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Geomagnetic Storms Related with Halo Coronal Mass Ejections and Their Relation with X-ray Solar Flares, Magnetic Clouds and Solar Wind Parameters During 2007-2014

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Abstract

We have analyzed geomagnetic storms (GMs) associated with coronal mass ejections speed ≥500Km/s, observed during the period of 2007-2014 with X-ray solar flares (SFs), magnetic clouds (MCs) and disturbances in solar wind plasma parameters, interplanetary magnetic fields (IMFB), southward component of interplanetary magnetic fields (IMFBz), solar wind plasma velocity (SWPV) and solar wind plasma temperature (SWPT). We have observed that majority of the geomagnetic storms (GMs) are associated with X-ray solar flares (SFs) of different categories, magnetic clouds and all the geomagnetic storms are associated with disturbances in solar wind plasma parameters. Positive correlation with correlation coefficient 0.59 has been found between magnitude of minimum Dst /-Dst/value of geomagnetic storms and peak value of associated disturbances in IMFB, 0.72 between magnitude of minimum Dst /-Dst/ value of geomagnetic storms (GMs) and magnitude of minimum nT /-nT/ value of associated disturbances in IMFBz. Further we have obtained positive correlation with correlation coefficient 0.53 between magnitude of minimum Dst /-Dst/value of geomagnetic storms (GMs) and peak value of associated disturbances in solar wind plasma temperature (SWPT) and 0.48 between magnitude of minimum Dst /-Dst/value of geomagnetic storms (GMs) and peak value of disturbances in solar wind plasma velocity (SWPV). We have concluded that halo coronal mass ejections (CMEs) associated geomagnetic storms are closely related with hard X-ray solar flares and disturbances in IMB, IMBz and SWPT.

1. Introduction

The strength of the magnetic field causes solar plasma events in the active region (AR) (18, 29, 14, 30, 28). Helical magnetic loops and the accumulation of electric current in active regions can cause solar storms (34). According to 32, these storms are clearly classified as solar energetic measures, or so-called geoeffective measures. The interaction between the geomagnetic field and the solar wind creates the geomagnetic turbulences. Since solar flares are electromagnetic emissions, they are not the sole cause of geomagnetic storms. Geomagnetic storms are caused solely by coronal mass ejections (CMEs), interplanetary coronal mass ejections (ICMEs), and co-rotating interaction regions (CIRs) (11, 31, 21, 6, 32, 38, 2, 25, 35, 16, 37, 36, 20, 3). Numerous studies have examined how geomagnetic storms affect space weather using a range of geomagnetic storm indices (10, 7, 12, 19, 27, 24, 22, 39, 20). In previous cycles, geomagnetic storms and the solar sources associated with them have been studied (26, 38, 35). Solar wind streams from coronal hole regions contributed a smaller percentage of storms, while solar sources data with intense geomagnetic storms (with Dst less than −100 nT) were found to be CMEs (38, 4, 35). The geomagnetic storms in solar cycle 24 were examined in a number of studies (8, 17, 35, 9, 20). 38 examined 85 geomagnetic storms in solar cycle 23 (1996–2005) based on solar source and interplanetary characteristics. They discovered that most storms started in solar active regions, that 11 storms were connected to quiet Sun regions, and that 11 storms were caused by coronal holes. Understanding Sun-Earth events involves a number of phenomena, including geomagnetic storms, CMEs, and solar flares. The most important aspect of space weather impacts on Earth is caused by geomagnetic storms (13, 15). The effects of solar wind structures on the Earth's magnetic field and ionosphere result in dangerous disruptions known as geomagnetic storms (33; 1). These disruptions have the potential to impair the functionality of both ground-based and space-based technological systems in extreme geomagnetic conditions (5; 23). In order to create predictive models for geomagnetic storm occurrences and design future capabilities for maintaining technological systems under extreme geomagnetic conditions, it is necessary to comprehend the underlying physical processes of the interplanetary drivers of geomagnetic storms.In present investigation we have analyzed geomagnetic storms associated with halo coronal mass ejections speed ≥500Km/s with X-ray solar flares, magnetic clouds, interplanetary shocks and disturbances in interplanetary magnetic fields, southward component of interplanetary magnetic field solar wind plasma temperature and solar wind plasma velocity during the period of 2007-2014

