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An analysis of the spectral properties of long-term galactic cosmic ray variability in the heliosphere via a multiple-dataset study

Pauli Väisänen (1), Ilya Usoskin (1,2), and Kalevi Mursula ()

(1) University of Oulu, Space Climate Research Unit, Oulu, Finland (pauli.vaisanen@oulu.fi), (2) Sodankylä Geophysical Observatory, University of Oulu, Finland

The heliosphere is formed by the open solar magnetic field and solar wind flow, modulating galactic cosmic rays (GCR) from galactic sources. Changes in the Sun and the heliosphere affect this solar modulation of GCR. The most prominent type of variation in the Sun is the 22-year solar cycle, caused by the Sun's magnetic activity including changing polarity, which influences the path of the GCR in the heliosphere. Other shorter- and longer-term variations are also observable and affect processes in the heliosphere, the near-Earth space and on Earth.

These variations can also be identified from the power spectral density (PSD) of GCR variability. Analysing the PSD can also reveal information about the distribution of power between different scales, observed as different power laws of the spectrum. Earlier work has identified spectral peaks using data, e.g., from neutron monitors. Less effort has been given to analyse data from in-situ spacecraft. Spectral peaks observed at Earth include, e.g., the 11-year solar cycle variation, the 1.75-year midterm quasiperiodicity, the 155-day Rieger periodicity, the 27-day solar rotational periodicity and the diurnal periodicity.

Using high quality long-term GCR data from instruments aboard various spacecraft (such as CRIS on ACE, CRS on Voyager 1&2, and COSPIN on Ulysses) and on Earth (neutron monitors), we extend the earlier Earth-based studies to in-situ heliospheric data and compare and analyse the spectral properties of GCR variability over long time scales. In addition to changes in time, we also look at GCR variability across different parts of the heliosphere. We identify spectral peaks and calculate the spectral index for undisturbed frequency ranges. With this comprehensive analysis, we can provide a reliable depiction of the heliospheric GCR variation in time, which helps us understand the process of solar modulation and the underlying space climate evolution.