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Radar study of thunderstorm activity in northeast India during the premonsoon season

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ABSTRACT. Radar observations at Agartala during the premonsoon months of April and May form the basis for this study. The preferred sectors and ranges of occurrence of convective cells around Agartala and the variation in the maximum heights attained during different periods of the day have been studied. Movement of convective cells, in relation to the upper wind in the area, has also been studied.

1. Introduction

The most important weather hazard to aviation in northeast India during the premonsoon season is the thunderstorm. Knowledge of the preferred areas and times of occurrence of convective cells, their heights and movement in the vicinity of airports and sectors of dense air traffic is useful to the weather forecaster as also the airline operators for flight-planning.

A radar study has been made of towering cumulus and cumulonimbus clouds during the premonsoon months of April and May 1962, 1963 and 1964 over a region of radius 100 nautical miles around Agartala airport. Fig. 1 shows the area covered by this study and its main geographical features.

2. Data

A 3-cm weather radar (Bendix WTR-1) with a three-degree pencil beam and an effective range of 100 nautical miles has been in operation at Agartala airport since January 1962. The routine radarscope observations copied on polar diagrams for operational use and special observations taken at other times have been utilised for the study. The study is confined to cells exceeding 6 km in height.

The region around Agartala was divided into six 60-degree sectors and each sector was divided into three range intervals, namely, 0-30, 30-60, and 60-100 nautical miles. The day was divided into three-hour intervals from 00 GMT. The formation of a *Cb* cell or a group of cells as observed on the radar in a specified sector, range interval and time interval was treated as a single case. If the same cell continued to be seen during the subsequent time interval in the same sector or had drifted into the adjacent sector, it was counted as a different case on each occasion. 588 such cases during April 1962, 1963 and 1964 and 397 cases during May 1962, 1963 and 1964 were available for the study. These were regrouped under four sectors depending upon the air routes passing through the region and further subdivided under four broad time intervals. The radar was not in operation between 1500-2300 GMT on a few occasions; however a careful check of the radar observations of Calcutta, the current weather data and weather diaries of a few observing stations in the area of radar coverage confirmed that the few cases of *Cb* during the missed observational period do not affect the conclusions significantly. The results are shown in Table 1 and Fig. 2.

3. Discussion

3.1. The following conclusions regarding convective activity during the premonsoon season can be drawn from Table 1.

3.1.1. *Favoured periods of the day for formation of Cb cells*—(a) Almost all the convective activity is confined to the afternoon hours during April; the activity is minimum and insignificant during the early morning hours.

(b) In the month of May there is an increase of *Cb* activity in the early morning and forenoon hours compared to April; the minimum activity is in the night.

3.1.2. *Preferred sectors*—(a) *Cb* activity is maximum in the 270°—030° sector in both the months; there is a marked rise from April to May in this sector and particularly during the early morning and forenoon hours. The activity during the afternoon is almost the same during both the months.

(b) *Cb* activity in the 030°—090° sector records a marked fall from April to May during the afternoon and night.

(c) *Cb* activity in the sectors 090°—210° and 210°—270° is more or less the same during different periods of the day in April as compared with the corresponding periods in May.

3.1.3. *Cb activity at different range intervals*—Fig. 3 shows the distribution of *Cb* formations at

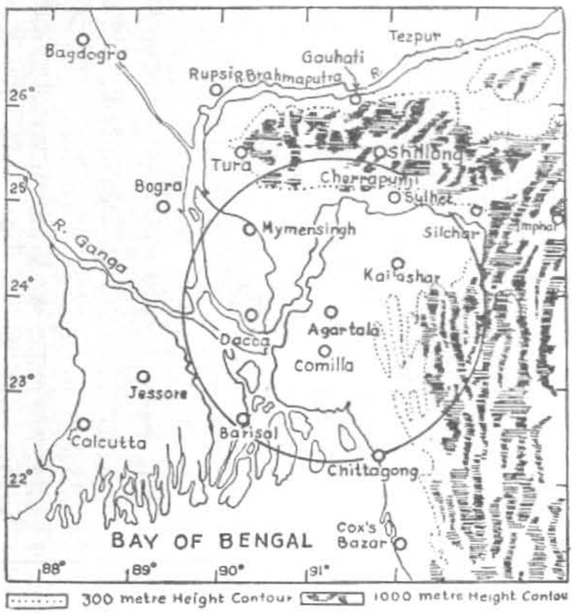

Fig. 1. Geographical map of the region showing the radar coverage area in relation to the continuous area

