Proceedings of ICRC 2001: 4099 © Copernicus Gesellschaft 2001

ICRC 2001

Athens Neutron Monitor and its aspects in the cosmic-ray variations studies

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Abstract. After many years break (since the 1978) the Athens Neutron Monitor renewed its operation due to joint efforts of Athens University (Greece) and IZMIRAN (Russia). In the present work the short history of this station and the modernization of the neutron monitor registration system, which made possible the real time presentation of current measurements in the Worldwide Network are described. The main properties and some advantages of this station in comparison with others are considered in the aspect of using its data for the Solar-Terrestrial and Space Weather studies.

1 Introduction

As it is known, the Neutron Monitor (NM) provides continuous ground based recording of the hadronic component in the atmospheric secondary radiation, which is related to primary cosmic rays. The world network of neutron monitors is a powerful tool to allow measurements of the cosmic ray spectrum down to low primary energies using the Earth's magnetic field as a spectrometer. The neutron monitor energy range is complementary to the upper range of energies measured by cosmic ray detectors flown in space. With their high counting rates neutron monitors excel at measuring the small intensity variations that occur in the galactic cosmic ray intensity at these high energies, especially when these variations are anisotropic, (Moraal et al., 2000; Simpson, 2000).

Athens Neutron Monitor (3NM-64) has worked from 1970 to 1978 and many problems had held this station out of operation for many years. Due to joint efforts of Cosmic Ray groups of Athens University (Greece) and IZMIRAN (Russia), Athens Neutron Monitor came back to the family of the Worldwide Network of Neutron Monitors from November 10, 2000 with real time presentation of current data. The renewed Athens NM corresponds to all modern requirements of data presentation, that allows the current data to be comfortable of using in different branches of the space investigation.

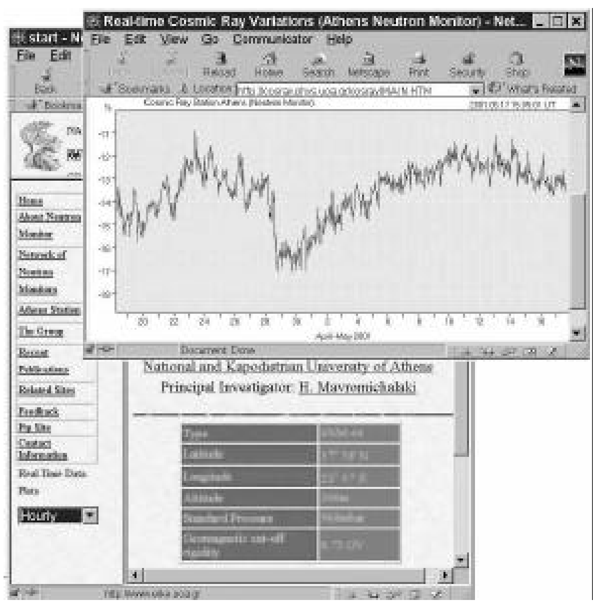

Fig. 1. Internet site of Athens Cosmic Ray Station.

The new Cosmic Ray Station is housed in a specially constructed room at the roof of Physics building at the campus of the National and Kapodistrian University of Athens at an altitude of 260m above sea level and has a vertical cut-off rigidity of 8.72 GV. It is the unique in the Balkan area and the east part of the Mediterranean Sea. The system consists of six BF_3 gas proportional counters with the enriched isotope B^{10} type BP28 Chalk River Canada. The necessity to compare a number of high rigidity stations in a good quality data is required for a detailed study of

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some kind cosmic ray variations and space weather conditions.

It is really the first low latitudinal station and the sixth among of the Worldwide NM Network able to present data in real time. The first page of Athens internet site is presented in Fig.1. (http://cosray.phys.uoa.gr). The development of this method of data presentation has many advantages to the space weather studies.

