550·38

The diurnal variation of sizes of sudden commencements and impulses in the Kodaikanal magnetograms

B. SRINIVASAMURTHY

Kodaikanal Observatory, Kodaikanal

(*Received 17 February 1959*)

ABSTRACT. Combined data of sudden commencements (SCs) and sudden impulses (SIs) recorded at Kodaikanal (geomagnetic latitude 0·6°N) during the period 1949-57 have been analysed in order to study the relationship between the diurnal variation (DV) in the amplitudes of the impulses and the DV in the horizontal component of the earth's magnetic field (the *Sq* variations in *H*). There is a statistically significant daytime enhancement in SC sizes similar to the enhancement in *Sq* variation. Furthermore, this enhancement is larger on days with larger *Sq* variation than on days with smaller *Sq* variation. These results confirm those obtained by Forbush and Vestine (1955) at Huancayo, another station near the geomagnetic equator.

1. Introduction

The diurnal variation of the amplitudes of SCs in relation to the variations in magnetic elements has been studied by several workers. Ferraro and Unthank (1951) found a similarity between the DV of SC sizes in *H* and the DV of *Sq* in *H* at Huancayo. Ferraro (1954), however, found that apart from Huancayo other stations, *e.g.*, Cheltenham, Tucson, San Juan, Honolulu and Watheroo, do not appear to show a daytime augmentation of mean hourly values of SC impluses. Suguira (1953), comparing the SC sizes at Huancayo and Cheltenham—stations on the same meridian but at different latitudes—found that there is a considerable enhancement in the size of daytime SCs near the geomagnetic equator. He also observed that the ratio of SC sizes at the two stations, increases in the morning, reaches a maximum around 11 hours local time, decreases towards the evening and remains constant throughout the night. This daytime augmentation in SC sizes at Huancayo was later examined in detail and found statistically significant by Forbush and Vestine (1955). A similar analysis was suggested by them for Kodaikanal, as one of particular interest, Kodaikanal being the only other established station near the geomagnetic equator. Sivaramakrishnan (1956), concluded from the data of SCs at Kodaikanal, Alibag and Huancayo for the period 1949-53, that the SC amplitude is largest at local noon and this noon increase in amplitude is maximum at stations near the geomagnetic equator. In the present investigation it is proposed to examine statistically the data for 1949-57 available at Kodaikanal in order to verify the significance of the above conclusions. In an earlier paper the author (Srinivasamurthy 1959) had studied the DV in the hourly frequencies of SCs and SIs at Kodaikanal.

2. Analysis

The method adopted in the analysis is very similar to that of Forbush and Vestine. 398 SCs and SIs which have been selected after comparison with the reports of other stations (published by the IAGA) have been included in this analysis. The distinction between SCs and SIs has not been retained. The size of impulse in *H*, which is generally a rise, and the departure $\triangle H$ of the average value of *H* for the hour preceding the hour of SC from the previous midnight value were measured from the magnetograms. The smoothed hourly mean values of $\triangle H$ and also of the size of impulses were determined and plotted in Fig.1 (a). The resemblance

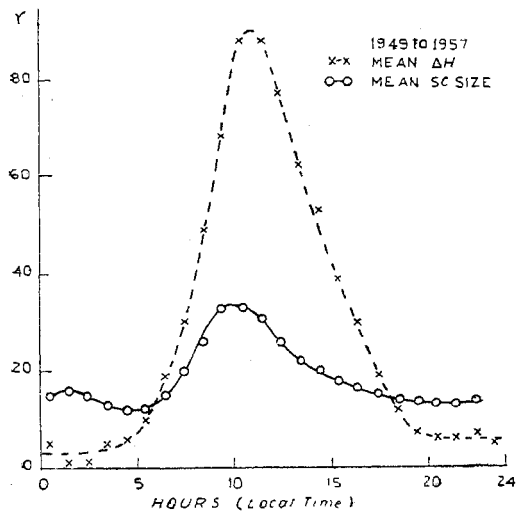

Fig. 1(a)

