

SPATIAL VARIABILITY AND GUSTINESS OF CYCLONE WINDS: GERVAISE, MAURITIUS, FEBRUARY 1975

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ABSTRACT

During the passage of the severe tropical cyclone Gervaise (central pressure 951 mb) over Mauritius wind records were obtained from nine anemometer stations, all of which experienced the central calm. Maximum gusts at these stations ranged from 47 m s^{-1} to 78 m s^{-1} , the large variability being attributed mainly to topography. Quick-run Dines anemograph recordings at Vacoas, taken in the maximum speed ring before and after the central calm, showed that the peak gust was approximately 50 per cent higher than the 1 minute average speed and that the gust frequency was about 15 per minute.

INTRODUCTION

Mauritius, an island about 1800 sq km in area, is situated in the southwest Indian Ocean, between latitudes $90^{\circ} 58'S$ and $20^{\circ} 32'S$ and longitudes $57^{\circ} 18'E$ and $57^{\circ} 49'E$, about 900 km off the east coast of Madagascar.

The southwest Indian Ocean experiences on the average about ten tropical depressions every year, of which three or four reach the 'intense tropical cyclone' intensity - maximum winds over 33 m s^{-1} . The lowest pressure ever recorded in the area is 932 mb during the passage of cyclone Lydie at Tromelin in March 1973. Indian Ocean tropical cyclones do not attain the intensities experienced in typhoons and hurricanes in the Pacific and Atlantic areas, where pressures below 900 mb have been observed.

Anemometer records have been made in Mauritius since 1874, when a Robinson cup instrument was installed at the Royal Alfred Observatory at Pamplemousses. A Dines anemometer was installed at the same site in 1903, and a second Dines instrument at Vacoas in 1925. In the 1950s interest in the details of cyclone winds greatly increased: after the cyclones of 1945, which destroyed 60 per cent of the sugar crop, a Cyclone Insurance Scheme was established in which the criterion for payments was the occurrence of certain threshold gust values at Pamplemousses and Vacoas. However, it was felt that winds at these stations would not always be representative of those experienced in other zones of the island, and the sugar growers asked for more anemometer stations. The Meteorological Service and the Sugar Research Institute were also keen to see more secondary climatological stations set up.

Today there are 10 anemometer stations in Mauritius, at the locations given in Fig 1. With the exception of Bigara, which is looked after by the Admiralty, all the instruments have been installed and are serviced by the Mauritius Meteorological Service. They are Dines anemometers manufactured by Messrs R.W. Munro of London.

