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DARWIN TROPICAL DIAGNOSTIC STATEMENT

APRIL 1988

ISSUED BY DARWIN RMC

The rising trend of the Southern Oscillation Index (SOI) stopped during April with a value of -1 being calculated. This figure has now been within a standard deviation since last September.

The Darwin MSL pressure anomaly returned to a small positive value of +0.6 reflecting the earlier than usual northward retreat of the monsoon trough. Only one tropical cyclone formed during March in the Darwin RMC analysis area (70^{O}E to 180^{O}E).

INDICES

1. Darwin mean MSL pressure March 1988: 1010.1 hPa
   pressure anomaly (1882-1985 mean): +0.6 hPa
2. Tahiti mean MSL pressure March 1988: 1012.3 hPa
   pressure anomaly: +0.4 hPa
3. Troup's Southern Oscillation index: -1
   5-month mean (centred upon January): -2

4. Troup's SOI for the last 28 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								

Graphs of the monthly SOI and the five month running mean SOI for the past ten years are given in figure 1. The period of fairly constant, small values since the El Nino event of 1987 is now quite evident.

TROPICAL CYCLONES

Unofficial cyclone tracks are shown in Fig 3.

Tropical cyclone "Dovi" was the only late season storm to form in the analysis area of the Darwin RMC. It was first located as a tropical disturbance near 13S 170E on the 8th of the month and then moved generally southward, or perhaps a touch east of southward, at around 5 knots. It reached tropical cyclone status on the morning of the 10th near 18S 170E. The storm then began three days of slow, erratic movement and appeared to move in an anticyclonic loop over the area between 170E and 171E to the east of Port Vila.

SEA SURFACE TEMPERATURE

The mean sea surface temperature and anomaly fields for April are shown in figures 4 and 5.

Although most of the region continued to be dominated by warm anomalies, their magnitude has generally decreased. In the Indian Ocean the warm anomalies are around 1 degree less than March. In the Australian region the decrease is smaller but still up to 1 degree. Further eastward toward the dateline there has been little change with perhaps slight cooling. In the northern hemisphere the only change is some slight cooling in the NW Pacific.

MSL PRESSURE AND GRADIENT LEVEL FLOW

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

At first sight the westerly anomalies across northern Australia seem to indicate late monsoonal activity. This could not be further from the truth as can be deduced from the graph of Darwin's monthly rainfall (Fig 10c) and the 950 hPa velocity potential (Fig 13). The westerly anomalies were in fact due to persistent low pressure troughs over inland Australia. This feature can be readily seen in Fig 9. The monsoon convergence maximum had in fact moved northward to the equator. By the middle of the month southeasterlies had become established across northern Australia but, by and large, their strength was low.

Comparison with mean charts shows that the subtropical ridge was up to 5 degrees southward from its normal latitude during April. This was due to persistent blocking in New Zealand and eastern Australian longitudes. However in the Indian ocean the subtropical ridge was in fact further north due to the number of active westerly troughs. In the southern tropics the monsoon convergence region was a little further north than normal.

The significant easterly anomalies through the north Tasman Sea are due to persistent blocking highs around New Zealand, and also the presence of tropical cyclone 'Dovi' near Vanuatu.

In the northern hemisphere most of the wind anomalies were weak. Moderate westerly anomalies in the southwest Pacific indicated weaker than normal northeast trades. This is consistent with a relatively inactive period in the equatorial convergence region.

A significant feature in the northern hemisphere is the development of gradient level convergence across Indochina and India. This is shown in the above average rainfall for April over the Indian subcontinent. However this is based on very small mean monthly totals. This would probably be the same over Indochina but data from this area was missing this month.

Strong positive pressure anomalies were recorded over New Zealand as a result of the blocking highs in that area and the south Tasman sea. The positive anomalies over eastern Australia eased as a result of the influence of upper level cut-off lows.

850 hPa DAILY MEAN ZONAL AND MERIDIONAL WINDS

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

At the start of April the late northwest monsoon burst which occurred at the end of March was still evident. These northwesterlies decreased quickly during the first few days of the month. This trend was reflected in the daily rainfall. For the rest of April southeasterlies predominated. The rain on the 9th was associated with a 'surge', or increase, in the southeasterlies undercutting the more humid air to the north.

UPPER LEVEL FLOW

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

The position of the southern hemisphere sub-tropical ridge (STR) has returned to a latitude close to normal. This further confirms the end of the southern hemisphere 'wet' season. A fairly strong sub-tropical jetstream (STJ) was present over eastern Australian and western Pacific longitudes around 25°. This position is a few degrees north of its normal latitude. This was a result of persistent cutoff lows in these areas which caused heavy rainfall along the east Australian coast during April.

The most significant feature of the 200hPa anomalies is the anticyclonic anomalies in the southwest Pacific and the Indian Ocean around 90E. This ties in well with persistent blocking in Tasman and east Indian Ocean longitudes evident at lower levels.

In the northern hemisphere the most significant feature is the continuation from March of a stronger than normal STJ. Anomalous southerlies through the Bay of Bengal appear to indicate that the trigger mechanism for the above average rain in India was not a monsoon circulation.

VELOCITY POTENTIAL

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

The maximum of gradient level convergence is just to the north of New Guinea and West Irian. This maximum has not shifted far from its March position, but the values have dropped significantly. This is reflected, as stated earlier, in relative inactivity of the tropical convergence zone.

The maximum of 200hPa divergence has remained at much the same latitude, but again a marked decrease in values has been observed. This trend toward increased convergence at 200 hPa is reflected in both hemispheres. In the northern hemisphere maxima of convergence are now quite evident to the north of India and in the northwest Pacific.

WIND CROSS SECTIONS

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

At 100°E and 130°E the pattern followed a seasonal trend with an increase in westerlies at all levels in southern latitudes. Also the maximum of westerlies in northern latitudes at low levels has moved northward. There was a significant decrease in the strength of the STJ.

At 160°E a similar decrease in the strength of the northern STJ was observed. The only variation at this longitude was that the southern hemisphere westerly regime had not moved any further northward.

The latitudinal cross section shows the weak and variable cross equatorial flow at most levels, this being fairly typical of the transition,'doldrum' season.

RAINFALL

Monthly rainfall quintiles for selected stations in April are given in Fig.2.

The most striking feature of the distribution was the heavy rain along the eastern Australian coast, particularly south from 25°S. This was caused, as mentioned previously, by the presence over eastern Australia of mid and upper level cut-off lows.

The low values across southern Australia are a function of the southward displacement of the subtropical ridge which prevented significant frontal incursions in that region. Dry weather occurred in the northern tropics as a result of the early northward retreat of the monsoon trough.

The high values in both the Indian subcontinent and central Australia are based on very low means and are not significant. The same could be said of the low values over China where persistent high pressure and lack of frontal incursions produced below average rain.

