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DARWIN TROPICAL DIAGNOSTIC STATEMENT

DECEMBER 1988

ISSUED BY DARWIN RMC

(Corrected version)

SUMMARY

The evidence for a strong Walker circulation continued during December. Sea surface temperature (SST) anomalies were strongly positive across the north Australian and Coral Sea areas. Significant negative SST anomalies continue in the central Pacific. Velocity potential maxima and minima at low and high levels were almost coincident over the maritime continent, indicating the presence of an upward branch of the Walker circulation. Rain across the Australian region was above average, and pressures were below average over north Australia and Indonesia. Although a 'break' period in the monsoon developed as the month progressed, and continued into early January, this is considered normal in terms of intraseasonal variation of wet season rain. We expect rain across most of the continent to continue to be mostly above average for the next two or three months.

INDICES

This month's value of the Southern Oscillation Index (SOI) is +10. The 5 month running mean of the SOI remains at +16. The contribution to the SOI from Darwin has decreased in magnitude from last month because the monsoon trough has moved well to the south over inland Australia in association with the strong Walker circulation. This may be a case where the trend in the SOI value is misleading taken on its own. Also there is evidence that the 40/50 day oscillation as identified by Madden and Julian (1972) modulates the Darwin pressure and so affects the SOI. The contribution from Tahiti continues to be significant.

1. Darwin mean MSL pressure, December 1988	:	1006.6 hPa
pressure anomaly (1882-1985 mean)	:	-0.6 hPa
2. Tahiti mean MSL pressure, December 1988	:	1012.2 hPa
pressure anomaly	:	+1.3 hPa
3. Troup's Southern Oscillation index	:	+10
5-month mean (centred upon October)	:	+16

4. Troup's SOI for the last 36 months:

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
1986	7	-12	0	1	-6	8	2	-7	-5	6	-13	-16
1987	-7	-14	-15	-22	-20	-18	-18	-13	-11	-6	-1	-6
1988	-2	-6	+1	-1	+10	-4	+11	+14	+20	+16	+20	+10

Graphs of the monthly SOI and the five month running mean SOI for the past ten years are given in Figure 1.

TROPICAL CYCLONES

Five tropical cyclones occurred between 70E and 180 during December. One cyclone occurred in the NW Pacific, one near Vanuatu, another south of the Bay of Bengal, and the remaining two occurred in the Australian region. Unofficial tracks are shown in figure 3.

Cyclone 05B started its life on the 5th as a depression just west of the northern tip of Sumatra. It moved broadly northward and reached cyclone status on the 7th. However the upper wind environment was not favourable for development. Southerly flow was evident through the system at middle and high levels. The cyclone weakened on the night of the 8th near the Andaman Islands and was downgraded to a tropical depression.

Cyclone Ilona, the first cyclone for the season in the Australian region, was first analysed as a depression off the north coast of the Northern Territory on the 11th. It moved steadily southwestward, skirting the northern tip of the Kimberleys late on the 12th. Early on the 13th the depression moved over the ocean offshore from Cape Leveque and intensified to cyclone status. On the 14th Ilona moved steadily westward to an area around 16S/115E and gradually intensified. It reached severe tropical cyclone status on the 15th. During the 15th and 16th the storm showed little discernible movement and deepened. On the 17th the cyclone recurved under the influence of a trough in the westerlies, and moved steadily southward toward the coast. It peaked at this stage at a maximum sustained wind of 85 knots and crossed the coast during the night of the 17th in a sparsely populated area near the mouth of the Fortescue river. Some damage was reported from mining towns such as Pannawonica and Tom Price, and from the Dampier/Karratha area. Ilona retained its identity well inland and produced heavy rain across much of inland Western Australia.

Tropical cyclone Val was the only cyclone in the NW Pacific during December. It was first analysed as a weak low near the Palau Islands on the 19th, remaining relatively inactive and slow moving until the 22nd when it started to move northwestward and deepen. Tropical cyclone status was reached on the 23rd. A significantly sheared upper wind environment restricted development, and the estimated maximum sustained wind never exceeded 35 knots as Val skirted the east coast of the Philippines. Warnings ceased as the storm weakened off the northeast coast of Luzon.

Coincident with the life cycle of TC Val, a depression was analysed on the 17th near the northern islands of Vanuatu. By the 20th it was near New Caledonia and had deepened a little. It remained in this position for a day or two then tracked east to northeastward. It was named as Eseta by Fiji on the evening of the 23rd, some 200 nautical miles eastward of the Vanuatu island chain. During the 24th and 25th it deepened to reach a peak sustained wind of 55 knots, and moved steadily to the southwest then southward as it was captured by a westerly trough which had amplified in the Tasman Sea. This was probably similar to cases reported by Davidson and Holland (1987) where a mixture of Rossby and gravity waves produced by the storm was a large factor in amplifying the trough. The storm weakened on the 26th as it moved over colder water and also into a sheared upper wind environment.

Tropical cyclone Delilah developed in the monsoon trough off north Queensland late in the month and moved eastward. As its life cycle extended into January it is not described further here.

SEA SURFACE TEMPERATURE

The mean sea surface temperature and anomaly fields for December are shown in Figures 4 and 5.

The sea surface temperature anomaly field has changed only slightly from November. The values are slightly more positive over northern Australia and the Coral Sea, with a warm tongue stretching from New Guinea to just west of New Caledonia. Advice from JMA, Tokyo, indicates that negative anomalies in excess of 2 still exist near the equator near and east of the dateline. This agrees with trial SST anomaly charts from NMC, Melbourne.

MSL PRESSURE AND GRADIENT LEVEL FLOW

Mean MSL pressure and anomaly charts for December are shown in Figures 6 and 7, and the gradient level (950 hPa) streamline and vector wind anomaly charts in Figures 8 and 9.

The broad area of negative anomalies over the Australian interior and the Queensland coast is a result of the monsoon trough being deeper and further south than normal. The tendency for troughing off the Queensland coast which was quite marked in November continued during December. The broad troughing across the Australian continent is also evident in the gradient level wind anomalies, with two cyclonic centres on the 'anomaly trough', one off the Queensland coast and the other off the central coast of Western Australia.

Enhanced northeasterly flow emanated from the subtropical ridge south of Japan, which was more intense than normal. Convergence of these north-easterlies into a cyclonic area east of the Philippines may reflect a better developed northern hemisphere monsoon trough than normal, culminating in tropical cyclone Val. The pressure anomaly pattern is broadly consistent with this.

850 hPa DAILY MEAN ZONAL AND MERIDIONAL WINDS AND RAINFALL AT DARWIN

Figures 10 (a), (b) and (c) are respectively plots of the 3-day running means of 850 hPa zonal and meridional winds and 24-hour rainfall totals, at Darwin, for December.

Following on from November, the initial burst of monsoon rain can be seen early in December. As often occurs following 'early' monsoon rain onset, southeasterlies again became established across the north coast. The rain from the 11th to the 14th was caused by the presence of the depression, mentioned in the section on tropical cyclones, which eventually deepened to become cyclone Ilona. After this period the wind varied between northwest and southwest as the monsoon trough/heat trough became established over the interior.

As can be seen, the total rain for December was 403 mm, compared with an average of 224 mm. Indeed the total rain from the start of the 'wet' season, nominally taken as September 1st, is only just below the highest on record to the end of the calendar year.

UPPER LEVEL FLOW

The mean 200 hPa streamline and vector wind anomaly charts for December are given in Figures 11 and 12.

A significant feature of the anomaly field is the anticyclonic departure over southeastern Australia, and large easterly anomalies across the northern half of the continent. Equatorial anomalies taken over the whole month are light. However early in December there was substantial southeast 'return' flow between 120°E and 150°E with the first outbreak of the north Australian monsoon rain. There was a further period of high level southeasterlies across the equator in the Indonesian region which coincided with a monsoon rain event in that region. For most of the month fairly innocuous easterlies prevailed at 200 hPa in equatorial regions.

Significant 200 hPa anomalies in the northern hemisphere were an anticyclonic departure over the ocean to the southeast of Japan and a cyclonic centre near India.

VELOCITY POTENTIAL

Charts of the velocity potential fields at 950 hPa and 200 hPa for December are given in Figures 13 and 14.

At 950 hPa the pattern of velocity potential has changed little from last month. The maximum is centred to the east of the Philippines, consistent with previous comments about the monsoon trough. The ridge along and off the Queensland coast is more marked. This agrees with the persistent troughing and well above average rain in that region. A strong south to southwest divergent wind component continues across Australia.

At 200 hPa the minimum of velocity potential moved into the maritime continent near Borneo. The gradient of velocity potential over northern Australia decreased from November, and the north to northwesterly divergent wind component decreased. Another interesting feature of the high level pattern is the maximum over China, implying significant convergence in that region.

