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Study of pre-monsoon thunderstorms over Gangetic West Bengal by radar

P. KOTESWARAM and A. C. DE

Meteorological Office, Dum Dum Airport, Calcutta

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ABSTRACT. By a study of hourly traces of PPI scope presentations on a Decca Type 41 Radar during pre-monsoon seasons of 1955—57, the directions of movement of thunderstorm sequences over Gangetic West Bengal were determined. Apart from the most predominant movement from NW/N, there were thunderstorms which moved from even SE, S or SW, though such cases were rare. The wind direction in NW'ly squalls was generally same as the direction of movement of the squall lines though squalls from other directions were also recorded sometimes. Vertical currents in the thunderstorm cells were studied by scanning with radar at different elevation angles and some of the observations are presented.

1. Introduction

An analysis of a large number of non-instrumental observations organised by the India Meteorological Department in connection with a Nor'wester expedition in 1941. showed that the thunderstorms of the pre-monsoon season over Bengal occurred in lines which travelled mostly from NW to SE but occasionally in other directions also like N to S and NE to SW. These results were included in *India met. Dep. Tech. Note* (1944) and were later generally verified by experience of forecasters. For the last four years, a Decca Type 41 Storm Detecting Radar has been working at Dum Dum airport, Calcutta and has afforded an opportunity of observing the development and movement of squall lines in the vicinity of the station. Das *et al.* (1957) analysed the movement of two Nor'westers which struck Dum Dum in 1955.

In this paper the hourly precipitation-echo maps during the Nor'wester seasons (March to May) of 1955—57 are examined.

2. Data used

The Decca Type 41 Radar works on 3-cm wave band and has pulse length of 2·0 and 0·2 μ sec, pulse repetition rate being 250 per second. The beam width is 4° between half power points and the peak power output 30 KW. It scans horizontally at different elevation angles up to +12°. The radar is rated for a range of 250 miles but is quite effective in detecting precipitation cells up to a range of 150 miles. It is worked for about 15 minutes every hour and the precipitation echoes on the PPI scope copied out on a polar diagram every hour (GMT). From successive position of these echoes it is possible to estimate the movement of precipitation cells. Interesting cases have also been photographed.

Local squalls are recorded by a Dines P.T. Anemograph installed at the airport and pressure and temperature variations on a daily barograph and wet and dry thermograph.

3. Thunderstorm sequences

There were 98 occasions when significant thunderstorm cells were detected and followed on the radarscope during the pre-monsoon seasons of 1955—57. The movement of these cells could be studied by examining the records of hourly PPI scope traces. The number of occasions when the cells moved from different directions of the compass were tabulated according to the month of their occurrence (Table 1).

On more than 50 per cent of the occasions the movement of the cells was indeterminate

TABLE 1

No. of occasions of movement of thunderstorm cells from different directions

Month	W	NW	N	NE	E	SE	S	SW	Uncertain
March		2	1				1	2	15
April	1	10	2	3					17
May		8	6	3		3	1		23
Total	1	20	9	6		3	2	2	55

and occurred as random cells. On the remaining occasions they were organised into lines and moved in definite directions. On 67 per cent of these cases, the cells advanced from the NW/N direction, 14 per cent from NE, 7 per cent from SE and on 5 per cent each from S or SW. Though the types given in *India met. Dep. Tech. Note*, 10, are most predominant, thunderstorms move sometimes almost from any direction. It will be seen that about 16 per cent of the sequences advanced from a southerly direction (SE to SW). The average speed of movement of the thunderstorm cells or lines was 15/25 mph.

