Inferring interplanetary magnetic field polarities from geomagnetic variations

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[1] In this paper, we propose a modified procedure to infer the interplanetary magnetic field (IMF) polarities from geomagnetic observations. It allows to identify the polarity back to 1905. As previous techniques it is based on the well-known Svalgaard-Mansurov effect. We have improved the quality and accuracy of polarity inference compared with the previous results of Svalgaard (1975) and Vennerstroem et al. (2001) by adding new geomagnetic stations and extracting carefully diurnal curve. The data demonstrates an excess of one of the two IMF sectors within equinoxes (Rosenberg-Coleman rule) evidencing polar field reversals at least for the last eight solar cycles. We also found a predominance of the two-sector structure in late of descending phase of solar cycle 16.

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1. Introduction

[2] It is well known that the large-scale solar magnetic field is a source of the interplanetary magnetic field (IMF). Therefore, investigating the IMF can be useful to obtain information about the magnetic field in the outer layers of the solar atmosphere, and its evolution over the solar activity cycle. In this paper we study a sector structure of the IMF - direction of the magnetic field either away from the Sun or toward the Sun (A and T days). It has become possible to restore IMF polarities in the pre-satellite era after the discovery of the Svalgaard-Mansurov (S-M) effect [*Svalgaard*, 1968; *Mansurov*, 1969], according to which opposite IMF directions lead to opposite sign of the geomagnetic variations at polar stations and, thus, can be inferred. Typical variations of geomagnetic field in A and T days are displayed in Figure 1. It was determined later that these variations are caused by ionospheric DPY current system [*Friis-Christensen and Wilhjelm*, 1975] — **D**isturbance **P**olar current powered by azimuthal **Y** component of the IMF (in GSM coordinate system) and located in cusp region. In the north polar cap this DPY current flows east when IMF B_Y component is positive and west when it is negative. In the southern polar cap the effect is reversed. Several techniques of IMF inference based on the S-M effect have been proposed early by *Svalgaard* [1975] with data set available from 1926, by *Mansurov* [1984] with dataset from 1957, by *Vennerstroem et al.* [2001] from 1905 and by *Berti et al.* [2006] from 1947. This starting time depends on the set of used stations. For example, in the Mansurov data set the earliest station with available data — Resolute Bay, started operate in 1957. Accordingly this catalogue of inferred polarities begins in 1957. Adding of non-polar stations, as Svalgaard and Vennerstroem *et al.* did, significantly extends catalogues but reduces their quality. In particular, as noted by *Russell and Rosenberg* [1974] and *Fougere* [1974], Svalgaard technique is biased and leads to different amounts of T/A sector depending on the level of geomagnetic activity: the disturbed days artificially favor the T sector. Moreover, the accuracy of results obtained from a single high-latitude station like Thule is not high: the success rate is about 82% when compared with satellite data for the period 1970–1972 [*Wilcox et al.*, 1975]. In contrast to this, Vennerstroem *et al.* data set has a better success rate and is independent of geomagnetic activity.

[3] Another conclusion comes from *Hiltula and Mursula* [2007] comparison of two data sets. The first one is a three-station (Sitka, Sodankyla and Godhavn) data set derived by *Vennerstroem et al.* [2001] (hereafter referred to as VZF). The second one is a combined data set by *Echer and Svalgaard* [2004] (hereafter ES) calculated as a weighted mean of the ground based data sets: by Svalgaard [1972], by Mansurov [1969] and by *Vennerstroem et al.* [2001] (where only Godhavn and Thule stations were used), and spacecraft data after 1964. These two polarity sets differ more in the early pre-satellite period. Hiltula and Mursula suggest that ES data set is more reliable in reproducing the IMF sector structure, especially in cycles 16–18. ES data in this period include only Svalgaard's and Vennerstroem's catalogues. It is not entirely clear how the contribution of each set was assessed, that is, which of them gives the more reliable results.

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