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27-Day Variations in Cosmic Rays During the Ascending and Descending Phase of the 24th Solar Activity Cycle

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ABSTRACT

Based on the study of the 27-day variations of the neutron component of cosmic rays at two stations of the Global Cosmic Ray Network (Moscow and Yakutsk) and the Tbilisi Cosmophysical Observatory in the ascending and descending phases of the 24th cycle of solar activity, it has been established that the 27-day variation profile describes a quasi-sinusoidal curve. The deviation from the sinusoidal curve is determined by the change in the number, coordinates and power of sunspots (2.2 in the ascending phase and 81.8 in the descending phase) in a given phase of solar activity.

Key Words: *Cosmic ray 27- day variations, Solar Cycle, Bartels Rotation Number, Carrington Rotation Number, Solar Activity ascending & descending phase, World -Wide Network of cosmic ray neutron monitors, quasisinusiudal curve.*

1. Introduction

The article discusses the daily data of the intensity of the neutron component of cosmic rays, corrected for the effect of atmospheric pressure, registered by the Tbilisi CosmoPhysical Complex and two stations of the World Network of Cosmic Rays, Moscow and Yakutsk, and studies the 27-day variations of the neutron component of cosmic rays, in the case of the ascending and descending phases of the 24th cycle of solar activity.

2. Materials and Methods,

The last completed 24-day solar cycle began in December 2008, with a mini-mum corrected sunspot number of 2.2 [1] and ended in December 2019. Activity was minimal until early 2010. [2] [3]. Activity reached its maximum in April 2014 with a 23 months smoothed sunspot numbers of 81.8 [4]
To study the 27-day variations of cosmic rays, the starting points of the Carrington rotation were chosen as the reference point in time.

Based on the acquisition, processing and analysis of daily data on the intensity of cosmic rays registered by the Tbilisi Cosmophysical Observatory and neutron monitors of two stations of the World Network of Cosmic Rays, Moscow and Yakutsk, verified at atmospheric pressure, the solar activity was studied during the ascending and descending phases of the last completed 24 cycles. The ascending phase of the 24-cycle solar activity was located in the time interval from December 17, 2008 to December 02, 2012, The descending phase of the 24-cycle solar activity was located in the time interval from April 7, 2014 to December 10, 2019.

a. For the stations of the World Wide Web, Moscow and Yakutsk

Accordingly, to study the 27-day variations of cosmic rays, 53 Carrington rotations corresponding to 53 rotations of the Sun around its own axis of rotation, in the ascending phase of the 24th cycle of solar activity, were considered separately, Similarly, 76 Carrington rotations corresponding to 76 rotations of the Sun around its own axis of rotation, in the descending phase of the 24th cycle of solar activity, were also considered separately. Thus, the 27-day variations in the intensity of the neutron component of cosmic rays registered by the World Cosmic Ray Network are described by 53 separate Carrington rotations during the ascending phase of the 24th solar cycle, and by 76 separate Carrington rotations during the descending phase of the 24th solar cycle.

b. For the Tbilisi Cosmo Physical Complex

The 27-day variations of the neutron component of cosmic rays registered by the Tbilisi Cosmo-physical Observatory, since December 2009, are described by 41 separately taken Carrington rotations, during the ascending phase of the 24-th cycle of solar activity, and by 76 separately taken Carrington rotations during the descending phase of the 24-th cycle of solar activity. The data of the Cosmic Rays Laboratory are posted at the newly created web address: http://cosmicrays.tbilisi.com/

2. Methods for detecting recurring and non-periodic dependencies:

epoch superposition method

Small effects of influence can be detected using a special method of averaging data values, which was originally used in the study of geomagnetic variations [5] and which is known as the method of superposition of epochs, or the Kri method. Suppose that n events have been observed, during which the effect of a certain influence on cosmic rays should be studied. For the beginning of each of these events, we record the numerical values of the cosmic ray intensity in the corresponding cells of the horizontal rows forming a vertical column. And we assign such a vertical column the corresponding number at the beginning of the count. The corresponding values for moments after zero time are recorded in the vertical columns with the next ordinal number. Thus, we fill in a total of 27 columns in order to detect a 27-day cycle. And we calculate the average of the values recorded in the horizontal rows within each column [5-20].

