Tendency for Relation between Rain Flows and Neutron Flux at Basic Environmental Observatory Moussala

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***Abstract*—.The recently developed at Basic Environmental Observatory Moussala lead free neutron monitor based on proportional counters type SNM-15 filled with BF_3 was used for continuous recording of neutron flux. At the same time at the observatory different measurements of atmospheric state are provided. The rain flows are recorded using automated meteo-station. A tendency for positive correlation between rain flows and neutron flux is observed. A possible explanation is discussed.**

1. Introduction

THE Basic Environmental Observatory (BEO) Moussala (Fig.1) is located on the top of the highest mountain at Balkan Peninsula, Rila mountain, namely at 2925m above sea level. Complex, high precision measurements of different atmospheric and environmental parameters are provided at the observatory. Different parameters, changes and processes in the Earth atmosphere, atmospheric physics and chemistry, aerosol physics, radiation processes are studied. At the same time different components of secondary cosmic rays, namely the atmospheric Cherenkov light, muon component, in attempt to study different problems of cosmic rays, space weather and connections of the Sun-Earth system are measured.

The detailed analyses of the collected data permits to study the possible relation between different kind of parameters and factors connected with environment, atmospheric processes and the system Sun - Earth. Generally the following specific objectives are pursued, in attempt to provide basic information for analysis of the connection between cosmic ray variation and atmospheric parameters. The aim is the detailed, precise and contemporary measurements of cosmic ray intensity especially the muon, electron, gamma and neutron component and the atmospheric Cherenkov light. Obviously, at the same time it is necessary to provide precise measurements of atmosphere parameters in different conditions.

The galactic cosmic rays, the solar cosmic rays and especially their secondaries, have different multiple effects on terrestrial processes, technological systems and human activity. The cosmic rays contributing significantly to the overall dosage are the main source of ionization. Changes in the large-scale atmospheric circulation are associated with solar activity phenomena [1] and long term cosmic ray intensity variations [2]. The possibility that galactic cosmic rays (GCR) are related to Earth's cloud cover [3, 4] and have an important impact on the Earth's climate forcing, has become a leading candidate to explain the observed sun–climate connection [5]. Currently the hypothesis of a relation between cosmic ray intensity and global cloud cover is subject of intense discussions. In this connection study of relation between rain flows and neutron flux is promising.

Fig. 1 BEO Moussala 2925 m above sea level

2. Lead Free Neutron Monitor

A neutron monitor is an instrument that measures the number of high-energy particles impacting Earth from space and provides continuous recording of the hadronic component in atmospheric secondary radiation. The purpose of the neutron monitor is to detect, deep within the atmosphere, variations of intensity in the interplanetary cosmic ray spectrum.

The introduction of the neutron monitor as a continuous recorder of the primary cosmic-ray intensity resulted from the design by Simpson [6] of a neutron monitor pile.

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In addition bare $^{10}BF_3$ counters, without lead and no moderating polyethylene cylinders are used to record thermalized low energy neutrons produced in the atmosphere and nearby matter by cosmic rays. Such type of counters are the basis for different neutron monitor configurations and lead free neutron monitor designs. Usually the response function of lead free neutron monitors shows larger sensitivity to low rigidity primary cosmic-rays from 2 to 8 GV [7].

The lead free neutron monitor at BEO Moussala (Fig.2) is mid latitude 42.11 N, mid rigidity 6.5GV and high altitude (2925m above sea level) neutron monitor. The principal aim of the device is to investigate the cosmic ray variations and to study the possible connection between cosmic ray and atmospheric processes, simultaneously with other equipment at BEO Moussala [8].