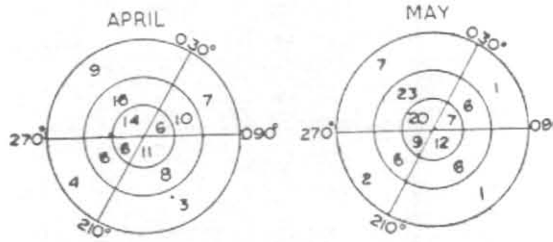

Fig. 3. Distribution of formation of *Cb* cells at different range-intervals in different sectors

(Figures indicate percentages)

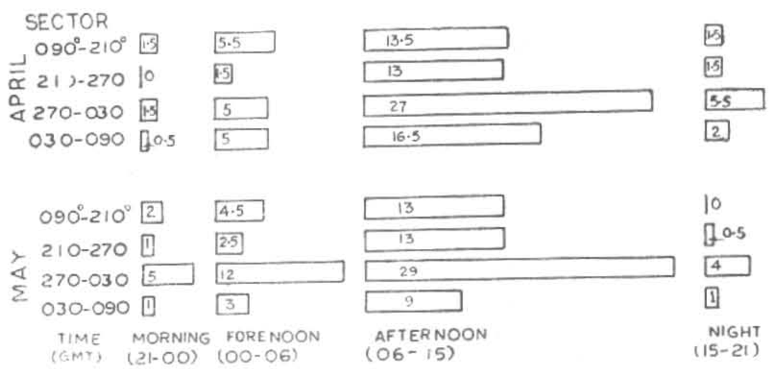

Fig. 2. Frequency of formation of *Cb* cells in specified sectors during different periods of the day, expressed as a percentage of the total number of formations during the month

different range intervals around the radar site. The three range intervals considered are 0—30, 30—60 and 60—100 n. miles.

It is seen that (a) the maximum number of cases of significant convective clouds are within 60 n. miles of the radar and in the 270°—030° sector in both April and May. This is of importance to aviation interests as a number of flights from Calcutta to Gauhati and upper Assam destinations pass through this sector.

(b) Next in importance is the sector 030°—090° which shows a decrease of convective activity from April to May beyond 60 n. miles from the radar.

(c) The others two sectors show more or less equal distribution of *Cb* formation in the three range intervals taken in order.

It would appear that the effect of range attenuation and hence the possibility of non-detection of distant echoes at the limit of the useful range of the radar might tend to lower the percentage of occasions of formation. However, frequent comparisons of the radar observations of Agartala and Calcutta for the overlapping radar coverage area showed that the formation of a significant convective cell was not missed by the Agartala radar even at the limit of its useful range. Therefore the percentage of occasions of formation of *Cb*

TABLE 1

Number of occasions of *Cb* cells in specified sectors during specified time intervals

Sectors	Time interval in GMT 21-00	00-06	06-15	15-21	Total
	April 1962, 1963 and 1964				
090°—210°	9(1·5)	33(5·5)	80(13·5)	7 (1·5)	129 (22)
210°—270°	2(0)	8(1·5)	75(13)	8 (1·5)	93 (16)
270°—030°	9(1·5)	28(5)	157(27)	33 (5·5)	227 (39)
030°—090°	3(0·5)	27(5)	98(16·5)	11(2·0)	139(24)
Total	23(3·5)	96(17)	410(70)	59(10·5)	588
	May 1962,1963 and 1964				
090°—210°	7(2)	18(4·5)	52(13)	0	77(19·5)
210°—270°	5(1)	10(2·5)	50(13)	2(0·5)	67(17)
270°—030°	21(5)	48(12)	112(29)	16(4)	197(50)
030°—090°	5(1)	13(3)	35(9)	3(1·0)	56(14)
Total	38(9)	89(22)	249(64)	21(5·5)	397

Corresponding percentages of the total number of cases are indicated within brackets

TABLE 2

Frequency of formation of *Cb* cells with maximum heights between specified limits during different periods of the day

