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ALERT SYSTEM FOR GROUND LEVEL COSMIC-RAY ENHANCEMENTS PREDICTION AT THE ATHENS NEUTRON MONITOR NETWORK IN REAL-TIME

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The prediction of solar activity is important for various technologies, including operation of low-Earth orbiting satellites, electric power transmission grids, high-frequency radio-communications etc. The Athens Neutron Monitor Network in Real Time, initiated in December 2003, provides data from twenty-one real-time neutron monitor stations, useful for real-time monitoring of cosmic particle fluxes. Recently a program for forecasting the arrival of dangerous middle energy particles on the Earth's surface has started. These program processes the data taken from the Neutron Monitor Network and informs us about the onset of ground level enhancements. In this way enough time to protect technological systems will be given.

Keywords: Proton events; Space weather forecasting; Neutron monitor network.

1. Introduction

In the form of solar wind, the Sun emits huge amounts of particles in space in a wide range of energies. The vast majority of these particles are protons, which are detected by the ground based neutron monitors together with galactic cosmic rays. Our objective here is to have an accurate and complete forecast of their arrival on Earth before it occurs, in order to take precautions. When solar energetic particles (SEP) reach the surface of the Earth, they are registered as Ground Level Enhancements (GLE) in Neutron Monitors. Their study allows us to prevent the great damage caused by lower energy particles.

2. Athens Neutron Monitor Network in real time

The Neutron Monitor Network (NMN) in Real Time of the Athens University[1] in collaboration with the cosmic ray group of IZMIRAN, has been operating since December 2003.[2]

At this moment we are in the position to collect data in real time from twenty-one real-time neutron monitor stations all over the world and store them to the main database located at the Athens server. The properties of each station along with their initialization parameters are stored in the stations properties database. Based on these data, the program constructs a global poling scheme in the form of a global configuration table GCT. Another program, called Scheduler, reads the GCT on a one-minute basis and decides if it is time for data collection. After that, a program, unique for each and every station available, initiates the collection of data. These data can be utilized in many ways such as with the creation of plots (Fig. 1).

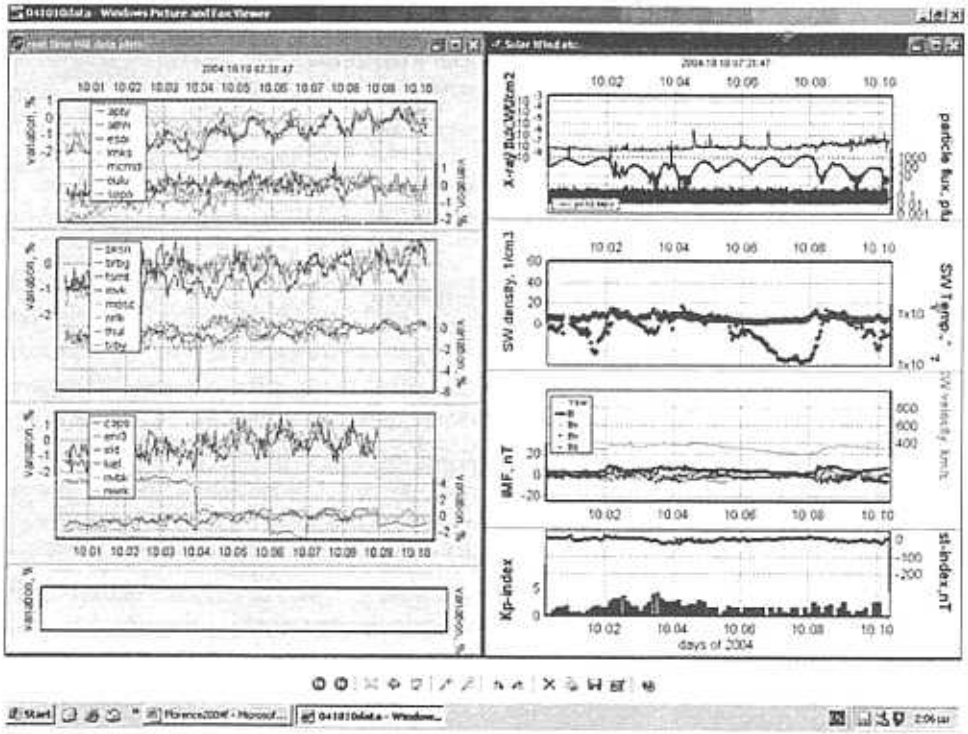

Fig. 1. Real time NM plots from the network database referenced to twenty-one real-time stations (left) and real-time data from the IMF, Kp index, solar wind speed, density and proton flux, etc (right) are presented.

3. The ALERT program

In the field of reliable space weather forecasting the data from the NMN in real time are used.[3] This work has progressed along two directions. The first one is the continuous flow of NM data from the entire planet to our system and their reliability. Every station has a program called "MONITOR". The primary goal of "MONITOR" is to check the status of the station and the conditions of the received data. If the station is not active or the data are of poor quality, "MONITOR" informs the main program (ALERT) that the referenced

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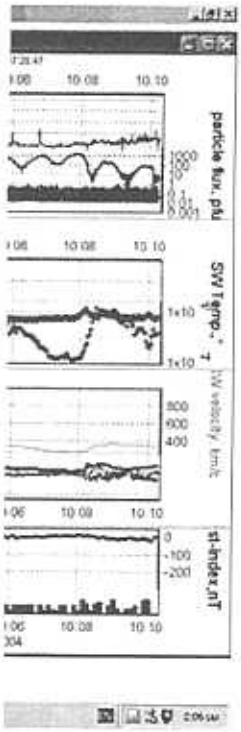

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stations should not be taken into account. Its role expands with the routines for the statistics. These are able to provide the mean values and the standard deviation of the collected data. The second one relates to the main program called "ALERT" that performs the forecast of the GLE. It presents one primary box where one can be informed for all the available data for the GLE alarm and especially, for the onset. When a GLE threat is detected, "ALERT" will show a warning in the screen and send mail to all the interested parties. The minimum requirements for successful forecast are to receive local enhancement data from at least three stations , two high latitudinal and one or two low latitudinal ones. At present, the primary condition is that the total counts of the one-minute data exceed 2.5σ during a 5-minute period, then "ALERT" is able to forecast a possible GLE.[4] Data of the X-ray band of the solar spectrum from the two geocentric satellites GOES-10 and GOES-12 are also used in the forecasting program. After that, it is possible to perform a complete real-time forecast with the minimum error considering that the X-ray data are supplementary to the NM ones. At the moment, the development of the ALERT program has been completed, and following a successful test with historical GLE data, it is time to test ALERT with real-time data from the network.[5]

4. Conclusions

Recently, an improved method for monitoring alert situations of the great solar proton events on the basis of on-line data has been applied from the Athens NMN. The developed concept and the described method derive on-line the SEP spectrum out of the magneto-sphere on the basis of continual registration of cosmic ray intensity by the ground level neutron monitors. The use of on-line data from ground level NMs together with satellite measurements allows the prediction of the SEP integral fluxes for different energies during the first 30–40 minutes of the event and the calculations of the fluency of the long duration events (up to few days).

Acknowledgements

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