Solar rotation is the rotation of the Sun around its axis.

The Sun is not a solid body, but rather consists of a gaseous plasma, and rotates with different periods at different latitudes. The solar rotation period is 25.67 days at the equator and increases with latitude, reaching 33.40 days at 75 degrees latitude [5]. The source of this differential rotation is an ongoing area of research in solar astronomy.[5]

Carrington rotation

The Carrington rotation is a system for comparing the positions of the Sun over a period of time, allowing the tracking of sunspot groups or the reappearance of flares at a later time. Since the rotation of the Sun varies with latitude, depth, and time, any such system is necessarily arbitrary and makes comparisons only meaningful over moderate periods. For the purposes of the

Carrington rotations, the solar rotation is taken to be 27.2753 days (see below). Under this scheme, each rotation of the Sun is assigned a unique number, called the Carrington rotation number, starting on November 9, 1853.

To study the 27-day variations in cosmic rays, the letters of the beginning of the Carrington rotation were chosen as the reference point in time.

The starting date for using the World Wide Web of Cosmic Rays data for the ascending phase of the 24^{-th} cycle of solar activity was December 17, 2008, which corresponds to the beginning of the 2078^{-th} Carrington rotation, and the final date for using the World Wide Web of Cosmic Rays data was December 02, 2012, which corresponds to the end of the 2131st Carrington rotation.

Thus, a total of CR2131 – CR 2078 = 53 Carrington rotations (CR) were considered for studying the ascending phase of the 24-th cycle of solar activity.

The starting date for using the World Wide Web of Cosmic Rays data in the descending phase of the 24-th cycle of solar activity was April 7, 2014, corresponding to the beginning of the Carrington rotation CR 2149, and the final date for using the World Wide Web of Cosmic Rays data was December 2, 2019, corresponding to the end of the Carrington rotation 2225. Thus, a total of CR 2225 – CR 2149 = 76 Carrington rotations (CR) were considered to study the descending phase of the 24-th cycle of solar activity.

3. Results

a)

