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DARWIN TROPICAL DIAGNOSTIC STATEMENT

DECEMBER 1986

ISSUED BY DARWIN RMC

INDICES

December mean MSL pressures:

Darwin	1009.7 hPa	(anomaly +2.6 hPa)
Tahiti	1010.5 hPa	(anomaly -0.4 hPa)

(anomalies from the 1882/1985 mean).

December Troup's SOI: -16
5-month running mean: - 7 (centred on October)

Darwin December rainfall: 115.0 mm (mean 224 mm); quintile range 1;
10 raindays (mean 16 days).

The SOI is more than 1 standard deviation below the mean for the second consecutive month. This was due to Darwin's much above average pressure; in November the deviation from normal was due to Tahiti being much below average. The low Darwin rainfall was typical of that over the whole Northern Australian region. In contrast to the conflicting signs in November, a number of other indicators in December supported the hypothesis that a moderate El Nino event was occurring.

TROPICAL CYCLONES

In the Northwest Pacific, four tropical cyclones occurred, three of which were typhoons. All of these systems had their genesis east of 155 E within an active near-equatorial trough (NET). According to JTWC Guam statistics, the mean number of tropical cyclones in this region is 1.2, with 0.6 typhoons. This is the first December in the 1959/86 record that so many systems have been observed in this region. Unofficial tracks are shown in figs. 1a and 1b.

Typhoon Kim continued its west-ward track from November and became an extra-tropical system after the 11th. Tropical storm Lex was a short-lived system with maximum windspeeds reaching 50 knots. Typhoon Marge developed around the 16th and peaked at 85 knots prior to landfall and dissipation over the Southern Philippines. Typhoon Norris formed on the 23rd and tracked westward toward the Philippines where it dissipated in early January.

In the southern hemisphere, tropical cyclone activity was unusually high near the dateline and into the western hemisphere - a characteristic of El Nino years. The phenomenom of cyclone pairs forming on both sides of the equator was observed twice: with TC Patsy near Vanuatu-New Caledonia, and Marge; and with severe TC Raja near Fiji, and Norris. Tracks are shown in fig. 1c. Another tropical cyclone, Sally, formed east of 180 in late December (ie off the edge of our charts), and subsequently caused serious damage to the Cook Islands. Although we have no statistics of cyclone frequency in this area, experience suggests that this number is well above average.

SEA SURFACE TEMPERATURES

The mean sea surface temperature (SST) isotherms, and SST anomalies, shown in figs. 2 and 3, are three week averages from the 2nd to the 24th.

The broad area of anomalous cold SST east of Australia appears to have migrated westward since November. Anomalous warm SST dominates the belt equatorward of latitude 10°, and extends into the Bay of Bengal. The warmest anomalies are located in the Java-Borneo region. The strength of the warm anomaly over Northern Australia has weakened since November. A weak cold anomaly persists in the Indian Ocean off Northwest Australia.

The SST anomaly pattern looks similar to that of the "peak phase composite" (at least west of 180) for March-May of an El Nino year, shown in Rasmusson and Carpenter (1982).

MSL PRESSURE AND GRADIENT LEVEL FLOW

The December mean MSL pressure and anomaly charts are shown in figs. 4 and 5, and the gradient level (950 hPa) streamline and wind anomaly charts in figs. 6 and 7.

In the southern hemisphere, pressures were higher than normal over all but the tropical Southwest Pacific, where they are below average. The associated wind anomalies are not in geostrophic balance with the pressure anomaly field in many areas; over the Indian Ocean this may be attributed to low data density, but over Australia the data from CLIMAT messages was considered dense enough for adequate analysis. Over the Southwest Pacific, the anomaly fields are in better balance.

The pattern of easterly wind anomalies across Indonesia and southwest wind anomalies over Indochina show that the monsoon flow is weaker than normal. The broad belt of westerlies over the equatorial Northwest Pacific indicate a more pronounced and northward NET in the northern hemisphere than in the mean. In conjunction with the large area of cyclonic wind anomaly over the Southwest Pacific corresponding to the more intense southern hemisphere NET, stronger than normal westerly winds prevail along the equator. These anomalous circulation regimes are characteristic of El Nino events.

The northerly wind anomalies south of Japan may suggest that northeast surges were displaced further east than normal, but these anomalies do not extend from higher latitudes. The southwest wind anomalies over Indochina, and examination of daily analyses, indicate that such surges were much less frequent than usual.

200 hPa FLOW

The mean 200 hPa streamline and wind anomaly charts for December are shown in figs. 8 and 9.

The most significant features were the anticyclonic wind anomalies along about latitude 25° in both hemispheres west of the dateline. This equator-straddling anomaly pattern is characteristic of periods of negative SOI (Arkin, 1982), and the extent of the pattern suggests that negative SOI will show some temporal persistence.

Stronger than normal easterlies along the equator east of Papua-New Guinea were associated with the poleward displacement of the upper subtropical ridge in both hemispheres. These easterlies overlaying westerly anomalies at low levels along the equator imply that a weaker than normal Walker circulation is operating.

The equatorial symmetry of the anomaly pattern persists west of 120°E, where a pair of cyclonic anomalies reflect anomalous troughing in the westerlies along 90°E in both hemispheres.

VELOCITY POTENTIAL AND DIVERGENT WIND

Charts for the 950 hPa and 200 hPa velocity potential and divergent wind for December are shown in figs. 10, 11, 12 and 13.

The major areas of tropical convection implied by these charts lie within about 5 degrees of the equator and east of the Philippines. This represents the expected southward migration of convection since November. These represent the expected southward migration of convection since November. Daily satpix revealed that over the Northwest Pacific the convection pattern was rather variable: convection was confined mostly north or south of the equator as often as it covered both areas. The branches of ascent of the mean Hadley cell were centred west of Java and east of PNG. This latter branch is displaced some 15 to 35 degrees eastward of its climatological position over equatorial Indonesia.

The 200 hPa pattern shows upper convergence over Australia, consistent with the positive pressure anomalies over the continent.

WIND CROSS-SECTIONS

Cross-sections of zonal wind along 100°E, 130°E and 160°E are shown in figs. 14, 15 and 16, while the equatorial cross-section of meridional wind is shown in fig. 17.

The equatorial cross-section shows the most marked change from November, with the transition from low-level southerlies and upper northerlies to low-level northerlies and upper southerlies occurring east of 100° E, as the monsoon migrated into the summer hemisphere.

SUMMARY

In December it became much more clear cut that a moderate El Nino event was occurring. If this is the case, it is the first time in the 105 year record of the SOI that such an episode has begun in the austral spring-summer. SST anomalies, MSLP anomalies, tropical cyclone activity and the lower and upper atmospheric anomalies all support the El Nino hypothesis. It is very probable that rainfall over Northern Australia will be below average this wet season, as will tropical cyclone frequency.

CORRIGENDUM

In the Darwin Diagnostic Statement for November 1986 (Vol. 5, No. 11), the Tahiti mean pressure of 1010.1 hPa was erroneously stated as being 1.7 hPa above the long-term mean. This should read "1.7 hPa below the 1882/1985 mean".

REFERENCES

Rasmusson,E.M. and Carpenter,T.H., 1982. Variations in tropical sea surface temperature and surface wind fields associated with the southern oscillation/El Nino. Mon. Weath. Rev., 110, 354-384.

Arkin,P.M., 1982. The relationship between interannual variability in the 200 mb tropical wind field and the southern oscillation. Mon. Weath. Rev., 110, 1393-1404.