Figs. 1-4 give the radarscope photographs illustrative of different types of thunderstorm sequences mentioned above. The radar pictures of the northwesterly type were discussed by Das *et al.* (1957) and will not be repeated here. Fig. 1 indicates a northerly sequence which was detected to the north of Calcutta at 1602 IST on 24 April 1955 and moved towards the city where it dissipated at 1807 IST. Fig. 2 gives a northeasterly sequence. At 1505 IST of 4 May 1957, a cellular echo was observed on the PPI scope about 100 to 140 miles northeast of Dum Dum. It moved to 30 miles northeast of the station at 2030 IST when it began dissipating. A decaying cell passed over the station at 2125 IST giving a northeasterly gust of 20 knots. In Fig. 3 is illustrated a southerly sequence. A number of cells were detected southeast of Calcutta between 1300 and 1400 IST of 20 May 1955. They passed to the north of the station and arranged themselves into a line by 1510 IST. The line type echo continued its northward movement at 1610 IST. In Fig. 4 is illustrated a sequence which moved over Calcutta from the southwest. At 1530 IST of 13 March 1956 a number of precipitation echoes could be detected along a line extending from southwest to southeast of the city. By 1710 IST they joined up into a line extending from west to south of the station at a distance of 20 to 40 miles. The line passed over Dum Dum at 1730 IST when a southerly squall of 32 kt was recorded.

4. Squalls and radar echoes

It is now well known that thunderstorm echoes occur either as cells or as lines. The latter have generally been identified with squall-producing thunderstorms and are called squall lines. In the absence of a close network of squall reporting stations, records of squalls at Dum Dum only were examined in relation to the structure and movement of the radar echoes as it approached the station. It was found that out of 36 squalls that occurred at Dum Dum during the period under examination, 24 (67 per cent) were associated with a line type of echo and 12 (33 per cent) with cell type. Table 2 gives the relation between the direction of movement of the radar echoes and direction of the squall at Dum Dum.

15 (40 per cent) of the squalls occurred with radar echoes of uncertain movement (*i.e.*, from thunderstorm cells which developed close to the station). The rest of the squalls occurred with the movement of line or cell type echoes over the station.