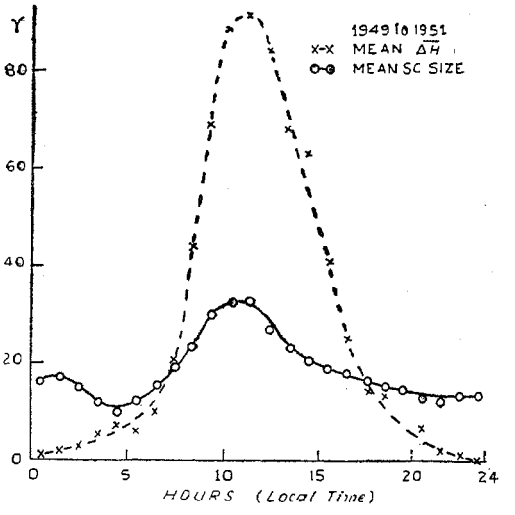

Fig. 1(b)

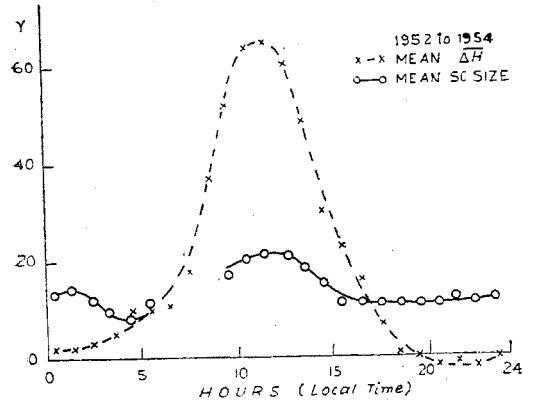

Fig. 1(c)

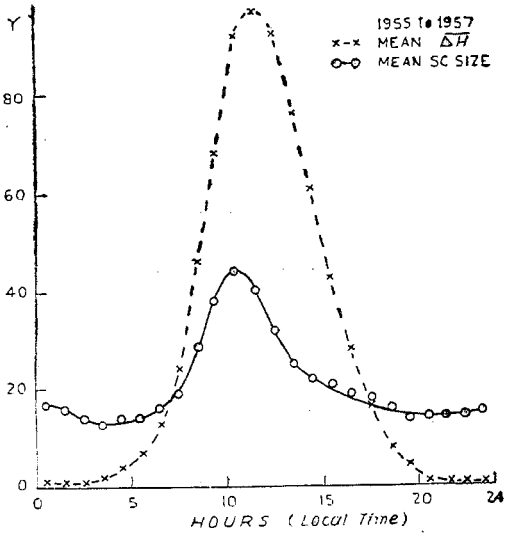

Fig. 1(d)

between the diurnal curves of mean $\triangle H$ and mean size y of the impulses can be clearly seen. Fig. 2 (a) gives the graph of hourly mean $\triangle H$ values *versus* the hourly mean SC sizes. In spite of a slight scatter of points for the higher values, a linear relationship

$$y = 12{\cdot}3 + 0{\cdot}21\ \triangle H \qquad (1)$$

is suggested. A comparison of equation (1) with that obtained by Forbush and Vestine shows that both the night mean size 'a' and the rate of enhancement 'b' with $\triangle H$ are smaller at Kodaikanal than at Huancayo. From a comparison of the amplitudes of about 70 storm sudden commencements (January 1950—June 1955) at Huancayo as reported in the *Journal of Geophysical Research* and the corresponding values at Kodaikanal, it is found that the amplitudes are generally higher at Huancayo, where the

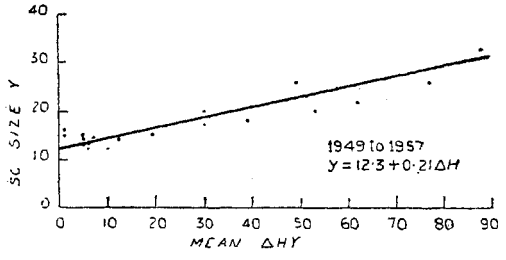

Fig. 2(a)

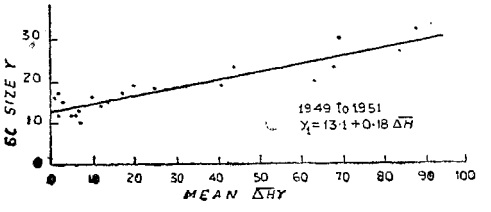

Fig. 2(b)