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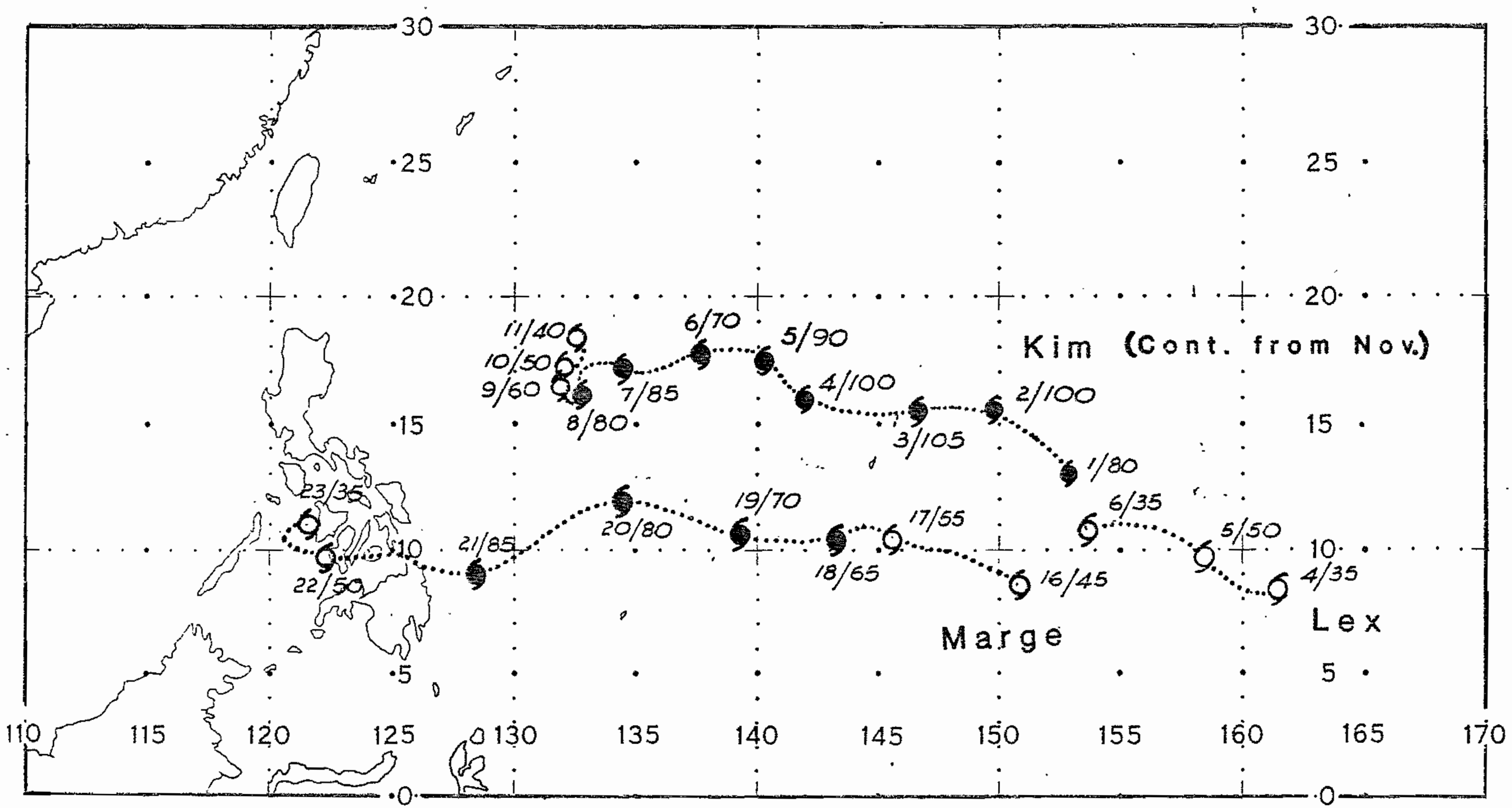

Fig. 1a UNOFFICIAL TRACKS OF CYCLONES KIM, LEX AND MARGE FOR DECEMBER 1986
Date (DD) and maximum sustained wind (ff) in knots denoted by DD/ff.

