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Comparative Study Of Symmetric And Asymmetric Forbush Decreases With Disturbances In Solar Wind Parameters

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Abstract
In this manuscript we have to consider those symmetric cosmic ray decreases which have magnitude≥ 3% and those asymmetric cosmic ray intensity decreases which have magnitude ≥ 4.0% for the time span of 17 years from 1997-2013. For this time span we have identified 47 and 74 symmetric and asymmetric cosmic ray intensity decreases respectively. In this manuscript we have presented the correlation between symmetric and asymmetric cosmic ray intensity decreases (Fds) with some solar wind plasma parameters like plasma density and velocity. Out of 47 symmetric cosmic ray decreases, 41 (87.23 %) symmetric cosmic ray intensity decreases have been found to be associated with jump in solar wind plasma density (JSWD) events and 37 (78.72%) have been found to be associated with jump in solar wind plasma velocity (JSWV) events. Magnitude of symmetric cosmic ray intensity decreases are negatively correlated with magnitude of jump in solar wind plasma density and magnitude of jump in solar wind plasma velocity with co-relation co-efficient - 0.15 and - 0.16 respectively. Out of 74 asymmetric cosmic ray decreases, 70 (94.59%) asymmetric cosmic ray intensity decreases have been found to be associated with jump in solar wind plasma density (JSWD) events and 67 (90.54%) have been found to be associated with jump in solar wind plasma velocity (JSWV) events. Again the magnitude of asymmetric cosmic ray intensity decreases are positively correlated with magnitude of jump in solar wind plasma density and magnitude of jump in solar wind plasma velocity with co-relation co-efficient 0.25 and 0.23 respectively.
Keywords: *- Fobrush decreases, Solar wind parameter, cosmic ray intensity.*

1- INTRODUCTION

Disturbances in solar wind plasma parameters such as proton speed, density and temperature, accompanied by highly fluctuating compressions of interplanetary magnetic field (IMF) cause short-term depressions in the galactic cosmic ray (CR) flux. Generally, these depressions are denoted as Forbush decreases (FDs), since they were first reported by Forbush (1937). Forbush decreases were related to solar activity by Simpson (1954). Depending on the nature and origin of the solar wind disturbances, they can be classified as interplanetary coronal mass ejections (ICMEs) and corotating interaction regions (CIRs). The ICMEs are the interplanetary counterparts of coronal mass ejections, i.e., powerful eruptions of coronal magneto plasma traveling through the heliosphere, whereas CIRs are related to the solar-wind high-speed streams originating in low latitude coronal holes.

By the studies we have shown that ICMEs produce sporadic strongly asymmetric depressions, while CIRs produce recurrent, more symmetric and relatively shallow depressions (for a comprehensive overview of short-term depressions in the CR count see Lockwood 1971 Cane 2000;Richardson2004). From the observational point of view, the influence of ICMEs and CIRs on CR modulation was previously investigated through a

number of studies employing the superposed epoch analysis (e.g. Iucci et al. 1979; Badurddin et al.1986; Badurddin 1996; Singh & Badurddin 2007), statistical analysis (e.g. Cane et al. 1996; Richardson et al.1996; Belov et al.2001, Calogovi'c et al 2009; Chilingarian & Bostanjyan 2010) and case-studies (e.g. Jamsen et al. 2007). The results were frequently mutually conflicting, and consequently did not provide a clear empirical background.

In this study we have identified symmetric and asymmetric cosmic ray intensity decreases, i.e. forbush decreases for the period 1997-2013 in association of solar wind plasma parameters.

Data Collection

For this study data of symmetric and asymmetric cosmic ray intensity decreases i.e. forbush decreases of magnitude ≥3% and ≥4%, have been taken from Oulu super neutron monitor for the prescribed time. Data of disturbances in solar wind plasma parameters, hourly data of solar wind plasma velocity and density has been used, these data has been taken from omni web data.

