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Influence of the Western Ghats on the Monsoon Rainfall at the coastal boundary of the Peninsular India

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ABSTRACT. Along the west coast of the Indian Peninsula, north of lat. 9°N, rainfall during the monsoon season usually increases from the coastal boundary towards the Western Ghats. Monthly normal rainfalls (for July) of the different stations along the coastal belt, plotted against their distance from the sea coast, show a significant correlation (—0·6) with the distance of the 150-metre contour from the coast and appear to be uncorrelated with the distances of the 600 m and 900 m contours from the coast. Apparently the gradient between the sea level and the 150-metre contour determines the magnitude of the coastal convergence, and the consequential vertical motion responsible for the rain.

1. Introduction

In the Indian Peninsula the Western Ghats and the regions to their west (Konkan, Kanara and Kerala) receive the heaviest rainfall during the southwest monsoon period, June to September. Right from the coastal boundary in the west rainfall generally increases towards the Ghats. Farther east in the lee of the Ghats rainfall abruptly decreases. In Kerala, south of about latitude 9°N, even though increase of rainfall from the coast towards the Ghats is not so noticeable, a recent study (Raghavan 1959) indicated that the distribution of rainfall in this region is primarily controlled by certain peculiar orographic features of the Ghats.

A study of the influence of the Ghats over this area is particularly important as daily synoptic forecasts for the whole region are largely influenced by the weather conditions experienced at the reporting observatories which are all situated within a distance of 5 km from the coast. In the study reported here, rainfall data from all the raingauge stations located within this 5 km belt, in addition to those from the stations reporting at the synoptic hours north of 9°N, have been considered. Rainfall normals for these stations were recently published by the India met. Dep. (1962).

2. The Western Ghats

The Western Ghats are the hill ranges that lie roughly north-south along the west coast of the Indian Peninsula. Southwards upto lat. 13°30′N the highest range is 600 metres a.s.l. Farther south the highest range is 900 metres high. This part of the Ghats at places extends eastwards and gains in height to culminate in steep peaks, some of them exceeding a height of 1200 metres a.s.l. At about lat. 11°N this range loses height to form the Palghat Gap, about 27 km wide and 150 metres high.

Towards the coast in the west, the main barrier is considerably steep. From its foot in certain areas a number of spurs, with average elevation of 150 metres, project westwards. At three distinct areas between latitudes 13°45′N and 15°15′N the spurs attain a height of 600 m away from the main barrier. North of lat. 16°N the spurs are broken at a number of places and remain as separate groups of hills, 150 m high. Hills less than this height are isolated and negligibly small in dimension.

The important topographic features of the region between the west coast and the crest of the Ghats may be represented roughly by the two west-east cross-sections illustrated in Fig. 1.

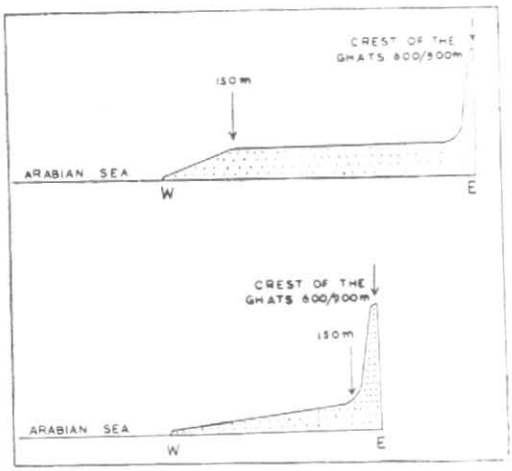

Fig. 1. Vertical cross-sections from the West Coast to the Ghats

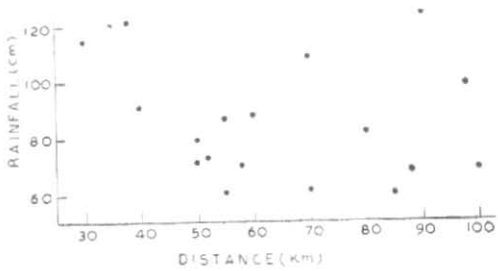

Fig. 2. Distance of the Ghats 600 m a.s.l. and normal rainfall in July in the West Coast

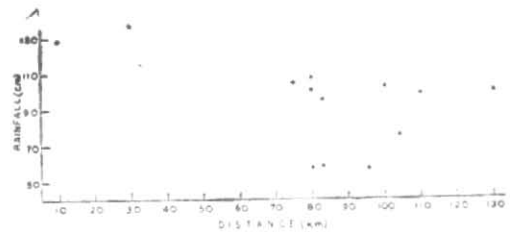

Fig. 3. Distance of the Ghats 900 m a.s.l. and normal rainfall in July in the West Coast

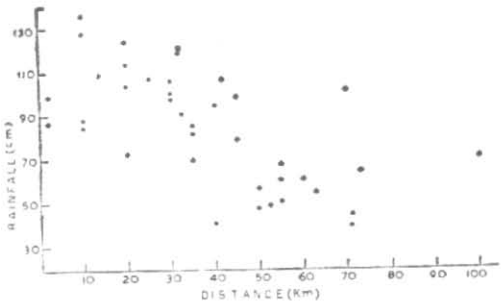

Fig. 4. Distance of the Ghats 150 m a.s.l. and normal rainfall in July in the West Coast

