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VERTICAL CURRENT AND POSSIBILITY OF DRY DOWNDRAFT INSIDE A *Cb* CLOUD AT CALCUTTA

The evening radiosonde balloon on 20 September 1977 at Dum Dum entered a thundercloud and was subjected to varying degrees of updrafts and downdrafts. The maximum downdraft was observed to be 7.9 mps. A part of the downdraft was warm, when the air temperature inside the *Cb* cloud rose by 9.2 deg C. The rate of warming was 1 deg. C per 129 gpm on an average and the percentage humidity fell from 82 to 63 per cent. A detailed study has also been made of the humidity and temperature profile inside the thundercloud.

2. Interesting features are noticed when a radiosonde balloon enters a *Cb* cloud during a thunderstorm. Up and down movements of the balloon under such circumstances have earlier been noticed and explanations for such vertical movements were given by Venkiteshwaran and Tilekan (1952), Kachare *et al.* (1957), Venkiteshwaran (1961), Gupta and Ghosh (1962) and Mukherjee and Rakshit (1964). Ghosh and Day (1967) have also studied vertical currents in a thundercloud over Gauhati. An attempt has been made in the present study to explain the up and down movements of a radiosonde balloon at Calcutta on 20 September 1977.

3. The radiosonde ascent was made with a PR 875 gm balloon whose free lift was 1750 gm. The balloon was released at 1645 IST on 20 September 1977 and was observed by means of WBRT ground equipment on 1680 mHz from the Meteorological Office, Calcutta Airport. During the ascent there was 2-3 okta *Cb* clouds, with dry thunder. The record of the ascent reveals that the balloon was subjected to upward and downward movements during its flight.

The tephigram obtained from the ascent giving the distribution of dry bulb temperatures with pressure is shown in Fig. 1. Graphs showing the variation of pressure, temperature and relative

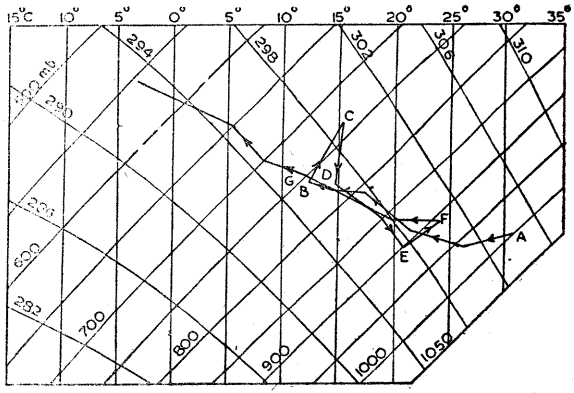

Fig. 1.Tephigram of Calcutta at the time of thunderstorm

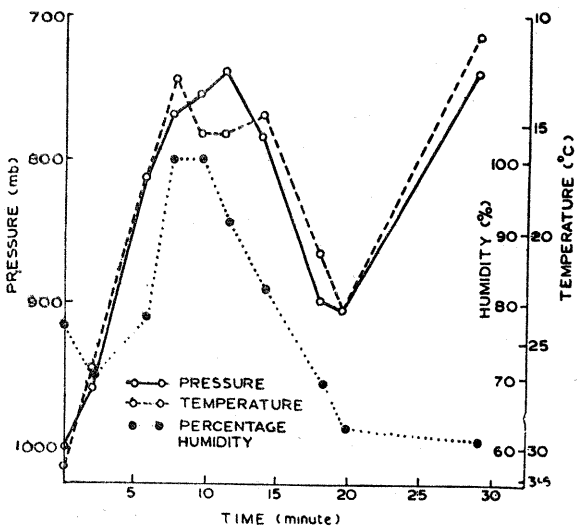

Fig. 2. Variation of pressure, temperature and percentage humidity during ascent

humidity with time as obtained from the ascent are given in Fig. 2.

