

**International Journal of Innovative Research in Science,  
Engineering and Technology**

*(A High Impact Factor, Monthly, Peer Reviewed Journal)*

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 7, Issue 3, March 2018

# **Study of Association between Geomagnetic Storm with Solar Wind and Interplanetary Magnetic Field during 1997-2008**

Suman Garia<sup>1</sup>, Lalan Prasad<sup>2</sup>

Assistant Teacher, Dept. of Education, M.B.Govt. P.G.College, Uttarakhand, India.<sup>1</sup>

Associate Professor, Dept. of Physics, M.B.Govt. P.G.College, Haldwani, Uttarakhand, India.<sup>2</sup>

**ABSTRACT:** In the present work we have chosen 209 Geomagnetic Storms (GSs) from 1997 to 2008. The comparative study of GSs with interplanetary parameters [plasma flow pressure, solar wind speed and  $B_z$  component of Interplanetary Magnetic Field (IMF)] is done in order to investigate the dependence of geomagnetic activity on interplanetary disturbances during the period of 11 years. The result of our analysis is that the enhanced plasma flow pressure and enhanced solar wind speed cause GSs when IMF  $B_z$  is southward. Also, the strength of GSs directly depends on the magnitude of plasma flow pressure near the earth. Here Disturbance storm time (Dst) index is taken as a measure of GS.

**KEYWORDS:** Coronal mass ejection, Geomagnetic storm, Interplanetary magnetic field.

## **I. INTRODUCTION**

Coronal mass ejections (CMEs) are the source of major disturbances in the interplanetary medium, which further produce sudden changes in the earth's magnetosphere and cause GSs. GSs occur within 5 days after the onset of CMEs and variation in geomagnetic disturbances generally follows the phase of the solar cycle (Prasad, Garia and Bhatt, 2013). The change in dynamic pressure of the solar wind and the orientation of the IMF is responsible to change the dynamic structure of earth's magnetosphere. The IMF  $B_z$  component is generated (i) when high-speed plasma flow modifies the ambient IMF (Gosling and McComasa, 1987), (2) as a result of solar wind turbulence and wave generation (Velli and Pruneti, 1997), (iii) when magnetic field lines extended from the sun merges (Schindler and Birn, 1999), and (iv) due to the transportation of IMF  $B_z$  component from the solar corona (Burlaga, 1987). This  $B_z$  component allow sufficient energy transfer from solar wind into the earth's magnetosphere through magnetic reconnection (Howard et al., 1985; Kaushik and Srivastava, 1999). The Dst is the conventional measure of ring current intensity and energy observed at earth's surface over low and moderate latitudes. It is the best indicator of ring current intensity and a very sensitive index to measure the degree of solar wind disturbances. Generally, when CME propagates, it enhances the speed of solar wind. The solar wind speed is an important parameter for the occurrence of geomagnetic disturbances. When a CME impacts the earth's magnetosphere, it temporarily deforms earth's magnetic field. The kinetic energy of a CME is around  $10^{23}$  to  $10^{24}$  Joule (Vourlidas et al., 2002). CMEs are known as the by the presence of CMEs related magnetic inhomogeneities in the hemisphere (Lara et al, 2005; Shrivastava, 2005). Mostly, the common disturbances in IMF the directional changes associated with rotational discontinuity. The earth's magnetosphere responds quite dramatically to the orientation of IMF. The geomagnetic activity related to IMF  $B_z$  (Akasofu, 1983; Gonzalez et al., 1994). The southern  $B_z$  component of IMF is the most geo-effective parameter (Tsurutani, et. al., 1988). Here we focus in finding some geo-effective interplanetary parameters, their association and their combined effect in creating GSs.

