

## Comparative study of Showalter's stability index and George's instability value $K$ for predicting local thunderstorm over Calcutta airport

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**ABSTRACT.** Showalter's stability index and George's instability value  $K$  have been calculated for 1200 observations of pre-monsoon months of Calcutta Airport. The results show that George's instability value  $K$  gives a better indication for occurrence or non-occurrence of a thunderstorm than Showalter's stability index. It has also been found that if the value of George's instability index works out to be 28 or less in the morning or evening radiosonde observation (which happens on about 48 per cent of the total occasions) non-occurrence of a thunderstorm over Calcutta Airport during the next 15 hours can be predicted with reasonable certainty.

### 1. Introduction

The standard method of prediction of thunderstorm from the radiosonde observations consists of plotting the data on a tephigram and examining the various layers for inversion, lapse rate and latent instability, with particular emphasis on estimating the energy used/released, if the air parcel is lifted upwards in the prevailing atmosphere. Since this process of analysis is cumbersome and time consuming, many authors have developed shortcut methods. One simple method was given by Showalter (1953). In this method, stability index is determined by lifting an air parcel at 850 mb dry adiabatically to 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. A positive value indicates stability while a negative value instability.

The use of Showalter's stability index for forecasting thunderstorm over Poona was investigated by Tripathi (1958) and over Madras by Joseph (1957). Basu (1961) and Seshadri (1961) applied it for Delhi. All of them have concluded that the method is reasonably satisfactory for predicting local thunderstorm.

Another shortcut method for measuring thunderstorm potential from an upper air sounding has been proposed by George (1960). The parameters, whose importance in causing thundery activity is well known, are—(i) The lapse rate in the lower troposphere; (ii) The moisture content in the lower layers; (iii) The vertical extent of the

moist layer; (iv) Low level convergence and (v) Upper air divergence.

The first three of these elements can be readily calculated from a radiosonde observation. George (1960) combined the first three elements empirically into one number, *i.e.*, an air mass instability index  $K$  given by the following expression :

$$K = (850 \text{ mb temp} - 500 \text{ mb temp}) + (850 \text{ mb dewpoint}) - (700 \text{ mb dewpoint depression}).$$

The first term is a lapse rate parameter, the second term represents low level moisture content and the third indirectly indicates the vertical extent of the moist layer. George computed  $K$  instability index for many stations in United States and Canada and demonstrated its utility.

In the present note, an attempt has been made to find out how far these short cut methods are useful for forecasting thunderstorm activity at Calcutta Airport and which one of the two, gives a better indication for its occurrence.

### 2. Data

Since most of the severe thunderstorms which are often accompanied by squalls causing extensive damage and devastation, occur over Calcutta before the onset of monsoon season, the data selected for this study is only for the pre-monsoon months March to June of the years 1967 to 1971. From the tephigrams of every morning and evening of Calcutta for the above mentioned period Showalter's stability index and George's  $K$  instability values were worked out. The *Monthly*

TABLE 1  
Showalter's Stability Index (S. I.)

		Showalter's Stability Index													Total
		≥5	+4	+3	+2	+1	0	-1	-2	-3	-4	-5	-6	≤-7	
No. of Occasions		317	44	48	105	80	125	136	114	80	60	48	29	19	1,200
	(a)	153	23	25	58	43	65	70	49	42	20	26	15	11	600
No. of thunderstorms		9	6	6	18	24	27	43	35	26	17	9	4	5	229
	(a)	5	4	3	12	12	15	29	15	16	7	5	3	3	129
Percentage		3	14	12	17	30	22	32	32	33	28	19	16	26	
	(a)	3	17	12	20	28	23	41	30	38	35	19	20	27	

NOTE: Figures against (a) correspond to 00 GMT ascents

TABLE 2  
George's Instability value  $K$

		K Instability Index													Total
		≤28	29	30	31	32	33	34	35	36	37	38	39	≥40	
No. of Occasions		579	24	70	61	64	55	83	63	54	51	38	29	29	1,200
	(a)	289	12	31	33	30	29	34	34	28	24	19	17	20	600
No. of thunderstorms		2	2	18	23	25	29	35	26	20	17	13	10	9	229
	(a)	2	1	6	12	15	16	17	16	12	10	8	6	5	126
Percentage		0	8	26	31	39	53	42	41	37	33	34	34	31	
	(a)	0.7	8	20	36	50	55	50	47	43	42	42	35	25	

NOTE: Figures against (a) correspond to 00 GMT ascents

*Meteorological Registers* of Calcutta airport. of the same period were then examined and the date and time of occurrence of the thunderstorms with their duration were noted. From 1200 observations thus studied, Tables 1 and 2 were prepared.