2. Experimental Data

In this investigation, halo coronal mass ejections speed ≥500Km/s related geomagnetic storms are analyzed with magnetic clouds ,solar flares and disturbances in solar wind plasma parameters interplanetary magnetic field, southward component of interplanetary magnetic field, solar wind plasma velocity ,temperature over the period of 2007-2014 .For this work the data of different types of coronal mass ejections will be taken from SOHO – large angle spectrometric, coronagraph (SOHO / LASCO) and extreme ultraviolet imaging telescope (SOHO/EIT) data. The data of magnetic cloud/ejecta, are used WIND group from WIND observations, ACE list of transient and disturbances. To determine disturbances in geomagnetic fields and solar wind plasma parameters, hourly data of Dst index and solar wind plasma temperature, velocity interplanetary magnetic field and southward component of interplanetary magnetic fields are used and taken from omni web data(http;//omniweb.gsfc.nasa.gov/form/dxi.html)). The data of X ray solar flares and other solar data, solar geophysical data report U.S. Department of commerce, NOAA monthly issue and solar STP data (http://www.ngdc.noaa.gov/stp/solar/solardataservices.html.) are used.

3. Data Analysis and Results

3.1 Analysis of Geomagnetic Storms with X-Ray Solar Flares During the Period of 2007-2014

Solar flares are drastic solar events in which vast solar plasma material is ejected from the sun into interplanetary states space and produces major disturbances solar wind plasma and geomagnetic storms in geomagnetic fields. Several investigators have studied geomagnetic storms with solar flares. In this study geomagnetic storms related with halo coronal mass ejections speed ≥500 Mk/s studied with X-ray solar flares observed during the period of 2007-2014. We have determined 41 geomagnetic storms and all the geomagnetic storms 41 out of 41 (100 %) are found to be associated with X –ray solar flares of different categories. The association rates of X-Class, M-Class and C-Class and B-class X-ray solar flares are 24.39%, 50%, 34.15% ,29.28 and 12.20 respectively. It is also observed that vast majority of the geomagnetic storms are associated with M-Class and C-Class solar flares.

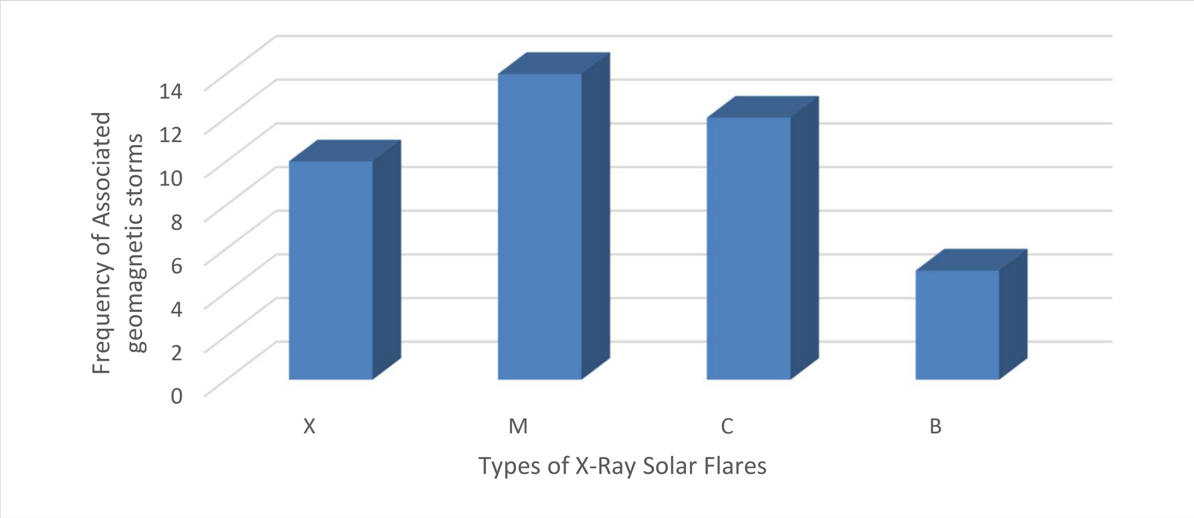

Fig.1 Shows bar diagram of types of solar flares and frequency of associated geomagnetic storms during the period of 2007-2014.

