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Line type angel echoes observed at Dum Dum Airport, Calcutta

P. BHATTACHARYYA, D. K. RAKSHIT and A. C. DE

Meteorological Office, Dum Dum Airport

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ABSTRACT. Two instances of line type angel echoes as observed on the scope of a high powered 3-cm radar at Dum Dum Airport, Calcutta, have been presented in this paper. These appeared in the vicinity of thunderstorm cloud cells and were detected prior to the occurrence of surface squalls. The possible sources of the angel echoes have been discussed. It has been suggested that the line type angel echoes were due to undercutting of the weather front.

1. Introduction

Instances of occurrence of angel echoes in India have been reported by Rai (1959) and Kulshrestha and others (1961, 1962). Two instances of line type angel echoes as observed on the high-power 3-cm radar (Type NMD-451A) at Dum Dum Airport (Calcutta) are reported in this communication.

2. Radar observations

2.1. *Radar observations on 12 June 1962*

On this day at 1000 GMT the radarscope showed some scattered echoes in the SW, NW and NE sectors. There were also two large echoes in the SE sector: one from 100° to 150° at 30-80 km covering about 1500 sq. km and the other from 090° to 115° at 80-110 km covering about 1000 sq. km. These echoes were from *Cb* clouds, the tops of which were more than 14 km. Both these echoes were seen moving towards NW and approaching the station. Next hour, *i.e.*, at 1100 GMT, these echoes joined each other and became a single echo, while their movement in SE-NW direction continued. The position of this combined echo was 110°/25-70 km through 130°/28-80 km extending to 165°/30-60 km. The maximum height of the top of the echo was 17 km.

At 1125 GMT, a diffused line type of echo oriented in the NNE-SSW direction located about 5 km to the east of the radar station was observed. This line was seen moving towards NW. A few photographs were then taken as presented in Fig. 1. Fig. 1 (a) shows the radarscope picture at 1135 GMT. The line type of echo is clearly seen along with a large number of ground clutters. The nearer edge of the precipitation echo towards the SE of the station is also seen in this figure. Five minutes later (*i.e.*, at 1140 GMT), the line echo moved further NW and emerged out of the ground clutters (Fig. 1 b). Eight minutes later (*i.e.*, at 1148 GMT), the line moved further NW and became diffused. At 1150 GMT (Fig. 1c), a larger range was used and the photograph shows the line along with the radar cloud referred to earlier. Dum Dum Airport experienced a squall of light intensity (51 km/hr) from SE at 1135 GMT, *i.e.*, approximately at the time when the line echo was over the station.

2.2. *Radar observations of 8 April 1963*

On this day in the afternoon, there was a lot of thunderstorm activity in the E-S-SW sectors of Dum Dum. A few photographs of the radarscope are shown in Fig. 2. At 1057 GMT (Fig. 2a) there were quite a number of large cells arranged in the form of a broken line, the position of the line being from 090°/90 km through 180°/40 km extending to 240°/100 km. There were in addition two isolated cells in the south and southwest at

25-40 km. Two line type angel echoes quite faint, appeared very near the station. These were oriented in N-S and E-W directions. Let us number these as I and II. At 1105 GMT (Fig. 2b) the line I moved westwards while the line II moved northwards. The elevation of the antenna was 5° above the horizontal. An enlarged view is shown in Fig. 2(c). Five minutes later, *i.e.*, at 1111 GMT (Fig. 2d) both the lines became quite prominent and moved further west and northwards (Fig. 2d). Further movements of these lines are shown in subsequent pictures—Fig. 2 (e–f). At 1119 GMT (Fig. 2g), these lines joined together. The lines became diffused by 1122 GMT (Fig. 2h) and disappeared thereafter.

