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Statistical Study Of Asymmetric Cosmic Ray Intensity Decreases With Interplanetary Magnetic Field And Solar Wind Plasma Parameters

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Abstract
For this study we have to consider asymmetric cosmic ray intensity decreases during 1997 to 2013. We have observed 74 asymmetric cosmic ray intensity decreases for this duration, out of which 87.83% are associated with jump in interplanetary magnetic field (JIMF). Further we inferred that out of 74, 94.59% asymmetric cosmic intensity decreases are associated with solar wind plasma parameters (density and pressure). From the analysis we have found that the magnitude of asymmetric cosmic ray intensity decreases is correlated with peak value of JIMF and magnitude of JIMF events with correlation coefficients 0.30 and 0.32 respectively. Further magnitude of asymmetric cosmic ray intensity decreases also correlated with jump in solar wind plasma density (JSWD) events and jump in solar wind plasma pressure (JSWP) events, correlation coefficient of magnitude of asymmetric cosmic ray intensity decreases with peak value and magnitude of JSWD events is 0.28 and 0.25. Correlation coefficient of magnitude of asymmetric cosmic ray intensity decreases with peak value and magnitude of JSWP events is 0.45 and 0.43.
Keywords: *- Interplanetary magnetic field, solar wind plasma parameters, cosmic ray intensity decreases.*

1- INTRODUCTION

Decreases in the cosmic ray count rate which last typically for about a week, were first observed by Forbush (1937) and Hess and Demmelmair (1937) using ionization chambers. It was the early 1950s work of Simpson using neutron monitors (Simpson, 1954) which showed that the origin of these decreases was in the interplanetary medium. There are two basic types. 'Non-recurrent decreases' are caused by transient interplanetary events which are related to mass ejections from the Sun. They have a sudden onset, reach maximum depression within about a day and have a more gradual recovery. 'Recurrent decreases' (Lockwood, 1971) have a more gradual onset, are more symmetric in profile, and are well associated with corotating high speed solar wind streams (*e.g.*, Iucci *et al.*, 1979a). Historically, all short term decreases have been called 'Forbush decreases'. However, some researchers use the name more selectively to apply to only those with a sudden onset and a gradual recovery, it i.e., the non-recurrent events associated with transient solar wind disturbances.

Disturbances in solar wind (SW) 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). Depending on the nature and origin of the solar wind disturbances (SWDs), 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. Because the pattern of the SW and IMF disturbances is different for these two phenomena.

2- DATA ANALYSIS

In this work hourly data of oulu super neutron monitor are used to determine asymmetric cosmic ray intensity decreases in cosmic ray intensity. The data of interplanetary shocks are taken from shocks arrival derived by WIND group from WIND observations, ACE list of transient and disturbances.). To determine disturbances in solar wind plasma parameters, hourly data of solar wind plasma density and pressure has been used and these data has been taken from omni web data also.

Table- Asymmetric cosmic ray intensity decreases associated interplanetary magnetic field and solar wind plasma parameters.