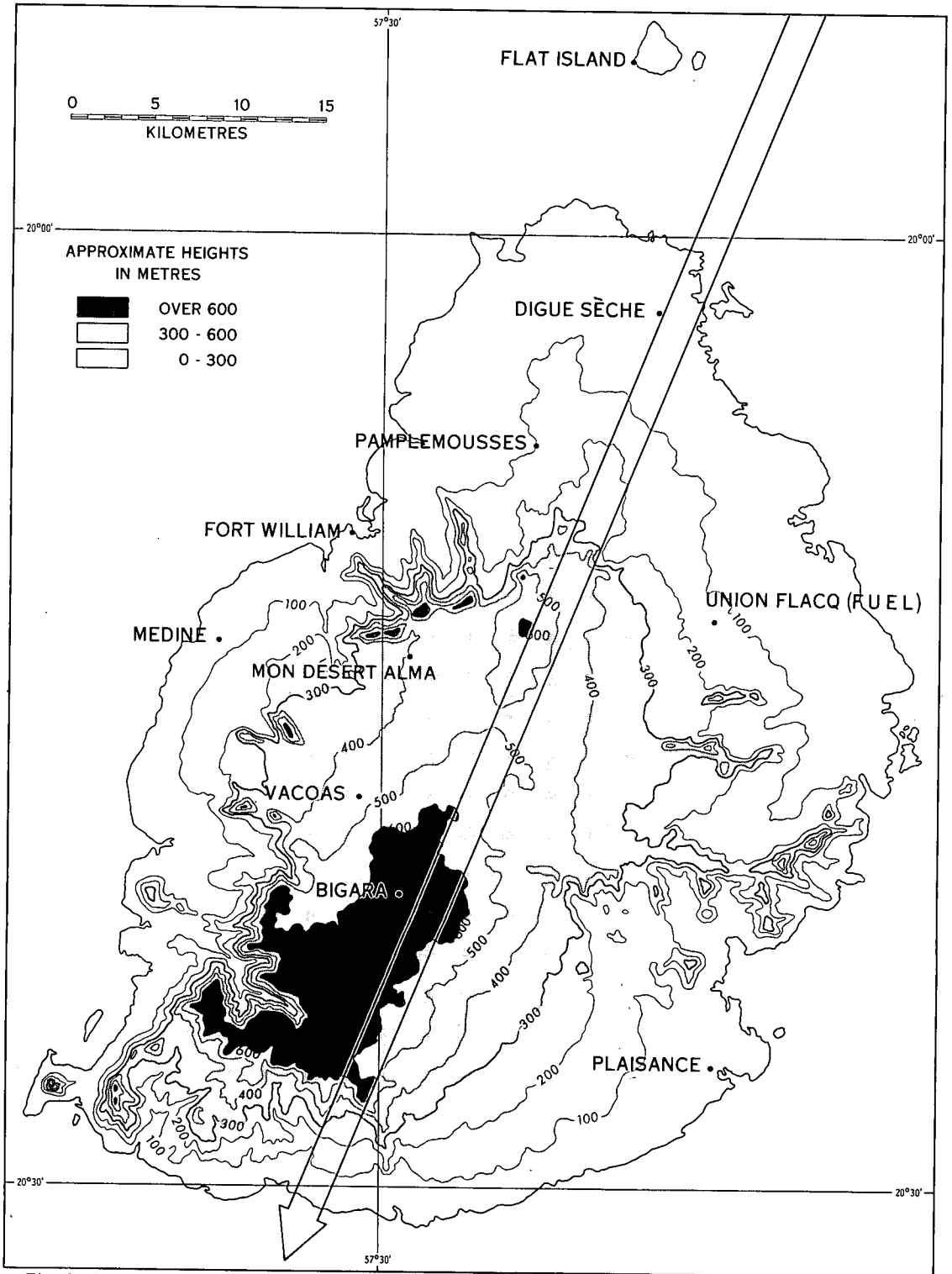


Fig 1 Map of Mauritius showing topography and the location of the ten recording anemometer sites. The broad arrow represents the track of cyclone Gervaise over the island.

CYCLONE GERVAISE, FEBRUARY 1975

The track of Gervaise is shown in Fig 2. It formed in the area south of Diego Garcia where a disturbance had been present for days. On 2 February the vortex, as confirmed by ships' observations, was organised into a depression of near moderate intensity. It continued to intensify and the next afternoon a ship about 110 km from the centre reported waves 15 m high. From that stage Gervaise was described as an intense tropical cyclone, and continued to move generally west-southwestwards up to the afternoon of the 5th, when the system came under the influence of a marked upper air trough which crossed Madagascar on that day. The track then gradually curved towards the south-southwest and on 6 February 1975 Gervaise crossed Mauritius as an intense cyclone with a central pressure of 951 mb. (See Fig 1 for details.) As the whole island is reported to have had almost the same length of calm, the track of the centre could only be inferred from the anemograms. The speed of movement of the centre across the island was about 5 m s^{-1} .

Gusts of 33 m s^{-1} , taken as the lower limit of dangerous winds, existed in a ring extending from 40 to 200 km around the centre. On the anemogram of Vacoas (Fig 3(a)) the wind is seen to start decreasing at 1750 hours, and to have reached a mean speed of 9 m s^{-1} at 1840 hours. Almost calm conditions prevailed from 2000 to 2130 hours but gusts of 22 m s^{-1} occurred again at 2240 hours with gusts in excess of 45 m s^{-1} being experienced until 0200 hours. Because of the gradual change in the wind speed, an absolute figure cannot be given for the duration of the calm but to most people it appeared to be four hours.

