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An objective method of forecasting thunderstorm over Dundigal airfield and neighbourhood in the pre-monsoon season

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ABSTRACT. In this study an attempt has been made to provide an objective method of forecasting thunderstorm activity over Dundigal airfield and neighbourhood during the pre-monsoon season (March to May). Inter-relationships of a number of meteorological parameters in the context of subsequent convective activity were studied by means of frequency tables. The six parameters, chosen were surface dew point, surface wind direction, Showalter stability index, wind direction at 850 mb, mean mixing ratio from 850 to 700 mb, and convective condensation level. These were combined graphically by correlation technique to form an objective forecasting aid.

The method was tested on independent data and the results were found to be in good agreement with the observations. A skill score of 0.72 and a percentage accuracy of 87% were achieved.

1. Introduction

A method of quick check on the possibility of thunderstorm occurrence has been developed by Showalter (1953) in which the 850 mb parcel, for mountain area stations a higher level, is lifted dry adiabatically to saturation and then pseudo-adiabatically to 500 mb. The lifted 500 mb temperature is then subtracted algebraically from the observed 500 mb temperature. A negative value shows instability (rising air warmer than the environment) and a positive value indicates stability.

This study aims to set up an objective technique for a Yes or No forecast of thunderstorm activity in the pre-monsoon period (March to May) over Dundigal airfield and neighbourhood for the period 1100 to 2100 IST (0530 to 1530 GMT).

Surendra Kumar (1972) had used a similar technique for forecasting thunderstorms/dust-storms in pre-monsoon season over Delhi and neighbourhood. A skill score of 0.45 and a percentage accuracy of 78 per cent were obtained by him.

2. Data used

The surface weather data for the period 1972 to 1977 were extracted from the current weather registers of Dundigal airfield while the upper winds and temperatures were extracted from the upper air data of Begumpet.

To ensure that the data used would be representative of Dundigal airfield and neighbourhood, the following criteria were used to define a thunderstorm period:

(*a*) Thunderstorm, thundershower, squall recorded at Dundigal airfield.

(*b*) *Cb* cloud recorded at Dundigal airfield.

The above criteria yielded a total of 181 occasions of thunderstorm occurrence for the months March to May during the years 1973-77. This comprised the development data. The period March to May 1972, was used to test the procedure and would be referred to as independent test data.

3. Selection of parameters

A number of meteorological parameters which were considered useful in the forecasting of thunderstorm were analysed and their dependence on occurrence of thunderstorm was studied by means of frequency tables as shown in Tables 1 to 6. The following parameters which showed the maximum dependence on the occurrence of thunderstorm activity were selected:

(*a*) Surface wind direction (0000 GMT).

(*b*) Surface dew point temperature (0000 GMT).

(*c*) Showalter stability index (1200 GMT of previous day).

