551·515 : 515·55 (545·8)

Squalls over east Uttar Pradesh

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(*Received 2 January 1964*)

ABSTRACT. A statistical study of squalls over east Uttar Pradesh is presented in this paper. A comparison of squalls occurring over east Uttar Pradesh with those occurring over Jodhpur station in west Rajasthan has been made and salient features have been brought out.

1. Introduction

East Uttar Pradesh is susceptible to squalls of high intensity as is shown by the squall at Bamrauli (Allahabad) on 21 March 1950 which reached the peak speed of 101 mph, the highest ever recorded in squalls over India. In order to find out how far this region is susceptible to squalls, the results derived from the climatological study of the available squalls data of Allahabad and Lucknow are given in this paper. For the purpose of study the standard definition of squall, *viz.*, a sudden increase of wind speed by at least 3 stages on the Beaufort Scale, reaching at least 22 kts and lasting for at least one minute has been taken into consideration. The frequency of occurrence of squalls at Jodhpur, a station in west Rajasthan which is situated near about the same latitudes as Allahabad and Lucknow but about 700 km to the west of the east Uttar Pradesh region has also been given and a comparison made with the frequencies of squall over east Uttar Pradesh.

2. Data utilised

Only two observatories, *viz.*, Allahabad (Bamrauli) and Lucknow (Amausi) situated in east Uttar Pradesh have been provided with Dines P.T. anemograph. The anemograph data of Bamrauli are available from 1948 onwards while that of Lucknow are only available from 1954. Hence, the data for 15 years (1948-62) in respect of Bamrauli and for 9 years (1954-62) of Amausi have been utilised for this study.

3. Monthly distribution of squalls

Fig. 1 shows the monthly distribution of squalls (for different years) for Allahabad, Lucknow and Jodhpur. This figure also shows that — (1) The month of November is completely free from squalls over east Uttar Pradesh, (2) In the winter months December to February occurrence of squalls is very infrequent. Only one squall in three or four years is expected to occur in January or February while in December the frequency is still less, (3) June is the month most susceptible to the occurrence of squalls and May is having the second largest frequency. These two months together account for 40 to 50 per cent of total number of squalls, (4) The monsoon months July, August and September account for about 30 per cent of the squalls. If we take second half of June also into account, as normally monsoon sets in over east Uttar Pradesh by the middle of June, then the frequency of squalls during monsoon period would be appreciably more, (5) Allahabad is much more prone to squalls than Lucknow in March.

When the squall frequencies of the three stations (Fig. 1) are compared, the following similar features are noticed —

(1) The largest number of squalls occur in June at Jodhpur as well as in east Uttar Pradesh and

(2) November is completely free from squalls while their occurrence is rare in winter months December to February.

The following differences are also noticed —

(1) October is completely free from squalls at Jodhpur, while the frequency of squalls in east Uttar Pradesh in October is appreciable, mostly confined to first half of the month, and

(2) At Jodhpur the frequency of occurrence of squalls in the monsoon month July is more than that of May. The figures of Allahabad and Jodhpur show minima in April and another one in August between the months January and September. Lucknow also shows the minima in April but the second minima in August is not shown. This may be due to the fact that Lucknow data are for a shorter period.

In this connection it will be worthwhile to mention something about the period which should

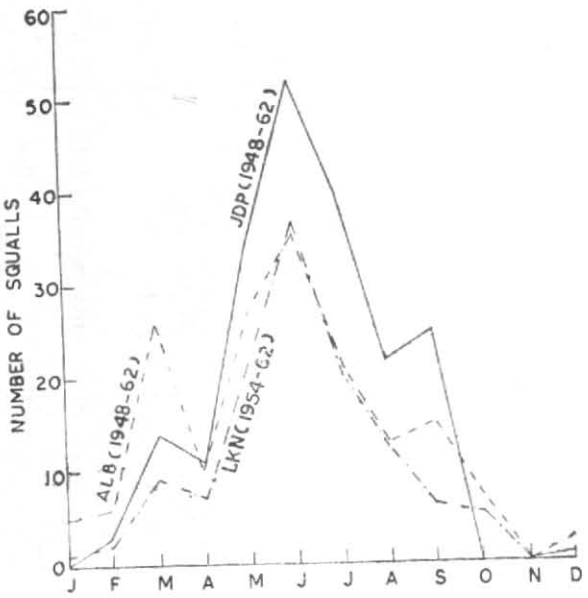

Fig. 1. Frequency of squalls

LKN — Lucknow, JDP — Jodhpur ALB — Allahabad

be used to have a reliable idea about the diurnal and monthly variation of squall frequency at a place. Normally, 5 years period is considered to be the minimum to have an idea about the frequency of a weather element at a place. However, for squalls a period of 5 years does not appear suitable as is shown by the frequencies given by Ramakrishnan and Gopinatha Rao (1954) for Allahabad. These figures were based on the 5 years period (1948-52) and are reproduced below –

