GEOMAGNETIC DISTURBANCE EFFECT ON THE SOLAR DAILY RANGE OF H FIELD

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ABSTRACT

In the present note, two extreme definitions of the solar daily range of the geomagnetic H field (*i*) $\Delta H(R) = H_{max} - H_{min}$ where H_{max} is the instantaneous highest value, and H_{min} the instantaneous lowest value of the H field during the day and (*ii*) $\Delta H(S) = H_{midday} - H_{night}$ where H_{midday} is the highest mean hourly value between 1100 and 1300 hrs. and H_{night} is the mean hourly value averaged over 0000–0300 hrs. and 2100–2400 hrs. have been compared. The variations of H_{max} and H_{min} with $\Delta H(R)$ and that of H_{midday} and H_{night} with $\Delta H(S)$ have been studied for a station under the equatorial electrojet (Trivandrum) and a non-equatorial station (Alibag) during the quiet sun period 1964–65 for quiet and disturbed days. It is found that while on disturbed days, $\Delta H(R)$ is contributed appreciably by variations in H_{min}, on quiet days the increase of $\Delta H(R)$ is primarily due to increase of H_{max}. The range $\Delta H(S)$ is contributed only by the changes in the daytime value of the field both on quiet as well as on disturbed days. The values of H_{midday} as well as H_{night} seem to be equally depressed on disturbed days, probably due to ring currents established on disturbed days. The range $\Delta H(S)$ as suggested by Chapman and Raja Rao remains unaffected by geomagnetic disturbances.

INTRODUCTION

OF late, there has been renewed interest in the daily range ΔH of the geomagnetic field H component, particularly after the development of magnetospheric physics. The solar daily variation of the geomagnetic H field at low latitude stations on quiet days is attributed to the S_q dynamo currents flowing in the E-region of the ionosphere. The daily variation range ΔH is amplified in a narrow belt of $\pm 3°$ centred around dip equator because of the enhanced W–E conductivity and the resultant additional electrojet current in this zone (Chapman, 1951). Many authors have used the definition $\Delta H = H_{max} - H_{min}$ where H_{max} and H_{min} are respectively the maximum and minimum instantaneous values of the H field during the day. The properties of such a range are obviously different on quiet and disturbed days. On quiet days the minimum occurs at night while on disturbed days it could occur at any time during day or night depending on the disturbances. Especially after the suggestion of Sarabhai and Nair (1969) that large H ranges are due to decrease of nighttime field rather than daytime increase and that this decrease is due to magnetospheric currents, there has been a renewed interest in the location and nature of the currents responsible for the changes in H.

Various criteria have been used to define the solar daily range of H by different authors. Chapman and Raja Rao (1965) have discussed the comparative merits of some of these, and have suggested a definition of diurnal range S derived from the mean hourly values of the H field. For a particular day it is equal to the highest mean hourly value *minus* the hourly value averaged over 0000–0300 hrs and 2100–2400 hrs. Many observatories publish in their monthly bulletins the range R defined by the maximum instantaneous value *minus* the minimum instantaneous value of H for each day. Sarabhai and Nair (1969), Hutton (1970) and Kane (1971) have studied the variation of H_{max} and H_{min} values in relation to the daily range. The purpose of this paper is to study the relative effect of geomagnetic disturbance on the ranges of H field defined by $\Delta H(R)$ and $\Delta H(S)$.

Kane (1971) showed that the ΔH values are positively correlated with H_{max} and negatively correlated with H_{min} and suggested that both increases as well as decreases contribute to large ΔH values at low-latitudes. Misra (1972) has shown that changes in ΔH defined as $H_{max} - H_{min}$ are due both to increase of H_{max} as well as decrease of H_{min}, while the range defined as the difference of the mean daytime and mean nighttime value is mainly contributed by changes in the daytime value.