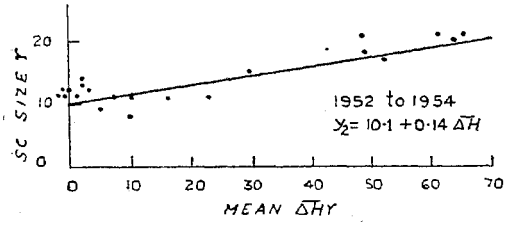

Fig. 2(c)

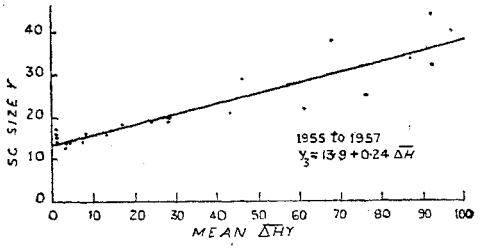

Fig. 2 (d)

Sq in H is also larger. The local time variations of mean values of amplitudes at Huancayo and Kodaikanal are given in Fig. 3.

3. Dependence of the factors 'a' and 'b' on relative sunspot numbers

The period under investigation covering almost a solar cycle has been divided into three-year periods 1949-51, 1952-54 and 1955-57, corresponding roughly to the post maximum, minimum and pre-maximum periods of the cycle. Hourly smoothed means of $\triangle H$ and the sizes of impulses have been determined for each period. The DV in mean $\triangle H$ has been fitted to the DV in *Sq* by taking the averages of hourly means of $\triangle H$ and the corresponding hourly means of *Sq* variation. (The hourly means of *Sq* variation were obtained for each three-year period by taking all days other than those exceptionally disturbed). $\overline{\triangle H}$, thus derived, gives a fair representation of *Sq* variation in H on the days (and hours) on which the impulses occurred. Figs. 1 (b), 1 (c) and 1 (d) give the DV in the $\overline{\triangle H}$ values and the DV in the mean SC sizes. From Figs. 2(b), 2(c) and 2(d) the following linear relationships can be obtained

$$y_1 = 13{\cdot}1 + 0{\cdot}18\ \overline{\triangle H} \qquad (2)$$

$$y_2 = 10{\cdot}1 + 0{\cdot}14\ \overline{\triangle H} \qquad (3)$$

and $$y_3 = 13{\cdot}9 + 0{\cdot}24\ \overline{\triangle H} \qquad (4)$$

The linear equations (1) to (4) have been derived by the method of least squares. The equations (2), (3) and (4) correspond to the three-year periods with average relative sunspot numbers 96·0, 16·6 and 190·0 respectively. A slight increase in the factors 'a' and 'b' with increase in sunspot numbers is seen from the above equations. The night-time mean size of SCs and the rate of enhancement with $\overline{\triangle H}$ are least near the period of minimum sunspot number, when incidentally, the number of impulses is also small.

4. SC sizes during day and night

The frequency distributions of SC sizes during A: day (0600-1800 LMT) and B: night (1800-0600 LMT) are represented in the histograms of Fig.4 (a). The percentage of SCs and SIs with amplitudes greater than 20γ is 48 in group A, whereas it is only 25 in group B; unusually large SCs are noticed

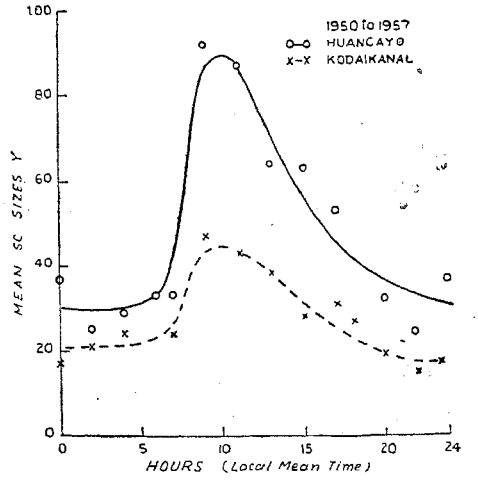

Fig. 3

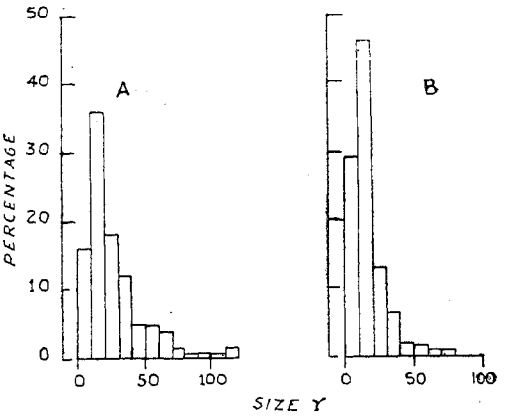

Fig. 4(a). Frequency distribution of SC sizes

A—For day (0600–1800 LMT)
B—For night (1800–0600 LMT)

