Australian Government

Bureau of Meteorology

DARWIN REGIONAL SPECIALISED METEOROLOGICAL CENTRE

October 1996, VOL 15 No 10

© PUBLISHED BY THE AUSTRALIAN BUREAU OF METEOROLOGY 2011

ISSN 1321 - 4233

THIS PAGE INTENTIONALLY LEFT BLANK

DARWIN TROPICAL DIAGNOSTIC STATEMENT

OCTOBER 1996

ISSUED BY DARWIN RSMC

SUMMARY

Most indicators suggest a continuing La Niña phase of the Southern Oscillation. The SOI remains positive with a very stable five-month mean. Warm SST anomalies persist over tropical waters of the Darwin RSMC area with cool anomalies in the equatorial central Pacific. Low level easterly wind anomalies were again evident over the central Pacific. The ISO was poorly defined with some evidence of an active phase near the end of the month. Tropical cyclone activity was below average over the northwest Pacific.

INDICES

1	Darwin mean MSL pressure, October 1996	1009.9	hPa
	pressure anomaly (1933 - 1992 mean)	-0.8	hPa
2	Tahiti mean MSL pressure, October 1996	1013.5	hPa
	pressure anomaly (1933 - 1992 mean)	-0.1	hPa
3	Troup's Southern Oscillation Index (SOI)	+4	
	5-month mean (centred upon August)	+7	
4	Time series of Troup's SOI:		

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1994	-2	0	-10	-20	-11	-10	-17	-16	-16	-15	-7	-13
1995	-5	-3	+3	-14	-8	-2	+4	+1	+3	-1	+1	-7
1996	+8	+1	+6	+8	+1	+14	+7	+5	+7	+4		

Figure 1 shows the monthly SOI and its five-month running mean for the past ten years.

The SOI fell slightly from last month, due mostly to a strong pressure fall at Tahiti in the last week. Darwin's and Tahiti's pressure anomalies for the month were slightly negative, both rising from low September values. The five-month running mean remained at +7 for the fourth consecutive month.

TROPICAL CYCLONES [Fig. 2]

As Typhoon Zane moved into the mid latitudes of the northern Pacific early in the month, the northwest Pacific came under the influence of a high pressure ridge. The monsoon trough was poorly defined to the east of the Indian subcontinent, and most of the convective activity in the equatorial western Pacific was a result of disturbances in an easterly flow. By the 9th of the month the monsoon trough/NET had reestablished itself and convective organisation improved, though it wasn't until the 16th that the first tropical cyclone formed. A result of this was that the number of TS's that formed during October in the northwest Pacific was below average (two compared with a mean of 4.3 - both reaching typhoon strength). Three other tropical cyclones were analysed; one formed in the Bay of Bengal, another in the Arabian Sea, and one in the southern Indian Ocean. Another system, 34W, caused some loss of life and livestock and extensive flooding in Thailand and Bangladesh though it never reached TS strength.

Typhoon Beth

First analysed as a depression in the tropical northwest Pacific, Beth moved westward into the Philippine Sea under the influence of a deep easterly steering flow. Initially organisation was poor, hindered by unidirectional mid to upper level flow. As the mid level STR weakened to the system's north with the passage of a mid latitude trough, its forward motion slowed. Approaching the Philippines it moved into a region of good upper divergence, organisation improved and the system was named on the 16th. Continuing to develop, it reached typhoon strength shortly before making landfall on northern Luzon late on the 17th. Interaction with land resulted in a brief weakening of the system below typhoon strength before re-intensification as it entered the South China Sea. As Beth continued its westward movement upper southwest winds increased as a trough approached from the west. This increased vertical shear and weakened the system, with it dissipating below tropical cyclone strength over water on the 20th.

Typhoon Carlo

This system formed as a TUTT cell induced a circulation at the surface. The initial track was to the west-northwest on the southern side of the mid level ridge. As the low level circulation moved into an area of upper divergence to the north of the TUTT, it developed and was named on the 21st. It continued to intensify as it moved to the northwest, reaching typhoon strength on the 23rd. At this time it turned north toward a break in the mid level STR and attained its maximum intensity on the 24th. Once through the STR the system was influenced by an approaching mid latitude trough. Interaction with this feature caused Carlo to accelerate toward the northeast and weaken as strong southwesterlies sheared the system and it became extra tropical on the 26th.

Tropical Cyclone 05A

A circulation embedded in the monsoon trough, this system developed in the Arabian Sea and was named on the 22nd. Initially it moved slowly north northeast and crossed into the Darwin RSMC area on the 23rd. Staying close to the border of the area, it continued northward due to southerly steering from a mid level anticyclone to the east. As the system moved out from under the upper ridge axis shear increased and it began to weaken . The development of TC 06B in the Bay of Bengal displaced the ridge to the east of TC 05A, causing it to slow then turn southwards. The system dissipated below cyclone strength on the 26th due to strong vertical shear.

Tropical Cyclone 06B

TC 06B was first analysed as a circulation embedded in the monsoon trough near the Andaman Islands on the 22nd. Located beneath the divergent area on the southern side of the upper ridge, it developed as it moved west under the influence of a deep easterly steering flow. It reached cyclone strength on the 25th despite strong easterly flow exposing the low level circulation. The cyclone turned to the north through a weakness in the STR and became influenced by a large amplitude trough approaching from the west. It accelerated to the north northeast and made landfall on the southern coast of Bangladesh on the 29th, quickly dissipating.

Tropical Cyclone Antoinette

TC Antoinette formed to the southwest of Sumatra in an area of persistent convection within the near equatorial trough. Located beneath an upper ridge axis and with good low level inflow from a high pressure system in the southern Indian Ocean, it was first analysed by the Darwin RSMC as a cyclone on the 17th. In an ambiguous region of responsibility, it was not named until the 18th, though probably retained cyclone strength throughout this period. Situated equatorward of the mid level ridge, Antoinette maintained a predominantly west-southwest track under the influence of moderate steering. Tropical cyclone strength was maintained as it passed to the west of 70°E and out of the Darwin RSMC area.

SEA SURFACE TEMPERATURE [Figs. 3, 4]

As has been the trend for the past four months, weak warm anomalies were evident over the majority of tropical waters of the Darwin RSMC area with slightly below average temperatures in the central Pacific. This pattern is consistent with continuing positive SOI values. The area of greater than 30°C to the north of New Guinea has persisted, expanding slightly. The most significant anomaly change from September has been the large area of warm anomalies greater than +1°C observed to the northwest of Australia. Over the rest of the RSMC area the anomaly pattern has shown little change. The mid latitudes of the northwest Pacific and southern Indian Ocean remain cooler than average, with near average temperatures over the southeast Pacific.

MSL PRESSURE [Figs. 5, 6]

Low pressure anomalies were observed over the majority of tropical waters of the RSMC region this month. In the mid latitudes pressures were generally greater than average, a significant change from last month which was dominated by below average pressure. The southern hemisphere STR was slightly south of its mean position and 2-4 hPa stronger. The northern hemisphere STR was close to its mean position though weaker over northern China and stronger in the north Pacific. Positive pressure anomalies in the northwest Pacific are probably a reflection of the below average number of TS's in this area. The monsoon trough was near its mean position, extending from India through Southeast Asia and into the western Pacific, with pressures mainly below average. The pressure minimum in the southwest Indian Ocean is most likely a reflection of the path of TC Antoinette.

850 hPa FLOW [Figs. 7, 8]

The southern hemisphere ridge axis at this level was approximately 5 degrees south of its mean position. With an enhanced circulation around the ridge the southern hemisphere was dominated by easterly anomalies. The largest anomalies were in the southern Indian Ocean where trade flow was stronger than average, and over Australia where northeast winds predominated. The ridge in the northern hemisphere was close to its mean position with only weak anomalies. The monsoon trough was slightly south of the mean producing easterly anomalies through the Bay of Bengal, South China Sea and western Pacific. In the Indian Ocean the NET was close to its mean position though anomalous cyclonic flow indicates that it was more intense than usual. In the equatorial western Pacific there were weak easterly anomalies consistent with weak La Niña conditions.

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

The 850 hPa wind at Darwin during October was close to average. The zonal flow remained easterly throughout with some fluctuations in speed. Rainfall was above average for the month and came from thunderstorm activity in an easterly regime with 85mm reported on the 20th.

CROSS-EQUATORIAL INTERACTION [Fig. 10]

There was little cross equatorial flow on average in the low and middle levels of the troposphere. Low level southerly flow was slightly less than average near 90°E consistent with strong early wet season activity in the southern hemisphere NET. There were anomalous northerlies near 120°E, 140°E and 160°E. Areas of stronger than average southerlies occurred near 107°E and 130°E. Upper level northerly components were close to average.

UPPER LEVEL FLOW [Figs. 11, 12]

The southern hemisphere upper ridge was slightly south of its mean position to the west of 110°E producing a divergent anticyclonic anomaly field in the southern Indian Ocean. Westerlies to the east of 110°E were below average as shown by the easterly anomalies over Australia. The northern hemisphere ridge was close to its mean position with mainly small anomalies. There was little cross equatorial flow in the east of the area with only small southerly anomalies in the Indian Ocean.

VELOCITY POTENTIAL [Figs. 13, 14]

The axes of low level convergence and upper level divergence (as indicated by the velocity potential diagrams) were not as well aligned as they have been in recent months. The 850 hPa velocity potential differed from the climatological mean with no maximum in the South China Sea. The 200 hPa velocity potential was better aligned with climatology. There was an area of maximum low level convergence over Western Australia though upper divergence did not assist vertical motion in that area. However considerable upper divergence is implied over the tropical southern Indian Ocean.

