Modulation of galactic cosmic ray intensity with a time scale of several days caused by CMEs and solar wind interaction regions

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The solar wind can modulate Galactic Cosmic Ray (GCR) intensity. Modulations with a time scale of several days are mainly caused by Coronal Mass Ejections (CMEs) and solar wind stream interaction regions. The modulation caused by CME is called Forbush decrease (FD). The modulation that occurs at intervals of 27 days associated with Co-rotating Interaction Regions (CIR) is called recurrent storm.

It has been considered that the mechanism of FD consists of two different processes as follows. (i) A turbulent region of solar wind magnetic field behind an interplanetary shock prevents incursion of GCR particles (shock effect). (ii) An interplanetary magnetic flux rope that has a low GCR density passes near the Earth (ejecta effect). A well-established model reproducing the ejecta effect has been proposed by Kuwabara et al. [2004]. On the shock effect, an open question is how the turbulent region makes a modulation of GCR density in the interplanetary space. A physical model of the shock effect has not been developed yet.

The mechanism of GCR modulation caused by solar wind stream interaction regions is also unsolved. Using the data obtained by satellite observations, Richardson et al. [1996] investigated the relationship between the start time of GCR intensity decrease and the solar wind structure. They suggested that a turbulent region of solar wind magnetic field takes an important role in understanding the mechanism of modulation caused by solar wind stream interaction regions, like the shock effect of FD. However some problems are left. The start time of GCR intensity decrease does not always correspond to the turbulent region of magnetic field. It has not been understood what factor decides the size of decrease.

With these backgrounds, the main purpose of this study is to reveal how the turbulent region of solar wind magnetic field generates a modulation of GCR intensity. We analyze the GCR data obtained by the Muon monitor network for the period from 2001 to 2004. The Muon monitor network measures the higher energy (˜60 GeV) GCR as compared with the satellite observations (˜1 GeV). We can study large-scale structure of solar wind, using the GCR data obtained by the Muon monitor network.

First of all, we associate GCR decrease events with the solar wind structure using the eye scan and the CME detection method reported by Richardson and Cane [2003]. It is found that the origins of GCR decrease events are divided into 4 groups: (a) CMEs, (b) rising phase of solar wind speed in solar wind stream interaction regions, (c) high speed stream, and (d) noo clear structure. Using this classification, we investigate the relationship between solar wind parameters and the size of GCR decrease caused by (a) CMEs and (b) solar wind stream interaction regions. It is found that the size of decrease positively correlates with the solar wind speed against the result of previous study. Fluctuations of magnetic field can be seen in CMEs and solar wind stream interaction regions. The relationship between the degree of fluctuations and the size of decrease will be also reported. We will also investigate whether the turbulent magnetic field area in the solar wind stream interaction region corresponds to the low GCR density region which is deduced by the model of Kuwabara et al. [2004]