The centres of high and low level velocity potential patterns fall broadly in the maritime continent and indicate an upward branch of a well defined Walker circulation.

WIND CROSS SECTIONS

Cross sections along 100°E, 130°E and 160°E of zonal wind for December are shown in Figures 15, 16 and 17 respectively; the equatorial cross section of meridional wind is given in Figure 18.

The cross sections of zonal wind all show an increase in equatorial westerlies at low levels. At high levels, easterlies now prevail at low latitudes. The upper level westerly jet over Japan and the north Pacific seems to have strengthened a little.

The equatorial cross section shows northerly low level flow west of 110°E, with light, variable low level meridional component between 110°E and 130°E. There were a few periods during the month when there was significant northerly cross equatorial low level flow. However only at the start of the month did the 'surge' from the north appear to be a contributing factor in outbreaks of monsoonal type rain. At this time last year the equatorial cross section pattern was not dissimilar to this month. However the first outbreak of monsoonal rain last year did not occur until toward the end of the month. The effect of cross equatorial flow on 'monsoon rain' outbreaks in northern Australia seems to be rather tenuous. There is some evidence that the Madden and Julian 40/50 day zonal oscillation has considerable influence on the degree to which these meridional surges affect the weather in northern Australia. Data is being collected in this office during this 'wet season' in an effort to determine the best method by which to detect and monitor this feature.

RAINFALL

Monthly rainfall quintiles for selected stations in December are given in Figure 2.

The trend of above average rainfall over most of Australia continues in line with earlier predictions from the National Climate Centre, Melbourne, and this office. This is in contrast from last month when, in general, only tropical Australia received above average rain.

REFERENCES

Davidson, N.E. and Holland, G.J., 1987. A diagnostic analysis of two intense monsoon depressions over Australia. Mon. Wea. Rev., 115, 380-392.

Madden, R.A., and Julian, P.R., 1972. Description of global-scale circulation cells in the tropics, with a 40-50 day period. J. Atmos. Sci., 29, 1109-1123

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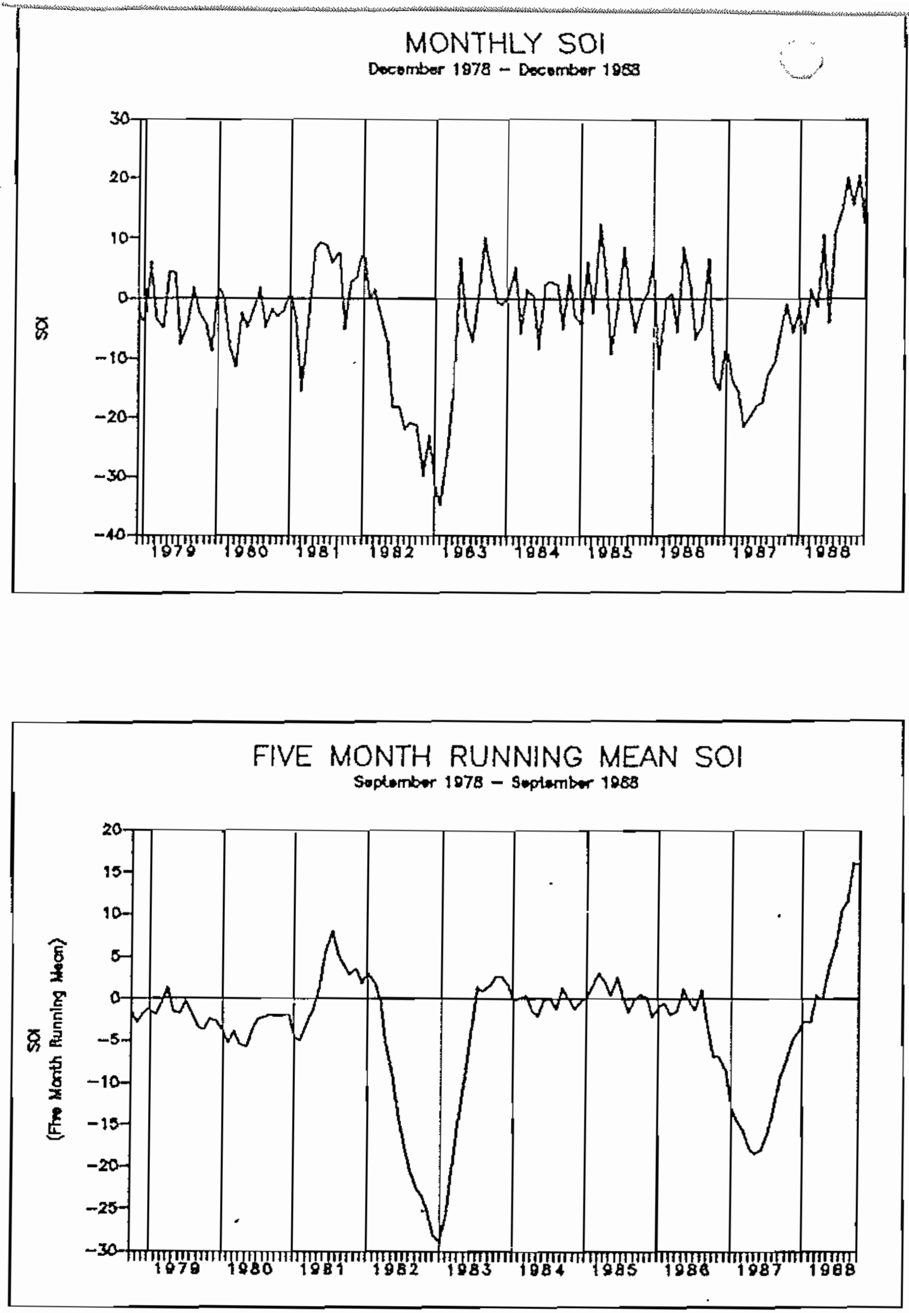


Fig.1 SOUTHERN OSCILLATION INDEX (1978-1988)
Monthly SOI and 5-month running mean SOI

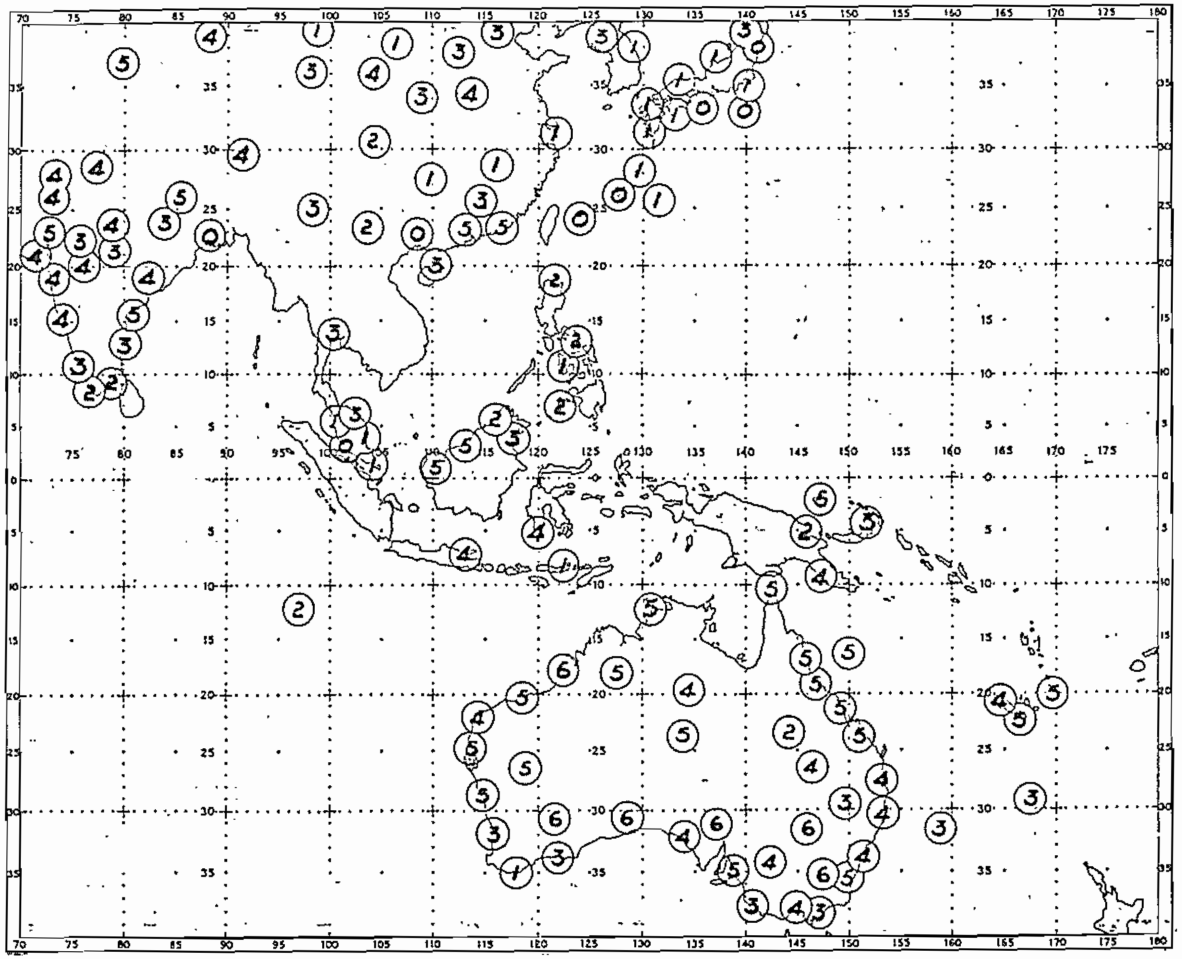


Fig.2 * MONTHLY MEAN RAINFALL QUINTILES from selected climat stations (DECEMBER 1988)