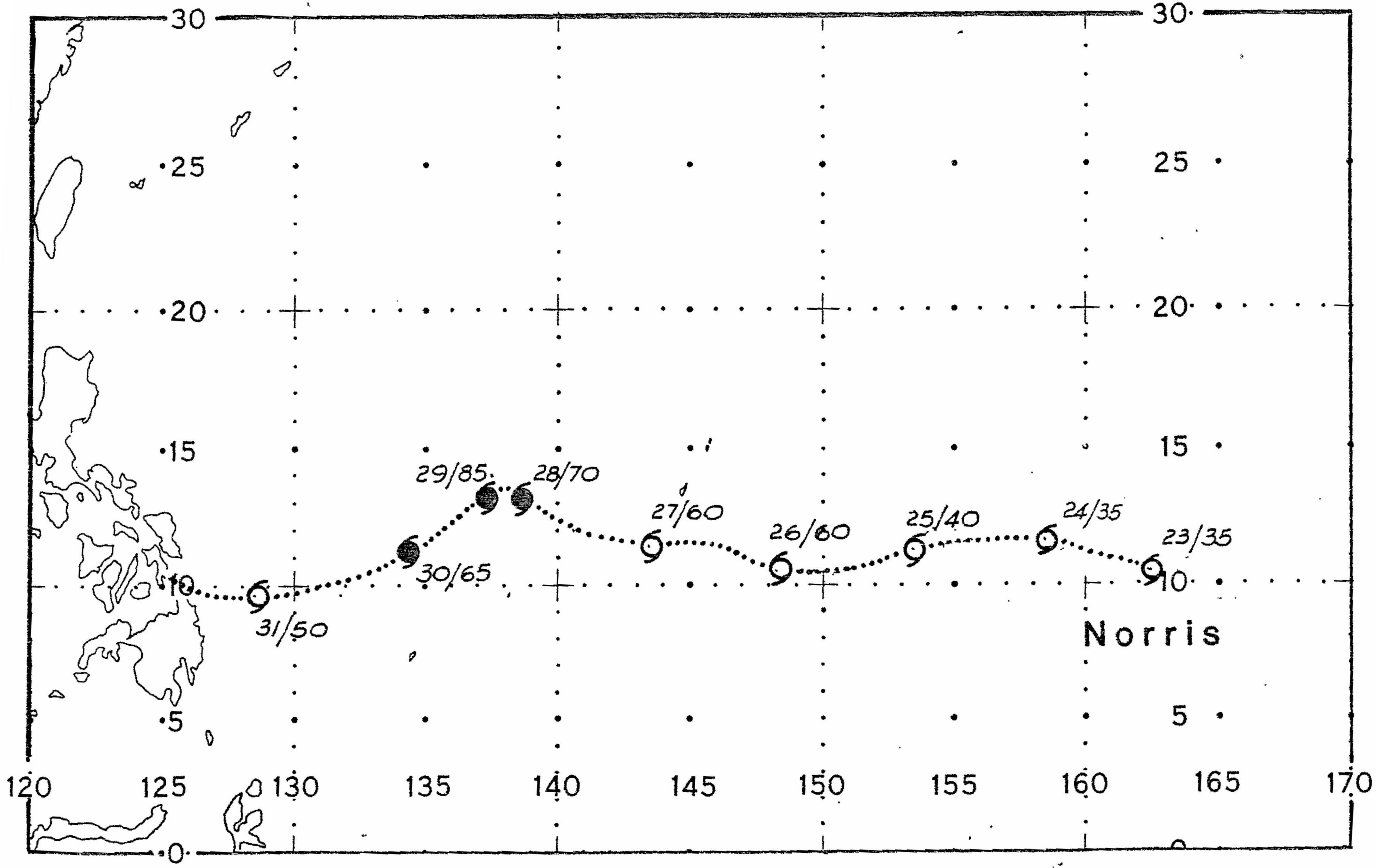

Fig. 1b UNOFFICIAL TRACK OF CYCLONE NORRIS FOR DECEMBER 1986

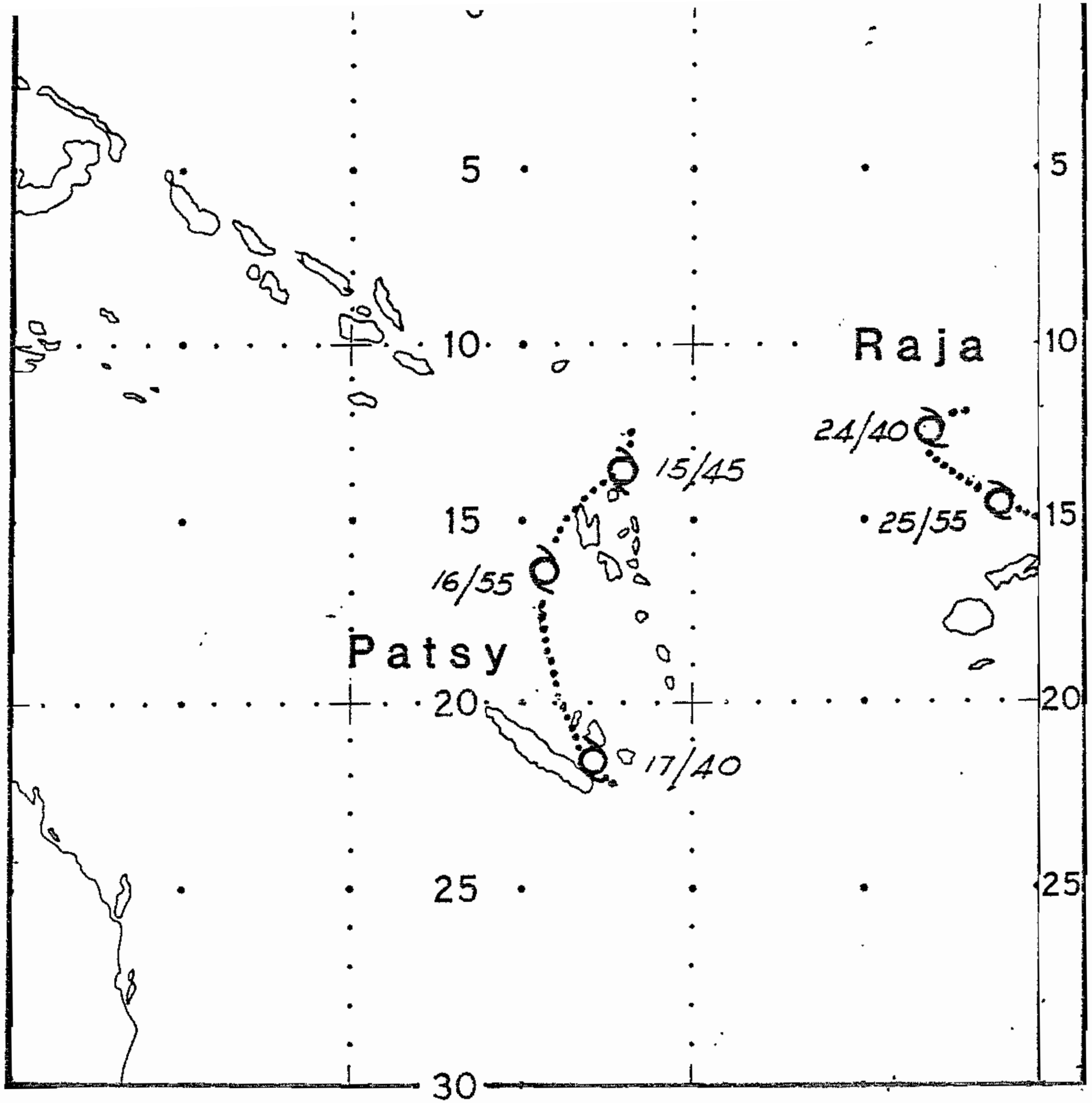

Fig. 1c UNOFFICIAL TRACKS OF CYCLONES PATSY AND RAJA FOR DECEMBER 1986

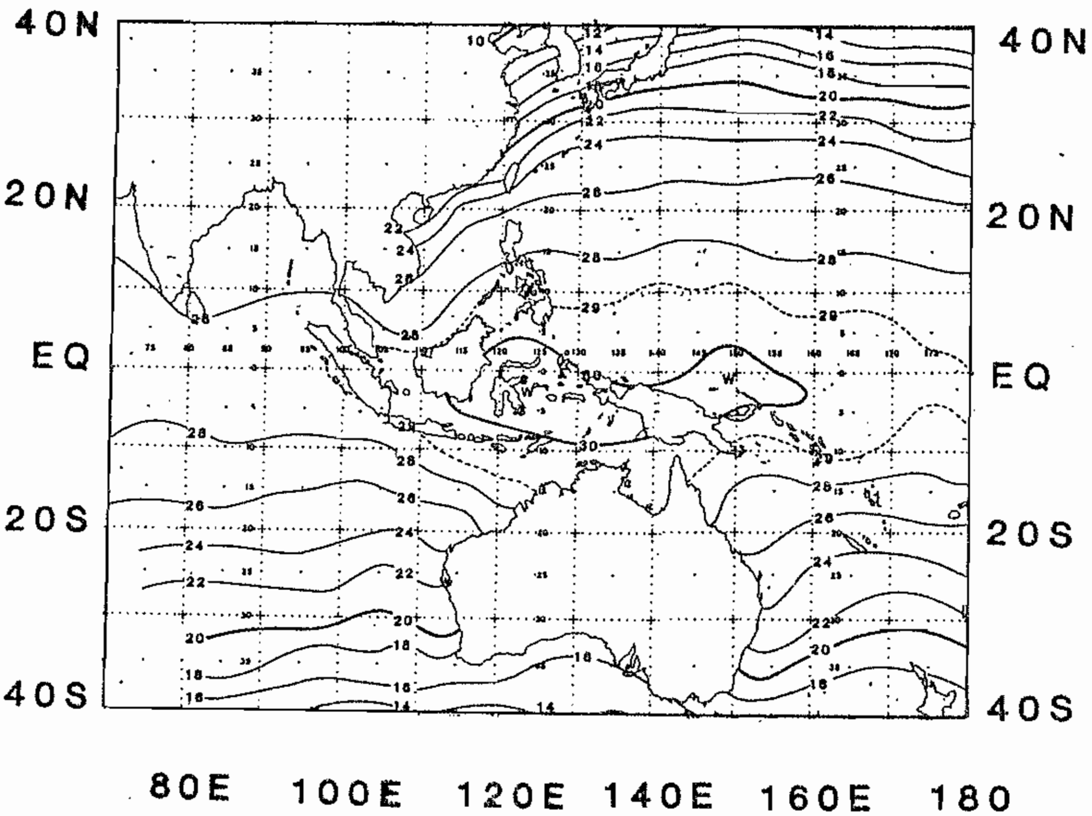

Fig. 2 MEAN SEA SURFACE TEMPERATURES, BASED ON DARWIN RMC ANALYSES AVERAGED OVER THE PERIOD 2nd-4th DECEMBER 1986
Isotherm interval 2 deg C.

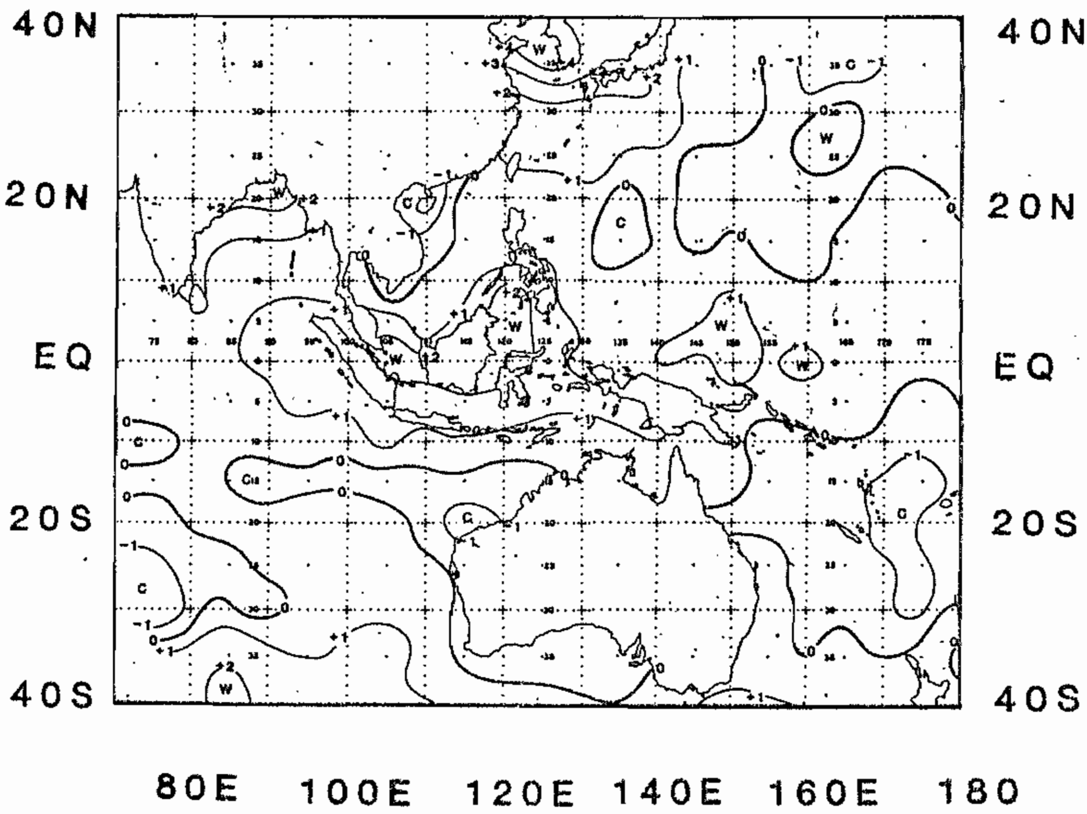

Fig. 3 SST ANOMALY CHART, BASED ON FIG. 2 AND THE CLIMATOLOGY OF REYNOLDS, NOAA REPORT NWS 31, 1983
Isotherm interval 1 deg C.