S. No.	Date	Asymmetric cosmic ray intensity decreases		Jump in interplanetary magnetic field			Jump in solar wind density			Jump in solar wind pressure		
		Onset set time dd (hh)	mag %	Start time	Maximum Jump Value in nT	Magnitude of Jump nT	Start time dd (hh)	Maximum Jump Value n/cc	Magnitude of Jump n/cc	Sart time	Maximum Jump Value in nPa	Magnitude of Jump nPa
1	10.04.97	10(18)	5	10(0)	6.5	3	09(19)	33.8	23.8	10(14)	na	na
2	01.05.98	01(20)	6	2(09)	14.4	9	01(19)	15.3	9.6	2(0)	6.39	4.84
3	04.07.98	04(16)	3	4(19)	13.4	9	04(10)	11.3	9.7	4(13)	3.84	2.87
4	25.08.98	25(12)	8	26(00)	16.2	10.2	25(19)	9.5	6.4	25(22)	6.46	5.46
5	24.09.98	24(12)	10	24(07)	28.6	20.9	24(05)	12	8.4	24(15)	8.06	6.42
6	08.11.98	08(04)	7	8(00)	36.2	20.6	08(02)	22.6	20.3	8(08)	12.9	7.38
7	22.01.99	22(20)	7	22(11)	19	10.8	23(06)	14.4	13.1	22(19)	3.61	20.11
8	12.12.99	12(16)	8	12(11)	14.5	10	12(14)	10.6	10.2	12(15)	5.48	5.27
9	11.01.00	11(12)	6	11(11)	19.1	8.4	11(05)	16.6	8.3	11(05)	7.52	4.52
10	07.04.00	07(00)	3	6(16)	31.4	15.4	06(12)	29.6	26.6	6(16)	20	18.34
11	08.06.00	08(08)	8	8(07)	24.9	18.1	08(08)	19.2	15.8	8(08)	20.07	18.29
12	15.07.00	15(12)	12	14(14)	15.5	10	14(14)	26.6	24.3	14(14)	32.53	30.98
13	14.09.00	14(20)	3	16(00)	10.4	7.1	15(17)	19.1	10.3	15(03)	5.83	4.49
14	17.09.00	17(12)	8	17(14)	30	24.6	17(13)	32.4	28.9	17(14)	25.31	21.67
15	28.10.00	28(00)	7	na	na	na	na	na	na		na	na
16	06.11.00	06(16)	7	6(09)	24.5	18.9	06(07)	17.6	15.7	6(17)	12.28	8.82
17	26.11.00	26(12)	8	26(08)	28.7	25.2	26(11)	35.4	29.3	26(11)	23.41	20.86
18	03.03.01	3(18)	3	3(08)	8.5	4.5	04(01)	11.4	4.04	3(10)	3.57	2.15
19	19.03.01	19(03)	4	19(09)	18.3	17.3	18(17)	12	6.7	19(06)	10.21	8.28
20	26.03.01	26(06)	6	na	na	na	na	na	na	na	na	na
21	04.04.01	04(16)	8	4(14)	16.8	9.4	04(14)	6.8	3.2	4(14)	5.66	3.67
22	07.04.01	07(12)	6	7(16)	14.8	10.1	06(12)	10.3	6.7	7(16)	4.33	3.04
23	11.04.01	11(16)	8.5	11(12)	32.3	27.3	11(10)	24.7	23	11(12)	24.54	23.54
24	28.04.01	28(04)	6	28(04)	18.9	13.2	28(00)	9.1	7.3	28(4)	9.07	8.28
25	27.05.01	27(12)	4		na	na	26(18)	10.2	3.8		na	na
26	17.08.01	17(16)	7	17(10)	32.1	27.3	17(10)	28.1	23.4	17(10)	22.75	21
27	27.08.01	27(18)	7	27(18)	19	12.5	27(09)	13.1	6.1	27(16)	7.6	5.6
28	25.09.01	25(20)	8	25(20)	24.7	19.3	25(20)	44.8	35.8	25(20)	42	40
29	11.10.01	11(16)	6	11(15)	26.5	18.7	11(11)	25	21.8	11(21)	22.13	14.77

