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DARWIN TROPICAL DIAGNOSTIC STATEMENT

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DARWIN TROPICAL DIAGNOSTIC STATEMENT

JANUARY 1986

ISSUED BY DARWIN RMC

14 FEBRUARY 1986

INDICES

The Darwin mean MSL pressure for January was 1004.7 mb, which was 1.6 mb below the 1938/83 average. Tahiti's mean MSL pressure was 1010.8 mb, equal to the 1938/83 average. These give Troups Southern Oscillation Index as +8, with a five month running mean, centred on November, of +1.

TROPICAL CYCLONES

Six tropical cyclones were named in the Southern Hemisphere during January: all formed in the monsoon trough. (Unoffical tracks are shown in figures 1 (a) - 1 (c)). Ophelia, Pancho and Vernon were marginal cyclones. Delfinina was a hurricane force system. Although gale force winds were associated with Hector, this system appeared to be an intense monsoonal depression rather than a warm-cored cyclone. Winifred developed at the end of the month, making landfall on February 1; it caused extensive damage along the coast of Northern Queensland.

No cyclones formed in the Northern Hemisphere. The average number of cyclones for January in the NW Pacific is 0.5 (JTWC statistics 1959-1984), and in the Australian region between 105E and 165E the average number is 3.9 (Bureau of Meteorology statistics 1959/1980). Thus cyclone activity for the month was close to average.

SEA SURFACE TEMPERATURES

Mean Sea Surface temperature (SST) and SST anomaly charts, averaged over the middle two weeks of January are shown in figures 2 and 3.

The most significant change from December SST anomalies was the appearance of an area of cool anomaly along 110E in Australian latitudes and to the south of Java. The cool anomaly corresponds in position with a southerly 950 mb wind anomaly which has been present near 110E since November, and which continues into January. The cool centre near 30S corresponds with a stronger cool centre in December, while the cool centre south of Java corresponds to the maximum of the southerly 950 mb wind anomaly in December.

The warmer than average temperatures in the vicinity of the Bay of Bengal have been evident since August. A warm anomaly near 10N 140E in December has weakened slightly in January. An examination of satellite photographs indicates relatively clear skies in the region during the first half of January. Stronger than average 950 mb winds are evident over the region in both December and January and may be the cause of the cooling.

MSL PRESSURE AND 950 mb STREAMLINES

The mean monthly MSL pressure and anomaly charts are shown in figures 4 and 5. The mean monthly 950 mb streamline and anomaly charts are shown in figures 6 and 7. The indraft near the equator south of the Bay of Bengal shown on the 950 mb chart is due to deficiencies in the automated tropical analysis scheme in regions of sparse observations. Low confidence is placed in the anomaly charts over the Indian Ocean, also due to lack of observations.

The most notable features of the low level flow in the tropics were the strong northerly wind anomalies in the South China Sea and immediately east of the Philippines, with decreased northeasterly flow east of 150E, and weaker than average easterly flow over the Bay of Bengal. Also, stronger than average westerly flow and corresponding negative pressure anomalies were evident over northern Australia. The northeasterly trades in the South China Sea were strong throughout the month, with gale force winds being reported at times during the first two weeks. During that period a significant proportion of the flow was diverted into persistent tropical lows in the southwest of the Bay of Bengal, including into a tropical depression which almost reached tropical cyclone strength.

Pressures over northern Australia fell markedly in the middle of the month, producing the negative MSL pressure anomalies apparent in figure 5, as the monsoon trough moved south and intensified. During this period a greater proportion of the northeast trades was diverted eastward into Australian longitudes. The position of the monsoon trough over Northern Australia corresponded well with its mean January position, but further to the east it was less well defined, producing an easterly 950 mb streamline anomaly east of New Guinea. The wind cross sections shown in figures 17 and 18 illustrate this further. Stronger than average low and middle level monsoon westerlies are evident at 130E while at 160E they are altogether absent.

At higher latitudes MSL pressure and 950 mb wind anomalies were small in the northern hemisphere, while in the southern hemisphere a significant negative pressure anomaly is evident in the Tasman Sea. This was due to the formation of cutoff lows in a blocking pattern several times during the month. The anticyclone to the south of Australia was stronger and further east than the climatological mean, producing stronger northeasterlies over the west of the continent. These caused enhancement of the Western Australian heat trough, and warmer than average temperatures in Western Australia, while the south eastern states experienced lower than average temperatures.

An examination of GMS photographs for January shows that the areas of persistent tropical convective activity correspond well with the regions of low level convergence depicted by the divergent component of the 950 mb wind (figure 14).

500mb FLOW

The mean 500 mb streamline analysis and geopotential height anomaly charts are shown in figs. 8 and 9. The long wave trough over Japan can be seen to be a little stronger than normal. In the south, the major midlatitude trough was located over the Tasman Sea, and the height anomalies show that this was stronger than normal. This was in fact the cyclonic portion of a higher latitude blocking ridge, and a number of fronts and cutoff lows sheared or amplified into the Tasman Sea area during the month. This trough extended back into the monsoon shear line and a broad cyclonic circulation west of Darwin. On daily analyses the location of this trough was quite variable in position, and the mean analysis has been somewhat biased by the influence of Hector during the month.

200 mb FLOW

The mean 200 mb streamline analysis is shown in fig. 10 and the vector wind anomaly chart is fig. 11. The outflow over Northern Australia, and the Indian Ocean subtropical ridge are further south than normal. Climatologically, the outflow is centred near Honiara, but this January it was displaced westward to Cape York Peninsula. This contributed to the general inactivity of the monsoon trough in the Southwest Pacific. The centre of action of the outflow was thus concentrated over Northern Australian longitudes, with a stronger than normal cross-equatorial current into the Northern Hemisphere. This strong return flow was a common feature of daily analyses, so that the upper pattern was always favourable for enhanced weather over the Indo-Australian area. As mentioned earlier, the low level flow was also favourably arranged for an active monsoon. The principal control on "bursts" of the monsoon was therefore the location of the middle level monsoon trough, which for much of the month was not vertically stacked over the surface trough. (The mean 500 mb streamlines show that in Australian longitudes, the 500mb shear line was located 5 to 10 degrees north of the surface trough).

The anomaly chart shows that the subtropical jet through China and Japan was stronger than normal, consistent with the deeper 500 mb longwave trough over the Sea of Japan and stronger northeast surges at 950 mb.

Over the Australian region the trough along the east coast was much more pronounced than normal (as at 500 mb). Intrusions of this trough into Darwin latitudes caused a number of TUTT-like features during the month. The westerlies over the continent were stronger than normal, presumably due to the increased baroclinicity between the monsoon trough and the stronger subtropical ridge referred to in the MSLP anomalies.

The 200mb divergent wind chart (fig. 15) shows that the major area of mass outflow extends from Sumatra to the Arafura Sea. In conjunction with the 950mb divergent wind chart (fig. 14), the dominant upward branch of the mean Hadley circulation was centred just west of Sumatra, with a broad secondary area of ascent over the Arafura Sea. The centre of subsidence of the Hadley cell lies over the Sea of Japan. In the Southern Hemisphere, the descending part of the Hadley cell is located in the southern part of the Eastern Indian Ocean.

Over the equatorial Southwest Pacific, the zonal branches of the Walker circulation are clearly seen. A companion zonal circulation can be seen operating in the opposite sense over the equatorial Indian Ocean west of 90E.

THE NORTH AUSTRALIAN MONSOON

The first active monsoon event of the Australian wet season occurred during the last half of January. Throughout the month, scattered thunderstorms persisted in the monsoonal westerlies north of 10S across Indonesian and Australian longitudes. This area of enhanced weather moved southward over Northern Australia for about two weeks. The January rainfall for Darwin was 660mm, (261mm above average). The time series of Darwin 24h rainfall is shown in fig. 20. The single large rainfall on the 12th was due to a shortlived monsoon depression, but the monsoon trough at middle levels remained to the north of Darwin, as may be seen from the time series of the 700mb zonal wind component shown in fig. 22. This figure clearly shows that the increase in rainfall coincided with the middle level flow reversal from easterly to westerly, commencing with the genesis of Hector on the 18th.

Interestingly, this genesis event did not appear to follow the usual pattern of low level westerly forcing following Northern Hemisphere cold surges through the South China Sea (as discussed by Love 1985). Such surges normally cause an increase in pressure in the Borneo area which accelerates the down-pressure-gradient westerlies through the Indo-Australian region. The Singapore minus Darwin pressure is a measure of the strength of these monsoonal westerlies. Fig. 21 shows the time series of pressure at both Darwin and Singapore: it can be seen that from the 10th onward, the Singapore pressure remained steady between 1011 and 1012 mb. Nonetheless, the pressure at Darwin fell considerably, tightening the gradient and causing strong westerly winds to develop over the Indonesian area and Northern Australia. Examination of synoptic maps indicates that in spite of a large high traversing the south of Australia on the 16th and 17th, no significant surge in the low southeasterlies of southern origin was discernible over the Australian tropics.

Thus the conclusion is that in this episode, the onset of the monsoon and the genesis of Hector were driven by the upper divergence pattern. The chart of 200mb divergent wind component (fig.15) supports this with considerable mass transport away from the Indo-Australian area, bearing in mind that the chart is a mean for the month rather than for the shorter period of the event. Also the 950mb wind anomaly chart suggests that there is no direct link between the anomalously strong westerlies over the Arafura Sea and the stronger than normal South China Sea flow, as the winds through the Java Sea are near average. Aloft, the 200mb wind anomalies imply that the outflow from the anticyclone over the North of Australia is stronger than in the mean.

The active Australian monsoon is a much more transient feature than than of other monsoon regimes, as evidenced by the return to midlevel easterlies at 700mb toward the end of January. The development of cyclones Vernon and Winifred in the Coral Sea allowed drier continental southeasterlies to extend northwards at middle levels into the Australian tropics, and this pattern has persisted into mid February, suppressing widespread convection compared with the earlier monsoonal burst.

Reference: Love, G., 1985: Cross-Equatorial Interactions during Tropical Cyclogenesis. Mon. Wea. Rev. 113 , 1499-1509.

