

# The Australian tropical cyclone season 1983-84

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There were twenty tropical cyclones in the Australian region during the 1983-84 season; nearly three times the number that occurred in the 1982-83 season. Eleven of the cyclones developed in the Western Region (WR) whilst seven had their genesis in the Eastern Region (ER) and two formed in the Northern Region (NR). The first cyclone developed late in October 1983. This was early compared with last season when the first cyclone developed late in January 1983. The last cyclone for the 1983-84 season was in the first week of April. There were five cyclones that made landfall along the Australian coast; three of these had two sea-to-land crossings. Overall, the landfalling cyclones caused relatively little structural damage as they passed over sparsely populated areas. However, cyclone Kathy devastated the Sir Edward Pellew Group in the southwest Gulf of Carpentaria and caused moderate to severe damage to the nearby mainland township of Borroloola. Kathy was also responsible for the death of one seaperson.

## Introduction

The 1983-84 tropical cyclone season in the Australian region commenced with the genesis of *Oscar* on 24 October 1983 and finished with the decay of *Lance* on 7 April 1984; it was the most active season during the last ten years. There were twenty cyclones during the season with the most active months being February and March which both had six. On one occasion in February there were three cyclones current, namely *Harvey*, *Annette* and *Willy*. Twelve cyclones were classified as severe (mean 10-minute winds of 120 km h<sup>-1</sup> or more), the most intense being *Kathy* which had an estimated lowest central pressure of 920 mb and estimated maximum winds of 205 km h<sup>-1</sup>. *Kathy* was one of the five cyclones that made landfall on the Australian coast. A wind gust of 232 km h<sup>-1</sup> was recorded at Centre Island ahead of *Kathy* before the Dines anemometer failed. *Kathy* produced a 4.2 m storm surge on Vanderlin Island and caused wind damage to trees over an area of 1.3 million hectares after it crossed the mainland coast. The other four cyclones that made landfall were *Quenton*, *Chloe*, *Jim*, and *Ferdinand*; the first three were classified as severe but the damage overall was relatively minor. After *Ferdinand* moved inland and weakened into a rain depression, near-record flooding occurred on the Daly and Katherine rivers. *Quenton* was the first November cyclone to cross the Australian coast in ten years.

## Large-scale features

The 1983-84 tropical cyclone season over much of the Australian region of responsibility was characterised by warmer than usual sea surface temperatures (SST) with a positive anomaly of 1 to 2 degrees Celsius.

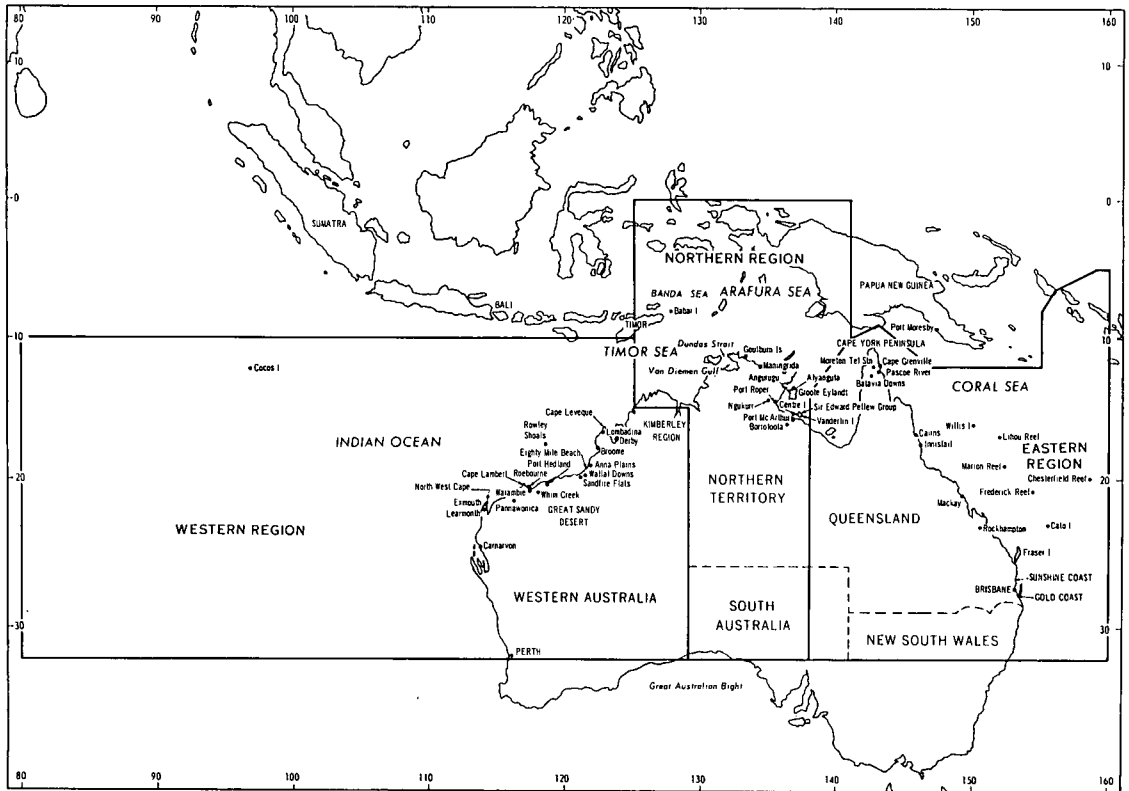
In the northern hemisphere, the northeast cold surges through the South China Sea were anomalously strong and at times were associated with an unusually active northwesterly monsoon through the Indonesian Archipelago into the Australian region. Higher than usual pressures were observed through the southeast Australian/Tasman Sea region which in the mean produced stronger southeast trades than usual. Figure 7 shows the mean 950 mb steamlines and isotachs at 2300 UTC for January 1984. The main features are the monsoon shear line (marked on the Figure by a heavy dashed line) and the inter-tropical convergence zone (ITCZ as shown by the hatching). These are defined respectively as the line of separation between the trade wind easterlies and equatorial westerlies and by the zone of confluence between streamlines originating in the northern and southern hemispheres. This resulted in a more intense monsoon trough than usual, particularly over the Western Region. In the Eastern Region, the monsoon trough was displaced further to the north. That is to say, the mid-latitude high pressure systems in both hemispheres were aligned in such a fashion as to produce anomalously intense Hadley cells between the subtropical ridges of the summer and winter hemispheres.

The Walker Circulation Index (Troup's Southern Oscillation Index) remained close to zero and there was no evidence that anomalies in the Walker Circulation were associated with any features of the cyclone season.

## Seasonal statistics

The Australian area for tropical cyclone warning responsibility is shown in Fig. 1. Any reference in the text to cyclones outside this area is tentative on-

**Fig. 1** Locality map, including the Western, Northern, and Eastern regions that comprise the Australian area of tropical cyclone forecasting responsibility.



ly. Place names and localities mentioned in this report are indicated in Fig. 1. A statistical summary for the season is contained in Tables 1 and 2 and forecast verification statistics in Table 3. With respect to these tables:

- (a) The ten-year average number of cyclones in the respective regions for the period 1974–75 to 1983–84 was derived from data from the regions. The average number of cyclones in the Australian region between longitudes 80° and 160° E for the above period was 13.8 and was derived from Lourenz (1981), unpublished records held by the Perth Tropical Cyclone Centre, and from the Cyard (Bureau of Meteorology Archives) listing of tropical cyclones.
- (b) Lourenz found the average number of cyclones per season over a 21-year period to June 1980 between longitudes 105° and 165° E was 10.5, of which 4.8 crossed the Australian coast, and that at least 30 per cent of these attained hurricane strength of 117 km h<sup>-1</sup>.
- (c) Estimates of central pressure and maximum winds have been based on the Dvorak (May 1982) technique with some slight variations by the regions to take into account local conditions. At peak intensity, *Kathy* had an

estimated central pressure of 920 mb. Since 1960 only five other cyclones in the Australian region have had estimated minimum central pressures of 920 mb or less. Colour enhanced IR GMS imagery for cyclones *Chloe* and *Kathy* are shown in Figs 8 and 9.

- (d) A tropical cyclone day is defined as a day on which one or more tropical circulations of at least tropical cyclone intensity (mean 10-min winds of 63 km h<sup>-1</sup> or more) existed in the Australian region for any part of the day commencing at 0000 UTC.
- (e) Table 2 lists the tropical depressions that later developed into tropical cyclones. The initial location may not necessarily be associated with the first appearance of a particular disturbance but is taken as that point from which a closed circulation deepened into a tropical cyclone in uninterrupted development. Figures 2 to 6 show the tracks of the twenty cyclones\* (and includes *Pearl*†) which occurred in the Australian region.

\* When the remnants of *Esther* moved into the Western Region it was originally thought that redevelopment took place and was re-named *Esther* during its warning phase. Post-analysis showed otherwise, and the new development became the *Unnamed* cyclone. † Post-analysis of *Pearl* showed that it did not reach cyclonic intensity.

**Table 1. Summary of the 1983-84 tropical cyclone season in the Australian region.**

	<i>Australian Region</i>	<i>Western Region</i>	<i>Northern Region</i>	<i>Eastern Region</i>
Number of cyclones in the 1983-84 season	20	11	4	7
Average number of cyclones (10-year average 1974-75 to 1983-84)	13.8	8.5	2.6	4.5
Initial location of tropical depression	21	12	2	7
Coastal crossing at cyclone intensity (sea to land)	10*	3	5*	2
Coastal crossing at cyclone intensity (land to sea)	5*	1	2*	2
Tropical cyclone days (one cyclone active)	85	57	6	27
Tropical cyclone days (two cyclones active)	5	5	0	0
Tropical cyclone days (three cyclones active)	3	0	0	0
Severe tropical cyclones	12	8	2	4

\* Includes island crossings of *Esther* and *Kathy*.

