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DARWIN TROPICAL DIAGNOSTIC STATEMENT

NOVEMBER 1988

ISSUED BY DARWIN RMC

SUMMARY

An early onset of southern hemisphere monsoonal patterns is highlighted by cross-equatorial northerly winds at low levels and southerly winds in upper levels. In the northern hemisphere, positive pressure anomolies have developed over China and gradient level northerly wind anomolies are present through southeast Asia. Across tropical Australia gradient level westerly wind anomolies are apparent, and above average vertical motion through the Australian/Indonesian region is reflected in the velocity potential fields and rainfall. At Darwin, the last days of November and the first days of December saw a shift to northwesterly wind combined with a significant burst in rainfall.

A continuing strong Walker circulation is evidenced by the high SOI, the warm SST anomolies around northern Australia combined with cold anomolies in the central Pacific, and the above average vertical motion in the Australian/Indonesian region.

INDICES

This month's value of the Southern Oscillation Index (SOI) is +20. The 5 month running mean of the SOI has risen to +16. Both Darwin and Tahiti are major contributors to the value, reversing a trend in recent months toward the Darwin pressure anomaly being the major contributor. This is more in agreement with continuing negative sea surface temperature anomalies in the central and eastern Pacific.

1. Darwin mean MSL pressure, November 1988	:	1007.4 hPa
pressure anomaly (1882-1985 mean)	:	-1.5 hPa
2. Tahiti mean MSL pressure, November 1988	:	1013.5 hPa
pressure anomaly	:	+1.7 hPa
3. Troup's Southern Oscillation index	:	+20
5-month mean (centred upon September)	:	+16

4. Troup's SOI for the last 35 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	

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

TROPICAL CYCLONES

Six tropical cyclones occurred between 70E and 180E during November. Two of these occurred in the northwest Pacific, where the average number (1959 to

1987) is 2.6 (JTWC: 1987 Annual Tropical Cyclone Report). Two cyclones occurred in the Bay of Bengal, and the remaining two occurred in the eastern Indian Ocean south of the equator. Unofficial tracks are shown in figure 3.

Early in November there was a paired trough system over the eastern Indian Ocean, lying near 5N and 5 to 10S. The southern trough was coincident with active convection, and provided the site for genesis of cyclones Adelinina and Barisaona.

Severe Tropical Cyclone Adelinina formed near 8S 77E during the 1st. It tracked to the south-southeast and intensified, reaching severe cyclone intensity by the 3rd. It then moved fairly slowly and erratically to the east, weakening below cyclone intensity during the 5th.

Severe Tropical Cyclone Barisaona had formed near 8S 98E by the 5th. It intensified only very slowly, moving slowly and erratically for the first couple of days. After the 7th it maintained a slow westward movement, continuing to intensify very slowly so that severe cyclone intensity was reached during the 14th. Barisaona then moved to the southwest out of the analysis area, before recurving and weakening at higher latitudes.

During the early part of the month the northern hemisphere monsoon trough remained active in the northwest Pacific near the Philippines.

Typhoon Skip had formed near 8N 139E by the 4th, and followed a steady west-northwest track. It reached typhoon intensity during the 5th, and peak intensity of 100 knot mean winds during the 6th. Skip crossed the central Philippines during the 7th and weakened to 75 knots. As it moved across the South China Sea it continued to weaken, below typhoon intensity on the 10th and dissipated over cooler water on the 12th.

Typhoon Tess formed near 9N 119E on the 4th. It moved to the west-northwest and intensified, reaching typhoon status briefly before crossing the coast of Vietnam and dissipating during the 6th.

By the middle of November, the trough near 5N in the eastern Indian Ocean had become fairly active. A tropical depression formed in this trough and moved north-northeast, to become Tropical Cyclone 03B on the 18th. It briefly reached an intensity of 50 knots before crossing the coast of Burma and dissipating.

The trough reformed near 5 to 10N on the 19th. On the 24th Severe Tropical Cyclone 04B formed near 10N 93E. 04B moved to the northwest, reaching severe cyclone intensity by the 26th. It continued northward (resisting recurvature) and reached a peak intensity of 100 knots during the 29th, before crossing the coast of Bangladesh and causing extensive devastation and loss of life.

SEA SURFACE TEMPERATURE

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

Extensive positive anomolies continue across northern Australia, with an area above +2^{o}C in waters to the north and northeast. There are now areas of slight negative anomoly in the northwest Pacific, after a season of mainly warm anomolies. Negative anomolies are apparent near the dateline at the equator.

Trial global sea surface temperature analyses from the National Meteorological Centre in Melbourne, when cross referenced against the SST climatology of Sadler et al from the University of Hawaii, indicate that there is still a significant area of negative anomalies, up to 2 to 3 degrees, in the central and eastern Pacific.

MSL PRESSURE AND GRADIENT LEVEL FLOW

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

An interesting feature of the northern hemisphere pattern is the area of positive pressure anomalies over the area covering China and the sea eastward to Okinawa. As a result significant northerly wind anomalies can be seen through the South China Sea. Northerly anomalies, although less in magnitude, extend southward across the equator.

The tendency for troughing off the north Queensland coast and Coral Sea is shown by the strong northwest anomalies in those areas. Sizeable negative pressure anomolies continue across northern Australia and surrounding areas. A significant development is the appearance of an area of negative anomaly in excess of 2 hPa along the Queensland coast, in line with the troughing mentioned above.

The most significant feature for the southern hemisphere as a whole is the degree of wind anomalies in the tropics with a northwest component, indicating the very early onset of monsoon conditions.
The positive pressure anomalies and northerly wind anomalies over the Tasman Sea have reappeared after an absence last month because of a couple of major, synoptic scale troughs. Prior to last month these anomalies had been evident through the southern winter and spring.

850 hPa DAILY MEAN ZONAL AND MERIDIONAL WINDS AND RAINFALL

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 November.

The patterns of zonal and meridional wind, and Darwin rainfall, show the build up to the first outbreak of monsoonal rain. The rain total for the month was again above average, fulfilling the prediction of an early 'wet' season from the work of Nicholls(1984). An easterly zonal component persisted until the monsoon onset at the end of the month. At the same time the meridional component turned to the north and the heavy rain commenced. This rain continued into the first part of December, with about 350 mm falling in less than a week. The total rain for November was 248 mm, compared to an average of 142 mm. Rain fell on 15 days, compared to an average of 12.

UPPER LEVEL FLOW

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

At 200 hPa the position of the northern hemisphere jet stream is further south than normal. Also the TUTT (Tropical Upper Tropospheric Trough) is slightly more marked than normal.

In the southern hemisphere the ridge was a little further southward from its normal position, with anomalous ridging in central Australian longitudes. Some southerly cross equatorial flow was evident in the monthly mean east of 140°E. Toward the end of the month daily analyses indicated that this southerly 'return' flow had extended westward to about 125°E, with the high at this level moving southward over northern Australia. This was obviously a contributory factor to the onset of monsoon rain.

VELOCITY POTENTIAL

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

At 950 hPa the centre of the maximum of velocity potential moved southward during the month. The area of maximum values extended from the southern Philippines to Malaysia. Values over Australia continued to increase and have become considerably higher than the previous few Novembers, especially over northern Australia. This is in agreement with the above average convection which has been in evidence on satellite pictures and rainfall figures. A substantial ridge in the gradient level velocity potential has developed through the Coral Sea, off the Queensland coast. This has been reflected in above average rain along the northern and central Queensland coast.

At 200 hPa the minimum of velocity potential which was over the Philippines on last month's mean chart has moved to the southwest of Sumatra. Values have decreased strongly over northwestern Australia as the trough of high level velocity potential off the west coast of Australia continues to deepen. In contrast to the gradient level pattern, a ridge of high level velocity potential persists through the Coral Sea and southward off the Queensland coast. However this appears to be a normal pattern judging from our limited data base of velocity potential fields, and values are significantly less than the previous few years.

WIND CROSS SECTIONS

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

All three cross-sections of zonal wind illustrate the progression of the season towards the southern hemisphere monsoon. Low level trade wind easterlies have weakened in the southern hemisphere and strengthened markedly in the northern hemispere. Lower tropospheric westerlies are appearing south of the equator, quite strong at longitude 100E. The northern hemisphere Sub-Tropical Jet has strengthened and shifted equatorward.