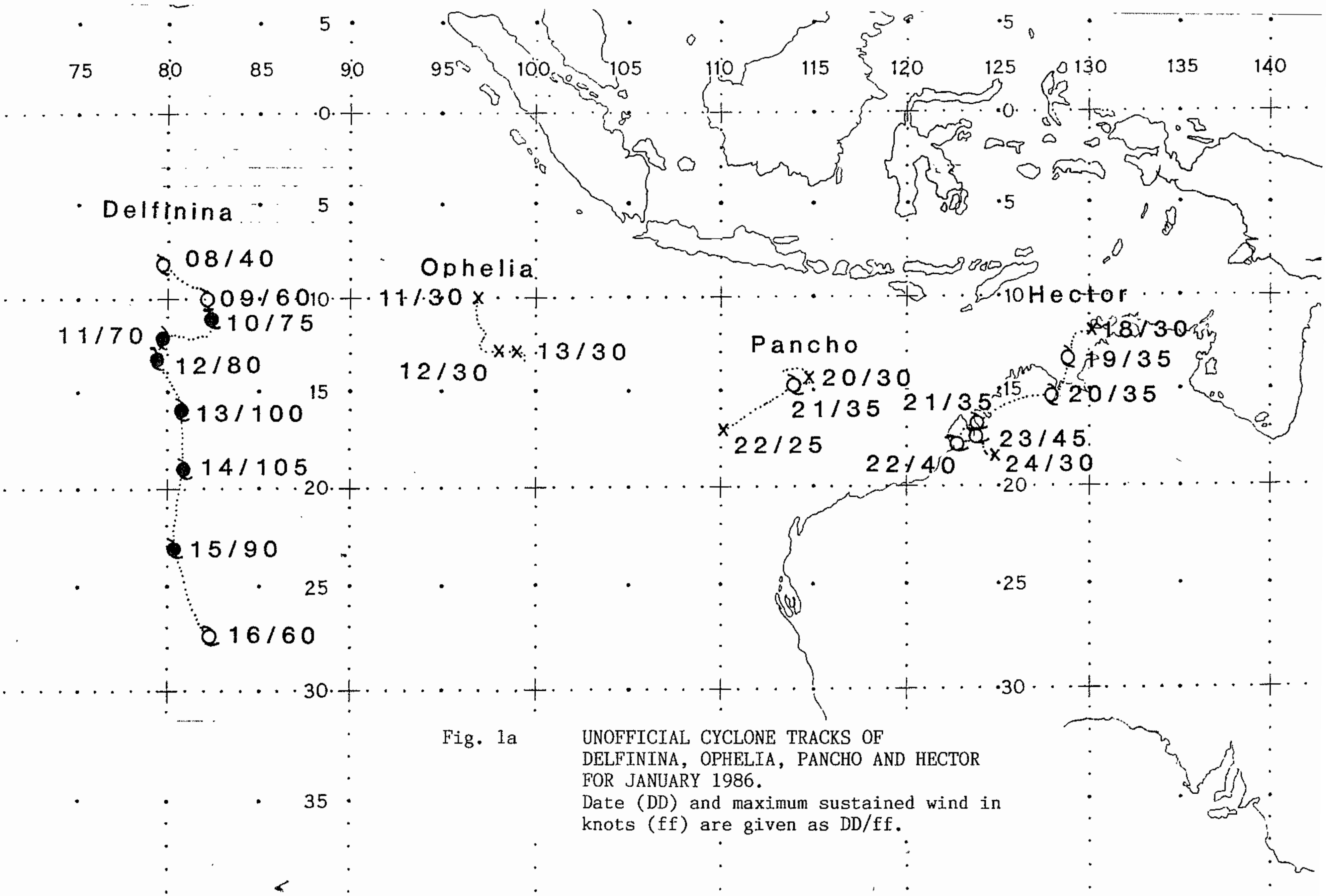

Fig. 1a UNOFFICIAL CYCLONE TRACKS OF DELFININA, OPHELIA, PANCHO AND HECTOR FOR JANUARY 1986.
Date (DD) and maximum sustained wind in knots (ff) are given as DD/ff.

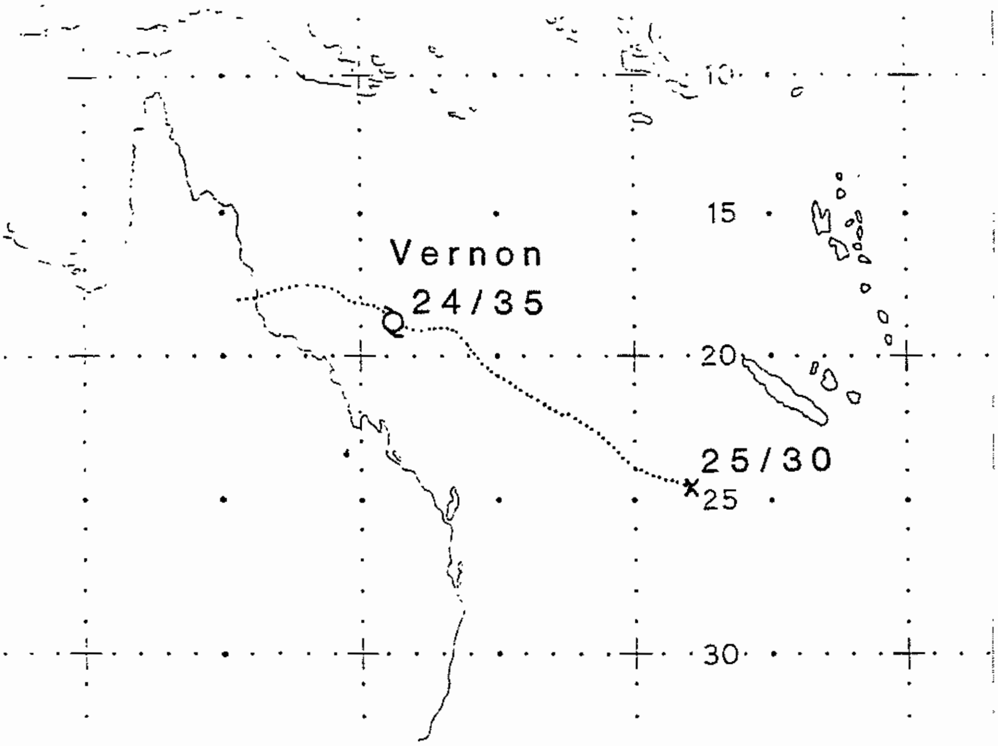

Fig. 1b UNOFFICIAL CYCLONE TRACK OF VERNON FOR JANUARY 1986.
Date (DD) and maximum sustained wind in knots (ff) are given as DD/ff.

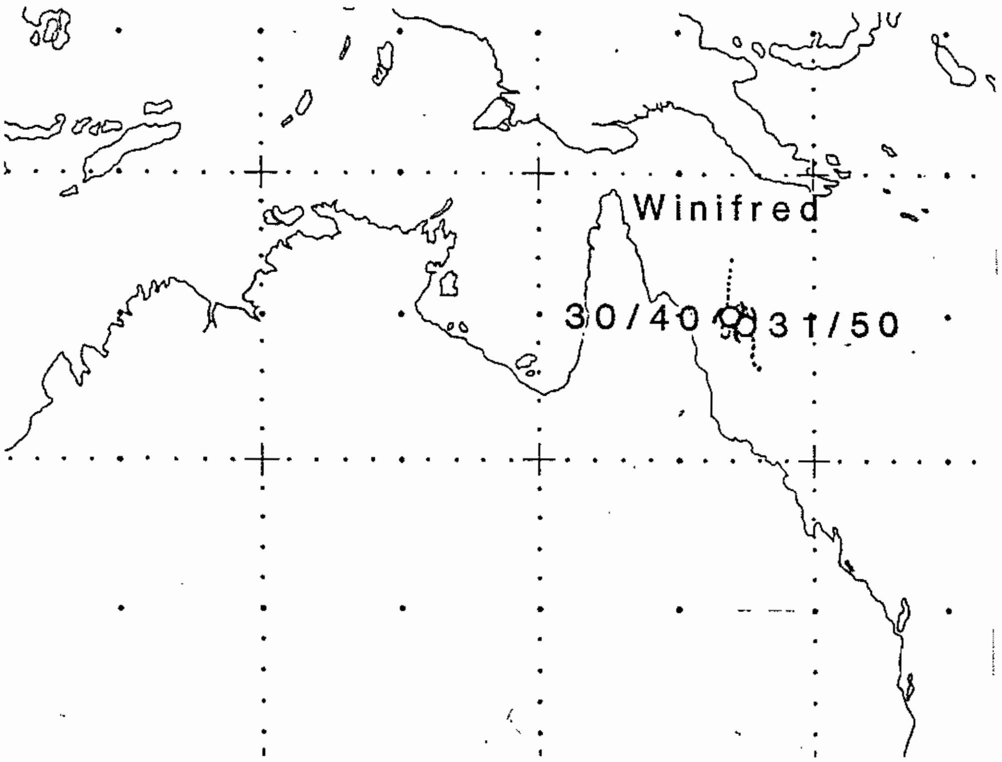

Fig. 1c UNOFFICIAL CYCLONE TRACK OF WINIFRED FOR JANUARY 1986.
Date (DD) and maximum sustained wind in knots (ff) are given as DD/ff.