3.2 Analysis of Geomagnetic Storms with Magnetic Clouds During the Period of 2007-2014

In this section we have analyzed halo coronal mass ejection speed ≥500 Km/s related geomagnetic storms with magnetic clouds observed during the period of 2007-2014. Total number of geomagnetic storms observed during the period of 2007-2014 is 41. Most of the geomagnetic storms 26 out of 41(63.41%) are found to be associated with magnetic clouds of different qualities. The association rates of excellent quality, good quality and poor-quality magnetic clouds are 15.38%,42.31% and 42.3% 63.63 % respectively**.**

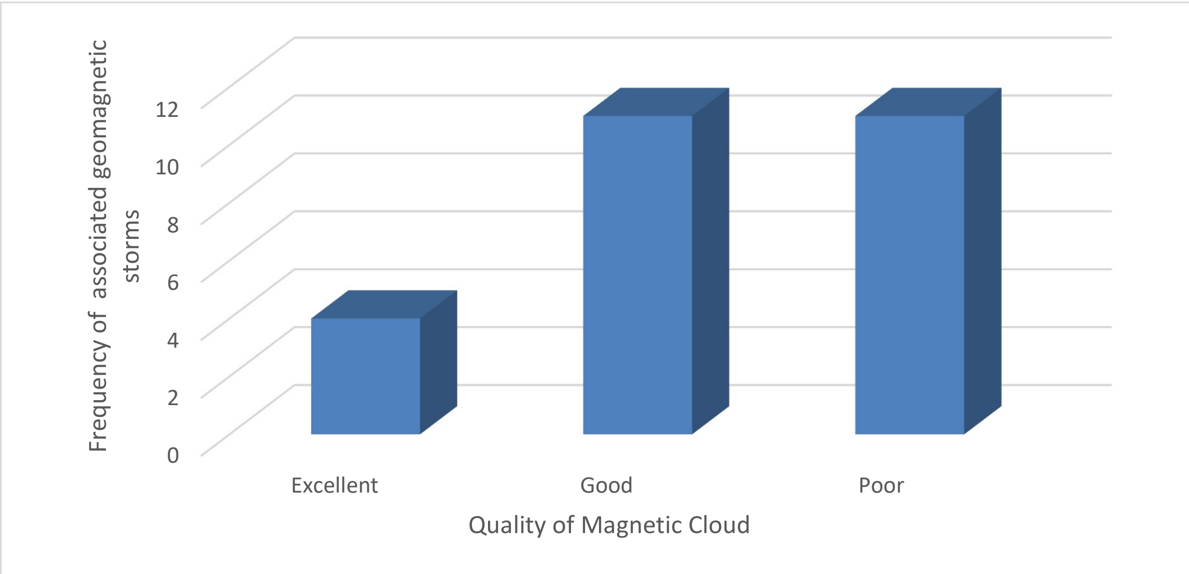

Fig.2 Shows bar diagram of types of magnetic clouds and frequency of associated geomagnetic storms during the period of 2007-2014.

3.3 Analysis of Geomagnetic Storms with Interplanetary Magnetic Fields Disturbances During the Period of 2007-2014

We have performed correlative of magnitude of minimum Dst (/-Dst/) of geomagnetic storms and peak value of associated disturbances in interplanetary magnetic fields to see that how the magnitudes minimum Dst (/-Dst/) of geomagnetic storms are correlated with peak value of interplanetary magnetic fields disturbances events during the period of 2007-2014. a scatter plot between the magnitude of minimum Dst (/-Dst/) of geomagnetic storms and peak value of disturbances in interplanetary magnetic fields events in fig.3. It is clear from the figure 4. that most of the geomagnetic storms which have large magnitude of minimum Dst (/-Dst/) are associated with such interplanetary magnetic fields disturbances events which have large peak values , but these two events do not have any fixed proportion, we have found some geomagnetic storms which have large magnitude of minimum Dst (/-Dst/) but they are associated with such interplanetary magnetic fields disturbances events which have small peak values and some geomagnetic storms which have small magnitude of minimum Dst (/-Dst/) but they are associated with such interplanetary magnetic fields disturbances events having large peak values . These results indicates that although these events do not have any quantitative relation but the geomagnetic storms of higher magnitude a of minimum Dst (/-Dst/) are generally associated with such IMF disturbances events which have relatively higher peak values. Positive correlations with correlation coefficient 0.59 have been found between magnitude of minimum Dst (/-Dst/) of geomagnetic storms and peak value of IMF disturbances during the period of 2007-2014.