Table-1:- Symmetric forbush decreases and solar wind plasma parameters.

		Symmetric Cosmic ray intensity decreases		Jump in Density		Jump in Velocity	
S.NO.	Date	Onset set time dd (hh)	mag%	Start time dd(hh)	Magnitude of Jumpn/cc	Start time dd(hh)	Magnitude of Jumpkm/s
1	06.10.97	06(08)	3	10(05)	4.8	na	na
2	17.11.97	17(12)	6	16(04)	8	16(11)	46
3	09.12.97	9(12)	3	na	na	na	na
4	06.01.98	6(00)	3	06(13)	19.1	06(12)	114
5	05.06.98	05(18)	5	04(22)	13.4	05(12)	41
6	23.10.98	23(12)	4	23(01)	7.5	23(04)	107
7	11.12.98	11(12)	4	10(15)	18.1	10(14)	39
8	05.05.99	5(12)	4	15(02)	16.6	15(14)	113
9	22.05.99	22(18)	4	na	na	na	na
10	12.09.99	12(02)	3	12(03)	31.4	12(02)	204
11	22.03.00	22(06)	3	22(01)	52.8	22(01)	227
12	12.10.00	12(04)	4	11(05)	1.7	11(08)	40
13	23.01.01	23(06)	3	23(05)	13.8	22(07)	80
14	22.07.01	22(18)	3	21(23)	2.5	22(12)	37
15	03.12.01	03(20)	3.5	03(05)	3.4	03(05)	46
16	27.01.02	27(18)	4	na	na	na	na
17	09.04.02	9(12)	4	09(08)	20.1	na	na
18	01.11.02	01(18)	4	01(09)	7.3	01(10)	68
19	09.01.03	9(18)	3	09(12)	13.1	09(08)	135
20	07.04.03	07(12)	4	07(04)	33.2	na	na
21	02.04.04	2(18)	3	na	na	na	na
22	05.08.05	5(12)	3	na	na	na	na
23	09.07.06	9(18)	3	09(15)	13.8	09(16)	99
24	09.11.06	9(12)	3	09(07)	31.3	09(11)	229
25	17.05.07	17(12)	3	17(15)	24	17(14)	309
26	05.01.08	5(00)	4	04(06)	33.5	04(19)	363
27	08.02.08	8(12)	3	08(22)	18.8	09(02)	379
28	14.06.08	14(18)	4	14(03)	33.7	14(12)	375
29	06.11.08	6(21)	3	06(08)	21.3	06(13)	287
30	22.12.08	22(12)	3	21(06)	21.3	21(23)	268
31	20.01.10	20(06)	3	20(11)	27.1	20(07)	215
32	14.09.10	14(18)	3	14(03)	6.2	14(02)	106

33	12.12.10	12(18)	5	11(20)	15.7	12(12)	342
34	11.04.11	11(6)	3	10(13)	49.9	11(06)	276
35	10.06.11	10(06)	3	10(06)	12.8	09(20)	81
36	16.06.11	16(12)	5	16(14)	5.1	16(06)	118
37	23.06.11	23(00)	4	22(03)	4.7	22(06)	249
38	05.08.11	5(06)	6	05(16)	25.9	05(05)	211
39	16.09.11	16(12)	3	16(19)	28.4	16(03)	185
40	21.11.11	21(00)	3	10(19)	21.8	11(19)	162
41	22.01.12	22(18)	4	22(22)	39.1	21(19)	138
42	13.02.12	13(12)	4	12(14)	22.3	na	na
43	18.01.13	18(00)	4	18(00)	30.2	18(00)	197
44	16.02.13	16(18)	3	16(00)	9.8	16(11)	84
45	24.04.13	24(18)	3	23(23)	30.5	23(19)	261
46	24.05.13	24(06)	3	24(12)	11.6	24(19)	355
47	25.06.13	25(00)	3	na	na	na	na

Table-2:- Asymmetric forbush decreases and solar wind plasma parameters.