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 7, Issue 3, March 2018

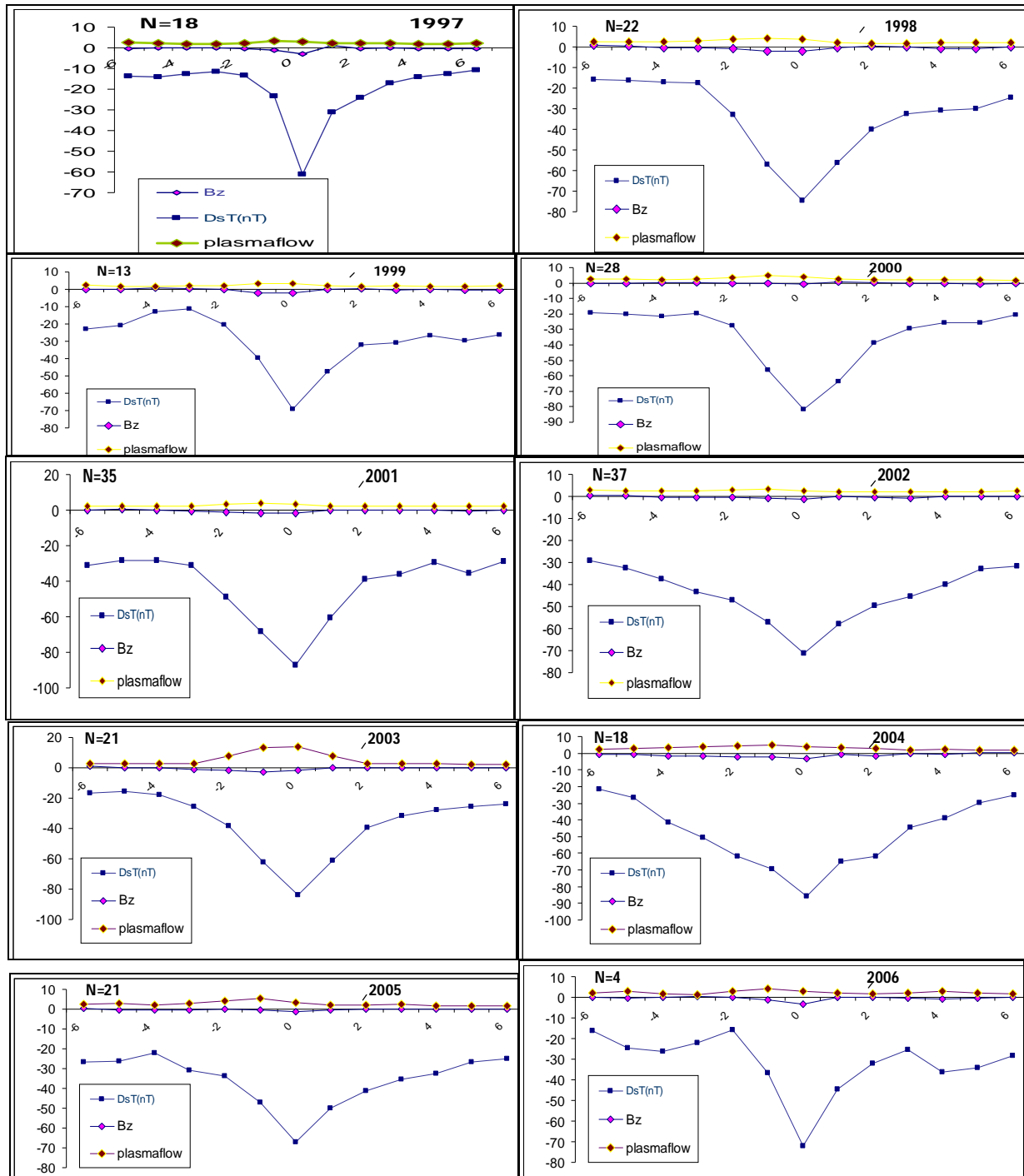


Fig 1: The result of chree analysis from -6 to +6 days with respect to zero epochs days is represented by the figure. The variation of mean value of Dst index, IMF B<sub>z</sub> component and plasma flow pressure are plotted. Zero days corresponds to the starting day of occurrence of GSs during 1997-2006

