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Radar-climatology of Delhi and neighbourhood: Convective cells of the hot weather season

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ABSTRACT. The paper presents a radar-climatological analysis of the cell-census for Delhi and neighbourhood based on the New Delhi radar data for the hot weather seasons of 1958, 1959 and 1960. The object is to investigate the various characteristics of the echo cells. The study covers cell-diameters, cell-spacings, their distributions, variations with the progress of the season, their inter-relationships, height-diameter relationships, etc.

1. Introduction

1.1. In an earlier paper, Kulshrestha and Jain (1964) stressed the importance of radar-climatology and stated that they had taken up systematic studies of the various radar-climatological features of Delhi and neighbourhood. The earlier paper, referred above, discussed the spatial and diurnal variations of precipitation echo distribution and was the first one of a proposed series of papers on the radar-climatology of the region. It also contained a brief account of the climatology of the region.

1.2. Continuing the series, the authors now propose to describe and discuss the various radar-climatological characteristics of the summer time convective cells.

2. Scope of the present study

2.1. The hot weather season in north India prevails from the end of the western disturbance season until the onset of the southwest monsoon in this area which means from about the middle of March to about the end of June. This period is characterised by abundant cellular convection in the troposphere. In most of the cases, insolation is responsible for initiating the convective development. A large number of these convective cells, under favourable conditions, culminate into thunderstorms. The drafts from thunderstorm cells raise blinding columns of dust and loose soil which are always present in abundance on the ground in this season due to excessive dryness. Most of the time, no precipitation from these cells reaches ground because it evaporates in the excessively dry lower tropospheric layers. RHI pictures very clearly depict the rainfall streaks starting downwards from the cells aloft but failing to reach ground.

2.2. Mitra and Kulshrestha (1961) have described in detail the radar characteristics of these summer thunderstorms of north India which are more popularly known as duststorms. The observations of cell-diameters, their distribution, the height-diameter relationships, as described in that paper, were based on only one season's data and were, therefore, not fully representative. No observations of cell-spacings or their relationships with other parameters were attempted.

2.3. Newell (1959) remarked "When a large number of cells are considered it appears that, in the mean, some orderly arrangement occurs which is somewhat analogous to that which arises in Benard cells". He further went on to say that "It is particularly pertinent to search for order at low latitudes where the vertical fluxes of heat

