

FIJI METEOROLOGICAL SERVICE

TROPICAL CYCLONE REPORT 96/7

TROPICAL CYCLONE GAVIN

2 - 11 March 1997

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FIJI METEOROLOGY SERVICE

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INTRODUCTION

Tropical Cyclone Gavin was the seventh and most intense cyclone to occur in the Regional Specialised Meteorological Centre Nadi (RSMC Nadi) - Tropical Cyclone Centre area of responsibility¹ in the 1996/97 season. It reached a maximum intensity with sustained winds² estimated at 100 knots³ on two occasions; the first while it was heading southwards towards Fiji, and the second after it had passed to the southwest of Fiji. Gavin had winds of about 90 knots during its passage through the Yasawa and Mamanuca Groups.

Gavin was the most intense cyclone to affect Fiji since Oscar (24 February - 2 March 1983). A pressure of 936.8 hPa was recorded at Yasawa-i-rara on 7 March, believed to be the lowest pressure ever recorded in Fiji.

In terms of damage, Gavin was the most destructive cyclone to affect Fiji since Kina (26 December 1992 - 5 January 1993). Gavin caused 18 deaths in Fiji and a damage bill estimated at F\$33.4 million (1997 dollars)⁴.

Gavin also caused severe coastal erosion and destruction of food crops over parts of Tuvalu, mostly to the southern islands of Niulakita and Nukulaelae. In Futuna, food crops were heavily damaged by the wind while sea water inundation resulted in road and public networks being partially destroyed as well as some fales (traditional houses) being damaged.

The track of cyclone Gavin and estimated extent of gale, storm, and hurricane force winds is attached.

HISTORY

Gavin was first identified as a slow moving tropical depression to the northwest of Rotuma and west of Tuvalu on 2 March 1997. Over the next two days the depression continued to develop while moving slowly towards the east-southeast. It was officially named "Gavin" by

¹ Equator to 25°South, 160°East to 120°West

² 10-minute average at a height of 10 metres above ground level. Momentary gusts can be significantly stronger. All winds are 10-minute averages unless otherwise stated.

³ 1 knot = 1.85 kilometres per hour = 0.51 metres per second.

⁴ Kina caused 23 deaths and damage estimated at \$F170 million (1993 dollars).

RSMC Nadi at 0000 UTC⁵ on 4 March with maximum winds near the centre estimated at 35 knots.

Gavin developed quite rapidly and began taking a more eastward track towards southern parts of Tuvalu the following night. The cyclone reached hurricane intensity around 0300 UTC on 5 March. By this time it had begun curving towards the south and had developed a well-defined eye. It passed about 30 miles⁶ to the southwest of Niulakita, the southernmost island of Tuvalu, around 1500 UTC that night with estimated winds around 85 knots near the cyclone centre. The weather station on Niulakita reported winds averaging 64 knots at 1800 UTC on the 5th.

Gavin began heading due south towards northern parts of Fiji. It reached maximum intensity (100 knots) for the first time around 0600 UTC on the 6th and was tracking directly for the Fiji Group. It passed about 135 miles to the west of the French territory of Futuna around 1000 UTC, with that island recording maximum winds of 24 knots at 0927 UTC but with a gust to 69 knots at 1112 UTC.

Gavin continued tracking towards Vanua Levu (northern Fiji) but took a turn towards the southwest from around 1200 UTC. The cyclone weakened slightly soon afterwards, probably caused by land influences disrupting the low-level inflow. The cyclone passed about 60 miles to the northwest of Labasa around 1800 UTC. At this stage the cyclone had estimated maximum winds of 90 knots and was now heading directly for the Yasawa chain of islands. The cyclone centre was clearly evident on radar from around 1930 UTC. Satellite and radar pictures of Gavin are shown in Appendix 1.

The eye of the cyclone passed directly over the meteorological station at Yasawa-i-rara around 0100 UTC on the 7th with the pressure falling to 936.8 hPa at that time. Records suggest that this is the lowest pressure ever recorded at any meteorological station in Fiji⁷. A copy of the barogram from Yasawa-i-rara during the passage of Gavin is shown in Appendix 2a. Three hours prior to that, the anemometer at the station recorded a southerly wind of 60 knots with a gust to 90 knots at 2200 UTC on the 6th. This was to be the last measured wind from the station as the anemometer mast was blown down shortly afterwards. However, the wind at the station continued to strengthen and reached an estimated average speed of 80 to 90 knots just prior to the eye passage. The maximum wind at the station was estimated at 90 knots from the northwest with momentary gusts to 120 knots. This occurred around 0230 UTC on the 7th, shortly after the eye had moved through.

Over the next few hours, Gavin tracked southwestward through the Yasawa group at a speed of about 12 knots. It passed 20 miles to the east of Viwa Island where the pressure fell to 948.7 hPa at 0430 UTC (see Appendix 2b). The maximum wind at the station occurred around 0300 UTC and was estimated at 80 knots with a gust to 95 knots.

⁵ Universal Co-ordinated Time - same as Greenwich Mean Time = Fiji Local Time minus 12 hours. All times UTC unless otherwise stated.

⁶ miles = nautical miles throughout this publication. 1 nautical mile = 1.85 kilometres.

⁷ Cyclone Oscar was responsible for causing a pressure of 952.7 hPa with a measured sustained wind of 80 knots and gust to 116 knots at Vunisea, Kadavu on 2 March 1983; like Gavin, Oscar also had maximum winds estimated at 100 knots.

Gavin passed about 30 miles to the west of Lautoka and Nadi during the late afternoon of the 7th. At Nadi, the pressure reached a minimum of 955.8 hPa at 0400 UTC while the anemograph recorded maximum winds of 54 knots and a gust to 90 knots around 0430 UTC.

The SEAFRAME STATION⁸ located at Lautoka wharf recorded 2-minute average northeasterly winds of 56 knots at both 0500 and 0600 UTC with a maximum gust of 86 knots occurring sometime within this hour (reports are only available on the hour).

The barogram and anemograph from Nadi are shown in Appendix 2c while data from the SEAFRAME STATION are shown in Appendix 2d.

By 0600 UTC on the 7th, Gavin had passed through the Yasawa group and was now located just west of the Mamanuca-i-ra group of islands with maximum winds still estimated at 90 knots. The cyclone continued on a southwest track, passing to the west of the Mamanuca-i-caka group. By 1800 UTC, Gavin had slowed down to a speed of about 6 knots and was intensifying again while moving further away from land. It commenced curving southwards shortly afterwards and from 0000 UTC on the 8th the cyclone began moving in a south-southeastward direction. Gavin reached maximum intensity (winds estimated at 100 knots) for the second time around 1200 UTC that night. It accelerated slightly to about 12 to 15 knots and headed in a general southerly direction from this time onwards. Gavin passed into Wellington's area of responsibility around 1200 UTC on the 9th and began to gradually weaken.

Gavin underwent extra-tropical transition from around 0000 UTC on the 11th. It tracked southwards towards New Zealand but curved away to the southeast when it was about 160 miles to the northeast of Whangarei, located in the north of North Island. The system eventually dissipated over open waters to the east of New Zealand.

A summary of wind and pressure reports from Fiji synoptic stations is presented in Table 1.

