

Irregular Fluctuations in H Field at Kodaikanal

B. SRINIVASA MURTHY

Astrophysical Observatory, Kodaikanal

(Received 28 December 1960)

ABSTRACT. Considering the hourly values of $(r_H - \bar{r}_{Hq})$, where r_H is the range in H for a particular hour and \bar{r}_{Hq} is the mean of ranges for the same hour on five international quiet days of the month, as measures of the hourly intensity of irregular fluctuations in the horizontal field, a study of the variations in their incidence at Kodaikanal is made for the period 1952-53. It is found that the fluctuations are the least in the early morning hours and the largest around local noon. The seasonal changes in the form of diurnal variation of the incidence of the fluctuations become prominent only for days with international character figure $C^2 \gg 1$. The effect of increased magnetic activity in all the seasons is a general increase in the intensity of fluctuations which, however, is not uniform for all hours. The increase is large around noon and the least, early in the morning; the increase during night, which is generally considerable, becomes particularly marked during equinoctial months.

1. Introduction

Irregular fluctuations of the earth's magnetic field which are not classifiable under regular S_D and storm time changes are a common feature in the records of magnetic observatories at all latitudes. Studies of the subject by several workers show that there is a marked diurnal variation in the incidence of these fluctuations and that the diurnal variation is subject to appreciable changes depending on the geographical position of the station, the season and the degree of general magnetic activity on the day. Stagg (1935) studied the local features of magnetic activity at several high latitude stations. He found a forenoon minimum and a single maximum in the night (21-24 hr local time) in the 55° - 69° latitude belt with no radical change in the form of the DV with season or magnetic character of the day. At higher latitudes, in what he terms the transition zone of 70° - 80° latitude, a noon and midnight maxima occur: here the form of DV depends entirely on the season and the magnetic character of the day. Near the pole the only characteristic feature is the early morning minimum. Using K indices for the years 1940-46, of six stations

uniformly distributed in longitude, Nicholson and Wulf (1955) found a local time variation with an early morning minimum and a late evening maximum which changed little with the seasons. Bartels, Heck and Johnston (1940) found that for the eight equinoctial months of 1938-39 the average K index at Huancayo was 3.5 for the interval 10-13 hr LST as compared to only 1.6 for the interval 01-04 hr LST. They also noticed that large fluctuations in the H field prevailed around noon but not during the night. By making measurements on hourly ranges in H , Narayanaswamy (1941) studied irregular fluctuations in the H field at Alibag. He found that the disturbance was least marked one or two hours before sunrise. A pronounced noon maximum and subsidiary maxima at 16-18 hr and 20-24 hr local time are the other features of DV of intensity of fluctuations. He also found the noon maximum to be predominant in summer while the night maximum dominated in winter. In every season the effect of increased magnetic activity was to cause an increase in the intensity of irregular fluctuations during all hours and particularly during the pre-midnight hours, noon increase