The equatorial cross-section of meridional wind also illustrates the progression towards the southern hemispere monsoon, and that it is well in advance of previous years. Lower tropospheric northerlies and upper tropospheric southerlies are apparent in longitudes 70 - 110E and 140 - 180E. The western Pacific pattern, in particular, is well in advance of the previous two years. Figures 9 and 12 indicate that this is a definite equatorial wind anomaly.

RAINFALL

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

Rainfall was above average over most of Australia, with the only exceptions being southern Queensland and inland New South Wales where falls were average to below average. Rainfall was also well above average throughout the equatorial region to the north of Australia.

China and Japan experienced much lower than normal rainfall during November. Lack of data makes it difficult to comment on India and Asia through the belt 10 to 20N, though cyclone activity would indicate the probability of above average falls.

REFERENCE

Nicholls,N. 1984. A System for Predicting the Onset of the North Australian Wet Season. J. of Clim. Vol 4, 425-435.

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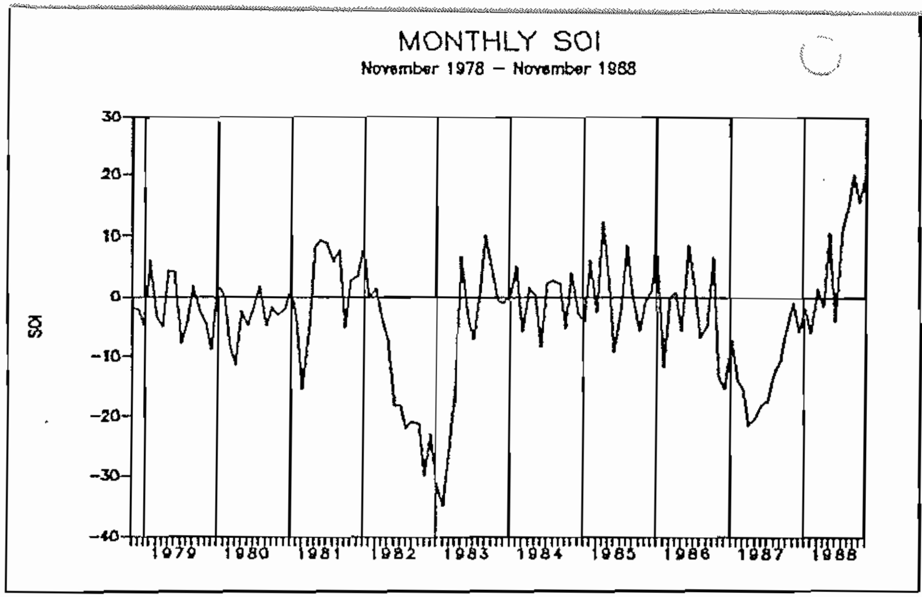


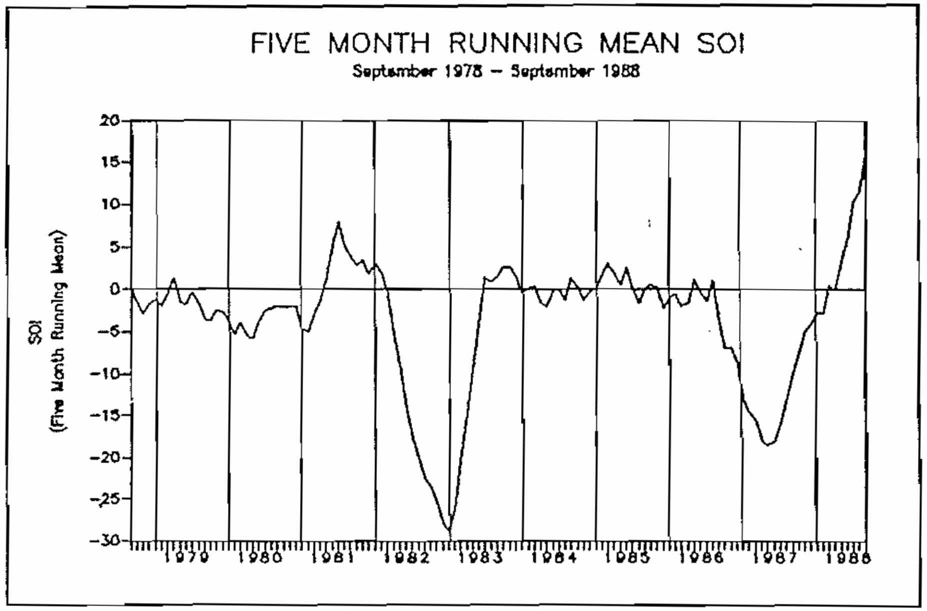


Fig.1 SOUTHERN OSCILLATION INDEX (1978-1988)
Monthly SOI and 5-month running mean SOI

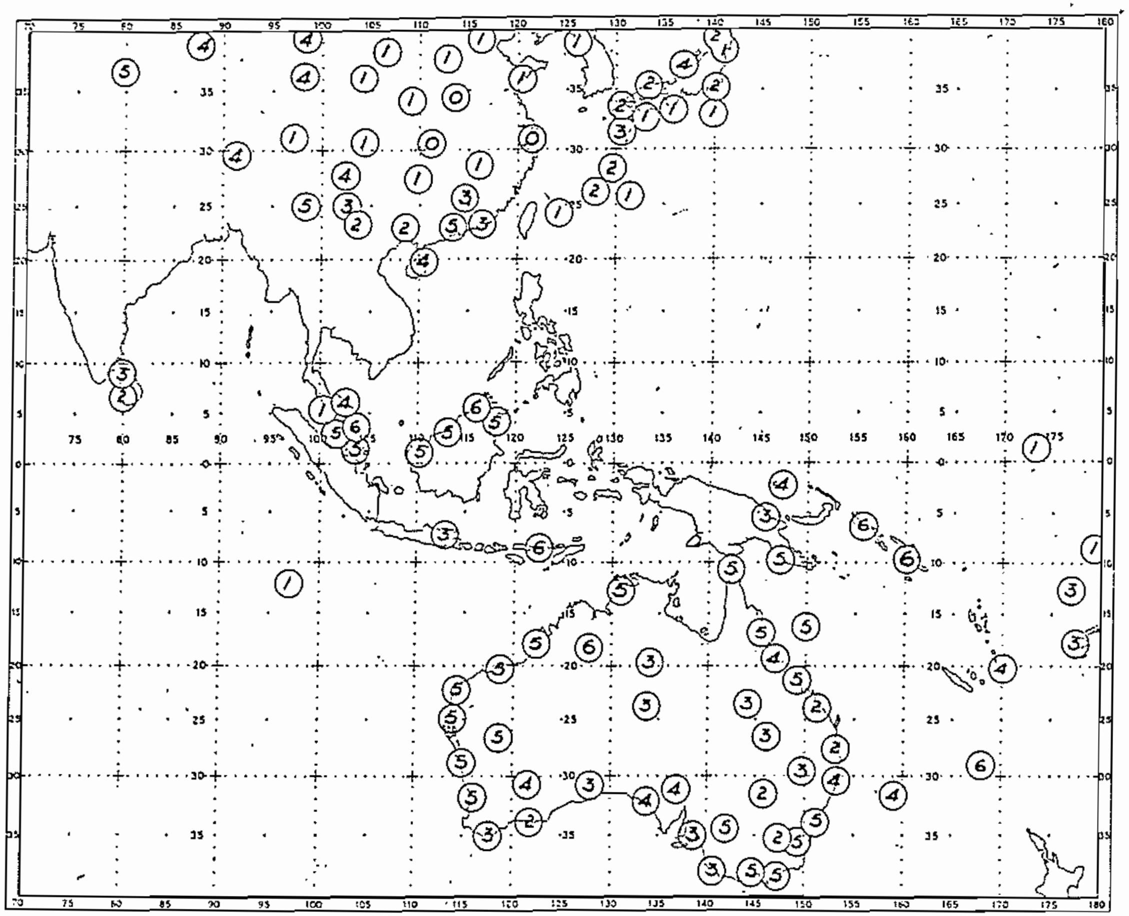


Fig.2 * MONTHLY MEAN RAINFALL QUINTILES from selected climat stations
(NOVEMBER 1988)