**Table 2. Tropical cyclones in the Australian region during the 1983-84 season.**

<i>No.</i>	<i>Name and life span as cyclone</i>	<i>Central location of tropical depression</i>	<i>First reached tropical cyclone intensity</i>	<i>Estimated lowest central pressure (mb)</i>	<i>Weakened below tropical cyclone intensity</i>
1	<i>Oscar</i> 22 Oct-1 Nov	7.6°S 88.6°E 0000 UTC 22 Oct	9.0°S 87.4°E 0600 UTC 24 Oct	968	21.3°S 91.4°E 0000 UTC 30 Oct
2	<i>Pearl</i> 11-14 Nov	8.4°S 91.6°E 0900 UTC 11 Nov	*Did not reach cyclone intensity	998	
3	<i>Quenton</i> 26-30 Nov	10.5°S 112.8°E 0000 UTC 26 Nov	13.6°S 114.7°E 1800 UTC 27 Nov	955	21.5°S 126.5°E 0600 UTC 30 Nov
4	<i>Fritz</i> 9-13 Dec	13.9°S 152.4°E 0600 UTC 9 Dec	14.8°S 149.1°E 0600 UTC 10 Dec	990	15.7°S 151.0°E 0300 UTC 13 Dec
5	<i>Esther</i> 19-20 Dec	6.1°S 129.6°E 0000 UTC 19 Dec	7.2°S 127.9°E 0300 UTC 20 Dec	990	8.2°S 127.9°E 1200 UTC 20 Dec

Table 2. Continued

No.	Name and life span as cyclone	Central location of tropical depression	First reached tropical cyclone intensity	Estimated lowest central pressure (mb)	Weakened below tropical cyclone intensity
6	<i>Unnamed</i> (formerly <i>Esther</i> in WR) 21-24 Dec	10.0°S 123.6°E 0600 UTC 21 Dec	13.1°S 117.9°E 0000 UTC 23 Dec	994	13.4°S 117.0°E 0600 UTC 23 Dec
7	<i>Sharon</i> 25-30 Dec	13.1°S 82.5°E 0000 UTC 25 Dec	13.6°S 81.4°E 1800 UTC 25 Dec	984	17.8°S 86.2°E 1200 UTC 28 Dec
8	<i>Tim</i> 2-10 Jan	13.5°S 107.8°E 0600 UTC 2 Jan	12.8°S 106.2°E 1500 UTC 4 Jan	980	20.3°S 104.0°E 0600 UTC 10 Jan
9	<i>Grace</i> 11-20 Jan	14.4°S 150.8°E 0000 UTC 13 Jan	16.4°E 150.9°E 0300 UTC 14 Jan	970	Moved into Nadi region about 0900 UTC 18 Jan
10	<i>Vivienne</i> 24-27 Jan	9.0°S 90.9°E 0000 UTC 23 Jan	10.8°S 89.8°E 1600 UTC 23 Jan	975 (In WR)	Moved into Mauri- tius region about 1200 UTC 27 Jan
11	<i>Harvey</i> 3-10 Feb	14.7°S 152.3°E 1800 UTC 3 Feb	16.2°S 154.8°E 0000 UTC 5 Feb	980	Moved int Nadi region about 1500 UTC 7 Feb
12	<i>Willy</i> 2-10 Feb	11.5°S 114.5°E 0000 UTC 2 Feb	11.5°S 113.6°E 1800 UTC 5 Feb	960	21.1°S 94.9°E 1800 UTC 9 Feb
13	<i>Annette</i> 5-16 Feb	9.4°S 101.1°E 1200 UTC 3 Feb	11.2°S 97.5°E 0600 UTC 5 Feb	960	Moved into Mauri- tius region about 0300 UTC 16 Feb
14	<i>Bobby</i> 17-23 Feb	16.2°S 120.0°E 1200 UTC 17 Feb	18.0°S 118.3°E 0000 UTC 18 Feb	950	27.0°S 103.0°E 1200 UTC 23 Feb
15	<i>Ingrid</i> 20-24 Feb	17.4°S 147.4°E 0900 UTC 20 Feb	17.0°S 150.5°E 1200 UTC 21 Feb	975	20.6°S 159.9°E 1800 UTC 24 Feb
16	<i>Chloe</i> 25 Feb-3 Mar	14.0°S 123.7°E 2100 UTC 25 Feb	14.3°S 123.2°E 0900 UTC 26 Feb	955	22.9°S 113.9°E 2100 UTC 1 Mar
17	<i>Ferdinand</i> 2-6 Mar	11.9°S 131.2°E 0200 UTC 2 Mar	11.5°S 133.6°E 1700 UTC 3 Mar	980	12.5°S 134.6°E 1700 UTC 4 Mar
18	<i>Jim</i> 5-9 Mar	11.6°S 151.4°E 2100 UTC 5 Mar	11.3°S 145.7°E 0600 UTC 7 Mar	970	14.9°S 134.4°E 2300 UTC 9 Mar

Table 2. Continued

No.	Name and life span as cyclone	Central location of tropical depression	First reached tropical cyclone intensity	Estimated lowest central pressure (mb)	Weakened below tropical cyclone intensity
19	<i>Daryl</i> 6-20 Mar	8.6°S 101.4°E 1200 UTC 6 Mar	12.4°S 100.7°E 1200 UTC 10 Mar	955	Moved into Mauri- tius region about 0300 UTC 16 Mar
20	<i>Kathy</i> 16-24	12.0°S 148.5°E 1800 UTC 16 Mar	12.0°S 147.0°E 0600 UTC 18 Mar	920	17.0°S 135.0°E 1400 UTC 23 Mar
21	<i>Lance</i> 4-7 Apr	13.5°S 153.4°E 0000 UTC 4 Apr	15.3°S 151.6°E 0300 UTC 5 Apr	992	21.1°S 152.5°E 0600 UTC 7 Apr

\* Coordinated Universal Time (UTC) ≈ GMT.

## Forecast verification

Preliminary 12-hour forecasting errors for cyclone positions in the Australian region during the 1983-84 season have only been calculated at this stage. The preliminary forecast 12-hour root mean square error (RMSE) for the Australian region was 181 km based on a sample size of 224. The preliminary mean 12-hour forecast error was 135 km.

Figure 11 shows the seasonal 12-hour RMSEs for forecast cyclone positions for the Australian region from 1973-74 to 1983-84. For the season 1973-74 to 1980-81, the forecast positions were verified against best track data whereas from the 1981-82 season, the forecast positions have only been verified against operational tracks.

Table 3 contains available forecast verification statistics for the 1983-84 season.

## Tropical cyclones of the 1983-84 season

### 1. Tropical cyclone Oscar, 22 October to 1 November 1983 (Fig. 2)

*Oscar* was the first cyclone for the 1983-84 season and developed from a low pressure system located to the northwest of Cocos Island on 22 October 1983. The low formed to the south of a well-defined monsoon trough lying east-west along 4°S. Development continued and the system reached cyclone intensity around 240600 UTC\*. Under the influence of upper-level easterlies, *Oscar* moved rapidly westward before recurving and assuming a southeast track as a result of the approach of an upper-level trough to the south.

Just after 260000 UTC *Oscar* began to move slowly westward again due to an easterly flow associated with a southern high. Following the slow collapse and eastward progression of this high, the cyclone moved slowly southwards and intensified and became a severe cyclone by 271800 UTC.

Table 3. Cyclone forecast verification statistics for the 1983-84 season.

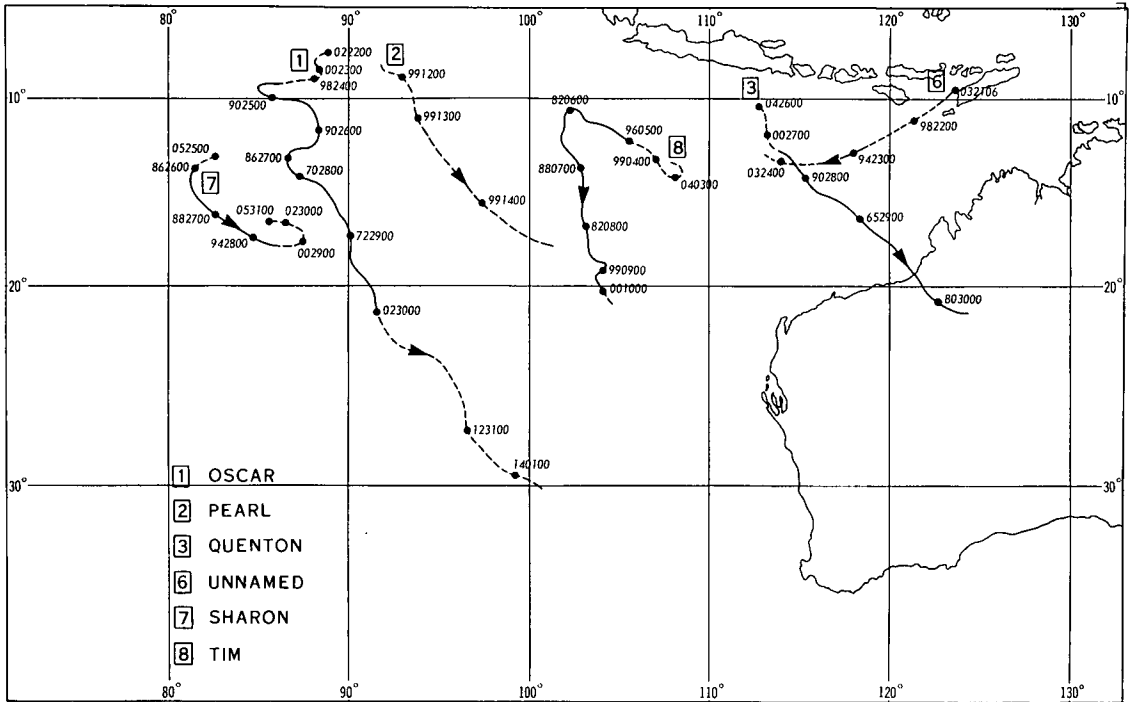
	Australian Region	Western Region	Northern Region	Eastern Region
Preliminary 12-hour RMSE	(KM) 181 (224)*	226 (155)	129 (33)†	113 (36)
Initial position errors	(KM) N/A	N/A	38.0 (31)†	77 (107)
Best track 12-hour RMSE	(KM) N/A	N/A	122.7 (31)	128 (87)
Persistence 12-hour RMSE	(KM) N/A	N/A	116.4 (31)	N/A
Top End 12-hour RMSE	(KM) N/A	N/A	N/A	147 (33)
Cyclogue 12-hour RMSE	(KM) N/A	N/A	N/A	124 (28)
Best track 24-hour RMSE	(KM) N/A	N/A	N/A	263 (34)
Top End 24-hour RMSE	(KM) N/A	N/A	N/A	210 (29)
Cyclogue 24-hour RMSE	(KM) N/A	N/A	N/A	189 (28)

