Effects of Solar Variation on Global Climate Change

Kalpana Singh[1]
Department of Applied Science & Humanities,
Azad Institute of Engineering Technology,
Lucknow (U.P)

Anoop Kuamr Singh[3]
Deptt. Of Geology University of Lucknow,
Lucknow 226007

Sham Singh,[2]
Deptt. Of App. Sci. CEC,
Landran, Mohali, Punjab India.

A. P. Mishra[4]
Department of Physics, A.P.S.University,
Rewa (M.P.) India,486003.

***Abstract*: The influence of solar output and its variability on the earth can be seen through interplanetary magnetic field and solar wind. All the forms of activity on the sun i.e. Sunspots, active regions and the transient phenomena such as flares and coronal mass ejections are strongly related to magnetic fields. The differential rotation, solar magnetic field, Sunspots, Solar flares and changing aspect of the Corona are assumed to be the main source of solar activity.Geomagnetic storm is a global disturbance in Earth's magnetic field usually occurred due to abnormal conditions in the interplanetary magnetic field (IMF) and solar wind plasma emissions caused by various solar phenomenon. Furthermore the magnitudes of these geomagnetic effects largely depend upon the configuration and strength of potentially geo-effective solar/interplanetary features. In the present study the occurrence of total number of halo (H) and Partial halo (PH) CMEs are 469 and 158 during the maxima time period (2013-2014) and also 2015 of solar cycle 24. the identification of 138 geomagnetic storms associated with disturbance storm time (Dst) decrease of more than -60 nT to -100 nT, have been made, which are observed during 1996-2013.We have studied geomagnetic storms (DST ≤ - 100nT) observed during solar cycle 24.**

Index Terms- Solar flares, CMEs, Sunspot number and geomagnetic stroms.

I. INTRODUCTION

Solar activity comprising sunspots and other phenomena is strongly related to disturbances in the Earth's magnetic field and it gives rise to various effects in the Earth's upper atmosphere. The interplanetary causes of intense storms (Dst ≤-60 to -100 nT) during solar cycle 23 has been investigated by many author. A CME produces disturbances in the solar wind preceded by a shock wave. Interplanetary space probes encountering such disturbance have recoded increased wind speeds and densities, and a rapidly varying magnetic field. When these interplanetary disturbances reach to the Earth, they give rise to geomagnetic storms. Their frequency varies with the sunspot cycle. At solar minimum about one CME in a week, rising to an average of two or three per day at solar maximum. Coronal mass ejections can be geoeffective, in the sense that they can cause geomagnetic storms, because they can bring to Earth strong southward fields at the dayside boundary of the magnetosphere, as a consequence allow solar wind energy, momentum, and mass access to the magnetosphere.Geo-magnetic storms generally occurred due to abnormal conditions in the interplanetary magnetic field (IMF) and solar wind plasma emissions caused by various solar phenomenon [1,2]. The study of these worldwide disturbances of Earth's magnetic field are important in understanding the dynamics of solar-terrestrial environment and furthermore because such storms can cause life threatening power outrages, satellite damage, communication failure and navigational problems [2-4]. It is well established fact that solar wind is continuously emanating from the sun's outer corona and engulf the entire heliosphere. It mainly consists of hot electrons and protons flowing supersonically and caused due to extremely high coronal temperature helping ionized plasma to overcome the gravitation attraction of the Sun. The density and speed of this flow is highly variable and depends solely upon the conditions which has caused it to eject. The solar wind carries with it the magnetic field of Sun, which when enters to the interplanetary medium is termed as Interplanetary Magnetic Field (IMF). The speed of CMEs may determine how geoeffective it will be, but not speed itself is particularly geoeffective [6]. Speed is factor in the solar wind electric field, which controls the merging role at the boundary of the magnetosphere, but its overall contribution to storm strength as an electric field factor is not large because speed varies much less than the other controlling parameters, such as the strength of the southern magnetic field [7]. CMEs which are faster than the solar wind are more geoeffective primarily because they compress southward fields in the vicinity of the leading edges [8]. CMEs are responsible for the most geoeffective solar wind disturbances. When a CME will arrive at Earth and whether or not it will be geoeffective. Further information CMEs can be found in literature [9-12]. There is need and ultimate goal of solar-terrestrial physics to be able to predict geoeffective CMEs. CME-associated flows tend to be responsible for the largest storms during the solar cycle 23. This conclusion is consistent with other studies, [13]. It was found that only ~13% of intense (Dst≤– 60 to100 nT) geomagnetic storms in solar cycle 23 were driven by streams, while the remaining involved CME-associated flows (ICMEs and/or upstream sheaths) [14]. We also note that occasionally [15] both CME-associated flows and streams may be involved in the production of a storm, [16-18]. However, for global