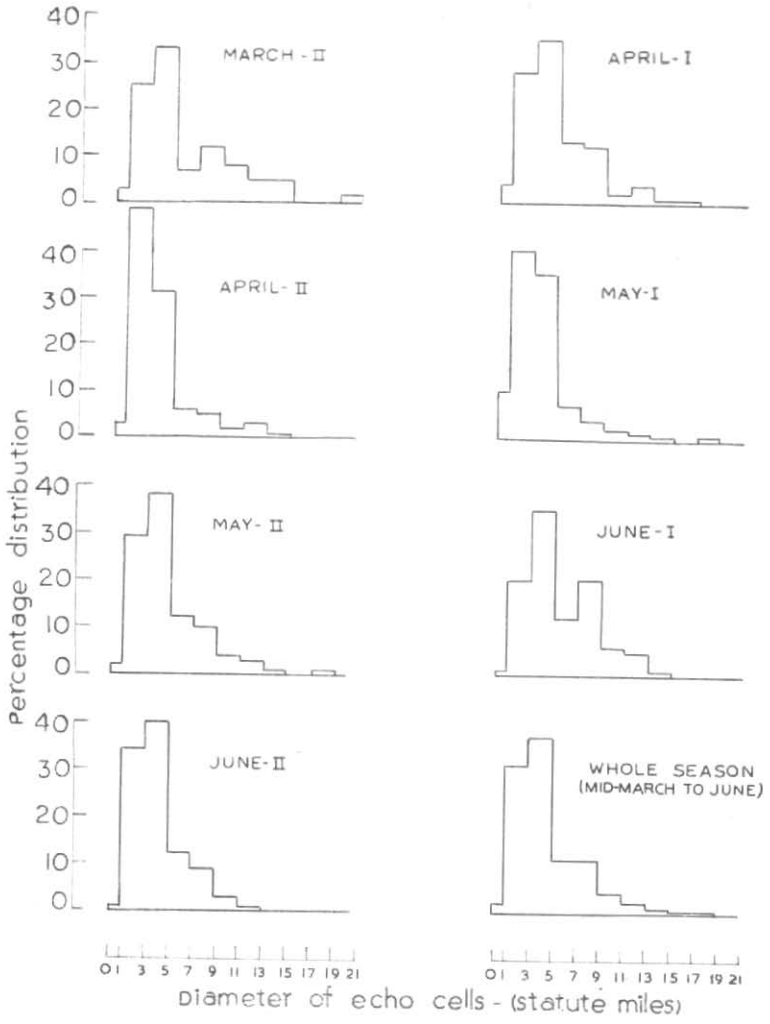

Fig. 1. Percentage distribution of diameters of echo cells of different sizes

and momentum are known to be different from those in middle latitudes". Therefore in a subsequent paper Newell (1960) suggested that "the cell-census should be enlarged and extended to other regions". It may be mentioned here that Newell's study pertained to a location at latitude 42°N.

2.4. Following these suggestions of Newell, a detailed cell-census was taken up for the region around New Delhi (Lat. 28° 35′ N and Long. 77° 12′ E) for the three summer seasons of 1958, 1959 and 1960. The results of this study are presented in this paper.

3. Data and the manner of analysis

3.1. The data were obtained with the help of a powerful 3-cm radar (AN/CPS-9) which is located at Safdarjung Airport, New Delhi, and is primarily intended for operational use for aviation-weather warning.

3.2. During each observation, radarscopes were photographed with a hand-operated 35 mm still-picture camera. The receiver-gain setting was kept at the normal. For

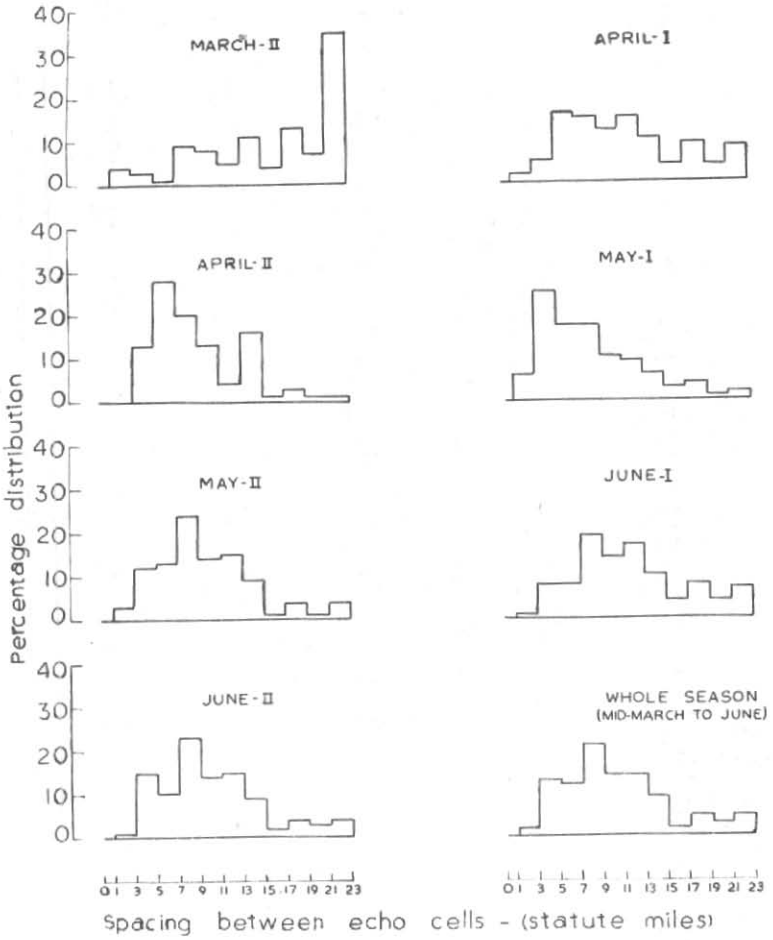

Fig. 2. Percentage distribution of spacing between echo cells

determining the cell-diameters, spacings etc, measurements were conducted on the projections of PPI and RHI photographs.

