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The vertical currents in a thundercloud over Gauhati on 20 March 1966

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ABSTRACT. The evening radiosonde balloon of 20 March 1966 at Gauhati, entered a thundercloud which gave hail, was under the influence of a strong downdraft for about 8·5 minutes. The maximum downdraft was found to be 17 m/sec. From the dimension of hail, the magnitude of the updraft has also been computed and found to be 15·3 m/sec. The detailed synoptic situation of the day has also been given.

1. Introduction

The study of downdrafts in a thundercloud is of fundamental importance to decide the circulation and the energy problems which are yet to be settled (Byers 1951). Data in relation to these have been very scanty, especially in India, where no concerted study has been made like the one done in the U.S.A. between 1946 to 1949 by the Thunderstorm Project (Byers and Braham 1949). In the present note the downdrafts experienced by the radiosonde balloon, which entered a thundercloud in the afternoon of 20 March 1966 at Gauhati, have been recorded and the updraft computed from the size of the hail which reached ground. The detailed synoptic situation has also been presented. Similar studies have also been made by Venkiteshwaran and others (1952, 1957, 1961) with F-type radiosonde.

2. Synoptic situation

The synoptic situation on 20 March in northeast India was very favourable for the occurrence of thunderstorm. The seasonal surface low lay over Bihar and adjoining West Bengal and Assam (Fig. 1). Moisture incursion was taking place in Assam in the lower levels (Fig. 2). A well-marked upper air trough in the westerlies existed at 6·0 km a.s.l. passing through Purnea and Puri (Fig. 3). The moisture incursion in the lower levels, divergence over Assam in the higher levels, lower level convergence facilitated by orography, the jet stream over Gauhati above 300 mb (Fig. 4) and location of an extratropical low over eastern parts of Tibet caused widespread thunderstorm activity in Assam.

Weather condition over Gauhati

The sky was cloudy with medium and high clouds since morning. The development of thunderclouds started near about 1100 IST and the first thunder was heard at 1300 IST. Thundershower accompanied with squall commenced at 1415 IST and ceased five minutes later. The wind before and during the squall was 090°/07 kt and 300°/30 kt respectively.

The second thunderstorm occurred at 1700 IST. But the shower accompanied with hail started at 1725 IST and the hailstorm continued for about three minutes. However, rain continued upto 1735 IST. Another shower commenced at 1825 IST and ceased at 1935 IST. The wind before and during the hailstorm was 080°/08 kt and 210°/10 kt respectively.

3. Radiosonde observation

Radiosonde balloon weighing 875 gm and containing radiosonde instruments and having a free lift of 1800 gm with rate of ascent of 17·9 km/hr or 4·97 m/sec was released at 1705 IST. The balloon entered the cloud after 12·5 minutes. It had a normal ascent upto 12·5 minutes through a layer having a lapse rate of about 7°C/km. After 12·5 minutes the pressure value rose from 648 mb to 677 mb in half a minute and the temperature fell from 1°C to —1°C. This shows that the balloon was descending through a layer of colder air. The balloon continued to descend further till it reached a pressure value of 844 mb on the 20·8th minute. The temperature, however, rose from —1°C to 14·5°C. Thereafter, the balloon started to rise again through layers having a temperature lower than the environment and also a steeper lapse rate. The rate of ascent of the balloon is shown in Fig. 5.

Table 1 shows the relevant portion of the flight when the balloon was descending which was indicated by the increase in pressure. The temperature initially fell from 1°C to —1°C but, thereafter, it rose continuously till the balloon ascended again. It practically attained a normal rate of ascent in the 37th minute. The pressure and temperature variation with time is shown in Fig. 6. The thick line shows pressure and the dotted line, the temperature.

