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A study of isolated radar echoes of rain clouds around Agartala airport and its neighbourhood

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ABSTRACT. Studies have been made of isolated radar echoes of rain clouds observed during different seasons of 1964 and 1965, in the neighbourhood of Agartala Airport (Tripura). The vertical decay rate of echo tops has been found to be greater than their growth rate in all the seasons and the movement of isolated cells closely related to the winds from 2·1 to 3·0-km level. The heights of the radar echoes at initial detection show that the precipitation generating levels in these clouds vary, though in most of the cases, the initial heights of the tops of radar echoes is below the freezing level. This suggests that the condensation-coalescence is the dominant precipitation mechanism over the region.

1. Introduction

De and Rakshit (1961) has suggested that the condensation-coalescence process, in which cloud droplets produced by condensation attain sizes large enough to continue to grow by coalescence is the predominant process by which precipitation occurs over the Gangetic valley. In the present investigation, precipitation echoes over the Meghna valley (Tripura) were studied by means of a medium powered Bendix radar installed at Agartala Airport, in order to ascertain whether the well-known Bergeron—Findlisen process or the condensation-coalescence mechanism is the causative factor for precipitation over that area. An attempt has also been made to study the rates of growth and decay of radar echoes and the guiding wind level which controls the movement of clouds.

2. Collection and evaluation of data

Isolated radar echoes on the PPI scope of the radar were selected and their positions and the rates of growth of the echoes noted by taking hourly radar observations till an echo either dissipated or merged with adjacent cells. In the absence of an RHI facility details of the minute changes in the cloud cell formation or dissipation were not observable but only the overall changes in the heights of tops of the isolated echoes could be noted. Data relating to 200 such cloud cells spread over 150 days during different seasons of 1964 and 1965 are presented and discussed.

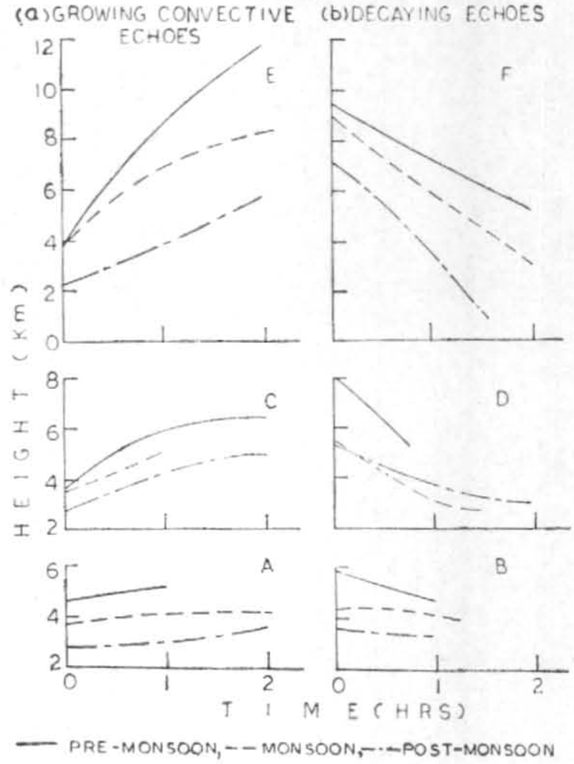
Following Battan (1953) the observed isolated echoes were divided into six grous (A to F) for the computation of the mean values of the variation in the tops of the echoes. The cases, in which the difference in the height of the echo top is 1·5 km or less from its initial stage of vertical development to its maximum or from the maximum to the final dissipating stage were respectively grouped under A and B. Similarly, the cases in which the above difference ranged from 1·5 to 3·0 km is grouped under C and D and those in which it exceeded 3·0 km under E and F. Only those echoes whose initial and final stages are known were considered for the study of their rates of growth and decay.

3. Analysis of data and discussion

3·1. *Seasonal variation*—The seasonal average heights of the tops of echoes of different groups with respect to time are presented in Fig. 1. It is seen that, in general, the average heights of the echoes is maximum in the premonsoon and minimum in the post-monsoon season.

The variation in height of the tops of growing echoes (Fig. 1a) of Group A is linear with time in the premonsoon, nearly stationary in the monsoon and has a slow initial rise followed by a rapid rise in the post-monsoon season. The development of echoes in Group C is seen to be rapid in the beginning and slow afterwards in all the seasons. The trend of the growth of echoes in Group E shows a rapid rise in the premonsoon, less rapid in the monsoon and almost linear in the post-monsoon months.