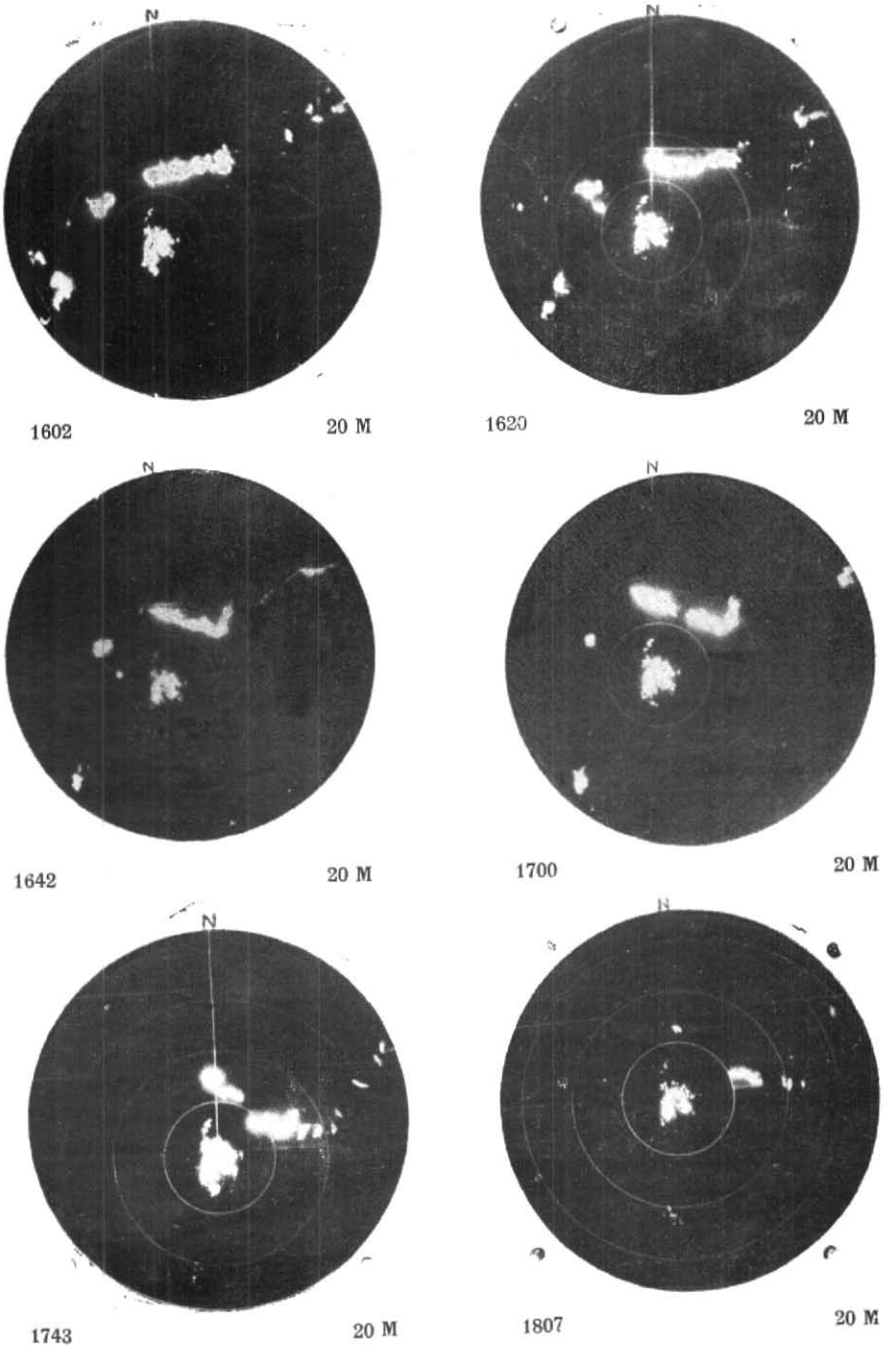

Fig. 1. PPI presentation of the storm detecting radar at Dum Dum airport on 24 April 1955
Figures in the left and right hand corners indicate time in IST and range rings in miles respectively

