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A RADAR STUDY ON THE HEIGHTS OF Cb CLOUDS AROUND GUWAHATI

1. A Cb cloud giving lightning and thunder is one of the most spectacular phenomena and existence of very high cumulonimbus clouds over northeastern India is fairly well known. Cb clouds are manifestation of great instabilities in the atmosphere, deserve special attention as they often accompanied by severe turbulence, heavy electric discharge, icing etc. and pose serious hazards to air navigation. Vertical extent up to which the Cb cloud grow have the direct bearing on the intensity of weather phenomenon, hence statistical knowledge of the height of Cb clouds of each place have to be studied specifically, particularly in respect of those places where they develop frequently.

2. An E.E.C, X-band Radar was installed at Guwahati Airport and made operational since 15th March 1997. Radar is operated every year from 15th March to 15th October and hourly observations are taken daily from 0000 UTC to 1300 UTC. During other months observations were not taken due to fair weather. In this study 7 years radar data of the period 1997-2003 for April to September months have been analyzed. Radar has maximum range of 480 km and peak power is 200 kW. The heights shown by radar have not been corrected for errors due to finite width of radar beam, keeping in view the observations by Cornford & Spavins (1973).

All Cb cells whose tops reached at a height of 5 km or more were considered for the study. All the observed cells were counted and tabulated hourwise and monthwise against heights (km) of Cb tops. Averages have been worked out by dividing total number of cells by year of

