ISSN 1512-1127

საქართველოს გეოფიზიკური საზოგადოების ჟურნალი

სერია ბ. ატმოსფეროს, ოკეანისა და კოსმოსური პლაზმის ფიზიკა

JOURNAL OF THE GEORGIAN GEOPHYSICAL SOCIETY

Issue B. Physics of Atmosphere, Ocean and Space Plasma

ტომი 19ბ 2016

vol. 19B 2016

ISSN 1512-1127

საქართველოს გეოფიზიკური საზოგადოების ჟურნალი

სერია ბ. ატმოსფეროს, ოკეანისა და კოსმოსური პლაზმის ფიზიკა

JOURNAL OF THE GEORGIAN GEOPHYSICAL SOCIETY

Issue B. Physics of Atmosphere, Ocean and Space Plasma

ტომი 19ბ 2016

vol. 19B 2016

საქართველოს გეოფიზიკური საზოგადოების ჟურნალი

მთავარი რედაქტორი: თ. ჭელიძე

სერია ბ. ატმოსფეროს, ოკეანისა და კოსმოსური პლაზმის ფიზიკა

ჟურნალის შინაარსი:

ჟურნალი მოიცავს ატმოსფეროს, ოკეანისა და კოსმოსური პლაზმის ფიზიკის ყველა მიმართულებას. გამოქვეყნებული იქნება: კვლევითი წერილები, მიმოხილვები, მოკლე ინფორმაციები, დისკუსიები, წიგნების მიმოხილვები, განცხადებები.

ЖУРНАЛ ГРУЗИНСКОГО ГЕОФИЗИЧЕСКОГО ОБЩЕСТВА

Главный редактор Т. Челидзе

серия Б. Физика Атмосферы, Океана и Космической Плазмы

Содержание журнала:

Журнал охватывает все направления физики атмосферы, океана и космической плазмы. В журнале будут опубликованы научные статьи, обозрения, краткие информации, дискуссии, обозрения книг, объявления.

JOURNAL OF THE GEORGIAN GEOPHYSICAL SOCIETY

Editor-in-Chief: T. Chelidze

Issue B. Physics of Atmosphere, Ocean and Space Plasma

Scope of the Journal:

The Journal is devoted to all branches of the Physics of Atmosphere, Ocean and Space Plasma. Types of contributions are: research papers, reviews, short communications, discussions, books reviews, announcements.

მისამართი:

საქართველო, 0160, თბილისი, ალექსიძის ქ. 1, მ. ნოდიას გეოფიზიკის ინსტიტუტი;

ტელ.: 233-28-67; Fax; (995 32 2332867); e-mail: tamaz.chelidze@gmail.com; akordzadze@yahoo.com; anzor_gvelesiani@yahoo.com; avtandilamiranashvili@gmail.com

გამოქვეყნების განრიგი და ხელმოწერა

სერია (ბ) გამოიცემა წელიწადში ერთხელ. ხელმოწერის ფასია (უცხოელი ხელმომწერისათვის) 30 დოლარი, საქართველოში – 10 ლარი, ხელმოწერის მოთხოვნა უნდა გაიგზავნოს რედაქციის მისამართით. შესაძლებელია ონლაინ წვდომა: http://openjournals.gela.org.ge/index.php/GGS/index

Адрес:

Грузия, 0160, Тбилиси, ул. Алексидзе, 1. Институт геофизики им. М. З. Нодиа;

Тел: 33-28-67; 94-35-91; Fax: (99532) 332867; e-mail: tamaz.chelidze@gmail.com; akordzadze@yahoo.com; anzor_gvelesiani@yahoo.com; avtandilamiranashvili@gmail.com

Порядок издания и условия подписи:

Том серии (B) издается по одному номеру в год. Подписная цена 30 долларов США, включая стоимость пересылки. Заявка о подписке высылается в адрес редакции. Возможен онлайн доступ http://openjournals.gela.org.ge/index.php/GGS/index

Address:

M. Nodia Institute of Geophysics, 1 Alexidze Str., 0160 Tbilisi, Georgia; Tel.: 233-28-67; Fax: (99532) 332867; e-mail: tamaz.chelidze@gmail.com; akordzadze@yahoo.com; anzor_gvelesiani@yahoo.com; avtandilamiranashvili@gmail.com

Publication schedule and subscription information:

One volume of issue (B) per year is scheduled to be published. The subscription price is 30 $, including postage.
Subscription orders should be sent to editor's address. Online access is possible: http://openjournals.gela.org.ge/index.php/GGS/index

Journal of the Georgian Geophysical Society,
Issue B. Physics of Atmosphere, Ocean and Space Plasma, v.19B, 2016, pp. 3-17

To light memory of Nodar Chiabrishvili, inexorally faithful to science, knight of honour and conscience.

On the Characteristic Functions and Parameters of Different Kind of Thermodynamic Systems: Experiment, Observation, Theory

Anzor I. Gvelesiani

Mikheil Nodia Institute of Geophysics of Iv. Javakhishvili Tbilisi State University
1, Alexidze Str., 0160 Tbilisi, Georgia, e-mail:<anzor_gvelesiani@yahoo.com>

ABSTRACT

The paper consists own results of laboratory experiments, results of wellknown other works using by us for introduce corrections and interpretations of some of them proceed from common point of view. There are discussion and comparison all of them with each other, in the light of classical works. In the first part of the article, briefly, is given the original laboratory bubble boiling method for modeling (BBMM) of vertical convective motion of two phase homo- and heterogeneous fluids (Georgian natural waters were investigated. The rest part of paper is devoted to the studying of thermodynamic parameters of systems, studying in geophysics and other ranges of science, technology, metallurgy, physical chemistry. In particular, except above-mentioned water solution, there are considered phase transformation processing in the following way: crystal$\rightarrow$liquid$\rightarrow$vapour and in the opposite direction. Thus, it is obtained similarity between: (1) Van-der-Waals (P,V)-phase diagram, stress-strain diagram (σ/ϵ), modelling earthquakes, and reconstructed by us figures (MPa/porosity) and (C_P^{-1}, T)-reverse heat capacity-temperature diagram for glycerin, $C_3H_8O_3$, and (h, E)-, dependence between depth of cosmic rays penetration into the Earth atmosphere and their energy; (2) space-time change of parameters of cosmic rays, solar wind, $F_{10.7}$ and ultra-violet radiation, and temperature-time change of nucleation of melted piperin, $C_{17}H_{19}NO_3$, in glass-like crystal state, and sulfides, arsenides, sulfates; (3) change of number of sunspots, W, and geomagnetic activity, c_P, in time, reconstructed by us (here), are in a good agreement with (ΔT, t); (4) (BBMM) bubble-boiling method, may be used for modelling of vertical convection, first of all, in the geo- and solar atmosphere; theoretically is confirmed our conclusion about Van-der-Waals-type and Tammann-type thermodynamic phenomena in geophysical spheres, metallurgical and physico-chemical investigations. It is necessary to note that well known Tammann's curve is not Gaussian one.

Keywords: glass-like state, convection, thermodynamic system, phase, bubble boiling, nucleation, magma, volcano, cosmic rays, magnetic field, solar wind, sunspot, alloys, modelling.

1.Introduction

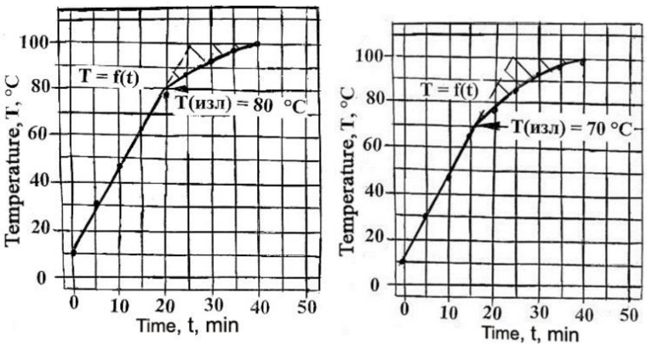
It is necessary to note that every review and last monographs, devoted to the geophysical problems are ended with words about urgent necessity of new experimental investigations all the more that thermodynamics first of all is experimental science. Vertical motion of the thermals in different geophysical spheres: in the atmosphere, oceans, mantle, Earth's liquid core etc., caused by the Archimedes force in the gravity field is a general element of any scale of the fluid convective motion. Experimental modelling of this type convective flows is the most actual one in geophysical spheres, different physical-chemical and technical processes equally [1-47].

Thermodynamic laws are empirical exceptionally, therefore they may be considered with using different ways, which, of course, are equivalen. It would be great mistake to be carried away the mathematics and forget about physics [15]. In this article, it is analyzed results of discussion some published important works and our investigation of thermodynamic parameters of natural waters of Georgia. Even this simplest case of vertical one-dimensional two-phase motion reveal a rich wealth of hydrodynamic regimes and phenomena. It is necessary to note that we did not discover any case of an infringement of the linear law of obtained original universal experimental curves (T, t), (ΔS, T), (t, ρ) and (T, ρ) of natural waters or artificial water solutions at the points of the second kind discontinuity. Thus, side by side well-known method of similarity and dimensional analysis, we have new original method, which effectively used in our work, and may be applied to investigation fluids convection in different geospheres: liquid core of the Earth, mantle plumes, magma of volcanoes, thermal and mineral waters, geysers, clouds and thermals in low atmosphere and upper one, cosmic rays, solar wind etc.

2.Construction of original universal experimental curves.

2.1. Fig. 1-5 show temperature-time dependences for natural waters: (1) spring of t. Tsalka (21.5 min), (2) the Black Sea, t. Anaklia (17 min), (3) sulphuric water of the Lake Lisi (14.5 min), (4) sulphuric waters of the old Tbilisi bath-houses (11 min); (5) honey water solution (7 min). In brackets given beginning of their bubble boiling moment.
This time signed below as "dsc" – the second kind discontinuity of these curves.

1 2



3 4 5

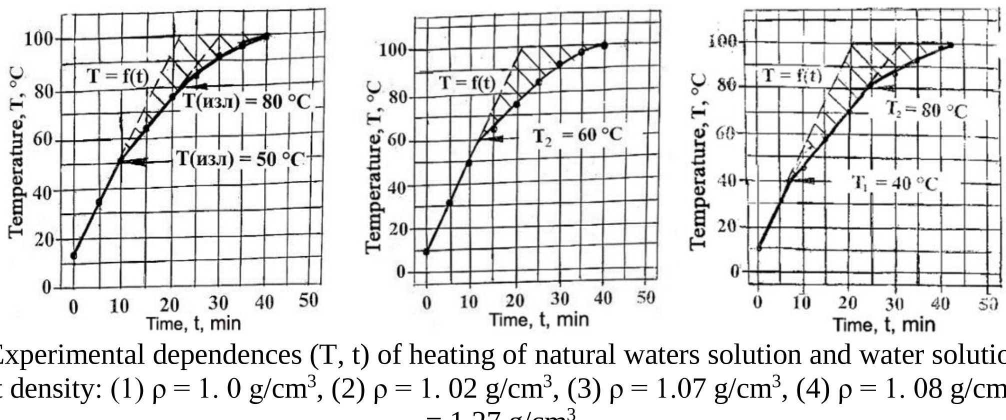
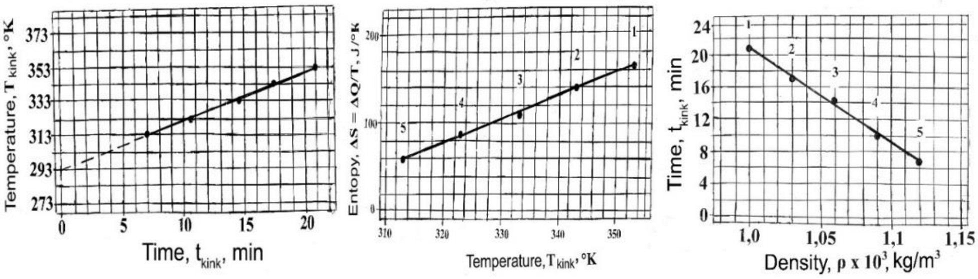


Fig. 1- 5. Experimental dependences (T, t) of heating of natural waters solution and water solution of honey of different density: (1) ρ = 1. 0 g/cm^3, (2) ρ = 1. 02 g/cm^3, (3) ρ = 1.07 g/cm^3, (4) ρ = 1. 08 g/cm^3; and (5) ρ = 1.27 g/cm^3.



(a) (b) (c)

Fig. 6. Universal curves of the parameters characterizing the change of bubble boiling regimes: $(T, t)_{dsc}$, (b) $(\Delta S, T)_{dsc}$, (c) $(t, \rho)_{dsc}$; **1** - spring of t. Tsalka (21.5 min); **2** - the Black Sea water near t. Anaklia (17 min); **3** - sulphuric water of the Lake Lisi (14.5 min); **4** - sulphuric waters of the old Tbilisi bath-houses (11 min); **5** – water solution of honey (7 min).

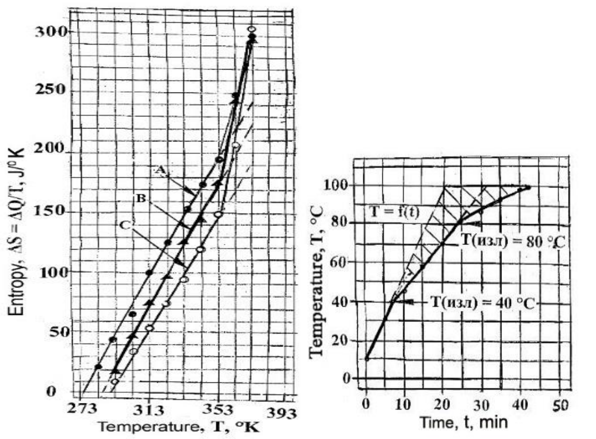
Dependences of investigated liquids thermodynamic characteristics in points of the second kind of discontinuity (dsc): $(T,t)_{dsc}$-, $(\Delta S, T)_{dsc}$-, $(t, \rho)_{dsc}$- curves have linear character (Fig. 6).
For example, empirical formulas at a power of heating the vessel with liquid of optimal volume [22] of $(T, t)_{dsc}$-, $(\Delta S, T)_{dsc}$-, and $(t, \rho)_{dsc}$, of (Fig. 6a,b,c) are following:

$$T_{dsc} = T_0 + \alpha \Delta t_{dsc1}, \qquad T_0 = 293\ K,\ \alpha = 2.86\ K/min; \qquad (1)$$

$$\Delta S_{dsc} = \Delta S_0 + \beta\, T_{dsc}, \qquad \Delta S_0 = 60\ J/K,\ \ \beta = 2.7\ J/K^2; \qquad (2)$$

$$(\rho_{dsc} - 1)/a + t_{dsc}/b = 1, \qquad a = 0.18\ g/cm^3,\ b = 21.5\ min. \qquad (3)$$

Represented below $(\Delta S, T)$- and (T, t)-curves very clearly show the points of the second kind of discontinuity.



(a) (b)

Fig. 7. (a) $(\Delta S, T)$ – entropy-temperature dependence: at the heating intensities: q = 75 J/s (A- branch); q = 47 J/s (B-branch), and q = 35 J/s (C-branch), respectively; (b) (T, t) – temperature-time dependence for q = 47 J/s).

As it is seen, Fig. 7 shows that: (a) $(\Delta S, T)$- curves have only one, $(T_2)_{dsc}$, point of discontinuity while (b) (T, t)-curve has two points of the dsc, $T_{1,\,dsc} = 40\ ^0C = 313$ K, and $T_{2,\,dsc} = 80\ ^0C = 353$ K. If $(\Delta S, T)$-dependence to express in degrees of ^0C for $T_0 > 10\ ^0C$, then in this dependence is revealed the $T_{1,\,dsc} = 40\ ^0C = 313$ K, too. A- and B- branches coincide. At $T_0 \leq 10\ ^0C$, if in formula $\Delta S = \Delta Q/T$ the temperature were taken in ^0C (instead of ^0K), then the entropy "does not loose" the first point of discontinuity, $T_{dsc} = 40\ ^0C$. This may be allow us to expand the laboratory method of modeling the convection in different geophysical environments for obtaining of dsc-points. BBMM method allows us to definite a density, at least, of any substance water solution using our universal experimental $(T, /\rho)_{dsc}$ curve.
Thus, test of artificial natural and mineral waters solutions, shows, for example, that measuring of temperature near the break (discontinuity) point (during some minutes after completion) were enough to obtain sufficiently full information about change of bubble boiling regimes, unknown density of solution etc.
Thus, the proposed method of bubble boiling allows during 7-20 minutes to determine enough accurately the density of water solution of any substance.

For example, water solutions of laundry salt (NaCl) and honey of the same volumetric density (ρ = 1.03 g/cm3) are identical by three measured parameters (T, ρ, t) and calculated entropy $\Delta S(T)$ on the dependence plot $T_{dsc}(\rho_{dsc})$ and T(t). Experiments on specially prepared samples of water solutions of honey with mass multiplicity (0:1:2:3:4:5) g /300 g of water confirmed excellently the discovered pattern (T_{dsc} /ρ_{dsc}): 80^0C/1.0 g –70^0C /1.0 g –60^0C /1.0 g –50^0C /1.0 g –40^0C /1.0 g (compare with Fig. 5c (!)).

2.2. Let us calculate a quantity of heat (Q) conducting through the side of cylindrical glass

$$dQ = \lambda \frac{T - T_{air}}{d} S_{side},$$

temperature (constant along the height (h) of the glass), T_{air} is the laboratory air temperature practically maintained constant before the end of bubble boiling process (100^0C) at the condition of where λ is the heat conductivity of the glass; d is the thickness of the glass side; T is glass temperature at an open window of the laboratory. Thus, we have

$$Q = -\lambda \frac{dT}{dr} 2\pi R_{bot} h, \qquad (4)$$

where dT/dr is an air temperature gradient at the side of glass, R_{bot} is a radius of the glass bottom, h is the height of water in the glass. There are possible two cases: (a) dT / dr < 0 or (b) dT / dr = 0. Then, in the first case

$$Q_1 = mc\,\Delta T + \Delta m\,L + \lambda \frac{dT}{dr} 2\pi R_{bot} h + Mc'\Delta T; \qquad (5)$$

in the second one we have (it is suggested that there is not a heat flux through the side of the glass)

$$Q_2 = mc\,\Delta T + \Delta m\,L + Mc'\Delta T, \qquad (6)$$

where M = 300 g is the mass of the glass; c′ = 0.779 J / (g · K) is the glass heat capacity; for usual glass, λ_1 = 0.7 J / (m · s·K) = 0.007 J / (cm · s · K); and for quartz glass, λ_2 = 1.36 J / (m · s·K) = 0.0136 J / (cm · s · K); $\Delta T = 90^0$C; d = 0.3 cm; $S = \pi R^2$, h = 8 cm, m = 300 g; Δm = 30 g; R_{bot} = 3.45 cm; ρ = 1 g / cm^3; c = 1 cal / g · K = 4.19 J / (g · K); L = $2.25\cdot10^3$ J / g; W_0 = 103 J / s, W_{bot} = 47 J / s.
Substituting the numerical values of parameters of ambient and researched thermodynamic object into above-mentioned expressions for thermo-balance gives following results:

$$Q_1 = (300 \cdot 4.19 \cdot 90 + 30 \cdot 2.25 \cdot 10^3 + 0.007 \cdot (90 / 3) \cdot 2\pi \cdot 3.45 \cdot 8 + 185 \cdot 0.779 \cdot 90)\ J = (113130 + 67500 + 36.4 + 12970.35)\ J = 193636.75\ J;$$
$$Q_2 = (113130 + 67500 + 12970.35)\ J = (180630 + 12970.35)\ J = 193600.35.$$

or

$$Q_1 = 193636.75\ J; \quad Q_2 = 193600.35.$$

As it is seen, a loss of a heat through the sides of the chemical glass is infinitesimal and is equal to 0.02 %.

$$Q'_1 = (300 \cdot 4.19 \cdot 90 + 30 \cdot 2.25 \cdot 10^3 + 0.0136 \cdot (90 / 3) \cdot 2\pi \cdot 3.45 \cdot 8 + 185 \cdot 0.779 \cdot 90)\ J = (113130 + 67500 + 72.8 + 12970.35)\ J = (180630 + 72.8 + 12970.35)\ J = 193673.15\ J;$$
$$Q'_2 = (300 \cdot 4.19 \cdot 90 + 30 \cdot 2.25 \cdot 10^3 + 185 \cdot 0.779 \cdot 90)\ J = (113130 + 67500 + 12970.35)\ J = (180630 + 12970.35)\ J = 193600.35\ J.$$

or

$$Q'_1 = 193673.15\ J; \ Q'_2 = 193600.35\ J.$$

2.3. Step-by-step calculation of heat balance (T_0 , T'_{dsc}, T''_{dsc}, T_b, t).

2.3.1. (T_0 , T'_{dsc}, t) Thermal mode and the smallest bubbles.
$T_0 = 10^0$C, $T'_{dsc} = 40^0$C, t = 7 min.

Q_{11} = (300 · 4.19 · 30 + 0.007 · (30 / 3) · 2π · 3.45 · 8 + 185 · 0.779 · 30) J = (37710 + 12.1 + 432.3) J = 38154.4 J;

Q_{21} = (37710 + 432.3) J = 38142.3 J.

Q_{11} = 38154.4 J; Q_{21} = 38142.3 J.

2.3.2. **(T'_{dsc}, T''_{dsc}, t) Transform to mode of large bu**bbles**.**

$T'_{dsc} = 40^0C$, $T''_{dsc} = 80^0C$, t = (25 – 7) min = 18 min.

Q_{12} = (300 · 4.19 · 40 + 0.007 · (40 / 3) · 2π · 3.45 · 8 + 185 · 0.779 · 40) J = (50280 + 16.12 + 576.4) J = 50872.52 J;

Q_{22} = (50280 + 576.4) J = 50656.4 J.

Q_{12} = 50872.52 J; Q_{22} = 50656.4 J.

2.3.3. **(T''_{dsc}, T_b, t) ragime of the largest bubbles.**

$T''_{dsc} = 80^0C$, $T_b = 100^0C$, t = (42.5 – 25) min = 17.5 min.

Q_{13} = (300 · 4.19 · 20 + 30 · 2.25 · 10^3 + 0.007 · (20 / 3) · 2π · 3.45 · 8 + 185 · 0.779 · 20) J = (25140+ 67500 + 8.06 + 288.2) J = 92936.26 J;

Q_{23} = (25140 + 67500 + 288.2) J = 92928.2 J.

Q_{13} = 92936.26 J; Q_{23} = 92928.2 J.

2.4. Now consider the dependence of liquid overheat by its heating from bellow at the bottom of the flask on the intensity of liquid boiling away (Δm/Δt). What is the temperature (T) of the flask bottom?

Heat amount, q = ΔQ/Δt, coming in a unit of time from a heater through the flask bottom in the water, equals to:

$$\Delta Q/\Delta t = \lambda(T - T_b)S/d, \qquad (7)$$

where T_b –the boiling point of water, λ – the coefficient of thermal conductivity of glass, d – thickness of glass at the bottom of vessel, S –the area of the flask bottom.

Suppose, all input energy in the flask is discharged on water evaporation

$$L\Delta m = W\,\Delta t, \qquad (8)$$

here L – hidden heat of vapor formation, Δm – evaporated during the time Δt the mass of water, W – heater power (J/s).

From here we have

$$T = T_b + \frac{dL\Delta m}{\lambda S\Delta t}, \qquad (9)$$

or

$$T = T_b + d \cdot W/(\lambda \cdot S), \qquad (10)$$

Overheat of bottom layer of water in the flask can be expressed as:

$$\Delta T = d \cdot W/(\lambda \cdot S), \qquad (11)$$

where λ ≈ 0.7 V/(m·K) = 1/600 cal/(cm·K); d = 0.3 cm, S = πR^2, h = 8 cm, m = $\pi R^2 h \rho$ = 300 g; ρ = 1g/cm^3, c = 1 cal/g·K, = 103 J/s.

Using above mentioned characteristics of our thermodynamic system we obtain

$$\Delta T = d \cdot P/(\lambda \cdot S) = 0.3 \cdot 103 / (0.7 \cdot 300/(8 \cdot 1)) \approx 1.18\ ^0C. \qquad (12)$$

First bubbles of large size (beginning of fluid bubble boiling process) (the temperature of water in a volume at first 5 min was 30 ^oC) appears during overheat of bottom layer of water in the flask, heated from bellow on the electric hot plate , ΔT ≈ 1.18 ^oC. Then, after 5 min measured temperature was equal to 40 ^0C and so on.

2.5. Initial fluid temperature in the flask was always equal to the air temperature in the laboratory of thermal vacuum chamber T = 10 ^0C (winter period). Based on the investigated by us original method of bubble fluid boiling the series of experiments has been performed to investigate thermodynamic parameters of natural waters in Georgia (thermal waters, mineral waters, mountain springs, sea and lake waters) and artificial solutions. To complete the thermodynamic picture we calculate, in the system of units S, total amount of heat, transferred to liquid thermodynamic system in time Δt = 2400 sec, starting at initial temperature of T_0 = 10 ^0C to the moment $T_к$ = 100 ^0C, intense bubble boiling, $\Delta Q = mc\,(T_к - T_0) = 0.3 \cdot 4.2 \cdot 10^3\,(100\,^0C - 10\,^0C) = 113.4$ kJ. After dividing the received heat on time Δt = 2400 sec, we get for intensity of heat q = ΔQ/ Δt of an investigated object the value q = 47 J/sec. Compatible our calculations with observations in Iceland [16].