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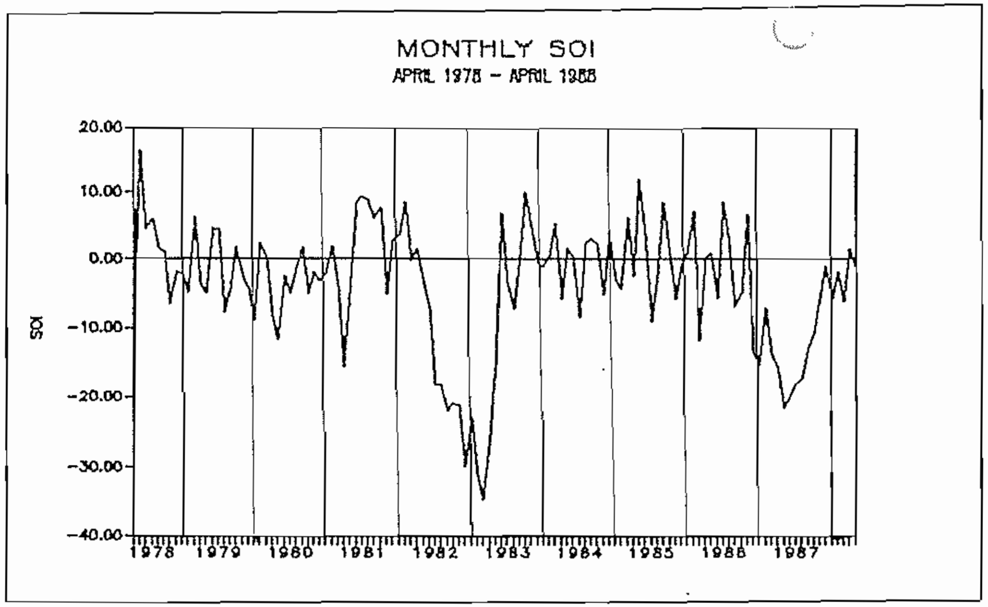


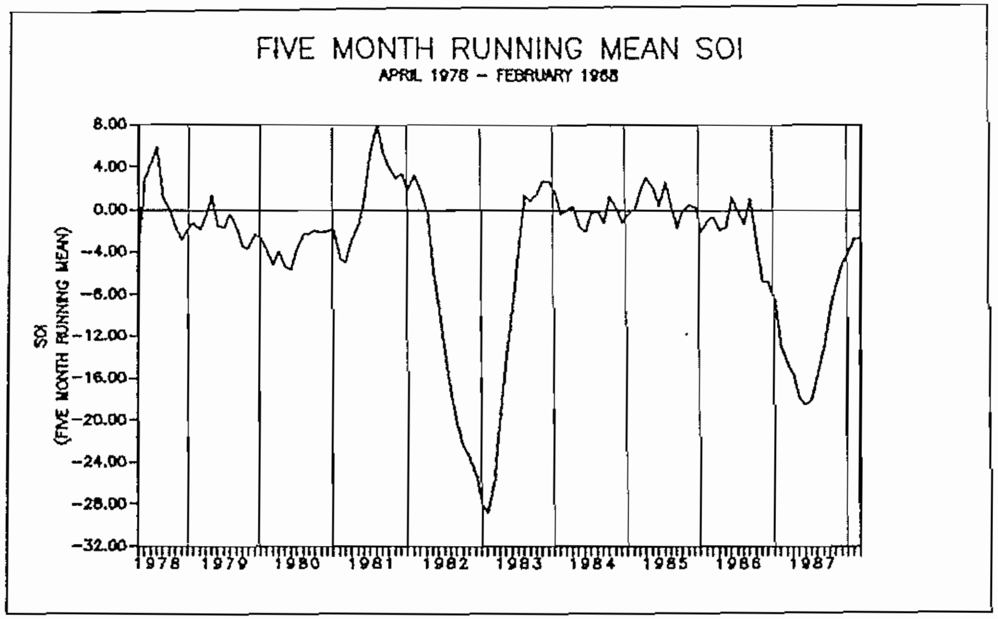


Fig.1 SOUTHERN OSCILLATION INDEX (1978-1988)
Monthly SOI and 5-month running mean SOI

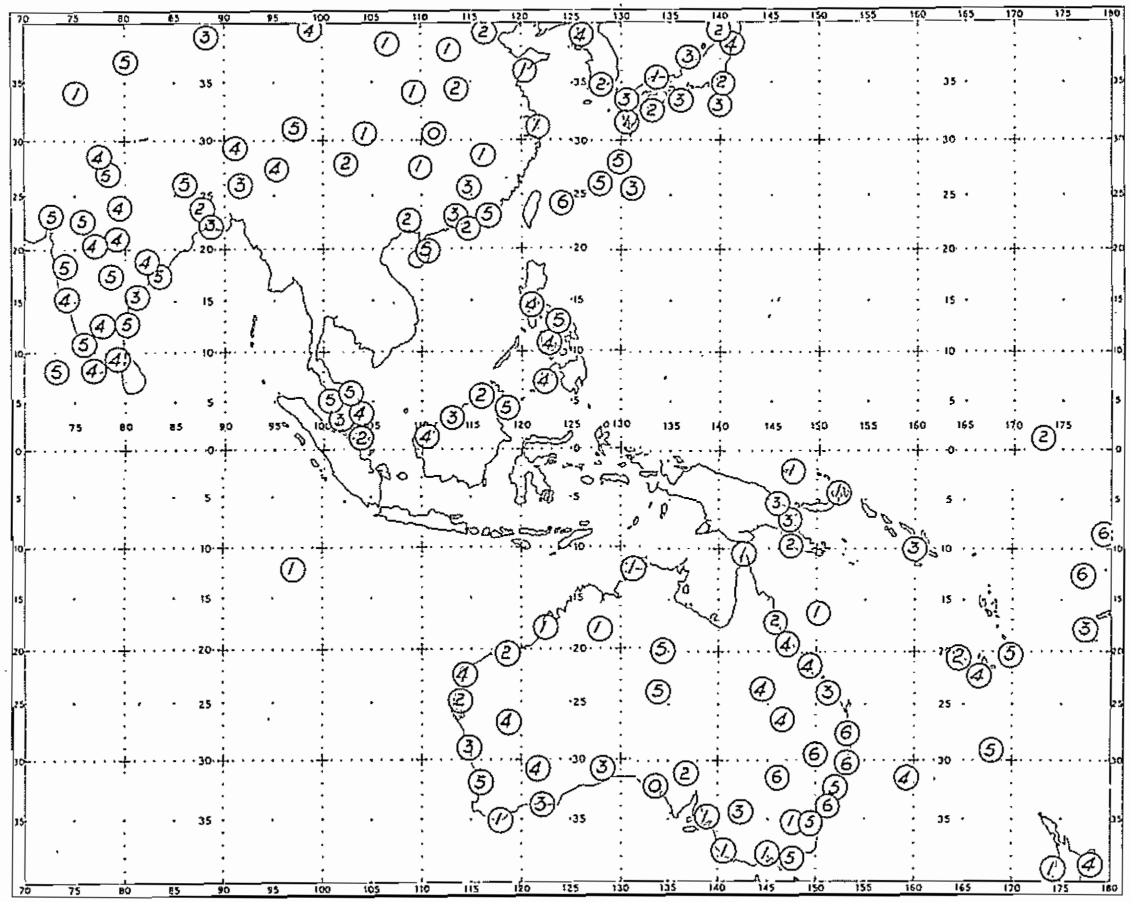


Fig.2 MONTHLY MEAN RAINFALL QUINTILES from selected climat stations
(APRIL 1978)

