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Radar study of a hailstorm over Gauhati on 17 April 1962

B. L. SHARMA

Meteorological Office, Gauhati

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ABSTRACT. On 17 April 1962 at 1520 IST, a hailstorm occurred over Gauhati Airport. Radarscope pictures showed four strong echoes in a straight line moving towards the station from the west with different speeds. The nearest echo was overtaken by other three very near the station, and they merged into a single cell, showing a small blunt protuberance in the rear. After a few minutes it developed into a hook as hailstorm broke over the station.

1. Introduction

Harrison and Post have reported that radar echoes, associated with hailstorms show finger like protrusions 1-5 miles in length and scallops or blunt protuberances 1-3 miles from the edge of the thunderstorm echo. V-shaped notches or holes (facing radar set) which cannot be due to attenuation were noticed in echoes associated with hail by Stout and Hiser (1955) while studying wind, hail and heavy rain storms with radar. They also suggested that these notches or holes might be the result of dissipation of a portion of the cloud accompanying release of hail.

Mull and Kulshrestha (1962) also noticed such types of protruding fingers or hooks suggesting the occurrence of hail, but it was difficult to say, particularly in the absence of any report, whether they were actually associated with hail or not.

These hooks or sharp protruding edges associated with thunderstorms have been observed over Gauhati during the last few years. On 17 April 1962 such an echo was observed due west of the station. The hailstorm occurred when the well-formed hook came over the radar station. This phenomenon is discussed in the light of the prevailing synoptic situation.

2. Radar observation and photographs

A Decca type 41 Weather Radar installed at Gauhati, operating on 3-cm wave band and having peak power output of 30 KW, was used in the present study.

No echo was observed due west of the station until 1330 IST on 17 April. When the radar was switched on again for routine operation at 1422 IST, a very strong patch was seen near the station from 10 to 15 miles towards the west. It was followed by another one in the same direction whose distance from the station was 24 to 28 n. miles in the west. These are shown in Fig. 1. Of the two, the former, nearer to the station, consisted of two patches, when seen at reduced gain and was more intense than the later, *i.e.*, the one being from 15—20 n. miles in the west, as Fig. 1 shows. Apart from these three, a fourth patch, with reduced intensity, as compared to the other three, also approached the station from the same direction and is shown in Fig. 2 at 285° from 20 to 25 n. miles.

The various echoes were observed to move with different speeds. The first one, nearest to the station, was found to have a speed of about 12 n. miles per hour (Figs. 1 to 3), the second one, of about 20 n. miles per hour (Figs. 1 and 2), the third one of about 35 n. miles per hour (Figs. 1 and 2), and the fourth, the farthest one from the station, of approximately 45 n. miles per hour (Figs. 2 and 3). Thus the speed of these echoes decreased with distance from the station.

These four echoes (Fig. 2) seemed to merge into one another near about 1507 IST (Figs. 3 and 4) about 4 n. miles to northwest of the station and after a few minutes transformed into a clear-cut round edged hook at 250° and 2 to 4 n. miles from the station (Fig. 4). This hook, later on, moved with an approximate speed of 35 n. miles per hour. At 1518 IST, the leading edge of the hook was approximately 2 n. miles from the station (Fig. 5). As soon as it touched the station 2 minutes later, a hailstorm commenced with a northwesterly surface squall of 45 kts. It was followed by heavy rain and thunder. (It may also be pointed out that rain at 1500 hrs had preceded the hailstorm and it can be seen that the farthest echo (Fig. 3) became very weak, due to attenuation.

At 1521 IST, at higher elevation of the antenna and low gain, these echoes, which had merged into one another near about 1512 hrs, gave the appearance of a prominent V-shaped hook at its rear edge with a clear notch or hole, *i.e.*, an open area towards the radar set, just after one minute of the commencement of the hailstorm (*see* Fig. 6). At 1525 hours the hook or the notch began to fill up (*see* Fig. 7). The hailstorm lasted for 8 minutes. After 1529 hrs the main echo drifted towards east. Another echo of line type character was seen at 10 n. miles in the northwest which had a tendency to move towards northeast (Fig. 8).