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

The ISO was not strongly defined during October with time series showing no clearly defined single active phase. After an enhanced burst at the end of September, conditions were generally less active by the end of the first week of October. Renewed activity began to be evident after mid-month with all velocity potential series indicating upper divergence. However pressure anomalies and OLR series make it difficult to identify the phase peak.

RAINFALL [Fig. 18]

The marked change in the pressure field over southern mid latitudes of the RSMC area is highlighted by generally below average rainfall over southern Australia and New Zealand. Conversely northern Australia received above average early wet season rainfall consistent with a positive SOI. Rainfall over southeast China was below average. Quintiles through India, Southeast Asia and Indonesia show generally above average rainfall, coinciding with the negative pressure anomalies observed through the area.

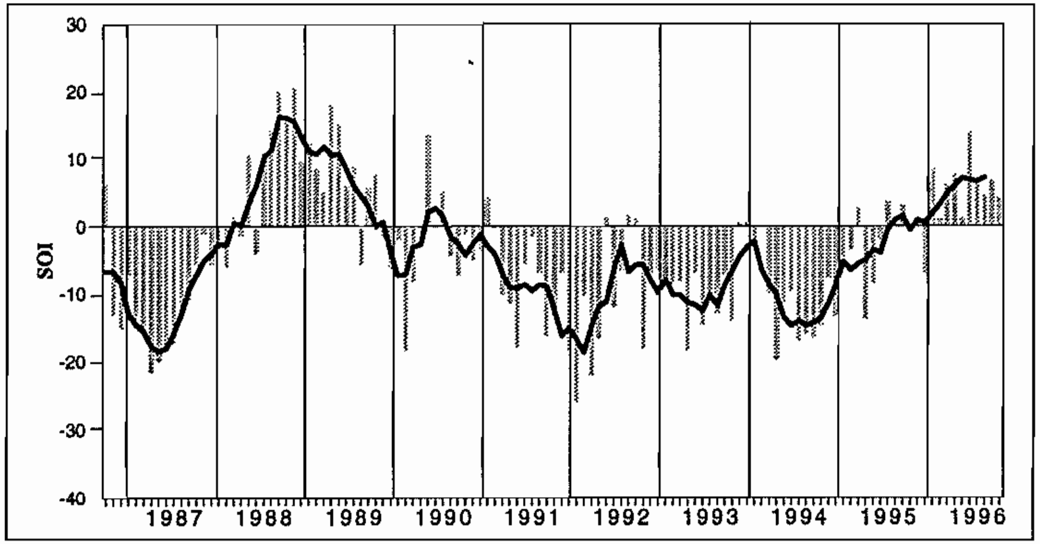

Fig.1 SOUTHERN OSCILLATION INDEX 1986 - 1996.
Monthly SOI (dashed line) and 5-month running mean SOI (solid line).

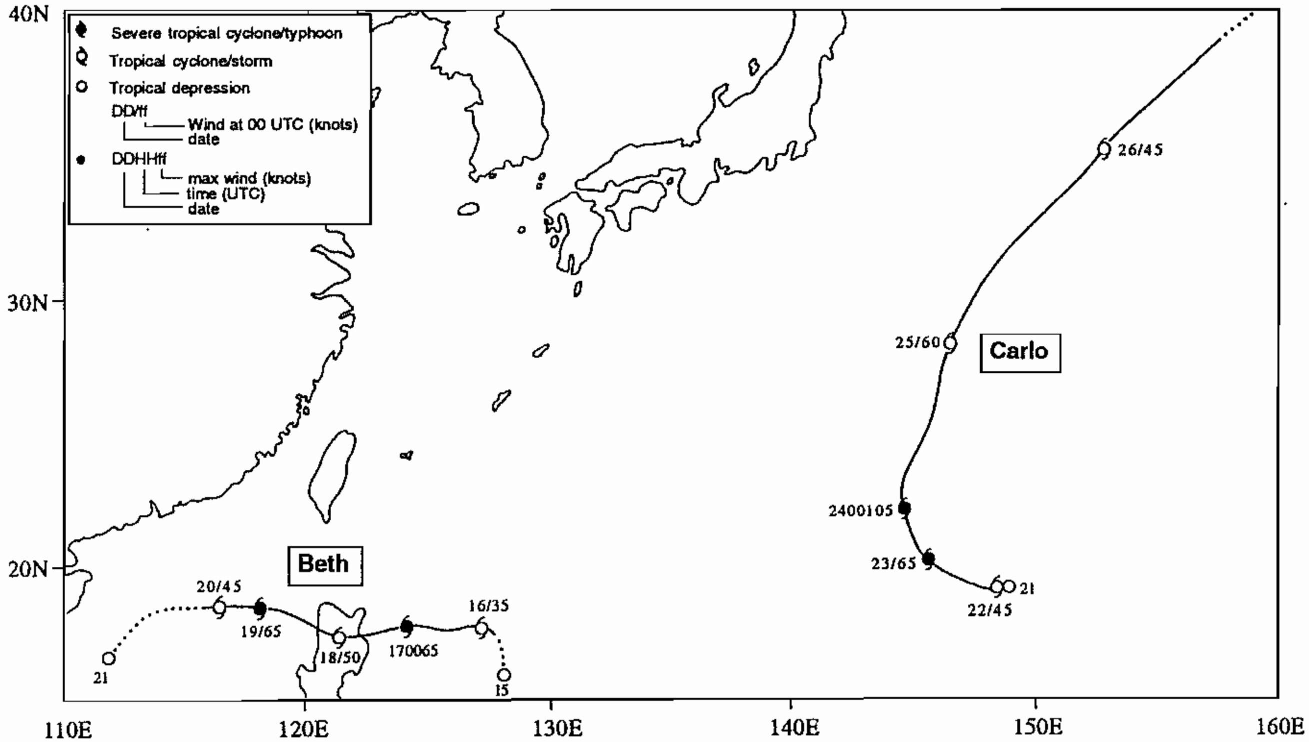

Fig.2(a) UNOFFICIAL TRACKS OF CYCLONES: BETH AND CARLO, OCTOBER 1996.

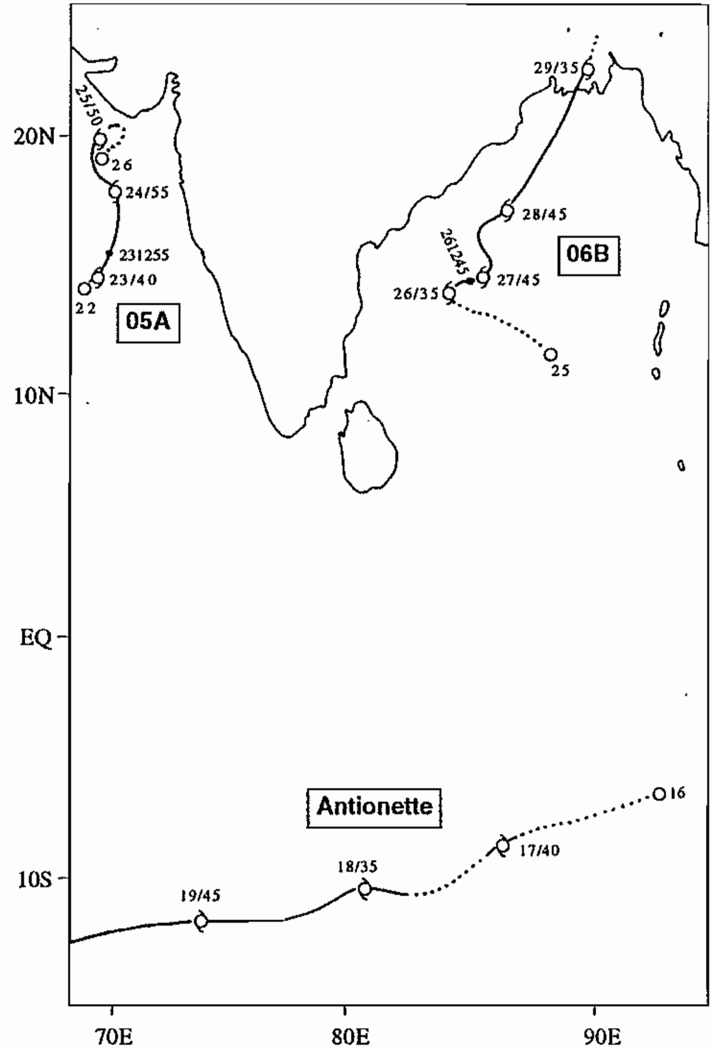

Fig.2(b) UNOFFICIAL TRACKS OF CYCLONES: ANTIONETTE, 05A AND 06B, OCTOBER 1996.

