International Journal of Innovative Research & Growth
A Peer Reviewed Journal
ISSN: 2455-1848
Journal homepage: http://www.ijirg.com/ijirg/
Volume: 12 Issue: 3, July 2023

Geomagnetic storms in relation to interplanetary magnetic fields and southward component of interplanetary magnetic field during solar cycle 24

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Article Info
Received 25 May 2023
Received in Revised form 03 July 2023
Accepted for publication 10 July 2023
DOI: 10.26671/IJIRG.2023.3.12.115
Citation:
Ochani, D., Parihar, S. S., Verma, P. L. (2023). Geomagnetic storms in relation to interplanetary magnetic fields and southward component of interplanetary magnetic field during solar cycle 24. *Int J Innovat Res Growth*, 12, 123-128.

Abstract

We have analyzed geomagnetic storms Dst $\leq$-50nT observed during the period of solar cycle 24 with disturbances in interplanetary magnetic fields (IMF) and southward component of interplanetary magnetic field (IMFBz) .We have determined that all the geomagnetic storms have been found to be associated with disturbances in interplanetary magnetic fields (IMF).Positive correlation with correlation coefficient 0.57 has been found between magnitude of geomagnetic storms and maximum value of disturbances in IMF. Positive correlations with correlation coefficient 0.52 have also been found between magnitude of geomagnetic storms and magnitude of disturbances in IMF. Further all the geomagnetic storms have been found to be associated with disturbances in southward component of interplanetary magnetic fields (IMFBz).Large positive correlation with correlation coefficient 0.70 has been found between magnitude of geomagnetic storms and maximum value of disturbances in southward component interplanetary magnetic fields (IMFBz) .Large positive correlations with correlation coefficient 0.66 have also been found between magnitude of geomagnetic storms and magnitude of disturbances in southward component of interplanetary magnetic fields (IMFBz),
Keywords: - Geomagnetic storms, Interplanetary magnetic fields (IMF) and southward component of interplanetary magnetic fields (IMFBz).

1. Introduction

The solar and interplanetary factors that cause magnetospheric disturbances are one of the key problems of solar-terrestrial physics in general and of the space weather program. This problem has been investigated for a long time and there is now a large body of experimental and theoretical results (Balasubramaniam, et al 1996) and reviews (Webb, 1995, Gonzalez, et al 1999, Crooker, 2000). The problem is far from being solved, by and large, the concept describing the connection of geomagnetic phenomena with processes on the sun. The source of energy for geomagnetic phenomena is the sun, which transfers energy to the earth’s magnetosphere by the solar wind. The solar wind energy arrives in the magnetosphere only when the interplanetary magnetic field (IMF) has a significant component parallel to the terrestrial magnetic dipole, i.e., it has an approximately negative (southward) IMF *Bz* component (Petrukovich, 1997). When the rate of energy input is higher than the rate of its quasistationary dissipation, energy is accumulated in the magnetosphere and reaches and exceeds a certain level, any small disturbance outside or inside the magnetosphere can result in the release of this energy which is observed as a reconnection of magnetic field lines, global reorganization of current systems in the magnetosphere, and heating/acceleration of plasma, i.e., a magnetospheric disturbance can be generated. Quasistationary solar usually does not contain long intervals of southward components of IMF since the field lies in the ecliptic plane. However, sometimes large-scale disturbances propagate in the solar wind, such as interplanetary shocks, magnetic clouds, regions of compression on the boundary of slow and fast streams (corotating interaction regions, CIR), and some other disturbances. They either contain an appreciable southward IMF*Bz* component within or they modify the environment in such a manner that this component can be present in the solar wind for several hours. Such behavior of the IMF can result in energy input into the magnetosphere and in the generation of magnetospheric disturbances (Gonzalez, et al 1999, Crooker, 2000, Gosling, et al 1991, Gosling, 1999). Coronal mass ejections from the sun are the dominant interplanetary phenomena that cause magnetic disturbances at the earth. The CMEs, depending on their shock front velocities, can compress the dayside magnetosphere up to a few Earth radii, but their get effectiveness is more associated with an intense southward interplanetary magnetic field (IMF) component, which permits an efficient transfer of energy from the perturbed solar wind to the earth magnetosphere through magnetic reconnection (Gonzalez, 1987). Geomagnetic disturbances are also intensified when there is a superposition of two or more CMEs with intense and long duration south magnetic components (Gonzalez, et al 2002) These geomagnetic storms are related to coronal mass ejections (CMEs) and shocks/sheath associated with them (Badruddin et al. 1986; Zhang & Burlaga 1988; Venkatesan & Badruddin 1990; Badruddin 1998; Cane 2000; Zhang et al. 2004; Kudela & Brenkus 2004; Gopalaswamy 2004).. Some scientists have studied ICMEs and geomagnetic disturbances and observed a strong association between interplanetary CMEs and interplanetary shocks (Manoharan, et al 2004) and interplanetary shocks and interplanetary shocks and resulting geomagnetic disturbances. Ayush et al. (2017) studied the association between geomagnetic storms and solar wind plasma parameters IMF Bz, density, temperature, and velocity and results obtained strongly suggest that IMF Bz has a strong impact on the cause of geomagnetic storms. Balveer, S., et al (2014) have reported that the Dst of geomagnetic storms had a strong correlation with solar wind velocity, IMF B. In this investigation an attempt has been made to explore possible relation between geomagnetic storms ≤-50nT and interplanetary magnetic fields and southward component of interplanetary magnetic fields during the period of solar cycle 24 .