From the above observations it is seen that the echo associated with the hailstorm, had clear-cut well-defined sharp edges of strong intensity. They were visible even at reduced gain with little change in brightness and did not disappear at 12° tilt of the radar antenna (12° is the limit for the tilt of this radar) suggesting that the echo was of considerable vertical extent. The very strong portion of the echo (hook) appears to be associated with the hailstorms, falling from the rear of the main cell, which then behaved like big water drops, as a result of their acquiring a wet coating during descent. As the intensity of the echo is directly proportional to six power of the drops diameter (*i.e.* $\propto D^6$), the intensity of the echo appeared to have been much greater than what it would have been from water droplets. In all the above photographs care has been taken to avoid blurring of the echo's edge due to high intensity of the echo by keeping receiver gain and brilliance low.

The surface squall direction was the same as the direction where the echoes merged into one another, *i.e.*, NW. The surface squall speed can also roughly be estimated from the movement of the echoes which were moving with speed of about 34 n. miles per hour; a bit less than the surface speed observed. The speeds of the echoes so noticed are all approximate and have been calculated with the help of available photographs.

3. Synoptic situation

The surface weather chart for 0830 IST on 17 April 1962 showed a low pressure area over Nepal and north Bengal. It moved by 1730 IST over north Bengal and northwest Assam. The 0530 IST upper air chart showed a wind discontinuity at 0·9 km passing through Dhubri, Pabna, Burdwan and Jamshedpur (Fig. 9).

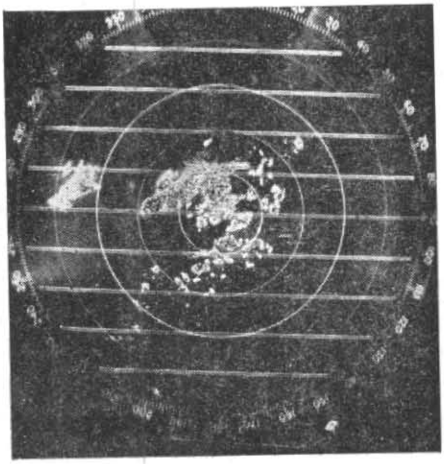
The vertical time-section of the winds at Gauhati showed the presence of a strong wind field above 3 km at 0530 IST on 17 April 1962 and increasing wind shear in the velocity profile. It also showed an isotach maxima of 80 knots over Gauhati (Fig. 13).

From the stream lines at 7.2 km at 0530 IST axis of upper air trough was present due west of Gauhati which later on had shifted towards the east at 1730 IST (Figs. 10 and 11).

Tephigram of 0530 IST showed the presence of large positive area. It also showed a small layer of inversion at low level.

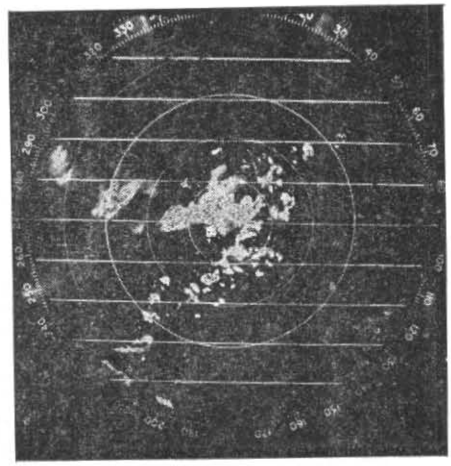
3.1. *Discussion*

There is a pronounced geographical and seasonal variation in the distribution of hailstorms. In general thunderstorms occurring in particular area and seasons only yield hailstones (Appleman 1958).



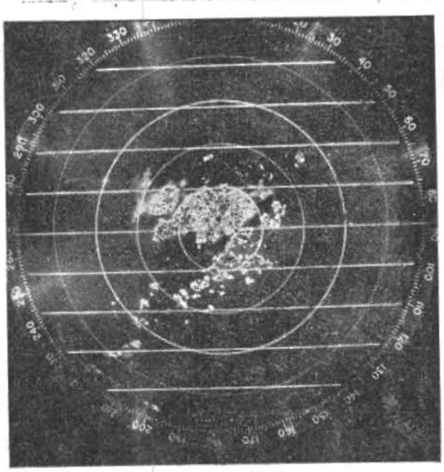
1446 5 n.m. 5

Fig. 1.