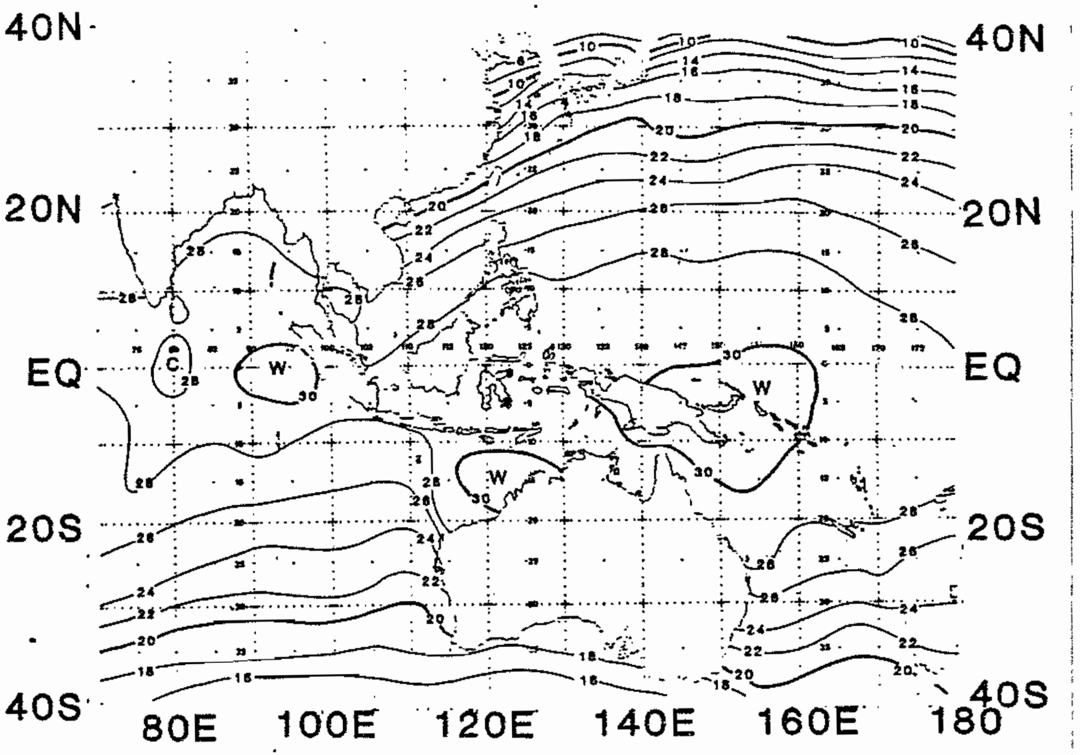

Fig. 2 MEAN SEA SURFACE TEMPERATURES, BASED ON DARWIN RMC ANALYSIS AVERAGED OVER THE MIDDLE 2 WEEKS OF JANUARY 1986. (CONTOUR INTERVAL 2°C).

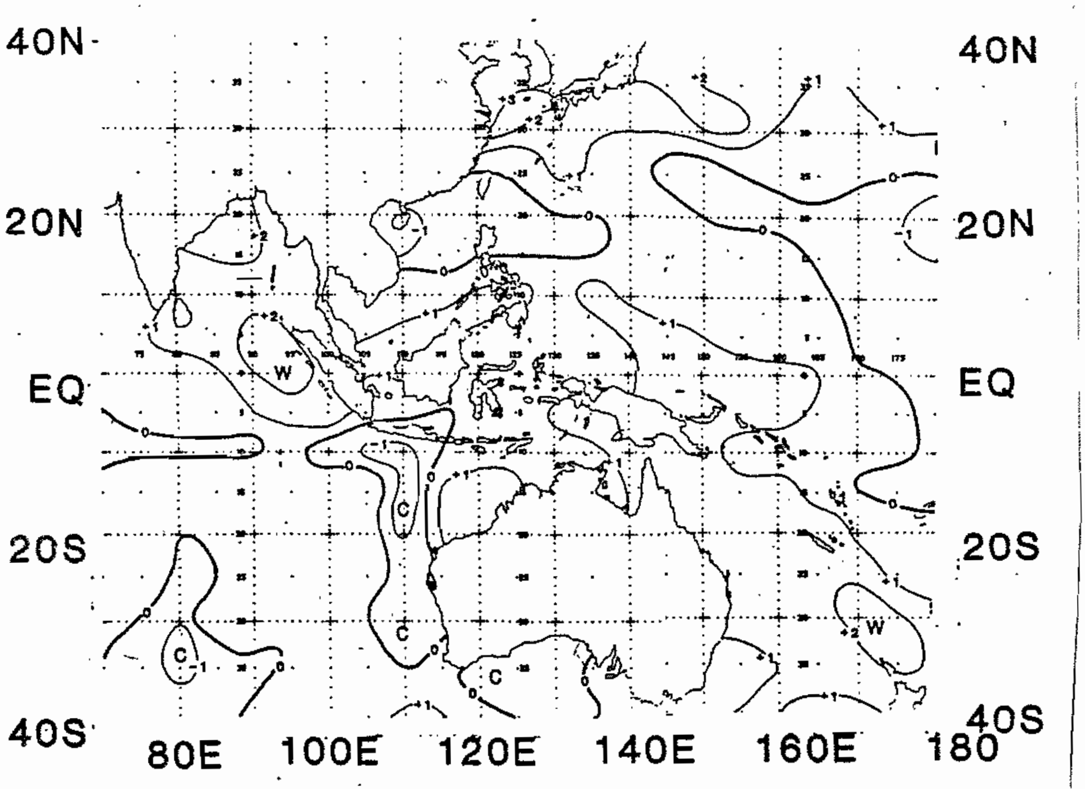

Fig. 3 SST ANOMALY CHART, BASED ON FIG.2 AND THE CLIMATOLOGY OF REYNOLDS, NOAA REPORT NWS 31, 1983. (CONTOUR INTERVAL 1°C).

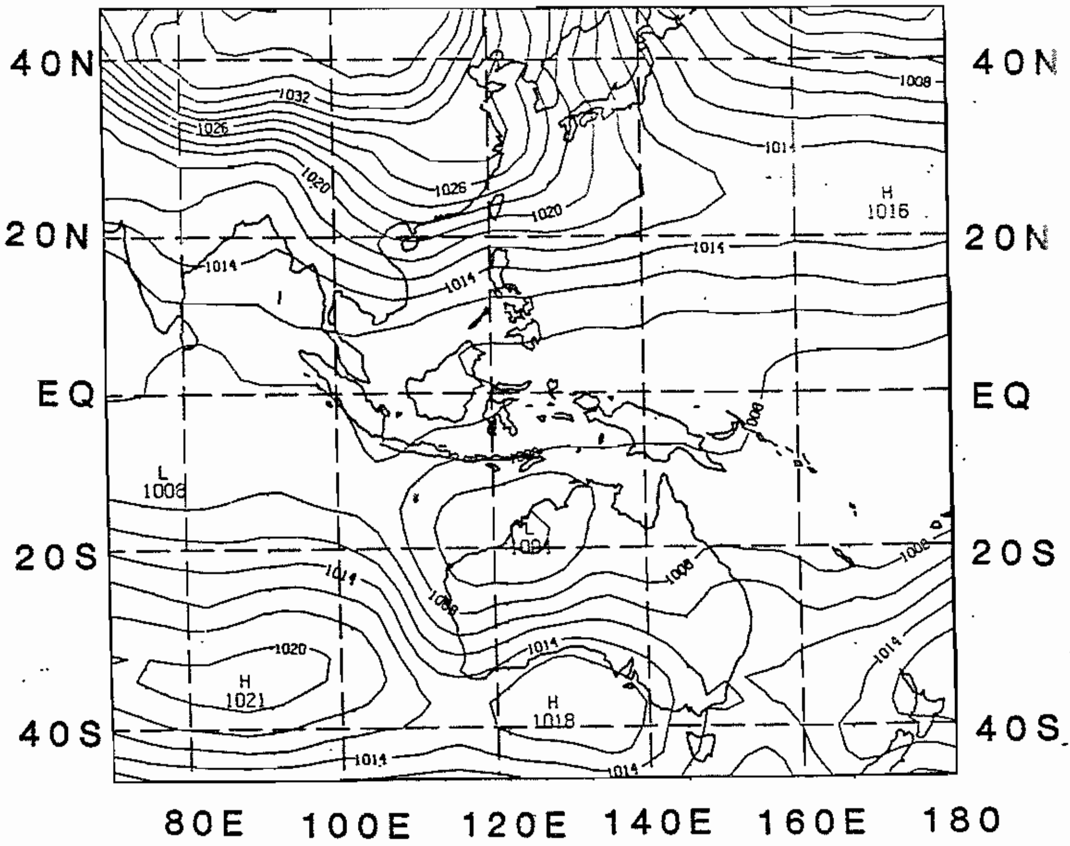

Fig. 4 JANUARY 1986 MONTHLY MEAN MSL PRESSURE
(CONTOUR INTERVAL 2 mb).

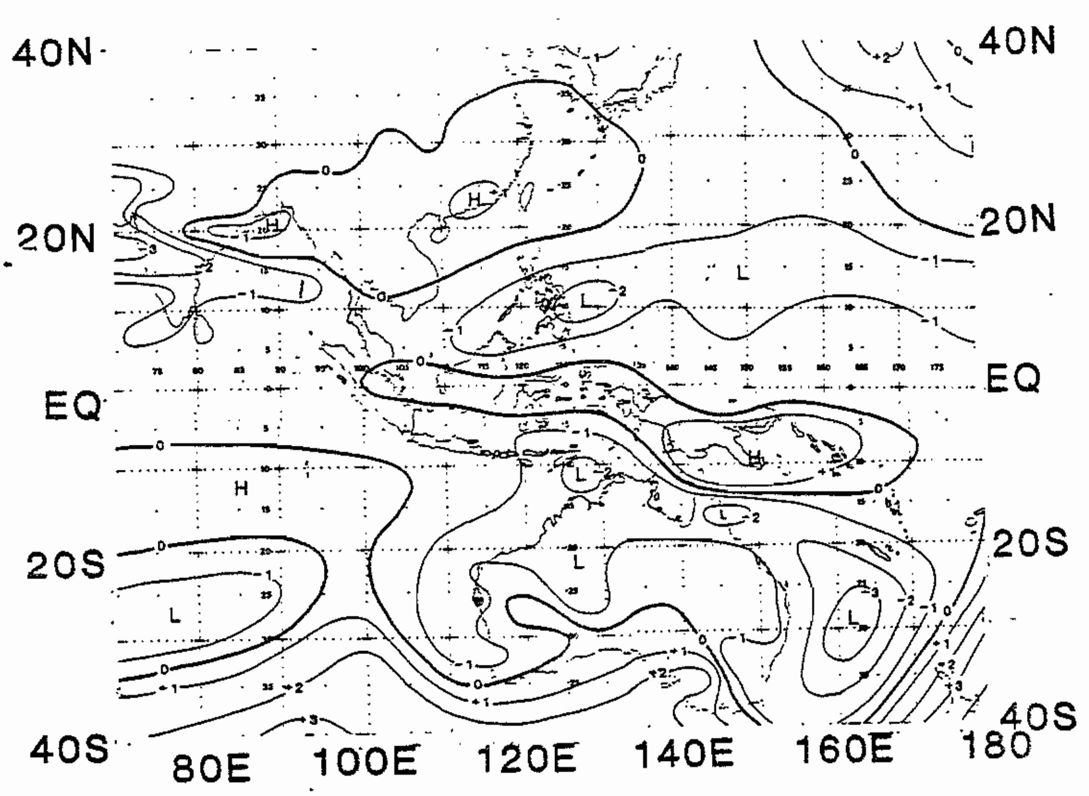

Fig. 5 MSL PRESSURE ANOMALY BASED ON MELBOURNE WMC DATA
SOUTH OF 10° S, ADJUSTED TO FIT CLIMATE MESSAGES WHERE
AVAILABLE. (CONTOUR INTERVALS 1 mb).

