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A SIMPLE METHOD OF FORECASTING THUNDERSTORMS

1. Three simple methods that are normally in use in the forecasting of thunderstorms are : (*i*) Showalter's (1953) stability index, (*ii*) Lifted index of Garway (1956) and (*iii*) George's instability index. However, lifted index gives good results only whenever absolute humidity is high and is therefore not a suitable index for our country. Tripathi (1956), Joseph (1957), Basu (1962), Seshadri (1962) and Kumar (1972) are of the opinion that Showalter's index is reasonably satisfactory for the prediction of local thunderstorms. The results of Singh and Agnihotri (1974) and Pendse *et al.* (1967) on the other hand suggest that George's index gives a better indication for the occurrence or non-occurrence of a thunderstorm than Showalter's index.

Analysis of 5 years data for Delhi and Allahabad has shown that Gerorge's index is better than Showalter's index. Even so, the success of forecasting thundestorms is only about 50 per cent.

In the present study an attempt has been made to suggest a simple method with improved accuracy in the forecasting of the occurrence or nonoccurrence of thunderstorms. The method is a modification of George's index.

2. *Data* — The upper air temperature data used in this study are for the months of March to May for the period of 5 years (1960-1964) for 00 and 12 GMT of Delhi and Allahabad stations. The current weather registers of these stations of the same period have been examined and the date and time of occurrence of thunderstorms only are noted. The indices have been computed by Showalter and George methods as also by the modified method suggested in the paper.

2.1. *Showalter's stability index* — The stability index of Showalter is determined by lifting an air parcel at 850 mb dry adiabatically at saturation and then moist adiabatically to 500 mb level. The 500 mb temperature of the parcel so obtained is then subtracted algebraically from the observed 500 mb temperature.

TABLE 1

Indices computed by Showalter method, George method and the modified method and the frequency of occurrence of thunderstorms at Delhi and Allahabad (Period of data : March to May 1960-64)

	Index range	Delhi			Allahabad *		
		Total number of forecasts	Number of occurrence of thunder-storms	Correct forecast	Total number of forecasts	Number of occurrence of thunder-storms	Correct forecast
(a) Showalter's stability index							
No thunderstorm forecast	≥4	274	4	270	335	4	331
	3 to 2	192	9	183	158	5	153
Thunderstorm forecast	1 to −1	245	21	21	221	24	24
	−2 to −3	122	13	13	89	9	9
	≤−4	73	13	13	71	12	12
(b) George's instability index							
No thunderstorm forecast	≤28	708	27	681	651	25	426
	29 to 32	103	17	17	106	14	14
Thunderstorm forecast	33 to 36	58	10	10	58	7	7
	37 to 39	16	2	2	27	6	6
	≥40	21	4	4	32	2	2
(c) Modified index							
No thunderstorm forecast	<−8						
	≥−8 with condition (A)	681	11	670	669	6	663
Thunderstorm forecast	≥−8 with condition (B)						
	−8 to −5	80	15	15	63	14	14
	−4 to 0	85	19	19	74	16	16
	1 to 5	44	12	12	52	8	8
	≥6	6	3	3	36	10	10

Condition (A) : 24—hourly change in dew point temperature of 850 mb level is negative
Condition (B) : 24—hourly change in dew point temperature of 850 mb level is positive

TABLE 2

Contingent table of occurrence/non-occurrence of thunderstorms — observed and forecast

Observed	Forecast: Delhi			Forecast: Allahabad		
	No thunderstorm	Thuderstorm	Total	No thuunderstorm	Thunderstorm	Total
(a) Showalter's stability index						
No thunderstorm	453	393	846	484	336	820
Thunderstorm	13	47	60	9	45	54
Total	466	440	906	493	381	874
(b) George's instability index						
No thunderstorm	681	165	846	626	194	820
Thunderstorm	27	33	60	25	29	54
Total	708	198	906	651	223	874
(c) Modified index						
No thunderstorm	670	176	846	663	157	820
Thunderstorm	11	49	60	6	48	54
Total	681	225	906	669	205	874

2.2. *George's instability index* — The airmass instability index (K) of George is given by the following expression :

K=[(850 mb temperature—500 mb temperature) + (850 mb dew point temperature) — (700 mb dew point depression)]

2.3. *Modified index* — In the above two methods, the parameters are considered in the layer in between 850 and 500 mb levels. However, moisture beyond 700 mb is invariably absent in the months of March to May. And also it is seen from the study of Kumar (1972) that occurrences of thunderstorms are more when the condensation level is in between 800 and 600 mb levels. This may be the probable cause for the failure of the above methods. Therefore, it is considered necessary to eliminate the lapse rate of 850 to 500 mb level parameter in George's index to improve its accuracy. Hence, a simple modified index has been suggested using only 850 mb dew point temperature and 700 mb dew point depression and the 24-hourly dew point change at 850 mb.

In this method K'(=850 mb dew point temperature —700 mb dew point depression) is first determined.

(*a*) If K' is <-8, then the non-occurrence of thunderstorm can be forecasted.

(*b*) If $K' \geqslant -8$ the occurrence or non-occurrence of thunderstorm can be forecasted depending upon the 24-hourly change of 850 mb dew point temperature.

If it is negative, non-occurrence can be forecasted and if positive there is a possibility of occurrence of thunderstorm within 24 hours. The above analysis is made for 00 and 12 GMT values so that there will be an overlapping period of 12 hours. It is possible that the conditions at 00 and 12 GMT according to above index are dissimilar. When a thunderstorm is not forecasted on the basis of an observation either 00 GMT or 12 GMT the forecast is considered valid for next 12 hours period only. On the other hand when a thunderstorm is forecasted on the basis of 00 GMT or 12 GMT data it is considered valid for the overlapping period also irrespective of the index computed on 12 GMT or 00 GMT observations.

Using the methods mentioned above the indices have been computed and are presented in Table 1 (a,b,c). The results of the three indices presented in Table 1 are arranged in a contingent Table 2 (a,b,c) and the skill scores are presented in Table 3.

TABLE 3

Scores of forecast using the three indices

	Showalter's index		George's index		Modified index	
	Delhi	Allahabad	Delhi	Allahabad	Delhi	Allahabad
A	55	61	79	75	79	81
B	78	83	55	54	82	89
C	89	88	83	87	78	76

A : Percentage of success of forecast occurrence/non-occurrence of thunderstorms (skill score)

B : Percentage of success of forecast occurrence of thunderstorms.

C : Percentage of failure of forecast occurrence of thunderstorm (*i.e.*, over-warning).

3. It is seen from Tables 1 to 3, the skill score for the successful forecast of occurrence/non-occurrence of thunderstorm is nearly 58 per cent in the case of Showalter's index and 77 per cent in the case of George's index and also the over warning is 88 per cent in the case of Showalter's index and 85 per cent in the case of George's index. Though the skill score of George's index is better than Showalter's index in forecasting of occurrence/non-occurrence of thunderstorms, the percentage of successful forecasting of the understorms alone is 54 per cent compared to 80 per cent in the case of Showalter's index.

However, with the modified index, it is possible to maintain a high skill score (80 per cent) comparable to George's index and improve the percentage of successful forecasting of thunderstorms alone (85 per cet) to a figure better than the Showalter's index. Further, the over warning (77 per cent) is less than by using either Showalter or George index.

These results suggest that the modified index can be used for better forecasting of occurrence/non-occurrence of thunderstorms.

On some of the occasions (Delhi=59 and Allahabad=45) when the modified index showed the possibility of thunderstorm, either precipitation or cloud amount >4 octas are seen; if these are also taken into account the figures for the performance of the modified method will show further improvement.

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