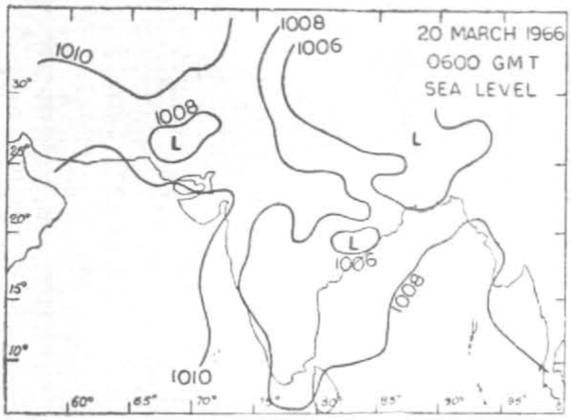

Fig. 1. Sea level pressure distribution

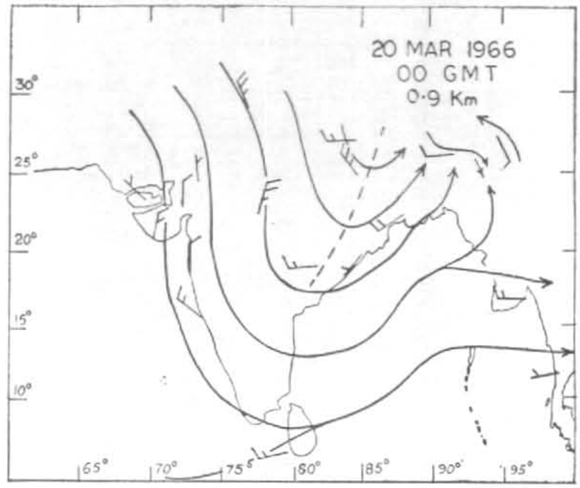

Fig. 2. Upper wind at 900 m a.s.l.

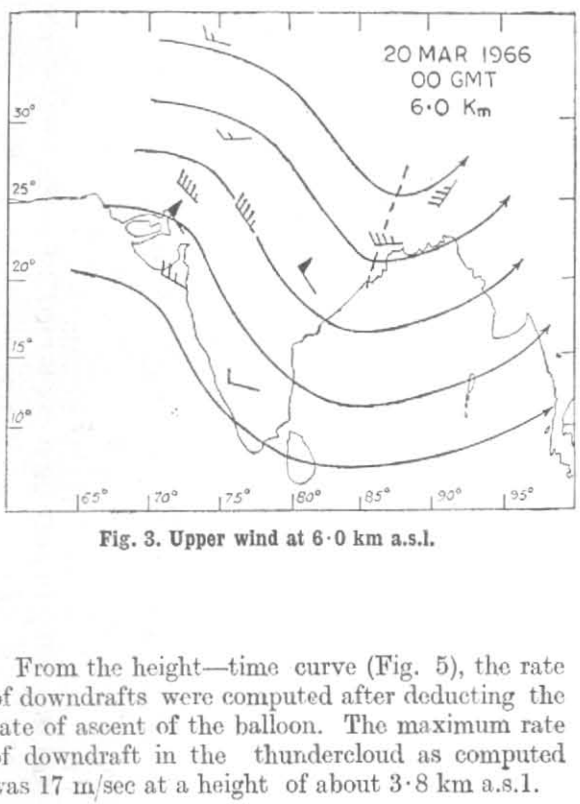

Fig. 3. Upper wind at 6·0 km a.s.l.

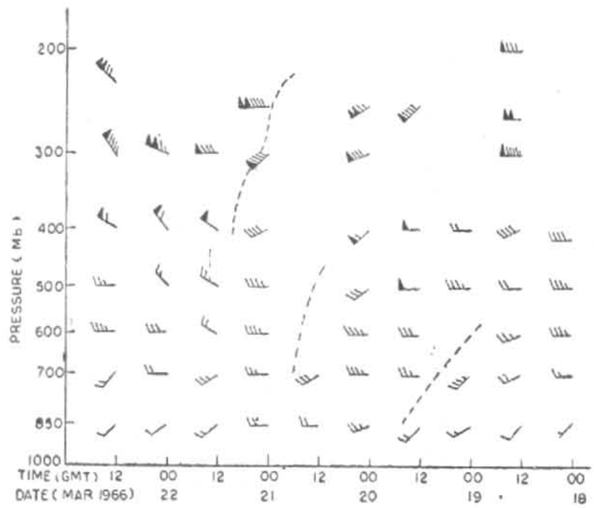

Fig. 4. Upper wind at Gauhati (Time cross-section) from 18 to 22 March 1966

From the height—time curve (Fig. 5), the rate of downdrafts were computed after deducting the rate of ascent of the balloon. The maximum rate of downdraft in the thundercloud as computed was 17 m/sec at a height of about 3·8 km a.s.l.

4. Hail

A number of hailstones were collected and were measured. They showed an average diameter of 1·2 cm. All the stones fell singly. Most of them were irregular in shape but some of them were spheroidal. The largest stone though irregular, could be called a sphere, had a diameter of roughly 1·8 cm. It was cut along its diameter. The central core was opaque and it had seven visible concentric layers of opaque and clear ice. On collecting the total water that formed by melting this stone was measured to be 1·3 mm and hence the specific gravity of the stone was about ·45.