Sample sizes in brackets.

\* Does not include data for TC *Pearl*.

† Applies only for cyclones *Ferdinand*, *Jim* and *Kathy*.

Fig. 2 Tracks of tropical cyclones 1,2,3,6,7 and 8 of the 1983-84 season. Broken lines denote pre and post-cyclone stage; full lines denote tropical cyclone stage. Key to number groups along the track in code form PPYYGG — PP central pressure (tens and units of millibars); YY — dates; GG — time (UTC whole hours).



*Oscar* reached its lowest estimated central pressure of 968 mb at 280900 UTC. From 282100 UTC *Oscar* began to weaken steadily due to its passage over cooler waters and also because of strengthening north-west winds over the system ahead of an upper-level trough. No eye was visible from the Japanese Geostationary Meteorological Satellite (GMS-2) imagery. Cyclone intensity was lost around 300000 UTC.

The remnants of *Oscar* then tracked to the southwest during the next two days and became embedded in a low pressure system of southern origin. The highest wind speed associated with *Oscar* was 83 km h<sup>-1</sup> recorded by a ship 230 km to the south-southeast of the centre at 260600 UTC.

**2. Tropical cyclone Pearl, 11 to 14 November 1983 (Fig. 2)**

A low began to develop to the southwest of Sumatra on 11 November 1983 in a poorly-defined monsoon trough lying east-west through the Indonesian Islands. Steered by upper-level northwesterly winds, the low moved in a southeast direction towards the vicinity of Cocos Island. Cyclone status was thought to be attained around 130000 UTC. A final gale warning to shipping was issued at 130500 UTC. Post-analysis showed that no gales were reported during the event and it is unlikely that the system ever achieved cyclonic strength due to the strong wind shear over the area. The low finally weakened on 14 November.

**3. Tropical cyclone Quenton, 26 to 30 November 1983 (Fig. 2)**

*Quenton* was the first cyclone of the season to make landfall and was also the first November cyclone in ten years to cross the Australian coast.

The initial low formed to the south of Java in the monsoon trough on 23 November and then drifted very slowly south during the next four days without detectable development. After about 260000 UTC, the low began to deepen and assumed a southeasterly track under the influence of a northwest steering flow. This track, with only slight deviations, was maintained until after *Quenton* crossed the coast. Cyclone status was achieved by 271600 UTC and intensification continued steadily with severe cyclone status being reached by about 282100 UTC.

By 290300 UTC, the central pressure had fallen to an estimated 955 mb and this intensity was maintained to landfall. No eye was visible from GMS imagery. *Quenton* crossed the coast halfway along the Eighty Mile Beach, 30 km north-northeast of Sandfire Flats Roadhouse. After crossing the coast, *Quenton* degenerated as it moved southeast across the Great Sandy Desert and lost its identity around 300600 UTC. The highest wind speed reported from a ship was 93 km h<sup>-1</sup> at 290600 UTC when it was located 148 km to the southwest of the centre.

The automatic weather station (AWS) at Rowley Shoals measured a wind speed of 139 km h<sup>-1</sup> when

the centre was 19 km to the north-northwest at 290300 UTC.

*Quenton* produced minimal damage due to the remote location of the coastal crossing. At Sandfire Flats, a caravan and a toilet were demolished and several transportable accommodation units were unroofed or badly damaged. The newly-installed Telecom microwave link between Port Hedland and Broome was dislocated when a bolt holding the transmission dish was broken. At Anna Plains station, several windmills were damaged and fifty head of cattle drowned when trapped on the beach.

#### 4. Tropical cyclone Fritz, 9 to 13 December 1983 (Fig. 6)

*Fritz* was the first tropical cyclone of the season in the Eastern Region and developed from a low in the monsoon trough about 300 km northwest of Willis Island on 9 December. The low drifted on a general easterly track and deepened with cyclonic intensity being reached around 100600 UTC.

From available satellite data, *Fritz* never developed a detectable eye and significant cirrus outflow was evident for only about 24 hours. The strongest wind reported in the vicinity of the cyclone was  $72 \text{ km h}^{-1}$  by a ship when situated 350 km southeast of the centre at 120600 UTC. *Fritz* at this time was at its most eastern position as it then moved back on a westerly track.

The lowest central pressure was estimated to be 990 mb at about 120900 UTC. Fairly rapid filling then took place with *Fritz* losing cyclonic intensity by 130300 UTC.

The remnant low decayed as it moved towards Willis Island. Fresh to strong southeast winds occurred along parts of the tropical coast of Queensland, otherwise the cyclone had little effect on Queensland's weather.

#### 5. Tropical cyclone Esther, 19 to 20 December 1983 (Fig. 4)

*Esther* was the first of four cyclones in the Northern Region for the season.

For several days prior to genesis an active monsoon trough was established across the Banda Sea near latitudes 6-8°S. At 190000 UTC a small, weak tropical low developed near the monsoon trough about 250 km northeast of Timor. During the next day the low moved slowly in a southwesterly direction and deepened. Cyclonic strength was reached at about 200300 UTC with an estimated central pressure of 994 mb.

*Esther* then moved in a southerly direction and continued to intensify. Peak intensity was reached at 200800 UTC with an estimated central pressure of 990 mb and estimated maximum winds of  $100 \text{ km h}^{-1}$  prior to crossing Babar Island. *Esther* weakened rapidly with its crossing of Babar Island and dissipated quickly as a cyclonic system in the waters to the south just after the crossing.

There were no ship reports available close to the

centre and no reports of damage were received from the islands in *Esther's* track.

#### 6. Unnamed tropical cyclone, 21 to 24 December 1983 (Fig. 2)

This cyclone was originally believed to have redeveloped from the remnants of *Esther* and consequently had this name during its warning phase. Post-analysis has shown that this was not the case and that the system formed from a cloud cluster which developed near the southern tip of Timor at 210600 UTC approximately four degrees west of the last known position of *Esther*.

An anticyclone over northern Australia provided unfavourable conditions for development as upper-level easterly winds maintained a strong shear across the region. The low was steered on a southwesterly track and gradually deepened. Cyclonic intensity was reached around 221800 UTC and existed for about nine hours. The estimated lowest pressure reached was 994 mb at 230000 UTC.

After losing cyclone status the remnant low moved to the west and lost its identity by 240600 UTC.

#### 7. Tropical cyclone Sharon, 25 to 30 December 1983 (Fig. 2)

The development of *Sharon* was rapid during 25 December. At 250000 UTC there was a 1005 mb low centred near 13.1°S 82.5°E in a poorly-defined monsoon trough. By 251800 UTC cyclone status had been reached with *Sharon* then having an estimated central pressure of 995 mb.

Further deepening took place as *Sharon* moved southeast and peaked with an estimated central pressure of 984 mb at 260300 UTC. The path was controlled initially by an upper-level high centred near 12°S 90°E. A slow decay began immediately after peak intensity and *Sharon* lost cyclone status by 281200 UTC. This was due to strengthening north-west winds over the system ahead of a marked upper trough. The residual low persisted up to 310000 UTC. No significant reports were received from shipping in the area.

#### 8. Tropical cyclone Tim, 2 to 10 January 1984 (Fig. 2)

At 020600 UTC a low with a central pressure of 1006 mb was located to the southeast of Christmas Island. During the next two days it moved southeast into a broad monsoon trough then to the northwest. By 040600 UTC the central pressure had fallen to 999 mb with the low continuing on a steady northwesterly track under the influence of upper-level southeasterlies. Cyclonic intensity was reached at about 041500 UTC when the central pressure was 996 mb.

*Tim* continued to deepen and move on a northwest track until 060000 UTC. After this time, *Tim* changed onto a general south-southeasterly track until the system decayed on 10 January.

