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X -Ray Solar Flare Related Forbush Decreases In Relation With Cosmic Ray Intensity And Disturbances In Solar Wind Plasma Parameters In The Rising Phase Of Solar Cycle 24

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Abstract
X-Ray solar flare related Forbush decreases (Fds) observed during the period of solar cycle 23 and rising phase of 24 (2000-2012) have been studied with coronal mass ejections (CMEs) and disturbances in solar wind plasma parameters. It is observed that all the X-Class, X-ray solar flare related Forbush decreases (Fds) are associated with halo and partial halo coronal mass ejections (CMEs) and most of them (82.35%) have higher speed CMEs with speed >1000Km/s. Large positive correlation with correlation coefficient 0.68 has been found between magnitude of X-ray solar related Forbush decreases (Fds) and speed of associated CMEs. Further all these Forbush decreases (Fds) have been identified as being associated with disturbances in solar wind plasma parameters, (Temperature, Density, Velocity). Positive correlations with correlation coefficient 0.44 and 0.37 have been determined between magnitudes of X-Ray solar flare related Forbush decreases (Fds) and peak value and magnitude of associated disturbances in solar wind plasma temperature, 0.32 and 0.42 between magnitudes of X-Ray solar flare related Forbush decreases (Fds) and peak value and magnitude of associated disturbances in solar wind plasma density. Positive correlations with correlation coefficient 0.32 and 0.14 have also been determined between magnitudes of X-Ray solar flare related Forbush decreases (Fds) and peak value and magnitude of associated disturbances in solar wind plasma velocity.
Keywords: *Forbush decreases (Fds), Coronal Mass Ejections (CMEs), Solar Wind Disturbances.*

1. INTRODUCTION

Forbush decreases are transient depressions in the galactic cosmic ray intensity which are characterized by a sudden onset, reaching a minimum within about a day, followed by a more gradual recovery phase typically lasting several days. These decreases are strongly related to coronal mass ejections and their interplanetary counter parts (Cane et al. 1996, 2000, Badruddin 1997,2000 ,2002,2003, Subhrmanayam et al 2005, Cane and Richardson, 2003,Badruddin, 1997, Kota 2001, Morfill, 1979, Richardson, et al 1996, Richardson, et al 1999 , Richardson, 2004, Cliver et al 2003).Cane et al (1996) have studied 30 years of neutron monitor data and found 86% of cosmic ray decreases to be attributable to CMEs. Cane et al (1997) have associated CME ejecta with short-term particle decreases observed by Helios 1 and 2. The observed depth of a Forbush event is found to depend on one's trajectory through the interplanetary coronal mass ejection .Forbush decreases are generally of lesser magnitude when only the forward shock is present (Cane et al., 1996). Cane H.V (2000) have studied cosmic ray intensity variations with coronal mass ejections and concluded that coronal mass ejections are large-scale phenomena that change the configuration of the interplanetary magnetic field (IMF) and clearly modulate the cosmic-ray intensity on short-term (few day) timescales . Zhang and Burlaga (1988) concluded that relatively large decreases in cosmic ray intensity is associated with magnetic clouds that are preceded by a shock, whereas only a small decreases in cosmic ray intensity is associated with magnetic clouds that are not preceded by shock. Badruddin (2003) has reported that abrupt onset of decrease in intensity starts upon the arrival of certain shocks and decreases continue till the passage of post shock turbulent sheath. He has further determined that turbulent shocks are much more effective in producing asymmetric cosmic ray intensity deceases (Fds) than non-turbulent shocks. Robert Penna et a l (2005) have investigate the relation between Forbush cosmic ray decrease recovery time and coronal mass ejection transit time between the Sun and Earth. Ifedili S.O (2004) has studied two-step asymmetric cosmic ray intensity decreases (Fds) with coronal mass ejections magnetic clouds, interplanetary shocks and interplanetary disturbances, interplanetary magnetic field (magnitude and direction). Interplanetary coronal mass ejection (ICME) impacting on slow solar wind, there is a sheath upstream of the ICME led by a fast forward shock and the large IMF variations in this sheath, which sustained the Forbush decreases (FDs) in the cosmic ray intensity. Chuchkov et al (2009) have analyzed the modulation structures of quasi-symmetric ("bays") short-term Forbush decreases. It is concluded that these Forbush decreases were recorded due to the stations flying through coronal mass-ejection regions.