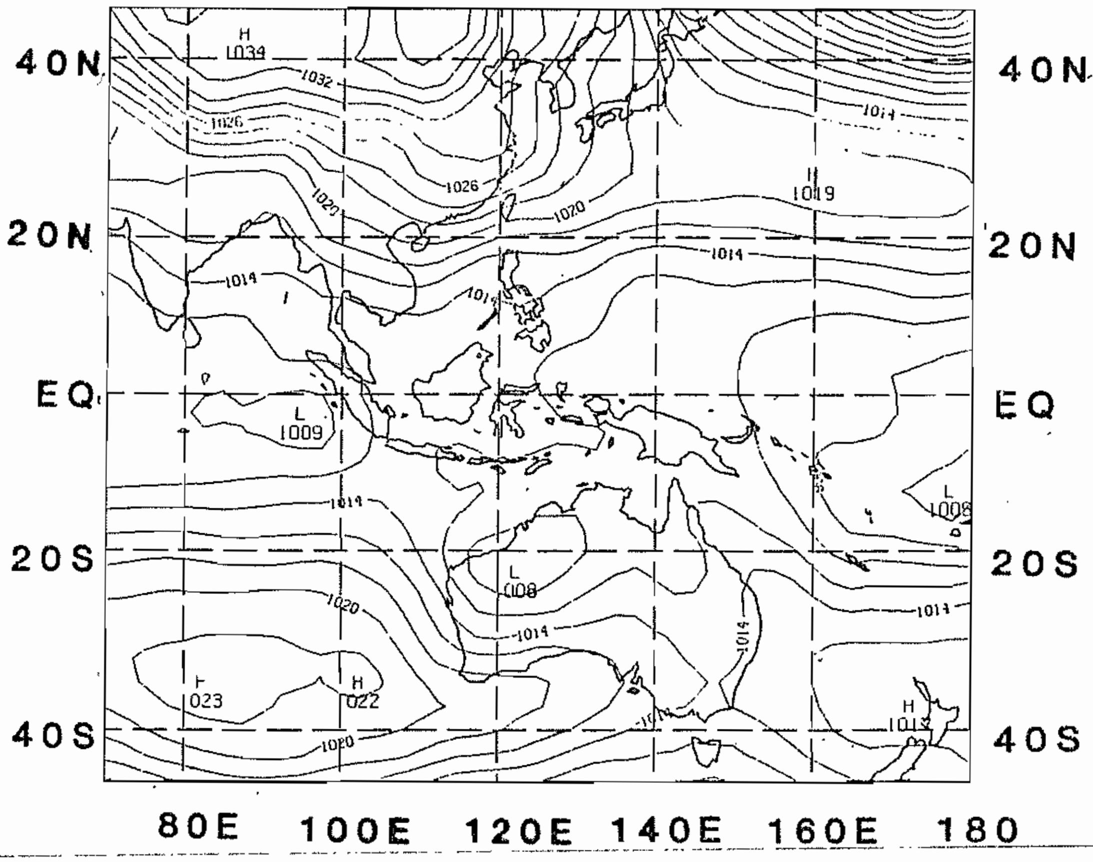

Fig. 4 MONTHLY MEAN MSL PRESSURE, DECEMBER 1986
Isobar interval 2 hPa.

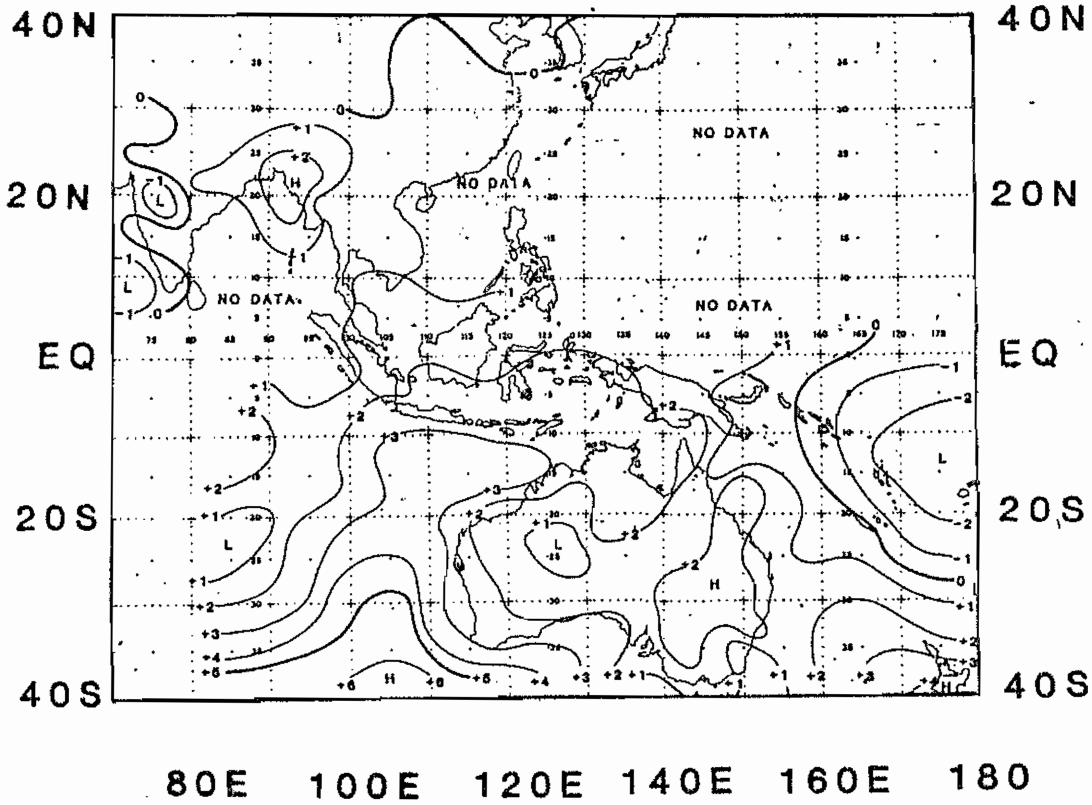

Fig. 5 MSL PRESSURE ANOMALY BASED ON CLIMAT MESSAGES
(AND MELBOURNE WMC DATA SOUTH OF 10 S)
Contour interval 1 hPa.

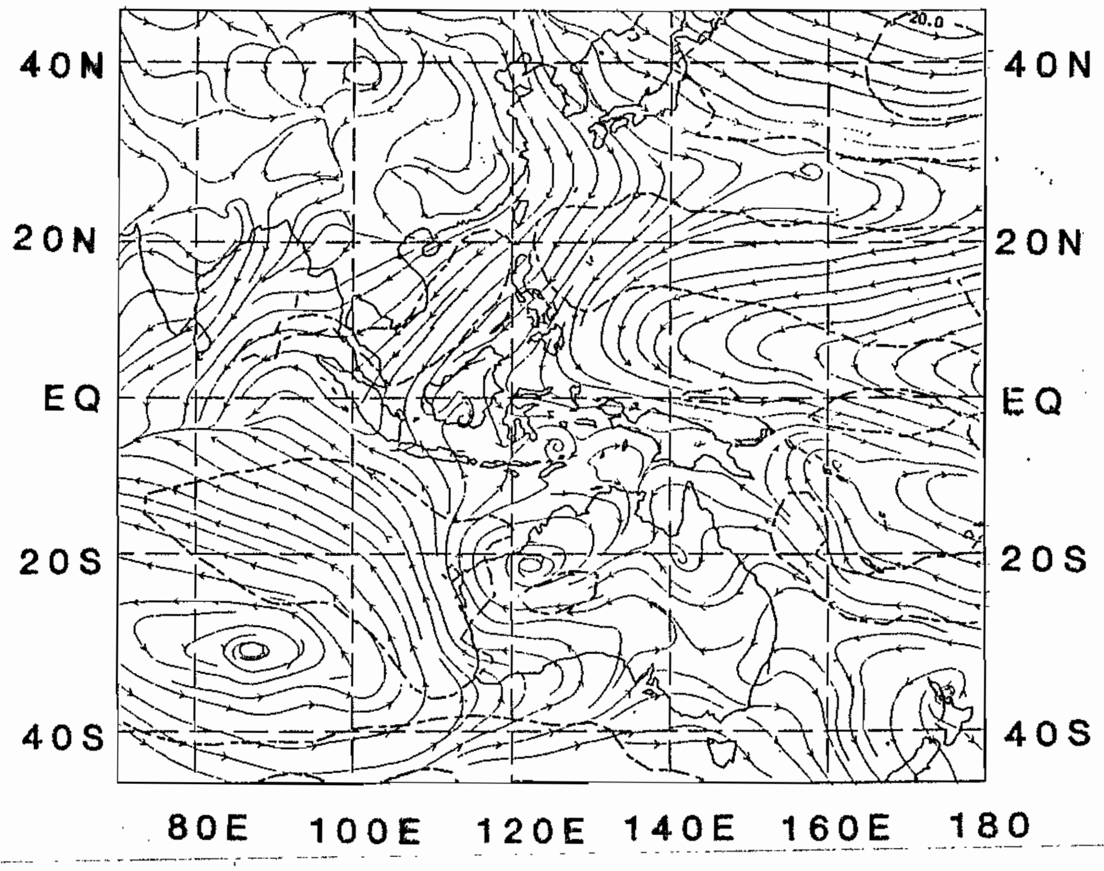

Fig. 6 950 hPa STREAMLINE ANALYSIS, DECEMBER 1986
Isotachs (dashed line) at 10 knot intervals.