Jan	Feb	Mar	Apr	May	Jun
1	2	6	1	12	5

Jul	Aug	Sep	Oct	Nov	Dec	Total
11	1	5	1	0	2	47

These figures show that at Allahabad maximum number of squalls occur in May and July while June is fourth along with September. However, Fig. 1 shows that for Allahabad June is undoubtedly the month having most squalls and the frequency in June is more than double than that of September. Another example could be given about Nagpur whose squall data for the period 1948-62 have been studied by the author. Ramakrishnan and Gopinatha Rao (1954) had given the squall frequency for Nagpur based on 1948-52 data as under —

Jan	Feb	Mar	Apr	May	Jun
0	7	5	10	22	25

Jul	Aug	Sep	Oct	Nov	Dec	Total
15	7	5	2	0	0	98

While the author has found the squall frequency for Nagpur based on 1948-62 data as —

Jan	Feb	Mar	Apr	May	Jun
3	7	38	36	67	126

Jul	Aug	Sep	Oct	Nov	Dec	Total
46	24	28	16	0	2	393

A comparison of figures for February, March and April shows very wide and interesting differences. Further in Ramakrishnan's table the frequencies for May and June are nearly equal while in the other table based on 15 years data June frequency is nearly double that of May. It shows, therefore, that a 5-year period is quite insufficient to give a correct idea of squall frequency distribution. Since squall data of a much larger period than 15 years are not available it cannot be said with any amount of certainty that the period of 15 years is the optimum period for showing the squall frequency distribution at a place. However, since squall is a very variable phenomenon it is felt that a minimum period of 15 years data should be used to have a fair idea of the monthly and seasonal variation of squalls at a place.

4. Diurnal variation of squalls

Figs. 2(a), 2(b) and 2(c) give the percentage frequency of diurnal variation of squalls in three-hourly intervals for Allahabad, Lucknow and Jodhpur. From Figs. 2(a) and 2(b) it is seen that (*i*) the largest frequency is between 15 and 18 IST and about 30 per cent of squalls occur during these hours, (*ii*) about 22 per cent of squalls occur between 18-21 IST and hence the 6-hour period 15-21 IST accounts for slightly more than 50 per cent of all squalls, (*iii*) Allahabad shows another large frequency of occurrence between 00-03 IST when about 16 per cent of squalls occur mostly during March to June. This characteristic is not shown by Lucknow, (*iv*) the frequency between 03 and 12 IST is least,

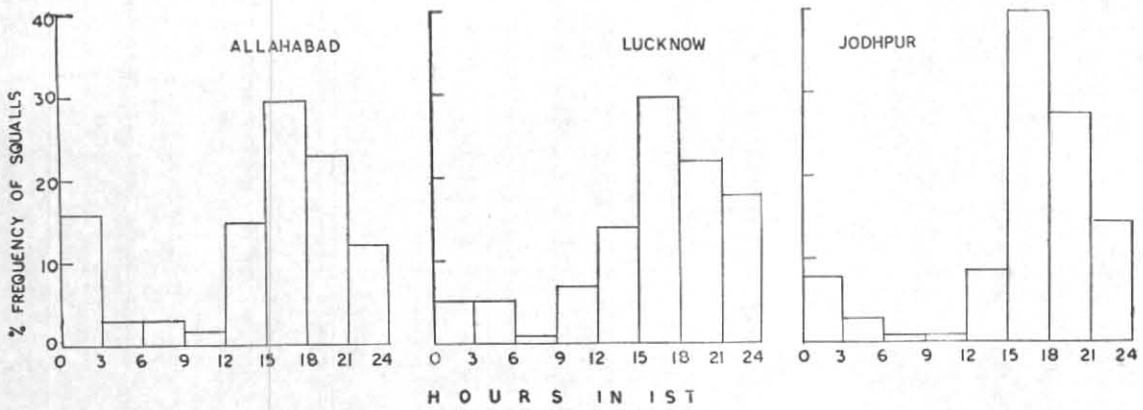

Fig. 2. Diurnal variation of squalls (Annual)

only about 10 per cent of squalls occurring during these hours.

As regards Jodhpur (Fig. 2c), the general pattern of distribution of squalls is roughly the same as at Allahabad except for the following differences —

(*i*) The peak between 00-03 IST (similar to Allahabad) is not shown,

(*ii*) 67 per cent (two-thirds) of squalls occur between 15-21 IST as against only 50 per cent over east Uttar Pradesh, and

(*iii*) The frequency of occurrence between 03-12 IST at Jodhpur (4 per cent) is much less than that over east Uttar Pradesh.

Diurnal variation of squalls with reference to their duration — Tables 1(a) to 1(c) show the diurnal variation of squalls at Allahabad, Lucknow and Jodhpur for each month with reference to their duration. These tables have been sub-divided for the duration limits of squalls (1) $\leqslant$10, (2) 11-20, (3) 21-30 and (4) $>$30 minutes. The percentage frequency of monthly totals with reference to the total frequency of squalls has also been indicated. These tables reveal the following salient features—

(*i*) Between 70 to 75 per cent squalls over east Uttar Pradesh are of short duration of $\leqslant$10 minutes. For Jodhpur, this frequency is much less, *viz.*, only 55 per cent

(*ii*) 12 to 17 per cent squalls over east Uttar Pradesh have a duration of 11-20 minutes and they mostly occur in the months of March, May and June, whereas its frequency is much greater over Jodhpur, being 31 per cent and these mostly occur in the months of May, June and July.