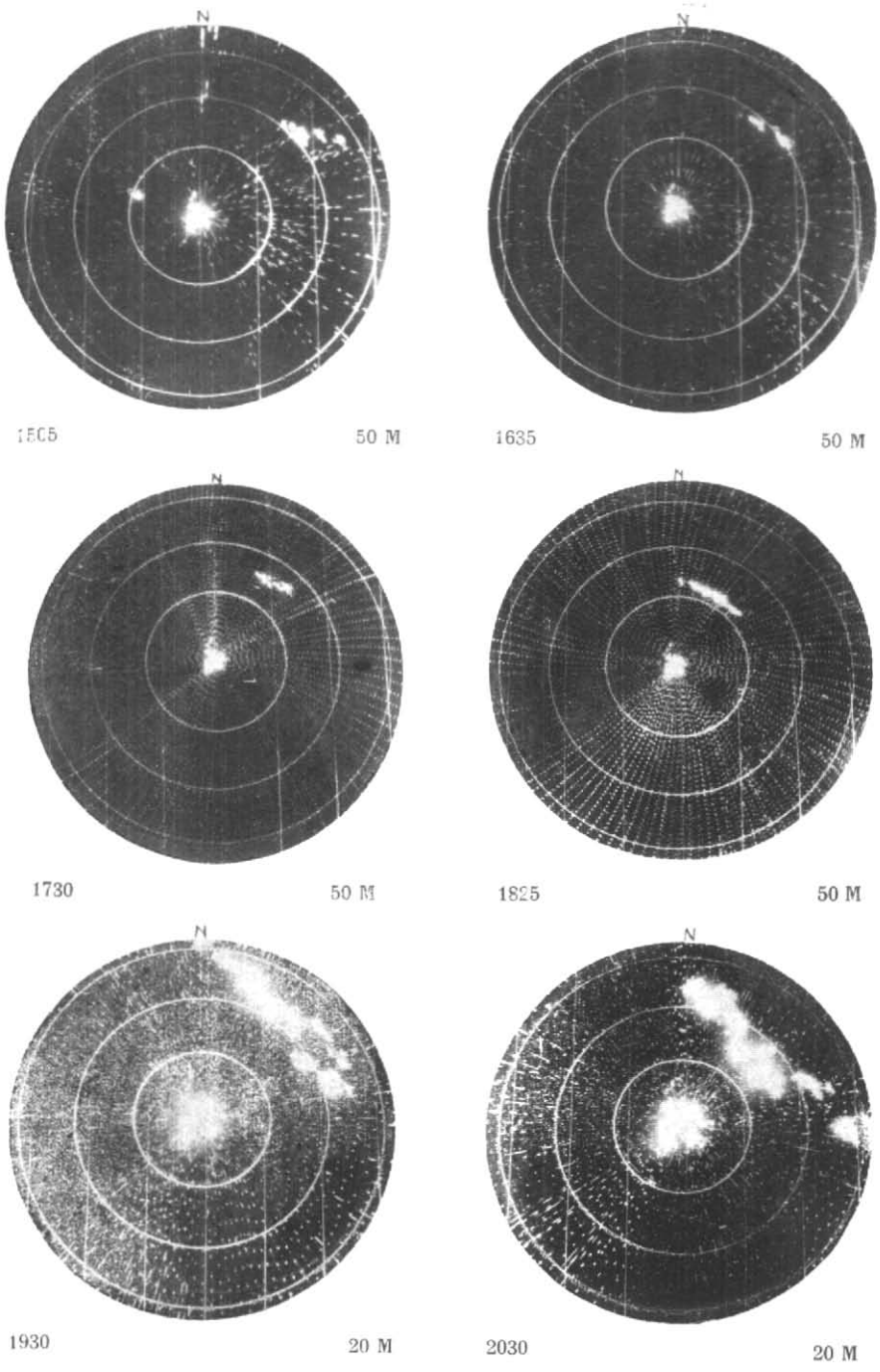

Fig. 2. PPI presentation of the storm detecting radar at Dum Dum airport on 4 May 1957
Figures in the left and right hand corners indicate time in IST and range rings in miles respectively