2. Data Reduction and Analysis

In this study, hourly Dst values has been used over the period solar cycle 24 to determine geomagnetic storms magnitude Dst≤-50nT. The Omni web data has been used for determination of disturbance in interplanetary magnetic fields (IMF) and southward component of interplanetary magnetic fields (IMFBz).

3.1. Statistical Analysis Between Magnitude of Geomagnetic Storms and Magnitude of Interplanetary Magnetic Fields Disturbances During Solar Cycle 24

In order to confirm the correlation between geomagnetic storm intensity and interplanetary magnetic field disturbance intensity in solar cycle 24 shown in Table 4.1, a scatter plot of magnetic storm intensity and interplanetary magnetic field disturbance intensity is created in figure 1. From this figure, it is clear that most of the large-scale magnetic storms are related to large-scale interplanetary magnetic field disturbances, but the strengths of these two phenomena are not in a constant relationship. We have found some magnetic storms with small magnitude but small magnitude interplanetary magnetic field disturbances, and some small magnitude but large magnitude interplanetary magnetic field disturbances. These results suggest that larger-magnitude magnetic storms are generally associated with such disturbances in relatively larger-magnitude interplanetary magnetic field events, although there is no quantitative relevance for these phenomena. A positive correlation with a correlation coefficient of 0.52 was found between the strength of the magnetic storm and the strength of the IMF disturbances.

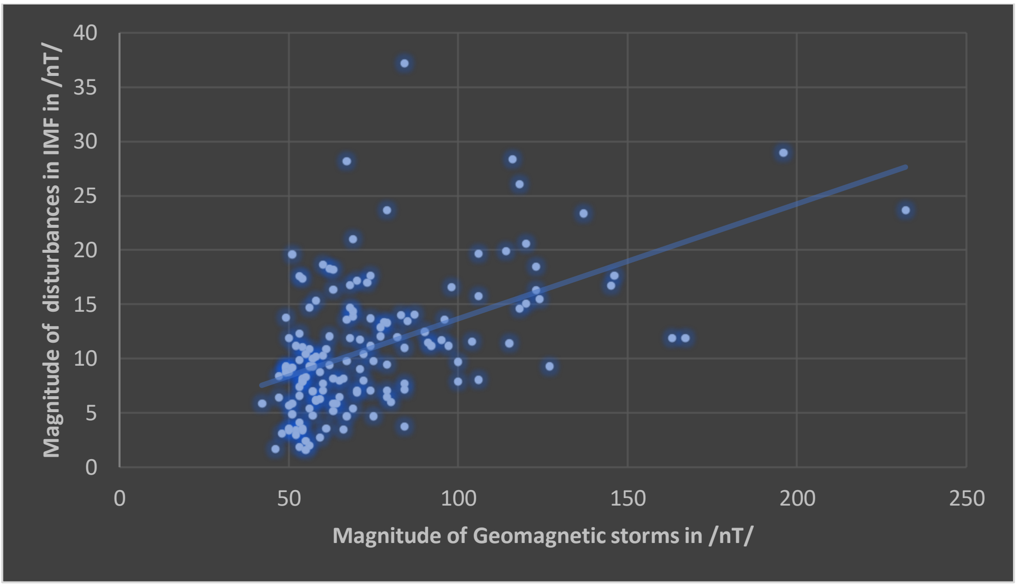

Figure-1 Shows scatter plot between magnitude of geomagnetic storms and magnitude of interplanetary magnetic fields (IMF) disturbances events during the period of solar cycle 24 .