2 Data and method

The modernization of the Athens NM registration system and primary processing of experimental data in real time is very important in our days as more and more experimental data are presented in the internet in real time. A block diagram of the system is illustrated in Fig. 2, where the six separate channels are connected via specific preamplifiers and discriminators to the registration system. The registration system collects also temperature and atmospheric pressure. Plots of monthly, daily, hourly, 5- and 1-min corrected for pressure cosmic ray data are provided to the Internet via our local Web and Ftp Server

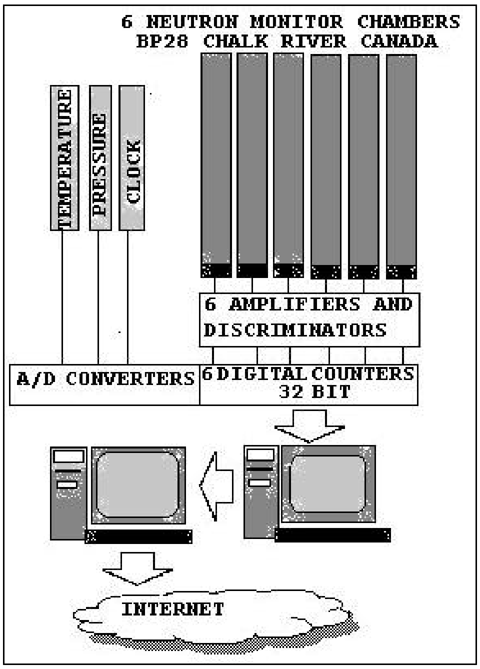

Fig. 2. The block-scheme of the Cosmic Ray Station of the University of Athens and its connection with INTERNET.

(http://cosray.phys.uoa.gr). Similar one-minute and five minute data relating to the atmospheric pressure and temperature have also been recorded. The analysis by separate counters became possible only by using of IZMIRAN experience (Belov et.al, 1999) with a processing program of the initial data and estimation the quality of these data from each channel. Along this work two Canadian preamplifiers were found to be of very unstable operating and they were replaced by the new preamplifiers produced by IZMIRAN Group. Perhaps this fact would be useful information for other responders of NM data. The real time presentation and primary processing data are very important and give the opportunity for checking the quality

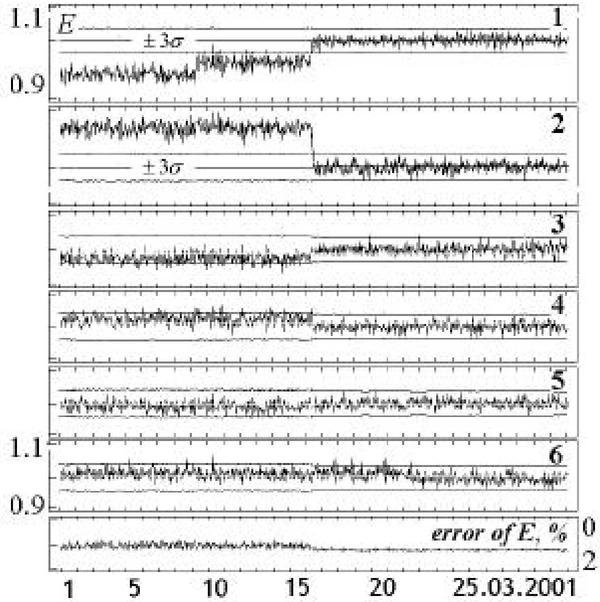

Fig. 3 An example of the channel efficiency checking the instrument variations within the March 2001. Vertical axis shows a magnitude of the efficiency for each channel in relative units.

of data, comparing directly with other stations, searching and removing of instruments variations, correction for meteorological effects. By this program we can exam automatically all channels separately and together.

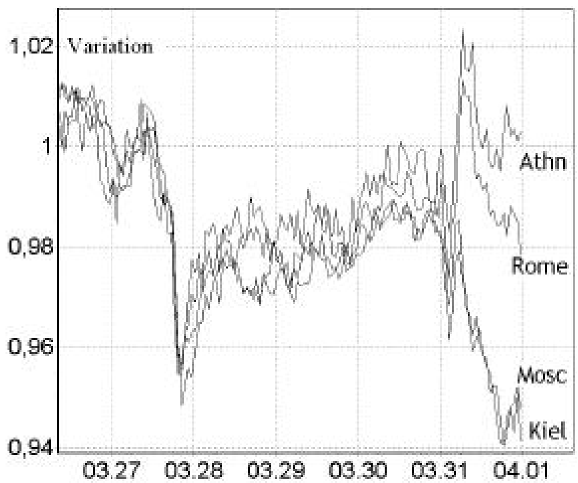

Fig. 4 Cosmic ray behavior on different neutron monitors during March-April 2001.

