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INFLUENCE OF VARIATIONS OF THE ANNUAL INTENSITY OF GALACTIC COSMIC RAYS ON THE MORTALITY OF THE POPULATION OF GEORGIA

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Summary: *Results of study of influence of variations of the annual intensity of neutron component of galactic cosmic rays on the mortality of the population of Georgia in 1995-2014 are presented. In particular, the previously obtained results on a direct correlation between the intensity of cosmic rays and total mortality of the population have been confirmed. However, as it turned out, an increase in the intensity of cosmic rays mainly increases the mortality rate of the male part of the population of Georgia. The mortality rate of women is very weakly dependent to the galactic cosmic rays influence.*

Key words**:** *galactic cosmic rays, mortality, ecology, bioclimatology, medical meteorology.*

Introduction

Research into the effect of cosmic rays on human health is being carried out in various countries [1-4], including Georgia [5-7]. In this work are presented the results of a study of the effect of the annual changeability of neutron component of galactic cosmic rays intensity on the mortality of the population of Georgia in 1995-2015.

Material and methods

In the work are used the data of National Statistics Office of Georgia about the total, male and female annual mortalities of the population of Georgia normalized to 1000 inhabitants [https://www.geostat.ge/en]. Information about mean annual values of intensity of neutron component of galactic cosmic rays (CR, impulse/min) is obtained at the Cosmic Rays Observatory of M. Nodia Institute of Geophysics [http://cr0.izmiran.ru/tbls/main.htm]. The observation period is 1995-2014.

In the proposed work the analysis of data is carried out with the use of the standard statistical analysis methods of random events and mathematical statistic methods for the non accidental time-series of observations [8].

The following designations will be used below: Min – minimal values, Max - maximal values, St Dev- standard deviation, R - coefficient of linear correlation, R^2 –coefficient of determination, K_{DW} – Durbin-Watson statistic, α - the level of significance (for significant correlation and regression ratios, the α value is not worse than 0.15). Res – residual component, Real - measured data.

The curve of trend is equation of the regression of the connection of the investigated parameter with the time at the significant value of the determination coefficient and such values of KDW, where the residual values are accidental. Background component is usually entered into the curve of trend. The value of

background component is most frequently unknown. From the physical considerations, random component can be represented in the form: Rand = Res + absolute value of the min value of Res. In this case random components have positive values with the minimum value = 0 (if there would be known the value of background component, that min Rand will be = Back). Accordingly, Trend + Back (sum of the trend and background components of time series) will be curve of equation of the regression of the connection of the investigated parameter with the time minus absolute value of the min value of Res. So, Real = (Trend + Back) + Res.

M_Total, M_Male and M_Female – total, male and female annual mortalities in Georgia normalized to 1000 inhabitants. ΔM_Total, ΔM_Male - growth of the annual total and male mortality with a change of the intensity of cosmic rays within the variation scope (max - min). The dimensions of the investigation parameters are omitted below.

Results

Results in table 1 and fig. 1-7 are presented.

Table 1. Statistical characteristics and trends types of CR, M_Total, M_Male and M_Female in Georgia in 1995-2014.

Variable	CR	M_Total	M_Male	M_Female
Max	9100	13.49	7.14	6.52
Min	8396	10.57	5.28	5.28
Mean	8763	12.33	6.27	6.06
St Dev	201	0.94	0.64	0.36
Cv, %	2.3	7.7	10.2	5.9
Trend type	Fifth order polynomial	Fourth order polynomial	Fifth order polynomial	Fifth order polynomial
R^2	0.78	0.98	0.97	0.92
K_{dw}	2.13	2.02	1.71	1.77

In table 1 the data about statistical characteristics and trends types of cosmic rays intensity and mortality (M_Total, M_Male and M_Female) in Georgia in 1995-2014 are presented. As follows from this table, the values of CR varied from 8396 up to 9100 (average = 8763), values of M_Total – from 10.57 up to 13.49 (average = 12.33), values of M_Male – from 5.28 up to 7.14 (average = 6.27) and M_Female - from 5.28 up to 6.52 (average = 6.06). Trends of CR, M_Male, and M_Female take the form of fifth power polynomials, trend of M_Total - fourth power polynomial (corresponding values of R^2 - $\alpha < 0.005$, and KDW - $\alpha = 0.05$).