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 11, November-2019

quantitative representation various geomagnetic indices have been introduced. The disturbance storm time (Dst index) is the conventional measure of ring current intensity and energy observed at Earth's surface over low and moderate latitudes. The Dst values are obtained from the longitudinal average of H variations measure at middle and low latitude observatories. It is the best indicator of the ring current intensities and a very sensitive index to represent the degree of solar disturbance. The another geomagnetic index, auroral electrojet magnetic intensity index ($A_{E)}$ [19] is measured auroral elecrojet intensity of the energy dissipated in the ionosphere and energy of precipitating electrons on the auroral and polar regions. The planetary global indices Kp and Ap measured the worldwide level of geomagnetic activity. The planetary index Ap represents the degree of global geomagnetic variability of each day and widely used in different branches of science to define the state of geomagnetic field. The storm time variations also known as geomagnetic storm deals the various characteristics of geomagnetic storms and their connection with solar source activities and interplanetary magnetic fields. These variations directly affect us and shows adverse effect in satellites, communication system and power losses.

In this paper the statistical study has been performed to analyze these geomagnetic storms recorded by various geomagnetic observatories identified with the help of Disturbance storm time index (Dst).We investigated various solar parameters/interplanetary magnetic field components which were potentially geo- effective and occurred during the solar activity period of solar cycle-23 & 24.

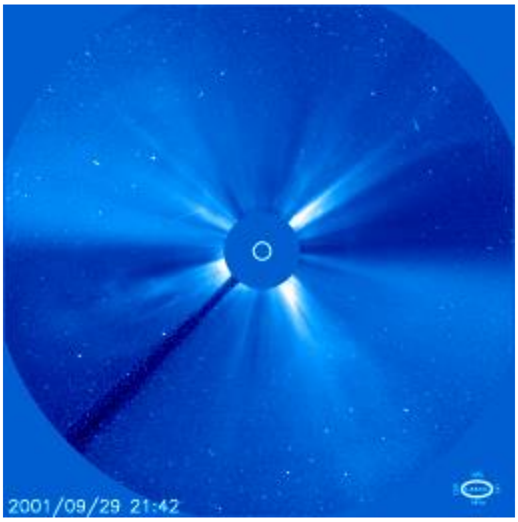

Fig. 1- shows the ejection of CMEs from the sun.

II. DATA SELECTION

In the present study we have analyzed all those large geomagnetic storms which are associated with Dst decreases of less than (-60 to 100) nT and are observed during the period 2008-2013. If the magnitude of storm (Dst value) recurs for several consecutive days/hours, then the last day/hour is taken as the storms day. A set of three large geomagnetic storms associated with Dst(≤-60 to100) nT are presented. We have analyzed association of storms with different solar and interplanetary disturbances and their correlation between them. The hourly values of geomagnetic index have been obtained by Solar Geophysical Data (Prompt Comprehensive report) of U.S. Department of Commerce, NOAA and omni web data.