Table 1 gives the pressure, altitude, temperature and relative humidity encountered by the balloon with reference to the time of release of the balloon. The updraft and downdraft values

TABLE 1

S. No.	Time (min)	Pressure (mb)	Altitude (gpm)	Observed vertical movement of the balloon (mps)	Vertical aircraft corrected to free lift only (mps)	Actual vertical aircraft caused by the cloud (mps)	Temperature (°C)	Humidity (%)
1	00	1002.6	6	—	—	—	31.2	77
2	1.9	960	360	+3.1	—2.6	0.0	26.6	70
3	5.7	812	1810	+6.4	+0.7	+3.3	17.4	78
4	7.6	767	2300	+4.3	—1.4	+1.2	12.9	100
5	9.6	754	2450	+1.3	—4.4	—1.8	15.4	100
6	11.3	739	2620	+1.7	—4.0	—1.4	15.4	92
7	13.9	784	2100	—3.3	—9.0	—6.4	14.6	82
8	18.0	902	950	—4.8	—10.5	—7.9	21.0	69
9	19.6	905	910	—0.4	—6.1	—3.5	23.8	63
10	29.1	739	2620	+3.0	—2.7	—0.1	11.0	61

at the corresponding mean levels have been calculated from this table. After release, the balloon was likely to rise freely with a constant rate of ascent of 5.7 mps had it not been subjected to any updraft and downdraft from the *Cb* cloud. The values of vertical airdraft have been calculated from the algebraic sums of the observed vertical movement of the balloon with the constant rate of ascent of 5.7 mps. From Table 1, it is seen that the balloon after release till 1.9 min when it was still outside the *Cb* cloud, was subjected to an airdraft of — 2.6 mps. Again, from 19.6 min to 29.1 min, when it came out of the *Cb* cloud, it was subjected to an airdraft of —2.7 mps. This shows that the airdraft outside the *Cb* cloud, in its immediate vicinity was of the value of — 2.6 to — 2.7 mps. The airdraft actually caused by the *Cb* cloud has therefore been calculated adding 2.6 mps with the observed airdraft corrected to constant rate of ascent.

4 (a). *Updrafts and downdrafts* — From the radar observations at the corresponding period of the day, taking account of the drift of the balloon as obtained from the trajectory of the flight, it has been ascertained that the balloon actually entered a *Cb* cloud, soon after its release.

As evident from Table 1, the balloon was subjected to varying degrees of updrafts and downdrafts from the *Cb* cloud. The maximum updraft was 3.3 mps from 1.9 min. to 5.7 min., and the maximum downdraft was 7.9 mps from 13.9 min to 18.0 min. The balloon actually entered the *Cb* cloud after 5.7 min from the time of release. Due to the downdrafts its upwards velocity was considerably reduced, but it ascended till 11.3 min. The balloon was then subjected to an increased downdraft and it began to descend first slowly and then at a faster rate. It continued to do so upto 19.6 min, after which the balloon came out from the *Cb* cloud and began to ascent gradually.

4 (b). *Humidity*—It is evident from Fig. 2, that as soon as the balloon entered the cloud at 5.7 min, the humidity began to rise sharply. The percentage humidity rose to 100 per cent from 78 per cent and remained steady at 100 per cent from 7.6 min to 9.6 min. It is assumed that the balloon encountered rain showers during this period. After 9.6 min the humidity began to fall gradually till 19.6 min, when the balloon left the cloud and its value came down to 63 per cent. From 19.6 min to 29. 1 min the percentage humidity was between 63 per cent and 61 per cent.

4 (c). *Temperature* — The temperature gradually fell as the balloon ascended, and it continued to do so till 7.6 min. The rate of fall of temperature upto this level was about 1 deg. C per 123 gpm on an average. A rise in air temperature by 2.5 deg. C was registered from 7.6 min to 9.6 min. Although the percentage humidity was 100 per cent and the balloon was ascending, such rise in temperature may be explained due to latent heat released inside the *Cb* cloud, through which the balloon was rising during the

period. The balloon further ascended till 11.3 min after which it began to descend. It is postulated that from 9.6 to 11.3 min, the effect of release of latent heat still continued, though at a lesser rate. As a result, although the balloon ascended during this period, the temperature of the air however remained steady, inspite of slight increase in altitude. From 11.3 min to 13.9 min, the balloon started descending being caught in the increased downdraft and a cooling of the order of 0.8 deg. C was produced. From 13.9 min to 19.6 min as the balloon continued to descend through the *Cb* cloud, the temperature gradually rose by 9.2 deg. C. The rate of warming was 1 deg. C per 129 gpm on an average. During this period the humidity also fell. Therefore, the change in temperature was almost dry adiabatic in nature. All these lead to the assumption that this last downdraft encountered by the balloon was dry. Studies on unsaturated downdrafts have earlier been done by Das and Subba Rao (1972). Eskridge and Das (1976) have also described downdrafts to be considerably warmer than the environmental air. After the balloon left the *Cb* cloud and began to ascend again, the air temperature obviously registered a fall with increase in altitude.

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