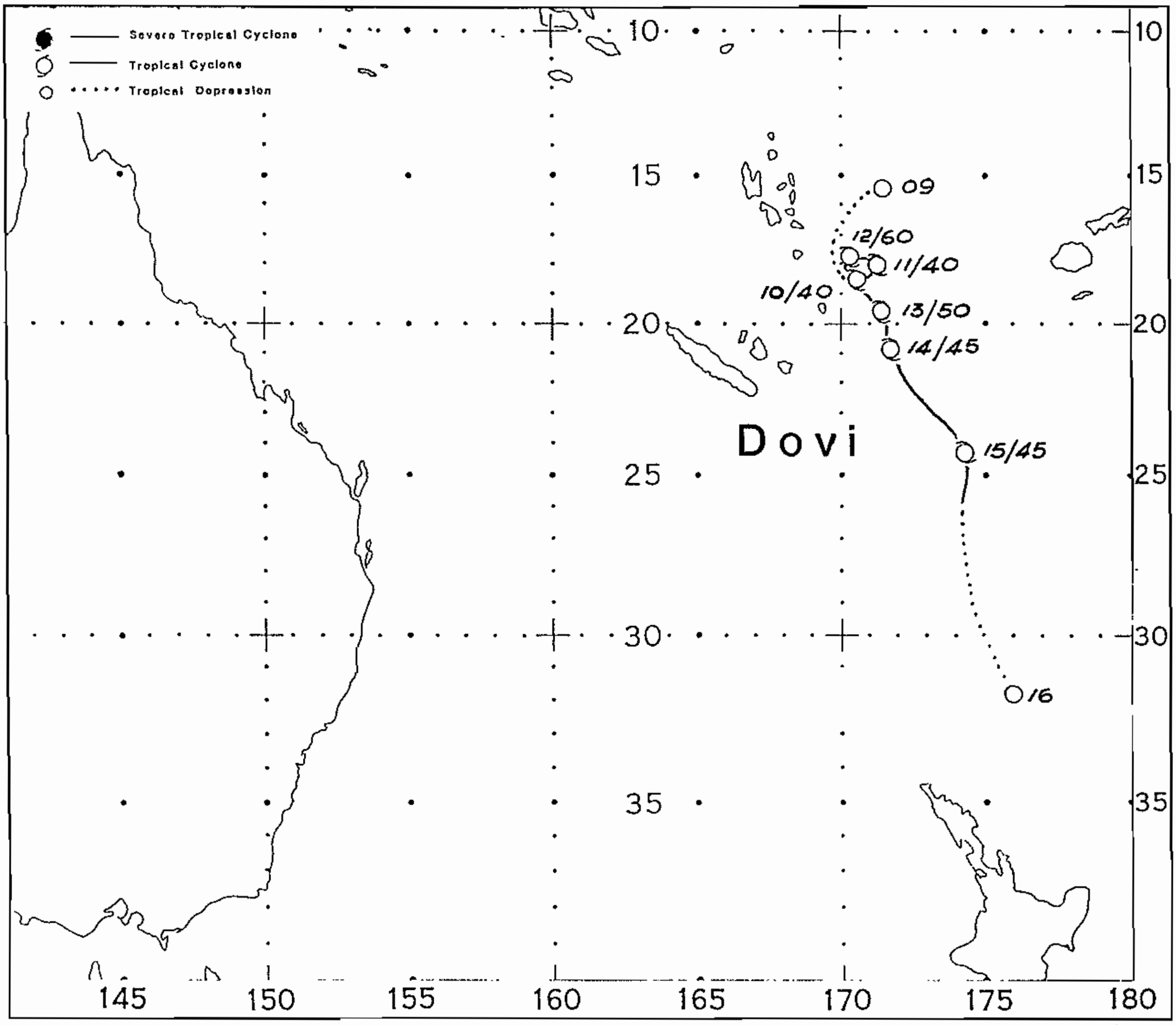


Fig.3 UNOFFICIAL TRACK OF CYCLONE DOVI
(APRIL 1988)
Date (DD) and maximum sustained wind (ff) in
knots denoted by DD/ff.

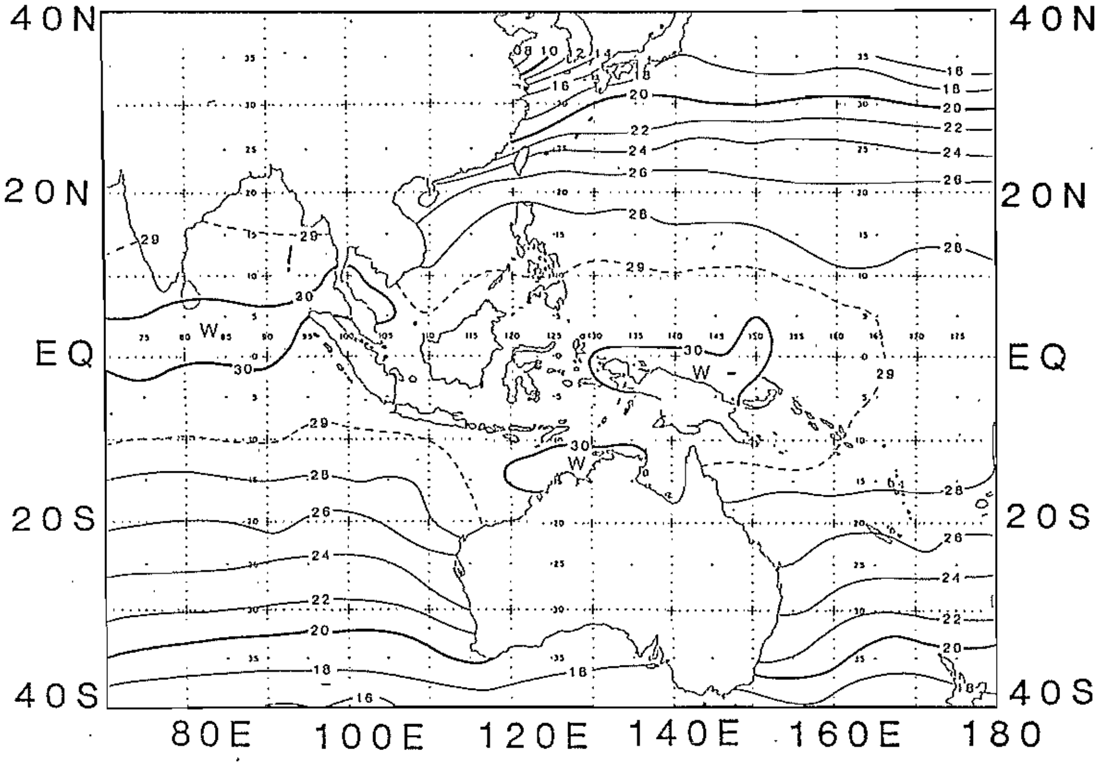


Fig. 4 MEAN SEA SURFACE TEMPERATURES, BASED ON WEEKLY DARWIN RMC ANALYSES AVERAGED OVER THE MONTH, APRIL 1988. Isotherm interval 2° C.

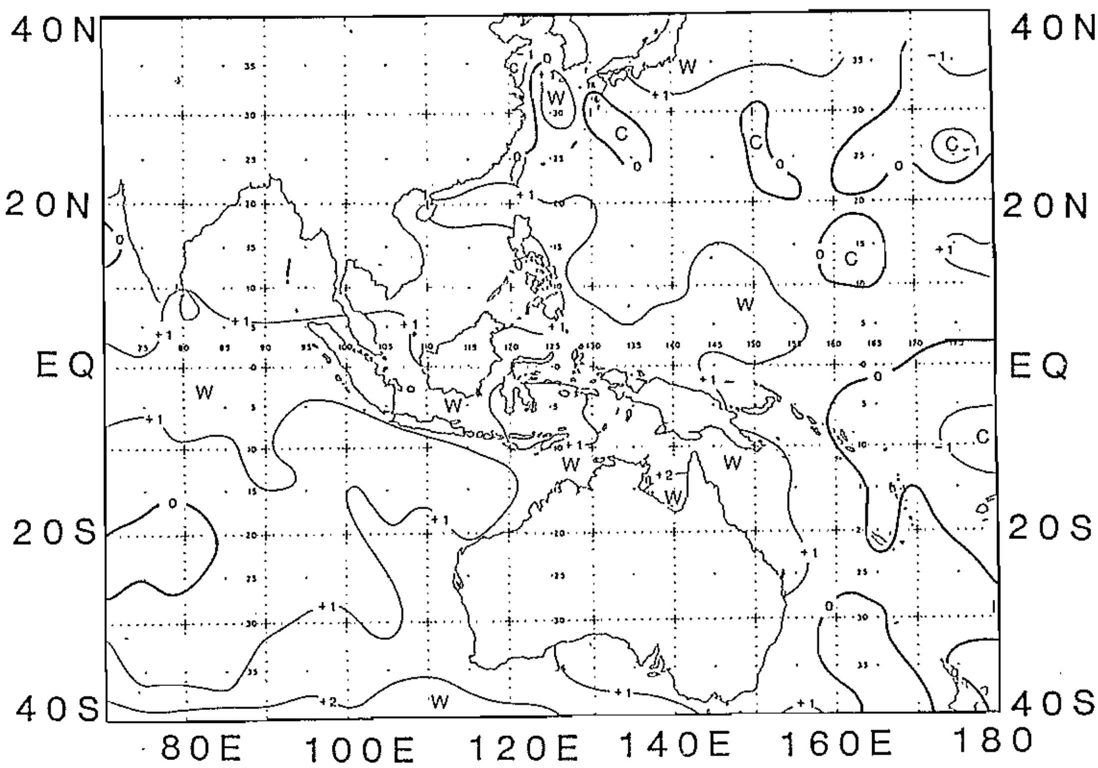


Fig. 5 SST ANOMALY CHART, BASED ON FIG. 4 AND THE CLIMATOLOGY OF REYNOLDS, NOAA REPORT NWS 31, 1983 Isotherm interval 1° C.