2. 6. Geysers. **Geophysical peculiarities.**

Geysers are underground reservoirs filled with ground water and heated by intense source of heat below the surface. The exit of them to the surface is going through a narrow channel, in the "quiet" period almost completely filled with water. "Active" period comes when water boils in the underground reservoir, and during the eruption of the geyser a channel is almost completely filled only with vapor, which is released outside. We'll estimate what a part of water is lost during one release. (The height of vapor fountain is h_2 = 10 m), if at the depth of geyser channel h_1 = 37m water is heated up to 140^0C.
Let's consider that specific temperature q of water vapor $L = 2.25 \cdot 10^6$ J/kg. Atmospheric pressure is normal, $P_0 = 1.015 \cdot 10^5$ Pa.
Liquid starts boiling at the moment when the pressure of saturated vapor inside the bubbles of gas (which are in liquid) becomes equal to external pressure. In our case pressure differs from the atmospheric one be the value of hydrostatic pressure created by water column in the geyser channel. Therefore, the water temperature in the geyser reservoir must be higher by the value of ΔT than the temperature of boiling water under the normal pressure, equal to 100^0C.
When water column in a channel at the time of water boiling is released outside, vapor pressure and liquid temperature are decreased up to atmospheric pressure and the boiling point at normal pressure, i.e. up to 100^0C. Amount of heat mcΔT released during temperature drop of all water mass in a reservoir is used for evaporation of some part Δm and message about its potential energy equal to Δmg (h1 + h2).
We note that "active" period of geyser is very rapid and takes relatively short time (compare with the intensive bubble boiling process in the laboratory vessel with water or any liquid**).** "Quiet" period is more long process where repeated warm-up of all water mass in the underground reservoirs happens through thermal conductivity. Water mass by the underground water inflow restores its initial reserve.
The heat sink at the moment of eruption can be neglected and we can consider that eruption happens by the internal energy of water in geyser reservoir.
We have

$$mc\,\Delta T = \Delta m\,[L + g\,(h_1 + h_2)], \qquad (13)$$

where L is a latent heat of the water evaporation.
For $\Delta T = 140^0C - 100^0C = 40^0C$, c = 4.19 kJ/(kg · K), $L = 2.25 \cdot 10^6$ J/kg

$$\frac{\Delta m}{m} = \frac{c\Delta T}{L + g(h_1 + h_2)} \approx \frac{c\Delta T}{L}, \quad \frac{\Delta m}{m} 100\% \approx 7.5\ \%. \qquad (14)$$

3. Ocean. Heat flux. Geophysical peculiarities [20].
3.1. The surface layers of the acting ocean are stirred by the winds and undergo a regular cycle of convection and restratification in response to the annual cycle of buoyancy fluxes at the sea surface. The buoyancy flux, B, is expressed in terms of heat and fresh water fluxes as

$$B = \frac{g}{\rho_0}\left(\frac{\alpha_\theta}{c_W}H + \rho_0\beta_S S(E-P)\right), \qquad (15)$$

where c_W = 3900 J Kg^{-1} K^{-1} is the heat capacity of water, H is the surface heat loss, E – P represents the net fresh water flux (evaporation minus precipitation). Over the interior of the ocean basin, heat fluxes rise to perhaps 100 W m^{-2} in winter, and E – P = 1 m yr^{-1}, implying a buoyancy flux B ~ 10^{-8} m^2 s^{-3}. Unlike the upper regions of the main thermocline where mixed layer h ≤ 10^2 m), at the **convection** sites the stratification is sufficiently weak, N/f ≈ 5-10, and the buoyancy forcing is sufficiently strong, ≥ 10^{-7} m^2 s^{-3}, corresponding to heat fluxes as high as 1000 W m^{-2}, convection may reach much greater depths h > 2 km). This results were discussed in our article [24].

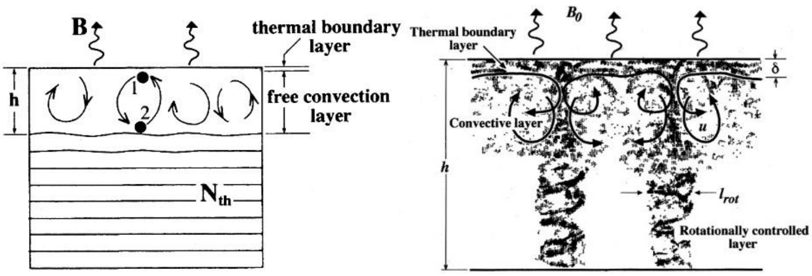


Fig. 8a. Convection in an ocean surface turbulent layer according to [20].

3.2. Convective phenomena of conductive fluid placed in external magnetic field (see ref. of [44]) and in the convective zone of the solar atmosphere under the photosphere [37]. Compare turbulent layers on surface of ocean (Fig. 8a) and zone of convection in the solar atmosphere (Fig. 8b).

Below are adduced some other results, where effect of the magnetic buoyancy is seen clearly both: (a) calculation of the plane solar magnetic field (sunspots), [44], and (b) the space solar wind, [49].

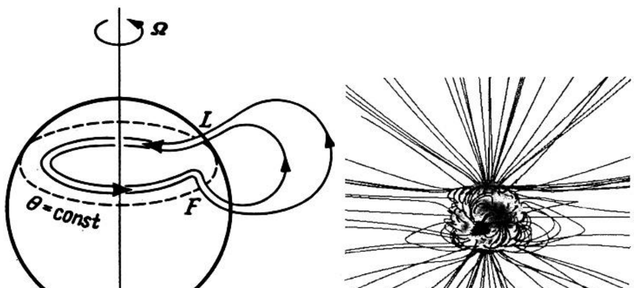
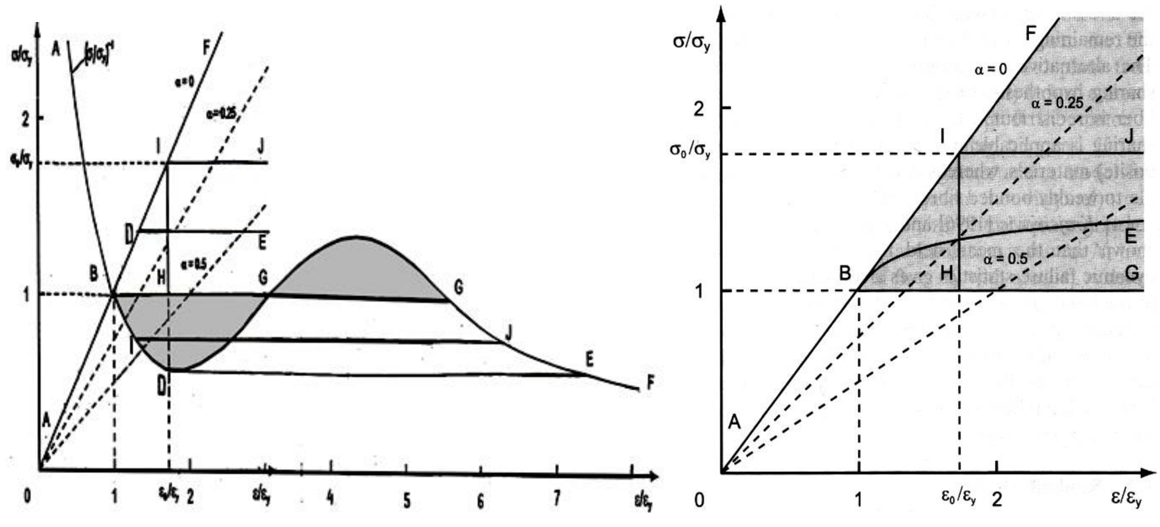


Fig. 8b. Pictures: (1) – formation of sunspots by the solar toroidal magnetic field, according to Parker (1955), [50]; (2) three-dimensional solar wind, according to Neugebauer (1999), [49].

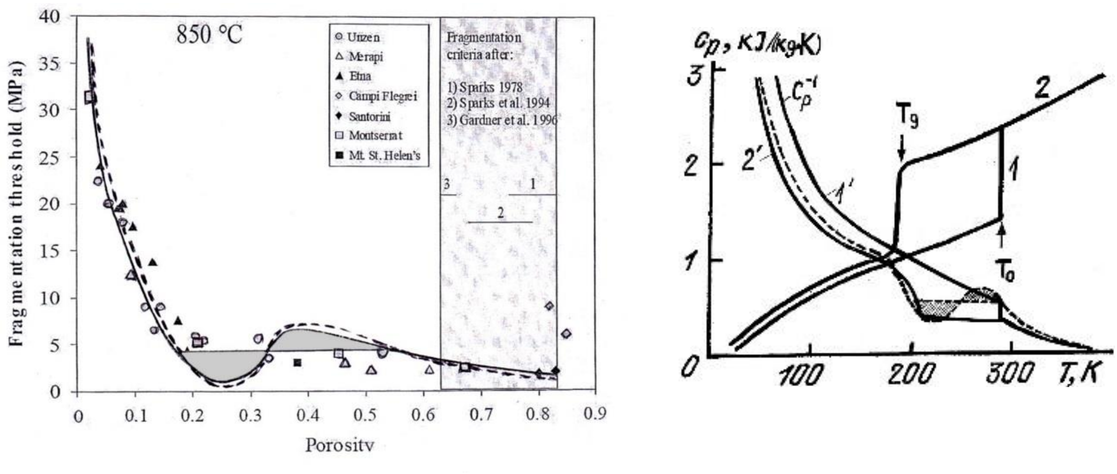
4. Van der Waals-like a brittle fracture (σ/ϵ)-dependence, according to [19, 27].



(a) (b)

Fig. 9. (a): Van der Waals' pressure-volume (P, V)- type diagram the $((\sigma/\sigma_y)^{-1}, (\epsilon/\epsilon_y))$-one [27]; and (b): stress-strain $((\sigma/\sigma_y), (\epsilon/\epsilon_y))$-diagram for a brittle solid [19].

The author of [19] sees the similarity between the diagram of the stress-strain process which take place in the rocks during the earthquakes and the pressure-volume one of water-vapor phase transformation during the bubble boiling process [27] (compare with above mentioned our BBM method [21-25] and Figs. 10-12).



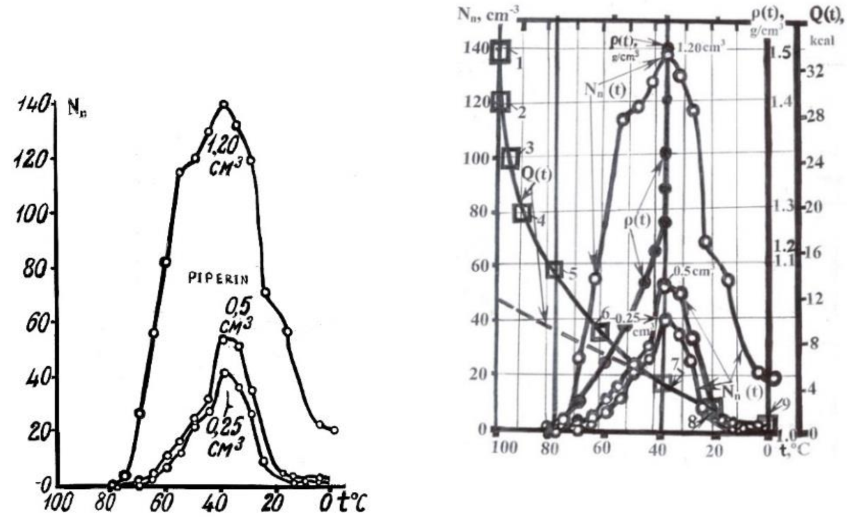
(a) (b)

Fig. 10. (a) – Results of [17], after remake, show Van der Waals-type "metastable" parts of the curve when right-side experimental points were taken into account. (b) – (C_p, T)- and (C_P^{-1}, T)-reverses heat capacity-temperature diagram for glycerin, $C_3H_8O_3$, (see ref. of [46]).

As can be seen, the experimental plots of the dependences of mirror reflection of some of parameters: (S, t), (S, V), (q, p) (N, t), (σ, ϵ), (τ, p) in the processes of phase transformation (boiling, glassy state etc.) demonstrate the "Van der Waals"- and "Andrews"-type forms (see [17, 19] and Figs. 9 -12a).

4.2. The samples used in the present study were collected at seven different volcanoes or volcanic centers and represent a broad range of composition and porosity (2 - 85 vol.%). The experimental data (representing approx. 400 experiments) show a strong relation between porosity and the fragmentation threshold at 850 °C. (Note that porosity/100 is plotted at the x-axis.) The grey box shows the range of different earlier fragmentation criteria defined by bubble coalescence [34] and shear induced foam instability [35].

5. Tammann curve's-type of nucleation of piperin crystals in glassy state [36].
This form of experimental curves proved to be very important in the present side by side Van der Waals one. Both of them plays important role in different scientific and technical spheres.



(a) (b)

Fig.11. (a) Tammann's (N_n, t)-piperin nucleus number-temperature curves [36];
(b) shows the Tammann's (N_n, t)-curve in center and added ρ(t)- and Q(t)-curves
for different natural waters and artificial solutions of different concentration.

It is very interesting to note that Tammann's exactly this, (40–80) ^{0}C, temperature interval of piperin crystals nucleation ([36]) coincides with the curves $(T, t)_{dsc}$ of Fig. 1-5 having the"dsc'' points of discontinuities in the same (40–80) ^{0}C interval, [21-25].Fig. 11 shows the temperature change of glycerin in crystal (1) and in glassing liquid (2) states at the normal atmosphere pressure, respectively. T_0 is the equilibrium temperature of melting and T_g is the temperature of the glassy structure formation.
For the rate of the crystal nucleation, J, in the supercooled melts we use simplified formula [6]:

$$Jdt = K\exp\left(-\frac{u_i}{kT}\right)\exp\left(\frac{A_s}{kT}\right)dt\,, \qquad (16)$$

where u_I is the energy of activation of phase transformation I → II, A_s – minimal free surface energy of the crystal form, K is constant, T is temperature, k is Boltsman's constant. For nucleus of spherical shape and averaged Q_s, σ, and d, instead of (16) we have

$$Jdt = K\exp\left\{-\left[\frac{u_I}{kT} + \frac{B}{(T_s - T)^2 T}\right]\right\}dt, \quad \left(B = \frac{4\omega}{3k}\left(\frac{M}{d}\right)^2 \frac{\sigma^3 T_s^2}{Q_s^2}\right). \quad (17)$$

Now, though the values of u_I and B are unknown in every separate case, nevertheless, one maydefine the bounds of their values, if instead of unknown the boundary energy crystal/melt in the expression of B, (17), were taken the surface tension. Calculations showed that theoretical (J, T)-curve [6] has the same shape as obtained by Tammann and his pupils on the base of numerous experiments [36].

Below Van der Waals' and Tammann's-type curves (Fig. 12) and (Fig. 13) are represented, respectively. They are in accordance with suggested classification of geophysical phenomena by force of their thermodynamic nature. In Fig. 12 upper curves of ion intensity-years (I, Y) arrange [as (P, V) for temperature, growing from below upwards before critical point in case of real gases (in thermodynamics)] and for h, depth of ions penetration into the Earth atmosphere (in case of cosmic rays). Visually behaviors of above described ion phenomena are similar. The lower, sunspot-years (W, Y) - and geomagnetic activity-years (C_P, Y)-curves are in a good accordance with each other during solar 11-year cycle (1950-1951). It would be interesting to attract once more Fig. 8b, Fig. 11 and Fig. 12.

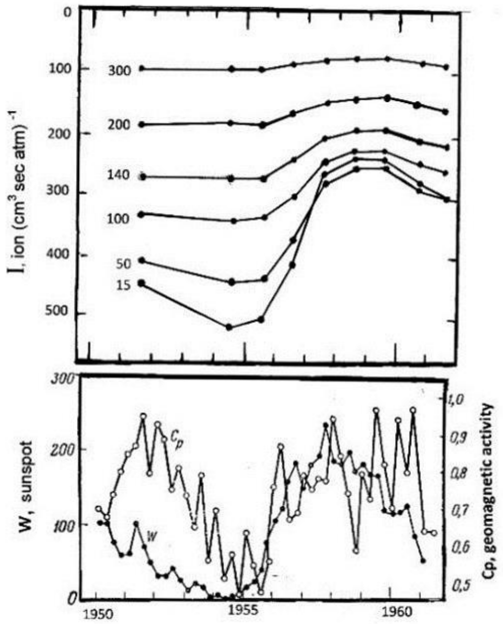


Fig. 12. Values of W, I, C_p – sunspots, cosmic rays intensity at different depths of penetration into atmosphere, geomagnetic activity during 1950 -1961 (Neher, Anderson, 1962; Thule, Greenland, AB USA).

To the Tammann'-type curves are belonged the curves the Solar $F_{10.7}$ and UV- ultra-violet radiation as it is clearly seen from Fig. 13. And not only the very hot solar plasma radiation, but also, of all hot alloys structural and thermal parameters have the same, Tammann character (Fig. 14-17).

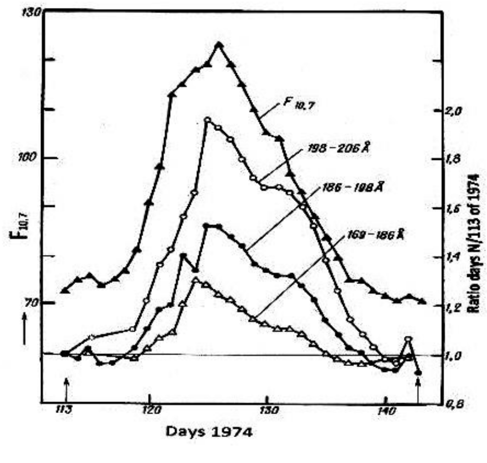


Fig. 13. Correlation of extreme ultraviolet with $F_{10.7}$ (Manson, 1976)

At last, consider some results from monograph [43], devoted to transformation of sulphides, arsenides and sulphates under mechanical and thermal influences. Obtained there graphical illustrations about structural and thermal characteristics of natural or artificial samples are also just Tammann's-type curves. Compare calculated, according to the formula (17), crystal nucleation-temperature (J, T)-dependence [6], Fig. 14-16, Fig. 11, 13 and Fig. 17.

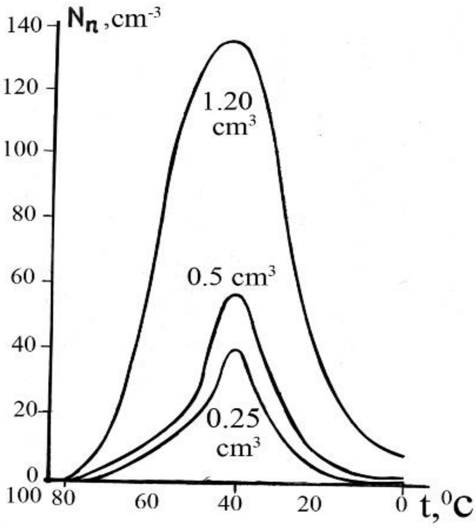


Fig. 14. Theoretical curve of intensity of crystal nucleus against temperature of supercooled melt according to [6]was used by us in order to construct Tammann's well-known experimental curve for piperin (Fig. 11) [36].

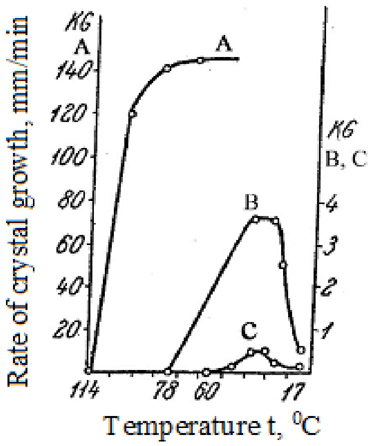


Fig. 15. Temperature dependence of crystallization rate of acetanilide –dinitrophenol benzyl [36]. A–acetanilide; B–binary eutectic of acetanilide with dinitrophenol; C-ternary eutectic. All of them are Tammann's-type curves, as we see, too.

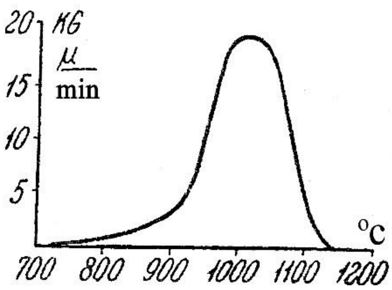


Fig. 16. The rate of spherolit glass needles growth against the
temperature ((RG,T) -dependence.
The length of spherolit needles measured by means of microscope and rate RG_{max} was ~ 20 μ/min (ref.[36]).

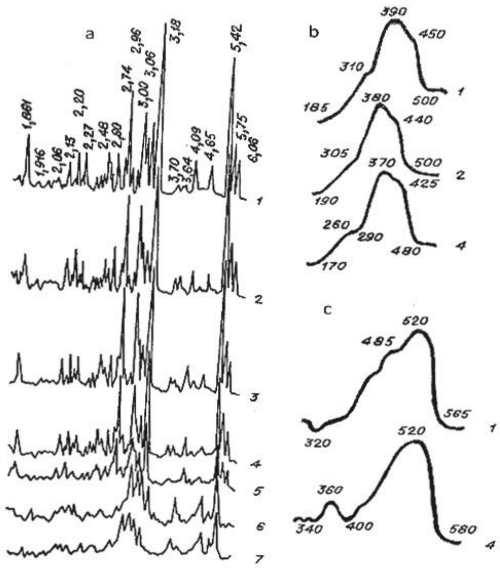


Fig. 17. Structural and thermal characteristics of realgar (As, S) and products of its mechanical processing. 1 – initial, 2-7 – activated (min) in 2-5 – water (0.5; 2; 7; 15), 6 –air (7), 7 – combined (14) environments; a difractograms; b, c – DTA-curves (platinum and quartz crucible furnaces) [36].

6. Conclusions.

Thus, it is obtained similarity between: (1) Van-der-Waals (P/V)-phase diagram [19], stress-strain diagram (σ/ϵ), modelling earthquakes [27], and reconstructed by us figures (MPa/porosity) [30-34] and (C_P^{-1}, T)-reverse heat capacity-temperature diagram for glycerin, $C_3H_8O_3$, [46] and (h, E)**-,** dependence between depth of cosmic rays penetration into the Earth atmosphere and their energy [42,41]; (2) space-time change of parameters of cosmic rays, solar wind, $F_{10.7}$ and ultra-violet radiation, [37-42] and temperature-time change of nucleation of melted piperin, $C_{17}H_{19}NO_3$, in glass-like crystal state, [36], and sulfides, arsenides, sulfates, [43]; (3) change of number of sunspots, W, and geomagnetic activity, c_P, in time, [42], reconstructed by us (here), are in a good agreement with (ΔT, t), [25]; (4) (BBMM) bubble-boiling method [21, 22] may be used for modelling of vertical convection, first of all, in the geo- and solar atmosphere, [21-25]; theoretically is confirmed our conclusion about Van-der-Waals-type and Tammann-type thermodynamic phenomena in geophysical spheres, metallurgical and physico-chemical investigations. It is necessary to note that well known Tammann's curve is not Gaussian one.

References

[1] Wallis G. B. One-dimensional two-phase flow. McGraw Hill Book Company, New York-San Louis-San Francisko-London- Sydney-Toronto-Mexico-Panama, 1970.
[2] Thomson J. On a changing tessellated structure in certain liquids. Proc. Philos. Soc. Glasgow, v. 13, 1882, pp. 464-468.
[3] Bénard M. Les tourbillons cellulaires dans une nappe liquide. Revue generale des Sciences pures et appliquee, v. 11, 1900, pp. 1261-71 and 1309-28.
[4] Chandrasekhar S. Hydrodynamic and hydromagnetic stability. Clarendon Press, Oxford, England, 1961, 652 p.
[5] Gibbs J. W. Thermodynamics. Statistical Mechanics. Moscow, Nauka, 1982, 584 p. (in Russian).

[6] Volmer M. Kinetik der Phasenbildung. Drezden-Leipzig: Steinkopf, 1939, 220 p.
[7] Frenkel Ya. I. Kinetic theory of liquids. Leningrad, Leningrad Department, Nauka, 1975, 592 p. (in Russian).
[8] Zel'dovich Ya. B. On the theory of new phase formation. JETF, 1942, T. 12, vip. 11-12, pp. 525-538, (in Russian).
[9] Kagan Yu. O kinetike kipenia chistoy zhidkosti. Zhurnal fizicheskoy khimii. T. XXXI, № 1, 1960, pp. 92-101, (in Russian).
[10] Skripov V. P. Metastable Liquids. M.: Nauka, GRFML, 1972, 312 p. (in Russian).
[11] Ermakov G. V., Lipnjagov E. V., Perminov C. A. New criterium for comparison of classic. T. 16, № 4, 2009, pp. 695-699, (in Russian).
[12] Golitsyn G. S. Energy of convection. Non-linear waves: Stochasticity and Turbulence. Gorky: AN SSSR, IPF, 1980, pp. 131-139, (in Russian).
[13] Boubnov B. M., Golitsyn G. S. Convection in rotating fluids. J. Fluid Mech., 1995, v. 219, pp. 215-239.
[14] Brennen Chr. E. Cavitation and bubble dynamics. University Press, 1995, 64 p.
[15] Kubo R. Thermodynamics. An advanced course with problems and solutions. North Holland Publishing Company–Amsterdam, 1968 (Russian ed.: M.: Mir, 1970, 304 pp.).
[16] Roberts M. J., Jökulhlaups: A reassessment of floodwater flow through glaciers. Reviews of Geophysics, 2005, 43, RG1002/ 2005, pp. 1-21.
[17] Zhang Y., Xu Z., Zhu M., Wang H. Silicate melt properties and volcanic eruptions. Reviews of Geophysics, 2007, 45, RG4004/ 2007, pp. 1-27.
[18] Jellinek A. M., Manga M. Links between long-lived hot spots, mantle plumes, D″, and plate tectonics, Reviews of Geophysics., 42, RG3002, 2004, doi: 10.1029/2003RG00014
[19] Rundle J. B., Turcotte D. L., Shcherbakov R., Klein W., Summis Ch. Statistical physics approach to understanding the multiscale dynamics of earthquake fault system. Reviews of Geophysics, v. 41, N 4, RG4001, 2003,pp. 5.1-5.30.
[20] Marshall J., Schott F. Open-ocean convection: observations, theory, and models. Reviews of Geophysics, 37, 1 / February, 98RG02739, 1999, pp. 1-64.
[21] Gvelesiani A. I**.** To the problem of one-dimensional two-phase/many-component flow in different geophysical mediums. J. Georgian Geophys. Soc., v.16B, 2013, pp. 118-127.
[22] Gvelesiani A., Chiabrishvili N. Laboratory modeling of thermals generation in geophysical environment by means of bubble boiling method. J. Georgian Geophys.Soc., v.16B, 2013, pp. 128-136.
[23] Gvelesiani A., Chiabrishvili N. Additional experiments about investigation of the peculiarities of the bubble boiling of clear water, H_2O, and sugar, $C_{12}H_{22}O_{11}$, and edible salt, NaCl, water solutions of different densities. J. Georgian Geophys. Soc., v.17A, 2014, 132-139.
[24] Gvelesiani A. Open thermodynamic systems: convection and similar processes modeling by the only fluids bubble boiling method. J. Georgian Geophys. Soc., v.17B, 2014, pp. 38-57.
[25] Gvelesiani A., Chiabrishvili N. Study of Georgian natural waters thermodynamic parameters behavior by means of original fluids bubble boiling method. J. Georgian Geophys. Soc., v.18B, 2015, pp. 52-63.
[26] Silvestri M. Hydrodynamics and heat exchange at drop-annular regime of two-phase flow. In book: Advances in Heat Transfer. (Ed. by T. F. Irvine, J. P. Hartnett), AP, New York-London, v. I, 1964.
[27] Debenedetti P. G. Metastable Liquids. Princeton Univ. Press, Princeton, N. J., 1996.
[28] Skripov V. P., Koverda V. P. Spontanous crystallization of super-cooled liquids. M.: Nauka, GRFML, 1984, 232 p. (in Russian)
[29] Dergarabedian P. The rate growth of vapor bubbles in superheated water. J. Appl. Mech., 1953, pp.537-545.
[30] Spieler O., Kennedy B., Kueppers U., Dingwell D. B., Scheu B., Tuddeucci J. The fragmentation threshold of pyroclastic rocks. Earth Planet. Sci. Lett., v. 226, 2004, pp. 139-148.
[31] Sparks R.S.J., The dynamics of bubble formation and growth in magmas: a review and analysis, J. Volcanol. Geotherm. Res., 28, 1978, pp. 257-274.
[32] Sparks R.S.J., J. Barclay, C. Jaupart, H.M. Mader, J.C. Phillips, Physical aspects of magma degassing. I. Experimental and theoretical constraints on vesiculation, Rev. Mineral. 30, 1994, pp. 414-445.
[33] Gardner J.E., R.M.E. Thomas, C. Jaupart, S. Tait, Fragmentation of magma during plinian volcanic eruptions, Bull. Volcanol. v. 58, 1996, pp. 144-162.
[34] McBirney A.R, T. Murase, Factors governing the formation of pyroclastic rocks, Bull. Volcanol., v. 34, 1970, pp. 372-384.