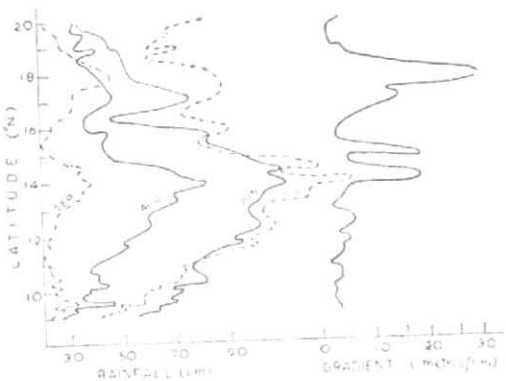

Fig. 5. Latitudinal variation of normal rainfall and gradient of upslope in the West Coast

3. Barrier Effect

When an air stream that is nearly saturated strikes against a long steep barrier, lying across the stream, most of the air would ascend over its crest. The greater the height of the barrier the higher the height the air has to ascend before crossing it. Where the vertical movement of air is stronger, rainfall can be normally expected to increase provided there is sufficient moisture in the air. As the vertical movement of air caused by the barrier effect would decrease with increasing distance from the barrier, rainfall by this cause would decrease upstream. If the hill ranges, 600 or 900 m in height, of the Ghats are the sole cause for such vertical currents and are responsible for the rainfall as far as the coastal belt, one should expect the rainfall at the coast to decrease with increasing distance of the ranges from the coast.

The normal rainfalls of the coastal stations in the typical month of July plotted against the distance between these stations and the hill ranges of 600 m and 900 m separately (Figs. 2 and 3) indicate that there is no noticeable correlation between the rainfalls and the distance of the crest line. Distances were measured from each station to the nearest height-contour of 600 m and 900 m due east.

One may like to note from Fig. 2 that the average distance between the coastal stations and the 600 m hill ranges is roughly 65 km which is about 100 times the height of the ranges. Similarly Fig. 3 shows that the average distance of the 900 m ranges is nearly 70 km which works out to about 80 times their height.

In order to find out whether the distance of the 150-m contours has any significant correlation with the rainfalls at the coastal stations, the rainfalls are similarly plotted against their distances from the 150-m contour and given in Fig. 4. This shows that the rainfalls at the coast generally tend to decrease with increasing distance of this contour from the coast. The correlation coefficient is —0·6. The average distance of these hill ranges from the coast is about 300 times their height.

4. Effect of coastal convergence

It was surprising that the 150-m contours show a significant correlation with the rainfalls at a distance of more than 300 times their height whereas the higher ranges of 600 m and 900 m fail to do so even at a distance of 100 times their height. Apparently coastal convergence caused through the increased friction—the other factor causing coastal rainfall—is determined by the gentle slope of the coastal belt as measured by the distance of the 150-m contour.

The ground upto the 150 m contour, unlike that between the 150 m and the 600 or 900 m contour, exhibit a steady slope. Apparently this slope controls the coastal wind convergence, which is turn determines the vertical velocity responsible for the rainfall. The correlation coefficient of —0·6, mentioned in the previous section, may be explained in this way.

5. Latitudinal variation of rainfall and slope effect

To examine this aspect in detail, in Fig. 5 is shown the latitudinal variation of normal rainfall with respect to the average gradient of up-slope (increase of height in metres within 1 km distance) downstream upto the 150-m contour from each station. The rainfall curves in the first instance show large variations from north to south. In the region between latitudes 20° and 19°N rainfall for the season as a whole is less than that in the region between lat. 19° and 18°N. It further increases beween lat. 18° and 17°N where the gradient of the terrain is the steepest so far. Thereafter with decrease of slope the rainfall decreases between lat. 17° and 16°N. Between lat. 16° and 14°N the gradient is having a general increase and this is remarkably reflected in the rainfall. If we examine the rainfall variations further south and compare them with the variations of gradient of up-slope, it can be seen from Fig. 5 that the variations of rainfall are intimately related to the variations of the gradient of

up-slope practically all along the coast. It is interesting to find that there is a strong tendency for the rainfall to be relatively high or low over the same area in each month. Such a recurring feature of rainfall is characteristic of orographic influence.

It may be pointed out that considering the density of rainfall stations and lack of satisfactory information on the exposure conditions of all the existing stations, one may not be justified at present in comparing the gradient of slope and the rainfalls over areas less than a latitude belt.

6. Conclusion

The present study indicates that the monsoon rainfall within 5 km of the sea coast is not normally influenced by the elevation or distance of the crest line of the Western Ghats from the sea coast. On the other hand, it is influenced by the average gradient measured upto the 150-m contour.

7. Acknowledgement

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REFERENCES

India met. Dep. 1962 *Mem. India met. Dep.*, **31**, Pt. 3, p. 63.

Raghavan, K. 1959 *Indian J. Met. Geophys.*, **10**, p. 291.