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An objective method of Forecasting Pentad Rainfall anomaly in Konkan coast during July

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ABSTRACT. The contingency technique has been applied to forecast the pentad rainfall over Konkan coast in the month of July. From the 700-mb level 5-day mean and 1-day mean charts, antecedent to abnormal and subnormal rainfall over Konkan coast, suitable predictor parameters have been obtained which are statistically significant. Using these predictors and pentad rainfall being the predictand, contingency tables have been prepared in the form of final forecast scheme. The technique has been evolved on the basis of 5-day mean and 1-day mean 700-mb contour charts for over-lapping pentads for the period 1957-1961. The independent data of 1962-1963 has been used for verification. The method has shown a skill score of 51 per cent.

1. Introduction

The versatile scheme for weather forecasting involving contingency tables, is not new and a sizeable literature exists on this topic. Number of workers have utilised contingency technique for short and medium range rainfall forecasting. In India, Jagannathan and Ramamurthi (1961) initiated the pilot study on this line for forecasting 5-day rainfall anomaly over Bombay and working on similar lines, Sajnani (1964) developed the technique for forecasting 5-day rainfall over Calcutta. Fundamentally the same method has been adopted by Mooley (*see* Ref.) for forecasting pentad rainfall anomaly in Kerala during July. In the studies by Jagannathan and Ramamurthi (1961) and Sajnani (1964), the predictors were chosen to be 5-day mean or 1-day mean contour height at 700-mb and 500-mb levels at significant stations while in the case of Kerala rainfall forecast (Mooley, *vide* Ref.) the predictors have been restricted to 700-mb level only, obviously due to non-availability of 1-day or 5-day mean charts for 500-mb or any higher level. Due to same reason this restriction has been maintained in the present study also. The predictors are chosen after studying the contrasting upper air patterns antecedent to abnormal and subnormal rainfall anomalies over the area under study.

After predictors have been chosen, scatter diagrams are plotted between pairs of them for the rainfall anomaly of the next non-overlapping pentad. For greater detail of the techniques used for plotting the scatter diagram, etc, the reader may refer to Jagannathan and Ramamurthi (*loc. cit.*). The points on the scatter diagram are divided by smooth curves in three classes, each being representative of three predictand classes — abnormal, normal and subnormal. Applying the contingency techniques as given by Wahl and White (1952) and Lund and Wahl (1955) contingency tables are prepared in the form of final forecast scheme.

2. Method of classifying the predictand

As mentioned earlier, the pentad rainfall anomaly is the predictand and it has been subdivided into three classes — abnormal, normal and subnormal. The pentad rainfall anomaly in terms of these three classes is available for the stations Bombay and Ratnagiri which have been supposed to be jointly representative of the Konkan coast rainfall anomaly. While delineating these classes, the limits of the rainfall have been fixed such that each class has the equal probability of occurrence. In the case, both the stations have the same character of rainfall the same character is taken for the Konkan coast, *viz.*, if Bombay and Ratnagiri, both have subnormal rainfall anomaly for a particular pentad 'subnormal' is the character given for the rainfall anomaly of Konkan coast. In the case, both stations have different characters, *viz.*, R_B is the rainfall for Bombay and R_R for Ratnagiri then $(R_B + R_R)$ is compared with the range $(R_{BS}+R_{RS})$ to $(R_{BA}+R_{RA})$ where R_{BS} and R_{BA} are respectively the higher limit of subnormal and lower limit of abnormal rain at Bombay. Values between R_{BS} and R_{BA} represent the normal rainfall over Bombay. The same notations hold for Ratnagiri also. So if $(R_B + R_R)$ is more than $(R_{BA}+R_{RA})$, the rainfall character to be designated to Konkan coast will be abnormal, if $(R_B + R_R)$ is less than $(R_{BS}+R_{RS})$, then subnormal and if $(R_B + R_R)$ lies between $(R_{BS}+R_{RS})$ and $(R_{BA}+R_{RA})$, then normal.

3. Actual predictors and their graphical correlation

The predictors have been chosen by the composite chart method (Jagannathan *et al.* 1963).