Results for two stations of the World Wide Web, Moscow and Yakutsk

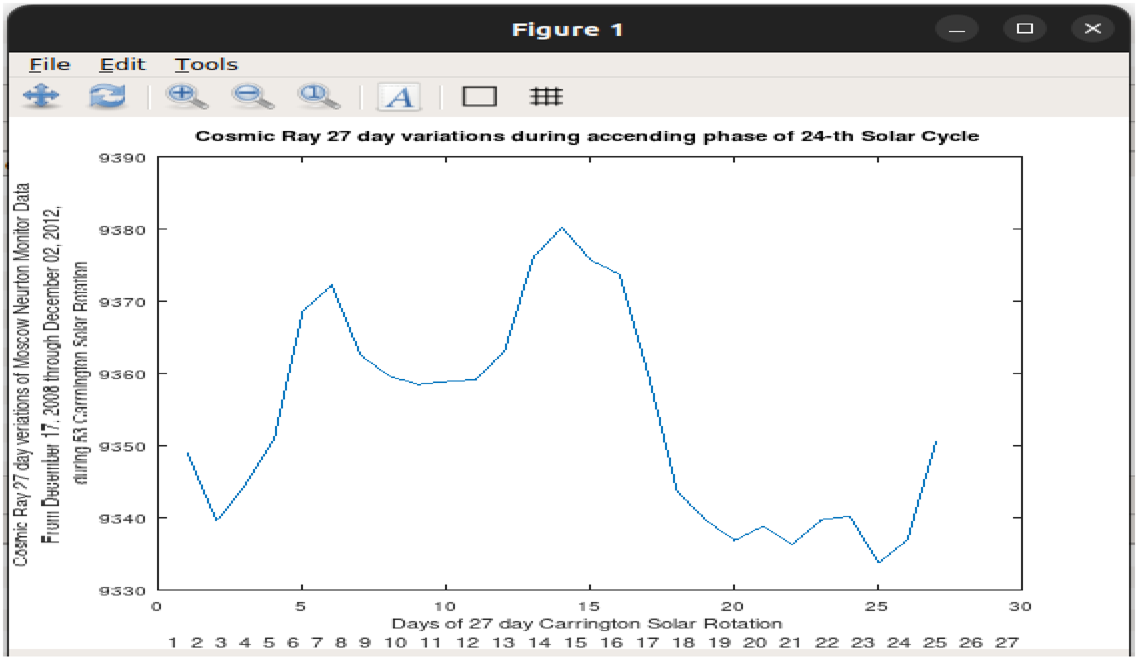