30	21.10.01	21(16)	5	21(16)	28.4	22	21(13)	22.2	16.4	21(15)	29.48	27.66
31	06.11.01	06(00)	12	5(10)	16.1	7	05(09)	46.1	31.4	5(11)	13.67	7.12
32	24.11.01	24(12)	10	24(05)	50.1	45.1	24(02)	49.3	40	24(4)	79.5	78.5
33	15.12.01	15(00)	5	15(10)	24.8	14.7	15(19)	31.8	21.4	15(11)	11.23	5.88
34	30.12.01	30(16)	5.5	na	na	na	na	na	na	na	na	na
35	10.01.02	10(16)	4.5	10(08)	18.5	8.9	09(23)	13.1	8.5	10(14)	8.42	5.55
36	23.05.02	23(12)	5	23(03)	34.8	25.2	22(15)	21	13.7	23(10)	11	10
37	10.11.02	10(02)	7	10(6)	15.7	8	09(11)	42	37	10(01)	12.22	6
38	17.11.02	17(00)	8	17(14)	10.3	2	16(23)	8.8	2.9	na	na	na
39	22.12.02	22(12)	4	22(08)	20.3	12	22(08)	35.5	23.3	22(08)	17	16
40	01.02.03	01(16)	5	01(11)	12.2	3	01(15)	17.2	20.1	1(21)	10.8	9
41	29.05.03	29(16)	7	29(12)	23	20	29(14)	50.3	24.2	29(14)	76	75
42	29.10.03	29(00)	25	nd	nd	nd	28(01)	na	na	nd	nd	nd
43	07.01.04	07(00)	8	6(19)	16.6	9	06(15)	5.6	3.1	na	na	na
44	21.01.04	21(16)	8	22(0)	19.2	14	21(23)	18.3	13.1	22(0)	16.23	15
45	26.07.04	26(16)	10	26(22)	26.1	23	26(17)	13.9	1.5	26(21)	30	29
46	07.11.04	07(08)	12	7(09)	45.8	40	7(03)	75.1	54.1	7(17)	47.5	40
47	08.05.05	08(06)	6	7(07)	15.9	9	07(10)	15	39.2	07(10)	15	10
48	15.05.05	15(00)	7	15(01)	54.8	45	14(19)	18.9	16.2	15(01)	35.8	34
49	28.05.05	28(20)	10	28(09)	12.6	7	28(04)	56	50	28(04)	11	10
50	23.08.05	23(20)	7	25(0)	55	50	24(00)	56.2	23.1	25(0)	41	40
51	11.09.05	11(00)	12	11(0)	18.4	13	10(22)	25	22.5	11(01)	41	39
52	14.12.06	14(18)	10	na	na	na	13(03)	10	9.3	na		na
53	21.05.07	21(03)	3	21(18)	12	4	22(00)	18.1	15.9	21(12)	4	3
54	08.03.08	8(000	3	8(3)	12	10	(06(04)	31.2	28.2	8(0)	8	7
55	05.04.10	05(12)	4	5(07)	18.8	13.6	5(07)	12.2	6.5	5(07)	10.49	8.49
56	03.08.10	03(12)	5	3(16)	14.4	11.5	03(16)	11.7	11.6	3(15)	7.47	3.51
57	18.02.11	18(00)	4.5	18(00)	30.6	27	18(00)	40.6	36.1	18(00)	20	19
58	05.04.11	05(06)	4.5		na	na	05(00)	13.1	12.2	na	na	na
59	23.06.11	23(00)	4		na	na	23(10)	7.8	6	na	na	na
60	10.07.11	10(12)	4	10(0)	6	5	10(18)	11.7	8.2	10(0)	2.22	1
61	05.08.11	05(06)	5	5(7)	13	9	05(11)	29.3	26.3	5(00)	4.58	3
62	25.09.11	25(12)	6	25(20)	24	19	25(06)	30.7	27	25(20)	42	41
63	24.10.11	24(18)	6	24(16)	18	11	23(11)	29.5	25	24(18)	15	14
64	01.11.11	01(00)	3	1(08)	13	8	31(09)	20	11.5	na	na	
65	24.01.12	24(06)	5	24(04)	10.4	3	24(09)	8.9	5.8	24(02)	7	6
66	07.03.12	07(06)	7	7(03)	17	10	06(20)	24.5	19.3	7(03)	8.36	7
67	05.04.12	05(18)	4	5(010	9	2	03(05)	21	17.6	5(06)	2	1
68	16.06.12	16(06)	5	16(09)	30.8	22	16(09)	54.7	51.1	16(09)	29.47	28
69	14.07.12	14(18)	7	14(17)	19	16	14(05)	20.2	16.2	14(16)	18	17
70	03.09.12	03(12)	6	3(10)	16	11	03(01)	27.1	19.1	3(10)	10	9
71	13.11.12	13(00)	3	13(06)	22	11	12(11)	32.9	27.1	13(02)	11	5
72	14.03.13	14(00)	8	14(15)	10	5	14(11)	22.6	17	14(12)	4	3