(*iii*) The frequency of long duration squalls, *viz.*, greater than 30 minutes duration is quite small (3 to 4 per cent) over east Uttar Pradesh and these mostly occur in summer months and have a definite bias for early morning hours 00-03 IST. Similar squalls frequency is double at Jodhpur (8·5 per cent) and these occur in summer months April to June and in September.

Diurnal variation of squalls with reference to their maximum speed — Tables 2(a) to 2(c) give the frequency distribution of squalls with reference to the maximum speed reached for Allahabad, Lucknow and Jodhpur. These tables have been sub-divided for the following speed limits — (1) $\leqslant$30, (2) 31-40, (3) 41-60, (4) 61-80 and (5) $>$80 kts.

The following salient features can be observed from these tables —

(*i*) About 40 per cent of squalls over east Uttar Pradesh have maximum speed of 30 kts or less, *i.e.*, they are mild. Similar frequency for Jodhpur is much less (26·9 per cent).

(*ii*) 32 to 38 per cent, *i.e.*, about one-third of squalls over east Uttar Pradesh as well as Jodhpur have a maximum speed 31-40 kts.

(*iii*) 20 to 25 per cent of squalls over east Uttar Pradesh have a maximum speed of 41-60 kts whereas the frequency over Jodhpur is 33 per cent. May and June are the main months when squalls of such intensity occur over east Uttar Pradesh. For Jodhpur the main months are May, June and July.

(*iv*) The frequency of occurrence of squalls $>$60 kts is negligible (about 2 per cent) both over east Uttar Pradesh and Jodhpur.

5. Direction of squalls

Tables 3 (a) to 3(c) give the monthly precentage frequencies of the number of occasions on which squalls occurred from different directions for Allahabad, Lucknow and Jodhpur respectively. The frequencies have been given in 16 points of compass and the total number of squalls occurring

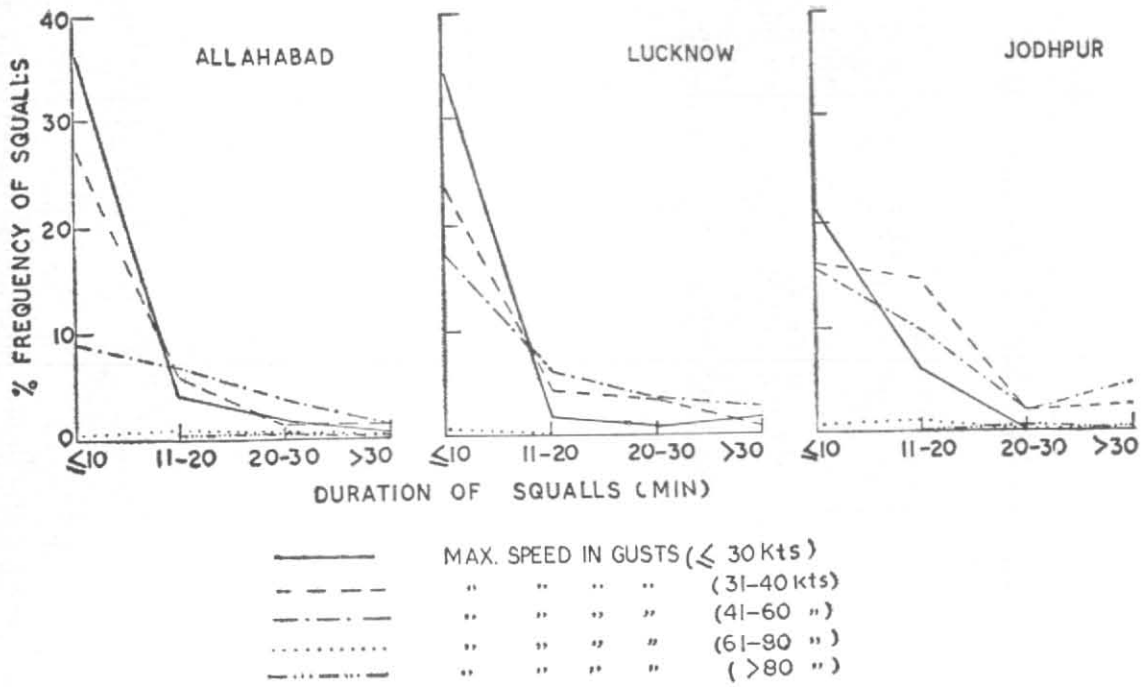

Fig. 3

from any direction for the whole year as well as their percentage frequencies have also been indicated in the tables.

From the tables the following salient features can be seen —

(1) More than 50 per cent of squalls occur from W to N direction at Allahabad.

(2) At Lucknow the main directions of occurrence of squalls are NW to N which account for over 40 per cent of squalls.

(3) At Lucknow the percentage of occurrence of squalls from W/WNW direction is only 6 while for Allahabad it is as high as 24 per cent.

(4) At Jodhpur the main direction of squall is NE from which 25 per cent of squalls occur. This is in contrast to east Uttar Pradesh area where the NE'ly direction account for less than 5 per cent.

