

Heights of tops of *Cb* clouds over India

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1. Introduction

1.1. Cumulonimbus clouds, which are manifestations of great instability in the atmosphere, constitute a serious hazard to aviation. Heavy turbulence, hail and lightning associated with *Cb* clouds may endanger safety of aircraft. Updraft and downdraft, which in some cases are as high as 6000 ft min^{-1} as also gusts experienced in *Cb* clouds may lead to loss of control or structural damage to aircraft. There have been instances of wind-screens of aircraft being holed, perspex astrodomes shattered and de-icer boots ripped off due to hail. Hence knowledge of the structure and in particular the vertical extent of *Cb* clouds is most essential for safe flight-planning. Very little data in respect of heights of tops of *Cb* clouds in India and other tropical countries are available. Piston-engined aircraft, which were in use in India till recently, generally flew at levels below 15,000 ft. The average tops of *Cb* clouds over India were estimated to be roughly between 10,000-33,000 ft (3-10 km).

1.2. Ramamurthy (1955) summarised the post-flight reports of the B.O.A.C. Comet Service for the routes Delhi-Calcutta and Bombay-Colombo during period May 1952 to December 1953. He concluded that the *Cb* tops were much higher than the prevalent estimates. However, these reports referred to fixed routes at scheduled times. With the introduction of jet aircraft and the meteorological reconnaissance flights by the Indian Air Force about 150 post flight reports from jet aircraft have become available for this study. There were in all 41 such reports. In

addition 17 reports of *Cb* tops in 1958-59 were available from the B.O.A.C. Comets operating through Palam (Delhi). 12 more reports of *Cb* tops were also available from other scheduled services operating on Karachi-Delhi-Rangoon route at cruising levels near 20,000 ft. The present study, is based on a total of 70 reports of *Cb* tops actually observed.

2. Heights of *Cb* tops

2.1. The jet aircraft operated generally at altitudes between 38,000—45,000 ft. The flying levels in most cases were within 2000 ft of reported tops of *Cb* clouds. Hence the heights of *Cb* tops as reported appear to be fairly accurate.

2.2. Table 1 shows the frequencies of heights of *Cb* tops for the whole year and for the different seasons, viz., winter (December-February), premonsoon (March-May), southwest monsoon (June-September) and postmonsoon (October-November).

A brief summary of the table is given below seasonwise —

- (a) *June-September*—The maximum number of reports (49) of *Cb* tops were for this season. The highest top reported was 50,000 ft. In 34 cases out of 49 the tops were higher than 37,000 ft. There were 13 instances with heights between 42,600—45,000 ft.
- (b) *October-November*—The lowest cloud top reported was 20,000 ft while the highest was 44,000 ft.

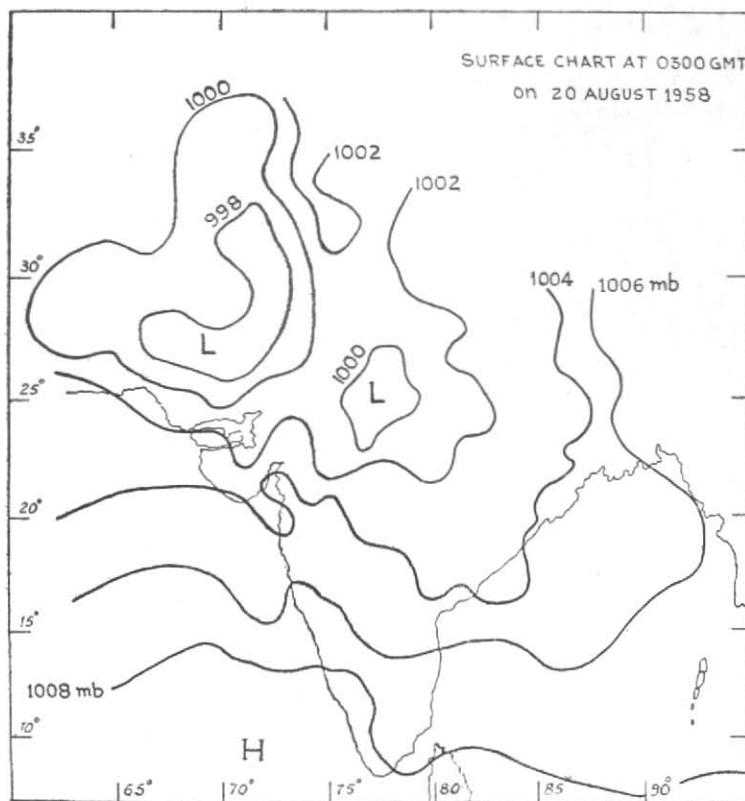


Fig. 1

TABLE 1
Frequencies of heights of tops (in ft) of
Cb clouds over India

Height (Thousands of feet)	Winter (Dec- Feb)	Pre- mon- soon (Mar- May)	Mon- soon (Jun- Sep)	Post- mon- soon (Oct- Nov)	Total
Below 17.5					
17.6—20.0				1	1
20.1—22.5		2	1	1	4
22.6—25.0		4	3	2	9
25.1—27.5					—
27.6—30.0			4	1	5
30.1—32.5			2	1	3
32.6—35.0		2	1	1	4
35.1—37.5			4	1	5
37.6—40.0		1	10	—	11
40.1—42.5	1		6	1	8
42.6—45.0			13	2	15
45.1—47.5					
47.6—50.0			5		5
Above 50					
No. of reports	1	9	49	11	70
Highest top (thousands of ft)	41	38	50	40	50
Lowest top (thousands of ft)	—	21	22	20	20