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 7, Issue 3, March 2018

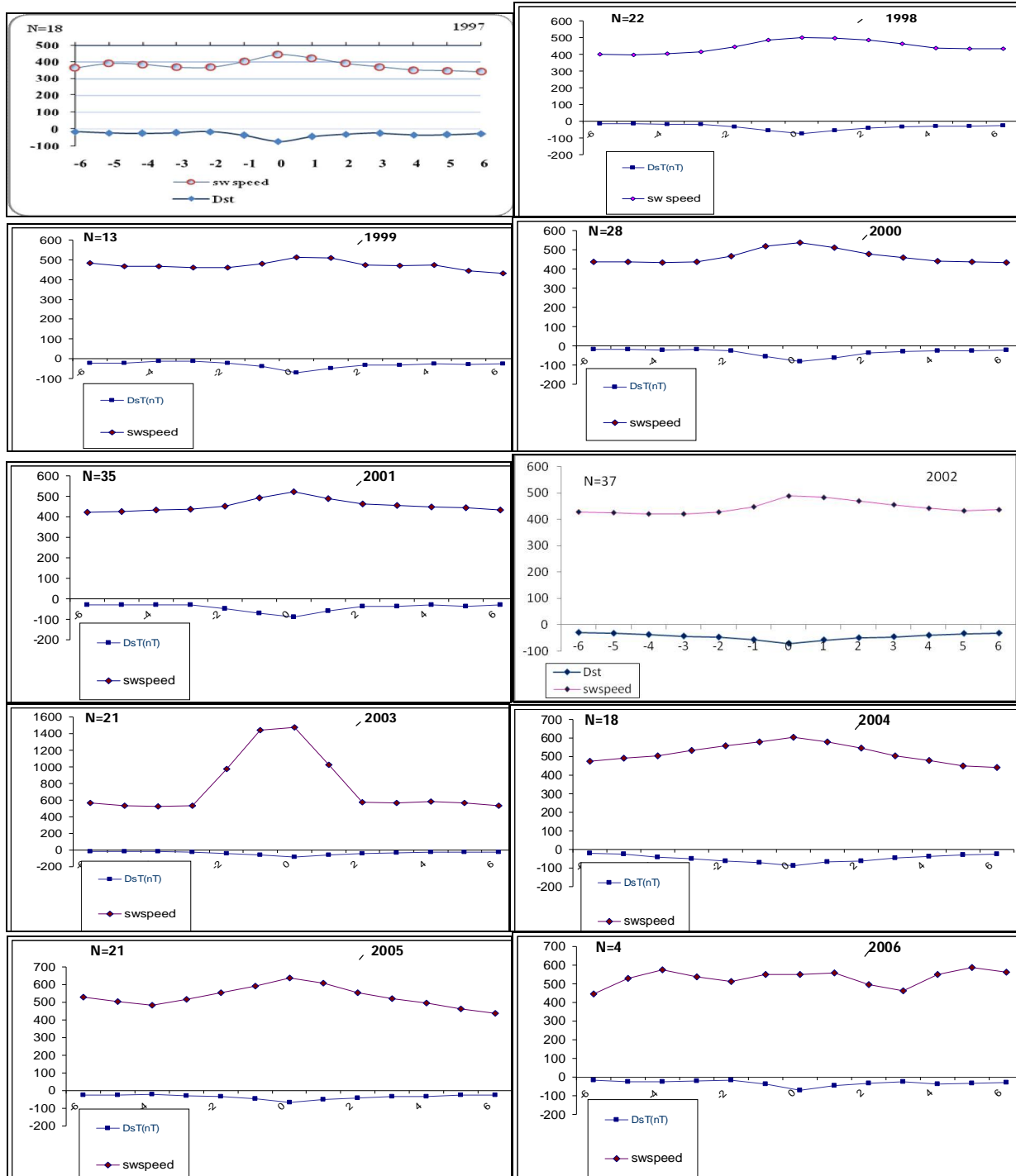


Fig 2: It represents the result of three analysis from -6 to +6 days with respect to zero epoch days. The variation of mean value of Dst index and solar wind speed is plotted. Zero days corresponds to the starting day of occurrence of GSs.

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 7, Issue 3, March 2018

Table 1: The correlation coefficient among interplanetary parameters (IMF  $B_z$  component, plasma flow pressure and solar wind speed) and Dst index.

S.No	Parameters	Correlation Coefficient( r )
1	Dst index and $B_z$	0.62
2	Plasma flow pressure and solar wind speed	0.89
3	Dst and plasma flow pressure	-0.466
4	Dst index and Solar wind speed	-0.45
5	$B_z$ and Plasma flow pressure	-0.47

In this paper we investigate the relationship among GSs and interplanetary parameters (plasma flow pressure, solar wind speed and IMF  $B_z$ ) for the time interval 1997-2009. We have taken IMF  $B_z$  component in Geocentric Solar Ecliptic (GSE) coordinate system. The present study investigates by means of superposed epoch analysis the Dst index of geomagnetic storm, IMF  $B_z$  component, solar wind speed and plasma flow pressure on a time scale of 13 days (days: 6 days before and 6 days after the occurrence of GSs).

## II. DATA COLLECTION AND ANALYSIS

We use Chree analysis by the super epoch method. The daily mean value of Dst, plasma flow speed, solar wind pressure and  $B_z$  component is taken from <http://omniweb.gsfc.nasa.gov/form/dx1.html>.

## III. RESULT AND DISCUSSION

In 11 years data, we found that the maximum numbers of GSs occurs in years 2002, 2001 are 35 and 37. The minimum (zero) GSs occurs in 2008, 2007. This is due to the fact that 2002, 2001 are the year of maximum solar activity whereas 2008, 2007 are the years belong to the minimum phase of solar cycle 23.

