Available online at www.sciencedirect.com

ScienceDirect

Journal of Taibah University for Science 10 (2016) 311–316

Journal of Taibah University for Science

www.elsevier.com/locate/jtusci

North-South asymmetry of the solar parameters during the different solar cycles

M.A. El-Borie [a], A.A. Abdel-halim [b], S.Y. El-Monier [b,*]

[a] *Physics Department, Faculty of Science, Alexandria University, Egypt*
[b] *Arab Academy for Science & Technology and Maritime Transport, Alexandria, Egypt*

Received 1 April 2015; received in revised form 19 January 2016; accepted 3 February 2016
Available online 15 February 2016

Abstract

Data of the solar and interplanetary parameters (IMF magnitude B, Solar wind speed V, Proton density n, and the Proton temperature T) during the period from 1975 to 2013, have been used to examine the asymmetry between the solar field north and south of the eliospheric current sheet (HCS). In this work, the asymmetry of the IMF magnitude is obvious, and has no magnetic solar cycle dependence over the considered epochs. The solar wind speed V is faster by about 26.9 km/s for toward polarity days than for away polarity days when the IMF points away from the Sun north of the current sheet and toward the Sun south of it. In addition, the solar plasma was more dense, hotter, and faster north of the HCS than south of it during cycles 22, and 23. Large asymmetries in V, n, and T occurred in 1994. Finally, we conclude that the asymmetry is real, and is a good indicator in studying the solar activity.

Keywords: Interplanetary parameters; North-South asymmetry of IMF; Solar activity distributions

1. Introduction

Our Sun influences and shapes the region of interplanetary medium, otherwise known as the heliosphere; the physical conditions within this space are under the influence of the Sun. Most interplanetary plasma parameters are highly variable on time scales ranging from minutes to solar activity cycle and also vary with heliospheric latitude and longitude [1]. The solar magnetic field is frozen in the solar plasma and carried outward by the solar wind. According to the rotation of the Sun, the magnetic field at equatorial latitudes forms a spiral structure. Adding to this, the neutral sheets result from this structure, maintaining a separation between northern and southern regions. This averaged warped heliospheric current sheet (HCS) separates regions with opposite polarities of the magnetic field. The structure of the HCS changes substantially during the 11-year sunspot Cycle [2–5], with a relatively flat sheet at the solar minima years, but neutral sheet waves extend up to 70° heliolatitude at solar maxima epochs. In addition, the solar field polarity reverses at each solar maximum

* Corresponding author. Tel.: +20 1285150332.
E-mail address: shadyelmonier@yahoo.com (S.Y. El-Monier).
Peer review under responsibility of Taibah University.

Production and hosting by Elsevier

http://dx.doi.org/10.1016/j.jtusci.2016.02.001

giving rise to a 22-year periodicity in the heliomagnetic field. The asymmetry of the interplanetary plasma, solar indices, and the cosmic ray between the northern and southern heliospheric current sheet has been the subject of many studies and has been discussed by several authors [6–15].

The work [16] showed that the N-S asymmetries are found in the declining and increasing phases, as well as times of maxima for all solar cycles that he studied.

Sanalkumaran and Prabhakaran [17], examined the N-S asymmetry for IMF, Ap, and V during the four cycles (20–23) and he found the phase of the asymmetry of IMF reverse every cycle, and the asymmetry of the Ap index appears similar to that of solar wind velocity and may be due to the existence of relic magnetic field in the solar convection zone. The Sun's magnetic activity is generally believed to be supplied by a hydromagnetic dynamo operating either in or at the base of the solar convective zone. Dynamo models predict the possibility of mixed parity solutions where the field has both dipolar and quadrupolar components. Such fields would be asymmetric with respect to the equator. Indeed, there is evidence that the Sun's field was highly asymmetric as it emerged from the Maunder Minimum [18]. Javaraiah and Ulrish [19] indicated that, there are considerable North-South differences in the differential rotation rates and the meridional motions of sunspots. Helioseismology measurements also show the existence of N-S differences in the solar rotation and meridional flow [20].

Beside that El-Borie et al. [21], examined the N-S asymmetry for the plasma parameters and the solar indices an he said that the N-S asymmetry for the solar plasma was more dense north of the current sheet than south of it during the second negative solar polarity epoch ($qA < 0$). In the present work, we examine the N-S asymmetries in the solar and interplanetary parameters (Field magnitude (B), Solar wind speed V, Proton density n, and the Proton temperature T) during the period from 1975 to 2013.

2. Data resources and method

In this work, used the daily data for the solar and interplanetary parameters (Field magnitude B (nT), solar wind speed V (Km/s), Proton density n (n/cm^3), and the proton temperature T (Kelvin)). These parameters have been analyzed according to the IMF sector to examine the presence of the North-South asymmetry during the period 1975–2013. Most of the daily data are available at the National Space Science Data Center (NSSDC) as an OMNI data base. The field direction is calculated on a daily basis in the geocentric solar ecliptic coordinate system. Then, we have separated the field direction into two polarities; away (A) polarity if the solar ecliptic azimuthally angle of the IMF daily averages lies between 45° and 225°; otherwise it is considered toward (T) the Sun. We have removed days on which the IMF is truly mixed and separated the considered data into two groups according to the away or toward daily average IMF vector, over the considered period.

The N-S asymmetry for the considered parameters has been calculated by using the following equation:

$$\text{Asymmetry} = T - A$$

T and A are the yearly average values of the parameter for toward and away days. It is important to note that during the negative solar polarity, toward sectors measurements correspond to northern hemispheric field and away sector measurements correspond to southern hemispheric fields. During the years of positive solar polarities the association is reversed.

3. Results and discussion

In this section, we have examined the asymmetry that exists between the very large-scale properties of toward and away sectors of solar parameters. The asymmetry between the northern and southern hemispheres sunspot activity is well known to solar observers and is one of the features used in the morphological description of the solar activity. The northern and southern active periods are generally quite different when long-term activity is considered. Throughout the period of solar cycles 12–21 (1878–1988), the N-S asymmetry of the sunspot numbers with respect to the solar equatorial plane has been studied [9].

Fig. 1 displays the yearly variations of the difference of the field magnitude B, between toward and Away

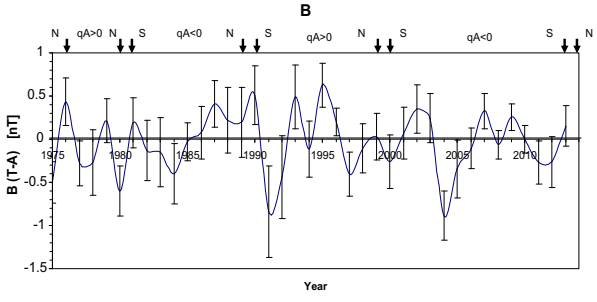

Fig. 1. The annual differences between the field magnitude north and south of the current sheet, during the period from 1975 to 2013. Times of Sun's north (N) and south (S) pole reversals of magnetic polarities are displayed by arrows in the top panel.