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DARWIN TROPICAL DIAGNOSTIC STATEMENT

APRIL 1992

ISSUED BY DARWIN RSMC

SUMMARY

Anomalies consistent with a mature negative ENSO event continued in April. Classic El Niño anomaly patterns persisted in wind flow near the dateline and the SOI remained well below minus 1 standard deviation, though it increased by a moderate amount. The 30-60 day oscillation produced an active phase in the first half of the month, contributing to anomalies which, in some cases, swamped those due to El Niño. The pulse produced three tropical cyclones in the southern hemisphere, close to the April average. Apart from this, there was evidence of the seasonal withdrawal of the monsoon from the southern hemisphere, particularly at central longitudes. Large positive SST anomalies persisted in the central Pacific though signs continued that these were decreasing.

INDICES

1. Darwin mean MSL pressure, April 1992	:	1011.0 hPa
pressure anomaly (1882 - 1985 mean)	:	+1.5 hPa
2. Tahiti mean MSL pressure, April 1992	:	1011.1 hPa
pressure anomaly	:	-0.8 hPa
3. Troup's Southern Oscillation Index	:	-17
5-month mean (centred upon February)	:	-19

4. Time series of Troup's SOI :

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
1990	-2	-18	-8	-1	+14	0	+5	-4	-7	-1	-5	-4
1991	+4	0	-10	-12	-18	-6	-2	-7	-16	-13	-7	-18
1992	-26	-10	-22	-17								

Figure 1 gives graphs of the monthly SOI and its five month running mean for the past ten years.

The magnitudes of the respective pressure anomalies (positive at Darwin, negative at Tahiti) both decreased, resulting in a moderate increase in the SOI from March; the 5-month mean SOI was fractionally lower. Other indicators generally remained consistent with a mature El Niño phase;

TROPICAL CYCLONES [Figs. 2(a), (b), (c)]

Three tropical cyclones were generated within the RSMC area during April, all in the southern hemisphere. This is close to JTWC Guam's 11-year mean of 3.1 for the combined southern Indian and Pacific basins. Two of the TC developed in association with an active phase of the 30-60 day oscillation early in the second week. An additional TD, which occurred in the southwest Pacific near New Caledonia in this period, did not intensify, though gale warnings were issued by both Nadi and Noumea offices. A third TC was more typical of El Niño conditions, developing near the dateline.

Severe TC Neville
The monsoon trough became active to the north of Australia during the first week and an embedded depression was evident near the Tanimbar Islands by the 3rd, drifting slowly east-southeast over the next 3 days. With a solid east-southeast gradient to the south and favourable upper outflow, it deepened more rapidly from the 6th, following a moderate cross-equatorial surge through east Indonesia; minimal tropical cyclone status was reached early on the 7th. A developing ridge over southern Australia caused Neville to turn westward, just off the north coast. Despite its proximity to land it then intensified quickly under well-developed upper outflow, but remained very compact. Moving away from land, it became very intense and its motion more erratic as the influence of the subtropical ridge eased. After reaching maximum intensity on the 9th it encountered persistent upper level shear, ultimately dissipating over water. Neville brought heavy rain and caused some tree and property damage about the northwest coast and islands of Australia's Northern Territory.

Note. The track of Neville, shown in Fig. 2(a), is based on the official (post-analysed) version from Darwin TCWC.

Severe TC Jane/Irna
At the end of the first week a depression was analysed in a developing monsoon trough southwest of Sumatra. TC genesis occurred following a moderate southeasterly surge under a favourably placed upper anticyclone. The cyclone tracked generally south toward a weakness in the low to mid-level subtropical ridge. This motion was arrested during the 11th when the mid-level ridge to the south began to intensify. Jane then accelerated westward, increasing upper shear causing temporary weakening. After peaking on the 15th, the cyclone tracked around the periphery of the ridge. It then interacted with an upper trough which produced an abrupt change in the path, and sheared the system, causing it to weaken and become extratropical. Jane was renamed Irna on exiting the Perth TCWC area.

TC Innis
A late-season monsoon trough was active east of Papua New Guinea (PNG) for much of April. Both cross-equatorial and southeasterly surges occurred in the last week and a depression had formed near the dateline by the 27th. An upper ridge gradually moved over the system and it reached TC intensity on the morning of the 29th. A strong ridge to the south produced westward motion initially. This ridge was soon vanquished by an eastward-moving trough which caused Innis to recurve to the southeast, and weaken due to increasing vertical shear early in May. It passed to the east of the Vanuatu island chain and is believed not to have caused significant damage.

SEA SURFACE TEMPERATURE [Figs. 3 and 4]

Comparison with March charts shows several changes within the RSMC area. The seasonal warming trend is evident in the northern hemisphere and cooling in the south. The area of above 30°C temperatures about the eastern Indian Ocean and western Indonesia expanded considerably.

Warm anomalies persisted near Japan and about Australia and the tropics generally; the anomaly was strengthened over the eastern tropical south Indian Ocean. Weak negative anomalies evident in March in the southwest Pacific contracted to a small area about northeast Papua New Guinea. The cool anomaly in the southern Indian Ocean near 80°-90°E was weaker than in March but has eroded some of the warm anomaly closer to the southwest Western Australian coast. The cool anomaly in the northwest Pacific was similar to the February pattern, after an apparent warming in March.

Operational 10-day mean charts from JMA Tokyo appear to show an eastward translation of the warmest anomalies in the equatorial Pacific and a slight weakening of the anomaly at its westward extremity near the dateline.

MSL PRESSURE AND GRADIENT LEVEL (950 HPA) FLOW [Figs. 5, 6, 7 and 8]

The charts depict active monsoonal conditions eastward from PNG and, to a lesser extent, in the southern Indian Ocean. Both these areas exhibit the influence of TCs. The monsoon essentially withdrew from north Australia and Indonesia during April although a weak northerly cross-equatorial anomaly is evident near 120°E. The continuing positive anomaly about much of the tropics swamped any reflection of TC Neville, a compact system. Other anomalies typical of the El Niño phase persisted, notably the westerlies near the equator east of PNG.

Changes in the south from March include the strengthening and extension toward New Zealand of the STR. This produced enhanced southeast to easterly flow in the Coral and Arafura Seas and southwest Pacific. In the southern Indian Ocean, cyclonic and negative pressure anomalies were similar to March, though centred further north.

Most of the subtropical part of the northern hemisphere sector was affected by below average pressure. This was particularly noticeable about Japan and the northwest Pacific, which experienced a number of intense depressions; the ridge over China was under-developed also. The north Pacific STR was located well south of its mean latitude, resulting in the extensive field of southwesterly anomalies. Stationary fronts were a feature of the northwest Pacific adjacent to south China, Taiwan and Japan.

Over the India/Bay of Bengal region the pressure and wind anomaly fields are not strongly coupled. Although the Bay anticyclone was above normal pressure, so too were pressures in the Indian heat trough, so vorticity and convergence associated with the latter were not enhanced. Pressures became lower toward the end of the month, with some increase in convection evident.

850 hPa WIND COMPONENTS AND DAILY RAINFALL AT DARWIN [Figs. 9(a), (b)]

The long-term mean flow reflects the withdrawal of the monsoon from the north Australian region, with a gradually increasing easterly component due to the consolidation of the STR over southern Australia.

After Severe TC Neville passed close to the north of Darwin in the second week, both the meridional and zonal curves reflect approximately average conditions. Easterlies were generally a little above the mean, consistent with above normal pressures associated with the ENSO phase.

Darwin rainfall was well above average for the month, and was almost entirely associated with an enhanced phase of the 30-60 day oscillation, culminating in the close passage of Neville. The highest daily falls were received after its passage, in feeder bands on its eastern flank.

CROSS-EQUATORIAL INTERACTION [Fig. 10]

The main change from March is the appearance of a number of southerly cross-equatorial channels at low levels - typical of the seasonal trend. Despite this, significant northerly channels were still analysed at 80°-90°E, 115°-130°E and east of 155°E, all regions where moderate cross-equatorial surges were implicated in TC genesis events. The strongest northerly component was in the easternmost region, followed by the Indian Ocean, in agreement with inferences from the 950 hPa and MSLP patterns. Note however that the 700 hPa northerly maximum at the dateline is thought to be spurious, possibly caused by input of insufficient bogus observations to TAS in the data-sparse Pacific.

At high levels, southerly flow was well developed at most longitudes, and generally above the long-term mean, perhaps indicating a vigorous return branch of the Hadley circulation, despite the phase of ENSO. This flow is attributed mainly to the influence of the 30-60 day event. See also comments in the next section.

UPPER LEVEL FLOW [Figs. 11 and 12]

The 200 hPa streamline pattern shows well-developed cross-equatorial flow from the southern hemisphere STR, although divergent flow is only obvious from the eastern Indian Ocean and southwest Pacific areas. The latter region still shows the characteristic El Niño pattern of double anticyclonic anomaly fields east of 160°E. At central longitudes most anomalies along the equator are southwesterly. Comparison with the climatological field in this area (essentially easterly) shows that many of these anomalies imply a weaker than average total wind, despite the increased cross-equatorial components noted in the previous section.