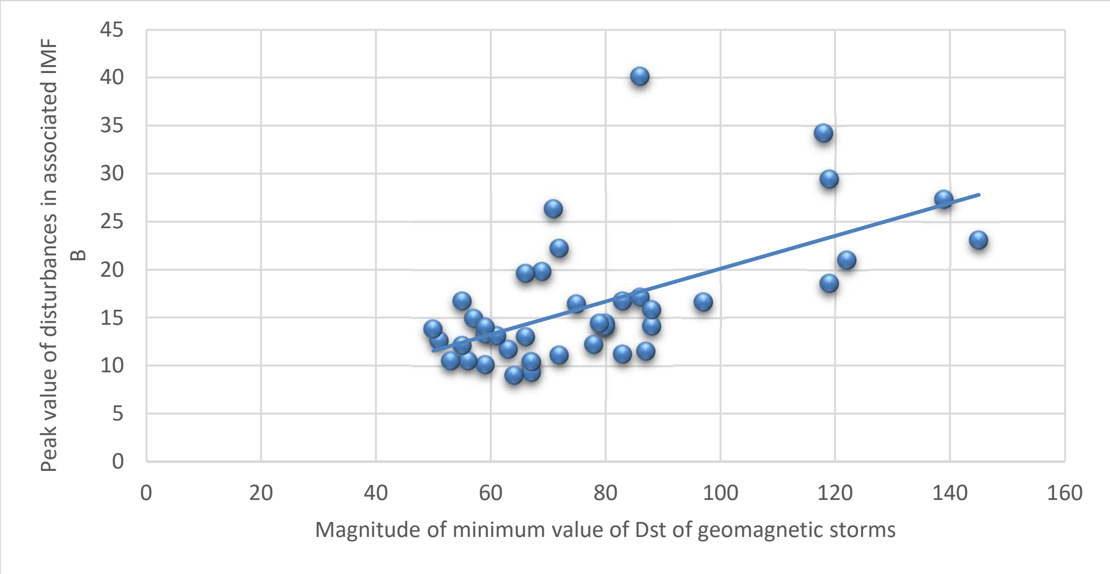

Fig.3 Shows scatter plot between magnitude of minimum Dst of geomagnetic storms and peak values of disturbances in interplanetary magnetic fields (IMF) events during the period of 2007-2014.

3.4 Analysis of Geomagnetic Storms with Southward Component of Interplanetary Magnetic Fields (IMF Bz) Disturbances During the Period of 2007-2014

We have performed correlative of magnitude of minimum Dst (/-Dst/) of geomagnetic storms and magnitude of minimum nT (/-nT/) of associated disturbances in southward component of interplanetary magnetic fields (IMFBz) to see that how the magnitudes of minimum Dst Dst (/-Dst/) of geomagnetic storms are correlated with magnitude of minimum nT (/-nT/) of southward component of interplanetary magnetic fields disturbances events during the period of 2007-2014. a scatter plot between the magnitude of minimum Dst (/-Dst/) of geomagnetic storms and magnitude of minimum nT (/-nT/) of disturbances in southward component of interplanetary magnetic fields events in fig.4. It is clear from the figure 4. that most of the geomagnetic storms which have large magnitude of minimum Dst (/-Dst/) are associated with such interplanetary magnetic fields disturbances events which have large magnitude of minimum nT (/-nT/) values , but these two events do not have any fixed proportion, we have found some geomagnetic storms which have large magnitude of minimum Dst (/-Dst/) but they are associated with such southward component of interplanetary magnetic fields disturbances events which have small magnitude of minimum nT (/-nT/) values and some geomagnetic storms which have small magnitude of minimum Dst (/-Dst/) but they are associated with such southward component of interplanetary magnetic fields disturbances events having large magnitude of minimum nT (/-nT/) values . These results indicates that although these events do not have any quantitative relation but the geomagnetic storms of higher magnitude a of minimum Dst (/-Dst/) are generally associated with such IMFBz disturbances events which have relatively higher magnitude of minimum nT (/-nT/) values. Large positive correlations with correlation coefficient 0.72 have been found between magnitude of minimum Dst (/-Dst/) of geomagnetic storms and magnitude of minimum nT (/-nT/) value of IMFBz disturbances during the period of 2007-2014.