WARNINGS AND ADVISORIES

(i) International Marine Warnings issued by Nadi

The first international marine warning for the pre-cyclone tropical depression was issued at 1800 UTC⁹ on 03 March. The Gale Warning stated that winds were expected to increase to 35 knots within 60 miles of the centre in the next 12 to 24 hours. However, the depression was named "Gavin" in the next warning, issued 6 hours later.

The warning issued at 0600 UTC on the 4th was upgraded to a Storm Warning when the estimated winds of 40 knots were expected to increase to 50 knots within 12 to 18 hours. Gavin continued to intensify quite rapidly and the warning was upgraded to a Hurricane Warning 12 hours later. At this stage, winds close to the cyclone centre were estimated at 55 knots but expected to increase to 65 knots (hurricane force) within 12 to 18 hours.

⁸ Operated by the National Tidal Facility, Flinders University, Adelaide.

⁹ This is the synoptic time; International Marine Warnings are routinely issued 75 minutes after the main synoptic time but updates may be issued at any time.

Table 1. Maximum Winds, Lowest Pressures, and Rainfall at Fiji Meteorological Stations. Barometer readings are used for pressure data when available.

STATION	WINDS			PRESSURE		RAINFALL
	Maximum Avg Wind (knots)	Highest Gust (knots)	Date/ Time (UTC)	Lowest Pressure (hPa)	Date/ Time (UTC)	24hr to 9am 8/3/97 (mm)
Udu Pt	40	65	06/2100	987.5	06/1730	24.2
Labasa	30	55	06/2200	987.0	06/2200	120.0
Matei	25	50	07/0000	992.0	06/1600	40.1
Nabouwalu	30	55	06/0900	983.0	06/2300	80.9
Yasawa	90 (est)	120 (est)	07/0230	936.8	07/0100	194.0
Viwa	80 (est)	95 (est)	07/0300	948.7	07/0425	148.8
Nadi	54	90	07/0430	955.8	07/0400	270.0
Lautoka*	56	86	-	965.6	07/0400	-
Laucala Bay	47	55	07/0305	987.8	07/0440	60.0
Nausori	46	54	07/0100	987.7	07/0400	36.7
Vanua Balavu	38	45	06/2100	992.0	08/0600	66.9
Lakeba	30	42	-	998.0	08/0430	68.1
Vunisea	35	45	07/0300	987.5	08/0600	58.8
Matuku	30	43	07/1200	990.0	08/0600	73.4
Ono-i-lau	20	29	08/0300	993.0	08/1700	48.1

*SEAFRAME STATION located at Lautoka wharf. Data from this station are only available hourly. Winds are 2-minute averages; 56 knot winds were recorded at both 0500 and 0600 UTC with a maximum gust of 86 knots occurring sometime within this hour.

Hurricane Warnings were subsequently issued every 6 hours until 1800 UTC on the 6th. An updated warning was issued at 1951 UTC mentioning that the cyclone had been re-located at 1900 UTC by radar about 60 miles to the west-southwest of the 1800 UTC position. At this stage, warnings mentioned sustained winds of 95 knots close to the centre and that the cyclone was moving towards the south-southwest at about 10 knots.

In the next warning, issued at 0000 UTC on the 7th, maximum winds were reduced slightly to 90 knots as the cyclone intensity decreased due to the affect of nearby land. This intensity was maintained in marine warnings until 1800 UTC on the 8th when it was increased to 100 knots as Gavin had moved well away from land and it was apparent that the cyclone had re-intensified. By 0600 UTC on the 9th, Gavin was beginning to gradually weaken and winds were reduced to 90 knots as the cyclone neared the border between the Nadi and Wellington area of responsibility (25° South).

Responsibility was handed over to Wellington 6 hours later, and the next warning, issued by Wellington around 1200 UTC on the 9th, weakened Gavin to about 85 knots. Gavin tracked

in a general southward direction with subsequent warnings gradually reducing the cyclone's intensity. By 0000 UTC on the 11th, Gavin had become an extra-tropical cyclone and the Wellington warning was downgraded to a Storm Warning with winds estimated at 60 knots near the system centre.

(ii) Tropical Disturbance Advisories issued by Nadi

Eleven Tropical Disturbance Advisories were issued every 12 hours on Gavin when the cyclone was located in the RSMC Nadi area of responsibility¹⁰. These were addressed to all the National Meteorological Services within the region and beyond. The Advisories contained technical information on the location, intensity and movement of the system, and any expected changes.

(iii) Special Weather Bulletins for Fiji and Rotuma

In addition to marine warnings described in (i) above, Special Weather Bulletins (SWBs) are also issued for land and coastal areas. These take the form of Tropical Cyclone Alerts issued whenever there is the possibility of gale force or stronger winds occurring within 24 to 48 hours, or Tropical Cyclone Warnings when gales or stronger are expected in the next 24 hours. The latter consist of Gale (34-47 knots), Storm (48-63 knots), or Hurricane (>64 knots) Warnings for specific areas.

A SWB was first issued for Rotuma at 0200 UTC on the 4th March (2pm local time - LT) placing that island on Tropical Cyclone Alert. Around this time Gavin was located about 300 miles northwest of Rotuma and heading slowly towards the island. Although Gavin soon began taking a more eastward track, which would have taken it relatively far north of Rotuma, the Alert was maintained in case the cyclone veered towards the south. Gavin did eventually move southeast and then southwards but this was not until after 0600 UTC on the 5th (6pm LT) when it was centred well north of Rotuma. The cyclone continued to veer southward from about 1800 UTC and passed about 140 miles to the northeast and then east of Rotuma. However, fortunately for Rotuma, the island was just outside the extent of gale force winds and the Alert was cancelled at 1930 UTC (7:30am LT, 6 March).

At the same time a Tropical Cyclone Alert was issued for Fiji as it was now apparent that Gavin was curving southwards towards the Group. At 2300 UTC (11am LT, 6 March) the Alert was upgraded to a Storm Warning for northern parts of the Group with a Gale Warning now in force for the rest of Fiji. At 0500 UTC on the 6th (5pm LT), a Hurricane Warning was issued for Fiji. At this stage destructive to very destructive storm to hurricane force winds were expected to affect northern parts of the Group the next morning, extending to Viti Levu and the Lomaiviti Group later the next day. At 1400 UTC (2am LT on the 7th) the Hurricane Warning was extended to include Yasawa, Mamanuca, and Viti Levu.

By 2000 UTC (8am LT), the cyclone centre was now more easily located by visible satellite imagery and also within radar range. It was apparent that Gavin had veered towards the southwest during the previous night¹¹. The SWB issued at this time mentioned the

¹⁰ Tropical Disturbance Advisories are now routinely issued every 6 hours.

¹¹ See Operational Aspect for a discussion.

expectation of hurricane force winds over Vanua Levu, Yasawa, Mamanuca, and northern and western Viti Levu, with gale force winds expected to affect the rest of Fiji.

At 0200 UTC on the 7th (2pm LT), storm or hurricane force winds were expected to affect the Yasawa and Mamanuca Groups and northern and western parts of Viti Levu with gale force winds affecting the rest of Fiji. At 0600 UTC (6pm LT), when Gavin was centred over the Mamanuca Group about 30 miles west-northwest of Nadi and still moving towards the southwest, it was possible that the cyclone would begin curving towards the southeast soon afterwards. Hence the warning issued at this time mentioned the expectation of storm or hurricane force winds also occurring over Kadavu. However, fortunately for Kadavu, the cyclone did not curve southeastward until about 12 hours later.