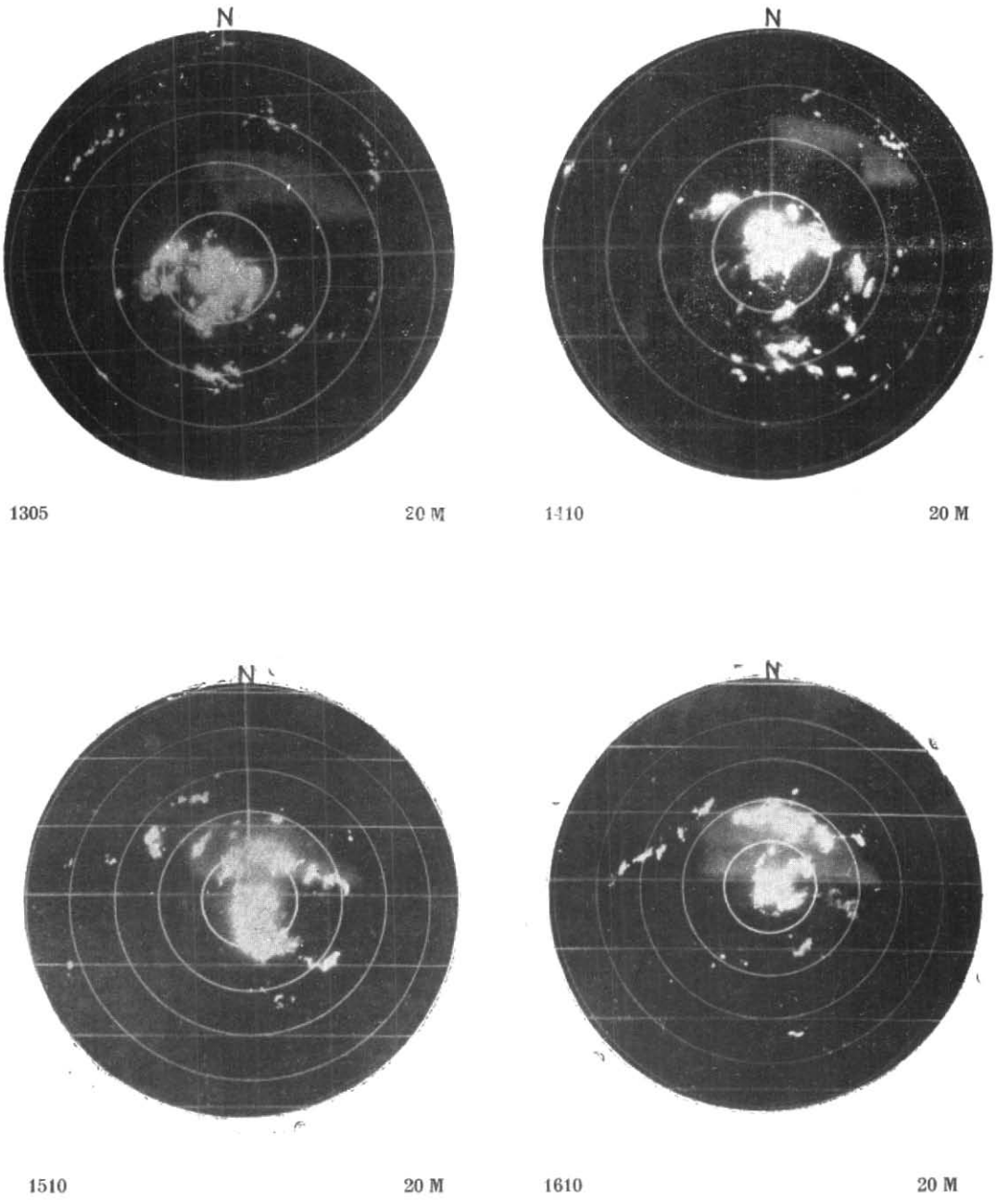

Fig. 3. PPI presentation of the storm detecting radar at Dum Dum airport on 20 May 1955
Figures in the left and right hand corners indicate time in IST and range rings in miles respectively

