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Interdependence between surface potential gradient and rainfall in monsoon rains

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ABSTRACT. In an attempt to establish a relationship between surface potential gradient and rainfall in the monsoon rains, measurements were made of these two parameters at three stations in the regions of the Western Ghats. The study indicates that while a definite conclusion in this regard is not possible, potential gradient and rainfall appear to be interdependent.

1. Introduction

A knowledge of the interdependence between cloud electrification (electrical state of cloud air) and precipitation development is of importance for a detailed understanding of the atmospheric electrical processes as well as for the consideration of weather modification experiments by electrostatic means. There are conflicting reports in literature, of the influence of cloud electrification on the growth of precipitation. Indeed, whether cloud electrification is an influencing agency for precipitation (Vonnegut and Moore 1958, Bradley and Semonin 1969) or whether it is an effect of precipitation (Chalmers 1967) is not clear.

Pending the question of how cloud electrification and precipitation influence each other, it is worthwhile to inquire about the possible association between rainfall and electrical state of surface air. Available literature in this regard also (Simpson 1949, Sivaramakrishnan 1953, Whitlock and Chalmers 1956, Dvali 1965 and Reiter 1972) does not make the issue clear. An attempt is, therefore, made in the following to examine whether the potential gradient at the surface and the monsoon rain on the slopes and in the region downwind of the Western Ghats are interdependent.

2. Equipment and locations of measurement

The potential gradient was measured by a recording equipment which was constructed for the purpose (Selvam 1970). A 6-microcurie Polonium-210 probe was used as the sensor with 311 K Analog Devices Electrometer operational amplifier. The input probe for the operational amplifier, in the measurements made during 1970 and 1971, consisted of 10^{10} ohm resistance with 10 : 1 step-down. Experimentally determined correction factor for the loading effect was applied to the readings. But, in the measurements made during 1973, the input probe consisted of 10^{12} ohm resistance with 100 : 1 step down. The output was recorded on a one milliampere strip chart recorder.

The rainfall was measured by a self-recording gauge of the conventional type fabricated by the India Meteorological Department.

Measurements were made at three stations Poona, Lonavla and Mahabaleshwar. While Poona is situated in the rainshadow plateau region downwind (east) of the Western Ghats, Lonavla and Mahabaleshwar are situated on the mountain slopes facing westerly monsoon stream. The period of measurement was June-September, which is the monsoon season. The locations of the stations and the durations of measurement are given in Table 1.

Only in the monsoon of 1973 it became possible to operate the potential gradient recorder and the self-recording raingauge in time-synchronism, *i.e.*, on one and the same strip chart recorder, and this was done.

3. Analysis

Only continuous type of rainfall situations have been considered so that the need for the correct assessment of the timings of the two events under study, namely, rainfall and potential gradient, is minimized. In the case of Lonavla and Mahabaleshwar, the total amount of rain recorded

TABLE 1

Station	Location			Duration of measurement
	Ht. above m.s.l. (m)	Lat. (°N)	Long. (°E)	
Lonavla	625	18°45′	73°24′	6—12 Jul and 27 Aug to 1 Sep 1971
Mahabaleshwar	1383	17°56′	73°40′	23—30 Jun 9—15 Aug 1971
Poona	559	18°32′	73°53′	Monsoons of 1970 & 1973

in given intervals of time and the values of surface potential gradient, average and maximum during those intervals, have been evaluated from the respective records. The intervals of time, which are arbitrary, considered for the purpose are 2 and 6 hr. While continuous rain of such long durations is frequent at Lonavla and Mahabaleshwar, it is not so at Poona. The method of analysis adopted in the case of Poona, is therefore different, and is as follows: The total 24-hr rainfall and total duration, in hours, of the negative value of the gradient recorded on that day have been evaluated.

In the time-synchronised records obtained at Poona during 1973, the times of occurrence of rain spells and the times of occurrence of the marked variations in potential gradient have been examined. Also, the mean values of the potential gradient under situations of different rainfall intensity have been evaluated for a continuous rain occasion.

The potential gradient values at Mahabaleshwar and Lonavla have not been reduced to plain ground values.

4. Results

The data evaluated in the manner referred to above are presented in Figs. 1-7. Only the averge values of the potential gradient are shown in these figures.

Mahabaleshwar—The 6-hourly analysis suggested close linear association between rainfall and potential gradient. The 2-hourly analysis also suggested a linear association. Also, the periods of occurrence of maximum average gradient (—ve) and maximum amount of rain (these periods are shown marked in figures by circles) coincided in the majority of days of measurement (Figs. 1 and 2).