3. Weather conditions

On 12 June 1962 Dum Dum Airport experienced a mild squall of 51 km/hr from SE at 1135 GMT. Fig. 3 shows the autographic records of thermograph, barograph and Dines P.T. Anemograph as recorded at Dum Dum Airport, on this day between 0930 and 1430 GMT. As a result of the squall there was a fall of temperature by about 6°C and rise in the value of relative humidity by 12 per cent (from 76 per cent to 88 per cent). Prior to the squall, the surface wind was light S'ly which became SE'ly during the occurrence of the squall. As the squall activity subsided, the wind returned to its normal condition (*i.e.*, light S'ly). A 'nose', though not very prominent, showing a sudden rise in the pressure value, appeared in the barographic record at the time of occurrence of the squall. The autographic records of Dum Dum Airport for 8 April 1963 are shown in Fig. 4 (a–c). Dum Dum Airport experienced two gusts, one E'ly of 37 km/hr at 1115 GMT and the second SSW'ly of 45 km/hr at 1205 GMT. The surface temperature fell by 11°C and the relative humidity rose by about 40 per cent. The barograph showed gradual rise (hump type) in surface pressure values between 1115 and 1150 GMT. The pressure then decreased slightly and again a 'nose' appeared at 1205 GMT. Alipore Observatory, located about 18 km to the southwest of Dum Dum Airport, experienced a SW'ly squall of 60 km/hr at 1057 GMT and a SW'ly gust of 46 km/hr at 1112 GMT (Fig. 4f). The barograph at Alipore showed a sudden rise between 1100 and 1135 GMT (Fig. 4e). Fig. 4 (d) shows the thermograph record for Alipore observatory.

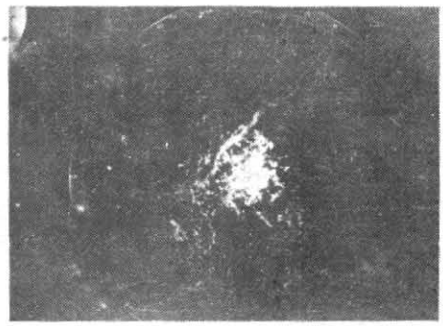
4. Discussion

The source of the line type angel echoes is still a subject of controversy. There are mainly two causes put forward for explaining the possible sources of these echoes. According to some workers these echoes might be caused by birds or insects flying in the upper air. In this connection it is worthwhile to mention the observations reported by Harper (1959). While his observations certainly showed that this may be the cause on at least some occasions, the large amount of subsequent observations by many workers in different countries have definitely proved that a very large majority of the line type angel echoes, specially those occurring in the vicinity of strongly convective precipitation cells (as in the present case), require a different explanation. The other idea is that these echoes might be due to some sources other than physical scatterers. This means that the radar beam is scattered back due to some inhomogeneity in the atmospheres. These inhomogeneities may be either due to gravity waves existing on a surface of density discontinuity or due to the 'nose' portion of an undercutting weather front (Leach 1957). The radiosonde ascent taken at Dum Dum Airport only one hour after the occurrence of angel echoes on the same day (1200 GMT), however, did not show any inversion.

To the authors, the possibility of these echoes arising due to reflection of radar energy at the boundary of the undercutting weather front appears to be quite reasonable, specially as the phenomenon has been found to occur in association with thunderstorm echo cells. The maximum height of the top of the echoes was about 16 km. This means that the convective activity was appreciable. A sketch of the thunderstorm

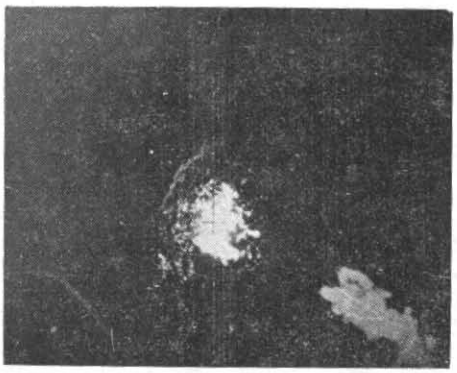
20/5 1135 1°

Fig. 1(a)



