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Effect of Mean Annual Changeability of Air Temperature, Surface Ozone Concentration and Galactic Cosmic Rays Intensity on the Mortality of Tbilisi City Population

[1]Avtandil G. Amiranashvili, [1]Teimuraz S. Bakradze,
[2]Nino T. Berianidze, [3]Nino D. Japaridze, [3, 4]Ketevan R. Khazaradze

[1]M. Nodia Institute of Geophysics of I. Javakhishvili Tbilisi State University, e-mail:
avtandilamiranashvili@gmail.com
[2]National Science Library of Georgia
[3]Ministry of Labor, Health and Social Affair of Georgia
[4]Georgian State Teaching University of Physical Education and Sport

ABSTRACT

The results of a study of the effect of the annual changeability of air temperature, surface ozone concentration and neutron component of galactic cosmic rays intensity on the mortality of the population of Tbilisi city in 1984-2010 are presented. The statistical characteristics of the investigated time-series are studied. In particular, it was found that within the variation range the contribution of the studied parameters to mortality variability is as follows: a random component of air temperature - 8.5%, real values of surface ozone concentration and cosmic ray intensity - 20.9% and 16.5%, respectively.

Key Words: Air temperature, surface ozone concentration, galactic cosmic rays, mortality, ecology, bioclimatology, medical meteorology.

Introduction

The meteorological, biometeorological, bioclimatic, geophysical and other parameters, which sufficiently affect the human beings, are the followings.

Separate meteorological and geophysical elements, space weather parameters and its combinations: air temperature [1-10], humidity, wind speed, atmospheric pressure, solar activity (Wolf's number), the geomagnetic fields, solar radiation, the cosmic rays [11-18], light ions, aerosols, ozone, other air toxic admixtures and etc. [19-26].

Different simple thermal indices involve more than one climatological parameter and consider the combined effects (air equivalent- effective temperature EET, Equivalent temperature (TEK), Wet-bulb-globe temperature (WBGT), Tourism Climate Index (TCI) [27-32]) and others.

The indices derived from energy budget models:

Physiologically Equivalent Temperature (PET), Standard Effective Temperature (SET), Physiological Subjective Temperature and Subjective Temperature (MENEX), the Universal Thermal Climate Index (UTCI) etc. [30, 33-36]).

Generally, the human's health is primarily affected by the lifestyle (50 – 55%), then – by the environment (25 – 30%), and finally – by heritage and medical care [19]. Additional anthropogenic load on the biosphere increases the level of above mentioned risk - factors influencing on human health and life [19, 24, 25].

The effects of the action of environmental factors on human health have different scales - from minute, hour, day, decade and month to the seasonal and annual [37-39]. For example, periodicity of 7 and

3, 5 day of mortality from the cardiovascular diseases (CVD) is established in the work [37]. Results of investigation of influence of monthly average values of air Equivalent-Effective Temperature EET and is represented monthly duration of magnetic storms D on the health of the population of Tbilisi city [27]. The analysis of regression connections of mortality from the CVD with the EET and D showed that the contribution of each of the variables into changeability of mortality is the following. In the range EET from – 5º to 4.6º: EET – 8.6%, D – 22.2%; in the range EET from 5.2º to 21.8º: T - 26.3%, D - is insignificant [27].

In work [19] is shown, that days situation together with air pollution by ozone in smog, the ozone forming gases and the aerosols under the conditions of Tbilisi an essential effect on human health have a variation in such factors as the thermal regime of air, atmospheric pressure, cosmic rays. Thus, increased surface ozone concentrations on the average growth of annual mortality of the inhabitants of Tbilisi city by 1680 people. This is equal to 14.1 % of entire average annual mortality of the population of Tbilisi, which is approximately 3 times higher than the same indices for the advanced countries [19, 25, 26].

In this work are presented the results of a study of the effect of the annual changeability of air temperature, surface ozone concentration and neutron component of galactic cosmic rays intensity on the mortality of the population Tbilisi city in 1984-2010.

Material and methods

In the work are used the data of National Statistics Office of Georgia about the common mortality of the population of Tbilisi city. The common annual mortality (M) of population to 1000 inhabitants is normalized [25].

