

A radar study of a squall-line at Agartala

D. V. SUBRAMANIAN

Meteorological Office, Agartala

(Received 26 November 1962)

ABSTRACT. The results of the study of a typical squall-line thunderstorm of the pre-monsoon season from the time of its formation to its decay, with the aid of the storm-warning radar at Agartala airport are presented in this paper.

1. Introduction

Thunderstorms of the Nor'wester type of varying degrees of violence are of frequent occurrence in Tripura and adjoining regions of Assam and East Pakistan in the pre-monsoon months and constitute the major aviation hazard of the season. In the past, the occurrence of such thunderstorms in this region have been studied with reference to the synoptic features by various workers (Ramaswamy 1956, Sen and Basu 1961, Chaudhury 1961). The installation of the storm-warning radar at Agartala as a meteorological aid for aircraft operations has greatly facilitated the detailed study of the structure, growth and movement of the thunderstorms in this region.

During the months of April and May 1962, the thunderstorms around Agartala were mostly of the scattered-cell type; very few squall-line thunderstorms were observed. One such squall-line thunderstorm which occurred on 17 April 1962 was studied in detail with the aid of radar.

2. Description of the equipment

The radar equipment at Agartala airport consists of a 3·2-cm aircraft radar (Bendix radar type RDR 1E) modified for ground use, with a peak power of 17 kw and an effective range of 100 nautical miles. It employs a 3-degree pencil beam for scanning and a Plan Position Indicator for displaying

the information. The radar beam can be tilted upto 15 degrees in the vertical.

A special feature of this radar is the 'Iso-echo contour' facility available for a fixed intensity of the echo-signal. Portions of the cloud giving greater signal returns appear as 'holes' in the cloud-echoes. In a fairly big area of cloud echoes of moderate and weak intensity, the presence of thunderstorm cells can be detected as the echoes returned by the cell-cores are very intense and switching the radar set to 'Contour' facility produces 'holes' as aforementioned in regions of relatively more intense cloud-echoes.

Radarscope observations are made every hour as a routine and more frequently when necessary. Interesting developments in the echo-patterns are photographed in sequence at suitable time intervals.

3. Synoptic situation

The sea-level weather chart of 0001 GMT on 17 April 1962 indicated a well-marked low pressure area over West Bengal and adjoining areas of Bihar and East Pakistan (Fig. 1a). The position of the trough line at 3000 ft a.s.l. is shown on the streamline charts (Fig. 1b). The flow of moist southerlies from the Bay of Bengal into East Pakistan and lower Assam was maintained during the greater part of the day with a slight shift of the trough line to the east of Calcutta at 0600 GMT and an increase in the depth of the moist current