(c) *December-February*—There was only one report for this season of a *Cb* top reaching upto 41,000 ft near Chanda in December 1959 at 0500 GMT.

(d) *March-April*—Of the nine reports available, in 6 cases the tops were between 20,000 ft and 25,000 ft. The highest top was 38,000 ft.

3. Weather phenomena near *Cb* tops

3.1. *Turbulence*—Turbulence was reported in the vicinity of *Cb* clouds on six occasions only. In two cases it was moderate, when the aircraft was flying at the same level as *Cb* tops. There was one occasion when the aircraft experienced turbulence when it flew through the top of a *Cb* cloud. In another instance, slight turbulence was experienced by an aircraft at 49,000 ft, i.e., 5000 ft above a *Cb* top which was at 44,000 ft.

3.2. *Upper winds*—Of the 39 reports of winds at the flying level in the neighbourhood of *Cb* tops, 31 referred to the monsoon season. In the majority of the cases (19), the wind direction was from eastnortheast to eastsoutheast, particularly over Uttar Pradesh and the central parts of the country. In five cases, it was northeast. There were only two cases when the wind was from the west or northwest.

The wind speed reported during the monsoon was between 25-40 kt. However, in a few cases it was 10 kt or less, while in other cases it reached 55 kt at the flying level.

In October 1959, there was one instance near Jaipur when the wind was 020°/140 kt at 43,000 ft, while the *Cb* top was 42,000 ft.

3.3. *Temperatures*—It is well known that in a strongly developing *Cb* cell, the in-cloud temperatures are higher than those of the environment at the corresponding altitudes while they are lower in the dissipating stage. For comparison purposes, it is essential to have in-cloud and environment temperatures. However, only one report of temperature at the *Cb* top was available, viz, -56°C at 42,000 ft. Hence no comparative study can be made. Environment-temperature reports indicate that at the level of *Cb* tops (43,000 to 47,000 ft) the free air temperatures were generally between -55°C to -62°C. These are in fair agreement with the normal upper air temperatures at 150-mb level obtained through radiosonde. In case of cloud tops in the range of 36,000 to 38,000 ft, the

corresponding temperatures were -38°C to -42°C . On one occasion a temperature of 72°C was reported near Allahabad in August 1959, at an altitude of 49,500 ft, 500 ft below the *Cb* top.

3.4. *Icing*—There was only one instance of slight icing when the aircraft flew through the top of a *Cb* cloud at 42,000 ft.

4. Typical synoptic situations

4.1. *20 August 1958*—On the morning of 20 August 1958 a 'low' over northwest Madhya Pradesh (Fig. 1) was becoming unimportant but the residual upper air cyclonic circulation persisted between 1 and 3 km a.s.l. An easterly wave had moved into the west central Bay of Bengal while the 'low' over Sind-Baluchistan was well-marked. At 1.5 km a.s.l., a trough line passed through Ajmer, Jhalawar, Varanasi and Bagdogra and a second one through Jhalawar, Raipur, Gopalpur and Tavoy.

Associated with these conditions, *Cb* developments were reported near Gaya and 12 miles north of Varanasi between 0415 and 0445 GMT. The *Cb* tops were at 50,000 ft and the aircraft flying at levels 49,000 ft and 50,000 ft experienced moderate turbulence and an easterly wind of 40 kt.

4.2. *12 November 1959*—A trough of low pressure extended on the morning of

12 November 1959 from the southwest Arabian Sea, west of the Laccadives Islands to the south Konkan coast. *Cb* cloud was reported at 0530 GMT near Mangalore, with tops reaching 44,000 ft.

The above instances indicate that *Cb* development can be pronounced, even in the cases of feeble 'lows' or troughs of low pressure.

5. Conclusions

5.1. From the available data, it appears that the prevalent estimates of heights of *Cb* tops in India have to be modified, as the observed values are much higher. This is particularly true in respect of southwest monsoon season (June-September), when the *Cb* tops have generally been between 40,000 ft and 44,000 ft and in some cases even shot up to 50,000 ft.

5.2. Many of the aircraft observations were recorded in the morning. It is quite possible that in some cases due to convection and greater instability the *Cb* cells developed to a greater extent in the afternoons. It is, therefore, necessary to obtain additional data of heights of *Cb* tops over India either through aircraft or radar.

6. Acknowledgement

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