3.3. As already mentioned, the data relate to the three summer seasons of 1958, 1959 and 1960. The analysis was done on a fortnightly basis; each fortnight being designated by a sub-script (*e.g.*, March II, April I, April II, etc). In all 4815 numbers of cell-diameters and 3239 numbers of cell-spacings were selected for analysis. Echo cells having diameters more than 21 statute miles were not included in the analysis as these were considered to be combinations of more than one cell. Further, only those cells, which could be distinguished as individual cells, were accepted for the study. The analysis includes echo cells at all stages of development.

3.4. The results of the analysis are presented in Figs. 1 to 8.

4. Discussion and Conclusions

4.1. Mean value of the diameter D of echo cells was found to be 4·6 statute miles.

4.2. Mean value of the spacing S between echo cells was found to be of the order of 11 statute miles.

4.3. Mean value of the ratio S/D (cell-spacing to cell-diameter) was found to be 2·4.

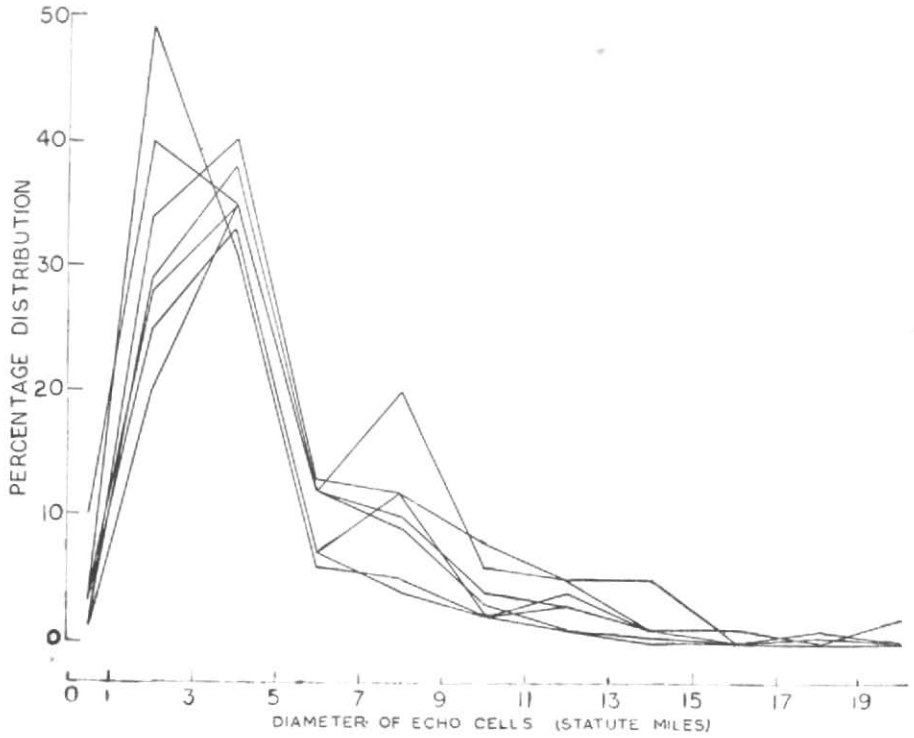

Fig. 3. Percentage distribution of cell diameters during the seven fortnights of the summer season