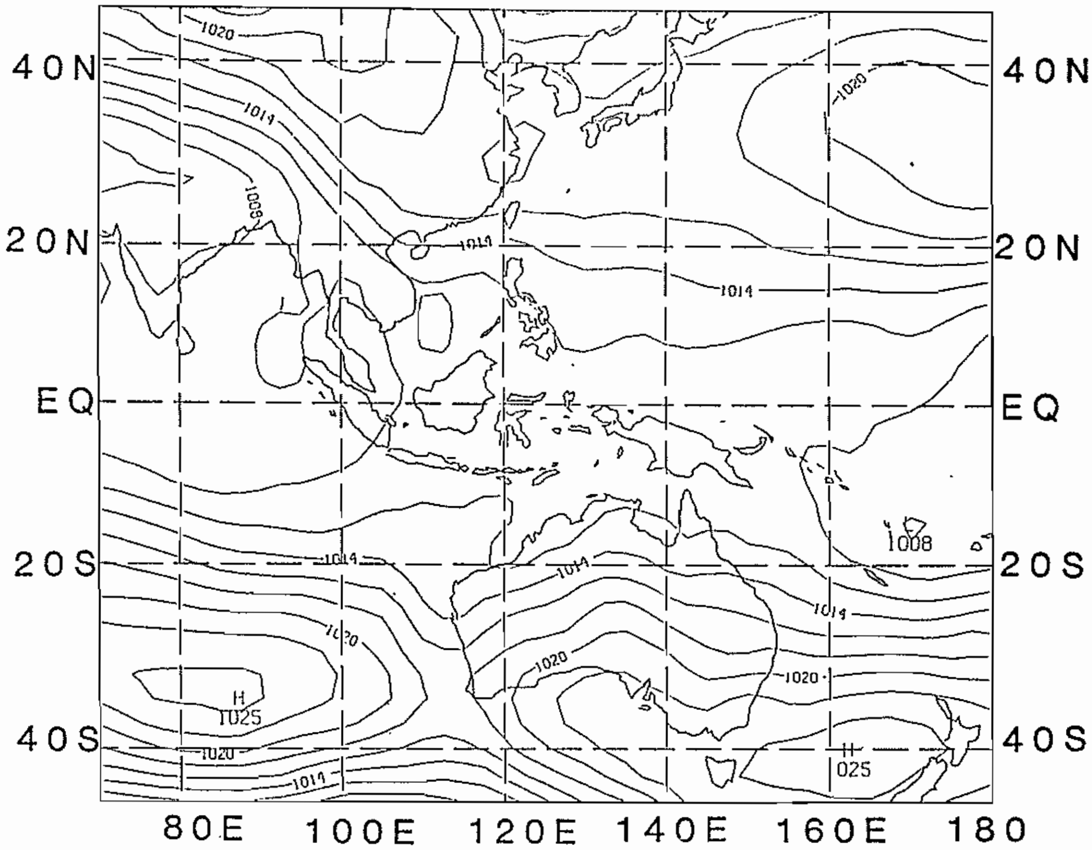


Fig. 6 MONTHLY MEAN MSL PRESSURE, APRIL 1988
Isobar interval 2 hPa

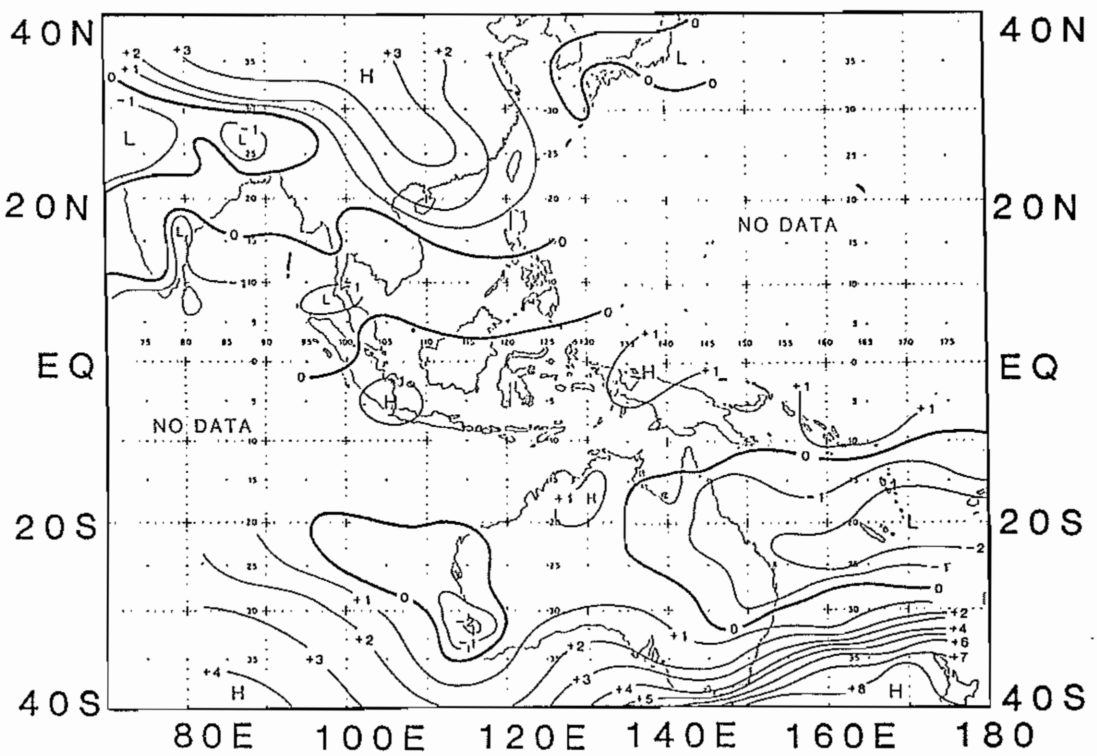


Fig. 7 MSL PRESSURE ANOMALY BASED ON CLIMAT MESSAGES
(AND MELBOURNE WMC DATA SOUTH OF $10^{o}S$)
Contour interval 1 hPa.