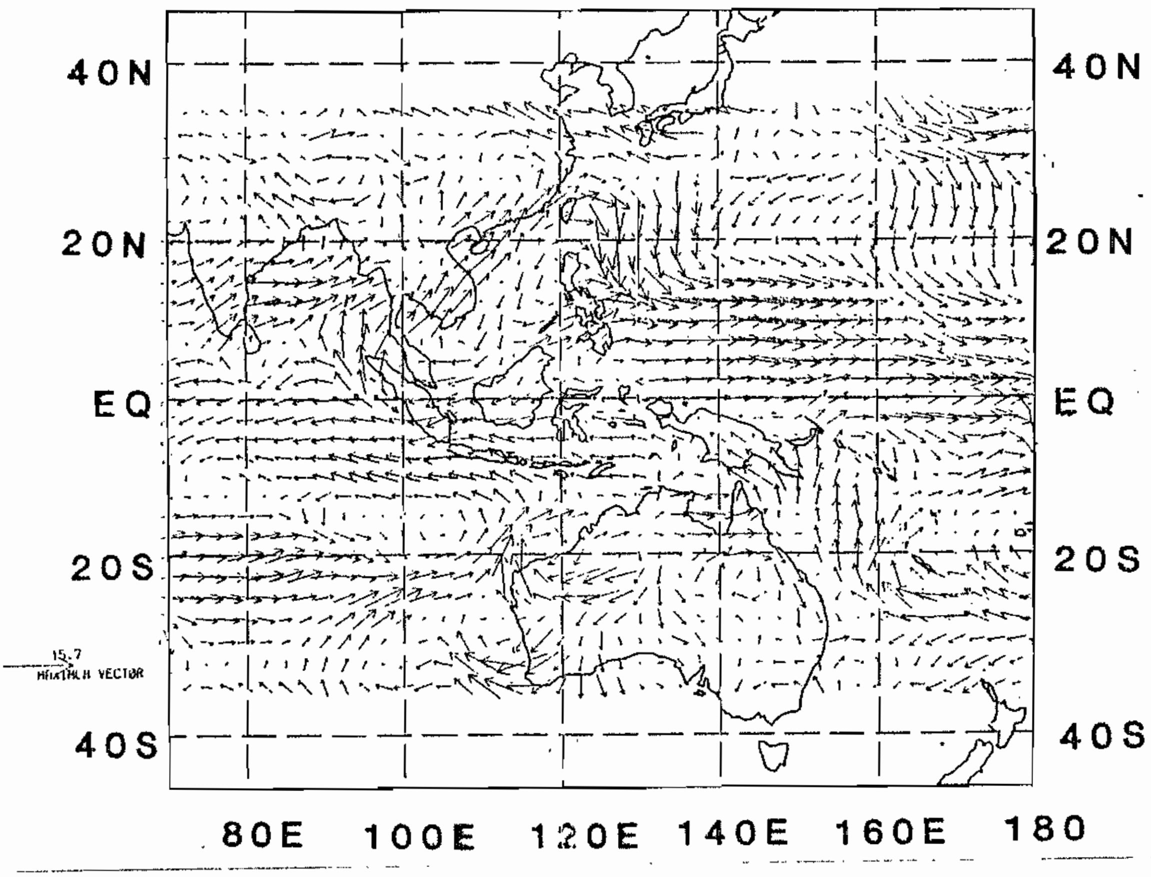

Fig. 7 950 hPa VECTOR WIND ANOMALY BASED ON FIG. 6
(Arrow length indicates magnitude).

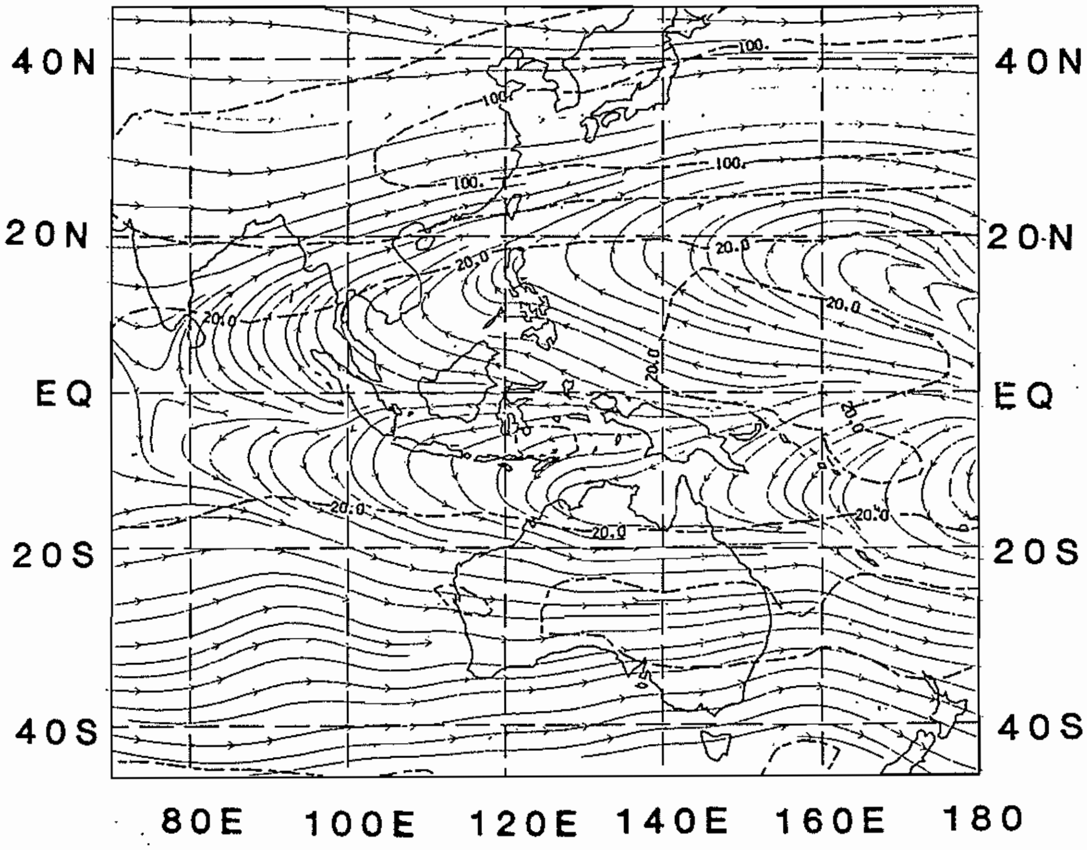

Fig. 8   200 hPa STREAMLINE ANALYSIS, DECEMBER 1986
Isotachs (dashed line) at 40 knot intervals.