The measurements of surface ozone concentration (SOC) were conducted by the electro chemical ozone instrument OMG-200. Here are presented observational data for 15 hours [40]. The unit of the ozone measurement is mcg/m^3.

The data of the Hydro meteorological Service of Georgia about the annual values of air temperature (T, °C) in Tbilisi are used. Information about annual values of intensity of neutron component of galactic cosmic rays (CR, impulse/hour) is obtained at the Cosmic Rays Observatory of M. Nodia Institute of Geophysics. The observation period is 1984-2100.

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 [41, 42].

The following designations will be used below: Min – minimal values, Max - maximal values, Range - variational scope, St Dev- standard deviation, R - coefficient of linear correlation, R^2 –coefficient of determination, K_{DW} – Durbin-Watson statistic, α- the level of significance. As in [43], 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 K_{DW}, 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.

Below in the text the dimensionality of the investigated parameters are omitted

Results of detailed statistical analysis of the changeability of mean annual values of SOC in Tbilisi in 1984-2010 in [25, 40] were represented. In particular, the changeability of the indicated time series is described by the fourth power polynomial. An increase in the SOC in the period from 1984 through 1995-1997 was observed, then - decrease. Thus, in average: in 1984 SOC = 37 mcg/m^3, into 1998 – 58 mcg/m^3, into 2010 – 40 mcg/m^3. There was presented [25] Information about changeability of M in the investigation period of time in Tbilisi in.

This work is the continuation of work [25]. In it, together with the action of surface ozone (both the direct action and the indicator of the pollution of atmosphere) on the mortality of the population of Tbilisi, the role of variations in the air temperature and is examined intensity of galactic cosmic rays in the changeability of values M.

Results and discussion

The results in tables 1-4 and fig. 1-2 are given.

Table 1

Characteristics of trend of M, SOC, T and CR in Tbilisi in 1984-2010

Variable	Form of the equation of regression	R^2 (with year)	K_{DW}
M	Fifth power polynomial [25]	0.86 (α =0.0001)	1.45 (α =0.05)
SOC	Fourth power polynomial [25, 40]	0.82 (α =0.0001)	2.03 (α =0.05)
T	Linear	0.13 (α =0.06)	1.55 (α =0.05)
CR	Seventh power polynomial	0.82 (α =0.0001)	1.89 (α =0.05)

In table 1, is presented the data about characteristics of trend of mortality, surface ozone concentration, air temperature and cosmic rays intensity in Tbilisi in 1984-2010. As follows from table 1 trends of M, SOC, and CR take the form of fifth power, fourth power and seventh power polynomials; trend of T is linear (corresponding values of R^2 and K_{DW}).

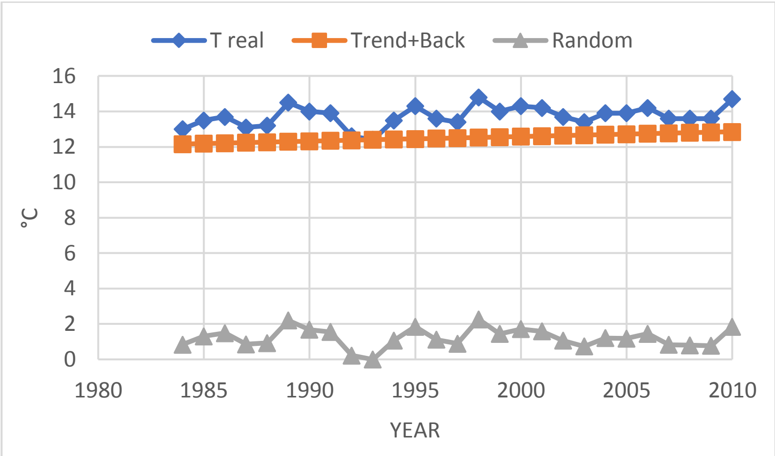

Fig. 1. Trend of the average annual air temperature in Tbilisi in 1984-2010.