The Hurricane Warning was downgraded to a Storm Warning at 0800 UTC on the 7th (8pm LT) as the cyclone had moved far enough away for any land area to experience hurricane force winds. The warning was downgraded to a Gale Warning at 2100 UTC (9am LT on the 8th) as Gavin continued to move slowly away from Fiji. The final SWB was issued at 0800 UTC on the 8th (8pm LT) when it was apparent that gales were no longer affecting any part of the Fiji Group.

In total, 32 SWBs were issued for Fiji and Rotuma. SWBs also mentioned the expectation of flooding of low lying areas due to heavy rain as well as sea flooding of low-lying coastal areas affected by storm or hurricane force winds¹².

(iv) Special Weather Bulletins for Tuvalu

SWBs were issued for Tuvalu from 1930 UTC on the 4th March when Gavin was moving eastwards at about 8 knots and centred about 240 miles west-northwest of Niulakita, the southernmost island of the Group. At this time a Tropical Cyclone Alert was in force with gale force or stronger winds expected to occur over central and southern Tuvalu the next day. The Alert was upgraded at 2230 UTC, with a Hurricane Warning now in force for Niulakita and Nukulaelae, a Storm Warning in force for Funafuti and Nukufetau, and a Gale Warning in force for the rest of Tuvalu. Winds were expected to increase to these categories later that night.

The next two SWBs, issued at 0130 UTC and 0430 UTC on the 5th, maintained the expectation of hurricane force winds for Niulakita and Nukulaelae, but reduced the area of storm force winds to Funafuti with gales over the rest of Tuvalu. By 0730 UTC, it was clear that Gavin was curving towards the southeast and the SWB issued at this time mentioned the expectation that hurricane force winds were only likely to affect Niulakita, storm force winds expected to affect Nukulaelae, and gales over the rest of Tuvalu.

At 1930 UTC, Gavin had passed to the south of Niulakita and was continuing to veer southwards away from Tuvalu. Hence, in SWB 9 issued at this time, the warning for Nukulaelae was downgraded to a Gale Warning with the Gale Warning cancelled for the rest of Tuvalu. However, the Hurricane Warning remained in force for Niulakita. This warning was downgraded to a Storm Warning at 2230 UTC and then to a Gale Warning at 0130 UTC

¹² caused by Storm Surge

on the 6th as Gavin moved further away. The final SWB was issued at 0730 UTC when gales were no longer expected to affect Tuvalu.

In total, 13 SWBs were issued for Tuvalu. They also included information on expected weather and marine conditions.

(v) Special Weather Bulletins for Wallis and Futuna

A SWB was first issued for Wallis and Futuna at 0230 UTC on 5 March, placing the two islands on Tropical Cyclone Alert. At this stage Gavin was moving slowly east-southeastward towards the islands. The Alert was upgraded to a Gale Warning for Futuna at 2045 UTC when it was clear that Gavin was curving southwards. By 0100 UTC on the 6th, Gavin was moving due south and expected to pass well to the west of Futuna. Hence, the Alert for Wallis was cancelled, while the Gale Warning was maintained for Futuna as that island was expected to be within the extent of gale force winds. Very rough seas and damaging heavy swell were also forecast. The final SWB for Wallis and Futuna (number 10) was issued at 1600 UTC on the 6th with the Gale Warning for Futuna cancelled as Gavin was now located well to the southwest of Futuna and moving further away.

EFFECTS

From the 5th to the 18th of March, Tuvalu was severely affected by cyclones Gavin (5-7 March) and Hina (12-18 March)¹³. According to a governmental report on the extent of damage to Tuvalu from both Gavin and Hina, the cyclones caused severe coastal erosion and destruction to food crops, mostly to the southern islands of Niulakita and Nukulaelae, whilst damage in northern and central islands was confined mostly to houses. A Damage Assessment Team estimated the total damage at AU\$2.14 million, with approximately 6.7% of land washed away. It is not known the percentage of damage caused solely by Gavin.

In Futuna, food crops were heavily damaged by the wind. However, most of the damage was confined to exposed northeast coastal parts of the island where a heavy swell caused sea flooding at high tide. This resulted in road and public networks being partially destroyed as well as some fales (traditional houses) being damaged. Little damage occurred in Wallis apart from the north coast where some fales and food crops were flooded by seawater at high tide.

Gavin was the most destructive cyclone to affect Fiji since Kina (26 December 1992 - 5 January 1993) and severely affected western parts of the Fiji Group.

The passage of Gavin through Fiji was coincident with the Spring tide period with normal values of maximum sea level approximately 2.2 metres. A combination of low pressure, strong winds and Spring tide caused a marked rise in sea level recorded at the SEAFRAME STATION (see Appendix 2d).

Sea flooding due to Storm Surge was severe over the Yasawa and Mamanuca chain of islands. Damaging heavy swells and high seas affected most of the country, with the sea wall at Levuka being largely washed away.

¹³Cyclone Keli (12-16 June 1997) also caused significant damage to parts of Tuvalu later in the season.

Heavy rain associated with Gavin caused serious flooding in Labasa and western parts of Viti Levu (including serious flooding of Nadi and Ba rivers). Major destruction of sugar cane and other food crops also occurred.

In Fiji, 18 deaths were attributed to Gavin. This included 10 people lost at sea when a fishing vessel, the *Wasawasa I*, sank, and another 8 deaths caused by landslides, electrocution, and drowning. The total damage bill was estimated at F\$33.4 million (1997 dollars).

OPERATIONAL ASPECTS

Overall, the warning system during cyclone Gavin performed credibly. At one stage there were SWBs current for Tuvalu, Wallis and Futuna, and Fiji and Rotuma, as well as international marine warnings for shipping and Tropical Disturbance Advisories.

Telecommunication circuits and reception of satellite and radar imagery were mostly uninterrupted during Gavin's close passage to RSMC Nadi. However, the link to Nausori radar was cut from 1600 UTC on the 7th (4am LT on the 8th) until 0400 UTC on the 8th (4pm LT) resulting in loss of Nausori radar data. Fortunately, the link to the Nadi radar remained unaffected during the entire event. There was minor flooding of the RSMC Nadi - Tropical Cyclone Centre located at the Nadi airport Operations building but computer equipment remained unaffected. The only significant loss of meteorological equipment occurred on Yasawa-i-rara with the loss of the anemometer mast (mentioned earlier).

Office telephone and fax lines became overloaded as soon as it became apparent that Gavin was threatening Fiji. Extra staff were called in to ease the situation, but there were still occasions when all 10 voice phone lines and 3 fax lines were busy at the same time. This also caused occasional delays in the manual dissemination of SWBs by fax¹⁴. The recorded message phone in Suva was also overloaded at times despite being given additional lines by Telecom Fiji. Some of these problems will be alleviated with the move to the new RSMC building in April 1998. This will entail automatic product dissemination by fax as well as the installation of polling fax machines. It is recommended that an additional recorded phone service is installed in the western division and that these be automated.

Although most forecasting staff were shielded as much as possible from public inquiries, the large number of requests for media interviews, which often occurred at inappropriate times, adversely affected the duties that needed to be performed by forecasters. Consequently, it is recommended that set times be scheduled for media interviews, possibly about 15 minutes after the issuance of a SWB for Fiji, but taking into consideration requirements for the issue of advisories, marine warnings, and SWBs to other Pacific Island Nations.

