dian Journal of Radio & Space Physics
ol. 8, October & December 1979, pp. 398-399

Daily Variation of the Equatorial Geomagnetic Field in the Vicinity of the IMF Sector Boundaries

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Received 9 *April* 1979; *revised received* 4 *June* 1979

The response of the equatorial geomagnetic field to the passage of over 170 spacecraft-observed and well-established sector boundaries during the period 1962-1972 has been studied. It is shown from superposed epoch analysis of the daily range of magnetic field from 10 days before to 10 days after sector boundary crossings, that the significant aspect of the association is not mainly the increase in the daily range following the boundary crossing, but also the minimum of the daily range before crossing. A distinct difference in the responses of the range of daily variation with respect to the type of boundary passage, namely, a transition from positive to negative polarity and negative to positive polarity, has been noticed.

1. Introduction

After the discovery of the sector structure of the interplanetary magnetic field (IMF) several interesting relations between geomagnetic activity and IMF direction in the ecliptic plane have been detected. Wilcox and Ness[1] showed that sector boundary crossing is to be associated with increased geomagnetic activity, a feature which was to be consistent throughout the rising portion of the previous solar cycle.[2] Rangarajan[3] noticed significant departure in the mean daily range on the day of sector boundary passage in relation to its magnitude on adjacent days with a measure of dependence on the phase of the solar activity. These responses were noticed to be identical at various stations spanning from dip equator to that near the focus of S_q.

Shapiro[4] has shown recently that the most significant aspect of the sector boundary passage is the minimum in average K_p before the boundary crossing, but not the usually observed maximum after crossing. From an analysis of K indices at three low latitude stations Rangarajan[5] has noticed always a minimum 2 days prior to the passage of boundary and a maximum on the same day during low solar activity and a day later during high solar activity. In this paper we have made an attempt to see whether such a characteristic of sector boundary transition could be found in the instantaneous daily range of the equatorial geomagnetic field.

2. Data and Analysis

The daily range used in the present study is defined as the difference between the instantaneous maximum and minimum of the daily horizontal field in a Greenwich day. Ranges derived from Kodaikanal (dip 3·5° N) magnetograms for the period 1962-72 have been used in a superposed epoch analysis with about 172 satellite-observed and well-established sector boundary crossings taken as key dates.

Fig. 1 shows the superposed epoch analysis of the daily range of the horizontal component of the geomagnetic field at Kodaikanal from 10 days before to 10 days after 172 satellite-observed and well-established sector boundary crossing dates during the period 1962-72. It can be seen from the top plot of Fig. 1 that the mean daily range shows a maximum in the immediate vicinity of the sector boundary passage, establishing the already reported behaviour. On the other hand, the minimum on day −3 is also found to be significant, approximately 2 standard deviations below the population mean.

The 172 dates of observed and well-defined sector boundaries used in this study (top plot in Fig. 1) consists of 85 dates with transitions from positive to negative polarity (bottom plot in Fig.1) and 87 dates with transition from negative to positive polarity (middle plot in Fig. 1).

3. Results and Discussion

There are quite a few differences in the behaviour of the mean daily range of the equatorial geomagnetic field with respect to passage of the two types sector boundary, namely, transition from positive to negative polarity and reverse. In the case of transition from positive to negative polarity

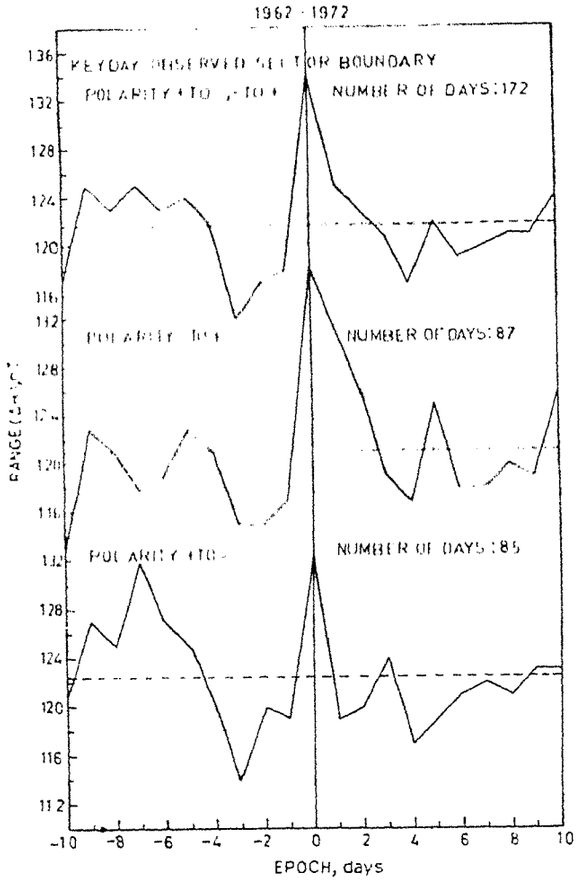

Fig. 1—Superposed epoch analysis of the range of mean daily variation of the equatorial geomagnetic field to passage of IMF sector boundaries during the period 1962-72 (The dashed horizontal lines indicate the population mean of all the data in each of the plots.)

(bottom plot in Fig. 1), there is a maximum on day −7 which is equal to the maximum on day 0. The minimum on day −3 is significant, about 2 standard deviations below the population mean. The mean daily range on days + 1 and + 2 is below the population mean whereas at least there are 4 separate days when the mean daily range is above the population mean before 0 day. In the case of boundary transition from negative to positive polarity (middle plot in Fig. 1), there is no other maximum observed except the one on day 0. The maximum on day 0 is comparatively more in magnitude than the maximum on day 0 of +/− boundary transition. Mean daily range on day + 1 and + 2 shows higher values above the population mean. The minimum on day − 3, although less, is significant and about 1·5 standard deviations below the population mean. In other words, it can be seen that the behaviour is almost reversed in the case of −/+ boundary transition. The differences in the two plots are all the more striking in view of the fact that the respective population means of daily range are almost the same, namely, 122·4 and 121.

Shapiro has observed that the minimum in K_p is mostly significant on day −1 compared to the maximum in the immediate vicinity of the sector boundaries. In the present study, the minimum in the daily range observed on day −3, although less in magnitude compared to the maximum on day 0, is significant.

It can be clearly seen from the present study that a distinct difference exists in the responses of the range of daily variation with respect to the type of boundary passage, namely, transition from positive to negative polarity and reverse. Although Wilcox and Ness found no evidence for a difference in the association between the types of boundary passage and K_p, later studies[6] revealed a large and distinct difference in the behaviour of magnetic activity with respect to the types of boundary passage. Bhargava and Rangarajan[7] also reported that the response of the low latitude field differed significantly depending upon the nature of polarity, type of boundary and phase of solar activity. Shapiro has observed similar differences in the response of K_p to the two types of sector boundaries.

Rangarajan[5] from an analysis of K indices corresponding to three low latitude stations concluded that while the minimum two days prior to the passage and a maximum following the sector boundary are inherent features, their respective magnitudes show perceivable dependence on the nature of the boundary and solar activity. He has also noticed that the response across the (+/−) boundary is distinctly larger, a feature observed by Shapiro and also in the present investigation.

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