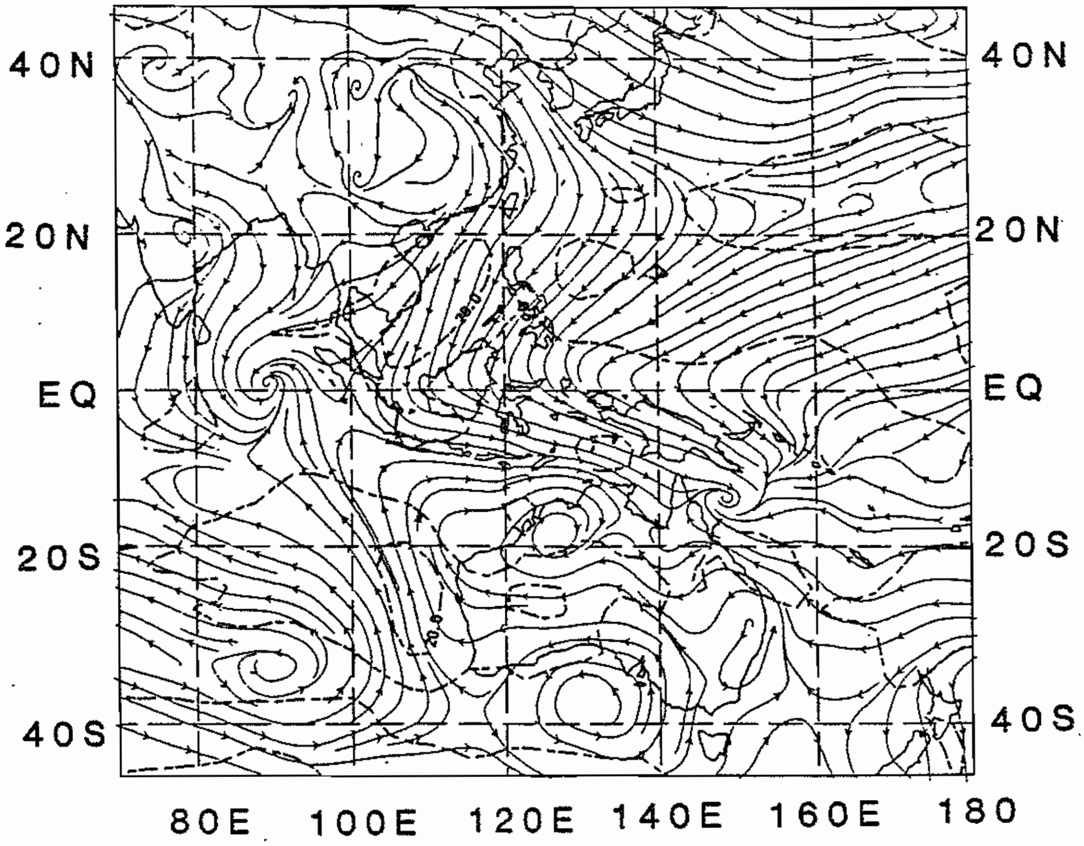

Fig. 6 JANUARY 1986 950 mb STREAMLINE/ISOTACH ANALYSIS. (10 KNOT INTERVAL ISOTACHS DASHED LINE).

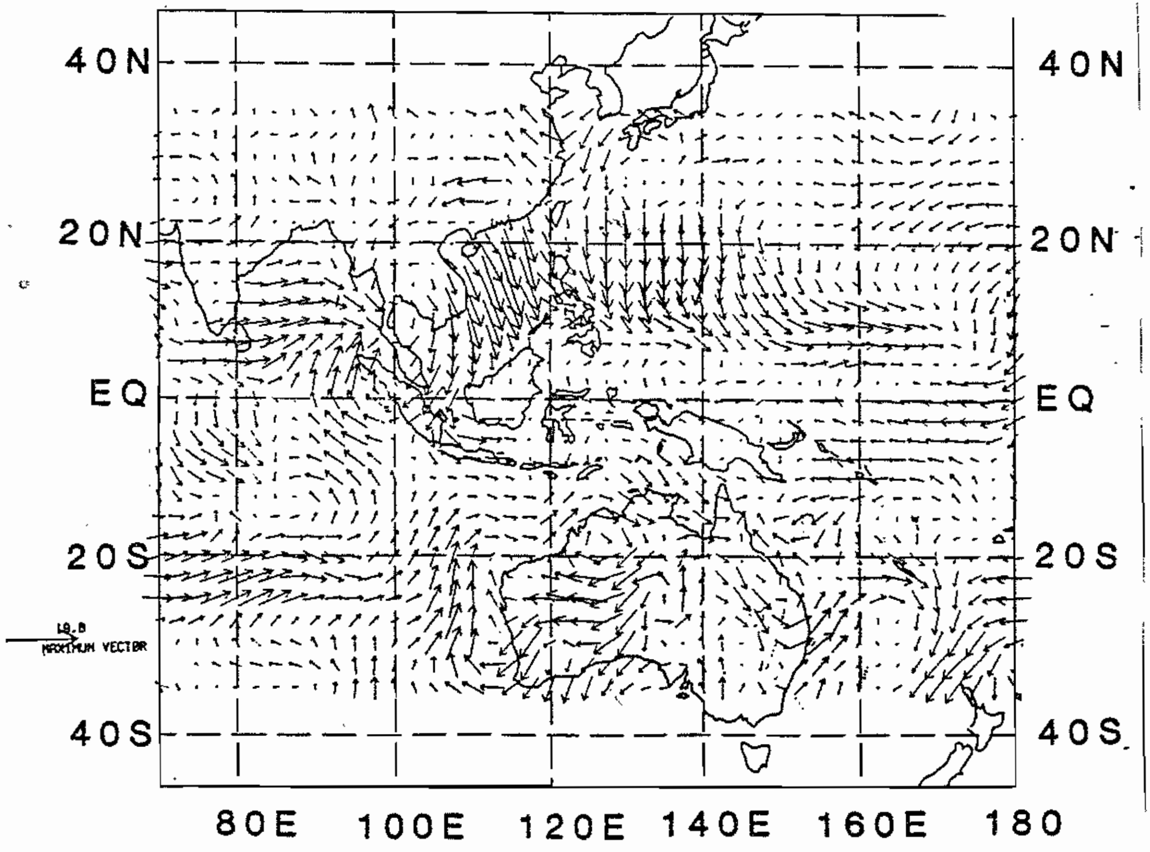

Fig. 7 950 mb VECTOR WIND ANOMALY BASED ON fig. 6 (ARROW LENGTH INDICATES MAGNITUDE).

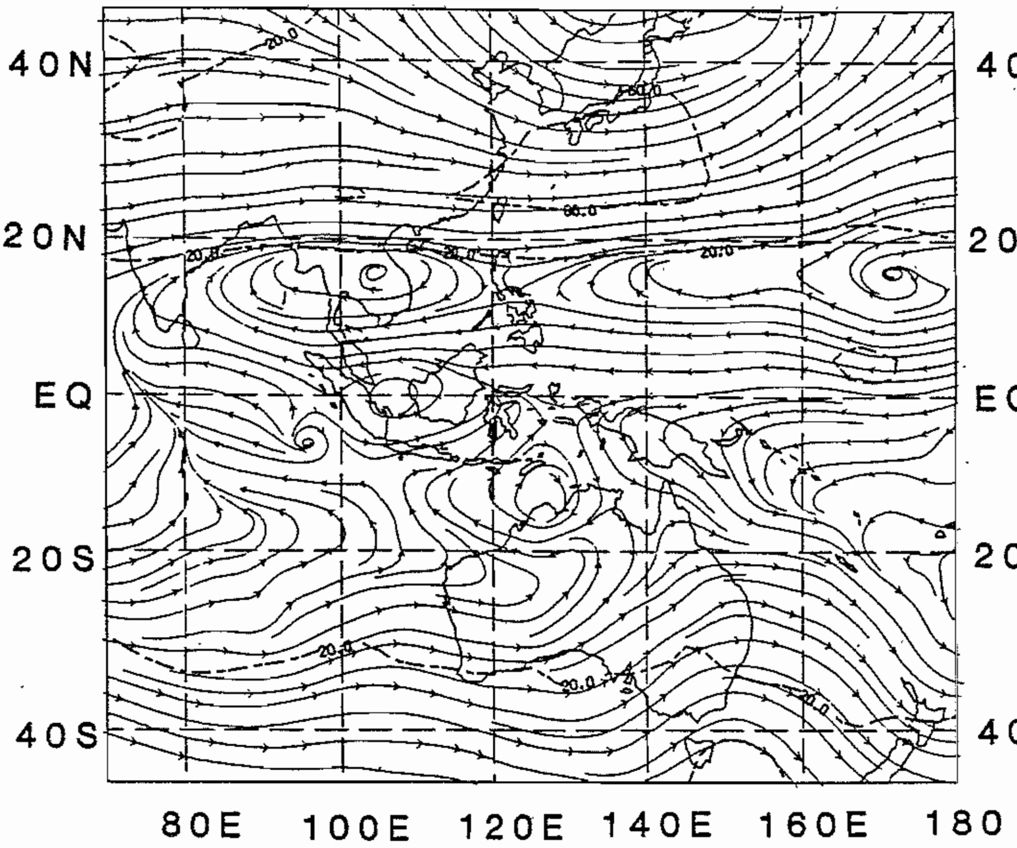

Fig. 8 JANUARY 1986 500 mb STREAMLINE/ISOTACH ANALYSIS.
(10 KNOT INTERVAL ISOTACHS DASHED LINE).

