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Radar study of premonsoon squall lines as observed at Gauhati airport

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ABSTRACT. Occurrences of line type echoes over Gauhati Airport with respect to their shapes, orientations, length, width, movements, times of occurrences, life cycles and associated upper air synoptic situations during the premonsoon months (March-May) for the period 1961-1969 have been studied. Formation and movments of 60 squall lines have been observed during the above period with the help of medium powered Decca and Bendix Radars. A correlation between the direction of movement of the lines with that of the upper winds at particular levels have been found.

1. Introduction

It is well known that the microwave technique as used in radar has immense contribution towards the development of meteorological forecasts. Formation, maturity and decay of thunder clouds can be visualised by the radar at any instant. Earlier workers (Byers and Braham 1949) have suggested that the movement of individual cells are controlled by winds at 10,000 ft and above. But no satisfactory solution is yet available to the problem of forecasting movement of line echoes. In the present paper an attempt has been made to correlate movement of the squall lines and upper winds. Kundu and De (1967) have found that movements of lines vary from season to season according to upper winds at different levels. De (1963) found satisfactory correlation between the speed of the squall lines and that of the upper winds at 700-mb level.

2. Location of Gauhati Airport

Gauhati Airfield is a plain station in the *Brahmaputra* valley. The *Brahmaputra* valley has the Himalayan ranges and the Tibetan plateau to the north, Garo-Khasi-Jaintia and Naga hills to the south and Yunan mountains to the east. The average elevation of these bariers are 4·0 km, 1·0 to 1·5 km and 3·0 km respectively. The river *Brahmaputra* flows along the whole length of the plains enclosed by the hills. The valley is about 550 km long and 70 km wide. The topography of the locality is likely to have a profound influence on the formation and movement of thunder clouds.

3. Data

The observations were made with medium powered Decca (30 KW) and Bendix (20 KW) Radars operating on a 3·2 cm wave band. The former had been in use at the station from 1961 to 1965 and the latter from 1967 onwards. Precipitation echoes as seen on the PPI scope are very carefully recorded every hour and plotted on polar diagrams.

Observations made at Gauhati Airport with the help of the above mentioned radars during the premonsoon months (March-May) for the period 1961 to 1969, with the exception of the year 1966, have been carefully analysed and the results presented in the present study. Observations for the year 1966 could not be studied because of the breakdown of the radar during the premonsoon months. The study has been restricted to the squall lines whose length is more than 30 n. miles at the mature stage and whose life span from their first appearence as lines (solid or broken) is 2 hours or more. In all 60 squall lines have been studied.

In order to find any correlation between cloud movement and upper wind direction and speed, the upper wind observations of Gauhati at two significant levels (700 mb & 500 mb) have been studied.

From Table 1 it may be seen that out of 60 squall lines during the period of 8 years, 7 were in March, 23 in April and 30 in May. It is apparent that the thunderstorm cells which develop into squall lines during premonsoon season is maximum in the month of May. It may be mentioned in this connection that 44 squall lines during premonsoon season

TABLE 1

Monthwise frequency distribution of line type echoes

	No. of squall lines	No. of squall lines which hit station
March	7 (12)	6 (10)
April	23 (38)	12 (20)
May	30 (50)	16 (27)
Total	60(100)	34 (57)

Figures in brackets indicate percentages

TABLE 2

Lengthwise frequency distribution of squall lines

Length of lines (n. miles)	March	April	May	Total
31—40	3 (43)	6 (26)	6 (20)	15 (25)
41—50	2 (29)	8 (35)	9 (30)	19 (32)
51—60	NIL	4 (17)	6 (20)	10 (17)
61—70	2 (29)	3 (13)	4 (13)	9 (15)
71—80	NIL	2 (9)	2 (7)	4 (7)
81—90	NIL	NIL	2 (7)	2 (3)
91—100	NIL	1 (4)	1 (3)	1 (2)
>100	NIL	NIL	NIL	NIL
Total	7 (12)	23 (38)	30(50)	60(100)

Figures in brackets indicate percentages

for the years 1959-1961 in respect of Dum Dum Airport have been studied by De (1963). Boucher and Wexler (1961) studied 27 precipitation lines at Blue Hill and 28 lines at Illinois.

4. Formation and development of lines

On most occasions squall lines have been noticed to owe their origin to isolated to scattered precipitation echoes on the PPI scope. These scattered cells, after an hour or so, have been found to increase in number and size and subsequently arrange in a line to form a full fledged squall line. Almost all squall lines were initially found to be broken ones which subsequently became more compact and ultimately formed solid lines.