20/5 1140 1°

Fig. 1(b)

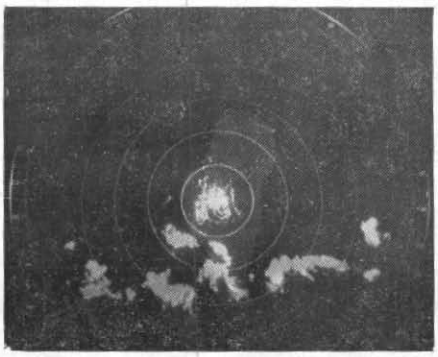


50/10 1150 1°

Fig. 1(c)

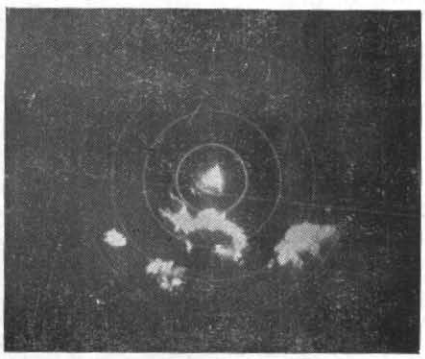
Figs. 1(a) to 1(c). Radarscope photographs (as taken on J. R. C. radar Type NMD 451A) at Dum Dum Airport on 12 June 1962

Figures from left to right — Range rings in km, Time in GMT and Elevation in degrees



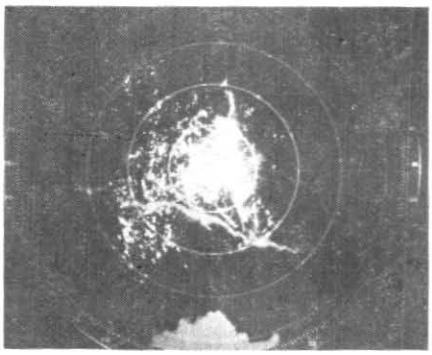
100/20 1057 0°

Fig. 2(a)



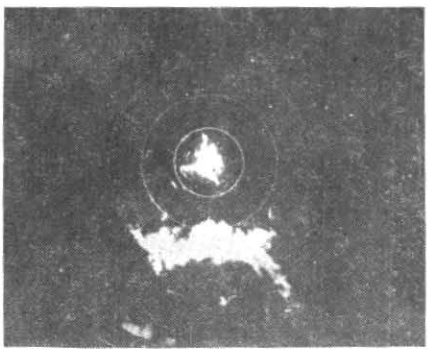
100/20 1105 5°

Fig. 2(b)



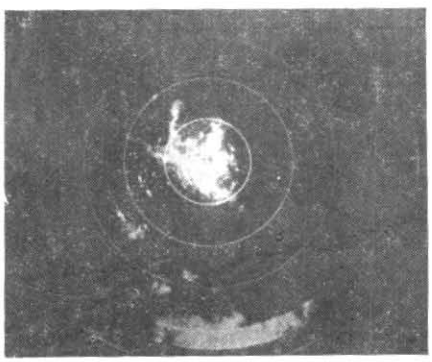
20/5 1106 1° 20/5 1111 2°

Fig. 2(c) Fig. 2(d)



100/20 1114 3° 20/5 1115 3°

Fig. 2(e) Fig. 2(f)



20/5 1119 3° 20/5 1122 3°

Fig. 2(g) Fig. 2(h)

Figs. 2(a) to 2(h). Radarscope photographs (as taken by J.R.C. radar Type NMD 451A) at Dum Dum Airport on 8 April 1963

Figures from left to right — Range/range rings in km, Time in GMT and Elevation in degrees