The estimated lowest central pressure of 980 mb

was reached at 060300 UTC and maintained until 061600 UTC with estimated maximum winds of 110 km h<sup>-1</sup>. Between 070900 and 080300 UTC a brief reintensification occurred with the central pressure falling from 990 mb to 982 mb. After 081200 UTC the system weakened steadily and was downgraded at 100600 UTC to a tropical low which then decayed rapidly. There were no significant reports from shipping in the area.

**9. Tropical cyclone Grace, 11 to 20 January 1984 (Fig. 4)**

A small low developed approximately 200 km east-northeast of Townsville on 11 January and then moved north-northeast and slowly deepened during the next two days. The low reached its most northern position approximately 250 km north-northeast of Willis Island at 130000 UTC and then moved southwards with cyclone status being reached at 140300 UTC.

*Grace* continued moving south and passed about 95 km east of Willis Island, 125 km to the west of Lihou Reef (AWS) and then turned towards the southeast and passed 50 km to the southwest of Marion Reef (AWS). Deepening continued with *Grace* becoming a severe cyclone when it reached its lowest estimated pressure of 970 mb around 160600 UTC. Continuing to move southeast, *Grace* approached to within 30 km of Frederick Reef (AWS) and 25 km to the northeast of Cato Island (AWS).

At 161600 UTC Frederick Reef (AWS) reported the strongest wind speed of 130 km h<sup>-1</sup> and a pressure of 991.5 mb when *Grace* was located 60 km to the west.

Visual satellite imagery on 15 and 16 January indicated a ragged eye. Mackay radar identified about one half of a hemisphere of the eye wall and allowed for positive fixes of the eye for some hours when at a range of almost 350 km. Upper-level shearing became evident on 17 January as the low-level circulation became exposed.

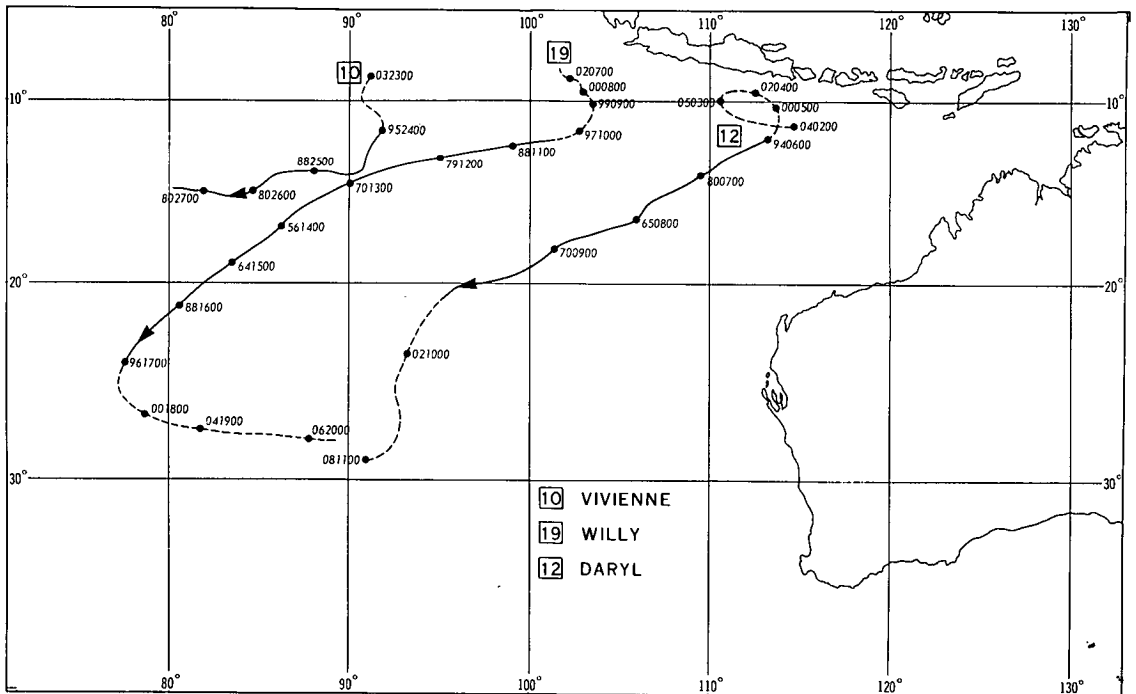
Weakening continued as the cyclone moved into the Nadi region on the evening of 18 January and lost cyclonic intensity on 20 January. The remnant low decayed to the southwest of Noumea on 21 January.

*Grace's* influence on Queensland's weather was confined to the central coast where moderate to fresh easterly winds and moderate to heavy rainfalls occurred on 16 January. No damage reports were received and only minor sand losses were reported from the Gold Coast and Sunshine Coast beaches.

**10. Tropical cyclone Vivienne, 24 to 27 January 1984 (Fig. 3)**

Much of the genesis and track of *Vivienne* is open conjecture as the system formed to the west of Christmas Island in a data-sparse area during the period between the failure of GMS-2 and the relocation of GMS-1.

**Fig. 3 Tracks of tropical cyclones 10,12 and 19 of the 1983-84 season. Symbols as per Fig. 2.**





The initial low formed at about 9°S 110°E on 23 January and gradually deepened whilst moving on a southerly track before coming under the influence of upper-level easterly winds. Cyclonic intensity was reached at about 231600 UTC. *Vivienne* turned onto a west-southwest track at about 241200 UTC and continued to deepen and was classified as a severe cyclone at 270600 UTC just before it crossed into the Mauritius forecasting area with an estimated central pressure of 975 mb at 271200 UTC. Weakening occurred following its movement into the Mauritius region.

**11. Tropical cyclone Harvey, 3 to 7 February 1984 (Fig. 4)**

The tropical low that was to become *Harvey* developed in the monsoon trough on 3 February to the northeast of Willis Island. The monsoon trough was lying across far northern parts of Australia to tropical cyclone *Beti* which had developed in Nadi's area of responsibility. *Beti* was centred near 18°S 164°E at 030000 UTC and was moving to the southeast. The low began to deepen and move southeast on 4 February as the low-level cloud-banding became more organised and cyclone status was reached about 050000 UTC.

During the next twenty-four hours *Harvey* moved southeast to south and deepened to a pressure of about 985 mb. *Harvey* then took a more easterly track and continued to intensity until 070000 UTC when it reached its lowest estimated central pressure of 980 mb. At this time *Harvey* was located 30 km

to the west-northwest of Chesterfield Reef (AWS) which then had winds of 111 km h<sup>-1</sup> (the strongest winds reported) and a pressure of 990.5 mb. GMS-1 imagery indicated a clearly defined circulation centre though no eye was visible.

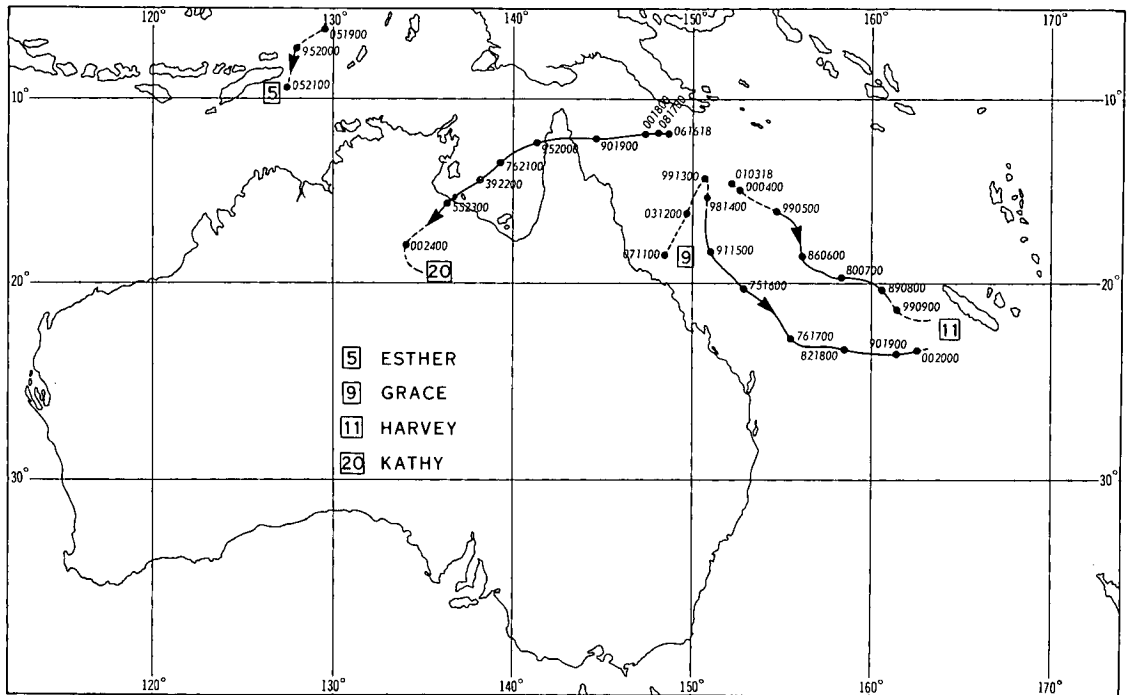
*Harvey* commenced to weaken as it moved in a general easterly direction until passing into the Nadi region just after 071800 UTC. The track then became southeast with *Harvey* losing cyclone status around 081800 UTC. The remnant low lost its identity on 10 February to the west of Noumea. No damage was reported.

**12. Tropical cyclone Willy, 2 to 11 February 1984 (Fig. 3)**

*Willy* developed from a weak low to the south of Java and immediately to the south of an active monsoon trough. A poorly-organised cloud cluster was evident on 2 February and during the next three days it described a clockwise loop. Increased organisation in the cloud-banding took place and cyclonic intensity was reached about 051800 UTC.