As mentioned in previous sections, there were some difficulties in tracking the centre of Gavin during the night of the 6th and early morning of the 7th. This is not an unusual occurrence during the night when higher resolution visible satellite imagery is unavailable. However, the centre of a cyclone as intense as Gavin would normally be well defined on

¹⁴Automatic dissemination by fax was not possible with the existing preparation system.

night-time infrared imagery due to the existence of a cloud-free 'eye'¹⁵. But unfortunately in the case of Gavin, dense high level cloud obscured the eye region during this overnight period. It is worth noting that the presence of a weather radar at Labasa, Vanua Levu, would have resulted in Gavin being more accurately tracked on its approach to the Fiji Group, and also that the cyclone's turn to the southwest would have been evident much earlier.

The re-location of Gavin during the morning of the 7th was mentioned in SWB 17 issued at 2000 UTC on the 6th (8am LT). Although this was a scheduled issue, it would have been prudent to have labelled this a "Flash" SWB due to the re-location and also the fact that the forecast positions had been significantly adjusted to compensate for the Gavin's altered track. Similarly, the first SWB for Tuvalu (containing an Alert) stated that the next SWB would be issued some six hours later. However, the next SWB, issued when after Gavin had made a turn to the northeast, was issued just three hours later and included Hurricane, Storm, and Gale Warnings for various parts of Tuvalu. This was a significant change in policy and should have resulted in SWB Number 2 for Tuvalu being labelled "Flash".

One or two SWBs for Wallis and Futuna were also not issued as expediently as they may have been. For example, SWB number 4, was scheduled to be issue at 2030 UTC on the 5th, but not actually transmitted until 2050 UTC. The main reason for this delay was a change in the cyclone's course towards the south at a time when the warning policy was being formulated for Wallis and Futuna. At this time it was not certain whether Gavin had in fact turned southwards, with such a turn sparing the need to place Wallis under Gale Warning. It would have been more prudent to have issued the bulletin at the designated time even though it may have meant placing Wallis on Gale Warning given that there was still uncertainty in this decision. An updated warning could then have been issued once the southward movement was verified. Also, the bulletin issued at 2050 UTC indicated that the next issue would be sent around 2330 UTC instead of the routine 6-hourly time of 0230 UTC on the 6th. Unfortunately this oversight went undetected and the next SWB was issued at 0100 UTC.

In hindsight, it is evident that Tropical Cyclone Alerts for Tuvalu and for Wallis and Futuna should have commenced about 12 hours prior to the actual first issue. However, overall Warnings for these countries were accurate and issued in a timely manner.

Due to the typical sparsity of synoptic and ship observations in the vicinity of tropical cyclones, the major method for estimating their intensity is based on interpretation of satellite imagery. This was the case for cyclone Gavin and operationally the estimated intensity of Gavin was very close to the post-event "best-track" analysis. Gavin's intensity as it passed through the Fiji Group was also verified by observations from nearby stations, particularly those from Yasawa-i-rara.

Model guidance for Gavin proved particularly useful. Forecast tracks from the UK Meteorological Office Global Model are shown in Appendix 3¹⁶. It can be seen that the early track of Gavin, including its passage close to Fiji, was well predicted. The model also correctly forecast Gavin's southward movement towards New Zealand. However, the extent

¹⁵Infrared sensors indicate the temperature of the cloud top. But even at night the centre of an intense cyclone will usually be evident on infrared imagery because the sensor will normally discriminate between the warm cloud-free eye region and the very cold surrounding high level cloud.

¹⁶These were available operationally about 5 hours after the model analysis times (0000 and 1200 UTC).

of the deceleration and eastward turn prior to dissipation (to the northeast of New Zealand) was not well predicted.

Verification statistics for Gavin are presented in Appendix 4. The small initial position error of 18 kilometres indicates that Gavin was well tracked. This average error includes an error of 92 kilometres due to the re-location at 1800 UTC on the 6th. It is also evident that 12 and 24 hour forecasts showed significant skill over persistence, most likely due to the sound model guidance mentioned above.

A list of recommendations based on the above operational aspects is presented in Appendix 5.

CONCLUSION

Cyclone Gavin was the most destructive cyclone to affect Fiji since Cyclone Kina and produced the lowest pressure recorded at any meteorological station in Fiji with a pressure of 937 hPa recorded at Yasawa-i-rara.

Although Gavin devastated many parts of the Fiji Group, particularly the Yasawa and Mamanuca islands, its turn to the southwest just before its passage through Fiji spared the heavily populated islands of Vanua Levu and Viti Levu the full brunt of the cyclone.

Sound model guidance caused the somewhat erratic movement of Gavin to be well predicted and warnings on winds, flooding, and storm surge were substantially timely and accurate.

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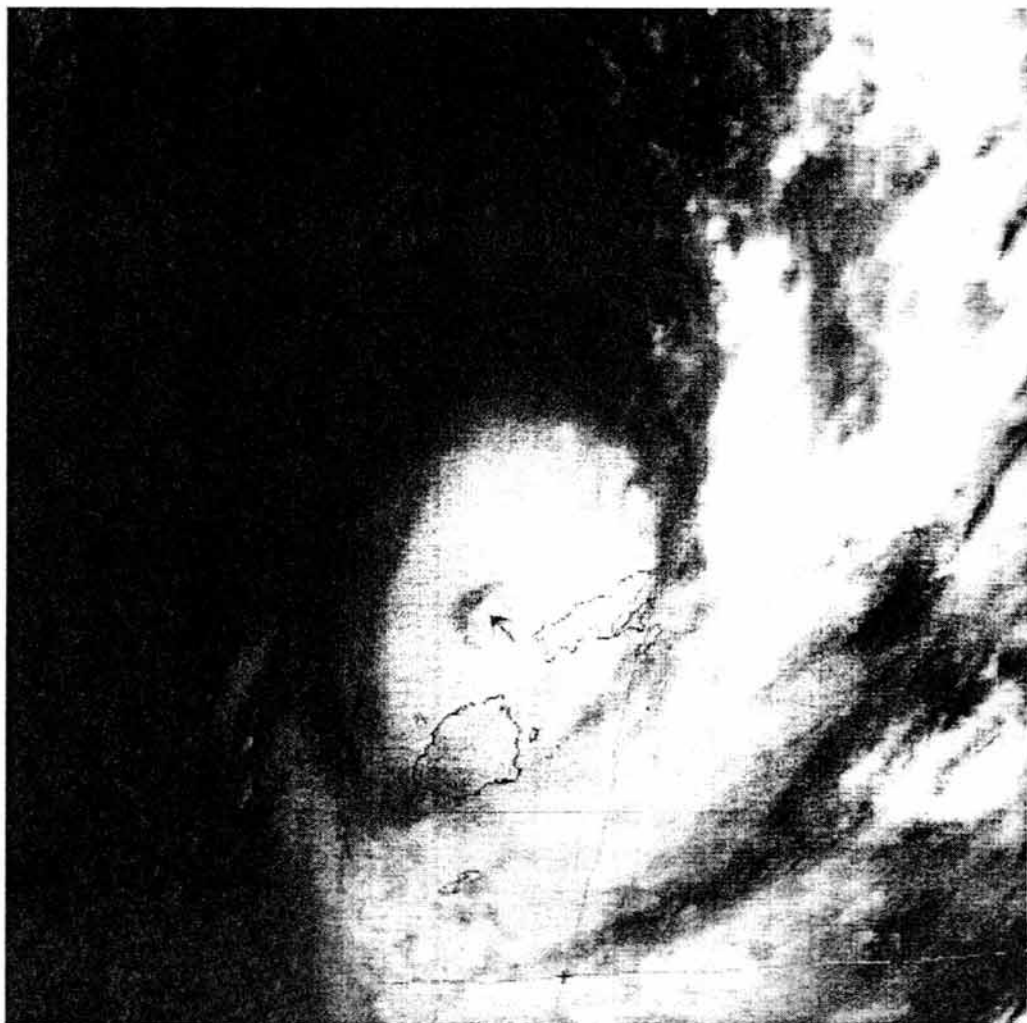
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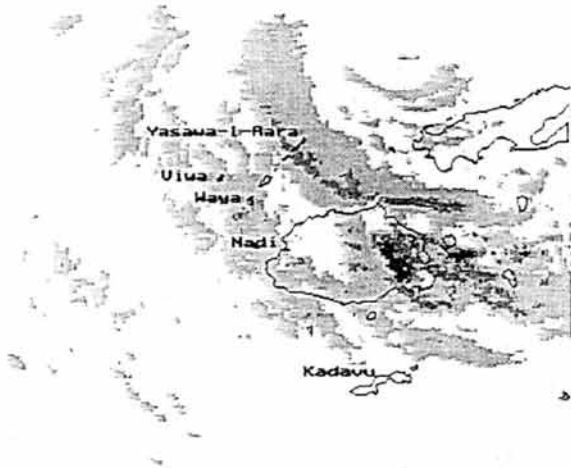
Appendix 1