Fig. 1. Solar Activity Ascending phase, Moscow

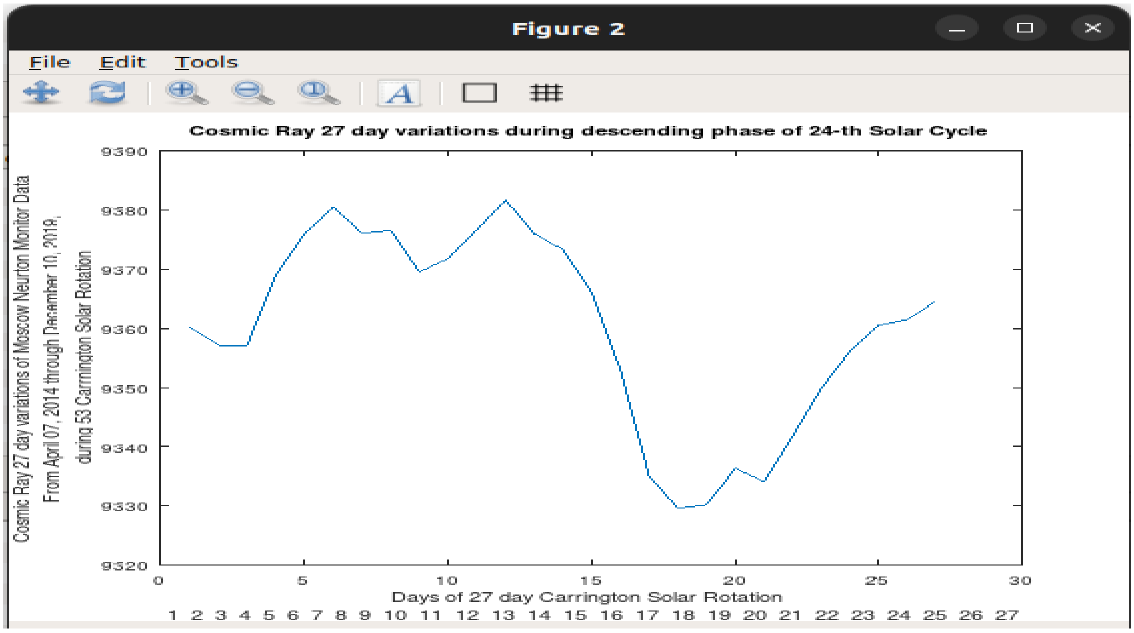
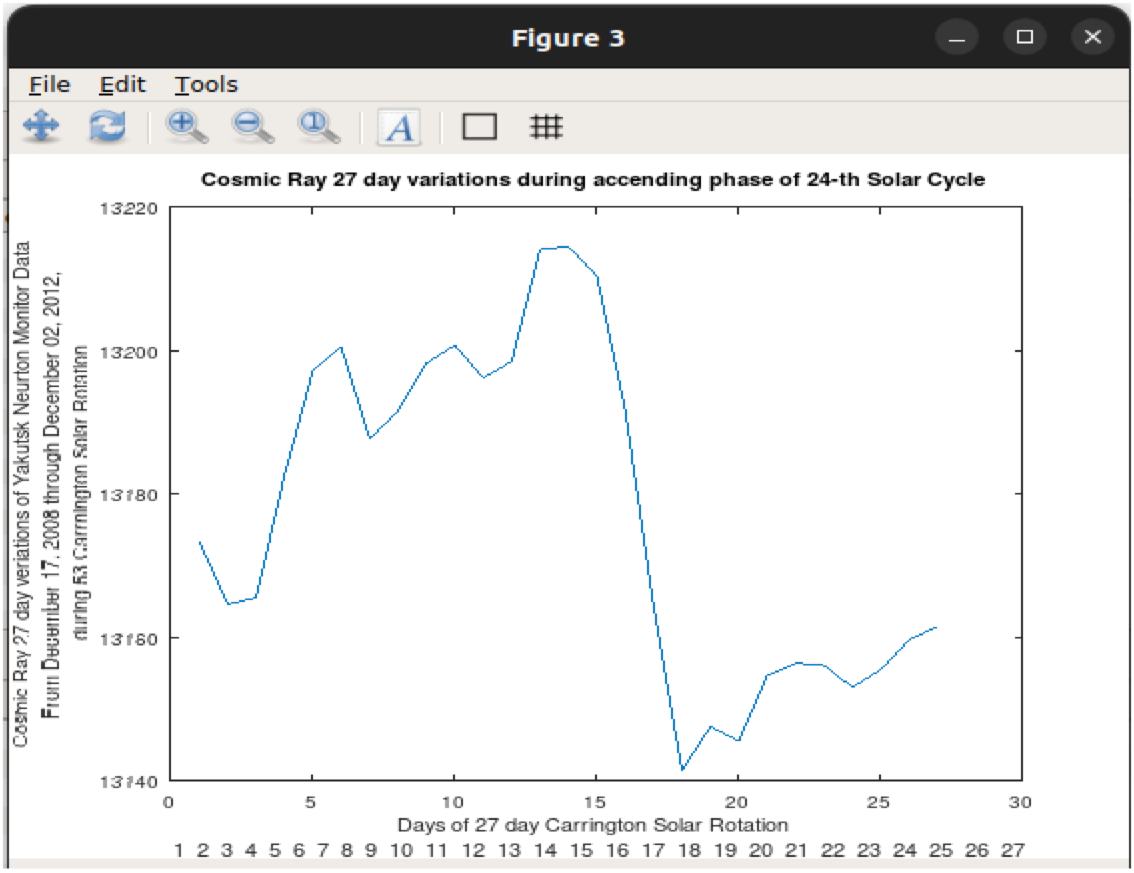