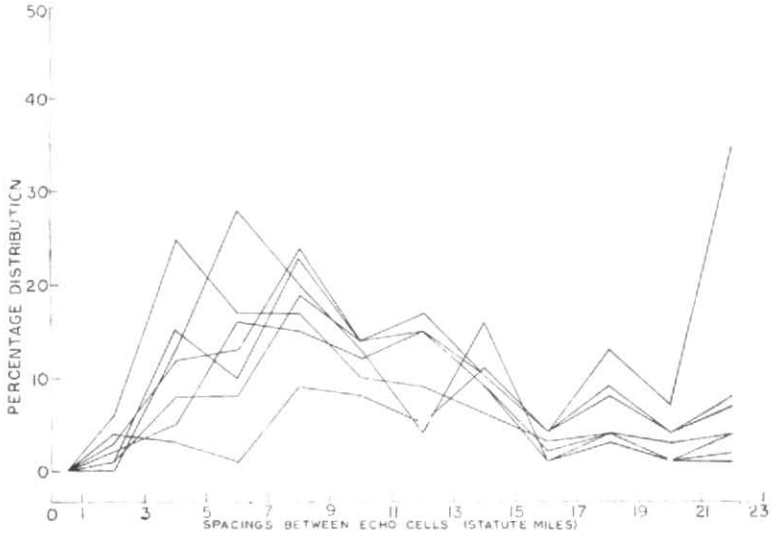

Fig. 4. Percentage distribution of cell spacings during the seven fortnights of summer season

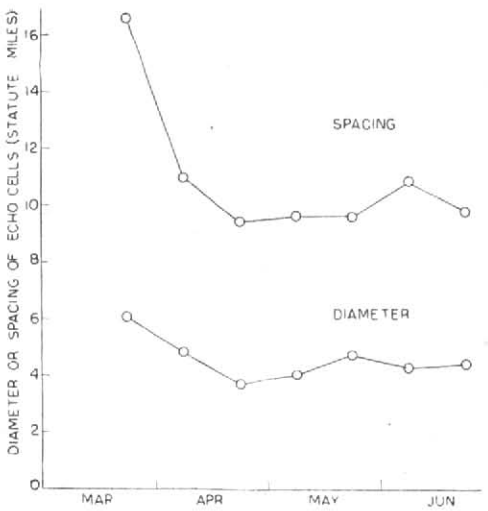

Fig. 5. Variation of average diameter and average spacing with the progress of the season

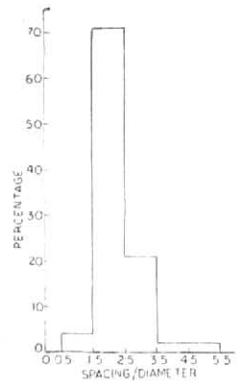

Fig. 6 (a)

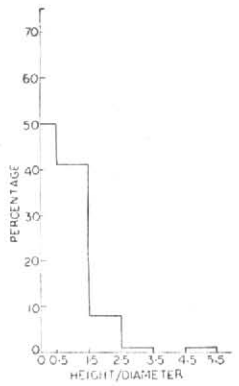

Fig. 6 (b)