(5) At Jodhpur during the months of March, April and May NW/WNW is the main direction of squall while in June and the monsoon months of July to September NE direction becomes the predominant one. Further with the advance of the monsoon season the NE frequency progressively increases while NW'ly frequency becomes negligible.

6. Frequency of squalls with reference to its duration and peak value of wind speed

Figs. 3(a) to 3(c) give the frequency curves of squalls with reference to their duration and the maximum speed recorded in gusts for Allahabad, Lucknow and Jodhpur. Five curves representing the maximum gust speed of $\leqslant$30, 31-40, 41-60, 61-80 and $>$80 kts have been drawn for each station.

From the figures it can be seen that —

(1) The frequency is largest for squalls having a maximum speed of $\leqslant$30 kts and duration $\leqslant$ 10 min. These account for about 35 per cent of the total squalls over east Uttar Pradesh. While at Jodhpur their frequency is significantly low, being only about 20 per cent.

(2) The frequency of squalls having maximum speed $\leqslant$30 kts falls off rapidly as their duration is increased and although squalls of maximum speed $\leqslant$30 kts and duration 21-30 min or more are not unknown over east Uttar Pradesh their frequency is negligible.

(3) At Jodhpur squalls of maximum speed $\leqslant$30 kts and duration more than 20 min do not occur.

(4) The trend in the squalls curves over east Uttar Pradesh is decrease in frequency with the increase in duration of squalls. However, at

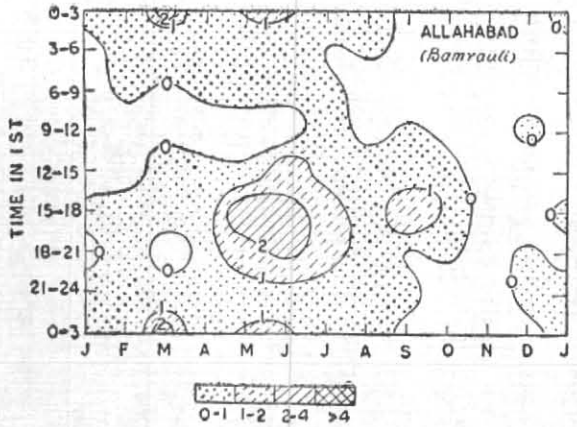

Fig. 4(a). Percentage frequency of occurrence of squalls

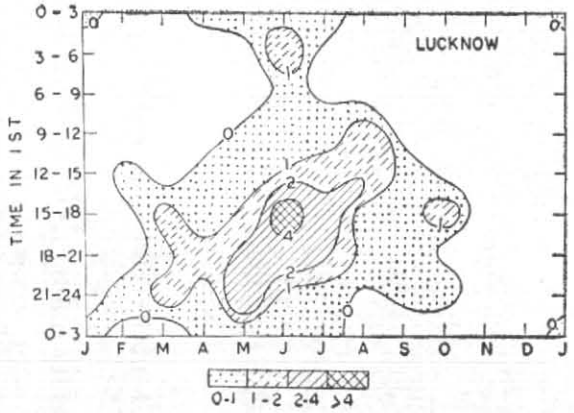

Fig. 4(b). Percentage frequency of occurrence of squalls

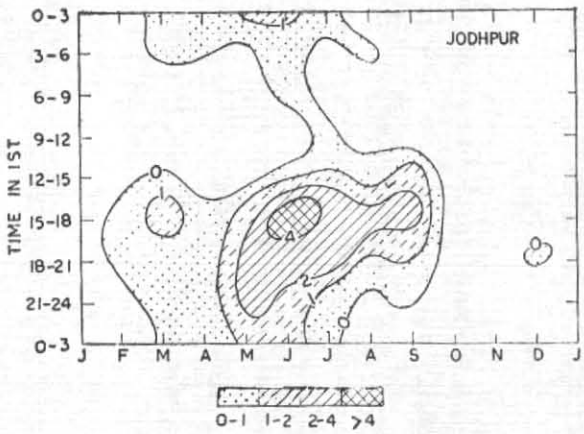

Fig. 4(c). Percentage frequency of occurrence of squalls

Jodhpur the curves of squall frequency having maximum speed 31-40 and 40-60 kts reach a minimum for squall duration 21-30 min and then shows an increase for squalls having duration >30 min. It further shows that most of the squalls at Jodhpur of duration >30 min have maximum gust speed between 41-60 kts.

(5) The frequency of squalls having a maximum wind speed 31-40 kts and duration 11-20 min is quite large for Jodhpur. This feature is not revealed by east Uttar Pradesh stations.

7. Multiple squalls

An examination of squall records of Allahabad and Lucknow shows that multiple squalls are not rare over east Uttar Pradesh. Table 4 gives the details of the occurrence of the multiple squalls at Allahabad and Lucknow.

It is seen from the table that Allahabad recorded 2 squalls in a day on 13 occasions in 15 years and 3 squalls in a day only once. However, Lucknow had recorded 4 and 3 squalls in a day on 1 occasion each and 2 squalls on 4 days in the 9-year period for which records are available. Allahabad does not show any bias for any particular month when 2 squalls occur in a day but it is seen that multiple squalls had occurred only in the afternoon and early part of night. On the other hand at Lucknow it is seen that multiple squalls mostly occur during the months May and June but these can occur even in forenoon hours. Usually there is a shift in wind direction for each squall when multiple squalls occurred. Normally the shift in direction is about 45° when a second squall occurs after a short duration after the first squall but a shift as much as 135° has also been noticed between multiple squalls.