Period (GMT)	Height group (km) 6·1—7·5	7·6—9·0	9·1—10·5	10·6—12·0	12·1—13·5	13·6—15·0	>15·1
	April 1962, 1963 and 1964—Total No. of cases 415						
21—00	17(56)	10(33)	2(7)	1(3)	—	—	—
00—06	30(41)	28(39)	7(10)	4(5)	3(4)	1(1)	—
06—15	74(29)	76(29)	34(13)	36(14)	24(9)	10(4)	6(2)
15—21	18(35)	11(20)	5(10)	10 (20)	5(10)	3(5)	—
	May 1962, 1963 and 1964—Total No. of cases 306						
21—00	18(60)	10(33)	2(7)	—	—	—	—
00—06	51(62)	20(24)	6(7)	2(3)	2(3)	1(1)	—
06—15	84(51)	35(21)	21(13)	17(10)	6(4)	2(1)	—
15—21	13(45)	9(31)	3(10)	4(14)	—	—	—

Note—Figures in brackets are percentage formations during the particular period, *e.g.*, forenoon or afternoon as the case may be and not of the total No. of cases

TABLE 3

Frequency of cloud movement associated with the upper winds at specific levels

	Upper wind level (ft) 3000	5000	7000	10,000	15,000	20,000	No agreement with any level	Total
No. of occasions	4	3	4	10	7	1	6	35

cells in the nearer range intervals is not relatively exaggerated.

3·2. *Maximum heights of Cb cells*

An analysis similar to the above was made of the maximum heights* attained by *Cb* cells during the different periods of the day in the different sectors as classified earlier. A total number of 415 cases in April 1962, 1963 and 1964 and of 306 cases in May 1962, 1963 and 1964 have been considered for this study. The maximum heights attained by the cells were grouped under height intervals of 1·5 km (5000 ft) as shown in Table 2.

It is seen from Table 2 that (a) maximum heights attained by cells in the early morning exceeded 9 km in 10 per cent of the cases in April and 7 per cent in May.

(b) In the forenoon, the maximum heights were more than 9 km in 20 per cent of the cases in April and 14 per cent only in May; of this, maximum heights of more than 12 km were reached in 5 per cent of the cases in April and 4 per cent in May.

(c) The cells forming in the afternoon had tops above 9 km in 42 per cent of the cases in April and 28 per cent in May; of this, maximum heights of more than 12 km were reached in 15 per cent of the cases in April and 5 per cent only in May.

Maximum heights of more than 15 km occurred in 2 per cent of the cases in April and not at all in May.

(d) During nights the maximum heights of more than 9 km occurred in 45 per cent of the cases in April and 24 per cent of the cases in May; of this, only 15 per cent had heights exceeding 12 km in April and none in May.

*Heights corrected for radar beam width and curvature of the earth

3.3. *Movement of Cb cells*

Movement of radar echoes of *Cb* cells in relation to the upper winds in the region, was also studied. For this purpose, only well-defined isolated echoes of *Cb* cells forming near about the synoptic hours and which retained their identity during the next observation, say within an hour, were selected from the routine radarscope observations. 35 such cases were available for the premonsoon months of 1963. The drift of the centroids of the echoes was measured and compared with the upper winds in the area. As the upper winds are not necessarily the same all over the area covered by the radar, these were obtained for the place at which the cell movement was observed, by interpolation from carefully analysed streamline charts for the relevant synoptic hour.

The echo movements, which agreed with the upper winds for the particular level to an occuracy $\pm 20°$ in direction and ± 5 knots in speed, were tabulated. The tolerance limits assumed were to allow for the errors in measurement of the drift of PPI echoes and errors of interpolation of upper winds from the charts. The results are presented in Table 3.

It is seen that echo movements agree with the upper winds at 10,000 ft in 30 per cent of the cases; and generally, *i.e.*, in 60 per cent of the cases with the winds at levels from 7000 to 15,000 ft. The observation is broadly in agreement with the results of earlier studies of radar echo movements— Byers and Braham (1949), Hiser and Bigler (1953), Rao *et al.* (1961)—where a high correlation of movement of isolated cells with winds at specific levels or layers between 5000 ft and 20,000 ft was reported. It may however be mentioned that in practice the extrapolation technique, based on the cell's movement during the earlier half an hour, met with better success than any of the relationships detailed above when such information was required for operational use at the airport.

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