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

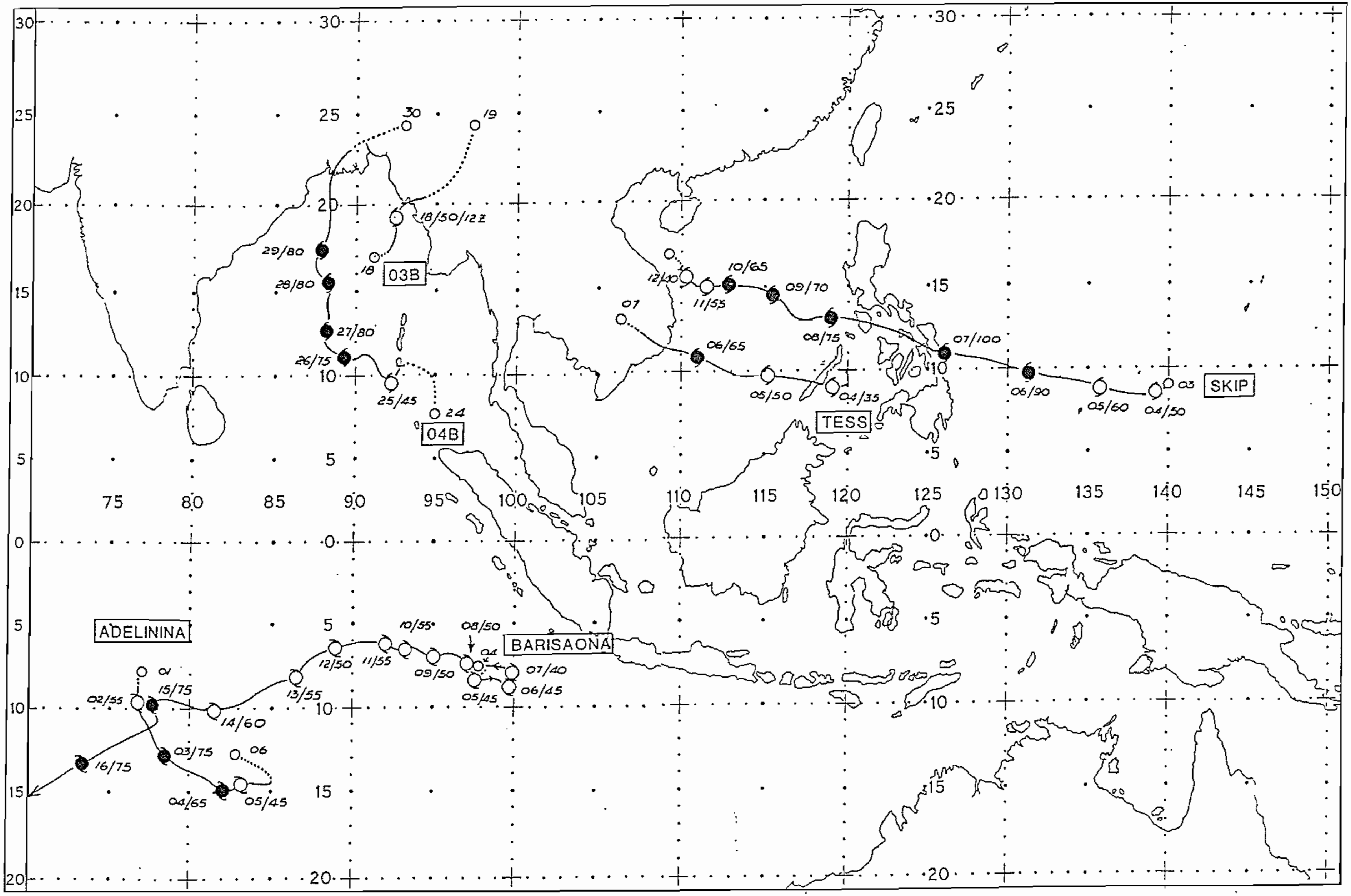


Fig.3 UNOFFICIAL TRACKS OF CYCLONES ADELININA, SKIP, TESS, BARISAONA, 03B, AND 04B (NOVEMBER 1988)
Date (DD) and maximum sustained wind (ff) in knots denoted by DD/ff.

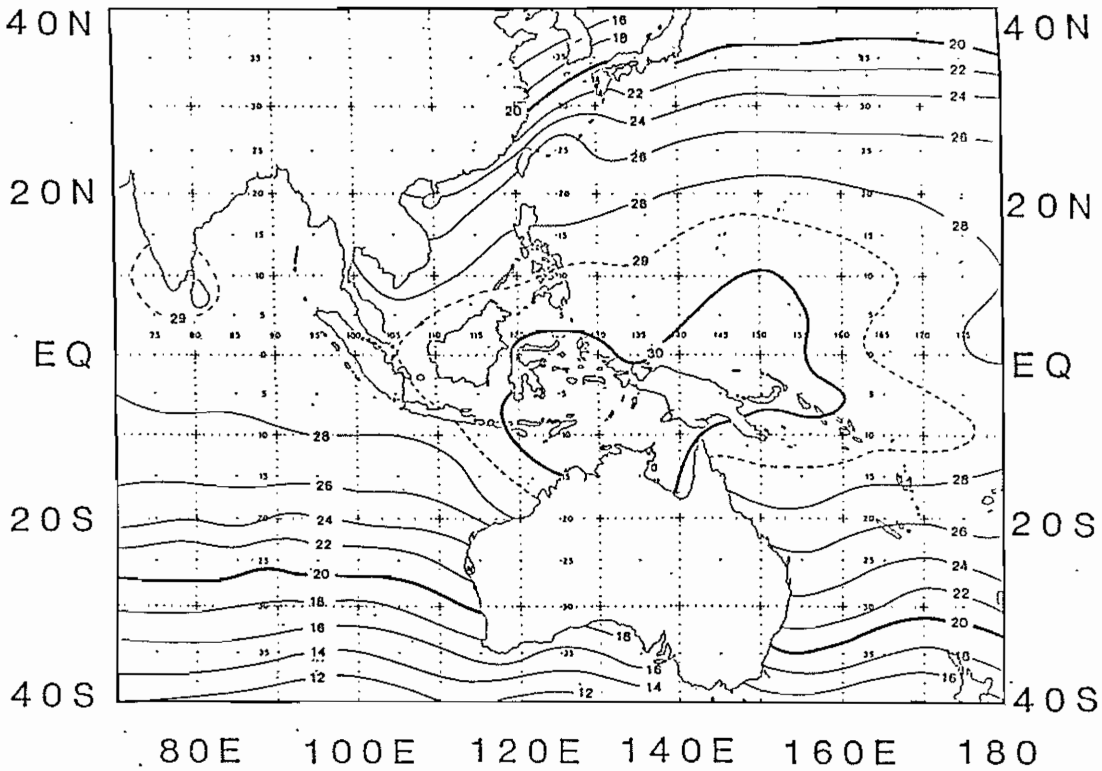


Fig. 4 MEAN SEA SURFACE TEMPERATURES, BASED ON WEEKLY DARWIN RMC ANALYSES AVERAGED OVER THE MONTH, NOVEMBER 1988. Isotherm interval 2° C.

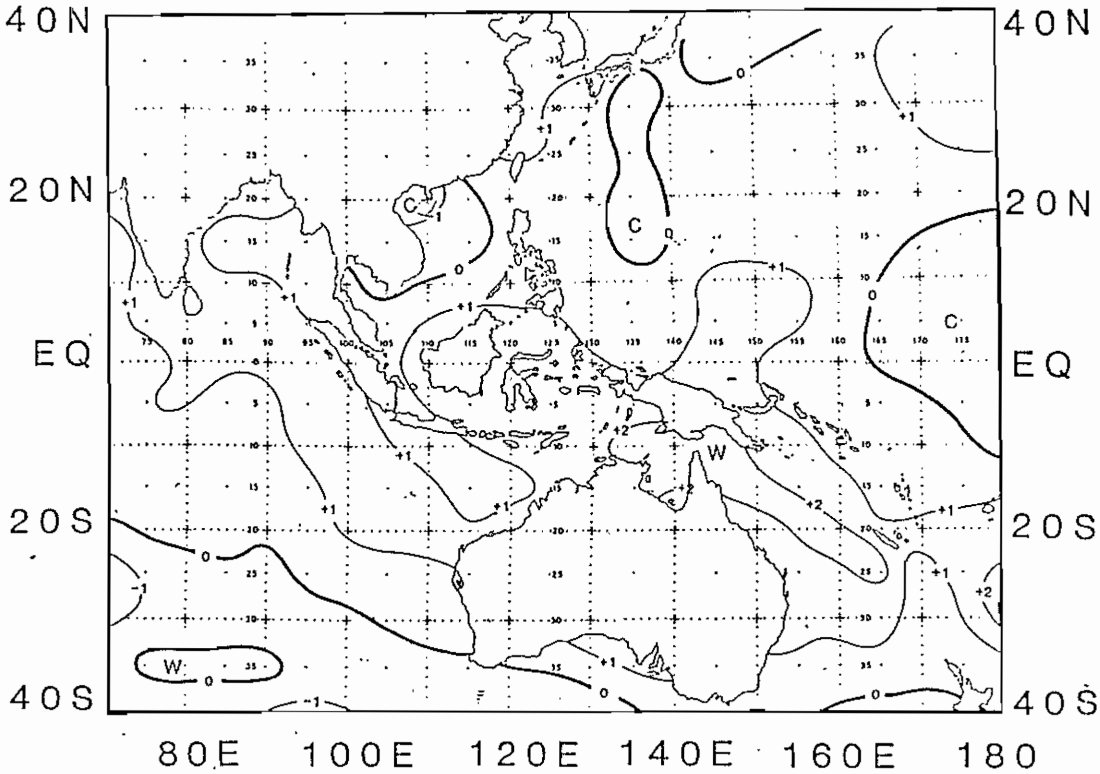


Fig. 5 SST ANOMALY CHART, BASED ON FIG. 4 AND THE CLIMATOLOGY OF REYNOLDS, NOAA REPORT NWS 31, 1983 Isotherm interval 1° C.