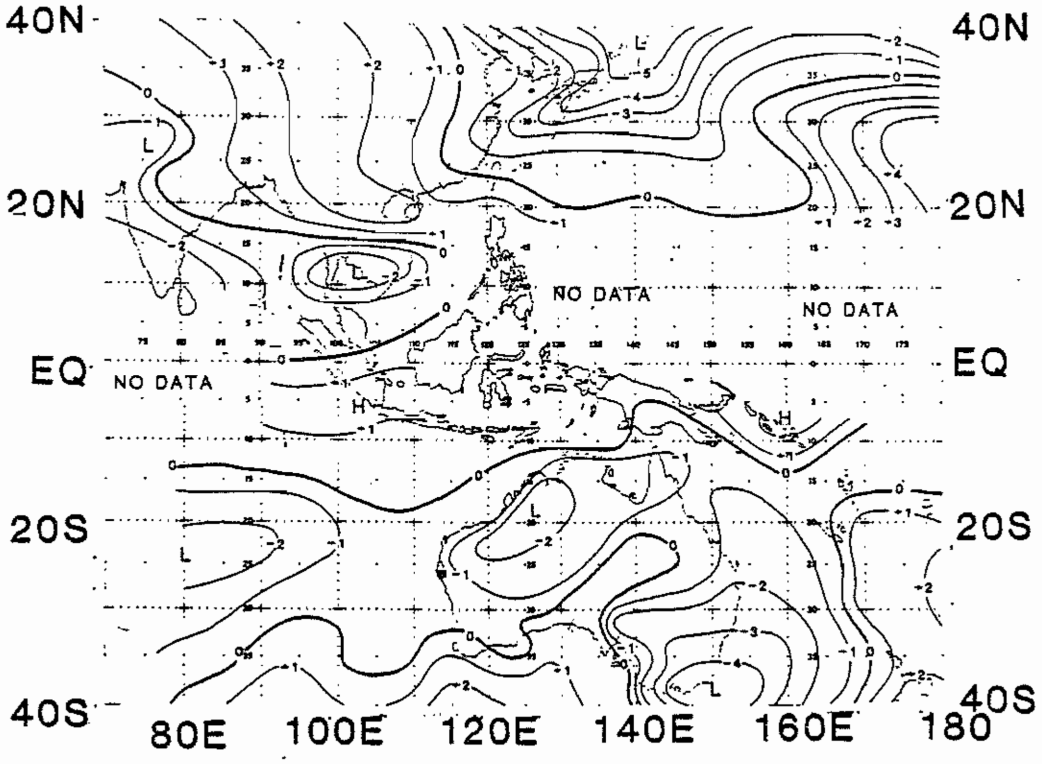

Fig. 9 JANUARY 1986 500 mb GEOPOTENTIAL HEIGHT ANOMALY.
(CONTOUR INTERVAL 1 gpdm)(DATA BASE AS PER FIG. 5).

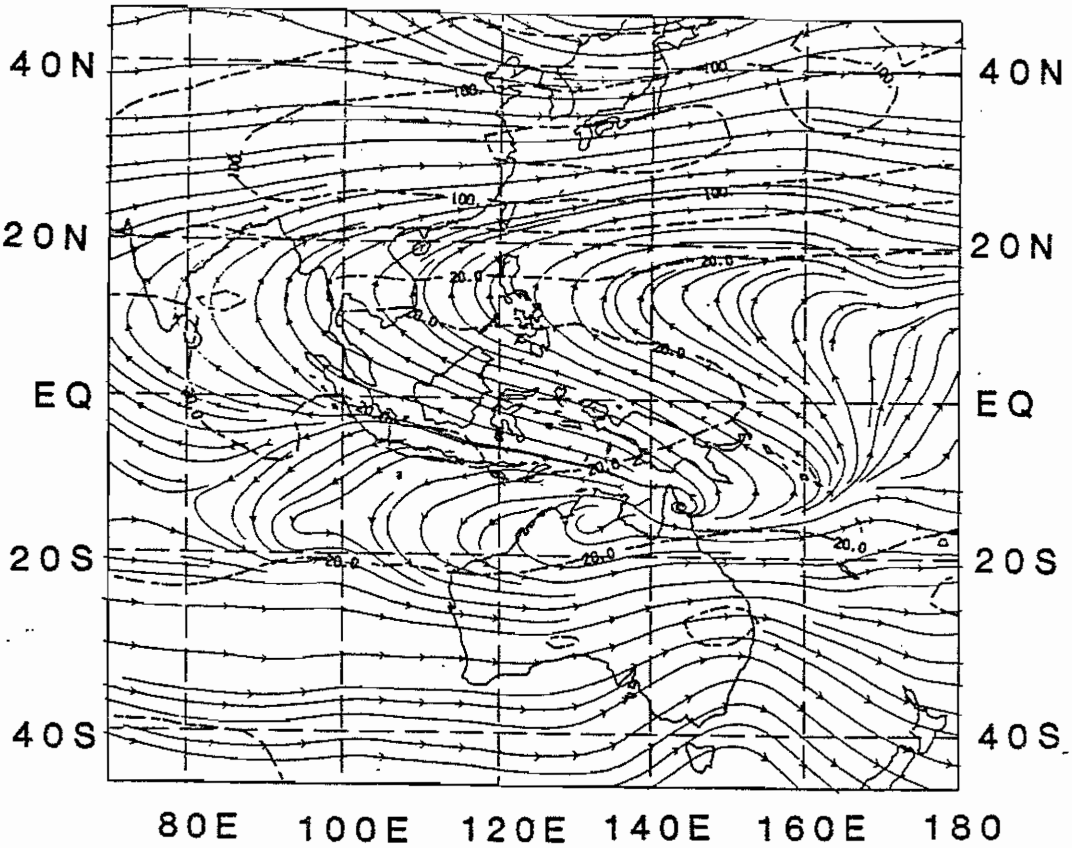

Fig. 10 JANUARY 1986 200 mb STREAMLINE/ISOTACH ANALYSIS. (40 KNOT INTERVAL ISOTACH DASHED LINE).

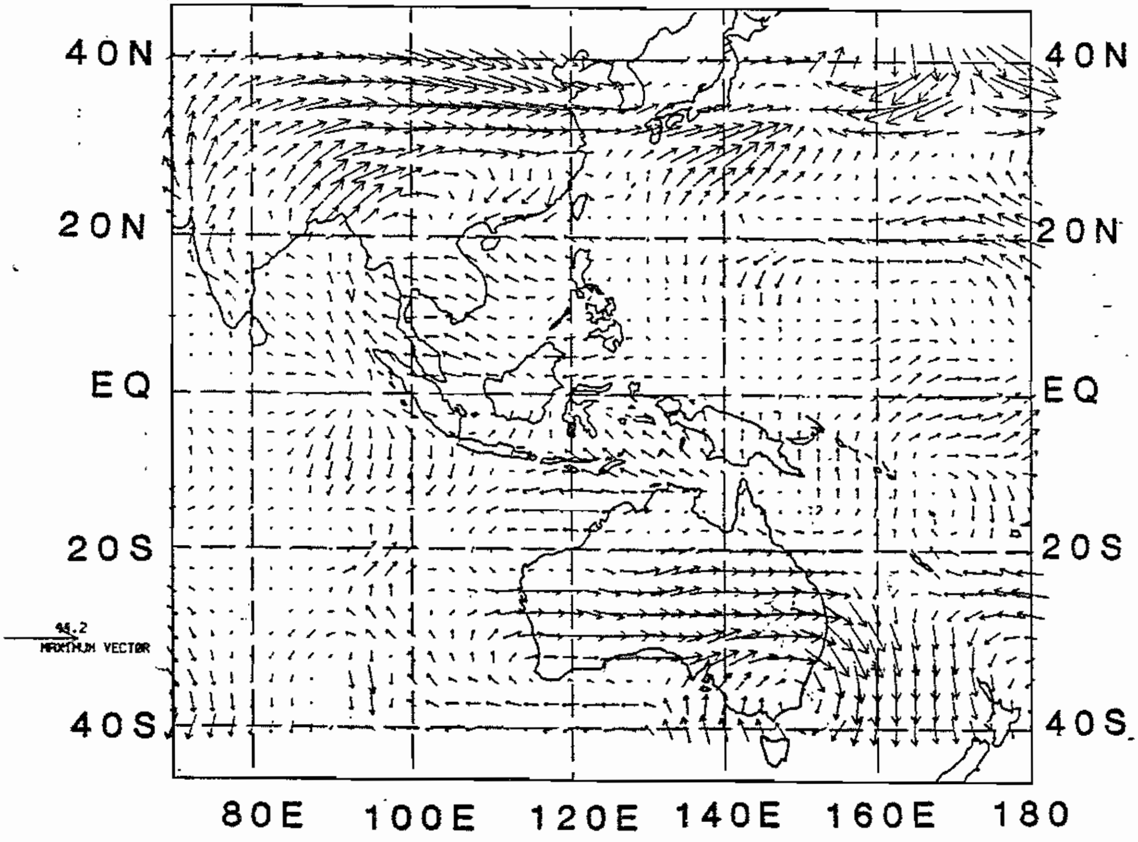

Fig. 11 JANUARY 1986 200 mb VECTOR WIND ANOMALY. (ARROW LENGTH INDICATES MAGNITUDE).