Further deepening occurred as *Willy* moved on a southwesterly track after 060000 UTC. *Willy* was upgraded to a severe cyclone at 071200 UTC as the estimated central pressure fell to 975 mb. The lowest estimated central pressure was 960 mb at around 080300 UTC. Severe cyclone status was maintained for nearly thirty-six hours as the system continued on a southwest track. GMS satellite imagery showed a clearly-defined circulation centre but an eye was visible for only a short period.

**Fig. 4 Tracks of tropical cyclones 5,9,11, and 20 of the 1983-84 season. Symbols as per Fig. 2.**



*Willy* decayed rapidly and lost cyclone status by 091800 UTC due to the shear created by strengthening upper-level northwesterly winds. The remnant low moved on a more southerly track and lost its identity by 110000 UTC. The strongest wind reported was 74 km h<sup>-1</sup> from a ship when it was located 410 km south-southwest of the centre at 090000 UTC.

**13. Tropical cyclone Annette, 5 to 16 February 1984 (Fig. 5)**

The low that was to become *Annette* formed to the northeast of Cocos Island on 3 February and then moved southwest and slowly deepened. At about the same time, *Willy* was forming to the east and another was simultaneously developing within the Mauritius area and was to become tropical cyclone *Haja*.

After strengthening to cyclonic intensity on 5 February, *Annette* developed an erratic southwest track that was interrupted by a double loop. The loops occurred as a result of the passage of an upper trough south of *Annette's* position. Further erratic movement was evident from 13 to 15 February before the cyclone moved into the Mauritius region on 16 February where further intensification took place. *Annette* reached severe cyclone status with a central pressure estimated at 960 mb around 081200 UTC and maintained this status for the remainder of its life in the Western Region. During most of the period from 151200 to 191200 UTC there was a clearly-defined eye. The eye was still visible at 191200 UTC when *Annette* was centred near 21°S 70°E and close to the horizon of GMS-1.

Winds of 74 km h<sup>-1</sup> were reported by a ship 40 km to the south of the centre at 081200 UTC. Another ship reported a wind of 93 km h<sup>-1</sup> at 080000 UTC, however this report was from a position well to the south of the cyclone position in an area where the gradient was intensified by the interaction with a southern ridge.

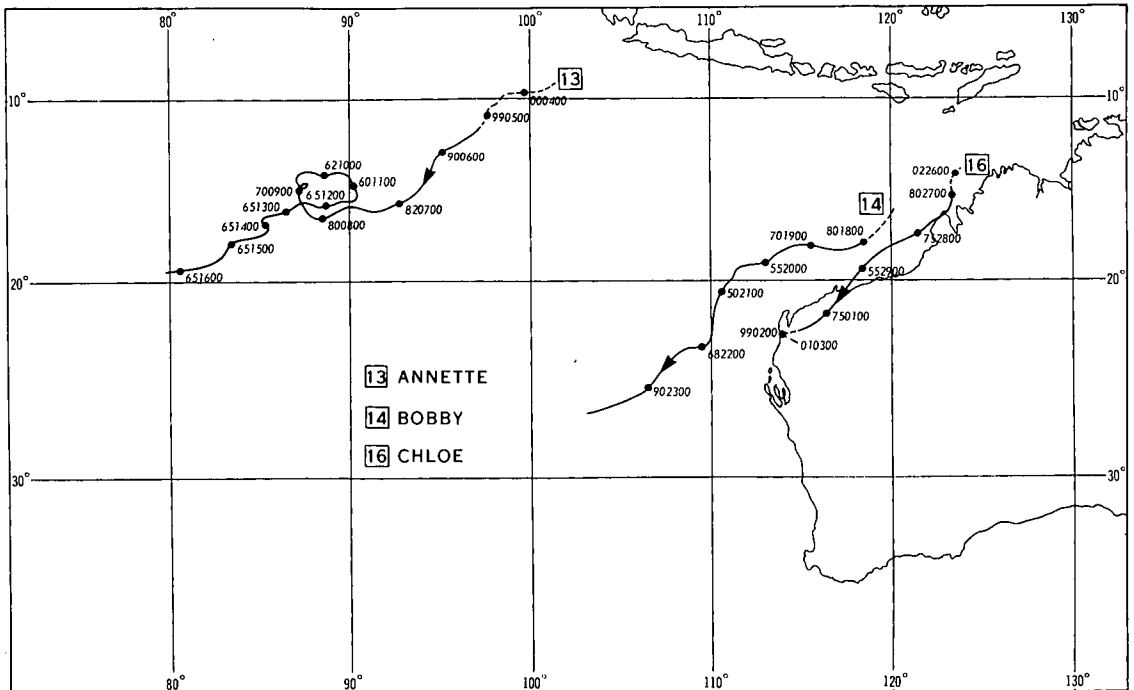
**14. Tropical cyclone Bobby, 17 to 23 February 1984 (Fig. 5)**

Although *Bobby* did not make landfall it followed the northwest coast of Western Australia at a distance of between 250 and 400 km from Broome to Carnarvon and it was necessary to issue warnings for four days to successive sections of the coast. The cyclone attracted considerable media interest, particularly as it moved further south and posed a possible threat to more populous regions of the State.

*Bobby* formed rapidly in a developing monsoon trough to the northwest of Broome during 17 February and moved quickly to the southwest. Cyclonic intensity was reached at 180000 UTC. Steered by upper-level winds associated with the western sector of an upper high over northern Australia, *Bobby* maintained a track almost parallel to the coast.

The cyclone intensified steadily as it continued around the coast and became severe at about 181600 UTC when located approximately 380 km northwest of Port Hedland. Peak intensity was reached at 210000 UTC with an estimated central pressure of 950 mb when centred at 20.7°S 110.3°E. A clearly

Fig. 5 Tracks of tropical cyclones 13,14, and 16 of the 1983-84 season. Symbols as per Fig. 2.



defined circulation centre or eye from GMS imagery was visible for most of *Bobby's* lifetime. The low-level circulation of *Bobby* was forced southwest over cooler waters during 22 February and upper-level northwesterly winds sheared the top off the storm. By about 231200 UTC the system had lost cyclone status and then rapidly decayed.

The strongest reported wind was 111 km h<sup>-1</sup> by a ship 130 km from the centre when the cyclone was near 23.5°S 108.7°E. Gale-force winds were experienced briefly on the coast in the Learmonth-Northwest Cape area.

**15. Tropical cyclone Ingrid, 20 to 24 February 1984 (Fig. 6)**

*Ingrid* formed from a tropical low that was first identified on 20 February when about 130 km east of Inisfail embedded in the monsoon trough. The low moved eastwards and deepened with cyclonic status being reached around 211200 UTC when about 100 km south of Willis Island. *Ingrid* continued to deepen whilst on a general easterly track and just attained severe cyclone status on the morning of 23 February. Peak intensity occurred at 230000 UTC when the estimated central pressure fell to 975 mb.

Lihou Reef (AWS) reported the strongest wind speed of 111 km h<sup>-1</sup> at 221200 UTC when *Ingrid* was located 55 km to the west-northwest. Weakening commenced from 230000 UTC and the track became southeast as strengthening northwest winds in the upper levels moved over the system. From 241200 UTC the track turned to the east and cyclonic intensity was lost at 241800 UTC just prior to the

remnant low moving east of 160°E and into the Nadi region where it quickly decayed. The only effects *Ingrid* had on the Queensland coast were strong winds and some minor flooding between Cairns and Mackay.

**16. Tropical cyclone Chloe, 25 February to 3 March 1984 (Fig. 5)**

*Chloe* was the second cyclone to cross the Western Australian coast this season and although of similar intensity to *Quenton*, did far more damage as it passed over or near a number of Pilbara towns. *Chloe* formed from a low that developed on 25 February about 400 km north of Derby in a complex trough lying along the Kimberley-Pilbara coast.

The low drifted slowly south during development and reached cyclone status at 260900 UTC. *Chloe* continued on a slow southerly track until 271200 UTC then turned to the southwest and passed briefly over land near Lombardina on Cape Leveque. Following its passage back over water again, *Chloe* reached severe cyclone status at about 280000 UTC and peak intensity at 290000 UTC when the estimated central pressure fell to 955 mb. Severe cyclone status and the southwesterly track were maintained to landfall near Roebourne. The barograph trace from Roebourne Post Office recorded a minimum pressure of 961 mb and an uncalibrated barograph from Cape Lambert registered a minimum pressure of 964 mb.

A narrow band of strong to gale force winds was experienced along the Pilbara coast from Wallal to

Fig. 6 Tracks of tropical cyclones 4, 15, 17, 18 and 21 of the 1983-84 season. Symbols as per Fig. 2.

