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Study of the heights of radar cloud tops in the Gangetic valley of West Bengal

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ABSTRACT. Results of a study of the heights of radar cloud tops in the Gangetic valley of West Bengal based on hourly radar observations for the premonsoon and monsoon seasons of 1959 to 1962 are reported. Percentage frequency distributions at different height intervals and also during different periods of the day for two seasons under study and on a ten-day period basis have been computed.

1. Introduction

In an earlier communication, Kulshrestha (1962) reported the results of a study of the heights of cumulonimbus cloud tops over north India based on observations made with a high powered radar at New Delhi. A somewhat similar study for the Gangetic valley of West Bengal has been attempted and the result presented in this paper.

2. Data

The study is based on observations made with a 3-cm 250 KW, peak power radar (Japanese, type NMD 451A) installed at Dum Dum Airport, Calcutta. The maximum range of the radar is 300 km and the radar thus gives a representative radar picture of cloud tops over an area of about 30,000 sq. km, around Dum Dum Airport. The radar is operated for 15 minutes every hour and a register giving details of the radarscope presentations maintained. On important occasions, photographs of radarscope pictures are also taken. Of these only the tallest convective radar clouds observed on the radarscope have been considered, radar cloud tops reaching less than 6·0 km during any observation being omitted. The available data during the summer months (premonsoon and monsoon seasons) of 1959 to 1962 have been analysed and presented.

In all, 3973 occasions have been studied. The details are given in Table 1.

3. Analysis of the data

The heights of the radar clouds were corrected for errors due to the curvature of the earth and also due to the finite beam width (1·2° in both vertical and horizontal) of the radar. The heights were subdivided into five height intervals, *viz.*, 6·0—7·0 km, 7·1—9·2 km, 9·3—12·3 km, 12·4—15·3 km and 15·4 km and above. The frequency distribution of heights of radar cloud tops is shown in Fig. 1. The number of occasions when the radar cloud tops reached different height intervals during different months are also shown in the figure. During the period under study, there were some occasions when the radarscope observations are not available. This has been indicated with an asterisk (*) in the figure.

In order to determine the distribution during different seasons, the data were divided into two groups — (*i*) Premonsoon season, March to May and (*ii*) Monsoon season, June to September. The total percentage frequency distribution among different height intervals in these seasons is shown in Table 2.

It is well known that, even in a particular season, the development of cloud tops is different during different periods of the day. In order to study the diurnal variation of the height of cloud tops, the data were subdivided in five broad periods, *viz.*,

Morning	0531 — 0830 IST
Noon	0831 — 1230
Afternoon	1231 — 1730
Evening	1731 — 2030
Night	2031 — 0530

The percentage frequency distribution of the cloud tops in different height intervals during these periods of the day in the two seasons was worked out and is presented in Table 3. The consolidated percentage frequency figures irrespective of the height intervals are shown in Table 4.

4. Discussion

The sudy gives a statistical picture of radar cloud tops during the premonsoon and monsoon seasons. For example, during the monsoon season, about 21 per cent radar clouds will have a maximum height of 7 km, the percentage figure during the monsoon season being about 35 per cent.

Table 2 shows that during the premonsoon season about 17 per cent radar clouds mature above 12·3 km, the figure during monsoon season being about 12 per cent. It is interesting to note that

TABLE 1

Number of occasions of radar cloud tops reaching different height intervals during premonsoon and monsoon seasons

	Height (km)									
	6·0-7·0	7·1-9·2	9·3-12·3	12·4-15·3	Above 15·3	6·0-7·0	7·1-9·2	9·3-12·3	12·4-15·3	Above 15·3
	1959					1960				
Mar	—	—	—	—	—	29	24	15	0	0
Apr	15	27	49	5	2	7	9	7	1	0
May	22	56	89	37	17	39	26	31	13	1
Jun	74	80	69	10	1	68	36	28	11	2
Jul	117	63	79	20	2	54	12	4	0	0
Aug	—	—	—	—	—	51	20	5	0	0
Sep	31	29	8	3	0	78	52	34	3	0
	1961					1962				
Mar	11	10	23	4	0	7	9	3	0	0
Apr	11	22	9	1	0	26	25	44	24	2
May	34	31	36	13	4	12	33	58	32	17
Jun	92	63	32	15	7	61	56	79	62	36
Jul	65	41	19	9	0	72	100	105	33	11
Aug	76	64	25	6	1	73	93	75	38	12
Sep	80	84	52	14	2	34	72	95	40	13