73	13.04.13	13(18)	5.5	13(18)	12	8	13(21)	19.2	15.9	13(22)	10	9
74	23.06.13	23(12)	4	na	na	na	na	na	na	23(03)	4	3

3- RESULT AND DISCUSSION

From the data analysis of asymmetric cosmic ray intensity decreases and JIMF we have found out of 74, 65 asymmetric cosmic ray intensity decreases have been found to be associated with jump in interplanetary magnetic field (JIMF). To sees how the magnitude of asymmetric cosmic ray intensity decreases is correlated with JIMF events. We have plotted a scatter diagram between magnitude asymmetric cosmic ray intensity decreases and maximum jump value of associated JIMF events and the resulting plot is shown in Figure-1. From the figure it is inferred that, most of the asymmetric cosmic ray intensity decreases of higher magnitudes are associated with such JIMF events having higher peak value but these two events do not have any fixed proportion and vice versa. We have found the Positive co-relation with co-relation coefficient 0.30 between the magnitude of asymmetric cosmic ray intensity decreases and peak value of JIMF events.

To know the statistical behavior of asymmetric cosmic ray intensity decreases with magnitude of JIMF events we have plotted a scatter diagram between magnitude of asymmetric cosmic ray intensity decreases and magnitude of associated JIMF events and the resulting plot is shown in Figure-2. From the trend line of the scatter plot, it may be inferred that there is positive correlation between magnitude of asymmetric cosmic ray intensity decreases and magnitude of JIMF events. Statistically calculated co-relation co-efficient is 0.32 between these two events.

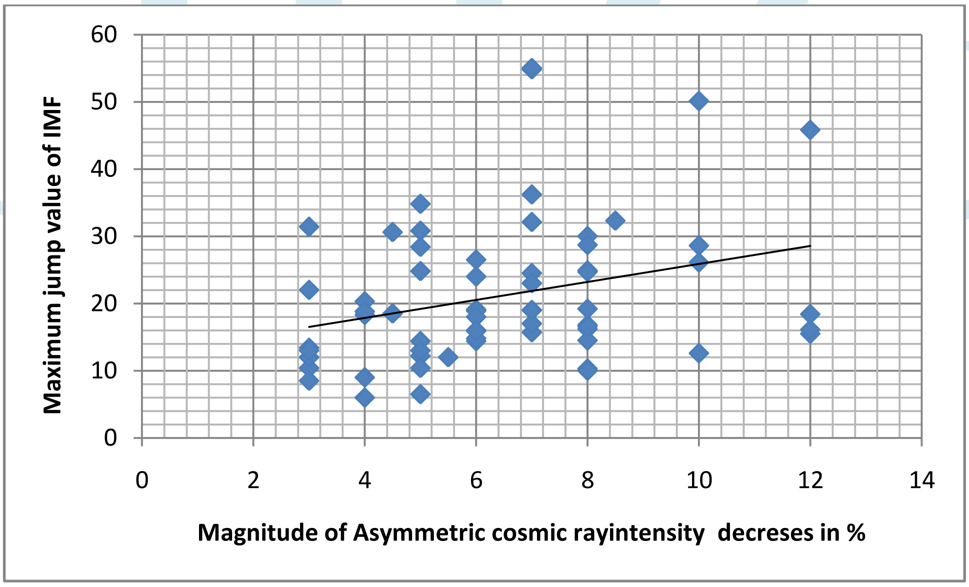

Figure-1 Scatter plot between magnitude of asymmetric cosmic ray intensity decreases and peak value of associated JIMF events. Showing positive correlation with correlation coefficient 0.30.

