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Distribution of SSC sizes at Alibag for the period 1921-1960

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ABSTRACT. Seasonal and annual distributions of frequency of occurrence at Alibag of SSCs of different sizes of the main impulse in H and the distribution of the mean sizes are studied. The bi-hourly mean sizes of SSCs are found to be larger in magnitude on either side of midnight and lower during the day-time with minimum in the interval 4-6 hr LMT.

1. Introduction

Ferraro *et al.* (1951) examining the hourly frequencies of SCs and SIs (Sudden Commencements and Sudden Impulses) at six stations urged that a synoptic study of SCs and SIs be facilitated by observatories analysing their own data for hourly frequencies, diurnal variation of mean amplitude in the horizontal force, seasonal variation and variation with the 11-year solar cycle. Akasofu and Chapman (1961), reviewing the studies of SCs and SIs by earlier workers, felt the need for further studies for the other observatories with long series of records. Colaba and Alibag Observatories provide one such long series of records.

Moos (1910), in his monumental study of the magnetic data from Colaba (Bombay), analysed the times of commencement of what he called X-disturbances, numbering 113, of varying degrees of magnitude that occurred during the period 1872-1904. He found a feeble tendency for them to crowd around 13 hr local time and a tendency to be more frequent during the equinoxes. Chakrabarty (1951) examined about 800 SCs from Alibag magnetograms for the period 1905-1944 and found a minimum between 04 hr and 07 hr and again at about 17 hr and a prominent maximum between 09 hr and 13 hr local mean time. In a preliminary study of SSC (Storm Sudden Commencement) occurrence of geomagnetic disturbances at Alibag (Lat. 18° 38′ N and Long. 72° 52′E) during the period 1921-1960, Sastri (1966) observed no systematic variation in the hourly (local mean time) disrtibution of SSCs which could be considered significant, though a broad tendency for the frequency to be higher during the day-time than during the night-time was noticed; also, a slightly higher frequency of occurrence was observed during the equinoctial months. Arranging SSCs by their sizes in the Horizontal Component, H, into three groups, $\leqslant 10\,\gamma$, 11–30 γ and $\geqslant 31\,\gamma$, the diurnal distribution of frequency of occurrence was found to depend to a large measure on the size of the SSCs (Sastri and Jayakar 1967). An attempt is made here to study the diurnal and seasonal distribution of the mean sizes and of different sizes of SSCs in H at Alibag during the period 1921-1960.

2. The Data

The sizes of SSC in H for the period 1937 to 1960 are taken from the published Annual Volumes of the Colaba Observatory while those for 1921 to 1936 are scaled from the magnetograms. The smallest size considered is 3 γ. The time reckoning refers to Alibag Local Mean Time which is 04 hr 51 min ahead of Greenwich Mean Time. Day is taken to begin at 06 hr and end at 18 hr local mean time in all seasons.

There are in all 813 SSCs. The largest size in H of SSC recorded during the period is 280γ on 8 July 1928 at 03 hr 02 min local mean time. A list of SSCs of large size ($\geqslant$ 75 γ) is given in Table 1. It is readily seen that large size SSCs are distributed equally in number during day and night hours. But, those occurring during the night are comparatively of larger sizes as noticed by Shirgaokar and Srivastava (1961). The average size of the SSCs occurring during the night is 138 γ and of those occurring during the day is 91 γ. Of the 18 SSCs enumerated in Table 1, 7 occur in the month of July of which 5 are comparatively larger sizes and occur during the night-time confirming the observation by Srivastava (1966).

A list of severe storms with range in $H > 600\,\gamma$ is given in Table 2. It is interesting to note that only 5 large size SSCs of Table 1 have been followed by very severe storms. 9 storms out of the 11 commenced during the day-time; a similar

TABLE 1

SSCs of large size in H ($\geqslant 75\ \gamma$) recorded at Alibag during 1921–1960