Visible wavelength satellite view of Tropical Cyclone Gavin at 2330 UTC, 6 March 1997 (midday LT on the 7th). Maximum intensity at this time estimated at 90 knots. Arrow indicates position of cyclone centre.



Appendix 1 (cont.)

Radar reflectivity images from Tropical Cyclone Gavin. Intensity is proportional to the degree of shading. Image Times in UTC. The cloud-free 'eye' region is clearly evident.



Nadi 06/03/97 19:00 000.0el MRG
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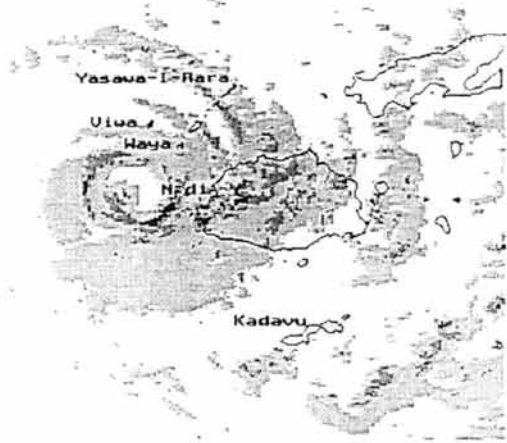
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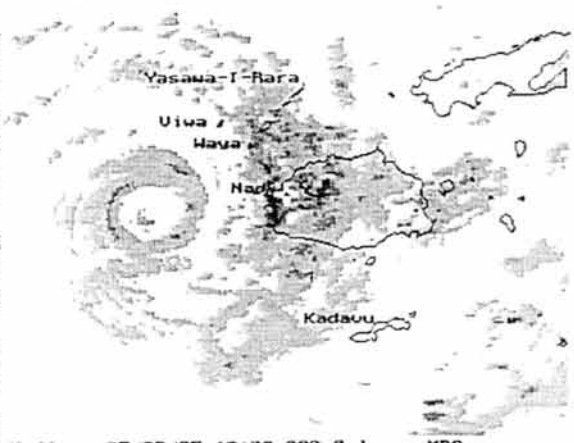
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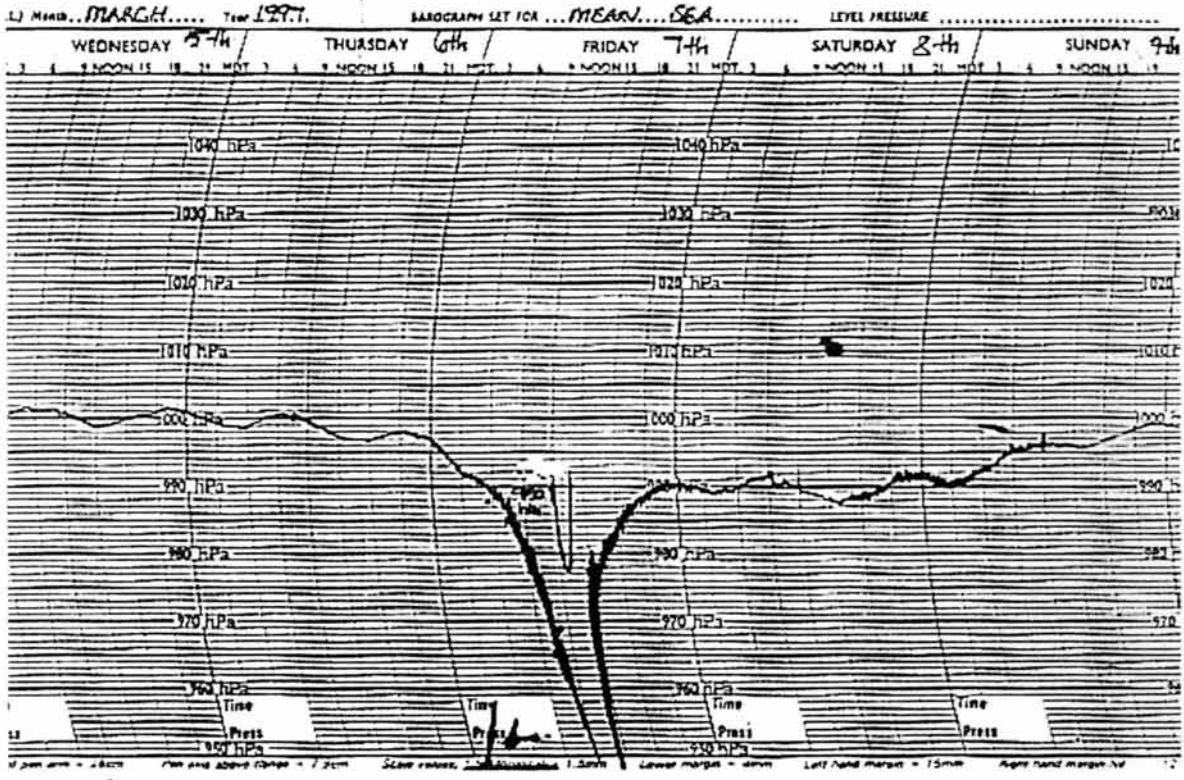