The number of occasions when Showalter's stability index had different values from plus 5 to -7 are shown in second row of Table 1 while the number of occasion when thunderstorm occurred over Calcutta airfield during the next 15 hours are shown in third row. There were many occasions when cumulonimbus development with or without lightning was observed, but no thunder was heard over the station. These cases are not included among the cases of thunderstorm occurrence. The ratio of the number of occasions of occurrence of thunderstorms to the number of occasions of particular stability index are shown in fourth row. Thus, out of 136 occasions when Showalter's stability index was -1 during the period of study, there were thunderstorms on 43 occasions, i.e., 32 per cent of the occasions.

In Table 2, second row shows the number of occasions when George's instability ( $K$ ) values varied from 28 to 40; the number of occasions out of these when thunderstorm occurred during the next 15 hours are shown in third row. Fourth row shows the percentage ratio of the number of occasions when thunderstorms occurred to the number of occasions of particular ( $K$ ) instability values.

### 3. Discussion

Results of Tables 1 and 2 (excluding lines against  $a$ ) were plotted on a graph paper and best fitting curves were drawn by inspection. These curves are shown in Fig. 1. Theoretically, these curves should show increased chance of occurrence of thunderstorms with increase in  $K$  instability values or with decrease in Showalter's stability index (S.I.) values, but it is observed from these curves that both  $K$  as well as Showalter's index curves show a maximum at certain index values and then a tendency of decreasing, even with increasing

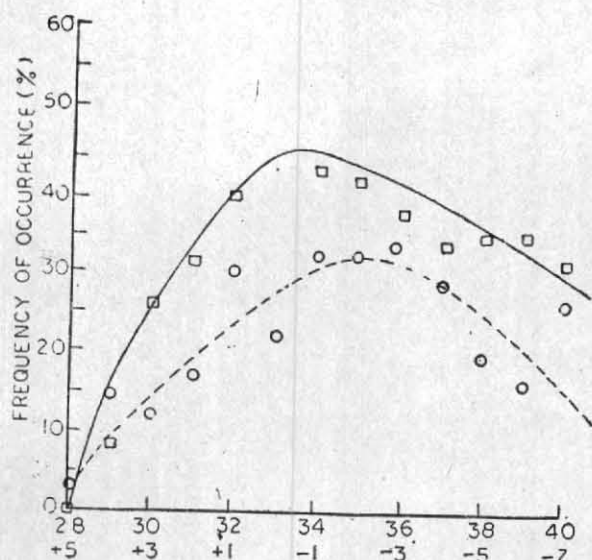


Fig. 1

--- George's instability value K

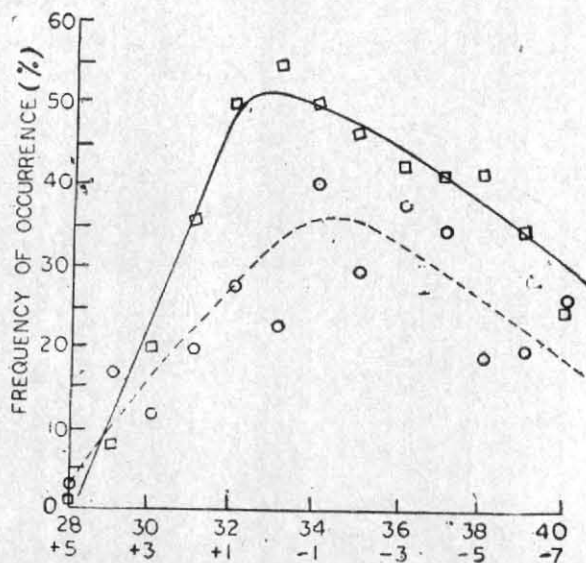


Fig. 2. 00 GMT ascents

--- Showalter's stability index (S.I.)

*K* values or decreasing Showalter's index values. The reason of this may be our presumption that characteristics of the atmosphere remain unaltered during the interval between radiosonde observation and occurrence of thunderstorm.