Date	Time of occurrence (LMT)	Size of SSC γ	Range in H of the storm γ	Relative magnitude of the storm
13 May 1921	1800	126	685	VG
22 Oct 1927	1130	75	410	VG
08 Jul 1928	0302	280	779	VG
18 Oct 1928	1216	79	402	VG
17 Jan 1938	0323	167	389	VG
16 Apr 1938	1136	130	532	VG
04 Aug 1938	0226	80	182	Ma
23 Apr 1939	1038	84	225	Ma
06 May 1939	0136	97	181	Ma
01 Mar 1942	1218	82	224	G
28 Mar 1946	1126	84	1038	VG
26 Jul 1946	2336	148	498	VG
17 Jul 1947	2239	108	295	G
08 Jul 1958	1239	95	610	VG
11 Jul 1959	2116	87	135	M
15 Jul 1959	1254	79	566	VG
17 Jul 1959	2129	149	304	G
30 Apr 1960	1705	113	>554	VG

VG=Very Great, G=Great, Ma=intermediate between Moderate and Great, and M=Moderate

TABLE 2

Very severe magnetic storms recorded at Alibag during 1921–1960

Date	Time of SSC (LMT) h	m	Size of SSC in H γ	Range in H γ
13 May 1921	18	00	126	685
08 Jul 1928	03	02	280	779
22 Jan 1938	07	33	74	613
24 Mar 1940	18	41	62	>757
01 Mar 1941	08	49	43	850
05 Jul 1941	09	50	29	>729
18 Sep 1941	09	05	27	>620
28 Mar 1946	11	26	84	1038
12 May 1949	11	31	46	607
08 Jul 1958	12	39	95	610
30 Apr 1960	17	05	113	>554

TABLE 3

Negative SSCs and SSCs followed by very weak magnetic disturbances at Alibag during 1921–1960

Date	Time of SSC (LMT)	Size of SSC in H γ	Range in H γ	Relative magnitude
03 Aug 1940	09 49	—13	158	Sa
16 Jul 1949	17 17	—38	85	Sa
14 Jun 1921	17 32	16	27	S
21 Jun 1931	19 15	6	25	S
19 Sep 1945	01 41	20	26	S
26 Nov 1946	20 51	7	10	S
14 Aug 1960	20 09	30	25	S

S=slight. Sa = intermediate between slight and moderate

TABLE 4

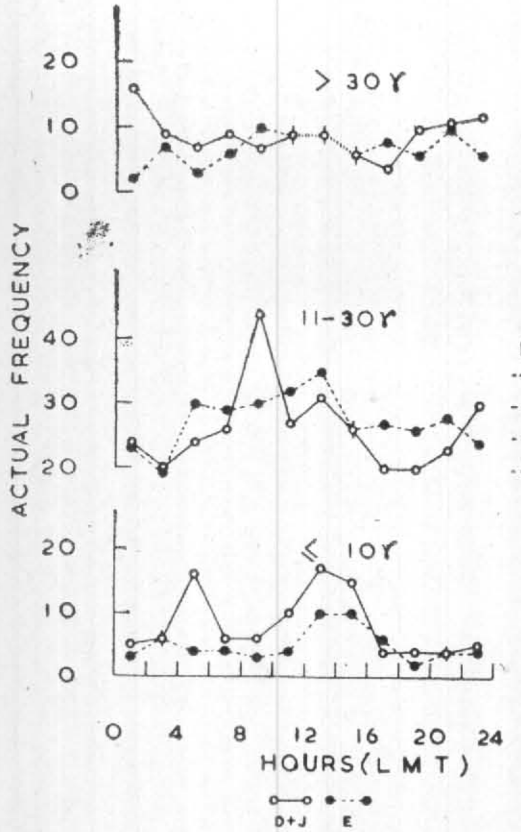
Distribution of SSCs of different sizes in the three groups and in the three seasons at Alibag during 1921–1960

Relative magnitude	Size of SSC in H $\leqslant 10\gamma$	$11\text{-}30\gamma$	$>30\gamma$	Total	SSCs of size $\geqslant 75\gamma$ in H
Great	11	64	71	146	14
Moderate	68	222	80	370	4
Slight	79	178	40	297	—
Total	158	464	191	831	18
D-Season	55	148	40	243	1
E-Season	60	149	82	291	7
J-Season	43	167	69	279	10

observation was made by Bhargava (1967) examining the data from Kodaikanal.

Two negative SSCs (SC−) and SSCs followed by very weak disturbances are given in Table 3. Chakrabarty (1951) found 28 cases which could be classified as 'inverted SCs' but felt that they were not really SCs but formed part of normal fluctuations. In fact, the negative SSC of 16 July 1949, was preceded by a slight disturbance from 10 hr 36 min LMT on the same day.