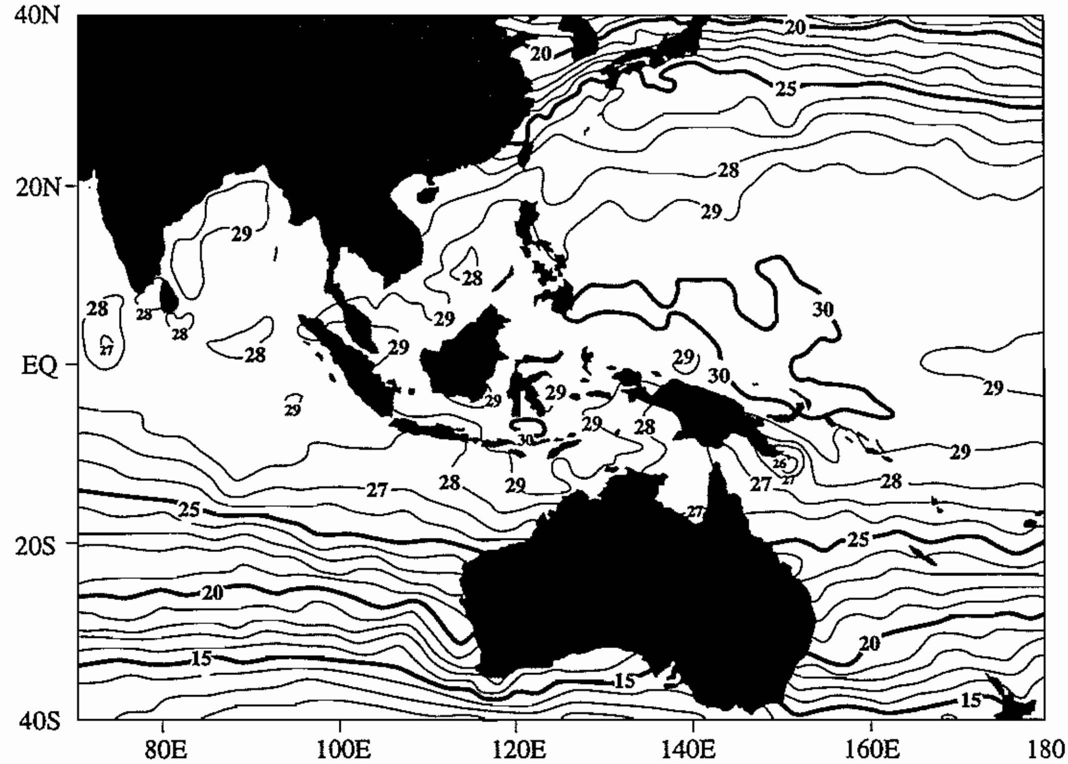

Fig.3 MEAN SEA SURFACE TEMPERATURE, OCTOBER 1996.
Contour interval 1°C. Heavy lines every 5°C .

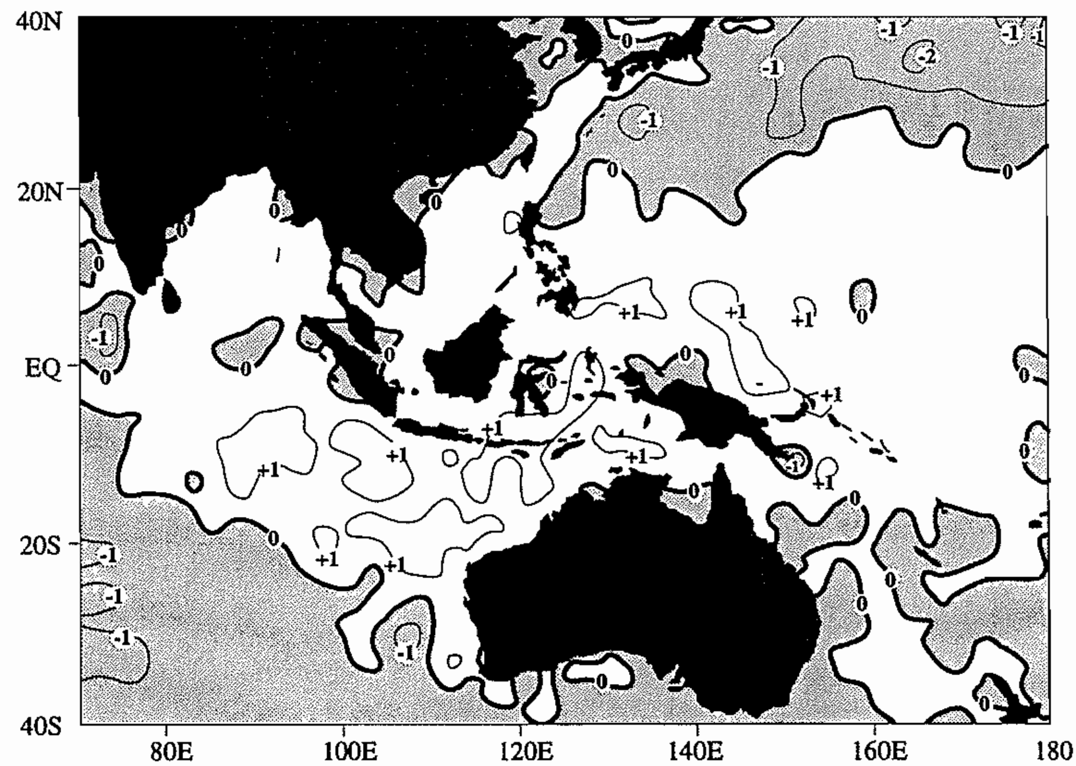

Fig.4 SEA SURFACE TEMPERATURE ANOMALY, OCTOBER 1996.
Contour interval 1°C. Heavy line represents 0°C anomaly, negative anomaly shaded.

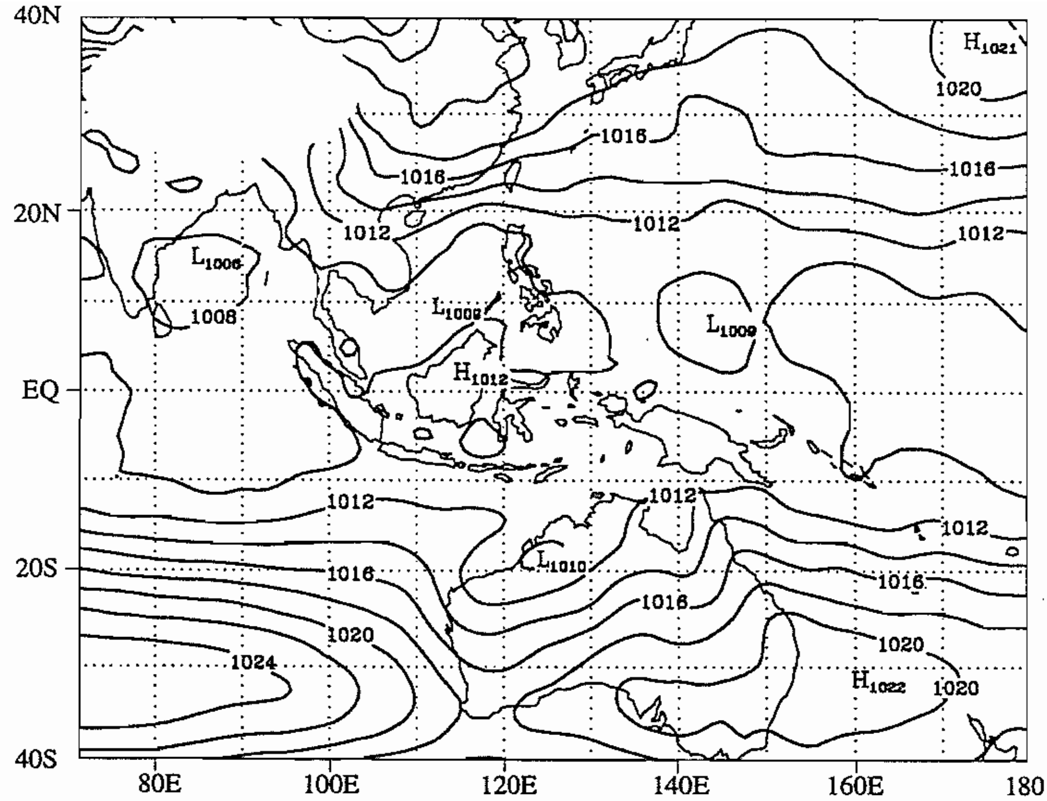

Fig.5 MEAN MSL PRESSURE, OCTOBER 1996.
Isobar interval 2 hPa.

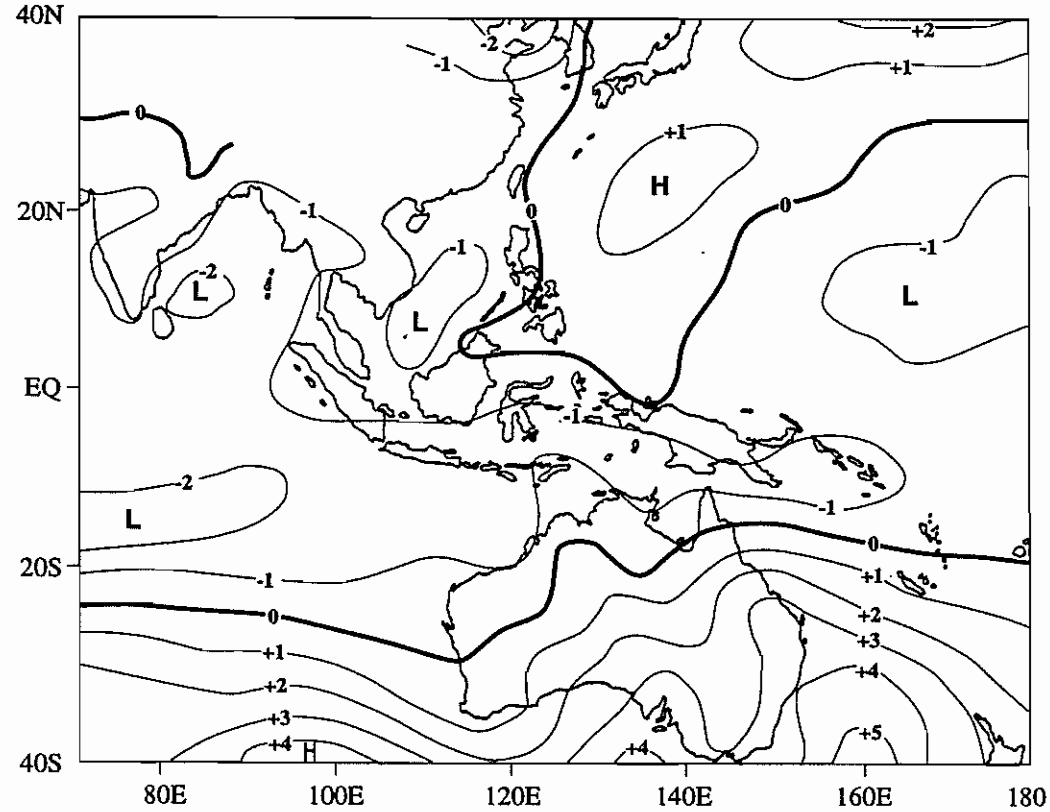

Fig.6 MSL PRESSURE ANOMALY, OCTOBER 1996.
Contour interval 1 hPa. Heavy line represents zero hPa anomaly.