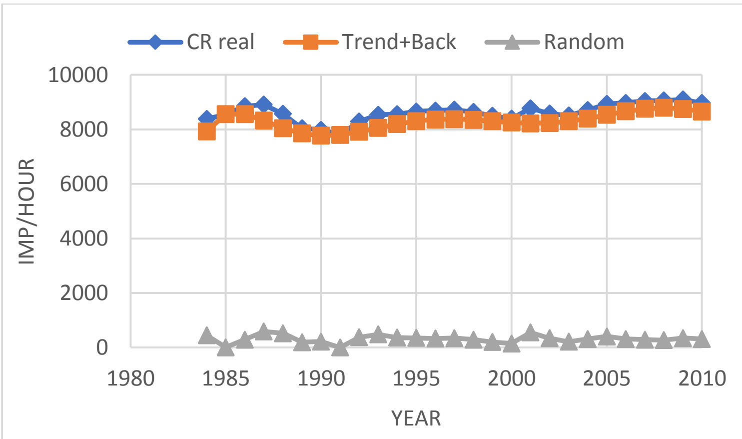

Fig. 2. Trend of the average annual intensity of galactic cosmic rays in Tbilisi in 1984-2010.

For the clarity in fig. 1 and 2 are presented the curves of real data, (trend+ background) and random components of time-series of mean annual air temperature and intensity of galactic cosmic rays in Tbilisi in

1984-2010. Analogous data for M and SOC in [25, 40] are given.

It should be noted that the trend of the average annual air temperature in Tbilisi into different time intervals had different nature. So, in 1963-1990 [43], 1878-1997 [44], 1906-1995 [45], 1907-2006 [46], 1957-2006 [47] the trend of T was linear. In the more prolonged period of time (1850-2012 [48]) the trend of T in Tbilisi took the form of the fourth power polynomial. As far as the trend of average annual cosmic-ray intensity in Tbilisi is concerned, into 1963-1990 it took the form of the ninth power polynomial [43].

In table 2 is presented the statistical characteristics of real data of time-series of average annual air temperature, surface ozone concentration, galactic cosmic rays intensity and common mortality of the population of Tbilisi city.

As follows from table 2, the values of T varied from 12.4 up to14.8 (average = 13.7), values of SOC – from 26.3 up to 61.8 (average = 44.1), values of CR – from 7803 up to 9100 (average = 8621) and M - from 8.03 up to 12.35 (average = 10.3).

The significant linear correlation M with SOC (positive) and CR (positive) are observed. Value of R between M and T is not significance.

Table 2

The statistical characteristics of real data of T, SOC, CR and M in Tbilisi in 1984-2010.

Variable	T	SOC	CR	M
Max	14.8	61.8	9100	12.35
Min	12.4	26.3	7803	8.03
Range	2.4	35.5	1297	4.32
Average	13.7	44.1	8621	10.3
St Dev	0.6	10.1	328	1.3
Correlation Matrix				
	T	SOC	CR	M
T	1	-0.08 (not sign)	0.02 (not sign)	0.01 (not sign)
SOC	-0.08 (not sign)	1	-0.26 (α=0.2)	0.39 (α=0.05)
CR	0.02 (not sign)	-0.26 (α=0.2)	1	0.24 (α=0.2)
M	0.01(not sign)	0.39 (α=0.05)	0.24(α=0.2)	1

In table 3 are presented the statistical characteristics of the random components of T, SOC, CR and M in Tbilisi.

As follows from table 3, max and average values of random components of investigation parameters respectively are equal: T – 2.3 and 1.2, SOC - 14.7 and 7.3, CR – 587.5 and 314.9, M – 1.60 and 0.65.

The significant linear correlation only between M and T is observed (negative).

Table 3

The statistical characteristics of random components of T, SOC, CR and M in Tbilisi in 1984-2010.

Variable	T	SOC	CR	M
Max	2.3	14.7	587.5	1.60
Range	2.3	14.7	587.5	1.60
Average	1.2	7.3	314.9	0.65
St Dev	0.54	4.2	141	0.5
Correlation Matrix				
	T	SOC	CR	M
T	1	-0.30 (α=0.1)	-0.40 (α=0.05)	-0.41(α=0.05)
SOC	-0.30 (α=0.1)	1	0.56 (α=0.005)	0.11 (not sign)
CR	-0.40 (α=0.05)	0.56 (α=0.005)	1	0.13 (not sign)
M	-0.41(α=0.05)	0.11 (not sign)	0.13 (not sign)	1

Shares of the average values of random components from the average values of the real values of the investigated parameters (fig. 1-2, table 2 and 3) constitute: for T – 8.8%, for SOC – 16.6 %, for CR – 3.7 % and for M – 6.3 %.