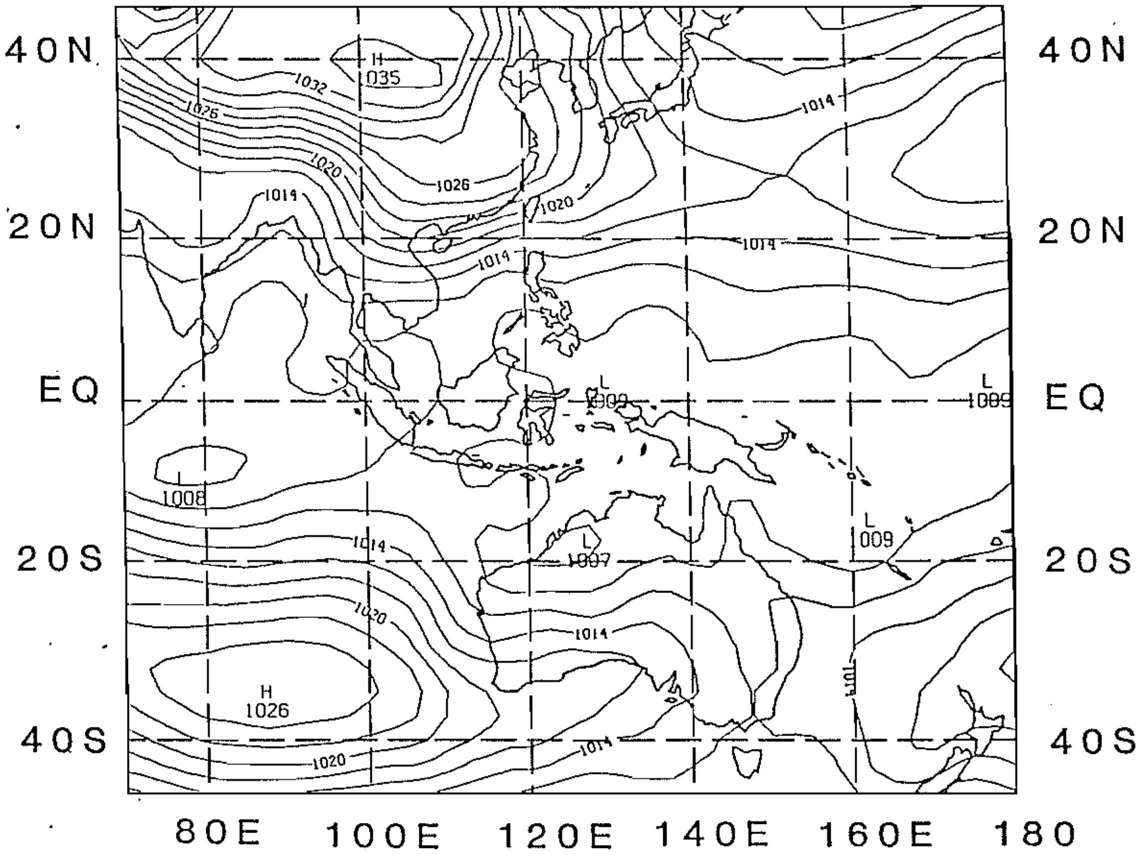


Fig. 6 MONTHLY MEAN MSL PRESSURE, NOVEMBER 1988
Isobar interval 2 hPa

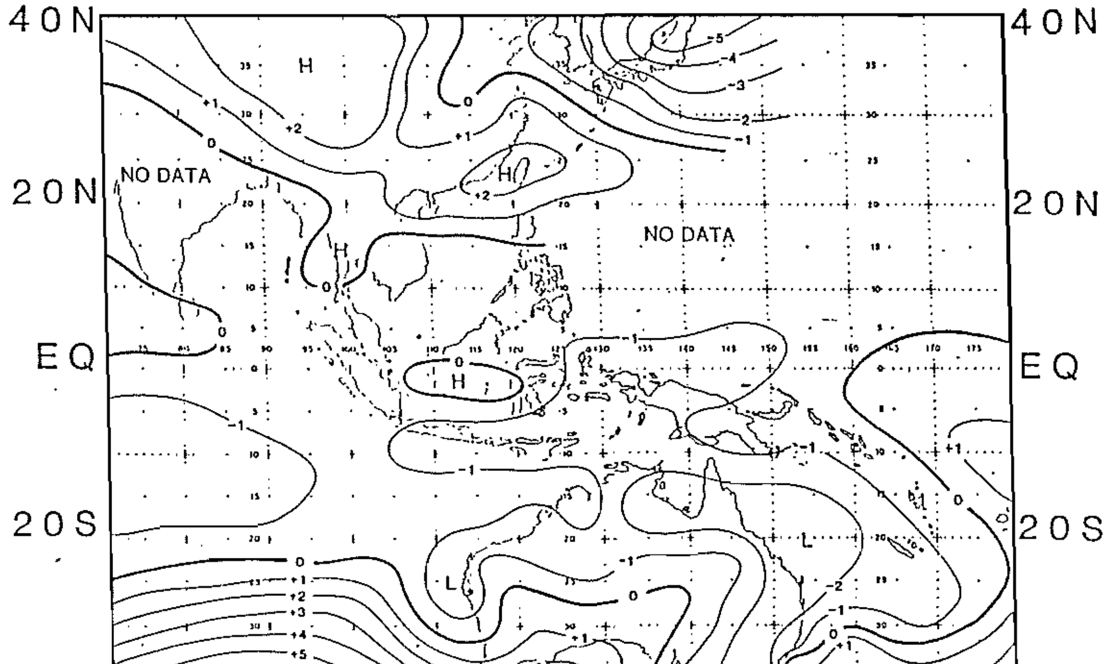


Fig. 7 MSL PRESSURE ANOMALY BASED ON CLIMAT MESSAGES
(AND MELBOURNE WMC DATA SOUTH OF 10^{o}S)
Contour interval 1 hPa.