III. RESULTS AND DISCUSSION

Large geomagnetic storms are often associated with CMEs or IP shocks in the solar wind resulting from the interaction between high-speed and low-speed plasma streams [20]. A CME produces a disturbance in the solar wind preceded by a shock wave. Interplanetary space probes encountering such disturbances have recorded increased solar wind speeds, densities and rapidly varying magnetic field. When these interplanetary disturbances reach the Earth, they give rise to geomagnetic storms. Storms driven by CME-associated flows have an occurrence rate that generally follows the solar activity cycle but may be temporarily depressed for a period around solar maximum. As the storm size increases, CME-associated flows contribute to a larger fraction of events. The long-term monthly mean sunspot numbers are shown in **fig. 2**

According to our selection criteria 138 large geomagnetic storms (Dst≤-60 to -100nT) have been observed during the sunspot cycle 23 and 24 **(fig. 3).** The large geomagnetic storms and 40 M-class flare has been observed which follow the different phases of cycle 23 and 24 **(fig. 4).** The occurrence of total number of halo (H) and Partial halo (PH) CMEs are 469 and 158 during the maxima time period (2013-2014) and also 2015 of solar cycle 24. **(fig.5).**

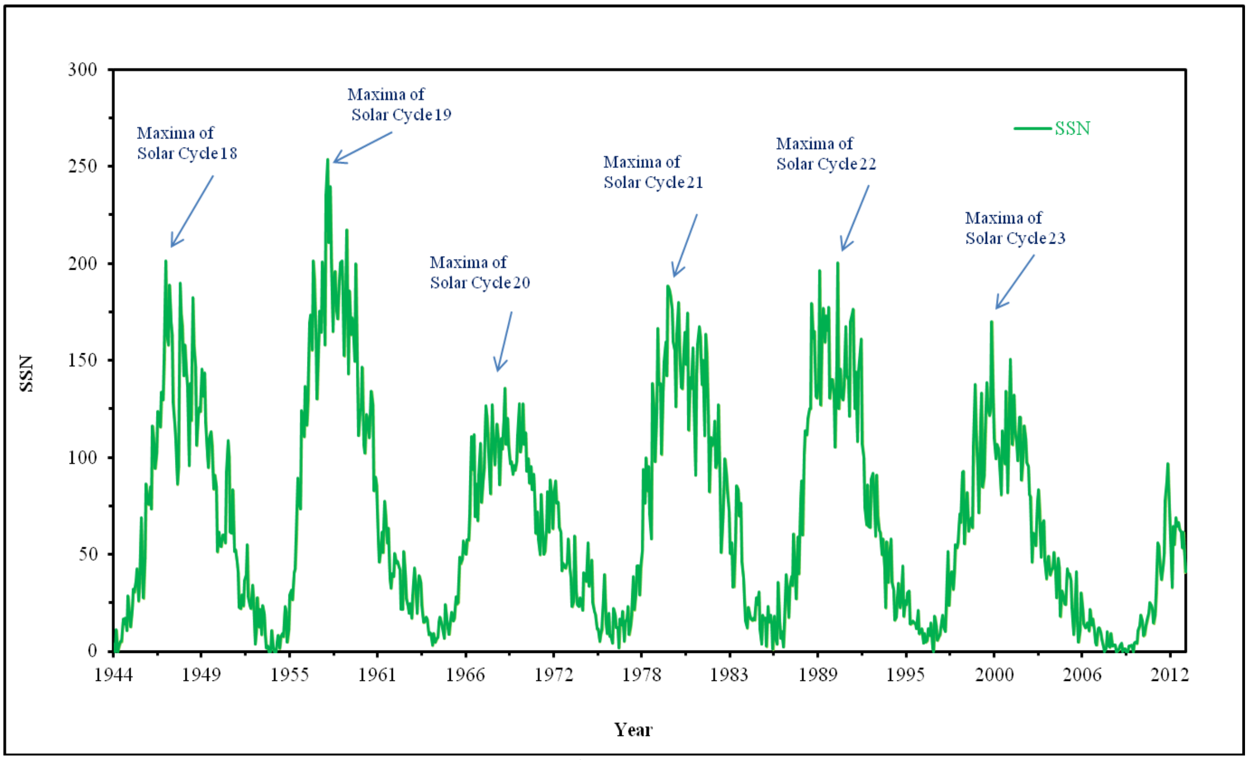

Fig. 2: Shows the Monthly mean sunspot number for period 1944 to 2013 which cover the solar cycle 18 to 24.

