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STUDY OF COSMIC RAY RESPONSE TO INTENSE GEOMAGNETIC STORMS OBSERVED WITH LOW LATITUDE MUON TELESCOPE AT THE BRAZILIAN SOUTHERN SPACE OBSERVATORY

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ABSTRACT

Forbush decreases are depressions of cosmic ray intensity observed by ground detectors when the interplanetary magnetic field (IMF) disturbances pass by the Earth's magnetosphere. A solar disturbance propagating away from the Sun affects the pre-existing galactic cosmic ray population of in a number of ways. In this work we analyse intense geomagnetic storms (Dst < - 100nT) observed in the period of July 20th to 30th, 2004. The cosmic ray observation data was obtained using the muon telescope of the Brazilian Southern Space Observatory-SSO of the INPE's Southern Regional Space Research Center at (2926'24''S; 5348'38''W). We focus on muon count rate fluctuation during the geomagnetic storm period. Observations made by ACE satellite are used to identify interplanetary structures responsible for the forbush decreases. Interplanetary data such us: plasma parameters (solar wind speed, density and temperature of protons), interplanetary magnetic field (B, Bx, By, Bz), observed by ACE satellite, and Dst index from Kyoto were used to characterize the interplanetary structures causing the storms and its geomagnetic characteristics. With an eye towards the forecasting of geomagnetic disturbances, the SSO muon telescope is part of the International Muon Detector Network, which will be able to predict the arrival of disturbances.

INTRODUCTION

It is believed that the physical mechanism responsible for the energy transfer from the solar wind to the Earth's Magnetosphere is magnetic reconnection between the Interplanetary Magnetic Field (IMF) and the Earth's Magnetic Field (Tsurutani and Gonzalez, 1997) as represented in Figure 1a. Thus, it is necessary that the IMF has substantial component in the –Z direction (considering GSM coordinate system), also called Bs, southward Bz. The interplanetary criteria for an intense geomagnetic storm, Dst < -100 nT, is a dawn-dusk interplanetary electric field greater than 5 mV/m for a period greater than 3 hours (Gonzalez and Tsurutani, 1987).
An interplanetary disturbance, propagating from the Sun to the Earth, affects the galactic cosmic ray population in many ways. One of the most known is the "Forbush decrease". Some interplanetary disturbances like the interplanetary counterparts of coronal mass ejections (CME) can cause depressions in high energy cosmic rays along the IMF main direction, being detected before the arrival of the CME to the earth (Munakata et al., 2000), according to the diagrama shown in Figure 1b.
Cosmic ray particles traveling close to light speed from this "depressed" region are observed as a "loss-cone precursor" at Earth typically 4 to 8 hours before the arrival of the interplanetary disturbance (Munakata et al., 2000). Since these structures are the main cause of intense geomagnetic storms, cosmic ray loss-cone precursors well be used to forecast space weather variability.

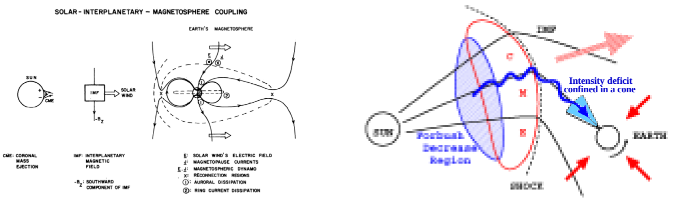

Figure 1. (a) Schematic of interplanetary-magnetosphere coupling, showing the reconnection process and energy injection into the nightside magnetosphere, which leads to the formation of the storm-time ring current (Gonzalez and Tsurutani, 1992). (b) Loss-cone precursors. Nagashima et al. [1992], Ruffolo [1999]

THE JULY 20-30th (2004) EVENT

In the period of July 20-30th three intense geomegnetic storms were observed. A sudden increase in the intensity of the Interplanetary Magnetic Field B, density, speed and temperature, on July 22nd, indicating the arrival of a shock wave, as observed by the ACE satellite is shown in Figure 2. Following this shock, a southward excursion of the Bz component some hours later was observed. A second shock was observed on July 24th, also shown in Figure 2. This second event had the characteristics of an interplanetary magnetic cloud, given its smooth rotation in the direction of the magnetic field. A third shock was observed on July 26th, and again a magnetic cloud-like structure observed.
The observations of the Ground Multi-Directional Cosmic Ray-Muon Detector, installed in the at Southern Space Observatory – SSO, in São Martinho da Serra, South of Brazil, show the percent variation for the vertical direction. This decrease was caused by the interplanetary structures and its associated shock waves.

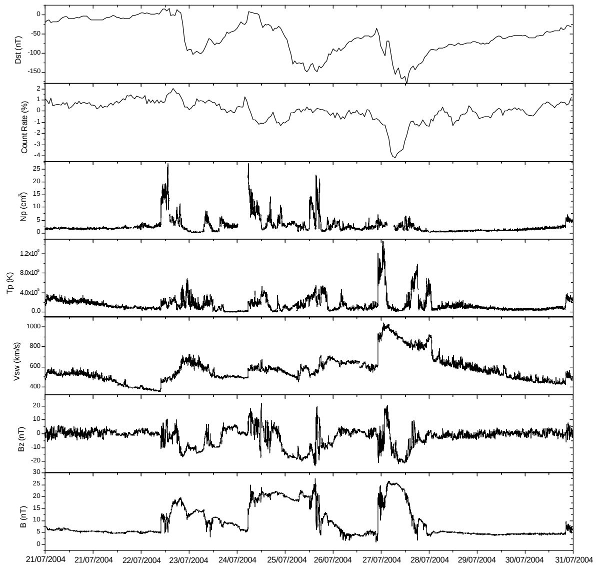

Figure 2. Dst index, Muon data, density, temperature, speed, Magnetic field (Bz), Magnetic field (B) observed by ACE from 20th to 30th of July, 2004 obtained with the Multi- Directional Cosmic Ray Detector, SSO, Brazil.

CONCLUSIONS

We have presented a brief analysis of the interplanetary origins of the 3 intense geomagnetic storms on July 20-30th, 2004 together with a preliminary analysis of the cosmic rays (muons) observations made at the Southern Space Observatory – SSO, Brazil. We analyzed the interplanetary structures associated with these events.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the ACE team for providing the data used in this work, obtained through the WDC-Kyoto, as well as the Kyoto University for the geomagnetic data and the Shinshu University – Japan for the donation of the SSO's Muon Detectors. The authors would also like to acknowledge the PIBIC program from CNPq supporting agency (Brazil).

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Monday, 25 July 2005 17:00 - 19:00
C223 - IAGA2005-A-01238