It is worthwhile mentioning here that the length of a precipitation line echoes depends on the type of radar used and the distance of the line from the observation site. It can be seen (Table 2) that the maximum frequency of lines is in the length group 31-40 n. miles.

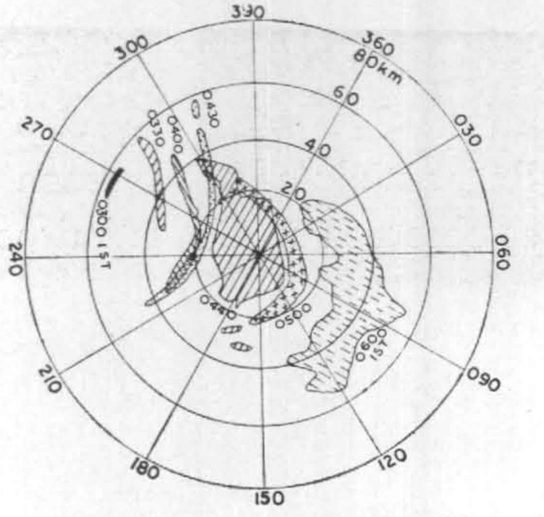


Fig. 1. Tracing of radarscope presentations of Gauhati airport on 13 May 1961

Time is indicated in GMT

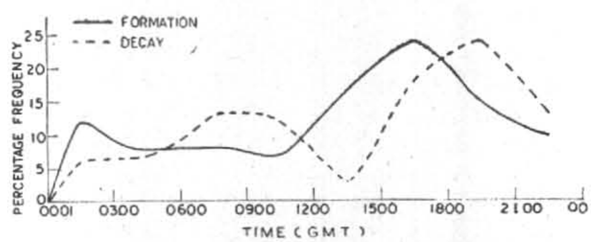


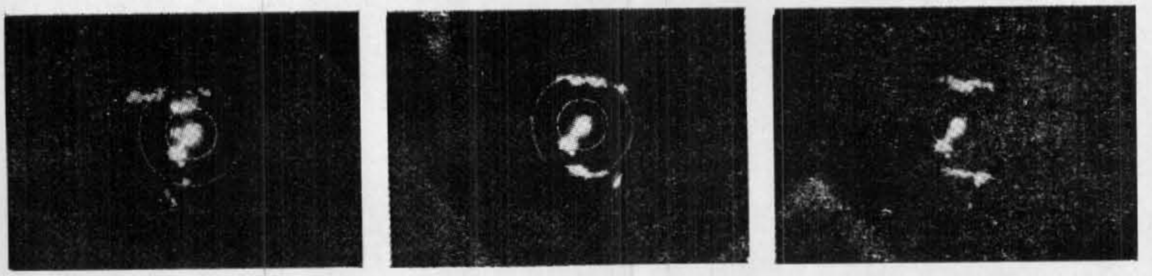
Fig. 2. Frequency distribution curves of formation/decay of Squall lines

5. Location and movement of lines

The initial locations of the squall lines as seen on the radar scope are mostly in the northern half of the radar station at distances ranging from 20 to 130 n. miles. The coverage of the lines is from 200° N to 090°N through 360° N, the maximum concentration being from 260°N to 045°N through 360°N. Most of the lines moved from WNW to ESE before they lost their identity as lines.

6. Life span and time of formation

It has already been stated that only those lines whose life span is two hours or more, have been considered in this study. The life span of the squall lines at Gauhati are generally two to three hours, but the same of five to six hours are also not uncommon. It may be seen from Table 3 and Fig. 2, that the frequency of formation of lines is maximum during 1500 to 1800 GMT, which is, however, not the time of maximum convection. From Fig. 2 it may be seen that the frequency of decaying of



1452 25 1853 25 1955 25

Fig. 3. Photographs of radarscope pictures taken at Gauhati Airport on 18 May 1969

Figs. in the left and right hand bottom corners indicate time in GMT and range rings in n. miles

TABLE 3

Frequency distribution of time of formation/decay of the squall lines

	Time (GMT) 0001-0300	0301-0600	0601-0900	0901-1200	1201-1500	1501-1800	1801-2100	2101-0000
Formation	7 (12)	5 (8)	5 (8)	4 (7)	10 (17)	14 (24)	9 (15)	6 (10)
Decay	6 (10)	4 (7)	8 (13)	7 (12)	2 (3)	11 (18)	14 (24)	8 (13)

Figures in brackets indicate percentages

the squall lines is maximum during 1800 to 2100 GMT which is the time of minimum convection. It is also clear from the same graph (Fig. 2) that the maximum frequency of decay follows (after 3 hours) the maximum frequency of formation, which is completely justified by the fact that the life spans of squall lines are about 2-3 hours.