2. EXPERIMENTAL DATA

In this study Forbush decreases observed during the period of 2000-2012 have been studied with coronal mass ejections, X-ray solar flares and disturbances in solar wind plasma parameters. The data of Forbush decreases have been taken from Oulu super neutron monitor. The data of disturbances in solar wind plasma parameters, solar wind plasma temperature, velocity, and density has been taken from Omni web data (http;//omniweb.gsfc.nasa.gov/form/dxi.html)). The data of coronal mass ejections (CMEs) have been taken from SOHO – large angle spectrometric, coronagraph (SOHO / LASCO) and extreme ultraviolet imaging telescope (SOHO/EIT) data. The data of X-ray solar flares are taken from STP solar data (http://www.ngdc.noaa.gov/stp/solar/solardataservices.html).

Table -1 X-Ray solar flare Related Forbush decreases and Associated Coronal Mass Ejections

T-1	Forbush decreases						Coronal Mass Ejections			Solar Flares	
S.NO	date	Onset set time dd (hh)	max. dec. time dd (hh)	Recovery time dd (hh)	mag%	Tfds-Tssc	Date time dd(hh)	Type H/P	Speed K/s	Date time dd(hh)	Class
1	08.06.00	08(08)	09(00)	17(00)	8	-1	06(16)	H	1130	06(16)	X-23
2	15.07.00	15(12)	16(04)	18(16)	12	-3	14(11)	H	1674	14(11)	X-57
3	26.11.00	26(12)	27(08)	02(08)	8	4	24(05)	H	1298	24(05)	X-20
4	27.08.01	27(18)	28(08)	03(20)	7	-2	25(17)	H	1433	25(16)	X-53
5	21.10.01	21(16)	22(04)	25(04)	5	-1	19(170	H	901	19(16)	X-16
6	06.11.01	06(00)	06(16)	08(20)	12	-2	04(17)	H	1810	04(16)	X-10

7	15.12.01	15(00)	17(12)	19(16)	5	na	13(15)	H	864	13(14)	X-62
8	30.12.01	30(16)	03(04)	08(20)	5.5	-4	28(20)	H	2239	28(20)	X-34
9	29.05.03	29(16)	31(04)	04(20)	7	4	27(24)	H	964	27(23)	X-13
10	29.10.03	29(00)	29(16)	04(20)	25	-6	28(11)	H	2686	28(10)	X-172
11	07.01.04	07(00)	09(00)	13(16)	8	4	06(06)	P	1469	06(06)	X
12	21.01.04	21(16)	22(12)	27(12)	8	-9	20(00)	H	1074	20(07)	X
13	07.11.04	07(08)	10(00)	18(00)	12	5	07(17)	H	1759	07(16)	X-20
14	11.09.05	11(00)	11(12)	21(05)	12	-1	09(20)	H	2257	09(19)	X-62
15	14.12.06	14(18)	15(000	19(18)	10	4	13(02)	H	1931	13(02)	X-34
16	25.09.11	25(12)	26(18)	5(12)	6	-24	22(10)	H	1905	22(10)	X-14
17	14.07.12	14(18)	15(12)	18(18)	7	1	12(16)	H	1092	12(16)	X-14

Table-2 X-Ray solar flare Related Forbush decreases and Associated Disturbances in Solar wind Plasma Parameters

	Fds		**Jump in Solar Wind Temperature**			**Jump in Solar Wind Density**			**Jump in solar wind Velocity**		
date	Onset set time dd (hh)	mag%	Start time dd(hh)	max	Magnitude of Jump in Deg k	Start time dd(hh)	Maximum Jump Value n/cc	Magnitude of Jump n/cc	Start time dd(hh)	Maximum Jump in Km/s	Magnitude of Jump km/s
08.06.00	08(08)	8	08(03)	887701	781686	08(08)	19.2	15.8	08(08)	773	253
15.07.00	15(12)	12	14(07)	676914	583648	14(14)	26.6	24.3	14(12)	882	209
26.11.00	26(12)	8	26(08)	594388	552597	26(11)	35.4	29.3	26(03)	624	252
27.08.01	27(18)	7	27(07)	348295	160985	27(09)	13.1	6.1	27(07)	558	34
21.10.01	21(16)	5	21(15)	502256	422395	21(13)	22.2	16.4	21(10)	677	360
06.11.01	06(00)	12	5(10)	136839	105551	05(09)	46.1	31.4	05(14)	426	141
15.12.01	15(00)	5	14(18)	137313	105398	15(19)	31.8	21.4	14(19)	350	69
30.12.01	30(16)	5.5	30(02)	na	61712	na	na	na	na	na	na
29.05.03	29(16)	7	29(14)	497719	489103	29(14)	50.3	24.2	29(14)	799	103
29.10.03	29(00)	25	28(08)	na	979536	28(01)	na	na	na	na	na
07.01.04	07(00)	8	06(18)	636415	555367	06(15)	5.6	3.1	06(18)	723	155
21.01.04	21(16)	8	21(12)	553467	509255	21(23)	18.3	13.1	21(16)	666	163
07.11.04	07(08)	12	07(10)	1793947	786124	7(03)	75.1	54.1	07(09)	726	386
11.09.05	11(00)	12	11(00)	2083103	1876759	10(22)	25	22.5	10(20)	1059	346
14.12.06	14(18)	10	13(12)	265379	240834	13(03)	10	9.3	13(06)	512	312
25.09.11	25(12)	6	25(18)	1007504	983838	25(06)	30.7	27	25(05)	689	381
14.07.12	14(18)	7	14(08)	556783	544250	14(05)	20.2	16.2	14(08)	667	357

