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Association of Geomagnetic Storms with CME and Solar Wind Velocity during Solar Cycle-24

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Abstract: Using a time series of geomagnetic storm (GMs) events between 2008 to 2019 obtained by selecting storms where disturbance short time Dst≤-50nT, we have analysed the probability of association of Moderate, Intense and Severe events. We have found 73 GMs associated with D_{st} observed during 2008-2019 of solar cycle 24. Total 43% GMs linked with CMEs in which 3.8% are Halo CMEs and 1.9% are Partial Halo CMEs associate with severe GMs. Severe GMs are observed to be the largest 5.5% of all GMs in which 5.1% severe GMs relate with CMEs. During the period of study, we observed total 169 CMEs associated with GMs in which 5.3% CMEs associated with severe GMs. During the period of study, we have analysed the correlation between GMs magnitude with CME speed and SWpv, with correlation coefficient -0.736 and -0.975, but for intense GMs the correlation coefficient obtained -0.620 and -0.578. Our study shows that CMEs in which Halo CMEs and SW_{pv} are good parameter to study the severe GMs. The study also analyses on the daily average database that GMs of largest magnitude with -127nT occurred in year 2015, which is the strongest GMs of solar cycle 24.

Keywords: Geomagnetic storm (GMs), Disturbance short time (D_{st}), Coronal Maas Ejection (CME), Solar wind plasma velocity (SW_{pv}), Solar Cycle 24.

INTRODUCTION

Geomagnetic storms are global disturbances most of the time occurred due to interaction between Earth's magnetic field and magnetized plasma emissions caused by various solar circumstances. Although GMs effects vary depending on the characteristics of each events, some common effects to most storms consist of a dayside compression of the magnetosphere (Borovsky &Denton, 2016; Cattell et al.,2017), enhancement of magnetospheric currents (Ganushkina et al.,2017), depletion and enhancement of trapped particles in the radiation belts (Moya etal.,2017;), enhanced precipitation in the auroral regions (Engebretson et al.,2008; Longden et al.,2008), changes in the dynamics and properties of the ionosphere and geomagnetically induced currents on the earth's surface among others. Such broad and global response and quick transfer of huge amounts of energy to the earth magnetic field can also have noteworthy influence in a wide range of technological instruments such as damages and interruptions to satellites and communication systems (Chapman et al.,2020), jamming of radio signals, but can also produce a threat to human probe at high latitudes and high altitudes through enhance radiation doses. Thus, the study of GMs occurrence and their intensity over time is underlying to improve our predicting models, and to prevent the risk associated with them.

In this paper the statistical study has been perform to the analysis of geomagnetic storm with D_{st} values. Further we compare association of GMs during the solar activity period for solar cycle 24.

DATA SOURCE AND METHOD

In this analysis we used daily average internet based provided data of GMs with D_{st} magnitude ≤ -50nT and their relationship with CMEs and solar wind plasma velocity (SW_{pv}) occurred during solar cycle 24 by the international space related research centre's that is OMNI web (http://omniweb.gsfc.nasa.gov/ow.html). The OMNI system has been accompanied its research using many grounds and space-based GPS and satellite stations since long ago. The properties of CMEs are collected from the data available through website SHAHO LASCO (htpp://.cdaw.gsfc.nasa.gov>CME_list). We investigate 3 different intense geomagnetic storms, **-50nT≥moderate>-75nT, -75nT≥intense>-100nT, severe≤-100nT**. To study the variation of solar wind plasma velocity and CME linear speed during intense and severe geomagnetic storm at a particular time, we used cross correlation between them with a polynomial fit. This analysis allows obtaining the degree of correlation between them.