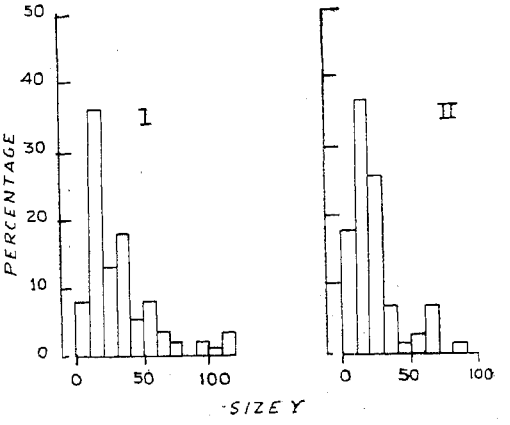

Fig. 4(b). Frequency distribution of SC sizes

I—For days with $\triangle H_t$ >median
II—For days with $\triangle H_t$ <median

only in group A. The standard deviations of sizes in A and B are 21γ and 12γ and the means 26γ and 17γ respectively. It is found that the difference in means is about five times as large as the standard deviation 1·7γ of the difference between the two means. The difference is thus significant; the mean size of impulses during the sunlit hours is greater than that during night.

5. SC sizes on days with large and small DV in H

If the DV in SC sizes actually corresponds to DV in H, the day-time enhancement in SC sizes should be more on days with larger variation in H. The SCs and SIs recorded during each hour t in the interval 0800-1600 LMT were classified into groups I and II according to whether the corresponding $\triangle Ht$ values were greater or less than the median $\triangle H$ for that hour. The frequency distributions of sizes are given in Fig. 4(b). The percentage of SCs with sizes greater than 30γ is 43 for group I and only 20 in group II. The samples standard deviations are 2·6γ and 1·7γ and the means 29·8γ and 23·1γ respectively. The difference in the means is nearly 20 times greater than the standard deviation 0·33γ of the difference and hence is significant.

6. Conclusion

The correlation between day-time SC amplitudes and the range of DV in H at Kodaikanal is established beyond doubt. The enhancement in size is, however, small compared to that at Huancayo. The close connection between the day-time enchancement in SC sizes and the enhancement in the Sq variation in H suggests that the seat

of these two phenomena may be one and the same. As suggested by Forbush and Vestine the currents associated with them may flow in or near the E-region of the ionosphere and enhancement in both cases may be due to the locally enhanced conductivity of the E-region near the geomagnetic equator. The possible relationships of these currents to wind motions have been discussed by Vestine (1954) on the dynamo theory of geomagnetic disturbances. Ferraro (1954) while agreeing to the suggestion that there are undoubtedly atmospheric contributions to the magnetic storm currents, for instance, in the auroral zone, finds it difficult to accept that a characteristically world-wide phenomenon like SC can be generated by winds in the atmosphere as if by trigger action. It is, however, premature to say whether the application of dynamo theory to geomagnetic disturbances can be fully satisfactory; only a beginning in this direction has been made by Vestine, Fukushima and others.

7. Acknowledgement

My thanks are due to Dr. A. K. Das and Shri B.N. Bhargava for their suggestions.

REFERENCES

Ferraro, V. C. A.	1954	*J. geophys. Res.*, **59**, p. 311.
Ferraro, V.C.A. and Unthank, H. W.	1951	*Geofis. pur. appl.*, **20**, pp. 3-6.
Forbush, S. E. and Vestine, E. H.	1955	*J. geophys. Res.*, **60**, p. 299.
Sivaramakrishnan, M. V.	1956	*Indian J. Met. Geophys.*, **7**, 2, p. 137.
Srinivasamurthy, B.	1959	*Ibid.*, **10**, 2, p. 209.
Suguira, M.	1953	*J. geophys. Res.*, **58**, p. 558.
Vestine, E. H.	1954	*Ibid.*, **59**, p. 93.