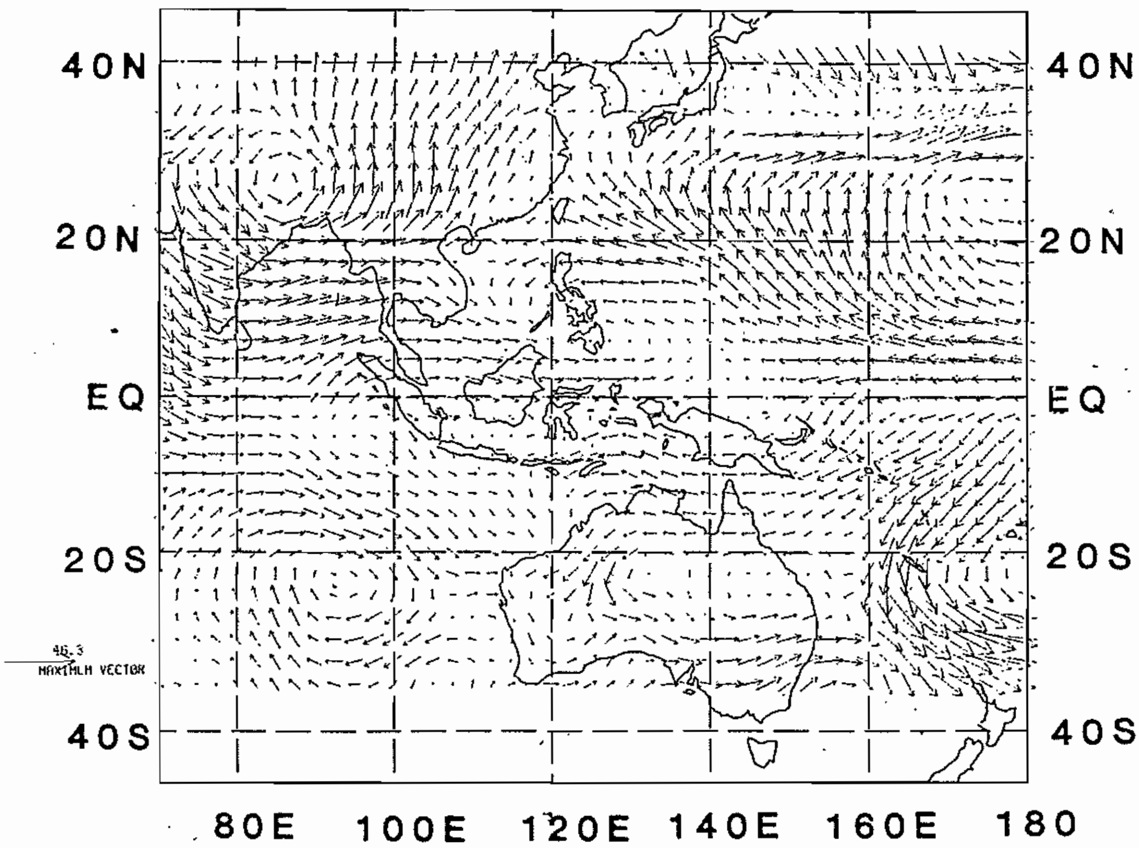

Fig. 9   200 hPa VECTOR WIND ANOMALY BASED ON FIG. 8
(Arrow length indicates magnitude).

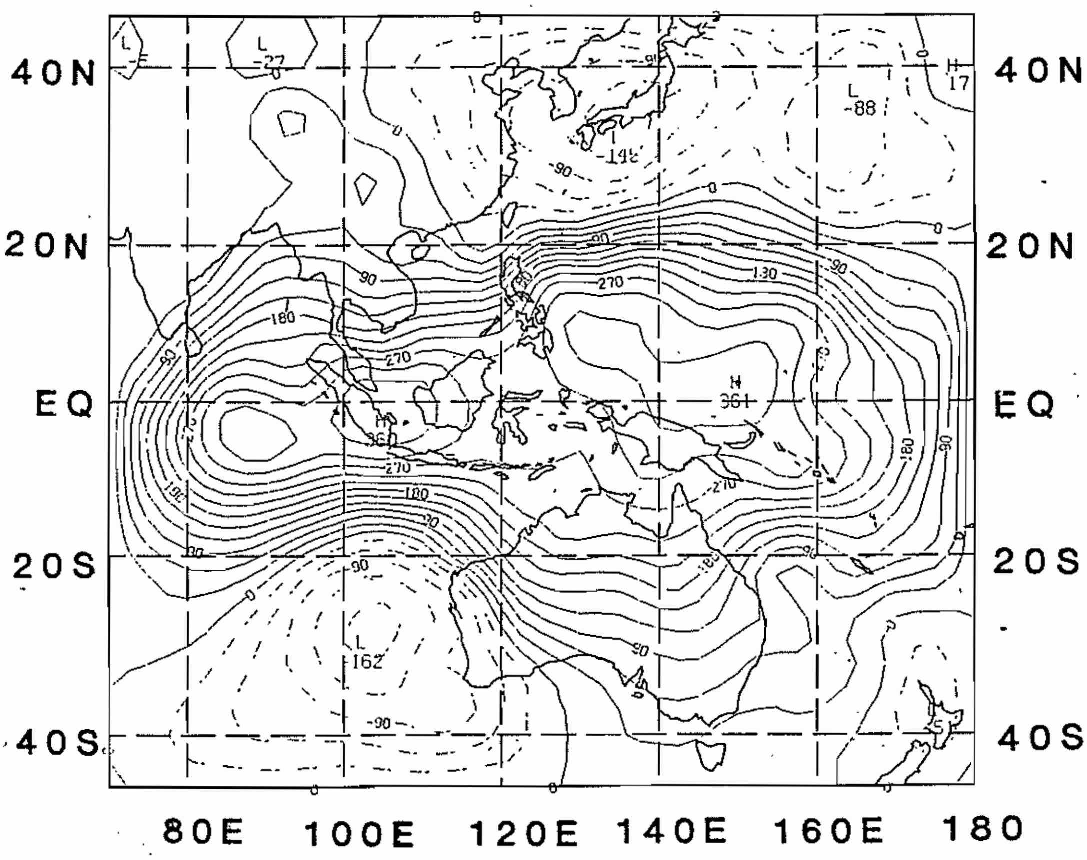

Fig. 10 950 hPa VELOCITY POTENTIAL, DECEMBER 1986
Contour interval 50 x 10^5 m^2 /s

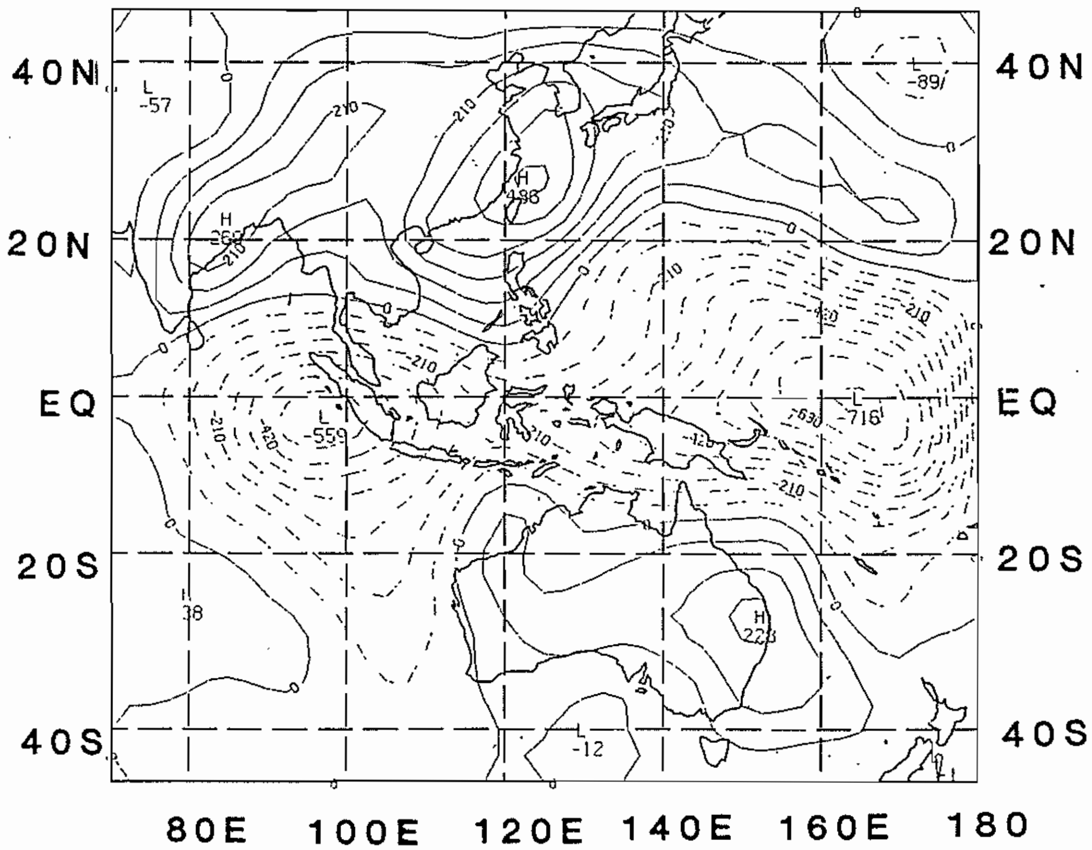

Fig. 11 200 hPa VELOCITY POTENTIAL, DECEMBER 1986
Contour interval 7 x 10^5 m^2 /s