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ANALYSIS AND RESULTS

In this study we have used D_{st} data that record the number and association of GMs with CMEs and SW_{pv} during solar cycle 24. We have plotted this data and we can give the answer of several query to do with how GMs occurs during the year, and the frequency of their Occurrence. In this study we have classified GMs with respect to their D_{st} magnitude in three categories, 1 Moderate(**-50nT≥moderate>-75nT)**, 2 Intense (**-75nT≥intense>-100nT)**, 3 Severe (**severe≤-100nT).** Figure 1 shows the occurrence of frequency of GMs for that year and figure 2 classified GMs into 3 categories on the basis of D_{st} value. We observed 73 GMs out of which 74% are moderate, 20.5% are intense and 5.5% are severe. From figure 1 it is evident that in the year 2008 and 2019 zero GMs and in 2015 largest number of GMs, and in 2012 second largest number of GMs occurred. From figure 3 it is also evident that in the year 2008, 2009, 2018 and 2019 zero CMEs, and in the year 2012 largest number of CMEs, and in year 2015 second largest number of CMEs associated for the study of GMs during that

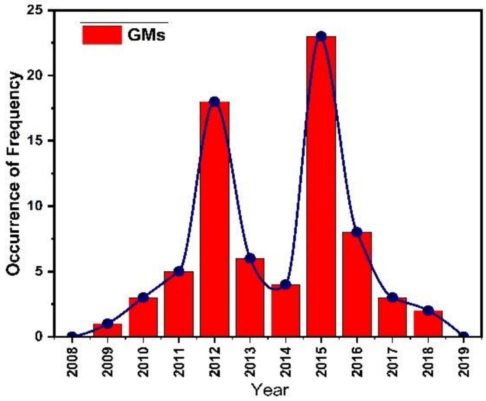

Figure 1- Occurrence of GMs during Solar Cycle 24

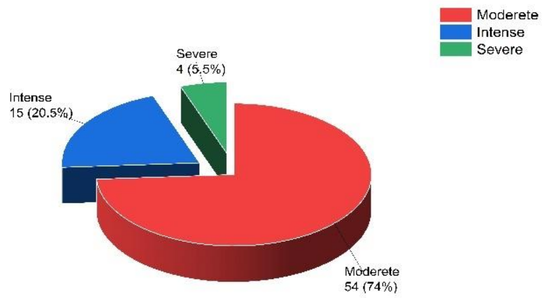

Figure 2 Classification of GMs during Solar Cycle 24

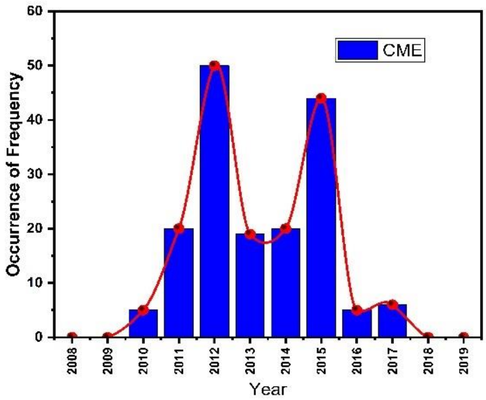

Figure 3- CMEs during the period of GMs for Solar Cycle 24

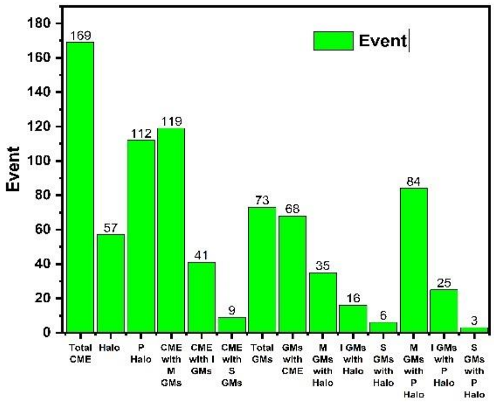

Figure 4- Associated CMEs with Classified GMs

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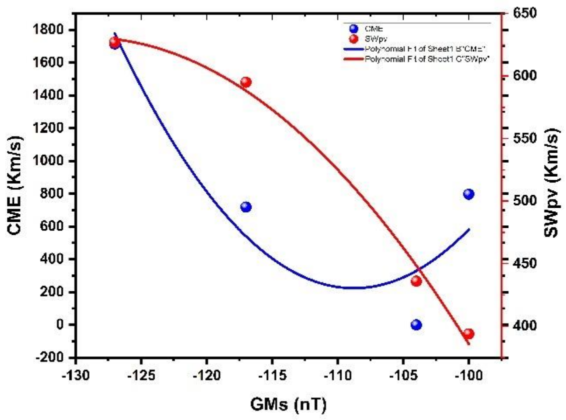