The equation of the multiple linear regression of the connection of annual common mortality of the population of Tbilisi city with T_{rand}, SOC_{real}, and CR_{real} is represented below:

$$\mathbf{M = -0.3881 \cdot T_{rand} + 0.06074 \cdot SOC_{real} + 0.0013088 \cdot CR_{real} - 3.183}$$

$R^2 = 0.30$ (α=0.01).

In table 4 are presented data about contribution of variations in the values of T_{rand}, SOC_{real}, and CR_{real} to the changeability of M.

Table 4

Contribution of variations in the values of T_{rand}, SOC_{real} and CR_{real} to the changeability of M.

Variable	In the limits of Range (%)	In the limits of St Dev (%)
T_{rand}	8.5	4.0
SOC_{real}	20.9	11.9
CR_{real}	16.5	8.3

As follows from table 4, within the variation range the contribution of the studied parameters to annual common mortality of the population of Tbilisi city variability is as follows: random components of mean annual air temperature - 8.5%, real values of surface ozone concentration – 20.9%, real values of neutron component of galactic cosmic rays intensity - 16.5%. In the limits of standard deviation – 4.0 %, 11.9 % and 8.3 %, accordingly.

Conclusions

In the linear approximation the greatest contribution to the changeability of the annual mortality of population in Tbilisi city introduces the pollution of the atmosphere (ozone as direct contaminator and as the index of air quality). Significant role in these variations plays the changeability of the intensity of galactic cosmic rays (as the indicator of geomagnetic activity). The smallest contribution to the changeability of the mortality of the population of Tbilisi city introduce variations in the random component of the average annual air temperature.

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ჰაერის ტემპერატურის, მიწისპირა ოზონის კონცენტრაციის და გალაქტიკური კოსმოსური სხივების ინტენსივობის საშუალოწლიური მნიშვნელობების ვარიაციების ზემოქმედება მოსახლეობის სიკვდილიანობაზე ქალაქ თბილისში

ა.ამირანაშვილი, თ.ბაქრაძე, ნ. ბერიანიძე, ნ. ჯაფარიძე, ქ. ხაზარაძე

რეზიუმე

წარმოდგენილია ჰაერის ტემპერატურის, მიწისპირა ოზონის კონცენტრაციის და გალაქტიკური კოსმოსური სხივების ნეიტრონული კომპონენტის ინტენსივობის საშუალოწლიური მნიშვნელობების ვარიაციების მოსახლეობის სიკვდილიანობაზე ზემოქმედების გამოკვლევის შედეგები ქალაქ თბილისში 1984–2010 წლებში. შესწავლილია გამოსაკვლევი მწკრივების სტატისტიკური მახასიათებლები. კერძოდ მიღებულია, რომ ვარიაციული განშლადობის ფარგლებში გამოსაკვლევი პარამეტრების წვლილი სიკვდილიანობის ცვალებადობაში შემდეგია: ჰაერის ტემპერატურის შემთხვევითი კომპონენტისა – 8.5%, მიწისპირა ოზონის კონცენტრაციისა და კოსმოსური სხივების ინტენსივობის რეალური მნიშვნელობებისა –20.9% და 16.5% შესაბამისად.

Влияние вариаций среднегодовых значений температуры воздуха, концентрации приземного озона и интенсивности галактических космических лучей на смертность населения городаТбилиси

А.Г. Амиранашвили, Т.С. Бакрадзе, Н.Т. Берианидзе, Н.Д. Джапаридзе, К.Р. Хазарадзе

Резюме

Представлены результаты исследования влияния годовой изменчивости температуры воздуха, концентрации приземного озона и интенсивности нейтронной компоненты галактических космических лучей на смертность населения города Тбилиси в 1984-2010 гг. Изучены статистические характеристики исследуемых рядов. В частности, получено, что в пределах вариационного размаха вклад исследуемых параметров в изменчивость смертности следующий: случайной компоненты температуры воздуха – 8.5 %, реальных значений концентрации приземного озона и интенсивности космических лучей – 20.9 % и 16.5 % соответственно.