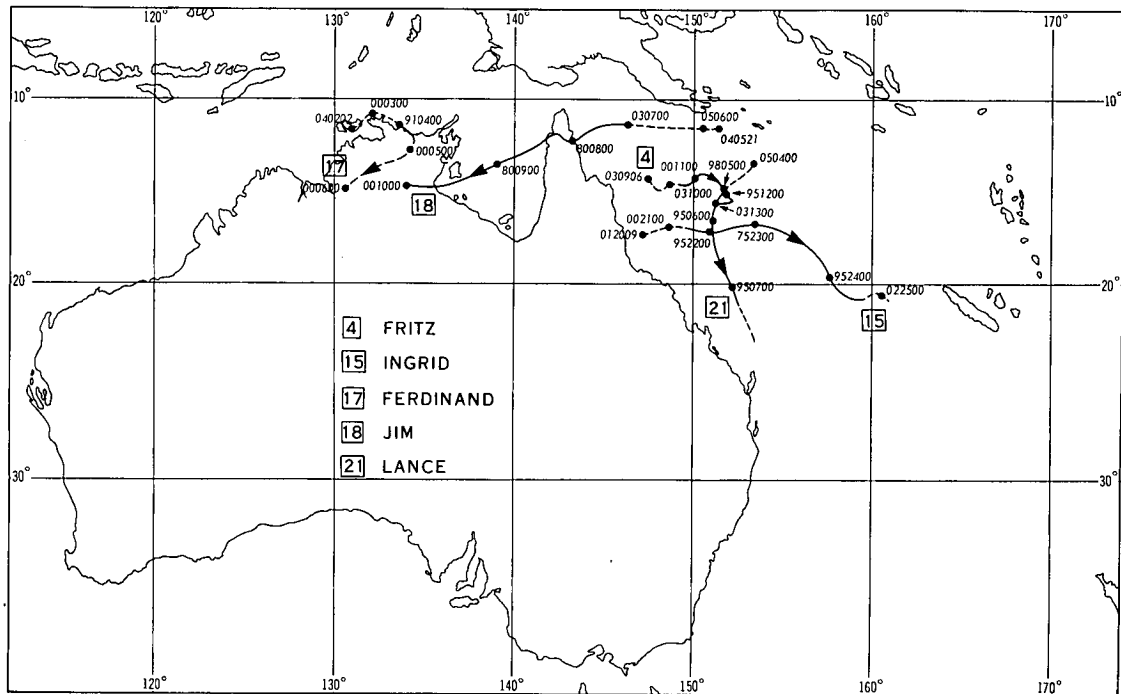
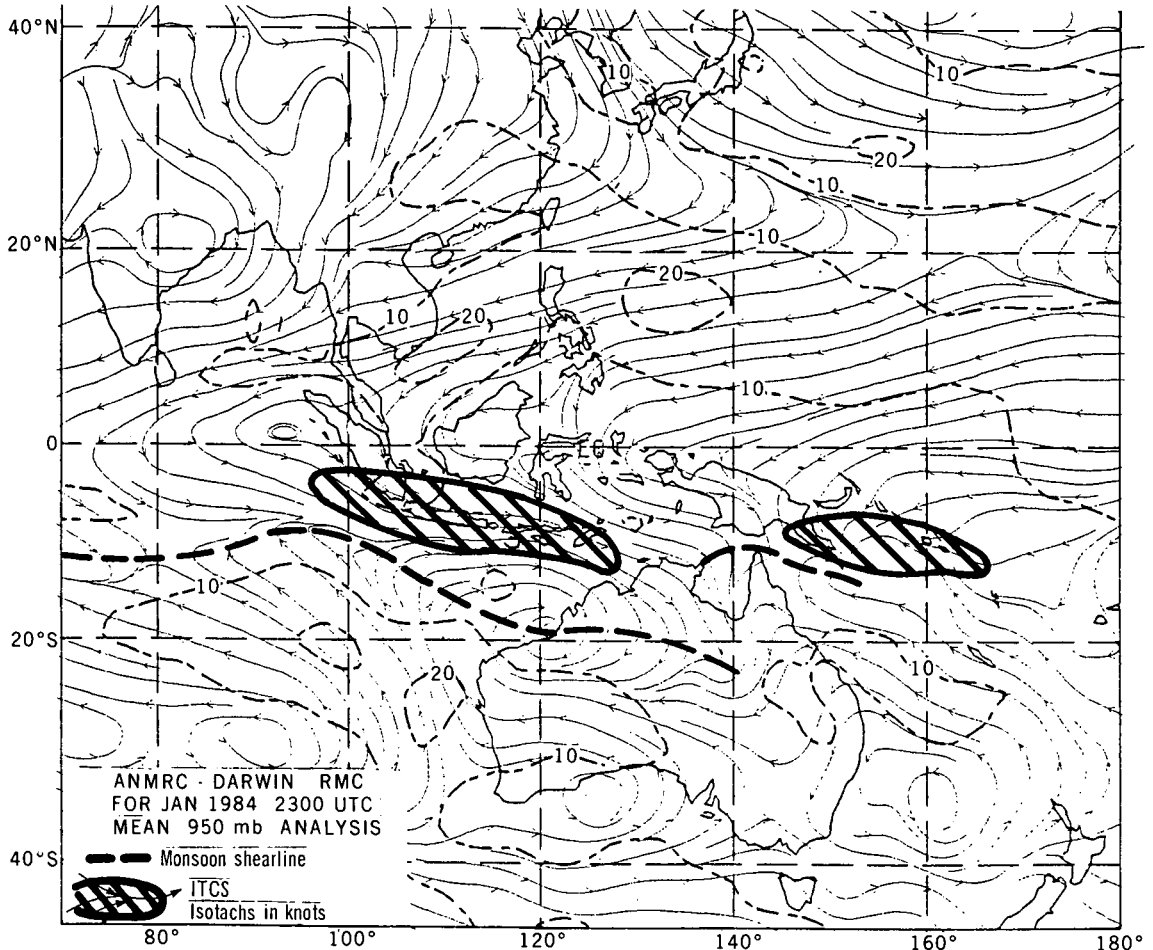


Fig. 7 ANMRC-Darwin RMC mean 950 mb streamlines at 2300 UTC for January 1984 (isotachs in knots).



Whim Creek during 28 February. These winds were only partially due to *Chloe* as a pressure surge from a high in the Great Australian Bight caused a rapid strengthening of the easterly gradient after approximately 280400 UTC. The winds produced areas of dust reducing visibility at times to 200 m in Port Hedland.

*Chloe* made its second landfall at 291400 UTC very close to Cape Lambert and the eye passed over Roebourne, 12 km inland, between 291330 and 291415 UTC.

Figure 8 shows the unenhanced and enhanced GMS imagery of *Chloe* at 291800 UTC approximately four hours after landfall. The mining town of Panawonica experienced a calm at 292100 UTC at which time the estimated central pressure had risen to 970 mb. Cyclone status was lost around 012100 UTC when *Chloe* was centred 80 km south of Learmonth, some 27 hours after landfall.

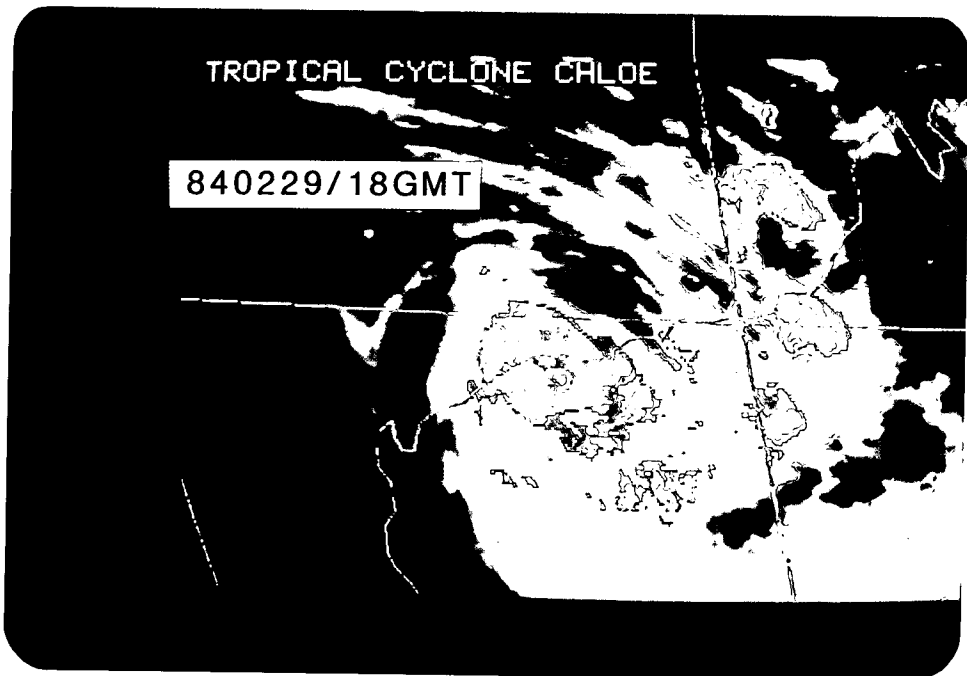
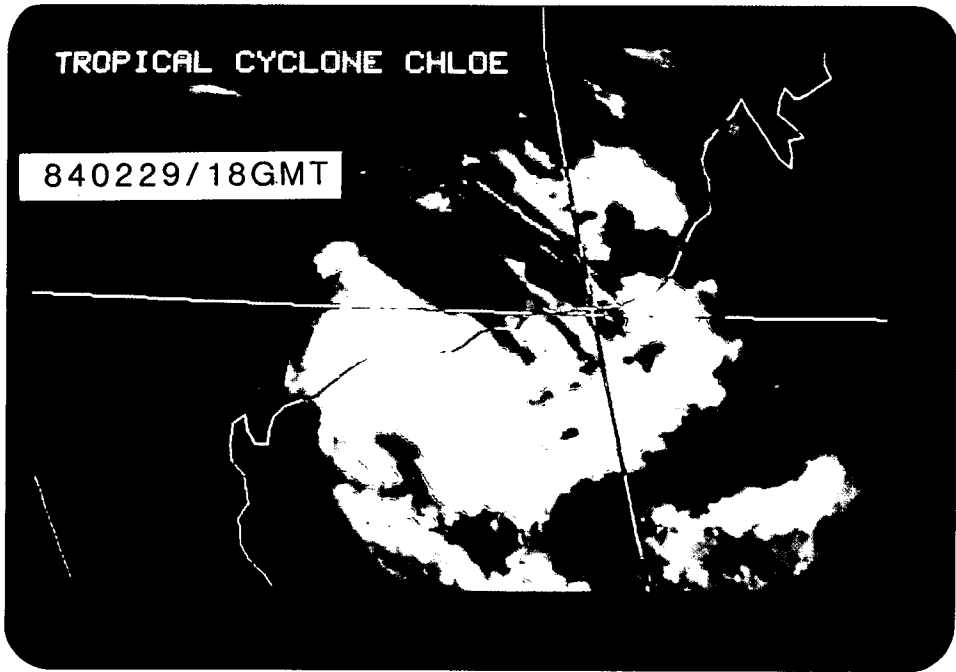
*Chloe*'s track appeared to be controlled mainly by an upper-level high centred over the Kimberley region. However, in the decaying stage, a ridge from

the Bight high cradled the remnant low just south of Learmonth before it decayed on 3 March. GMS imagery indicated a clearly-defined circulation centre for most of *Chloe*'s life and an eye was visible only once at 290600 UTC.