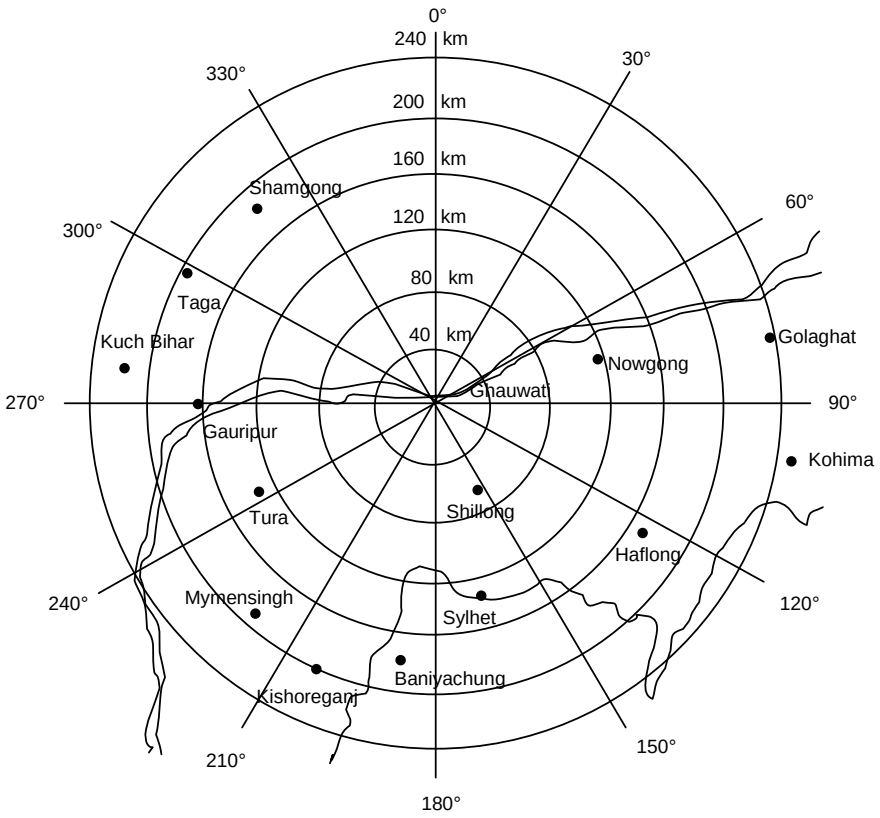

Fig. 1. Guwahati airport and 240 km around

TABLE 1

Average frequency distribution of Cb cells

Month	Hour (UTC)														Total
	0000	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	
Apr	4.9	5.4	5.6	4.4	4.6	6.0	8.6	10.7	11.1	12.0	13.0	12.7	12.4	8.7	120.1
May	3.9	5.4	5.6	5.9	6.0	6.1	8.1	10.7	13.3	16.3	14.0	13.3	11.0	7.3	126.9
Jun	5.2	6.1	5.7	6.4	7.3	7.6	9.2	11.8	11.4	12.8	13.8	11.1	9.9	6.4	124.6
Jul	0.4	1.9	2.1	2.9	2.3	3.9	4.3	6.4	8.7	7.9	10.5	6.8	7.2	4.3	69.6
Aug	0.7	0.7	0.9	0.2	0.4	0.4	2.0	3.8	7.8	3.8	6.5	5.1	4.7	3.4	40.5
Sep	0.2	0.4	0.7	0.9	0.2	1.3	1.3	3.8	3.6	3.6	2.5	3.6	3.4	0.7	26.3
Total	15.2	19.9	20.5	20.7	20.8	25.5	33.6	47.2	55.9	56.3	60.3	52.6	48.6	30.8	507.9

the study. As the available data was not continuous on some occasions, the observed number of cells against particular period was adjusted by multiplying with a factor depending on the total period of shortfall. This was done for making comparative studies between data for different months.

The preferred areas of formation of very high Cb cells in a particular month was examined by plotting the Cb cells of more than 10 km height for 0600 UTC to 1300 UTC in polar diagrams and marking the areas of high tops. This analysis was done on 240 km range polar diagram due to the reason that reported Cb cells of more than 10 km height are very rare beyond 240 km. This represents an area coverage of 1,80,000 sq. km around Guwahati Airport and shown in Fig. 1.

3. *Average frequency distribution of Cb cells* - Average monthly and hourly frequency distribution of Cb cells is shown in Table 1. It is seen from the table that the

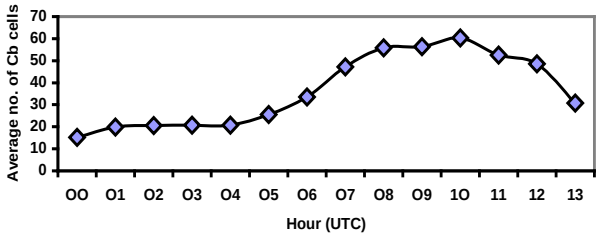

Fig. 2. Hourly distribution of Cb cells

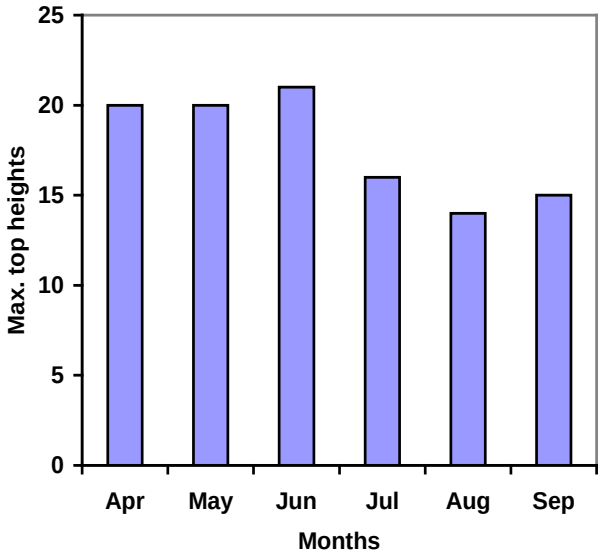

Fig. 3. Monthly maximum top heights

frequency is maximum (126.9) in the month of May followed by June (124.6) and April (120.1). It was found minimum (26.3) in the month of September. Hourly distribution of Cb cells is shown in Fig. 2. It is seen that hourly frequency of Cb cells is maximum at 1000 UTC followed by 0900 UTC and minimum at 0000 UTC. It is seen that average hourly frequency of Cb cells is varying between 15 to 25 during 0000 UTC to 0500 UTC and after that it starts increasing and reaches the maximum 60.3 at 1000 UTC then again frequency found decreasing.

3.1. *Average frequency distribution of Cb cells in relation to top height* - Average frequency distribution of Cb cells attaining certain height or more is shown in Table 2. Monthwise maximum tops are plotted in Fig. 3. It is seen that in the month of April to June maximum top height of Cb cell around Guwahati is 20 to 21 km and average frequency of the Cb cells attaining 5 km or more height found to be in the range 120 to 127 and out of them around 30% cells developed to 9 km or more height, 10% to 12 km or more and 3% to 15 km or more height. Where as in the month of July to September maximum top height reduced to the 14 to 16 km range and average frequency

