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The role of orography on wind and rainfall distribution in and around a mountain gap : Observational study

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ABSTRACT. A study of rainfall distribution along the 30 km wide Palghat Gap (Lat. 10°46′) at about 97 m above mean sea level between Nilgiris (1 to 1·5 km) and Anamalais (2 to 2·5 km) shows the rainfall decrease gradually and continuously from the coast against the gap cross section. Along the sections north and south of the gap, the rainfall increases upto a certain height from the coast in the windward side and decreases gradually in the lee-side. It is seen that the percentage increase of rainfall at the mountain section with reference to the gap is about 100 per cent at a distance of 60 km from the coast and at a height of about 750 m and decreases thereafter before the peak of the barrier is reached. It is found also that the monsoon winds at the exit of the gap are twice or thrice of the wind speed at the gap.

1. Introduction

A question is usually asked what would be the effect of the removal of the Western Ghats (extending from 8° N to 20° N and about 1200 km in length), on the monsoon ra'nfall of the west Peninsular India. The 30-km wide Palghat gap (latitude 10° 46′) at about 90 metres a.s.l between Nilgiris (elevation about 1 to 1·5 km) and Anamalais (elevation about 2 to 2·5 km) mountains is an area where nature has provided a gap (Fig. 1).

It has been known that during the monsoon season, the winds even at Tiruchirapalli which lies due east and about 200 km away from the gap become very strong. Also the existence of strong winds in the region east of the gap has been so well known to the people living in this region, that there are proverbs in the local language which figuratively point to the experience of strong winds.

During the southwest monsoon season the windward side of this mountain range and the narrow coastal plains receive copious rainfall. According to Blanford (1886), the more potent cause for the heavy rainfall along the west coast is the forced ascent of a portion of the current from the low coastal country of the Malabar and the Konkan to the crest of the Western Ghats only about 50-100 km from the coast. But at the gap where there is no barrier to arrest the oncoming monsoon current the rainfall picture is quite different.

With this background an attempt has been made to give a descriptive account of the characteristics of rainfall and wind distribution observed in and around this gap, so that it may be of interest to meteorologists in other parts of the world who might have made studies on the effect of a similar gap in a mountain chain on the distribution of rainfall and wind.

2. Rainfall

In Fig. 2 are depicted three cross sections, the first one along Lat. 11°28′ across the Nilgiri hills which are north of the gap, the second one along Lat. 10°46′ across the gap and the third one along Lat. 10°03′ across the Anamalai hills which are to the south of the gap. The continuous curve in the figure indicates the contour of the topography along the latitude while the histograms represent the normal rainfall of a month, June at selected stations. The stations from left to right are given below for the three latitudes.

For 11°28′ *N*—(1) Quilandi, (2) Vayittri, (3) Devala, (4) Gudalur, (5) Ootacamund, (6) Kotagiri, (7) Satyamangalam, (8) Gobichettipalayam, (9) Bhavani and (10) Sankagiridrug.

For 10°46′ *N*—(1) Ponnani, (2) Ottapalam, (3) Parli, (4) Palghat, (5) Chitur, (6) Pollachi, (7) Dharapuram, (8) Mulanur, (9) Aravakuruchi and (10) Palaviduthi.

For 10°03′ *N* —(1) Cochin, (2) Alwaye, (3) Neriamangalam, (4) Munnar, (5) Devikulam, (6) Bodinayakanur, (7) Periyakulam, (8) Cholavandan, (9) Tallakulam and (10) Melur.

