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Determination of the horizontal dimensions of mesoscale precipitating system

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ABSTRACT. Assuming that a mesoscale precipitating system is circular in nature and has a uniform speed of its movement, expressions for its horizontal extent and the velocity of propagation over a station have been derived from simple geometrical considerations. Using S.R. raingauge data for 1964 (monsoon period) of three sites situated about 10 to 15 km apart so as to form three vertices of a triangle, area of some of the rain giving systems over Poona has also been studied in the paper.

1. Introduction

Rainfall from thunderstorms or monsoon precipitation of short duration is often so localised that stations 10 or 15 km away do not experience rain from the same cloud system (Aggarwal 1961, Staff of ITM 1964). However, in cases of monsoon rainfall of the order of two hours or more, rain recording stations 10 or 15 km away also record rain in quick succession, suggesting a definite extent as well as movement of the rain bearing system (Hem Raj and Billa 1964). This aspect of monsoon rainfall can be used to estimate the horizontal extent and the velocity of propagation of rain giving systems over a station. This note outlines the results of such an evaluation at Poona with the help of rainfall records at three stations.

2. Methods

The rain giving systems can have irregular shapes but, one can work out consequences assuming the shape to be circular. In studies relating to cumulus clouds Anderson (1960) and Newton (1963) have assumed the clouds to be cylinders. Based on this assumption, the area of the base of a comparatively small single rain giving cloud system can be calculated when three S. R. raingauge observatories (located about 10-25 km apart) form the three vertices A, B and C of a triangle. Let t_2 and t_3 be the differences in the time of commencement of rain at B and C respectively, after it has commenced at A. Let T_1, T_2 and T_3 be the durations of rainfall at the three observatories, V the horizontal velocity of the precipitating system, θ the angle which the direction of the motion makes with the side AC. Then it follows from the Fig. 1 —

$$\mathrm{CR}+\mathrm{RN} = b\cos\theta + \mathrm{AM}$$

Or, $$Vt_3 + VT_3/2 = b\cos\theta + VT_1/2$$

Or, $$V(t_3+T_3/2-T_1/2) = b\cos\theta \qquad (i)$$

Similarly, $$V(t_2+T_2/2-T_1/2) = c\cos(A-\theta) \qquad (ii)$$

where a, b and c are the sides of the triangle opposite to angle A, B and C respectively.

The velocity V of the system can be found from equation (i),

$$V = (b\cos\theta)/(t_3+T_3/2-T_1/2) \qquad (iii)$$

Knowing V and θ, the radius R of the circular system can be determined from the following relation.

From Fig. 1,

$$\mathrm{LN} = \mathrm{ON}+\mathrm{OL}$$

$$= \mathrm{LM}+\mathrm{MN} = \mathrm{AP}' = \mathrm{AR}' \qquad (iv)$$

Now $\mathrm{AR}' = b\sin\theta$, $\mathrm{AP}' = c\sin(A-\theta)$

$$\mathrm{ON}^2 = \mathrm{OR}^2 - \mathrm{NR}^2 = R^2 - (VT_3/2)^2$$

$$\mathrm{OL}^2 = \mathrm{OP}^2 - \mathrm{LP}^2 = R^2 - (VT_2/2)^2$$

Substituting the above values and putting $b\sin\theta + c\sin(A-\theta) = x$, *Eq.* (iv) becomes

$$x = \sqrt{\{R^2-(VT_3/2)^2\}} + \sqrt{\{R^2-(VT_2/2)^2\}} \qquad (v)$$

which on squaring and simplifying reduces to

$$R^2 = \frac{1}{4x^2}\left[\frac{V^2}{4}(T_3+T_2)^2+x^2\right]\left[\frac{V^2}{4}(T_3-T_2)^2+x^2\right]$$

Hence the area πR^2 of the system can be calculated. The method however fails, if rain commences and ends at all the three sites simultaneously, or when one site receives no rain.

3. Application of the method over Poona

The method outlined above was used to calculate area of some of the rain giving systems over Poona. S. R. raingauge data for 1964 were available at two sites, one at the Central Agrimet Observatory situated in the Agricultural College, Poona and the other at the Air Force Met. Office, Lohagaon. A third S.R. raingauge was temporarily installed during the period July-September

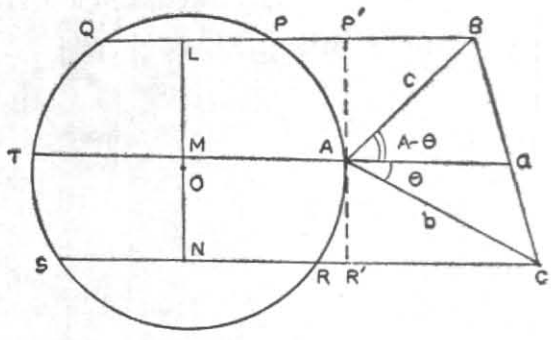

Fig. 1

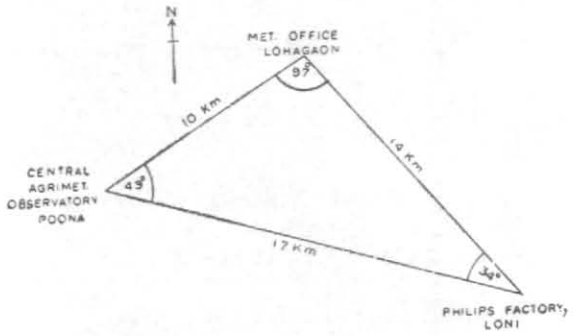

Fig. 2

TABLE 1

S. No.	Date 1964	Poona S	Poona T	Lohagaon S	Lohagaon T	Loni S	Loni T	Velocity (kmph)	Radius (km)	Area (sq. km)
1	6 Aug	1845	2045	1905	2050	1910	2100	43	39	4780
2	16 Aug	1430	1920	1400	1920	1530	1915	17	45	6350
3	11-12 Sep	2200	0415	2210	0400	2143	0315	23	77	18634
4	15-16 Sep	0005	0330	2350	0310	2350	0305	33	55	9507
5	18-19 Sep	2230	0415	2300	0340	2315	0415	30	138	61281

S — Time of commencement (IST) T — Time of cessation (IST)

1964 at the Philips India Factory at Loni, situated on the Poona-Sholapur Road. The locations of the three sites are shown in Fig. 2.

The results of the calculation of the areas of five different rain giving systems are given in Table 1. It is seen from this table that three systems (S. Nos. 1, 2 and 5) moved generally from the west whereas the other two systems moved generally from the east. The velocity varied considerably from system to system. The direction of these systems thus calculated are in general agreement with the prevailing winds at the nearest observational hour at 1·5-km level, although the speeds do not show sufficient correspondence.

4. Total rainfall proceeds by a rain bearing system

The rainfall amounts and duration at three sites can be used to determine the average rate of precipitation within the rain system. If we know the total life time of the rain system, one may venture to compute the total volume of water that falls from such a system. The data from the three raingauge stations cannot provide any information about the life time of the rain bearing system.

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