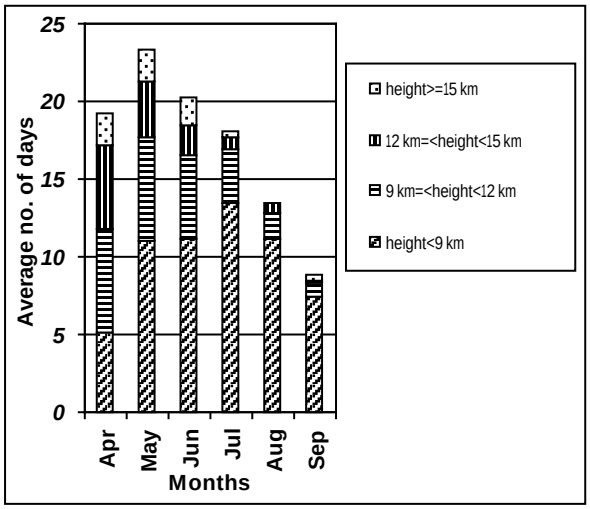

Fig. 4. Average no. of days in a month with Cb cells in respect to daily max. height

of the Cb cells attaining 5 km or more height found to be in the range 26 to 70 and out of them around 9% cells developed to 9 km or more height, 2% to 12 km or more and 1% to 15 km or more height. Percentage of tall Cb cloud is quite appreciable in the months April to June whereas developments of Cb cells are quite low in the months July to September.

3.2. *Frequency distribution of Cb tops in relation to daily maximum height* - A day with the Cb cell was counted against the highest (km) top attained by cells during that particular day. Such a Maximum top height may be considered as "Daily Maximum Height". The average number of days in each month during the period under study was counted and tabulated against respective daily maximum height and shown in Table 3. Average no. of days with Cb cells of the height 5 km or more are shown in Fig. 4. It is seen that average number of days in a month in respect to daily maximum height of 5 km or more are maximum 23.3 in the month of May followed by June (20.2) & April (19.3) and found minimum 9.0 in the month of September. Average number of days of the daily maximum height in the range 10 km or more are maximum (11.9) in the month of April followed by May (10.3), whereas in the range of 15 km or more are maximum 2 each in the month of April & May.

3.3. *Preferred places of formation of high Cb cells* - In order to examine whether there is any preferred area of Cb cell to grow very high, Cb tops of the height more than 10 km were plotted on polar diagrams of 240 km range and areas of high tops were marked by drawing contour

TABLE 2

Average frequency distribution of Cb tops attaining certain heights or more

Height (km)	Apr	May	Jun	Jul	Aug	Sep
5	120.1	126.9	124.6	69.6	40.5	26.3
6	107.6	108.7	98.4	53.1	27.7	15.9
7	88.4	77.1	64.0	27.3	16.8	8.8
8	66.9	51.6	37.2	14.3	8.5	3.1
9	50.6	32.4	24.6	7.0	3.6	1.8
10	39.6	22.9	17.3	3.7	2.7	1.3
11	27.9	15.1	10.7	2.1	1.1	0.7
12	18.1	11.0	7.8	1.7	0.7	0.7
13	11.0	7.0	5.2	1.0	0.2	0.4
14	6.6	3.9	4.0	0.8	0.2	0.4
15	4.1	2.6	3.1	0.6	0.0	0.4
16	2.4	1.0	2.4	0.4	0.0	0.0
17	1.3	0.9	1.7	0.0	0.0	0.0
18	0.7	0.6	1.2	0.0	0.0	0.0
19	0.6	0.1	0.7	0.0	0.0	0.0
20	0.4	0.1	0.3	0.0	0.0	0.0
21	0.0	0.0	0.2	0.0	0.0	0.0

TABLE 3

Average no. of days with Cb cells in respect to daily maximum height attaining certain height or more

Height (km)	Apr	May	Jun	Jul	Aug	Sep
5	19.3	23.3	20.2	18.2	13.4	9.0
6	18.4	22.3	18.7	15.7	11.6	7.0
7	17.3	19.7	16.1	11.2	7.8	5.2
8	16.0	15.9	12.5	7.4	5.4	2.9
9	14.1	12.3	9.2	4.8	2.2	1.6
10	11.9	10.3	6.6	3.3	1.6	1.1
11	9.4	7.4	4.8	1.7	1.1	0.7
12	7.4	5.6	3.8	1.2	0.7	0.7
13	4.6	4.6	3.1	0.6	0.2	0.4
14	3.3	3.0	2.2	0.4	0.2	0.4
15	2.0	2.0	1.9	0.4	0.0	0.4
16	1.4	0.9	1.6	0.2	0.0	0.0
17	0.7	0.7	1.4	0.0	0.0	0.0
18	0.4	0.4	1.0	0.0	0.0	0.0
19	0.4	0.1	0.7	0.0	0.0	0.0
20	0.4	0.1	0.3	0.0	0.0	0.0
21	0.0	0.0	0.2	0.0	0.0	0.0