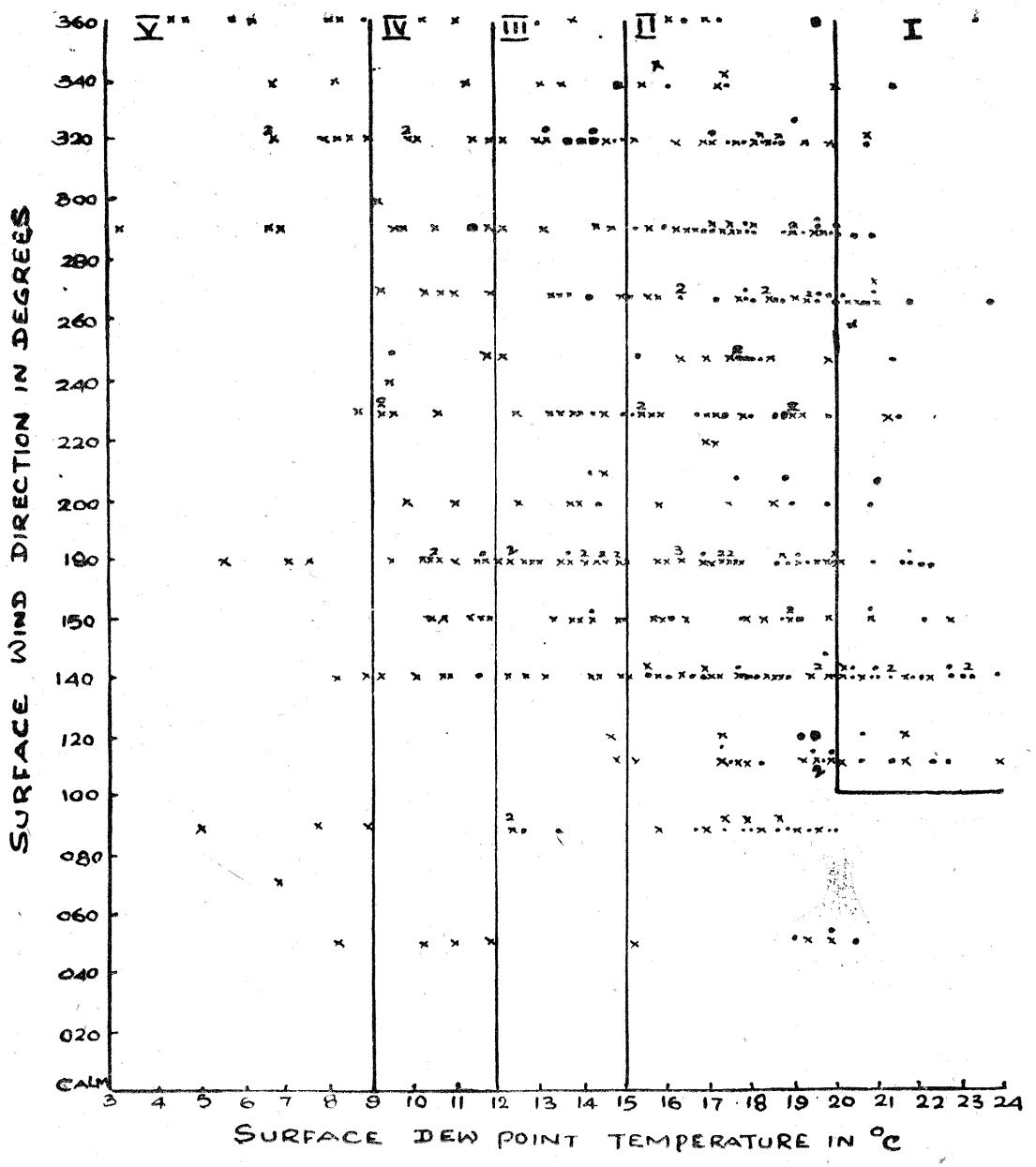

Fig. 1

TABLE 1

Stability index

	⩾—6.0	—5.9 to —5.0	—4.9 to —4.0	—3.9 to —3.0	—2.9 to —2.0	—1.9 to —1.0	—0.9 to 0.0	0.1 to 1.0	1.1 to 2.0	2.1 to 3.0	3.1 to 4.0	4.1 to 5.0	5.1 to 6.0	>6.0
Total No. of days	22	11	19	28	34	33	38	19	37	47	26	33	17	38
No. of days of thunderstorm	16	9	13	18	17	16	17	8	10	14	8	10	5	14
Percentage	72.7	81.8	68.4	64.2	50	48.5	44.7	42.1	27.2	29.78	30.76	30.3	29.4	36.8