ANEMOMETER RECORDS OF GERVAISE: SPATIAL VARIABILITY

The anemometer records for Vacoas, Mon Désert Alma, Union Flacq (FUEL) and Plaisance are shown in Fig 3. The maximum sustained (1 minute average) wind and gust before and after the calm at each of the 10 anemometer stations in Mauritius are given in Table 1. No corrections have been made for low pressure (due to altitude or to the presence of the cyclone) or for the height of the anemometer above the ground. Furthermore it is realised that the Dines instrument does not always register the highest speeds reached in gusty conditions, due to lack of complete alignment with the wind direction (Harris 1970). The response of the pipes leading from the head to the cylinder is also believed to be not as fast as could be desired.

From the satellite photograph reports received at Mauritius - the receiver here being unfortunately out of action - it was inferred that Gervaise was associated with maximum sustained winds of about 36 m s^{-1} . As 'sustained winds' in American usage signifies the wind averaged over a one minute period, it was further inferred that the maximum gusts would be about 50 to 55 m s^{-1} . These figures provided the basis for public warnings.

Before the centre reached Mauritius, the Cyclone Warning Centre at Vacoas had lost contact with other anemometer stations, and the maximum gust of 53 m s^{-1} at Vacoas seemed to justify the faith placed in satellite reports. However, when the anemograms from the different stations became available two days later, after the roads had been cleared of fallen trees and traffic had resumed, the variability they presented was greater than had been expected.

Both Table 1 and Fig 3 indicate that cyclone winds, especially gusts, are greatly affected by the topography. The maximum sustained wind speeds recorded generally varied between 35 and 40 m s^{-1} at the different localities. The sustained speed read off the anemometer charts cannot be given to a better accuracy than the nearest 5 m s^{-1} . The only figures given more accurately are for Vacoas, where they were obtained by dividing the area under the curve on a fast-run anemogram (Fig 4) by the distance on the time coordinate.

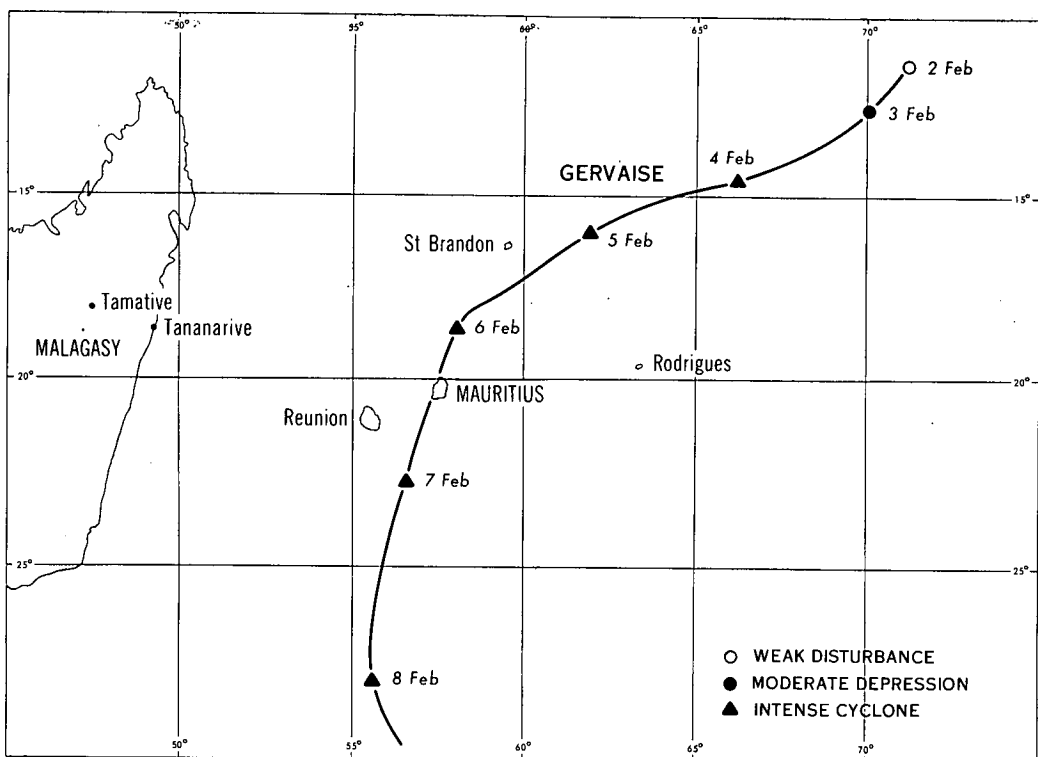


Fig 2 Track of cyclone Gervaise, February 1975. Positions indicated are at 0600 GMT daily.