It may be seen from the figure how the windward rainfall and the lee-side rainfall differ from each other in the three cross sections. To the north

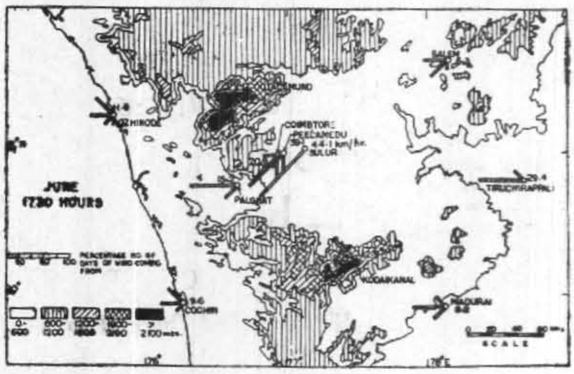

Fig. 1

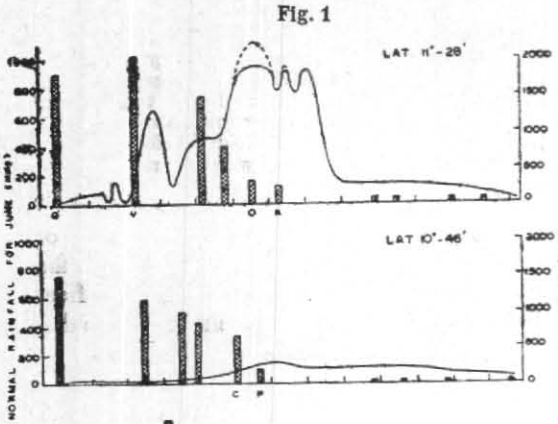

Fig. 2

of the gap, the station Vayittri about 700 m in height and about 40 km from the coast (marked V on the figure) gets the maximum rainfall. Quilandi, a station on the coast (marked Q) gets lesser amount of rainfall than Vayittri. The highest peaks Ootacamund and Kotagiri (marked O and K) show significantly less rainfall and the rainfall decreases considerably in the lee-side afterwards.

From the cross section of the gap, it may be seen that the westerly winds meet with topography of 150 m and 300 m heights only. It may also be noted that there is no increase of rainfall from the coast towards the eastern side, but there is a gradual decrease of rainfall from the coast to the lee-side. The distance between Chittur and Pollachi (marked C and P) in the gap section is only about 25 km but the rainfall has decreased from 337·8 to 100·8 mm in this short distance.

In the southern section the rainfall pattern is the same as in the northern counterpart, *i. e.*, the increase of rainfall in the windward side upto a certain height in the barrier and the decrease at the top and lee-side of the Ghats.

More west-east cross sections at half degree interval from 08° 30'N to 19° N have been prepared to depict the variation of rainfall from the coast to a distance of 160 km (Fig. 3). The continuous curve in Fig. 3 refers to mean normal rainfall for monsoon season (June to September), while the dotted curve refers to the topographical contours. The cross section north and south of the Palghat gap brings out the features described above relating to Fig. 2.

It is, therefore, seen that wheteas the pattern of variation of rainfall along the lee-side is nearly similar in all the three cross sections, the rainfall curve in the windward side along the gap is different from the rest. Fig. 3(e) shows the variation of rainfall from the coast towards the interior along a region where there is no mountain barrier. Comparing this rainfall pattern, with those in Figs. 3(d) and 3(f) where there are mountains, it is possible to estimate the effect of the barrier in rainfall from the monsoon current. For this purpose, the rainfall curves in Fig.3 (d, e and f) are plotted in Fig. 4. The mean SW monsoon rainfall during June to September is plotted for the three sections for the stations mentioned above. The gradual decrease of rainfall from the coast and the sudden drop in rainfall from Chittur (C) to Pollachi (P) in the lee-side in the gap section is clearly seen in the figure. It is seen that the rainfall goes on increasing upto a distance of 60 km from the coast, and decreasing afterwards, north and south of the gap, whereas the rainfall is decreasing in the gap section continuously from the coast. It is also interesting to note that the coastal stations rainfall is not affected much in all the three sections mentioned above.

The mean monsoon rainfall amounts at various distance from the coast along the gap and across the mountain sections as in Fig. 4 are given in Table 1. The percentage increase of rainfall at the mountain section with reference to the rainfall along this gap section is given in Col. 4. It is clear that the rainfall increases by about 100 per cent on the windward side, a distance of 60 km from the coast and at a height of 750 m and then decreases thereafter before the peak of the barrier is reached.