Fig. 2. Solar Activity Descending phase, Moscow



3. Solar Activity Ascending phase, Yakutsk.

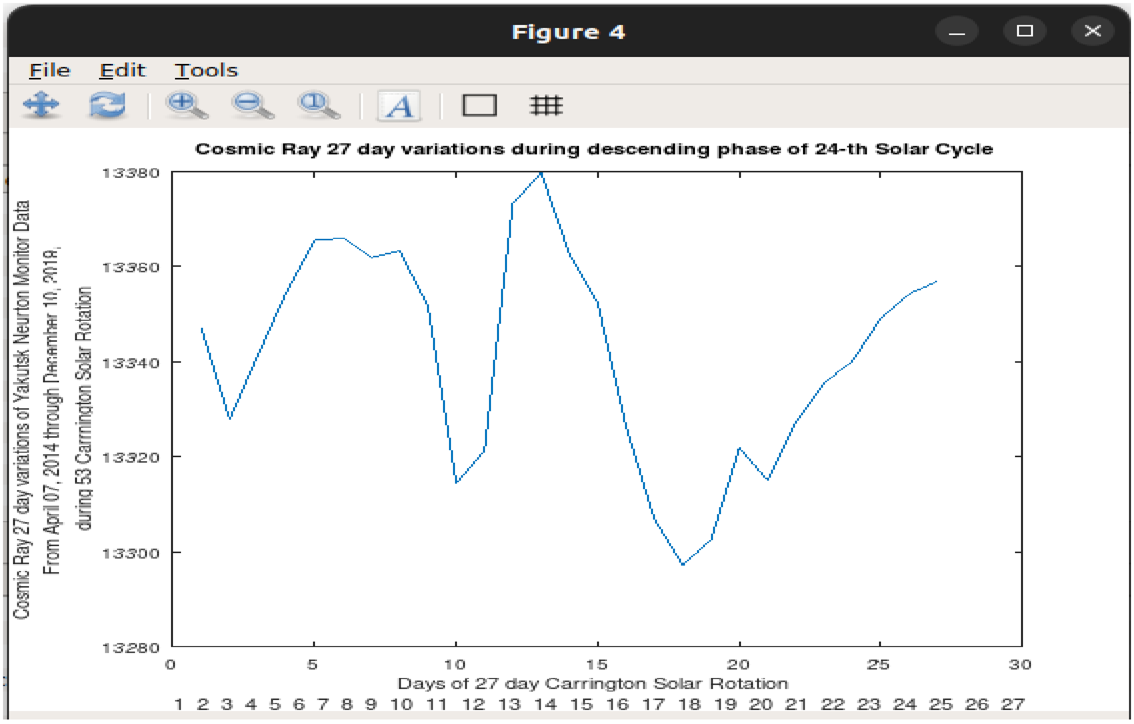


Fig. 4. Solar Activity Descending phase, Yakutsk.

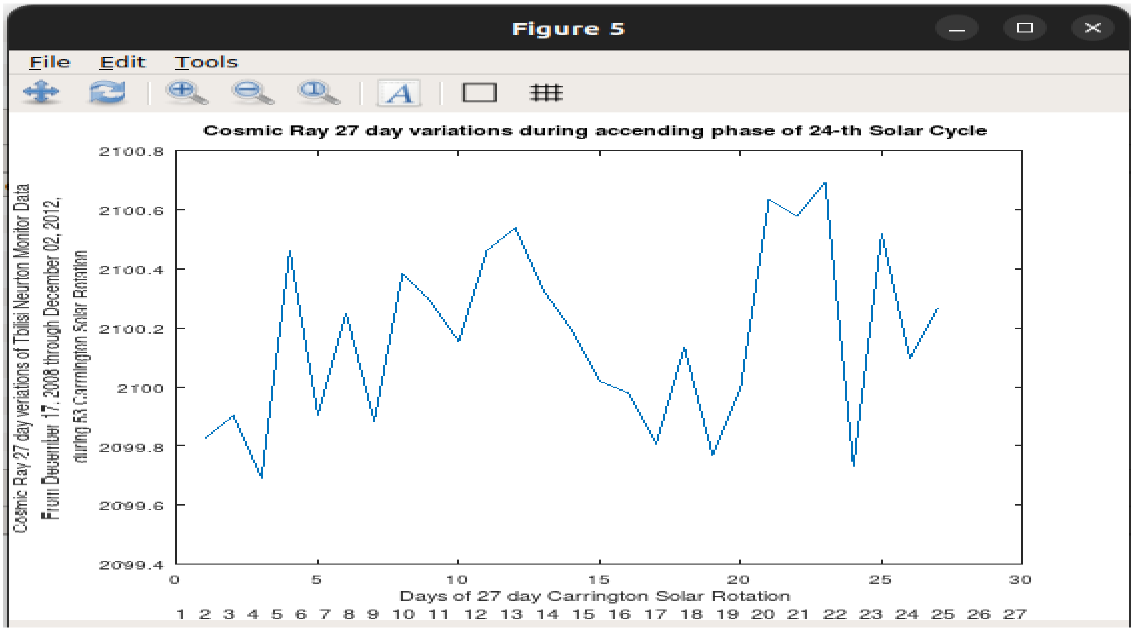


Fig. 5. Solar Activity Ascending phase, Tbilisi.