3.2. Statistical Analysis Between Magnitude of Geomagnetic Storms and Maximum Value of Disturbances in Interplanetary Magnetic Fields (IMF) For Solar Cycle 24

Correlation studies have been conducted to examine how the intensity of geomagnetic storms correlates with the maxima of interplanetary magnetic field perturbations during the solar cycle. 24. Figure 2 shows a scatter plot of magnetic storm intensity and maximum interplanetary magnetic field disturbance. From this figure, it is clear that most of the large-scale magnetic storms are related to such maximum interplanetary magnetic field disturbances, but there is no fixed relationship between the magnitude and maximum value of these two phenomena. We have found some geomagnetic storms with large magnitude but small maximum magnitude interplanetary field disturbances, and some small magnitude but very large maximum magnitude interplanetary magnetic field phenomena with geomagnetic storms. These results suggest that larger-magnitude geomagnetic storms are generally associated with such disturbances in interplanetary magnetic phenomena with relatively higher maxima, although these phenomena have no quantitative relevance. A positive correlation with a correlation coefficient of 0.57 was found between the magnitude of the geomagnetic storm and the maximum value of the IMF disturbances.

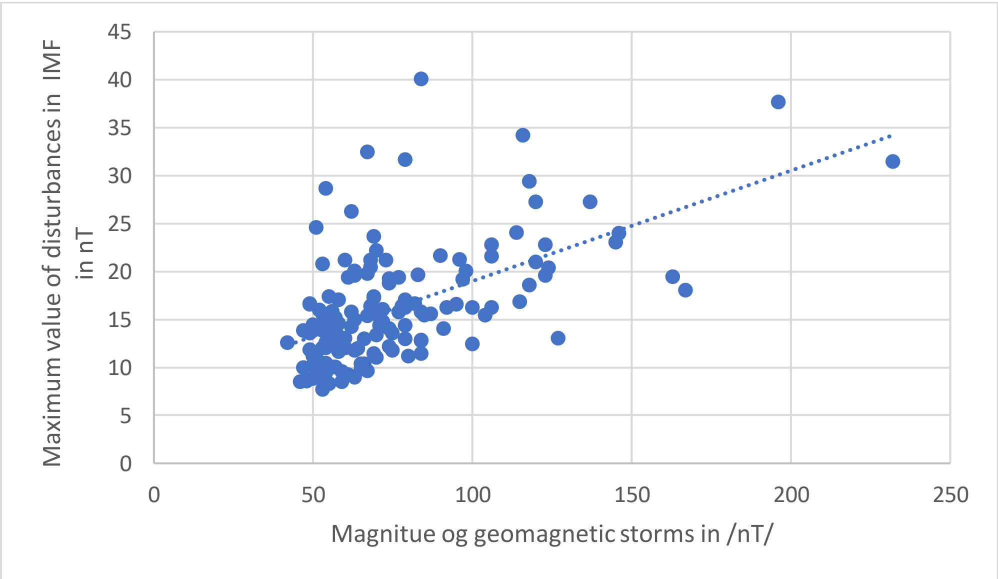

Figure- 2 Shows scatter plot between magnitude of geomagnetic storms and maximum value of interplanetary magnetic fields (IMF) disturbances events during the period of solar cycle 24 .

3.3. Statistical Analysis Between Magnitude of Geomagnetic Storms and Magnitude of Disturbances in Southward Components of Interplanetary Magnetic Fields (IMFBz) During Solar Cycle 24

The correlative analysis has been performed to see that how the magnitudes of geomagnetic storms are correlated with magnitude of disturbances in southward components of interplanetary magnetic fields events, we have plotted a scatter diagram between the magnitude of geomagnetic storms and magnitude disturbances in southward components of interplanetary magnetic fields events in fig.3. It is clear from the figure 3 that most of the geomagnetic storms which have large magnitude are associated with such disturbances in southward components of interplanetary magnetic fields events which have large magnitude, but the magnitude of these two events do not have any fixed proportion, we have found some geomagnetic storms which have large magnitude but they are associated with such disturbances in southward components of interplanetary magnetic fields events which have small magnitude and some geomagnetic storms which have small magnitude but they are associated with such southward components of interplanetary magnetic fields events having large magnitude. These results indicates that although these events do not have any quantitative relation but the geomagnetic storms of higher magnitude are generally associated with such disturbances in southward components of interplanetary magnetic fields events which have relatively higher magnitude. Large positive correlations with correlation coefficient 0.66 have been found between magnitude of geomagnetic storms and magnitude of disturbances of southward component of IMFBz disturbances during solar cycle 24.