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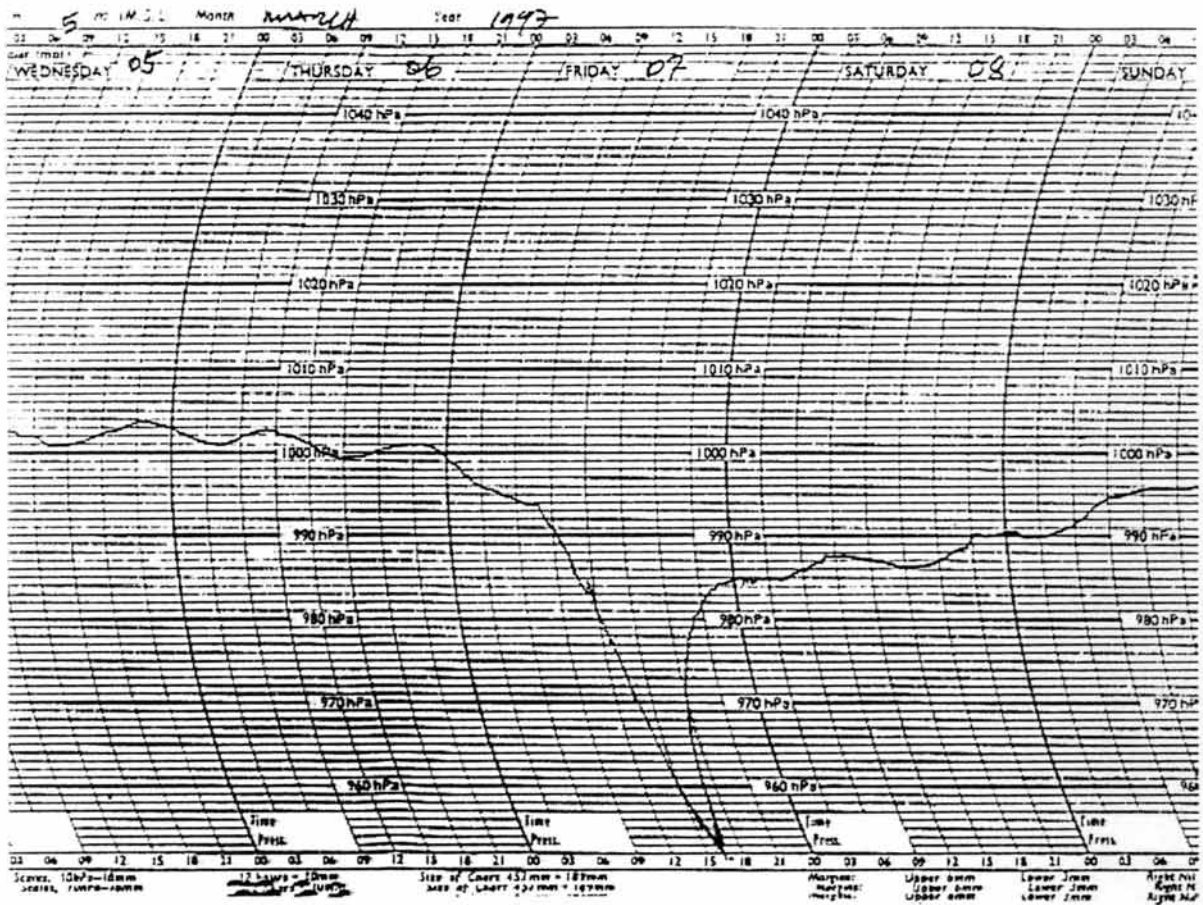
Nadi 07/03/97 10:00 000.0el MRG
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Barogram from Yasawa-i-rara Meteorological Station.



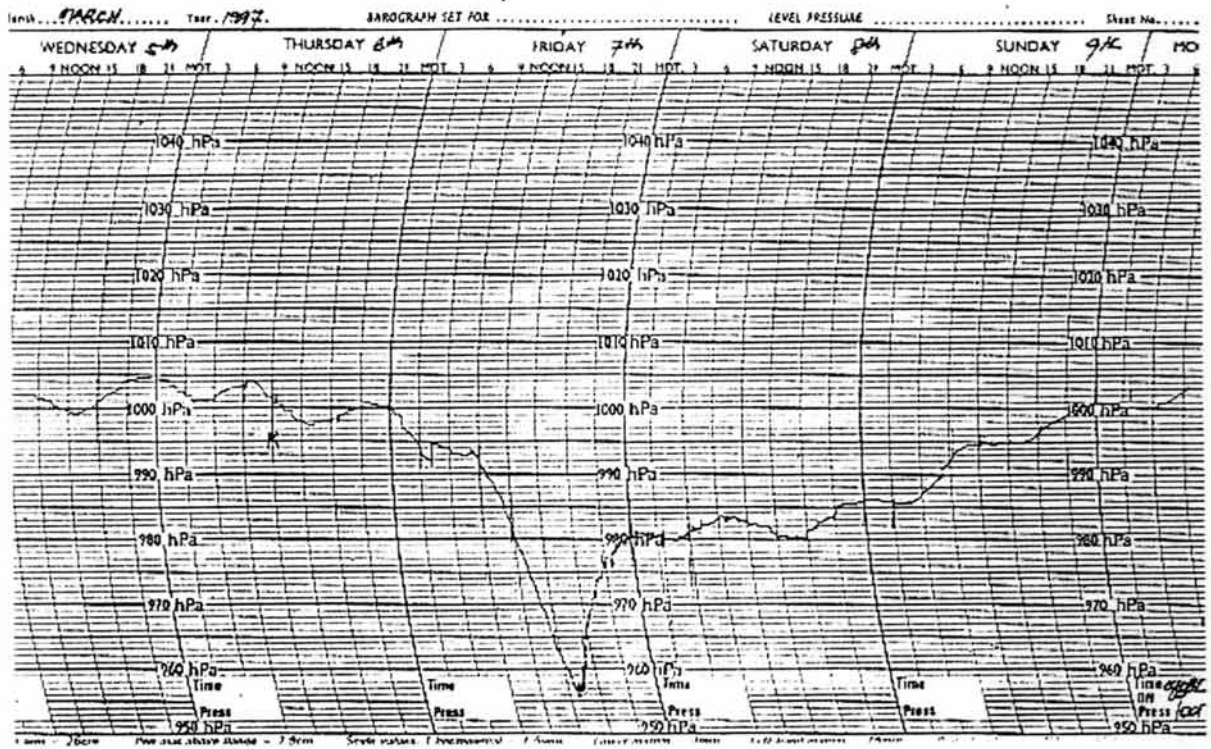
Note: the barogram shows a lowest pressure of 937.1 hPa at around 1300 LT (0100 UTC). The actual lowest pressure was 936.8 hPa, recorded by the more accurate station barometer at the same time.

Barogram from Viwa Meteorological Station.