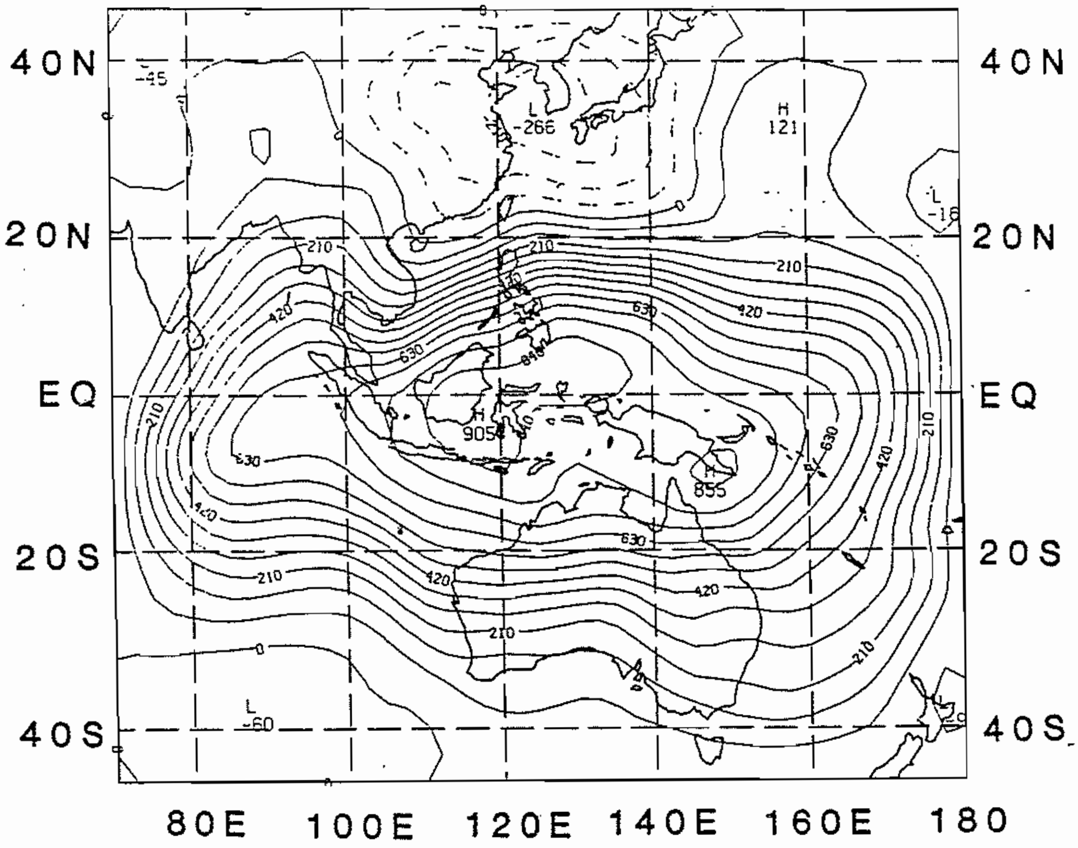

Fig. 12 JANUARY 1986 950 mb VELOCITY POTENTIAL. (CONTOUR INTERVAL 70 x $10^5 M^2 S^{-1}$).

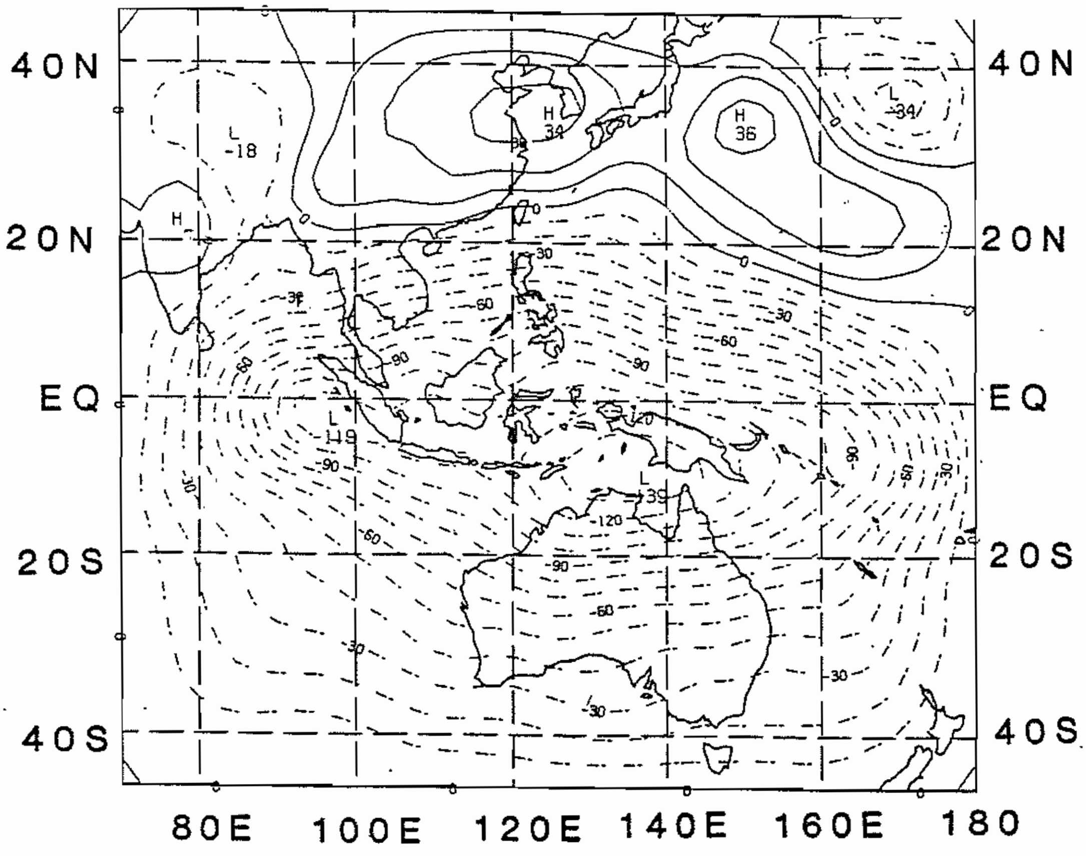

Fig. 13 JANUARY 1986 200 mb VELOCITY POTENTIAL (CONTOUR INTERVAL $10 \times 10^5 M^2 S^{-1}$).

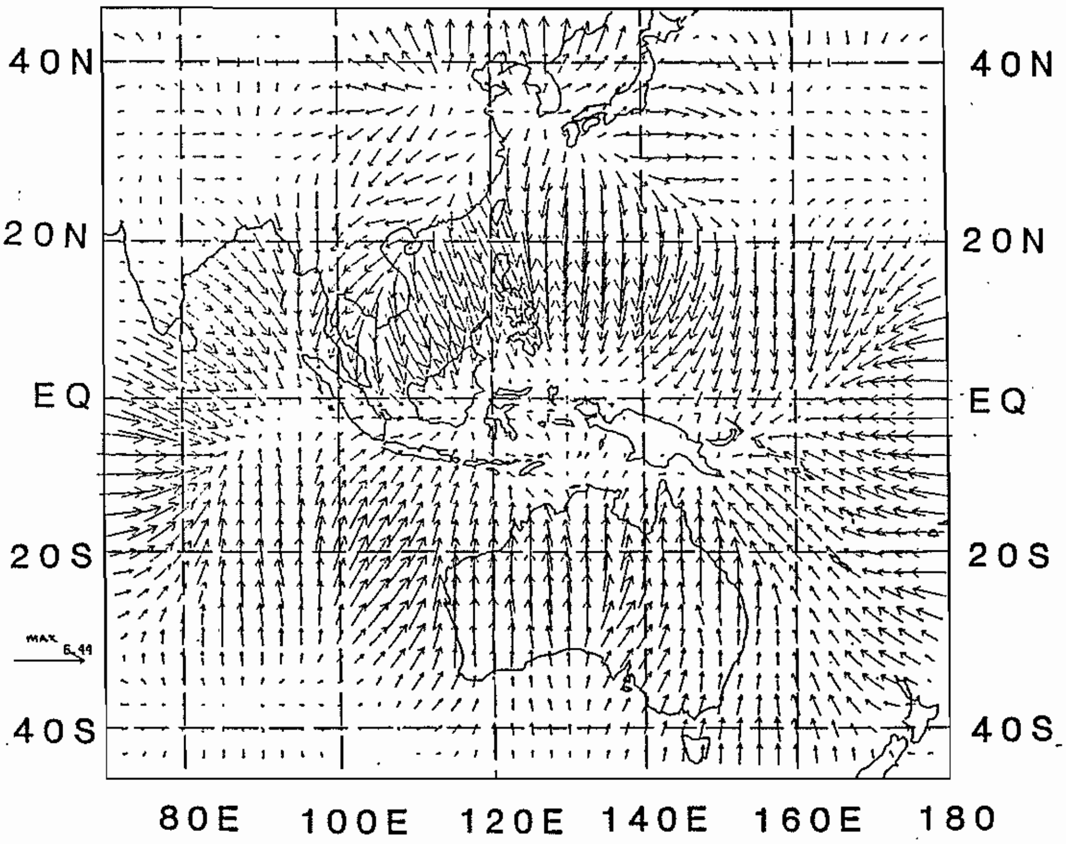

Fig. 14. JANUARY 1986 950 mb DIVERGENT WIND.
(ARROW LENGTH INDICATES MAGNITUDE).

