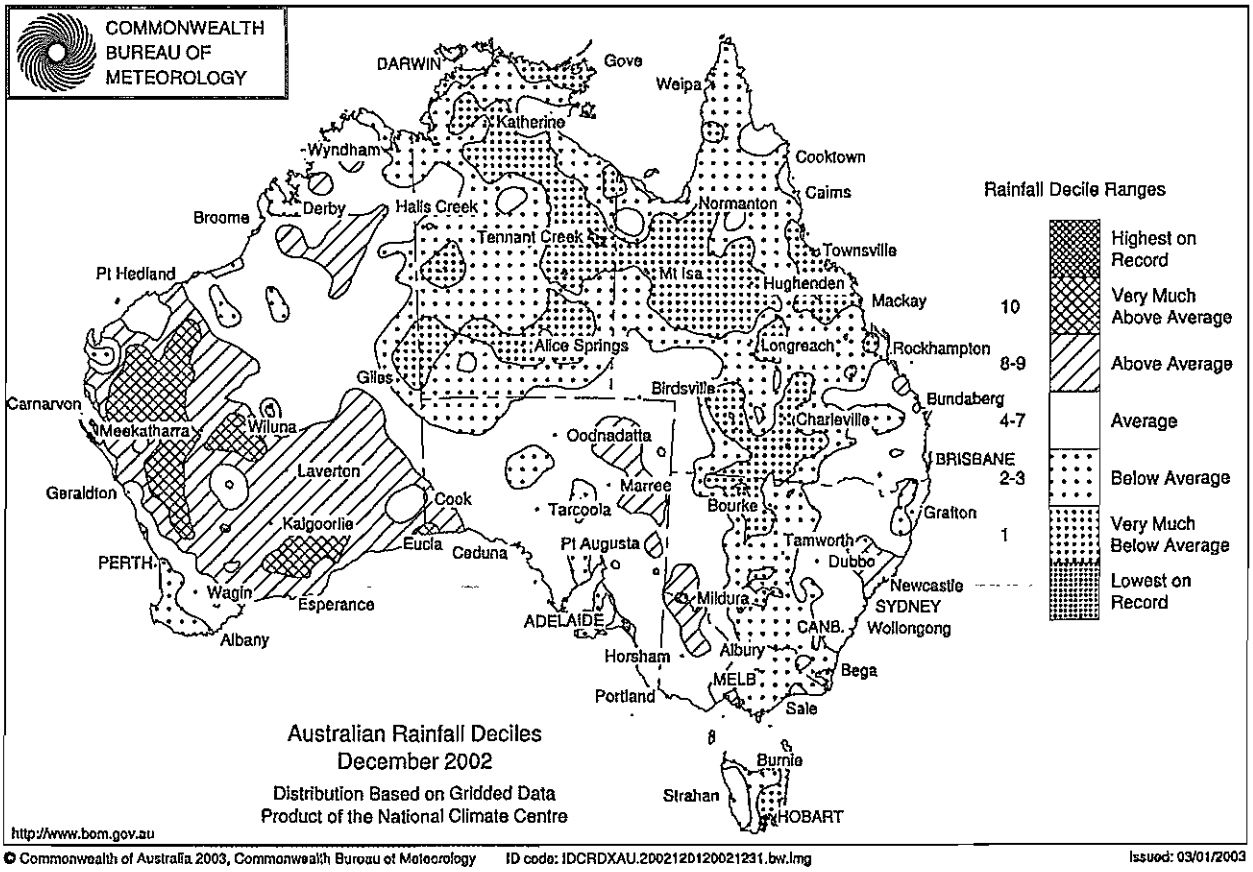

Fig.18 (b) AUSTRALIAN RAINFALL DECILES, DECEMBER 2002.