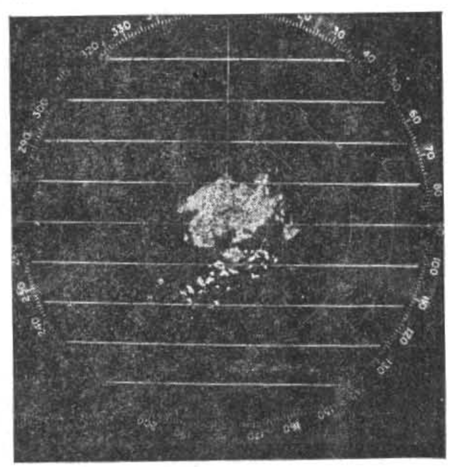
1456 5 n.m. 3

Fig. 2



1507 5 n.m. 5

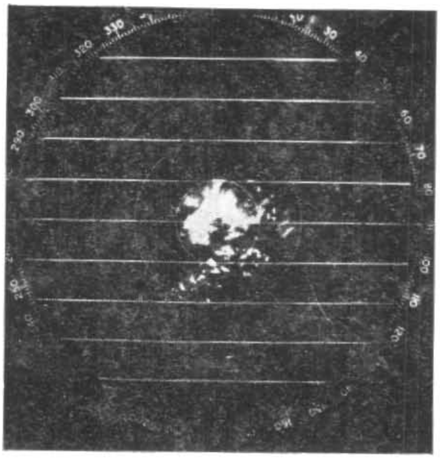
Fig. 3



1517 5 n.m. 5

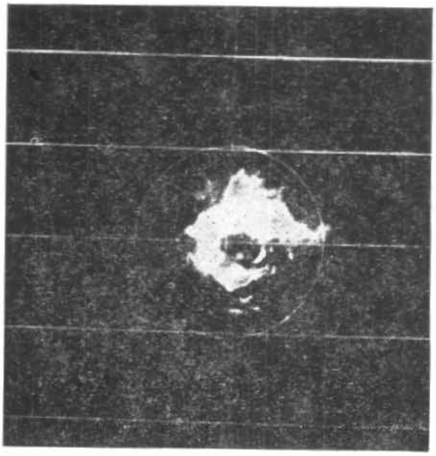
Fig. 4

Figures below the photographs indicate (from left to right) time in IST, distance between two rings, and elevation of radar antenna in degrees respectively



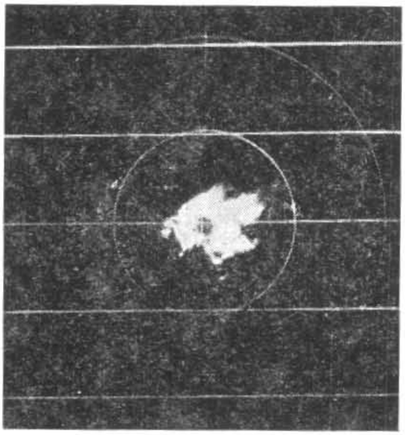
1518 5 n.m. 5

Fig. 5



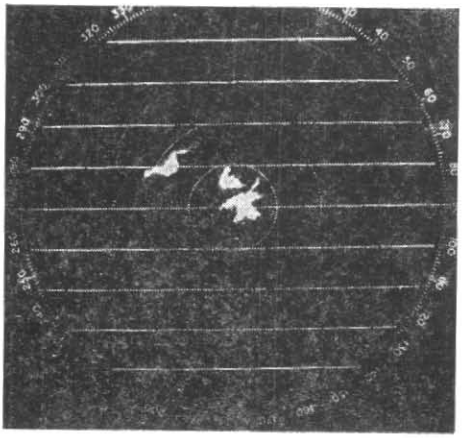
1521 5 n.m. 8

Fig. 6



1525 5 n.m. 8

Fig. 7



1529 5 n.m. 10

Fig. 8

Figures below the photographs indicate (from left to right) time in IST, distance between two rings, and elevation of radar antenna in degrees respectively