The decay rate (Fig. 1 b) of echoes of different groups in different seasons is found to be variable. The average heights of the tops of the decaying echoes of Group B is maximum in the premonsoon and least in the monsoon while in the case of Group D it is maximum in the monsoon than in the pre-



(a) (b)

Fig. 1. Mean values of the seasonal variation in the tops of (a) growing convective echoes & (b) decaying echoes of different groups around Agartala airfield

monsoon. In case of Group F it is maximum in the premonsoon and least in the post monsoon.

The average decay of echoes of Group B is linear in the pre-monsoon and monsoon, falling gradually and then rapidly in the post monsoon season. Decay curve of Group D falls rapidly at first and then slowly in the premonsoon and post-monsoon but is linear in monsoon season, whereas that of Group F is linear in the premonsoon and monsoon but falls gradually first and then rapidly in the post-monsoon season.

3·2. *Altitude variation*—In general the increase in average height of echoes with time (Fig. 2 a) is minimum in Group A and is maximum in Group E in all the seasons. Similarly, echoes of Group B show the least whereas Group F the highest decay rates (Fig 2 b).

3·3. *Height of echo tops at initial detection*—Out of 200 only 137 echoes could be observed from their initial stage of development.

The most prominent feature of the distribution of the initial heights of echo tops (Table 1) is the high frequency of their appearance below the freezing level. The average heights of tops of initial echoes in premonsoon, monsoon and post-monsoon seasons are 4·2, 3·6 and 3·3 km respectively. The corresponding freezing levels are 4·6, 5·5 and 4·6 km. This indicates that the condensation-coalescence precipitation mechanism is more active in this region.

3·4. *Rate of vertical growth and decay of echoes*—The average rates of growth and decay of the echoes are maximum in the premonsoon and minimum in the post-monsoon seasons (Fig. 3). Also when the rate of growth is vigorous, the corresponding rate of decay is also high. The average growth rate of echoes in the premonsoon, monsoon and post-monsoon seasons are 36, 20 and 19 m/min respectively whereas their corresponding decay rates are 26, 16 and 10 m/min.

It is further seen that the average growth and decay rates are maximum for E and F groups and minimum for A and B groups. In other words, larger clouds grow and decay at a faster rate (Fig. 4). The average rates of vertical growth for E, C and A groups of echoes are 36, 20 and 4 m/min respectively and their rates of decay are 44, 19 and 13 m/min. In general, the rate of decay of the tops of echoes in different groups is greater than the corresponding rate of vertical growth. This, of-course, may not be true for all stations. The

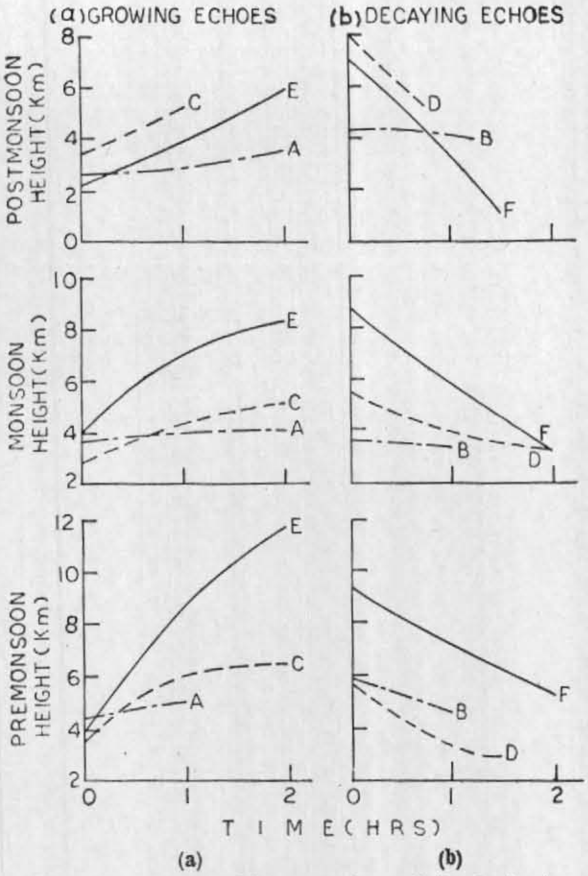


Fig. 2. Mean values of the groupwise variation in the tops of the (a) growing echoes & (b) decaying echoes in different seasons around Agartala airport