The feature suggests that a short travel upwards is sufficient for the monsoon current to shed copious rainfall. According to Rao (1958), convective instability is the normal feature of monsoon, and therefore, the monsoon current becomes convectively unstable, when lifted up during travel along a short distance.

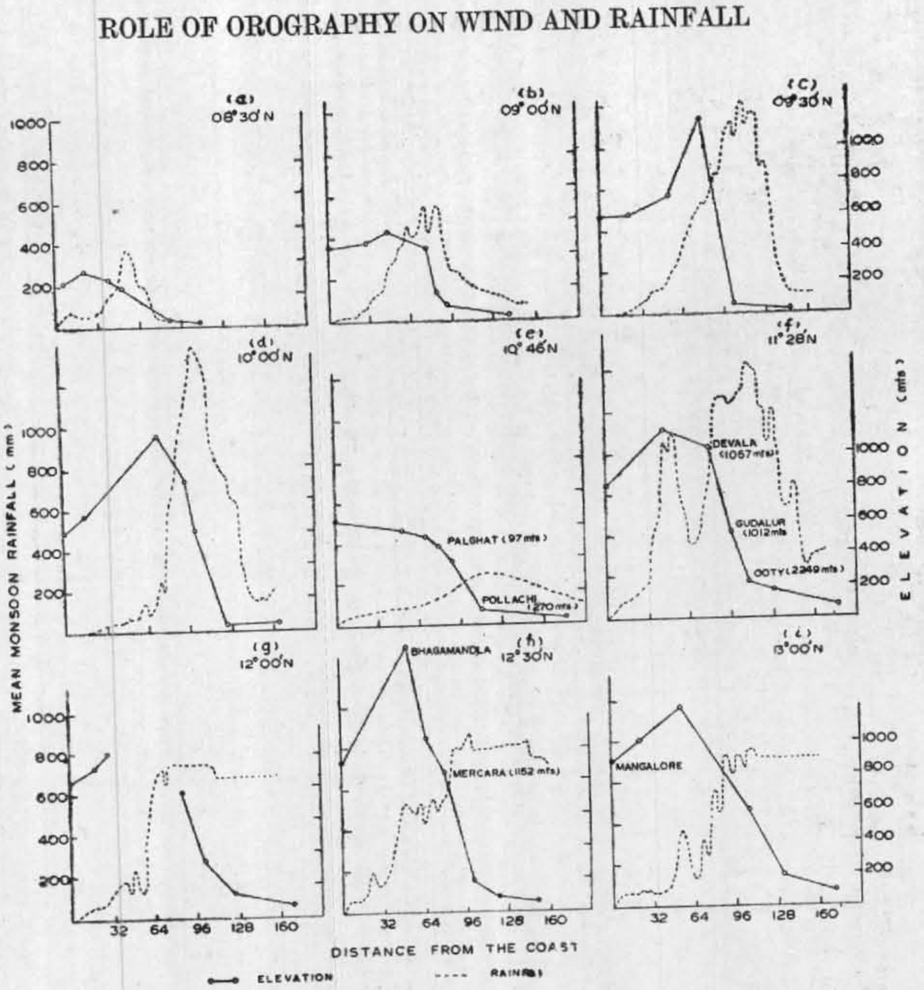

Fig. 3

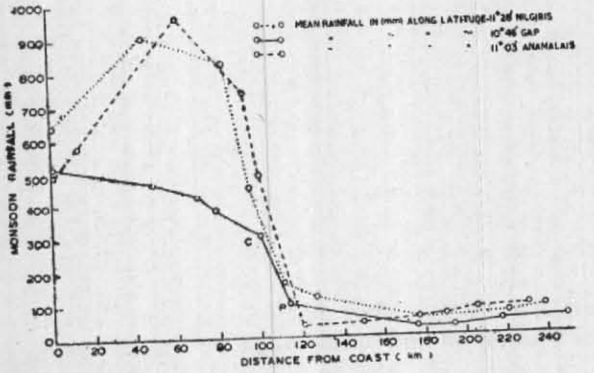

Fig. 4

TABLE 1

Gap and hill precipitation from the coast

Distance form the coast (km)	Gap mean monsoon ranfall (mm)	Hill mean monsoon rainfall (mm) as in Fig. 4	Percentage increase of rainfall due to orography
0	520	565	9
20	495	690	39
40	475	820	73
60	445	903	103
80	385	835	117
100	310	437	41
120	95	87	0