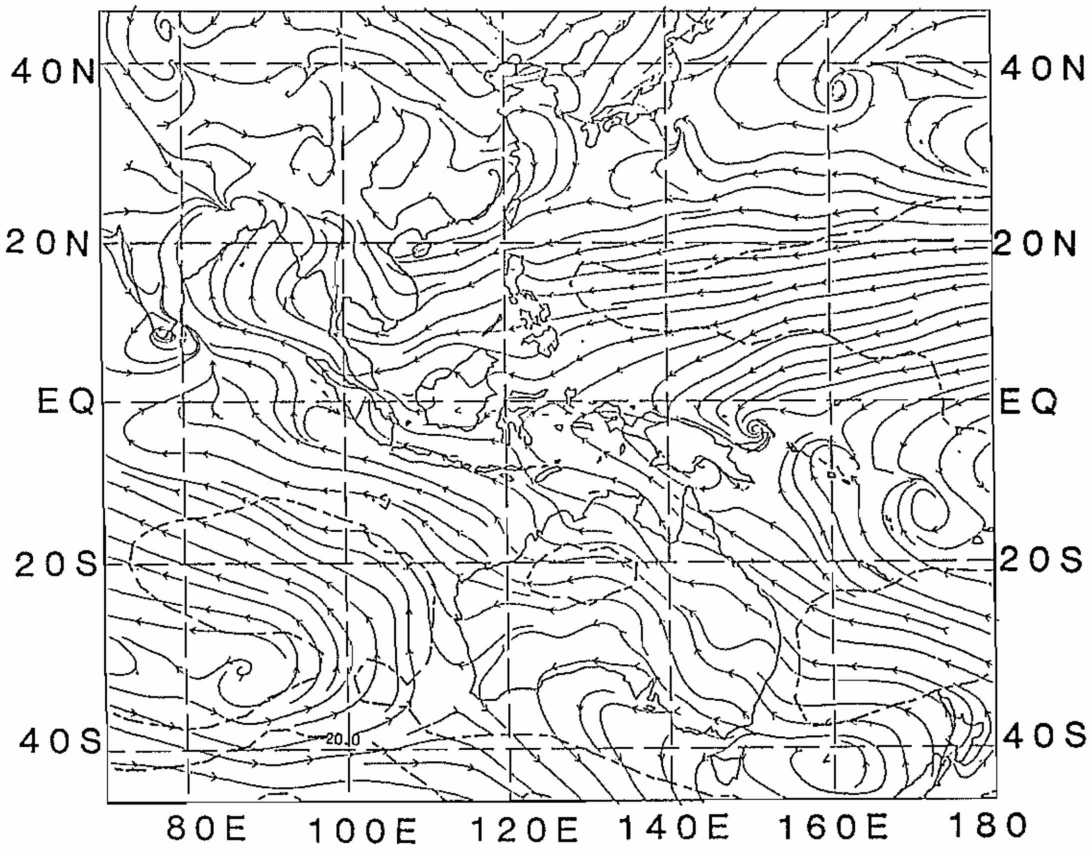


Fig. 8 950 hPa STREAMLINE ANALYSIS, APRIL 1988
Isotachs (dashed line) at 10 knot intervals

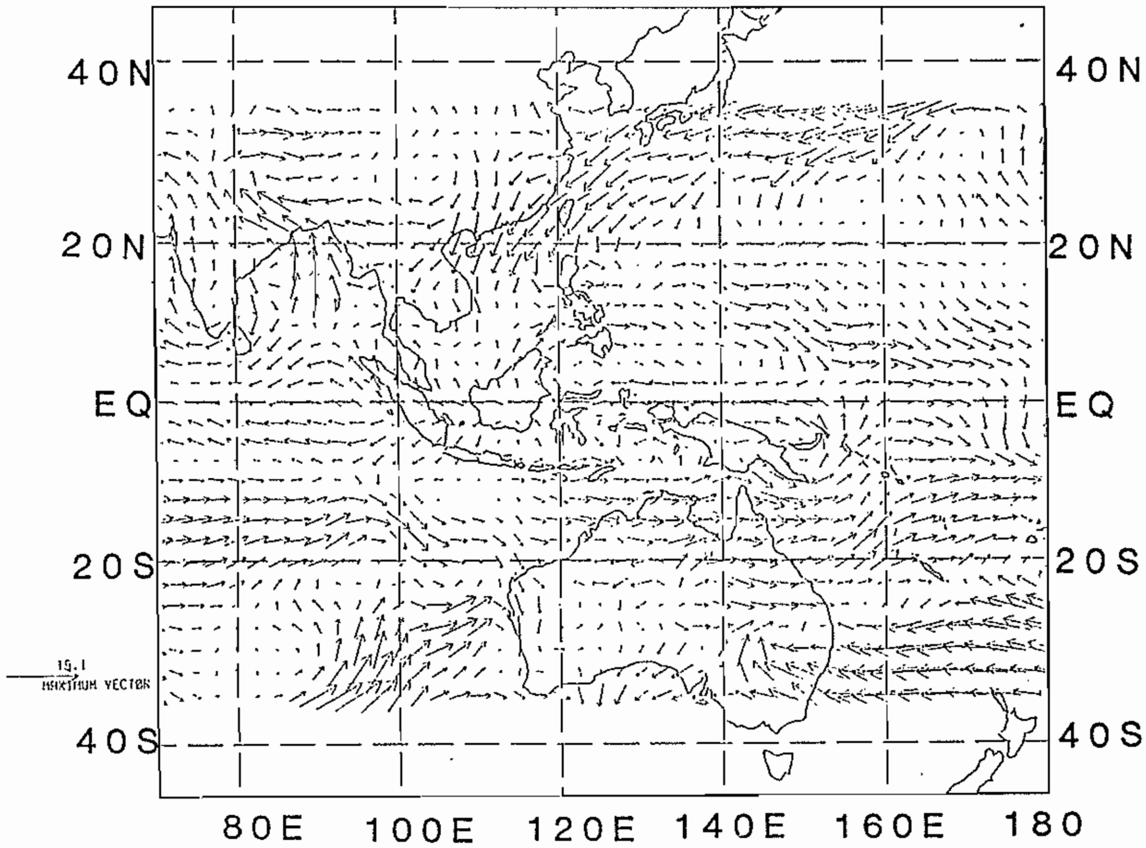


Fig. 9 950 hPa VECTOR WIND ANOMALY BASED ON FIG. 8
(Arrow length indicates magnitude)