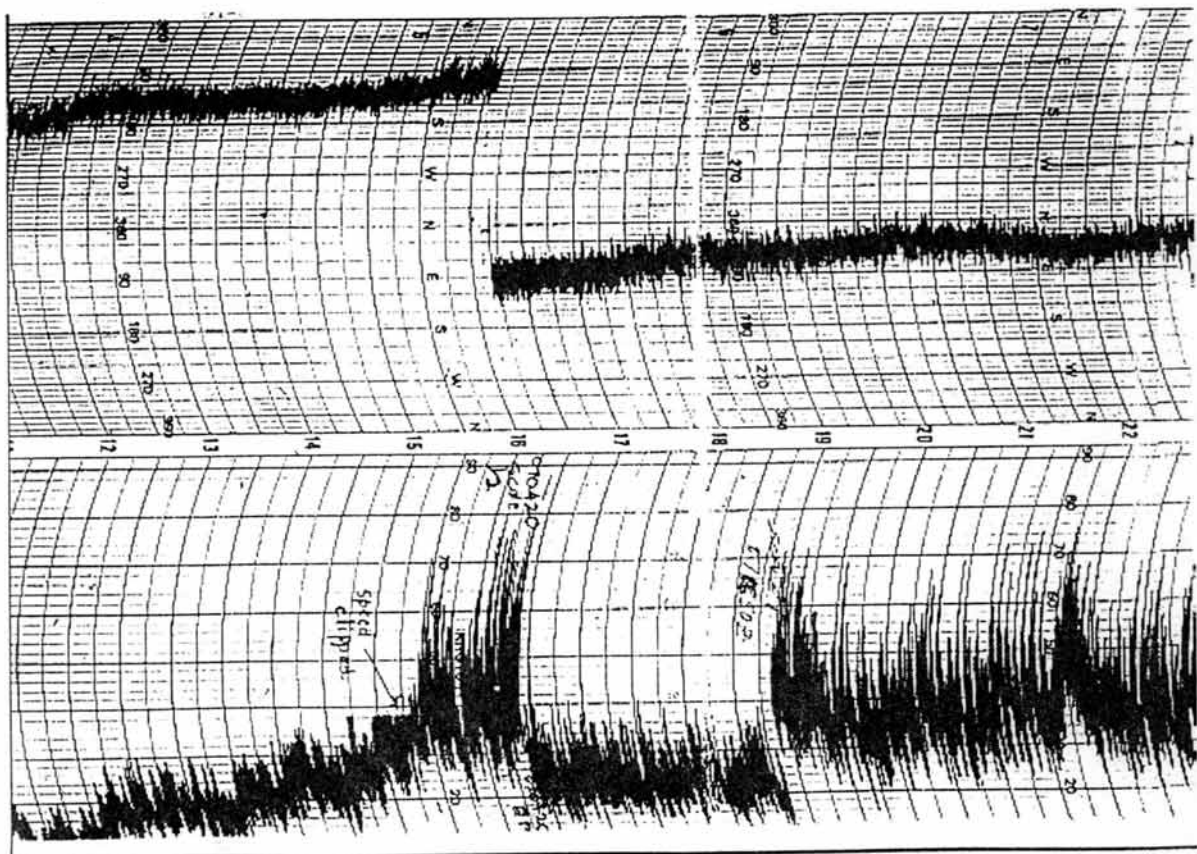


Lowest pressure 948.7 hPa at 1630 LT on 7th March (0430 UTC).

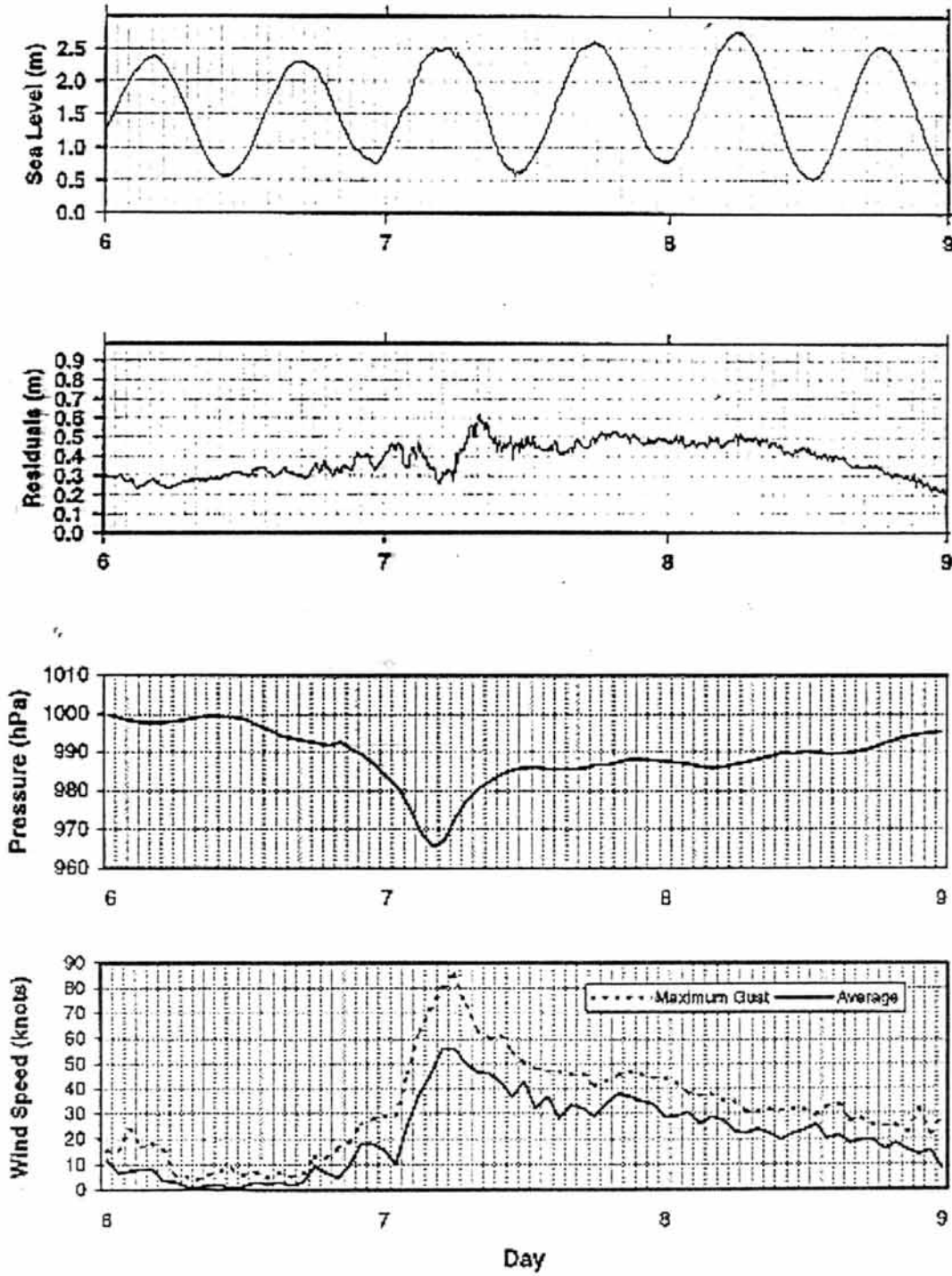
Barogram from Nadi Airport Meteorological Station.



Anemograph from Nadi Airport Meteorological Station.