Also notable is the extensive field of westerly anomalies lying from India to the northwest Pacific. This appears to stem from the location of the northern hemisphere STR, which lay equatorward of its April mean position. In the southern hemisphere two major mid-latitude troughs were analysed, with evidence of blocking about the southeastern Australia/Tasman region. Northwesterly flow over the southwest Pacific was enhanced by this as well as the strong STR to the north.

VELOCITY POTENTIAL [Figs. 13, 14, 15(a), 16(a)]

Strongest tropical uplift, as implied by 200 hPa divergence and 950 hPa convergence, is inferred over PNG and the southwest Pacific. Major low level convergence and upper divergence are analysed in the eastern Indian Ocean southwest of Java also, but the patterns are less obviously coupled in this region. Also note significant low-level convergence associated with the India/Indo China heat trough and along an axis extending east-northeast into the northwest Pacific from north Vietnam. The latter also has some upper support, though the respective convergent and divergent axes are not coincident. Satellite imagery shows that this region experienced persistent cloud bands associated with extended stationary fronts during the month.

Both time-longitude series show a strong pulse of the Madden-Julian oscillation across the RSMC area, with a period between about 40 and 50 days, reaching the dateline by the third week. Upper divergence was enhanced at mid longitudes for almost 2 weeks encompassing the TC Neville event. Some seasonal increase in upper divergence is evident in the northern series.

RAINFALL AND CLOUD COVER [Figs. 15(b), 16(b), 17 and 18]

Increased convection associated with the 30-60 day event is obvious in the equatorial and southern time-longitude series, in good phase agreement with velocity potential series. Breaks in the OLR minima indicate that the convection was by no means continuous across the RSMC region. This is due no doubt to ENSO considerations as well as the lateness of the season in the southern hemisphere. The westward motion of TC Neville can be discerned.

Although low quintile values persisted over significant areas of the tropics, due to continued suppression by El Niño of the Walker circulation, some exceptions are apparent. They include a few high values about north Australia, PNG and the southwest Pacific, mostly the result of enhanced convection in the first half of the month, and particularly TC activity. Some high values were reported from Western Australia, probably originating from northwest cloud bands, which were active during April; note the anomalous troughing at 200 hPa (Figs. 11, 12).

Much of southern Asia received low rainfall; high pressures have been noted over India. However there is evidence of increased falls on an axis extending east northeast from north Vietnam, where some enhanced tropical uplift is diagnosed.

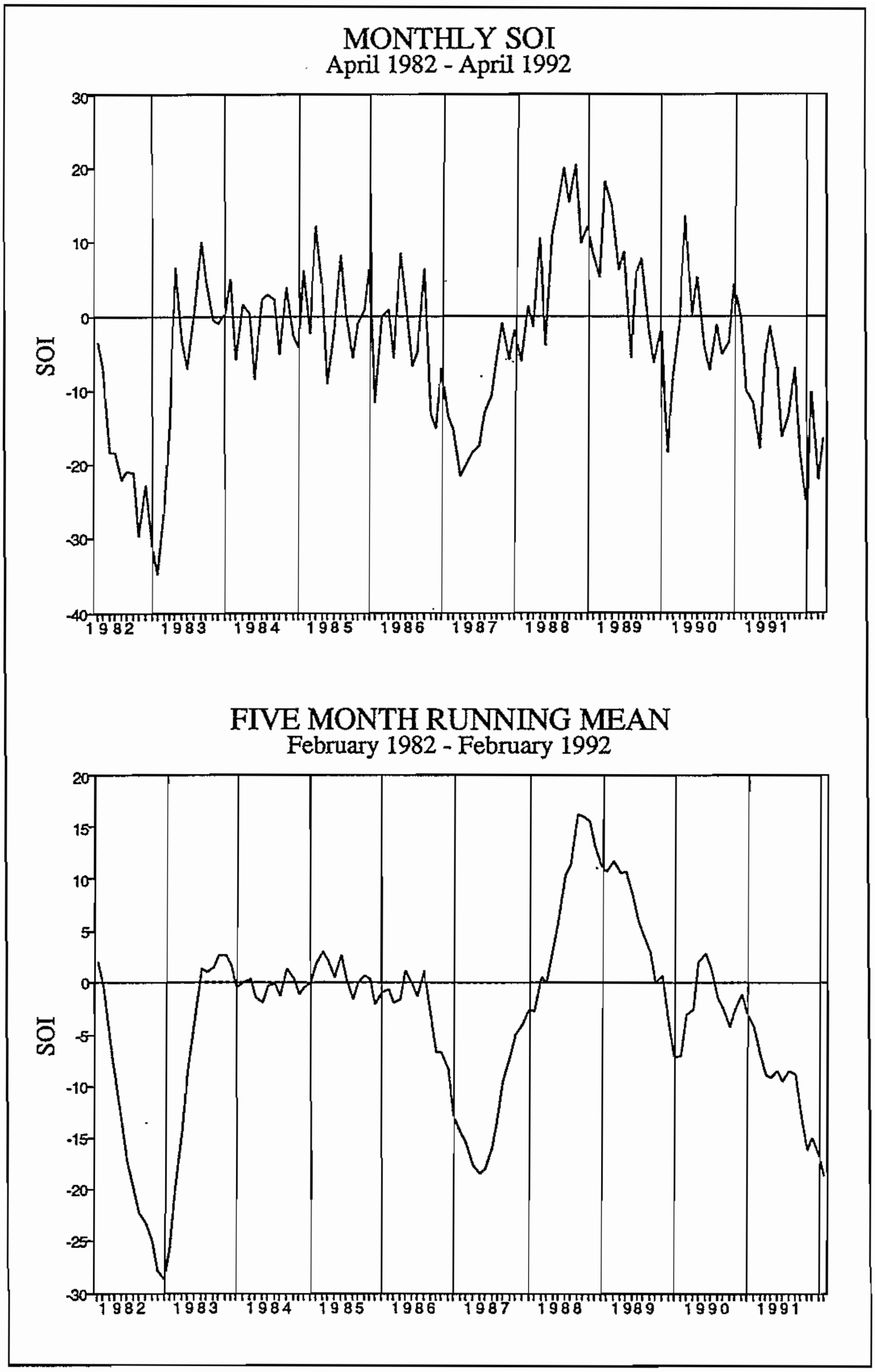


Fig.1 SOUTHERN OSCILLATION INDEX 1982 - 1992.
Monthly SOI and 5-month running mean SOI.