lines. It is seen from the study that high Cb cells are very less in 0000 UTC to 0500 UTC period, hence these are not considered while examining for preferred places. Though the area of formation of high Cb cells at particular day or time depend upon the prevailing synoptic situations and other meteorological factors, the above analysis gave a

general idea regarding the places of formation of high Cb cells in a particular month. The results are given as :

April - In the month of April, at 0600 UTC Cb cells upto 12 km high are generally observed around Guwahati within 120 km range, with the progress of time Cb cells of the height 14-16 km are found in west to northwest of Guwahati in 120 km range and all over the southwest sector beyond 80 km range. Some pockets of Cb cells of 14-16 km heights are also seen in east to southeast of Baniyachung in Bangladesh, covering districts of south Assam, Tripura & Mizoram, and in between Nowgang & Golaghat in Assam. In the afternoon period highest Cb cells (18-20 km tops) are mostly found in the range 120-240 km southwest of Guwahati around Tura in Meghalaya and Mymensingh & Kishoreganj in Bangladesh.

May - In this month Cb activity is found maximum. At 0600 UTC Cb cells upto 12 km high are more numerous and found between 90° and 330° direction, formation of high Cb cells is minimum in the northeast sector. As the afternoon approaches the activity increases and cells of 14-16 km height are found in north & south of Gauripur, west of Guwahati, between Guwahati & Shillong and over the districts of south Assam and adjacent Sylhet in Bangladesh. Very high Cb cells (18-20 km tops) are found confined between 240° and 300° direction in the area near to Kuch Bihar in West Bengal and Gauripur in Assam (120-240 km west of Guwahati).

June - In the month of June with the arrival of monsoon, formation of high Cb cells is found more dominantly in SW sector. Cb tops upto 12 km high start growing between 0600 & 0700 UTC around Guwahati within 80 km range. As the afternoon approaches the activity increases and by 1000 UTC cells of 14-16 km height are found developing 40-80 km southwest of Guwahati between Tura & Shillong, between Guwahati & Shillong, from southeast through south to northwest of Tura (120-240 km southsouthwest to westsouthwest of Guwahati) and some portions in northeast close to Guwahati. By 1200 UTC development reaches maximum and very high Cb cells (18-20 km tops) are found over Mymensingh, Kishoreganj, Baniyachung in Bangladesh, south of Tura in Meghalaya (120-240 km southsouthwest of Guwahati).

July - As the monsoon advances in the July, the height of highest Cb top comes down to 16 km only. Cb tops of the height 14-16 km are mostly found at north of Guwahati and between Guwahati & Shillong. Cells of the height less than 14 km are also found around Guwahati mostly within 120 km range.

August - In this month height of highest Cb top further lower down to 14 km. Cells of the height 11-14 km are few and mostly within 80 km range of Guwahati.

September - In this month with the withdrawal of monsoon, the Cb activity around Guwahati ceases and found minimum. Cells are mostly near to Guwahati & Shillong.

4. Following conclusions emerges out from the study :

(*i*) Average frequency of Cb cells around Guwahati is maximum in the month of May followed by June and minimum in September. Its hourly average frequency is maximum at 1000 UTC and minimum at 0000 UTC for the period between 0000 UTC and 1300 UTC.

(*ii*) Highest top height of Cb cells is 20 to 21 km in the month of April to June and 14 to 16 km in the month of July to September.

(*iii*) Average number of days in a month in respect to the daily maximum height of 5 km or more are maximum 23.3 in the month of May and minimum 9.0 in September.

(*iv*) Majority of Cb cells has the preference to form and grow to high height during 0600 UTC to 1300 UTC period, *i.e.*, local afternoon and evening time.

(*v*) There are some particular places where Cb cells grow very high, and it is found that 18-20 km Cb tops grow mostly in southwest and northwest sectors of Guwahati. Cells of 14-16 km height grow also in southeast sector in addition to southwest & northwest sectors. Cell formation is minimum in northeast sector.

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