3. DATA ANALYSIS AND RESULTS

From data analysis of Forbush decreases and associated coronal mass ejections and X-ray solar flares listed in Table 1 it is observed that all the X-Class ,X-ray solar flare related Forbush decreases (Fds) are associated with halo and partial halo coronal mass ejections(CMEs .We have 17 Forbush decreases in our list and we have no data of CMEs for one Forbush decrease event for association .Out of 16 Forbush decreases all are associated with coronal mass ejections (CMEs) .The association rates of halo and partial halo coronal mass ejections have been found 94.11% and 5.88% respectively .It is also observed that majority (82.35%) of the associated CMEs are of higher speed CMEs with speed >1000Km/s. Large positive correlation with correlation coefficient 0.68 has been found between magnitude of X-Class ,X-ray solar related Forbush decreases (Fds) and speed of associated CMEs.

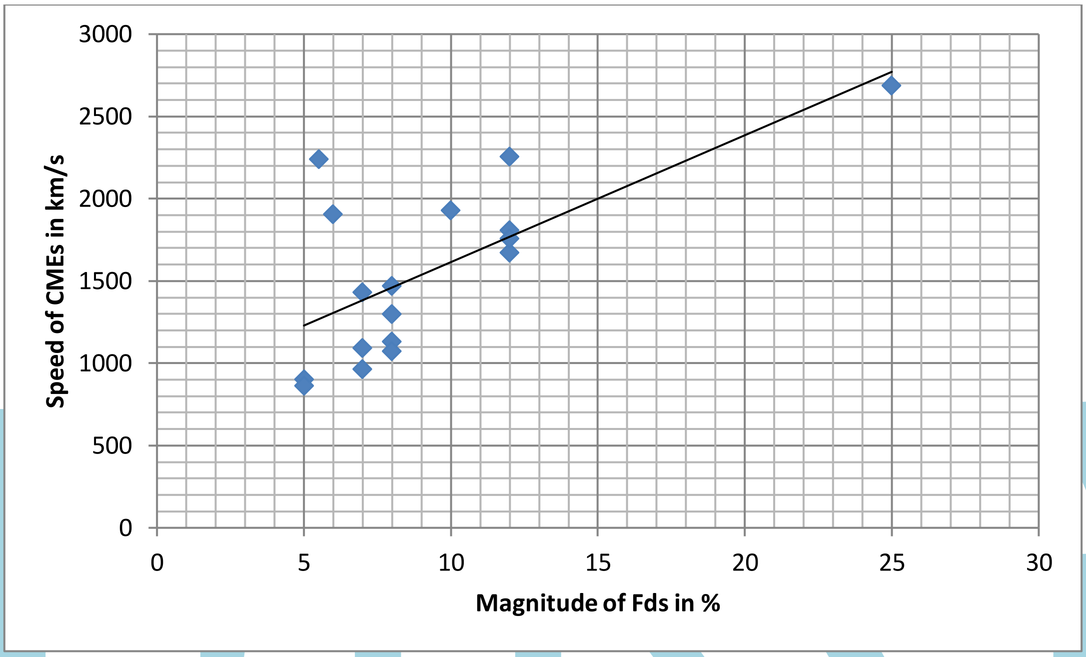

Figure-1- Scatter plot between magnitude of Forbush decreases and speed of associated CMEs.