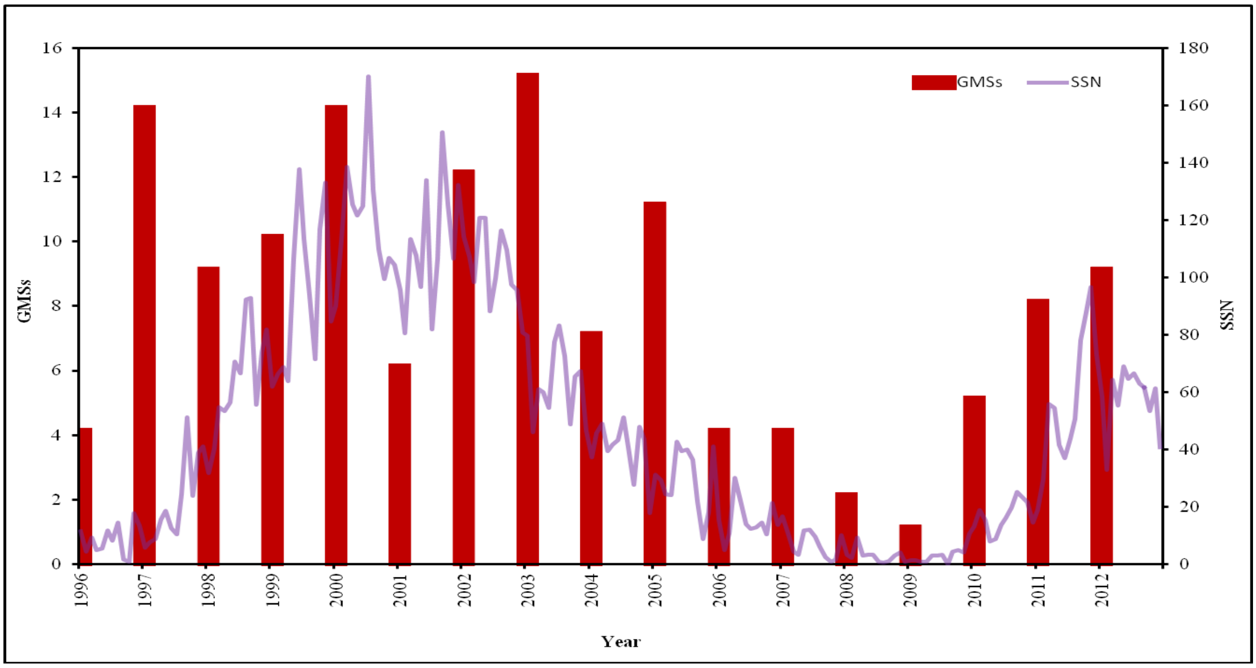

Fig. 3: Shows the sunspot number and geomagnetic storms (Dst ≤-60 to -100nT) during the period 1996 to2013.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 11, November-2019