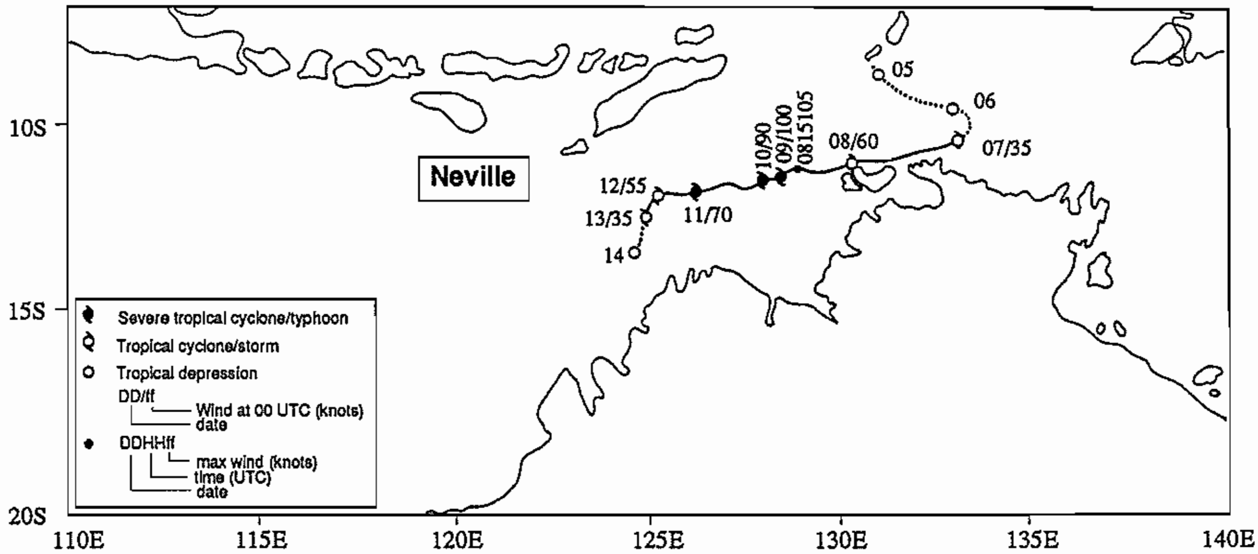


Fig.2(a) OFFICIAL TRACK OF CYCLONE NEVILLE, APRIL 1992

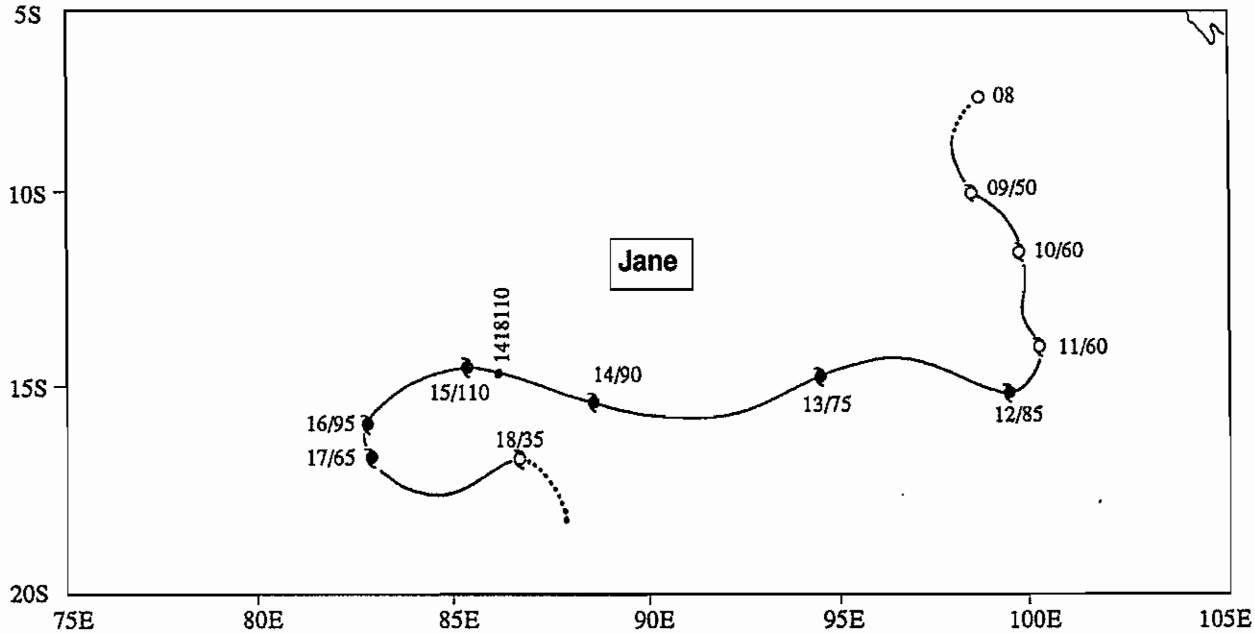


Fig.2(b) UNOFFICIAL TRACK OF CYCLONE JANE, APRIL 1992

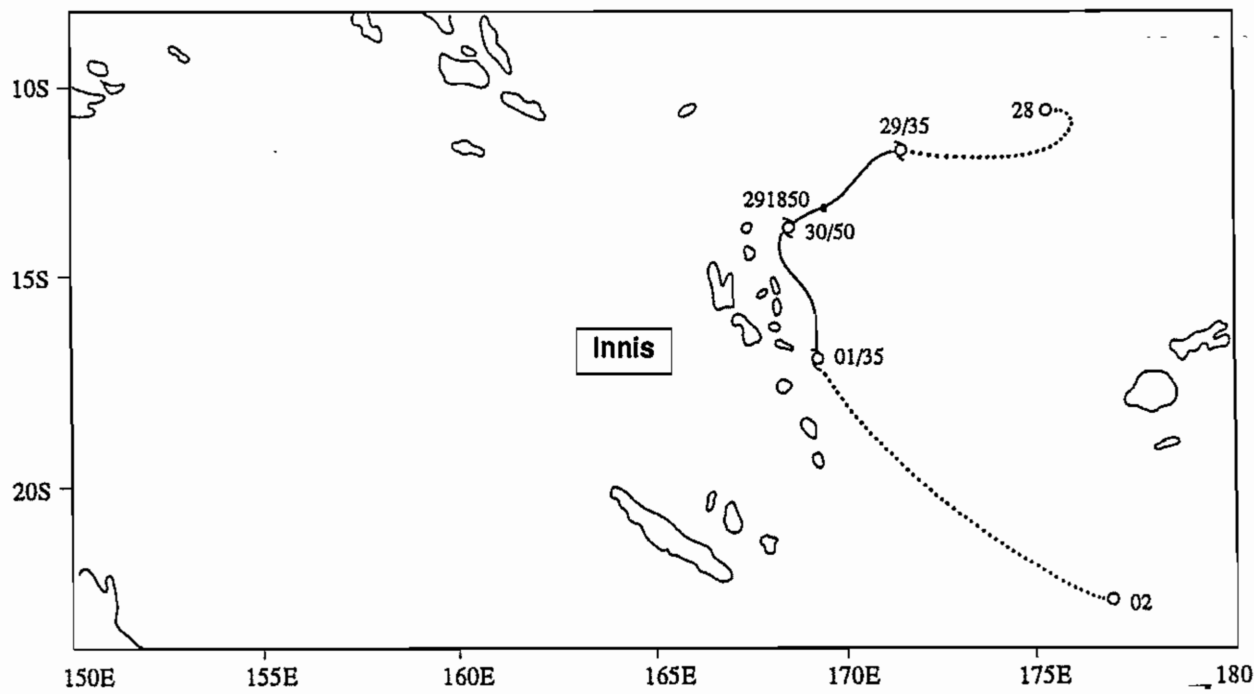


Fig.2(c) UNOFFICIAL TRACK OF CYCLONE INNIS, APRIL 1992

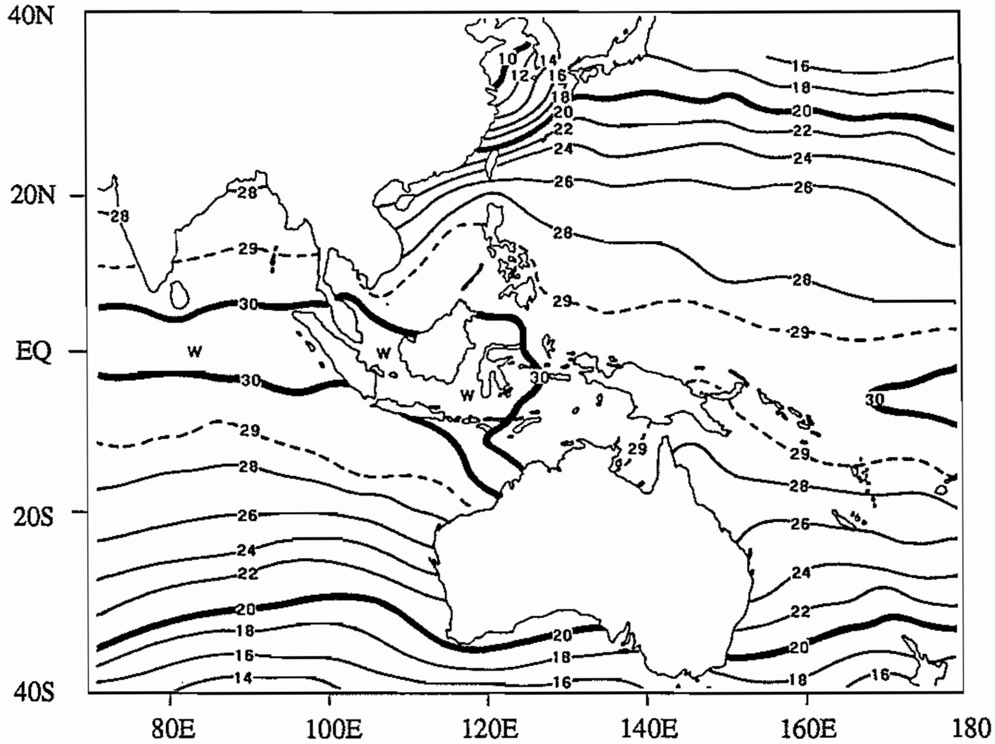


Fig.3 MEAN SEA SURFACE TEMPERATURE, APRIL 1992, based on weekly Darwin RSMC analyses averaged over the month.
Isotherm interval 2°C.

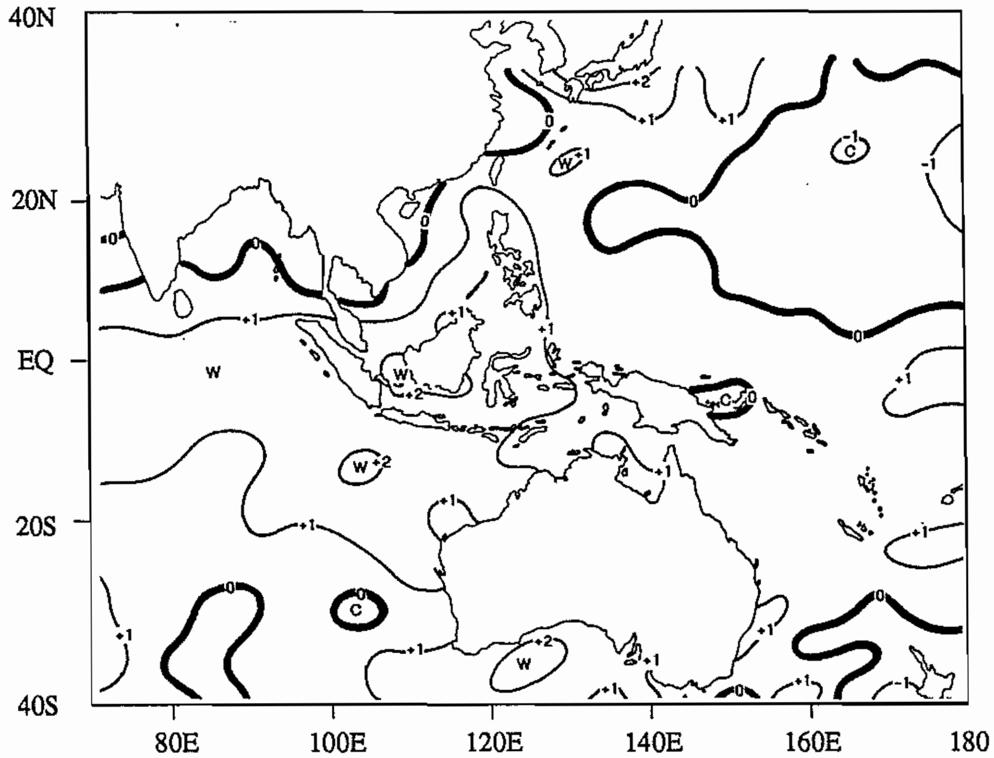


Fig.4 SST ANOMALY, based on Fig.3 and the climatology of Reynolds (NOAA Report NWS 31, 1983).
Isotherm interval 1°C.

