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Earth as a giant spectrometer: neutron monitor network and latitude survey

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The Earth's magnetic field acts as a natural spectrometer for cosmic rays. Because the geomagnetic cutoff rigidity varies with geographic location, particles of different energies are selectively filtered depending on their arrival direction and the position of the observer. Space based missions such as the PAMELA (Payload for Antimatter Matter Exploration and Light-nuclei Astrophysics) satellite and Alpha Magnetic Spectrometer (AMS-02) aboard the International Space Station provide high-precision measurements of charged cosmic rays, antimatter components, and solar particles in low Earth orbit illustrating the influence of the Earth's magnetic field. Their major disadvantage is the fact that these missions cover not all cutoff rigidities for all times, so that e.g. the onset of a Solar Energetic Particle event may be missed.

The combination of high energy protons and helium can be measured by ground-based detectors, like neutron monitors. Although these detectors don't provide the energy spectra and chemical composition a network of such detectors well placed over the provides such information. E.g. Spaceship Earth is a conceptual framework that envisions our planet as a shared vessel traveling through space based on a global real time neutron monitor network, consisting of a coordinated array of neutron monitor stations distributed across a wide range of latitudes and longitudes.

To utilize the measurements of each neutron monitor the response to the primary radiation environment including the propagation in the Earth magnetic field and the interaction of the particles in the atmosphere and in the local environment producing the secondary particle environment needs to be computed. This function is known as the Yield function that can be validated or derived independently by so called latitudinal surveys. Such latitudinal surveys are performed on a vessel that travels over a wide range of geomagnetic latitudes from the equator to the poles. The validated yield functions are utilized to invert the neutron monitor network measurements to derive the proton spectra during solar energetic particle events.

Here we review the status, developments and methodology of using a global neutron monitor network to derive space environment quantities that are relevant for space weather.

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