DAILY RANGE OF H ON QUIET AND DISTURBED DAYS

In the present paper we have taken the published hourly values of H at Alibag and Trivandrum for the years 1964 and 1965. The range in H has been calculated for each of the five international quiet days of all months using the following two definitions:

$$\Delta H(R) = H_{max} - H_{min} \text{ (instantaneous values)} \quad (1)$$

$$\Delta H(S) = H_{midday} - H_{night} \text{ (mean hourly values)} \quad (2)$$

where H_{midday} is the highest mean hourly value between 1100 and 1300 hrs and H_{night} is the hourly averaged value over 0000–0300 and 2100–2400 hrs. Similarly the process is repeated for the five international disturbed days of each month in 1964–65. The ranges are then grouped into 0–9 γ, 10–19 γ, 20–29 γ, etc., and the corresponding mean values of H_{max} and H_{min} for each of these groups are evaluated separately for quiet and disturbed days.

Alternately, if we define the range as given by equation (2) and plot the corresponding values of H_{midday} and H_{night} against the range $\Delta H(S)$ the results will be as in Fig. 2. It is seen that on quiet as well as on disturbed days H_{midday} shows an increase with $\Delta H(S)$ while H_{night} remains fairly constant with $\Delta H(S)$ both on quiet as well as disturbed days. Therefore, there is negligible contribution from H_{night} to the observed change in $\Delta H(S)$ on quiet and disturbed days.

