

Forbush decreases during the ascending phase of solar cycle 24

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Abstract: In this work the Forbush decreases from January 2010 to April 2012, covering the most part of the ascending phase of the solar cycle 24, were studied. Using the IZMIRAN database of Forbush decreases extracting from the worldwide neutron monitor network, a statistical analysis of 280 selected events was performed, focusing on two most important of them. The first one occurred on February 18, 2011 presented a $\sim 5\%$ decrease at cosmic ray intensity and the second one happened on March 8, 2012 with an amplitude of $\sim 11\%$. For these two events, a further study on the way that the solar events affected the interplanetary space and finally provoked the cosmic ray decreases on Earth was done. It is resulted that the neutron monitor records during these events, depend on the cut-off rigidity of the station.

1 Introduction

A Forbush decrease (Fd) is a sudden and rapid decrease in the intensity of the galactic cosmic ray component with a duration of about one week, which is due to strong solar events (solar flares, coronal mass ejections) and were first observed by Forbush (1937). Forbush decreases with a gradual onset are symmetric in profile and are well associated with corotating high speed solar wind streams [1], [2]. These cosmic ray decreases are recorded on Earth by the neutron monitor stations of the world wide network. The amplitude of the decrease is due to the different cut-off rigidity of each neutron monitor that expresses the difficult that a cosmic ray particle can penetrate the Earth's magnetic field.

2 Data and Method

A number of 280 events have been studied, taken place between January 2010 and April 2012. From all them, 16 events were selected with the criterion that they presented a decrease with an amplitude $> 3\%$. From the IZMIRAN database the cosmic ray parameters were calculated for particles of rigidity 10 GV which is close to the effective rigidity of the particles being registered by neutron monitor worldwide network [3]. From the same database the flare or CME data associated with the Fds and the sudden storm commencement data (SSC) that took place at the Earth's magnetosphere were obtained. The neutron monitor data were obtained from the High resolution Neutron Monitor Database-NMDB (www.nmdb.eu), including the Athens Neutron Monitor Station of the University of Athens (<http://cosray.phys.uoa.gr>). Finally, the geomagnetic indices Dst and Kp were examined, showing the affect of the shock wave on the Earth's magnetosphere.

3 Results and Conclusions

From the 16 events that have been chosen for study (see Table), only two events were caused by X-ray flares. The first one is the Forbush decrease on 18.02.2011 due to an X-ray flare (X2.2) that occurred on 15/02/2011 at 01:44UT in AR 11158. The decrease had an average amplitude of 5,2%. It was

followed by a halo CME that was recorded by SOHO/LASCO on 15/02/2011 at 02:24UT with a speed of 669 km/sec. A SSC took place, when the shock arrived at Earth on 18/02/2011 at 01:36UT [4].

DD.MM.YY hh:mm	Amp (%)	K_p	Flares	CMEs
03.08.10 5:41 PM	3.3	6.7	C3.2	yes
18.02.11 1:36 AM	5.2	5.0	X2.2	yes
29.03.11 4:30 PM	3.1	3.9	-	yes
04.06.11 8:45 PM	3.5	6.4	C3.7	yes
22.06.11 3:00 AM	4.1	6.3	C7.7	yes
11.07.11 9:00 AM	3.5	3.9	B4.7	yes
05.08.11 6:00 PM	4.3	7.8	M9.3	yes
26.09.11 2:37 PM	4.4	6.3	M7.1	yes

DD.MM.YY hh:mm	Amp (%)	K_p	Flares	CMEs
24.10.11 6:00 PM	4.9	7.3	-	yes
22.01.12 6:14 AM	3.0	5.0	M3.2	yes
24.01.12 3:04 PM	3.2	4.3	M8.7	yes
26.02.12 9:00 PM	3.5	5.3	-	yes
07.03.12 4:21 AM	4.5	6.0	M2.0	yes
08.03.12 11:05 AM	11.7	8.0	X5.4	yes
12.03.12 9:21 AM	5.7	6.3	M8.4	yes
04.04.12 7:00 PM	4.2	4.0	-	yes

The second one is a Forbush decrease (Fig.1) that took place on 08.03.2012 and is due to an X-ray flare (X5.4) occurred on 07/03/2012 at 00:02UT in AR 1429. It was followed by a halo CME recorded by SOHO/LASCO on 07/03/2012 at 00:24UT with a linear speed of 2684km/sec. A SSC occurred, when the shock arrived on Earth on 08/03/2012 at 11:05UT.

From our study it is concluded that there is a temporal continuity between the solar events and the associated phenomena that are recorded on Earth. The Fds are directly associated to the production of CMEs on the Sun and the created shock waves, but both of them are not necessarily connected with a solar flare. It is also obvious that the ascending phase of the solar cycle 24 is characterized by a plenty of Fds, but not strong events. They are caused by flares with importance $\leq M$ and only two of them are caused by X-flares. The amplitude of the recorded Fds ranges from 3% to 12%, and appears to be the same in the polar and middle latitude stations, independent of the cut-off rigidity of each station until about 6 GV.

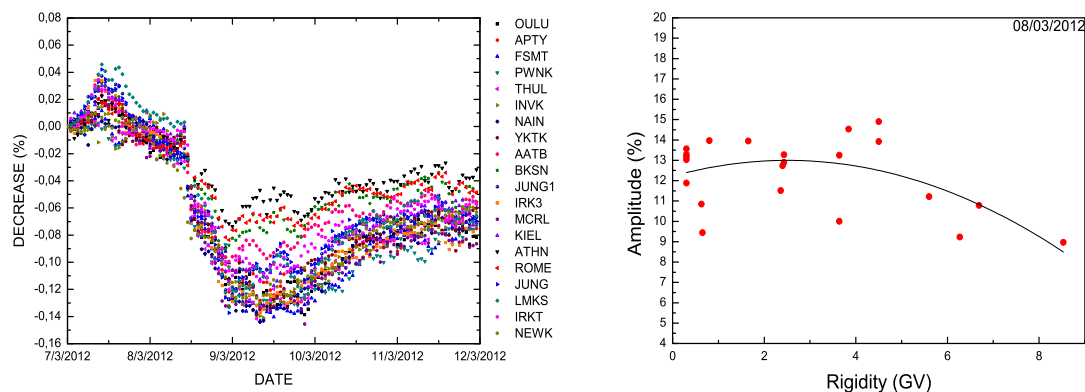


Figure 1: The cosmic ray intensity (%) during the Fd on 08.03.2012 as recorded from the neutron monitors (left) and the amplitude of this event with respect to the cut-off rigidity of each station (right) are presented.

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References

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