TABLE 2

Frequency distribution of *Cb* cloud tops among different height intervals during premonsoon and monsoon seasons

Height group (km)	Premonsoon period (Mar-May)		Monsoon period (Jun-Sep)	
	No. of cases	Frequency (%)	No. of cases	Frequency (%)
6·0-7·0	213	20·8	1026	34·7
7·1-9·2	272	26·6	865	29·3
9·3-12·3	364	35·6	709	24·0
12·4-15·3	130	12·7	264	8·9
Above 15·3	43	4·2	87	2·9

TABLE 3

Frequency distribution of *Cb* cloud tops reaching different height intervals during different periods of the day

Period (IST)	Premonsoon period (March-May)										Monsoon period (June-September)									
	Height (km)										Height (km)									
	6·0-7·0		7·1-9·2		9·3-12·3		12·4-15·3		>15·3		6·0-7·0		7·1-9·2		9·3-12·3		12·4-15·3		>15·3	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Morning (0531-0830)	14	23·3	19	31·7	22	30·7	5	8·3	0	0·0	155	50·0	89	28·6	55	17·7	11	3·5	1	0·3
Noon (0831-1230)	24	26·4	23	25·3	27	29·8	16	17·6	1	1·1	217	32·8	187	28·3	179	27·1	55	8·3	23	3·5
Afternoon (1231-1730)	87	16·9	138	26·9	192	37·4	67	13·1	29	5·7	286	27·3	286	27·3	300	28·6	133	12·7	44	4·1
Evening (1731-2030)	39	17·3	53	23·6	88	39·1	34	15·1	11	4·6	142	37·8	124	33·0	73	19·4	27	7·2	10	2·6
Night 2031-0530)	49	36·9	39	29·3	35	26·3	8	6·0	2	1·5	226	40·8	179	32·3	102	18·4	38	6·8	9	1·8