* Quintile 0 denotes record low rainfall
Quintile 6 denotes record high rainfall

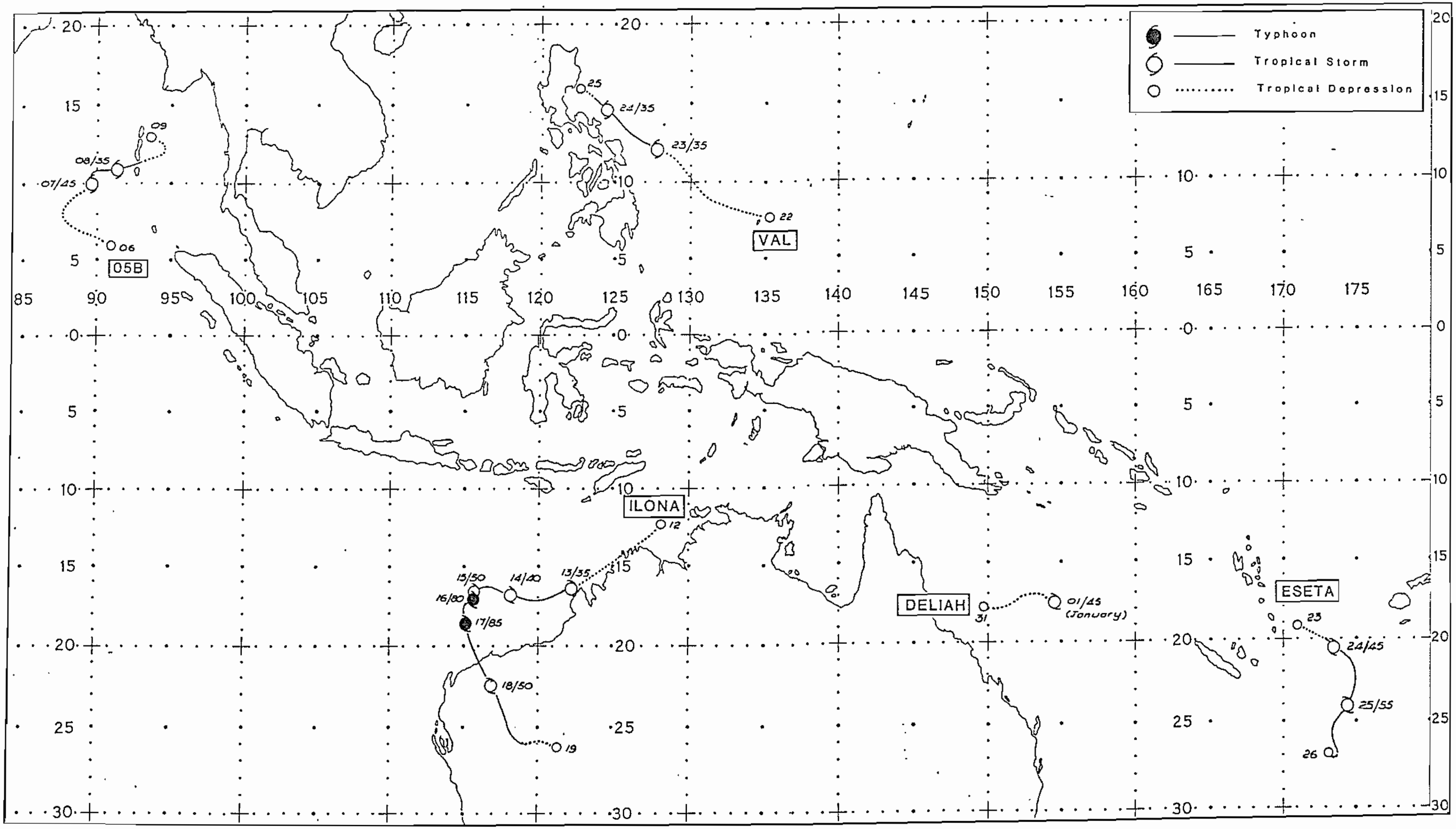


Fig.3 UNOFFICIAL TRACKS OF CYCLONES 05B, ILONA, VAL, ESETA AND DELIAH (DECEMBER 1988)
Date (DD) and maximum sustained wind (ff) in knots denoted by DD/ff.

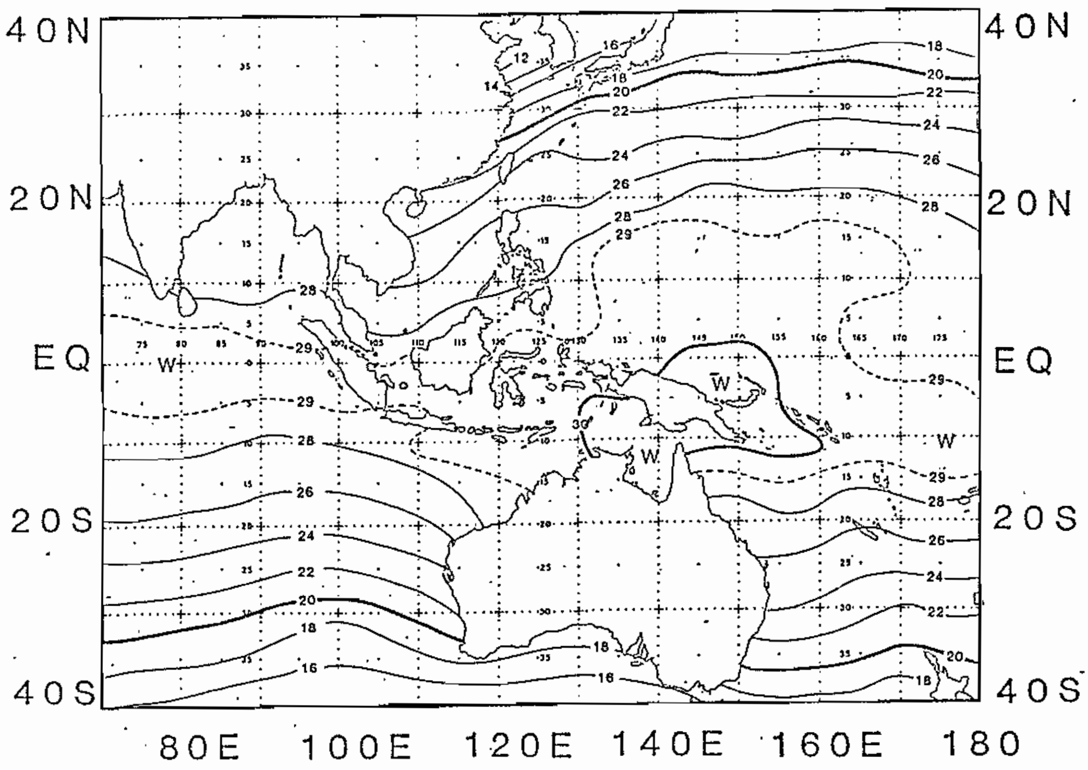


Fig. 4 MEAN SEA SURFACE TEMPERATURES, BASED ON WEEKLY DARWIN RMC ANALYSES AVERAGED OVER THE MONTH, DECEMBER 1988. Isotherm interval 2° C.