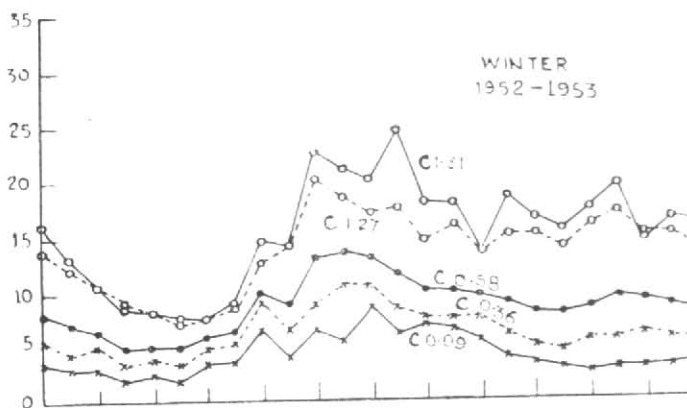


Fig. 1

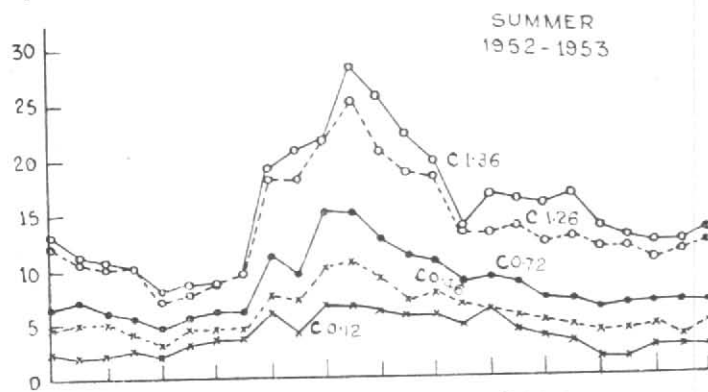


Fig. 2

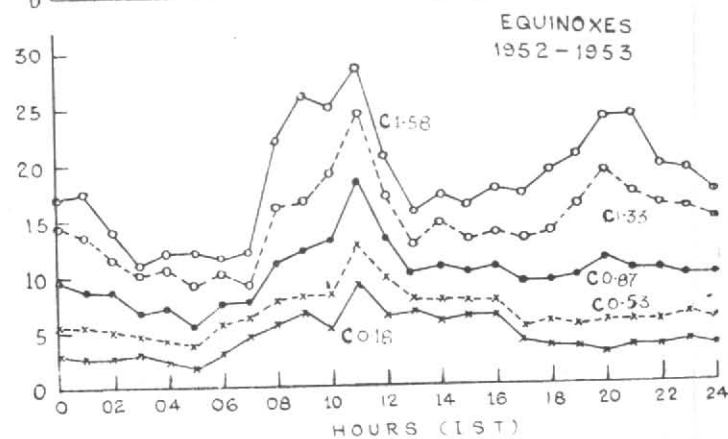


Fig. 3

○—○ INT.DIST. ○---○ DAYS C ≥ 1 ●—● ALL DAYS
 x—x DAYS C < 1 x—x INT. QUIET

in intensity being very small except in summer. These results are compared with the results of a similar analysis of irregular fluctuations in H field at Kodaikanal, near the magnetic equator.

2. Method of analysis

In the absence of finalised three hour range K indices at Kodaikanal the intensity of fluctuations has been arrived at by measurements of hourly range r_H in preference to any alternative mode of characterisation which may be a subjective one. The range r_H however, would not be a correct measure of the intensity of fluctuations only as they are superposed on the normal DV of H . This is particularly so during about three hours before and after noon when the DV of the H field shows a steep rise and a steep fall respectively. The DV in H in each hour which was obtained by the mean range \bar{r}_{Hq} on five international quiet days in a month was, therefore, subtracted from the ranges r_H for the corresponding hour to give the hourly departures $(r_H - \bar{r}_{Hq})$ which would represent the intensity of only the fluctuations in H field. While arriving at the values of $(r_H - \bar{r}_{Hq})$ the ranges were considered with their appropriate signs; positive and negative signs were assigned to the measured values of hourly ranges according as the later end of the swing was respectively, on the side of increasing or decreasing H . Magnitudes of hourly departures $(r_H - \bar{r}_{Hq})$ were obtained for each hour on each day of 1952-53. Monthly means of these were calculated for each hour for the following groups: (i) all days, (ii) five international quiet days, (iii) five international disturbed days, (iv) with days international C figure < 1 and (v) days with international C figure ≥ 1 . Means were deduced for the winter months (November, December, January and February), the summer months (May, June, July and August) and equinoctial months (March, April, September and October) for each of the five groups. The curves in Figs. 1, 2 and 3 represent the mean DV of the intensity of fluctuations

for the five groups of days in the three different seasons.

3. Results

All the curves show a morning minimum (04-06 hr IST) and a noon maximum (10-12 hr IST) as characteristic features. The shape of the curves for quiet and fairly quiet days resembles the normal quiet day solar daily variation at Kodaikanal. This suggests that these fluctuations possibly arise in the Sq current system. It may be mentioned that a day-time augmentation in sizes of sudden commencements and impulses at Kodaikanal has also been noticed leading to a similar conclusion (Srinivasamurthy 1960).

The effect of increased magnetic activity in all seasons is an increase in the intensity of irregular fluctuations given by $(r_H - \bar{r}_{Hq})$ for all hours of the day; this rise however, is not uniform for all hours and seasons. In Fig. 4, the curves giving differences between the $(r_H - \bar{r}_{Hq})$ values for five international disturbed days and those for five international quiet days for the three different seasons have been plotted. The contribution of the disturbance field to the intensity of fluctuations is semidiurnal with maxima around noon and late in the evening. From Fig. 4 it is seen that the rise around noon is generally very large; the increase in the night-time which is considerable in winter and summer is marked during equinoctial months. The change in the intensity of the fluctuations with increased magnetic activity is the least in the early morning hours for all seasons. The monthly mean values of $(r_H - \bar{r}_{Hq})$ for 00-24 hours and the three sub-groups 00-08 hr, 08-16 hr, and 16-24 hr are given in Fig. 5. Like all other measures of magnetic activity these annual variation curves also show maxima at the equinoxes. The curve for 08-16 hr is marked by an asymmetry about the equinoxes. The summer minimum is most pronounced for 08-16 hr.