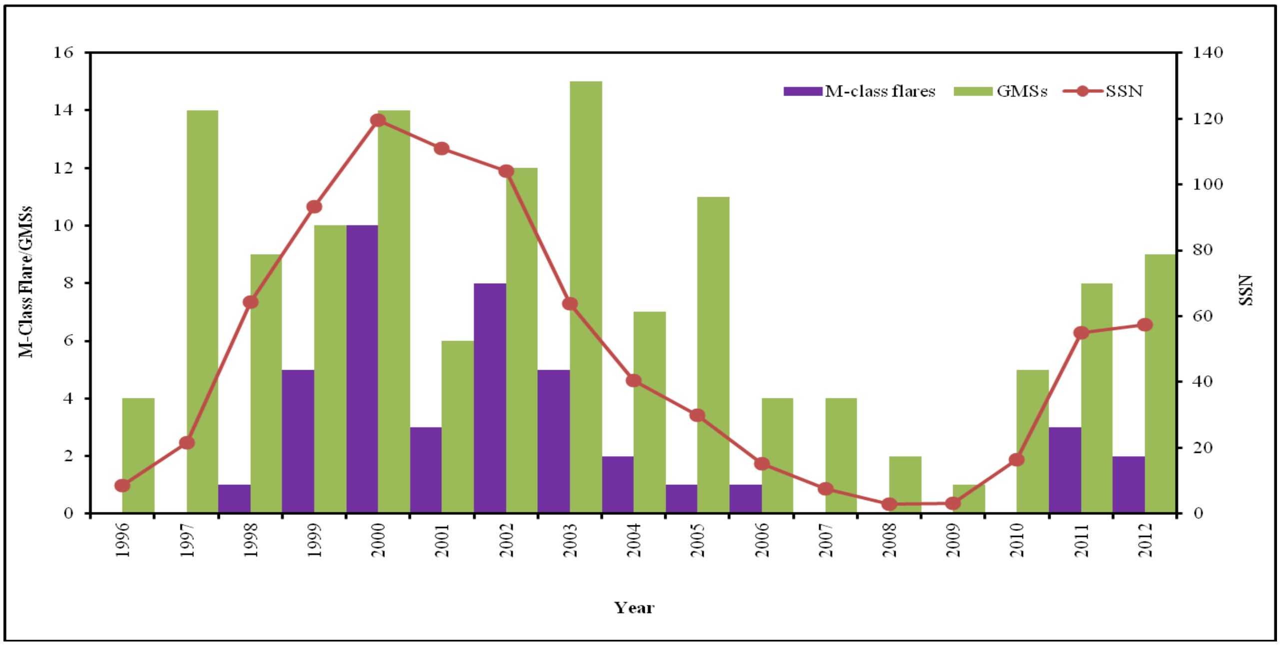

Fig. 4: Shows the sunspot number and occurrence of M-class flares associated with large geomagnetic storms (Dst ≤-60 to 100nT) during the period 1996 to 2013.

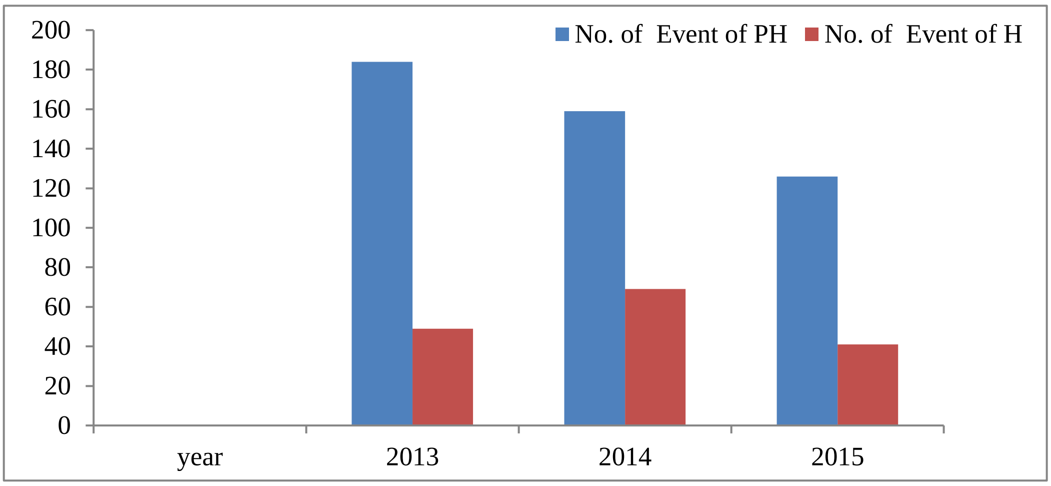

Fig. 5: shows the occurrence of Partial Halo (PH) and Halo (H) CMEs during year 2013, 2014 &2015

IV CONCLUSION

The Earth's magnetosphere and upper atmosphere can be greatly agitated by variations in the solar wind caused by disturbances on the Sun. Changes in the orientation of the interplanetary magnetic field (IMF) and major increases in the velocity and density of solar wind particles prominent the magnetosphere result in geomagnetic storms. Geomagnetic storms are seen at the surface of the Earth as perturbations in the components of the geomagnetic field, caused by electric currents flowing in the magnetosphere and upper atmosphere. An important challenge to solar-terrestrial physicst is to understand which solar and interplanetary process caused the geomagnetic activity. Solar output in terms of solar plasma and magnetic field ejected out into interplanetary medium consequently create the perturbation in the geomagnetic field. The transfer of energy and plasma from Sun to Earth is also interesting. Throughout the heliosphere, the solar wind plasma carrier embedded within it solar magnetic field lines. The transfer of energy, momentum and mass from the Sun to Earth for a number of solar perturbations under a variety of interplanetary configuration is also a major scientific objective.