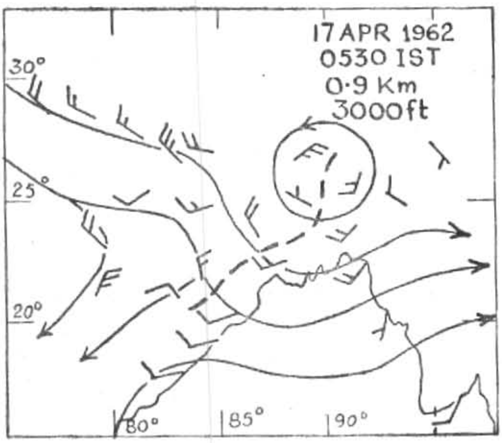


Fig. 9

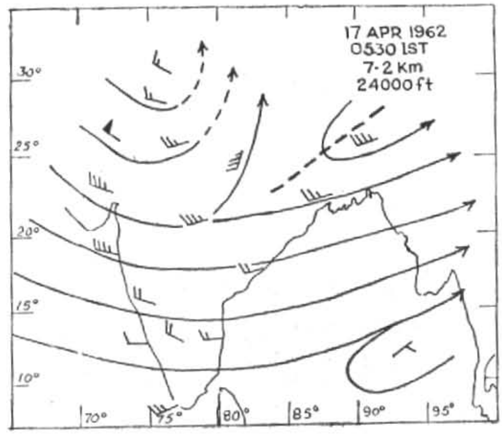


Fig. 10

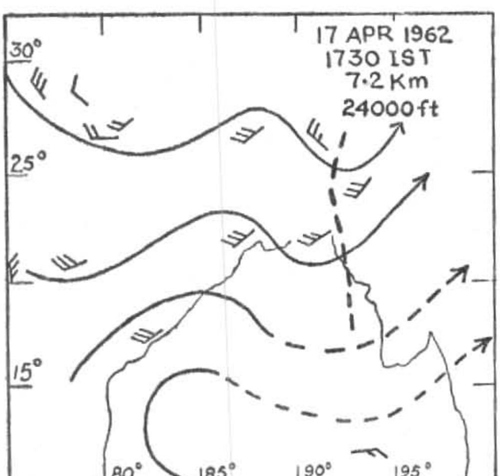


Fig. 11

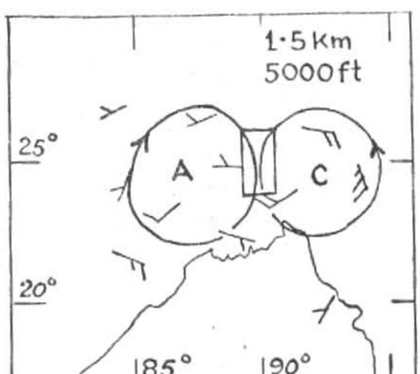


Fig. 12

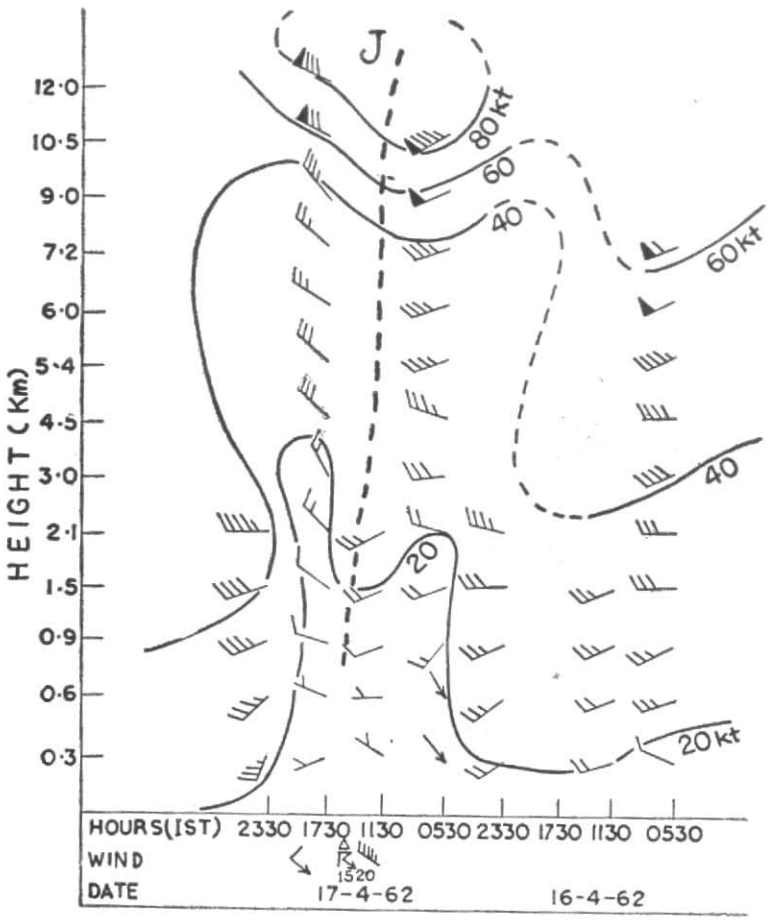

J
80 kt
60
40
60 kt
40
20
20 kt
12·0
10·5
9·0
7·2
6·0
5·4
4·5
3·0
2·1
1·5
0·9
0·6
0·3
HEIGHT (Km)
HOURS(IST) 2330 1730 1130 0530 2330 1730 1130 0530
WIND
1520
DATE 17-4-62 16-4-62

Fig. 13

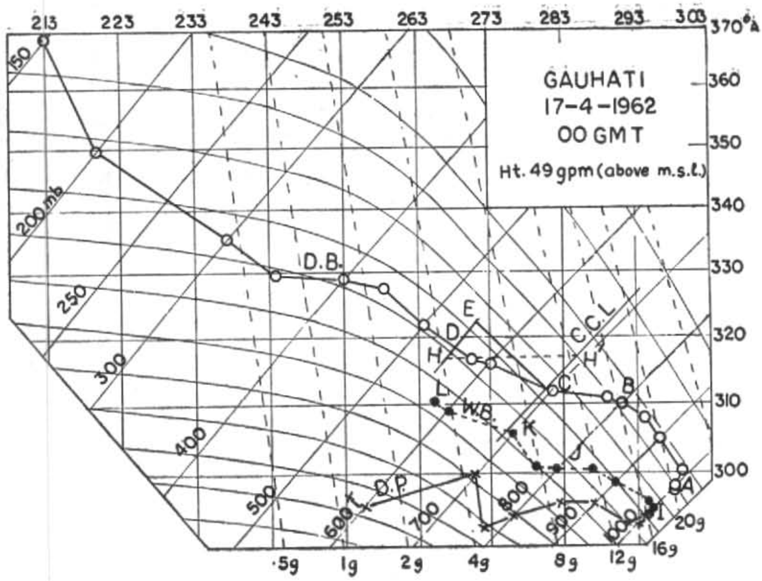


Fig. 14

It has been observed that during the seven-year period of 1955—61, hailstorms occurred on 14 days over Gauhati Airport. Out of these 14 days, 5 occurred in March, 8 in April and 1 in May. Thus the hailstones are generally associated with pre-monsoon thunderstorms in this area. This shows that vigorous convection is essential for the formation of hailstones, and the condition to produce the convection activity as given by Koteswaram and Srinivasan (1958), *namely*, the superposition of upper divergence associated with a high level perturbation over a low level convergent area (a low at the surface extending upto 900 metres into the upper atmosphere) is satisfied on this day. Further, the isotach maxima appears to have passsed over Gauhati exactly at the time when the hailstorm occurred.