Table 1 Maximum wind speeds recorded in cyclone Gervaise, February 1975

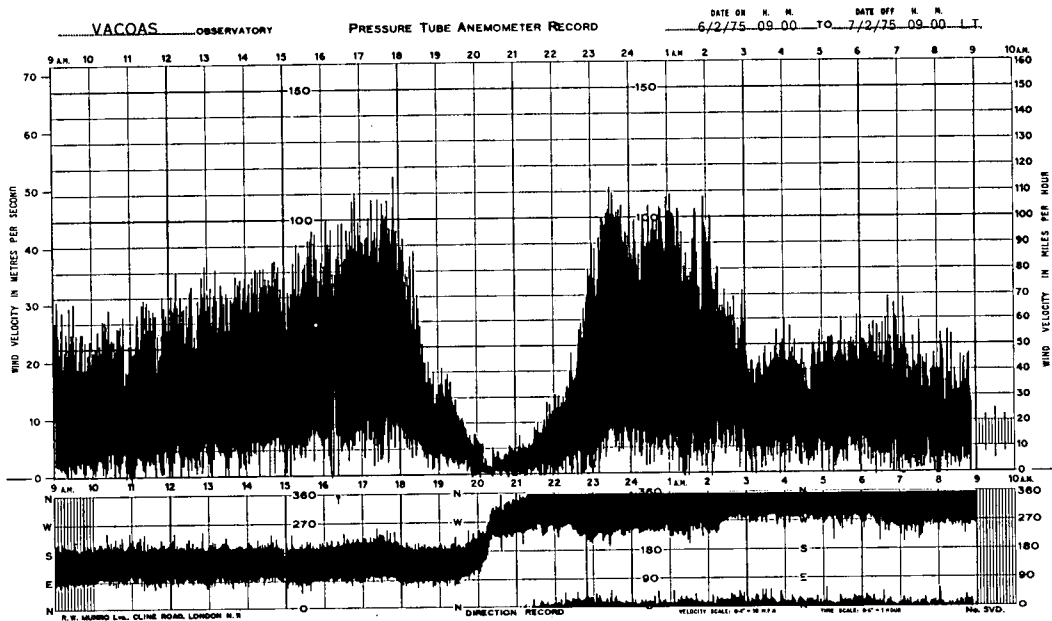
Station name	Elevation	Maximum wind before calm		Maximum wind after calm	
		Sustained	Gust	Sustained	Gust
	m	$m s^{-1}$	$m s^{-1}$	$m s^{-1}$	$m s^{-1}$
Flat Island*	91	47	64	45	60
Digue Sèche†	30	-	49	-	-
Pamplemousses‡	82	-	-	31	47
Fort William¶	6	45	65	40	57
Union Flacq (FUEL)	146	33	47	29	43
Mon Désert Alma	387	36	52	49	78
Medine	91	38	57	33	50
Vacoas	425	32	53	31	51
Bigara	579	36	54	38	58
Plaisance	58	38	57	38	56

* Anemometer stands adjoining a lighthouse on a steep promontory.