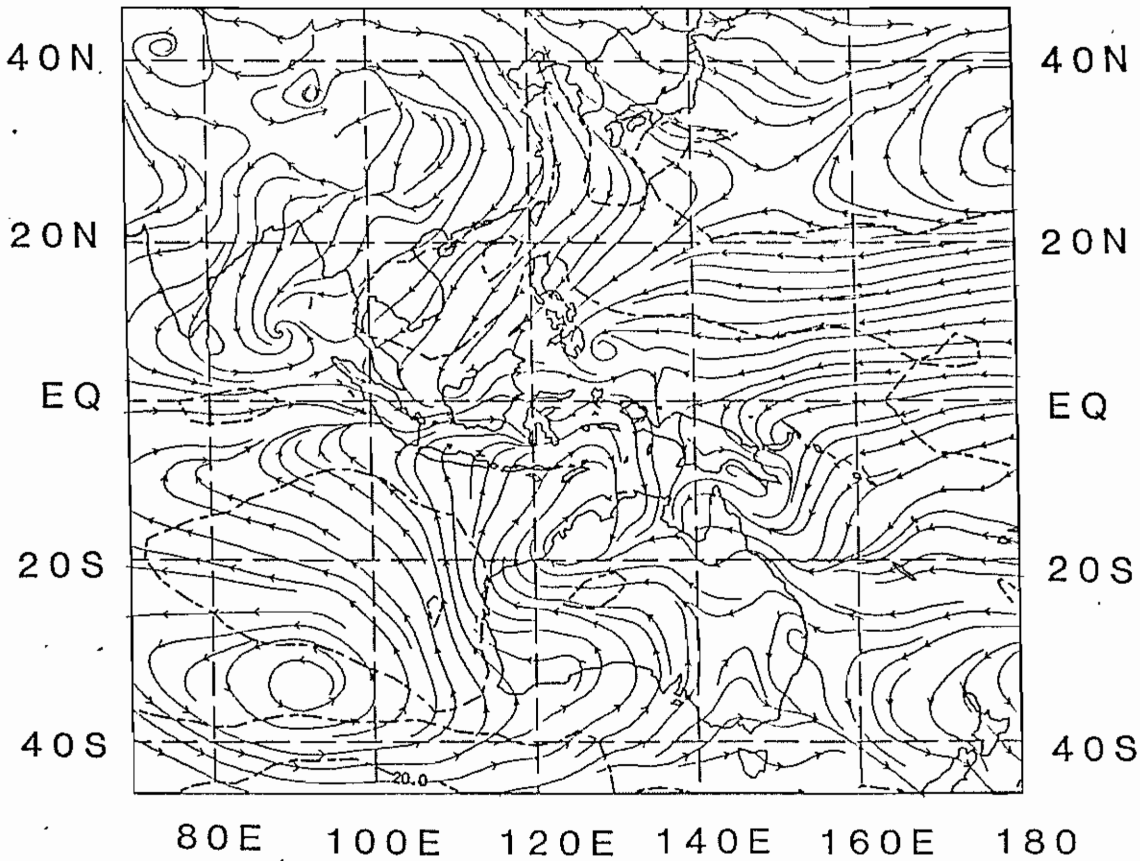


Fig. 8 950 hPa STREAMLINE ANALYSIS, NOVEMBER 1988
Isotachs (dashed line) at 10 knot intervals

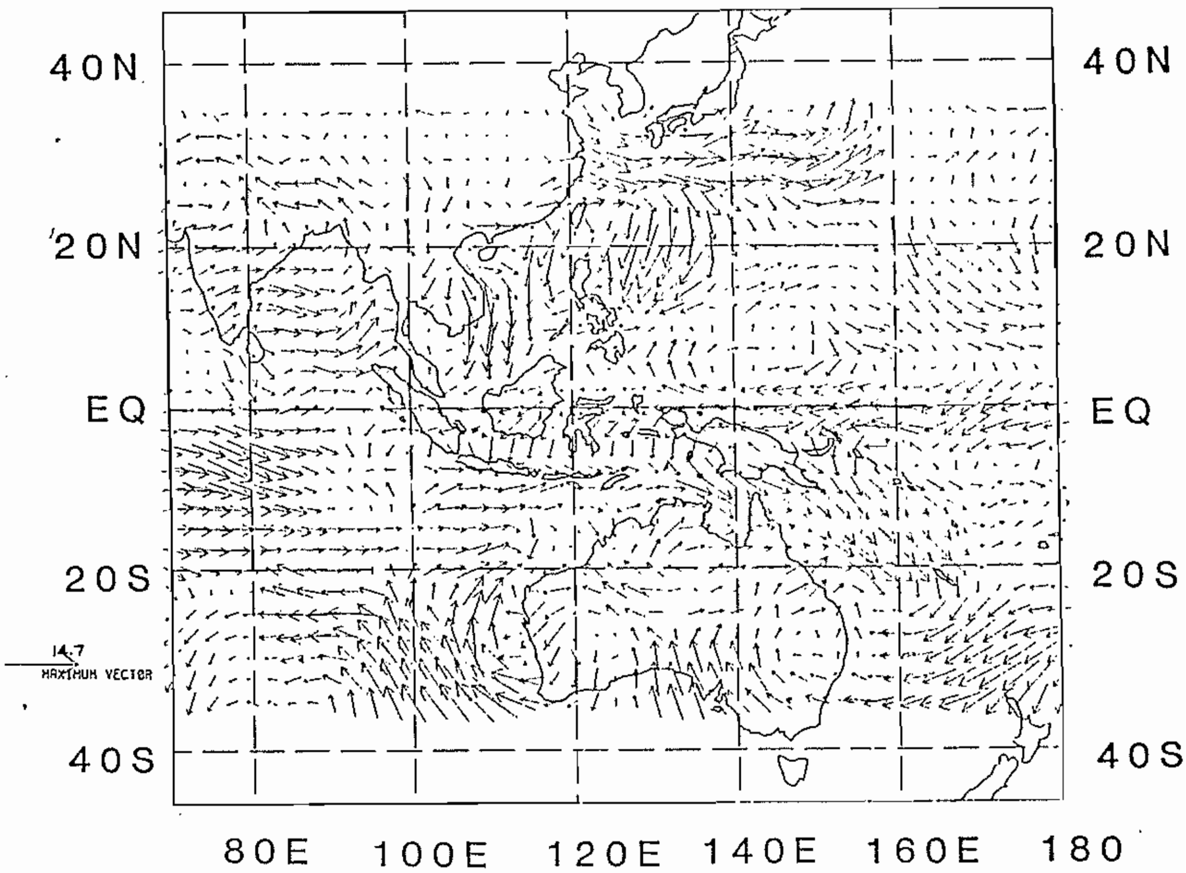


Fig. 9 950 hPa VECTOR WIND ANOMALY BASED ON FIG. 8
(Arrow length indicates magnitude)

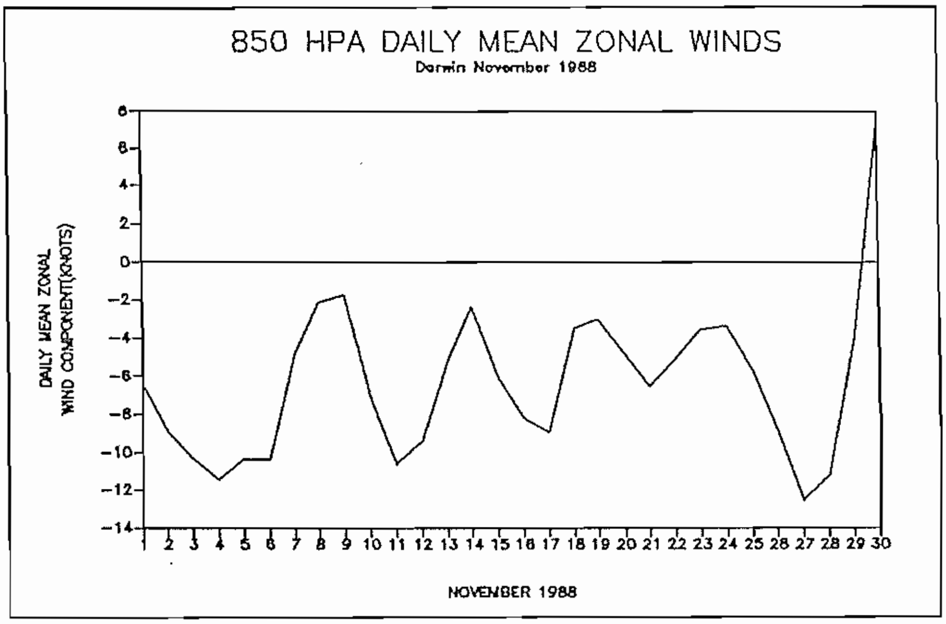
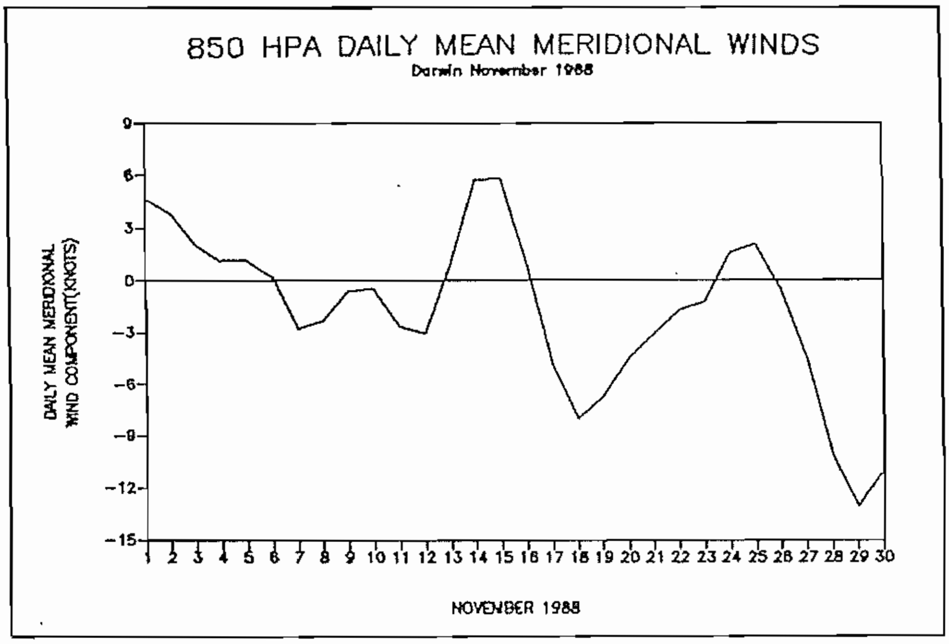
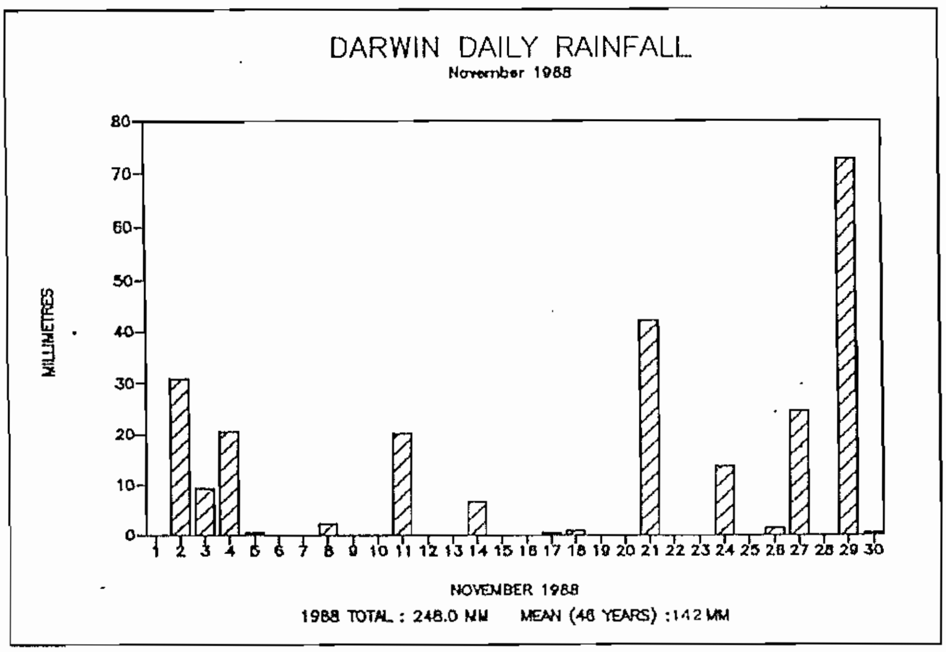