3. Wind

The observatory stations which record wind in and around the Palghat gap are a few in number. The monthly mean wind speed at 1200 GMT for the month of June and also the percentage number of days of wind coming from specified directions are shown in Fig. 1. The westerlies at Palghat and the southwesterlies at Coimbatore, Peelamedu and Sulur and westerlies at Tiruchirapalli and the southwesterly components at Salem and northwesterly components at Kodaikanal and Madurai show clearly that the winds fan out at the exit of the gap. The coastal winds are variable. There is not much difference in wind speed between

TABLE 2

Mean surface wind speed (kmph)

Station	No. of years	0300 hrs GMT				1200 hrs GMT			
		Jun	Jul	Aug	Sep	Jun	Jul	Aug	Sep
Tiruchirapalli	11	26·2	27·4	26·0	21·8	29·4	35·2	28·3	17·5
Coimbatore	11	17·5	18·5	18·6	17·6	20·9	20·9	23·1	22·1
Peelamedu	6	27·7	26·6	24·7	20·7	39·1	36·8	39·3	35·3
Sulur	5	27·8	30·1	27·0	23·3	44·1	45·9	45·6	39·3
Palghat	11	11·9	11·7	11·9	10·9	15·2	15·3	15·9	15·6
Salem	11	6·0	5·9	5·9	5·3	6·3	5·7	4·8	3·0
Madurai	11	4·9	4·7	4·1	3·8	8·2	7·4	6·4	6·1
Kozhikode	11	7·8	6·3	5·5	5·1	11·9	10·8	10·9	10·6
Cochin	11	5·5	6·8	6·2	5·7	9·6	10·7	11·2	11·8
Ootacamund	11	9·3	12·7	8·3	6·1	8·6	10·5	7·3	5·3
Kodaikanal	11	12·0	16·6	12·9	8·9	12·9	15·5	11·9	7·4

coastal stations like Cochin and Kozhikode and the inland stations like Salem and Madurai. But the wind speeds at Coimbatore, Peelamedu, Sulur (at the exit of the gap), Tiruchirapalli (away from the gap) are twice or even thrice the wind speed at Palghat (in the gap). This phenomena is seen both in the morning and evening hours for the months from June to September (Table 2).

So, there are large scale synoptic factors which play an important role in and around this mountain gap. The speed, direction, the dynamics of the air motion which determine to what depth and through what layers the air mass is lifted and the microphysics of the cloud which determine whether the water is condensed as cloud will reach the ground as rain or whether it will be merely evaporated in the lee-side, are worth studying in this region. It will be, therefore, of interest to make a detailed study of the effects of orography on the distribution of the wind and rainfall in this region, a natural laboratory for meteorologists.

4. Conclusion

It is therefore, intersting to find that the monsoon rainfall decreases from the coast to the lee-side at the Palghat gap cross section and also monsoon winds increase twice or thrice at the exit of the gap, when compared to the winds at the gap. The percentage increase of orographic rainfall due to hills with reference to this gap is found to be of 100 per cent on the windward side at a distance of 60 km from the coast and at height of >70 m.

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REFERENCES

Blanford H. F. 1886 *Mem. India met.Dep.*, **3**.

Rao, K. N. 1958 *Monsoons of the World*, p. 44.

India, met. Dep, 1968 *Climatological Tables of Observatiories in India (1931-60)*

— *Monthly and annual normals of rainfall and of rainy days (1901-1950).*