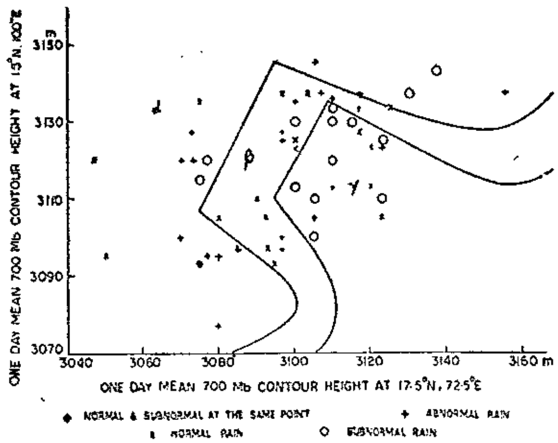

Fig. 1(a). 1 day mean 700-mb contour height at 17·5°N/72·5°E

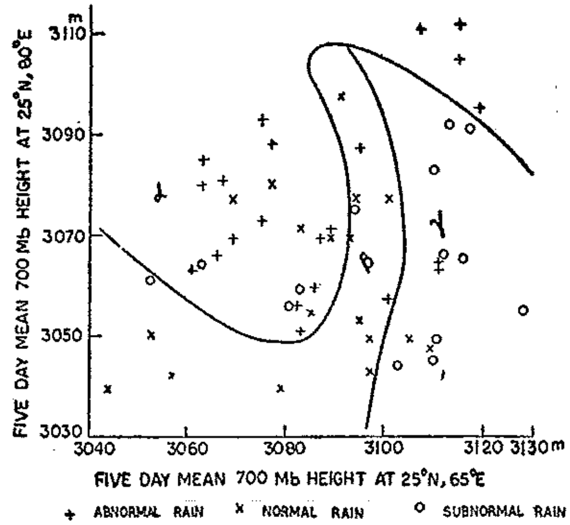

Fig. 1(b). 5-day mean 700-mb height at 20°N/65°E

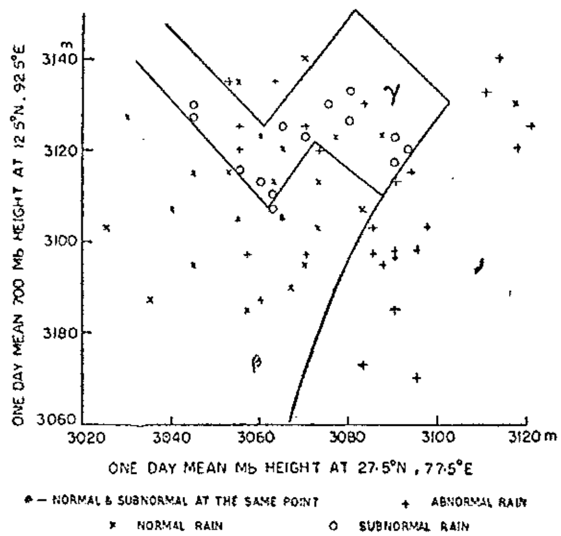

Fig. 1(c). 1 day mean 700-mb height at 27·5°N/77·5°E

The predictors, which have been selected finally for the preparation of contingency tables are as follows —

(*i*) Mean contour height at 20°N, 65°E during preceding pentad,

(*ii*) Mean contour height at 25°N, 85°E during preceding pentad,

(*iii*) Mean daily contour height at 17·5°N, 72·5°E on day just preceding the pentad for which rainfall has been considered,

(*iv*) Mean daily contour height at 15·0°N, 100·0°E on day just preceding the pentad for which rainfall is considered,

(*v*) Mean daily contour height at 27·5°N, 77·5°E on day just preceding the pentad for which rainfall is considered, and

(*vi*) Mean daily contour height at 12·5°N, 92·5°E on day just preceding the pentad for which rainfall is considered.

The reason for taking grid point values is that sometimes, height reported by a station may be wrong by 10 to 20 metres. In such case, if the contour height charts is analysed and the grid point value is picked up, the error may be smoothened out.

Three predictor pairs were made taking two at a time out of above mentioned six predictors. Every pair of predictors was graphically correlated with the rainfall character over Konkan coast in the subsequent pentad. Scatter diagrams were plotted between the values of predictors for the rainfall character of the next non-overlapping pentad. The points on the scatter diagrams were classified by smooth curves into three different groups, α, β and γ so that the association between the parameters and the rainfall over Konkan coast, classified as *A*, *N* and *S* could be determined by the contingency analysis. The points were separated in such a way that in the region α, fall the maximum points of abnormal, in β for normal and in γ for the subnormal rainfall anomaly. Only those predictor pairs were selected which gave the best separation into three classes, the smoothness of the separating curves being retained. The scatter diagrams which have been finally selected to be used in the final prediction scheme have been given in Figs. 1 (a), 1 (b) and 1 (c).

It is worth mentioning here that it is one of the obvious advantages of the contingency technique that we can find association between two parameters even if relation is non-linear and moreover linear relations between meteorological parameters are exceptions rather than rule.

TABLE 1

Contingency tables

Predictor class	Predictand class A	N	S	Total
	(a) Predictors : 700-mb height at 17·5N°, 72·5°E and 15·0°N, 100·0°E on the immediately preceding day			
α	12	4	4	20
β	8	10	1	19
γ	3	4	9	16
Total	23	18	14	55
	(b) Predictors : Mean 700-mb height at 20°N, 65°E and 25·0°N, 85·0°E during preceding pentad			
α	18	5	3	26
β	2	11	2	15
γ	3	2	9	14
Total	23	18	14	55
	(c) Predictors : 700-mb height at 27·5°N, 77·5°E and 12·5°N, 92·5°E on the immediately preceding day			
α	18	3	0	21
β	5	15	1	21
γ	5	5	13	23
Total	28	23	14	65

4. Preparation of contingency tables and testing of predictor pairs

For each predictor pair, contingency tables have been prepared taking the areas represented by α, β and γ on the scatter diagram as predictor and the classes A, N and S of the rainfall of the following pentad as predictand. These contingency tables have been shown in Table 1.

