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Letters to the Editor

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ACCURACY OF RADAR FIXES OF A TROPICAL CYCLONE — A CASE STUDY

An interesting case of a tropical cyclone being tracked by three radars simultaneously occurred on the 17 and 18 October 1982. The positions reported by radars at Karaikal, Machilipatnam and Madras are shown in Fig. 1 and may be seen to differ by several kilometres from each other.

At the stage when the eye of a cyclone is not clearly visible on the radarscope, the centre is estimated by extrapolating the visible spiral rainbands. It is usual to use spiral overlays of crossing angles between 5 and 30 degrees. Spirals with larger and larger crossing angles are used as one proceeds from the innermost band to the outer. This is based on the finding (in the case of mature steady state hurricanes and typhoons) that the inflow angle increases from near zero at the radius of maximum winds (R) to a maximum of about thirty degrees at about $3R$ and then decreases very gradually (*see, e.g.,* Schwerdt *et al.* 1979). In a non-steady state system, there will be an asymmetry leading to different inflow angles in different sectors. The storm which we are considering developed rapidly and its toal life over the sea was only about 24 hours. It did not reach hurricane intensity. Moreover it developed very close to the coast and the spiral bands suffered deformation as some of them were partly over land. Hence the fitting of spiral overlays to the radar echoes was highly subjective. The accuracy of eye fix was reported as fair (within 30 km) or poor (within 50 km) by all the radars at this stage.

In recent studies by Raghavan and Lakshminarayanan (1974), Raghavan and Veeraraghavan (1979) and Raghavan *et al.* (1980) factors such as the angle of arc of spiral bands seen, the distortion of the bands when they come over land, the wave propagation conditions, the beamwidth errors of the radar, the appreciable height of the radar beam at long ranges and the personal errors of observation involved in realtime radar reports have been identified as contributing to errors in radar fixes. In the present case, however, even when the eye was seen by the radars and the storm was close to the coast, the accuracy of

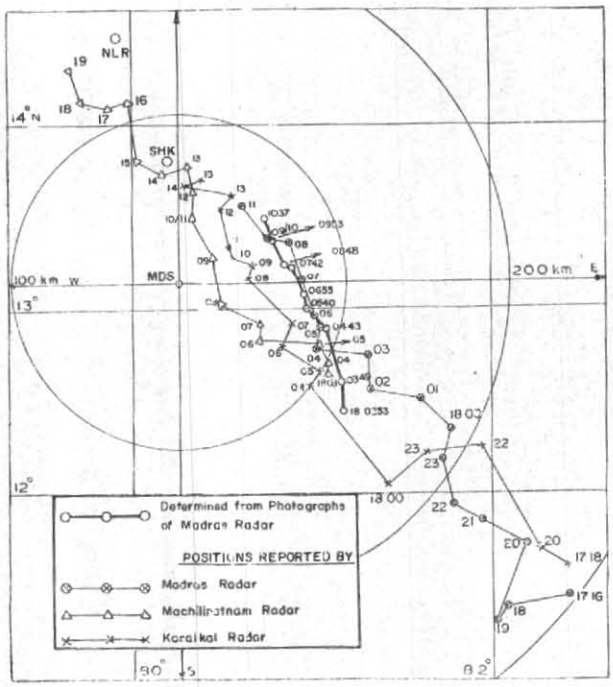

Fig. 1. Radar determined track of Sriharikota cyclone 17-18 Oct 1982 (All times in GMT)

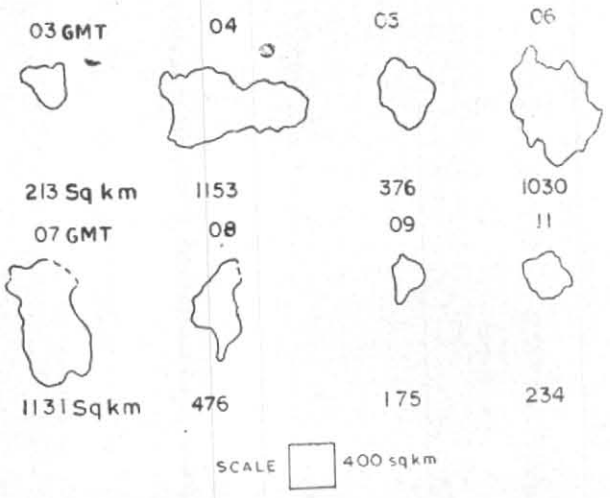

Fig. 2 Cyclone of 18 October 1982 (eye geometry as seen from Madras radar photographs)

