PRECURSORS OF THE FORBUSH DECREASE ON 2006 DECEMBER 14 OBSERVED WITH THE GLOBAL MUON DETECTOR NETWORK (GMDN)

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ABSTRACT

We analyze the precursor of a Forbush decrease (FD) observed with the Global Muon Detector Network on 2006 December 14. An intense geomagnetic storm is also recorded during this FD with the peak Kp index of 8+. By using the "two-dimensional map" of the cosmic ray intensity produced after removing the contribution from the diurnal anisotropy, we succeed in extracting clear signatures of the precursor. A striking feature of this event is that a weak loss-cone (LC) signature is first recorded more than a day prior to the storm sudden commencement (SSC) onset. This suggests that the LC precursor appeared only 7 hr after the coronal mass ejection eruption from the Sun, when the interplanetary (IP) shock driven by the interplanetary coronal mass ejection was located at 0.4 AU from the Sun. We find the precursor being successively observed with multiple detectors in the network according to the Earth's spin and confirmed that the precursor continuously exists in space. The long lead time (15.6 hr) of this precursor which is almost twice the typical value indicates that the interplanetary magnetic field (IMF) was more quiet in this event than a typical power spectrum assumed for the IMF turbulence. The amplitude (–6.45%) of the LC anisotropy at the SSC onset is more than twice the FD size, indicating that the maximum intensity depression behind the IP shock is much larger than the FD size recorded at the Earth in this event. We also find the excess intensity from the sunward IMF direction clearly observed during ~10 hr preceding the SSC onset. It is shown that this excess intensity is consistent with the measurement of the particles accelerated by the head-on collisions with the approaching shock. This is the first detailed observation of the precursor due to the shock reflected particles with muon detectors.

Keywords

cosmic rays; interplanetary medium; methods: data analysis; solar-terrestrial relations; Sun: coronal mass ejections (CMEs)

PACS

96.50.sb Composition, energy spectra and interactions

96.60.ph Coronal mass ejection

96.50.Bh Solar and interplanetary electric and magnetic fields (including solar wind fields)

96.50.Fm Shock waves

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