

ANALYSIS OF GROUND LEVEL ENHANCEMENTS USING NEUTRON MONITOR DATA

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The careful study of solar energetic particle (SEP) events provides crucial information on particle scattering and transport in the interplanetary medium as well as understanding of their acceleration mechanisms. A precise analysis of SEP spectral and angular characteristics using neutron monitor (NM) data requires realistic modelling of propagation of those particles in the Earth's magnetosphere and atmosphere [1]. The spectral and angular characteristics of ground level enhancement (GLE) particles (a special class of SEPs leading to enhancement of ground based NMs), specifically using the information retrieved by ground based detectors can be derived using the relationship between the NM count rates and the primary particle flux via the NM yield function. The NM yield function considers the full complexity of particle transport in the geomagnetosphere and the atmosphere of the Earth as well as the detector response itself i.e. the NM registration efficiency and effective area. The analysis of a GLE event using NM data consists of several consecutive steps: computation of asymptotic viewing cones and rigidity cut-offs of the NMs by modelling of particle propagation in a model magnetosphere; assumption of an initial guess of the inverse problem; application of an optimization procedure (inverse method) for derivation of the primary SEPs energy spectrum, anisotropy axis direction, pitch angle distribution, details given in [2]. The method is similar to that used by [3], but using new NM yield function [4]. Here we are using the Planetocosmics code and realistic magnetospheric models, namely IGRF as the internal model and Tsyganenko 89 with the corresponding Kp index as the external one for computation of asymptotic directions. We present the derived spectral and angular characteristics of SEPs during several major GLE of the solar cycle 23 and solar cycle 24, namely the Bastille day event on 14 July 2000 (GLE 59), the GLE 69 on 20 January 2005, the GLE 70 on 13 December 2006 and the GLE 71 on 17 May 2012. The SEP spectra and pitch angle distributions were computed in their dynamical development [5]. The obtained results are briefly discussed and compared with recent and previous estimations. Possible applications related to space climate and space weather are discussed.

[1] A. Mishev and I. Usoskin, *Journal of Physics: Conference Series* 409 (2013) 012152.

[2] A. Mishev et al., *Journal of Geophysical Research* 118 (2013) 2783.

[3] J. Cramp et al., *Journal of Geophysical Research* 102 (1997) 24237.

[4] A. Mishev et al., *Journal of Geophysical Research* 119 (2014) 670.

[5] A. Mishev and I. Usoskin, *Solar Physics* 292 (2016) 1225.