Fig.10 (a) DARWIN 850 hPa 3-DAY MEAN ZONAL WIND, NOVEMBER 1988



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



(c) DARWIN DAILY RAINFALL, NOVEMBER 1988

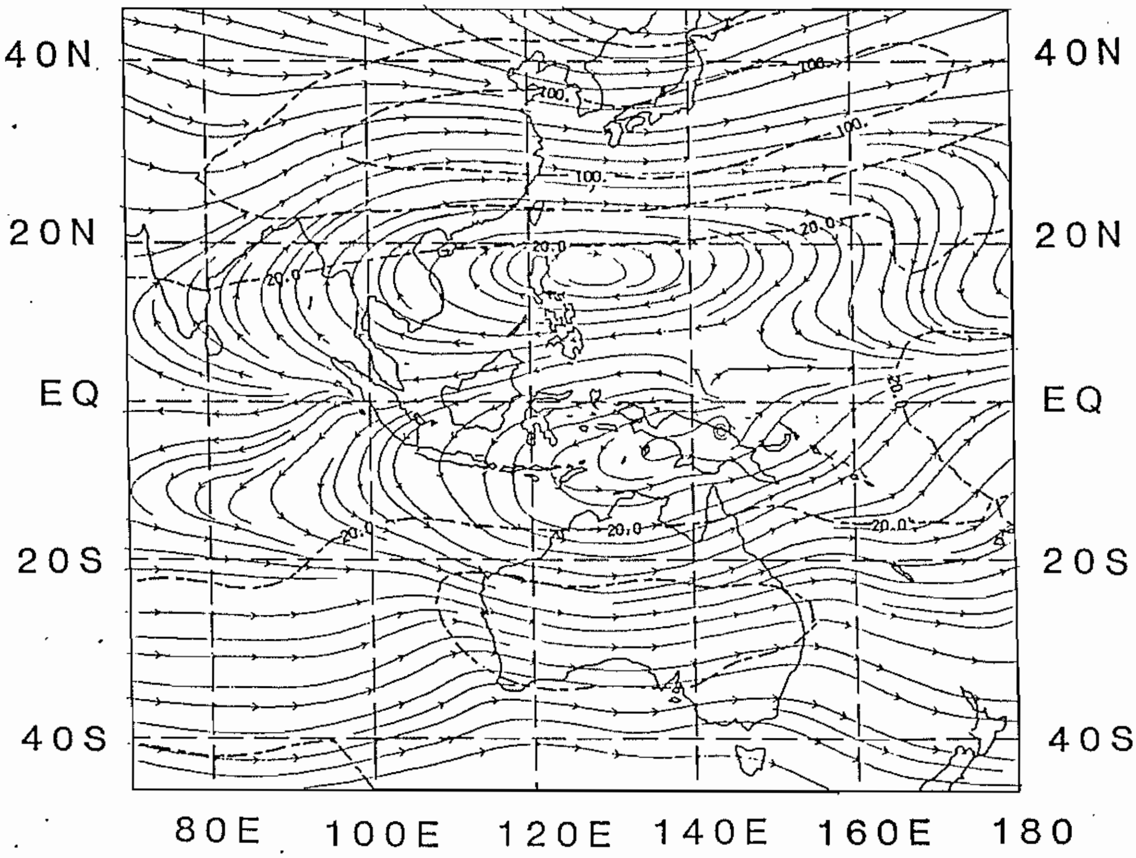


Fig.11 200 hPa STREAMLINE ANALYSIS, NOVEMBER 1988
Isotachs (dashed line) at 40 knot intervals.

