An unusual behaviour of cosmic rays and interplanetary parameters during 2005

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Abstract: In the present work analogous analysis has been made for the extreme events occurred during July 2005. Specifically, rather intense Forbush decrease was observed at different neutron monitors all over the world during 16 July 2005. It started some hours before arrival of a weak shock associated with a CME from 14 July 2005. It is rather a peculiar event, as it is not a ground level enhancement of solar cosmic rays and not a geomagnetic effect in cosmic rays. An effort has been made to study the effect of this unusual event on cosmic ray intensity as well as various solar and interplanetary plasma parameters. It is noteworthy that during 11 to 18 July 2005, the solar activity ranged from low to vary active. Especially low levels occurred at the 11, 15 and 17 July whereas high levels took place on the 14 and 16 July 2005. A series of Forbush effects took place from 12 July causing a decrease in cosmic ray intensity of about 2%, by the 16 July 2005. An intensive Forbush decrease of cosmic ray intensity observed on 16th July, 2005. The characteristics of this Forbush decrease on 16th July, 2005 indicate that it does not comprise ground level enhancement of solar cosmic rays neither a geomagnetic effect in cosmic rays. The Sun is observed active during 11 to 18 July 2005 and the interplanetary magnetic field intensity lies within 15 nT and solar wind velocity was limited to ~ 500 kms^{-1}. The geomagnetic activity during this period remains very quite, Kp index did not exceed 5, the disturbance storm time Dst index remains ~ - 70 and no sudden storm commencement (SSC) has been detected during this period.

Introduction

The transient disturbances in the interplanetary space usually are accompanied by the short period decreases — Forbush effects of the galactic cosmic ray (GCR) intensity [1–5]. Generally, two types of the Forbush effects of the GCR intensity are distinguished — sporadic and recurrent. The sporadic Forbush effects are characterized with a rapid decrease phase during the one–two days and by a subsequent recovery phase lasting for few days. Solar flares and coronal mass ejections (CMEs) produced large variations in cosmic ray intensity. A lot of attempts have been made in the past to explore the relation between these phenomena as well as their impact on cosmic rays [6-8] .

Nowadays, the analysis of spacecraft data reveals that these events are common in the solar wind. About 30% of coronal mass ejections (CMEs) observed in the solar wind exhibit internal field rotations, characteristic of magnetic flux rope. However, the relationship between the CMEs observed near the Sun and magnetic clouds is poorly understood.

Forbush decreases associated with shock-associated cloud are caused by magnetic field variations associated with interplanetary disturbances [9]. Badruddin et al. [10] have reported a possible correlation between magnetic clouds and cosmic ray intensity decrease while Kudo et al.

[11] have reported an increases in cosmic ray intensity that may be related to the geomagnetic D_{st} index and Iucci et al. [12] have found short term increase in CR intensity occurring inside the Forbush decrease, that possible may be associated with magnetic clouds. Zhang and Burlaga [13] infer that the cosmic rays are mainly modulated by fluctuation rather than by drifting in the strong smooth field in the magnetic cloud.

The magnetic clouds can interact with other flows [14]. Magnetic clouds are ideal objects for solar terrestrial studies because of their simplicity and extended intervals of southward and northward magnetic fields [15]. Gosling [16] has shown that approximately 1/3 of interplanetary manifestations of solar ejecta (also called CMEs by some authors) are magnetic clouds. A magnetic cloud like a well defined CME acts as a driver and forms a driver shock wave; propagation and properties of the shock and driver it self. Hence like interplanetary shock, magnetic clouds provide us with a link between ejected material, field and energy on the sun and significant magneto spheric activity via solar wind.

These events are not always associated with interplanetary shocks but only when they travel faster than the ambient solar wind. Besides the identification of magnetic clouds locating cloud boundaries is an open problem Lepping et al., [17]1990. Zhang and Burlaga [13] showed that the clouds are usually spatially shorter than the interval defined by counter-streaming electrons, suggesting that the clouds are parts of larger transient structures.

Many workers have shown the structure and dynamics of interplanetary magnetic clouds and their effects on the magneto sheath and magnetosphere. The association of geomagnetic activity to magnetic clouds and other IMF features are given by Farrugia et al. [18] and Tsurutani and Gonzalez [19]. Farrugia et al. [20] have shown that a major geomagnetic storm and associated aurora were produced by the extended interval of the negative B_z in the front part of magnetic cloud. As the magnetic cloud moved past the Earth, the magnetic field slowly rotated northward giving an extended interval with positive B_z in which the geomagnetic activity subsided.

Data and analysis

The temperature and pressure corrected hourly data (counts of neutrons) of cosmic ray intensity from Moscow neutron monitor have been used, where the long-term change from the data has been removed by the method of trend correction. The days of Forbush decreases have also been removed from the analysis to avoid their influence in cosmic ray variation. Interplanetary magnetic field and solar wind plasma data have been taken from the interplanetary medium data book.

Results and Discussion

In the present work we have rigorously studied the extreme events occurred during July 11 to 17, 2005. The hourly data of cosmic ray neutron monitor of Moscow for these events have been plotted in Fig 1. As depicted if figure, a series of Forbush effects took place from 12 July causing a decrease in cosmic ray intensity of about 2%, by the 16 July 2005. As a result an intensive Forbush decrease of cosmic ray, on 16th July is evident. A sharp enhancement of cosmic ray intensity occurred right after the main phase of the Forbush decrease on 16th July, was followed by a second decrease within less than 12 hours. The characteristics of this event indicate that it does not comprise a ground level enhancement of solar cosmic rays neither a geomagnetic effect in cosmic rays. The event seems to be caused by the interplanetary disturbances in the inner heliosphere at the time when earth crossed a periphery of a giant Forbush effect started after the flare on 14th July and play a significant role for the solar activity of the previous days.