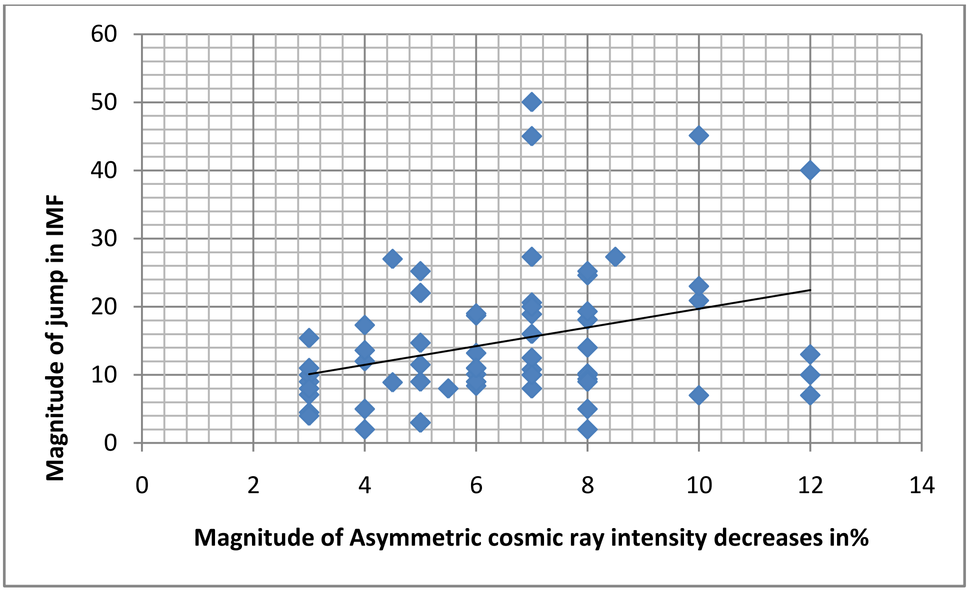

Figure-2 Scatter plot between magnitude of asymmetric cosmic ray intensity decreases and magnitude of associated JIMF events. Showing positive correlation with correlation coefficient 0.32.

From the data analysis given in table-1 it is observed that we have 74 asymmetric cosmic ray intensity decreases out of which 70 (94.59%) asymmetric cosmic ray intensity decreases have been found to be associated with jump in solar wind plasma density (JSWD) events and jump in solar wind plasma pressure (JSWP) events.

To know the statistical behavior of asymmetric cosmic ray intensity decreases with JSWD events we have plotted a scatter diagram between magnitude of asymmetric cosmic ray intensity decreases and maximum jump value of associated JSWD and the resulting plot is shown in Figure-3. We have found the Positive co-relation with co-relation coefficient 0.28 between the magnitude of asymmetric cosmic ray intensity decreases and peak value of JSWD events.

To know the statistical behavior of asymmetric cosmic ray intensity decreases with magnitude of JSWD events we have plotted a scatter diagram between magnitude of asymmetric cosmic ray intensity decreases and magnitude of associated JSWD events and the resulting plot is shown in Figure-4. We have found the Positive co-relation with co-relation coefficient 0.25 between the magnitude of asymmetric cosmic ray intensity decreases and magnitude of JSWD events.

To know the statistical behavior of asymmetric cosmic ray decreases with JSWP events we have plotted a scatter diagram between magnitude of asymmetric cosmic ray intensity decreases and maximum jump value of associated JSWP events and the resulting plot is shown in Figure-5. From the trend line of the scatter plot, it may be inferred that there is positive correlation between magnitude of asymmetric cosmic ray intensity decreases and peak value of JSWP events. Statistically calculated co-relation co-efficient is 0.45 between these two events.

To know the statistical behavior of asymmetric cosmic ray intensity decreases with magnitude of JSWP events we have plotted a scatter diagram between magnitude of asymmetric cosmic ray intensity decreases and magnitude of associated JSWP events and the resulting plot is shown in Figure-6. From the trend line of the scatter plot, it may be inferred that there is positive correlation between magnitude of asymmetric cosmic ray intensity decreases and magnitude of JSWP events. Statistically calculated co-relation co-efficient is 0.43 between these two events.