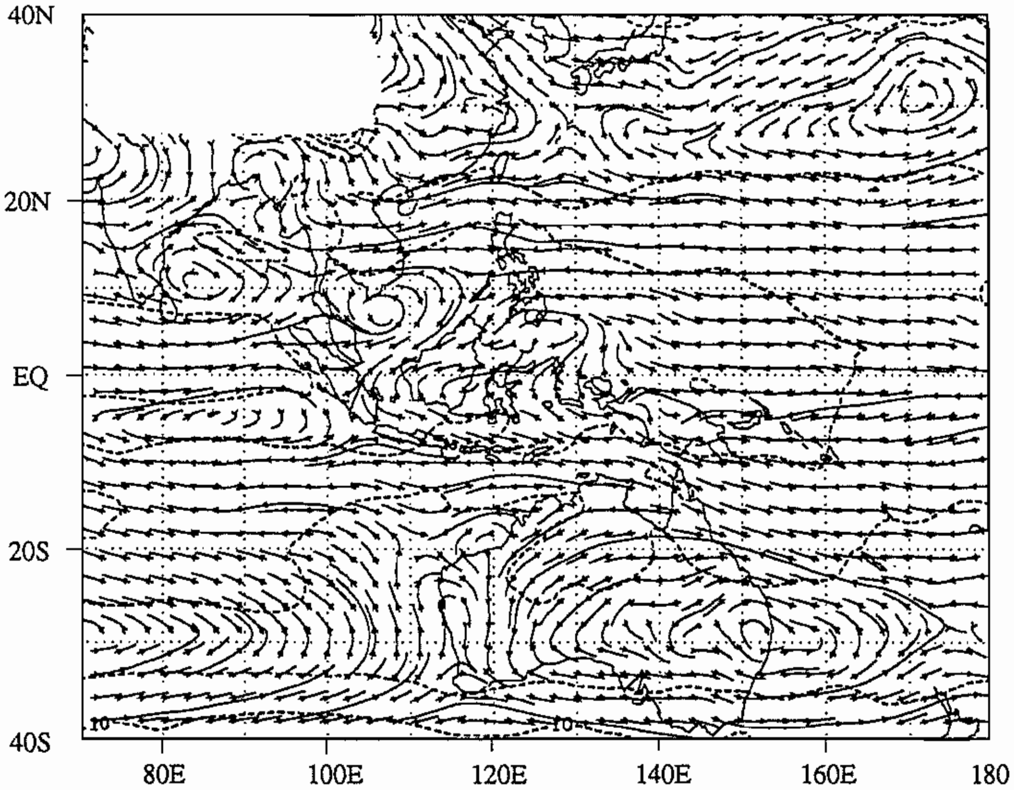

Fig.7 850 hPa MEAN STREAMLINE ANALYSIS, OCTOBER 1996.
Isotachs at 5 ms^{-1} intervals.

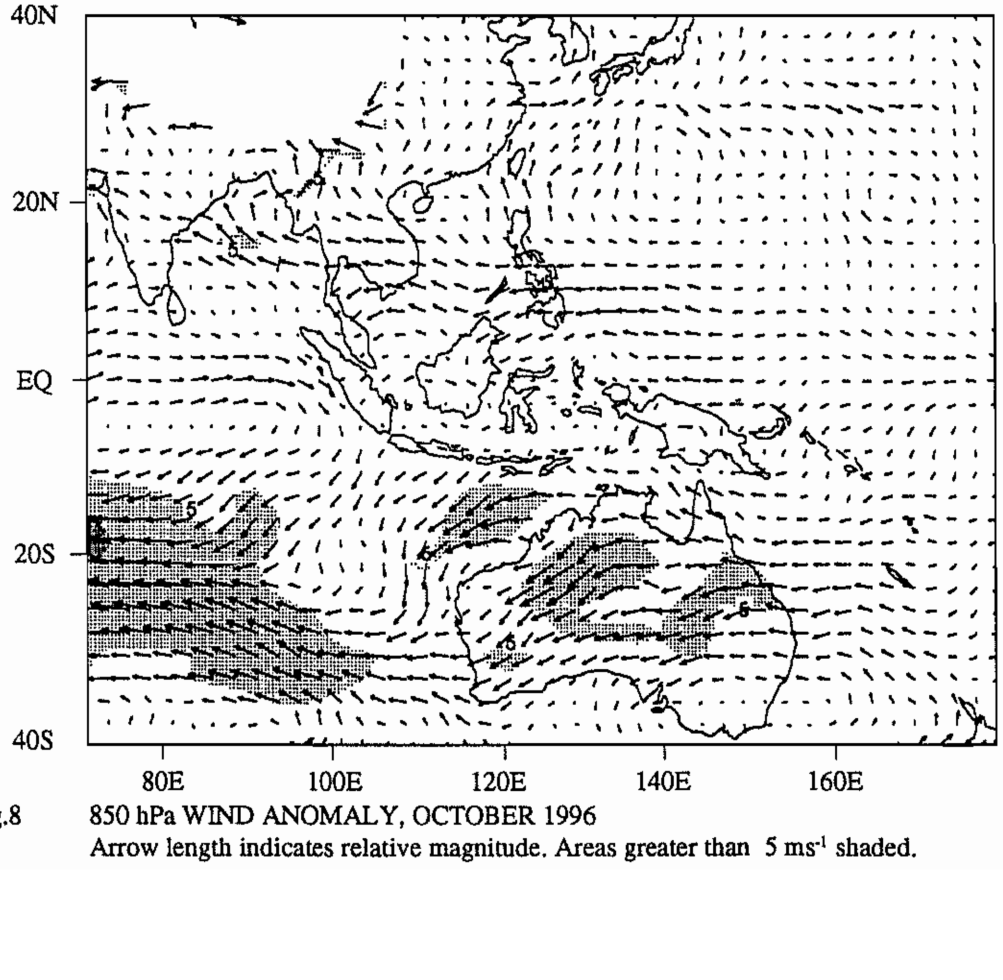

Fig.8 850 hPa WIND ANOMALY, OCTOBER 1996
Arrow length indicates relative magnitude. Areas greater than 5 ms^{-1} shaded.

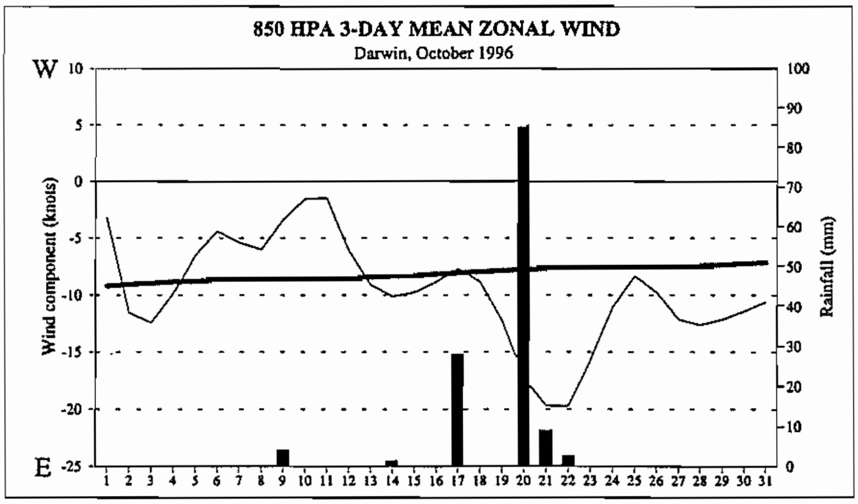

Fig.(9a) DARWIN 850 hPa SYMMETRICAL MEAN ZONAL WIND, OCTOBER 1996.
Solid line represents the mean seasonal zonal wind cycle.

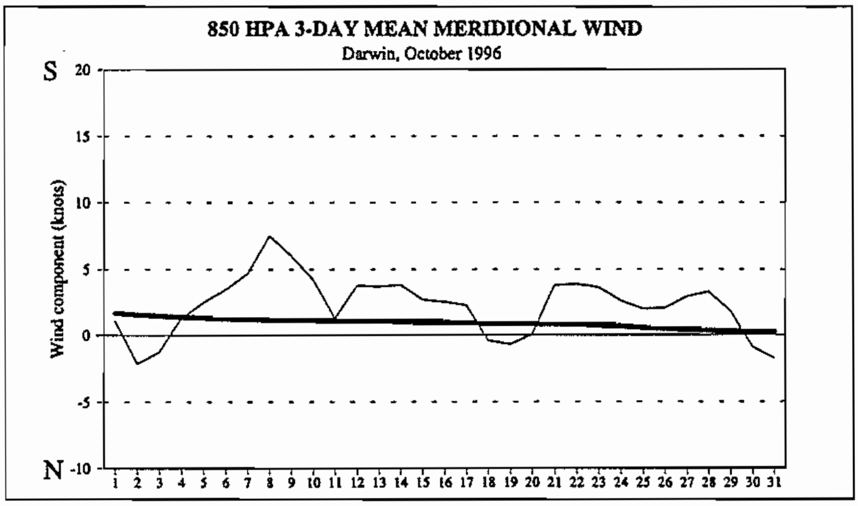

Fig.(9b) DARWIN 850 hPa SYMMETRICAL MEAN MERIDIONAL WIND, OCTOBER 1996.
Solid line represents the mean seasonal meridional wind cycle.