Examination of Table 1 shows that Showalter's stability index was *plus* 5 or more on 317 occasions out of 1200 occasions studied, and that thunderstorms have occurred on 3 per cent of these occasions while examination at Table 2 shows that *K* instability value was 28 or less on 579 occasions out of 1200 occasions and that thunderstorm have occurred only on two of these occasions, thus we find that probability of occurrence is only 0.3 per cent when *K* value is 28 or less. Therefore, non-occurrence of thunderstorm can be predicted with much more reliability and on many more occasions by calculating *K* instability values than by Showalter's stability index (S.I.).

The curves of percentage of occurrence of thunderstorms over Calcutta Airport for the various values of Showalter's stability index and George's instability value *K* are shown in Fig. 1. These curves clearly bring out the greater utility of George's *K* value compared to Showalter index for predicting thunderstorms over Calcutta Airport.

#### 4. Prediction of thunderstorm over Calcutta Airport from the morning (00 GMT) ascent

The curves of percentage of occurrence of thunderstorm over Calcutta Airport during the pre-monsoon months March to June for the various values of Showalter's stability index of the morning (00

GMT) ascents (Table 1) and for the various values of George's instability value *K* of the morning (00 GMT) ascents (Table 2) are shown in Fig. 2. The curve of George's instability value *K* shows that chance of occurrence of thunderstorm during the next 15 hours is about 50 per cent when *K* value of 00 GMT ascent lie between 32 and 35 and that chance of occurrence is about 45 per cent when *K* value lies between 31 and 39. This curve also shows that when *K* value is 28 or less, the probability of occurrence of thunderstorm during the next 15 hours is less than 1 per cent.

From the George's instability value *K* curves shown in Figs. 1 and 2, it is found that the chance of occurrence of a thunderstorm during the next 15 hours is about 38 per cent when *K* value based on 12 GMT ascent lies between 32 and 35 and that the chance of occurrence is about 34 per cent when *K* value of 12 GMT ascent is between 31 and 39. This indicates that George's instability value *K* of 00 GMT ascent has greater forecasting value than George's instability value *K* of 12 GMT ascent for predicting thunderstorm over Calcutta Airport.

While non-occurrence of a thunderstorm during the next 15 hours over Calcutta Airport can be predicted with reasonable certainty by calculating George's instability value *K* alone; for making a precise forecast of occurrence of a thunderstorm, the knowledge of the last two parameters (low level convergence and upper air divergence) is also essential. These elements can be judged subjectively by inspecting surface and upper air charts.



### 5. Low level convergence

It has been demonstrated by many research workers that the low level convergence is a necessity for generation of thunderstorm activity. The suitable conditions for producing low level convergence for generation of nor'westers is the existence of a low level 'low' to the west of Calcutta or the intensification or extension of the seasonal trough into Gangetic West Bengal. The low level velocity convergence associated with straight southerly flow at least upto 3000 ft asl, is also a fitting condition for causing thunderstorm over Calcutta and neighbourhood.

### 6. Upper air divergence

The superposition of upper air divergence over a low level convergent area represents an ideal picture for an intense thunderstorm. The upper air divergence can be judged subjectively by examining flow patterns at 300 and 200-mb levels. Koteswaram and Srinivasan (1958) pointed out that upper air divergence responsible for Nor'westers over West Bengal occurs in association with high level perturbations. The various types of these perturbations are: (i) a trough (or ridge); (ii) a straight jet stream; (iii) a trough (or ridge) with an embedded jet and (iv) an anticyclonic vortex. In the case of scarcity of data at high levels on the constant pressure charts, the passage of these perturbations can be detected by inspecting vertical time-sections of winds over Calcutta. A few illustrations when thunderstorms

occurred over Calcutta with the passage of different types of perturbations are given by Ramaswamy (1956) and by Koteswaram and Srinivasan (1958).

### 7. Result

The results of this study are :

1. George's  $K$  instability value which can be very easily calculated directly from radiosonde observation (without even plotting the tephigram) give far better indication for the occurrence or non-occurrence of a thunderstorm than Showalter's stability index.

2. If the value of George's  $K$  instability index works out to be 28 or less in the morning or evening radiosonde observation of Calcutta Airport, during the months of March to June (which happened on 48 per cent of occasions studied), non-occurrence of thunderstorm during the next 15 hours can be predicted with reasonable certainty.

3. Thunderstorm is likely to occur over Calcutta Airport and neighbourhood, if in addition to suitable  $K$  instability value, conditions are favourable for producing low level convergence and upper air divergence.

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