[35] Zhang Y., A criterion for the fragmentation of bubbly magma based on brittle failure theory, Nature, v. 402, 1999, pp. 648 – 650.
[36] Tammann G. Kristallisieren u. Schmelzen, Leipzig, 1903; Die Aggregatzustände, Leipzig, 1922.
[37] Akasofu S.-I., S. Chapman. SolarTerrestrial Physics. Part I. Oxford, Clarendon Press, 1972.
[38] Eddington A. S.The internal constitution of the stars. Cambridge Univ. Press, London, 1926.
[39] Hinterreger H. E. J. Atmosp. Terr. Phys., v. 38, 1976, p. 791.
[40] Manson J. E. Solar specter between 10 and 300 Å. In book: The Solar Output and its variation. Colorado Associated University Press, Boulder, 1976 (pp. 287-312 Russian ed.,1980).
[41] Dorman L. I. Cosmic Rays Variations and Study of Cosmos. North-Holland, Amsterdam, 1974.
[42] Neher H., Anderson V. Cosmic rays of balloon altitudes and the solar cycle. J. Geophys. Res., v. 67, N 4, 1962, pp. 1301-1315.
[43] Kulebakin V. G. Apply mechanic-chemistry in hydro-metallurgic processes. Novosibirsk: Nauka , SO AN SSSR, Inst. Gorn. Dela, 1988, 272 c.
[44] Moffatt H. K. Magnetic field generation in electrically conducting fluids. Cambridge: Cambridge University Press. London-New York-Melbourne, 1978, pp. 344 (Russian ed.).
[45] Spieler O., Kennedy B., Kueppers U., Dingwell D.B. et all. The fragmentation threshold of pyroclastic rocks. Earth and Planetary Sciences Letters, Sep. 30, 226 (1-2), 2004, pp. 139-148.
[46] Skripov V. P., Koverda V. P. Spontanous crystallization of super-cooled liquids. M.: Nauka, Gl. red. fiz.-mat. lit., 1984, 232 p.
[47] Leppert G., Boiling P.K. Advances in Heat Transfer. Academic Press, New York –London, 1964, pp. 142-198.
[48] Gvelesiani A. On the hierarchy of mesoscale vortexes in the turbulent media. Reports of Enlarged Session of the Seminar of I. Vekua Institute of Applied Mathematics, v. 27, 2013.
[49] Neugebauer M. The three-dimensional solar wind at solar wind minimum. Reviews of Geophysics, v. 37, N 1/February, RG4001, 1999, pp. 107-127.
[50] Parker E. N. The formation of sunspots from the solar toroidal field. Astrophys. J., v. 122, 1955, pp. 293-314.

სხვადასხვა ბუნების თერმოდინამიკური სისტემების პარამეტრების და მახასიათებელი ფუნქციების შესახებ: ექსპერიმენტი, დაკვირვება, თეორია

ა. გველესიანი

რეზიუმე

ნაშრომი შეიცავს ლაბორატორიული ექსპერიმენტების ახალ შედეგებს და მათ ინტერპტაციას. განზოგადებულია სხვა ავტორების კარგად ცნობილი შედეგები, რომელთა განხილვისას შეგვაქვს სათანადო კორექტივები ერთიანი თერმოდინამიკური კუთხით მოვლენების ფიზიკური შინაარსიდან გამომდინარე, დაყრდნობით კლასიკად ქცეულ შრომებზე, სტატიის შესავალში მოკლედ აღიწერება ჩვენს მიერ შემოთავაზებული ვერტიკალური კონვექციის მოდელირების ბუშტოვანი დუღილის მეთოდი (BBMM. ნაშრომის ძირითადი ნაწილი ეძღვნება გეოფიზიკის, ფიზიკა-ქიმიის, მეტალურგიის, ტექნიკის სათანადო დარგების ობიექტების თერმოდინამიკური მახასიათებლების კვლევა. ყურადღების ცენტრშია ფაზური გარდაქმნები: კრისტალი $\rightarrow$ სითხე $\rightarrow$ ორთქლი და პირიქით. და ბოლოს დადგენილია: (1) ვან-დერ-ვაალსის (P,V)-დიაგრამის მსგავსება დაძაბულობა-დეფორმაცია (σ,ϵ)-დიაგრამას და დაზუსტებულ ჩვენს მიერ წნევა-ფოროვნება (ΔP,(ΔV/V))-დიაგრამა, შებრუნებული სითბოტევადობა-ტემპერატურა (C_P^{-1}, T)-დიაგრამა გლიცერინისათვის, $C_3H_8O_3$, და E ენერგიის მქონე კოსმოსური სხივების დედამიწის ატმოსფეროში h სიღრმეზე შეღწევის (h, E)-დიაგრამასთან; (2) მსგავსება კოსმოსური სხივების, მზის ქარის, მზის $F_{10.7}$ და ულტრა-იისფერი გამოსხივების, პიპერინის, $C_{17}H_{19}NO_3$,

გალღვობილი მასის ნუკლეაციის სვლა მინისებრივ მდგომარეობაში და სულფიდების, არსენიდების და სულფატების სტრუქტურულ-თერმიული მახასიათებლების; (3) მზის ლაქების რიცხვის, W, და გეომაგნიტური აქტივობის პარამეტრის, C_P, მზის 11-წლიან ციკლში ცვლილების მრუდები ხარისხობრივად ეთანხმება ჩვენს მიერ მიღებულ ტემპერატურის ცვლილებას დროში, (ΔT, t), (4) BBMM-მეთოდი შეიძლება გამოყენებულ იქნას კონვექციური პროცესების განხილვისას გეოსფეროებში, მზის ატმოსფეროში და სხვ. თეორიულად მტკიცდება ჩვენი დასკვნა ვან დერ ვაალსის და ტამანის მოვლენების მსგავსება სხვადასხვა გეოსფეროში, მეტალურგიულ და ფიზიკურ-ქიმიურ პროცესებში. უნდა აღინიშნოს ის გარემოება, რომ ტამანის მრუდს არაფერი აქვს საერთო გაუსის მრუდთან.

О характеристических функциях и параметрах термодинамических систем различной природы: эксперимент, наблюдения, теория

А. И. Гвелесиани

Резюме

Работа содержит собственные новые результаты лабораторных экспериментов и их интерпретаций. Обобщаются хорошо известные результаты других работ, используемых нами для внесения в них корректив термодинамически с единой точки зрения, в свете классических работ. В первой части статьи кратко описываются возможности моделирования вертикальной конвекции в двухфазной многокомпонентной текучей среде лабораторным методом (BBMM).Остальная часть статьи посвящена исследованию термодинамических свойств объектов геофизических, физико-химических, технических наук, металлургии и др. Установлено: (1) сходство (P/V)-диаграммы Ван-дер-Ваальса с (σ/ϵ)-диаграммой напряжение-деформация и уточнёнными нами диаграммами (ΔP/(ΔV/V)) давление-пористость и (C_P^{-1}, T) обратная теплоёмкость-температура для глицерина, $C_3H_8O_3$, (h, E)-зависимости глубины проникновения в атмосферу Земли космических лучей от энергии; (2) сходство пространственно-временного хода параметров космических лучей, солнечного ветра, $F_{10.7}$ и УФ радиации Солнца с нуклеацией расплавленной массы пиперина, $C_{17}H_{19}NO_3$, в стеклообразном состоянии, и со структурно-термическими характеристиками сульфидов, арсенидов, сульфатов; (3) графическая зависимость числа солнечных пятен, W, и геомагнитной активности, C_P, от времени, реконструированная нами (здесь), хорошо согласуется с зависимостью (ΔT, t); (4) оригинальный метод пузырькового кипения (BBMM), может оказаться полезным для лабораторного и численного моделирования вертикальной конвекции в геосферах и атмосфере Солнца. Теоретически подтверждается наше заключение о сходстве явлений Ван дер Ваальса и Таммана с сответствующими явлениями в различных геосферах, металлургии и физико-химических исследованиях. Необходимо отметить, что хорошо известная кривая Тамманна не есть Гауссова кривая.

Journal of the Georgian Geophysical Society,
Issue B. Physics of Atmosphere, Ocean and Space Plasma, v.19B, 2016, pp.18-25

Spatial Distribution of Dust Concentration in Kakheti Atmosphere in Case of Nonstationary Sources of Pollution

[1]Aleksandre A. Surmava, [2]Natia G. Gigauri

[1]M. Nodia Institute of Geophysics, I. Jvakhishvili Tbilisi State University; Institute of Hydrometeorologi,Georgian Technical University, Tbilisi; aasurmava@yahoo.com.
[2]Georgian Technical University,Tbilisi.

ABSTRACT

Using a regional model of atmospheric process in the Caucasus and equation of transfer-diffusion of passive contaminant the distribution patterns of dust dissipated in the atmosphere of Kakheti are obtained.
It is shown that dust dissipated from cities in the atmosphere is basically concentrated in boundary layer. Maximum values of dust are concentrated in 100 m surface air layer. Spatial dust distribution region increases and concentration decreases along with height increase. Urban influence zone is determined. It equals to 20-30 km for Tbilisi, approximately 10 km for Rustavi and for other cities does not exceed 2-4 km. Kinematics of dust propagation is studied. It is determined that in 2-100 m layer of atmosphere the process of turbulent diffusion take precedence in the process of dust propagation. From 100 m to 1 km the processes of diffusive and advective transfers are identical, while above 1 km the preference is given to advective transfer.

Key words*: air pollution, equation of mass transfer, numerical simulation, maximum allowable concentration*

1. Introduction

Kakheti is the eastern near-border region of Georgia. Its area is 11,3 thousand km^2. It is one of the most important parts of Georgia from the viewpoint of agricultural production and resort-recreational destination. That is why study of background pollution and propagation of polluting agents in Kakheti region is of great ecological importance.

Today there are no air polluting powerful enterprises of industrial purposes located at the territory of Kakheti. Pollution of the atmosphere takes place in big cities – Tbilisi and Rustavi, and also resulting from regional propagation of polluting agents dissipated in the atmosphere of small cities located in Kakheti and its adjacent territory.

Based on the fact that there are no ongoing observations over air pollution at the territory of Kakheti, the numerical modeling of background pollution may be considered as one of the main tools of study of ecological cleanness of atmosphere. For this purpose is represented the numerical model of expected pollution of Kakheti region and the level of background dust pollution of atmosphere determined by means of this model. The polluted air of the cities of Kakhety and in the vicinity of Georgia and Azerbaidjan are taken as the sources of contaminant in model. The presented article is a firs try of investigation of Kakheti air pollution

2. **Goal setting**. The area 236×180 km of size is considered, in the centre of which Kakheti is placed, while to the west, north and north-west are located the Main Caucasus and Small Caucasus mountain chains, while to the south-east is placed Shirvan steppe. Orography height varies from 77 m to 3-4 km.

The relief is very complicated here. That is why for proper description of atmospheric processes is convenient to use the relief succeeding coordinate system $\zeta = (z - \delta)/h$, where z is vertical orthogonal coordinate, $\delta = \delta_0(x, y)$, δ_0 - altitude of relief; $h = H - \delta$; $H(t, x, y)$ - tropopause height; t is a time; *x* and *y* – orthogonal coordinate axes directed to the east and north.

Equation for dust atmospheric propagation in the taken coordinate system will be written in following form [1, 2]

$$\frac{\partial C}{\partial t} + u\frac{\partial C}{\partial x} + v\frac{\partial C}{\partial y} + (\tilde{w} - \frac{w_0}{h})\frac{\partial C}{\partial \zeta} = \mu \frac{\partial^2 C}{\partial x^2} + \frac{\partial^2 C}{\partial y^2} + \frac{1}{h^2}\frac{\partial}{\partial \zeta}\nu\frac{\partial C}{\partial \zeta} \quad , \qquad (1)$$

where C is dust concentration in atmosphere u, v, w and $\tilde{w}$ are the components of wind velocity along x, y, z and ζ axes; ; w_o - rate of dust particle sedimentation determined according to Stoke's formula;μ and ν – kinematic coefficients of horizontal and vertical turbulence; values of wind velocity and turbulence factor in near-border layer of atmosphere and in free atmosphere are defined by means of regional model [3] of atmospheric process development in Caucasus, while in atmospheric boundary layer 100m in thickness – according methodology developed in [3] and [4].

Numerical integration of equation (1) with the use of corresponding initial and boundary conditions is executed using Crank-Nicolson method and using the splitting method and monotonous scheme [1].

The temporary variation of concentration in the cities is following:

$$C(t, x_i, y_i, z_0) = \begin{cases} C_{min}(t\ x_i, y_i, z_0) & \text{if} \quad 24n \le t \le 24n + 6 \\ C_{min}(t, x_i, y_i, z_0) + \Delta C \sin(0.5\pi(t-6)/3) & \text{if} \quad 24n + 6 < t < 24n + 9 \\ C_{max}(t, x_i, y_i, z_0) & \text{if} \quad 24n + 9 < t < 24n + 21 \\ C_{min}(t, x_i, y_i, z_0) - \Delta C \sin(0.5\pi(t-21)/3) & \text{if} \quad 24n + 21 < t < 24(n+1) \end{cases}$$

where $C_{min}(t, x_i, y_i, z_0)$ and $C_{max}(t, x_i, y_i, z_0)$ are the maximal and minimal concentrations of pollutant substance in the points of source; x_i and y_i are the coordinate of cities; index i denotes the city, $\Delta C = C_{min}(t, x_i, y_i, z_0) - C_{max}(t, x_i, y_i,, z_0)$, z_0 = 2 m; $C_{max}(t, x_i, y_i, z_0)$ and $C_{min}(t, x_i, y_i, z_0)$ are equal to 0.8 and 0.2 parts of the monthly mean concentration in city i, respectively. The data of National Environment Agency [5] are taken as the initial and boundary value of the monthly mean concentrations at a height of 2 m in atmosphere at the territories of Tbilisi and Rustavi, while for territories of other cities, where the observations over dust pollution was not conducted, concentration values are calculated according to given methodology [6].

Numerical integration is made on spatial grid comprising of 118×90×31 points. Grid steps are 2 km in horizontal direction, while in vertical it varies from 2 to 15 m in the surface layer, and from 15 to 300 m in the boundary area and free atmosphere. Time step is 10 sec.

Dust dispersal in Kakheti region is modeled in case of air non-stationary pollution sources. Climate conditions corresponding for June are taken. Meteorological situation corresponds with western stationary winds, when the velocity of geostrophic background winds is 1 m/sec at the height of 10 meters. The speed linearly increases along with height and reaches 23 m/sec at a height of 9 km.

3. **Results of modeling.** Results obtained by calculations are shown on Fig. 1-Fig. 7. On these figures, the values of concentration are calculated in units of daily maximum allowable concentration (MAC = 0.015mg/m^3) of dust.

On Fig. 1 and Fig. 2 is shown the distribution of dust concentration in the atmosphere at different heights in the midnight (t = 0 hour), 4 hours after beginning of dispersal. As is seen from drawings, dust concentrations are virtually equal in atmospheric surface layer at a height of 2 and 10 meters. Dust is basically concentrated at urban territories and rapidly decreases with the increase of distance from cities. The value of horizontal gradient of concentration is depended on local orography adjacent to source and on the direction of background wind.

In case of Tbilisi city the concentration at a height of 2 meters from earth surface and at 2 km distance decreases 10-30 times, while at 2-20 km distance dust content reduces from 0,1 MAC (maximum allowable concentration) to 0,01 MAC.

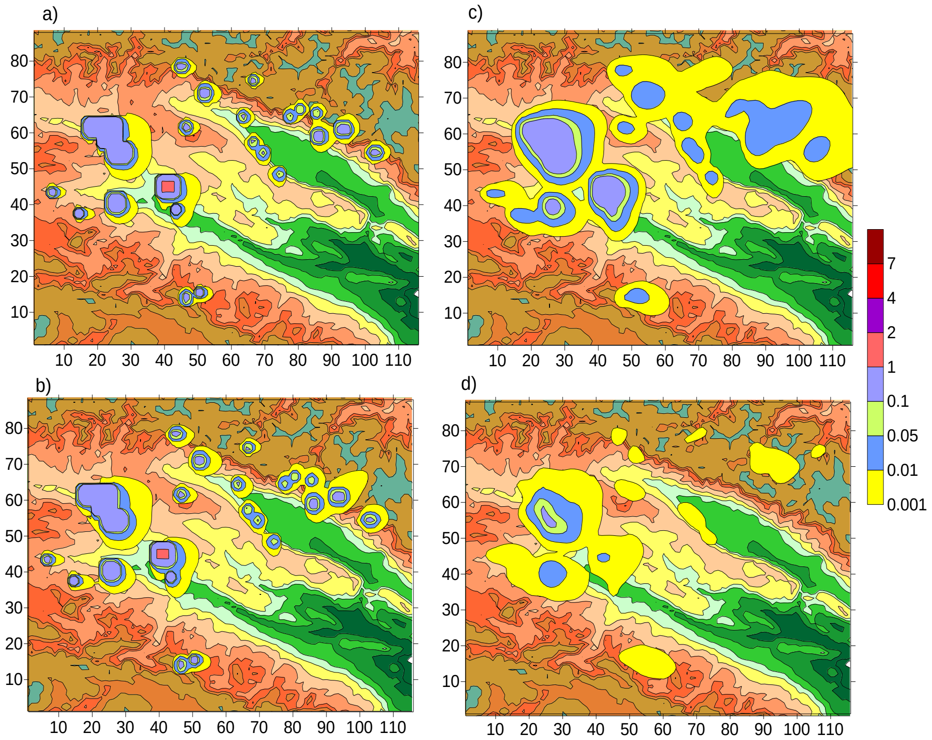


Fig. 1. Dust concentration in atmosphere at the height of z = 2 – a), 10 – b), 100 – c) and 600 - d) meters, when t = 0 hour.

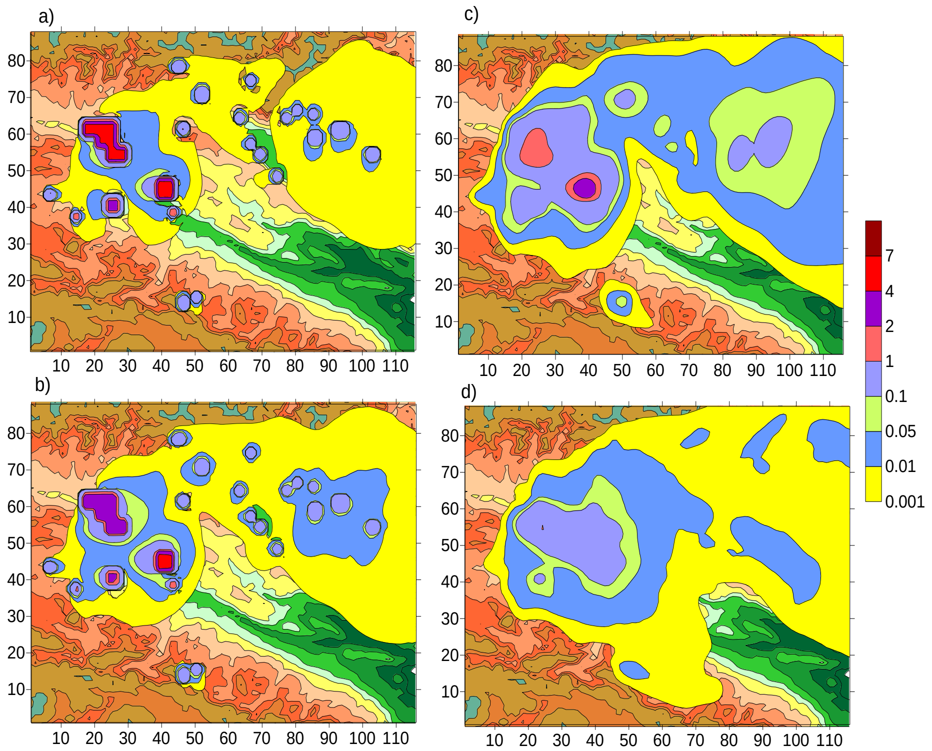


Fig. 2. Dust concentration in atmosphere at the height of z = 2 – a), 10 – b), 100 – c) and 600 - d) meters, when t = 12 hour.

In case of Rustavi the similar reduction takes place at 2-10 km distance. With increase of height the area of dust dispersal significantly increases. At a height of 100 meters the dust-loaded (dust-filled) area forms two basic and one relatively small cloud above Tbilisi, Rustavi, the Georgian part of the Greater Caucasus and above Aghstafa and Kazakh. With the increase of distance from atmospheric surface layer the dust concentration reduces and becomes insignificant at a height of 2 kilometers.

At 12 noon when concentration in atmospheric surface layers of cities reaches its maximum the dustiness zone significantly enlarges. At a height of both 2 and 10 meters, as well as at higher levels the dust of atmospheric surface layer is dispersed (concentrated) in the northern part of region (Fig. 2), where it creates the uniform cloud of shaped form, in which the concentration changes from 5 MAC to 0,001 MAC. Size of the area, where C > 0,01 MAC is minimal at a height of z = 2 m, increases with distance from earth surface and reaches maximum value in 100m ≤ z ≤ 600m layer. In atmospheric surface layer the dust as a united cloud, is dispersed in south-east direction and is located above central part of region (Fig. 3). The value of concentration decreases in upper part of boundary layer. Above 2 km the value of dust concentration is less than 0,001 MAC.

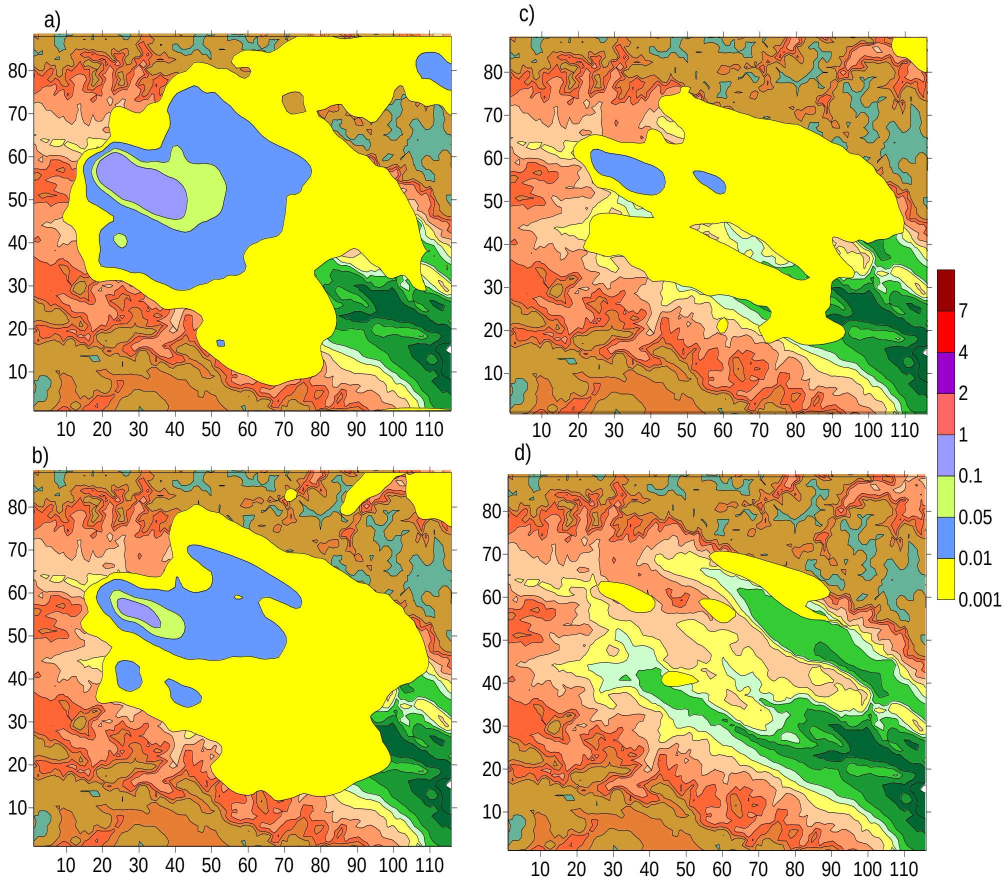


Fig. 3. Dust concentration in atmosphere at the height of z = 1 km – a), 1.5 km – b), 2 km – c) and 3 km - d) meters, when t = 12 hour.