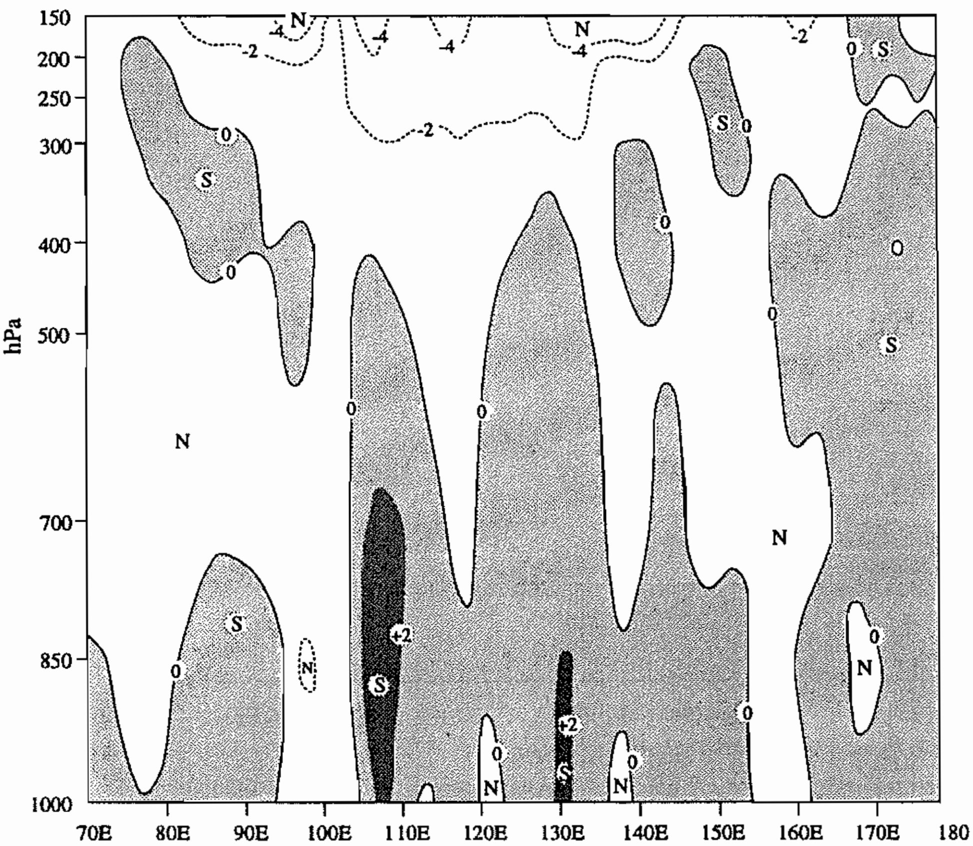

Fig.10 EQUATORIAL CROSS-SECTION OF MERIDIONAL WIND, OCTOBER 1996.
Isotachs at 2 ms-1 intervals, southerly shaded.

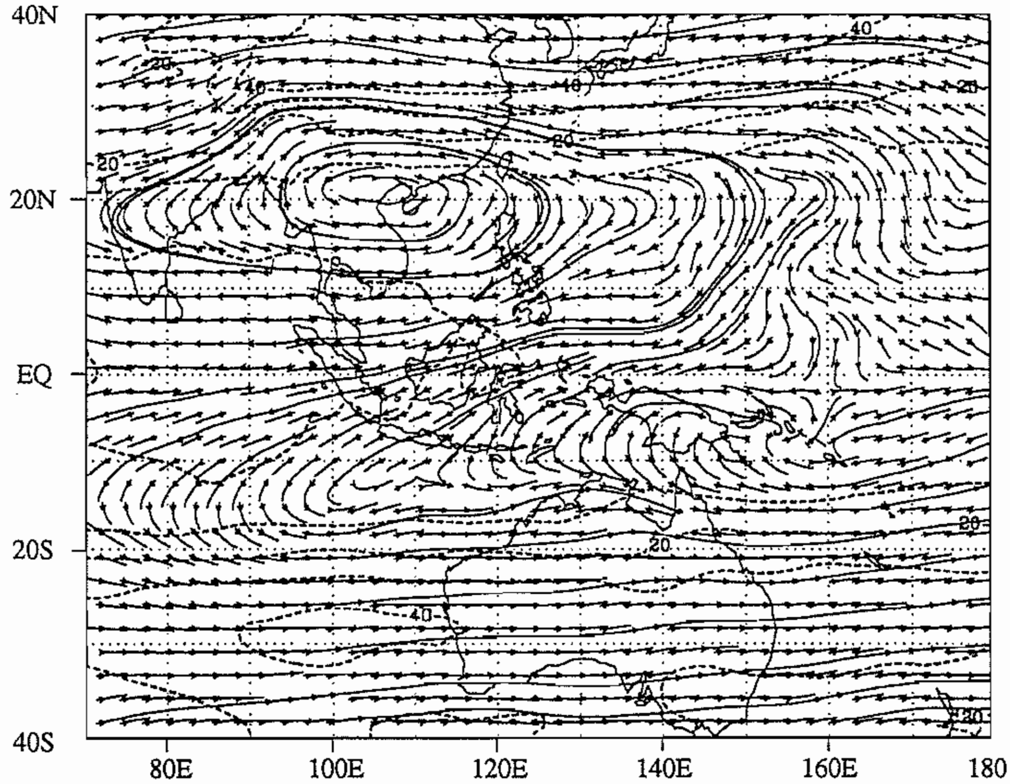

Fig.11 200 hPa MEAN STREAMLINE ANALYSIS, OCTOBER 1996.
Isotachs at 10 ms^{-1} intervals.

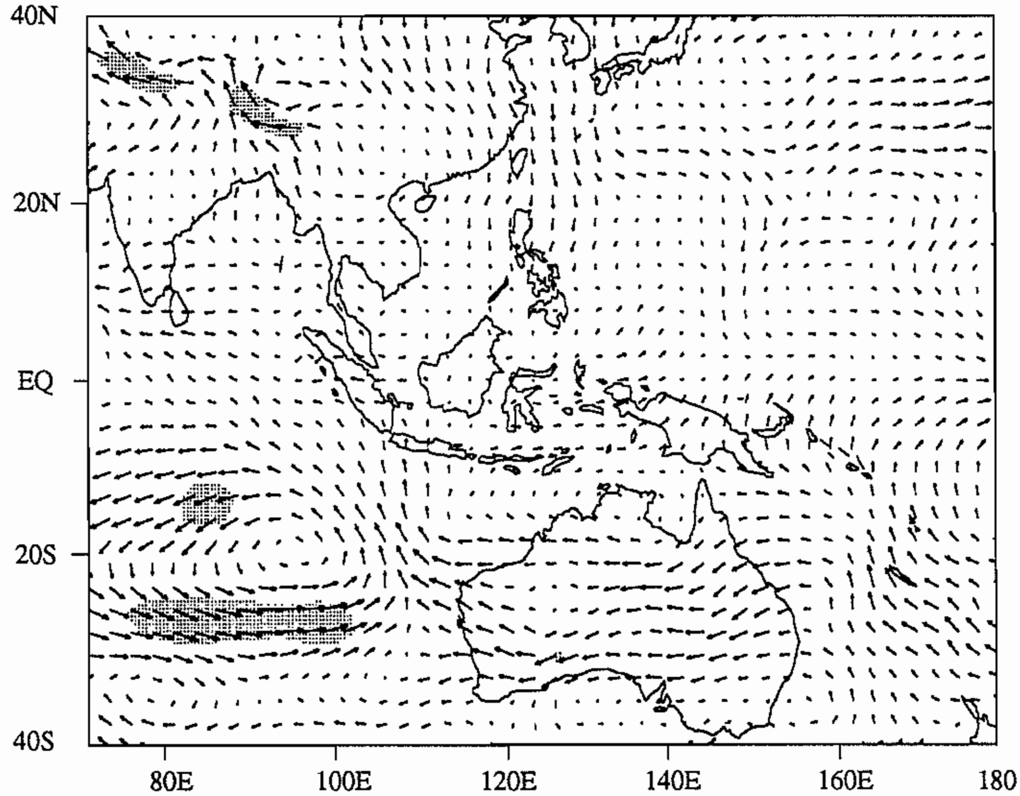

Fig.12 200 hPa WIND ANOMALY, OCTOBER 1996
Arrow length indicates relative magnitude. Areas greater than 10 ms^{-1} shaded.