A comparison of curves in Figs. 1-3 with

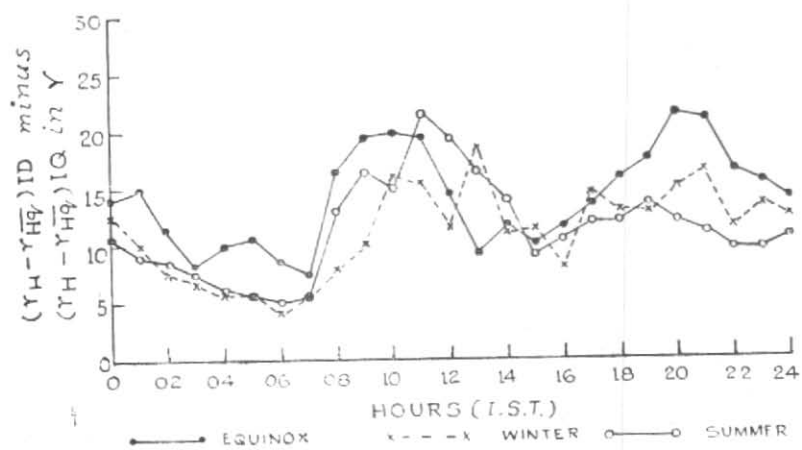


Fig. 4

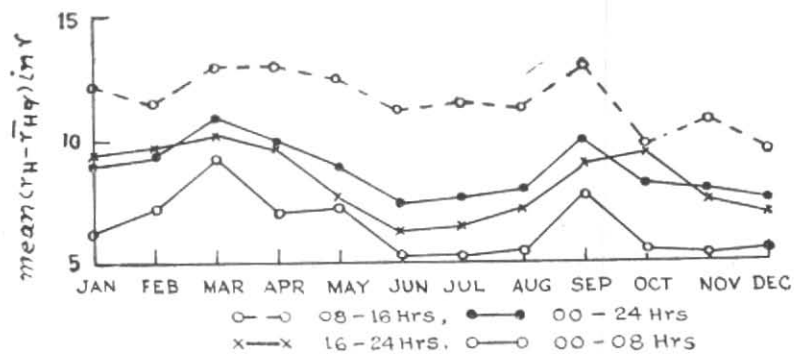


Fig. 5

the DV curves of fluctuations at Alibag obtained by Narayanaswamy (1941) shows that there is a resemblance between the two in summer, the noon maximum at Kodaikanal being the more marked of the two. Whereas at Alibag there is no marked change from noon to midnight in the intensity of fluctuations during the winter and equinoctial months, the noon values remain decidedly higher than night values at Kodaikanal. For highly disturbed days during equinoxes and winter the disturbance at night at Alibag becomes higher than at noon and the smoothed DV curve approaches a 24-hr wave. At Kodaikanal though the night values of disturbance increase substantially, they do not exceed noon values and the smoothed curve approaches two 12-hr waves. This trend is conspicuous in the equinoctial months at Kodaikanal. The seasonal changes in the form of the DV of incidence of fluctuations become marked only for days with high C figures. From a study of the curves for international disturbed days in Figs. 1-3 it can be seen that the seasonal change is marked in the evening and night-time disturbance. From a similar observation together with the correlation between the night maximum of disturbance and the maximum in the diurnal variation of *aurora polaris* and the appearance of intense E_s at Tikhya Bay, Nikolsky (1947) inferred that two distinct types of corpuscular radiation are responsible for the different kinds of disturbance in evidence at different times of the day.

4. Fluctuations in H and spread F echoes

The nocturnal prevalence of fluctuations even on quiet days has been explained by Nicholson and Wulf (1955) in terms of increased turbulence during the night in the ionosphere revealed by increased occurrence of spread F echoes. Intense spread F echoes are a common feature of night-time ionograms at Kodaikanal as at other equatorial stations. The magnetograms on the other hand show that the hours after sunset are generally quiet, and free from irregular fluctuations. There does not appear to be any obvious

correspondence between the two phenomena — F scatter and the incidence of fluctuations in the magnetic field. In a preliminary study of F scatter at Kodaikanal Bhargava (1958) has found that the day to day variation in F scatter incidence indicate a negative correlation with geomagnetic activity. He found that upto a C figure of 1.0 there is a progressive decrease in per cent occurrence of scatter with increasing magnetic activity and for $C > 1$ there is a more rapid decrease that tends to vanish on highly disturbed days. Booker and Wells (1938) found no correlation between F scatter and geomagnetic activity.