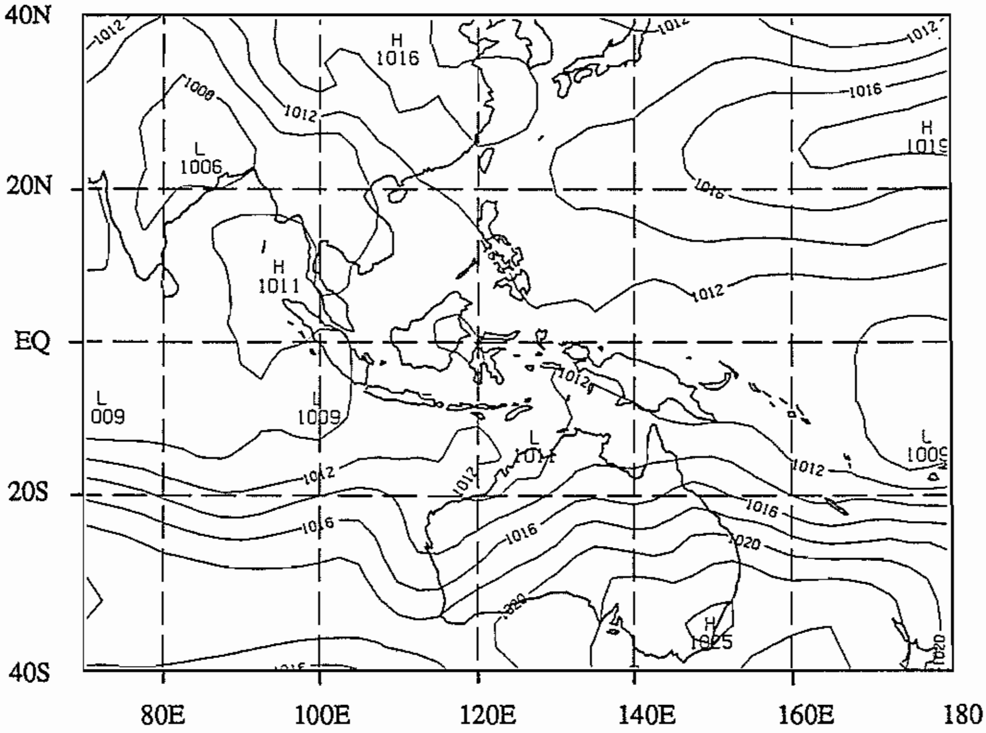


Fig.5 MEAN MSL PRESSURE, APRIL 1992.
Isobar interval 2 hPa.

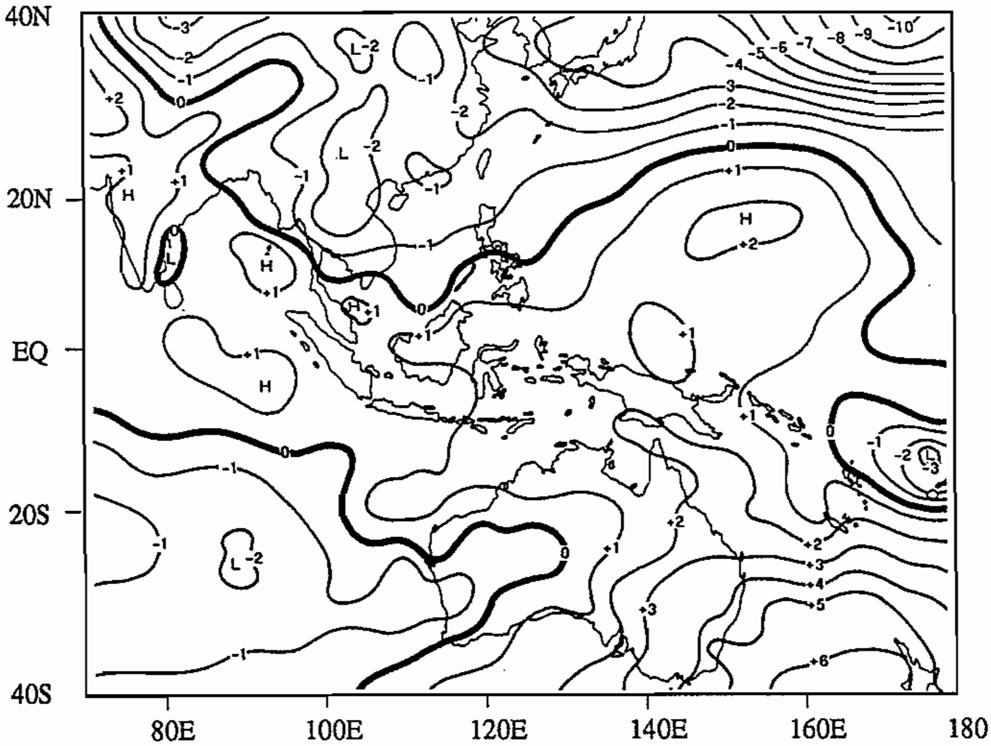


Fig.6 MSL PRESSURE ANOMALY, APRIL 1992, based on CLIMAT messages, and Fig.5 with 6-year climatology.
Contour interval 1 hPa.

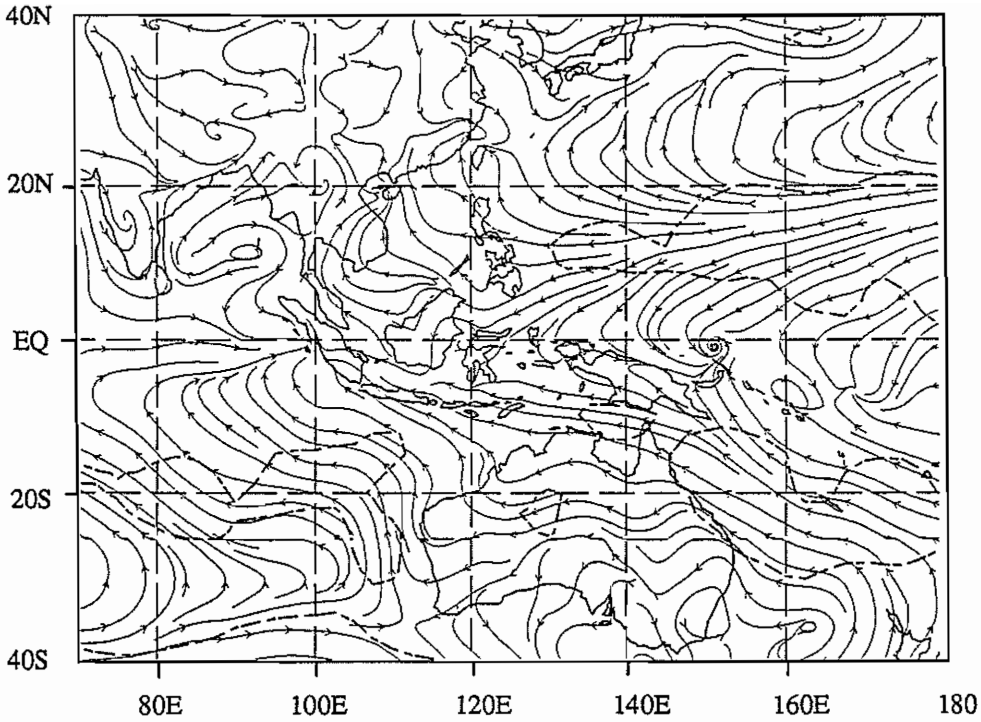


Fig.7 950 hPa MEAN STREAMLINE ANALYSIS, APRIL 1992.
Isotachs (dashed line) at 10 knot intervals.