On Fig. 4 and Fig. 5 are shown the dust concentrations in atmospheric surface sub-layer and boundary layer, when t = 21 hr. For this moment of time at urban territories at a height of 2 m the dust concentration is maximal and starts to decrease in time. When comparing Fig. 4 and Fig. 5 with Fig. 2 and Fig. 3 one can see the changes taken place during 9 hours. Namely, the area with c > 0,01 MAC is reduced in atmospheric surface sub-layer and is enlarged in 100m ≤ z ≤ 600m layer. Differences between concentration distributions above 600 m are insignificant. Obtained result is caused by daily variations of thermal, dynamic and turbulent field. Their daily variations are big in atmospheric surface sub-layer, gradually decrease in boundary layer and are getting small in free atmosphere.

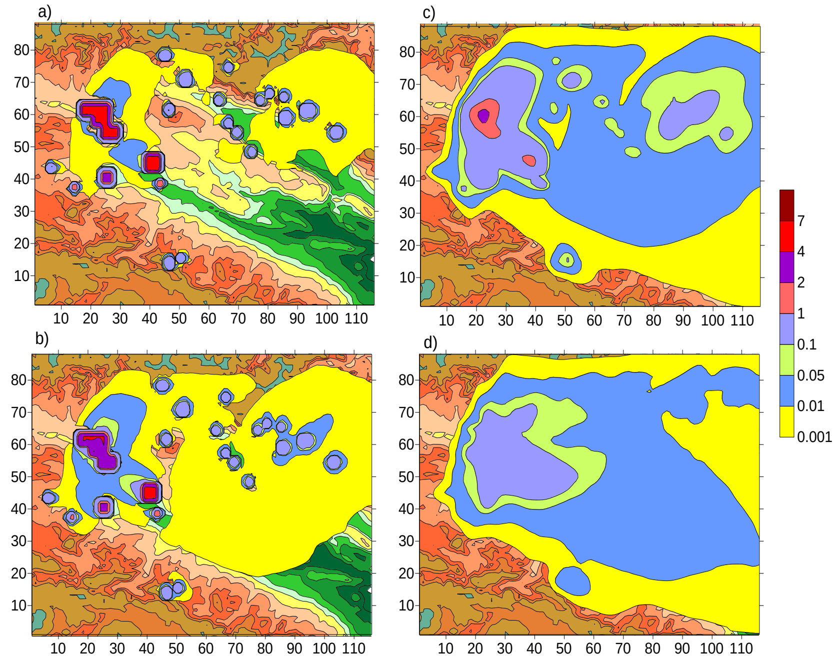


Fig. 4. Dust concentration in atmosphere at the height of z = 2 – a), 10 – b), 100 – c) and 600 - d) meters, when t = 21 hour.

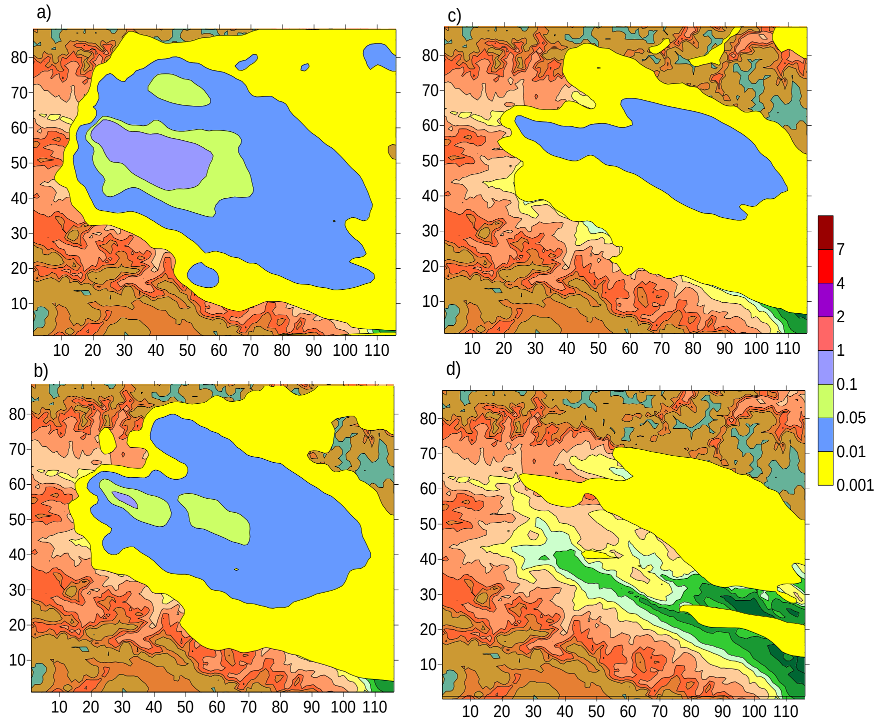


Fig. 5. Dust concentration in atmosphere at the height of z = 1 km – a), 1.5 km – b), 2 km – c) and 3 km - d) meters, when t = 12 hour.

On Fig. 6 and Fig. 7 is shown spatial distribution of dust concentration, when t = 24 hr. As is seen, concentrations in atmospheric surface sub-layer are significantly reduced directly on urban territories and are

less decreased at their adjacent areas. Concentration change is also small in upper part of atmospheric surface layer. Mentioned effect shows us the inertness of spatial distribution of pollution.
Analysis of calculation results, which were carried out for second day (24hr $\leq t \leq$ 48hr) showed that quasi-periodical change of dust concentration takes place in time and it changes a bit in the space.

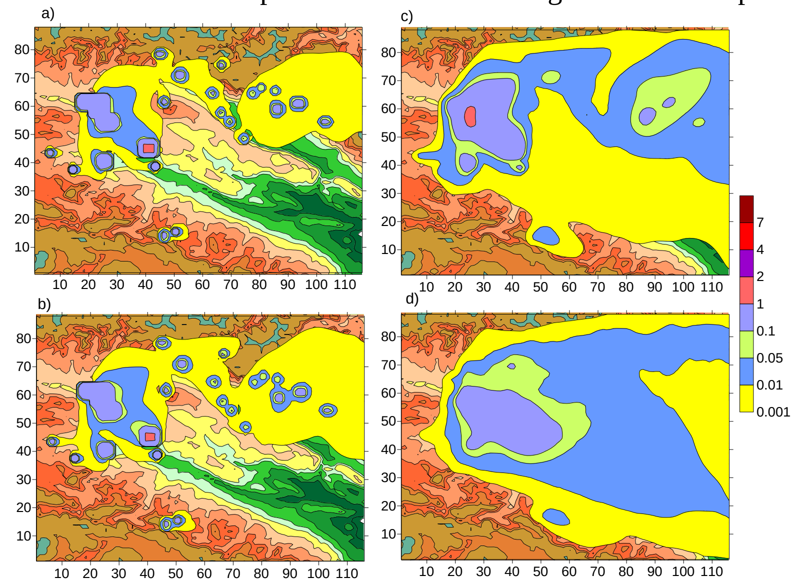


Fig. 6. Dust concentration in atmosphere at the height of z = 2 – a), 10 – b), 100 – c) and 600 - d) meters, when t = 24 hour.

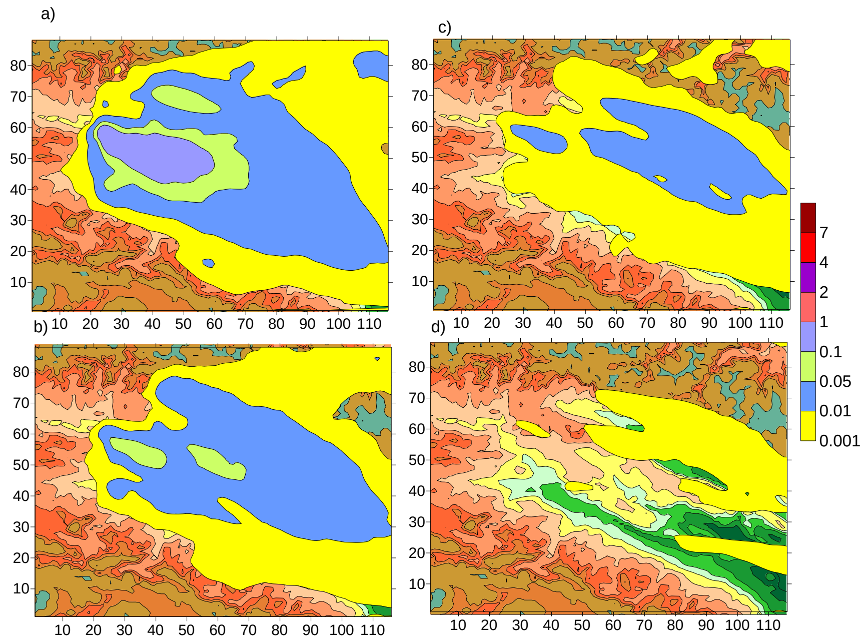


Fig. 7. Dust concentration in atmosphere at the height of z = 1 km – a), 1.5 km – b), 2 km – c) and 3 km - d) meters, when t = 24 hour.

Dust mass is concentrated in the central part of Kakheti region and covers major part of region's territory. But, the concentration $c \geq 0{,}01$ MAC is obtained only at the territories of contaminated cities of Tbilisi, Rustavi and other small atmosphere-polluting cities, as well as roughly at the territory of 300-400 sq. km around them.

4. Conclusions. Conducted numerical modeling showed that quasi-periodical dust distribution is formed at the territory of Kakheti under conditions of stationary western winds and non-stationary dusting of cities. Kinematic analysis of dust dispersal process showed that in 100 m atmospheric surface layer the basic mechanism of dust dispersal is represented by vertical and horizontal turbulent diffusions. The share of advective transfer and turbulent diffusion in the boundary layer of the atmosphere is approximately equal, while in the free atmosphere advective transfer is dominant.

There were determined the areas, where dust concentration varies in a range of $C \geq 0{,}01$ MAC. This area in case of Tbilisi and Rustavi is located within a circle of 20-30 km radius and 10 km radius from city boundaries, respectively. In case of small cities the zone with $C \geq 0{,}01$ MAC is located within circle of 2-4 km radius. Concentration values are near 0,001 MAC at greater distances from cities.

When considering various practical ecological problems, we often need to know background concentrations at the adjacent territory of cities. Today, the urban background concentrations or even 0 are taken as background concentrations for these territories that is not completely reasonable. Studies conducted in this article give us an opportunity to determine the values of background concentrations at the adjacent territories of cities. In particular, in the zones 20 km, 10 km and 2-4 km width, adjacent to Tbilisi, Rustavi and small cities, respectively, 0,03 of daily MAC should be taken as background concentration, and 0,01 MAC – beyond these zones.

Conducted modeling is the first ever theoretical study of air purity at adjacent territories of Georgian cities. Obtained results showed that for territories with compound relief forms is expedient to conduct calculations with less than 2 km horizontal step (spacing). It is necessary to carry out experimental observations of air pollution and to compare theoretically calculated concentrations with values obtained via field observations.

References

[1] Marchuk G. I. Matematicheskoye modelirovaniye v probleme okruzhayushchey sredy. L., Gidrometeoizdat, 1982, 320 s., (in Russian).

[2] Berlyand M.Ye. Sovremennyye problemy atmosfernoy diffuzii i zagryazneniya atmosfery. L., Gidrometeoizdat, 1975, 448 s., (in Russian).

[3] Kordzadze A. A., Surmava A. A., Demetrashvili D. I., Kukhalashvili V. G. Izvestia, Atmospheric and Oceanic Physics. 43, 6, 2007, pp. 722-730.

[4] Kazakov A. L., Lazriyev G. L. O parametrizatsii prizemnogo sloya atmosfery i deyatel'nogo sloya pochvy. Izvestia AN SSSR. Fizika atmosfery i okeana, 1978, t. 14, №3. s. 257-265, (in Russian).

[5] Ed. Georgian National Environmental Agency. Short review of Georgian environment pollution. www.nea.gov.ge (in Ceorgian).

[6] RD 52.04.186-89. Rukovodstvo po kontrolyu zagryazneniya atmosfery. M.,1991, 693 s., (in Russian).

კახეთის ატმოსფეროში მტვერის კონცენტრაციის სივრცული განაწილება დაბინძურების არასტაციონალური წყაროების შემთხვევაში

ა. სურმავა, ნ. გიგაური

რეზიუმე

კავკასიაში ატმოსფერული პროცესების განვითარების რეგიონალური მოდელის გამოყენებით და პასიური მინარევის გადატანა - დიფუზიის განტოლების რიცხვითი ინტეგრირებით მიღებულია ატმოსფეროში გაფრქვეული მტვრის განაწილების სურათები

მიწის ზედაპირიდან სხვადასხვა დონეზე. ნაჩვენებია, რომ ქალაქებიდან ატმოსფეროში გაბნეული მტვერი ძირითადად კონცენტრირებულია ატმოსფეროს მიწისპირა 100მ ფენაში. სიმაღლის ზრდასთან ერთად იზრდება მტვრის სივრცული გავრცელების არე და მცირდება კონცენტრაცია. განსაზღვრულია ქალაქების გავლენის ზონები. ქ. თბილისის გავლენის ზონა შეადგენს 20-30 კმ, ქ. რუსთავისათვის - დაახლოებით 10 კმ-ს, ხოლო სხვა ქალაქებისათვის არ აღემატება 2 - 4 კმ-ს.
შესწავლილია მტვრის გავრცელების კინემატიკა. მიღებულია, რომ ატმოსფეროს 2 – 100 მ ფენაში მტვრის გავრცელება უპირატესად ტურბულენტური დიფუზიით ხდება. 100 მ-დან 1 კმ-დე ფენაში დიფუზიური და ადვექციური გადატანის პროცესები ტოლფასია, ხოლო 1 კმ-ის ზევით ძირითადია მტვრის ადვექციური გადატანა.

Пространственное распространение пыли в атмосфере в Кахети в случае нестационарных источников загрязнения

А. А. Сурмава, Н.Г. Гигаури

Резюме

С помощью региональной модели развития атмосферных процессов на Кавказе и уравнения переносса и диффузии примеси получены пространственные распределения пыли на разных высотах в атмосфере Кахети. Показано, что основая масса пыли сконцентрирована в приземном слое атмосферы толщиной около 100 м. С удалением от приземного слоя расширяется пространство распространения пыли и уменьшается его концентрация. Определены зоны влияния городов на запыленность окружающей среды. Для г. Тбилиси зона влияния простирается на 20-30 км, для г. Рустави -10 км, а для остальных малых городов - 2-4 км.
Изучена кинематика процесса распространения пыли. Получено, что в нижнем 2-100 м слое атмосферы турбулентная диффузия играет преобладающую роль в процессе распространения пыли. В слое от 100 м до 1 км влияния турбулентной диффузии и адвективного переноса одинаковые, а выше 1км адвективный перенос преобладает над турбулентной диффузией.

Journal of the Georgian Geophysical Society,
Issue B. Physics of Atmosphere, Ocean and Space Plasma, v.19B, 2016, pp. 26-34

Hydrodynamic Model of Formation of Karst Voids

Zurab A. Kereselidze, Davit T. Odilavadze, Marina S. Chkhitunidze

M. Nodia Institute of Geophysics of Iv. Javakhishvili Tbilisi State University
M. Alexidze 1, 0160, Tbilisi, Georgia
z_kereselidze@yahoo.com; odildavit@gmail.com

ABSTRACT

The physical representation of the dynamic picture of the karst development pursues various objectives, among which, in particular, is to assess the characteristic time scale of their formation. Obviously, this problem is quite complicated because of the many-sidedness of the process of karsting, proceeding with both: general characteristics and local features. In particular, karst voids can have a variety of forms, some of which have some regularity due to similarity with a certain geometric figure. For example, for karst, a funnel-shaped form with a base on the earth's surface is quite common. The effectiveness of the leaching factor is directly dependent on the geological quality of the medium and the duration of the action of the water. It seems that to confirm the uniformity of the mechanism, the action of which leads to the elution of the solid rock, one can turn to the approximation of the hydrodynamic boundary layer arising when flowing over a solid surface. The rate of washing out of solid rock from the karstic cavity depends on the flow of water, which can vary depending on the flow regime. However, we can talk about some average characteristic, if we assume, for example, that the water movement is laminar. it should be noted that the value of the rate of karst leaching used for numerical evaluation is very approximate. it nevertheless seems that with the help of the model we have used, it is possible to obtain more accurate quantitative estimates.

Key words: hydrodynamic, karst voids.

Introduction

Investigation of natural causes leading to the formation of karst voids, formed both on the surface and in the depth of the Earth, is a common problem of geophysics and hydrogeology. The physical representation of the dynamic picture of the karst development pursues various objectives, among which, in particular, is to assess the characteristic time scale of their formation.

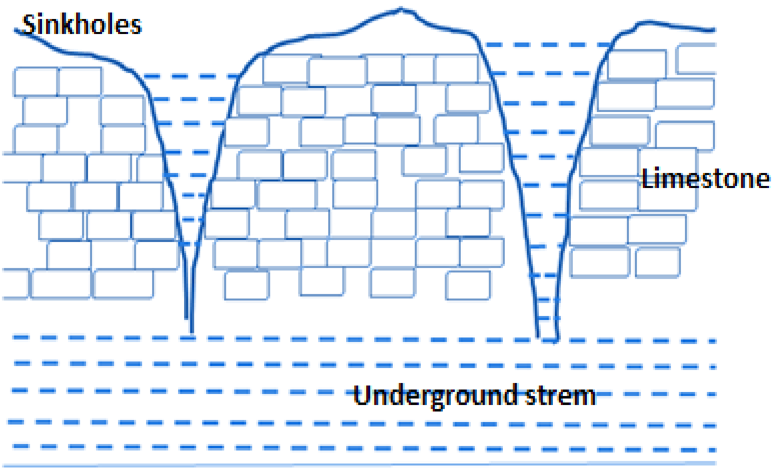


Fig.1

Obviously, this problem is quite complicated because of the many-sidedness of the process of karsting, proceeding with both general characteristics and local features [1]. Specificity is mainly determined by local geology and climate, however, not only these factors [2]. For example, there is a variety in the form of karst voids, noted in spatially separated places, but almost identical in terms of the action of natural factors [3-5]. In particular, karst voids can have a variety of forms, some of which have some regularity due to similarity with a certain geometric figure. For example, for karst, a funnel-shaped form with a base on the earth's surface is quite common (Fig. 1).

The nose of the funnel can join with the channel of the underground river or a reservoir of groundwater or with a cave. However, despite the wide variety of forms of karst voids, for everyone there are common factors that give rise to their formation. First of all, it concerns the universality of the mechanism of washing out of solid rock, which leads to the appearance of voids. The effectiveness of the leaching factor is directly dependent on the geological quality of the medium and the duration of the action of the water. Undoubtedly, under the same hydrological conditions, the process of elution of the rock in limestone or in sandstone should be more intense than, for example, in basalts. Although porosity, i.e. the moisture capacity of basalts is higher than that of sandstones and limestones, basalts are also higher in resistance to shear due to their hardness. It is also obvious that the formation of voids in a solid rock directly depends on the intensity of atmospheric precipitation, which, in addition to the surface, also has a deep effect, feeding groundwater. Simultaneously with climatic factors, the process of karst formation is also affected by the orography of the area, which determines the topology of surface runoff. Moreover, in direct dependence on orography, there is also a typology of deep water bearing channels (filtration capillaries) supplying underground reservoirs [3].

The essence of the problem

It seems that to confirm the uniformity of the mechanism, the action of which leads to the elution of the solid rock, one can turn to the approximation of the hydrodynamic boundary layer arising when flowing over a solid surface. The general condition necessary for its occurrence in the process of washing out solid rock with water is certainly present. Because Water is a real liquid, when it moves in karst cavities of any shape, viscous effects must necessarily occur.

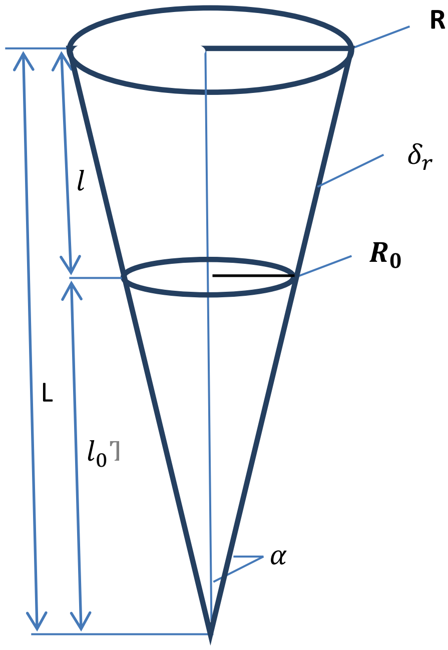


Fig. 2

For a qualitative representation of the karst cavity, it is convenient to use its geometric analogy, for which one can use a figure whose cross-sectional area decreases with increasing of height. Obviously, in the case of radial symmetry, such a figure can be a cylinder, which in the limit passes into a cone (Fig. 2).

Obviously, for the completeness of the geometric similarity of the karst funnel and cone, the latter must be truncated. It is for the funnel of such a form that a mathematically rigorous analytical solution is known that determines the thickness of the laminar boundary layer on the inner surface of the funnel [6]

$$\delta_r \approx 1.5(M^3 - M^{16})^{\frac{1}{2}} \cdot \left[\frac{\nu \cdot l^3 \cdot (\sin\alpha)^2}{R_0^2 \cdot \left(\frac{2\bar{P}}{\rho}\right)^{\frac{1}{2}}}\right]^{\frac{1}{2}}, \qquad (1)$$

In this expression there are parameters of the cone and the flow of water. In particular: $\delta_r$is the thickness of the laminar boundary layer, l_0 is the distance from the top of the funnel to its arbitrary cross section of radius R_0, inclusive of the funnel neck, L is the funnel length, $l = L - l_0$, α is the half-angle of the approximate cone solution, $M = \frac{l_0}{L} < 1$ is a dimensionless parameter present in the mathematical scheme for solving the problem. The flow velocity through the cone funnel in expression (1) is present through the pressure drop between the vertex and the funnel base $\bar{P}$, and ν is the coefficient of the kinematic viscosity of the water.

It follows from expression (1) that in the case of constancy of the parameters of the approximation cone and the kinetic viscosity of water viscosity, the velocity of flow through the funnel will be the only parameter that controls the thickness of the boundary layer. Consequently, the radius of the truncated top of the cone can be identified with the radius of the neck of the funnel. For a significant number of karst craters, this analogy is quite plausible, although in the case of a conventional economic funnel of a classical shape, the cone-shaped part ends in a fairly long cylindrical leg. The karst cavities may not have such an end, although they are no less than a conical funnel, similar in shape to a truncated cone.

Thus, the flow of liquid through the funnel is largely determined by the viscous boundary layer arising on its inner surface. However, the thickness of the boundary layer, in addition to the viscosity of water, is also dependent on the water velocity. Therefore, the structure of the flow in the funnel should be quite complicated. In particular, at a distance from the boundary layer, the viscosity effect should decrease and the likelihood of a laminar flow change to turbulent flow increase. Consequently, based on the degree of loading (the level of filling the karst cavity) funnel with liquid, it is physically possible to assume the possibility of realizing various types of motion that can correspond to the following typologically different patterns:

1. Laminar flow, which can occur only in the case of a weak funnel load in the event that the flow of water through the funnel is constant. The movement of water in the direction of the neck of the tapering funnel occurs in the field of gravity. Therefore, laminar flow can theoretically be resistant to small perturbations only when the pressure gradient is constant between the base of the funnel and its neck. Otherwise, the layer structure of the flow will be violated, i.e. there will be the possibility of water turbulence. Such a transformation of the flow structure does not at all mean that the boundary layer on the inner surface of the funnel must completely disappear. For example, the boundary layer can simply detach from the surface. However, in this case, you should expect a decrease in water flow in the funnel, which can change the degree of its load.

2. Mixed forward-rotational motion, which occurs when the load of the funnel increases. Such a movement primarily means an increase in the transverse pressure gradients in the funnel. Along with the increase in the volume of water entering the funnel, the violation of the laminar flow structure may be caused to some extent by the roughness of the surface of the funnel. In the case of a karstic cavity, as an impulse giving rise to a disturbance of the flow, it may be, for example, a mechanical collapse or the ingress of large stones that are carried by the flow of water into the cavity. However, the most probable reason for the appearance of rotational motion in a karstic funnel is the detachment of the viscous boundary layer from its internal surface. Theoretically, this phenomenon can be considered the beginning of the emergence of turbulent water movement, when large-scale eddies begin to appear in it. In the karst funnel, the characteristic dimensions of these vortices must be commensurate with the geometric parameters of the cavity. In the process of

intensification of turbulent motion in the funnel, one cannot exclude the decrease of the longitudinal pressure gradient, and, consequently, the flow of water.

3. Fully developed rotational movement, periodically occurs in the funnel at its maximum load, which is physically real only for a small volume funnel. In this case, it cannot be said that for some time the longitudinal flow, which determines the flow of water, can be weakened or even completely stopped in the funnel. However, this hydrodynamic effect does not mean that pressure gradients can completely disappear, because rotational movement in the funnel will continue. A similar phenomenon sometimes occurs in the economic funnel, which is tightly seated in the neck of the bottle with an incompletely filled liquid. The effect of "locking" the funnel is facilitated by the leveling of the longitudinal pressure arising in the field of gravity due to the increased pressure of compressed air from the side of the bottle (the so-called air cork). In this case, to continue the process of filling the bottle, it is necessary to raise the funnel, i.e. eliminate the air plug. Obviously, "locking" the karst cavity can be an extremely rare short-term phenomenon, probably arising in a funnel connected to an underground water reservoir.