		Symmetric Cosmic ray intensity decreases		Jump in Density		Jump in Velocity	
S.NO.	Date	Onset set time dd (hh)	mag%	Start time dd(hh)	Magnitude of Jumpn/cc	Start time dd(hh)	Magnitude of Jumpkm/s
1	10.04.97	10(18)	5	09(19)	23.8	10(13)	244
2	01.05.98	01(20)	6	01(19)	9.6	01(10)	255
3	04.07.98	04(16)	3	04(10)	9.7	04(13)	248
4	25.08.98	25(12)	8	25(19)	6.4	25(23)	466
5	24.09.98	24(12)	10	24(05)	8.4	24(23)	387
6	08.11.98	08(04)	7	08(02)	20.3	08(01)	172
7	22.01.99	22(20)	7	23(06)	13.1	22(12)	211
8	12.12.99	12(16)	8	12(14)	10.2	12(15)	332
9	11.01.00	11(12)	6	11(05)	8.3	11(12)	193
10	07.04.00	07(00)	3	06(12)	26.6	06(15)	221
11	08.06.00	08(08)	8	08(08)	15.8	08(08)	253
12	15.07.00	15(12)	12	14(14)	24.3	14(12)	209
13	14.09.00	14(20)	3	15(17)	10.3	15(01)	90
14	17.09.00	17(12)	8	17(13)	28.9	17(15)	298
15	28.10.00	28(00)	7	na	na	na	na
16	06.11.00	06(16)	7	06(07)	15.7	06(07)	41
17	26.11.00	26(12)	8	26(11)	29.3	26(03)	252
18	03.03.01	3(18)	3	04(01)	4.04	03(10)	69
19	19.03.01	19(03)	4	18(17)	6.7	19(08)	169
20	26.03.01	26(06)	6	na	na	na	na
21	04.04.01	04(16)	8	04(14)	3.2	04(14)	282
22	07.04.01	07(12)	6	06(12)	6.7	na	na
23	11.04.01	11(16)	8.5	11(10)	23	11(12)	233
24	28.04.01	28(04)	6	28(00)	7.3	27(22)	297
25	27.05.01	27(12)	4	26(18)	3.8	26(18)	194
26	17.08.01	17(16)	7	17(10)	23.4	17(09)	264
27	27.08.01	27(18)	7	27(09)	6.1	27(07)	34
28	25.09.01	25(20)	8	25(20)	35.8	25(20)	274
29	11.10.01	11(16)	6	11(11)	21.8	11(16)	198
30	21.10.01	21(16)	5	21(13)	16.4	21(10)	360
31	06.11.01	06(00)	12	05(09)	31.4	05(14)	141