From Mason's equation (Mason 1956) for the rate of melting of hailstone, the size of the hail which was 1·8 cm in diameter on reaching the ground, was calculated to be 2·7 cm in diameter at the freezing level in the cloud, which was roughly 3·0 km a.s.l. The terminal velocity that can be attained by a hail of corresponding size and density is found to be 15·3 m/sec (Bilham and Relf 1937). Therefore, a minimum updraft of 15·3 m/sec must be necessary to maintain the hail in the cloud.

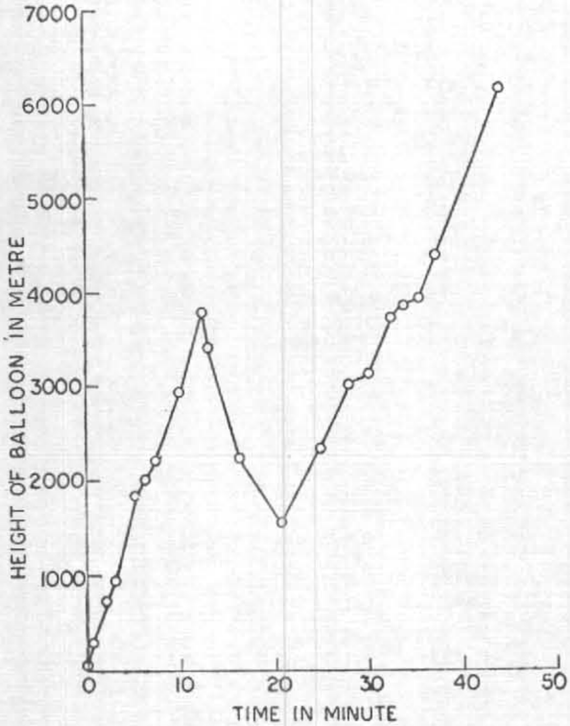

Fig. 5. Rate of ascent of balloon

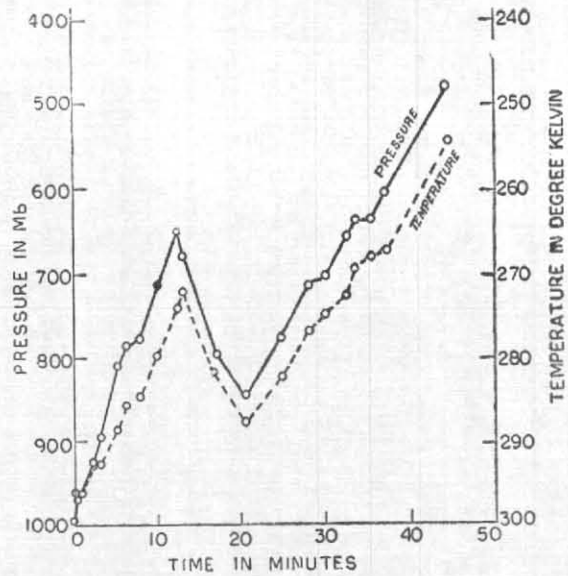

Fig. 6. Pressure and temperature variation during ascent

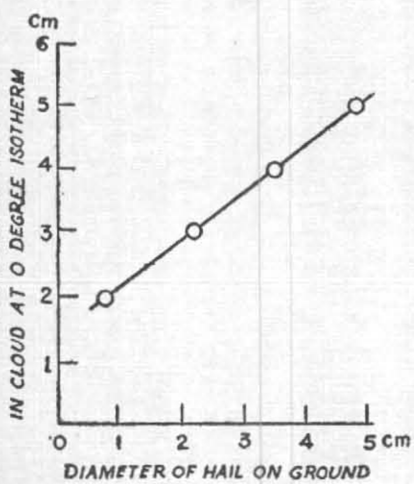

Fig. 7. Diminution of hail size on reaching ground from freezing level in cloud

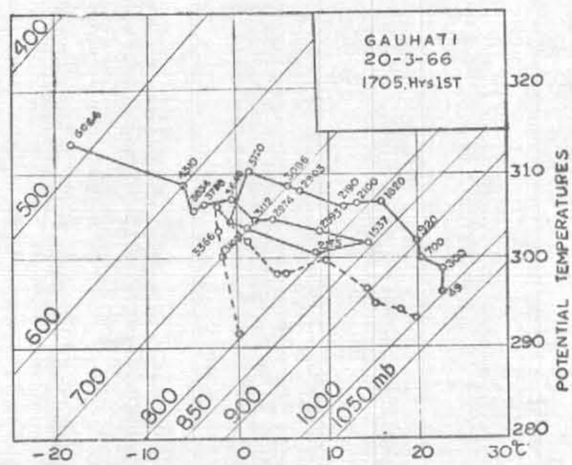

Fig. 9. Tephigram of Gauhati at the time of thunder-cum hailstorm

[Surf. Pr.=995·4 mb, Stn. ht. 49 gpm a.s.l.]

