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Implementation of the ground level enhancement alert software at NMDB database

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ABSTRACT

The European Commission is supporting the real-time database for high-resolution neutron monitor measurements (NMDB) as an e-Infrastructures project in the Seventh Framework Programme in the Capacities section. The realization of the NMDB will provide the opportunity for several applications most of which will be implemented in real-time. An important application will be the establishment of an Alert signal when dangerous solar particle events are heading to the Earth, resulting into a ground level enhancement (GLE) registered by neutron monitors (NMs). The cosmic ray community has been occupied with the question of establishing such an Alert for many years and recently several groups succeeded in creating a proper algorithm capable of detecting space weather threats in an off-line mode. A lot of original work has been done to this direction and every group working in this field performed routine runs for all GLE cases, resulting into statistical analyses of GLE events. The next step was to make this algorithm as accurate as possible and most importantly, working in real-time. This was achieved when, during the last GLE observed so far, a real-time GLE Alert signal was produced. In this work, the steps of this procedure as well as the functionality of this algorithm for both the scientific community and users are being discussed. Nevertheless, the transition of the Alert algorithm to the NMDB is also being discussed.

1. Introduction

Solar energetic particles (SEPs) are a manifestation of violent energy release processes occurring at the solar atmosphere, such as powerful solar flares and significant coronal mass ejections having intermediate energies ranging from 10 keV/nucl to GeV. The observations of such events may provide fundamental information on the origin, the acceleration mechanisms and the propagation processes of such particles at the Sun and the corresponding interplanetary space shocks. These dynamic processes reaching the Earth cause geomagnetic storms, heating of the upper atmosphere, changes of the electrodynamic properties of the ionosphere, and creation of the geomagnetically induced currents on the Earth surface. All these conditions of space weather change dramatically with Solar Extreme Events (SEE) development, influenced the reliability of space-born and ground-based technology systems, and endanger human health and life as well. It is of major importance to elaborate reliable methods for monitoring and forecasting dangerous space weather phenomena and to define the mechanisms of various effects. Neutron monitors and muon detectors record secondary cosmic rays created by interactions of >0.5 GeV primary cosmic rays with Earth's atmosphere. During a typical SEP event the particle flux increases up to 10–100 MeV energy range, which is insufficient to produce detection in ground level detectors. On the other hand, the most extreme SEP events provide a significant signature at ground based monitors and are defined as sudden, strong and quick enhancements in the cosmic radiation, the ground level enhancements (Fig. 1). Due to the fact that the time needed for the propagation of such SEPs (extreme and hazardous SEP events) from the Sun to the Earth depends on the energy,

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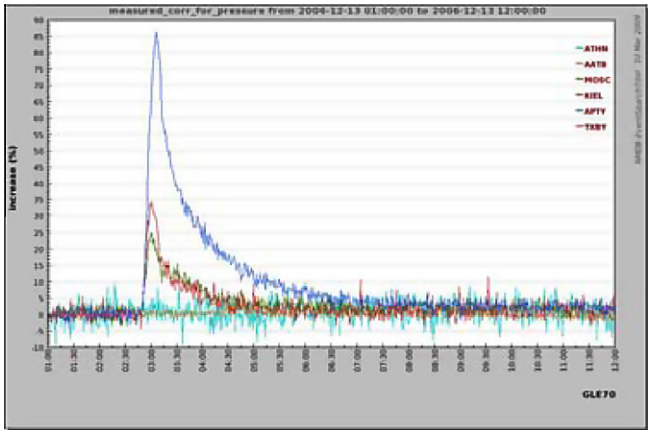

Fig. 1. GLE70 illustrated by the online user tool of NMDB; credit OBSPARIS – N. Fuller.

charged particles reaching the Earth will be recorded by NMs earlier than low-energy protons which are registered on board satellites. In addition, at higher energies the time needed in order to reach the maxima of the flux is also much shorter. Thus, GLE observations from ground based monitors make it possible to establish a warning signal on the arrival of extreme SEP events, earlier than methods based upon lower energy charged particles (Dorman and Zukerman, 2003).