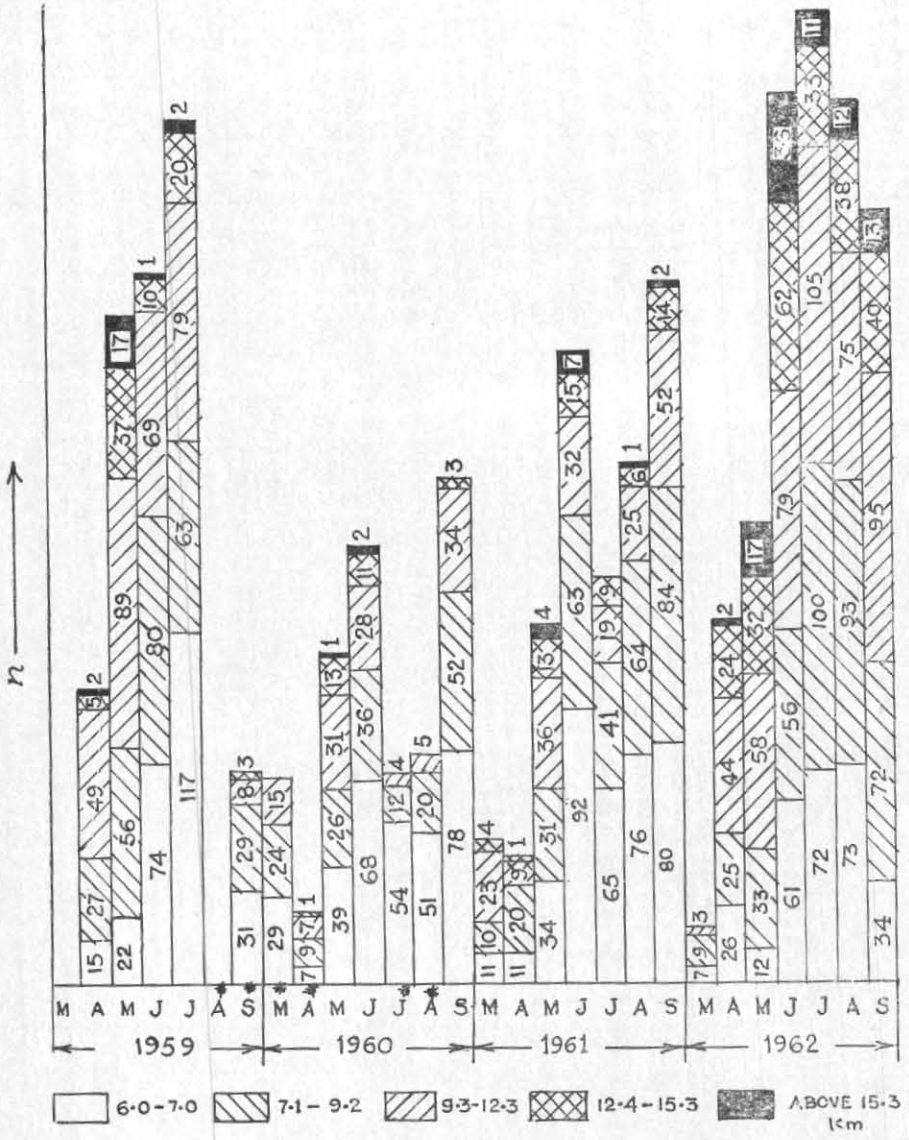

Fig. 1. Frequency distribution of maximum heights of radar cloud tops around Dum Dum Airport, Calcutta

*Data not available for August 1959, upto 16 September 1959, for 9–11 and 23–31 March 1960, 1–4, 12–20 and 27–30 April 1960 and from 16 July to 16 August 1960

radar clouds dissipate below 9·3 km on 47 per cent occasions during the premonsoon season and on 64 per cent occasions during the monsoon season. The number of occasions when the radar clouds extend beyond 15·3 km is quite small, being 4 per cent and 3 per cent during premonsoon and monsoon seasons respectively. These figures are comparable to those obtained earlier by De (1963) for the study on high radar clouds above 10 km based on radar observations made at Dum Dum airport during the summer months of 1961.

It will be seen from Table 3 that in any particular height interval, the maximum number of occasions of the development of radar clouds is in the afternoon. This is to be expected because this is the period of maximum convergence. It is also seen that in the premonsoon season, the percentage frequency tends to increase during the day-light hours and in the evening from 6·0—7·0 km height interval upto 9·3—12·3 km height interval. Above 12·3 km the percentage frequency tends to decrease abruptly. But during the night hours the percentage frequency tends to decrease as the height interval increases. The situation is quite different in the monsoon season when during the entire period the percentage frequency tends to decrease as the height interval increases.

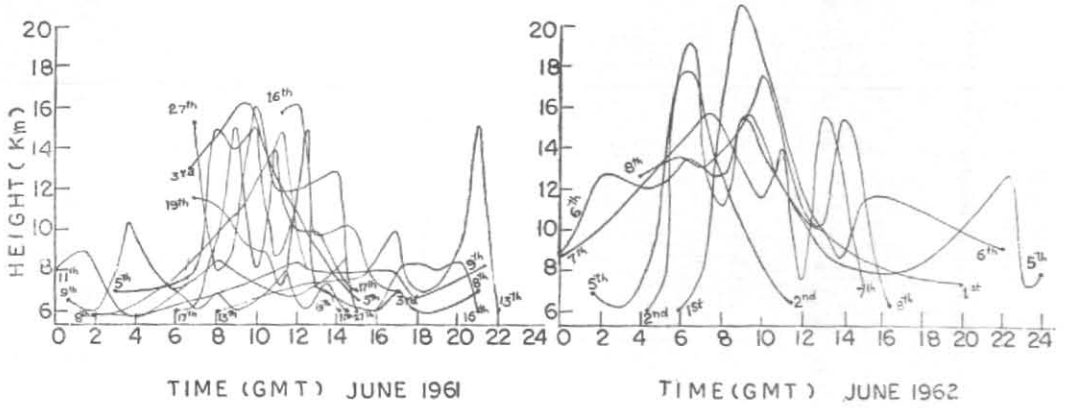

Fig. 2. Maximum heights of radar cloud tops on different days during June 1961 and 1962

