H-CMEs and X-class Solar Flare Related Forbush Decreases with Solar Wind Disturbances

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Received: June 03, 2018 Accepted: July 21, 2018

ABSTRACT *We have considered only H-CMEs and X-class solar flare related Forbush decreases (Fds) odd magnitude ≥ 3%, obtained from the analysis of hourly count rate of cosmic rays particles recorded by Oulu neutron monitor during the period 2003-2014 and parameters of solar wind disturbances. From the study of H-CMEs and X-class solar flare related Forbush decreases (Fds) with parameters of solar wind disturbances, we have determined positive correlation between magnitude of Forbush decreases and peak values of associated parameters of solar wind disturbances with co-relation co-efficient 0.67 between magnitude of Forbush decreases and peak values of associated solar wind temperature, 0.69 between magnitude of Forbush decreases and peak values of associated solar wind density, 0.47 between magnitude of Forbush decreases and peak values of associated solar wind velocity, 0.66 between magnitude of Forbush decreases and peak values of associated solar wind pressure.*

Keywords: *Forbush decreases, H-CMEs and Solar Wind disturbances.*

1. INTRODUCTION

Forbush decreases (Fds) is a transient and rapid decreases in the observed cosmic rays intensity followed by a gradual recovery typically lasting several days [1, 4]. These decreases are most likely produced by perturbations in the interplanetary magnetic field and particle flow which propagate away from the Sun [2,3] and are strongly related to coronal mass ejections and their interplanetary counter parts [5,6,7,8,11,12]. Badruddin [10] has reported that abrupt onset of decreases 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 Fds than non-turbulent shocks. He reported that H-CMEs are more effective transient modulator of cosmic ray intensity than other CMEs and produces significant Fds. It has been proved by the recent studies of Forbush decreases with coronal mass ejections that the decreases are strongly associated with CMEs. The role of CMEs and their near-earth counter parts in causing Forbush decreases at the earth has been well documented by H.V. Cane [8]. Cane et al [5] have studied Forbush decreases for 30 years period with coronal mass ejection and found that 86% FDs are associated with CMEs and interplanetary shocks that they generate. Fast CMEs often propagate through the solar wind at super-Alfvenic speeds, driving shocks ahead of them. The shocks driven by CMEs are frequently responsible for driving Forbush decreases in cosmic ray intensity [8, 9, 13, 14]. Subhrmanayam et al [15] have inferred that Fds are associated with front side halo coronal mass ejections (CMEs) and near-Earth magnetic clouds. The associated Forbush decreases are expected to have significant contributions from the cosmic ray depressions inside the CMEs/ejecta. The Forbush decreases in cosmic ray intensity have also been studied by several scientists and have inferred that the measure cause of these decreases (Fds) are coronal mass ejections and their interplanetary manifestations [6, 7]. Belov et al [9] have studied Forbush decreases with interplanetary disturbances. They have concluded that magnitude of FDs is directly proportional to Hm and Vm, where Hm maximum disturbance value for the interplanetary magnetic field strength and Vm is maximum solar wind velocity. P. L. Verma et al [16] have studied Forbush Decreases with associated solar wind disturbances and co-relate magnitude of Forbush decreases with peak value of solar wind plasma parameters. They have concluded that magnitude of Forbush decreases depends upon the peak values of disturbances in solar wind parameters. Brijesh Singh and P. L. Verma [17] have been studied Forbush decreases to be associated with halo and partial halo coronal mass ejections and it is also concluded that disturbances in solar wind temperature and velocity are closely related to Forbush decreases.

In this investigation an attempt has been made to determine the role of H-CMEs in producing Forbush decrease and to co-relate the magnitude of FDs with peak values of associated solar wind disturbances parameters.

2. EXPERIMENTAL DATA

In this investigation hourly count rate of cosmic ray, recorded by Oulu neutron monitor over the period 2003-2014 has been used to determine Forbush decreases (FDs). The Oulu Neutron Monitor (NM) is situated in Northern Finland (65.05°N, 25.47°E). The local vertical geomagnetic cut off rigidityis about 0.8GV and the neutron monitor in Oulu is one of the most stable and reliable stations of the world neutron monitor Network. In this work we have selected only those FDs, which have decreased greater than 3.0% (odd magnitude). The hourly data of solar wind temperature, density, velocity and pressure have been used over the period 2003-2014 to determine peak values of solar wind temperature, density, velocity and pressure. These data have been taken from the NSSDC omeni web system. The data of CMEs have been taken fromSOHO, LASCO, CME catalogue, which consists all CMEs manually, identified since 1996 from large angle and spectrometric coronagraph (LASCO) on board the solar and heliospheric observatory mission (SOHO).