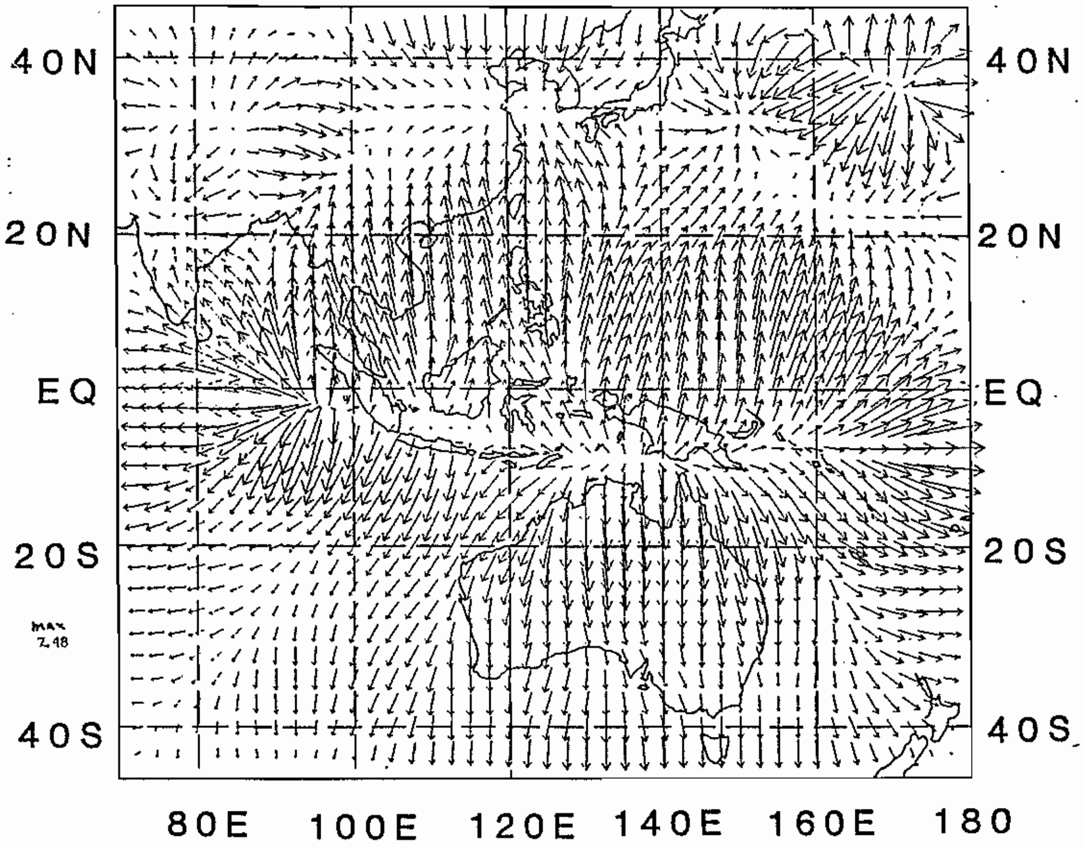

Fig. 15 JANUARY 1986 200 mb DIVERGENT WIND.
(ARROW LENGTH INDICATES MAGNITUDE).

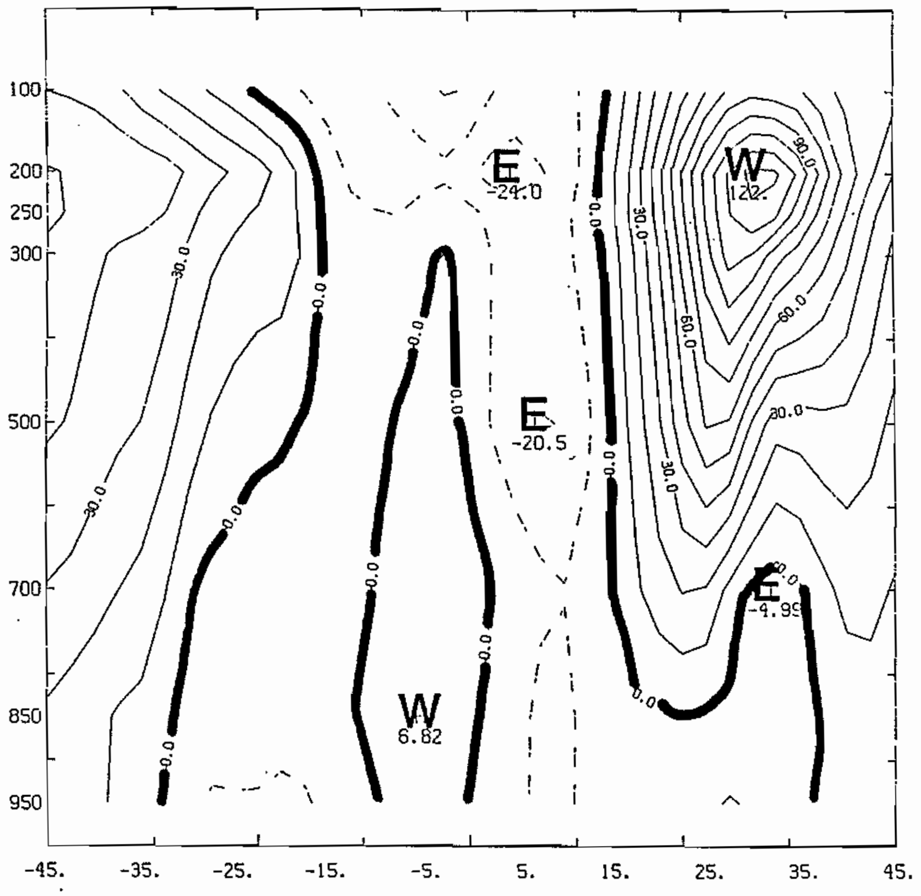

Fig. 16 JANUARY 1986 CROSS SECTION OF ZONAL WIND ALONG 100°E (CONTOUR INTERVAL 10 KNOTS).

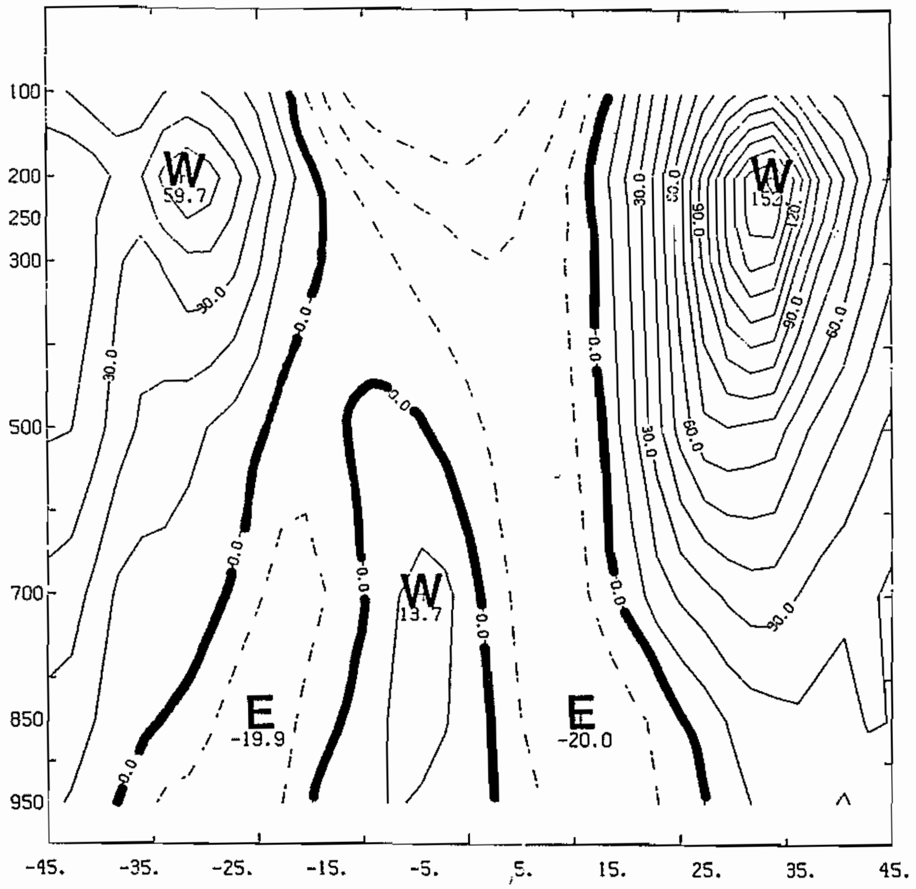

Fig. 17 JANUARY 1986 CROSS SECTION OF ZONAL WIND ALONG 130°E (CONTOUR INTERVAL 10 KNOTS).

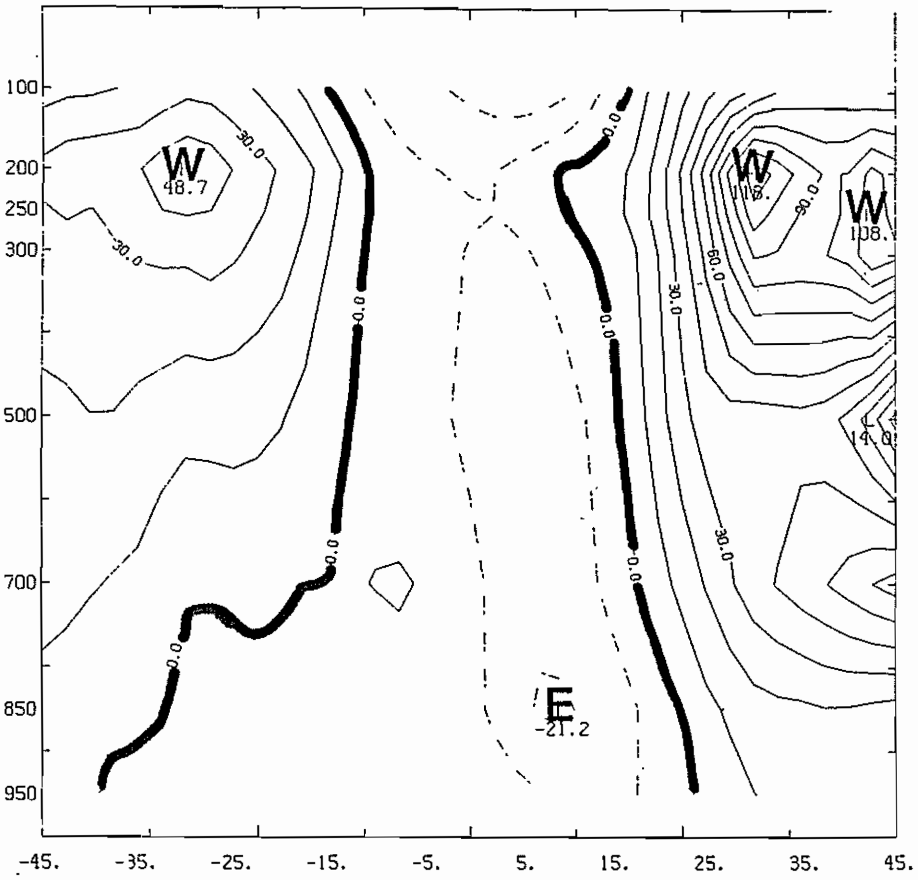

Fig. 18 JANUARY 1986 CROSS SECTION OF ZONAL WIND ALONG 160°E (CONTOUR INTERVAL 10 KNOTS).