The 813 SSCs are arranged by their sizes in three groups, $\leqslant 10\ \gamma$, $11\text{–}30\ \gamma$ and $> 30\ \gamma$ and are also divided into three classes by the criterion of the relative magnitude of the disturbance that follows (Sastri 1966). The distributions are given in Table 4. The distribution in the three seasons, D, E and J (Sastri 1966) is also



SSC SIZE	FREQUENCY D+J	FREQUENCY E	E/TOTAL %
>30γ	109	82	43
11-30γ	315	149	32
≤10γ	98	60	38

Fig. 1. Bi-hourly distribution of the frequency of occurrence of SSCs at Alibag for the period 1921-1960 in the solstitial seasons (seasons D and J combined) and Equinoctial season (season E) for the three size-ranges: $\leqslant 10\gamma$, 11-30γ and $>30\gamma$

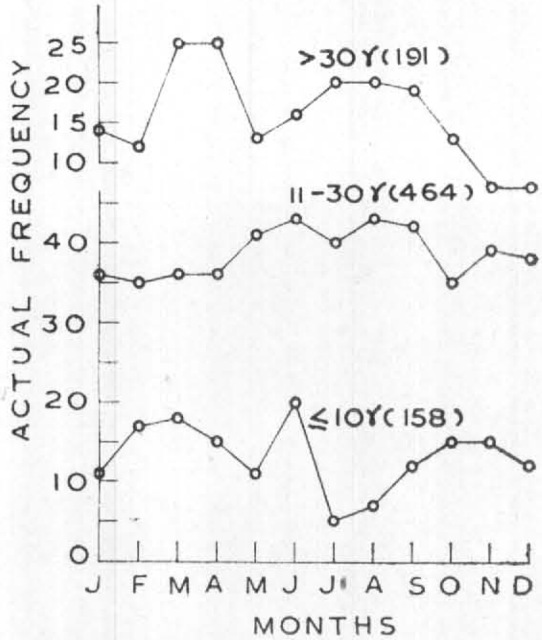


Fig. 2. Distribution of monthly frequencies of occurrence of SSCs at Alibag for the period 1921-1960 in the three size-ranges: $\leqslant 10\gamma$, 11-30γ and $>30\gamma$

(The figures in brackets is the total frequency in the size-range)

given in the lower half of the table. The occurrence of SSCs of size $> 30\,\gamma$ in E season is double of that in D season and about 40 per cent of the total number of SSCs in that size-range. Nearly 50 per cent of the great storms begin with SSCs of size $>30\,\gamma$. About 55 per cent of the SSCs are in the size-range 11-30 γ and about 55 per cent of the storms have the range of H between $60\,\gamma$ and $160\,\gamma$, which corresponds to the characterisation of the storm by the observatory as 'Moderate'.

3. SSCs in different size-range

Bi-hourly distribution of the frequencies of the SSCs are arranged for each of the twelve months of the year for all the three size-ranges. The frequencies for corresponding intervals are added up for all the months comprising the solstitial seasons (seasons D and J), and similarly for the equinoctial months. These are presented in Fig. 1. For the size-range $\leqslant 10\,\gamma$ solstitial season has two maxima whereas the early morning maximum is absent in E season has two size-range $> 30\,\gamma$, the maximum frequency in solstitial season and minimum frequency in E season are around midnight.

The distribution of monthly frequencies in the three size-ranges are shown in Fig. 2. The distribution for the size-range $\leqslant 10\,\gamma$ is semi-annual but for a spurt in frequency for June. In contrast

