DAILY RANGE OF THE H COMPONENT OF GEOMAGNETIC FIELD IN AND NEAR THE ELECTROJET

R. K. MISRA

Physical Research Laboratory, Ahmedabad-9, India

ABSTRACT

Characteristics and interrelations of the solar daily variations of H at Trivandrum, a station within the equatorial electrojet and at Alibag, a low latitude station, during a low sunspot period are discussed. It is shown that any change in the daily range Δ H at Alibag is contributed 63% by the decrease of instantaneous minimum value of H ($H_{min.}$) and only 37% by the increase of instantaneous maximum value of H ($H_{max.}$), whereas the contribution of the two effects is equal for Trivandrum. Using the rSq type of daily range of H, it is found that when a large number of days are considered, the daily range at equator is predominantly due to the increase of daytime value of H.

It is also shown that there is a very high correlation between $H_{min.}$ at the two stations and a rather poor correlation between the $H_{max.}$ values, indicating that the night-time changes in H are produced by currents at great heights.

INTRODUCTION

THE daily variation of H at low latitudes is known to be anomalously large at stations within a narrow belt of width ± 3° dip centred on the magnetic equator and has been attributed to strong currents called equatorial electrojet flowing eastward. This extra current is due to the special features existing over the magnetic equator where crossed electrical and magnetic fields give rise to the vertical Hall polarization field which is unable to leak out due to the magnetic lines of forces being horizontal near the magnetic equator, leading to exceptionally large east-west conductivity.

It was suggested by Nair *et al.* (1970) that the daily variation at any station would depend upon both the daytime enhancement due to ionospheric currents and the night-time decrease due to the magnetospheric currents. The relative contributions of these effects would depend upon the latitude of the station. The magnetospheric contribution would produce almost the same effect at the two stations, Alibag and Trivandrum, separated by about 1100 Km. On the other hand, H at the equator is largely influenced by the equatorial electrojet. Consequently the difference between the solar daily range at Trivandrum and Alibag was suggested to be purely an ionospheric current index. This was confirmed by a linear relationship between the difference of ranges and the ionospheric drift speed at Thumba. It was estimated that on the average the ionospheric contribution to the daily range at Alibag represents a daytime enhancement of 17 γ on a total range of 50 γ.

Olson (1970) has calculated the quiet day variations in the earth's surface magnetic field caused by the magnetopause, neutral sheet and ring currents. The different model current systems produce variations similar to the average Sq pattern but smaller in magnitude.

Sarabhai and Nair (1971) have later given a conceptual theory for the daily range of H at any station taking into account (1) the dynamo currents mainly at the ionospheric E region, (2) the surface currents at the magnetopause, (3) the tail currents, (4) the eccentric ring current and (5) the partial ring current in the magnetosphere.

The present work describes some analyses of the solar daily variation of H at Trivandrum, a station within the equatorial electrojet and at Alibag, a low latitude station not influenced by the equatorial electrojet during a low sunspot period. The yearly bulletin published by the Colaba Observatory of the Indian Meteorological Department gives the hourly mean value of the geomagnetic field H, instantaneous minimum ($H_{min.}$) and maximum ($H_{max.}$) values of H as well as the daily range $\Delta H = (H_{max.} - H_{min.})$ for each day.

The Relative Contributions of $H_{max.}$ and $H_{min.}$ Towards Δ H

In order to study the contributions of H_{min} and $H_{max.}$ to Δ H, a mass plot of H_{max} and H_{min} against Δ H for both the stations are shown in Fig. 1. Similar curves have been shown by Sarabhai and Nair (1969) separately for H_{max} and $H_{min.}$. It is seen, that at both Alibag and Trivandrum an increase in Δ H is due to both the increase of $H_{max.}$ and decrease of $H_{min.}$. Precisely speaking, for Alibag, the correlation coefficient between Δ H and H_{min} is $-0{\cdot}70$ and between Δ H and $H_{max.}$ is + 0·48. Regression line between of Δ H with H_{max} or $H_{min.}$ is given by the following equations :

$$H_{max.} \text{ (Alibag)} = 38{,}807 + 0{\cdot}35 \ \Delta H$$

$$H_{min.} \text{ (Alibag)} = 38{,}805 - 0{\cdot}63 \ \Delta H.$$

They indicate that the internal component of H field at Alibag is 38806 γ averaged for the period of study.