32	24.11.01	24(12)	10	24(02)	40	24(03)	504
33	15.12.01	15(00)	5	15(19)	21.4	14(19)	69
34	30.12.01	30(16)	5.5	na	na	na	na
35	10.01.02	10(16)	4.5	09(23)	8.5	10(01)	289
36	23.05.02	23(12)	5	22(15)	13.7	23(03)	468
37	10.11.02	10(02)	7	09(11)	37	01(15)	50
38	17.11.02	17(00)	8	16(23)	2.9	16(23)	52
39	22.12.02	22(12)	4	22(08)	23.3	22(10)	59
40	01.02.03	01(16)	5	01(15)	20.1	01(06)	393
41	29.05.03	29(16)	7	29(14)	24.2	29(14)	103
42	29.10.03	29(00)	25	28(01)	na	na	na
43	07.01.04	07(00)	8	06(15)	3.1	06(18)	155
44	21.01.04	21(16)	8	21(23)	13.1	21(16)	163
45	26.07.04	26(16)	10	26(17)	1.5	26(15)	417
46	07.11.04	07(08)	12	7(03)	54.1	07(09)	386
47	08.05.05	08(06)	6	07(10)	39.2	07(17)	215
48	15.05.05	15(00)	7	14(19)	16.2	14(20)	557
49	28.05.05	28(20)	10	28(04)	50	28(04)	188
50	23.08.05	23(20)	7	24(00)	23.1	24(00)	308
51	11.09.05	11(00)	12	10(22)	22.5	10(20)	346
52	14.12.06	14(18)	10	13(03)	9.3	13(06)	312
53	21.05.07	21(03)	3	22(00)	15.9	22(17)	279
54	08.03.08	8(000	3	(06(04)	28.2	07(21)	389
55	05.04.10	05(12)	4	5(07)	6.5	5(06)	299
56	03.08.10	03(12)	5	03(16)	11.6	3(15)	181
57	18.02.11	18(00)	4.5	18(00)	36.1	18(00)	197
58	05.04.11	05(06)	4.5	05(00)	12.2	05(00)	122
59	23.06.11	23(00)	4	23(10)	6	23(08)	236
60	10.07.11	10(12)	4	10(18)	8.2	10(19)	266
61	05.08.11	05(06)	5	05(11)	26.3	04(13)	271
62	25.09.11	25(12)	6	25(06)	27	25(05)	381
63	24.10.11	24(18)	6	23(11)	25	23(17)	224
64	01.11.11	01(00)	3	31(09)	11.5	na	na
65	24.01.12	24(06)	5	24(09)	5.8	24(10)	289
66	07.03.12	07(06)	7	06(20)	19.3	07(02)	344
67	05.04.12	05(18)	4	03(05)	17.6	na	na
68	16.06.12	16(06)	5	16(09)	51.1	16(03)	222
69	14.07.12	14(18)	7	14(05)	16.2	14(08)	357
70	03.09.12	03(12)	6	03(01)	19.1	03(04)	243
71	13.11.12	13(00)	3	12(11)	27.1	12(12)	170
72	14.03.13	14(00)	8	14(11)	17	14(13)	415
73	13.04.13	13(18)	5.5	13(21)	15.9	13(22)	148
74	23.06.13	23(12)	4	na	na	21(15)	248

2- RESULT AND DISCUSSION

The data of symmetric cosmic ray intensity decreases and associated solar wind plasma parameters (density, velocity) are listed in table-1. From the data analysis, we have found 47 symmetric forbush decreases during the period1997-2013. Out of these 47 events 41 (87.23 %) symmetric forbush decreases have been found to be associated with jump in solar wind plasma density (JSWD) events and 37 (78.72%) have been found to be associated with jump in solar wind plasma velocity (JSWV) events. We use the statistical method to find the correlation between these two parameters. The statistically calculated correlation coeficient between the magnitude of

symmetric forbush decreases with the magnitude of solar wind plasma density and velocity is - 0.15 and - 0.16 (Fig.-1 & 2). It may be inferred that there is a negative correlation between these parameters which means that the symmetric forbush decreases are not well correlated with plasma parameters.

Further the data of asymmetric cosmic ray intensity decreases and associated solar wind plasma parameters (density, velocity) are listed in table-2. From the data analysis, we have found 74 asymmetric forbush decreases during the period1997-2013. Out of these 74 events 70 (94.59%) asymmetric forbush decreases have been found to be associated with jump in solar wind plasma density (JSWD) events and 67 (90.54%) have been found to be associated with jump in solar wind plasma velocity (JSWV) events.

To know the statistical behavior of asymmetric forbush decreases with magnitude of solar wind plasma density we have plotted a scatter diagram between magnitude asymmetric forbush decreases (Fds) and magnitude of associated JSWD and the resulting plot is shown in Figure 3. From the figure it may be inferred that there is positive correlation between magnitude of asymmetric forbush decreases (Fds) and magnitude of JSWD events. Statistically calculated co-relation co-efficient is 0.25 between these two events.