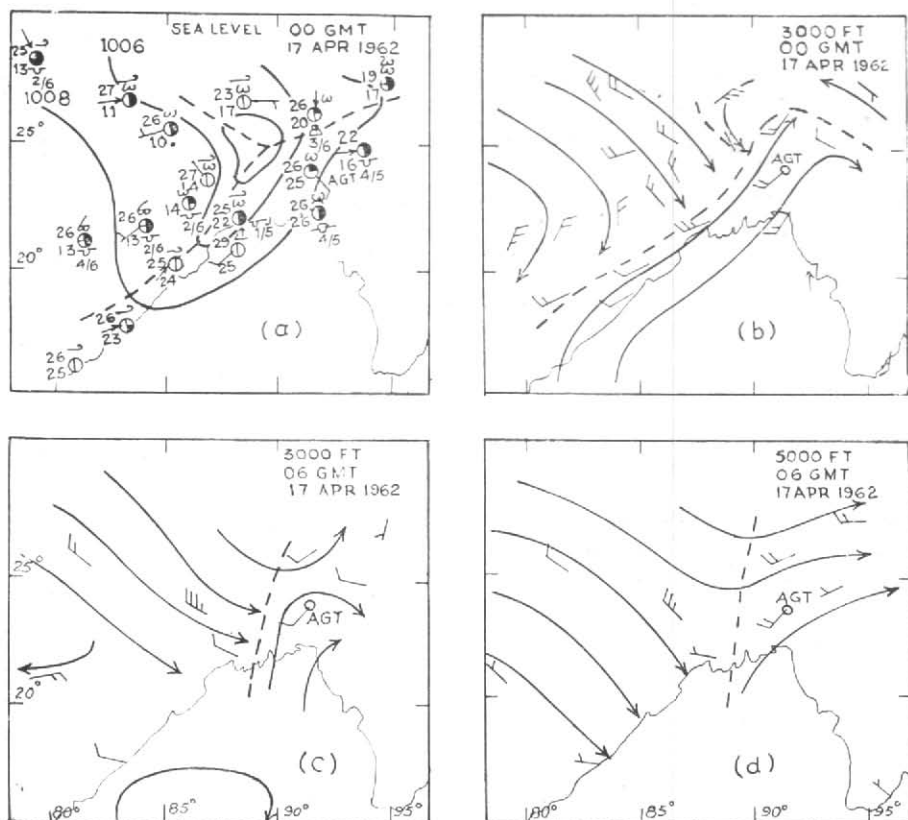


Fig. 1

as shown on the streamline charts (Figs. 1c and 1d). Thus with the prerequisites for the thunderstorm, namely, moisture and low level convergence being present, the insolation in the area during the day provided the 'trigger' for the occurrence of the thunderstorm in the afternoon.

4. Description of the echo patterns

On the day referred to, convection activity started in the area around noon as inferred from the initial formation of the radar echo, as a mere speck at 65 n. miles to the west of the station at 1330 IST. Within an hour a cluster of cells rapidly developed around this and oriented themselves along a SSW/NNE line. Meanwhile another group of more intense cells were seen developing to the north and northeast at a distance of 10 to 15 n. miles from the station. The general field of the

thunderstorm cells at 1530 IST is shown in Fig. 2(a). The iso-echo photo (Fig. 2b) taken at the same time on a range of 50 n. miles shows three cells at $260^{\circ}/45$ n.m., $270^{\circ}/45$ n.m., and $310^{\circ}/43$ n.m. in the western sector and two cells at $030^{\circ}/23$ n.m., and $015^{\circ}/34$ n.m. to the north. Except for the cell in the NW which was 3 to 5 miles across its core, other cell cores were only 1 to 2 miles in extent. The tops of the clouds at this stage were at 13,900, 16,500 and 15,000 metres for the WSW, WNW and NNE cells respectively. At 1600 IST, more cells could be seen along the line oriented NNE/SSW between $240^{\circ}/45$ n.m. to $310^{\circ}/35$ n.m. through $270^{\circ}/35$ n.m. Though the line appeared 8 miles across on the average, the iso-echo pattern revealed that the core of the cells was only 1 to 4 miles in extent and not very active at this stage. But the group of four intense cells to

the north had already formed a line oriented WSW/ENE from 300°/17 n.m. to 020°/28 n.m. through 330°/22 n.m. and had slightly moved to the WNW (Fig. 2c).

Due to the proximity of the cells to the station and their great vertical extent, the tops of the clouds were at an elevation of more than 15° which is the limit for tilting the scanner in the vertical plane. Hence the heights* of cloud tops could not be accurately determined from this stage onwards and were assumed to be at least as high as they were initially, *i.e.*, 15,000—16,000 metres if not more at the peak of their activity. By 1615 IST, the main line had moved 4 miles towards the station but the line to the north remained more or less stationary for reasons not apparent; more cells were seen developing on the western end of this line; there were at least six cells with cores ranging from 1/2 to 2 miles in extent. Within the next fifteen minutes the main line moved by about 9 miles towards the station and merged with the line in the northwest forming a formidable array of very closely packed cells, extending from 240/32 n.m. to 360/30 n.m. through 250/20 n.m. and 290/20 n.m. as shown in Fig. 2(d). By decreasing the radar-receiver gain, about a dozen cells were estimated in the iso-echo pattern at this stage. By 1645 IST the squall-line had moved another four miles and a WNW squall with a speed of 40 knots struck the station at 1650 IST.