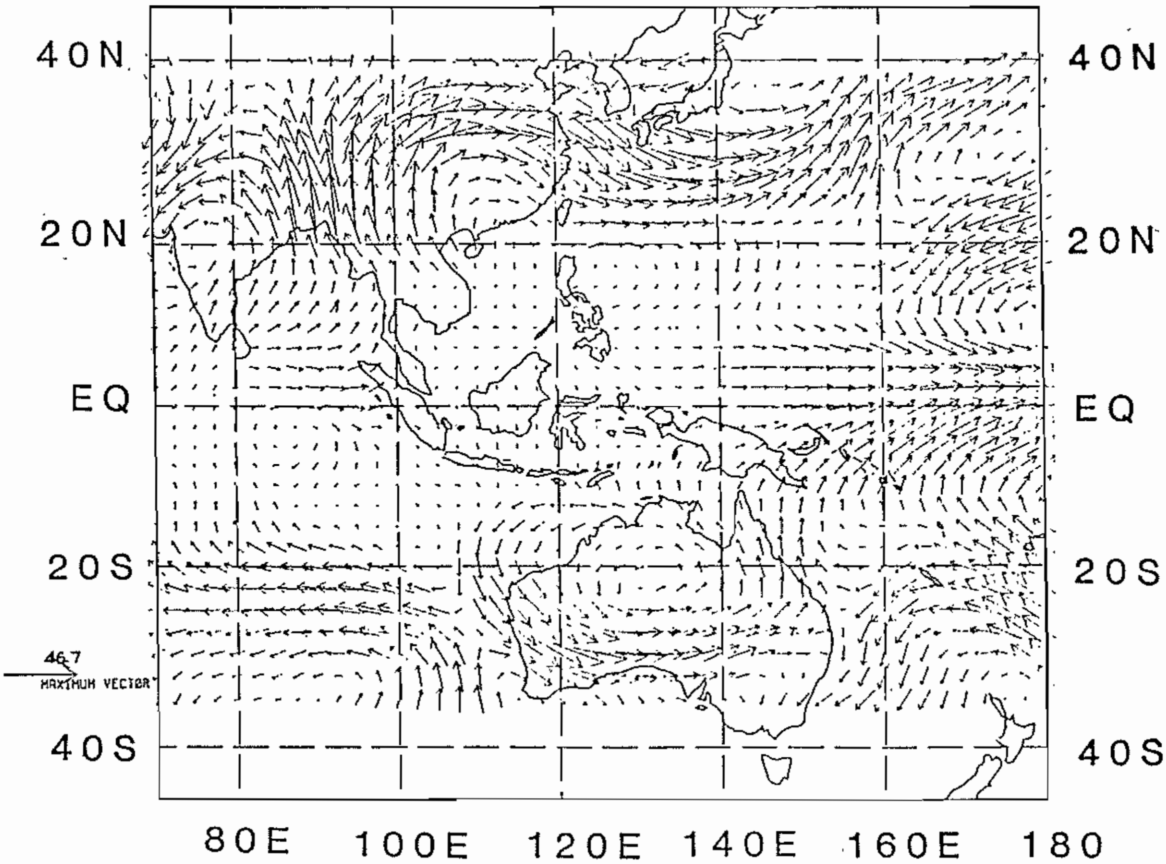


Fig.12 200 hPa VECTOR WIND ANOMALY BASED ON FIG. 11
(Arrow length indicates magnitude).

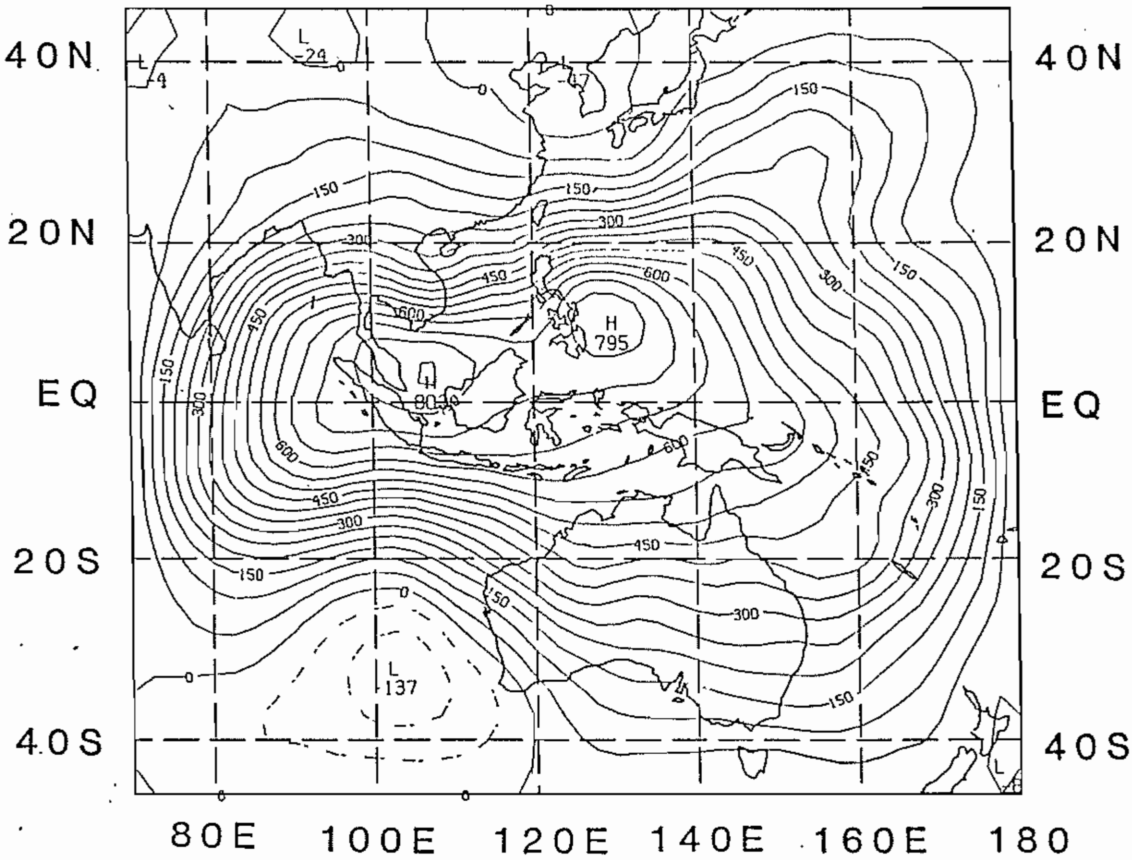


Fig.13 950 hPa VELOCITY POTENTIAL, NOVEMBER 1988
Contour interval 50 x 10^5 $m^2 s^{-1}$

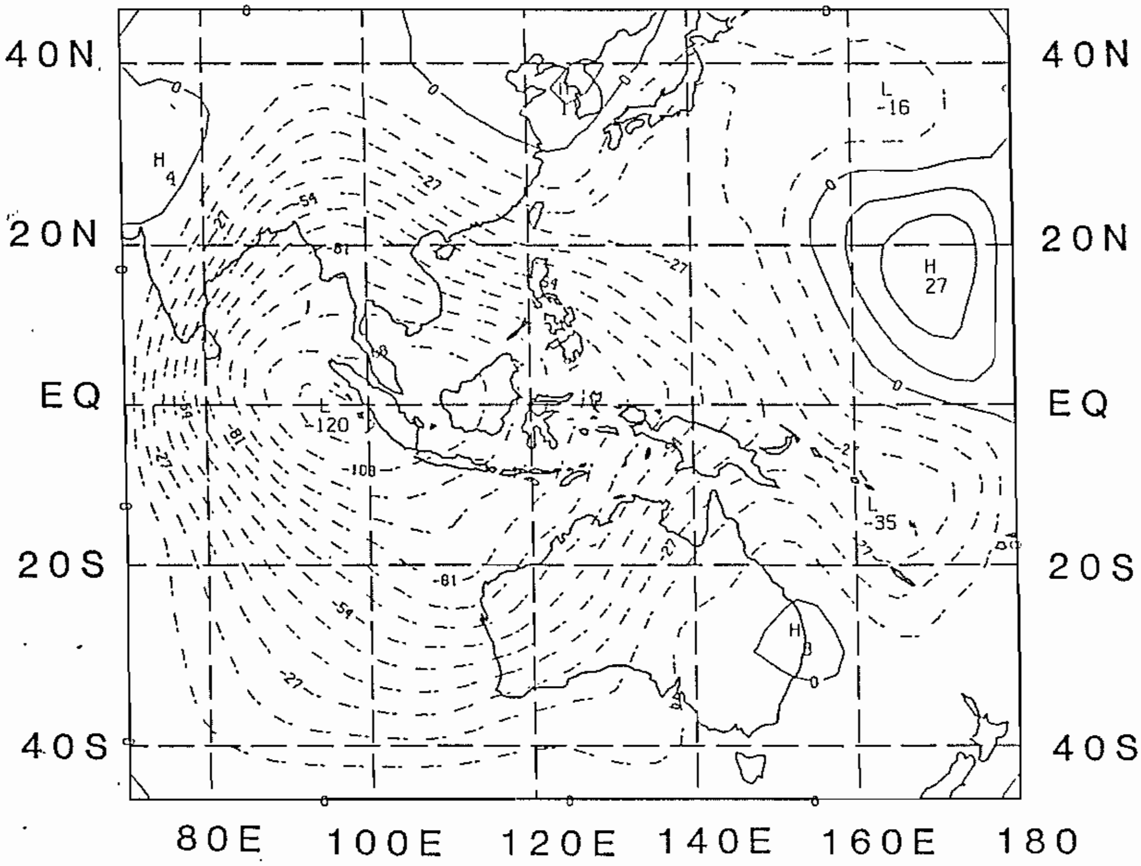


Fig.14 200 hPa VELOCITY POTENTIAL, NOVEMBER 1988
Contour interval 9 x 10^5 $m^2 s^{-1}$