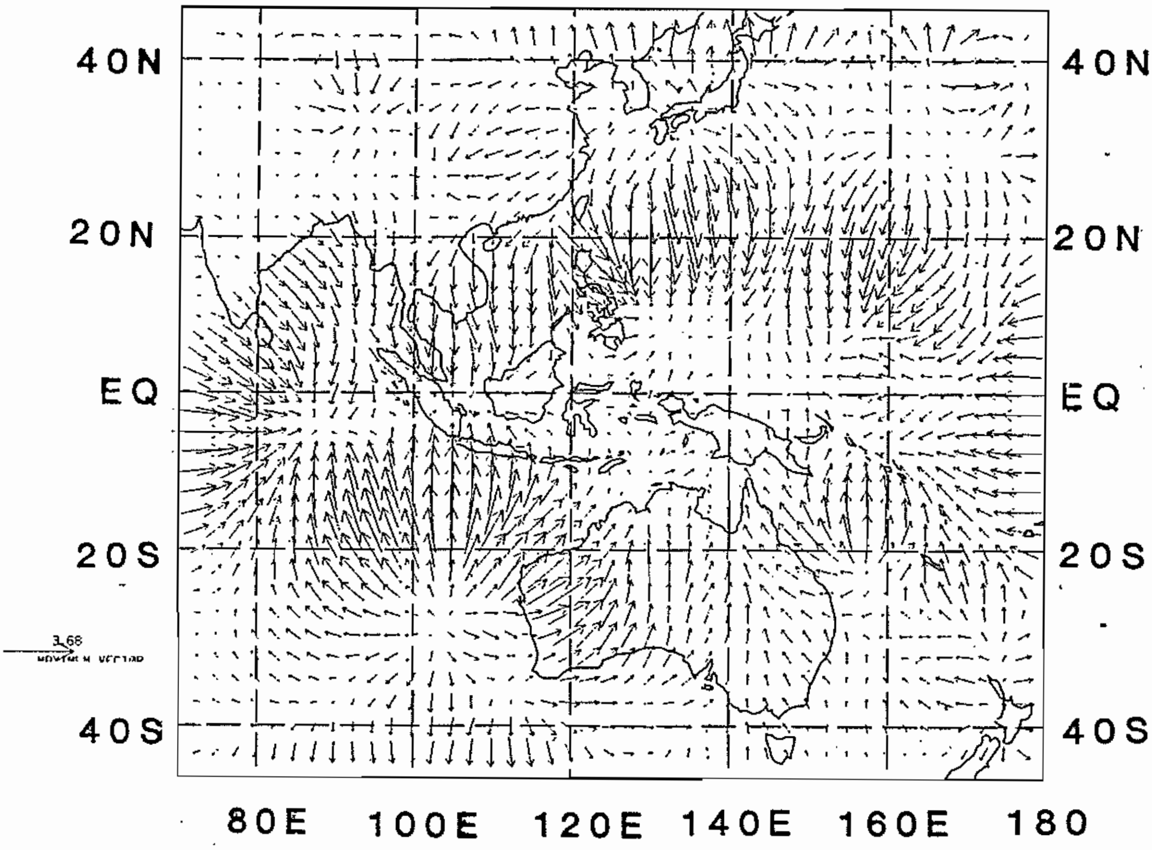

Fig. 12   950 hPa DIVERGENT WIND, DECEMBER 1986
(Arrow length indicates magnitude).

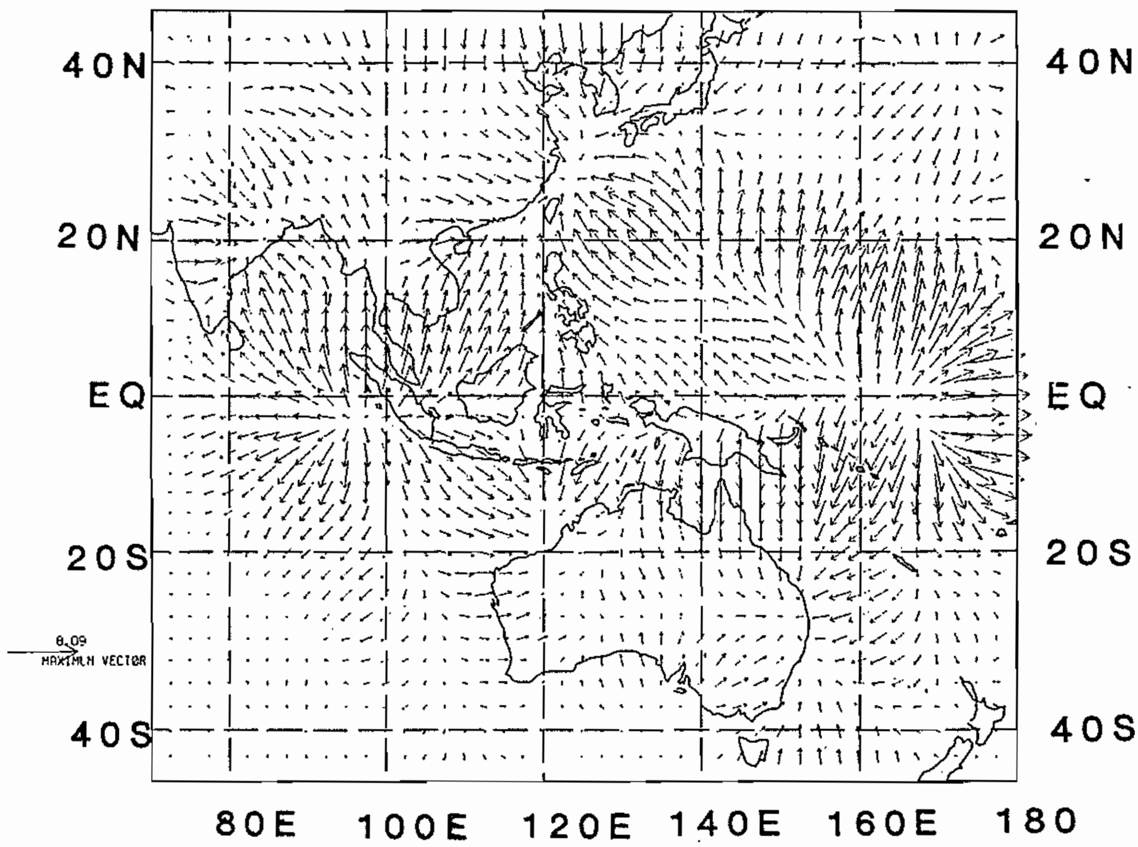

Fig. 13   200 hPa DIVERGENT WIND, DECEMBER 1986
(Arrow length indicates magnitude).

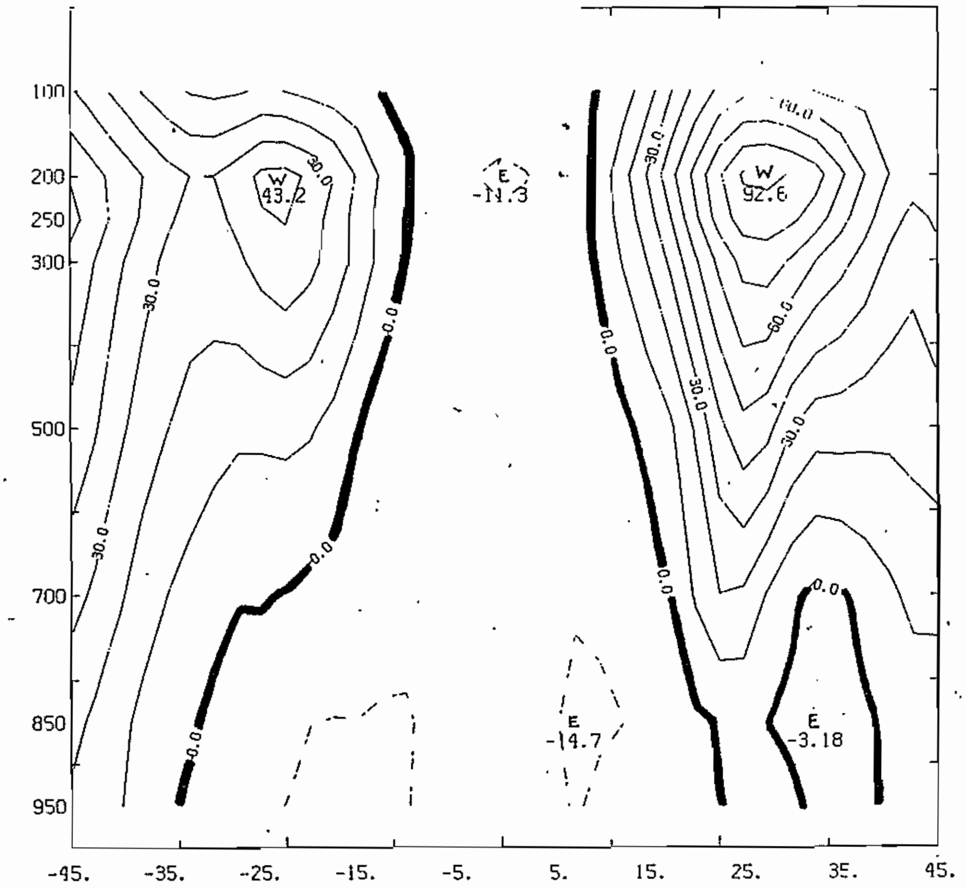

Fig. 14 CROSS-SECTION OF ZONAL WIND ALONG 100 E, DEC 1986
Isotach interval 10 knots.