8. Monthly and diurnal variation of squalls

Figs. 4(a) to 4(c) show the percentage frequency of monthly diurnal variation of squalls at Allahabad, Lucknow and Jodhpur. The figures show that the highest frequency of slightly more than 4 per cent

for Lucknow and Jodhpur is in the month of June between 15-18 IST. This means that one squall could be expected during these hours every 20 days on an average in this month. For Allahabad the maximum frequency (2·5 per cent) is between 15-18 IST in May and 15-21 IST in June. Lucknow shows a backward progress of the time of occurrence of maximum squall frequency from May to August. During May the time of occurrence of maximum squall frequency is between 21-24 IST while during August it is 12-15 IST. This feature is not shown by Allahabad although a feature somewhat akin to this is shown by Jodhpur where maximum squall frequency in May occurs between 21-24 IST while during August and September it occurs between 15 and 18 IST. However, Allahabad shows the peculiarity of a maximum squall frequency occurring during 00-03 IST in March which is not shown either by Lucknow or Jodhpur.

9. Conclusion

The study shows that east Uttar Pradesh is less susceptible to severe squalls than west Rajasthan. Not only the squalls occurring over east Uttar Pradesh are less severe but, normally, their duration of occurrence is also less than those occurring over west Rajasthan. It also shows that the remarkable squall of March 1950 at Allahabad which recorded the highest velocity in India (101 mph) was a freak one and the chances of squall of similar intensity occurring are indeed small.

REFERENCE

Ramakrishnan, K. P. and Gopinatha Rao, B. 1954 *Indian J. Met. Geophys.*, 5, 4, p. 337.

TABLE 1(a)

Frequency of squalls duration at Allahabad

Time (IST)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
						⩽ 10 minutes							
0 — 3	2	1	5	1	3	4	1	2					19
3 — 6		1		1		1							3
6 — 9		1		1	1	1							4
9 —12									1			1	2
12—15			4	2		4	3	2	4	2			21
15—18	1	1	1	1	6	4	7	2	8	3			34
18—21		1	3	3	5	6	6	2		1		1	28
21—24	1	1	1		1	1	1	3	1			1	11
Total	4	6	14	9	16	21	18	11	14	6		3	122
% frequency	2·4	3·6	8·3	5·4	9·6	12·6	10·8	6·6	8·3	3·6		1·8	73·0
						11 — 20 minutes							
0 — 3			1			1							2
3 — 6			1					1					2
6 — 9							1						1
9 —12							1						1
12—15					1	2		1					4
15—18					5	3				1			9
18—21			2		1	1	1						5
21—24	1		2			1			1				5
Total	1		6		7	8	3	2	1	1			29
% frequency	0·6		3·6		4·2	4·8	1·8	1·2	0·3	0·6			17·0
						21 — 30 minutes							
0— 3			2										2
3— 6													
6— 9													
9—12													
12—15													
15—18				1	1	3							5
18—21			2			2							4
21—24						1							1
Total			4	1	1	6							12
% frequency			2·4	0·6	0·6	3·6							7·0
						> 30 minutes							
0 — 3			1		2								3
3 — 6													
6 — 9													
9 —12													
12—15													
15—18													
18—21			1										1
21—24					1								1
Total			2		3								5
% frequency			1·2		1·8								3·0

TABLE 1 (b)

Frequency of squalls duration at Lucknow

Time (IST)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
						⩽ 10 minutes							
0 — 3	1			1	1		1						4
3 — 6						5							5
6 — 9						1							1
9 —12					1		1	3					5
12—15		1		1		2	3	5	2				14
15—18			3		3	12	5	1	2	3			29
18—21			2	2	5	5	4	1	1				20
21—24		1		1	6	1	1		1	1			12
Total	1	2	5	5	16	26	15	10	6	4			90
% frequency	0·8	1·7	4·3	4·3	13·6	21·9	11·9	8·5	5·0	3·4			75·6
						11 — 20 minutes							
0— 3													
3— 6													
6— 9													
9—12													
12—15						1	1						2
15—18				1		1							2
18—21						2	1						3
21—24			4		2					1			7
Total			4	1	2	4	2			1			14
% frequency			3·4	0·8	1·7	3·4	1.7			0·8			11·8
						21 — 30 minutes							
0 — 3						1							1
3 — 6													
6 — 9						1		1					2
9 —12					1								1
12—15					1		1						2
15—18				1				1					2
18—21						1							1
21—24				1	2	3	1	2					9
Total				0·8	1·7	2·5	0·8	1·7					7·5
% frequency						> 30 minutes							
0 — 3							1						1
3 — 6						1							1
6 — 9													
9 —12													
12—15						2							2
15—18					1								1
18—21							1						1
21—24					1	3	2						6
Total					0·8	2·5	1·7						5·0
% frequency													

TABLE 1(c)