Table – 1

Association of H-CMEs and X-class Solar Flare related Forbush decreases with peak value of parameters of Solar Wind disturbances.

FORBUSH DECREASES			CMEs		SOLAR FLARE		TEMPERATURE		DENSITY		VELOCITY		PRESSURE	
Date	Onset set time dd(hh)	Magnitude %	Date time dd(hh)	Type	Date time dd(hh)	Class	Start time dd(hh)	Peak value of Temperature in ⁰K	Start time dd(hh)	Peak value of density in n/cc	Start time dd(hh)	Peak value of velocity in km/s	Start time dd(hh)	Peak value of pressure in npa
29.05.03	29(12)	9.5	28(01)	H	28(00)	X-36	29(18)	447719	29(08)	54.4	29(07)	799	29(05)	76.05
17.01.05	17(11)	17.5	15(23)	H	15(22)	X-26	17(06)	1395296	17(04)	55.7	17(07)	798	17(10)	58.22
06.08.05	06(03)	3.4	30(07)	H	30(06)	X-13	06(14	542186	05(20)	8.1	06(14)	726	06(05)	3.88
14.12.06	14(13)	9	13(03)	H	13(02)	X-34	14(10)	1527913	14(11)	15.5	14(10)	955	14(11)	23.84
26.09.11	26(11)	5.5	24(13)	H	24(09)	X-19	26(10)	1007504	26(05)	30.7	26(10)	704	26(11)	15.89
08.03.12	08(11)	11.5	07(00)	H	07(00)	X-54	08(10)	1551472	08(08)	16.9	08(09)	708	08(08)	16.25
28.02.14	28(11)	3.5	25(01)	H	25(01)	X-49	28(01)	200911	28(15)	8.5	28(09)	483	27(09)	11.99
12.09.14	12(16)	5.5	10(18)	H	10(17)	X-16	12(13)	786006	12(15)	21.2	12(14)	726	12(15)	17.15

3. ANALYSIS AND RESULTS

The statistical analysis we have considered only H-CMEs and X-class solar flare related Forbush decreases (Fds) odd magnitude ≥ 3%. We have found only 08 H-CMEs and X-class solar flare related Forbush decreases (Fds) during the period 2003-2014. All Forbush decreases are associated with parameters of solar wind disturbances i.e. temperature, density, velocity and pressure. From the study of Forbush decreases with parameters of solar wind disturbances i.e. solar wind temperature, solar wind density, solar wind velocity and solar wind pressure, it is inferred that Forbush decreases of higher magnitudes are found to be associated with peak value of considered parameters of solar wind disturbances. We have determined positive correlation between magnitude of Forbush decreases and peak values of associated parameters of solar wind disturbances with co-relation co-efficient 0.67 between magnitude of Forbush decreases and peak values of associated solar wind temperature, 0.69 between magnitude of Forbush decreases and peak values of associated solar wind density, 0.47 between magnitude of Forbush decreases and peak values of associated solar wind velocity, 0.66 between magnitude of Forbush decreases and peak values of associated solar wind pressure.

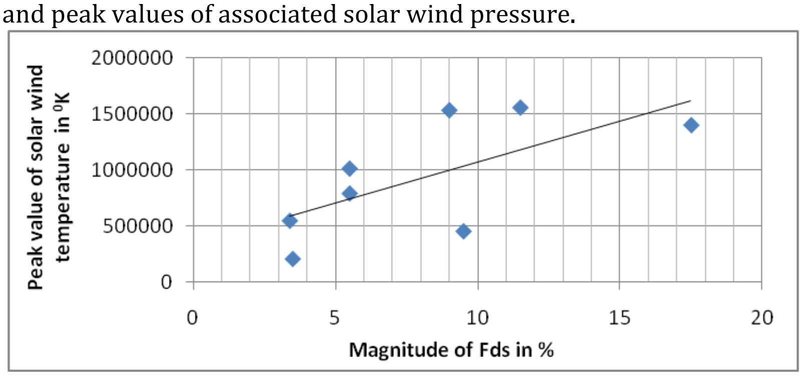

Figure1. Shows the scatter plot between magnitudes of Forbush decreases and peak values of solar wind temperature, showing positive correlation with correlation coefficient 0.67.