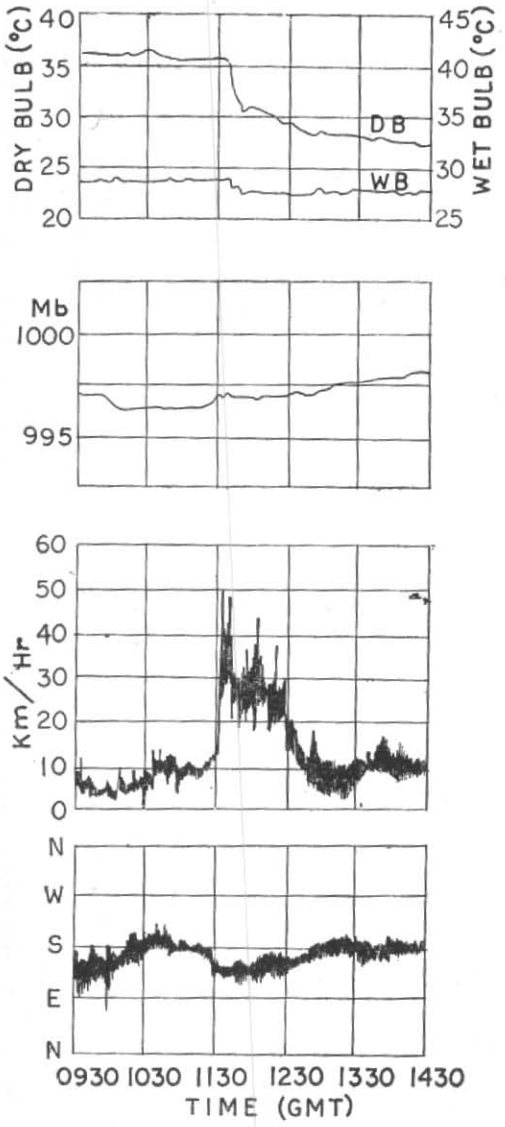


Fig. 3. Records of autographic instruments at the Forecasting Office, Dum Dum Airport on 12 June 1962

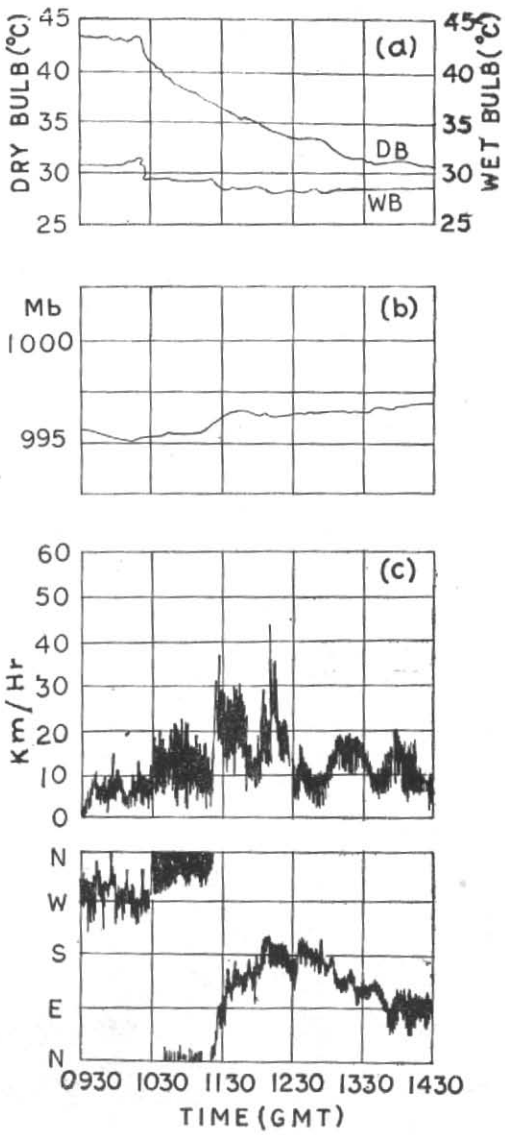


Fig. 4 (a–c). Records of autographic instruments at the Forecasting Office, Dum Dum Airport on 8 April 1963