Again from the analysis the trend line of the scatter plot shown in figure-4, it may be inferred that there is positive correlation between magnitude of asymmetric forbush decreases (Fds) and magnitude of JSWV events. Statistically calculated co-relation co-efficient is 0.23 between these two events.

By the analysis we have inferred that asymmetric forbush decreases are well correlated with solar wind parameters as compared with symmetric forbush decreases.

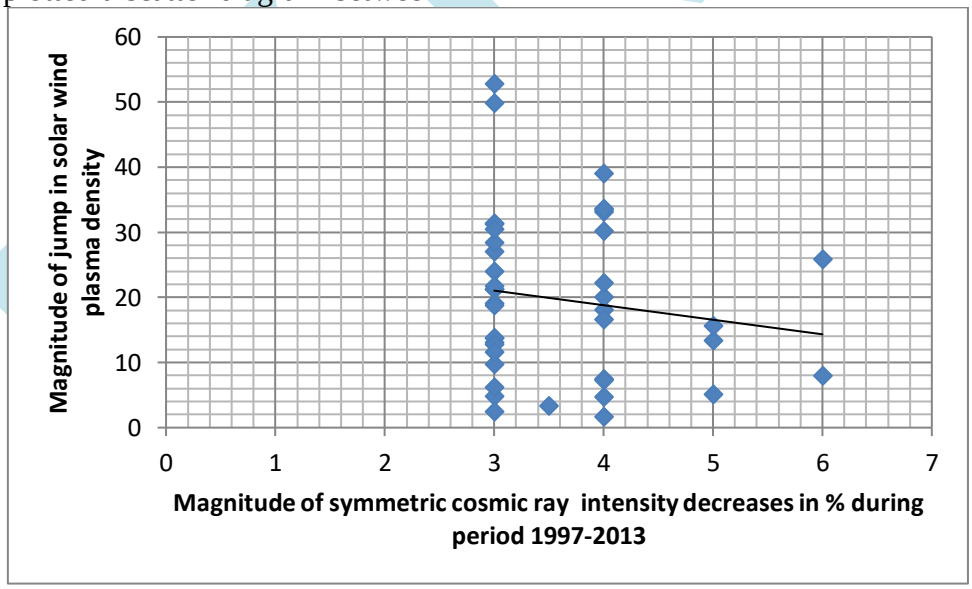

Figure1 -Shows scatter plot between magnitude of symmetric forbush decreases and magnitude of jump in solar wind plasma density showing negative correlation with correlation coefficient -0.15.

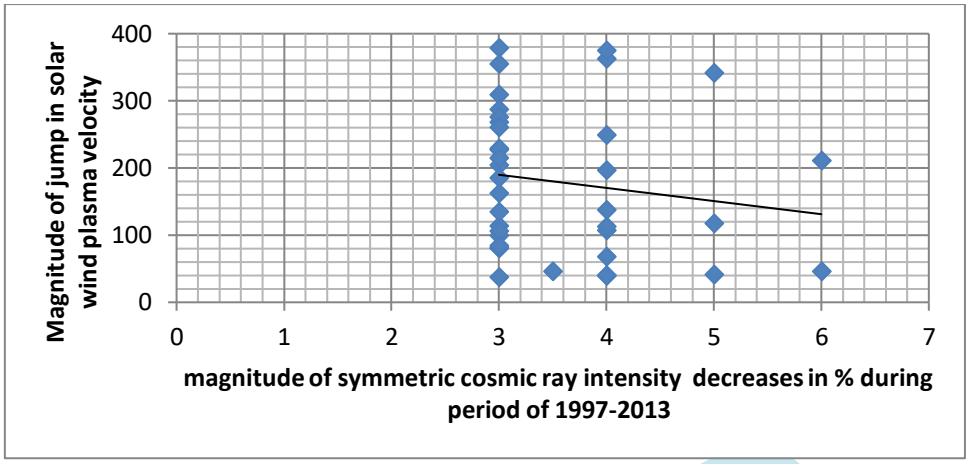

Figure2 -Shows scatter plot between magnitude of symmetric forbush decreases and magnitude of jump in solar wind plasma velocity showing negative correlation with correlation coefficient -0.16.