A qualitative picture of washing out the karst cavity

Reducing the flow of water in the karst funnel, up to its "locking", can contribute to those factors that are able to level the longitudinal pressure gradient. The effect of these factors causes the turbulence of water, as a result of which large-scale eddies appear, which, over time, are fractured into smaller-scale vortices. If the fragmentation of the vortices is slower than their generation, the intensity of the large-scale rotational motion in the funnel increases for a time, which can contribute to an increase in the thickness of the viscous boundary layer on the inner surface of the funnel. At the same time, it cannot be said that the boundary layer can completely fill some part of the funnel in the direction of its narrowing and, thus, so slow down the flow in order to substantially reduce the water flow. Obviously, the probability of such an effect can be quite high in only a karstic cavity of a small volume. In this case, an unstable flow can arise, which can be typologically represented as an alternation of the states of "opening" and "locking" the funnel. As mentioned above, this situation can arise only if the karst cavity is connected to an underground water reservoir.

The pulsating character of motion, in comparison with laminar flow, can significantly enhance the viscous interaction between solid rock and water and, thus, depend on the efficiency of washing out of the inner surface of the karst. To substantiate this assumption, let us consider a qualitative model that can be supported by quantitative estimates. It is known that the cause of the appearance of a viscous boundary layer is the effect of adherence of liquid particles to a solid surface. From a mechanical point of view, this means that the tangential stress between the water layers is insufficient to overcome the surface friction force that appears on the streamlined surface. According to Hooke's law, the shear stress is proportional to the shear strain rate [7,8]

$$\tau = G\gamma. \qquad (2)$$

In liquids, the shear stress: $\tau = \mu\left(\frac{\delta u}{\delta y}\right)$, where μ- is the dynamic viscosity coefficient, u - is the longitudinal velocity, y the coordinate is the perpendicular to surface, G is the shear modulus, γ is the coefficient whose value for the liquid can be taken equal to unity .

It is obvious that the magnitude of the tangential stress depends on the steepness of the profile of the velocity distribution of the fluid in the boundary layer. Flourishing (2) determines the stability threshold of static equilibrium in a fluid. Otherwise, if the magnitude of the tangential stress exceeds a certain limit determined by the shear modulus, the laminar flow structure must change. Therefore, water turbulence will begin, as a result of which a viscous boundary layer can come off a solid surface. Consequently, the magnitude of the shear stress is an indicator that determines the moment when the laminar flow regime changes to turbulent. To estimate the magnitude of the tangential stress between the layers of water, one must determine its flow velocity. Strictly speaking, for this it is necessary to solve the boundary layer equation with boundary conditions corresponding to a particular flow problem, which is even an analytically insoluble problem even for a stationary flow. However, in some problems, the physical consequences of which do not require particularly accurate quantitative evidence, one can take advantage of the possibility of rough estimates. However, these estimates must necessarily follow from a qualitatively correct model. For the problem of analyzing the action of the hydrodynamic mechanism contributing to the occurrence of karst voids, in our opinion, this possibility is quite possible. This statement is based on the physical visibility of the model we use. This facilitates the analysis of qualitative conclusions from the model, without which it is impossible to judge the reliability of quantitative estimates. The simplicity of our model is primarily due to the ability to determine the hydrodynamic parameters without a rigorous analytical solution, which is achieved by the way of using the method of physical analogy, which allows using previously known analytical results. In particular, in order to estimate the magnitude of the tangential stress from formula (1), δy can be replaced by a finite linear scale of velocity variation, i.e. Thickness of the boundary layer δ_r . In addition, because the motion in the funnel is due to the action of gravity, at any level of the karst cavity δu can be regarded as the magnitude of the free fall speed. Moreover, for rough estimates, the average values of these parameters can be quite sufficient: $\underline{\delta_r}$ and $\underline{u}$.

Thus, within the framework of our model it is possible to remain within the limits of statics, i.e. there is no need to solve the equation of water motion. For example, knowing the characteristic value of the velocity, it is easy to estimate the magnitude not only of the component of the tangential stress (2), but also other components of the stress tensor. In a cylindrical coordinate system, these components are determined by the expressions [7, 8]

$$\tau_{r\varphi} = \mu\left[r\frac{\partial}{\partial r}\left(\frac{\partial u_\varphi}{\partial r}\right) + \frac{1}{r}\frac{\partial u_r}{\partial \varphi}\right],$$
$$\tau_{\varphi z} = \mu\left[\left(\frac{\partial u_\varphi}{\partial z}\right) + \frac{\partial u_z}{\partial \varphi}\right], \quad (3)$$
$$\tau_{rz} = \mu\left[\left(\frac{\partial u_r}{\partial z}\right) + \frac{\partial u_\varphi}{\partial r}\right],$$

Where u_r, u_φ and u_z are the velocity components, the coefficient of dynamic viscosity of water.

Without a special assumption, we can assume that the magnitude of any component of the flow velocity outside the boundary layer depends on the rate of free fall. At the same time, proceeding from the very essence of the definition of the boundary layer, its thickness should be much smaller than the radius of the funnel section, at least at a certain distance from its base. However, such an assertion may turn out to be incorrect due to the narrowing of the funnel near its nose, where the boundary layer can completely occupy its cross section. In addition, it is obvious that the dependence of the velocity on the azimuth angle φ can be significant only in the case of an inhomogeneous vorticity, the intensity of which must increase in proportion to the decrease in the cross-sectional area of the funnel. In this case, it is quite right to assume that the value of the component τ_{rz} is significantly higher than the values of the other components of the stress tensor. Therefore, their influence on the process of washing out solid rock in the boundary layer can be considered unimportant. This means that the viscous interaction is mainly due to the rotational motion of the liquid in the plane of the cross-section of the funnel. In the general case, this rotation will be unstable because of its non-uniform nature. Consequently, the non-stationary picture of the movement of water through the funnel is represented as a sequence of decaying from large to small vortices. It can be obtained by means of the kinematic velocity model, used, for example, in the work to simulate the inhomogeneous rotational motion of an ionospheric plasma in an incompressible approximation [9]

$$u_\varphi = u\frac{R_0 - r}{R_0}(\cos\varphi - \sin\varphi),$$
$$u_r = u\frac{R - r}{2R_0}(\cos\varphi + \sin\varphi), \quad (4)$$
$$u_z = u,$$

Where $0 \le r \le R$ is the radius of the cross-section of the approximation cone, and u is the characteristic velocity.

If the vertical velocity is assumed constant, then it is obvious that the remaining components (4) satisfy the plane equation of continuity

$$\frac{1}{r}\frac{\partial(rV_{r})}{\partial r}+\frac{1}{r}\frac{\partial V_{\varphi}}{\partial \varphi}=0, \quad (5)$$

which is one of the conditions for the dynamic possibility of motion along the model (4). Such a case will correspond to a qualitative typological picture, the evolution of which should lead to the formation of a chain of vortices whose linear scale will gradually decrease during the movement of water in the karst funnel (Fig. 3)

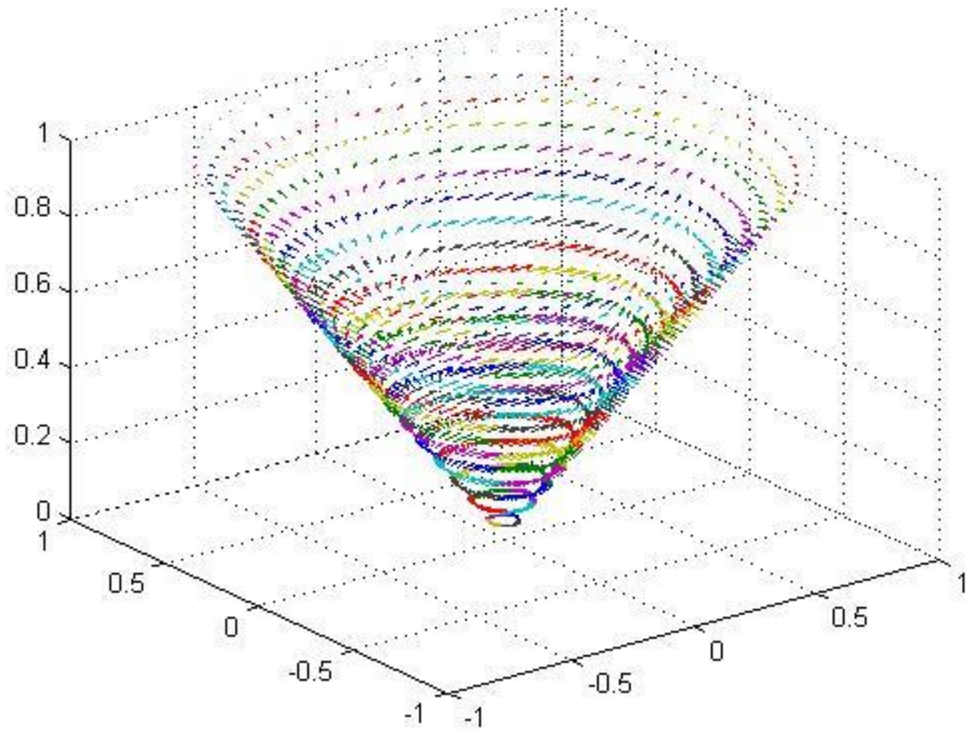


Fig. 3

To quantify the intensity of the leaching process in a karst funnel, as the main linear scale of the inhomogeneity, one can use the characteristic thickness of the viscous boundary layer in the middle of the funnel. To estimate it numerically by expression (1), we use the model cone with the following parameters: $L=10m$, $R=1m$ (radius of cone base), $sin\alpha\approx 0.1$, $M\approx 0.5$, $R_0\approx 0.5$. The coefficient of kinematic viscosity of water: $\nu\approx 1.3\times 10^{-6}m^2s^{-1}$. The free-fall speed at the selected cross-section level, which is related to the pressure drop:

$$u=\left(\frac{2\bar{P}}{\rho}\right)^{\frac{1}{2}}=10\,ms^{-1}.$$

We shall regard this quantity as the average characteristic for the entire cone. As a result of substituting formula (1) for all the numerical parameters, we get that the characteristic thickness of the viscous boundary layer is $\delta_r\approx 10^{-3}m$. It should be noted that this quantity is of the same order of magnitude, for example, for the thickness of the boundary layer at Horizontal flat plate. The validity of such a statement is obvious and the principle of hydrodynamic similarity operates.

To observe it, we must determine the dimensionless Reynolds number corresponding to our model cone: $Re\approx\frac{uR}{\nu}\approx 8\times 10^{6}$. It is known that in the case of a flow past a flat plate, the thickness of the boundary layer depends on the square root of the Reynolds number in accordance with the inverse proportionality law [7,8]. Consequently, for $\underline{Re\approx 8\times 10^{6}}$, the boundary layer on a flat plate, like the thickness on the inner surface of the model cone, will have a characteristic thickness commensurate with $10^{-3}m$.

Thus, if we take into account some structural monotony of karst craters, which arise only because of the washing out of different hard rocks, it can be assumed that the characteristic value of the thickness of the viscous boundary layer on the inner surface of almost any karstic funnel should be within one millimeter. The model we used also quite clearly represents the mechanical result of the tangential stress effect between a solid rock and water. Obviously, to effectively wash out the shear stress on the inner surface of the karst cavity must repeatedly exceed the magnitude of the water shear modulus, which serves as a criterion for static equilibrium between layers of a laminar viscous fluid. Within the framework of our model, when the parameters are: $\mu = 10^{-3} kg\, m^{-1} s^{-1}$, $u = 10 ms^{-1}$ and $\delta_r \approx 10^{-3}$, the characteristic value of the tangential stress: $\tau = 10\ Nm^{-2}$. Obviously, in comparison with the given value, the water shear modulus is negligibly small: $G = 1{,}3\times 10^{-5} Nm^{-2}$ [10]. Hence it obviously follows that the boundary layer must be detached from the inner surface of the karst cavity. Also, there is no doubt that the movement of water in the karst cavity with its significant load, i.e. in the case of a sufficiently intense runoff, cannot be laminar.

Therefore, it is the effect of the separation of the boundary layer, which is the cornerstone of our model. Its main goal is to determine the characteristic time scale of the change in the volume of the karst cavity due to the washout effect, i.e. in the assessment of the rate of removal of solid rock from the karstic cavity. It is known that the washout effect usually occurs in a very thin layer, the thickness of which is commensurable or slightly larger than the molecular size ($\sim 10^{-6} m$). The elution coefficient for most of the terrestrial rocks varies in a characteristic range: $/10^{-5} - 10^{-3}/\ \ kg\, liter^{-1}$ [4,5]. According to our assumption, the process of elution must occur in the volume of the hydrodynamic boundary layer. The washout intensity can increase many-fold due to the rotational motion of the liquid and due to the separation of the boundary layer. The time scales of the elution time depend on the specific conditions. However, using the expression for the volume of the boundary layer

$$V_{\delta_r} \approx \pi R L \delta_r, \tag{6}$$

we can approximately estimate the characteristic value of the rate of washout of solid rock from the karstic cavity.

Conclusion

The volume of the model cone used above approximates the karst cavity: $V \approx \frac{1}{3}\pi R^2 L \approx 10 \mathrm{m}^3$. The volume of the boundary layer on the inner surface of the model cone is $V_{\delta_r} \approx 0.03\ m^3$. Consequently, the mass of the solid rock washed from the boundary layer in the case of the full cone load in the case of zero water flow can be $m_0 \approx 3/10^{-4} - 10^{-2}/$ kg. The rate of removal of solid rock from the karstic cavity depends on the flow of water, which can vary depending on the flow regime. However, we can talk about some average characteristic, if we assume, for example, that the water movement is laminar (minimum washout mode) and the water flow rate is $Q \approx 3\ liter/s$. In this case, through the neck of the cone-shaped funnel within an hour, it can pass $\nu = 10 m^3$ volume of water, which corresponds to: $m \approx /10^{-1} - 10/$ kg mass of solid rock. If this process continues, for example, 100 days, then the maximum mass of washed solid rock can be 24 tons. Consequently, the volume of the cone approximating the karst cavity can increase by $V_0 \approx 10 - 12 m^3$, i.e. approximately twice. However, it should be noted that the value of the rate of karst leaching used for numerical evaluation is very approximate. It was obtained in the linear approximation. Despite such a shortcoming, which is a consequence of a rather crude physical analogy, it nevertheless seems that with the help of the model we have used, it is possible to obtain more accurate quantitative estimates. In particular, in order to increase the reliability of the results, it is necessary to use integral relations, in which the effect of nonlinear increase in the washout rate, which varies with the growth of the volume of the karst cavity, should be reflected.

References

[1] Gvozdetskiy N.A. Karstovyye Landshafty. Moskva, iz-vo MGU, ISBN 3-211-00128-1, 1988, 112 s. Vakhrushev B.A.
[2] Karst geomorphology and the notion of karst relief. Speleology and karstology, vol.1, Simpheropol, 2008, pp. 47-53.
[3] Kirtener D.A., Uskov I.B. Klimaticheskiye faktory i teplovoy rezhim v otkrytom i zashchishchennom grunte. Leningrad, Gidrometizdat, 1982, 228 s.
[4] Timofeyev D.A., Dublyanskiy V.N., Kiknadze T.Z. Terminologiya karsta. Moskva, Nauka, 1991, 260 s.
[5] Koronovskiy V.N., Yakushova A.F. Osnovy geologii. Moskva, Vysshaya shkola, 1991, 416 s.
[6] X. Binnie A.M. Harris. D.P. The application of Bonndary-Layer Theory to Swirling Liquid Flow Through a Nozzle. Quart. J. Mech. and Applied,Math.. v.3, 1950, pp. 89-106.
[7] Shlikhting G. Teoriya pogranichnogo sloya. Moskva, Nauka, 1974, 711 s.
[8] Loytsyanskiy L.G. Mekhanika zhidkosti i gaza. Moskva, Nauka, 1973, 847 s.
[9] Kirtskhalia V., Kereselidze Z., Dzhondzholadze N., Chkitunidze M. An Analytical Model of an Asymmetrical Temperature Field in the Polar and Auroral Ionosphere. Georgian Int. J. of Sci. and Tech., №4, 2012, pp.381-90.
[10] Korenchenko A.Ye., Beskachko V.P. Opredeleniye skorosti sdviga vody v eksperimentakh s plavayushchim diskom. Prikladnaya mekhanika i tekhnicheskaya fizika, t.49, №1, 2008, s.100-103.

კარსტული სიცარიელის წარმოქმინის ჰიდროდინამიკური მოდელი

ზ.კერესელიძე, დ. ოდილავაძე, მ.ჩხიტუნიძე

რეზიუმე

კარსტის განვითარების დინამიური სურათის ფიზიკურ მოდელირებას აქვს სხვასადხვა მიზანი, რომელთა შორის არის კერძოდ, მათი ჩამოყალიბების დამახასიათებელი დროის მასშტაბის შეფასება. ცხადია, რომ ეს ამოცანა საკმაოდ რთულია კარსტული პროცესების მრავალფეროვნების გამო, რომელიც ვლინდება თითქმის ყველგან, როგორც საერთო მახასიათებლებით, ასევე ადგილობრივი განსაკუთრებულობებით. კარსტულ სიცარიელეებს შეიძლება ჰქონდეთ საკმაოდ განსხვავებული ფორმები, რომელთა ნაწილს აქვს რეგულარობა გარკვეული გეომეტრიული ფიგურის მსგავსების გამო. მაგალითად, კარსტის საკმაოდ გავრცელებული ფორმა არის ძაბრისებური ფორმა ფუძით დედამიწის ზედაპირზე. გამორეცხვის ფაქტორის მოქმედების ეფექტურობა პირდაპირ არის დამოკიდებული გარემოს გეოლოგიურ თვისებებზე და წყლის მოქმედების ხანგრძლივობაზე. როგორც ჩანს, მექანიზმის ერთგვაროვნების დასადასტურებლად, რომლის მოქმედება იწვევს მკვრივი ნიადაგის გამორეცხვას, შეიძლება მივმართოთ ჰიდროდინამიკური სასაზღვრო ფენის მიახლოებას, რომელიც წარმოიქმნება მკვრივი ზედაპირის გარსდენის დროს.
ნიადაგის გამოტანის სიჩქარე კარსტული ღრუდან დამოკიდებულია წყლის ხარჯზე, რომელიც შეიძლება იცვლებოდეს დინების რეჟიმზე დამოკიდებულად. თუმცა შეიძლება ვისაუბროთ, გარკვეულ საშუალო მახასიათებელზე, თუ დავუშვებთ, რომ წყლის მოძრაობა არის ლამინარული.

უნდა აღინიშნოს, რომ რიცხვითი შეფასებისათვის გამოყენებული კარსტის გამორეცხვის სიჩქარის სიდიდე არის საკმაოდ მიახლოებითი. მიუხედავად ამისა, წარმოგვიდგება რომ, ჩვენს მიერ გამოყენებული მოდელის საშუალებით შეიძლება მივიღოთ უფრო ზუსტი რაოდენობრივი შეფასებები.

Гидродинамическая модель образования карстовых пустот

З.А. Кереселидзе, Д.Т. Одилавадзе, М.С. Чхитунидзе

Резюме

Физическое моделирование динамической картины развития карста преследует различные цели, среди которых, в частности, является оценка характерного временного масштаба их образования. Очевидно, что эта задача является достаточно сложной из-за многобразия процесса карстрирования, протекающего практически повсеместно, как с общими характеристиками, так и местными особенностями. Карстовые пустоты могут иметь самые различные формы, часть которых имеет некоторую регулярность из-за подобия с определенной геометрической фигурой. Например, для карста достаточно распространенной является воронкообразная форма с основой на земной поверхности. Эффективность действия фактора вымывания находится в прямой зависимости от геологических качеств среды и длительности действия воды. Представляется, что для подтверждения однообразия механизма, действие которого приводит к вымыванию твердой породы, можно обратиться к приближению гидродинамического пограничного слоя, возникающего при обтекании твердой поверхности.

Скорость выноса твердой породы из карстовой полости зависит от расхода воды, который может менятся в зависимости от режима течения. Однако, можно говорить о некоторой средней характеристике, если предположить, например, что движение воды является ламинарным.

Необходимо отметить, что использованная для численной оценки величина скорости вымывания карста является весьма приблизительной. Тем не менее представляется, что при помощи использованной нами модели можно получить более точные количественные оценки.

Journal of the Georgian Geophysical Society,
Issue B. Physics of Atmosphere, Ocean and Space Plasma, v.19B, 2016, pp.35-40

Application of MODIS LST and Aurface Air Temperature Data for Snow Cover Analysis in Georgia

[1]Genadi A. Tvauri., [2]Nino N. Lomidze, [2]Tatiana D. Jinjolia, [1]Ketevan J. Koridze

[1]M. Nodia Institute of Geophysics of Iv. Javakhishvili Tbilisi State University, 1, Alexidze st. Tbilisi, Georgia
[2]V. Batonishvili Institute of Geography of Iv. Javakhishvili Tbilisi State University, 6, Tamarashvili st. Tbilisi, Georgia

ABSTRACT

MODIS global Land Surface Temperature (LST) and Emissivity 8-day L3 Global 1 km and surface air temperature data measurements of different meteorological stations were used for analysis of snow cover in Georgia. It was shown that application of snow cover map correction algorithms based only MODIS Snow product data and algoritms with addition of LST and surface air temperatures give almost the same result. It was supposed that for snow cover map correction MODIS snow product data are quite enough and no additional correction is nessesary.

Keywords: aurface air temperature, snow cover, MODIS

The 8-day composite MODIS Terra snow product (MOD10A2) was used for snow cover analysis in Georgia for 14 hydrological years (September 2000- June 2014) [1]. The snow products were generated by the NASA Godard Space Flight Center and made available by the National Snow and Ice Data Center (NSIDC), Colorado, USA [2].In the MODIS Terra snow product (MOD10A2) Snow covered areas are mapped as a Maximum Snow Extent. The second dataset of MOD10A2 files, Eight Day Snow Cover was used to correct contaminated pixels.

It should be noted that the MODIS 8 day composite snow products must be handled carefully. Fig. 1a shows that in the image of snow cover for September, 2010, there are some "contaminated" pixels, corresponding to the snow covered areas in Kolkheti region.Second dataset of MOD10A2 snow data, Eight Day Snow cover Gives possibility to make some corrections. Applied algorithm supposes, that pixels marked as "snowy" with duration of only one day may be marked as "cloudy", i.e. free of snow pixels.

From the other hand, application of discontinuities enhancement Laplace filter (3x3) to the snow cover map detects border of snow cover area. Resulted border may be layed over Terra Aster DEM (preliminary downgraded to MODIS Terra snow product spatial resolution – 500 m).Resulted border was layed over Terra Aster DEMand histogram of border pixel elevation may be obtained. Therefore the stable snow border mean elevation may be determined.

Application "one day snow pixel" algorithm on snowy pixels with elevations less than stable border mean elevation cleans "dirty pixels" and gives much more better result, represented on the Fig. 1.b.

Additional correction may be performed with application of ground measurement data, snow observations and especially air temperature distribution. This kind of correction also gives possibility to filter contaminated pixels and get more correct results.

For this purposeLand surface temperature satellite data and the air temperature ground measurement data were used.MODIS global Land Surface Temperature (LST) and Emissivity 8-day L3 Global 1 km (MOD11A2) data were applied for analysis of land surface temperature fields [3]. Air temperature data measurements of different meteorological stations in the East and West Georgia were used also.

The September-June of 2010-2011 hydrological year Air temperature measurement data of 9 meteorological stations were kindly provided by by the National Environmental Agency of Georgia (NEA). Geographical coordinates, also altitudes of these stations are shown in Table 1.

At all mentioned stations air temperature measurements are provided 8 times per day (00.03.06.09.12.15.18.21 UTC). The MODIS local passing time is about 10:30 and 22:30 and we selected corresponding surface observation data measured at 06:00 and 18:00 UTC.