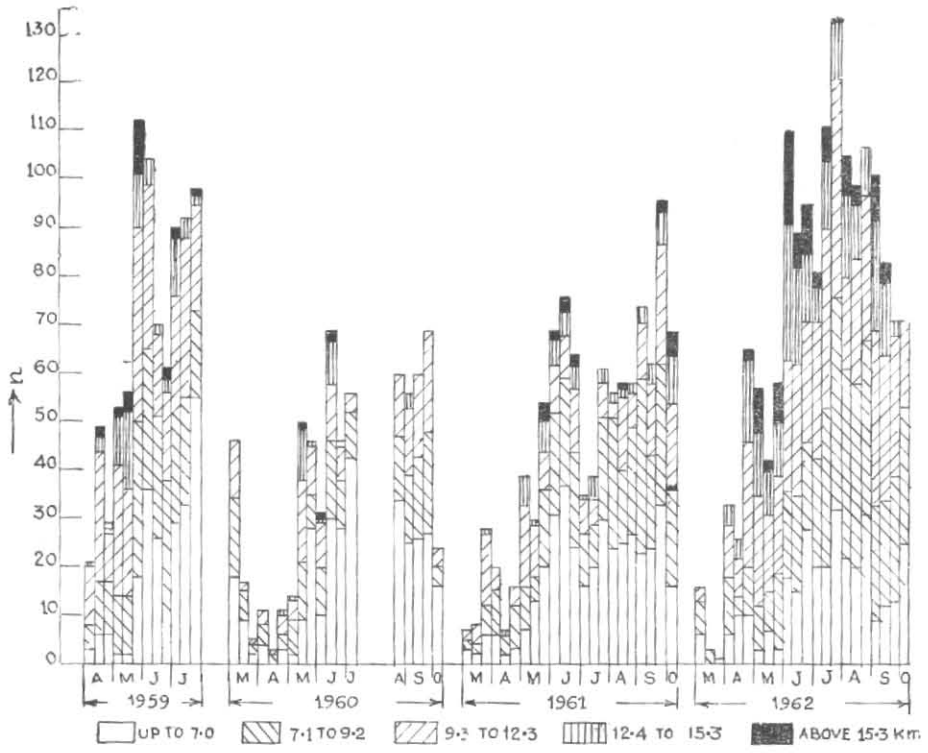

Fig. 3. Number of occasions radar cloud tops reaching different height intervals on 10-day period during different months of years 1959–1962