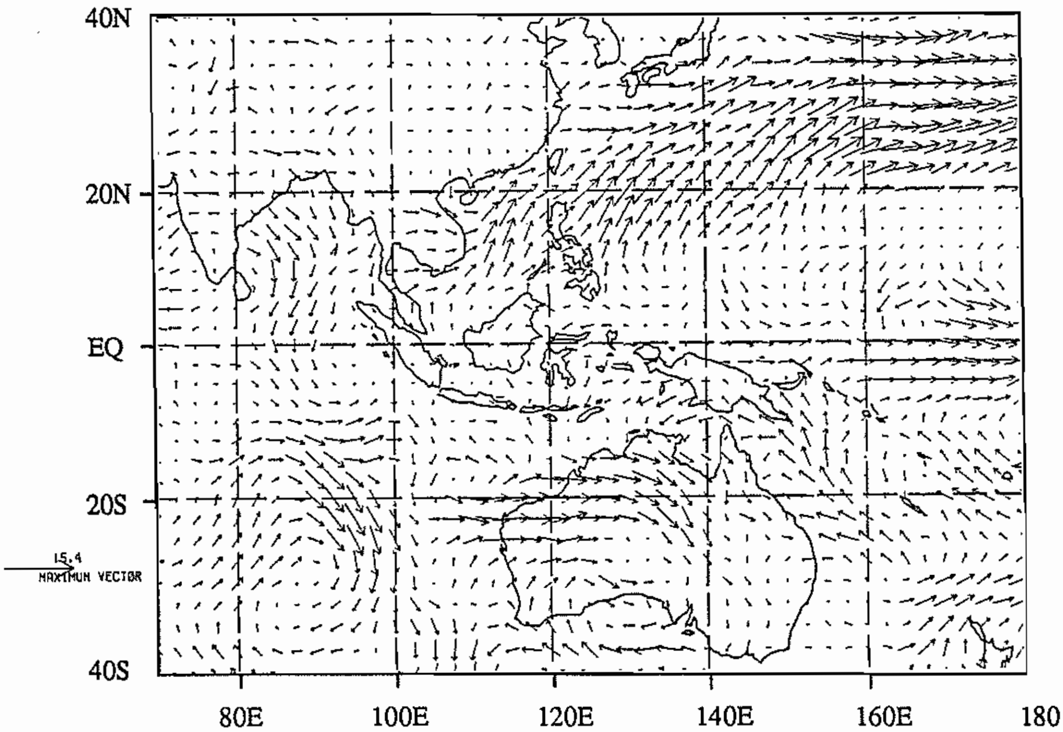


Fig.8 950 hPa WIND ANOMALY, based on Fig.7.
Isotachs (dashed line) at 10 knot intervals.

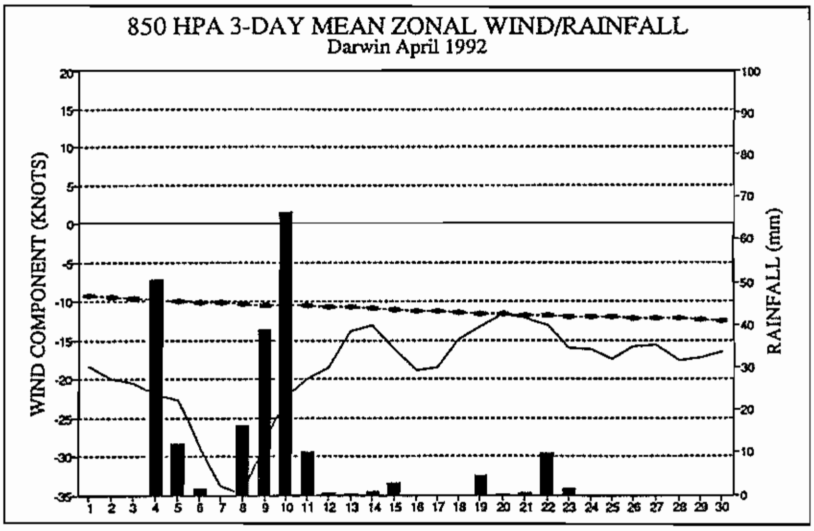
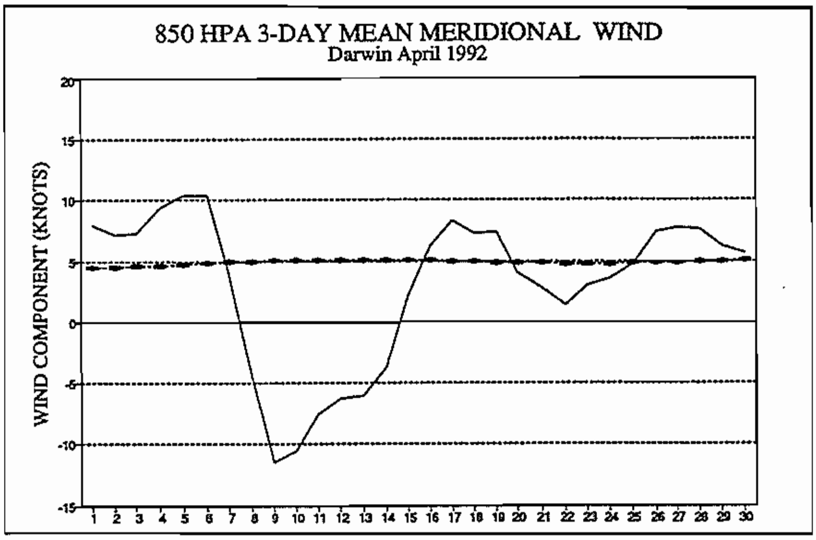


Fig.9(a) DARWIN 850 hPa 3-DAY SYMMETRICAL MEAN ZONAL WIND, APRIL 1992.
Dashed line represents the mean seasonal cycle.



(b) DARWIN 850 hPa 3-DAY SYMMETRICAL MEAN MERIDIONAL WIND, APRIL 1992.
Dashed line represents the mean seasonal cycle.

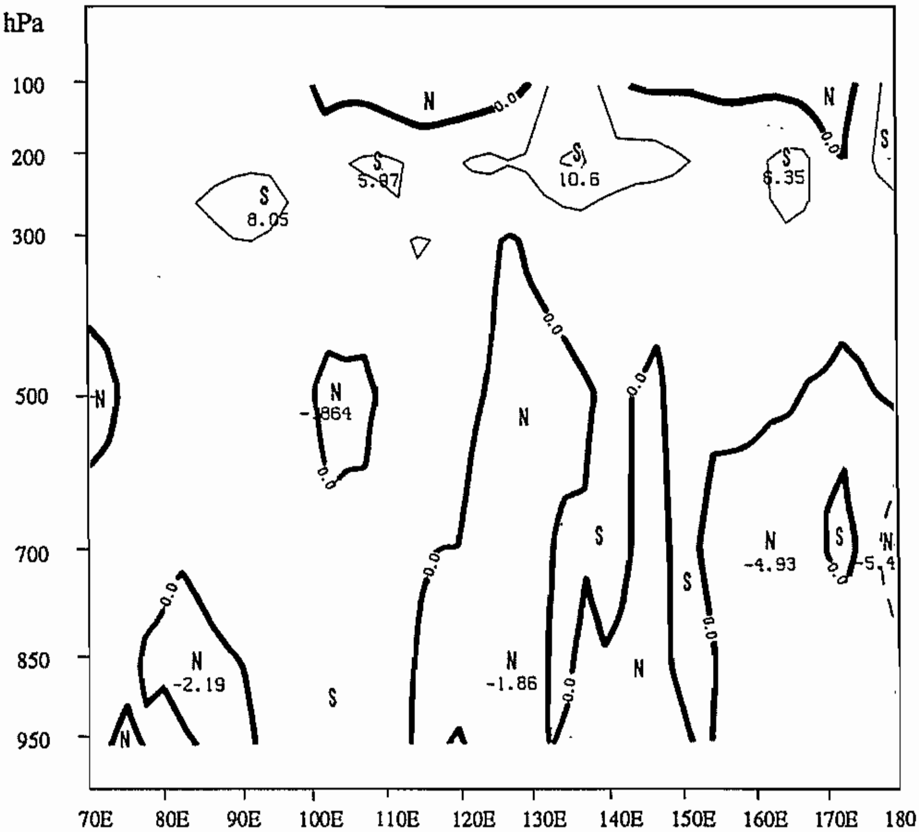


Fig.10 EQUATORIAL CROSS-SECTION OF MERIDIONAL WIND, APRIL 1992.
Isotachs at 5 knot intervals.

