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A study of Thunderstorms around Gauhati Airport

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ABSTRACT. Current weather observations of Gauhati Airport from 1955 to 1961 and radar observations of 1960 and 1961 have been analysed. Monthly frequency of days with thunder attains a maximum in May and remains practically steady during monsoon. During pre-monsoon, frequency of occurrence of thunderstorms is highest during night and in monsoon and post-monsoon maximum frequency of thunderstorm occurs during afternoon. Analysis of radar observations reveals the profound influence of southern hills on the development of thunderstorms. During monsoon, thunderstorm activity follows closely the anabatic wind activity. No steering level could be found whose wind can be taken as guide for the movement of thunderstorms. However, during pre-monsoon, thunderstorms approach the station mostly from a westerly direction whereas during monsoon they come from south. In general, monsoon thunderstorms move slowly compared to pre-monsoon thunderstorms.

1. Introduction

Study of thunderstorms at a particular place with its frequency of occurrence, duration, spatial distribution and movement is very useful from the forecasting point of view. Rao and Raman (1961) have shown that in India, Assam has the highest frequency of thunderstorms.

A storm detecting radar Decca type 41 is in operation at Gauhati Airport since January 1960. It has a detectable range of 150 nautical miles. The radar was operated at hourly intervals from 0400 to 2200 IST daily during the year 1960 and for 24 hours a day during 1961. On occasions when interesting weather phenomena were observed the radar was operated more frequently. Radar observations of these two years and the current weather data for the period 1955-61 have been analysed. As winter is generally a fair weather period and radar was not operated regularly during the season, no analysis of the data collected during winter season has been made.

2. Location of Gauhati Airport

Gauhati Airport is situated in the Brahmaputra Valley and at the foot of Garo-Khasi-Jaintia range on the southern bank of Brahmaputra river. To the north, lies the great Himalayan Range with great average height and many snow covered peaks. The valley has a gentle slope from east to west.

3. Current weather data

Current weather watch is maintained at the Gauhati Airport Observatory by the departmental staff for all the 24 hours of the day. The data for the period 1955-61 have been analysed in this paper. It is seen that on an average, Gauhati Airport gets thunder on 119 days in a year. Monthly frequency of days with thunder is indicated in Table 1.

A study of the diurnal variation of thunderstorms at several stations in India during different seasons was made by Raman and Raghavan (1961). It appears from the paper that they took data of Gauhati town, which is a part-time observatory. As pointed out by Rao and Raman (1961) the observations from stations manned by part-time staff are not always complete.

Raman and Raghavan divided the day into four 6-hourly periods. A day in the present case is divided into eight 3-hourly periods and the percentage frequencies of thunderstorms have been worked out in the same way as by the above authors. The relevant data are shown graphically in Fig. 1.

It may be mentioned here that this diurnal variation represents conditions for the

TABLE 1

Monthly frequency of days with thunder

(Figures given in nearest whole number)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	3	8	12	19	17	17	17	16	8	1	1

TABLE 2

Duration of thunderstorms at Gauhati

(Figures represent number of cases)

	Duration in hours				
	½–2	2–4	4–6	6–8	>8
			Pre-monsoon		
1955	20	28	14	5	3
1956	18	24	11	4	7
1957	9	11	5	8	5
1958	9	14	7	8	12
1959	8	7	11	5	12
1960	14	11	4	3	6
1961	10	22	4	6	5
Total	88	177	60	39	50
			Monsoon		
1955	32	38	9	1	2
1956	20	22	18	3	1
1957	20	34	12	5	2
1958	24	37	8	2	7
1959	28	25	12	5	4
1960	26	32	10	5	3
1961	41	42	11	3	1
Total	191	230	80	25	20
			Post-monsoon		
1955	2	4	1	0	0
1956	7	3	3	0	0
1957	1	3	1	1	0
1958	1	3	2	0	0
1959	2	3	1	0	0
1960	3	5	0	0	0
1961	3	6	0	0	0
Total	19	27	8	1	0

TABLE 3

	Pre-monsoon		Monsoon		Post-monsoon	
	(*a*)	(*b*)	(*a*)	(*b*)	(*a*)	(*b*)
1960	250	358	535	1373	20	73
1961	281	465	592	1017	7	24