2. The NMDB co-operation

The real-time database for high-resolution neutron monitor measurements (NMDB) project (www.nmdb.eu) stands for the co operation of twelve different countries within the Seventh Framework Programme of the European Commission, with the scope to create a real-time database with high resolution data (Steigies et al., 2007; Steigies, 2008). A European digital repository for cosmic ray data by pooling existing data archives and by developing a real-time database collecting observational results in the highest time resolution from as many NM stations as possible operated by European and some neighbouring countries has been set up. The central database comprises all neutron monitor data acquired in the last 50 years and new continuously updated observations from 23 NMs with 1-min and 1-h resolution, operated by the institutes that constitute the present proposal. The project will also develop some applications of the database to Space Weather tasks (Butikofer and Fluckiger, 2009; Mavromichalaki et al., 2010), e.g. estimation of radiation doses, atmosphere's ionization (Bazilevskaya et al., 2008; Usoskin et al., 2009), monitoring of the predictors of interplanetary disturbances hitting the Earth and so on.

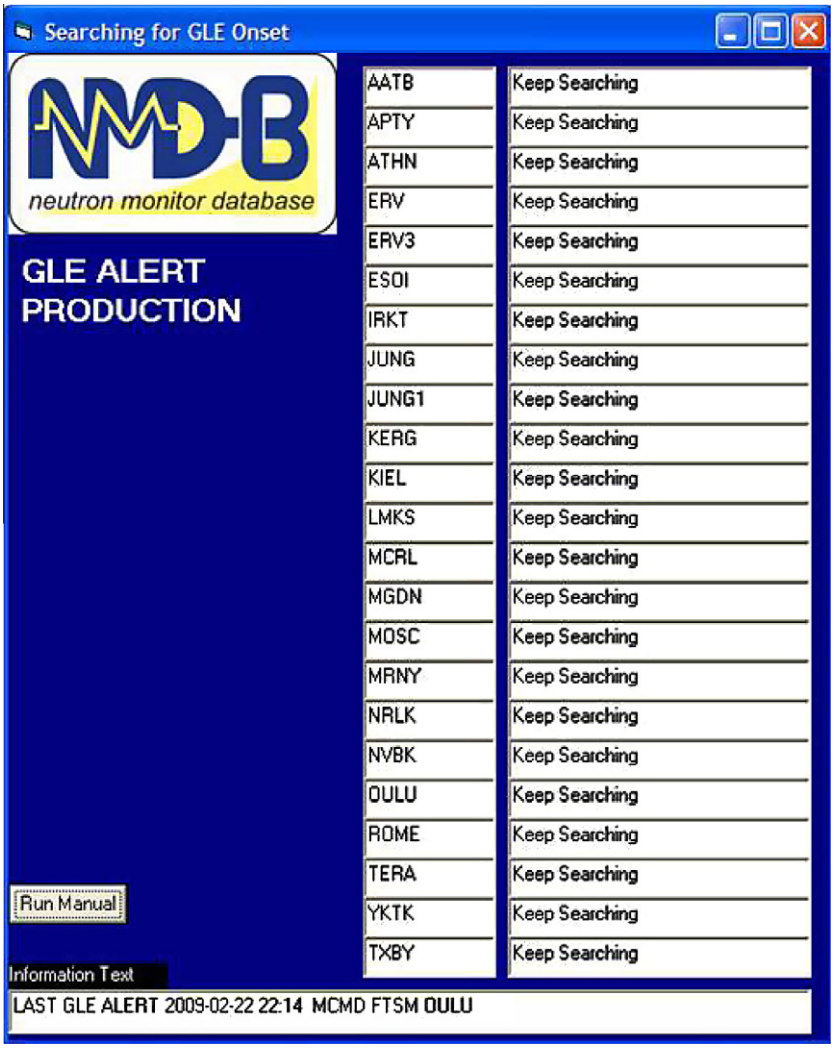

Fig. 2. GLE Alert executable searching for general GLE Alert in order to issue an alarm signal.