

## A radar study of Heights of Tops of Cumulonimbus clouds around New Delhi

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*(Received 3 July 1962)*

**ABSTRACT.** A study of the height of *Cb* tops around Delhi as observed by the high power 3-cm AN-CPS 9 radar on 311 occasions during the various seasons from August 1960 to March 1962 has been made. The seasonal and diurnal variation of the maximum heights of *Cb* tops around Delhi have also been studied for this period. The heights of *Cb* tops grow beyond 40,000 ft during the monsoon season on a large number of occasions whereas during the other seasons the tops are much less. There is a tendency of enhanced *Cb* activity towards the afternoon in the hot weather period while during other seasons, there does not seem to exist any such preferred period.

### 1. Introduction

Cumulonimbus clouds constitute a serious hazard to aviation. The hazards manifest themselves in the form of heavy turbulence, hail and lightning which may endanger the safety of the aircraft by causing structural damage. Hence the vertical extent upto which the *Cb* clouds grow is of utmost importance. An analysis of the heights of *Cb* tops over India based on the debriefing reports of Comet flights was made by Ramamurthi (1955). Deshpande (1961) analysed the Comet reports as well as the I.A.F. reconnaissance flight reports. A study of *Cb* tops over north India based on radar echo tops was made by Kulshreshtha (1962). In this paper an attempt has been made to make further study of the variation of *Cb* tops around New Delhi for the 20-month period from August 1960 to March 1962, based on the routine observations of *Cb* tops by the high power 3-cm AN-CPS 9 radar. Only such of the *Cb* tops which have been observed by the radar within a radius of 200 miles around the radar station at Delhi have been considered so that the data may be more representative of conditions around Delhi covering an approximate area of 1.26 lakh square miles. In order to obviate the errors due to finite radar beam

width, 10,000-ft height intervals have been chosen. The year has been divided into the following four seasons for computing the number of occasions of *Cb* tops in various height groups in the above-said height intervals.

Winter (January—February), Hot weather period (March—May), Monsoon period (June—September) and Post-monsoon (October—December).

### 2. Analysis

The total number of occasions of *Cb* development taken up for study is 311 during the 20-month period, under investigation. Fig. 1 indicates the frequency distribution of the heights of *Cb* tops as well as the number of occurrences in each height group during the period August 1960 to March 1962. A study of the data indicates that the *Cb* tops have invariably reached the height of 25,000 ft. Table 1 gives the frequency distribution of the *Cb* tops among the different height groups, the heights indicated being the maximum echo tops reached by the clouds. It is seen that on 91.3 per cent occasions the tops have been less than 40,000 ft and only on 8.7 per cent occasions they have exceeded this height.

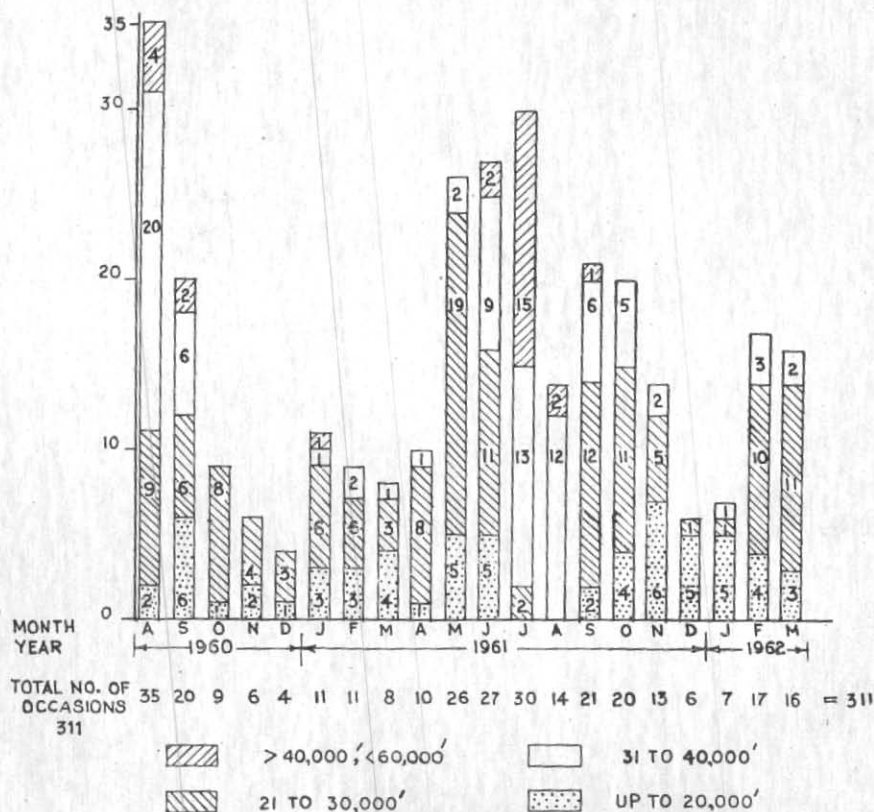


Fig. 1. Distribution of heights of *Cb* tops around New Delhi (August 1960 to March 1962)

NOTE—All heights are above ground

Figures inside denote the number of occasions in different height groups

TABLE 1

Height of <i>Cb</i> tops (1000's of ft)	No. of occasions	Percentage of total
11 to 20	62	19.8
21 to 30	136	43.9
31 to 40	86	27.6
41 to 50	27	8.7
Total	311	