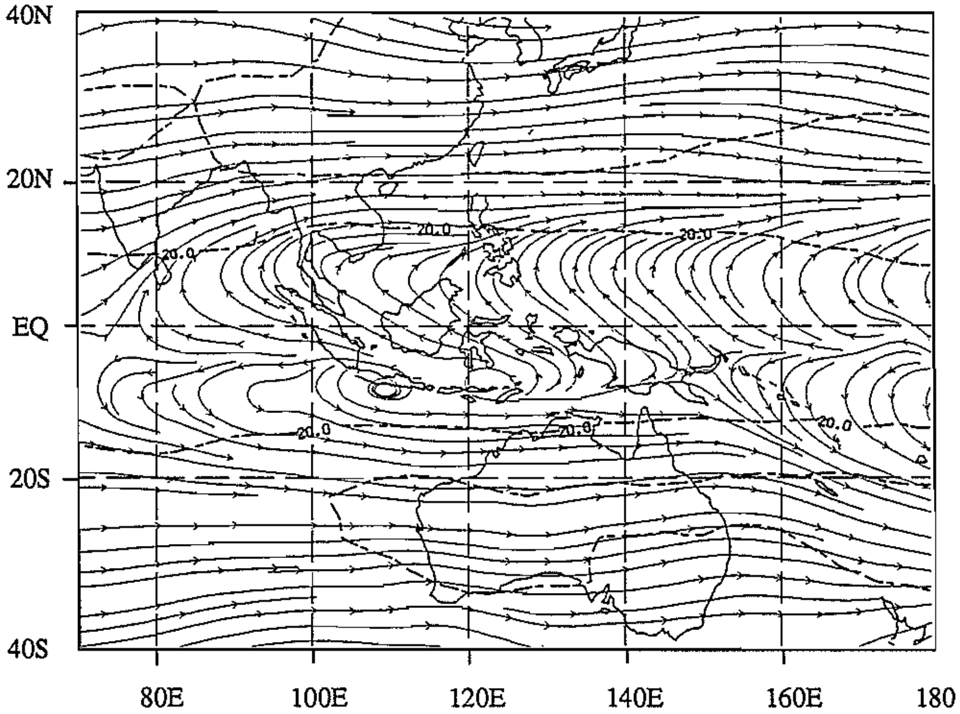


Fig.11 200 hPa STREAMLINE ANALYSIS, APRIL 1992.
Isotachs (dashed line) at 40 knot intervals, minimum 20 knots.

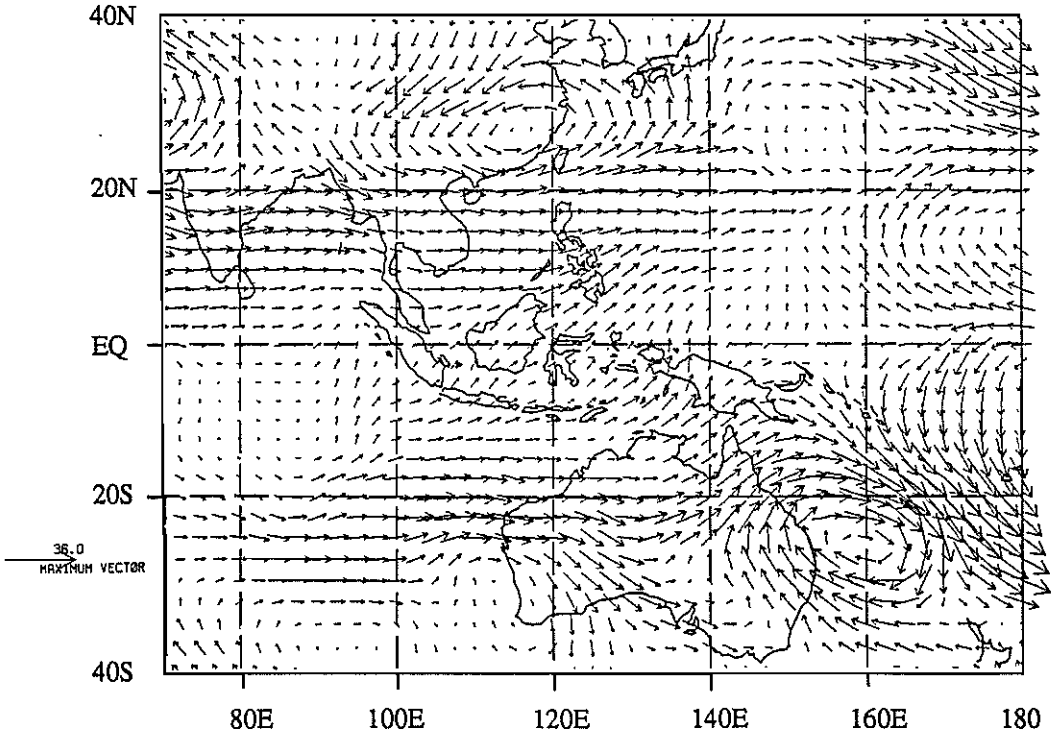


Fig.12 200 hPa WIND ANOMALY, based on Fig.11.
Isotachs (dashed line) at 20 knot intervals

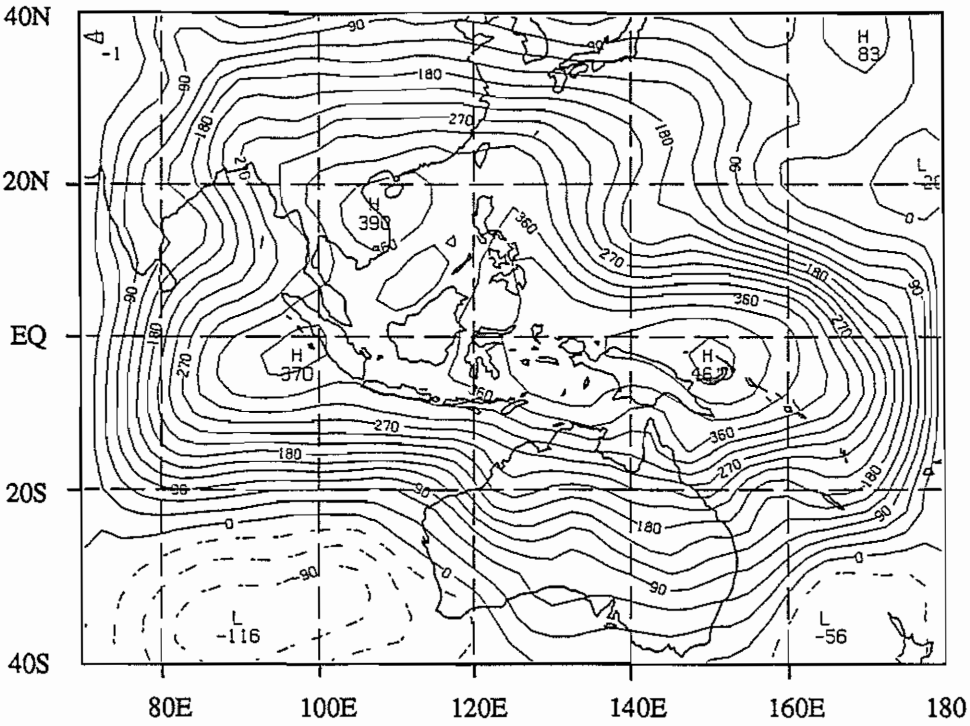


Fig.13 950 hPa VELOCITY POTENTIAL, APRIL 1992.
Contour interval 30 x 10^4 m^2 s^{-1}.

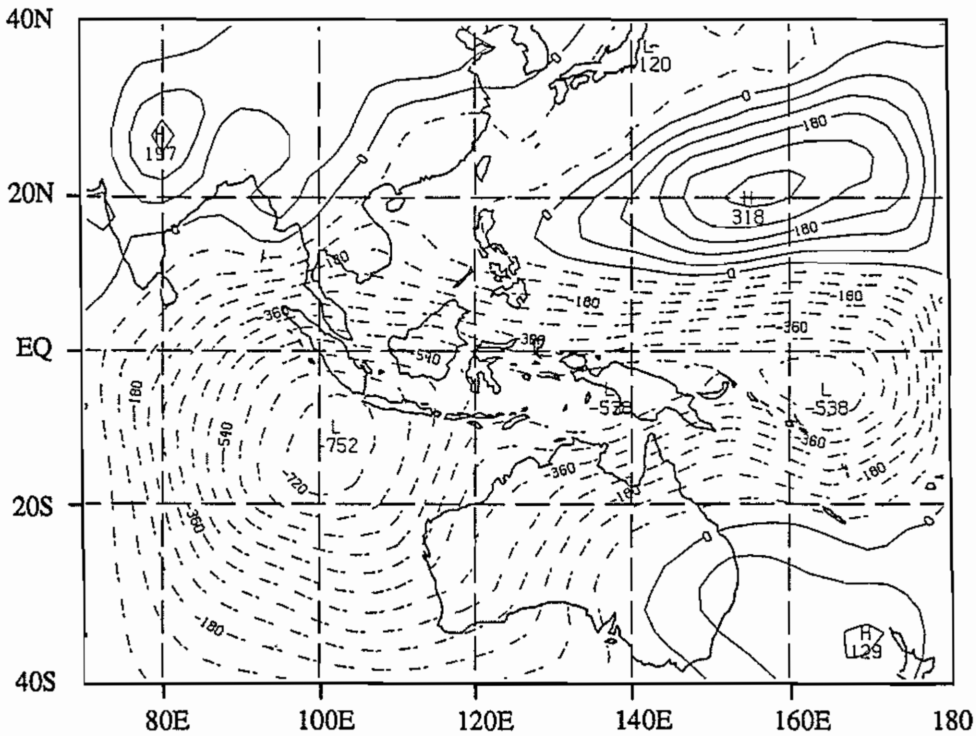


Fig.14 200 hPa VELOCITY POTENTIAL, APRIL 1992.
Contour interval 60 x 10^4 m^2 s^{-1}.