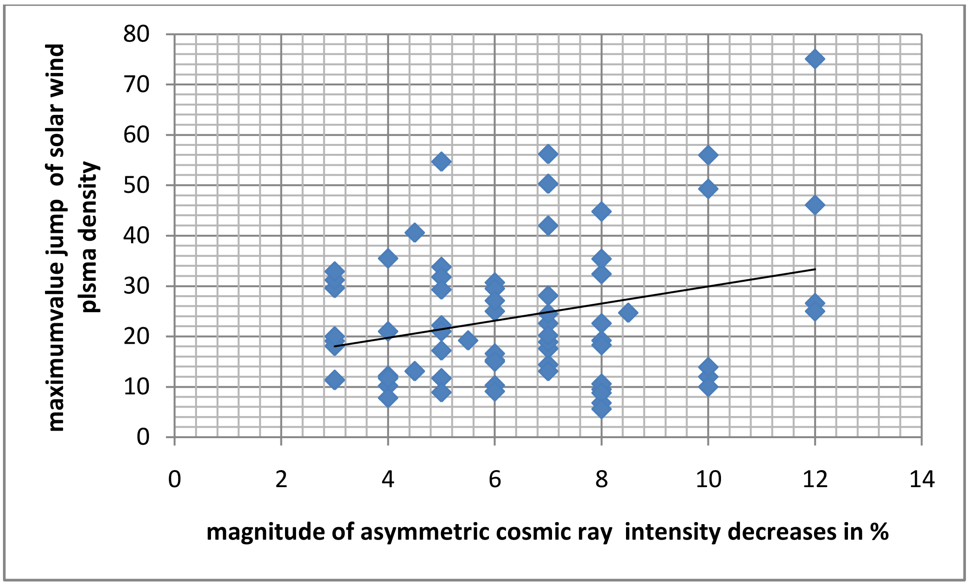

Figure-3 Scatter plot between magnitude of asymmetric cosmic ray intensity decreases and peak value of associated JSWD events showing positive correlation with correlation coefficient 0.28.

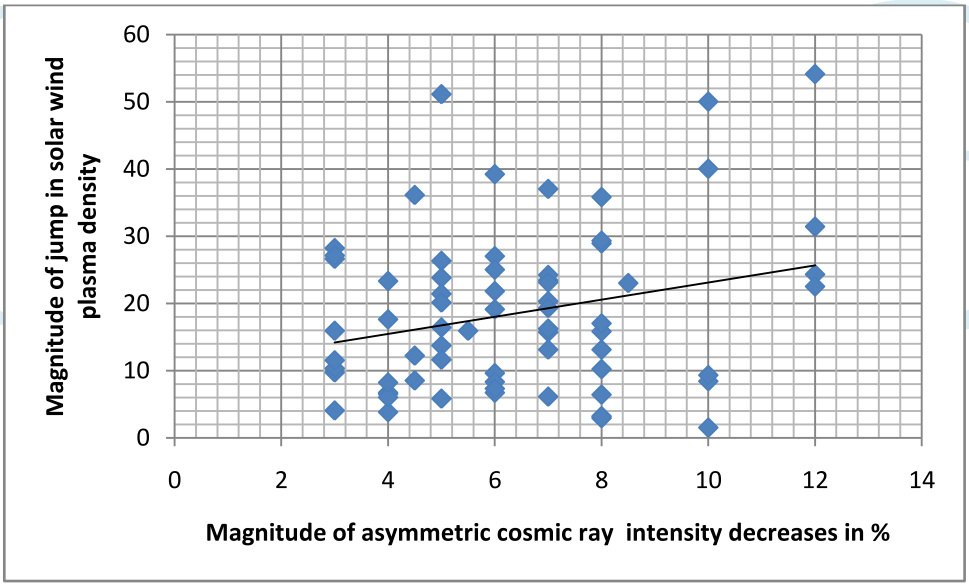

Figure-4 Scatter plot between magnitude of asymmetric cosmic ray intensity decreases and magnitude of associated JSWD events showing positive correlation with correlation coefficient 0.25.