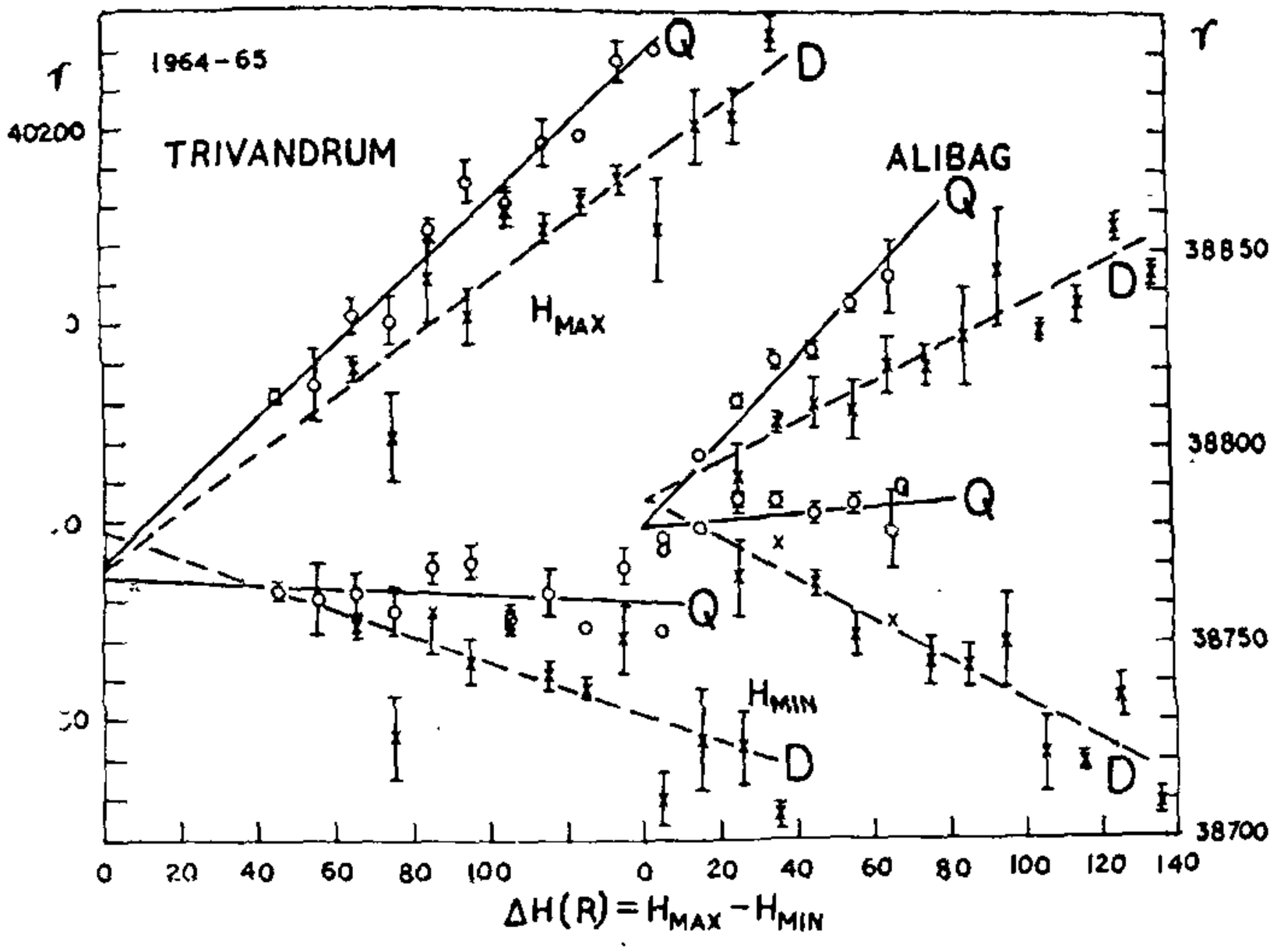

FIG. 1. Variation of H_{max} and H_{min} plotted against the range $\Delta H(R)$ for quiet (Q) and disturbed (D) days for the stations Trivandrum and Alibag. O for quiet days and X for disturbed days.

Figure 1 shows a plot of H_{max} and H_{min} against the range $\Delta H(R)$ defined according to equation (1). It is evident that on quiet as well as disturbed days H_{max} shows an increase with increasing value of $\Delta H(R)$, while H_{min} remains almost steady on quiet days; on disturbed days H_{min} seems to be negatively correlated with $\Delta H(R)$. This indicates that on quiet days variations in $\Delta H(R)$ are due to an increase in daytime value as a result of the ionospheric currents and not due to changes in H_{min}. On the contrary, $\Delta H(R)$ is composed of an increase in daytime value as also a decrease in nighttime value for disturbed days. The variations of H_{max} and H_{min} are similar for both the stations Alibag and Trivandrum. The decrease in nighttime value on disturbed days could be due to currents flowing in a direction opposite to that of S_q currents at large heights, possibly at magnetospheric heights, so that they affect both the stations similarly.

Summary and Conclusions

The variation of H_{midday} with the range $\Delta H(S)$ can be described by the following best-fitted straight line equations:

For quiet days

at Trivandrum $H_{midday} = [40097 + 1{\cdot}00\ \Delta H(S)]\gamma$

at Alibag $H_{midday} = [38791 + 0{\cdot}82\ \Delta H(S)]\gamma$

For disturbed days

at Trivandrum $H_{midday} = [40079 + 1{\cdot}03\ \Delta H(S)]\gamma$

at Alibag $H_{midday} = [38778 + 0{\cdot}90\ \Delta H(S)]\gamma$

H_{night} remains fairly constant with $\Delta H(S)$ on quiet as well as on disturbed days for both the stations.

The variation of H_{max} and H_{min} with $\Delta H(R)$ can be represented by the following best-fitted least square straight line equations;

For quiet days

at Trivandrum $H_{max} = [40090 + 0{\cdot}91\ \triangle H(R)]\ \gamma$
at Trivandrum $H_{min} = [40086 - 0{\cdot}04\ \triangle H(R)]\ \gamma$
at Alibag $H_{max} = [38785 + 0{\cdot}49\ \triangle H(R)]\ \gamma$
at Alibag $H_{min} = [38778 + 0{\cdot}08\ \triangle H(R)]\ \gamma$

For disturbed days

at Trivandrum $H_{max} = [40087 + 0\ 73\ \triangle H(R)]\ \gamma$
at Trivandrum $H_{min} = [40097 - 0{\cdot}33\ \triangle H(R)]\ \gamma$
at Alibag $H_{max} = [38779 + 1{\cdot}04\ \triangle H(R)]\ \gamma$
at Alibag $H_{min} = [38786 - 0{\cdot}51\ \triangle H(R)]\ \gamma$