Following the method evolved by Rao and Mukherjee (1958) for forecasting hailstorms, the 24-hr vectorial wind changes for 1·5 km level on the day of occurrence of hailstorm and the previous day (at 0530 hrs) were plotted, as shown in Fig. 12. It was found that the conjuction of cyclonic and anticylonic vortices shown by a rectangle lay a few miles west of Gauhati and the cyclonic vortex was being embedded in a moist air from head Bay.

Thus it can be inferred that the border region of cyclonic and anticyclonic vortices might have provided a suitable place for the occurrence of the hook-shaped protuberance, which was also suggested by Mull and Kulshrestha (1962).

4. Size of hailstones

The size of the hailstones received at the ground has been calculated by a method, given by Fawbush and Miller (1953), from tephigram (Fig. 14).

The diameter d of the hailstone (in inches) $=(0\cdot008\,bh)^2$, where b=DE (°C) and h=HH′ (°C) through the centroid of the triangle CED and parallel to dry adiabat.

A B C D : Ascent curve (D. B.)

I J K L : W. B. curve

C : Convective condensation level and

E is a point on saturated adiabat curve through CCL corresponding to —5°C isobar.

Putting these values in the above formula, the diameter d comes out to be 4·6 mm, which is just equal to the measured value.

5. Acknowledgement

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