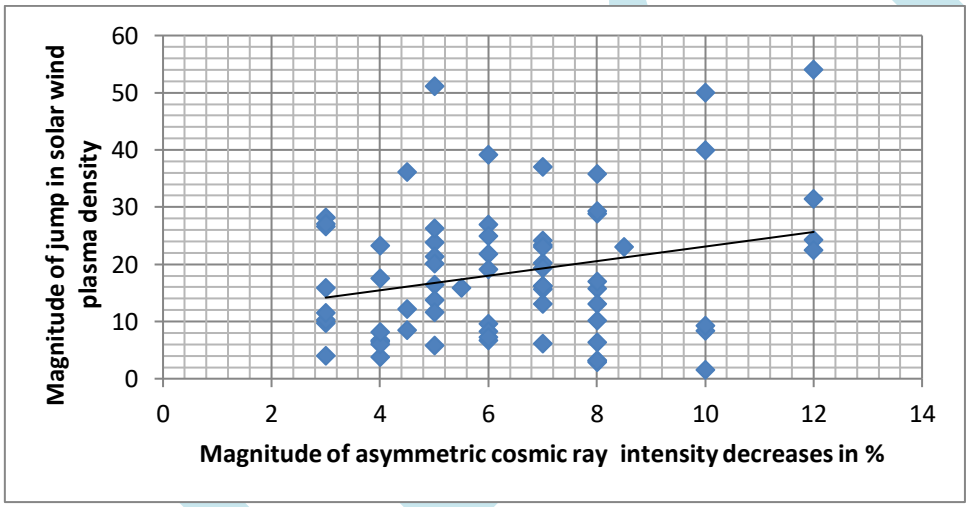

Figure3-Shows scatter plot between magnitude of asymmetric forbush decreases (Fds) and magnitude of associated JSWD events showing positive correlation with correlation coefficient 0.25.

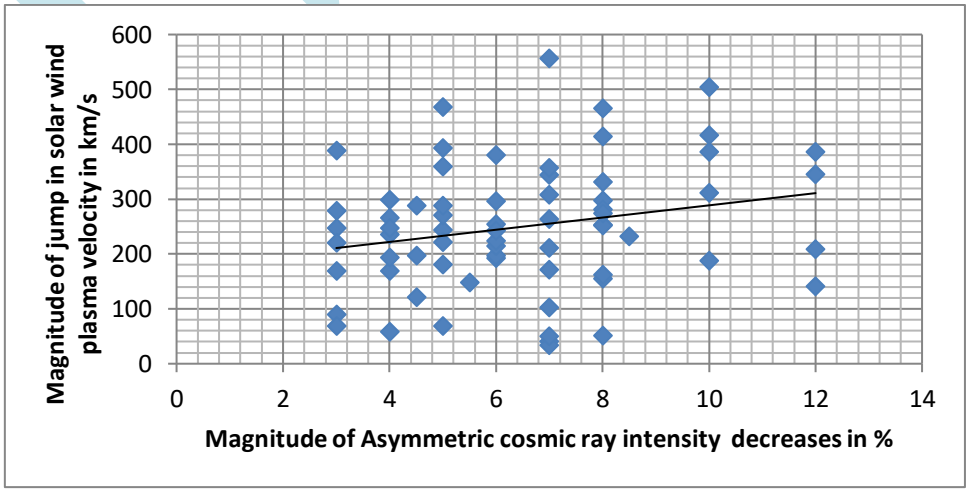

Figure4 Shows scatter plot between magnitude of asymmetric forbush decreases (Fds) and magnitude of associated JSWV events showing positive correlation with correlation coefficient 0.23.

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