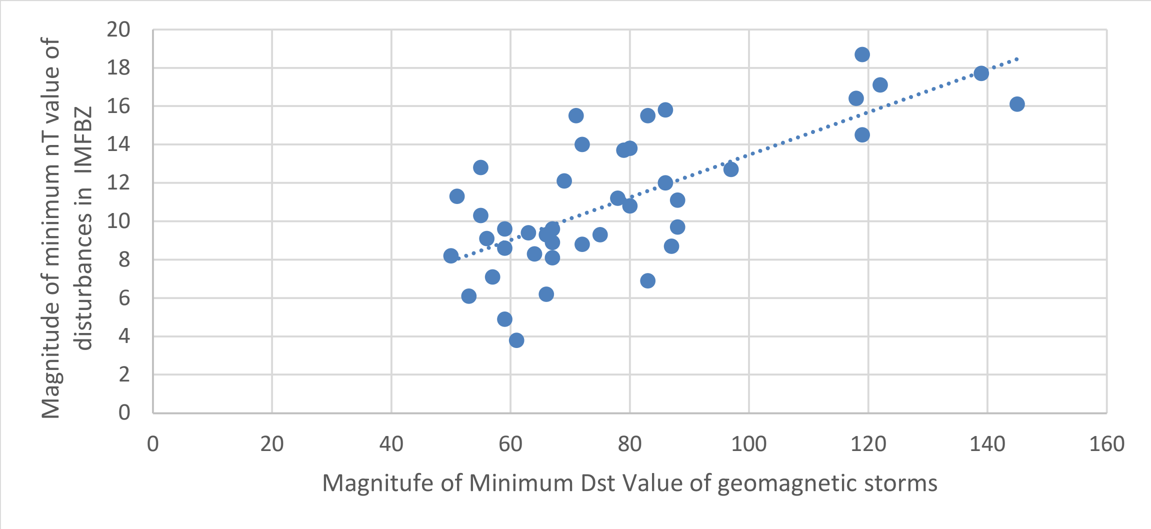

Fig.4 Shows scatter plot between magnitude of minimum Dst of geomagnetic storms and magnitude of minimum values of IMFBz disturbances during the period of 2007-2014.

3.5 Analysis of Geomagnetic Storms with Disturbances in Solar Wind Plasma Temperature During 2007-2014

In this correlative study to see that how the magnitudes of minimum Dst of geomagnetic storms are correlated with peak value of disturbances in solar wind temperature events. We have plotted a scatter diagram between the magnitude of minimum Dst /-Dst/of geomagnetic storms and peak value of associated disturbances in solar wind plasma temperature events in fig.5. It is clear from the figure that most of the geomagnetic storms which have large magnitude of minimum Dst /-Dst/ are associated with such disturbances in solar wind temperature events which have large peak values , but the magnitude of these two events do not have any fixed proportion, we have found some geomagnetic storms which have large magnitude of minimum Dst /-Dst/ but they are associated with such disturbances in solar wind temperature events which have small magnitude and some geomagnetic storms which have small magnitude of minimum Dst /-Dst/ but they are associated with such solar wind temperature events having large peak values . These results indicates that although these events do not have any quantitative relation but the geomagnetic storms of higher magnitude of minimum Dst /-Dst/ are generally associated with such disturbances in solar wind temperature events which have relatively higher peak values. Positive correlations with correlation coefficient 0.53 have been found between magnitude of geomagnetic storms and peak values of solar wind temperature disturbances during 2007-2014.