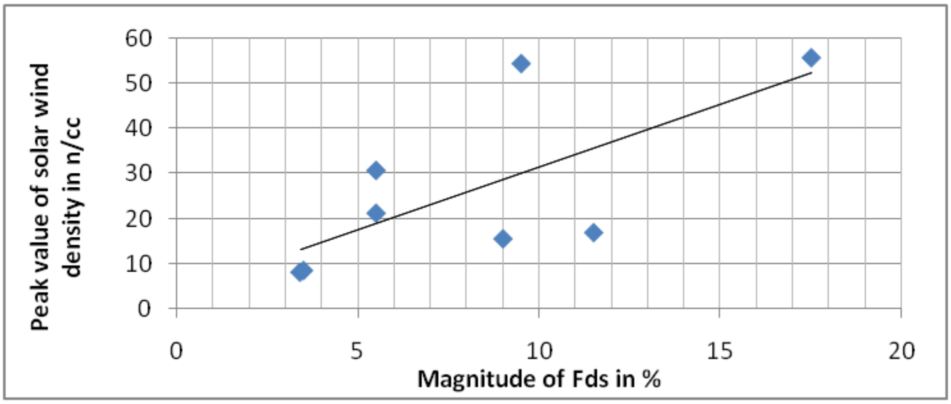

Figure 2. Shows the scatter plot between magnitudes of Forbush decreases and peak values of solar wind density, showing positive correlation with correlation coefficient 0.69.

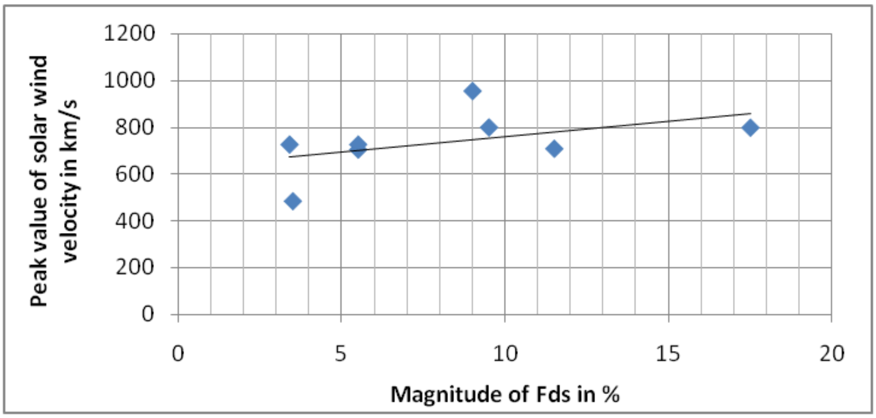

Figure 3. Shows the scatter plot between magnitudes of Forbush decreases and peak values of solar wind velocity, showing positive correlation with correlation coefficient 0.47.

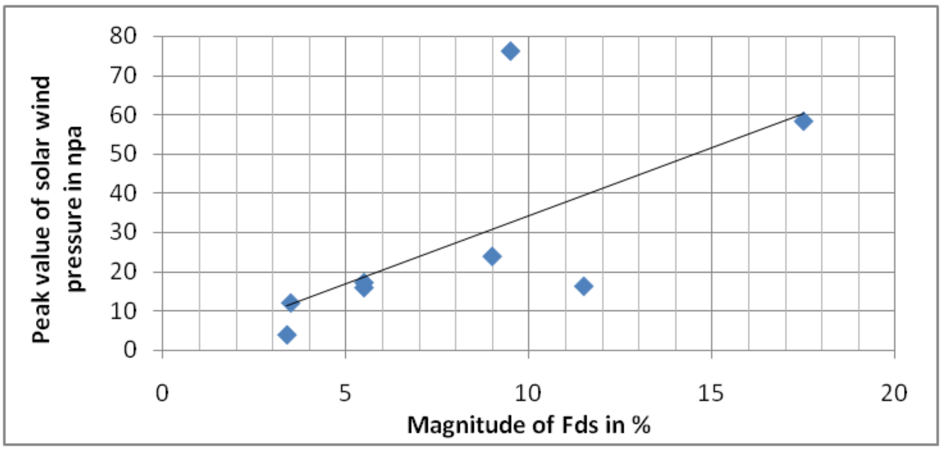

Figure 4. Shows the scatter plot between magnitudes of Forbush decreases and peak values of solar wind pressure, showing positive correlation with correlation coefficient 0.66.

4. CONCLUSION

In present study, we have considered only H-CMEs and X-class solar flare related Forbush decreases (Fds) odd magnitude ≥ 3%. All Forbush decreases are associated with parameters of solar wind temperature, density, velocity and pressure. We have concluded that H-CMEs are the most important events in which large amount of solar plasma materials are expelled from the solar corona into interplanetary space which are responsible to generate storms in parameters of solar wind disturbances and Forbush decreases in cosmic ray intensity. The positive correlation between magnitude of Forbush decreases and peak values of solar wind temperature, density, velocity and pressure suggests that magnitude of Forbush decreases depends upon the peak values of disturbances in solar wind parameters.

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