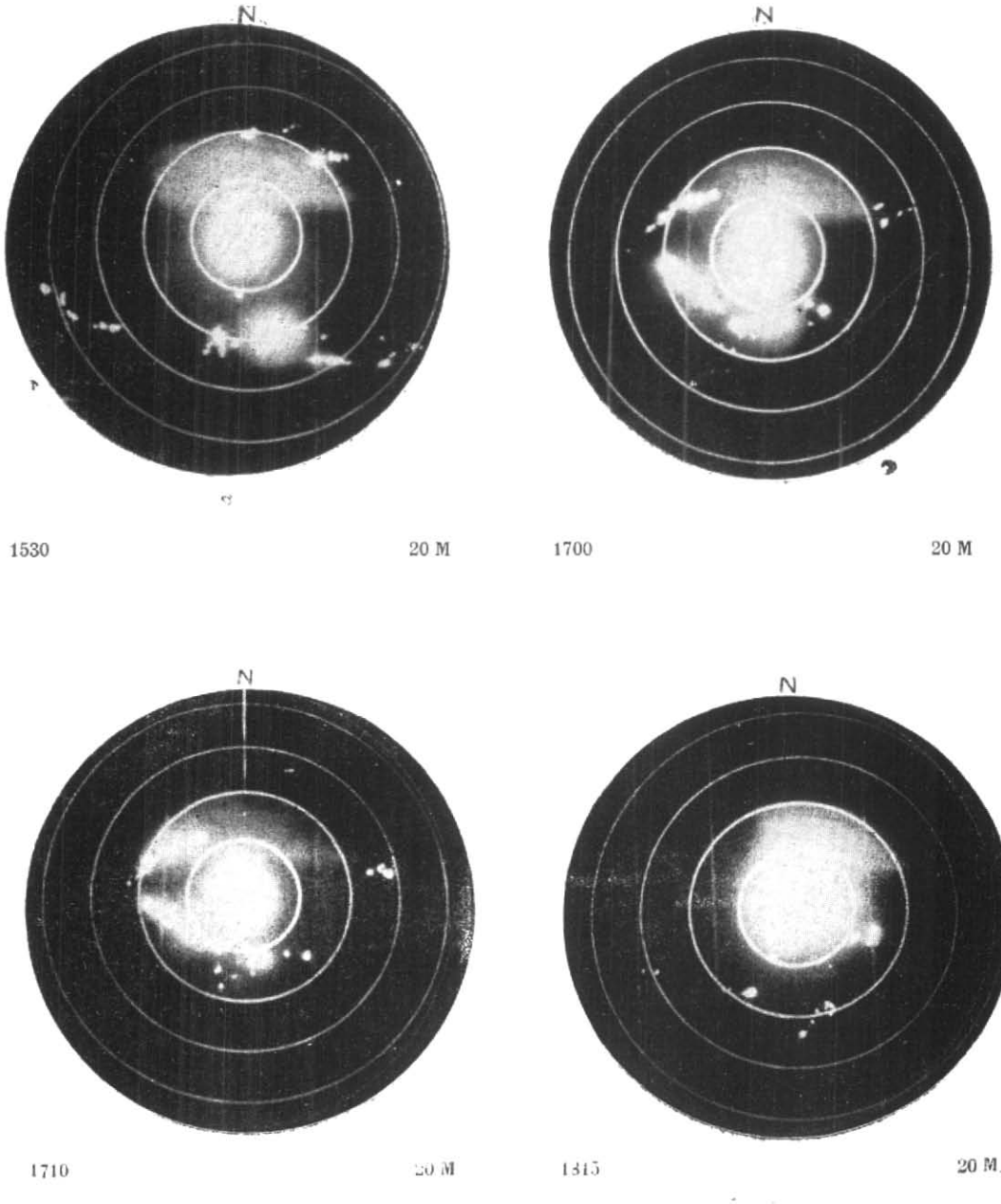

Fig. 4. PPI presentation of the storm detecting radar at Dum Dum airport on 13 March 1956

Figures in the left and right hand corners indicate time in IST and range rings in miles respectively

TABLE 2

Relation between direction of wind in squalls and movement of radar echoes

No. of squalls from	No. of radar echoes from								Uncertain
	W	NW	N	NE	E	SE	S	SW	
W									3
NW		6	1						4
N		1							2
NE		3							1
E			2	1		1			
SE		1				1			1
S		1					1		3
SW		1						1	1

Sequences from northwest which form 66 per cent of moving squall lines gave squalls from almost all directions though northwesterly squalls predominated. The other sequences are too few to draw any definite conclusion.

5. Vertical currents in thunderstorm cells during the pre-monsoon season

By continuously operating the radar at different tilts and recording the heights and tops of precipitation echoes at intervals of 2 minutes, Koteswaram and De (1959) had determined the approximate vertical structure of rain in *Cu* cells during the post-monsoon season. A similar technique was employed to measure the location of the level at which water particles originated, the speed of vertical growth and decay of the echoes as well as the maximum height to which radar echoes extended from time to time in the pre-monsoon thunderstorms. The errors involved in the determination have been discussed in the previous paper of Koteswaram and De (1959). Since it was necessary to spot a sufficiently near cell just at the time of formation of raindrops within it, the number of cases available for study was very limited.

Five cases in May 1957 were analysed. The freezing level during the period was 15/17,000 ft a.s.l. Precipitation echoes were first detected between 11/18,000 ft and grew up to 20/30,000 ft. In one case, on 22 May 1957, it grew as high as 45,000 ft (free air temperature —39.5° C). The rates of growth and decay of the echoes varied from 1500 to 3300 ft min^{-1}. On 22 May 1957 the rate of growth was 6800 ft min^{-1} and decay 4500 ft min^{-1} and the top of the echo remained at 45,000 ft hardly a minute. Within four minutes it lowered from 45,000 to 27,000 ft. The rates of growth and decay of the echoes which may be taken to indicate the vertical currents in the cloud agree well with the values determined for post-monsoon cumulus cells (2500-3000 ft min^{-1}).

6. Conclusions

The study has generally confirmed the results of the earlier Nor'wester investigation (*India met. Dep. Tech. Note* 1944) regarding the existence of different types of the thunderstorm sequences over northeast India in the pre-monsoon season. Apart from the four types mentioned in the earlier investigation,

the sequences from the SE, S or SW also occur, though rare. The direction of north-westerly squalls generally coincides with the direction of approach of thunderstorms, though exceptions also exist. The vertical currents in these pre-monsoon thunderstorms are of the order of 1500—3300 ft min^{-1} and on occasions may be as high as 6800 ft min^{-1}. The radar provides a very useful tool for such studies and detailed examination of the structure, movement and growth of radar echoes is bound to throw more light on the phenomenon of the occurrence of Nor'westers over West Bengal.

REFERENCES

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