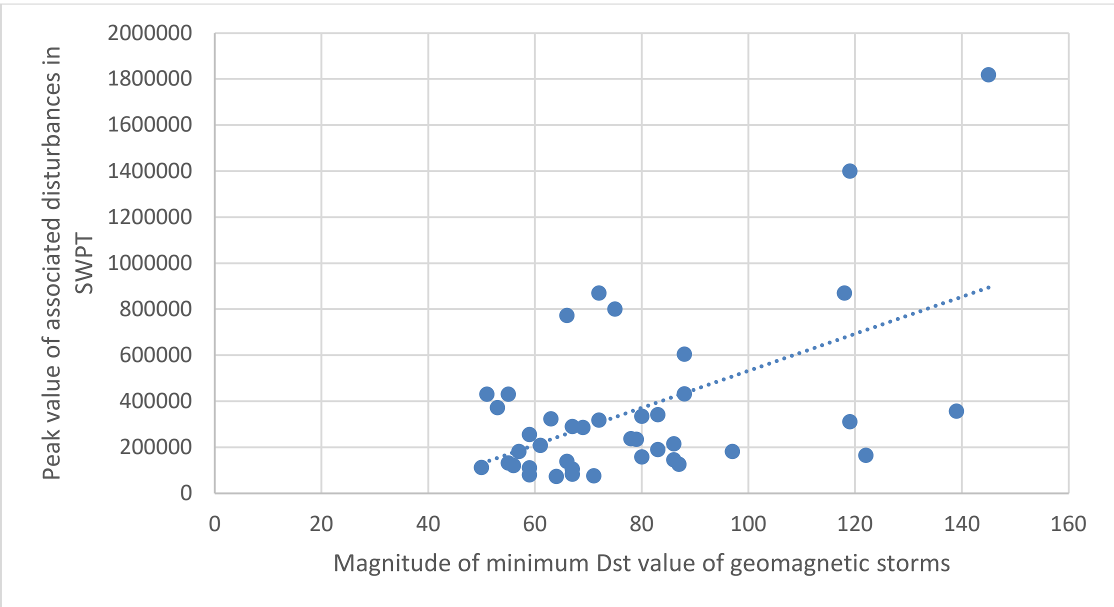

Fig.5 Shows scatter plot between magnitude of geomagnetic storms and peak value of disturbances in solar wind plasma temperature during the period of 2007-2014.

3.6 Analysis of Geomagnetic Storms with Disturbances in Solar Wind Plasma Velocity During the Period of 2007-2014

In this correlative study to see that how the magnitudes of minimum Dst /-Dst/of geomagnetic storms are correlated with peak value of disturbances in solar wind velocity events. We have plotted a scatter diagram between the magnitude of minimum Dst /-Dst/ of geomagnetic storms and peak value of associated disturbances in solar wind plasma velocity events in fig.6. It is clear from the figure that most of the geomagnetic storms which have large magnitude of minimum Dst /-Dst/ are associated with such disturbances in solar wind velocity events which have large peak values , but the magnitude of these two events do not have any fixed proportion, we have found some geomagnetic storms which have large magnitude of minimum Dst /-Dst/ but they are associated with such disturbances in solar wind velocity events which have small magnitude and some geomagnetic storms which have small magnitude of minimum Dst /-Dst/ but they are associated with such solar wind velocity events having large peak values . These results indicates that although these events do not have any quantitative relation but the geomagnetic storms of higher magnitude of minimum Dst /-Dst/ are generally associated with such disturbances in solar wind velocity events which have relatively higher peak values. Positive correlations with correlation coefficient 0.48 have been found between magnitude of minimum Dst /-Dst/ of geomagnetic storms and peak values of solar wind velocity disturbances during 2007-2014.