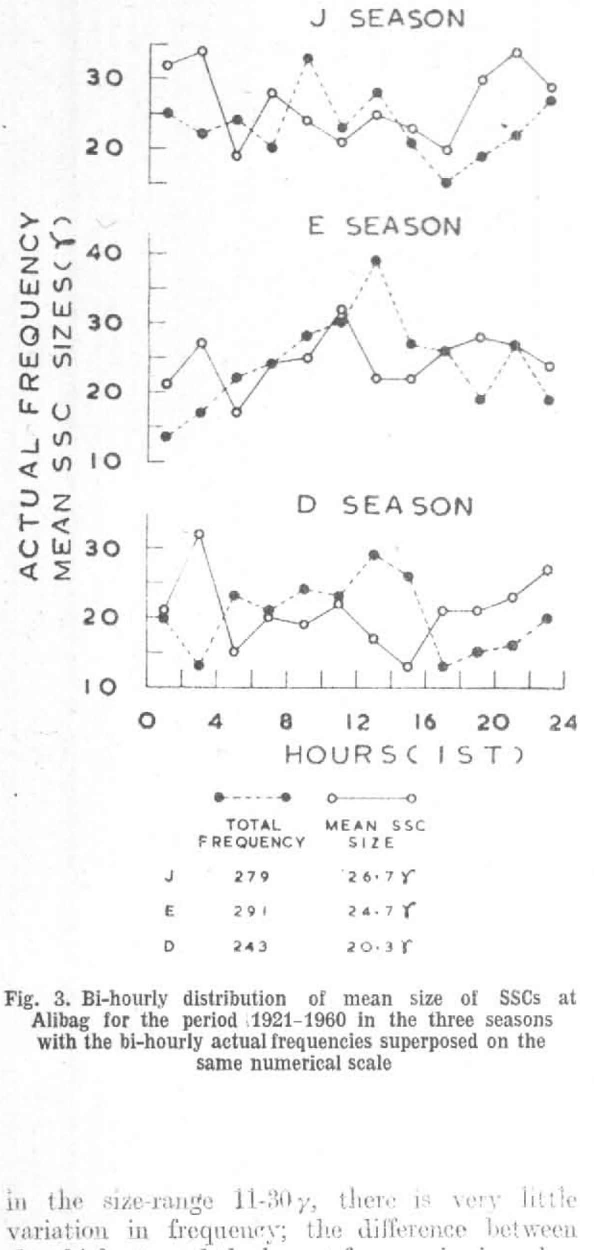


Fig. 3. Bi-hourly distribution of mean size of SSCs at Alibag for the period 1921–1960 in the three seasons with the bi-hourly actual frequencies superposed on the same numerical scale

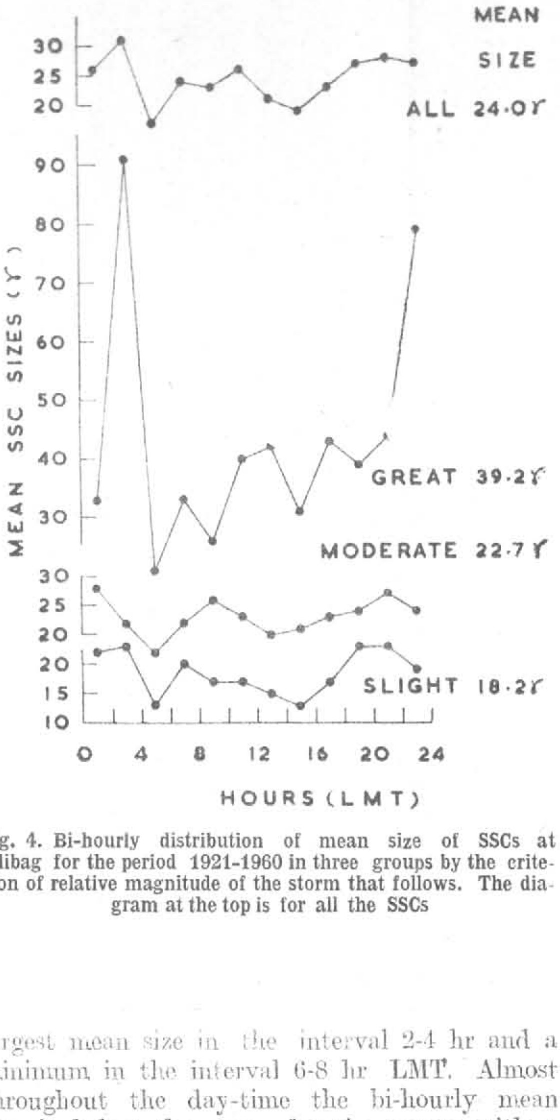


Fig. 4. Bi-hourly distribution of mean size of SSCs at Alibag for the period 1921-1960 in three groups by the criterion of relative magnitude of the storm that follows. The diagram at the top is for all the SSCs

in the size-range 11-30 γ, there is very little variation in frequency; the difference between the highest and the lowest frequencies is as low as 8. The two months March and April, account for 25 per cent of total frequency for the size-range $>30\ \gamma$; November and December have the lowest frequency.