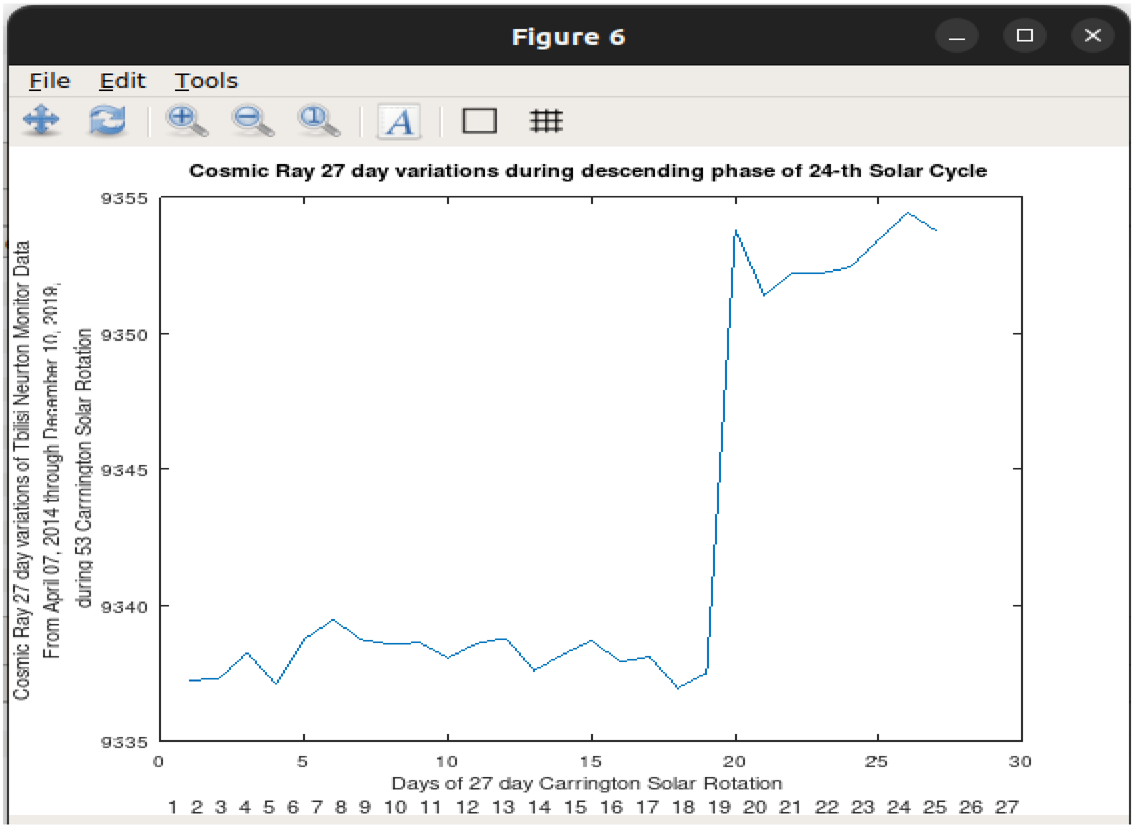


Fig. 6. Descending phase, Tbilisi

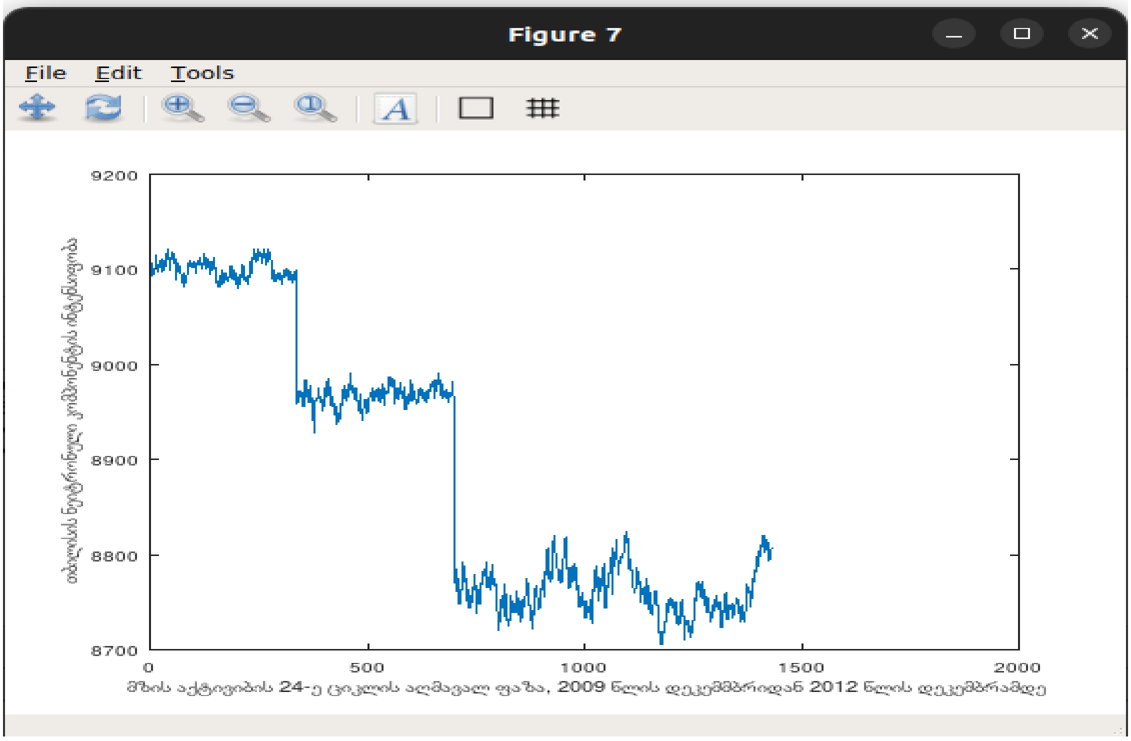


Fig. 7. Tbilisi Neutron Monitor intensity change during the ascending phase of the 24-cycle