After this, the line had considerably shrunk in length and was seen to be breaking up at both ends to individual cells though the centre of the line remained intact and closely packed (Fig. 2e). The thunderstorm passed overhead at 1720 IST (Fig. 2f). As the precipitation had started by this time, the radar could not 'see' more than 5—8 miles to the north, south and east of the station. The relevant portions of the records of the self-recording instruments have been reproduced in Fig. 3(a). 9 mm of rain fell during the passage of the thunderstorm, *i.e.*, between 1720 and 1730 IST corresponding to an intensity of 5.4 cm per hour. As there is no anemograph

*Heights given have been corrected for the finite beam width

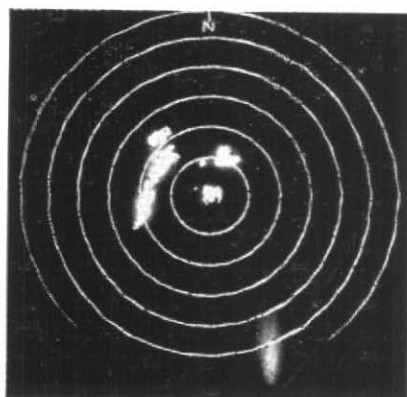
at Agartala, the surface winds recorded at six-minute intervals are reproduced in Fig. 3(b).

The squall-line broke up after it had passed over the station. Thunderstorm activity drifted to the northeast of the station and intensified. The C.W. observatory at Kailashahar airport 50 n. miles to the northeast of Agartala reported thunderstorm accompanied by a southerly squall of 44 knots at 1755 IST; and hail was reported between 1810 and 1815 IST. Occurrence of a 'violent thunderstorm with hail' at Fatikroy, a place 15 miles to the south of Kailashahar, was also reported.

5. Analysis

A composite picture of the movement of the squall-line is depicted on a polar diagram in Fig. 4. For this purpose the line passing through the centre of most of the cells has been taken to be the position of the squall-line at each observation (the corresponding times are noted on the figure). The squall-line formed about one and a half hours after the initial appearance of the scattered cells on the PPI. At the peak of its activity it was about 70 miles long and apparently 9 miles wide. The actual width across the line might have been more but not seen as such on the PPI due to the attenuation suffered by the radar beam in penetrating the squall-line. Initially it moved in an ESE direction and then in an easterly direction. Its average speed of movement was 28 mph. The squall line lasted for one and a half hours. These figures agree fairly well with those arrived at by De and Sen (1961) in their 'Radar study of Nor'-westers of Bengal'.

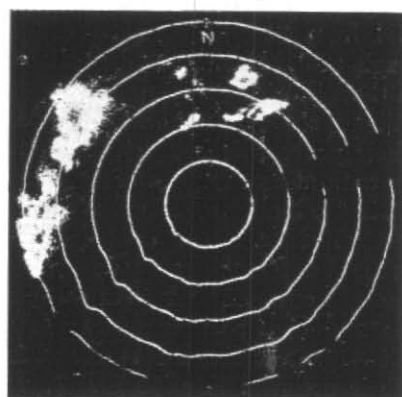
After the initial formation of the line, the growth of new cells as observed on the iso-echo patterns had been along the squall-line only. This confirms the findings of Byers that the area between two existing cells whose edges are less than 3 miles apart is the most favourable one for the development of new cells due to displacement of warm air by the cold outflow from the two parent cells. This phenomenon has been noted by Das *et al.* (1957) also, in their study of Nor'westers at Calcutta.