Table 1

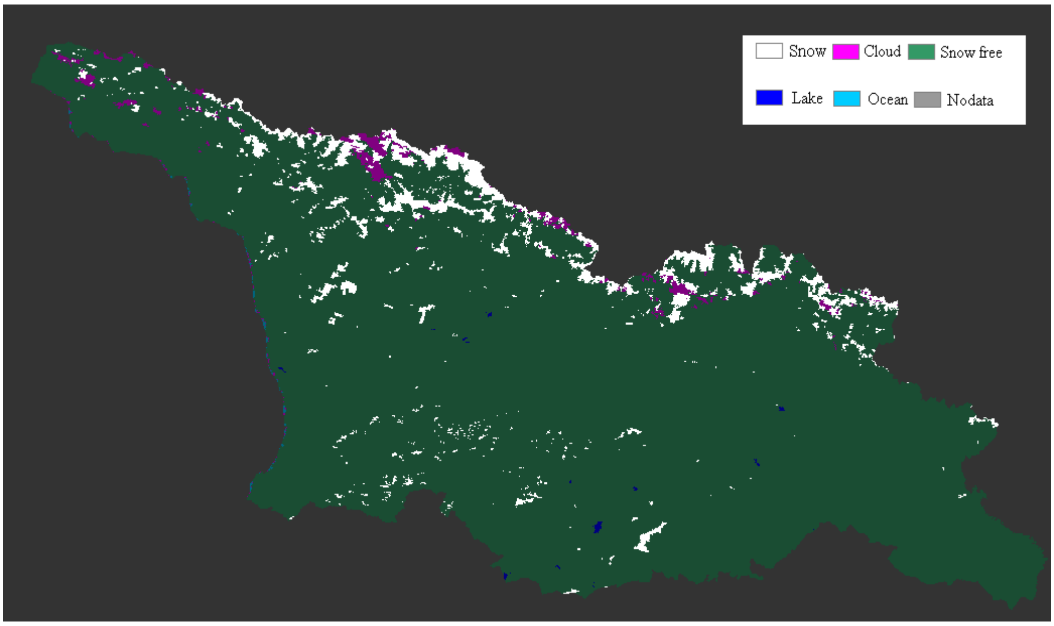
No	Station name	Latitude	Longitude	Elevation
1	Kutaisi	42°16´ N	42°38´ E	116
2	Zugdidi	42°30´ N	41°53´ E	117
3	Tbilisi	41°45´00´´ N	44°46´10´´ E	428
4	Bolnisi	41°27´ N	44°33´ E	534
5	Ambrolauri	42°31´ N	43°09´ E	544
6	Telavi	41°55´41´´ N	45°30´44´´ E	566
7	Gori	41°59´ N	44°07´ E	612
8	Pasanauri	42°21´ N	44°42´ E	1064
9	Mtasabueti	42°02´ N	43°29´ E	1245

Investigation of statistical relationship between 8-day Terra MODIS LST and meteorological data of surface air temperature were performed by using 280 observation data of 9 meteorological stations for September-June period of 2010-2011 hydrological year. Mean air temperature for each 8-day MODIS LST dataset were calculated from daily surface air temperature measurements and only clear sky data were taken into account. Results of Linear regression analysis is given on Fig. 2

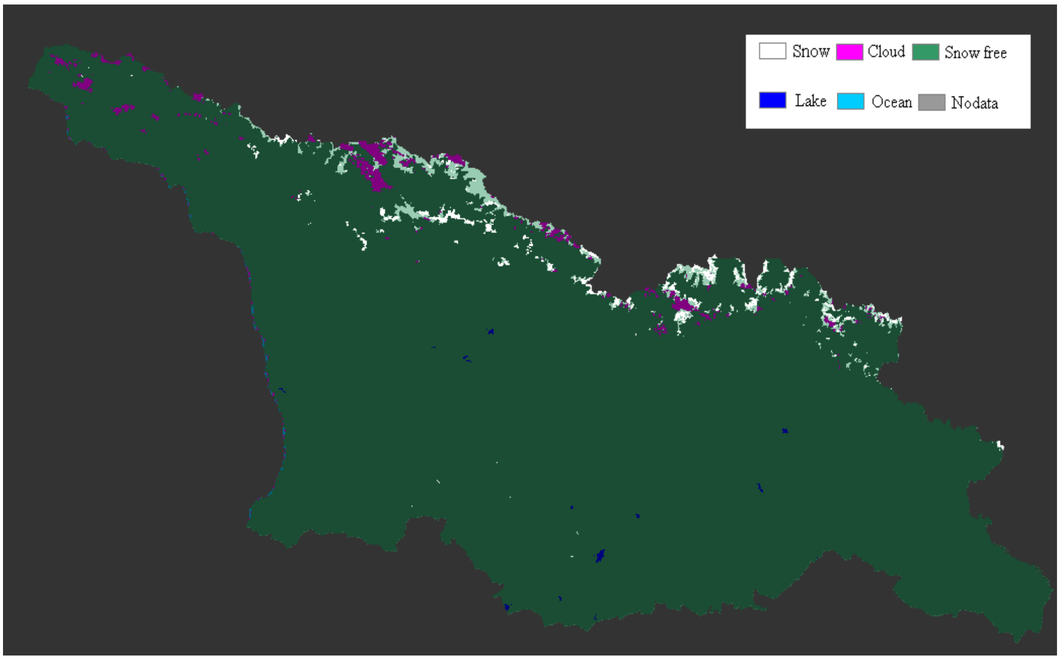
The estimated air temperature values were calculated according to the regression equation and corresponding temperature maps were created. Both MODIS LST and estimated air temperature data were used for snow cover map correction analysis.

Application of LST and estimated air temperature (T_o) parameters for Snow cover map correction and “dirty pixel” clearing supposes use of “one day pixel” filter for LST > 0 ºC area. Fig. 3 shows results of all applied corrections.

Comparison of Fig.1, Fig 3 and Fig. 4 shows that there is no significant difference between results of application of “dirty snow pixel” filter algoritms based only Tera MODIS Snow product data and algoritms with addition of Terra MODIS LST and surface air temperature meteorological data.

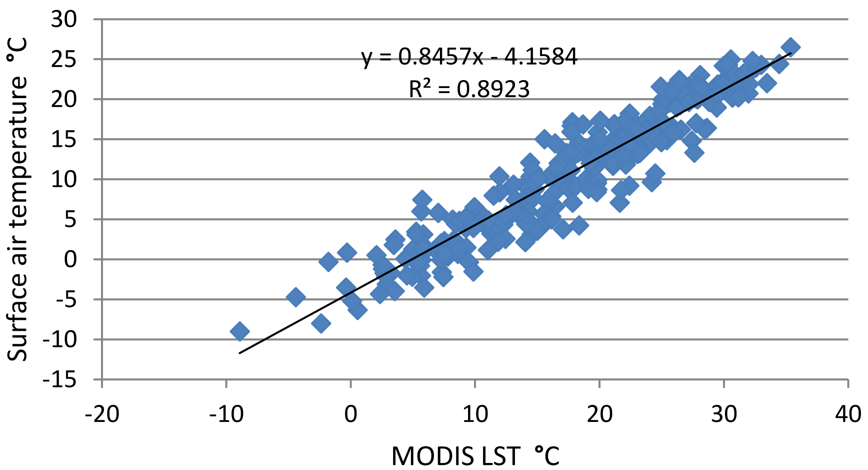


a. Before correction



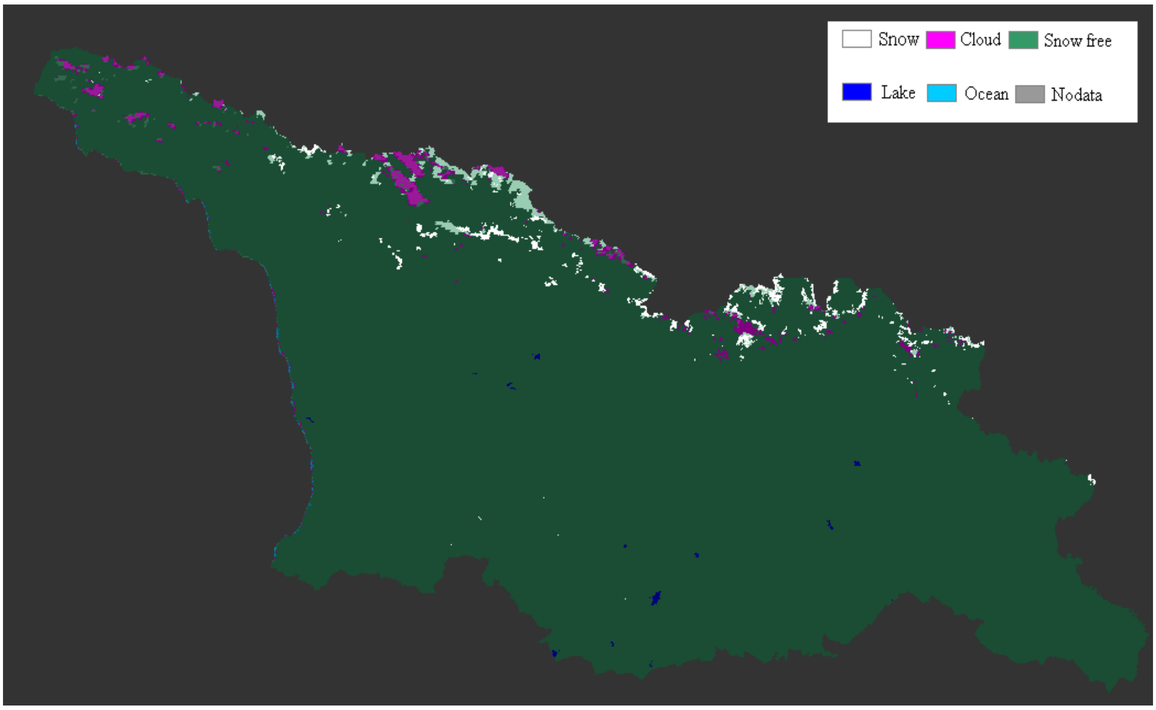
b.   After application of “one day snow pixel”, “stable snow line elevation” algorithm

Fig. 1. Snow Cover images 2010, 16 of October, before and after correction

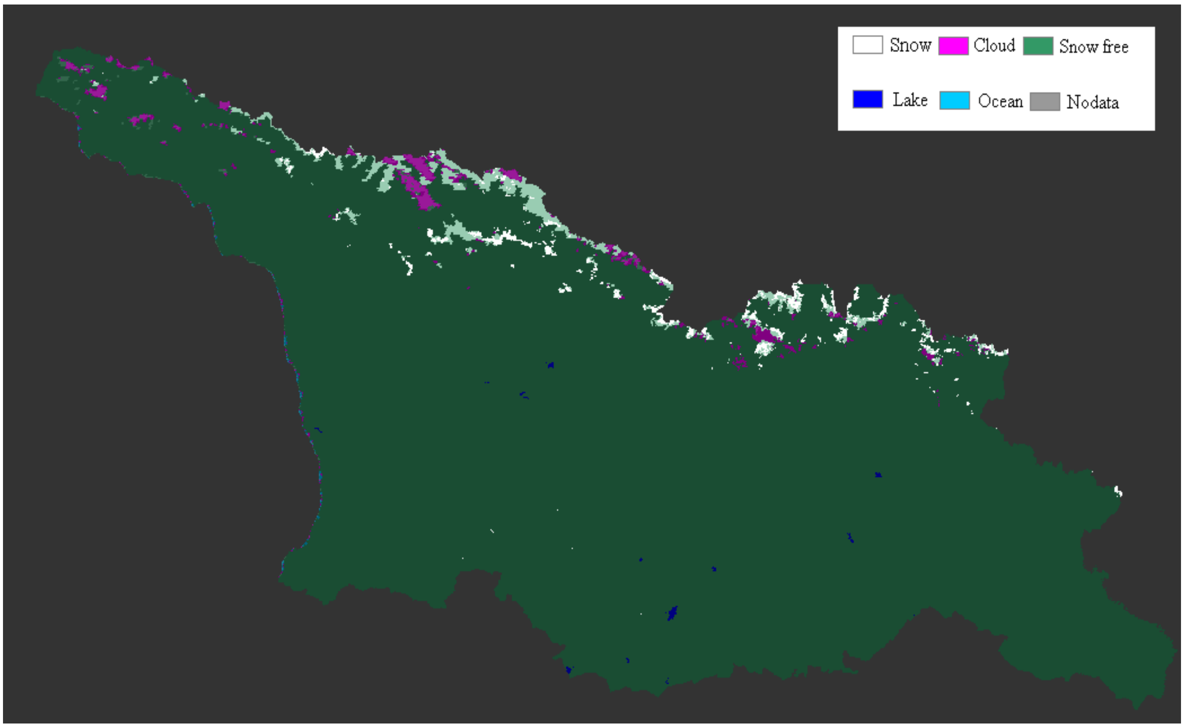


Regression Statistics	
Multiple R	0.944634
R Square	0.892333
Adjusted R Square	0.891946
Standard Error	2.601437
Observations	280

Fig. 2 statistical relationship between 8-day Terra MODIS LST and meteorological data of surface air temperature

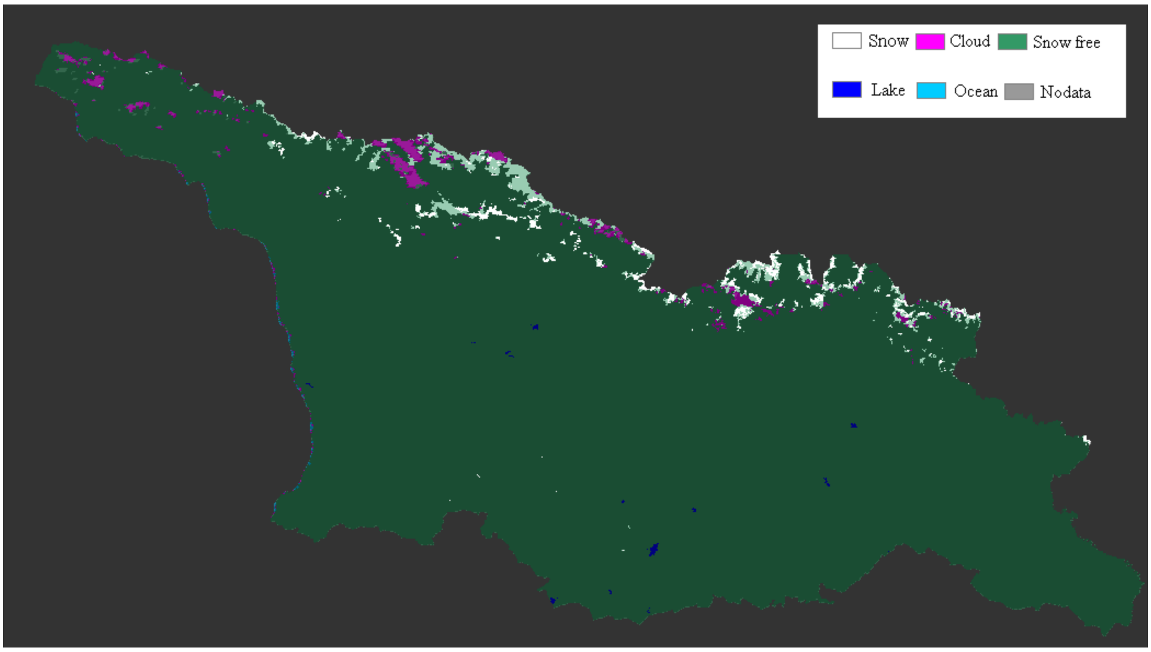


a. “One day snow pixel”, “LST > 0 ºC”

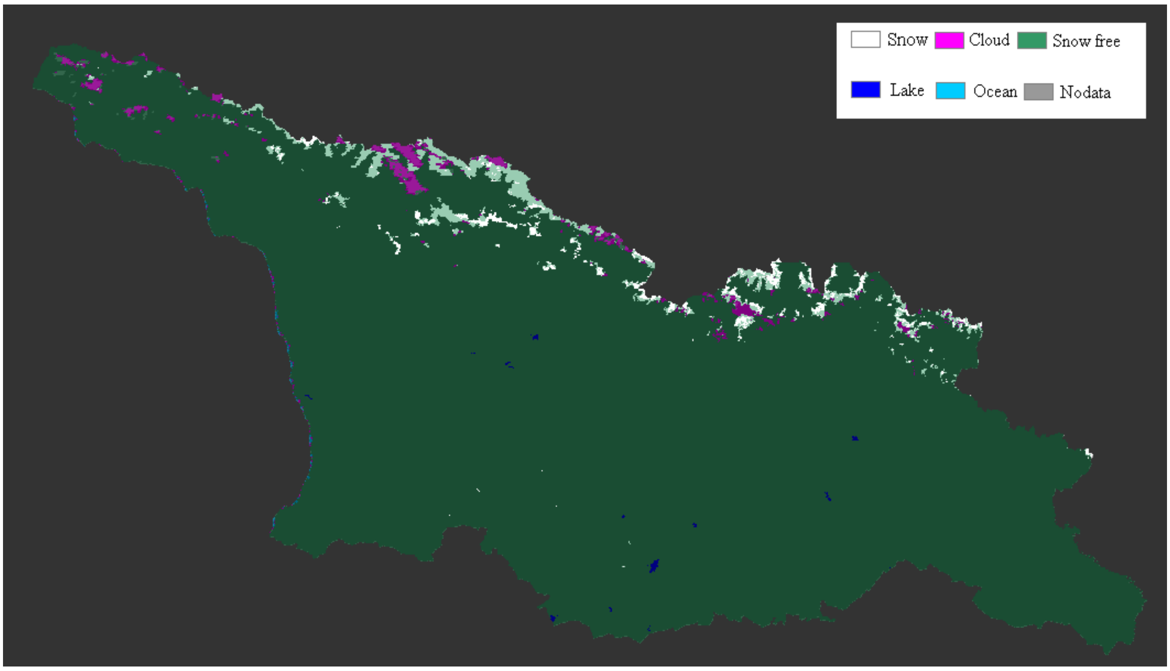


b. “One day snow pixel” and “T_o> 0 ºC”

Fig. 3. Result of application of “one day snow pixel”, “LST > 0 ºC” and “T_o> 0 ºC” algorithms on 2010, 16 of October snow cover image



a. “One day snow pixel”, “stable snow line elevation” and “LST > 0 °C”



b. “One day snow pixel”, “stable snow line elevation”, “LST > 0 °C” and “T_o> 0 °C”

c.

Fig. 4. Result of application of “one day snow pixel”, “stable snow line elevation”, “LST > 0 °C” and “T_o> 0 °C” algorithms on 2010, 16 of October snow cover image.

References

[1] Lomidze N., Jinjolia T., Koridze K., Tvauri G., Zilpimiani D. Application of Remote sensing and GIS technologies for study of seasonal snow cover in Georgia, The Journal of the Georgian Geophysical Society, Issue (B), Physics of Atmosphere, Ocean, and Space Plasma, v. 17, 2014, pp.106-110.
[2] Hall D. K., Salomonson V. V., Riggs G. A. MODIS/Terra Snow Cover Daily L3 Global 500m Grid. Version 5. January to December 2012. Boulder, Colorado USA: National Snow and Ice Data Center.

[3] Wan Z., Hook S., Hulley G. “MOD11A2 MODIS/Terra Land Surface Temperature/Emissivity 8-Day L3 Global 1km SIN Grid V006.” NASA EOSDIS Land Processes DAAC, 2015. Available: https://doi.org/10.5067/MODIS/MOD11A2.006

MODIS სენსორის ქვეფენილი ზედაპირის ტემპერატურისა და ჰაერის ტემპერატურის მეტეოროლოგიური მონაცემების გამოყენება საქართველოს თოვლის საფარის ანალიზისათვის

გ. თვაური, ნ. ლომიძე, ტ.ჯინჯოლია, კ. ქორიძე

რეზიუმე

საქართველოს თოვლის საფარის ანალიზის მიზნით გამოყენებული იქნა MODIS სენსორის ქვეფენილი ზედაპირის ტემპერატურისა და გამოსხივების 8-დღიანი გლობალური L3 დონის 1 კმ სივრცითი გარჩევითობის და აგრეთვე მეტეოროლოგიური სადგურების ჰაერის ტემპერატურის გაზომვის მონაცემები. ნაჩვენები იქნა, რომ მხოლოდ MODIS სენსორის თოვლის საფარის მონაცემების საფუძველზე განხორციელებული კორექტირების ალგორითმები და ქვეფენილი ზედაპირისა და ატმოსფერული ჰაერის ტემპერატურის გამოყენებაზე დაფუძნებული ალგორითმების შედეგები თითქმის არ განსხვავდება ერთმანეთისაგან. მიღებული შედეგების თანახმად, თოვლის საფარის კორექტირების მიზნით MODIS სენსორის თოვლის საფარის მონაცემების გამოყენება სავსებით საკმარისია და დამატებითი კორექტირება აუცილებელი არ არის.

Применение данных температуры подстилающей поверхности MODIS и метеорологических данных температуры воздуха для анализа снежного покрова Грузии

Г.А. Тваури, Н.Н. Ломидзе, Т.Д. Джинджолия, К.Дж. Коридзе

Резюме

Для анализа снежного покрова Грузии были использованы данные MODIS LIST и метеорологические данные измерений температуры атмосферного воздуха у земной поверхности. Было установлено, что результат применения алгоритмов коррекции карт снежного покрова, основанных только на данных дистанционного зондирования и алгоритмов с применением данных температуры подстиляющей поверхности земли и температуры воздуха у поверхности земли незначительно отличаются. Было предположено, что для коррекции карты снежного покрова вполне достаточно применение только данных MODIS и нет необходимости в проведении дополнительной коррекции.

Journal of the Georgian Geophysical Society,
Issue B. Physics of Atmosphere, Ocean and Space Plasma, v.19B, 2016, pp. 41-48

Modeling of Exhaust (Waste) Water in the Extraction of Hydrogen Sulfide Black Sea

[1]Marat S. Tsitskhishvili, [2]Alexander E. Shaptoshvili

[1]Georgian Academy of the Ecological Science, Georgia
[2]Israel Energy Initiatives

ABSTRACT

Numerical models, "basic control parameters", Simulation for the case of waste water discharge into the river, model parameters, MacCormack's predictor-corrector. Due to selection of more realistic parameter values in the numerical schemes, the use of Kolmogorov's approximation of turbulent diffusion obtained practically relevant values of pollution fields for the different placement of sources of pollution. The paper presents the results of calculations of pollution fields.

Key words: water pollution, hydrogen sulfide.

When implementing technical schemes energy use hydrogen sulfide from the deep layers of the Black Sea, there are problems of ecologically safe discharge "waste water." Offers numerical models allow calculating environmentally safe concentrations in the wastewaters at various depths of discharge into the sea and for different flow rates (reset) of wastewater.

Modern optimal management of the natural environment in order to achieve sustainable development must be based entirely on the processes of knowledge on detailed analysis, diagnosis and prognosis! Application of physic - mathematical modeling allows to predict the dynamics of the subsequent results of human impact on natural and social complex systems.

Extreme complexity of natural geo-environmental complex units (ecosystems) forces to build mathematical models only with a certain approximation. Purely empirical approach to the study of such complex systems is irrational; modeling allows identifying the main factors shaping, which is why the model, despite the proximity and limitations helps the cause - effect analysis system.

When modeling in natural environments (atmosphere, hydrosphere) must first of all:
- Clearly define the system;
- To evaluate the connection and exchange streams;
- Highlight the main features of the system;
- To assess the degree of accuracy required;
- To determine the dimensionality of the system;
- Evaluate a representative set of variables minimum defining the state of the system;
- Establish a system of basic equations describing the evolution of the system;
- Must be mentioned to define "basic control parameters", giving physically
a real sense of an abstract mathematical model.

As we move through the steps above to provide a consistent model increasingly filled with physical meaning, which allows us to call such a physical - mathematical modeling.
The most critical part of the so-called simulation the definition of "input - output", i.e. forming the boundary conditions. For natural ecosystems , with a spatial (geographic or geometric) isolating systems important to take these inputs and outputs, sources and sinks , namely the boundary conditions determine the impact of the environment on our " selection system" it is through these factors.

This is a first in a series of works devoted to the admixtures expansion in the high-speed stream. 2-dimensional model of admixture expansion in the high-speed stream is suggested. The model is based on the 3-dimensional model vertical averaging with taking into account ``shift" and ``turbulent" viscosity. Some numerical tests realized, with the stability of numerical scheme proving. 2-dimensional model gives us a possibility of approximation the concrete be high-speed stream cause we can take in account: depth, fluid speeds and a geographical configurations, depending on where the discharge takes place - in the coastal zone, estuary or far at sea.

1. Simulation for the case of waste water discharge into the river.

The 3-dimensional equation of passive admixtures expansion is:

$$\frac{\partial c}{\partial t}+\vec{\nabla}_h\cdot\left(c\vec{U}_h\right)+\frac{\partial}{\partial x_3}\left(cU_3\right)=S+\vec{\nabla}_h\cdot\left(k\vec{\nabla}_h c\right)+\frac{\partial}{\partial x_3}\left(\lambda\frac{\partial c}{\partial x_3}\right) \qquad (1)$$

where [1]:

$$\vec{\nabla}_h\cdot\left(c\vec{U}_h\right)-\text{horizontal advection}$$

$$\frac{\partial}{\partial x_3}\left(cU_3\right)-\text{vertical advection}$$

$$\vec{\nabla}_h\cdot\left(k\vec{\nabla}_h c\right)-\text{horizontal diffusion}$$

$$\frac{\partial}{\partial x_3}\left(\lambda\frac{\partial c}{\partial x_3}\right)-\text{vertical diffusion}$$

$$S-\text{external sources}$$

Let us introduce a vertically averaged admixtures concentration:

$$\bar{c}=\frac{1}{H}\int_{-h}^{\xi}c\,dx_3$$

where $H(x,y)$ - full depth, ξ - surface of water,

and the deviation from the average concentration:

$$\hat{c}=c-\bar{c},\quad -\text{on the assumption of }\int_{-h}^{\xi}\hat{c}\,dx_3=0$$

Integrating (1) in the vertical direction, one obtains:

$$\frac{\partial\bar{c}}{\partial t}+\overline{\vec{U}_h}\cdot\vec{\nabla}_h\bar{c}=\Lambda+\Sigma+T \qquad (2)$$

where:

$$T:\ \int_{-h}^{\xi}\vec{\nabla}_h\cdot\left(k\vec{\nabla}_h c\right)dx_3$$

$$\Sigma:\ \frac{1}{H}\vec{\nabla}_h\cdot\left(H\int_{-h}^{\xi}\hat{\vec{U}}_h\hat{c}\,dx_3\right)$$

$$\Lambda-\text{sum of external sources.}$$

Σ is the ``shift" effect contribution. It describes the following set of effects: there is two contributions appearing when we average in any direction - first is an advection by average moving and second is average of a product of deviations from the average, which gives us an addition in the form of ``turbulent" diffusion.

Let us estimate now the shift effect. Let us subtract (2) from (1) for obtaining the equation for $\hat{c}$:

$$\frac{\partial\hat{c}}{\partial t}+\overline{\vec{U}_h}\cdot\vec{\nabla}_h\hat{c}+\hat{\vec{U}}_h\cdot\vec{\nabla}_h\hat{c}+U_3\frac{\partial\hat{c}}{\partial x_3}+\Sigma-\vec{\nabla}_h\cdot\left(k\vec{\nabla}_h c\right)+T+\hat{\vec{U}}_h\cdot\vec{\nabla}_h\bar{c}=\frac{\partial}{\partial x_3}\left(\lambda\frac{\partial\hat{c}}{\partial x_3}\right)+S-\Lambda \qquad (3)$$

Further $|\hat{c}| = |\bar{c}|$, but $\left|\hat{\vec{U}}_h\right|$ is not less than $\left|\overline{\vec{U}_h}\right|$ as function of x_3. It is possible to show that the main contribution from left side comes from horizontal advection $\hat{\vec{U}}_h \cdot \vec{\nabla}\bar{c}$.

