Forbush event detected by CARPET on 2012 March*

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Abstract

We present a Forbush decrease (FD) event observed with CARPET cosmic ray detector operating at EL Leoncito (CASLEO San Juan, Argentinian) since 2006. The FD occurred from 8 to 16 on March 2012, it was caused by a couple of CMEs launched on 2012 March 7 associated with a X5 solar flare. CARPET data, after correcting by atmospheric variations, shows a FD with intensity $\sim 5\%$, which started just at the time of interplanetary shock that caused a intense geomagnetic storm. The FD event detected by CARPET showed a temporal evolution very similar to the one observed by Neutron Monitor of Rome detector. The onset of FD events occur few hours before geomagnetic storms, so statistic study of the correlation between their characteristics and storm intensity can be used to forecast geomagnetic activity level.

INTRODUCTION

The Earth's environment is constantly changing due the influence of solar phenomena, which is known as space weather. Solar flares and coronal mass ejections (CMEs) are responsible for significant disturbances in the nearby space (e.g. [1, 2]). Particularly CMEs are considered to be the cause of sudden decrease observed in the ground counting rates of galactic cosmic rays, these events are denominated Forbush Decrease (FD) [3]. The cosmic rays flux decrease is attributed to scattering of the galactic cosmic rays by the large scale magnetic structure of CMEs propagating in the Earth's nearby, which works as a shield. The FD normally starts in close association with interplanetary shocks, which occurs before geomagnetic storms, but the relation between FD and geomagnetic activity is complex. Geomagnetic storms require intense southward Interplanetary Magnetic Field (IMF), while cosmic ray flux is affected by large scale redistribution of IMF even when the CME is not passing nearby the Earth [4, 5]. In this work, we present a FD detected by CARPET cosmic ray detector operating in the Argentine Andes since 2006 [2]. The event was observed on 2012 March 8 and occurred in close association with a complex geomagnetic activity produced by the impact of two CMEs in the Earth's magnetosphere.

INSTRUMENTATION

CARPET detector was designed for the observation of the cosmic rays flux with energies in the range of 10^5 and -10^{12} eV. It is an important tool for the study of atmospheric, geomagnetic and solar phenomena. CARPET was installed in April 2006 at CASLEO, San Juan, Argentina, (site with magnetic rigidity of 11.8 GV and altitude of 2550 m). It is an array of 24 blocks of gas-discharge cylindrical Geiger counters. Each block consists of five upper and lower counters, separated by an 7 mm thickness aluminum absorber. Data is obtained in three mode signals, named: (a) UP and (b) LOW modes correspond to the total count rate of the 120 upper and the 120 lower counters, respectively, allowing detection of electrons and positrons with energies > 0.2 MeV, protons > 5 MeV, muons > 1.5 MeV and γ-rays > 0.02 MeV; and (c) TELESCOPE mode corresponds to the simultaneous particles detected by upper and lower counters allowing detection of electrons with energies > 5 MeV, protons > 30 MeV and muons > 15.5 MeV [2, 6].

DATA ANALYSIS

Cosmic rays flux measured on ground is influenced by changes in the pressure and temperature, producing significant variations in the measurements. Thus, it is important to remove these influences from cosmic rays ground-based data, before studying its relation with any extraterrestrial phenomena [7].

Cosmic rays flux recorded by CARPET was corrected for atmospheric influence using the integral method applying the Equations 1 and 2. The following equations estimate the cosmic rays variations ΔI^{CP} and ΔI^{CT} due to changes in atmospheric pressure and temperature, respectively [8, 9]:

$$\Delta I^{CP} = \beta \Delta p \tag{1}$$

$$\Delta I^{CT} = \int_{h_0}^{h_f} \alpha(h')\, \Delta T(h') dh' + \alpha^G \Delta T(h_G) \tag{2}$$

where Δp is the pressure variation, β is the barometric coefficient, $\Delta T(h')$ is the temperature variation, $\alpha(h')$ is the temperature coefficient in the altitude h', h_0 is the altitude where the atmospheric depth is close to zero ($h_0 \sim 111.0$ km), h_f equals to 14.0 km, $\Delta T(h_G)$ is the ground temperature deviation ($h_G = 2.5$ km) and α^G is the temperature coefficient on the ground.

Atmospheric pressure and temperature coefficients were calculated for the period of 2012 August 8. This period presents significant variations of the atmospheric pressure and temperature and extremely low geomagnetic activity.

Thus, it was calculated the pressure $\beta = -0.37\%/hPa$ and temperature $\alpha = -0.38\%/°C$ coefficients and it was obtained the pressure-corrected CARPET cosmic rays data [9].

OBSERVATIONAL RESULTS

The FD event on 2012 March 8 and 9 occurred in association with a complex geomagnetic activity produced by the impact of two CMEs in the Earth's magnetosphere. The two CMEs were launched from the Sun early on March 7 during a GOES X5 solar flare; they were classified as full halo and present a velocity of $\sim$ 2700 km/s and $\sim$ 2000 km/s (`\http://cdaw.gsfc.nasa.gov/CME_list/`). Figure 1 shows the corrected cosmic ray flux for the FD event detected by CARPET in TELESCOPE mode, which is compared with the flux detected by Neutron Monitor of Rome. Both detectors observed the FD event, which started in close association with the strong interplanetary shock that occurred at $\sim$ 12:00 UT on 2012 March 8 (Figure 1c), and before the strong geomagnetic storm that maximum (Dst $\sim$ -140 nT) was on 2012 March 9 (Figure 1d). The FD event shows similar variation in both instruments, starting just at the peak time of the interplanetary shock, reaching the minimum flux on March 9, and a slow recovering phase till $\sim$ March 16. During the FD, cosmic rays flux decrease $\sim$ 4.9% in CARPET detector and $\sim$ 8.5% in Neutron Monitor of Rome detector.