The Sun was rather active during this period and we have observed 35 C-class, 13 M-class and 1 X-class solar flares and five Halo coronal mass ejections during 11 to 18 July 2005. Though the main flares occurred, the interplanetary space near the Earth was not strongly disturbed during this period. The interplanetary magnetic field intensity lies within 15 nT and solar wind velocity was limited to ~ 500 kms^{-1}. The geomagnetic activity during this period was also very quite, Kp index did not exceed 5, the lowest Dst index remains ~ - 70 and no sudden storm commencement (SSC) has been detected during this period.

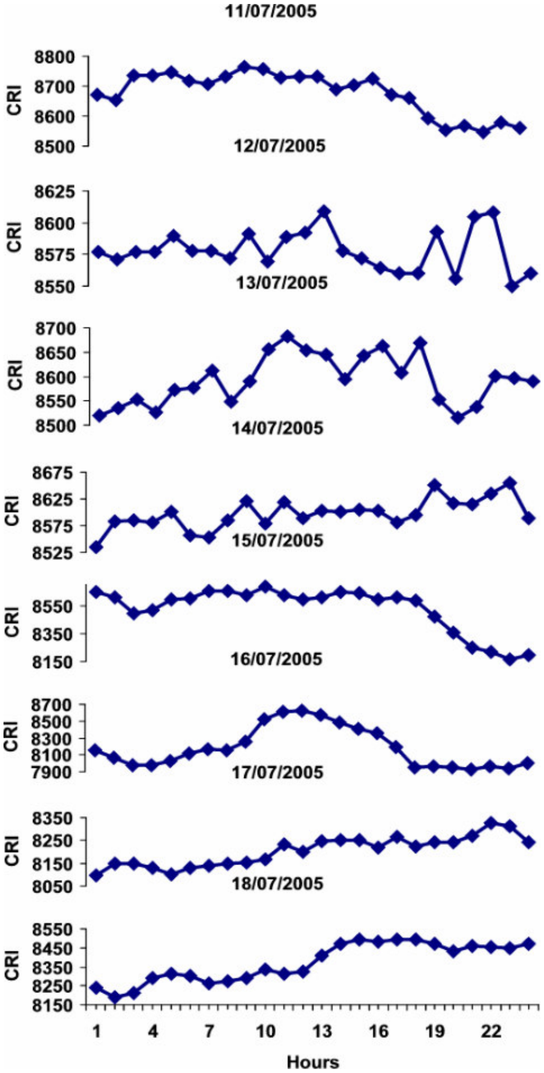

Fig 1: Cosmic ray intensity variation during July 11 – 18 2005.

It is noticed that the solar activity remains low to very active during the period 11 to 18th July 2005. Particularly the solar activity found to remain low during 11, 15 and 17 July, whereas it remains very high during 14 and 16 July 2005. The sunspot numbers as depicted in Fig 2 found to continuously decreased from 11th July until it remain completely absent on 18th July 2005. Thus a blank Sun appeared on 18th July and it remains blank for a number of days till 22nd July 2005.

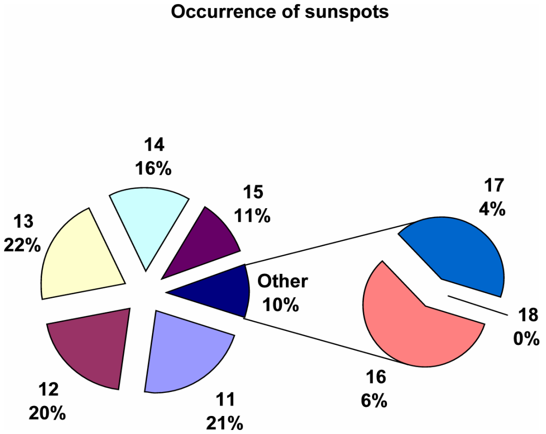

Fig 2: Frequency of occurrence of sunspot numbers during July 11 – 18 2005.

Conclusions

From the present investigations following conclusions may be drawn:

- A series of Forbush effects took place from 12 July causing a decrease in cosmic ray intensity of about 2%, by the 16 July 2005.
- An intensive Forbush decrease of cosmic ray intensity observed on 16th July, 2005.
- The characteristics of this Forbush decrease on 16th July, 2005 indicate that it does not comprise ground level enhancement of solar cosmic rays neither a geomagnetic effect in cosmic rays.
- The Sun is observed active during 11 to 18 July 2005 and the interplanetary magnetic field intensity lies within 15 nT and solar wind velocity was limited to ~ 500 kms^{-1}.
- The geomagnetic activity during this period remains very quite, Kp index did not exceed 5, the disturbance storm time Dst index remains ~ - 70 and no sudden storm commencement (SSC) has been detected during this period.

Acknowledgements

The authors are indebted to various experimental groups, in particular, Prof. Margret D. Wilson, Prof. K. Nagashima, Miss. Aoi Inoue and Prof. J. H. King for providing the data.

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