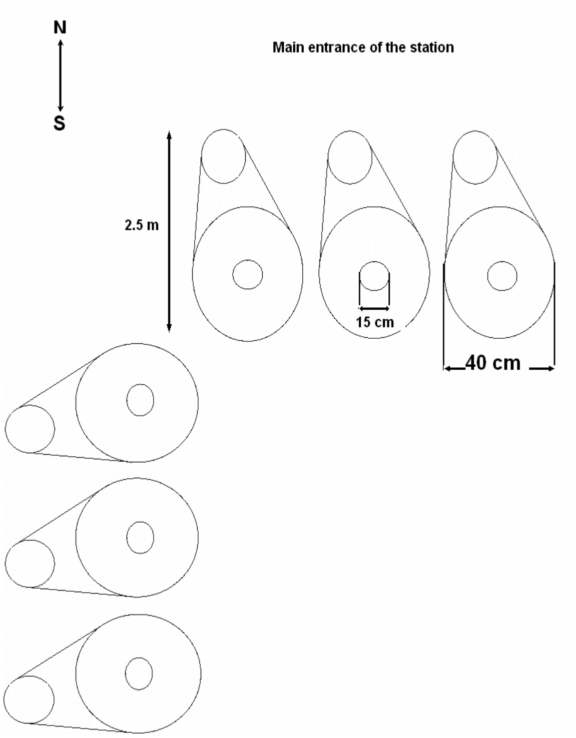

Fig. 2 Sketch of the lead free neutron monitor at BEO Moussala

3. MEASUREMENTS

In this section are described several preliminary measurements carried out with the lead free neutron monitor at BEO Moussala. The detector complex is operational since April 2007. For the analysis barometric corrected data were used. At the same time measurements of daily rain precipitations are carried out using automated meteo-station Vaisala. The results are shown in Fig.3-5.

Generally a tendency for relation between rain flows and neutron flux is observed. As example in Fig. 3 we observe a slight increase of neutron flux during the first week of April 2007. During this week the barometric pressure was with huge fluctuations. Therefore the mentioned effect is masked. At the end of the same month a significant increase of the neutron flux is observed in correlation with rain flows.

Similar effect is observed for May and July 2007. In fact we observe a tendency for increasing of counting rates of lead free neutron monitor during rain flows, because the low statistics.

