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Space Weather Prediction and Effects on Space Missions (3)

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THE GLOBAL MUON DETECTOR NETWORK – GMDN AND SPACE WEATHER PREDICTION

Abstract

The main objective of this work is to present an overview of the global network of ground based multi-directional muon detectors (GMDN). With the expectation of the approval by European Commission of the NESTEC Project (NExt generation Space TEChnology), the GMDN may be upgraded in 2010 including new muon detectors in Bremen, Germany and in Hermanus South Africa, and it will become an international collaboration consisting of 10 institutions from 6 countries in 5 continents. A multi-directional muon detector for measuring high-energy galactic cosmic rays (GCRs) was installed in 2001 and expanded in its detection area in 2005, through an international cooperation between Brazil, Japan and USA, and has been in operation since then at the Southern Space Observatory - SSO/CRS/INPE - MCT, (29.4°S, 53.8°W, 480m a.s.l), Sao Martinho da Serra, RS, in southern Brazil, as an important component of the GMDN. The observations conducted by this detector are used for forecasting the arrival of the interplanetary coronal mass ejections (ICMEs) and the geomagnetic storms at the Earth. The detector measures high-energy GCRs by detecting secondary muons produced from the hadronic interactions of primary GCRs (mostly protons) with atmospheric nuclei. Since muons have a relatively long life-time (about 2.2 microseconds at rest), they can reach the detector at ground level preserving the incident direction of primary particles. The multidirectional detector can measure the GCR intensity in various directions at a single location, such as SSO in Brazil. ICMEs accompanied by a strong shock often forms a GCR depleted region behind the shock. The Forbush decrease is observed when the Earth enters in this depleted region. Some particles from this depleted region leak into the downstream, traveling with almost the speed of light, much faster than the approaching shock, and creating the precursory loss-cone anisotropy around the sunward IMF direction at the Earth. Loss-cones are typically visible 4-8 hours prior to the shock arrival and the onset of major geomagnetic storm at the Earth. This cosmic-ray precursor can be detected sometimes as early as ten hours prior to the shock arrival at the Earth. With the real time data from the upgraded GMDN, the methodology and the technique for applied international services will permit very accurate Space Weather forecasting in near future.