TABLE 2  
Season-wise distribution of maximum height of *Cb* tops

Height (1000's of ft)	Winter		Hot weather		Monsoon		Post-monsoon	
	No. of occasions	%	No. of occasions	%	No. of occasions	%	No. of occasions	%
11 to 20	17	36.0	13	21.0	17	11.1	13	27
21 to 30	22	46.9	40	64.5	40	26.8	28	57.4
31 to 40	7	14.4	9	14.5	70	44.5	7	15.6
41 to 50	1	2.7	Nil	..	27	17.6	Nil	..
Total	47		62		154		48	

TABLE 3  
Distribution of *Cb* tops during the various parts of the day in the four seasons

Height group (1000's of ft)	Period of the day (hrs IST)							
	00—06		06—12		12—18		18—24	
	No. of occasions	Percentage	No. of occasions	Percentage	No. of occasions	Percentage	No. of occasions	Percentage
WINTER								
Upto 20	16	57.2	12	48	9	40.9	5	33.3
21 to 30	12	42.8	11	44	10	45.5	9	60
31 to 40	Nil	..	2	8	3	30.6	1	6.7
41 and above	Nil	..	Nil	..	Nil	..	Nil	..
Total	28		25		22		15	
HOT WEATHER PERIOD								
Upto 20	21	63.5	12	36.4	23	34.6	20	64.4
21 to 30	11	33.3	15	45.5	38	56.5	11	35.6
31 to 40	1	3.2	4	12.1	6	8.9	Nil	..
41 and above	Nil	..	2	6.0	Nil	..	Nil	..
Total	33		33		67		31	
MONSOON								
Upto 20	44	44	21	20.9	13	10.6	42	36.2
21 to 30	45	40.5	55	53.8	43	35.0	45	39.2
31 to 40	15	13.7	26	25.3	53	43.0	24	20.4
41 and above	3	3.6	Nil	..	14	11.4	5	4.3
Total	107		103		123		116	
POST-MONSOON								
Upto 20	5	16.8	15	48.5	12	75	9	60
21 to 30	18	59.5	12	38.5	4	25	6	40
31 to 40	7	23.7	4	13.0	Nil	..	Nil	..
41 and above	Nil	..	..	..	Nil	..	Nil	..
Total	30		31		16		15	

Fig. 2 represents the maximum heights of radar echo tops of *Cb* clouds reached during the different periods of the year. It is seen that the heights of *Cb* tops are the greatest during the monsoon period. There is a marked tendency for the *Cb* top formation to get reduced in height as the season advances from the monsoon to hot weather period through winter. Table 2 gives a frequency distribution of the number of occasions of *Cb* tops in each height group during the various seasons. It is found that except in monsoon season, the heights are less than 30,000 ft on 84 per cent occasions. During the monsoon season, on 44 per cent of occasions the tops are from 31,000 to 40,000 ft and on 17.6 per cent occasions they go beyond 41,000 ft. These show that in general the maximum number of occasions of development of *Cb* tops beyond 31,000 ft occur during the monsoon season around Delhi. The winter seems to have the least number of occasions of *Cb* development.

The extent of development of *Cb* tops during different parts of the day has also been examined. For this purpose, a day has been divided into four periods of 6-hour duration each. Table 3 gives the number of occasions and percentage occurrence of maximum *Cb* tops during these periods in the four seasons. It is seen that in the hot weather period there is a definite tendency for the development of *Cb* tops to get augmented during the period 12-18 hrs. This may be due to the strong thermal convection set up during the afternoons in this season. But during the other seasons, there does not seem to exist any preferred periods for attainment of maximum heights of *Cb* tops. There is a tendency for the majority of *Cb* cells to decay towards midnight in the seasons except in the monsoon

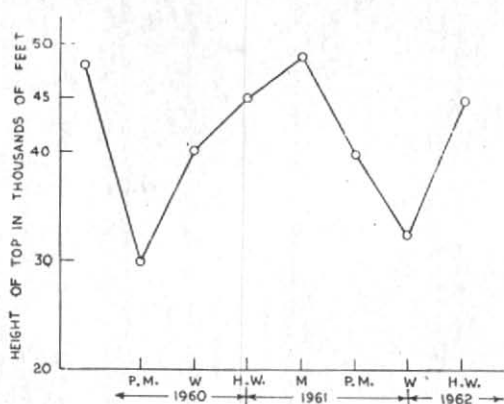


Fig. 2. Seasonal variation of heights of *Cb* tops around New Delhi — 1960-62

when the development or decay of *Cb* seems to take place during any part of the day.

### 3. Conclusions

(i) About 80 per cent of *Cb* clouds forming around Delhi grow and decay below 40,000 ft and only about 10 per cent extend beyond this height.

(ii) In the seasonwise distribution except in the monsoon season, more than 96 per cent of the *Cb* mature below 40,000 ft. During monsoon, in about 18 per cent cases *Cb* tops grow beyond 41,000 ft.

(iii) There does not seem to be any preferred period for the attainment of maximum heights by *Cb* clouds in the different seasons other than the hot weather period when there is a tendency for *Cb* to grow towards the afternoon.

As such this radar study shows that the height of *Cb* tops around Delhi are generally about 40,000 ft and seem to be in agreement with the heights of *Cb* given by Deshpande (1961) in his analysis.

### REFERENCES

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| Deshpande, D. V.   | 1961 | <i>Indian J. Met. Geophys.</i> , <b>12</b> , 1, p. 29 |
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