Frequency of squalls duration at Jodhpur

Time (IST)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
						⩽10 minutes							
0 — 3			1	1	3	1	1						7
3 — 6						1		1					2
6 — 9						1							1
9 —12								1					1
12—15						1	2	1	3				7
15—18		2	4	1	5	7	12	5	8				44
18—21		1	1	2	2	7	9	5	3			1	31
21—24			2	2	4	6	1	1	1				17
Total		3	8	6	14	24	25	14	15			1	110
% frequency		1·5	4·0	3·0	7·0	11·9	12·4	7·0	7·5			0·5	54·7
						11 — 20 minutes							
0 — 3					2	4							6
3 — 6			1	1		1							3
6 — 9													
9 —12													
12—15							3	1	2				6
15—18			3	1	2	10	5	3	4				28
18—21			1		4	3	4	1	1				14
21—24				1	4	1							6
Total			5	3	12	19	12	5	7				63
% frequency			2·5	1·5	6·0	9·3	6·0	2·5	3·5				31·3
						21 — 30 minutes							
0 — 3						1							1
3 — 6													
6 — 9													
9 —12													
12—15			1					1					2
15—18						2		2					4
18—21						2	1						3
21—24							1						1
Total			1			5	2	3					11
% frequency			0·5			2·5	1·0	1·5					5·5
						>30 minutes							
0 — 3					1								1
3 — 6													
6 — 9													
9 —12													
12—15						1							1
15—18						2			1				3
18—21					4	1			2				7
21—24				2	3								5
Total				2	8	4			3				17
% frequency				1·0	4·0	2·0			1·5				8·5

TABLE 2 (a)

Frequency of maximum speed of squalls at Allahabad

Time (IST)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
						⩽ 30 knots							
0 — 3	2		5	2	3	3		2					17
3 — 6		2	1										3
6 — 9				1		1							2
9 —12							1		1			1	3
12—15			2			1	1	3	1	1			9
15—18		1		1			4	2	5	3			16
18—21		1	5		3		3	1		1			14
21—24	2							2	1			1	6
Total	4	4	13	4	6	5	9	10	8	5		2	70
% frequency	2·4	2·4	7·6	2·4	3·6	3.0	5·4	6·0	4·8	3·0		1·2	41·6
						31 — 40 knots							
0 — 3		1	1		1	2	1						6
3 — 6				1		1							2
6 — 9					1								1
9 —12													
12—15						2	1		2				5
15—18	1		1	1	8	4	2		3	1			21
18—21			1		3	5	2	1				1	13
21—24		1	3		2	2	1	1	1				11
Total	1	2	6	2	15	16	7	2	6	1		1	59
% frequency	0·6	1·2	3·6	1·2	9·0	9·6	4·2	1·2	3·6	0·6		0·6	35·0
						41 — 60 knots							
0 — 3			3		1								4
3 — 6								1					1
6 — 9													
9 —12													
12—15			1	2		3	1		1				8
15—18					5	5	1			1			12
18—21			1	2		4	2						9
21—24						1							1
Total			5	4	6	13	4	1	1	1			35
% frequency			3·0	2·4	3·6	7·8	2·4	0·6	0·6	0·6			21·1
						61—80 knots							
0 — 3													
3 — 6													
6 — 9							1						1
9 —12													
12—15			1										1
15—18						1							1
18—21													
21—24													
Total			1			1	1						3
% frequency			0·6			0·6	0·6						1·8
						> 80 knots							
0 — 3													
3 — 6													
6 — 9													
9 —12													
12—15													
15—18													
18—21			1										1
21—24													
Total			1										1
% frequency			0·6										0·6

TABLE 2 (b)

Frequency of maximum speed of squalls at Lucknow

Time (IST)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
						⩽ 30 knots							
0 — 3	1			1	1								3
3 — 6						1							1
6 — 9													
9 —12							1	3					4
12—15						2	2	3	1				8
15—18			1		1	7	4	1	1	1			16
18—21				1	2	2	3						8
21—24					4		2						6
Total	1		1	2	8	12	12	7	2	1			46
% frequency	0·8		0·8	1·7	6·7	10·1	10·1	6·0	1·7	0·8			38·7
						31 — 40 knots							
0 — 3						1	2						3
3 — 6													
6 — 9						1							1
9 —12						1		2					3
12—15		1		1		1	2	1	1				7
15—18			1		2	4			1	1			9
18—21			1	1	1	2	1	1	1				8
21—24			1	1	3	1				1			7
Total		1	3	3	6	11	5	4	3	2			38
% frequency		0·8	2·5	2·5	5·0	9·3	4·2	3·4	2·5	1·7			31·9
						41 — 60 knots							
0 — 3													
3 — 6						5							5
6 — 9													
9 —12					1								1
12—15					1								1
15—18			1	1	1	4	2			1			10
18—21			1	1	3	3	1	1					10
21—24			3		1	1			1	1			7
Total			5	2	7	13	3	1	1	2			34
% frequency			4·2	1·7	6·0	10·9	2·5	0·8	0·8	1·7			28·6
						61 — 80 knots							
0 — 3													
3 — 6													
6 — 9													
9 —12													
12—15													
15—18													
18—21													
21—24		1											1
Total		1											1
% frequency		0·8											0·8
						> 80 knots							
						NIL							

TABLE 2 (c)