A special program created by IZMIRAN Group on the basis of algorithm developed in IZMIRAN also (Belov et al., 1988), allows determining efficiency for each channel selecting “out of order” channels and editing data of these channels. Besides, statistical errors of obtained characteristics for each particular channel and the whole detector are estimated. An example of such a control and checking the current data is presented in Fig.3. There was the changing of the electronic level because of the tune in two channels, that lead to the efficiency variations. But the final result did not failure after the right (automatically) processing, that we can see in Fig. 4. Moreover, the last Forbush effect occurred in the series one during this period, revealed an interesting behavior on different stations.

The procedure of data control and edition are especially important for data control publication in real time when the requirements for data quality are extremely high.

To measure atmospheric pressure the semiconductor detector MPX4115A of Motorola producing is used at Athens station. These measurements showed the good enough characteristics: high precise and stability.

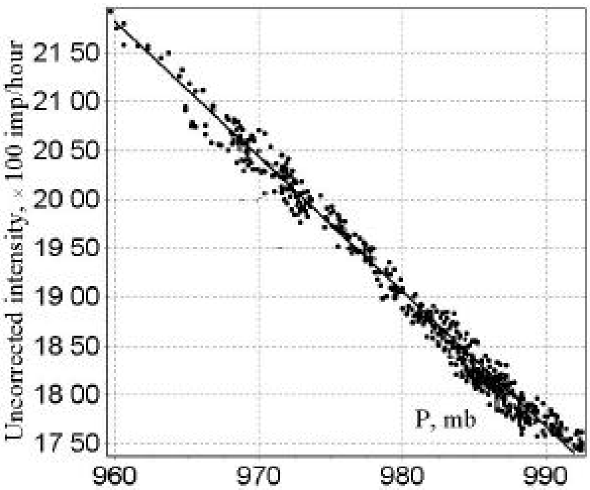

Fig. 5. Dependence of uncorrected CR intensity and atmospheric pressure P for the Athens NM.

It is well seen in Fig 5, where the correlation between neutron monitor count rate and atmospheric pressure is presented. A correlation coefficient (r =0.987) is high even without correction for the primary variations, and barometric coefficient for Athens was obtained as b = -(0.704 ± 0.012) %/mb.

3 Possibilities

The renewed Athens NM station seems to have many possibilities and can be used for scientific and educational purposes.

In Fig. 6 the position of Athens for the asymptotic directions of vertical incident CR among of some other stations of worldwide network is presented. In the combination with the high - and middle - latitude stations the study of ground level proton events (GLEs) and the selection of a solar neutron events is possible. Pyle (2000) reviewed the sensitivity of neutron monitors for solar flare neutron detection in stations of the worldwide network showing the advantage of a high geomagnetic cut-off and high altitude.

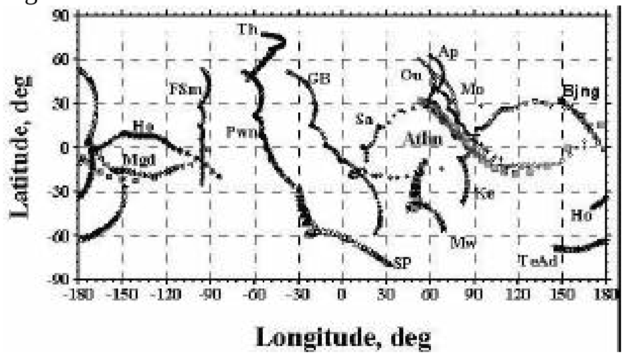

Fig. 6. Longitude-latitudinal distribution of the asymptotic directions for different stations of the worldwide network in geographic coordinate system.

This station is important for estimation solar cosmic ray spectra since its cut-off rigidity is closed to the upper energy limit of particles during the great proton flares. Frequently the upper energy of the particles of the particles accelerated at the sun is ranged within 5-10 GeV, that is very close to the minimal energy of particles recorded in Athens.

In the combination with all other NM station, using for the global survey method, the density and anisotropy of cosmic rays is possible to be derived for any moment and especially during Forbush effects.

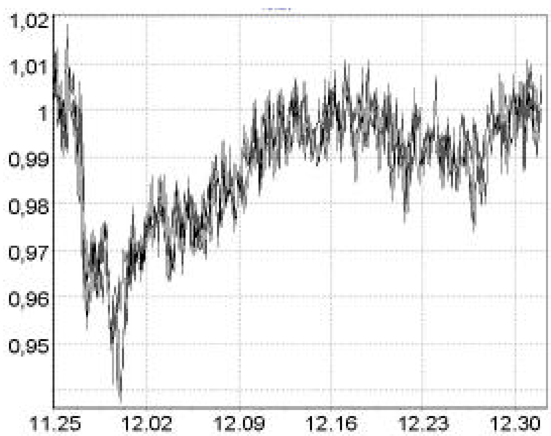

Fig. 7 November-December 2000 Forbush Effect. The neutron monitor count rate (%) is along the vertical axis.

