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Galactic cosmic ray spectrum and effective radiation dose on flights during Forbush decreases

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Abstract: In this work the power spectrum during the Forbush decrease caused by a burst of solar activity in August 2010, was studied. Moreover applying the algorithms Magnetocosmics / Planetocosmics and Cari-6 during these events, the rate of the effective radiation dose that affects the crew and passengers during flights was calculated.

1 Introduction

Fast decreases of galactic cosmic ray (GCR) intensity for 1-2 days followed by its gradual recovery in 5-7 days are called as Forbush decreases (Fds). They are observed after large flares on the Sun and solar coronal mass ejecta [1]. Amplitude of the Fd is defined as the difference between the GCR intensity at the onset and the minimum point of this. A relationship between the cosmic ray intensity variations and the average effective dose on-board has been found. Particularly with the decreasing or increasing cosmic ray intensity during different events such as GLEs, Fds etc., the effective radiation dose on flight is also decreased or increased [2],[3]. In this work the spectral index of the GCR intensity during the Forbush decrease of the ascending phase of solar cycle 24 in August 3-7, 2010, is studied. On August 1, a series of solar events gave rise to a combination of Earth - directed halo CMEs (http://www.sidc.be/sunspots/bulletins/monthly). At end using the algorithms Magnetocosmics / Planetocosmics (http://kspc22.unibe.ch.) developed by the University of Bern, Switzerland and Cari-6 developed at the FAA's Civil Aerospace Medical Institute, (http://jag.cami.jccbi.gov/cariprofile.asp), the effective radiation dose on board during the flight Athens - New York was calculated.

2 Data Analysis

According to the coupling coefficient method [4], secondary cosmic ray measurements can be linked to the primary incident cosmic ray particles via specific mathematical functions that take into account the acceptance vectors for each detector (neutron monitor), based on its local characteristics [4],[5]. In order to study analytically the temporal changes of the rigidity spectrum of the GCR intensity that was recorded on August 3-7, 2010, daily averaged data of seven neutron monitors obtained from the High-Resolution Neutron Monitor Database -NMDB (http://www.nmdb.eu), were used. According to the coupling coefficient method the amplitude of the Forbush decrease in free space was calculated considering that it should be independent of the local characteristics of the detector. In our analysis we have calculated the integral ourselves providing the values of ranging from 0.5 to 2 with a step of 0.01, considering the coupling coefficient expression for the solar minimum [4]. In order to pinpoint the spectral index , we considered the difference between the mean amplitude and the amplitude of the specific detector. Then its standard deviation for a series of 151 values of was calculated taking the difference of the amplitudes to be minimum (Fig. 1)

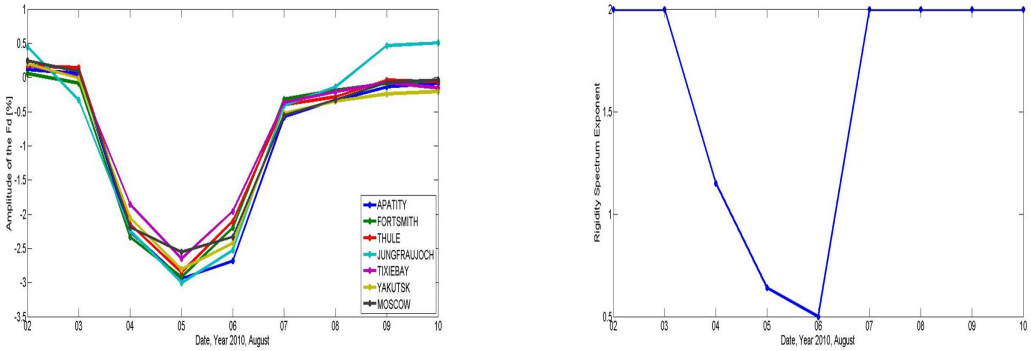

Figure 1: The calculated variations of the GCR intensity in the heliosphere for the neutron monitors of Apatity, Fortsmith, Thule, Jungfraujoch, Tixie Bay, Yakutsk, Moscow (left panel) and the temporal changes of the rigidity spectrum exponent (right panel) from 2 to10 of August 2010, are presented.

3 Radiation Dose during Forbush decrease

In the case of Forbush decrease of August 3, 2010 the effective radiation dose rate was plotted (using the Maggnetocosmics /Planetocosmics) and actually its values seem to be decreased 1 Sv /hour in the polar regions due to the Forbush decrease. Applying the two algorithms for the calculation of the total effective radiation dose on the flight Athens -New York in August 5, 2010, the day with the minimum amplitude and spectral index of the Fd, it is noticeable that was found equal to 41.41 microSv using the Maggnetocosmics /Planetocosmics and equal to 43.97 microSv using the Cari-6 software.

4 Results and Conclusions

The calculated values of the rigidity spectrum exponent presented in this work are in agreement with previous studies [5]. The estimated effective radiation dose was decreased during the Forbush decrease, as it was expected. The results of both software Magnetocosmics /Planetocosmics and Cari-6 applied on August 5, 2010, where the spectral index had the minimum value 0.64, were comparable.

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