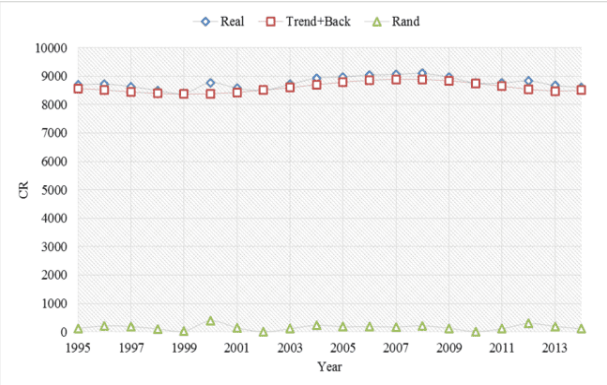

Fig. 1. Trend of the mean annual intensity of galactic cosmic rays in Tbilisi in 1995-2014.

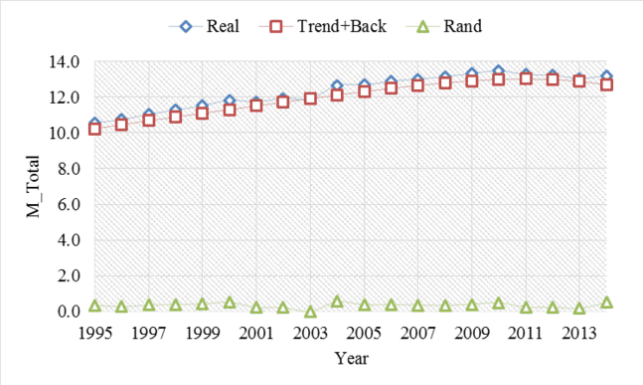

Fig. 2. Trend of the annual total population mortality in Georgia in 1995-2014.

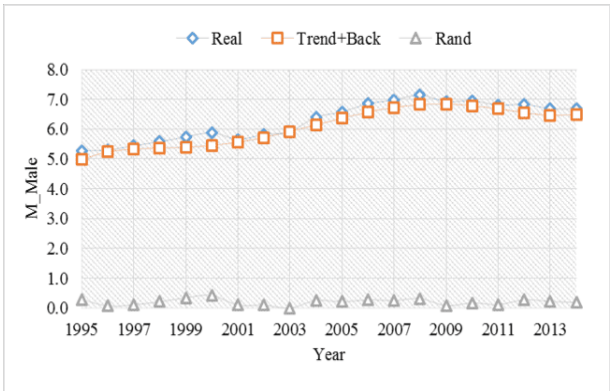

Fig. 3. Trend of the annual male mortality in Georgia in 1995-2014.

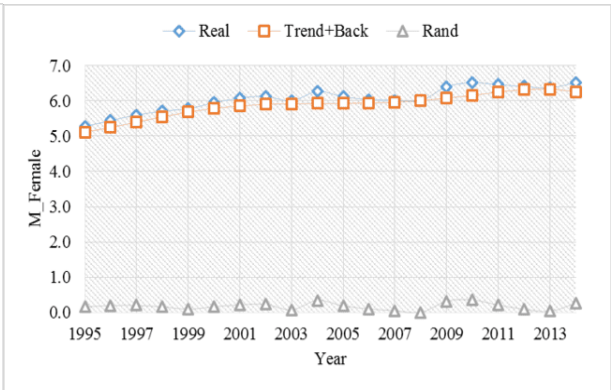

Fig. 4. Trend of the annual female mortality in Georgia in 1995-2014.

For the clarity in fig. 1-4 are presented the curves of real data, (trend+ background) and random components of time-series of mean annual intensity of galactic cosmic rays, annual total population mortality, as well as male and female annual mortalities in Georgia in 1995-2014.

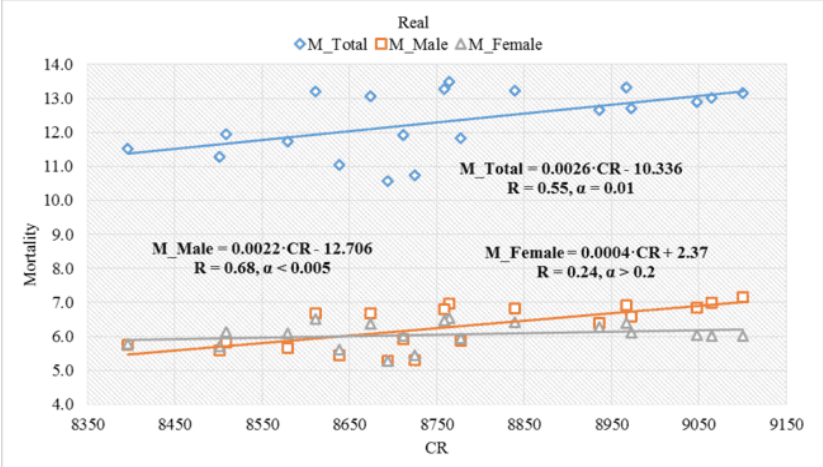

Fig. 5. Linear correlation and regression between annual cosmic ray intensity and total, male and female mortalities in Georgia (real data).

