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A theoretical study regarding heterogeneity of rainfall over Madhya Maharashtra

A. K. MUKHERJEE and K. C. SINHA RAY

Meteorological Office, Pune

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सार — मध्यमहाराष्ट्र के विभिन्न जिलों में हुई सामान्य वर्षा के अध्ययन के समय मुखर्जी, एवं अन्य (1979,1980) ने विविध जिलों पर से उत्तर से दक्षिण की ओर जाती हुई एक रेखा निरूपित करने का सुझाव दिया था। इस रेखा के पश्चिम की ओर के कस्बों एवं रेखा के पूर्व की ओर के कस्बों में जुलाई एवं अगस्त में हुई वर्षा के बंटन का अन्तर लगभग स्पष्ट हो जाता है। इस शोधपत्र में निरूपण रेखा के दोनों ओर वर्षा की इस असमांगता को सैद्धान्तिक रूप से समझाने का प्रयास किया गया है। इस अध्ययन में सरकार (1967) द्वारा पर्वतीय वर्षा के लिए विकसित द्विविभीय निदर्श का प्रयोग किया गया है। अध्ययन से पता चला है कि यह रेखा उन स्थानों से होकर जाती है जहां पश्चिमी घाट के प्रतिपवन पार्श्व में पर्वतों की वजह से वर्षा लगभग नगण्य है।

ABSTRACT. While studying the normal rainfall over different districts in Madhya Maharashtra, a line of delineation running north-south across the districts was suggested by Mukherjee *et al.* (1979, 1980). This line roughly distinguishes the rainfall distribution in the talukas to the west and the talukas to the east during the months of July and August. In the present paper an effort is made to explain theoretically this heterogeneity of rainfall on both sides of the line of delineation. A two dimensional model for orographic rainfall developed by Sarker (1967) was used for this study. This study shows that the line of delineation roughly coincides with the place where the rainfall due to orography becomes nearly zero in the lee side of the Western Ghats.

1. Introduction

Mukherjee *et al.* (1979, 1980 a, b and c) analysed normal daily rainfall of all the raingauge stations of Madhya Maharashtra and came to the conclusion that in the months of July and August the eastern and western parts of districts adjoining Western Ghats behave differently. They took 14 stations for Nasik district, 11 in Ahmednagar, 7 in Pune, 9 in Satara, 6 in Sangli and 7 in Kolhapur districts and determined correlation coefficients of daily normals of rainfall for pairs of stations. They came to the conclusion that a line can be drawn in the north-south direction over the districts demarcating the eastern and western parts of the districts having different rainfall characteristics. The rainfalls of western stations are positively correlated amongst themselves. Similarly, rainfalls among eastern stations are also positively correlated. But the rainfalls between these two parts are negatively correlated or not correlated. The line of demarcation is parallel to the ridge line of Western Ghats. Mukherjee *et al.* (1980 c) also showed from actual daily rainfalls of the 14 stations of Nasik district for a period of ten years that the increase in rainfall over western parts of the district occurred when westerlies at 850 mb level over Bombay strengthened whereas the eastern part showed no increase.

These facts strongly suggest that the rainfall over western part is mainly orographic and the line of demarcation indicates the extent of orographic influence on rainfall. To check this hypothesis, contribution of rainfall due to orography has been calculated along the Bombay-Lonavala-Pune section by the method used by Sarker and the place where the influence vanishes determined. The agreement between the results of these two is very good.

2. Data

Only July rainfall in Pune district has been considered here. Daily normals of rainfall for 7 stations for 50-year period 1901 to 1950 were examined. The results were published elsewhere by Mukherjee *et al.* (1980 b). Table 1 gives the correlation coefficients between the stations. Fig. 1 shows the map of Pune district with the line of demarcation.

Mean westerly wind speed for Bombay (Santacruz) for July for the years 1970-1979 and mean temperature for the same period which were used for computation, are shown in Fig. 2.