Maximum wind gusts at Port Hedland were 183 km h<sup>-1</sup> at the Port Authority Control Tower and 135 km h<sup>-1</sup> at the meteorological office. Cape Lambert recorded a gust of 220 km h<sup>-1</sup> at 291213 UTC when the mean wind speed was southerly at 170 km h<sup>-1</sup>; at this time the pressure was 965 mb.

Flooding occurred at Roebourne where the Harding River topped its banks; however no damage occurred and the floods receded quickly. There was heavy rain over the Gascoyne catchment but no flooding resulted. The main structural damage occurred at Roebourne where three houses were destroyed, twelve houses unroofed and 26 houses suffered minor damage. One caravan was destroyed and nineteen were damaged. At Warambie station sheep losses were estimated in thousands, and at Exmouth there was severe mud staining to houses.

Fig. 8 The unenhanced (top) and the enhanced (bottom) GMS infrared imagery at 291800 UTC March 1984 of tropical cyclone Chloe when centred at 21.2°S 116.8°E about four hours after landfall. The Dvorak EIR T number intensity estimate was 5.0 and the estimated central pressure was 965 mb. (The time on the pictures is given in GMT.)



### 17. Tropical cyclone Ferdinand, 2 to 6 March 1984 (Fig. 6)

A weak tropical low centred in the Van Diemen Gulf was part of the active monsoon trough that was established across the northern parts of the Northern Territory. GMS imagery showed a large area of convection over the Top End and the Timor Sea to the northwest of Darwin. During 2 and early 3 March the low slowly intensified and tracked in a generally northeasterly direction through Dundas Strait and then turned eastwards with cyclonic intensity being reached around 031700 UTC.

*Ferdinand* continued to intensify and moved in an east to southeasterly direction close to and approximately parallel to the northern coast of the Northern Territory. Peak intensity occurred about 040800 UTC when the estimated central pressure was 980 mb and estimated maximum winds were 115 km h<sup>-1</sup>.

A ship experienced winds estimated to be in excess of 110 km h<sup>-1</sup> for over one hour from 040030 UTC and Maningrida recorded a maximum gust of 96 km h<sup>-1</sup> at 040330 UTC when the cyclone was about 40 km to the northwest of the station. The lowest pressure reported by a ship was 991.5 mb at 041050 UTC.

*Ferdinand* crossed the coast just to the east of Maningrida at about 041200 UTC and rapidly transformed into a rain depression. The depression turned to a southwest track and caused near-record floods on the Katherine and Daly rivers. The surface feature dissipated over the Kimberley region on 6 March but a well-organised cloud pattern persisted up to 8 March as it moved southwards over inland parts of Western Australia before losing identity.

Minor damage was reported at Goulburn Island and around Maningrida.

### 18. Tropical cyclone Jim, 5 to 9 March 1984 (Fig. 6)

A low commenced to form in the monsoon trough from about 052100 UTC approximately 150 km to the southeast of mainland Papua New Guinea and then moved westwards and gradually deepened. Cyclonic intensity was reached about 070600 UTC when the low was centred 200 km southwest of Port Moresby.

*Jim* continued on a general westerly track whilst slowly deepening and made landfall around 080000 UTC near Cape Grenville on Cape York Peninsula with an estimated central pressure of 980 mb. Weakening occurred as *Jim* moved westwards across the Cape and apart from some slight to moderate damage to vegetation and the uprooting of some medium to large trees, no other damage was reported. A wind gust of 93 km h<sup>-1</sup> was reported from Moreton when *Jim* was about 35 km to the north-northeast of the station. *Jim* entered the Gulf of Carpentaria just north of Weipa about 080800 UTC and moved quickly in a west-southwesterly direction and slowly reintensified.

The second landfall was made at Port Roper at about 091800 UTC just after reaching peak intensity and severe cyclone status. The lowest pressure attained was estimated to be 970 mb with estimated maximum winds of 120 km h<sup>-1</sup>. After moving inland, *Jim* weakened rapidly and lost cyclone status at 092300 UTC.

At 090200 UTC a ship reported 56 km h<sup>-1</sup> winds when located 160 km to the northwest of *Jim* and another ship reported a similar speed at 090800 UTC when situated 110 km west-northwest of the centre. Aerial surveillance revealed no damage to the coastal strip spanning the Roper River mouth or over the southern side of Grootte Eylandt, but there was evidence of a storm surge just south of the Roper River mouth. A fifteen metre fishing boat was beached an estimated 3 to 6 m above the tide level and the observer at Alyangula reported an estimated storm surge of 1.5 m at 091430 UTC.

As the remnants of *Jim* moved up the Roper River valley, reports were received from Ngukurr (70 km inland) and Roper River police station (100 km inland) that the winds gusted to an estimated 95 to 110 km h<sup>-1</sup> around 092100 UTC. Roper River police reported wind damage to trees. No casualties were reported.

### 19. Tropical cyclone Daryl, 6 to 20 March 1984 (Fig. 3)

*Daryl* was the last cyclone of the season in the Western Region and had the longest track. From initial development until the post-cyclonic low lost all identity, the system travelled over 2800 km. The initial low developed to the south of the monsoon trough in the vicinity of 9°S 101°E during 6 March. Development was slow, being inhibited by strong shear between low-level southeasterlies and upper-level northwesterly winds. The low moved slowly southeast during 7 and 8 March then turned to the southwest on 9 March.

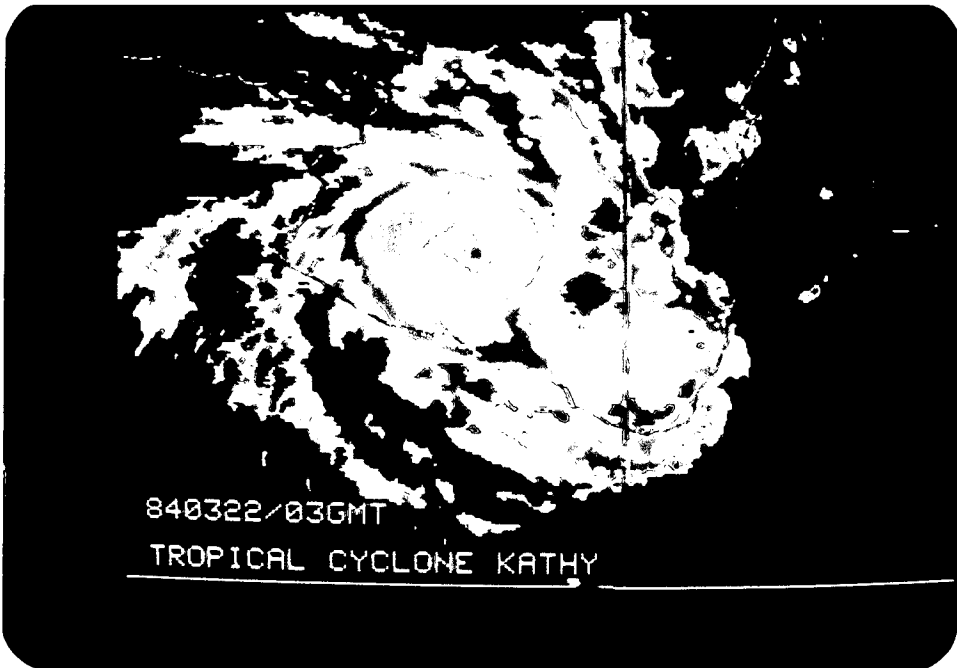
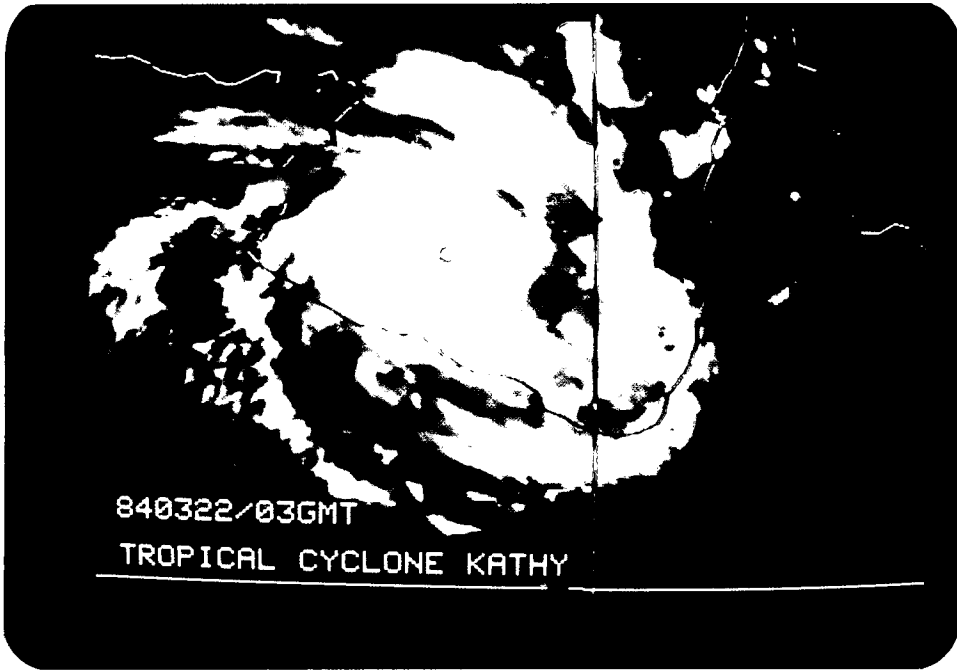
After cyclone status was reached at 101200 UTC, *Daryl* moved on a very consistent southwesterly track and deepened slowly. Severe cyclone status was reached at 121200 UTC and from GMS imagery an eye was visible between 122100 and 141200 UTC. The estimated lowest central pressure of 955 mb occurred at about 140900 UTC and then slow weakening commenced.