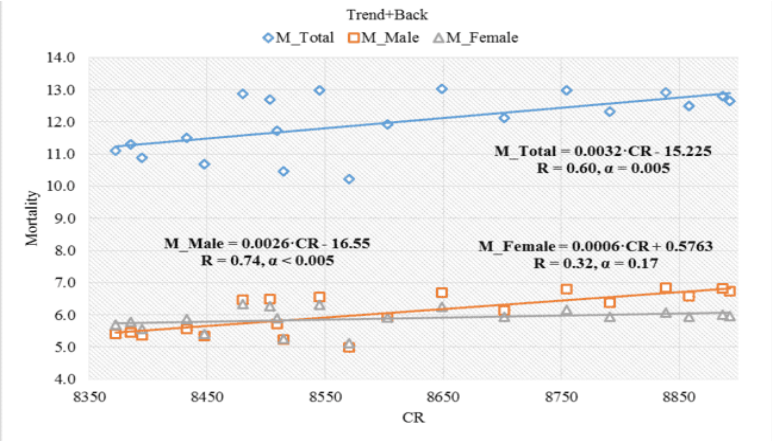

Fig. 6. Linear correlation and regression between annual cosmic ray intensity and total, male and female mortalities in Georgia (trend+ background components).

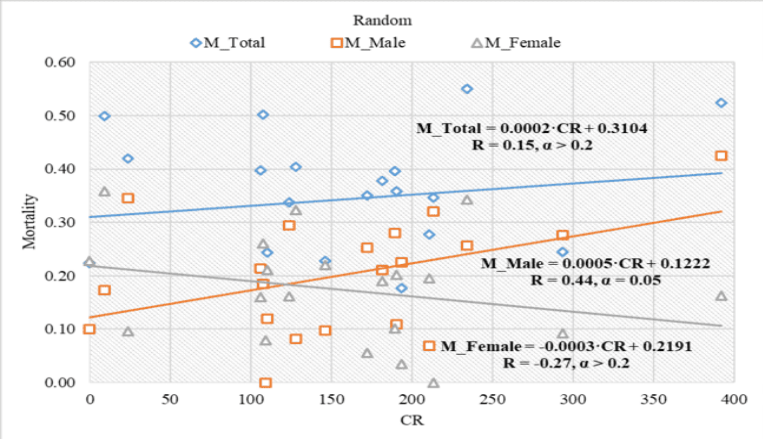

Fig. 7. Linear correlation and regression between annual cosmic ray intensity and total, male and female mortalities in Georgia (random components).

In fig. 5-7 data about linear correlation and regression between annual cosmic ray intensity and total, male and female mortalities in Georgia are presented: fig. 5 – for real data, fig. 6 - for trend+ background components, fig. 7 – for random components. As follows from fig. 5 and 6 a significant positive linear correlation and regression is observed between the CR and M_Total for real data and for trend + background components ($R = 0.55$, $\Delta M\_Total = 1.83$ and $R = 0.60$, $\Delta M\_Total = 1.76$, respectively; $\alpha \leq 0.01$). In all cases, a significant positive linear correlation and regression is observed between the intensity of galactic cosmic rays and the male mortality of the population of Georgia (fig. 5-7. $R = 0.68$, $\Delta M\_Male = 1.55$; $R = 0.74$, $\Delta M\_Male = 1.43$; $R = 0.44$, $\Delta M\_Male = 0.28$, respectively; $\alpha < 0.05$). Simultaneously the mortality rate of women is very weakly dependent to the galactic cosmic rays influence (fig. 5-7, $R = 0.24$, 0.32 and -0.27 respectively; $\alpha \geq 0.17$, few significant correlation).

Conclusion. In the future, we plan to carry out these studies, taking into account the age of the population of Georgia.

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