Numerical study on the solar modulation of low-energy cosmic rays measured with CALET

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Responsible Representative

Shoko Miyake, Associate Professor, National Institute of Technology (KOSEN), Ibaraki College

Contact Information

Shoko Miyake(miyakesk@ee.ibaraki-ct.ac.jp)

Members

Shoko Miyake

Abstract

We reveal the solar modulation of the galactic cosmic ray that is the relationship between the solar activity and the variation of the flux of low-energy particles, performing the numerical calculation of the cosmic-ray propagation in the heliosphere and the magnetosphere.

Reasons and benefits of using JAXA Supercomputer System

This project needs a large amount of computational resources for the following two reasons: We have to calculate the cutoff rigidity for each event measured by CALET.; We need to iteratively calculate and be compared with observations to find the best solar modulation model that reproduce the observations.

Achievements of the Year

We have revised how to treatment of the geomagnetic cutoff variation for the analysis of the low-energy electrons and protons measured by the CALorimetric Electron Telescope (CALET). A main improvement point is that we adopted a reconstructed trajectory in a charge detector (CHD) and an imaging calorimeter (IMC) as an incident direction to calculate the cutoff rigidity for each event. We have calculated the effective cutoff rigidity by reconstructing particle trajectories in the magnetosphere, implementing a realistic description of the geomagnetic field based on the IGRF-13 and TS05 empirical models. By identifying the incident direction, we have minimized the uncertainty of the cutoff rigidity that varies greatly depending on the incident direction. We then have analyzed the flux of electrons and count rate of electrons and protons, using the cutoff rigidity to select events that were not affected by the geomagnetic cutoff variation.

We also have calculated the flux of electrons and protons with the drift model of the cosmic-ray solar modulation that has considered a drift motion and a non-linear diffusion process in the heliospheric magnetic field. We have obtained numerical results that is largely consistent with the observations, which means that the charge-sign dependence shown by observation is consistent with the drift model prediction of the solar modulation. Further development of the drift model of the solar modulation will be conducted by continuing verifications like this work.

Publications

- Non peer-reviewed papers

Solar Modulation During the Descending Phase of Solar Cycle 24 Observed with CALET on the International Space Station, S. Miyake, et al. (CALET Collaboration), Proceedings of Science (ICRC2021) 1270.

- Oral Presentations

1) Solar Modulation During the Descending Phase of Solar Cycle 24 Observed with CALET on the International Space Station, S. Miyake, et al. (CALET Collaboration), ICRC2021, online, July, 2021.

2) Observation of the solar modulation of GCRs and relativistic electron precipitation events with CALET during the descending phase of solar cycle 24, S. Miyake et al. (CALET Collaboration), JPS 2021 Autumn Meeting, online, Sep., 2021.

3) Observation of low-energy electrons and protons with CALET around the solar minimum at the solar cycle 24/25, S. Miyake et al., JPS 2022 Annual (77th) Meeting, online, March, 2022.

- Poster Presentations

Latest results from observations of the solar modulation of galactic cosmic rays and REP by CALET, S. Miyake et al. (CALET Collaboration), 22nd Space Science Symposium, online, Jan., 2022.

Usage of JSS

Computational Information

Process Parallelization Methods	N/A
Thread Parallelization Methods	N/A
Number of Processes	1
Elapsed Time per Case	12 Hour(s)

- **JSS3 Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.00

Details

Computational Resources		
System Name	CPU Resources Used (core x hours)	Fraction of Usage[*2](%)
TOKI-SORA	0.00	0.00
TOKI-ST	19.01	0.00
TOKI-GP	0.00	0.00
TOKI-XM	0.00	0.00
TOKI-LM	0.00	0.00
TOKI-TST	0.00	0.00
TOKI-TGP	0.00	0.00
TOKI-TLM	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage[*2](%)
/home	10.00	0.01
/data and /data2	100.00	0.00
/ssd	100.00	0.03

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage[*2](%)
J-SPACE	0.00	0.00

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

- **ISV Software Licenses Used**

ISV Software Licenses Resources		
	ISV Software Licenses Used (Hours)	Fraction of Usage*2(%)
ISV Software Licenses (Total)	0.00	0.00

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.