Chapman and Rajarao (1965) have defined another index of the solar daily range, rSq, which is equal to the difference of the hourly maximum value (HD) and the mean of the night-time values (HN) for the hours 00–03 and 21–23.

The maximum hourly values being taken at roughly midway between two night-time periods chosen, the rSq will be free from the slow variations of the magnetic field H.

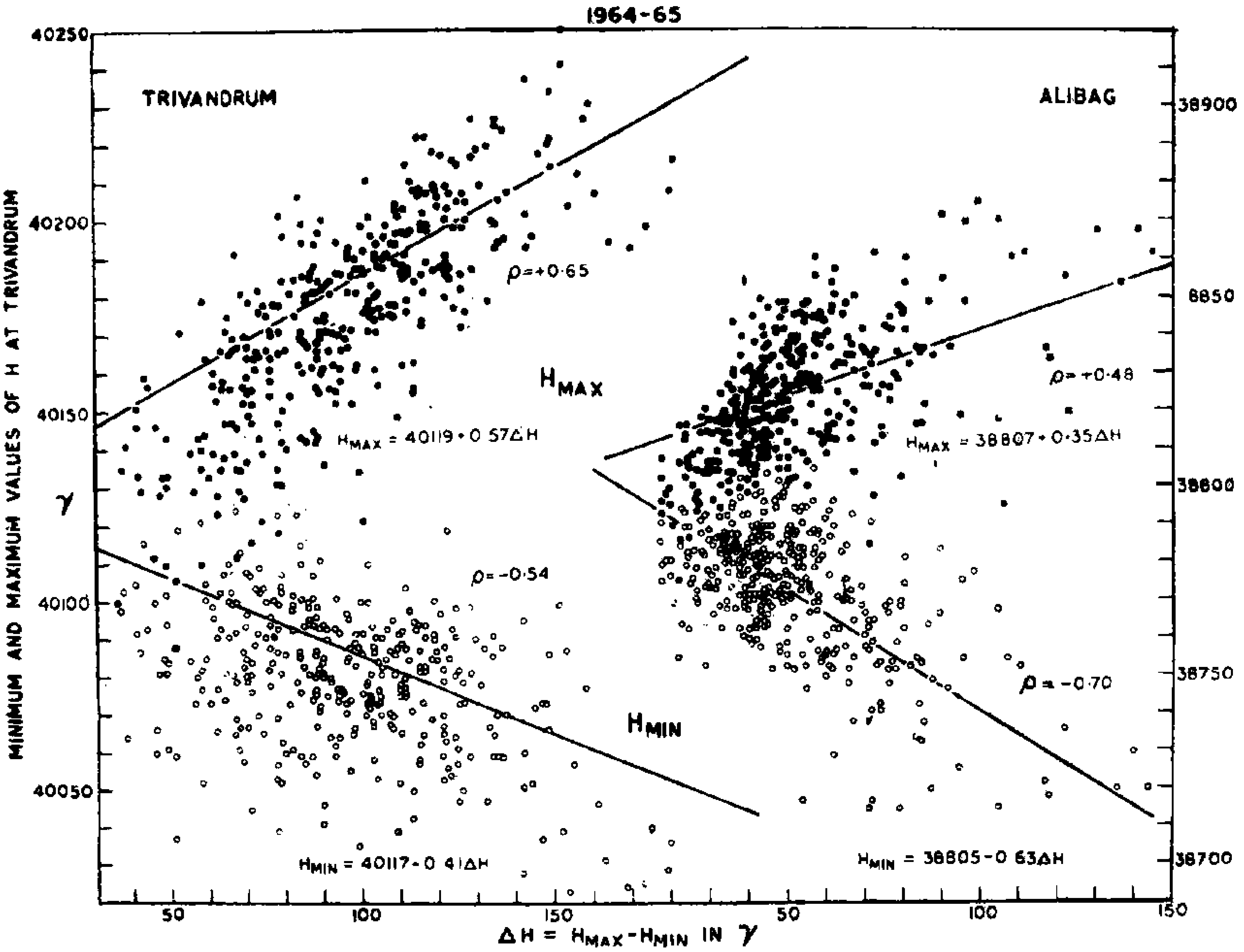

FIG. 1. Mass plot showing correlation of Δ H with $H_{max.}$ and with $H_{min.}$ separately for Trivandrum and Alibag.