Dst decreases with increasing magnetopause shielding currents, a measure of magnetospheric compression produced by an increase in solar wind velocity. These quantitative relationships are invaluable for modeling studies and space weather phenomena.

V ACKNOWLEDGMENT

All authors are thankful to their respective Departments and Universities for providing the necessary facilities. Anoop Kumar Singh is thankful to D. S. Kothari PDF UGC (4-2/2006 (BSR)/ES/17-18/0008) Fellowship for financial support.

REFERENCES

[1] S.I. Akasofu, "Solar-wind disturbances and the solar wind-magnetosphere energy coupling function," Space Sci. Rev., 34, 173-183, 1983

[2] J. A. Joselyn and P. S. McIntosh, "Disappearing solar filaments: A useful predictor of geomagnetic activity," J. Geophys. Res., 86, 4555, 1981

[3] Lakhina G.S., "solar wind-magnetosphere-ionosphere coupling and chaotic dynamics", Surveys in Geophysics, Vol 15, No.6/Nov, pp 703-754 DOI: 10.1007/ BF00666091, 1994.

[4] W. D. Gonzalez, J. A. Joselyn, Y. Kamide, H. W. Kroehl, G. Rostoker, B. T. Tsurutani, V. M. Vasyliunas, "What is A Geomagmetic Storm?," J. Geophys. Res., 99, 5771-5792, 1994

[5] Kaushik, S.C. and Shrivastava, P.K., Influence of magnetic clouds on interplanetary features, Indian Journal of Ph**ysics**, 74 B (2), **2000**, 159 - 162.

[6] Sham Singh and A. P. Mishra Indian J Phys DOI 10.1007/s12648-015-0703-y

[7] Sham Singh , Divya Shrivastava And A.P. Mishra Indian J.Sci.Res. **3,** 121-125, 2012

[8] Kaushik, S. C. and Shriastava, P.K., An investigation of two types of interplanetary transient disturbances and their effects on cosmic ray intensity in relation with solar wind plasma parameters, Indian Journal of Radio and Space Physics, 28,1999,203-210.

[9] Shea, M. A and D. F. Smart (1990), A summary of major solar events, solar physics, 127, 297-320.

[10] B Tsurutani, W Gonzalez, F Tang and Y Lee *Geophys. Res. Lett.* **19** 73 (1992)

[11] N Crooker *J. Atmos. Sol.Terr. Phys*. **62** 1071 (2000)

[12] D Webb *Geophys. Rev*. **33** 577 (1995)

[13] T Forbes *J. Geophys. Res.* **89** 21 (2000)

[14] S Dubey and A Mishra *Earth Moon Planet*. **84** 34 (2000)

[15] E Echer, W Gonzalez, B Tsurutani, and A Gonzalez *J. Geophys.Res*. **113** 1 (2008)

[16] Sham Singh, Divya Shrivastava, Shri Ram Lahauriya, Adya Prasad Mishra **4,** 349-354 (2012) Natural Science doi:10.4236/ns.2012.46048

[17] J Zhang, I Richardson, D Webb, N Gopalswamy, E Huttunen *J. Geophys. Res.* doi:10.1029/2007JA012321 **112** A10102 (2007)

[18] L Burlaga, K Behannon, and L Klein *J. Geophys. Res*. **92** 5725 (1987)

[19] A Dal Lago, W Gonzalez, L Balmaceda, L Vieira, E Echer and F Guarnieri *J. Geophys. Res.* doi:10.1029/2005JA011394 **111** A07S14 (2006)

[20] I Richardson, D Webb, J Zhang, D Berdichevsky, D Biesecker and J Kasper *J. Geophys. Res.* doi:10.1029/2005JA011476 **111** A07S09 (2006)

Kalpana Singh
Department of Applied Science & Humanities,
Azad Institute of Engineering Technology, Lucknow (U.P)