Cosmic ray data from Athens corrected for pressure, are presented in Fig. 7 for the big Forbush event of November 26, 2000. It was the first recorded event after station renewal. Asymptotic directions of the Athens NM and some other stations of high rigidity are calculated for the start of the event (22:00 UT) and presented in Fig. 8. The similar asymptotic directions for the stations of different cutoff rigidity (Rc) (Rome, Athens, Esoi) give a chance to study really anisotropic effects in CR at this time.

The Athens NM cut-off rigidity (8.72GV) is close to Rome (s.l., 6.32GV), Beijing (s.l., 9.56GV), Erevan (2000m, 6.7GV), Tsumeb (s.l., 9.3GV), Mexico (2000m, 9.53GV), ESOI (2025m, 10GV), Tibet (4000m), Alma-Ata-B (3340m, 6.69GV) NM stations. It is useful to altitude dependence studies of high rigidity stations using them in a global spectrographic method. There are enough mountain stations of high rigidity on different altitudes, but only two (Beijing and Tsumeb) suited at sea level. Now Athens will make an essential contribution to these studies and to studies of latitudinal sea level distribution as well.

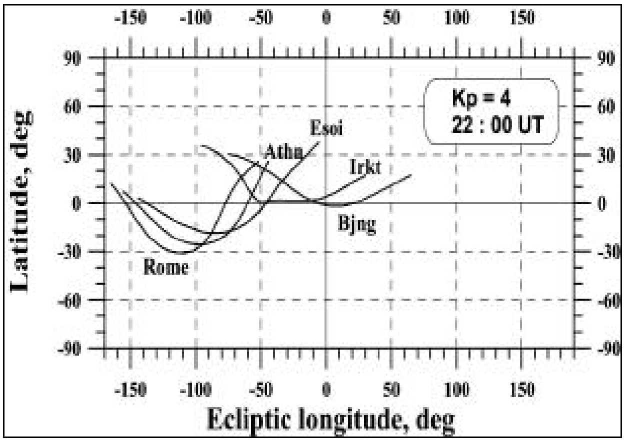

Fig. 8. Asymptotic cones of some different NM stations (Roma, ESOI, Irkutsk, Beijing and Athens) at the start of the Forbush effect of Nov.26, 2000, 22:00 UT.

The longitudinal effect is also studied along well-distributed ring by the low latitudes.

Low latitudinal stations are very important for the studying of the geomagnetic effects in CR during the strong geomagnetic storms. This is illustrated in Fig. 4, where a manifestation of such an effect is especially clearly pronounced during the last giant Forbush effect on the low latitudes at the end of March-beginning of April 2001. The unique magnetic storm of minimal Dst=-377, maximal Kp=9-**,** and daily Ap=192 occurred on the 31st of March. We see from Fig. 4 a big difference in the CR behavior on the stations with low (Moscow and Kiel) and high (Rome, Athens) cutoff rigidity. By the preliminary estimations, cutoff rigidity for the CR at the low latitudinal stations was reduced not less than on 1 GV in the maximum of this geomagnetic storm.

Obvious preference and useful application of this station may be in the use for a correction for snow effect. Since there is never being the snow, this NM avoids the false effects because the snow, which can get up to 4-5% in some others places (high latitudes, mountains). These data appear to be used (and have been used already) to correct for the snow effect data from the stations of close cut-off rigidities and longitudes.

Apart of all these aspects of this station the analysis of these cosmic ray data in real time will be useful for forecasting space phenomena dangerous on satellite electronics, as well as on people health and technology at ground level (Dorman et al., 1999). Including more NM data the "real-time" production of the CR activity indices and checking their relevance for scientific purposes related to the forecasts of Space Weather events is an interesting task in our days (Belov et al., 1995; Dorman 1995). Significant progress in identifying the relevance of CR anisotropy for Space Weather forecasts is expected to be obtained from the measurements of high latitude NM networks (Kudela et al., 2000; Bieber and Evenson, 1997).

Acknowledgements. This program has been supported by the Special Research account of the University of Athens. The work of IZMIRAN was partly supported by RFFR, grants 99-02-18003 and 01-02-17580.

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