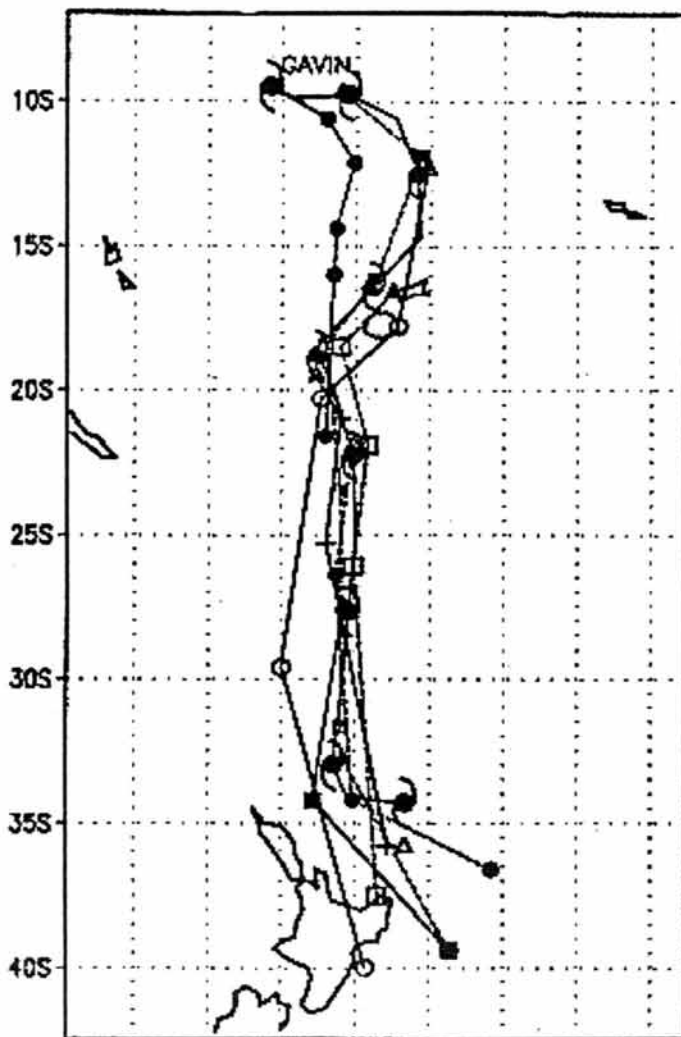


Data from SEAFRAME STATION located at Lautoka wharf.



Forecast tracks of Tropical Cyclone Gavin from the UK Meteorological Office Global Model.

**FORECAST TRACKS of TROPICAL CYCLONE GAVIN
UK METEOROLOGICAL OFFICE GLOBAL MODEL**



- | | | |
|---------------|---------------|---------------|
| —●— UK 970304 | —■— UK 970305 | —○— UK 970306 |
| —□— UK 970307 | —+— UK 970308 | —◆— UK 970309 |
| —■— UK 970310 | —⊖— UK 970311 | —⊞— UK 970312 |

KEY to FORECAST TRACKS (Triangles denote analysed positions)

24 HOURLY REAL TIME OBSERVED POSITIONS

DATE/TIME OF FIRST SYMBOL 00Z 04 MARCH 1997

Verification Statistics

Position forecast verification statistics for Cyclone Gavin based on warnings issued by RSMC Nadi are shown below. For comparison, verification statistics are compared with forecasts based on a simplistic track movement over the previous 12 and 24 hours (known as persistence forecasts). The forecasts are generally perceived to be of some use or skill if they have smaller errors than persistence forecasts.

Forecast Lead Time	Number of warnings	Average Error (kilometres)	Persistence Error (kilometres)
0 hr	23	21	-
12hr	21	89	137
24hr	19	157	371

Recommendations

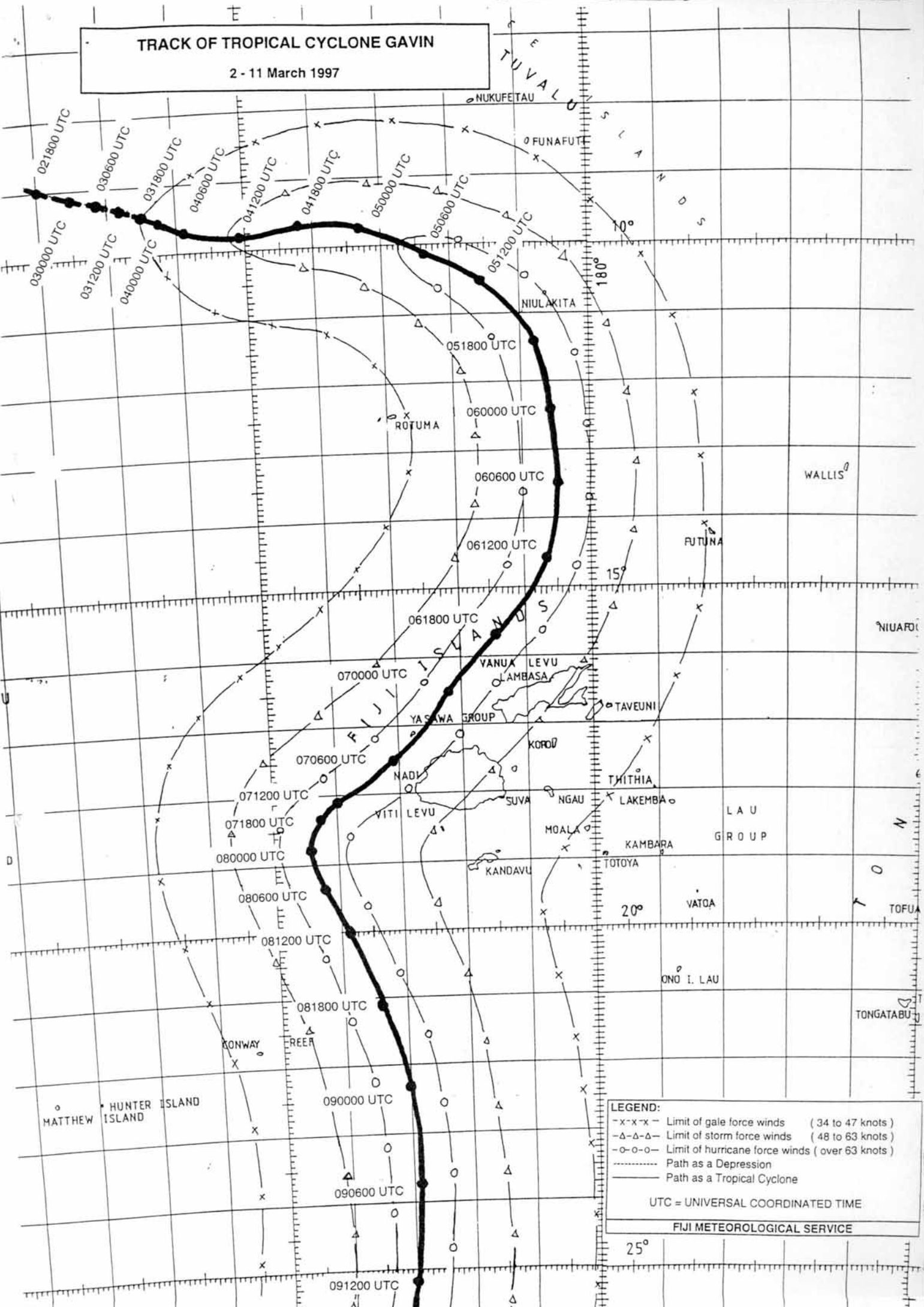
An additional recorded phone service be installed in the Western Division. This service and the existing one in Suva should be automated.

Set times be scheduled for media interviews to prevent disruption to operational duties. For Fiji, these times should occur about 15 minutes after the issuance of a Special Weather Bulletin, but consideration must be given to allow for the issue of advisories, marine warnings, or Special Weather Bulletins to other Pacific Island Nations.

An increased effort must be made to ensure that Special Weather Bulletins are issued and disseminated in a timely manner. Also, Special Weather Bulletins containing significant changes to forecast policy should be labelled "Flash".

TRACK OF TROPICAL CYCLONE GAVIN

2 - 11 March 1997



LEGEND:

- x-x-x- Limit of gale force winds (34 to 47 knots)
- Δ-Δ-Δ- Limit of storm force winds (48 to 63 knots)
- o-o-o- Limit of hurricane force winds (over 63 knots)
- Path as a Depression
- Path as a Tropical Cyclone

UTC = UNIVERSAL COORDINATED TIME

FIJI METEOROLOGICAL SERVICE