*Daryl* passed into the Mauritius forecast area at 160300 UTC with a central pressure of 990 mb and almost immediately began to recurve as upper-level northwest winds strengthened ahead of a series of frontal systems. The decaying low re-entered the Western Region at 181300 UTC embedded in a westerly stream that carried it to 28.2°S 88.9°E before the low lost its identity on 20 March.

### 20. Tropical cyclone Kathy, 16 to 24 March 1984 (Fig. 4)

*Kathy* was the most severe cyclone for the season and at peak intensity had an estimated central pressure

Fig. 9 The unenhanced (top) and the enhanced (bottom) GMS infrared imagery at 220300 UTC March 1984 of tropical cyclone Kathy when centred at 14.9°S 137.9°E. The Dvorak EIR T number intensity estimate was 6.0 and the estimated central pressure was 934 mb. (The time on the pictures is given in GMT.)



of 920 mb and estimated maximum winds of 205 km h<sup>-1</sup>.

The first signs of a low developing approximately 350 km southeast of Port Moresby occurred at 161800 UTC. This low moved westwards and deepened with cyclone status being reached at about 180600 UTC. *Kathy* did not develop further at this stage as it progressed along a west-southwesterly track. Landfall was made on Cape York Peninsula just before 191200 UTC near the mouth of the Pascoe River.

*Kathy* moved across the Cape overnight and into the Gulf of Carpentaria just north of Weipa around 192200 UTC. Weakening took place during this period and only slight tree damage was reported.

The strongest reported wind was 60 km h<sup>-1</sup> at Batavia Downs at 191800 UTC when *Kathy* was about 55 km to the north-northwest. During 21 and 22 March *Kathy* moved slowly over the warm waters of the Gulf on a general southwesterly track. Rapid intensification took place on 21 March with severe cyclone status being reached around 210900 UTC.

*Kathy* reached peak intensity around 221200 UTC when located approximately 100 km northeast of Vanderlin Island and the Dvorak EIR T number estimate at this time was 6.5. Between 211600 and 222100 UTC GMS-1 imagery showed a clearly-defined eye and at Fig. 9 are unenhanced and enhanced photographs of *Kathy* at 220300 UTC. The cyclone weakened slightly before landfall at Port McArthur at about 222130 UTC.

The lowest reported pressure was 938 mb from a

trawler close to the Centre Island meteorological station. The station's barograph registered a minimum pressure of 940 mb during the passage of the eye of the cyclone and, before the Dines anemometer failed, the highest recorded wind gust was 232 km h<sup>-1</sup>.

Cyclone *Kathy* devastated the Sir Edward Pellew Group and several small camps were demolished. A fishing fleet experienced hurricane winds and phenomenal seas for about eight hours as the cyclone passed over them. Three trawlers were forced aground above the high water mark and one sank with the loss of one crewperson. Figure 10 is a photograph of a trawler stranded on Willi Islet near Vanderlin Island.

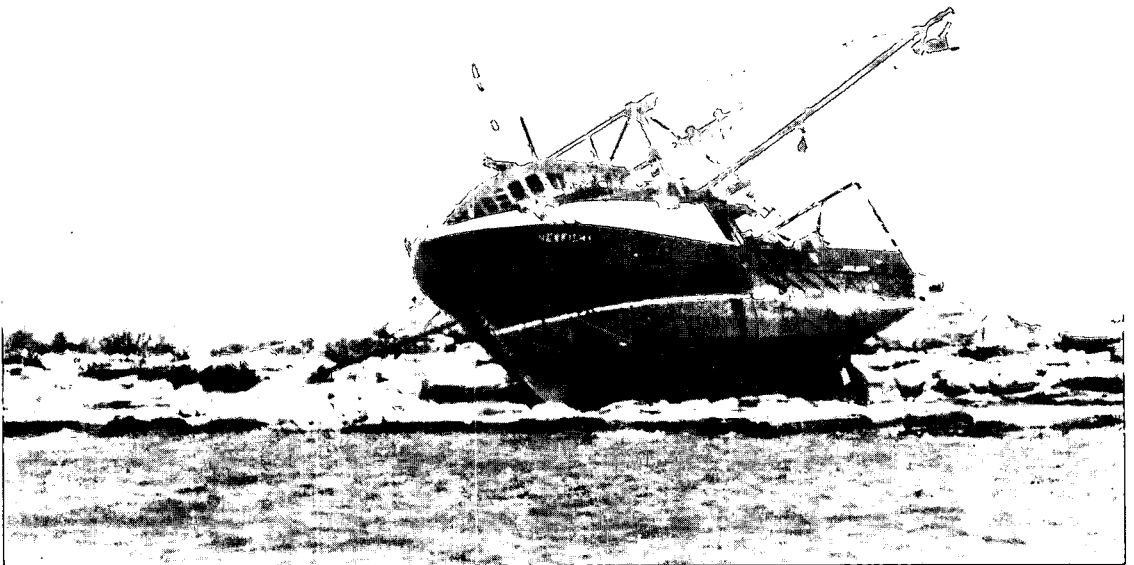
*Kathy* crossed the mainland coast around 222130 UTC just north of Borroloola township where there was moderate to severe damage. A 4.2 m storm surge was measured on the east coast of Vanderlin Island. Large numbers of dugongs and green turtles were carried inland due to the flat open nature of the coast at landfall and a dugong was found 8 km inland.

*Kathy* continued to move inland on a southwesterly track and lost cyclone status at 231400 UTC when about 200 km from the coast. The remnant low decayed about 24 hours later after turning to the southeast.

#### 21. Tropical cyclone Lance, 3 to 7 April 1984 (Fig. 6)

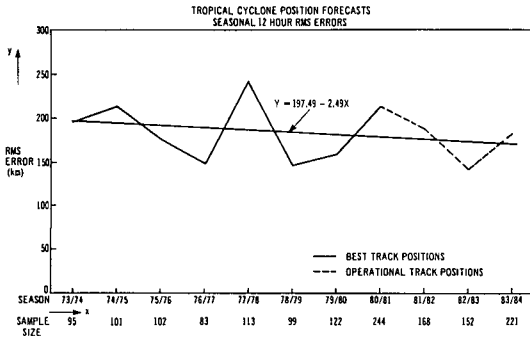
Tropical cyclone *Lance* was the last cyclone for the 1983-84 season in the Australian region. A weak low developed in the monsoon trough on 4 April. The low at this stage was centred about 500 km southeast

Fig. 10 Trawler aground at Willi Islet due to tropical cyclone *Kathy*.





**Fig. 11 Seasonal 12-hour RMS forecasting errors for tropical cyclone seasons 1973-74 to 1983-84. (Seasonal errors for 1981-82 to 1983-84 are preliminary.)**



of mainland Papua New Guinea and subsequently moved southwest and gradually deepened. Cyclone status was reached around 050300 UTC when *Lance* was located about 650 km east-northeast of Cairns. The lowest estimated central pressure of 992 mb occurred at 051200 UTC with *Lance* then moving on a southerly track. Between 051500 and 070600 UTC the central pressure remained at about 995 mb and during this period *Lance* turned to the south-southeast.

Upper-level northwest winds became established over the system and sheared the deep layer convection to the east and cyclone intensity was lost from about 070600 UTC. By 072100 UTC the remnant low had decayed about 250 km east-northeast of Rockhampton. The strongest reported wind associated with *Lance* was 96 km h<sup>-1</sup> from a ship at 050600 UTC when it was located 165 km to the southwest of the cyclone.

A new low developed around 072100 UTC near the northern tip of Fraser Island ahead of a marked upper-level trough that was moving northeast over New South Wales. This low moved south-southeast and deepened to about 980 mb by 081500 UTC when it was centred approximately 200 km east-northeast of Brisbane. During 8 and 9 April heavy rain and storm-force winds were experienced along the Moreton coast and nearby islands. After 090900 UTC the low moved away to the east and gradually weakened. The low was not classified as a tropical cyclone.

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