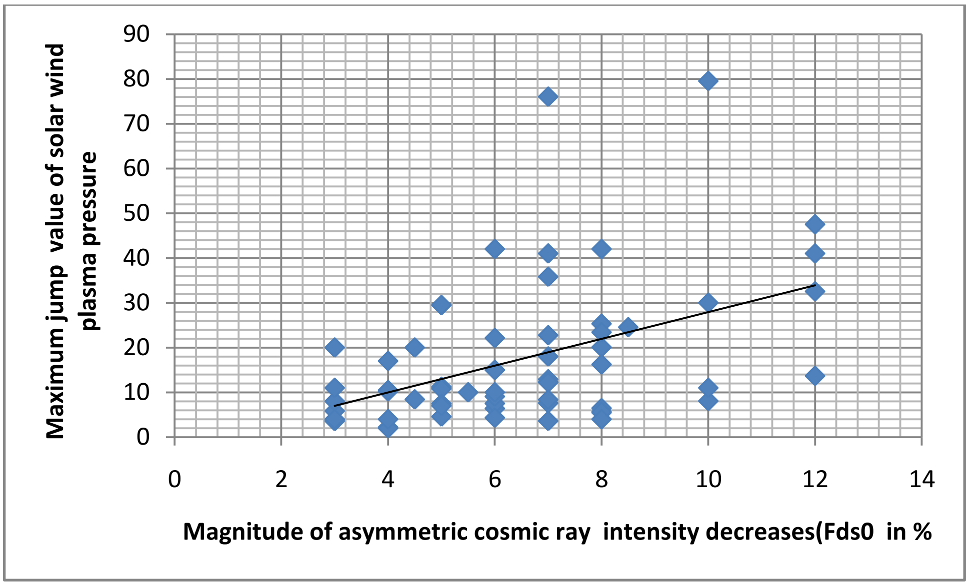

Figure-5 Scatter plot between magnitude of asymmetric cosmic ray intensity decreases and peak value of associated JSWP events showing positive correlation with correlation coefficient 0.45.

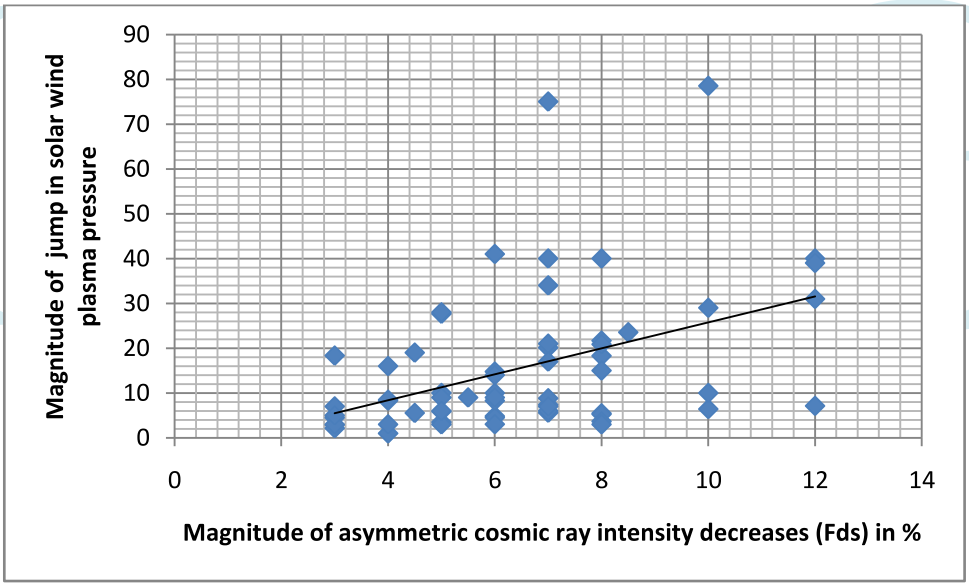

Figure-6 Scatter plot between magnitude of asymmetric cosmic ray intensity decreases and magnitude of associated JSWP events showing positive correlation with correlation coefficient 0.43.

4- CONCLUSION

From this study we have found that there are 74 asymmetric cosmic ray intensity decreases out of which 65 are associated with jump in interplanetary magnetic field. Positive co-relation with correlation co-efficient 0.32 has been found between magnitude of asymmetric cosmic ray intensity decreases and magnitude of JIMF events. Positive correlation have also been found between magnitude of asymmetric cosmic ray intensity decreases and associated jump in solar wind plasma parameters. From these results it is concluded that majority of the asymmetric cosmic ray intensity produce disturbances in solar wind plasma parameters.

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