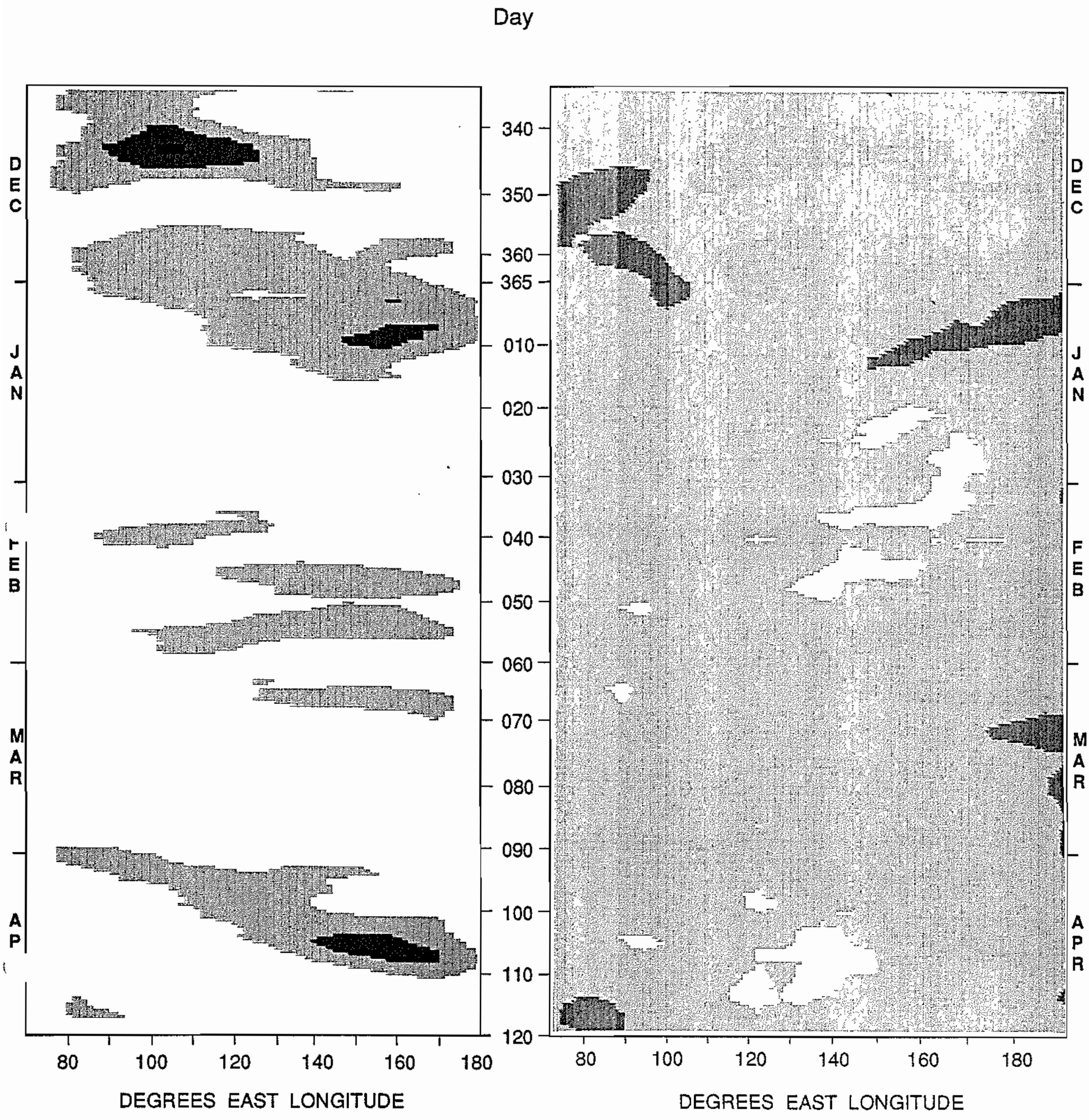
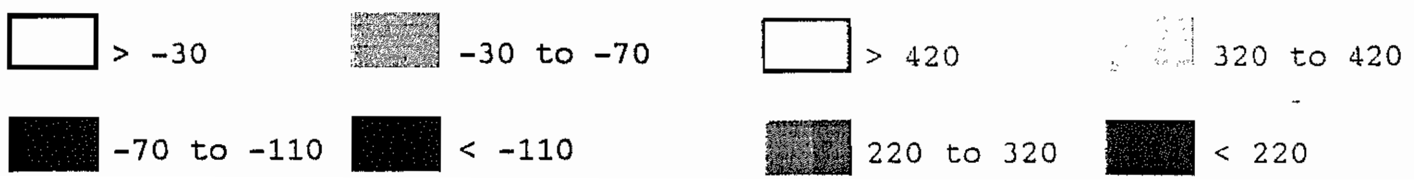


Fig.15 (a)

TIME LONGITUDE CROSS SECTION OF
200hPa VELOCITY POTENTIAL,
averaged between 5°N and 15°N,
values 10^5 m^2 s^{-1}.

Fig.15 (b)

TIME LONGITUDE CROSS SECTION OF
OUTGOING LONG WAVE RADIATION,
averaged between 5°N and 15°N,
values watt m^{-2}.



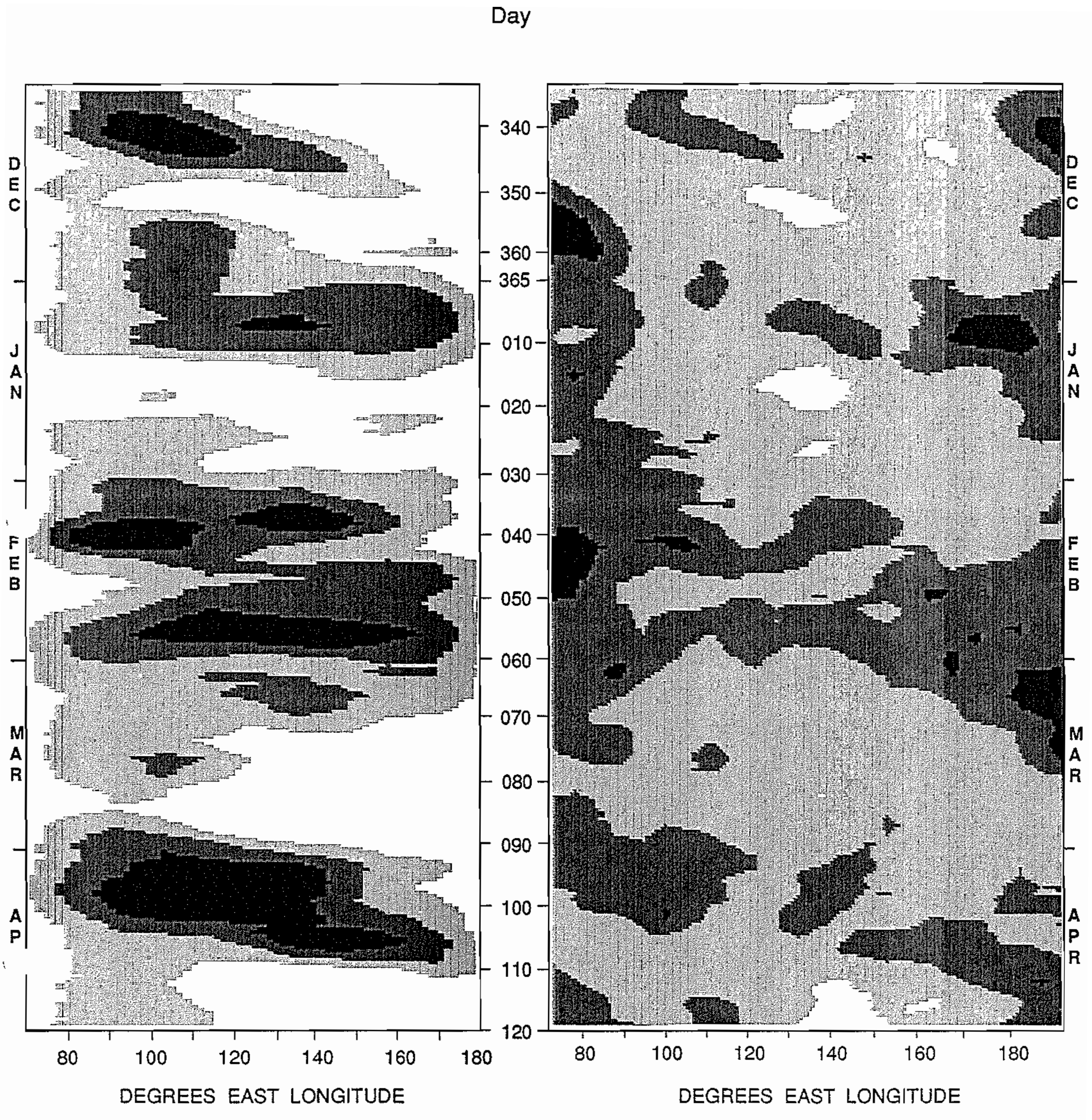
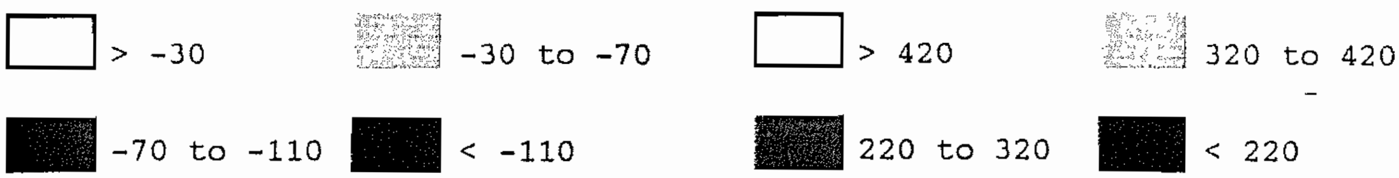


Fig.16 (a)

TIME LONGITUDE CROSS SECTION OF 200hPa VELOCITY POTENTIAL, averaged between 5°S and 15°S, values 10^5 m^2 s^{-1}.