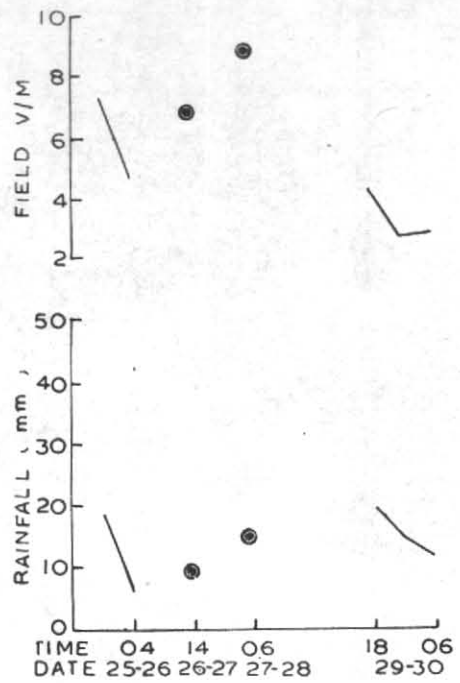

Fig. 1. Average field (v/m) and total rainfall (mm) during 6 hour periods of continuous rain at Mahabaleshwar from 25-30 June 1970. The time marks shown indicated the end of the 6 hr. period in IST. The alternate periods on the same day are not marked.

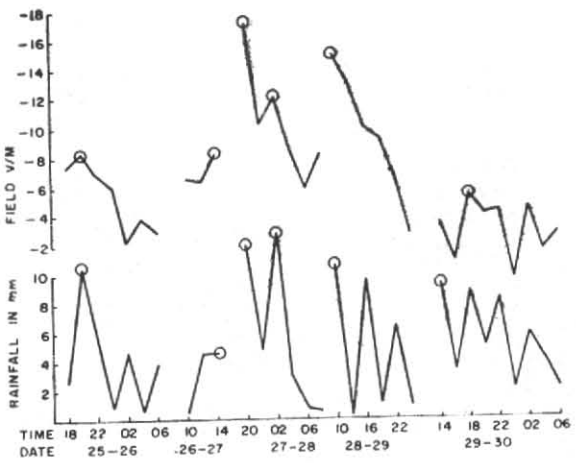

Fig. 2. Average field (v/m) and total rainfall (mm) during 2 hour periods of continuous rain at Mahabaleshwar from 25-30 June 1971

Lonavla—The 6-hourly analysis did not bring out a consistent association. The 2-hourly analysis also did not show an association. Further, the periods of occurrence of maximum average gradient and maximum amount of rain did not coincide on the majority of the days of measurement (Figs. 3 and 4).

Poona—A weak linear association was suggested between rainfall and potential gradient during the monsoon of 1970 as a whole (Fig. 5).

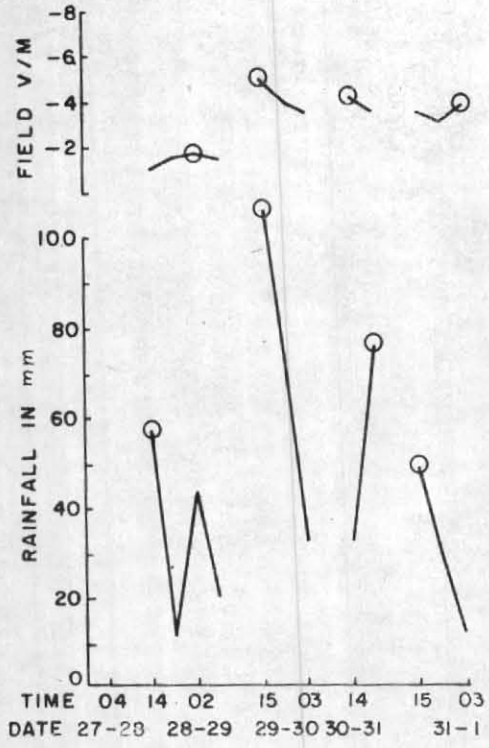

Fig. 3. Average field (v/m) and total rainfall (mm) during 6 hour periods of continuous rain at Lonavla from 27 August to 1 September 1971.