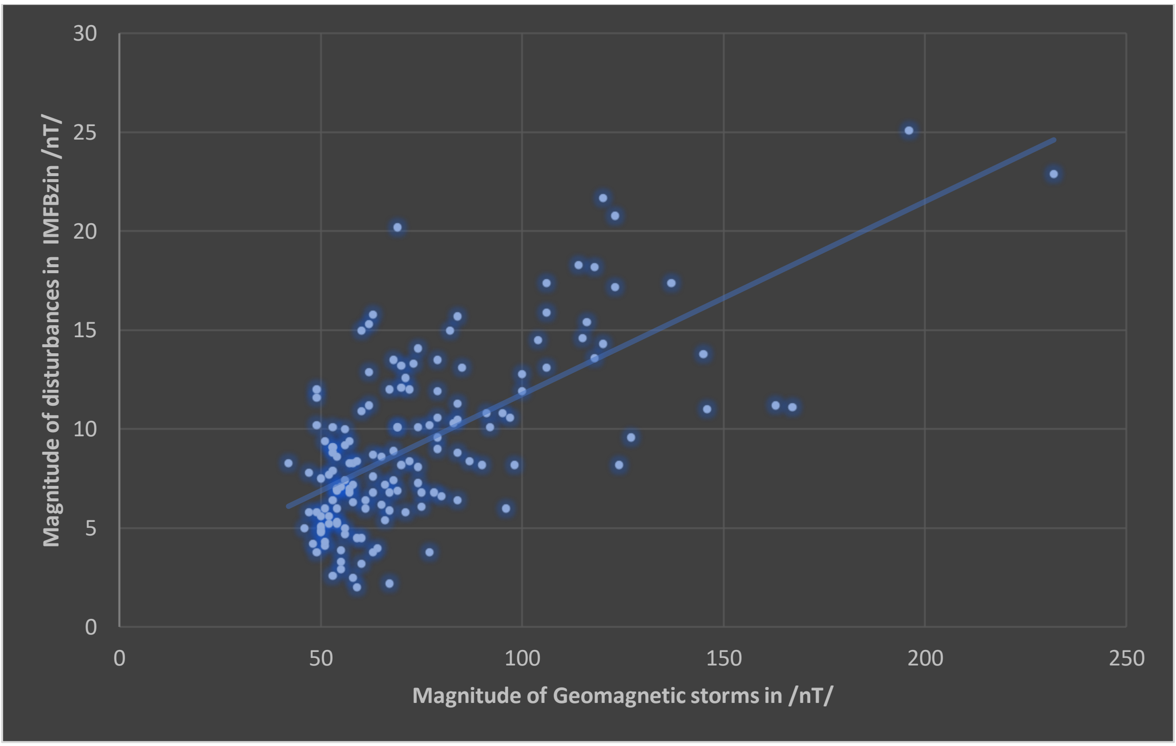

Figure-3 Shows scatter plot between magnitude of geomagnetic storms and magnitude of disturbances in southward component of interplanetary magnetic Fields (IMFBz) disturbances events during the period of solar cycle 24.

3.4-Statistical analysis between magnitude of geomagnetic storms and maximum value of disturbances in southward components of interplanetary magnetic fields (IMFBz)during solar cycle 24

In this part of the study correlative analysis has been performed to see that how the magnitudes of geomagnetic storms are correlated with maximum value of disturbances in southward components of interplanetary magnetic fields events during solar cycle 24, We have plotted a scatter diagram between the magnitude of geomagnetic storms and maximum value of disturbances in southward components of interplanetary magnetic fields events in fig 4. It is clear from the figure that most of the geomagnetic storms which have large magnitude are associated with such disturbances in southward components of interplanetary magnetic fields events which have large maximum value, but the magnitude and maximum value of these two events do not have any fixed proportion, we have found some geomagnetic storms which have large magnitude but they are associated with such disturbances in southward components of interplanetary magnetic fields events which have small maximum value and some geomagnetic storms which have small magnitude but they are associated with such southward components of interplanetary magnetic fields events having large maximum value. These results indicates that although these events do not have any quantitative relation but the geomagnetic storms of higher magnitude is generally associated with such disturbances in southward components of interplanetary magnetic fields events which have relatively higher maximum value. Strong positive co-relation with correlation coefficient 0.70 has been found between magnitude of geomagnetic storms and maximum value of IMFBz disturbances during solar cycle 24.