3. Model

We considered the Western Ghats as a two dimensional barrier in $(x\text{-}z)$ plane with a zonal

Fig. 1. Line of demarcation in Pune district in July

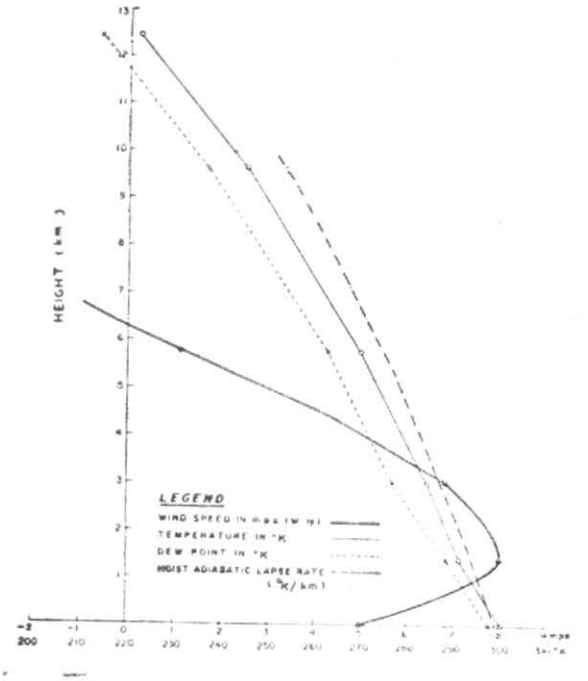

Fig. 2. July mean meteorological parameters for Bombay (Santacruz)

TABLE 1

Correlations coefficients between daily normal rainfall at seven stations in Pune district in July

Station	Ghod	Pune	Junner	Talegaon	Jejuri	Dhond	Indapur
Ghod	1	PNL	PNL	X	X	NNL	NNL
Pune		1	PL	X	X	NNL	NNL
			0.9				
Junner			1	X	X	X	X
Talegaon				1	PL	PL	PL
					0.9	0.9	0.9
Jejuri					1	PL	PL
						0.9	0.9
Dhond						1	PL
							0.9
Indapur							1

PL : Positive Linear : In a scatter diagram the points are situated around a straight line with C.C. values positive.

PNL : Positive Non-Linear : In a scatter diagram the points are situated around a curved line with C.C. values positive.

X : No correlation : No significant C.C. and points are scattered randomly in scatter diagram.

NNL : Negative Non-Linear : In a scatter diagram points are situated around a curved line with C.C. values negative.