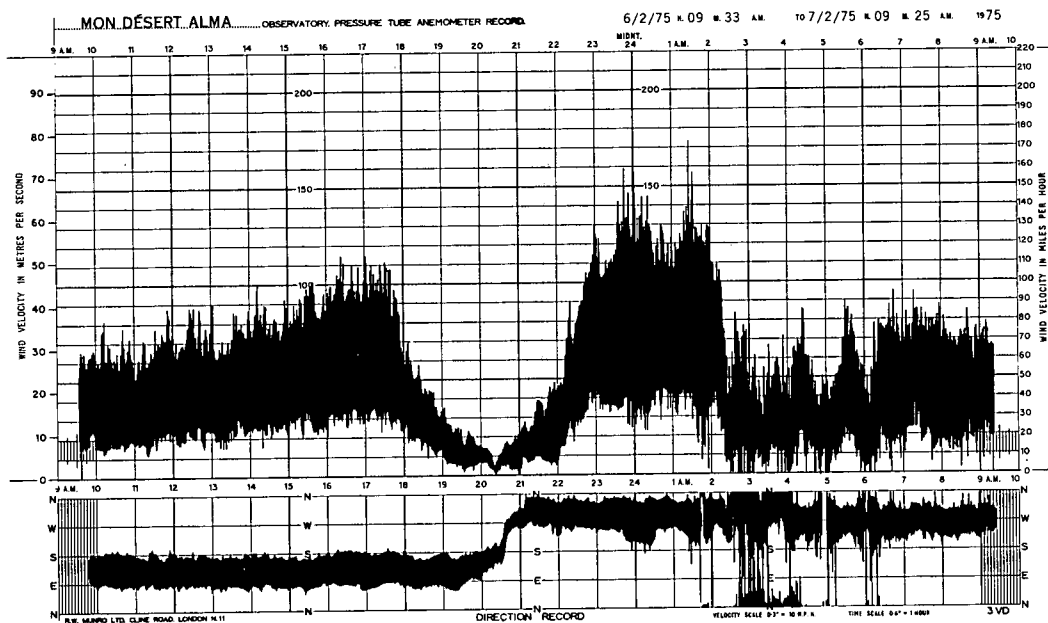
† Driving clock stopped; only the maximum gust could be read.

‡ Anemogram blank for 3 hours during intense stage preceding passage of the centre.

¶ Anemometer head 21 m above ground.

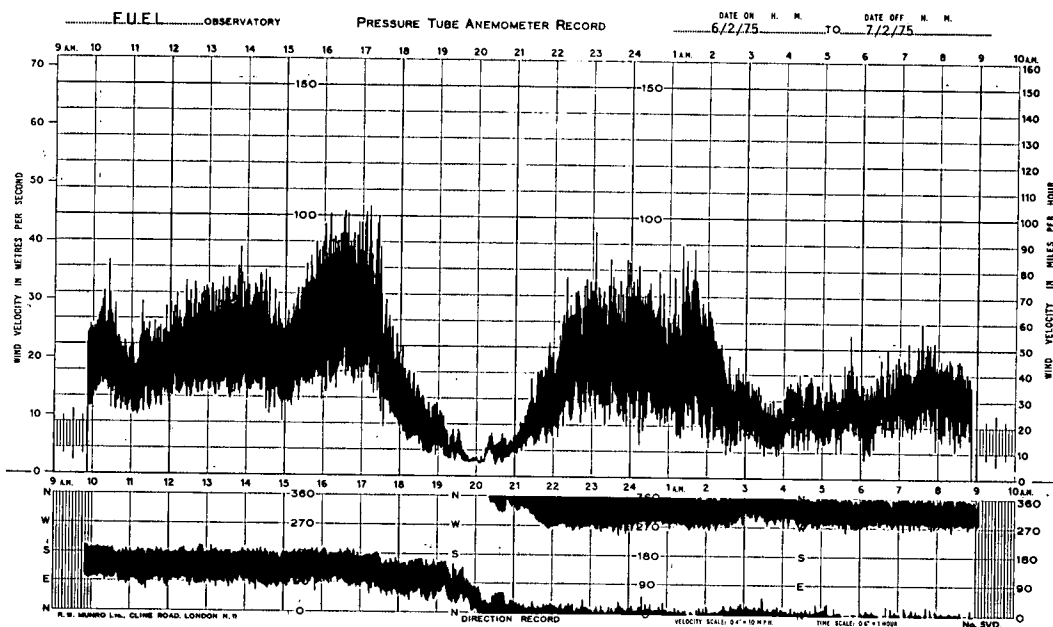


(a)

