551·515·4 (541) "33·3/33·5"

Thundersqualls at Jamshedpur during pre-monsoon months, March to May

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(Received 12 June 1969)

ABSTRACT. The paper presents the results of study of pre-monsoon thundersqualls at Jamshedpur, in Bihar Plateau. The study has been made on the basis of detailed and critical analysis of data provided by autographic meteorological instruments at the station, recording elements of wind, pressure, temperatures and rainfall during five pre-monsoon seasons, March to May, 1962-66.

1. Introduction

The month of March marks the transition from the winter to summer over north India, when the prevailing anti-cyclonic circulation of the winter season begins to give way to a shallow low pressure area, with its central region over Bihar and West Bengal. Occasionally, the low gets accentuated due to the passage eastward of a secondary western disturbance across the region, or as a result of the progressively moving wave of low in the upper air westerlies. Under the influence of the surface low an incursion of relatively moist air tends to occur over the region, although in many instances the moist air flow is restricted to a height below 1 km or even less. As the season progresses, the low pressure system becomes somewhat deeper, and the resulting inflow of moist air extends to a height of some 1·5 to 2·0 km. The wind flow in the upper air, brings in air of continental character, with a fairly high lapse rate of temperature approaching dry adiabatic. The over-running of the convectively unstable moist air below, by dry air above results in a certain degree of latent instablility in the atmosphere, favouring development of thunderstorms which may sometimes be quite severe. Rainfall accompanying the thunderstorm provides a welcome relief to the rather prolonged drought conditions, or scanty rainfall during winter months, and helps bring down the day temperature to a good extent.

The studies on the subject of pre-monsoon thundersqualls (Nor'westers) in Bengal has engaged attention by meteorologists in India— Sohoni (1928), Sohoni and Paranjpe (1937), Desai and Mull (1938), Mull and Rao (1950), Desai (1950), and Desai and Rao (1954). Such studies have in general been based on a close and critical study of the happenings in Calcutta and neighbourhood. The present study is based on a detailed examination of the features as brought out by autographic records at Jamshedpur.

2. Analysis of data

All available data, provided by the autographic records of wind, pressure, temperatures and rainfall during the five pre-monsoon seasons, 1962-66, have been studied closely, with reference to 71 thundersqualls at Jamshedpur in which the peak value of wind speed reached 50 km/hr and above. Very mild squalls, and also those which occurred within an hour of incidence of an earlier squall, have not been taken into account.

In general, the squalls have been grouped under two heads, (A) moderate (50-69 km/hr) and (B) strong to severe with speed 70 km/hr and more.

3. Month-wise distribution of squalls

A general examination of the squalls at the station (Table 1) shows that these are more frequent during the months of April and May, compared with those occurring during March. This feature is more prominently brought out when we consider strong to severe squalls, that is, squalls belonging to group B.

It is further seen from Table 1 that the squalls occurring in April and May are, on the average, more intense than those during March.

4. Direction and intensity of squalls

The frequencies of squalls from the eight directions of the compass are shown in Table 2. Considering squalls from the three direction groups, (*i*) NE to SE (directions having easterly component)

TABLE 1

Frequency of squalls occurring during the three months

Group	Mar	Apr	May	Total
A	8	9	14	31
B	5	17	18	40
A and B	13	26	32	71
Average peak speed (km/hr)	68	77	74	—

TABLE 2

Frequency of squalls from different directions

	NE	E	SE	S	SW	W	NW	N	Total
No. of squalls from each direction	5	1	3	2	3	13	34	10	71
Av. peak speed (km/hr) of squalls belonging to (*i*), (*ii*) and (*iii*)		62		69			75		
Speed range (km/hr)		56–94		58-79			52-114		
Distribution under A and B		A-5 B-4		A-4 B-4			A-23 B-34		

TABLE 3

Thundersqualls during different 3-hr periods (IST)

Group	00-03	03-06	06-09	09-12	12-15	15-18	18-21	21-24	Total
A	1	—	—	—	5	16	6	3	31
B	—	1	1	—	3	22	12	1	40
A and B	1	1	1	—	8	38	18	4	71

(*ii*) SE to SW (directions having S'ly component), and (*iii*) W to N (typical Nor'westers), certain interesting features relating to these squalls are observed and are included in the table.

It is seen that by far the most frequent are squalls from directions W to N , the percentage frequency being as high as about 80.

5. Diurnal variations of squalls

Dividing the day into eight 3-hr periods, the number of squalls which hit Jamshedpur during different epochs of the day are given in Table 3.

Considering all the squalls, it is seen that the two 3-hr periods, 15 to 18 hr, and 18-21 hr IST are most susceptible to development of thundersqualls at the station, there being as many as nearly 80 per cent of them occurring during these hours.