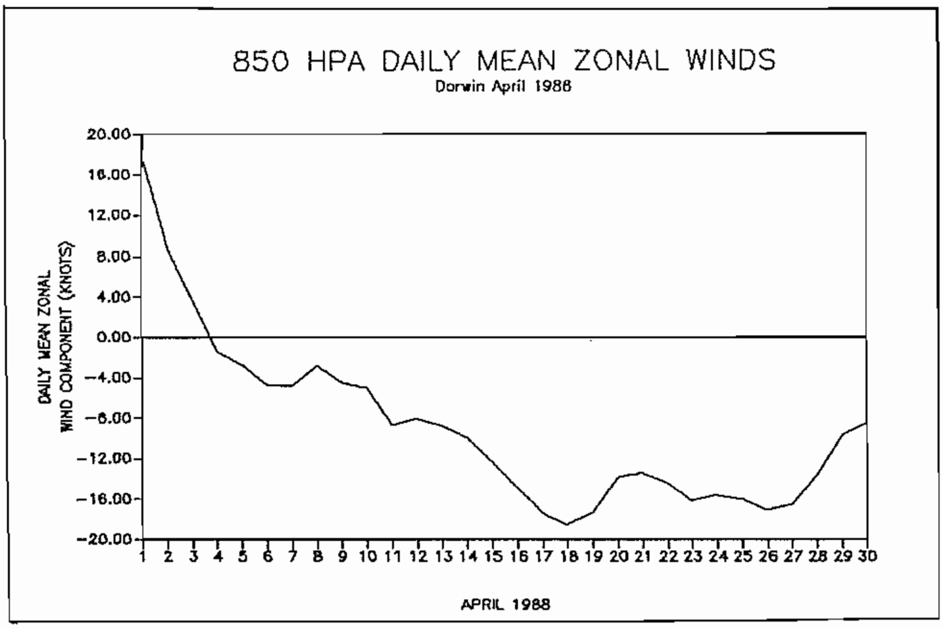
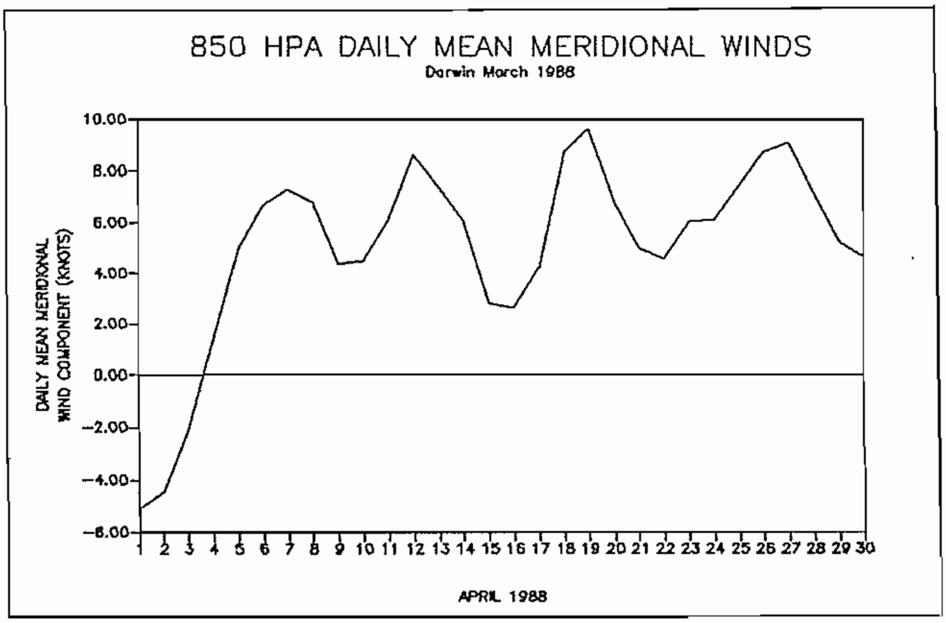
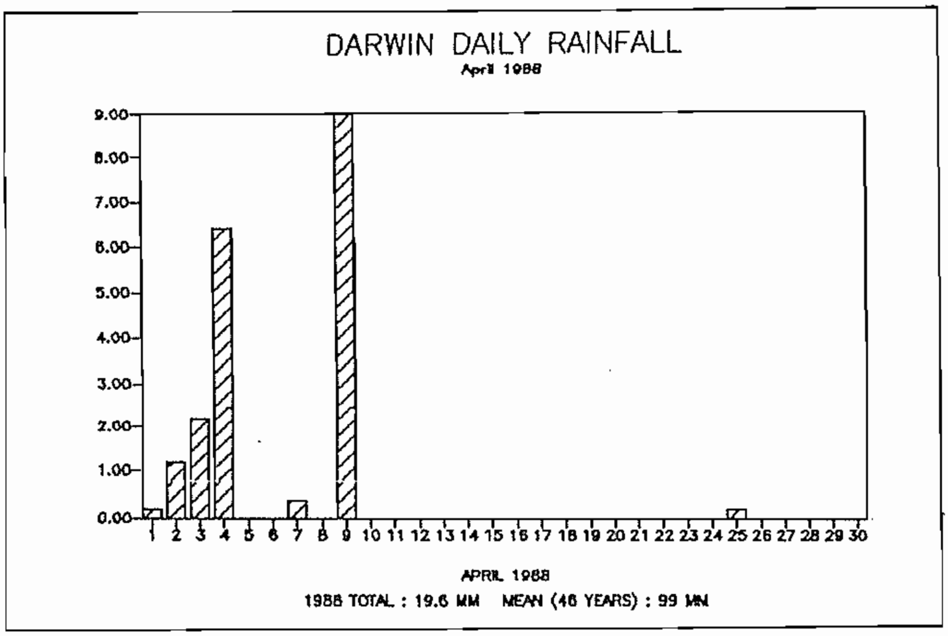


Fig.10 (a) DARWIN 850 hPa 3-DAY MEAN ZONAL WIND, APRIL 1988



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



(c) DARWIN DAILY RAINFALL, APRIL 1988

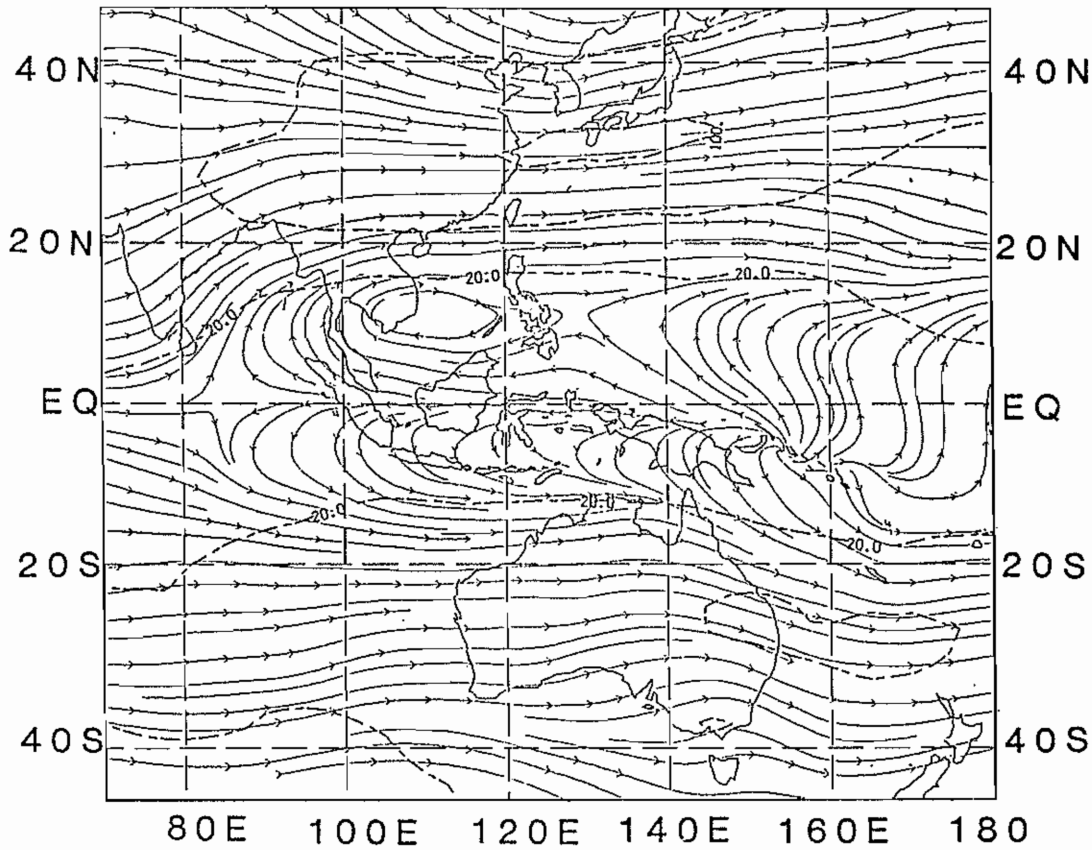


Fig.11 200 hPa STREAMLINE ANALYSIS, APRIL 1988
Isotachs (dashed line) at 40 knot intervals.