From the data analysis of Forbush decreases and associated disturbances in solar wind plasma temperature listed in Table 2, it is observed that most of the Forbush decreases are associated with disturbances in solar wind plasma temperature. We have 17 Forbush decreases in which 15 the Forbush decreases (88.23%) are associated with jump in solar wind plasma temperature.

To know the statistical behavior of Forbush decreases with peak value of associated JSWT events, a scatter plot has been plotted between magnitude of Forbush decreases and peak value of temperature of associated JSWT events and the resulting plot is shown in Figure 2. From the Figure it is inferred that, most of Forbush decreases of higher magnitude are associated with such JSWT events which have relatively higher peak temperature but these two events do not have any fixed proportion, We have found some Forbush decreases which have higher magnitude but they are associated with such JSWT events which have lower values of peak temperature and vice versa. Positive correlation has been found between magnitude of Forbush decreases and peak temperature of associated JSWT events. Statistically calculated co-relation co-efficient is 0.44 between these two events.

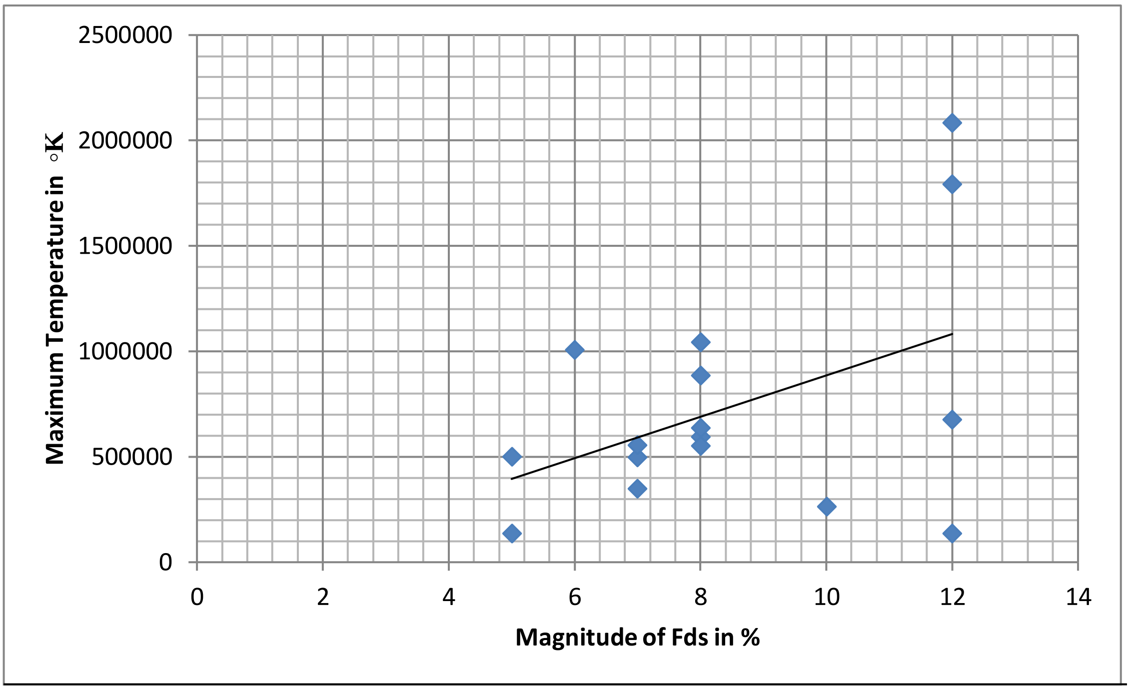

Figure-2- Scatter plot between magnitude of Forbush decreases and peak value of associated JSWT events.

To know the statistical behavior of Forbush decreases with magnitude of jump of associated JSWT events a scatter plot has been plotted between magnitude of Forbush decreases and magnitude of jump in solar wind plasma temperature of associated JSWT events and the resulting plot is shown in Figure 3. From the Figure it is inferred that, most of Forbush decreases having higher magnitude are associated with such JSWT which have relatively higher magnitude of temperature but these two events do not have any fixed proportion, We have found some Forbush decreases which have higher magnitude but they are associated with such JSWT events which have lower values of magnitude of temperature and vice versa. Positive correlation has been found between magnitude of Forbush decreases and magnitude of jump of associated JSWT events. Statistically calculated co-relation co-efficient is 0.37 between these two events.