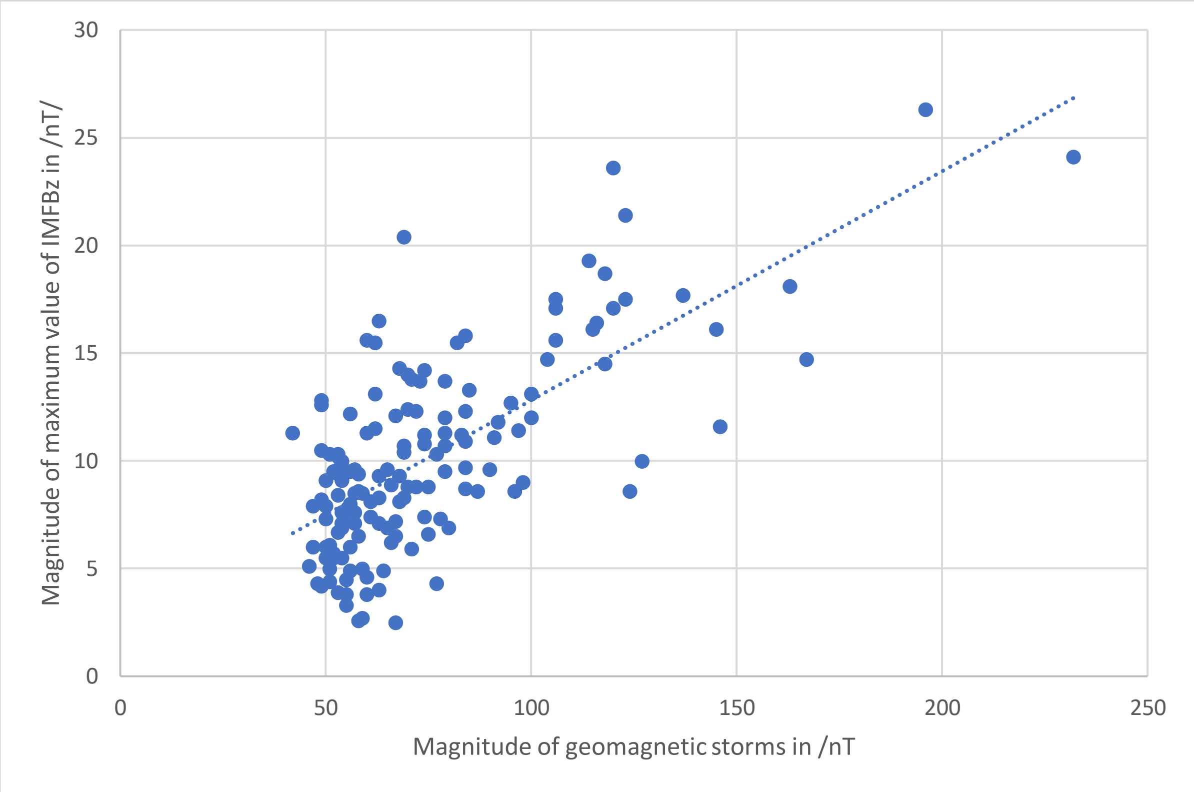

Figure-4 Shows scatter plot between magnitude of geomagnetic storms and maximum value of associated disturbances in southward components of interplanetary magnetic fields (IMFBz) events during the period of solar cycle 24.

4. Results and Conclusion

From the analysis following results are as follows.
All the geomagnetic storms have been found to be associated with disturbances in interplanetary magnetic fields.
Positive correlation with correlation coefficient 0.57 has been found between magnitude of geomagnetic storms and maximum value of disturbances in IMF.
Positive correlations with correlation coefficient 0.52 have been found between magnitude of geomagnetic storms and magnitude of disturbances in IMF.
All the geomagnetic storms have been found to be associated with disturbances in southward component of interplanetary magnetic fields (IMFBz) .
Large positive correlation with correlation coefficient 0.70 has been found between magnitude of geomagnetic storms and maximum value of disturbances in IMFBz .
Large positive correlations with correlation coefficient 0.66 have been found between magnitude of geomagnetic storms and magnitude of disturbances in southward component of IMFBz .
Results obtained strongly suggest that IMF Bz has a strong impact on the cause of geomagnetic storms.

Acknowledgement

The authors are very thankful to data services to provide the data freely available. Authors are also thankful to reviewers of the manuscript and IJIRG team.

Conflict of Interest

The authors declares that there is no conflict of interest.

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