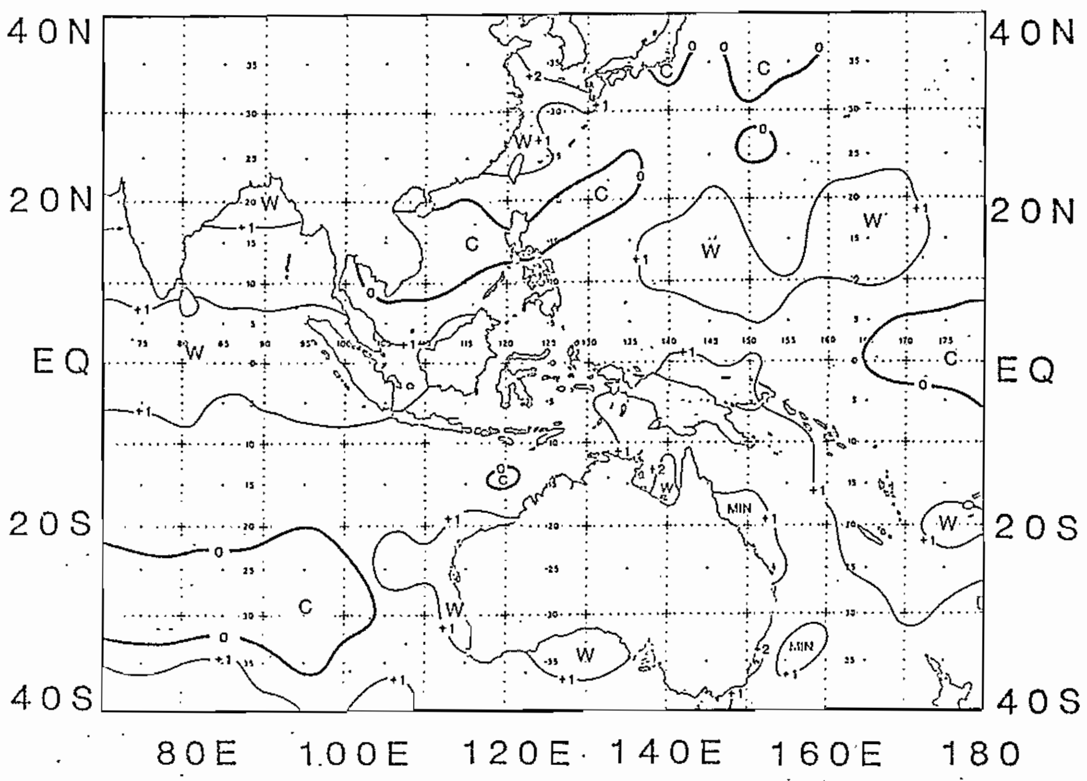


Fig. 5 SST ANOMALY CHART, BASED ON FIG. 4 AND THE CLIMATOLOGY OF REYNOLDS, NOAA REPORT NWS 31, 1983 Isotherm interval 1° C.

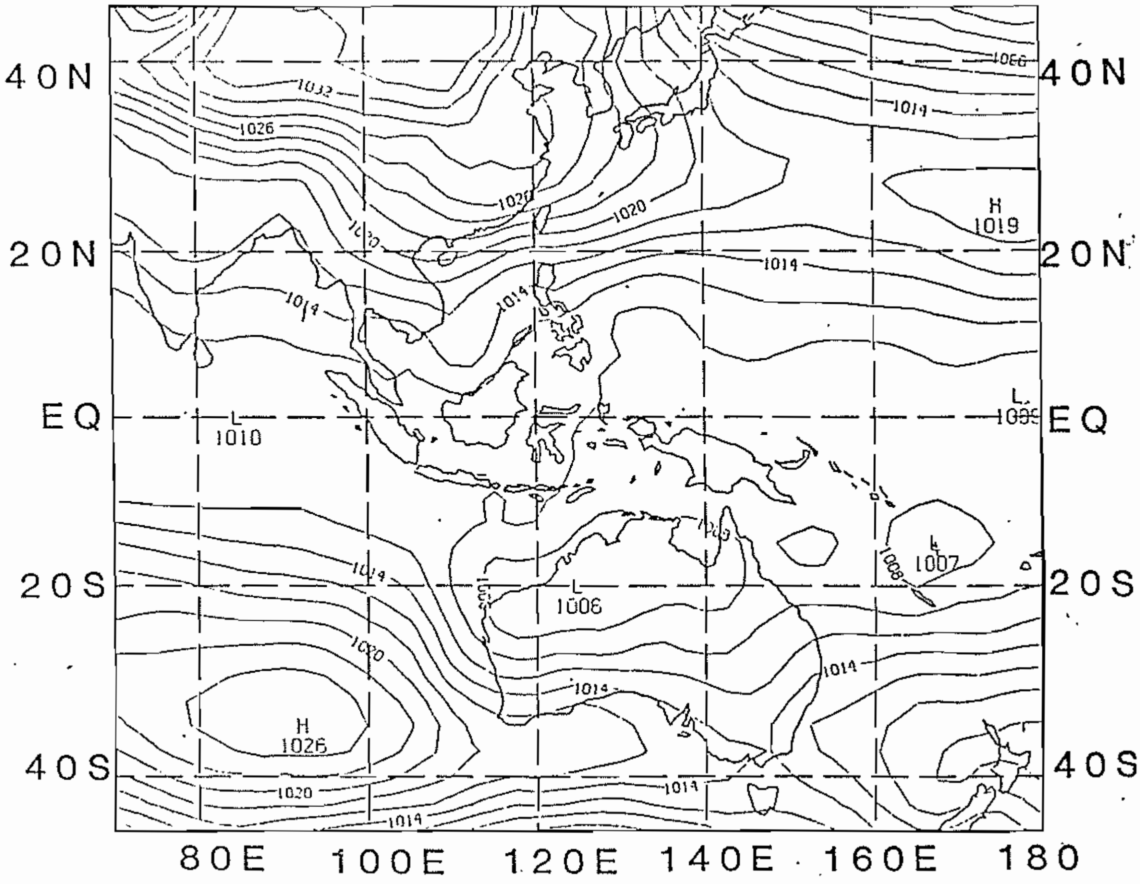


Fig. 6 MONTHLY MEAN MSL PRESSURE, DECEMBER 1988
Isobar interval 2 hPa

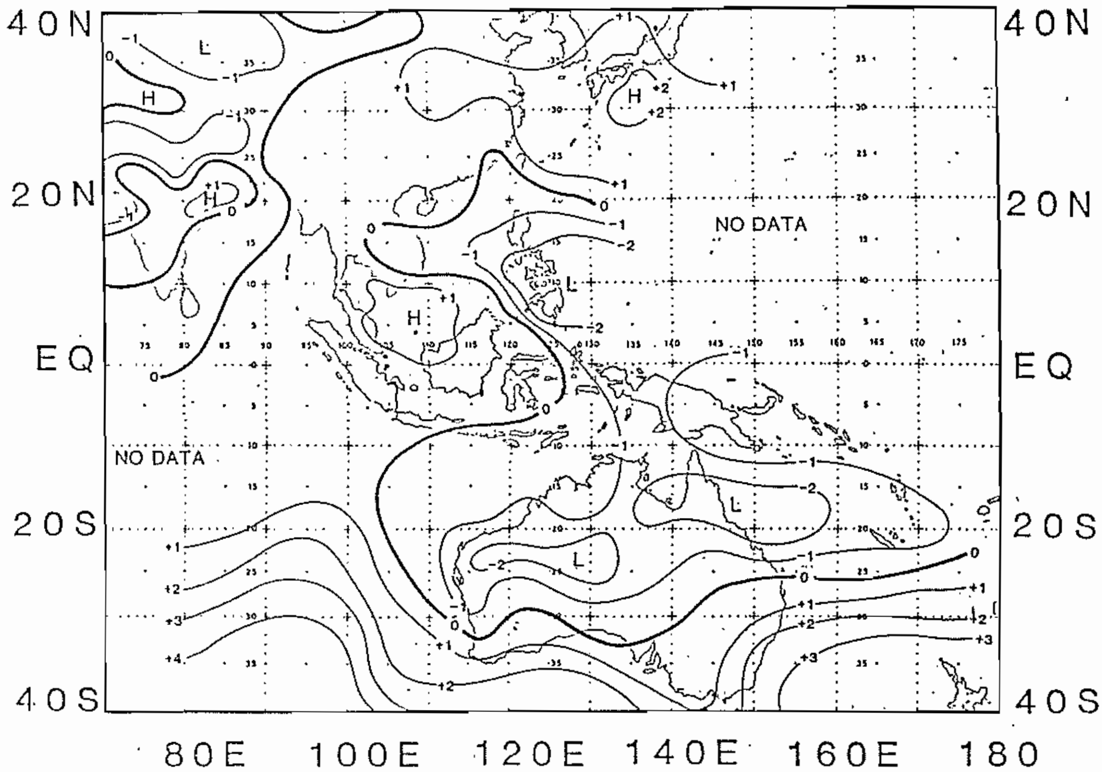


Fig. 7 MSL PRESSURE ANOMALY BASED ON CLIMAT MESSAGES
(AND MELBOURNE WMC DATA SOUTH OF 10^{o}S)
Contour interval 1 hPa.