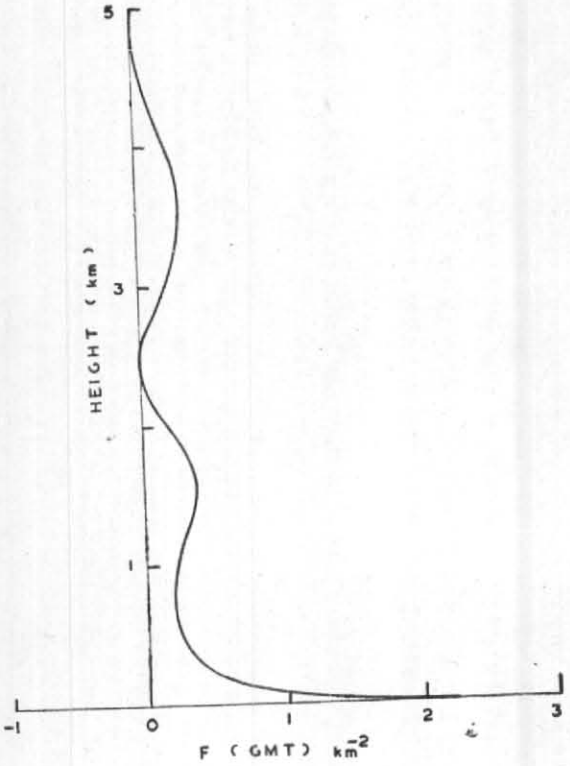

Fig. 3

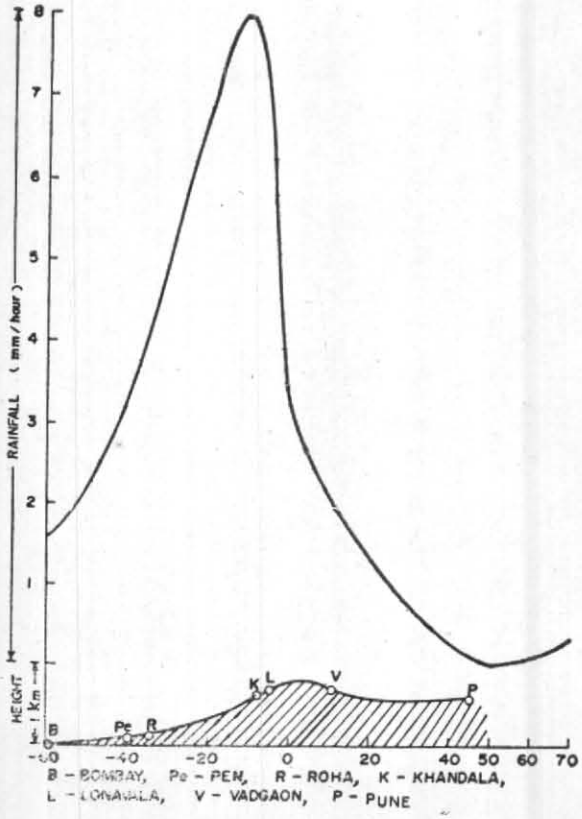

Fig. 4. Computed rainfall intensity in Bombay-Pune section

current $\bar{U}$ which blows perpendicular to the barrier. Considering a saturated atmosphere and a laminar steady non-rotating flow the equation for perturbation vertical velocity (w) can be written as

$$\frac{\partial^2 w}{\partial x^2} + \frac{\partial^2 w}{\partial z^2} + f(z)\, w = 0$$

$$\text{where, } f(z) = \frac{g(\gamma^* - \gamma)}{\bar{U}^2 \bar{T}} - \frac{1}{\bar{U}} \frac{d^2 \bar{U}}{dz^2} +$$

$$+ \left\{ \frac{\gamma^* - \gamma}{\bar{T}} - \frac{g}{\chi R \bar{T}} \right\} \frac{1}{\bar{U}} \frac{d\bar{U}}{dz} -$$

$$- \frac{2}{\chi R \bar{T}} \left(\frac{d\bar{U}}{dz} \right)^2 - \left(\frac{g - R\gamma}{2 R \bar{T}} \right)^2$$

$$\text{and } \chi = \frac{g}{g - R\gamma^*}$$

γ^* = pseudo-adiabatic lapse rate

γ = actual lapse rate

$\bar{U}$ = undisturbed wind

$\bar{T}$ = undisturbed temperature

R = gas constant

g = acceleration due to gravity

The solution of this equation is obtained by a quasi-numerical method using the techniques followed by Sarker (1967). The computation of rainfall has been done using the model developed by Sarker (1967) and Sarker *et al.* (1978) by using mean air stream characteristics for July over Santacruz. The terrain induced vertical velocity computed along the Western Ghats section is shown in Fig. 3.

Fig. 4 gives the orographically induced mean rainfall along the section. Actual rainfall may differ from this picture. Close to the coast, influence of offshore vortices in July is greater than that of orography (Mukherjee *et al.* 1978). But it may be expected that at least for the rainfall at Khandala the agreement should be good since the influence of orography is maximum here. The average rainfall at Khandala is 2.6 mm per hour which is, however, very much lower than the computed rate. This may be due to the assumption that the air is saturated for all days for the entire tropospheric column. But since the purpose is to determine the place of zero intensity and thus the place upto which the orographic influence extends, it is assumed that this model may be used for this purpose.

The wave-length of the lee wave for the mean wind stream characteristic is 15 km. The computed intensity of rainfall as shown in Fig. 4 indicates that the rainfall becomes nil at 110 km from the coast. It is found that this place is only 5 km

away from that indicated by the demarcation line over Pune district as found from statistical analysis of rainfall data by Mukherjee *et al.* (1980 b).

4. Conclusion

The difference of rainfall characteristics in July between the western and eastern parts of districts in Madhya Maharashtra adjoining Western Ghats is mainly due to the influence of orography on rainfall extending upto a certain distance on the leeward side. The forecasts for rainfall in these two parts in July and August should be from different considerations.

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