Figure 5- Correlation between Severe GMs with CME Speed and SW_{pv}

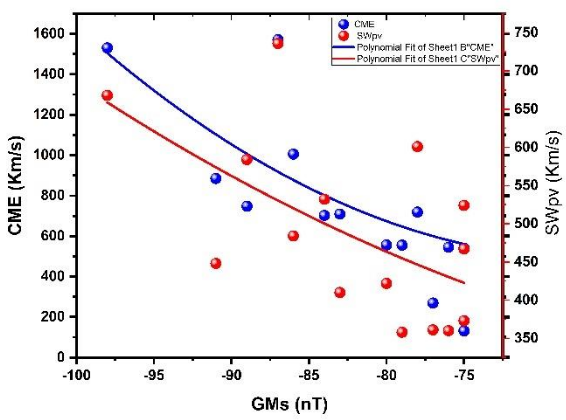

Figure 6- Correlation between Intense GMs with CME Speed and SW_{pv}

time of period. From figure 4 we observed 169 CMEs out of which 70% are associated moderate GMs, 24.3% associated with intense GMs, and 5.3% associated with severe GMs. We also observed from figure 4 that out of 169 CMEs happens during GMs in which 33.7% are Halo CMEs and 66.3% are Partial Halo CMEs. Out of 119 CMEs linked with moderate GMs 29.4% are Halo CMEs and 70.6% are Partial Halo (figure 4). During intense GMs out of 41 CMEs 39% are Halo CMEs and 61% are Partial Halo CMEs. figure 6 shows the cross correlation between intense GMS with CME speed and SW_{pv}. We found average and negative Correlation between intense GMs and CME speed with correlation coefficient -0.620. It is also observed from study that correlation between Intense GMs and SW_{pv} is average and negative with correlation coefficient -0.578.

STUDY OF SEVERE GMS

During the period of study 4 severe GMs occurred in which first occurred in 18 March 2015, second occurred in 23 June 2015, third occurred in 21 December 2015, and fourth occurred in 26 August 2018. From fig 1 it has been investigated that largest number of GMs (23) occurred in 2015 out of which 3 are observed as severe GMs. Year 2015 is the first descending phase year of solar cycle 24. From figure 3 it is also investigated that the second largest number CMEs (44) out of 169 associated with GMs during year 2015.

We also observed from figure 4 that 9 CMEs associated with severe GMs. It is also analysed from figure 5 out of 9 CMEs associated during the study of severe GMs, 6 are Halo CMEs and 3 are Partial Halo CMEs, which are the 5.3% of total CMEs (from figure 4). From figure 3 we have observed that there is no CMEs associated with fourth severe GMs. We have observed from figure 4 GMs associated with CMEs are 43% out of which 5.1% severe GMs are linked with CMEs. It is found that 5.5% severe GMs occurred during solar cycle 24. We have analysed severe GMs magnitude with CME speed and SW_{pv} during that period of time. We have found good and negative correlation between them with correlation coefficient -0.736 and -0.975 (figure5).

CONCLUSION

It is evident that most of the severe GMs associated in the year 2015 with largest which is the first year of declining phase of solar cycle 24, and the second largest number of CMEs associated with GMs during period of study. The strongest magnitude -127nT occurred in 2015 during that period of study. We have found that 5.5% severe GMs occurred in which 5.3% CMEs happen and 5.1% are associated with them.

In this study we analysed that, out of 43% GMs linked with CMEs, in which 3.8% are Halo CMEs and 1.9% are partial Halo CMEs associated with severe GMs. We have established good and negative correlation between GMs magnitude with CME speed and SW_{pv}. The correlation coefficient obtained -0.736 and -0.975 between them. We concluded the average and negative correlation between intense GMs with CME speed and SW_{pv} with correlation coefficient -0.620 and -0.578.

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