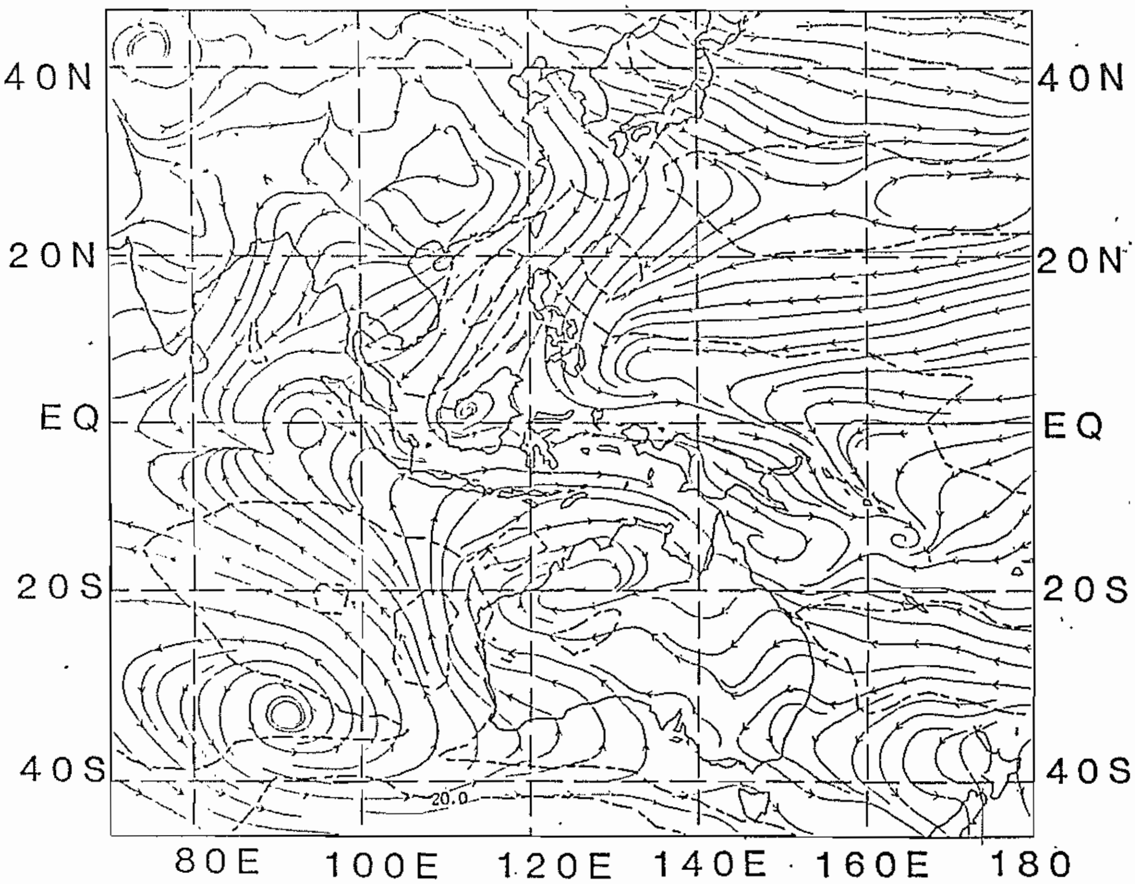


Fig. 8 950 hPa STREAMLINE ANALYSIS, DECEMBER 1988
Isotachs (dashed line) at 10 knot intervals

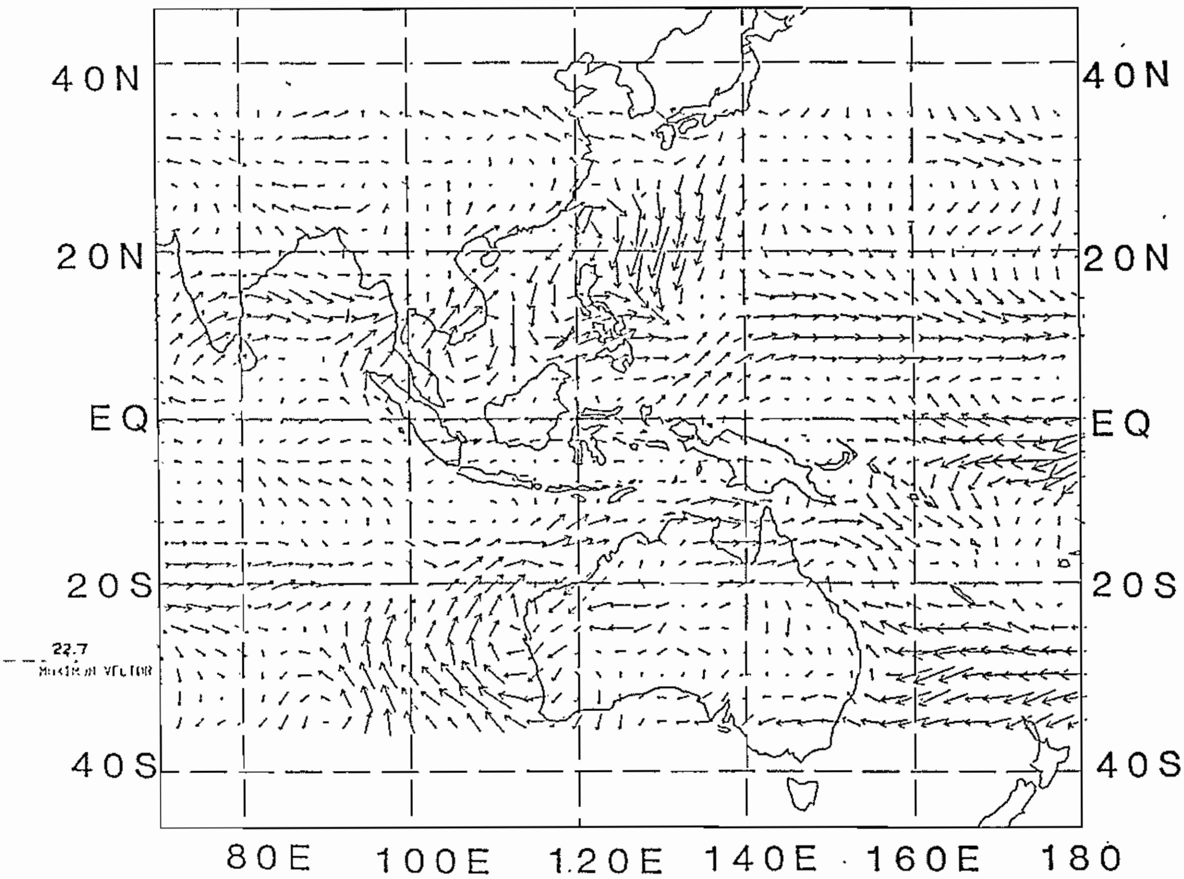


Fig. 9 950 hPa VECTOR WIND ANOMALY BASED ON FIG. 8
(Arrow length indicates magnitude)