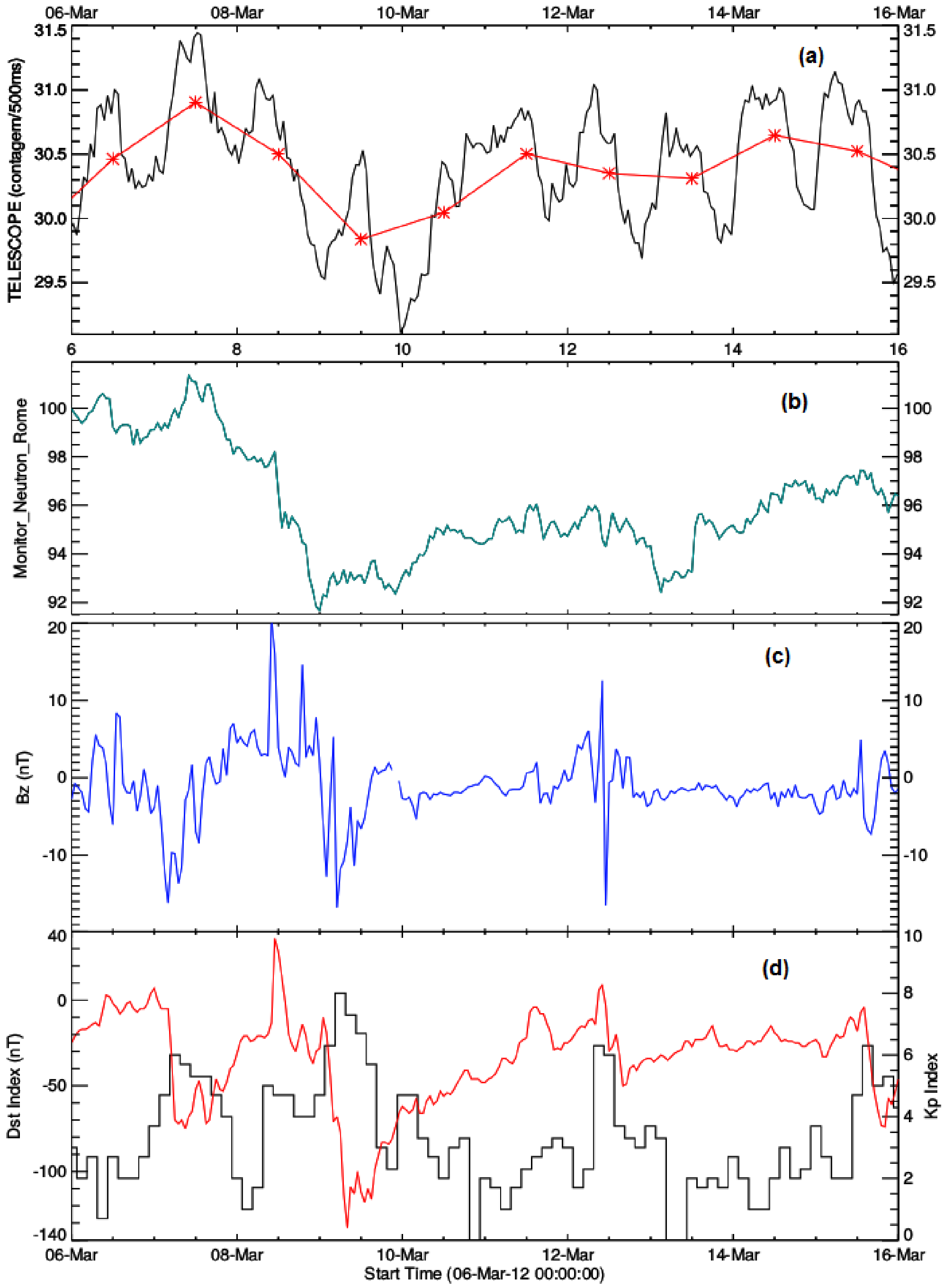

FIG. 1: Forbush Decrease occurred between 2012 March 8 and 10: (a) Corrected cosmic rays flux detected by CARPET TEL channel (red curve represents the flux integrated to 12 hours), (b) flux detected by Neutron Monitor of Rome (cyan curve), (c) interplanetary magnetic field (blue curve), and (d) KP index (black curve) and Dst (red curve) during.

CONCLUSIONS

CARPET detector installed at CASLEO has been used to study cosmic rays fluctuations in long and short term scales [2]. In this work, we presented the cosmic ray flux observed during a FD on 2012 March 8. CARPET TEL mode data used here was corrected by atmospheric pressure and afterwards by the temperature variations using the integral method [8, 9]. The results show the potential of CARPET to detect a FD. The onset Forbush Decrease events occurs before the main phase of the geomagnetic storm, indicating that could be used as a geomagnetic forecast index. Thus, the FD can provide in advance, valuable complementary information about geomagnetic storms, which can be used for space weather forecasting. To better characterize the FD and the associated geomagnetic storm intensity, it is necessary to perform a statistical study.

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