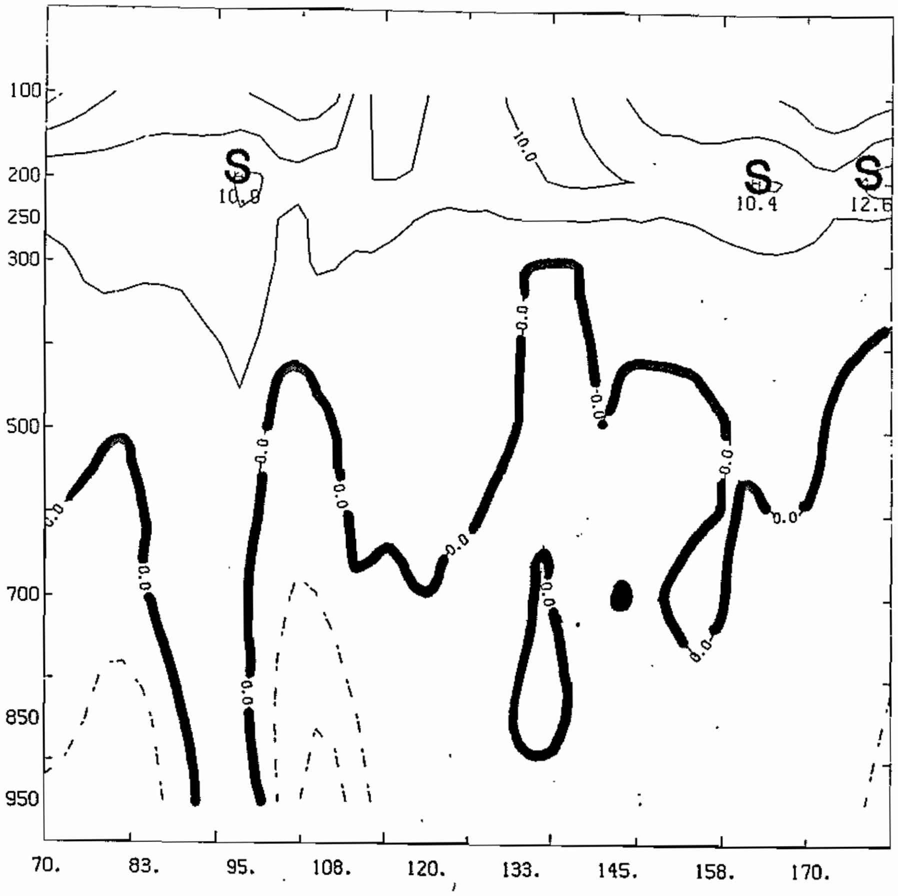

Fig. 19 JANUARY 1986 EQUATORIAL CROSS SECTION BETWEEN 70E and 180E (CONTOUR INTERVAL 5 KNOTS).

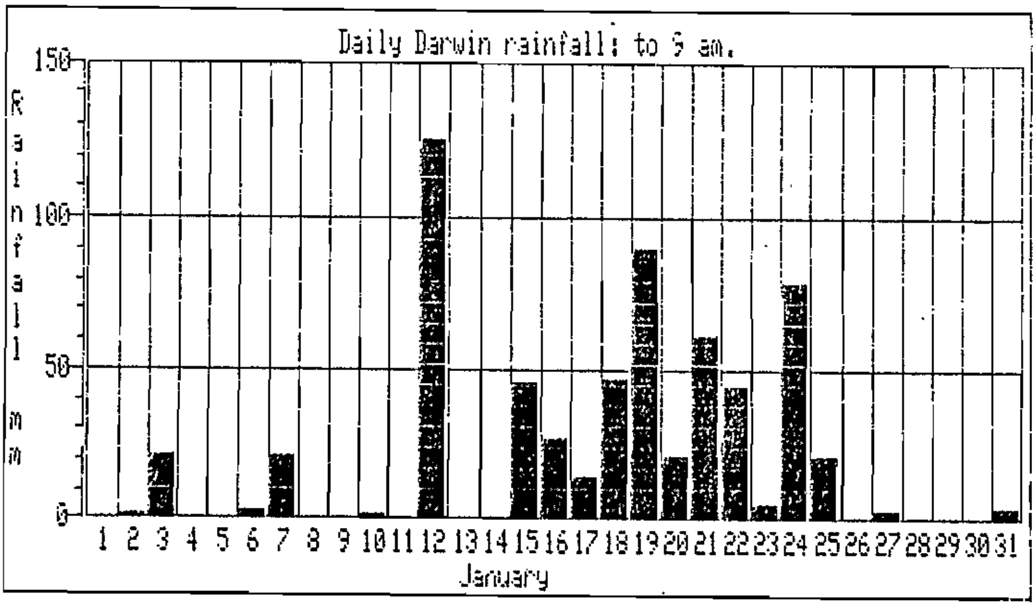

Fig. 20 DAILY RAINFALL TO 9am FOR JANUARY MEASURED AT DARWIN AIRPORT.

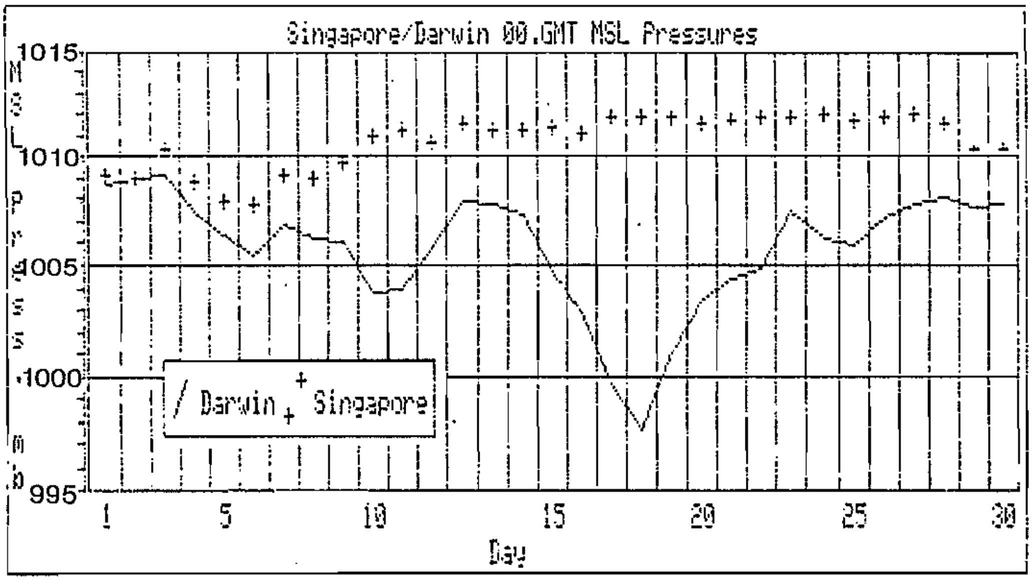

Fig. 21 MSL PRESSURES AT OOGMT AT SINGAPORE AND DARWIN FOR JANUARY.

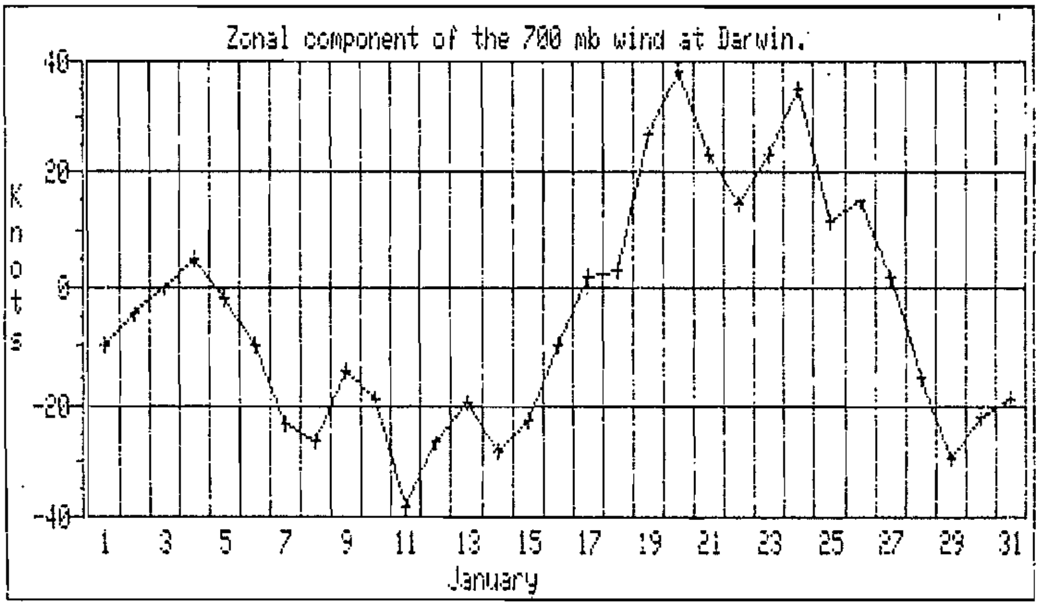

Fig. 22 EAST-WEST COMPONENT OF 700mb WIND MEASURED AT DARWIN DURING JANUARY. WESTERLY WINDS ARE POSITIVE.

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

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