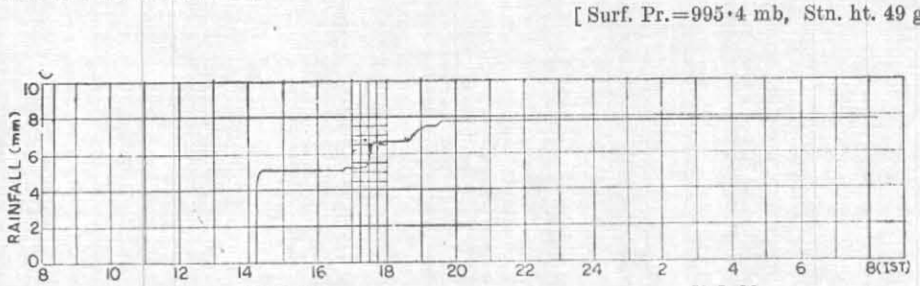

Fig. 8. S. R. Raingauge chart of Gauhati of 20-21 March 1966

TABLE 1

Radiosonde observation and the calculated vertical curents

Serial No.	Time	Pressure (mb)	Altitude (m)	Vertical air draft (m/sec)	Temperature (°C)
1	10·0	712	2961	−0·1	+6·7
2	12·5	648	3794	+0·6	+1·0
3	13·0	677	3433	—17·0	—1·0
4	16·85	794	2218	—10·2	+8·5
5	20·8	884	1568	—7·7	+14·2
6	24·85	775	2368	—2·2	+9·0
7	27·9	712	3033	—1·2	+3·5
8	30·0	700	3174	—3·8	+1·8
9	32·5	657	3713	—1·4	—0·6
10	33·5	637	3874	—2·3	—4·0
11	35·5	633	3911	—4·6	—5·2
12	37·1	602	4396	—0·5	—6·0

Fig. 7 shows for the various diameter of hail at freezing level in the cloud, the corresponding size of the same on reaching the ground assuming the ground temperature to be 20°C, the lapse rate 7°C/km, the distance through which the hail fell to be 3·0 km and that the atmosphere was fully saturated during the hailstorm and no evaporation or sublimation of hail occurred during the fall. The graph (Fig. 7) has been computed from Mason's (1956) equation by omitting the condensation term.

5. Conclusions

From Table 1 it is seen that at 12·5th minute the vertical airdraft was 0·6 m/sec but at 13th minute it became —17·0 m/sec. This shows that the rate of ascent changed from 5·57 m/sec to a rate of descent of 12·03 m/sec in an interval of 30 sec. This rate of descent of the balloon amounts nearly to 43 km/hr (the rate of ascent of the balloon was 18 km/hr, *i.e.*, 4·97 m/sec). This large change in momentum occurred in 30 sec only. The temperature during this period changed only from 1°C to —1°C. Thus the period, when the balloon was in sub-zero temperature, was less than 30 sec. Within this short period and at a temperature of only —1°C, a rapid and heavy ice accretion is unlikely so as to cause a change of velocity from 18 km/hr to —43 km/hr, *i.e.*, a total change of 61 km/hr. Furthermore, it is seen that the time of release of the balloon was 1705 IST and the time when the balloon experienced maximum downdraft was between 1717·5 IST and 1718 IST, but the precipitation along with hails started at 1725 IST, *i.e.*, 7 minutes later. Therefore, the descent of the balloon due to ice accretion or precipitation can be ruled out (Fig. 8).

It will be noticed that the second thunderstorm although accompanied with hail did not give rise to squall. This is mainly because due to earlier thunderstorm the temperature of the air at lower levels had already decreased and thus reducing the contrast of the temperature between the down currents of air from the second thunderstorm and the ground.

The tephigram (Fig. 9) shows that the downdrafts are cooler than the environment. The maximum contrast of temperature being found in the region of maximum downdraft.

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