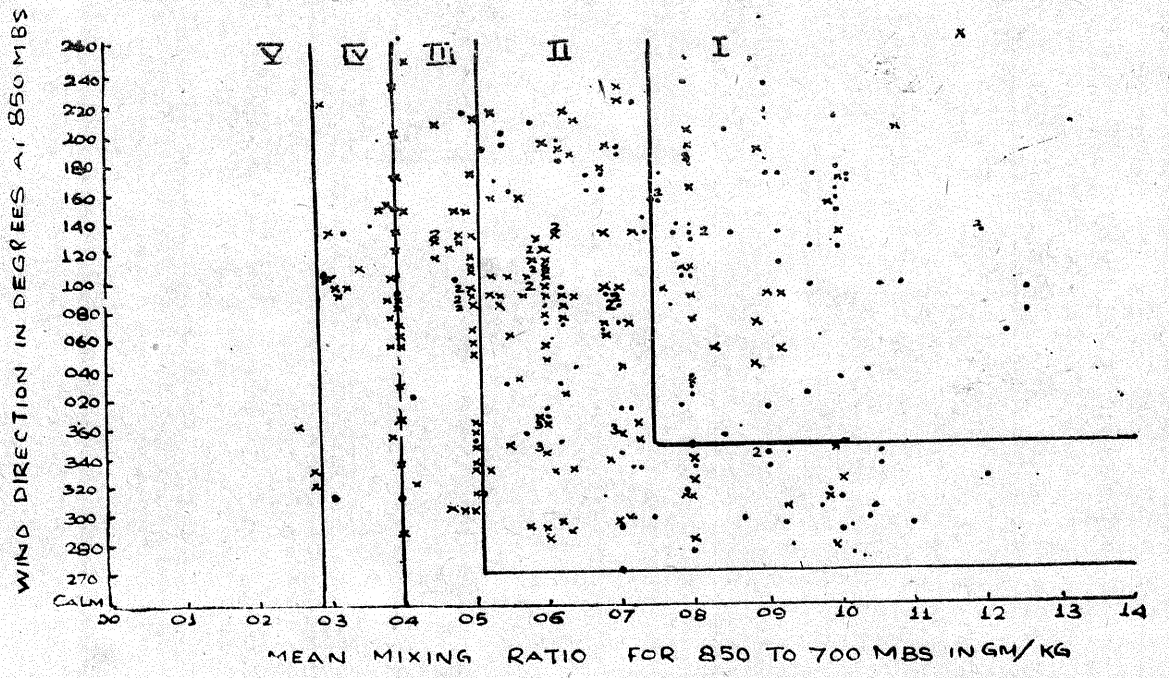

Fig. 2

TABLE 2

Surface wind direction

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
Total No. of days	22	8	14	8	23	34	61	34	49	24	33	15	34	45	42	24
No. of days of thunderstorm	7	3	4	3	7	13	29	8	19	9	15	7	20	18	15	10
Percentage	31	37	28	37	25	38	47	23	38	37	45	46	58	40	35	41

(*d*) Wind direction at 850 mb (1200 GMT of previous day).

(*e*) Convective condensation level (1200 GMT of previous day).

(*f*) Mean mixing ratio from 850 to 700 mb (1200 GMT of previous day).

The parameters (*a*), (*c*) and (*d*) were selected because they represented the influence of the lower level instability on thunderstorm occurrence while (*b*), (*e*) and (*f*) were selected because they highlighted the influence of the lower level and higher level moisture.

4. Combination of parameters

After testing various combinations of parameters, the following combinations were selected and scatter diagrams plotted:

(*a*) Surface wind direction and surface dew point temperature.

(*b*) Mean mixing ratio from 850 to 700 mb and wind direction at 850 mb.

(*c*) Showalter stability index and convective condensation level.

Using the first combination of surface wind direction and surface dew point temperature a scatter diagram (Fig. 1) was plotted (a dot representing an occurrence and a cross representing a non-occurrence). The number shown against a dot or cross represents its frequency. Similarly scatter diagrams for the combinations (*b*) and (*c*) were also plotted (Figs. 2 and 3).

Using the category number of Figs. 1 and 2, a fourth scatter diagram was plotted in which the numerators represented the number of thunderstorm periods and the denominators represented the total number of cases, with the indicated category numbers from Figs. 1 and 2.