Figs. 6 (a,b). Percentage distribution of S/D and H/D

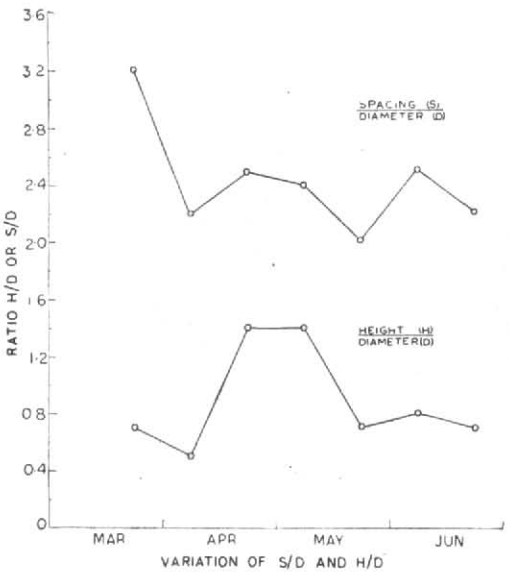

Fig. 7

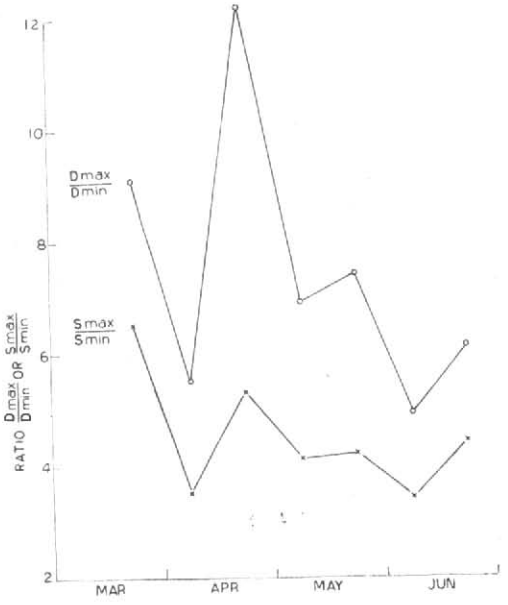

Fig. 8

4.4. Mean value of the ratio H/D (cell-height to cell-diameter) was found to be 0·9.

4.5. The ratio of the diameters of the largest and the smallest echo-cell was calculated for each PPI picture. The mean value of these ratios, *i.e.*, $|D_{max}/D_{min}|_{mean}$ was found to be 7·4.

4.6. Similarly, value of $|S_{max}/S_{min}|_{mean}$ was found to be of the order of 4·5.

4.7. The percentage distributions of cell-diameters and cell-spacings for each fort-night with the progress of the season and for the entire season are shown in Figs. 1 and 2 in the form of histograms. The nature of

variation of these distributions is also presented in Figs. 3 and 4 in the form of superimposed graphs.

4.8. It will be seen that about 68 per cent of the cells during this season have diameters between 1 and 5 statute miles. The most preferred diameter appears to be of the order of 4 statute miles and constitutes about 37 per cent of the total number of echo cells investigated. Fig. 3 shows that the graphs depicting the distribution of cell-diameters during successive fortnights exhibit a close correspondence.

4.9. Although the percentage distribution of cell-spacings does not show such a striking correspondence during the successive fortnights of the season, yet there is enough evidence to indicate that they also follow the same trend with the progress of the season. This observation is borne out by Fig. 4.

4.10. It will be seen from Fig. 2 that about 83 per cent of the cells have spacings between 3 and 15 statute miles.

The most preferred spacing appears to be of the order of 8 statute miles and is found to constitute about 21 per cent of the total number of cell-spacings observed.

4.11. The variations of mean diameter and mean spacing with the progress of the season are shown in Fig. 5. It will be seen that cell-diameters and cell-spacings are the largest in the earlier part of the season. (They again have comparably large values in July). They reach the lowest values of the season in the second fortnight of April. Thereafter they show a slight rise.

4.12. This rising trend continues, in the case of cell-spacings, till the first half of June after which cell-spacings again show slight decrease during the later half of June. For the most part of the season, *i.e.*, from April to June, cell-spacings have an average value of about 10 statute miles.

4.13. In the case of cell-diameters, the rising trend after April II continues till May II after which cell-diameters remain almost the same upto the end of June. It is seen that for a large part of the season, mean cell-diameter is of the order of 4 statute miles only.

4.14. The distribution of the ratio S/D is shown in Fig. 6a. It will be seen that 71 per cent of S/D values are of the order of 2 and another 21 per cent are of the order of 3. It can, therefore, be concluded that almost all (92 per cent) of the observed S/D values lie between $1 \cdot 5$ and $3 \cdot 5$.

4.15. The distribution of the ratio H/D is shown in Fig. 6b. It is seen that 50 per cent of the values are less than $0 \cdot 5$. Another 41 per cent are of the order of unity. It is, therefore, concluded that almost all (91 per cent) of the observed H/D values do not exceed $1 \cdot 5$.

4.16. The variations of S/D and H/D ratios with the progress of the season are shown in Fig. 7. The two graphs are found to have the same trend with the progress of the season.

4.17. Similarly, the graphs depicting the variation of $D_{\max}/D_{\min}$ and $S_{\max}/S_{\min}$, with the progress of the season, (Fig. 8), are found to follow a similar pattern.

5. Acknowledgements

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