cloud cells (Fig. 5) has been drawn in the light of the suggestions made by the Thunderstorm Project (Byers and Braham 1949). It may be seen that the leading edge of the downdraft (Plane AA in Fig. 5) may have a sharp change in the meteorological parameters over a short region in the horizontal plane at the surface level. This microstructure may not always be revealed by the self-recording instruments due to their low sensitivity. That is why the barograph record of 12 June 1962 (Fig. 3) did not show any marked change in the value of the surface pressure at the time of occurrence of the squall. The line type echoes were formed ahead of the convective cells and may also be termed

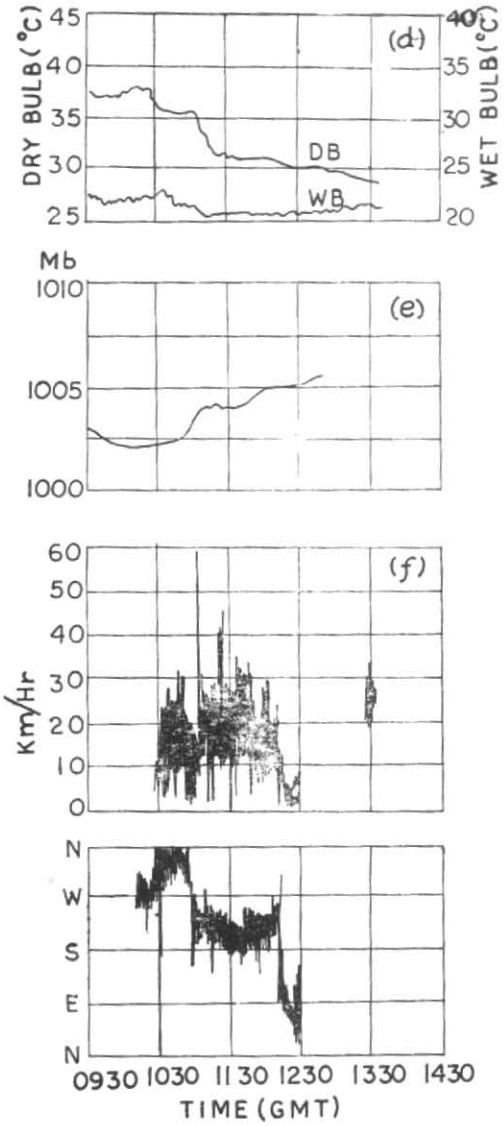


Fig. 4(d-f). Records of autographic instruments at the Meteorological Office, Alipore on 8 April 1963

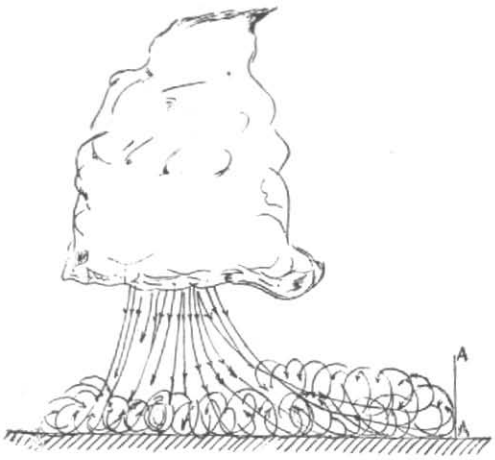


Fig. 5. Sketch showing first gust stage of a thunderstorm cloud

(After Thunderstorm Project)

as 'squall pre-curser' or 'first gust' line. This line when seen on the radarscope gives an advance intimation about the occurrence of surface squall. As the thunderstorm cells moved, the lines also moved. The direction of movement and speed of the 'first gust lines' compare favourably with those recorded by Dines P/T. It is noteworthy that on 8 April 1963 Alipore observatory recorded a surface squall when the second line (line II) was over that station.

5. Acknowledgements

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