TABLE 1

Deviation in km of reported fixes of 18 October 1982 cyclone taking Madras photographs as reference

Time (GMT)	Method of fix from photograph	Karaikal			Madras			Machilipatnam		
		Deviation	Method of fix	Accuracy reported	Deviation	Method of fix	Accuracy reported	Deviation	Method of fix	Accuracy reported
03	Eye	— not reported —			+35	Spiral	Fair	—22	Spiral	Fair
04	Do.	—20	Eye	Fair	—25	Eye	Do.	—15	Do.	Do.
05	Do.	—28	Do.	Do.	—05	Do.	Do.	—12	Do.	Do.
06	Do.	—28	Do.	Good	—05	Do.	Do.	—35	Do.	Do.
07	Do.	—20	Do.	Do.	+05	Do.	Do.	—32	Do.	Do.
08	Do.	—25	Do.	Do.	+15	Spiral	Do.	—50	Do.	Poor
09	Do.	—20	Do.	Do.	+20	Do.	Do.	—42	Do.	Do.
10	Interpolation	—27	Do.	Do.	—03	Do.	Do.	—52	Do.	Do.
11	eye	—27	Do.	Do.	—15	Do.	Do.	—43	Do.	Do.

Deviations to the left and right of the reference track are considered negative and positive respectively.

radar fixes did not improve appreciably. According to Willoughby *et al.* (1982) the eye forms only when the maximum wind reaches about 32 m/sec (the hurricane stage). In weaker storms it is often found that the eye is formed partially. In a non-steady state storm such as this, of less than hurricane intensity, weak echoes often form and dissipate in the eye region, making the delineation of the clear area of the eye a highly subjective operation. The shape and size of the eye opening were, therefore, irregularly changing from hour to hour (Fig. 2). The spiral bands did not help appreciably to improve the centre fix, as they were distorted. Hence, even when the eye was visible the radar fixes could mostly be classified as fair (within 30 km) or poor (within 50 km).

While the relevant specifications of the three radars are broadly comparable, the effective detection capability of a given reflectivity at the eyewall region will differ appreciably from one radar to the other depending on the distance of the radar from the storm. For instance at 11 GMT of 18th the storm was about 60 km from Madras and 300 km from Machilipatnam. Hence the lowest reflectivity that Machilipatnam could have detected is about 14 dB higher than that detectable by Madras, due to range attenuation alone. If beam height is considered the detection capability of the farther radar becomes still worse. Hence if the centre position is fixed using the geometry of the eye opening alone by the radar nearest to the storm it is likely to give positions farther from the coast than the more remote radars whatever may be the method of fix used by the latter.

The eye geometry reassessed using Madras radar photographs taken at approximately hourly intervals is shown in Fig. 2 for those hours for which the eye could be delineated. The track resulting from this exercise is also shown in Fig. 1. The deviations of the positions reported by the three radars from the reassessed reference fixes are shown in Table 1. It will be seen that the positions reported by Machilipatnam and Karaikal are in all cases nearer the coast than the reference track as is to be expected from the argument in the preceding paragraph. The differences vary from 15 to 52 km. The reported and reassessed tracks of Madras themselves differ appreciably. While a small part is due to difference in time between the photograph and radar report, the major difference is due to subjectivity in delineation of the eye centre.

Thus in non-steady state cyclones of sub-hurricane intensity the radar fixes are often not as accurate as the meteorologist would like them to be. The accuracy may be within about 30 km in most cases. In an intense system, however, the eyewall is usually well-defined with no transient echoes confusing the geometry and the spiral bands are also well formed and inflow angles are as expected. Hence the fixes are likely to be more accurate.

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