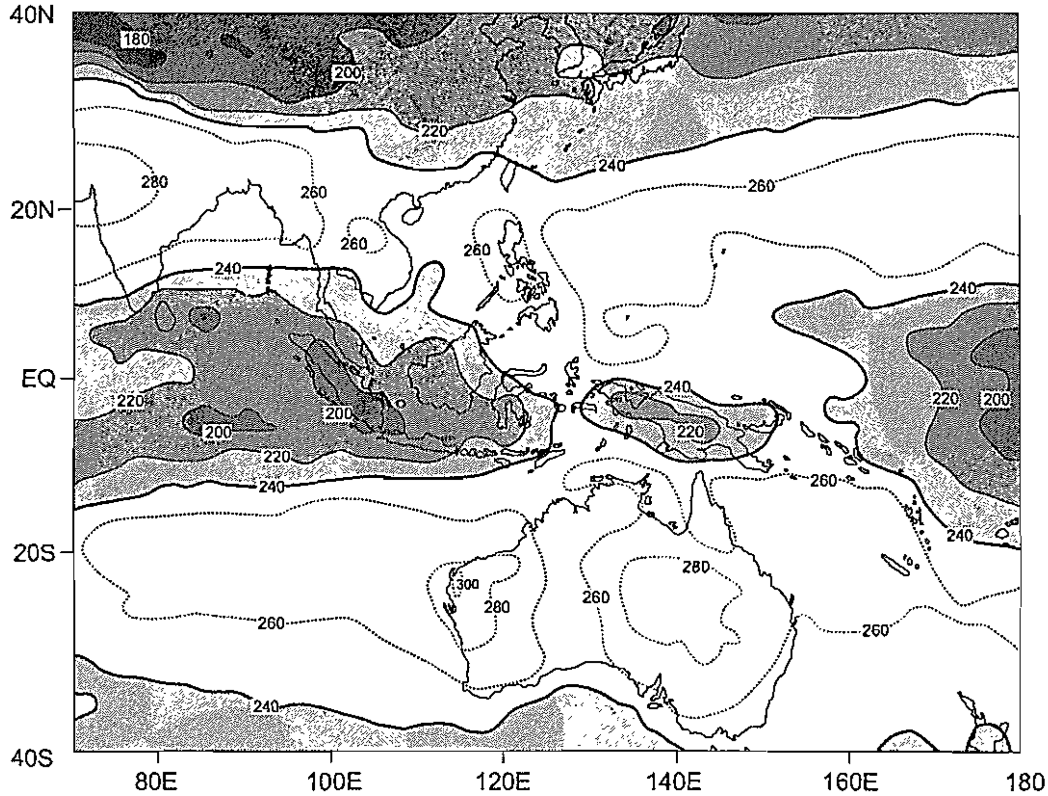

Fig.19 (a) MEAN OUTGOING LONG WAVE RADIATION, DECEMBER 2002.
Contour interval 20 watt m^{-2}.

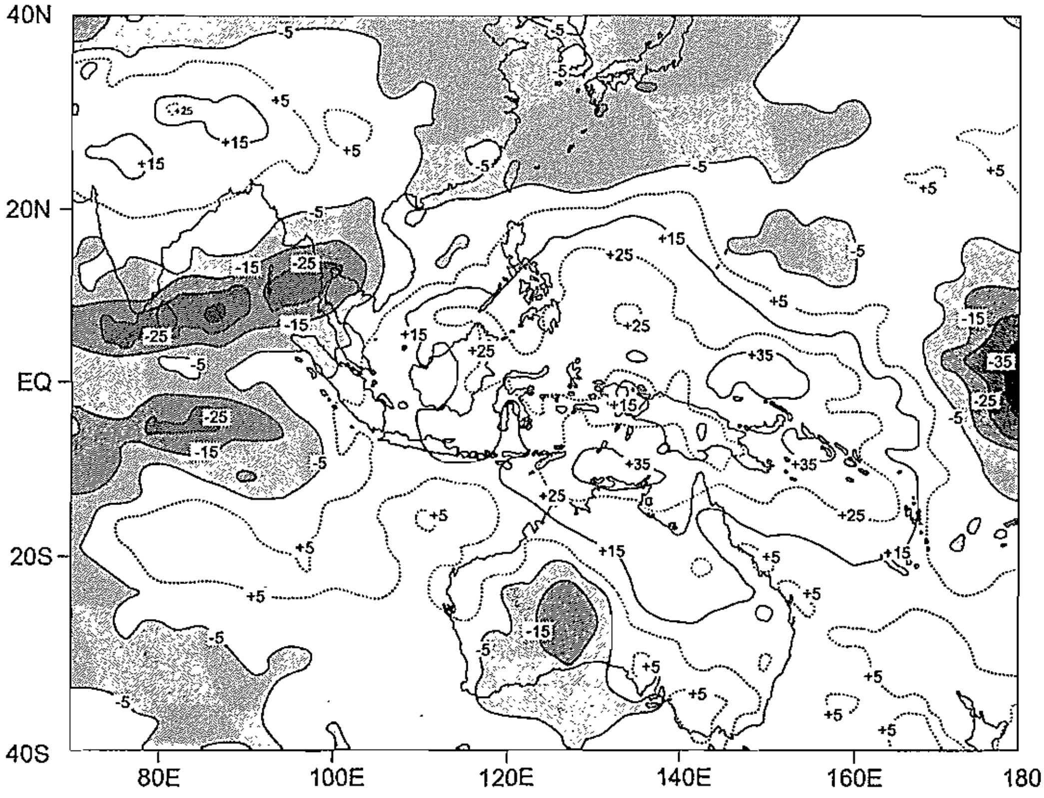

Fig.19 (b) OUTGOING LONG WAVE RADIATION ANOMALY, DECEMBER 2002.
Contour interval 10 watt m^{-2}.