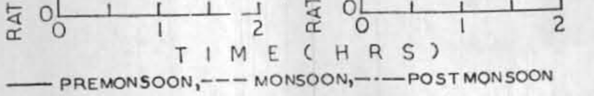


Fig. 3. Mean values of the variation of rates of growth and decay of echoes during different seasons around Agartala airfield

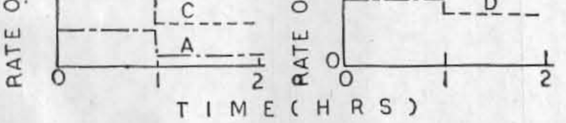


Fig. 4. Mean values of the variation of rates of growth and decay of echoes of different groups around Agartala airfield

variations of the decay or growth rate, however, might give an idea about the duration of a thunderstorm over a particular area.

The average rates of the vertical growth and decay of echoes of all groups month-wise and season-wise are presented in Table 2. The rates of growth are found to be higher in March, April and September and lower in other months than the corresponding rates of decay. These might have some bearing in the insolation and the resultant convection. Further, the rates of growth of echoes are more than those of their decay in the premonsoon months but less in the other two seasons.

TABLE 1

Average heights of echoes at initial and final stages in their formation during different seasons of 1964-65

	Initial stage		Average freezing level (km)	Final stage	
	No. of cells	Average heights (km)		No. of cells	Average heights (km)
Premonsoon	26	4·2	5·3	23	4·0
Monsoon	98	3·6	6·1	97	3·6
Post-monsoon	13	3·3	5·3	14	3·7
Total	137	3·7	5·6	134	3·7

TABLE 2

Average rates of growth and decay of echoes in different months and seasons for the period 1964-65, irrespective of groups

	No. of Obs.	Rate of growth (m/min)	No. of obs.	Rate of decay (m/min)
		Premonsoon		
Mar	13	30	7	29
Apr	19	36	18	26
May	10	23	11	38
Total	42	31	36	30
		Monsoon		
Jun	18	22	14	27
Jul	18	20	19	23
Aug	20	21	22	26
Sep	9	28	13	24
Total	65	22	68	25
		Post-monsoon		
Oct	12	18	9	24
Nov	—	—	—	—
Total	12	18	9	24

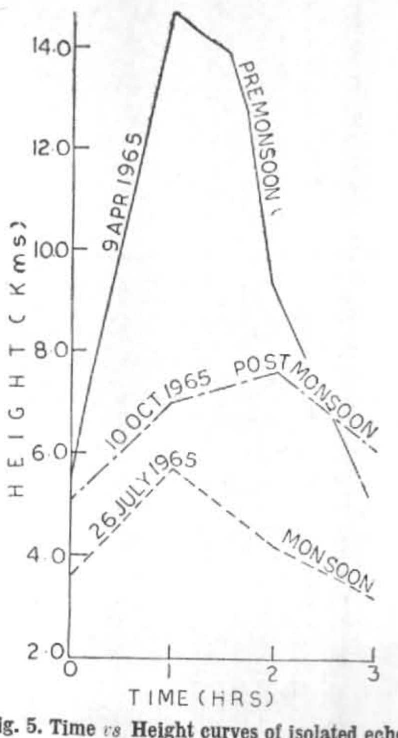


Fig. 5. Time *vs* Height curves of isolated echoes at Agartala airfield

3.5. *Vertical growth and decay of cloud cells*— It is well known that a cloud consists of many individual cells which grow quickly and dissipate at certain rate, one after the other. Moreover, they develop in stages. The height-time curves of isolated echoes chosen at random reveal (Fig. 5) that these radar clouds developed and dissipated in steps like individual cells embedded in a cloud.

3·6. *Final heights of echo tops* — Out of 200 echoes, 135 could be observed to their final stages of dissipation. On other occasions either the echo merged with other echoes or could not be followed till it dissipated completely. The height up to which the echoes retain their identity is considered interesting as it gives an idea of the level upto which rain drops are present in sizeable diameter to give radar echoes. This level is found to be lower than that of initial formation of the echo over the station.

3.7. *Movement of isolated echoes* — From a study of the translation of individual radar cells, Byers and Braham (1949) found that the correlation between echo movement and wind speeds between 1·5 and 6·0 km was quite high. According to Brooks (1946) small echoes move with the winds at 1·5 km and the larger ones with winds at 3·3 km.