solar activity, from 2009 to 2012

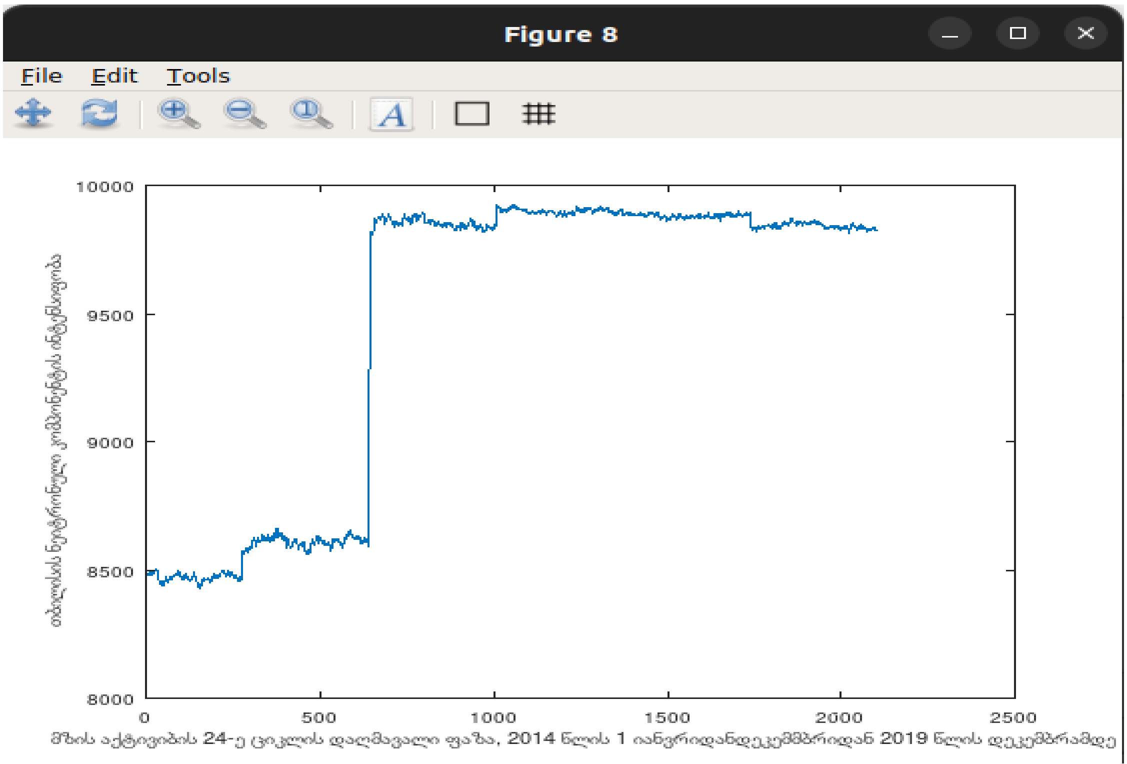


Fig. 8. Tbilisi Neutron Monitor intensity change during the declining phase of the 24-cycle solar activity, from 2014 to 2019.