Then:

$$\hat{\vec{U}}_h \cdot \vec{\nabla}\bar{c} \sim \frac{\partial}{\partial x_3}\left(\lambda \frac{\partial \hat{c}}{\partial x_3}\right) + S - \Lambda \qquad (4)$$

It is possible in principle obtain $\hat{c}$ through $\vec{\nabla}\bar{c}$. Then multiplying by $\hat{\vec{U}}_h$ and integrating by vertical direction one obtains the expression for the shift effect. The expression of $\hat{c}$ by $\hat{\vec{U}}_h$ in a common case will contain double integral of $\hat{\vec{U}}_h \cdot \vec{\nabla}\bar{c}$ by vertical direction. We could avoid the integrals in the equation by making an assumption of a form of dependence of $\hat{\vec{U}}_h$ and Λ of time and coordinates. Bowden suggested [2]:

$$\hat{\vec{U}}_h = \overline{\vec{U}_h} \cdot \phi(\eta) \qquad (5)$$

$$\lambda = \|\vec{U}_h\| \cdot H \cdot g(\eta) \qquad (6)$$

where $\eta = \frac{1}{H}(x_3 + \xi)$

(5) is very strong and restrictive supposition. But from observational results follows that it is very realistic. Then:

$$\left(\overline{\vec{U}_h} \cdot \vec{\nabla}_h \bar{c}\right)\phi = \frac{\|\vec{U}_h\|}{H}\frac{\partial}{\partial \eta}\left(g \frac{\hat{c}}{\partial \eta}\right) + S - \Lambda \qquad (7)$$

Integrating twice, multiplying by $\hat{\vec{U}}_h$ and averaging in the vertical dimension, one obtains:

$$\Sigma = \frac{1}{H}\vec{\nabla}_h \cdot \left[\frac{\gamma_1 H^2}{\|\vec{U}_h\|}\overline{\vec{U}_h}\left(\overline{\vec{U}_h} \cdot \vec{\nabla}_h \bar{c}\right)\right] \qquad (8)$$

Combining (2) and (8) finally we will have:

$$\frac{\partial \bar{c}}{\partial t} + \overline{\vec{U}_h} \cdot \vec{\nabla}_h \bar{c} = \Lambda + \frac{1}{H}\vec{\nabla}_h \cdot \left[\frac{\gamma_1 H^2}{\|\vec{U}_h\|}\overline{\vec{U}_h}\left(\overline{\vec{U}_h} \cdot \vec{\nabla}_h \bar{c}\right)\right] + \vec{\nabla}_h \cdot k\vec{\nabla}_h \bar{c} \qquad (9)$$

This is the model equation.

2. Model parameters

The motions could be considered as a hierarchy of turbulent vortexes with different scale of length and time. Suppose it could be described by Kolmogorov theory; then the energy is distributed by different scales of motions as:

$$E(l) \sim \varepsilon^{2/3} l^{5/3} \qquad (10)$$

where l is a typical scale of length, ε - the speed of energy transport by descending cascade of vortexes. From this the typical speed and time are:

$$v_l \sim \varepsilon^{-1/3} l^{1/3} \qquad (11)$$

$$\tau \sim \varepsilon^{1/3} l^{2/3} \qquad (12)$$

This means that the model smoothing the motions with scales less of:

$$l : \ \varepsilon^{1/3}\tau^{5/3} \quad (13)$$

By Kolmogorov their contribution in the evolution equation is the ``diffusion" term but with ``turbulent" diffusion coefficient:

$$\nu : \ \varepsilon^{1/4} l^{4/3} : \ \varepsilon\tau^{2} \quad (14)$$

$\varepsilon : \ 10^{-6}$ for rivers [1], and from expression for the shift viscosity as function of average speed and depth we have:

$$\nu : \ \mathrm{P}\vec{U}_h\mathrm{P}\cdot H : \ 10^{1}$$

Then from length part of (14) we receive:

$$l^{4/3} : \ 316.23, \quad l : \ 74.08$$

i.e. the scale of length is $l : \ 100$ m.

From time part of (14) we receive:

$$\tau : \ 3162.28\,\text{sec}$$

and time scale is $\tau : \ 1$ hour.

Consider now the ``turbulent" viscosity. Let us take the grid step as 10 m. Than the the ``turbulent" viscosity will be:

$$\nu : \ 10^{-10/4}\cdot 10^{4/3} : \ 0.68$$

From time part of (14) we receive:

$$\tau^{2} : \ 10^{6}, \quad \tau : \ 10^{3} : \ 0.25\,\text{hour}$$

The ``turbulent" viscosity is about 10 times less than shift viscosity which describes the physics of model - it is acceptable. Next, the time scale is such that the numerical model allows us to obtain the time resolution more accurate than the physical model.

Further the scheme viscosity is $\mathrm{P}\vec{U}_h\mathrm{P}^2\,\Delta t$ (this is for a MacCormack predictor-corrector type scheme[3]). If we will take a time step about 0.5 sec, the scheme viscosity will be negligible.

2. Deterministic models of waste water into the sea, at entering rivers. (East coast of the Black Sea)

The passive admixture's turbulence diffusion equation has form:

$$\frac{dc}{dt} + \frac{d}{dt}(cU) + \frac{d}{dy}(CV) = \frac{d}{dx}\left(K_x\frac{dc}{dx}\right) + \frac{d}{dy}\left(K_y\frac{dc}{dy}\right) + \frac{d}{dz}\left(K_z\frac{dc}{dz}\right)$$

where $k = 10$ sm^2/sec, $K_x, K_y = 5*10^{+6}$ sm/sec is the turbulent viscosities, c is concentration Grid's step is 26.88 km in horizontal direction and 20 m in vertical before depth 200 m. Number of grids knots is 4983 (Fig. A).

For numerical solving of the problem the MacCormack's predictor-corrector, second order in space and time desintegrated scheme was used. Let us introduce the operator

$$C^{*}_{i,j,k} = L_x(\Delta t_x)C^{n}_{i,j,k}$$

$$C^{*}_{i,j,k} = C^{n}_{i,j,k} - \Delta t_x\Delta_x + (C^{n}_{i,j,k}\cdot U_{i,j,k} - M^{n}_{i,j,k}\Delta_x\cdot C^{n}_{i,j,k})$$

$$C^{*}_{i,j,k} = 1/2(C^{*}_{i,j,k} + C^{n}_{i,j,k}) - 1/2\Delta t_x\Delta_x - (C^{*}_{i,j,k}\cdot U_{i,j,k} - M^{n}_{i,j,k}\Delta_x\cdot C^{*}_{i,j,k})$$

$$M^{n}_{i,j,k} = 1/2(K_{x,i,j} + K_{x,i-1,j})$$

$$M_{i,j,k} = 1/2(K_{x,i+1,j} + K_{x,i,j})$$

Analogous operators $L_y(\Delta t_y)$, $L_z(\Delta t_z)$ were introduced. Then the scheme takes the form:

$$C^{n+1}_{i,j,k} = L_x(\Delta t/2) L_y(\Delta t/2) L_z(\Delta t/2) L_z(\Delta t/2) L_y(\Delta t/2) L_x(\Delta t/2) \cdot C^n_{i,j,k}$$

Such a scheme was searched because the turbulent viscosities is horizontal and vertical directions are very different and scheme allows us to do the independent steps in different directions (D. Anderson et al. 1990). The time step is determined as:

$$\Delta t/2 = \min(\Delta t_x, \Delta t_y, \Delta t_z)$$

$$\Delta t_x = \frac{(\Delta x)^2}{|U|\Delta x + 2K_x}, \quad \Delta t_y = \frac{(\Delta y)^2}{|V|\Delta y + 2K_y}, \quad \Delta t_z = \frac{(\Delta z)^2}{2K_z}$$

and can be big enough.

The results are showed at the pictures as follows:

Maximum of Remissible Consenttation (MPC) is 5.10^{-6} g/sm^3

0.01 MPC	<	=	C	<	0.5 MPC	–5
0.05 MPC	<	=	C	<	0.1 MPC	–4
0.1 MPC	<	=	C	<	0.2 MPC	–3
0.2 MPC	<	=	C	<	0.5 MPC	–2
0.5 MPC	<	=	C	<	1 MPC	–1
1 MPC	<	=	C	<	2 MPC	1
2 MPC	<	=	C	<	5 MPC	2
5 MPC	<	=	C	<	10 MPC	3
10 MPC	<	=	C	<	20 MPC	4
20 MPC	<	=	C	<	50 MPC	5

1. Source is in the Batumi area (Fig. B).
Source acts constantly on the depth 40 m.
The concentrations of admixture in sources is: $1.9*10^{-6}$ g/sm^3
Time step is 4 hour. 1 month of process has been calculated.
Picture is such as in Rioni case.

2. Source is in the Novorossisk area (Fig. C).
Source acts constantly on the depth 20-40 m.
The concentrations of admixture in sources is: $1.9*10^{-6}$ g/sm^3
Time step is 4 hour. 1 month of process has been calculated.
Admixture propagates at the East and North-East directions: in the cyclonic motion area and in the Kerch Strait.

3. Sources are in the rivers Rioni's, Inguri's, Bzib's mouths (Fig. D).
Sources act constantly on the depth 40 m.
The concentrations of admixture in sources is:
Rioni: $0.156*10^{-6}$ g/sm^3
Inguri: $0.007*10^{-6}$ g/sm^3
Bzib: $0.019*10^{-6}$ g/sm^3
Time step is 4 hour. 1 month of process has been calculated.
Admixture propagates at the South-West cyclonic motion area.

4. All sources work together (Fig. E).
Time step is 8 hour. 1 year of process has been calculated.
After 3 months the description of admixture reaches a ``quasi-stationar" state and then does not change.
The tendency of growing the admixture in the cyclonic motion areas is clear.
Concentrations great than 1 MPC are seen at the 150 km radius around the Poti, Batumi, Novorosiisk and Kerch Strait.

Admixture propagates at the big depth, for example, at the sources's areas concentration is 5 MPC at the 120 m depth.

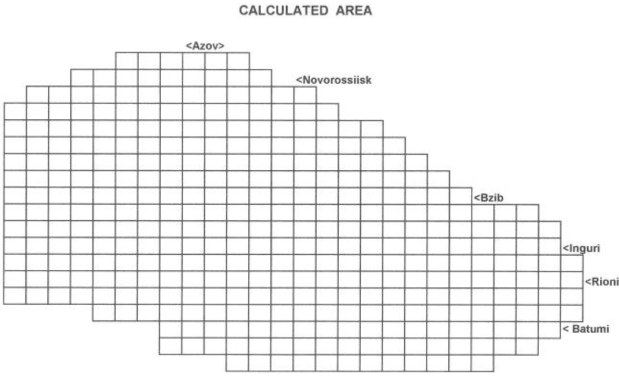


Fig. A

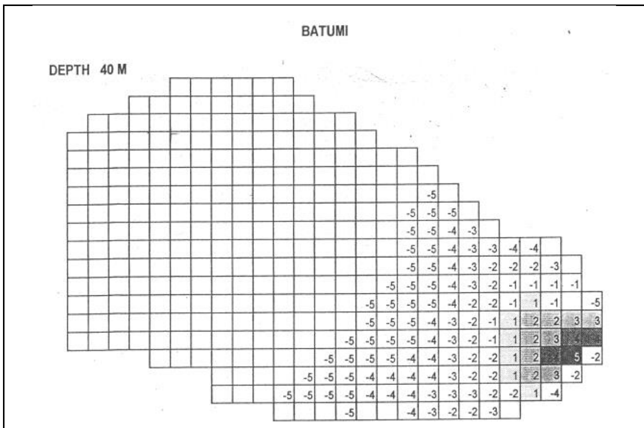


Fig. B

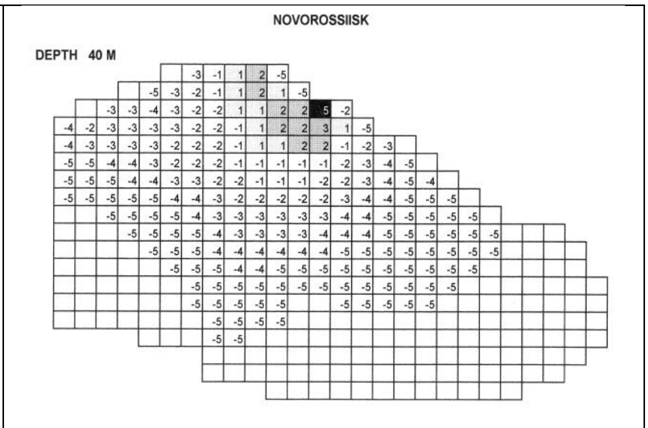


Fig. C

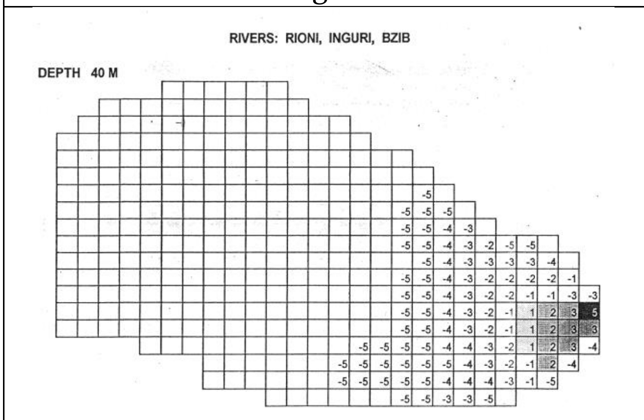


Fig. D

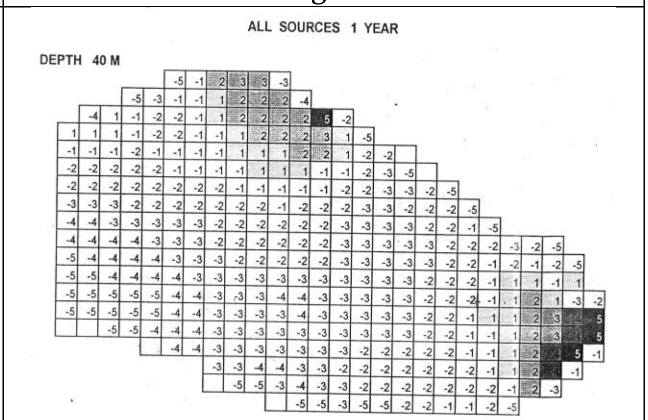


Fig. E

Picture 1. (A - Calculated Area; B - Source is in the Batumi area; C - Source is in the Novorossiisk area, D - Sources is in the rivers Rioni, Inguri, Bzib area; E - All sources work together).

Conclusion

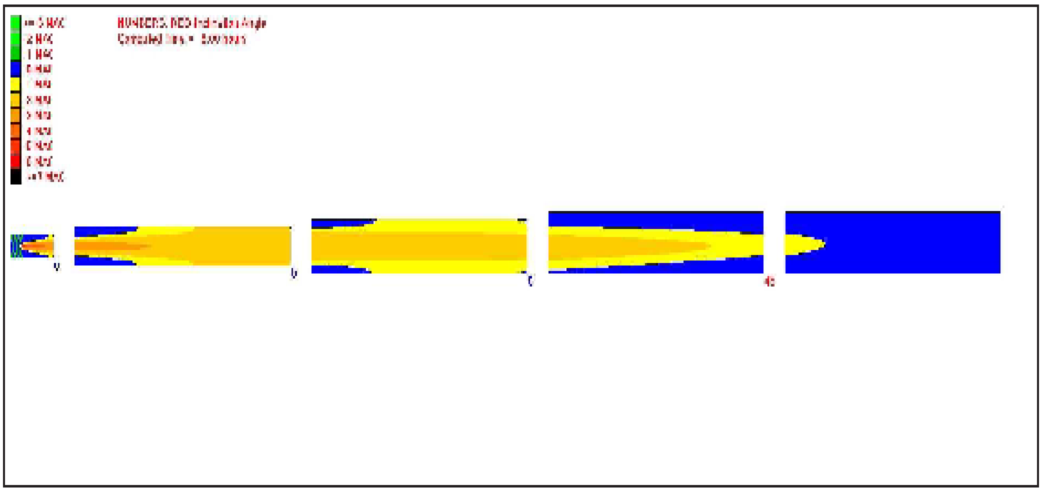
Thus the state independence and free market economics made actual not only creation of juridical basis, but international unification as well. Climatic unification may be made according the following scheme: 1) coastal regions with high humidity, 2) regions with average humidity, 3) highlands, 4) regions with low humidity and desert-like climate. Such regioning for standardization need sources and a lot of time. In this sphere the international cooperation may be very effective. On the other hand, from the standpoint of the international unification of the standards there is also a need to consider ways in which economic instruments may be employed as policy tools for improving atmosphere quality, especially in the most cost effective manner, possible under free market economics. That will improve regional economic situation. Finally, the coordination between economy-wide policies, including micro and micro-economic as well as sectoral policies should also be evaluated.

Analysis of medicoepidemiological data in separate regions of the studied area, the approach of estimation of ecological loading with arbitrary multiplicative parameters allowed to estimate ecological loading on population and carry out the regional mapping of contaminated areas.

The numeral models are worked out to forecast the molismological condition of the Black Sea coasts zone and water permithing to carry out the integral management of the coastal zone depending on the variability of anthropogenic pollutants.

3. Numerical tests, for yielding discharge of waste water into the river (the worst conditions of pollution).

The numerical tests were done. The model high-speed stream consisting of 5 sections with wight from 300 till 800 m was taken. The admixtures source is working constantly at one point at the beginning of the high-speed stream. The fluid speed is 1 m/sec along the fluid axis and it is decreasing to 0 at the banks of river. The depth is 10 m at the centre of high-speed stream and is decreasing to 0 at the banks (Picture 2).



Picture 2.

The 2-step MacCormack numerical scheme was used. The tests shows scheme stability.

As illustration is shown the result of 8 hours of expansion calculation. Numbers of Maximum allowable concentration - MACs - is taken as levels at the picture.

References

[1] Modeling of Marine systems, ed. by J. C. J. Nihoul, Elsevier Oceanography Series, 10, 1975, 269 p.

[2] Bowden K. F. J. Fluid Mech., **21**, 1965, 21:83.

[3] Peyret R., Taylor T. D. Computational Methods for Fluid Flow. Springer-Verlag, New-York, Heidelberg, Berlin, 1983, 358 p.

დაჭუჭყიანებული წყლების მოდელირება შავი ზღვის გოგირდწყალბადის მოპოვებისას

მ. ციცქიშვილი, ა. შაფთოშვილი

რეზიუმე

რიცხვითი მოდელები, კონტროლის ძირითადი პარამეტრები, მდინარეში „ჩაშვების" შემთხვევის მოდელირება, მოდელის პარამეტრები, მაკ-კორმიკის პრედიქტორ - კორექტორი. რიცხვით სქემებში პარამეტრების რეალური მნიშვნელობების შერჩევით, კოლმოგოროვის აპროქსიმაციის გამოყენებით დიფუზიის აღწერისას, მიღებულია პრაქტიკულად ღირებული მნიშვნელობები დაჭუჭყიანების ველებისა, დამაჭუჭყიანებელი წყაროების სხვა და სხვა განლაგებისათვის. სამუშაოში მოყვანილია დაჭიუჭყიანების ველების გათვლის შედეგები.

Моделирование отработанных (сточных) вод при добыче сероводорода Черного моря

М.С. Цицкишвили, А.Е. Шаптошвили

Резюме

Численные модели, “основные параметры контроля”, моделирование для случая сброса сточных вод в реку, параметры модели, предиктор-корректор Мак-Кормака. За счет подбора более реальных значений параметров в численных схемах, использования Колмогоровского приближения турбулентной диффузии, получены практически значимые величины полей загрязнения для различного размещения источников загрязнения. В работе приведены результаты расчетов полей загрязнения.

Journal of the Georgian Geophysical Society,
Issue B. Physics of Atmosphere, Ocean and Space Plasma, v.19B, 2016, pp.49-58

Gumati and Vartsikhe Power Plants' Impact on the River Rioni New Delta Development

[1]George J. Lominadze, [2]Irakli G. Papashvili, [1]Giorgi I. Kavlashvili

[1]Vakhushti Bagrationi Institute of Geography of Tbilisi State University
[2]LTD Gamma

ABSTRACT

Based on analysis of the volume change of the sediment, brought to the sea by the River Rioni, was estimated the state of the seacoast, neighboring estuary of the Black Sea. The relief of the Black Sea coast and its dynamics greatly depend on the sediment, brought by rivers. In Georgia reduction of the amount of the sediment, brought by rivers mainly is caused by an anthropogenic factor. The submarine canyons' influence on the morphology and dynamics of the coast are also important. It was always difficult to determine the proportion of man-made and natural factors on the accumulative coasts of the River Rioni Black Sea estuary. The possibility to evaluate such processes appeared based on the analysis of the sequence of the events which took place in the River Rioni delta after 1939. Here is offered the forecast of the development of the section next to the River Rioni estuary of the Black Sea.

***Key words*:** Submarine canyon, river sediment, litho-dynamic system

Introduction

The largest part of the Georgia's Black Sea coastal zone genetically belongs to accumulation type and its present-day sustainability greatly depends on the river sediment [1,2,3]. In natural conditions, the volume of river sediment annually brought to the sea is sufficient, and in some cases more than sufficient, for providing of the positive balance of the coastal zone. In cases, when the volume of river sediment for various reasons is declining, coastal and underwater slope begins to react accordingly. This process is mainly expressed by the coast washout and change of the underwater profile. At present, reduction of the river sediment mostly is caused by the man-made impact because of extraction of the sediment from the river beds or their containment by the dams. In this case, it is difficult to determine the degree of the negative impact and quantitative indicators, as the sediments from the coastal zone are lost on steep slopes of submarine canyons and accumulative capes. The possibility to evaluate such processes appeared based on the analysis of the sequence of the events which took place in the River Rioni delta after 1939. In the new mouth developed the powerful accumulation processes, in consequence of which was formed a new delta on the area of 1300 hectares. The sediments, brought by the rivers to the accumulative coasts play major litho-dynamic role in the formation of beaches and submarine slope. The Alluvium, come from the rivers to the marine estuaries intermixes with the sediment here and forms a talus fan, which is mostly made up of sediments of relatively large fractions. Small fractions spread farther from the shore and are deposited on the underwater slope.The relief of the underwater slope itself conditions the outline of the coast and morphometry, petrographical and granulometric composition of the beaches. The submarine canyon heads, located near the coastline significantly influence the coast construction and lithodynamics [4,5,6,7]. In sum, the sediment, come from the rivers, in consequence of sea storms and flows influence participates in complex litho-dynamic processes, resulting in creation of large accumulation forms. They, in most cases, after passage of several stages of development tend to a stable condition [8]. For example, in the coastal zone of Georgia Kakhaberi and Kolkheti coastal lowlands, Sukhumi, Pitsunda, Kodori and Batumi accumulative capes belong to the similar forms [9,10]. The mentioned accumulative forms and the contemporary appearance of the coastal zone of Georgia was formed about 5-6 thousand years ago, when after the rapid rise the Black Sea level it has reached the current situation [11]. Along the persistent coast was formed the local ecosystem with its characteristic ecotones in the river estuaries and deltas [12].

Depending on the amount of sediment brought to the sea by rivers, they can be divided into 3 groups. In the first group are the great rivers, bringing much more sediments to the sea, than the sea waves and currents along the shore can move [13]. In this case, the river estuaries should be subjected to continuous accumulation. In fact, this process is not observed, because in front of all big rivers of the sea side of Georgia are located submarine canyon's heads. The most part of river sediment is lost in such canyons; however, the necessary amount for the stability of the coast escapes the canyon head and is distributed along the sea coast. In some respects the mouths of rivers near the submarine canyons, accomplish a function of natural sediment distributor [14], by means of which the coastal zone maintains its stable condition.

The second and third group rivers bring to the sea less amount of sediments, the volume of which is always less than the transporting ability of wave energy. The total amount of the mentioned river sediments is completely spent for feeding the coast and to some extent is involved in the formation of the litho-dynamic systems. Their mouths do not take the form of delta and more or less keep the coastline azimuth, existing within the litho-dynamic system scope [9,10].

The region of studies, material and methods

River Rioni belongs to the above examined first group and its estuary is located in the center of the eastern part of the Black Sea. Here are the beaches of fine sand, which is characteristic for the Rioni litho-dynamic system [15,16]. The average inclination of the profile of the underwater slope, having dynamic equilibrium, varies within the frames of $tg\alpha = 0{,}007\text{-}0{,}009$ ($0^0 27$ "- $0^0 30$"). In the submarine canyon source area of Poti (Rioni) the profile is unstable and its inclination is $tg\alpha = 0{,}03\text{-}\ 0{,}038$ ($1^0 43$ "- $2^0 12$"). Immediately in the underwater canyon head, which begins from a 7-meter depth, the inclination varies within the scope of 2^0-4^0. Towards the greater depth the canyon thalweg gains great inclination, which in some places reaches 20^0-25^0. Canyon side skirts are characterized by quite a large inclination, and in some cases equal 45^0 [17,18].

The underwater slope surface Poti (Rioni) litho-dynamic system till the depths of 8-10 meters is composed of fine silt sand. The main source of feeding of coast beaches and underwater slope sediments is the River Rioni. In the natural conditions, the river solid sediment volume was approximately 8-10 million m^3 per year, which was 7-8 times higher than the waves' and currents' transporting energetic capacity. Thus, the main part of the amount of sediment was flowing into the submarine canyon, otherwise in the old mouth of the River Rioni would continue constant accumulation and, accordingly, growth of the coastal land. Based on the analysis of historical cartographic materials it was revealed that within the frames of the old delta were passing pretty intense periodic changes, though it was due to the natural migration of river branches and distribution of the liquid and solid flows among the branches. In any case, regardless of the mentioned changes, the largest volume of the River Rioni sediment, in the second half of the Holocene, was moving to the great depths of the submarine canyon, from where it could not return to the upper part of the shelf again [19,4].