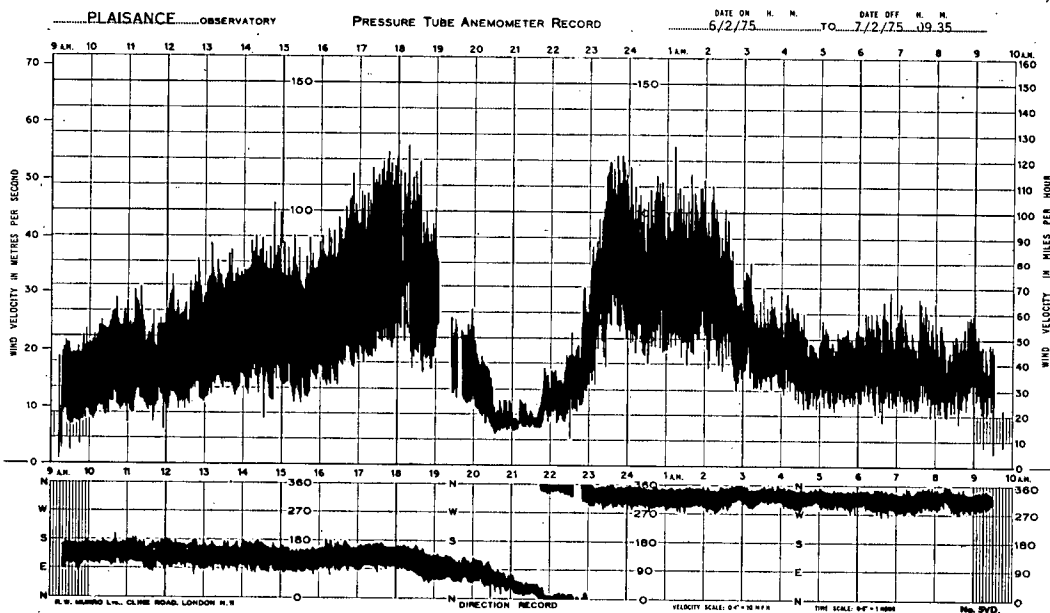


(b)

Fig 3 Dines anemograms recorded during the passage of Gervaise at
(a) Vacoas and (b) Mon Désert Alma.



(c)



(d)

Fig 3(cont.) Dines anemograms recorded during the passage of Gervaise at (c) Union Flacq (F U E L) and (d) Plaisance.

Two stations stand out in Table 1: Flat Island and Mon Désert. At Flat Island the anemometer stands on the edge of a rocky promontory which rises sharply to 90 m on the southwestern side of an otherwise low-lying flat island about 3 sq km in area. At this station the wind recorded from practically any direction is consistently higher than at stations on Mauritius itself.

At Mon Désert, the local enhancement appears very sensitive to direction. The anemogram (Fig 3) is similar in general shape to those of the other anemometer stations before the passage of the centre with a maximum sustained wind speed of about 36 m s^{-1} , gusts reaching 49 m s^{-1} eight times, and a maximum peak at 52 m s^{-1} . The wind was then coming from the southeastern sector. From azimuth 045° to 200° the surroundings are clear of topographical obstructions up to a distance of 15 km. The plateau slopes gently to the east and west, as can be seen from Fig 1. Winds from northeast through to south are therefore very much like those in the unobstructed northern and eastern plains.

After the passage of the central calm however, the winds at Mon Désert increased to unexpected values. The maximum sustained one minute speed reached 49 m s^{-1} ; on four occasions the gusts exceeded 70 m s^{-1} , and on one of those it reached 78 m s^{-1} . While at most stations the winds recorded after the passage of the centre were slightly lower than those before, at Mon Désert they were considerably higher in the second phase for about 3 hours. After that period the direction changed from about 25 degrees north of west, to a more northerly direction. The speeds then quickly came down to values comparable with those at other stations at the corresponding times. A further two hours later, the direction record shows a westerly wind, again with speeds of the same order as at other stations.

The local nature of the Mon Désert winds is further borne out by a visit to the surrounding area. The village of Saint Pierre, about 1 km to the northeast of the anemometer, did not suffer more damage than other localities. Small wood and iron sheet houses went through the cyclone unscathed. A very open decorative stand of old slender palm trees, all over 20 m tall, surrounding a house about 1.5 km to the west of the anemometer did not show signs of the passage of the cyclone.