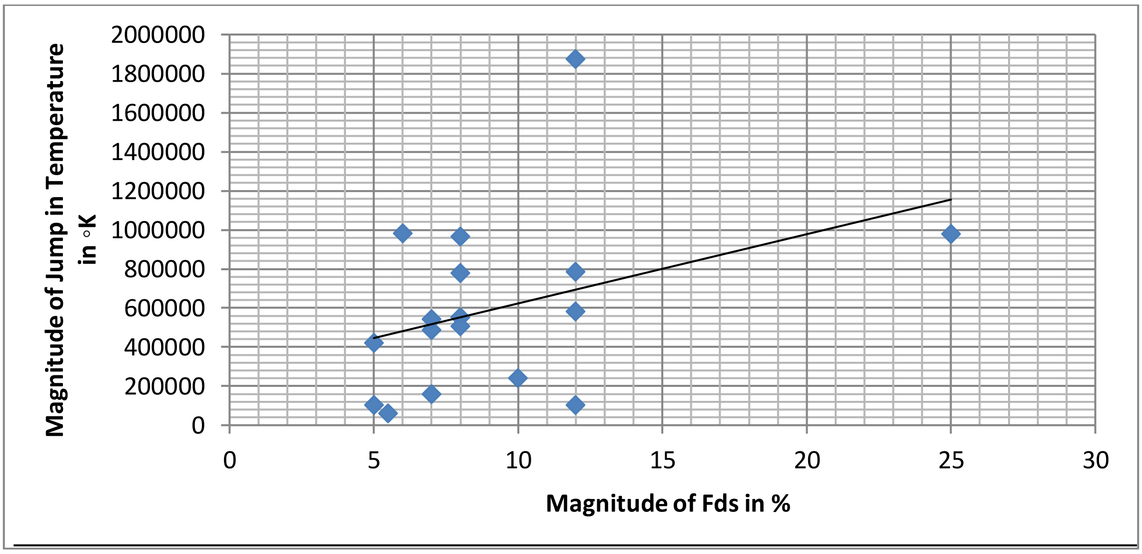

Figure-3 Scatter plot between magnitude of Forbush decreases and magnitude of jump of associated JSWT events.

From the data analysis of Forbush decreases and associated disturbances in solar wind plasma density listed in Table 2, it is observed that most of the Forbush decreases are associated with disturbances in solar wind plasma density. We have 17 Forbush decreases in which 15 the Forbush decreases (88.23%) are associated with jump in solar wind plasma density.

To know the statistical behavior of Forbush decreases with peak value of associated JSWD events a scatter plot has been plotted between magnitude of Forbush decreases and peak value of density of associated JSWD events and the resulting plot is shown in Figure 4. From the Figure it is inferred that, most of Forbush decreases having higher magnitude are associated with such JSWD events which have relatively higher peak density but these two events do not have any fixed proportion, We have found some Forbush decreases which have higher value but they are associated with such JSWD events which have lower values of peak density and vice versa. Positive correlation has been found between magnitude of Forbush decreases and peak density of associated JSWD events. Statistically calculated co-relation co-efficient is 0.32 between these two events.