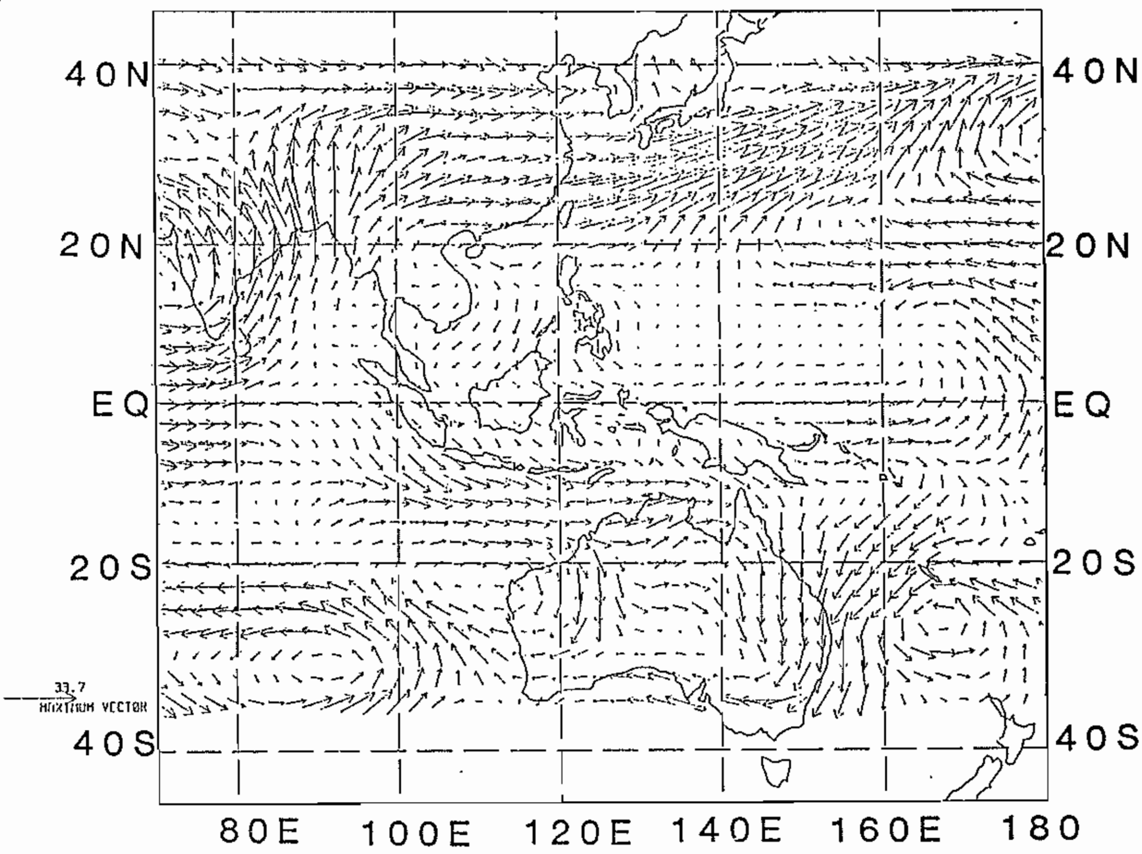


Fig.12 200 hPa VECTOR WIND ANOMALY BASED ON FIG. 11
(Arrow length indicates magnitude).

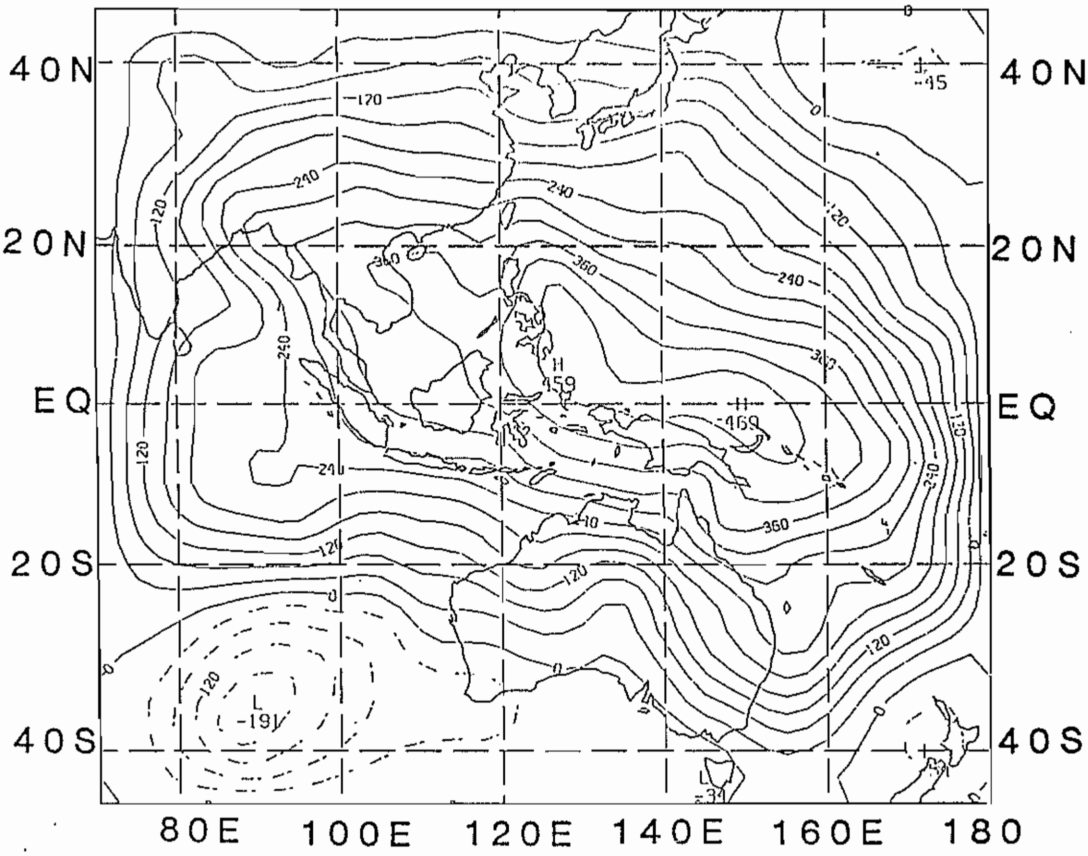


Fig.13 950 hPa VELOCITY POTENTIAL, APRIL 1988
Contour interval 40 x 10 ^{5} m ^{2} s^{-1}

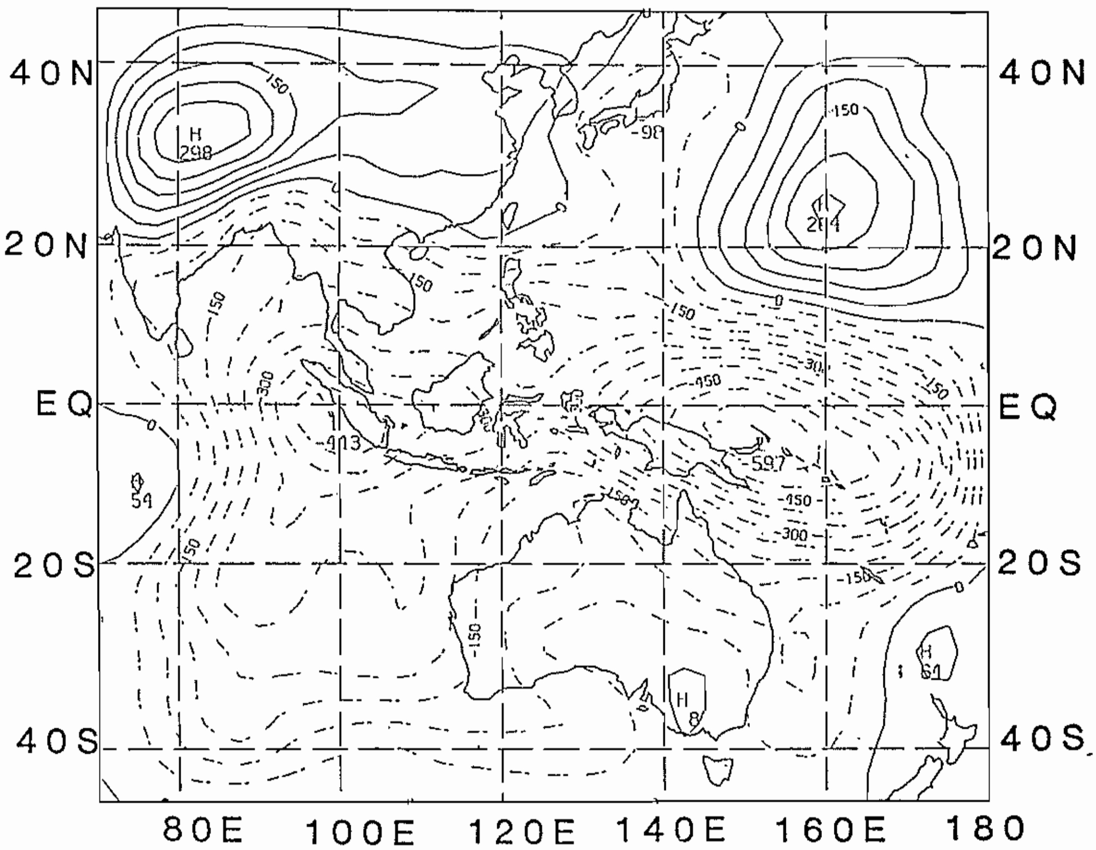
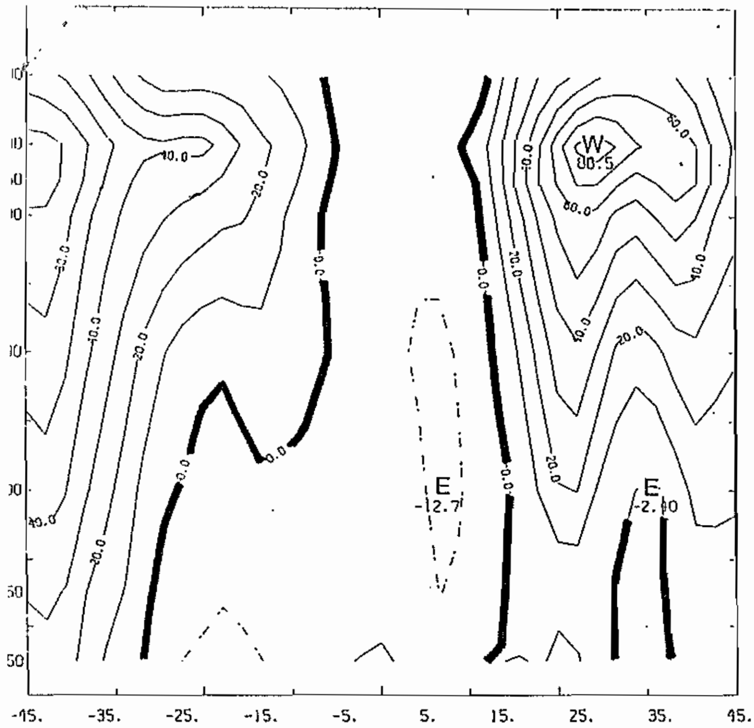