4. Discussion

The 27-day variations of the Neutron Monitor of the World Wide Web (Moscow and Yakutsk) show that the 27-day variation profile describes a quasi-sinusoidal curve (Fig. 1, Fig. 2, Fig. 3, Fig. 4). The difference between the quasi-sinusoidal profiles in the rising and falling phases should be caused by different sunspots in the rising and falling phases. The 27-day variation profile of the Tbilisi Neutron Monitor does not describe a quasisinusoidal curve (Fig. 5, Fig. 6), which can be explained by the variation pro- file of the hourly intensity data of the Tbilisi Neutron Monitor (Fig. 7, Fig. 8).

5. Conclusion

The 27-day variation profile of the neutron component of cosmic rays is described by a quasi-sinusoidal curve, and the deviation from the sinusoidal curve is caused by the coordinates and strength of sunspots.

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კოსმოსური სხივების 27-დღიანი ვარიაციები მზის აქტივობის 24-ე ციკლის აღმავალ და დაღმავალ ფაზაში

გ. ვანიშვილი, თ. ბაქრაძე, ე. ალანია, ტ. ერქომაიშვილი, ვ. ყავლაშვილი, მ. ღუღუნაშვილი, ო. ხაჯიშვილი

რეზიუმე

მზის აქტივობის 24-ე ციკლის აღმავალ და დაღმავალ ფაზაში, კოსმოსური სხივების მსოფლიო ქსელის ორი (მოსკოვი და იაკუტსკი) სადგურის და თბილისის კოსმოფიზიკური ობსერვატორიის, კოსმოსური სხივების ნეიტრო- ნული კომპონენტის, 27 -დღიანი ვარიაციების შესწავლის საფუძველზე დადგენილია, რომ 27-დღიანი ვარიაციის პროფილი აღწერს კვაზისინუსოი- იდას. სინუსოიდალური წირიდან გადახრა განისაზღვრება მზის აქტივობის მოცემულ ფაზაში მზის ლაქების (2.2 აღმავალ ფაზაში და 81.8 დაღმავალ ფაზაში) რიცხვის, კოორდინატებისა და სიმძლავრის ცვლილების მიხედვით.

საკვანძო სიტყვები: კოსმოსური სხივების 27-დღიანი ვარიაციები, მზის ციკლი, ბარტელის ბრუნვის რიცხვი, კარინგტონის ბრუნვის რიცხვი, მზის აქტივობის აღმავალი და დაღმავალი ფაზები, კოსმოსური სხივების ნეიტრონული მონიტორების მსოფლიო ქსელი, კვაზი-სინუსოიდური მრუდი.

27-дневные вариации космических лучей в восходящей и нисходящей фазах 24-го цикла солнечной активности

Г. Ванишвили, Т. Бакрадзе, Е. Алания, Т. Эркомаишвили, В. Кавлашвили, М. Гугунашвили, О. Хаджишвили

Резюме

На основе исследования 27-дневных вариаций нейтронной компоненты космических лучей в восходящей и нисходящей фазе 24-го цикла солнечной активности на двух станциях Глобальной сети космических лучей (Москва и Якутск) и Тбилисской космофизической обсерватории установлено, что профиль 27-дневных вариаций описывает квазисинусоидальную кривую. Отклонение от синусоидальной кривой определяется изменением числа, координат и интенсивности солнечных пятен (2,2 в восходящей фазе и 81,8 в нисходящей фазе) в течение данной фазы солнечной активности.

Ключевые слова: 27-дневные вариации космических лучей, солнечный цикл, число вращения Бартельса, число вращения Каррингтона, восходящая и нисходящая фазы солнечной активности, всемирная сеть мониторов нейтронов космических лучей, квазисинусоидальная кривая.