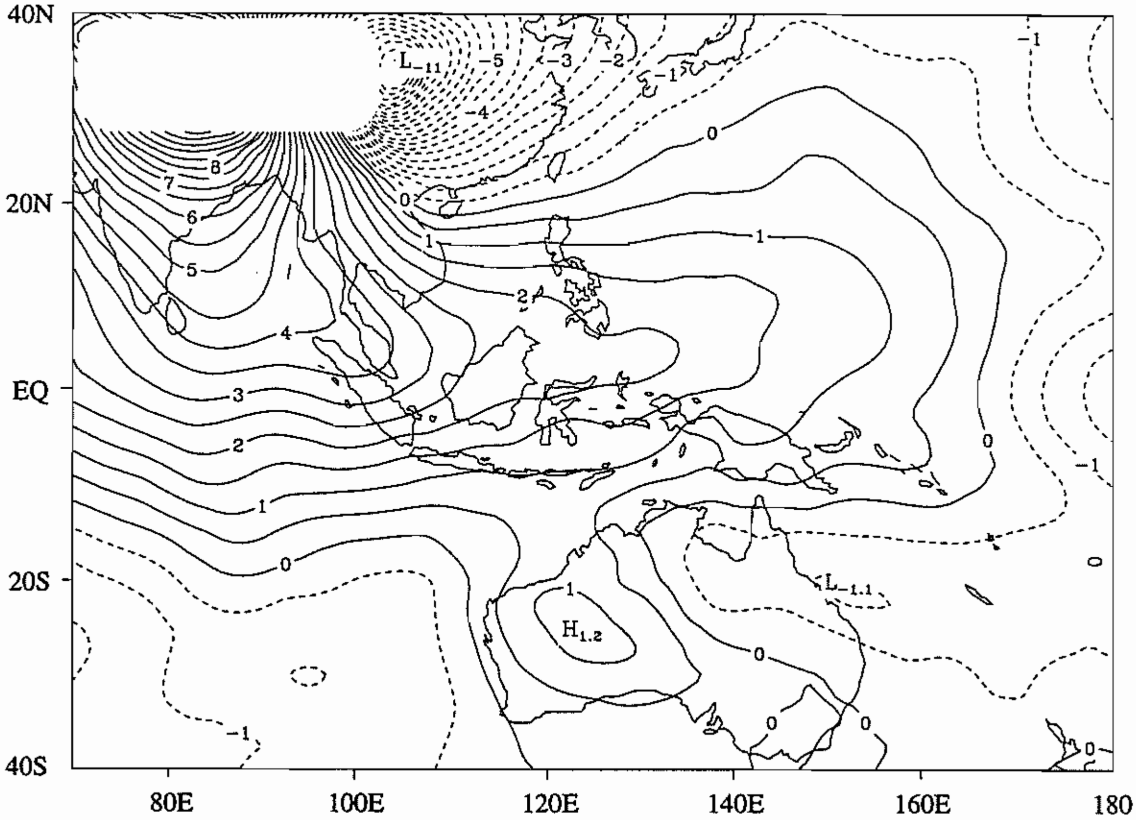

Fig.13 850 hPa VELOCITY POTENTIAL, OCTOBER 1996, (x 10^6 m^2 s^{-1}).

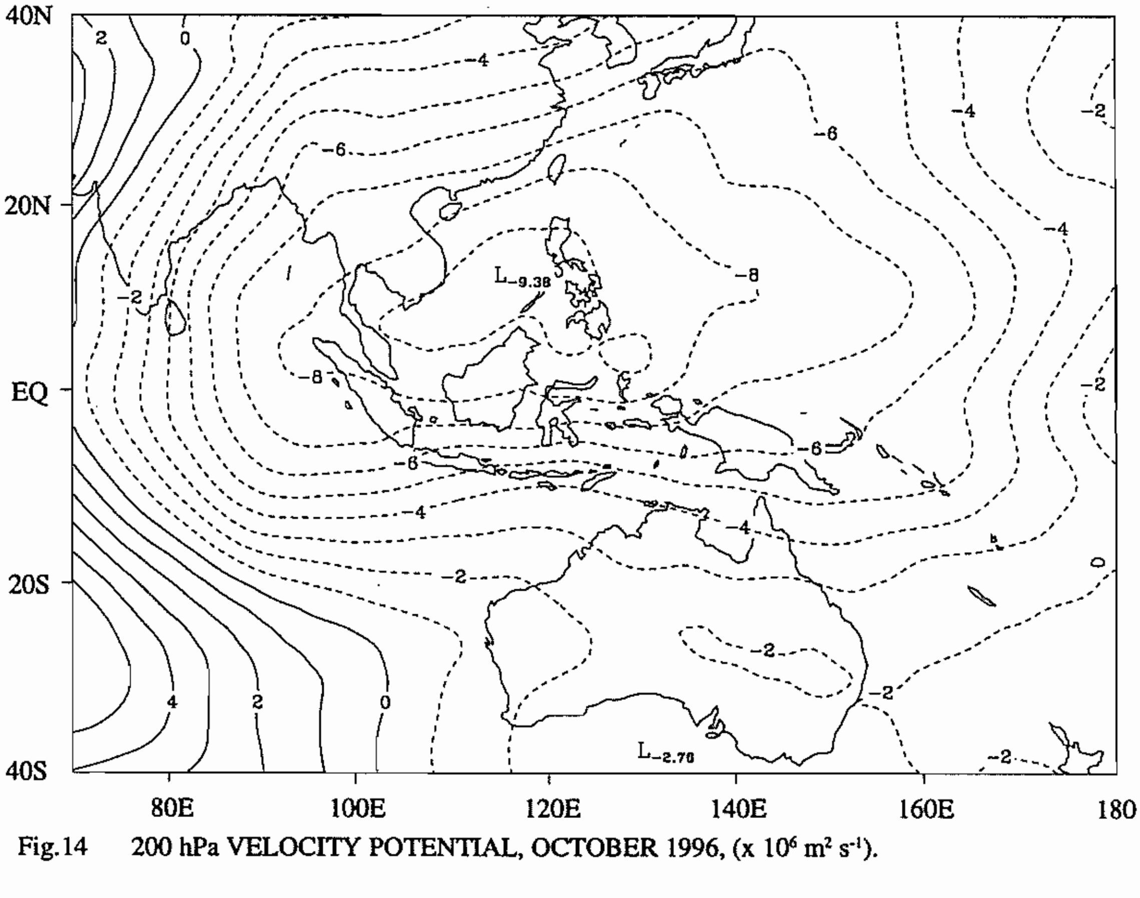

Fig.14 200 hPa VELOCITY POTENTIAL, OCTOBER 1996, (x 10^6 m^2 s^{-1}).

Time/longitude cross sections, southern series.

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

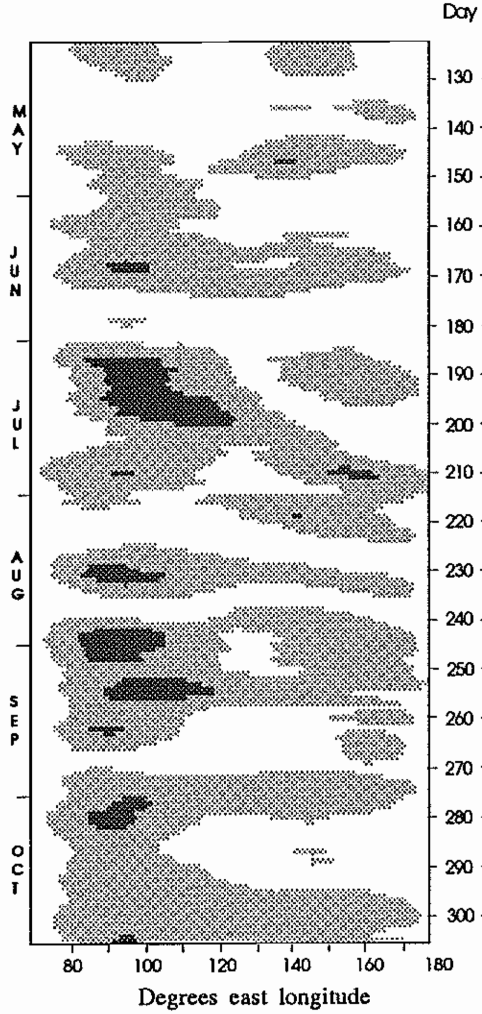

Fig.15(a) **200 hPa velocity potential based on TAPS output (10^5 m^2 s^{-1}).**

> -30 | -30 to -70 | -70 to -110 | < -110

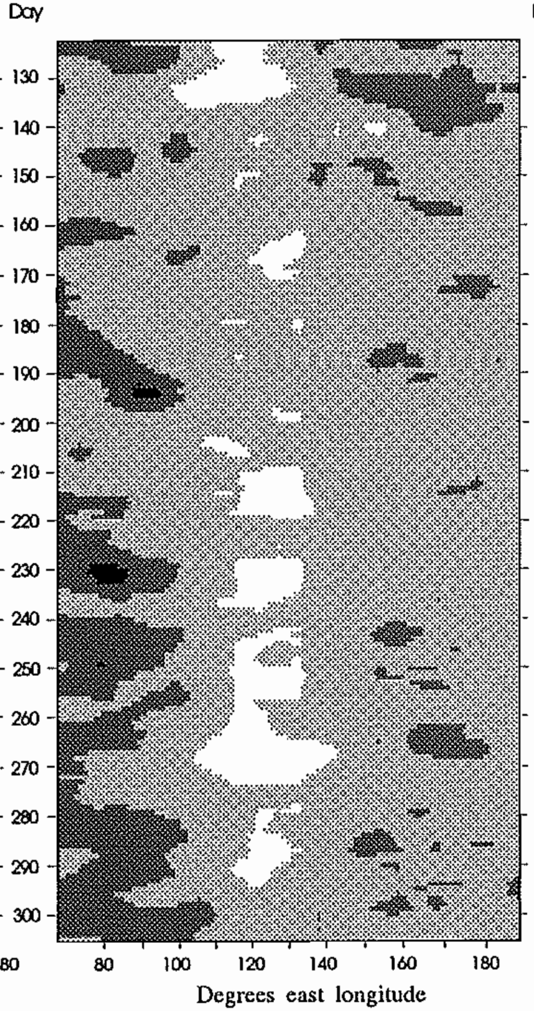

Fig.15(b) **Outgoing long wave radiation (watt m^{-2}).**

> 420 | 320 to 420 | 220 to 320 | < 220

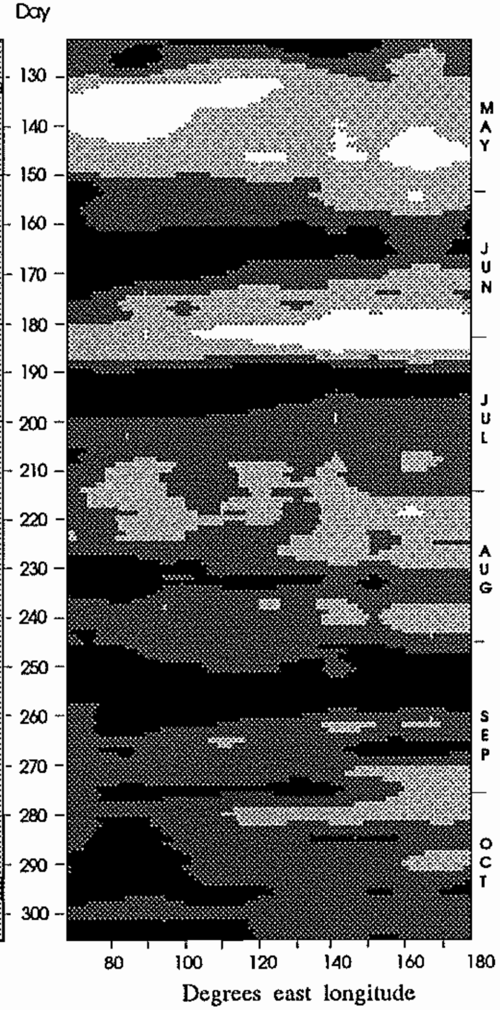

Fig.15(c) **Mean sea-level pressure anomaly based on TAPS output (hPa).**

> 1.5 | +1.5 to 0 | 0 to -1.5 | < -1.5

Time/longitude cross sections, equatorial series.