Explanatory Notes

1. ***Darwin Tropical Diagnostic Statement*** is a near real-time monthly diagnostic summary of the major tropical circulations within the Darwin Regional Specialised Meteorological Centre (RSMC) area of analysis responsibility, which covers 40°N-40°S, 70°E-180°. Caution does need to be exercised when quoting from this publication as not all information within it has been confirmed.

2. **Features** discussed generally include:

. El Niño - Southern Oscillation (ENSO) aspects
. Tropical cyclone (TC) occurrence
. Sea surface temperature (SST)
. Mean sea level pressure (MSLP).
. Lower and upper level wind
. Up-motion and convection
. Intra-seasonal variability

3. **Data sources:**

(i) SOI = 10 x {dP (Tahiti) - dP (Darwin)} / SD

where	dP (Tahiti)	=	Tahiti (91938) monthly pressure anomaly (monthly mean minus 1933-1992 mean, averaging 3-hourly observations)
	dP (Darwin)	=	Darwin (94120) monthly pressure anomaly (monthly mean minus 1933-1992 mean, averaging 0900, 1500LT observations)
	SD	=	monthly standard deviation of the difference.

(ii) Operational tropical cyclone tracks based upon Darwin RSMC manual operational analyses. A tropical cyclone is defined as having mean wind > 17 m s^{-1} (34 kn) or a named system. Standard practice is to accept intensity and position as promulgated by the responsible warning agency, whenever possible. This may cause apparent discontinuities in intensity or track when cyclones cross warning area boundaries. Limited post analysis may sometimes be performed when warranted. A severe TC (equivalent to typhoon or hurricane) is defined as having mean wind > 32 m s^{-1} (63 kn).

(iii) Cyclone climatology is based on *1998 Annual Tropical Cyclone Report*, JTWC Pearl Harbor (Aldinger and Stapler 1999), which contains a 39 year climatology of the northwest Pacific, 24 years of the Bay of Bengal and 18 years of the South Indian/Pacific Oceans. Earlier north Indian Ocean records are taken from WMO *Technical Document No. 430, Tropical Cyclone Report No.TCP-28* (Mandal, 1991), which contains a 99 year climatology.

(iv) SST analysis based on Darwin RSMC weekly automated operational analyses (RSMC subset of Melbourne Specialised Oceanographic Centre (SOC) global analysis: blended *in situ* and satellite data, 1°C resolution. The 1° x 1° global SST climatology from the US National Centers for Environmental Prediction (Reynolds and Smith 1995). A high resolution global sea surface temperature climatology, *J. Clim.*, *8*, 1571-1583) is used for the calculation of anomalies and as the default field for the analysis first guess.

(v) From November 1997, mean MSLP and upper wind data from Darwin RSMC real-time Tropical Limited Area Prediction Scheme (TLAPS - refer Puri et al, 1996, *BMRC Research Report No. 54, 41*). Anomalies and 200 hPa velocity potential data from the Bureau of Meteorology's Global Assimilation and Prediction System (GASP - refer Bourke et al 1990. The BMRC global assimilation and prediction system. *ECMWF Seminar proceedings: Ten years of medium-range weather forecasting*, Sep 89) and ECMWF climatology, 1979-1989. MSLP anomaly analysis modified using CLIMAT messages.

(vi) The mean seasonal cycles for the Darwin 850 hPa wind components were constructed by averaging daily values over 39 years (1950 to 1988), each curve smoothed with 600 passes of a three day running mean weighted 1-2-1.

(vii) Outgoing long-wave radiation (OLR) time-longitude information from GMS-5 digital data. OLR is taken as a proxy for tropical convection.

(viii) Australian monthly rainfall totals and deciles from the Bureau of Meteorology National Climate Centre, via their Web site at: http://www.bom.gov.au/climate/

(ix) OLR mean and anomaly maps provided by the NOAA-CIRES Climate Diagnostics Center, Boulder, Colorado, USA, from their Web site at http://www.cdc.noaa.gov/.

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4. **Some commonly-used acronyms**:

ISO	- intra-seasonal oscillation
JMA	- Japan Meteorological Agency
JTWC	- Joint Typhoon Warning Center, Pearl Harbor
MT	- monsoon trough
NET	- near-equatorial trough
PAGASA	- Philippine Atmospheric, Geophysical and Astronomical Services
PNG	- Papua New Guinea
RSMC	- Darwin Regional Specialised Meteorological Centre (see note 1)
SCS	- South China Sea
SPCZ	- South Pacific convergence zone
STR	- subtropical ridge
TC	- tropical cyclone (see note 3(ii))
TD	- tropical depression
TS	- tropical storm (generally used for TC in northern hemisphere sector)
TUTT	- tropical upper tropospheric trough

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