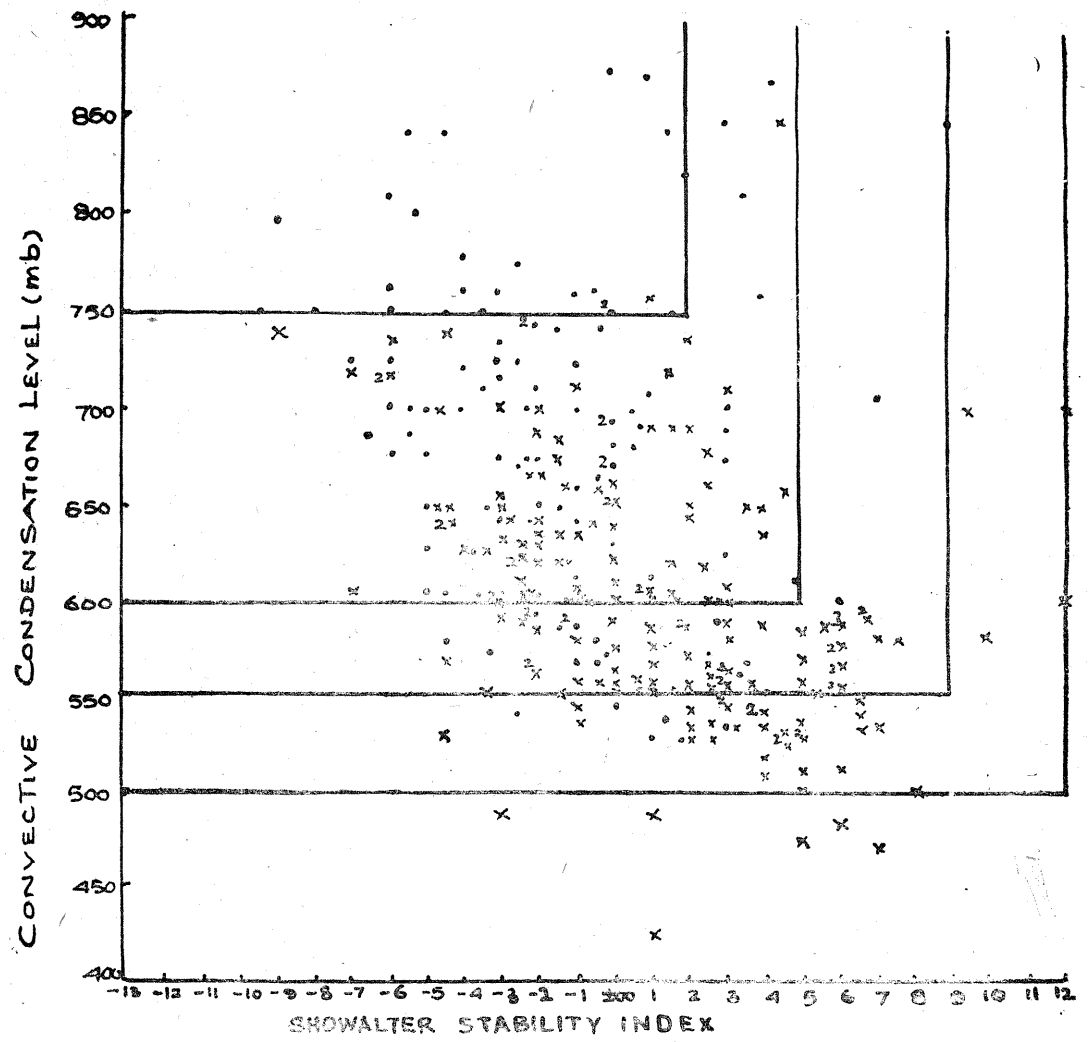

Fig. 3

TABLE 3

Surface dew point temperature

Dew point temp. (°C)	Total number of days	No. of occurrences	Percentage
⩽15	171	24	14
15.1-16	48	13	25
16.1-17	46	17	37
17.1-18	70	30	43
18.1-19	53	24	44
19.1-20	82	44	53
20.1-21	39	22	60
>21	54	37	70

TABLE 4

Mean Mixing Ratio (850 to 700 mb)

MMR (gm/kg)	Total No. of days	No. of days of thunderstorm	Percentage
⩽3	15	1	6
3.1 to 4.0	40	6	15
4.1 to 5.0	41	7	17
5.1 to 6.0	75	22	30
6.1 to 7.0	80	36	45
7.1 to 8.0	64	34	53
8.1 to 9.0	25	15	60
9.1 to 10.0	36	25	69
>10·0	22	13	81