6. Abrupt changes in meteorological elements, associated with squalls

Pressure change— As is well known, abrupt changes in meteorological elements, notably, pressure and temperature (dry and wet bulb) are associated with a squall at a station. As regards pressure, this in most cases is an abrupt rise. The magnitude of pressure jump is usually greater, the greater the peak speed reached in the squall, although this trend may not hold good in all individual instances of squalls. The postulation of Roy and Mukherjee* has been largely confirmed by our findings in relation to the squalls at Jamshedpur (Table 4).

Besides, the maximum speed reached in a squall, there are certain other factors also, which appear to govern the magnitude of the pressure jump.

*Following the principle underlying Bernoullis' theorem, A. K. Roy and B. K. Mukherjee, in their findings on 'Pre-monsoon thundersqualls in Gangetic West Bengal' (under publication) have suggested the square law, indicating that the rise of pressure is proportional to the square of the peak speed reached in a squall.

Amongst these, the more important is the direction from which the squall comes. This is being dealt with separately.

Dry and wet bulb changes — The passage of a squall over a station is almost invariably accompanied by a fall in dry bulb (D. B.) temperature . The time when the fall in D. B. temperature starts usually coincides with the beginning of squally weather (*i.e.*, when the average speed reached in gust attains about 30 km/hr). In other words the first phase of the squall life ushers in a drop in temperature when the horizontal drift of air from the cold downdraft reaches the station concerned. The average fall in dry bulb temperature in groups A and B of squalls is 3·6° C and 6·1°C respectively. A fall in wet bulb temperature also occurs, although the fall is usually small—the mean value, in the case of squalls coming under groups A and B being of the order of 0·5°C and 1·5°C respectively.

Precipitation features associated with a squall — As we all know, the precipitation behaviour of two thunderstorms may differ considerably, although the intensity of the storm is approximately the same. One important difference that has been noted in this regard relates cases in which (*a*) rain precedes the squall maximum, (*b*) rain follows the squall maximum and (*c*) little or no rain is associated with the spuall. In general, it is seen that, for the squall speed of the same order, the associated pressure rise is appreciably greater in the case in which the peak speed is reached after the commencement of rain, than in the cases when rain follows the squall maximum. Also, the pressure jump is the least in the cases of squalls not accompanied by any measureable rain. Table 5 gives the detailed features in this regard.

An interesting feature that has been noted in this connection is that, out of the 9 cases of squalls from directions having an E' ly component amongst the 71 squalls examined, there is no instance of rain following the epoch of squall maximum*.

7. Comparison of squalls from directions having northerly and southerly components

Table 6 brings out certain characteristic differences in regard to the meteorological elements and their changes, associated with N'ly as against S'ly squalls.

It is seen from the table that the magnitude of pressure rise is significantly smaller in the

TABLE 4

Pressure change associated with squalls belonging to different speed groups

Speed range (km/hr)	No. of cases	Mean speed (km/hr)	Mean pressure change (mb)
50–59	11	56	+0·8
60–69	20	65	+0·9
70–79	17	74	+1·0
80–89	13	84	+1·6
90–99	8	93	+2·5

TABLE 5

Squalls and associated precipitation behaviour

Pecipitation features	Average speed (km/hr)	Average pressure (km/mb)	Rainfall (mm)
Group A			
(a) Rain precedes squall maximum	63	+1·4	2·5
(b) Rain follows squall maximum	60	+0·9	0·9
(c) Squall without measurable rain	62	+0·7	0·0
Group B			
(a) Rain precedes squall maximum	84	+2·0	8·3
(b) Rain follows squall maximum	84	+1·8	4·1
(c) Squall without measurable rain	81	+1·3	0·0

TABLE 6

Squalls from some N'ly and S'ly directions and associated changes in meteorological elements

Group	Speed (km/hr)	Pressure (mb)	D.B. (°C)	W.B. (°C)	Rainfall (mm)
Squall having N'ly components					
A	61	+0·8	—3·6	—0·8	1·1
B	86	+1·9	—7·0	—1·6	5·0
Squalls having S'ly components					
A	65	+0·5	—3·9	—0·3	0·5
B	73	+0·8	—1·6	—0·2	2·5

This also provides another corroboration of the findings reached by Roy and Mukherjee referred to earlier case of southerly squalls, compared with those coming from some northerly direction.

A similar trend as in the case of pressure change has also been noted generally in relation to temperature changes and amount of rainfall associated with squalls of the two categories.

8. Acknowledgement

The authors are grateful to Shri A. K. Roy for having kindly read through the manuscript and for his many helpful suggestions. They also wish to express their thankfulness to Shri J. Basu for help in collection and tabulation of data used for the study.

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*The explanation given by Roy and Mukherjee in the unpublished paper (*loc. cit.*) is that the prevailing wind on a day favourable for a thundersquall being from some southerly direction, while a southerly squall attaining a certain peak speed, say V km/hr, means superposition on the prevailing S-ly wind, with mean speed v km/hr of the horizontal drift of air from the squall head, of speed $(V-v)$ km/hr in the case of N-ly squall of the same intensity it involves superposition of a much stronger horizontal drift, with speed $(V+v)$ km/hr