Frequency of maximum speed of squalls at Jodhpur

Time (IST)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
						⩽ 30 knots							
0 — 3					1	2							3
3 — 6			1	1		2		1					5
6 — 9						1							1
9 —12								1					1
12—15								1	3				4
15—18		2	2		1	4	2	2	4				17
18—21		1	1	2	1	2	5	2	3				17
21—24					2	2	1	1					6
Total		3	4	3	5	13	8	8	10				54
% frequency		1·5	2·0	1·5	2·5	6·4	4·0	4·0	5·0				26·9
						31 — 40 knots							
0 — 3				1	3	2	1						7
3 — 6													
6 — 9													
9 —12													
12—15						1	3	2	2				8
15—18			2		2	4	8	7	7				30
18—21			1		5	6	2	4	4			1	23
21—24				2	4	2							8
Total			3	3	14	15	14	13	13			1	76
% frequency			1·5	1·5	7·3	7·8	7·3	6·5	6·5			0·5	37·8
						41 — 60 knots							
0 — 3			1		2	1							4
3 — 6													
6 — 9													
9 —12													
12—15			1			1	1						3
15—18			3	2	4	12	8	1	1				31
18—21					4	4	6						14
21—24			2	2	5	3	1		1				14
Total			7	4	15	21	16	1	2				66
% frequency			3·5	2·0	7·5	10·8	8·0	0·5	1·0				32·8
						61 — 80 knots							
0 — 3													
3 — 6													
6 — 9													
9 —12													
12—15							1						1
15—18						1							1
18—21						1							1
21—24				1									1
Total				1		2	1						4
% frequency				0·5		1·0	0·5						2·0
						> 80 knots							
0 — 3						1							
3 — 6													1
6 — 9													
9 —12													
12—15													
15—18													
18—21													
21—24													
Total						1							1
% frequency						0·5							0·5

TABLE 3 (a)

Percentage frequency of direction of squalls at Allahabad

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	X	T
Jan	0·0	20·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	20·0	20·0	40·0	0·0		5
Feb	0·0	0·0	0·0	0·0	0·0	0·0	16·7	0·0	0·0	0·0	0·0	0·0	0·0	16·7	50·0	16·7		6
Mar	19·0	3·8	0·0	0·0	0·0	0·0	3·8	0·0	0·0	15·2	3·8	3·8	19·0	11·4	15·2	3·8		26
Apr	10·0	0·0	0·0	0·0	0·0	0·0	0·0	10·0	20·0	30·0	10·0	10·0	0·0	0·0	0·0	0·0	10·0	10
May	7·4	3·7	7·4	0·0	0·0	0·0	0·0	0·0	7·4	3·7	14·8	3·7	18·5	15·1	14·8	7·4		27
Jun	8·6	11·5	2·9	2·9	0·0	0·0	0·0	2·9	0·0	8·6	2·9	5·8	8·6	24·1	5·8	24·1		35
Jul	4·8	9·6	4·8	0·0	9·6	0·0	28·3	0·0	4·8	4·8	4·8	0·0	9·6	0·0	14·3	4·8		21
Aug	0·0	0·0	15·4	0·0	0·0	0·0	7·7	7·7	7·7	7·7	0·0	0·0	15·4	30·8	0·0	7·7		13
Sep	6·7	6·7	13·3	13·3	6·7	6·7	6·7	13·3	0·0	6·7	0·0	0·0	6·7	6·7	6·7	0·0		15
Oct	0·0	14·3	0·0	0·0	28·6	0·0	14·3	0·0	0·0	0·0	14·3	0·0	0·0	0·0	28·6	0·0		7
Nov	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0		0
Dec	0·0	33·3	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	33·3	33·3	0·0		3
T	13	12	8	3	5	1	11	5	6	14	9	5	19	21	22	13	1	168
% frequency of the total	7·7	7·2	4·8	1·8	3·0	0·6	6·6	3·0	3·6	8·2	5·4	3·0	11·3	12·5	13·1	7·7	0·6	

X — Direction not determined T — Total number of squalls

TABLE 3(b)

Percentage frequency of direction of squalls at Lucknow

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	X	T
Jan	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	100·0	0·0		1
Feb	50·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	50·0	0·0	0·0	0·0	0·0	0·0		2
Mar	0·0	0·0	11·1	0·0	0·0	0·0	22·2	0·0	0·0	0·0	11·1	11·1	0·0	22·2	22·2	0·0		9
Apr	0·0	0·0	14·3	0·0	0·0	0·0	0·0	0·0	14·3	14·3	0·0	0·0	14·3	0·0	14·3	28·6		7
May	14·3	9·6	9·6	0·0	0·0	0·0	0·0	0·0	4·8	4·8	4·8	0·0	0·0	0·0	28·8	24·0		21
Jun	16·8	5·6	0·0	0·0	2·8	0·0	5·6	5·6	0·0	2·8	8·4	14·0	2·8	8·4	19·6	8·4		36
Jul	10·0	10·0	0·0	5·0	0·0	5·0	15·0	5·0	0·0	5·0	5·0	15·0	0·0	0·0	10·0	10·0	5·0	20
Aug	8·3	8·3	0·0	8·3	25·0	8·3	8·3	8·3	0·0	0·0	0·0	0·0	0·0	0·0	16·7	8·3		12
Sep	0·0	0·0	0·0	0·0	33·3	0·0	16·7	16·7	0·0	0·0	0·0	0·0	0·0	0·0	16·7	0·0	16·7	6
Oct	0·0	0·0	0·0	20·0	0·0	0·0	0·0	40·0	0·0	20·0	0·0	0·0	0·0	0·0	0·0	20·0		5
Nov	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0		0
Dec	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0		0
T	13	7	4	3	6	2	9	7	2	5	7	9	2	5	22	14	2	119
% frequency of the total	10·8	5·9	3·4	2·5	5·0	1·7	7·6	5·9	1·7	4·2	5·9	7·6	1·7	4·2	18·5	11·7	1·7	