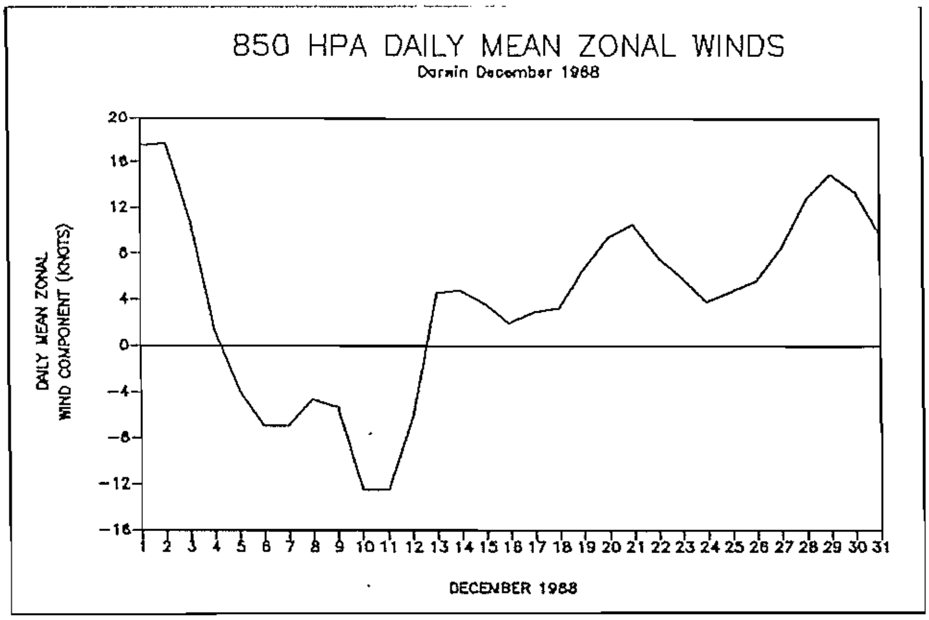
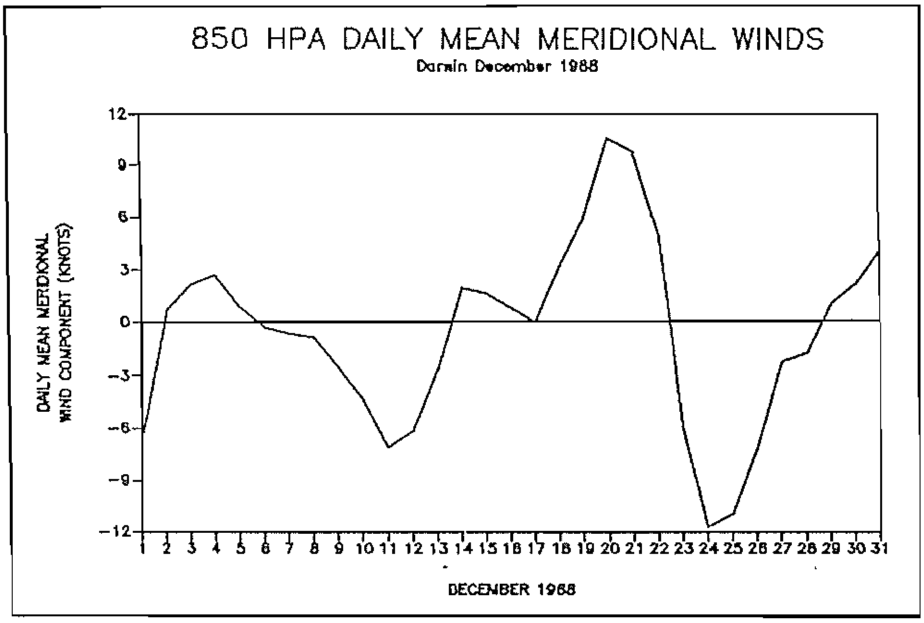
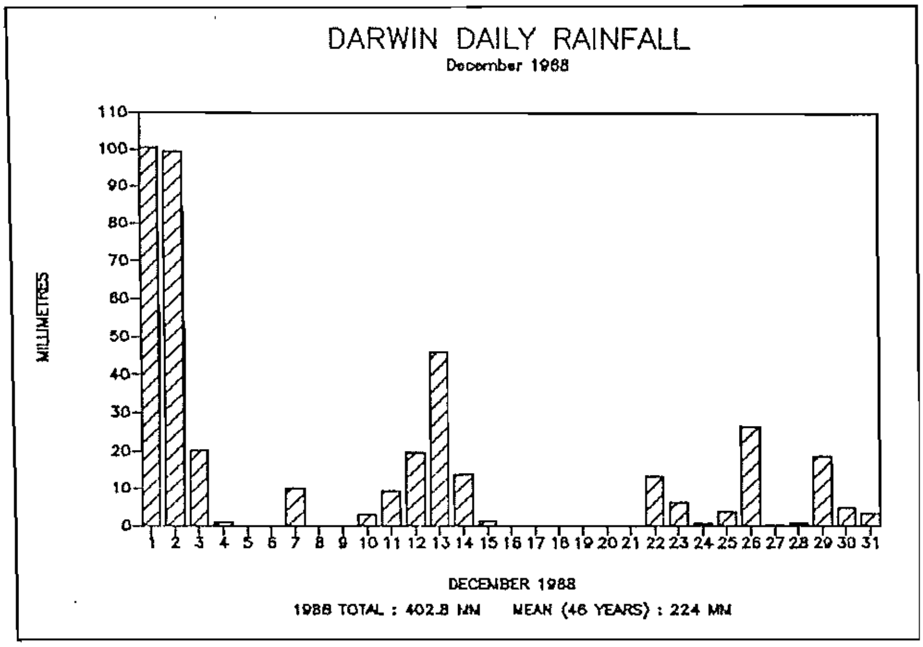


Fig.10 (a) DARWIN 850 hPa 3-DAY MEAN ZONAL WIND, DECEMBER 1988



(b) DARWIN 850 hPa 3-DAY MEAN MERIDIONAL WIND, DECEMBER 1988



(c) DARWIN DAILY RAINFALL, DECEMBER 1988

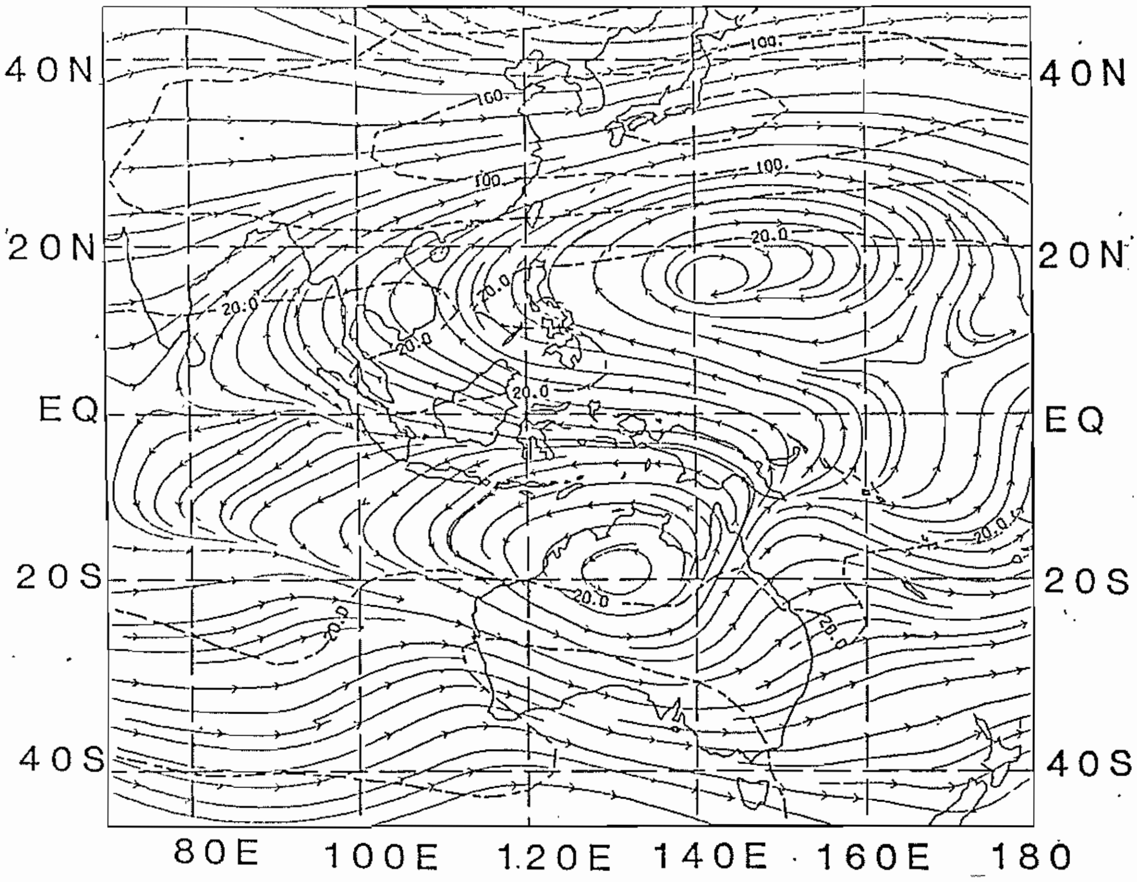


Fig.11 200 hPa STREAMLINE ANALYSIS, DECEMBER 1988
Isotachs (dashed line) at 40 knot intervals.