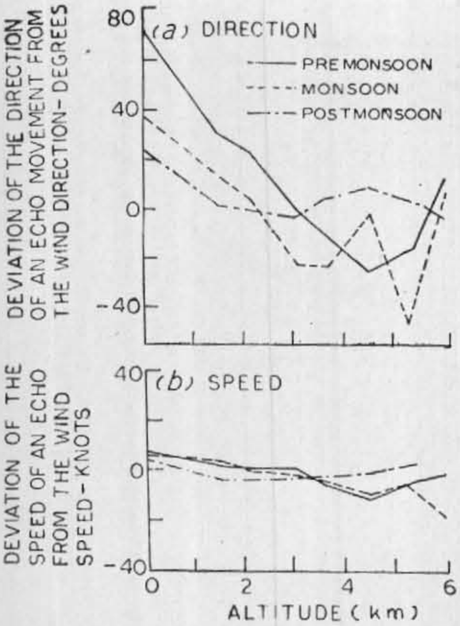


Fig. 6. Mean deviation between direction and speed of echo translation for different groups and the corresponding wind direction and speed as a function of altitude in different seasons

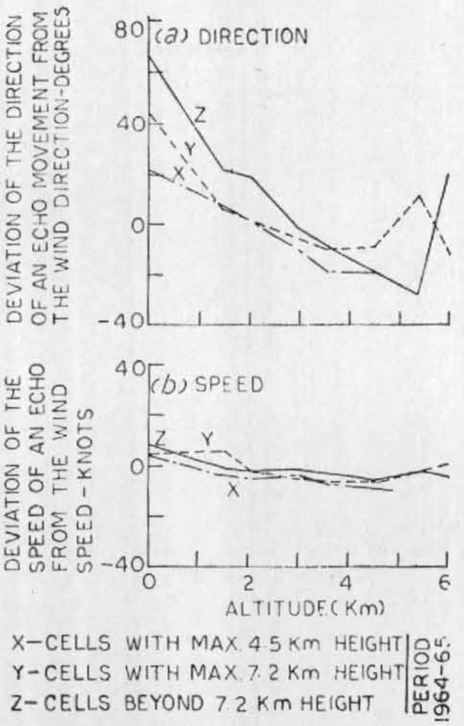


Fig. 7. Mean deviation between the direction and speed of echo translation for the different groups and the corresponding wind direction and speed as a function of altitude

Kundu and De (1967) have shown that a good correlation exists between the movement of line-type echo and the actual winds in 1·5 to 4·5-km layer. It is generally believed that the correlation of the isolated echoes with wind speed at the level at which the cloud is located will be higher. The study of 135 radar echoes when correlated with the available pibal wind observations indicates (Fig. 6) that the average movement of the echoes is closely associated with the winds near 9-km level during the premonsoon, 2·1-km level in the monsoon and 2·3 km level in the post-monsoon months. This shows that isolated echoes in general drift with the winds at 3·0-km level during the premonsoon and at 2·1 to 2·3 km in monsoon and post-monsoon seasons. In the premonsoon months, echoes grow to heights higher than those during other seasons. The drift of echoes in the premonsoon, therefore, probably shows a greater dependence on the winds at higher levels.

The radar echoes were further grouped into three categories X, Y and Z according as their tops extended upto 4·5 km or greater than 4·5 km but less than 7·2 km or greater than 7·2 km in order to find out the correlation of the drift of these cloud cells with the winds at certain level. It is observed (Fig. 7) that the movement of the echoes of the groups X, Y and Z is closely associated with the winds at 2·1, 2·2 and 3·0-km level respectively.

4. Conclusions

The present study leads to the following conclusions—

4·1. The average height of the isolated echo tops is maximum in the premonsoon and minimum in the post-monsoon season.

4·2. The higher the heights of the isolated echoes, the greater are the rates of ascent and descent of the echo tops.

4·3. The frequency of echoes appearing below the freezing level is very high in all seasons.

4·4. The precipitation in Meghna valley is mainly governed by the condensation-coalescence mechanism.

4·5. The rate of decay of echo tops is generally faster than the rate of growth except in March, April and September.

4·6. The average heights of echo tops at the final dissipation stages is lower than that at initial detection.

4·7. Isolated echoes drift with winds at 3·0-km level in the premonsoon and with winds at 2·3-km level in the monsoon and post monsoon seasons.

4·8. Isolated echoes extending upto 7·2 km are guided by the winds at 2·1-km level and those beyond 7·2 km by the wind at 3·0-km level.

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