1530

Fig. 2(a)

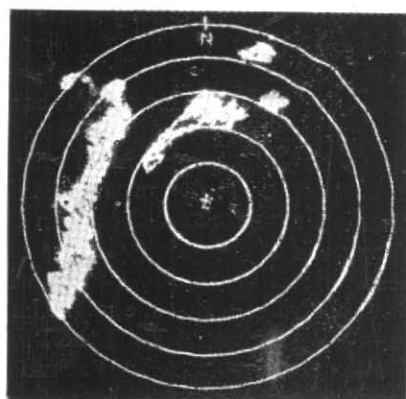
25



1530

Fig. 2(b)

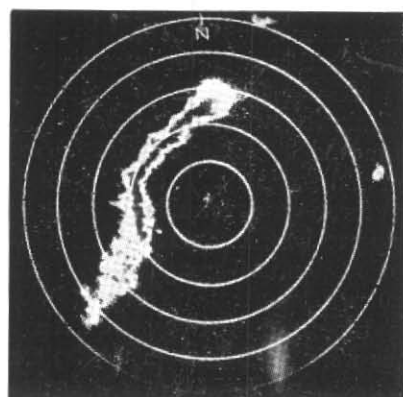
10



1600

Fig. 2(c)

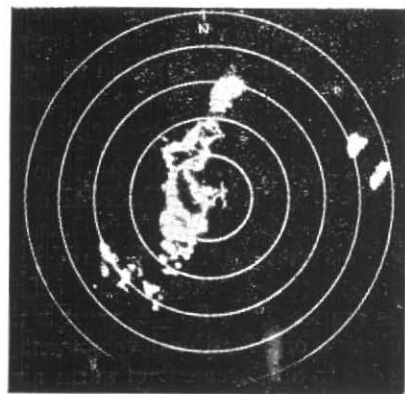
10



1630

Fig. 2(d)

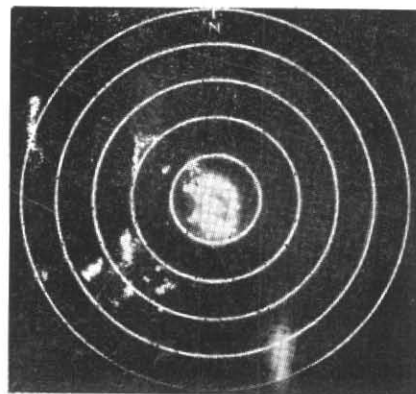
10



1645

Fig. 2(e)

10



1720

Fig. 2(f)

10

Fig. 2. PPI photographs showing the formation, movement and decay of the squall-line on 17 April 1962

Figures in the left and right hand bottom corners indicate time in IST and range marker in nautical miles respectively