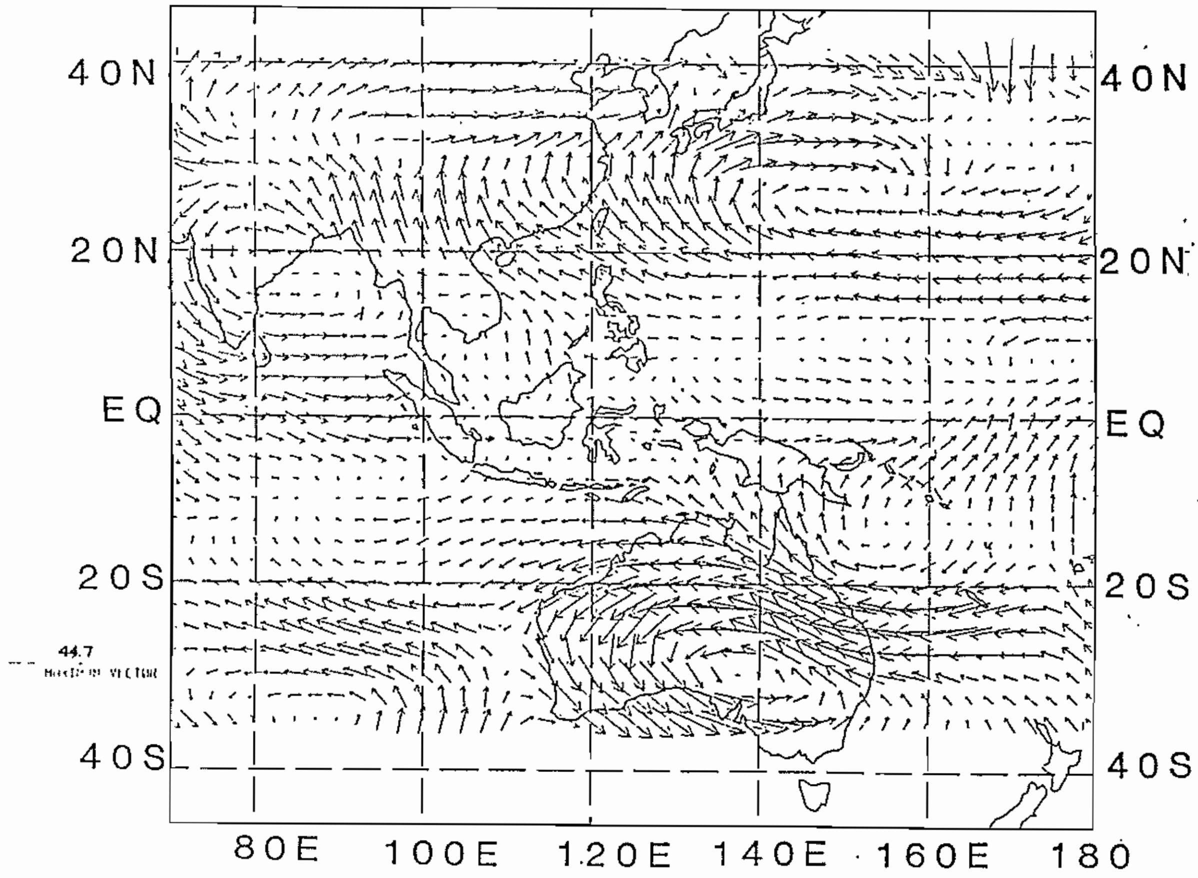


Fig.12 200 hPa VECTOR WIND ANOMALY BASED ON FIG. 11
(Arrow length indicates magnitude).

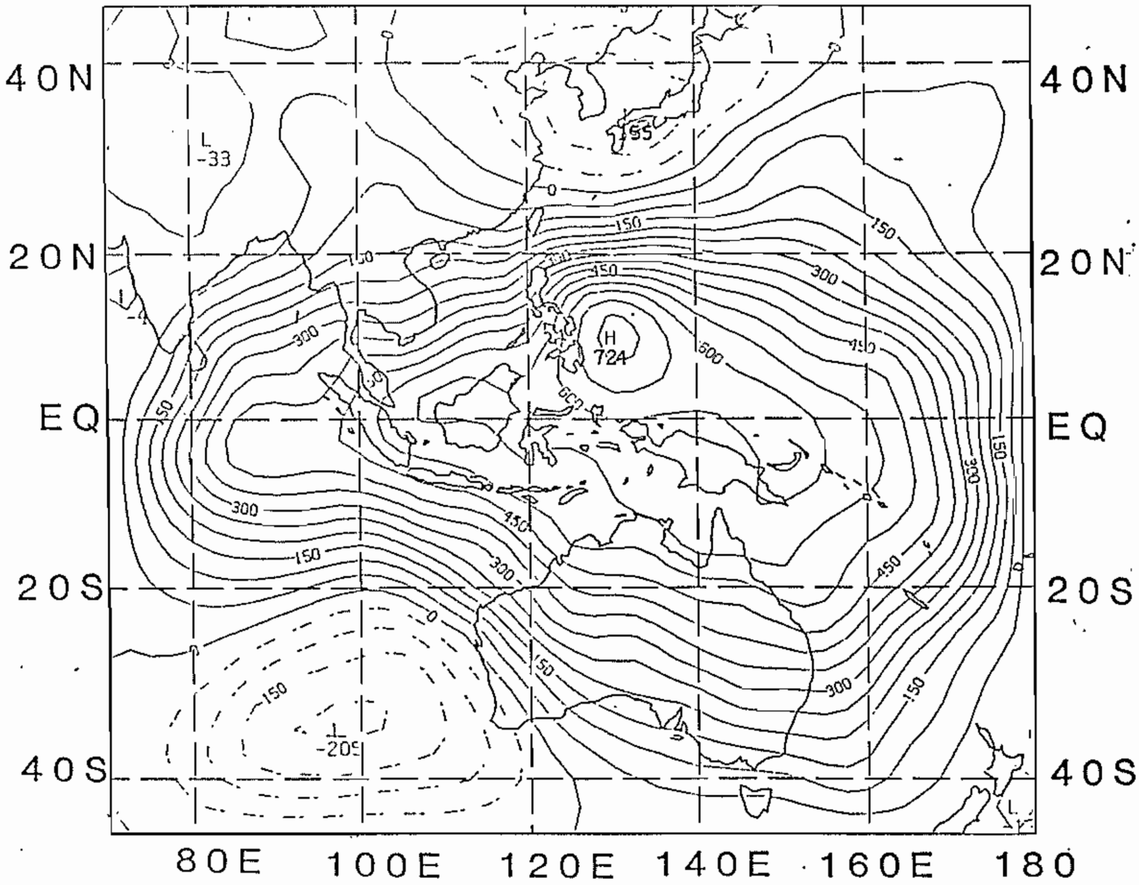


Fig.13 950 hPa VELOCITY POTENTIAL, DECEMBER 1988
Contour interval 50 x 10^5 m^2 s^{-1}

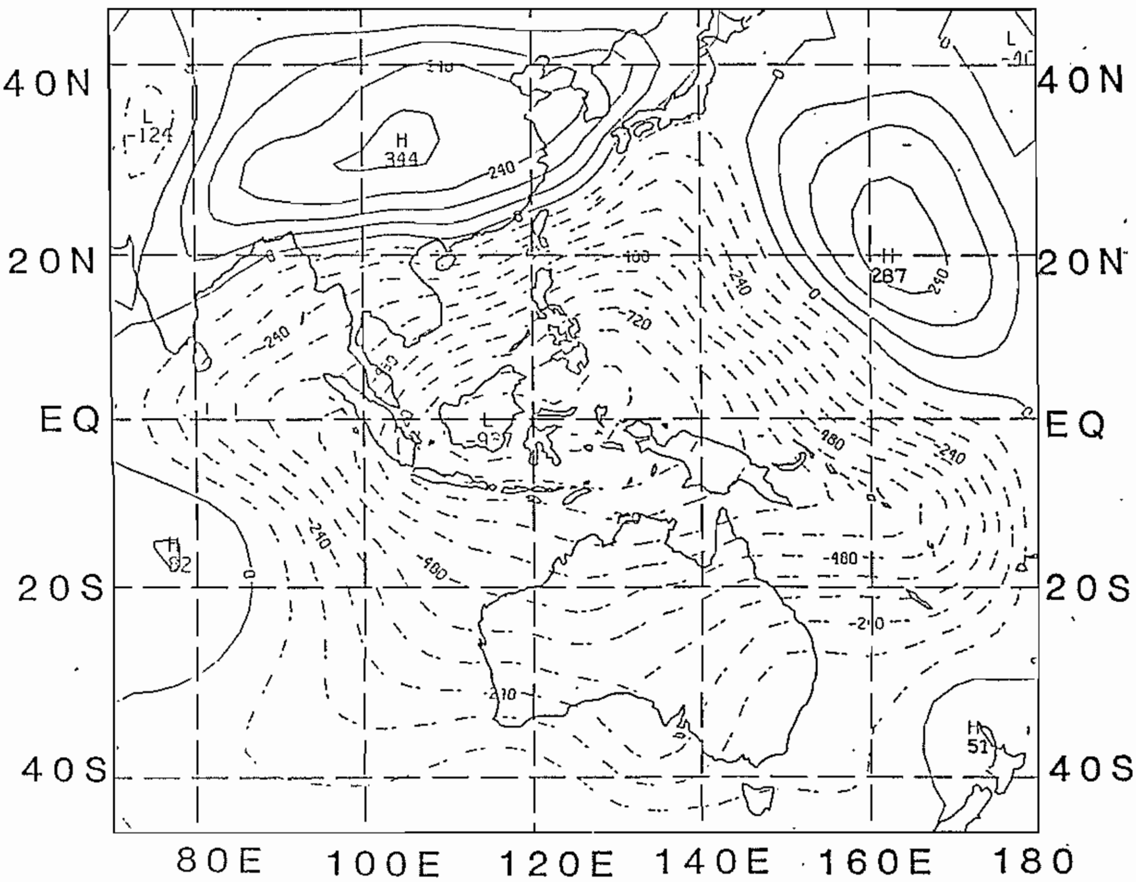
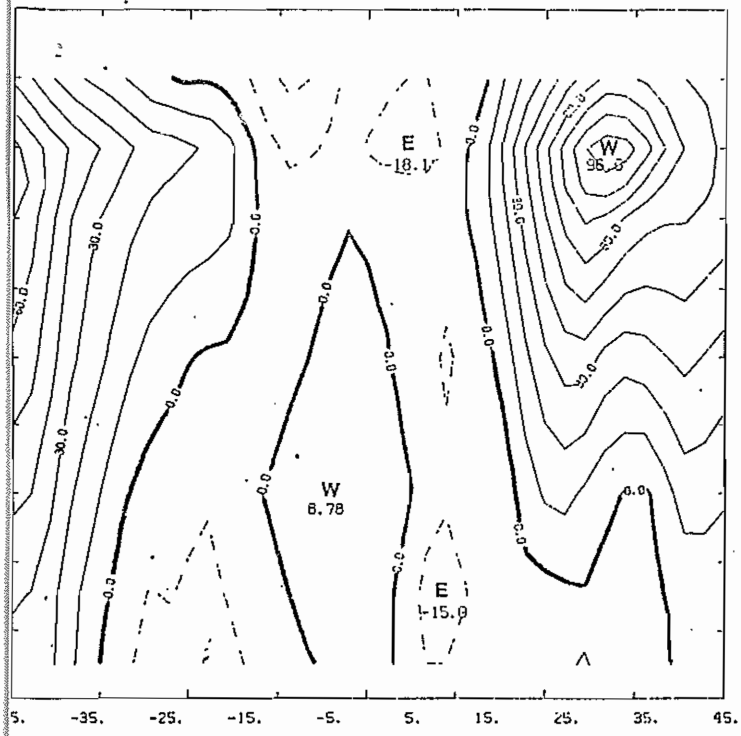