Further for any change of Δ H at Alibag, the contribution due to the decrease of H_{min} is 2/3 Δ H (63%) and due to the increase of $H_{max.}$ is 1/3 Δ H (35%).

In the case of Trivandrum, the correlation ρ between Δ H and H_{min} is − 0·54 and between Δ H and H_{max} it is 0·65. Referring to the regression lines it is seen that a change in Δ H at Trivandrum is equally contributed by the increase of $H_{max.}$ as well as the decrease of $H_{min.}$:

$$H_{max.} \text{ (Trivandrum)} = 40{,}119 + 0{\cdot}57 \ \Delta H$$

$$H_{min.} \text{ (Trivandrum)} = 40{,}117 - 0{\cdot}41 \ \Delta H.$$

The internal component of H field is 40,118 γ.

Unlike Δ H, which is derived from the instantaneous values of H, the index rSq is less affected by the geomagnetic disturbance field.

A mass plot showing variation of rSq with H_D and H_N are shown in Fig. 2, for Trivandrum as well as for Alibag. It is seen that in case of Trivandrum there is a correlation coefficient of 0·87 between the midday values H_D and the range (rSq) while the correlation between the midnight values (H_N) and the range (rSq) is almost zero. Thus the day-to-day variation of the average daily range (rSq) is on the average contributed entirely by the variation of the midday maximum value. For Alibag, the correlation between midday value and the range is 0·73 while that between the midnight value and the range is again almost zero. The increase in the rSq at Alibag is contributed by the decrease of the night-time value, by only about 14%. This indicates that when a large number of days are taken, then the daily range is predominantly due to the increase of the daytime value of H at low latitude stations.

The generally high correlations between the night-time value of H at stations within the equatorial electrojet and at others outside it for the night-time hours, and not so much for the daytime hours, indicates that definitely two sources are operating in the generation of solar daily range. The various magnetospheric currents have been shown to have appreciable effect in the night-time H values