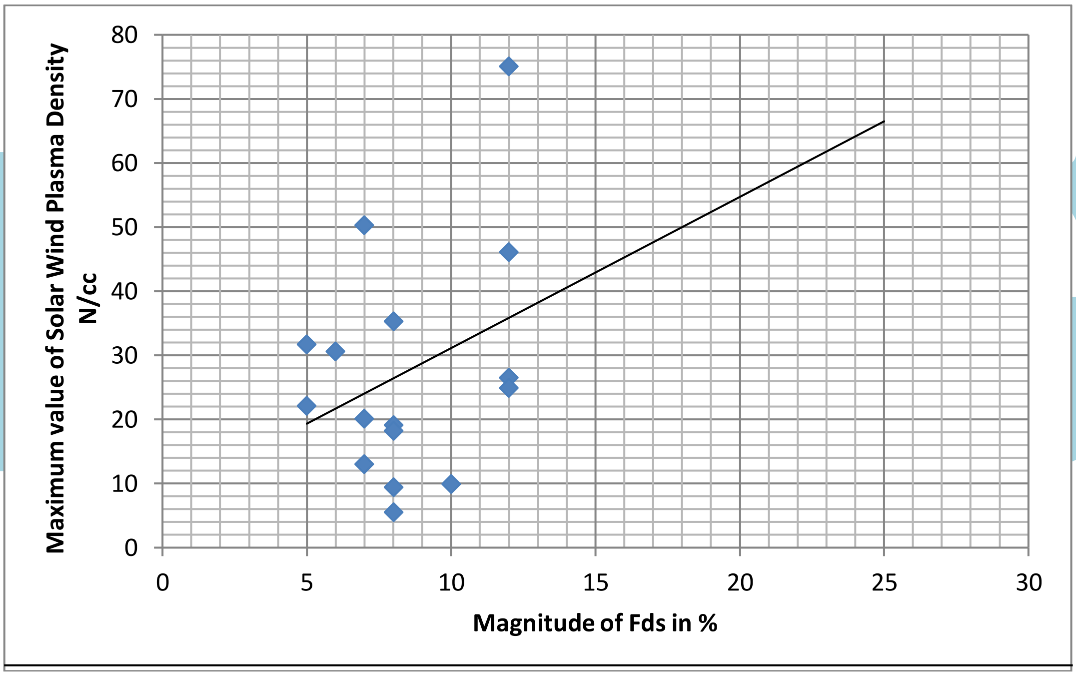

Figure-4- Scatter plot between magnitude of Forbush decreases and peak value of associated JSWD events.

To know the statistical behavior of Forbush decreases with magnitude of associated JSWD events a scatter plot has been plotted between magnitude of Forbush decreases and magnitude of jump in solar wind plasma density of associated JSWD events and the resulting plot is shown in Figure 5. From the Figure it is inferred that, most of Forbush decreases having higher magnitude are associated with such JSWD which have relatively higher magnitude of density but these two events do not have any fixed proportion, We have found some Forbush decreases which have higher value but they are associated with such JSWD events which have lower values of magnitude of density and vice versa. Positive correlation has been found between magnitude of Forbush decreases and magnitude of associated JSWD events. Statistically calculated co-relation co-efficient is 0.42 between these two events.

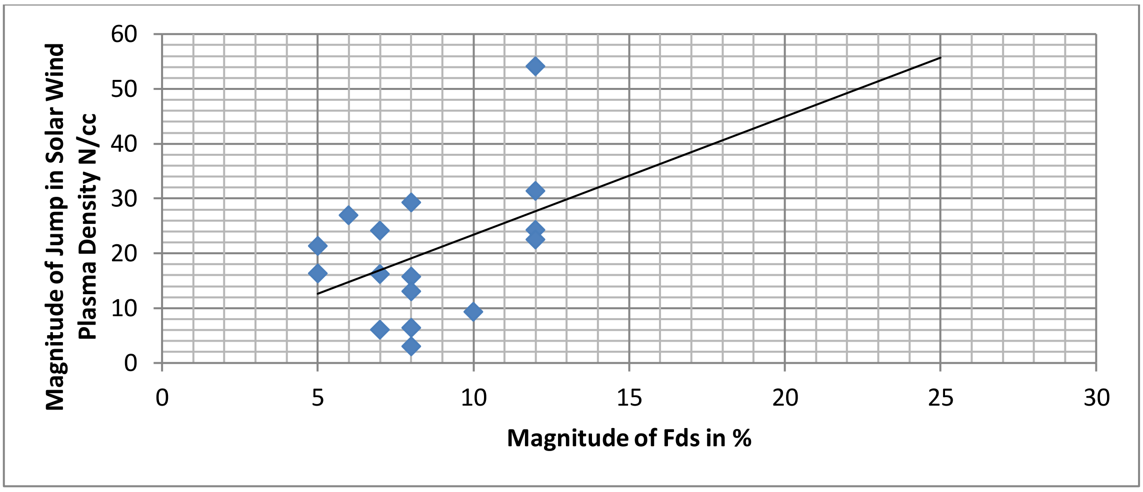

Figure- 5- Scatter plot between magnitude of Forbush decreases and magnitude of jump of associated JSWD events.

From the data analysis of Forbush decreases and associated disturbances in solar wind plasma velocity listed in Table 2, it is observed that most of the Forbush decreases are associated with disturbances in solar wind plasma velocity . We have 17 Forbush decreases in which 15 the Forbush decreases (88.23%) are associated with jump in solar wind plasma velocity. To know the statistical behavior of Forbush decreases with peak value of associated JSWV events a scatter plot has been plotted between magnitude of Forbush decreases and peak value of velocity of associated JSWV events and the resulting plot is shown in Figure 6.