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

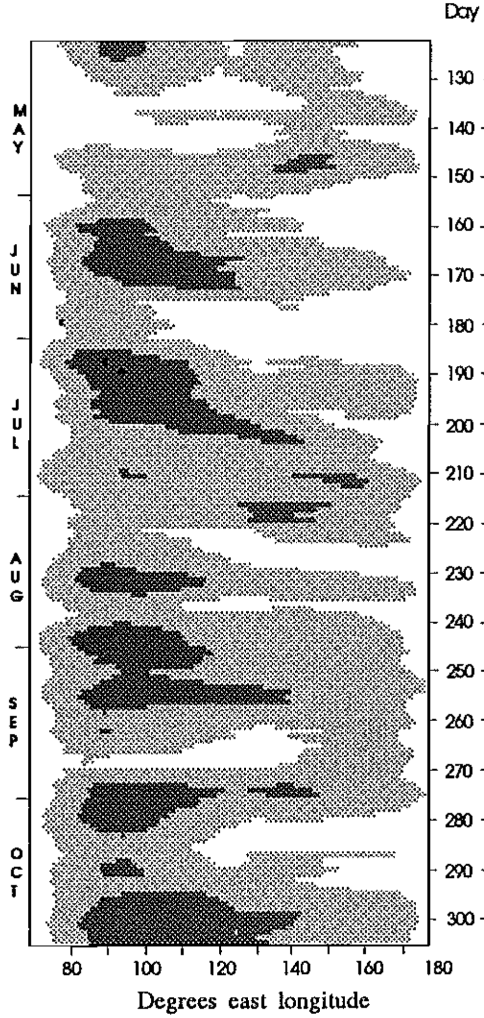

Fig.16(a) **200 hPa velocity potential based on TAPS output ($10^5\ m^2\ s^{-1}$).**

> -30 | -30 to -70 | -70 to -110 | < -110

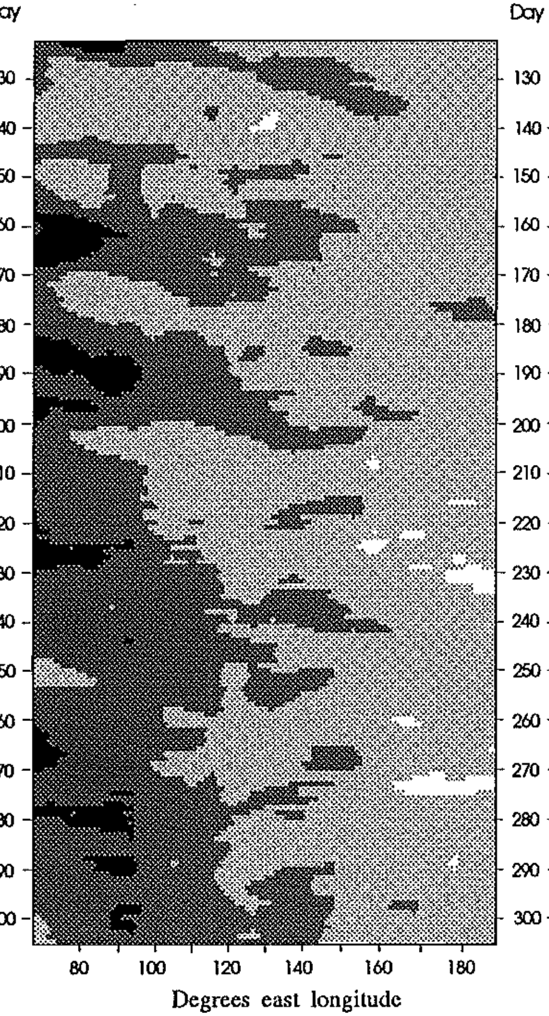

Fig.16(b) **Outgoing long wave radiation (watt m^{-2}).**

> 420 | 320 to 420 | 220 to 320 | < 220

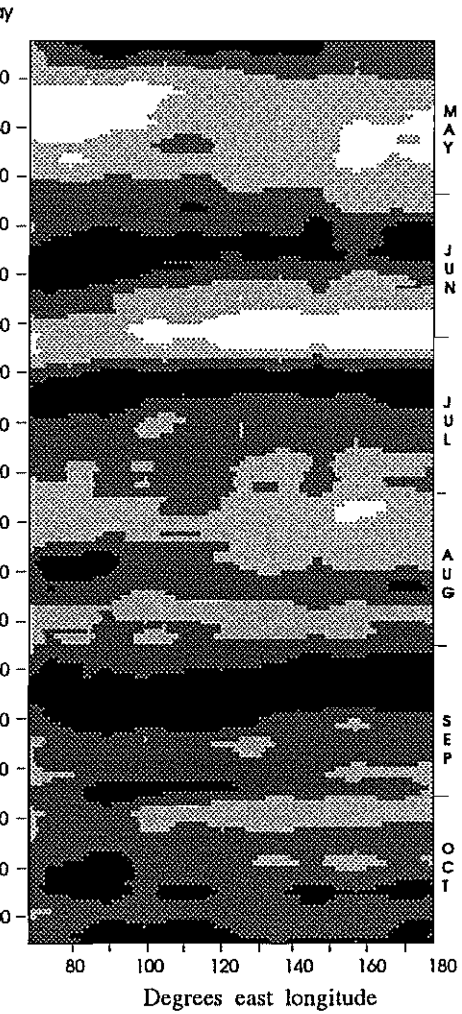

Fig.16(c) **Mean sea-level pressure anomaly based on TAPS output (hPa).**

> 1.5 | +1.5 to 0 | 0 to -1.5 | < -1.5

Time/longitude cross sections, northern series.