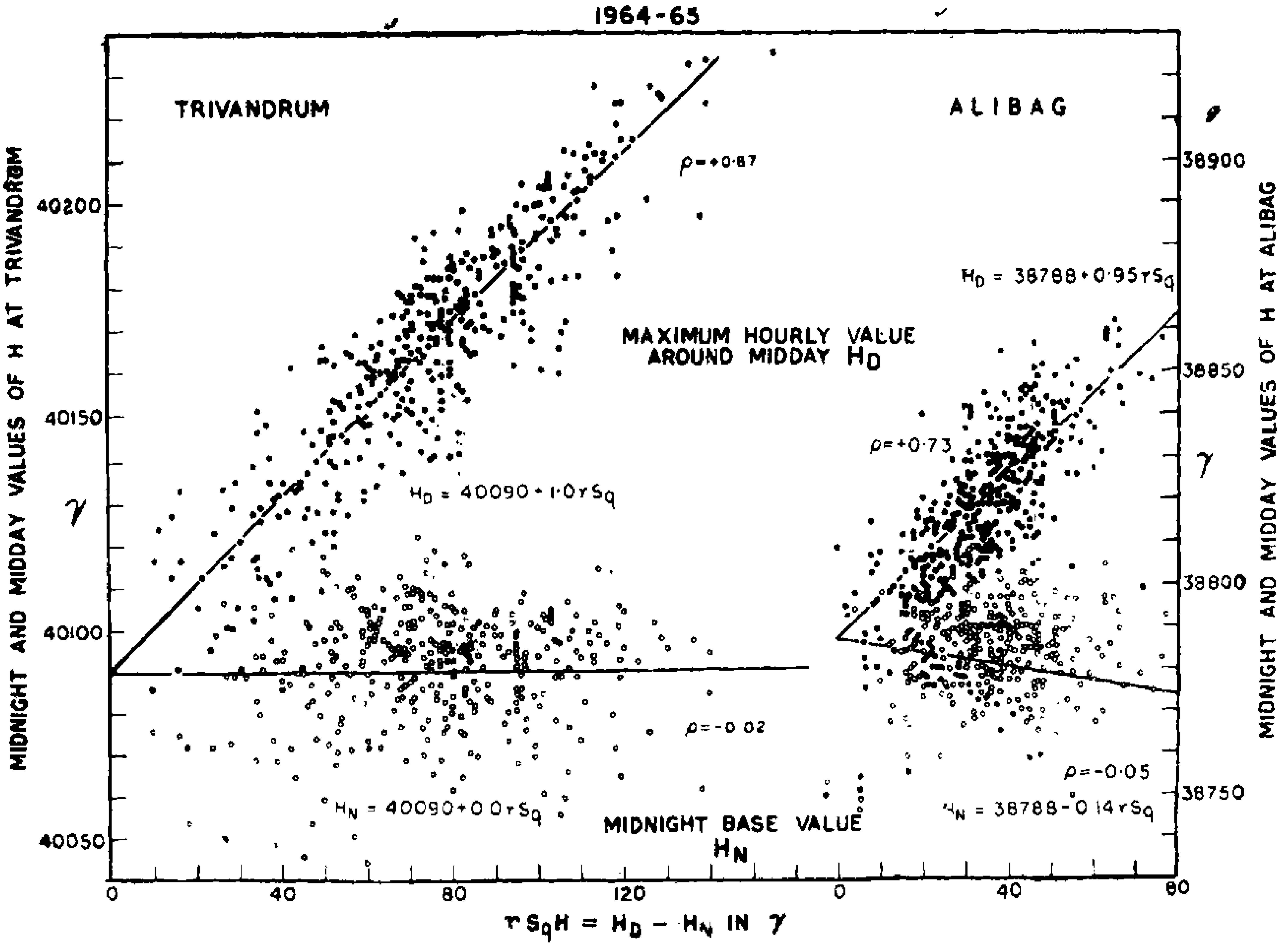

FIG. 2. Mass plot showing correlation of rSq with maximum hourly value around midday (H_D) and the midnight base value (H_N) separately for Trivandrum and Alibag.

It is seen that, in general, at the two places there is a very high correlation between $H_{min.}$ and rather low correlation between the H_{max} (*see* Fig 3). This indicates that the night-time values of the magnetic field H are affected in the same sense but the daytime values are partly independently varying between Trivandrum and Alibag.

DISCUSSIONS

There are two main points under discussion here. Firstly, the contributions of the daytime and night-time currents towards the solar daily range at a low latitude station. Secondly, the interrelation of the equatorial electrojet currents to the world-wide S_q currents.

and surely do affect the solar daily range. Recent measurements have indicated the presence of ionospheric currents during the night time (Balsley, 1969; Rastogi *et al.*, 1966; Davis *et al.*, 1967) and these are in a direction opposite to that of the daytime currents. A relatively high correlation between the night-time values of H at two stations favours that these changes are produced by currents at great heights possibly at magnetospheric levels.

The individual values of daily range ΔH at equatorial and non-equatorial stations are weakly correlated but the difference in the daily ranges at the two stations is not correlated with the daily range at non-equatorial station. This suggests that the equatorial electrojet currents at the magnetic equator vary independently of the variations of world-wide S_q and should be considered as the additional current system over the S_q. This range of H in the absence of equatorial electrojet current is about 40 γ if the hourly average values of H are used, and about 50 γ if the instantaneous values of H are used. It is thus concluded that the difference between the daily ranges at equatorial and non-equatorial station is a much better index of the ionospheric currents rather than the daily range of the equatorial electrojet station itself. This has been confirmed by the correlation between ionospheric drift at Thumba having higher correlation with $\Delta H_T - \Delta H_A$ than with ΔH_T alone (Chandra *et al.*, 1971).

Further analyses of the daily ranges at low latitude stations in relation to the solar radiation and wind parameters would further identify the agencies causing the geomagnetic variations at low latitudes.