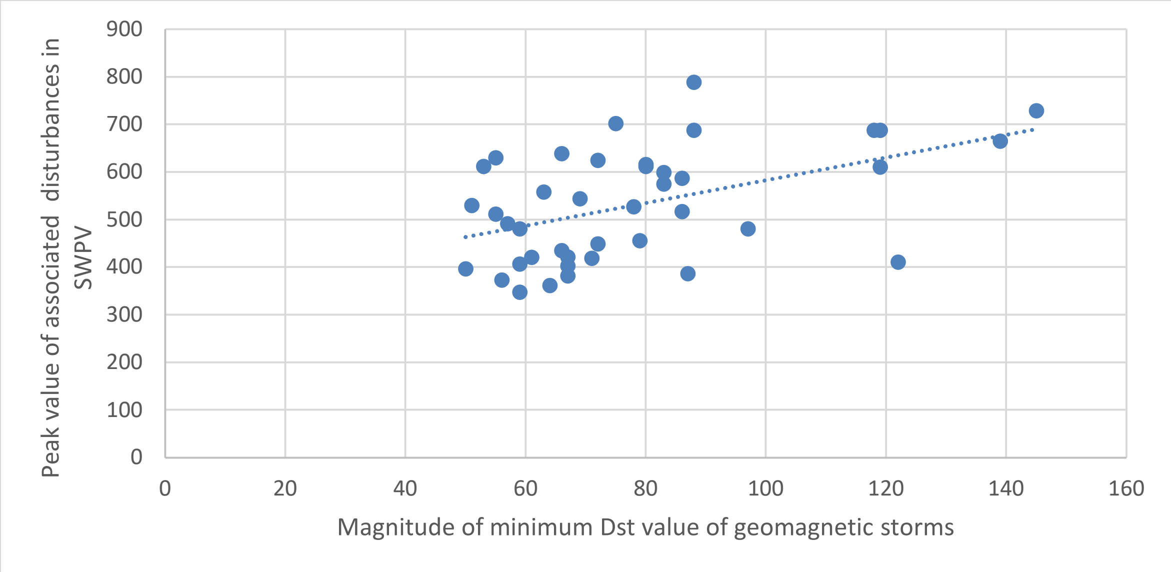

Fig.6 Shows scatter plot between magnitude of geomagnetic storms and peak value of disturbances in solar wind plasma velocity during the period of 2007-2014

4. Main Results

From the analysis of geomagnetic storms (GMs) with halo coronal mass ejections speed ≥500Km/s, observed during the period of 2007-2014, we have observed that

1-Majority of the geomagnetic storms (GMs) are associated with X-ray solar flares (SFs) of different categories,

2-Majority of the geomagnetic storms (GMs) are associated with magnetic clouds of different qualities.

3-All the geomagnetic storms are associated with disturbances in solar wind plasma parameters, interplanetary magnetic fields (IMFB), southward component of interplanetary magnetic fields (IMFBz), solar wind plasma temperature (SWPT)and solar wind plasma velocity (SWPV).

4-Positive correlation with correlation coefficient 0.59 has been found between magnitude of minimum Dst /-Dst/value of geomagnetic storms and peak value of associated disturbances in IMFB,

5-Strong positive correlation with correlation coefficient 0.72 between magnitude of minimum Dst /-Dst/ value of geomagnetic storms (GMs) and magnitude of minimum nT /-nT/ value of associated disturbances in IMFBz.

6-Positive correlation with correlation coefficient 0.53 between magnitude of minimum Dst /-Dst/value of geomagnetic storms (GMs) and peak value of associated disturbances in solar wind plasma temperature (SWPT)

7-Positive correlation with correlation coefficient 0.48 between magnitude of minimum Dst /-Dst/value of geomagnetic storms (GMs) and peak value of disturbances in solar wind plasma velocity (SWPV).

5. Conclusion

In this investigation halo coronal mass speed ≥500Km/s related geomagnetic storms observed during the period of 2007-2014 are analysed with magnetic clouds (MCs), solar flares (SFs), disturbances in solar wind plasma parameters solar wind plasma velocity (SWPV), solar wind plasma temperature (SWPT) interplanetary magnetic fields (IMFB) and southward component of interplanetary magnetic fields (IMFBz). We have concluded that halo coronal mass ejections (CMEs) associated geomagnetic storms are closely related with hard X-ray solar flares and disturbances in interplanetary magnetic fields (IMB), southward component of interplanetary magnetic fields (IMBz), solar wind plasma temperature (SWPT) and solar wind plasma velocity (SWPV).

Conflict of Interest

We have no conflicts of interest to disclose.

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