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

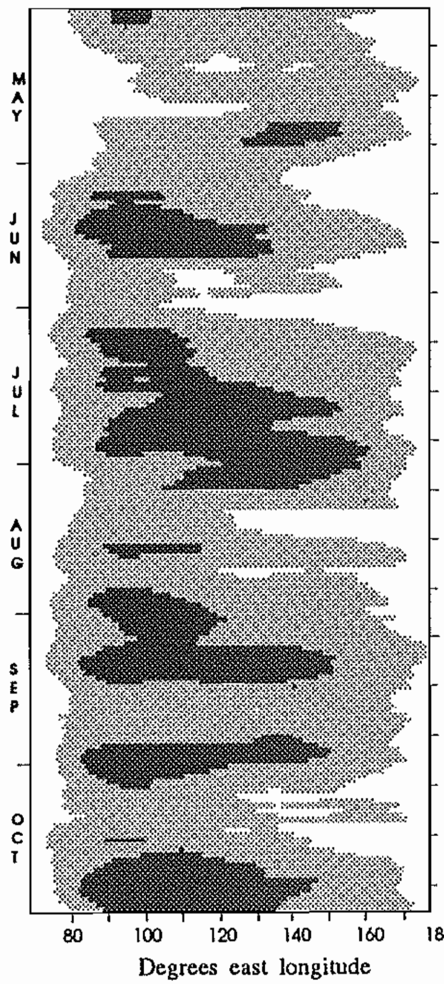

Fig.17(a) **200 hPa velocity potential based on TAPS output (10^5 m^2 s^{-1}).**

	> -30		-30 to -70
	-70 to -110		< -110

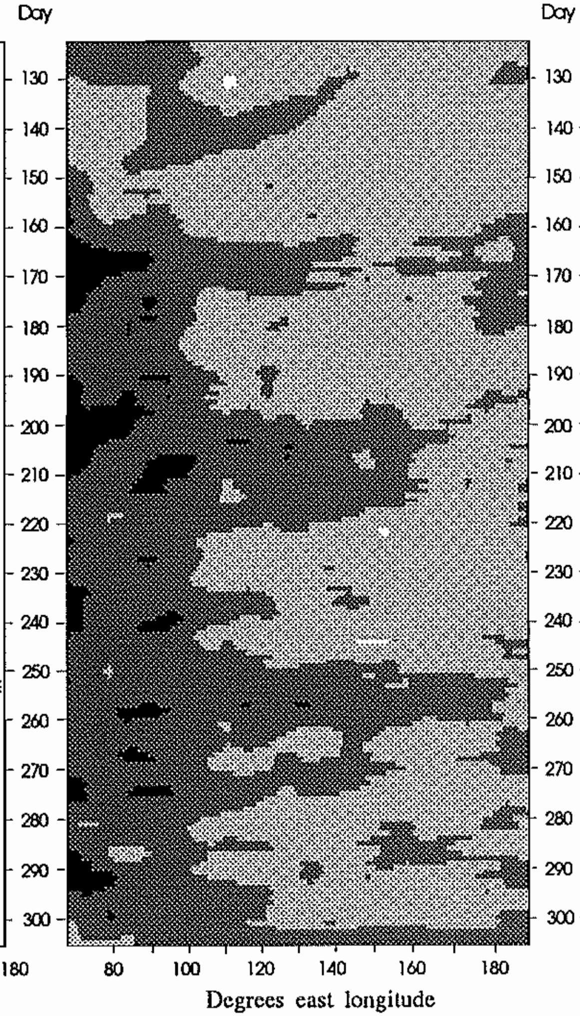

Fig.17(b) **Outgoing long wave radiation (watt m^{-2}).**

	> 420		320 to 420
	220 to 320		< 220

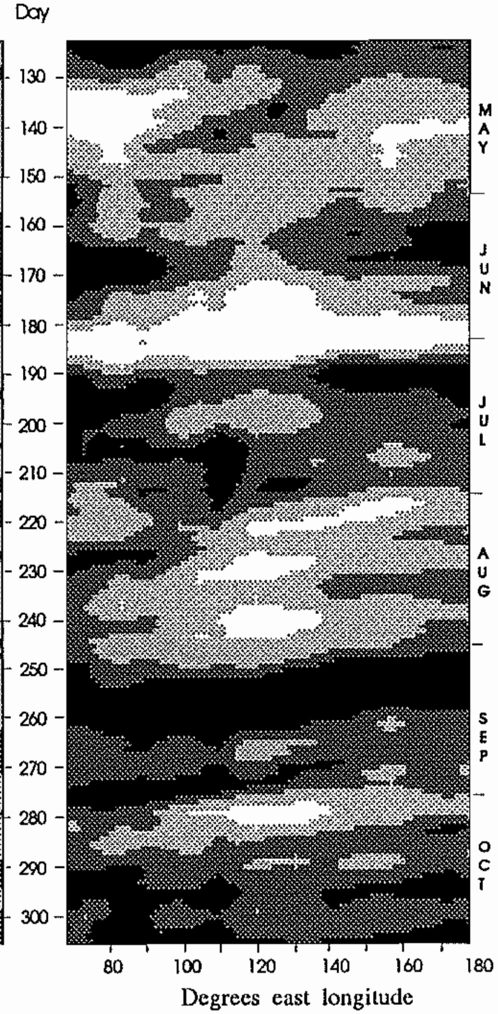

Fig.17(c) **Mean sea-level pressure anomaly based on TAPS output (hPa).**

	> 1.5		+1.5 to 0
	0 to -1.5		< -1.5

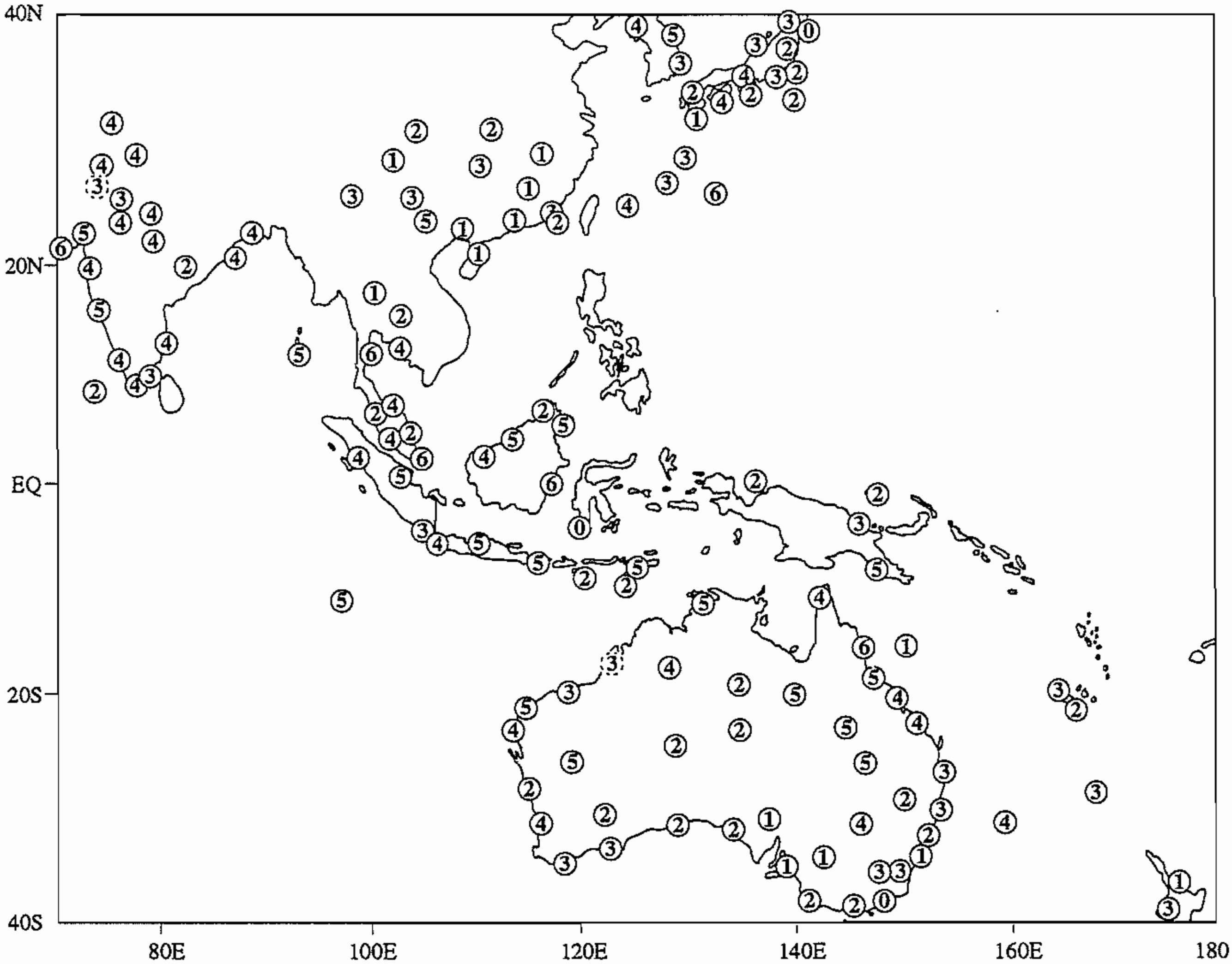

Fig.18 MEAN RAINFALL QUINTILES, OCTOBER 1996, from CLIMAT messages.

Quintile 0 denotes record low rainfall.
Quintile 6 denotes record high rainfall. } see Explanatory Notes: no. 3 (viii)

( ) Indicates actual rainfall is nil.

THIS PAGE INTENTIONALLY LEFT BLANK

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) $SOI = 10 \times (\Delta P_{TAH} - \Delta P_{DAR}) / \sigma$

where ΔP_{TAH} =Tahiti (91938) monthly pressure anomaly (monthly mean minus 1933-1992 mean, averaging 3-hourly observations)

ΔP_{DAR} = Darwin (94120) monthly pressure anomaly (monthly mean minus 1933-1992 mean, averaging 0900, 1500LT observations)

σ = monthly deviation of the difference.

(ii) Operational tropical cyclone tracks based upon Darwin RSMC manual operational analyses. A tropical cyclone or cyclonic storm is defined as having mean wind > 17 ms^{-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) or very severe cyclonic storm is defined as having mean wind > 32 m s^{-1} (63 Kn).

(iii) Tropical cyclone climatology for the northwest Pacific and the south Indian and Pacific Oceans is based on *2004 Annual Tropical Cyclone Report*, by Atangan, J.F. and Preble, A., (2004), US Naval Pacific Meteorology and Oceanography Center/ Joint Typhoon Warning Center, Pearl Harbour, Hawaii, USA, (available at https://metoc.npmoc.navy.mil/jtwc/atcr/2004atcr/), which contains a climatology of 59 years. 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 automated operational analyses (RSMC subset of the Australian National Meteorological and Oceanographic Centre (NMOC) 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) Mean MSLP, upper wind data, anomalies and 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 NCEP2 22 year climatology, 1979-2000. MSLP anomaly analysis modified using CLIMAT messages.
Upper level equatorial cross section derived from Darwin RSMC real-time Tropical Limited Area Prediction Scheme (TLAPS - refer Puri et al, 1996, *BMRC Research Report No. 54, 41*).

(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) OLR time longitude plots and maps derived from the US National Oceanic and Atmospheric Administration.

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

ISO	- Intra-seasonal oscillation
JMA	- Japan Meteorological Agency
JTWC	- Joint Typhoon Warning Center, Pearl Harbour
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
TD	- Tropical depression
TC	- Tropical cyclone (see note 3(ii))
STC	- Severe tropical cyclone
CS	- Cyclonic storm
VSCS	- Very severe cyclonic storm
TS	- Tropical storm (generally used for TC in northern Hemisphere sector)
TUTT	- tropical upper tropospheric trough

5. **Subscription rates** All costs in $AUSTRALIAN:

Annual subs.	Postage	Subs (incl postage)
95.50 (86.80 ex GST)	12.00 (Australia)	107.50
	24.00 (Asia/Pacific)	110.80
	36.00 (Rest of the world)	122.80

6. **For further details contact:**

The Regional Director,
Bureau of Meteorology,
PO Box 40050, Casuarina,
Northern Territory 0811 AUSTRALIA
Telephone: (International: 61) (08) 8920 3813
Fax: (International: 61) (08) 8920 3832
E-mail: climate.nt@bom.gov.au