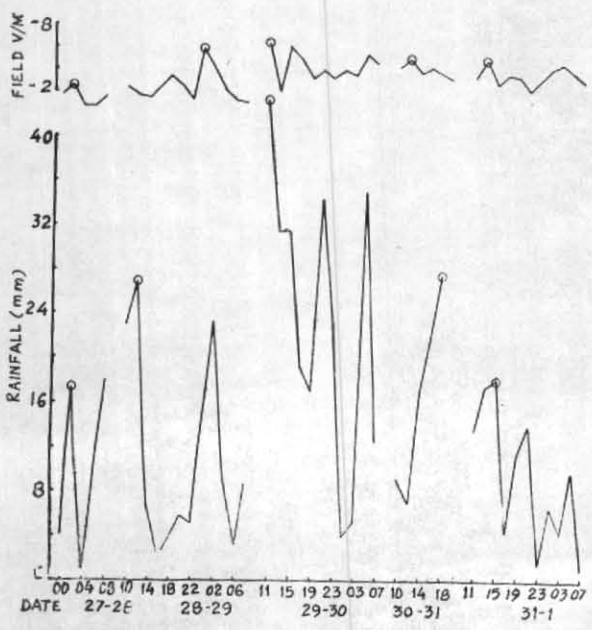

Fig. 4. Average field (v/m) and total rainfall (mm) during 2 hour periods of continuous rain at Lonavla from 27 August to 1 September 1971.

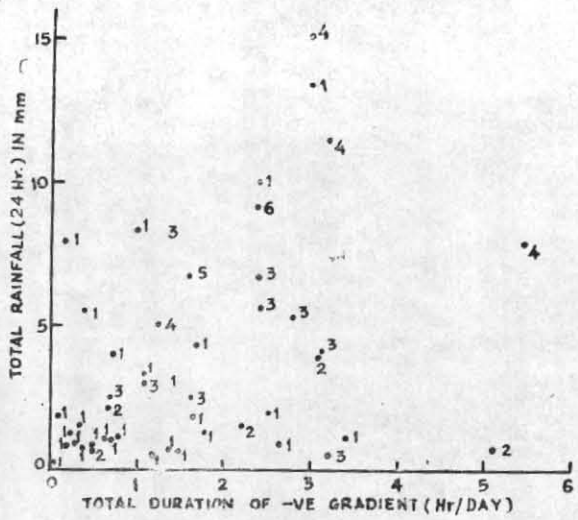

Fig. 5. Total rain (mm) total duration (hr) of negative field and the maximum negative field (v/m) during 24 hr. periods at Poona during monsoon 1970. Numbers 1 to 6 indicate the following ranges for the values of the maximum negative field (v/m). 1 : 0-72 ,2:72-144, 3 : 144-240, 4 : 240-360 5 : 360-480 and 6 : 480-600

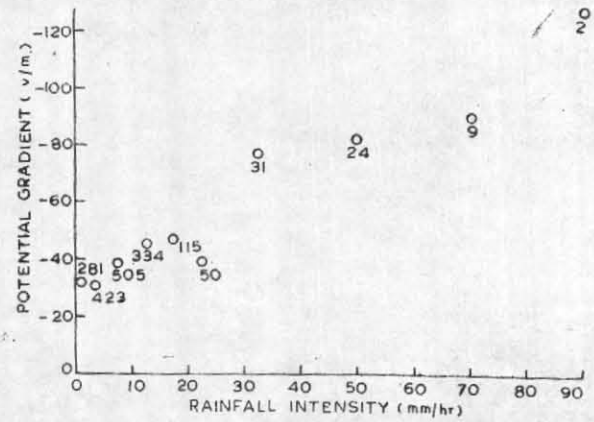

Fig. 6 .Mean values of potential gradient for different ranges of rainfall intensity. The ranges considered are 0-2, 2-5, 5-10. 10-15, 15-20, 20-25, 25-40, 40-60, 60-80, 80-100 and 100-120. Each range is shown by its mean value. The numbers against each point in the figure denote the number of values of which the given point is the mean.