The conclusion would appear to be that the mountain range to the north of Mon Désert must have produced some deviation in the winds from the northwestern sector, and also a strong channelling effect which gave rise to the high speeds. An oscillation in the vertical may also have been set up by the passage of strong winds over the mountains to the west-northwest. These observations would seem to cast doubt on all the previous conclusions (based on fewer observations) about the return periods of high winds and gusts at Mauritius. It seems that in the neighbourhood of hills we can only speak of winds at fixed localities, and should refrain from extending the statistics of one spot to the surrounding region except where the terrain is smooth and passably flat.

THE MORPHOLOGY OF CYCLONE GUSTS

For nearly fifteen years the Mauritius Meteorological Service has had a device for extending the time scale of the Dines anemometer in readiness at Vacoas for an opportunity to record details of cyclone gusts. The device was constructed simply by mounting a second drum, rotated by an electric motor, close to the original. On 6 February 1975 fifteen such quick-run anemograms were made. Two of these (including one which recorded the maximum gust) are shown in Fig 4.

It will be noted from Fig 4 that the gusts at Vacoas behaved as one would expect. They come in small packets or groups and individual gusts differ considerably from one another. The arrival of a gust is often seen as a rapid increase in speed followed by an equally rapid decrease. In Fig 4(b), for instance, in one gust the speed increases from 7 m s^{-1} to 46 m s^{-1} in 3 seconds; the subsequent decrease is rapid to 40 m s^{-1} and then much less so. The most usual frequency of cyclone gusts appears to be one every 4 seconds, but this sometimes increases to one every 3 seconds.