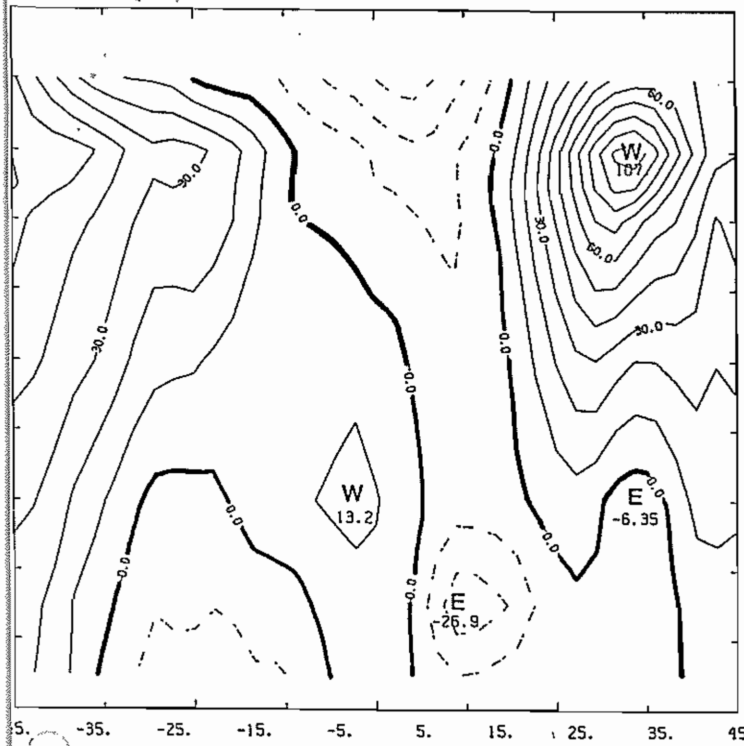


Fig.15

OSS-SECTION OF ZONAL WIND ALONG 100^{O}E, NOVEMBER 1988
otach interval 10 knots.

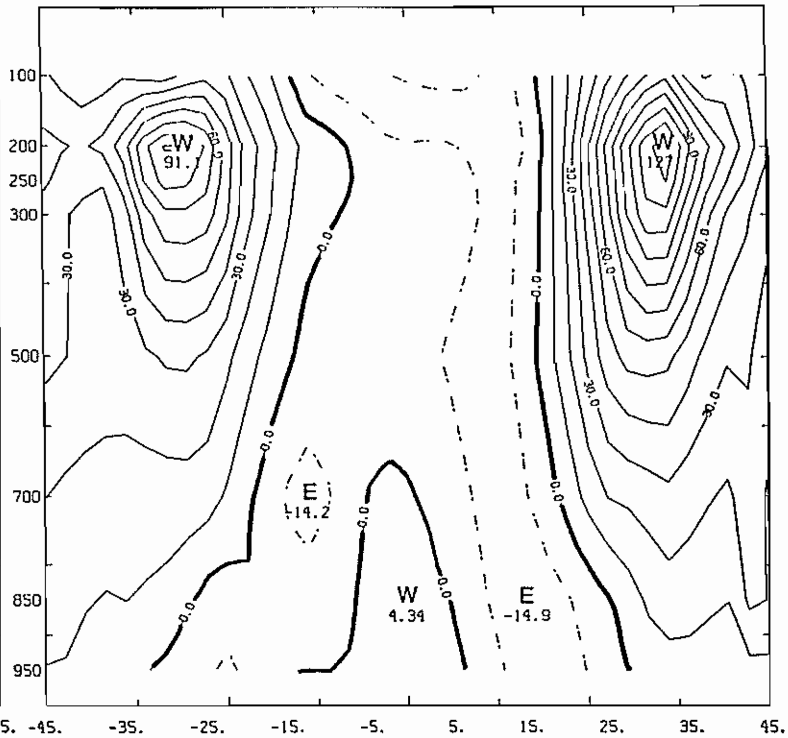


Fig.16

CROSS-SECTION OF ZONAL WIND ALONG 130^{O}E, NOVEMBER 1988
Isotach interval 10 knots.

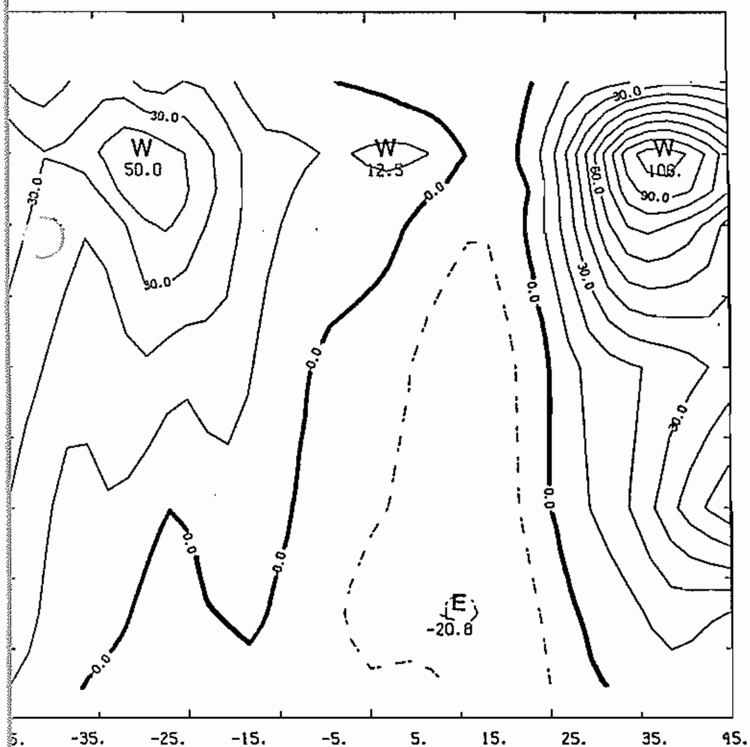


Fig.17

OSS-SECTION OF ZONAL WIND ALONG 160^{O} E, NOVEMBER 1988
otach interval 10 knots.

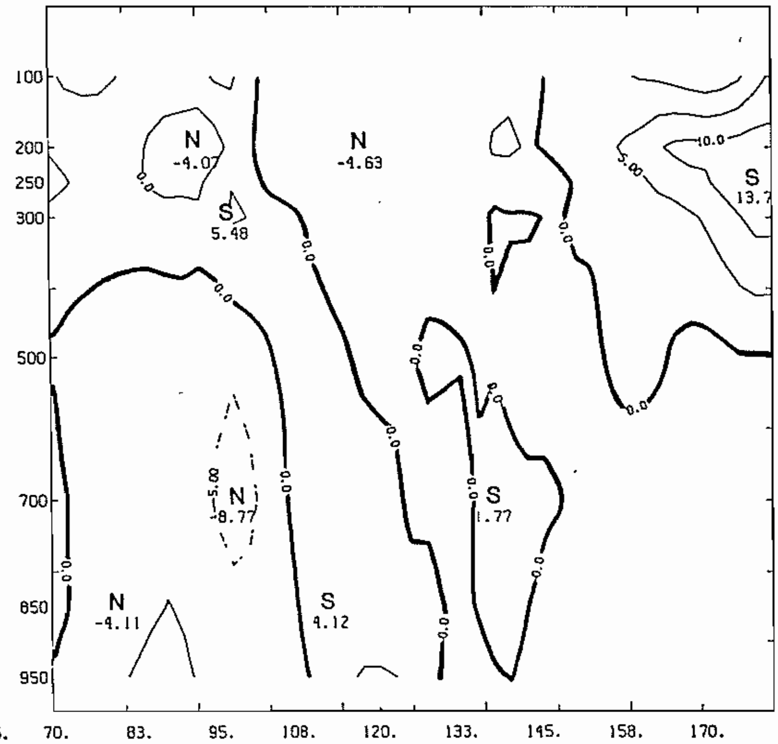


Fig.18

EQUATORIAL CROSS-SECTION OF MERIDIONAL WIND
BETWEEN 70^{O}E AND 180^{O}E, NOVEMBER 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(ΔP_{TAH} - ΔP_{DAR}) /σ

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	SPCZ	- South Pacific convergence zone
JMA	- Japan Meteorological Agency	STR	- Subtropical ridge
JTWC	- Joint Typhoon Warning Center, Pearl Harbour	TD	- Tropical depression
MT	- Monsoon trough	TC	- Tropical cyclone (see note 3(ii))
NET	- Near-equatorial trough	STC	- Severe tropical cyclone
PAGASA	- Philippine Atmospheric, Geophysical and Astronomical Services	CS	- Cyclonic storm
PNG	- Papua New Guinea	VSCS	- Very severe cyclonic storm
RSMC	- Darwin Regional Specialised Meteorological Centre (see note 1)	TS	- Tropical storm (generally used for TC in northern Hemisphere sector)
SCS	- South China Sea	TUTT	- tropical upper tropospheric trough

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

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	36.00 (Rest of the world)	122.80

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