It is now worthwhile to discuss how the Naga-Khasi-Jaintia-Garo hill ranges influence the air flow over the *Brahmaputra* valley in general and over Gauhati in particular. Naga-Khasi-Jaintia-Garo hill ranges run from east to west from 95°E to 90°E between latitudes 25° N and 26°N. On the east of these ranges are the Burma hills, almost perpendicular to the former. Moist southerlies from the Bay of Bengal and the dry easterlies originating from the Tibetan plateau, approaching *Brahmaputra* valley are, therefore, obstructed from being mixed together due to the presence of the hill ranges to the south and east as stated earlier. As the average height of the hill ranges is less than 1·5 km a.s.l. this sort of protection is likely to be confined to the lowest level of troposphere, say, 1·5 km a.s.l. Strong southerlies can, however, cross over the barrier at levels 1·5 km and above. These southerlies being more warm and moist are pushed above by the dry easterlies.

It is well known that due to nocturnal radiation, the Garo-Khasi-Jaintia hills cool down more rapidly than the plains. As a result, katabatic wind blows down towards the valley. This katabatic flow brings the moist southerlies and dry easterlies down to the valley. These two types of winds having completely different characteristics form a 'front type' structure at night, which explains the occurrence of the maximum number of thunderstorms at night over the *Brahmaputra* valley. The same phenomenon may explain the second smaller maximum (Fig. 2) during the period 0001 to 0300 GMT.

7. Movement of lines

The average speed of movement of the lines has been found to be 12 kt, the minimum and maximum being 5 and 25 kt. This value is slightly less than that found by Harper and Beimers (1958), Swingle and Richards (1953) and Boucher and Wexler (1961). An interesting example of the formation of two lines, one to the north and the other to the south of the station and their movement from west to east is shown in Fig. 3. It is interesting to note that though two squall lines formed so close to the station, none did hit the station.

An attempt has been made to find out a correlation between the movement of squall lines and upper winds at particular levels. No satisfactory correlation could, however, be found to exist between the movement of the squall lines and the upper winds at any particular level. However, on many occasions it has been seen that the direction of upper winds at 700 mb roughly coincides with the direction of movement of the squall lines (as in the case shown in Fig. 3). This is in conformity with the results of earlier workers (De 1963, Wexler and Boucher 1961).

Though most of the lines moved from W/NW to E/SE, quite a few lines were found to move from N to S whereas the upper winds at 850, 700 and 500 mb were westerlies. It has also been found that the movement of the lines depended much on the height of the line type echoes. Average heights of the squall lines studied were of the order of 9 km. Lines of higher heights have been found to move roughly according to the direction of upper winds at levels between 700 and 500 mb.

It is well known that a squall line consists of a number of individual cloud cells formed very close to each other. It is, therefore, expected that the movement of the squall lines would depend on the movement of individual cells constituting the squall lines. But since the life span of a squall line is more than that of individual cloud cells (De and Rakshit 1961), the movement of individual cells can not determine the movement of the line. From the above discussions it becomes evident that the movement of premonsoon squall lines cannot be explained in terms of the mean winds of the layer in which the line is imbedded.

8. Concluding remarks

The following relevant features come out of the present study of premonsoon squall lines over the *Brahmaputra* valley—

(*i*) Initially the squall lines form as isolated/scattered cloud cells to be developed into broken lines.

(*ii*) Average speed of the squall lines is 12 knots.

(*iii*) Average length of the squall lines is 45 n. miles and average width 5 n. miles.

(*iv*) Average life time of the squall lines is 3-4 hours.

(*v*) Fairly satisfactory correlation exists between movement of squall lines and upper wind direction at 700 mb level.

(*vi*) Squall lines in the premonsoon season form generally in the sector from 200°N through 360°N to 090°N.

(*vii*) Maximum number of lines form during the period 1500 to 1800 GMT and dissipate during the period 1801 to 2100 GMT.

(*viii*) Average height of the squall lines is 9·0 km.

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