(*a*) Rainfall associated with thunderstorms
(*b*) Total rainfall (seasonal) in mm

TABLE 4

Days of hailstorms

	Mar	Apr	May	Total
1955	2	1	0	3
1956	1	2	0	3
1957	0	0	0	0
1958	0	2	0	2
1959	0	0	0	0
1960	0	1	0	1
1961	2	2	1	5

TABLE 5

Days of squall

	Mar	Apr	May	Jun	Jul
1955	4	5	2	0	0
1956	4	5	3	0	0
1957	0	1	4	1	0
1958	0	2	3	2	0
1959	0	0	0	0	0
1960	0	0	0	0	1
1961	1	2	1	0	0

station itself and does not fully cover those of the surrounding areas. Places within the radar range have different types of diurnal variation of thunderstorms, presumably because of difference in topography.

As regards duration of thunderstorms, frequencies for periods ½—2 hours, 2—4 hours, 4—6 hours, 6—8 hours and more than 8 hours are calculated and the relevant data are shown in Table 2.

Current weather data and hyetograms for two years (1960—61) were analysed for rainfall associated with thunderstorms. The data are shown in Table 3. It is found that a high percentage of rain falls from clouds when no thunder is heard. Whereas this feature is expected during monsoon season, this is not normally expected during premonsoon.

The frequencies of days of hailstorms and squalls in association with thunderstorms are shown in Tables 4 and 5. It is found that hailstorms occur mostly during the months of March and April.

4. Analysis of radar observations

All hourly radar observations were recorded and drawn on polar diagrams. On inspection of these diagrams, it was considered suitable to divide the polar co-ordinates into sectors of 30 degrees each. For the purpose of this analysis the following limitations were taken into account—

(*a*) Radar echoes from definite rain patches were not considered.

(*b*) Only echoes beyond 10 nautical miles from the station were considered, because information regarding nearer echoes could be obtained more easily from the current weather observations.

(*c*) The sector with a formation of one individual cell at a particular hour has been considered as a sector with thunderstorm activity.

(*d*) Any cell observed in the radarscope was taken to be fresh except those which could be definitely recognised as moving cells observed earlier.

(*e*) As the radar is not high powered and also not fitted with RHI, it may not reveal all the information about thunderstorms. Obviously a better instrument would have given more comprehensive results.

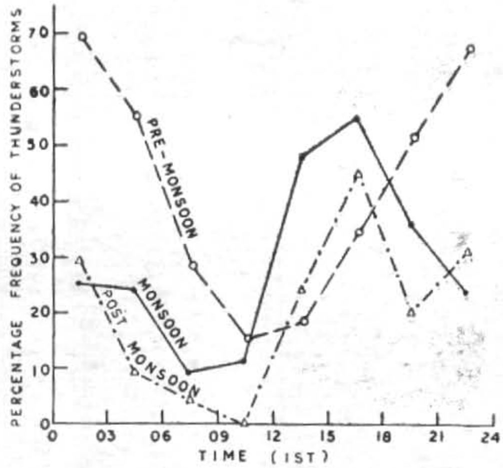
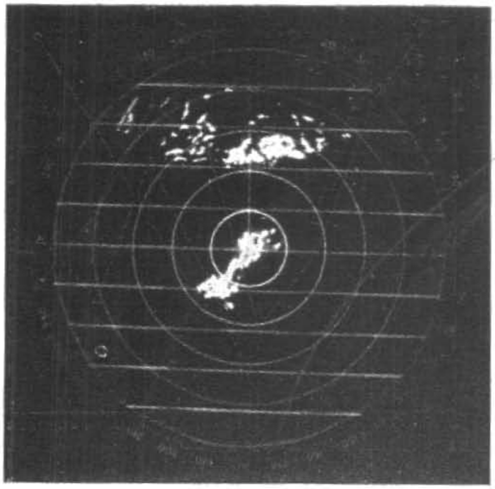


Fig. 1. Diurnal variation of thunderstorms at Gauhati Airport

The photograph showing the permanent echoes around Gauhati Airport for a range of 100 nautical miles with antenna tilt of 3° is given in Fig. 2. Since Gauhati Airport is having hills almost on all sides, it was found that the operation of radar with an antenna tilt 3° is most suitable for the purpose of obtaining maximum number of weather echoes. The distribution of thunderstorms in different sectors and ranges as observed through radar is shown in Figs. 3 and 4 respectively.