The time-synchronised records during the monsoon of 1973, however, pointed out a nearly one-to-one correspondence between potential gradient and rainfall suggesting close association between the two parameters. Further, evaluation of the mean potential gradient under situations of different rain intensity showed a clear tendency for higher values for higher rates of rainfall (Fig. 6). The time-synchronous records, a representative sample of which is reproduced in Fig. 7, showed that the change in the potential gradient occurred earlier than the change in the rain intensity. But, considering that the change

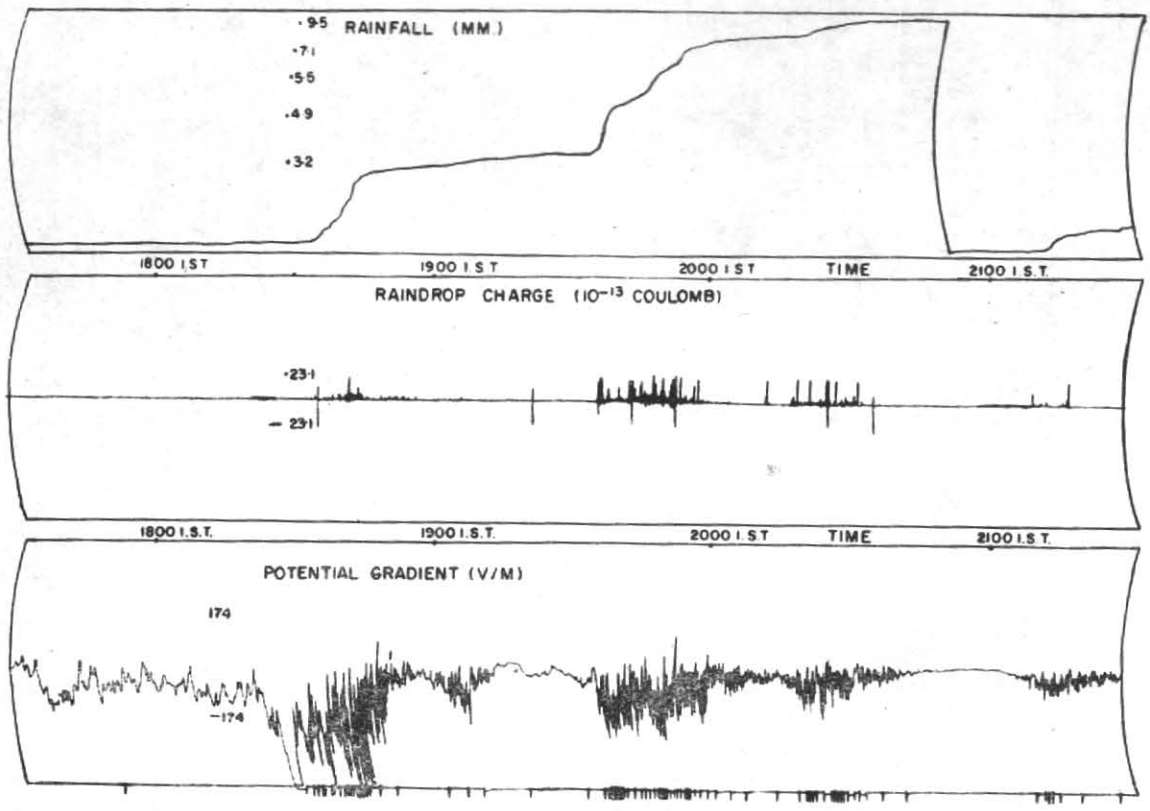

Fig. 7. Simultaneous recordings of potential gradient (v/m), raindrop charge (10^{-13} coulomb) and rainfall (mm) at Poona on 8 July 1973 from 1800 to 2100 IST

TABLE 2

Comparison of potential gradient at Lonavla (LON) and Mahabaleshwar (MHB) for nearly the same intensity of rain

Total rain (mm)				Potential gradient (v/m)			
2 hr		6 hr		Maximum (—ve)		Average (—ve)	
LON	MHB	LON	MHB	LON	MHB	LON	MHB
1·0	1·0			—9·3	—16·8	—2·6	—6·1
5·3	5·5			—7·5	—16·8	—3·5	—6·9
9·8	9·5			—9·3	—39·9	—3·4	—9·9
		20·9	21·2	— 13·1	— 33·6	—1·5	—4·3

in rain intensity cannot be detected until sometime after the receipt of the raindrops into the collecting gauge, it cannot be said from the recordings obtained whether there was a consistent time difference between the two parameters and if so, which preceded which.

5. Discussion

Measurements made at Mahabaleshwar and Poona have suggested that (1) there is an association between the times of occurrence of rainfall and the times of variation in potential gradient, and (2) the potential gradient is more negative when the rainfall is more. Measurements at Poona in one continous rain situation have pointed out higher values of potential gradient for higher rates of rainfall.

Measurements made at Lonavla did not however, support the above trend. The reason for