Fig.14 200 hPa VELOCITY POTENTIAL, DECEMBER 1988
Contour interval 80 x 10^5 m^2 s^{-1}



ig. CROSS-SECTION OF ZONAL WIND ALONG 100°E, DECEMBER 1988
Isotach interval 10 knots.

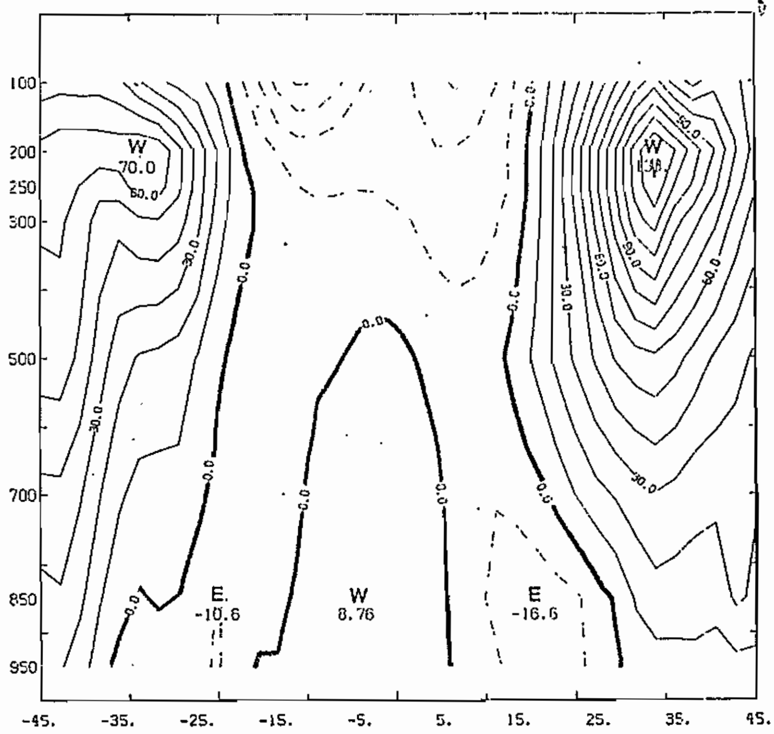
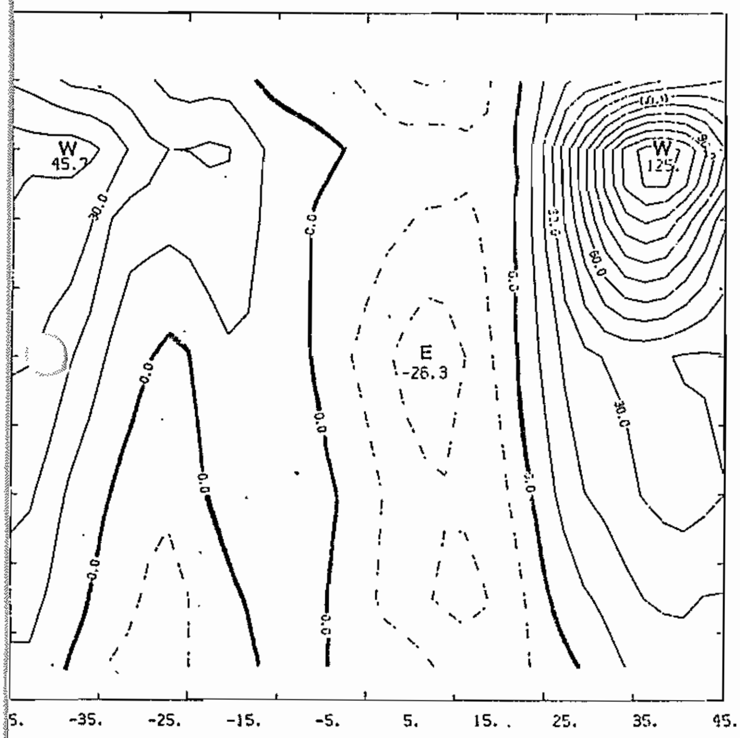


Fig.16 CROSS-SECTION OF ZONAL WIND ALONG 130°E, DECEMBER 1988
Isotach interval 10 knots.



ig.17 CROSS-SECTION OF ZONAL WIND ALONG 160° E, DECEMBER 1988
Isotach interval 10 knots.

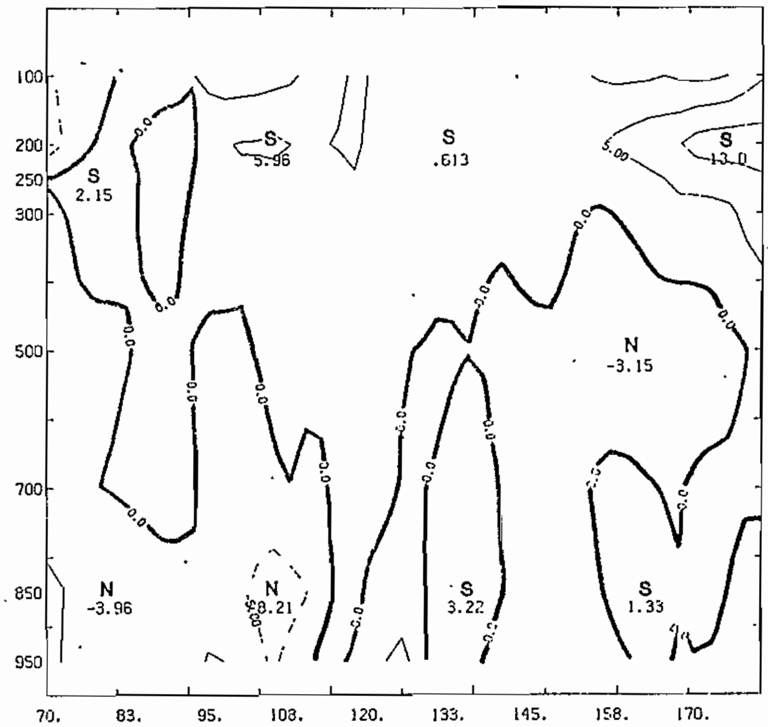


Fig.18 EQUATORIAL CROSS-SECTION OF MERIDIONAL WIND
BETWEEN 70°E AND 180°E, DECEMBER 1988. 5 knot isotachs.

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

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:

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	24.00 (Asia/Pacific)	110.80
	36.00 (Rest of the world)	122.80

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