On analysis of data, we found that the plasma flow pressure is maximum one day before the GS whereas solar wind speed maximum during the GS (fig. 1 and 2). It implies that the ring current injection increases when the magnetosphere is more compressed by high plasma flow pressure (solar wind dynamic pressure) near the earth. When CME from the sun propagates in interplanetary space it creates disturbances in solar wind. ICME (CME in interplanetary space), when arrive near the earth it contains compressed solar wind plasma ahead of high speed solar wind. This compressed solar wind plasma exerts a dynamic pressure on earth's magnetosphere. When we calculated the correlation coefficient between plasma flow pressure and solar wind speed, it was found that there is a high positive correlation ( $R=0.89$ ), which implies that both interplanetary parameters are highly related to one another and enhanced value of these parameter is responsible for GSs. There is a linear positive correlation between IMF  $B_z$  versus the Dst with correlation coefficient 0.62. The all GSs occurred when IMF  $B_z$  is southward (e.g.,  $B_z$  is negative) near the earth during 1997 to 2008. Thus, the strength of GSs depends on IMF  $B_z$  but the peak value of  $B_z$  and peak value of Dst not takes place simultaneously (fig.1). This south direction of IMF, allow sufficient energy transfer from solar wind into earth's magnetosphere through magnetic reconnection to trigger the GSs.

## IV. CONCLUSION

The disturbances in IMF are solar related directly as CME initiated shocks or indirectly through solar wind stream interaction. Thus, we found that

# International Journal of Innovative Research in Science, Engineering and Technology

*(A High Impact Factor, Monthly, Peer Reviewed Journal)*

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 7, Issue 3, March 2018

- (i) The enhancement of plasma flow pressure is followed by enhanced solar wind speed near the earth and this enhanced solar wind speed ( $>440$  km/s) mostly occurs during time of GSs.
- (ii) Plasma flow pressure together with solar wind speed near the earth is a geo-effective parameter, when IMF  $B_z$  component is southward.
- (iii) The strength of GSs directly depends on the magnitude of plasma flow pressure near the earth.
- (iv) The GSs and  $B_z$  component is highly correlated but the peak value of southward  $B_z$  component and peak value of Dst do not occur simultaneously.

Therefore plasma flow pressure, solar wind speed and IMF  $B_z$  component are together are effective parameters to trigger GSs in our case.

## ACKNOWLEDGEMENT

We are thankful IUCAA, Pune, India for content page service. The authors would like to thank the SPDF-OMNI Web service for providing data.

## REFERENCES

- [1] Akasofu, S.I., "solar wind disturbances and the solar wind magnetosphere energy coupling function," Space Sci.Rev., 34,173-183,1983
- [2] Burlaga, L. F., Behannon, K. W., Klein, L. W., "Compound streams, magnetic clouds, and major geomagnetic storms", J. Geophys. Res., 92, 5725,1987.
- [3] Gonzalez, W.D., JOSELYN, J.A., Kamide, Y., Kroehl, H.W., Rostoker, G., Turutani, B.T., Vasyliunas, V.M., "What is A Geomagnetic Storm" J. Geophys. Res., 99,5771-5792,1994.
- [4] Gosling, J. T., McComas, D. J., "Field line draping about fast coronal mass ejecta: A source of strong out-of-the ecliptic magnetic fields", Geo phys. Res. Lett., 14,355, 1987.
- [5] Prasad, L., Garia S., Bhatt, B., "Association between geomagnetic storms and forbush decreases", International Journal of Physics and Applications, 5, 77-81, 2013.
- [6] Schindler, K., Birn, J., "Thin current sheets and magnetotail dynamics", J. Geophys. Res., 104, 25,001, 1999.
- [7] Turutani, B.T., Gonzalez, W.D., Tang, F., Akasofu S., Smith, E., "Origin of interplanetary southward magnetic fields response for major magnetic storms near solar maximum (1978-1979)", J. Geophys. Res., A8, 8519 – 8531, 1988.
- [8] Velli M., Pruneti, F., "Alfven waves in the solar corona and solar wind", Plasma Phys. Control. Fusion, 39, B-317, 1997.
- [9] Howard, R.A., Sheely Jr. N.R., Koomen M.J. and Michels D.J., "Coronal Mass Ejections, 1979-1981," J. Geophys. Res., 90, 8173-8191, 1985.
- [10] Kaushik S.C. and Srivastava P.K., "Effect of interplanetary transients disturbances in cosmic ray intensity", Bulletin of astronomical society of India, 27, 85-90, 1999.
- [11] Vourlidas, A., Buzasi, D., Howaed and E. Esfandiari, Mass and energy properties of LASCO CMEs, in solar variability: From Core to Outer Frontiers, ESA SP-506, 9194, 2002.
- [12] Lara, A., Gopalswamy, N., Caballero-Loenz, R. A., Yashire, V. S. and Valde-Galicia J. F., "Coronal mass ejections and cosmic ray modulation", ApJ., 625, 2005.
- [13] Shrivastava. "Study of large solar flares in association with halo coronal mass ejections and their helio-longitudinal association with Forbush decreases of cosmic ray". Proc.29 Int. Cosmic Ray Conf., Vol. 1, Pune, India.: 355-358, 2005.