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Cosmic Ray Intensity and Spectral Changes during 27-day Variations Compared with Heliospheric Parameters Using Time-Delay Measurements from Antarctic Neutron Monitor Stations

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Neutron monitors (NMs) are ground-based detectors of the secondary particles produced in atmospheric cascades from primary cosmic rays. Using neutron time-delay data from neutron monitors (NMs), we can extract the leader fraction, L, of neutron counts that do not follow a previous neutron count in the same counter tube due to the cosmic ray shower. L is the inverse of the neutron multiplicity and serves as a proxy of the cosmic ray spectral index over the rigidity range of the NM response function. We present a comparative analysis of L from four Antarctic NM stations outfitted with special electronics to collect neutron time-delay distributions: South Pole (SP), McMurdo (MC), Jang Bogo (JB) and Mawson (MA). To first order L varies in concert with the count rate C, reflecting unrolling of the GeV-range Galactic cosmic ray (GCR) spectrum as part of solar modulation during the declining phase of solar cycle 24 and during solar minimum. We use wavelet analysis to study the periodicity of L, the count rate C, and heliospheric parameters to consider their relationship with the 27-day variations. Variation in C was much more variable over 27 days due to high-speed solar wind streams (HSSs) and corotating interaction regions (CIRs), also in strong combination with the higher harmonics, while L usually had a very weak variation. Near the solar minimum of 2019-2020, we observed essentially no 27-day variation in C. In contrast, during 2015-2016, near solar maximum, the 27-day variation in L and C was much stronger and fluctuating. Our results indicate weak GeV-range GCR spectral variation due to HSSs and CIRs, relative to the flux variation, in contrast with the strong observed spectral variation due to solar modulation. We acknowledge logistical support from Australia's Antarctic Program and support from the National Astronomical Research Institute of Thailand, grant RTA6280002 from Thailand Science Research and Innovation, and US NSF Office of Polar Programs Award No. 1341312.

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