4. Mean sizes of SSCs

In Fig. 3 are presented the distribution of mean size of SSCs in the bi-hourly intervals in the three seasons with the bi-hourly actual frequencies superposed on the same numerical scale. It is readily seen that the mean sizes of SSCs are largest on either side of midnight in all the seasons, also indicated by Srivastava (1966), and a minimum in the interval 4-6 hr. Kazmi (1963), analysing the Quetta data, found the largest mean size in the interval 2-4 hr and a minimum in the interval 6-8 hr LMT. Almost throughout the day-time the bi-hourly mean size is below the mean for the season with a minimum in the interval 14-18 hr in all the seasons. This appears to lend support to the suggestion by Ferraro (1954) that over the daylight hemisphere, the higher conductivity in the ionosphere tends to shield the stations below from the external magnetic field produced by the corpuscular stream responsible for SSC. The mean size of SSCs is least for D season (20 γ) and largest for J season (27γ) and intermediate in E season (25 γ), in agreement with the finding by Bhargava (1967), though the differences in the mean size from season to season are much smaller than those for the three observatories he considered.

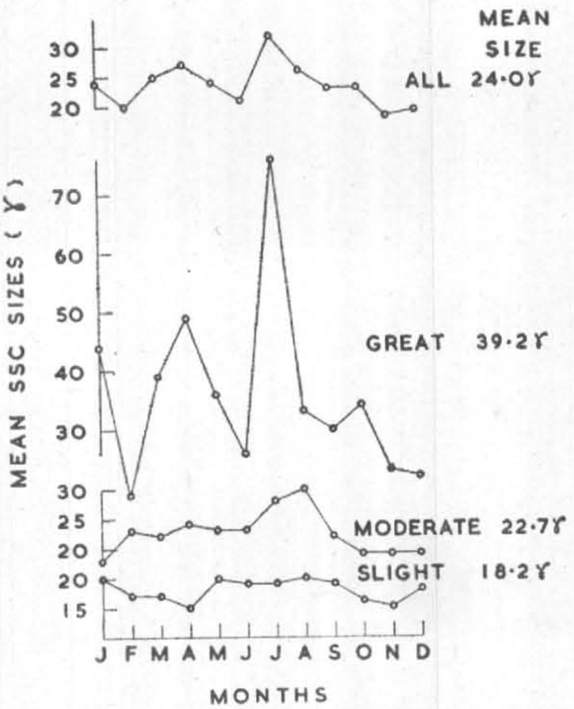


Fig. 5. Distribution of monthly mean size of SSCs at Alibag for the period 1921-1960 in three groups by the criterion of relative magnitude of the the storm that follows. The diagram at the top is for all the SSCs

The SSCs are divided into three groups by the criterion of relative magnitude of the storm that follows and the distribution of the bi-hourly mean sizes are presented in Fig. 4. The minimum in the interval 4-6 hr is prominent in all the three groups. The mean sizes are larger during the night. Conspicuous increase in mean size is observed around midnight for the group of SSCs followed by great storms. The gradual increase from the minimum in the interval 4-6 hr to the maximum around midnight is also well defined in this group.

Distribution of monthly mean sizes is presented in Fig. 5 for all the three groups as well as for all SSCs. There is a large increase in the mean size in July for the group of SSCs followed by great storms, though the frequency distribution was found to be semi-annual with maxima in the equinoxes (Sastri 1966). Only January and April have slightly higher mean sizes than the annual mean size for this group. For the other two groups there is not much variation in the mean sizes except for a small increase in July and August and a flat minimum from October to January for the group of SSCs followed by moderate storms. The monthly mean size curve for all the SSCs (diagram at the top in Fig. 5) closely resemble the curve for Quetta data(Kazmi 1963)with largest mean size for July, also noticed by Srivastava (1966). It resembles in general, similar curve for Honolulu (Ferraro *et al.* 1951). The annual mean size of SSCs in the solar cycle follows the annual mean Zurich sunspot number in a general way, as also indicated by Kazmi (1963).

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