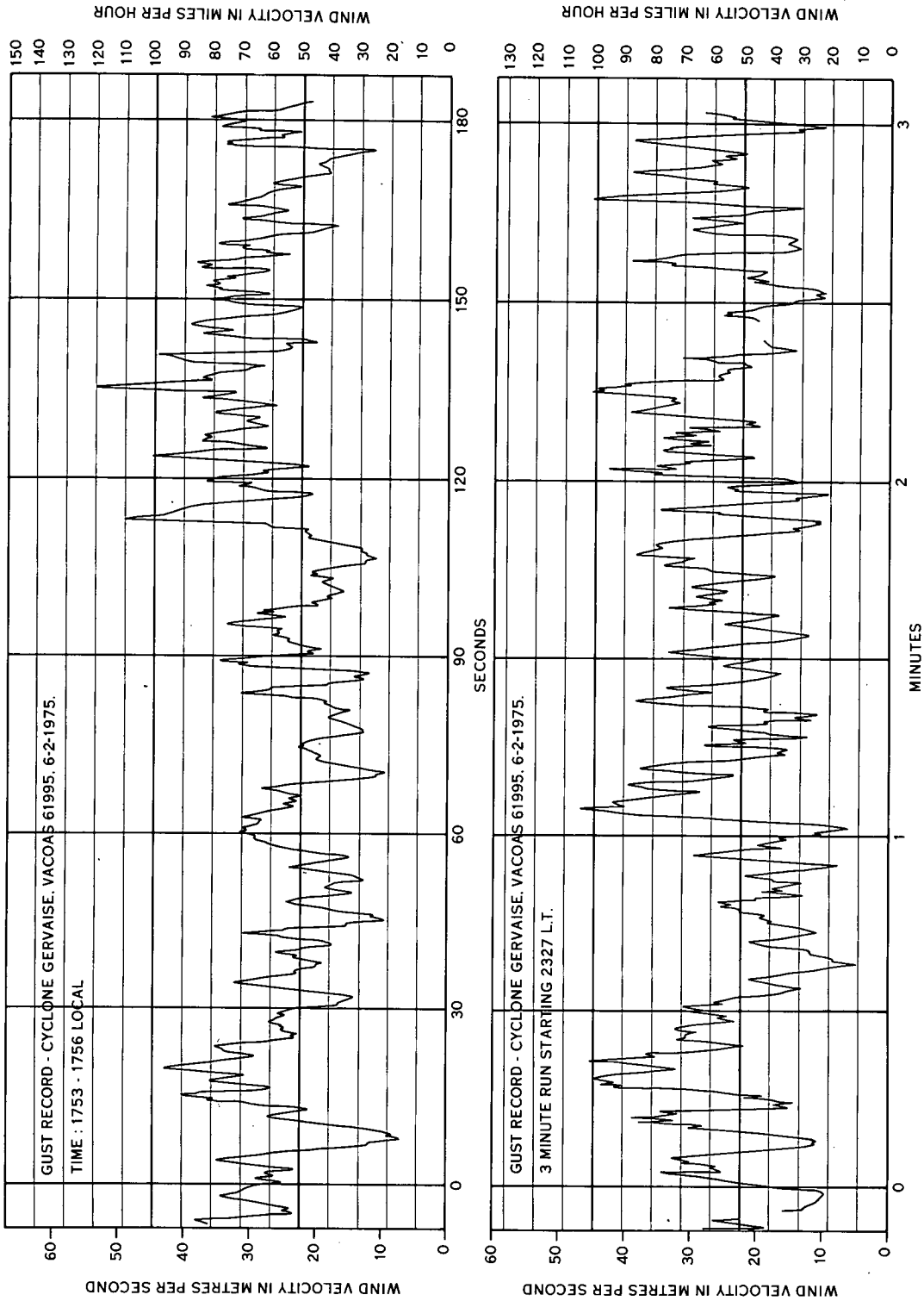


Fig 4 Two quick-run Dines anemograms recorded at Vacoas. For each recording the speed of rotation of the drum was 12 cm per minute.

A preliminary examination of the gust records available shows that the peak gust is approximately 50 per cent higher than the 1 minute speed. Building engineers are reportedly adopting the 3 second mean value of the wind in the gust for their wind-load calculations. At Vacoas this value would appear to lie between 80 and 90 per cent of the peak. As the peak is easily read off the anemogram, at Mauritius the practice is adopted of giving the peak values with the statement that 90 per cent of that value may be taken as the 3 second gust.

A comparison of the anemograms at Vacoas and Plaisance suggests that the Vacoas gust signature may not hold elsewhere. The peak winds at Vacoas and Plaisance are comparable, but while at Plaisance there is a period of about three hours during which the pen descends below the 18 m s^{-1} mark only twice, at Vacoas, in the corresponding period, the speed is shown to decrease frequently to below 5 m s^{-1} and a few times to below 2 m s^{-1} . This difference could be due to the fact that Vacoas is an area with greater roughness than Plaisance. The latter is an airfield, with no trees or buildings within half a mile of the meteorological station. The Vacoas meteorological station is situated on a plot 60 m by 180 m in a residential area with houses and a large number of big trees all around the plot and beyond. The wind arriving at the station from any direction would be considerably more turbulent than at Plaisance.

At Bigara, elevation 850 m (anemogram not shown), the gustiness had a small amplitude comparable to that at Plaisance (Fig 3(d)) before the passage of the centre, with some three hours during which the speed was never lower than 13 m s^{-1} . After the passage of the centre the wind was as gusty as at Vacoas (Fig 3(a)), dropping to the 5 m s^{-1} level frequently. A visit to the site confirms that to the east and southeast the terrain is much smoother than in the western sector.

The effect of surface obstructions is also apparent in the winds at Mon Désert, situated near a village, where the peak of 78 m s^{-1} is followed by a drop to 19 m s^{-1} . Roughness conditions at other stations are intermediate between those of Vacoas and Plaisance and so are the anemometer records.

CONCLUSION

The maximum winds experienced at different localities that have been within the band of maximum winds of cyclone Gervaise showed wide differences: the range of maximum gusts was from 47 to 78 m s^{-1} . Although this variability may have been due in part to the local and temporary variations of the cyclone itself, a major factor appears to have been the topography.

The structure of gusts is very variable, but in general the peak speed, as recorded by the Dines anemometer, was never maintained for more than half a second. The frequency of the gusts at Vacoas appeared to be roughly fifteen per minute.

REFERENCE

Harris, R.J. 1970. *The Nature of Wind*. Construction Industry Research Seminar, London, 18 June 1970.