5. Noon maximum of incidence of fluctuations

The maximum incidence of fluctuations at noon is closely related to the noon maximum in the quiet day diurnal variation of H which has a fairly large range at Kodaikanal. The overhead Sq currents are enhanced at noon, the narrow belt of current augmentation being the so-called equatorial electrojet. As suggested by Onwumechilli (1959) the irregular fluctuation H at noon may be connected with the fluctuations in the solar ionising radiation to which the augmenting electrojet is sensitive. (The irregular fluctuations in the magnetic field around noon have been called the equatorial indentations by him). At Ibadan and Kano, two widely separated equatorial stations, he found that the indentations were almost coincident in the times of occurrence at the two places and that the differences between Sq ratios and the indentation size ratios were within the limits of error and concluded that the indentations are another widely distributed phenomena, and their magnitudes are proportional to the large diurnal ranges in the field. The large range of fluctuations near the magnetic equator and their preponderance around noon may be the result of the fluctuations in the ionising agent affecting the magnetic changes most effectively near the magnetic equator, resulting from the small value of the zenith angle of the sun and the great enhancement of ionospheric conductivity.

The fluctuations in the field on the other hand may also be a consequence of dynamo action by large scale atmospheric motions in the electrically conducting region. Wulf and Hodge (1950) are of the opinion that many conspicuous and even violent changes from day to day in magnetic records may be a direct reaction of correspondingly marked changes in the atmospheric circulation over the locality of the observatory. The regular convection currents to which the diurnal magnetic variation is ascribed are likely to be disturbed by local air currents in such a way as to give magnetic variations at points distant five to six times the ionospheric height a totally different character. Vacquier (1937) has found for two stations 800 miles apart 58 per cent of the fluctuations in V to behave independently both in type and time of occurrence.

It has recently been found by Beynon

and Brown (1959) that vertical drifts of ionisation take place in the region E , which is about the height of the seat of S_q currents. It is reasonable to suppose that considerable fluctuations in the ionisation take place consequent to redistribution by movements due to interaction of electric field with the earth's main magnetic field. The effective conductivity in the S_q current sheet may in turn vary and the variations may get reflected as fluctuations in H field.

A comparative study of many selected fluctuations on quiet days at Kodaikanal and Alibag and nearby IGY field stations at Chidambaram and Trivandrum will be of interest in the light of possible explanations summarised above.

6. Acknowledgement

I am thankful to Dr. M. K. Vainu Bappu and Shri B. N. Bhargava for kindly going through the manuscript.

REFERENCES

- | | | |
|--|------|--|
| Bartels, J., Heck, N. H. and Johnston, H. F. | 1940 | <i>Terr. Mag.</i> , 45 , p. 331. |
| Beynon, W. J. G. and Brown, G. M. | 1959 | <i>J. atmos. terr. Phys.</i> , 14 , p. 138. |
| Bhargava, B. N. | 1958 | <i>Indian J. Met. Geophys.</i> , 9 , 1, p. 35. |
| Booker, H. G., and Wells, H. W. | 1938 | <i>Terr. Mag.</i> , 43 , 249. |
| Narayanaswamy, R. | 1941 | <i>Ibid.</i> , 46 , p. 147 |
| Nicholson, S. B. and Wulf, O. R. | 1955 | <i>J. geophys. Res.</i> , 60 , p. 389. |
| Nikolsky, A. P. | 1947 | <i>Terr. Mag.</i> , 52 , p. 105. |
| Onwumechilli, C. A. | 1959 | <i>J. atmos. terr. Phys.</i> , 13 , p. 222. |
| Srinivasamurthy, B. | 1960 | <i>Indian J. Met. Geophys.</i> , 11 , 1, p. 64. |
| Stagg, J. M. | 1935 | <i>Proc. Roy. Soc.</i> , London, 149 A, p. 298. |
| Victor Vacquier | 1937 | <i>Terr. Mag.</i> , 42 , p. 17. |
| Wulf, O. R. and Hodge, M. W. | 1950 | <i>J. geophys. Res.</i> , 55 , p. 1. |