X — Direction not determined T — Total number of squalls

TABLE 3 (c)

Percentage frequency of direction of squalls at Jodhpur

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	X	T
Jan	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0		0
Feb	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	33·3	0·0	33·3	33·3	0·0		3
Mar	7·1	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	14·2	21·3	17·1	0·0	14·2	28·4	7·1		14
Apr	9·1	18·2	18·2	0·0	0·0	0·0	0·0	0·0	0·0	0·0	9·1	9·1	9·1	0·0	27·3	0·0		11
May	17·8	14·8	11·8	0·0	3·0	3·0	8·9	0·0	0·0	0·0	31·0	0·0	8·9	11·8	14·8	3·0		34
Jun	11·5	3·8	25·0	0·0	7·7	5·7	5·7	3·8	7·7	0·0	3·8	0·0	0·0	0·0	17·4	3·8	5·7	52
Jul	2·6	5·2	33·3	5·2	12·8	2·6	15·3	2·6	2·6	2·6	0·0	5·2	2·6	0·0	5·2	2·6		39
Aug	4·5	9·2	50·0	0·0	13·6	9·1	0·0	0·0	0·0	4·5	0·0	0·0	4·5	0·0	4·5	0·0		22
Sep	4·0	4·0	28·0	13·0	28·0	4·0	4·0	0·0	0·0	4·0	4·0	0·0	0·0	0·0	8·0	0·0		25
Oct	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0		0
Nov	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0		0
Dec	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	100·0	0·0	0·0	0·0	0·0		1
T	17	14	50	5	20	8	13	3	5	5	8	6	6	7	26	5	3	201
%frequency of the total	8·5	7·0	24·7	2·5	10·0	4·0	6·5	1·5	2·5	2·5	4·0	3·0	3·0	3·5	12·8	2·5	1·5	

X — Direction not determined

T — Total number of squalls

TABLE 4

Multiple squalls

	Time of commencement (IST)	Duration (min)	Maximum speed (kts)	Direction From	Direction To
	ALLAHABAD				
1948 22 May	(1) 1620	2	31	W	NNE
	(2) 1735	8	36	WNW	N
1949 7 Mar	(1) 1940	5	28	E	W
	(2) 2025	25	39	W	SE
1950 21 Mar	(1) 1615	5	37	NE	SW
	(2) 1955	25	88	E	W
1950 8 May	(1) 1705	3	37	W	N
	(2) 1720	5	41	W	NW
1951 26 Jul	(1) 1550	2	45	E	SE
	(2) 1645	2	38	E	E
1953 5 Feb	(1) 1545	5	30	N	NW
	(2) 1845	2	27	SE	NW
1955 2 May	(1) 1635	2	36	N	NW
	(2) 1947	6	27	NNE	SW
	(3) 2005	15	40	N	S
1956 15 Mar	(1) 1957	30	29	E	N
	(2) 2210	20	31	W	N
1956 22 Mar	(1) 0015	30	29	E	N
	(2) 1935	45	26	NE	NNW
1956 5 Jun	(1) 1545	15	47	SW	WSW
	(2) 1750	15	61	WNW	SW
1957 1 Jun	(1) 1920	5	36	SSW	SSE
	(2) 1945	20	41	SE	NE
1957 5 Aug	(1) 2302	3	28	SE	WNW
	(2) 2315	2	33	WNW	NNW
1961 30 Jan	(1) 0010	6	49	N	NW
	(2) 1730	4	52	E	NNE
1961 1 Apr	(1) 1815	2	48	NE	SSW
	(2) 1830	3	66	SSW	SW
	LUCKNOW				
1957 28 Jun	(1) 0830	2	35	ENE	NNE
	(2) 2020	1	24	ESE	SSW
1959 26 May	(1) 2025	10	69	E	NE
	(2) 2355	3	54	ENE	NNW
1959 25 Aug	(1) 1055	3	56	NE	E
	(2) 1135	3	45	SW	SE
1961 21 Jun	(1) 1520	5	57	ESE	SSE
	(2) 1530	5	65	SSE	SSE
	(3) 1655	5	61	Calm	WNW
1962 30 May	(1) 0120	5	45	ENE	N
	(2) 1825	35	68	NW	NW
	(3) 1905	10	67	W	S
	(4) 2155	5	59	SSW	NW
1962 31 May	(1) 1910	2	38	Calm	SW
	(2) 2315	2	25	Calm	NNW