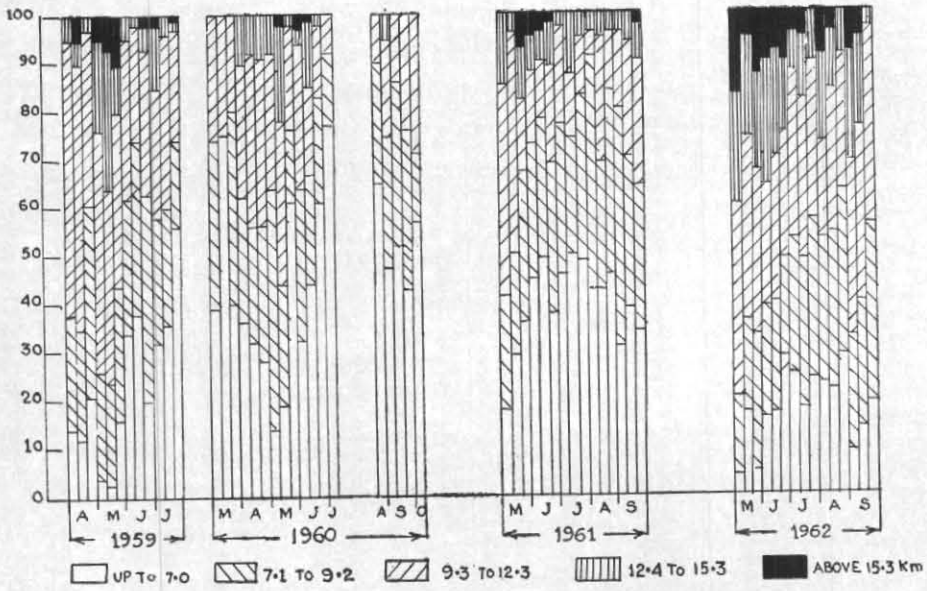

Fig. 4. Percentage frequency distribution of the number of occasions of radar cloud tops reaching different height intervals on 10 day period during different months of years 1959-1962

From Table 4 it is seen that irrespective of the height intervals, the percentage frequency at any period of the day or night is much higher in the monsoon than in the premonsoon season. Thus in the afternoon, the radar cloud top is maximum on 32·8 per cent occasions in the pre-monsoon and 67·2 per cent occasions in the monsoon season.

The above discussion is based on the average values for the whole month. In order to obtain a more detailed picture and to see if any preference for maximum development exists during any part of the day, the maximum heights at different hours of the day were plotted. Two such plots are shown in Fig. 2. It will be seen that a well pronounced peak occurs at the noon and in the afternoon. A secondary peak, though not very pronounced, is also seen to occur sometime in the night or early morning.

In view of local and temporal peculiarities, conclusions drawn from observations on individual days might not represent the true pattern of variation. In order to eliminate the local peculiarities, the data were analysed on a ten-day period basis, each month being divided into three periods. The result of the analysis for different height intervals is shown in Fig. 3. While the number of occasions when the radar cloud tops reach different height intervals varies, on the average, the number reaches peak values sometime during the latter half of May. Another significant peak (up to a height of 12·3 km) occurs during the latter half of July. A third significant peak occurs during early September.

TABLE 4

Frequency distribution of *Cb* cloud tops during different periods of the day in the premonsoon and monsoon

Period	Pre-monsoon		Monsoon	
	No.	Frequency (%)	No.	Frequency (%)
Morning (0531-0830 IST)	60	16·2	311	83·8
Noon (0831-1230 IST)	91	12·1	661	87·9
Afternoon (1231-1730 IST)	513	32·8	1049	67·2
Evening (1731-2030 IST)	225	37·4	376	62·6
Night (2031-0530 IST)	133	19·3	554	80·7

The percentage frequency distribution for the ten-day period for different height intervals is shown in Fig. 4. Here again the percentage figure is found to vary. From a perusal of Figs. 3 and 4 it will be seen that the peak frequency distribution does not generally agree with the peak value corresponding to the number of observations.

5. Concluding remarks

1. The monthly average values of the maximum radar cloud tops based on hourly radar observations reveal that —

(*i*) during the pre-monsoon season, the percentage frequency distribution tends to increase from height intervals 6·0—7·0 km to 9·3—12·3 km and decrease abruptly as the height increases,

(*ii*) during the monsoon season, the percentage frequency tends to decrease gradually with the increase of height,

(*iii*) during the pre-monsoon season, the number of occasions of the maximum radar cloud tops for different height intervals, increases as the day advances,

(*iv*) during the monsoon season, the number of occasions increases from morning till afternoon, decreases in the evening and again increases in the night hours, and

(*v*) irrespective of the height intervals, the percentage frequency at any period of day or night is higher in monsoon than in the pre-monsoon season.

2. The analysis of the radar observations on the maximum radar cloud tops on the average of ten-day period reveals that — (*i*) the number of occasions of maximum radar cloud tops attains several peak values, two prominent peaks being in the latter halves of May and July and another less prominent peak in early September, (*ii*) the percentage frequency distribution figures also indicate several peak values which do not generally agree with the peak values corresponding to the number of observations.

REFERENCES

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Kulshrestha,	1962	*Ibid.*, **13**, 2, pp. 167-172.