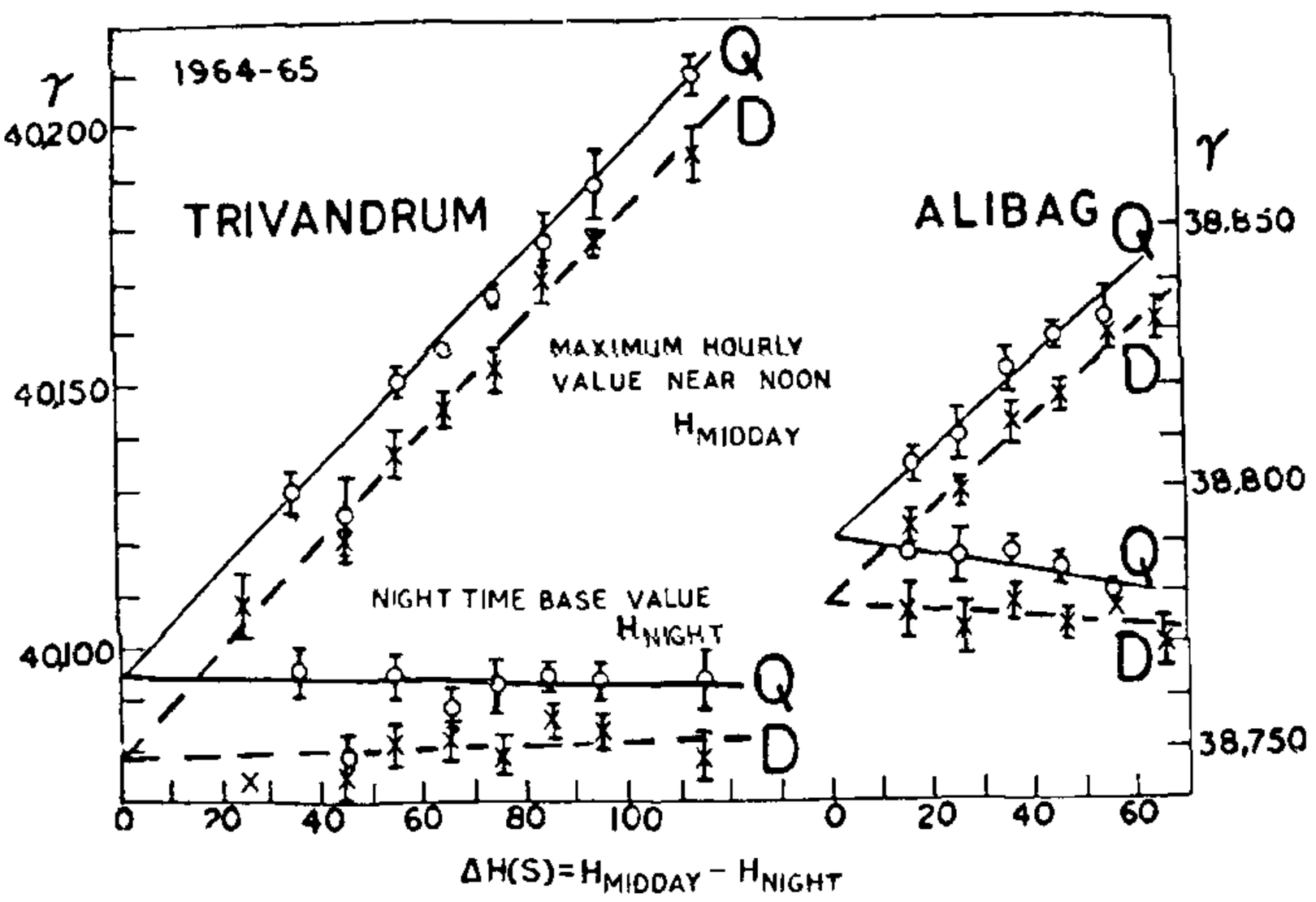

FIG. 2. H_{midday} and H_{night} plotted against the range $\triangle H(S)$ for quiet (Q) and disturbed (D) days for the stations Trivandrum and Alibag. O for quiet days and X for disturbed days.

This suggests that while the range $\triangle H(S)$ is hardly affected by magnetic disturbance, $\triangle H(R)$ is greatly affected by the degree of magnetic disturbance. The apparent discrepancies in similar studies by different authors are due to the different definitions of the range in H. It is concluded that for any comparative studies of geomagnetic H-field-range with other geophysical parameters at low-latitudes, the definition of the range should be quite clear and preferably the range $\triangle H(S)$ should be used.

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