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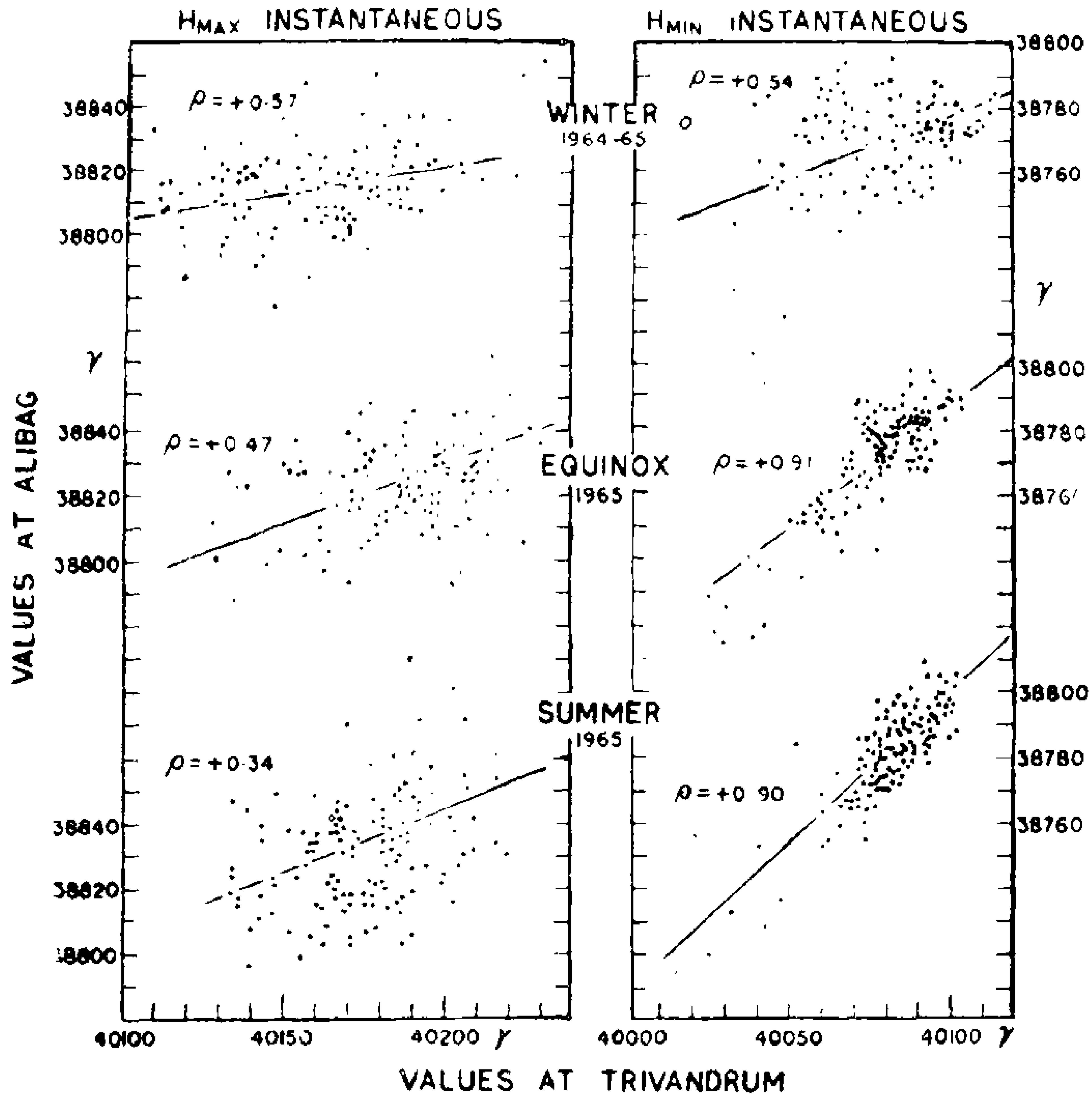

FIG. 3. Mass plot showing variation of H_{max}. and H_{min}. simultaneously at Trivandrum and Alibag for each of the seasons.

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