From the Figure it is inferred that, most of Forbush decreases having higher magnitude are associated with such JSWV events which have relatively higher peak velocity but these two events do not have any fixed proportion, We have found some Forbush decreases which have higher magnitude but they are associated with such JSWV events which have lower values of peak velocity and vice versa. Positive correlation has been found between magnitude of Forbush decreases and peak velocity of associated JSWV events. Statistically calculated co-relation co-efficient is 0.32 between these two events.

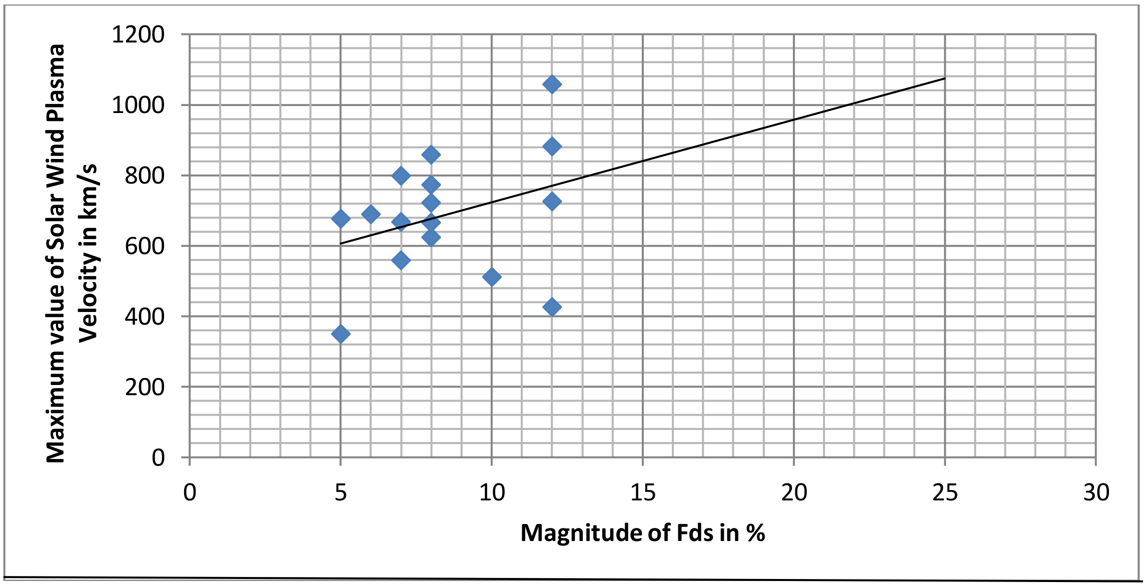

Figure-6- Scatter plot between magnitude of Forbush decreases and peak value of associated JSWV events.

To know the statistical behavior of Forbush decreases with magnitude of associated JSWV events a scatter plot has been plotted between magnitude of Forbush decreases and magnitude of jump in solar wind plasma velocity of associated JSWV events and the resulting plot is shown in Figure 7. From the Figure it is inferred that, most of Forbush decreases having higher magnitude are associated with such JSWV events which have relatively higher magnitude of velocity but these two events do not have any fixed proportion, We have found some Forbush decreases which have higher magnitude but they are associated with such JSWV events which have lower values of magnitude of velocity and vice versa. Positive correlation has been found between magnitude of Forbush decreases and magnitude of associated JSWV events. Statistically calculated co-relation co-efficient is 0.14 between these two events.