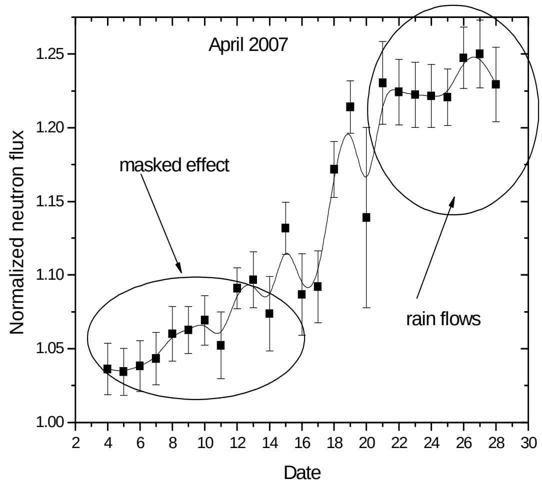

Fig. 3 Neutron flux and rain flows at Moussala for April 2007

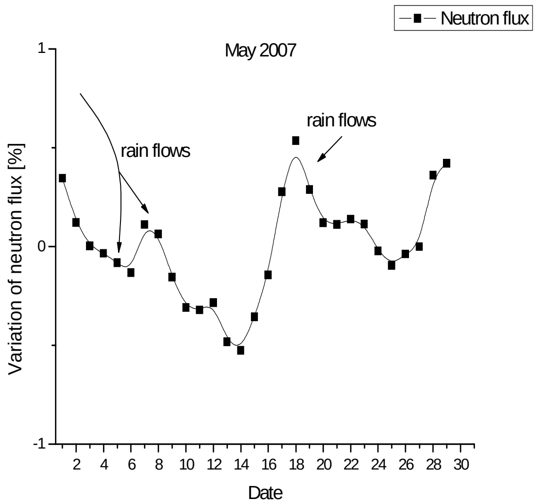

Fig. 4 Neutron flux and rain flows at Moussala for May 2007

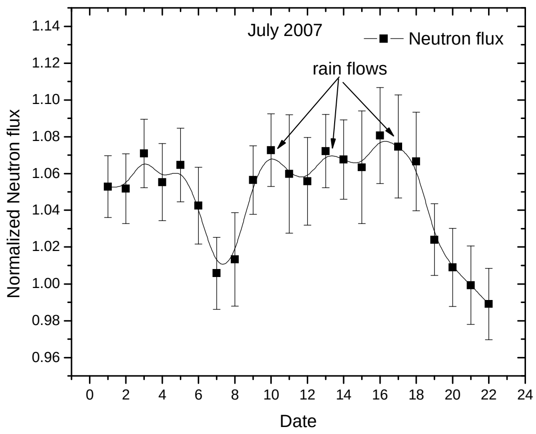

Fig. 5 Neutron flux and rain flows at Moussala for July 2007

4. DISCUSSION

The impact of the atmosphere on neutron monitor counting rates is well known. The atmospheric corrections are based on both, theoretical and experimental investigations of meteorological phenomena related to passage of particles through the atmosphere. Generally the meteorological effects are associated with changes in the air mass overburden. During stable atmospheric conditions, the barometric pressure recorded at the monitor site is related with air overburden.

At the same time in materials containing atoms of low atomic mass, neutrons of all energies can lose a significant fraction of their energy in a single elastic collision and such materials are referred to as moderators. In heavy nuclei appreciable energy loss in a collision is only possible at high energies where inelastic scattering can occur.

. Presently several arguments claim that the solar activity affects the global climate in different aspects and timescales. One possibility is based on climate response to changes in the cosmic ray flux and radiative budget. This is connected with tropospheric response to solar variability, precisely the heating of the troposphere during solar maximum. The latter is related with modulation of the large-scale tropospheric circulation systems. Additionally the stratospheric ozone plays important role on the modulation of the radiative influence of the climate. There is a general agreement that the variations of global tropospheric temperature are partly related to solar activity.

However, the problem how exactly the solar variability can influence the climate is still open.

The variations of solar and galactic cosmic rays may be responsible for the changes in the large-scale atmospheric circulation. It is possible to associate such type of phenomena with solar activity, precisely with cosmic particles of 0.1–1 GeV. Possible mechanism of cosmic ray effects on the lower atmosphere involves changes in the atmospheric transparency, which is connected with cloud cover. This is due to changes in the stratospheric ionization produced by the considered cosmic particles, during the solar cosmic ray bursts.

The dynamics of the temperature profiles, as well as the changes of other meteorological characteristics may be associated with the solar cosmic ray bursts with the particle energy E_p>90 MeV. The effect takes place within the first 10 hours after the burst and consists in the tropospheric heating and the stratospheric cooling. Therefore several mechanisms can be proposed to explain the observed tendency for relation between neutron flux and rain flows. However, taking into account that during rain flows the quantity of water in the atmosphere increases, and the moderating capabilities of the latter, the effect can be easy explained by moderation.

6. CONCLUSION

The precise measurements with lead free neutron monitor give excellent possibility to understand the role of cosmic ray variation on the Earth climate, and to check different mechanisms of such type of influence. Moreover this gives the possibility to check different proposed models from an experimental point of view.

This permits to study the influence of galactic cosmic rays on the solar radiation input to the lower atmosphere, especially increases of the total radiation fluxes associated with Forbush-decreases in the galactic cosmic rays, the possible influence of different helio- and geophysical factors such as solar flares, galactic cosmic ray variations, auroral phenomena on the solar radiation input to the lower atmosphere, as well as the latitudinal dependence of such effects. The recently observed tendency for increasing of lead free neutron monitor counting rates during rain precipitation is explained by moderating effects.

ACKNOWLEDGMENT

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