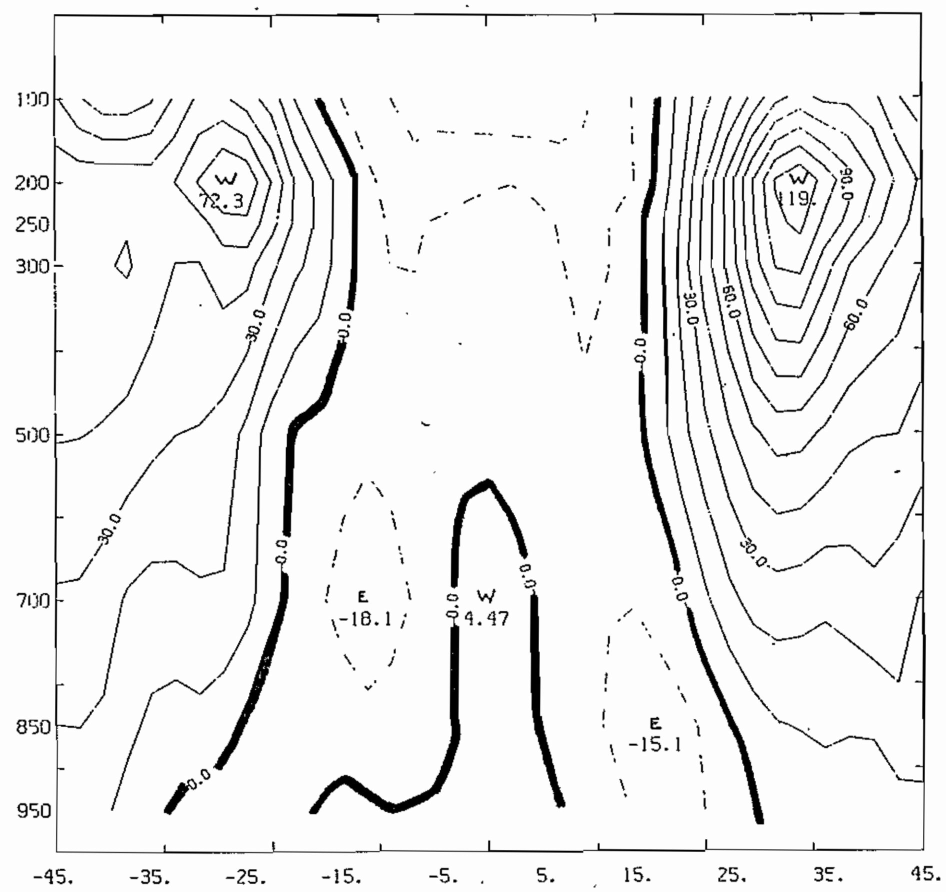

Fig. 15 CROSS-SECTION OF ZONAL WIND ALONG 130 E, DEC 1986
Isotach interval 10 knots.

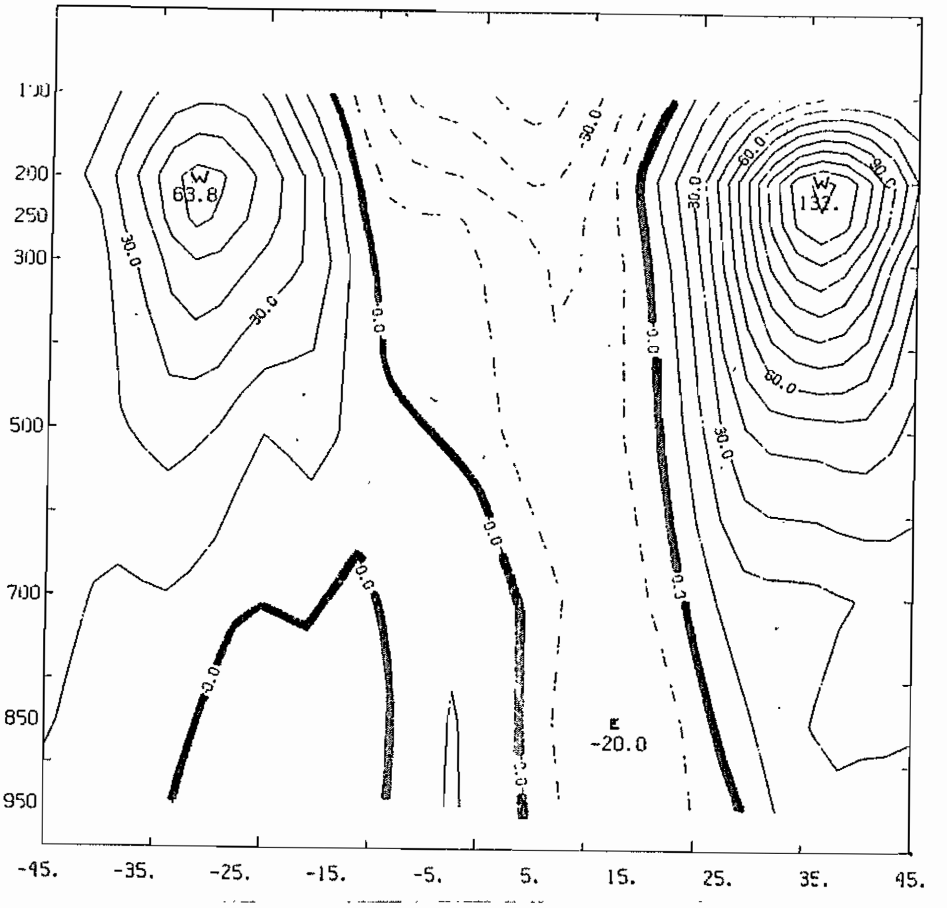

Fig. 16 CROSS-SECTION OF ZONAL WIND ALONG 160 E, DEC 1986
Isotach interval 10 knots.

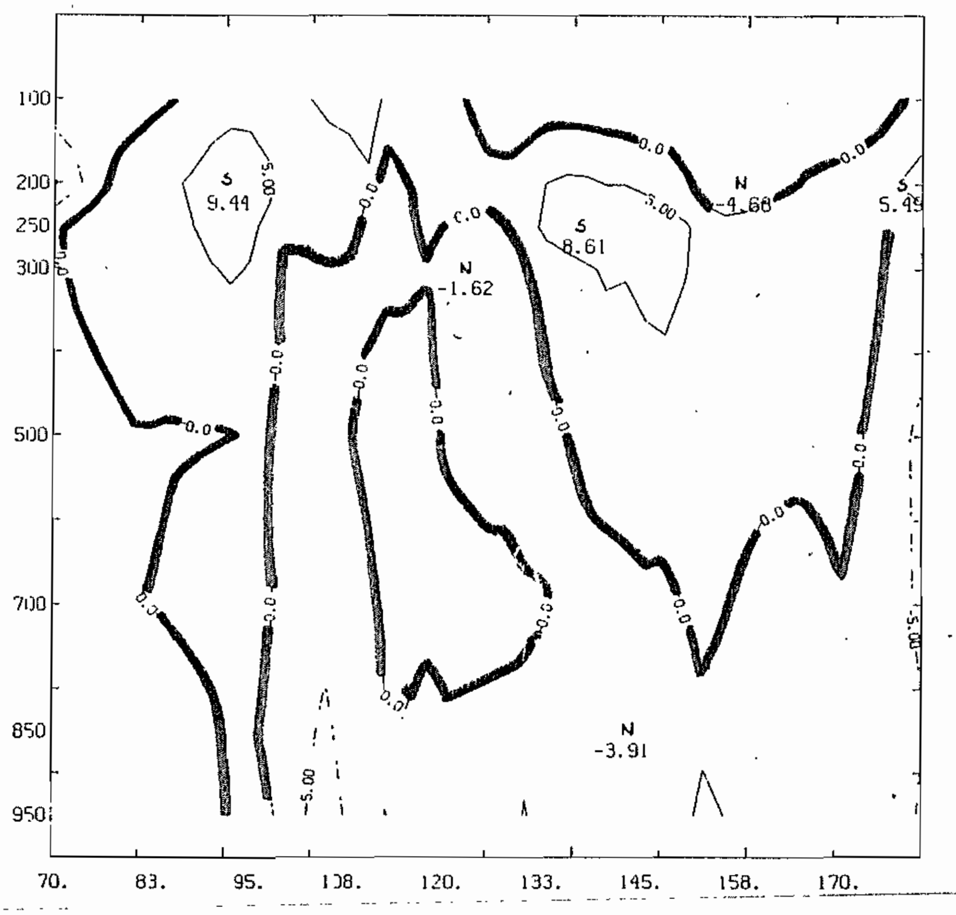

Fig. 17 EQUATORIAL CROSS-SECTION OF MERIDIONAL WIND
BETWEEN 70E AND 180E, DEC 1986. 5 knot isotachs.

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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

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