It is clear from these figures that most of the thunderstorms develop over the soeuthern hills during all seasons. It is of intrest to compare this finding with the climatological data of annual thunderstorm frequencies. Among all aerodrome stations in the Brahmaputra valley, Gauhati Airport is closest to the southern hill range. It will be seen from Table 6 that this place has the highest thunderstorm frequency also,



100 n. miles Tilt 3°

Fig. 2. Permanent echoes around Gauhati airport

It should be stated here that the distribution of thunderstorms as observed through radar in different sectors and different ranges will not give the complete picture of the distribution of thunderstorms around Gauhati Airport. Apart from the obstructions due to the nearby hills, particularly the Garo-Khasi-Jaintia range of the south and Himalayan range of the north, thunderstorms occurring nearer to the station often attenuate the radar beam resulting in the non-detection of other storms in the same line. It is also probable that with the increase in distance, thunderstorms of localised nature with small growth may escape detection. With a view to have an idea about this type of limitations radar observations during the pre-monsoon period of 1960 and 1961 were compared with all available surface observations from all the stati ns within the radar range. The data of four selected stations (Rupsi to the west, Mazbat to the north, Tezpur to the north-east and Shillong to the south) are shown in Table 7.

Even in the current weather observations a peculiar variation of thunderstorm activity during day-time in the monsoon season

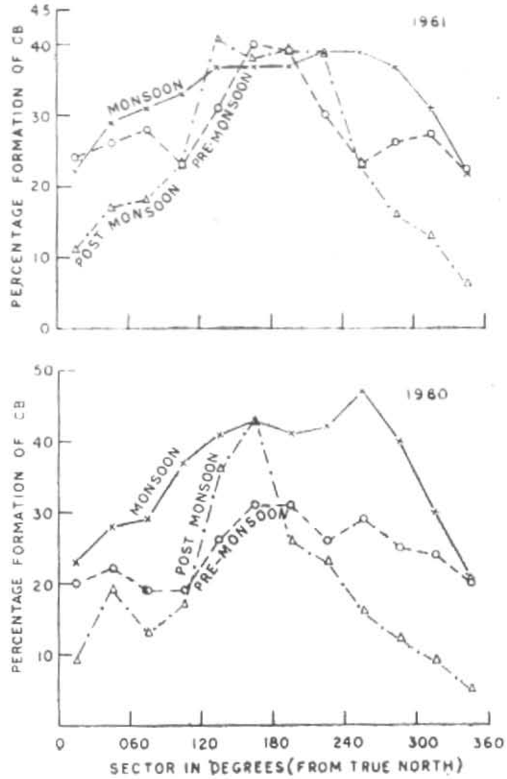


Fig. 3

(except for vigorous monsoon period) could be observed. It was seen with radar that *Cb* cells start growing over the southern hills sometime around 10 IST, grow to a maximum by about 14 hrs and decay before evening. The mean variation in this day-time thunderstorm activity for different months of the monsoon period of 1960 and 1961 are shown in Table 8. Here, beginning of activity means the time of detection of the first radar echoes, maximum activity is the time when maximum area was found to be covered on the radarscope and end of activity is the time when the last echo was observed. It may be noticed here that this day-time variation of thunderstorm activity is very similar to that of anabatic wind activity found in hills (Wagner 1938, Braham and Draginis 1960).