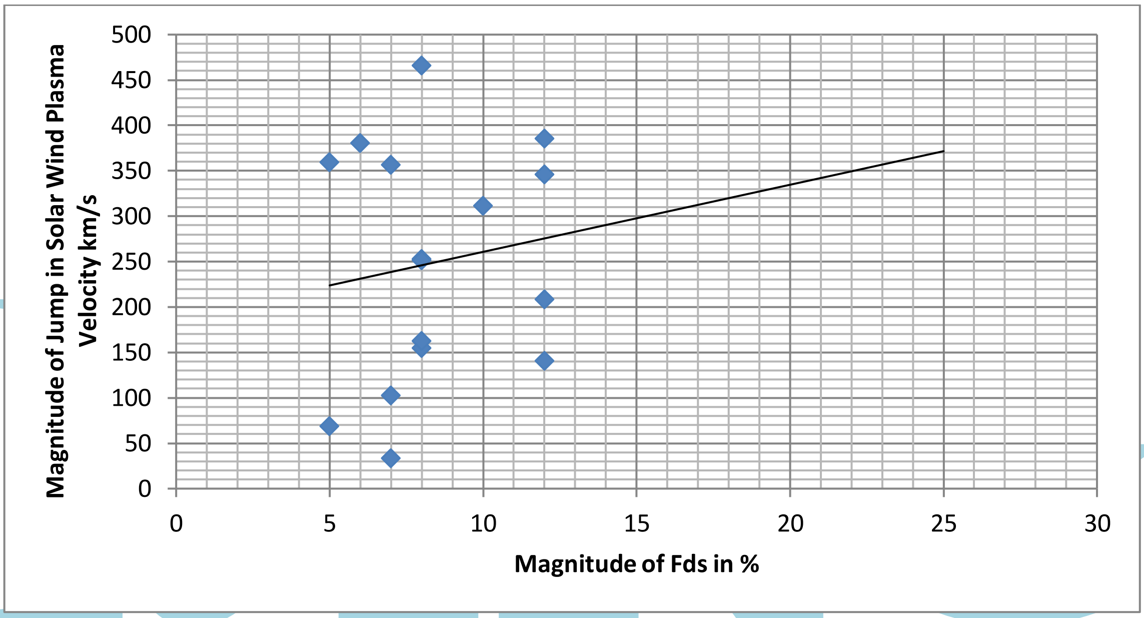

Figure-7- Scatter plot between magnitude of Forbush decreases and magnitude of associated JSWV events.

4. CONCLUSION

From our study it is observed that all the X-class related Forbush decreases are associated with coronal mass ejections. The association rates of halo and partial halo coronal mass ejections have been found 94.11% and 5.88% respectively. Majority (82.35%) of the associated CMEs are of higher speed CMEs with speed >1000Km/s. Large positive correlation with correlation coefficient 0.68 have been found between magnitude of X-Class ,X-ray solar related Forbush decreases (Fds) and speed of associated CMEs. Positive correlations have been found between magnitude of Forbush decreases and maximum, magnitude of jump in solar wind plasma parameters, solar wind plasma temperature, density and velocity. From these results it is concluded that X-Class X-Ray solar flare related Forbush decreases are mainly caused by coronal mass ejections. Further magnitude of Forbush decreases are closely related to disturbances in solar wind plasma parameters.

5. REFERENCES

[1]-Badruddin, Astrophys. Space Sci., 246, 171, 1997.

[2]-Badruddin, Nuvo Cimento, . 23C, 217, 2000.

[3]-Badruddin, Phys. 209, 195, 2002.

[4]-Badruddin and Singh, Y. P Ind. J. Phys. 77, 497, 2003.

[5]-Cane H.V.I.G. Richardson and T.T. Von Rosenving J. Geophys. Res. 10(A10) 21-561, 21572, 1996.

[6]-Cane H.V.I.G. Richardson, and G.wibberenze J. Geophys.Res. 102(A4) 7086, 1997.
[7]-Cane, H. V. Space Sci. Rev. 93, 55, 2000.
[8]-Cane, H. V., and I. G. Richardson, J. Geophys. Res., 108(A4), 1156, 2003.
[9]- Cliver, E. W., Ling, A. G., & Richardson, I. G. ApJ, 592, 574,2003.
[10]-Chuchkov E. A. Tulupov V. I. . Okhlopkovand V. P Lyubimov G. P. Moscow University Physics Bulletin Volume 64, Number 3 / June, 2009.
[11]-Ifedili, S. O. J. Geophys. Res. 109, A02117, 2004.
[12]-Kota J. and. Jokipii, J. R Proc. 27th Int. Cosmic Ray Conf., Hamburg, pp. 3577,2001.
[13]-Morfill, G. Richter A. K. and. Scholar, M J. Geophys. Res., Vol. 84, 1505, 1979.
[14]-Robert F. Penna , Alice C. Quillen, J. Geophys. Res. Vol.110, A09S05, 2005.
[15]-Richardson, I. G. Wibberenz G. and Cane, H.V J. Geophys. Res., Vol. 101, 13483, 1996.
[16]-Richardson, I. G. Cane H.V. and Wibberenz, G J. Geophys. Res., vol. 104, 12549, 1999
[17]-Richardson, I. G. Space Sci. Rev., Vol. 111, 267, 2004.
[18]-Subramanium P Antia H.M.Dugad S.R.GoswamiU.D.,Gupta S.K.Mohanty Nonaka P.K.,Nayak T.,.Tanaka P.K.Tanwar S. C Proc. 29thInt. Cosmic Ray Conf., Pune, 2, 73, 2005.
[19]-Zhang G. and Burlaga, L. F. J. Geophys. Res. 93, 2511, 1988.