Fig.14 200 hPa VELOCITY POTENTIAL, APRIL 1988
Contour interval 5 x 10 ^{5} m ^{2} s^{-1}



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

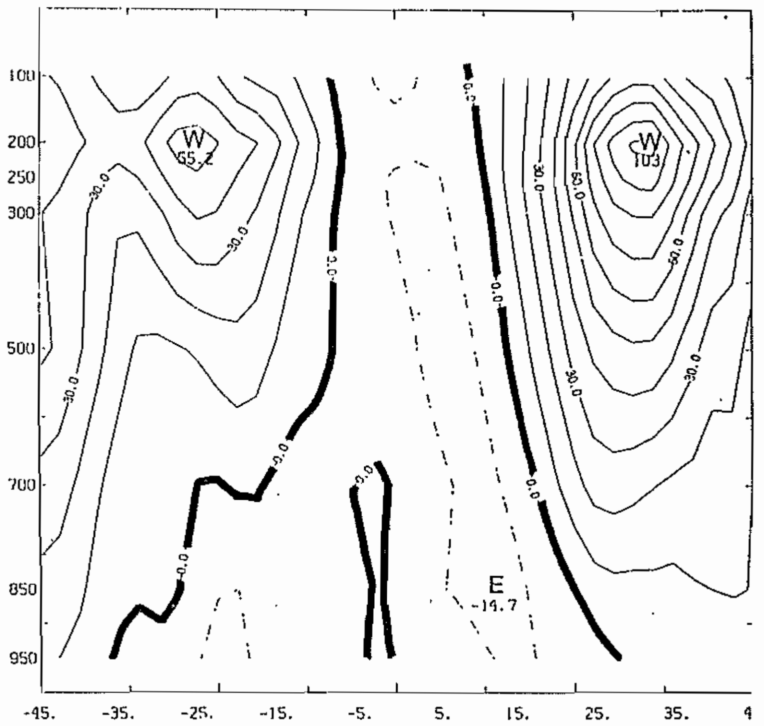


Fig.16 CROSS-SECTION OF ZONAL WIND ALONG 130°E, APRIL 1988
Isotach interval 10 knots.

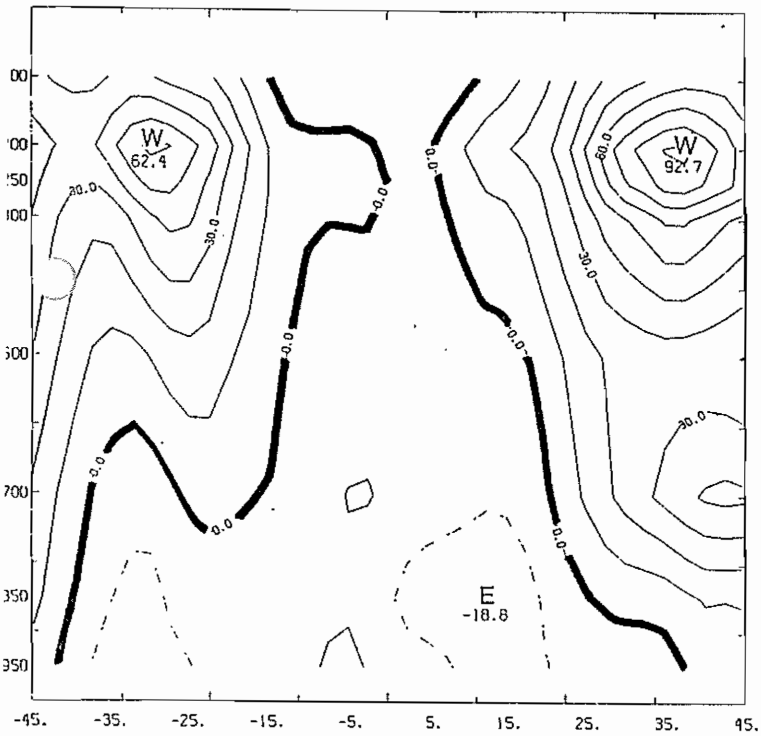


Fig.17 CROSS-SECTION OF ZONAL WIND ALONG 160° E, APRIL 1988
Isotach interval 10 knots.

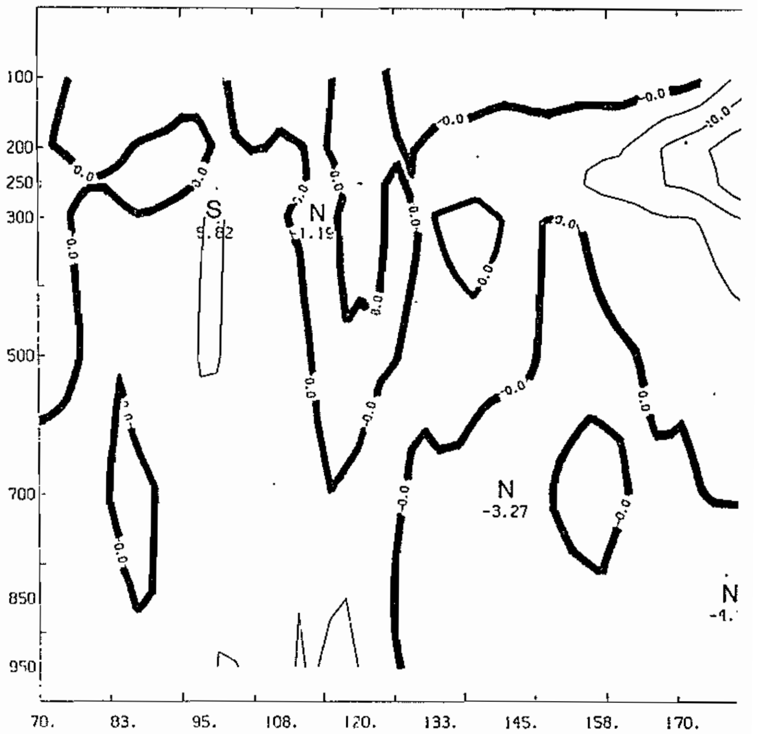


Fig.18 EQUATORIAL CROSS-SECTION OF MERIDIONAL WIND BETWEEN 70°E AND 180°E, APRIL 1988. 5 knot isotach

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

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:

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