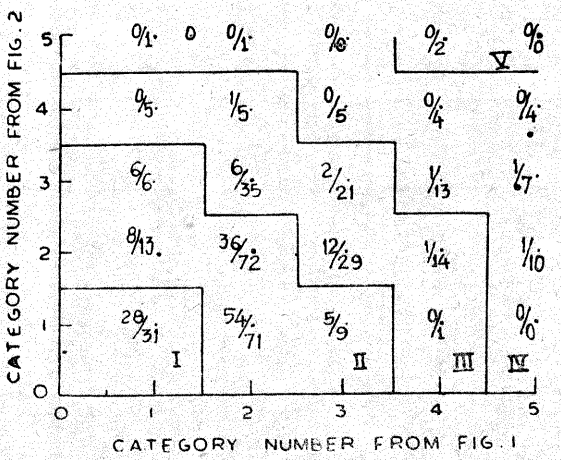

Fig. 4

TABLE 5

Convective Condensation Level (CCL)

CCL range (mb)	Total No. of days	No. of days of thunderstorm	Percentage
400-500	20	2	10
501-600	152	35	23
601-700	148	70	47
701-800	60	45	75
>800	18	15	84

Using the category numbers from Fig. 3 and Fig. 4 a fifth scatter diagram was plotted wherein the denominator represented the total number of cases with the indicated category numbers from Figs. 3 and 4 and the numerator represented the number of cases of thunderstorms. This figure was divided into two parts by a solid line, representing 50 per cent probability of occurrence. The area on the left hand side representing the probability higher than 50 per cent was taken as Yes forecast and the one on the right hand side was taken as No.

5. Results and tests

The procedure was tested on the independent test data, of 1972 (March to May). The skill score turned out to be 0.72 and percentage accuracy was 87 per cent.

1972 (Independent test data)

		Forecast		
		Occurrence	Non-occurrence	Total
Observed	Occurrence	30	5	35
	Non-occurrence	6	41	47
	Total	36	46	82

Skill score 0.72
Percentage accuracy 87 per cent

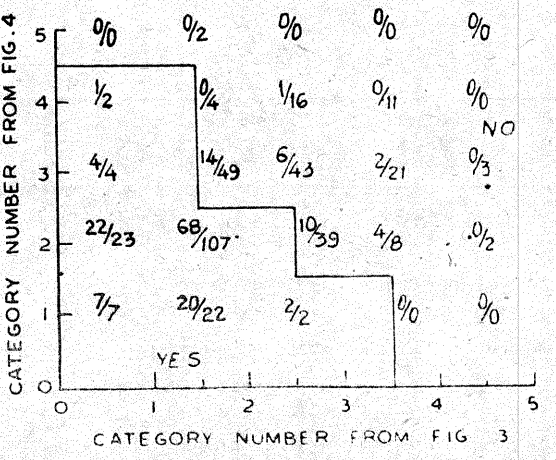

Fig. 5

Data for the year 1977 was also used to test the procedure. The skill score was 0.68 and percentage accuracy 84 per cent.

1977 (Development data)

		Forecast		
		Occurrence	Non-occurrence	Total
Observed	Occurrence	35	8	43
	Non-occurrence	4	29	33
	Total	39	37	76

Skill score 0.68
Percentage accuracy 84 per cent

6. Application of technique

(*a*) Evaluate the various parameters, *i.e.*, stability index, mean mixing ratio and convective condensation level from 1200 GMT tephigram.

(*b*) Plot the surface wind direction and surface dew point temperature of 0000 GMT in Fig. 1 and find the category number.

(*c*) Plot the mean mixing ratio and wind direction at 850 mb of 1200 GMT in Fig. 2 and find the category number.

(*d*) Plot the stability index and convective condensation level of 1200 GMT in Fig. 3 and find the category number.

(*e*) Using the category number from Figs. 1 and 2, find the category number in Fig. 4.

TABLE 6

Wind direction at 850 mb

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
Total No. of days	49	15	8	21	24	30	30	25	30	34	23	21	15	32	38	45
No. of days of thunderstorm	10	3	2	3	4	7	4	8	12	10	4	5	6	8	15	12
Percentage	20.4	20	25	14.2	16.6	23.5	13.3	32	33.3	29.4	17.3	23.6	40	25	34.2	26.6

(*f*) Using the category number from Figs. 3 and 4 and the plot on Fig. 5, find the area in which it falls (to the left or right of solid line) and determine the appropriate Yes/No forecast.

Acknowledgement

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