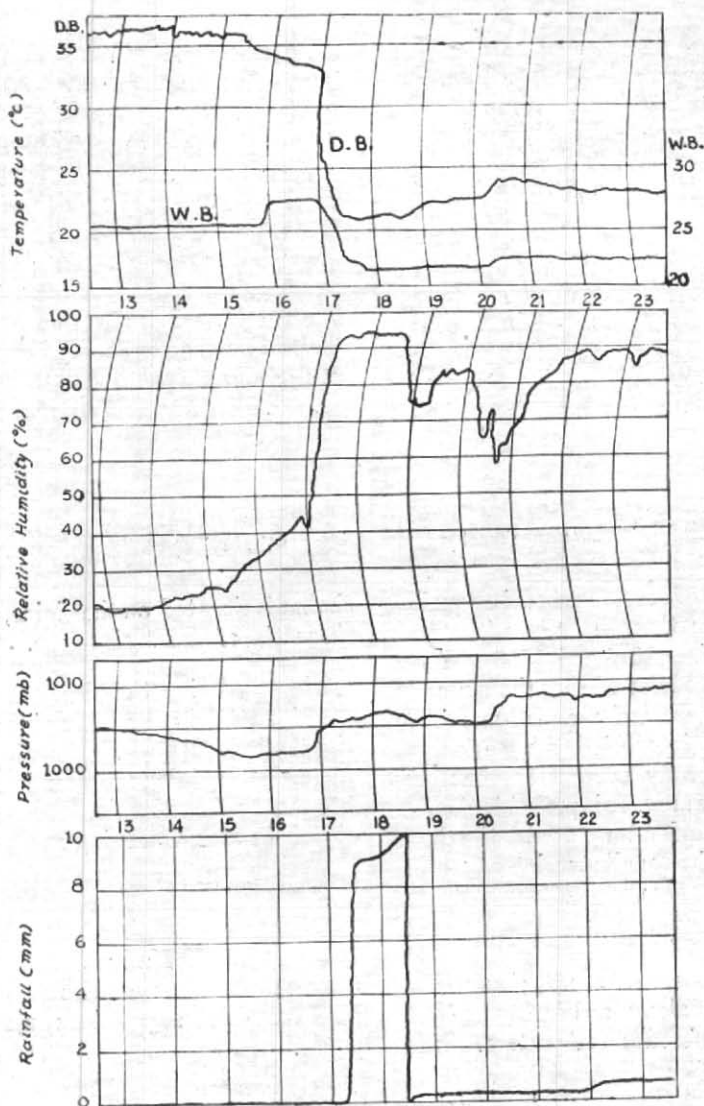


Fig. 3(a). Autographic records at Agartala on 17 April 1962

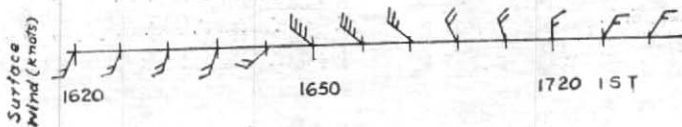


Fig. 3(b)

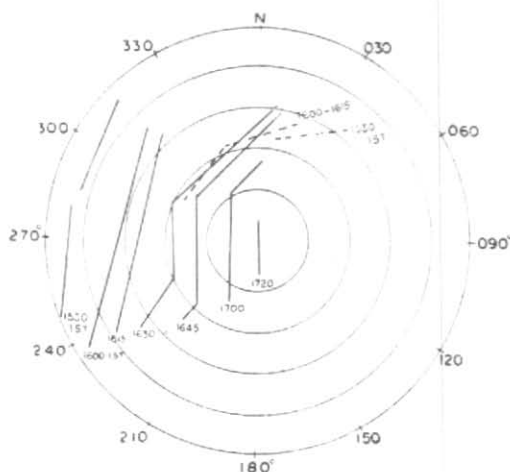


Fig. 4
(Range marker interval—10 nautical miles)

From the times of occurrence of the squall at Agartala and the thunderstorm with squall at Kailashahar, *i.e.*, 1650 and 1755 IST respectively, it may be inferred that the spreading of the downdraft from the squall-line in an easterly direction intensified the weak thunderstorm cells already present in that area from 1600 IST onwards. It is probable that the severity of the thunderstorm as also the direction from which the squall struck that station were due to the nature of the terrain to the east of Agartala. Several parallel ranges of hills run in a N/S direction from 16 miles to the east of Agartala onwards, their northern boundaries lying along a bearing of 060 (approx.) with reference to Agartala. Kaila-

shahar is situated on the plains, near the northern tip of one such range.

The squall-line thunderstorms of the type described above, occurring in this region as also the influence of the terrain to the east of Agartala in guiding the thunderstorm activity offer scope for more detailed studies with the aid of the storm warning radar at Agartala.

6. Acknowledgement

The author desires to express his thanks to Dr. L. S. Mathur, Deputy Director General of Observatories (Instruments) for his valuable suggestions relating to this paper.

REFERENCES

- | | | |
|---|------|--|
| Byers, H.R. | 1951 | <i>Compendium of Meteorology</i> , Amer. met. Soc. |
| Chaudhury, A. K. | 1961 | <i>Indian J. Met. Geophys.</i> , 12 , 1, p. 33. |
| Das, P. M., De, A. C. and Gangopadhyaya, M. | 1957 | <i>Ibid.</i> , 8 , 4, p. 403. |
| De, A. C. and Sen, S. N. | 1961 | <i>Ibid.</i> , 12 , 1, p. 51. |
| Ramaswamy, C. | 1956 | <i>Tellus</i> , 8 , 1, p. 26. |
| Sen, S. N. and Basu, S. C. | 1961 | <i>Indian J. Met. Geophys.</i> , 12 , 1, p. 15. |