Fig.16 (b)

TIME LONGITUDE CROSS SECTION OF OUTGOING LONG WAVE RADIATION, averaged between 5°S and 15°S, values watt m^{-2}.



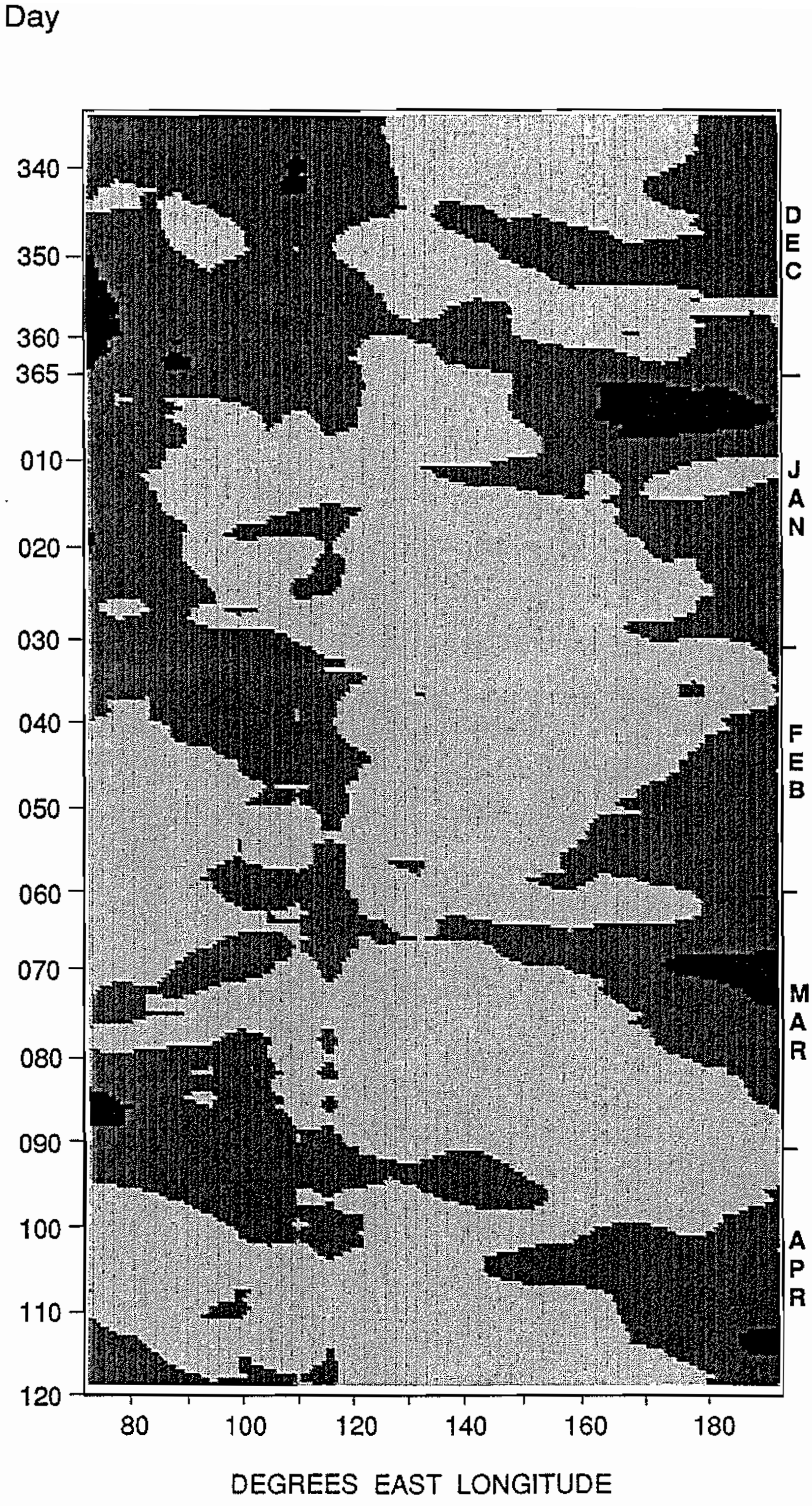


Fig.17

TIME LONGITUDE CROSS SECTION OF
OUTGOING LONG WAVE RADIATION,
averaged between 5°N and 5°S,
values watt m^{-2}.

> 420

320 to 420

220 to 320

< 220

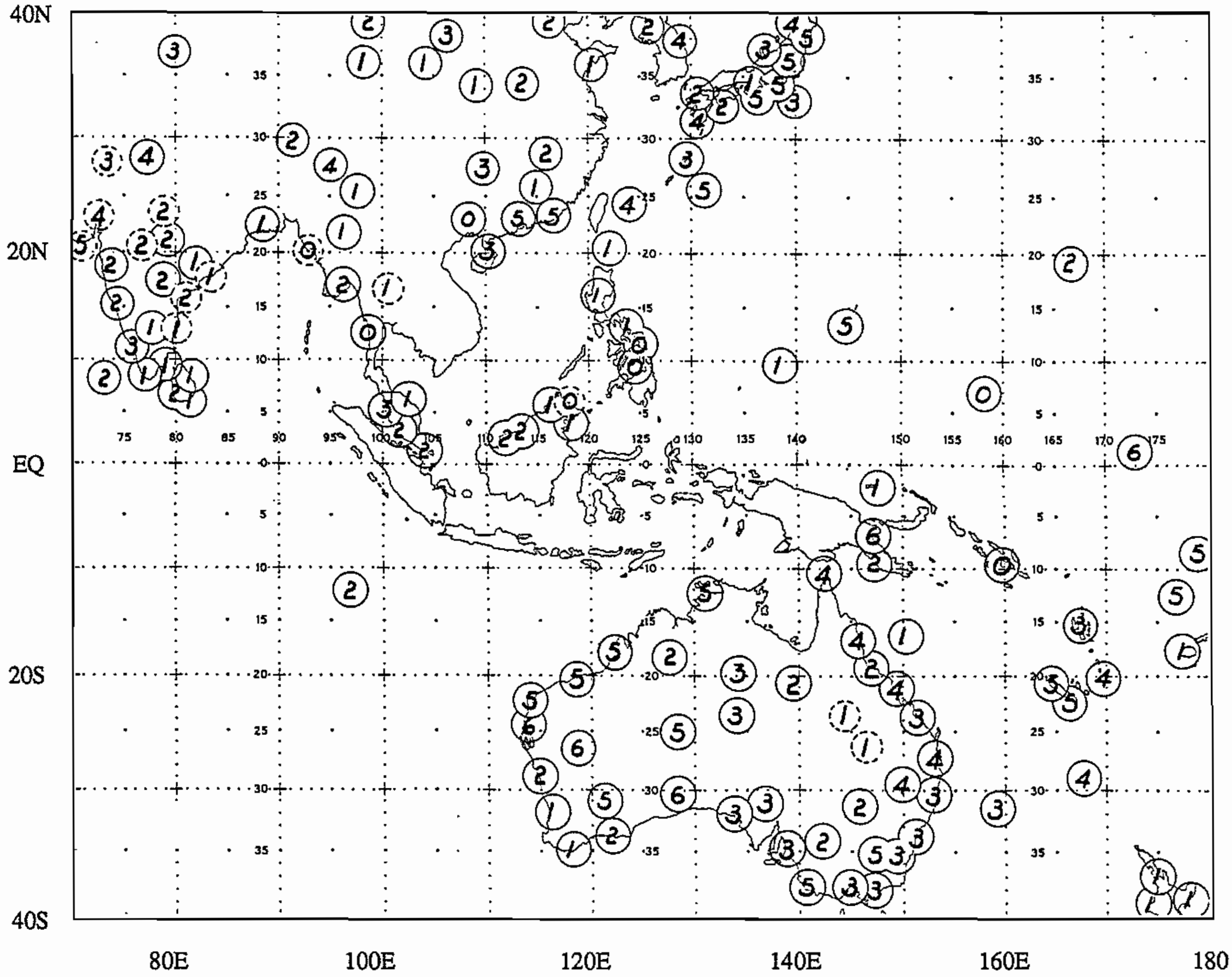


Fig.18 MEAN RAINFALL QUINTILES, APRIL 1992, from CLIMAT messages.

Quintile 0 denotes record low rainfall.
Quintile 6 denotes record high rainfall.
Indicates actual rainfall is nil.

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

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