TABLE 6

Annual frequencies of days of thunder at different stations in Brahmaputra Valley

Rupsi*	Guahati	Tezpur	Jorhat	North Lakhim-pur	Mohan-bari	Passi-ghat*
80	119	100	83	62	113	34

These data refer to the average from 1955 to 1959
*These data refer to the average from 1956 to 1959 as these stations were started later

TABLE 7

Number of occasions of existence of echoes on radarscope when thunderstorms were occurring at different stations during pre-monsoon season

Station	Location		Echo		
	Bear-ing (Deg.)	Dis-tance (N. miles)	Obser-ved	Not observed	
				Echo in front	No echo in front
Tezpur*	063	75	5	0	3
Shillong (C.S.O.)	152	35	39	5	6
Rupsi	273	92	13	18	8
Mazbat	043	57	20	7	1

*Only data for 1960 of the departmental observatory has been considered. This observatory was closed during monsoon season of 1960

Rao, Raghavan and Soundararajan (1961) have studied the movement of thunderstorms at Madras by studying the movement of each individual cell during the period of their study. At Gauhati, however, this is not possible due to the high thunderstorm activity and the peculiar topography which causes simultaneous generation and existence of several individual cells around the station and the limitation of operating the radar at hourly intervals only. For the study of their movements, thunderstorms which showed line type characteristics and those which could be followed with fair amount of certainty were considered. The thunderstorms whose movement were studied were grouped for different seasons and the seasonal variation of their motion along the four quadrants (North, East, South and West) were determined. The result is shown in Table 9. Attempts were also made to correlate this movement with prevailing upper winds at Gauhati but no steering level could be obtained.

TABLE 8

Day-time variation of thunderstorm activity during monsoon months

		Thunderstorm activity		
		Beginning	Maximum	End
			Time (IST)	
Jun	1960	1041	1405	1814
	1961	0956	1322	1700
Jul	1960	1024	1341	1730
	1961	1026	1351	1742
Aug	1960	1015	1334	1734
	1961	1028	1320	1707
Sep	1960	1019	1339	1723
	1961	1010	1327	1700
Mean		1021	1337	1726

TABLE 9

Movement of thunderstorms from different directions during different seasons

(Figures represent actual number of cases)

Season	Movements			
	N'ly	E'ly	S'ly	W'ly
Pre-monsoon	1	0	5	20
Monsoon	0	1	37	14
Post-monsoon	0	0	2	1

5. Synoptic situation

Synoptic situations leading to the development of thunderstorms were studied for different seasons. So far as hazards are concerned, pre-monsoon thunderstorms are known to be more severe than those in other two seasons. Special attention was given to the study of thunderstorms in this season,

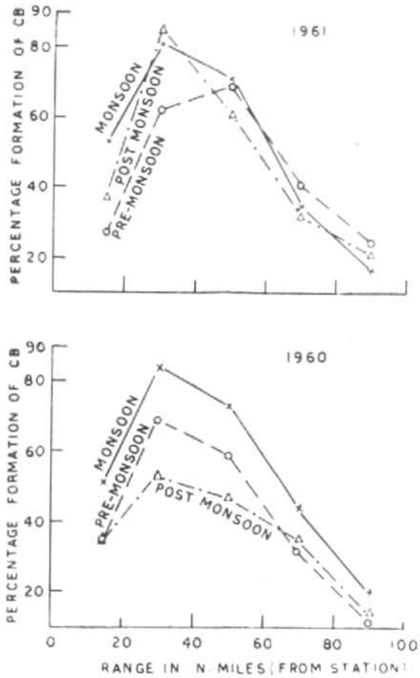


Fig. 4

Careful study of the synoptic situations leading to the development of thunderstorms around Gauhati for the years 1960 and 1961 confirmed Sen and Basu's (1961) conclusions. As the cases were few the role of upper divergence in causing intense thunderstorm activity around Gauhati could not be properly assessed. On the morning of 25 May 1960, there was good thunderstorm activity to the north of Gauhati. Mazbat got heavy thundershowers. On this day, the moisture incursion did not take place by the accentuation of the seasonal trough. In fact the mechanism of moisture incursion on this day was not properly understood.

During monsoon, *Cb* cells were found to be present on all days. Hence, no study of special synoptic situation was conducted. Post-monsoon thunderstorms were few and so the synoptic situations could not be properly studied. However, the authors felt that the change from monsoon to winter over Assam was rather sudden. In fact situations in November appeared to be similar to those in winter. First week of October appeared to show monsoon conditions. For the two years under study, the transition from monsoon to winter appeared to have taken place between 2nd week of October and 1st week of November.

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