Table 2 gives the pairs of predictors, the computed information ratio I_c and the 99 per cent confidence limits of the expected information ratio, $L_{99}(I_E)$. In the above mentioned table it is seen that I_c is greater than even $L_{99}(I_E)$ which means that there exists less than one chance in hundred that this value would have been obtained by chance. Therefore, these three predictor pairs have been included in the final forecast scheme.

5. Contingency ratios and final forecast scheme

The normalized contingency ratios, R'_{ij} are used to make the final forecast scheme. Here, $R'_{ij} = 1+(R_{ij}-1)(k.l.f^{\circ}_{ij}/N_0)^{\frac{1}{2}}$ where notations have their usual meaning (Jagannathan *et al.* 1963).

The combined effect of several predictors upon the various predictand classes j is given by the product of the contingency ratios of these predictors within these predictand classes. This product $\Pi\,(R'_{ij})$ can be computed for each class j of the predictand, given for each predictor in its appropriate class i. The highest product is the most probable class in the predictand. Just for convenience in calculations the logarithms rather than R'_{ij}, are used because it is easier to add a few columns than to multiply them. In order to avoid -ve values, 10 is added to $\log_{10}(R'_{ij})$ values. Thus the final tables (Table 3) used in forecasting scheme contain the value $(10+\log_{10}R'_{ij})$ in the cell referring to predictor class i and predictand class j.

TABLE 2

Predictors, their information ratio (I_c) and expected information ratio for 99 per cent confidence limit L_{99} (I_E)

Predictor pair	I_c	$L_{99}(I_E)$
I	·1395	·1119
II	·2362	·1119
III	·3247	·0962

Here,

$$I_c = \frac{\sum_{i=1}^{k} S_i \ln S_i - \sum_{i=1}^{k}\sum_{j=1}^{l} O_{ij}\ln O_{ij}}{N\ln N - \sum_{j=1}^{l} S_j \ln S_j}$$

and

$$I_E = \frac{\frac{1}{2}(k-1)(l-1)}{N\ln N - \sum_{j=1}^{l} S_j \ln S_j}$$

TABLE 3

Values of $(10+\log_{10}R'_{ij})$ based on data for period 1957—1961

Predictor pair	Predictor class	Rainfall anomaly: Abnormal	Normal	Subnormal
I				
1-day mean contour height at 17·5°N, 72·5°E and 15·0°N, 100·0°E	α	10·1668	9·7993	9·9284
	β	10·0029	10·1942	9·5451
	γ	9·6862	9·9024	10·4520
II				
5-day mean contour height at 20°N, 65° E and 25°N, 85°E	α	10·2562	9·7422	9·6781
	β	9·5627	10·3060	9·8155
	γ	9·7489	9·7414	10·3162
III				
1-day mean contour height at 27·5°N, 77·5°E and 12·5°N,92·5°E	α	10·3177	9·5986	9·3194
	β	9·7100	10·3081	9·5839
	γ	9·6381	9·7714	10·3701

TABLE 4

Verification of forecasts

		Forecast rainfall anomaly			Total
		A	*N*	*S*	
Observed rainfall anomaly	*A*	7	1	0	8
	N	1	3	2	6
	S	2	1	5	8
	Total	10	5	7	22

6. Verification

The validity of the technique, used here, was tested on independent data of the period 1962-1963 (July) which were not used for evolving the technique. The results obtained by the scheme developed here, and the actual results were compared. The result has been given in Table 4. It is seen that on 10 occasions abnormal rainfall was forecast against an actual number of 7.

The skill score S has been calculated by the formula —

$$S = (C - E)/(T - E)$$

where, C = number of correct forecasts, T = total number of forecasts issued and E = number of forecast expected to be correct by climatology alone. In the present case, $C = 15$, $T = 22$ and $E = 7 \cdot 5$ giving a skill score of ·51, which is comparable with the skill score of ·46 obtained by Jagannathan and Ramamurthy for Bombay and ·44 by Mooley for Kerala. Skill score of ·51 will mean that the forecast is correct on 67 per cent of total cases on which forecast was issued.

7. Conclusion

The study reveals that fairly good association exists between the parameters on the 700-mb chart and the pentad rainfall over Konkan coast. Similar results have emerged in earlier studies by Mooley for Kerala coast. It is proposed to test the usefulness of other isobaric levels also. The stability of the significance of used parameters should also be tested from time to time in order to allow for the long range modifications in the entire system. Being prompted with the encouraging results of this technique applied to the parameters on 700-mb surface, similar studies will be pursued for the other areas also.

8. Acknowledgement

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