In 1873 began construction of the port of Poti, arrangement of the south end of which was completed in 1888. The port got its final appearance in 1905. The constructed port disturbed the conditions of alongshore distribution of the sediments, coming from Rioni – it did not let them pass any more to the north. In fact, the litho-dynamic system was divided into two parts – the south and north coasts from the port. Because of this in the old mouth of the Rioni began intensive accumulation of sediments, both on land and in the upper part of the underwater canyon. The sea waves could no longer distribute equally such a large volume of sediment, and the large volume of accumulated on the steep slopes mass, due to gravitational forces from time to time was moving instantly to the great depths. As a result, erosion processes under the water were activated, causing movent of the canyon head in the direction of the coast and the constructed mole. They began to sink old barges and the vessels in the canyon head to stop the canyon's movement forward, but the accomplished measure could not stop the ongoing movement of canyon towards the coast [20].

The course of litho-dynamic processes was radically changed since 1939, when the main bed of the River Rioni was displaced and its new estuary turned out to be north of the port. Thus, the river estuary was moved away from the submarine canyon head. These changes caused a unique opportunity for research. Specifically, it was the study of the River Rioni solid sediment sedimentation process for average years long profile of the surrounding underwater slope. In the newly created estuary, loss of river sediment fell to a minimum, because the great depths of the underwater slope were located quite far away from the shoreline. Therefore, most of the river sediment after entering the sea was settling down on the underwater slope, in front of the new estuary. The small fractions of suspended sediment in the water extend far from the shore and its quantity is hard to measure, though, as it is known, it is not considered as a coast forming sediment [21,22].

The shape of the Black Sea coast zone, where the River Rioni branch has created a new main estuary, was making a linear and slightly concave arc having 170 ° azimuth, along the coast were sandy beaches with full profile, the width of which was varying between 60-80 meters. The coast was stable and was fed mainly with the rivers Rioni and Khobi sediments. After the construction of the port feeding of the coast from the River Rioni stopped, but the River Khobi sediment was enough for the sustainable development of the coast. The sedimentsalongshore streamwasdirectedfrom the River Khobi estuary towardssouthandits flow was aboutabout 50-70 th. m^3 peryear. Until 1939 sediment was accumulating near the Poti port and this was not favorable for the marine navigation. Because of silting of the entrance channel of the port the port administration was conducting periodic deepening the bottom, but the volume of the work completed at that time was not large and it did not make severely negative influence. Today, the shore, located between the port of Poti and River Khobi in litho-dynamic terms, can be considered as an independent segment, the sediment balance of which is positive - that is, loss of sediment or its migration to other areas is not observed.

For study of the River Rioni new delta were used the old cartographic materials, which were compared to a new survey. Based on the materials were calculated areas of increase of land and volumes of accumulation up to 20 meters depth (Table 1).

Results and discussion

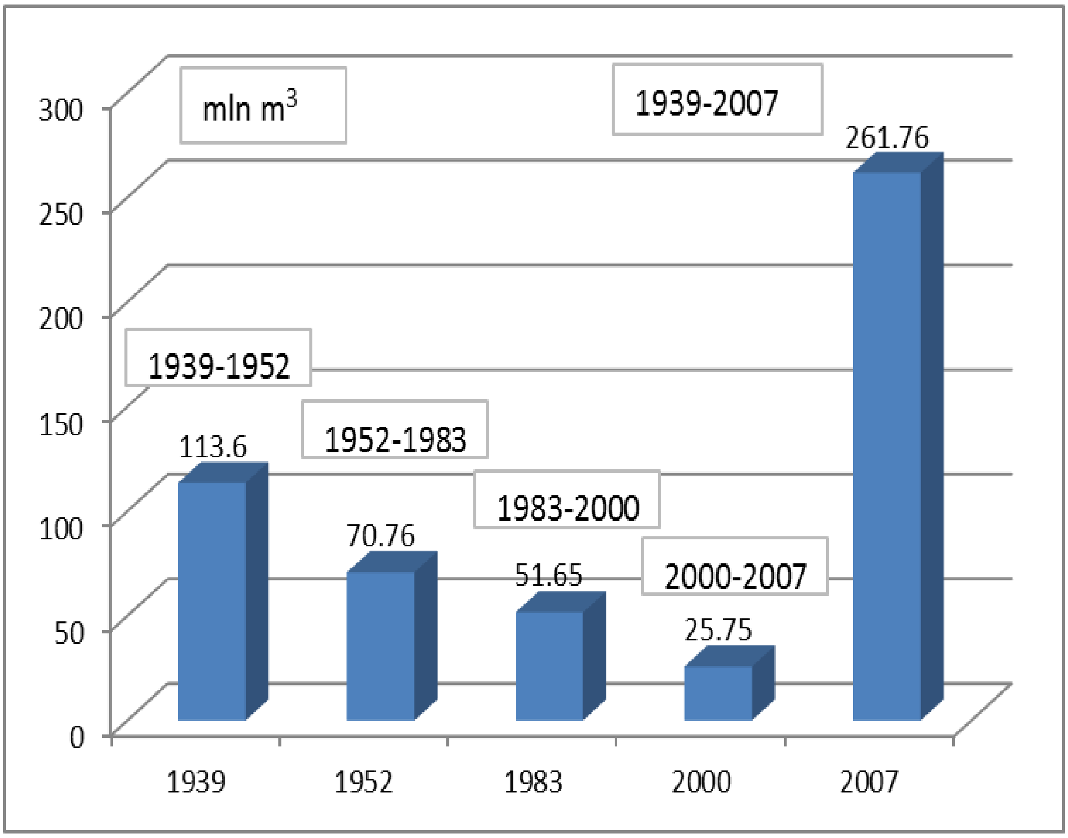
After displacement of the main flow of the river to the north, the coastal zone has undergone significant changes. By 2010, the coast on the south of the port, suffered a washout, in consequence of which the sea has swallowed the area of 300 hectares of land. In addition, in the north of the port, a strong accumulation caused increase of land by 1 300 ha. Overall, in the Rioni litho-dynamic system terrestrial increment was 4.3 times larger than the area of washout. The absolute value of the increase made 950 ha. The area of land surplus would be higher, if not annual extractions of sediments from the Poti port entrance channel. In consequence of deepening works the total volume of the sediment removal, ranging from 1939 to the present, made about 35-40 million m^3. Construction of power plants of Gumati - 1956 and Vartsikhe – 1976 has made the greatest impact on the river sediment reduction. The river sediment volume has been reduced also about by 300-400 thousand m^3 after 1959, when were built the watershed dam and flood gate-regulator, by means of which a part of the liquid flow moves in the direction of the city. Nevertheless, powerful river accumulative process in the estuary and its adjacent coastal area has not stopped, but its speed greatly reduced. This fact shows how great was the impact of the submarine canyon on the coastal zone development (see Figure 1). Overall, in the north of the Poti port was formed a new delta of the River Rioni. By 2005, in both estuaries of the delta emerged the islands, and this indicates that the delta development passes to a multi-branch stage. Table 1 –in 1939-2007 years in the coastal zone between the

River Khobi and Poti port were accumulated 261.76 million m³ sediments. Taking into consideration the volumes of deepening of the entrance channel, it appears that there would be accumulated approximately 300 million m³ (Nomogram 1).

Table 1

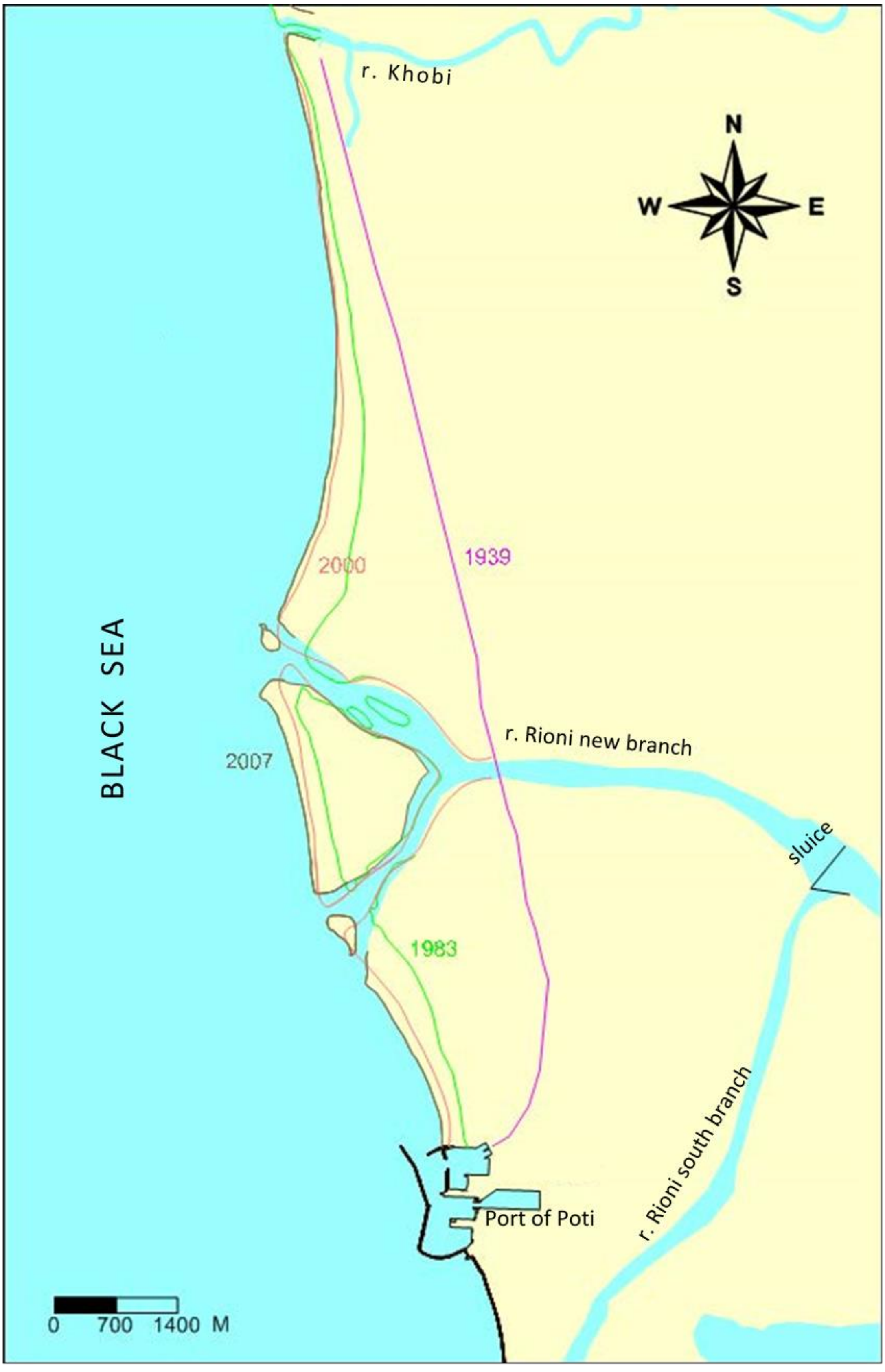
The land growth and sediment accumulation in the River Rioni new delta (from the Poti port – to the River Khobi estuary) in 1939-2007 years.

Observations' years	Accumulation to the depth, m	Accumulation, million m^3	Average per year million m^3	Land increase, ha	Average per year, ha
1939 - 1952	10	64.07	4.93	537	41,3
	20	113.6	8.74		
1952 -1983	10	34.14	0.98	327	10,5
	20	70.76	2.02		
1983 - 2000	10	28.29	2.02	234	13,1
	20	51.65	3.03		
2000-2007	10	11,37	1.62	106	15.1
	20	25.75	3.68		
1939- 2007	10	137.87	2.03		
	20	261.76	3.84	1204	17.71



Nomogram 1. The sediment volumes, accumulated in the coastal zone at different times

Fig. 1. Coastal zone development scheme during 1939 - 2007 years, between the port of Poti and the River Khobi estuary.



River sediment was significantly reduced in 1953, when was built the Gumati power plant dam. In 1959 was completed construction of the Poti dam and they started passing of a certain amount of liquid flow of the River Rioni in the direction of the city. In consequence the annual volume of the river sediment, directed to Nabada (the new estuary) reduced by about 300-400 thousand m^3. At the end of the sixties of the last century, Vartsikhe power plant came on-stream, significantly reducing the River Rioni sediment volume. Based on the analysis of existing materials the annual sediment accumulation in the 1939-1952 period amounted to 8.74 million m^3. After 1952, the accumulation of sediments in the delta has dropped 4.33 times and amounted to 2.02 million m^3 / year (Fig. 2).

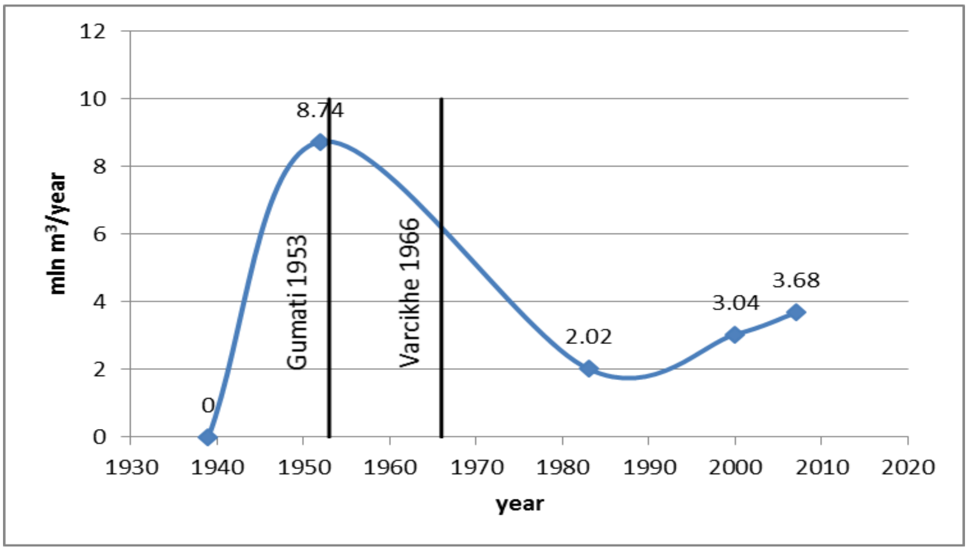


Fig. 2. The annual sediment accumulation volumes Between the mouths of Poti port and the River Khobi estuary.

Starting from the mid eighties the volume of sediment accumulation has risen and in 2007 increased by 1.8 times. This happened in consequence of filling of power plants' hydro reservoirs with sediment, which gradually led to passing of increased amount of sediment by the dams. Appropriately increased sediment accumulation rate, as it is shown on the cumulative curve (Fig. 3).

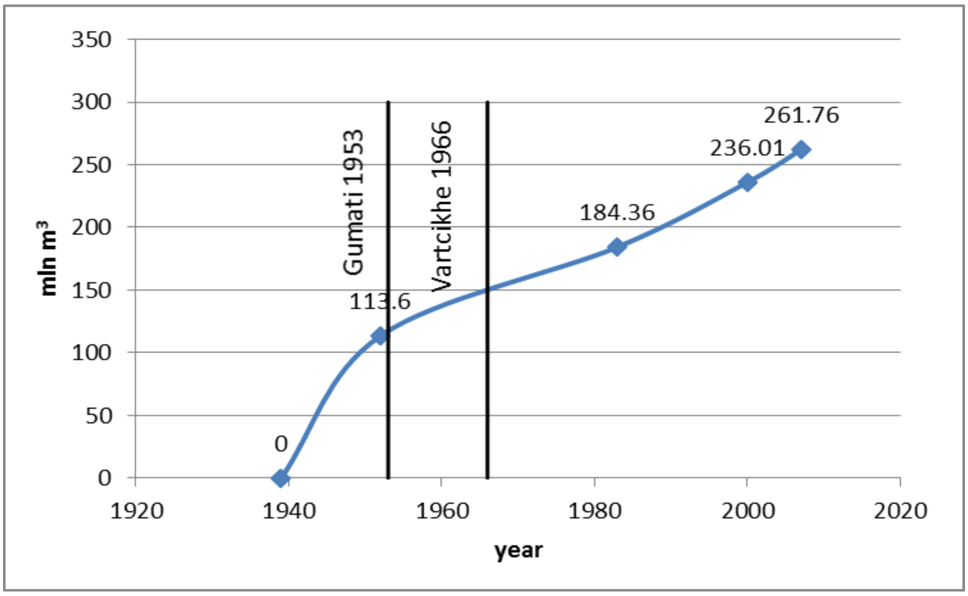


Fig. 3. Cumulative curve of the sediment accumulation.

Finally was formed an asymmetrical shape delta, the northern flank of which is much longer than the southern one. Here it should be noted that the new delta would have symmetrical form if not the Poti port hydraulic structures and permanent removal of sediment from the entrance channel. The azimuth of the delta north shoreline is 200°, which corresponds to the annual migration of 560 thousand m^3 of sediment in the north direction. The azimuth of the south direction shoreline is 168 ° corresponding to the annual migration of 370 thousand m^3 of sediment in the south direction. Sediment migration volumes are computed according to V. Sakvarelidze method [23].The mentioned method was giving good results for sandy beaches. Hence it can be said that the northern branch of the new delta brings to its sea mouth 60%of the total sediments and the southern branch - 40%. The azimuth of the delta central island's shoreline is 168 °. It is interesting that, wave field resultant vector is exactly perpendicular to the coastline of the island; it is deviated from the direction of the west towards south by 11 °. This means that here, in the coastal line, in the island section prevail equal values of the sediment bilateral migration, or sediment integral move in any direction is not observed. At present, the coastline in the scope of the island is advancing by 10-12 m / year speed. The rate of the delta south and north branches' increase in the first 300-meter sections respectively are 18 and 20 meters per year. The distance between the sea estuaries of the branches over time gradually increases. In 2000, for example, the distance between the 2 branches of the delta was 3080 meters and by 2007 it increased to 3 390 meters. The increase of the distance between the estuaries of the branches point to the activation of the general accumulation in the mentioned period, caused by filling of the power plants' reservoirs with sediment. In fact, the reservoirs were filled with sediment over the second half of the eighties of the last century and after that in the coastal zone is observed gradual growth of the annual accumulation volume and of surplus land (Fig. 2 and Fig. 4).

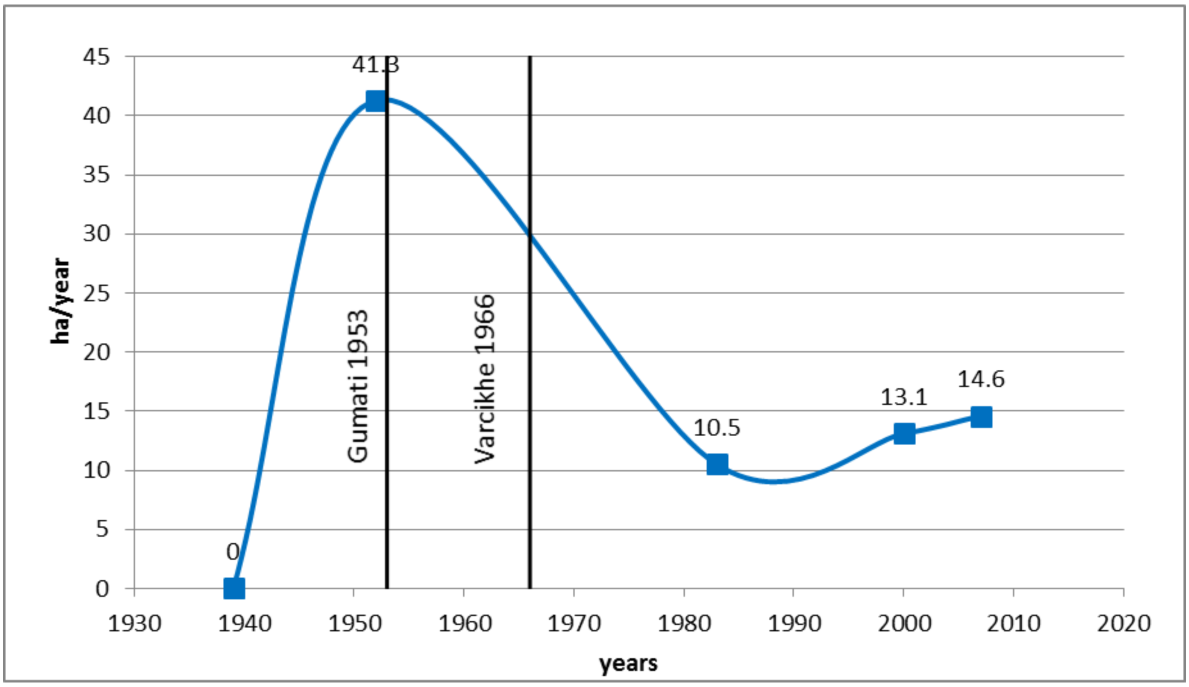


Fig. 4. The dynamics of the surplus land within the new delta scope.

As the Fig. 4 shows, by 1985 land increase rate was less than 10 ha / year. In the following years the rate has gradually increased and amounted to 14.6 ha / yearby 2007. It is expected that the rate of land surplus will further increase at the expense of the sediment increasing, and by 2020 will reach to 20 ha / year. Calculations show that if the power plants are not built, the overall gain of the land would reach the current figure i.e. 1204 ha at the beginning of the 70-ies of the last century (Fig. 5).

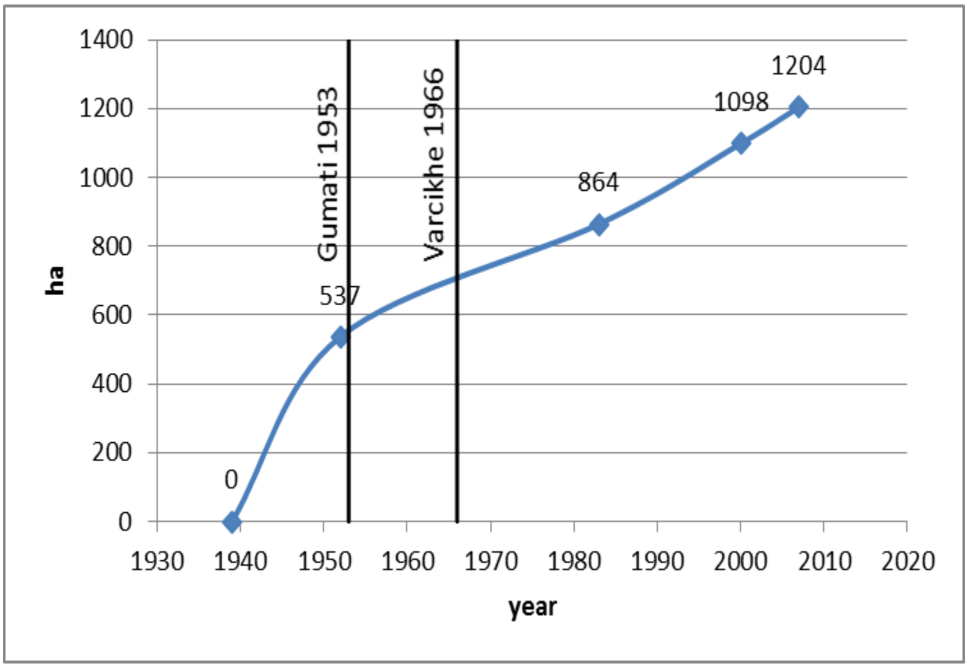


Fig. 5. The cumulative curve of the land area increase.

Unfortunately, no such observations were carried out on the River Rioni city channel sea estuary. Here, the water passing in the river upstream began in 1959, at the 7th kilometer from the estuary after the watershed dam was built, i.e. in the period, when the solid sediment entering was significantly diminished because of Gumati power plant. As is well known in this period the Poti coast experienced intensive wash-out. At present, during the visual inspection of the Poti coast can be observed the coastline stabilization, which is associated with a general increase of the River Rioni sediment. If the overall trend of increasing of the river sediment volume continues, bringing the sediments through the city channel will increase as well. In this case, it is possible to sustain the stability of the coastline, surrounding Poti.

Conclusion

In the conditions of increased amount of the sediment will be activated the accumulation processes within the new delta. The coastline progress rates will rise and accordingly nearby underwater slope sedimentation process will become more intense. In this case, Poti port will have certain problems, in the entrance channel of it will be activated silting intensity. If on the River Rioni new power plants are under construction, solid sediment amount will be reduced again. This will result in a significant decrease of the growth rate of the new delta and activation of washouts in the Poti coastal line.

References

[1] Zenkovich V.P. The problem of stabilizing the coasts of the Georgian SSR. M, Geomorphology, №1, 1977, pp.50-54 (in Russian, English Abstract).

[2] Zenkovich V.P., Schwartz M.L. Restoration of the Georgian SSR Goast. Shore and Beach. v.l. 56, N 1, 1988, pp. 8-12.

[3] Safyanov G.A. The coastal zone of ocean in the 20th century. M .: ed.”Misl” 1978, 263 p. (in Russian).

[4] Matkava D.I, Papashvili I.G, Russo G.E. A Loss coastal sediments in submarine canyons of the Black Sea coast of Georgia and its methods of termination. ed. GruzNIINTI, Tb., 1987, 40 p. (in Russian).

[5] Shepard F.P., Dill P.F. Submarine Canyons and Other Sea Valleys, ed. John Wiley & Sons Inc, 1971, 382 p.

[6] Lominadze G., Papashvi I. Enguri Submarine Canyon Erosive Development in the Epoch of Pleistocene-Holocene, 2nd International Symposium on Kazdaglar (mount Ida) and Edremit, Human Environment Interactions and Ecology of Mountain Ecosystems, Proceedings and Abstracts, 2013, pp. 497-504.

[7] Lominadze G., Papashvili I., Khorava S. Development of the River Deltas of the Black Sea East Coast, XIX INQUA Congress, Abstracts, Nagoya, Japan, 2015.

[8] Zenkovich V.P. Marine Geomorphology. M: "Misl",1980, 279 p., (in Russian)

[9] Kiknadze A.G. Morphodynamics coastal zone and optimize its use by the example of the Black Sea coast of Georgia. Thesis for the degree of Doctor of Geographical Sciences . Tb., 1991, 66 p. (in Russian).

[10] Papashvili I., Lominadze G., Khorava S. The Tendences of Modern Development of the Rioni-Supsa Interfluve Region of the Sea Shore. Materials of International Conference “Applied Ecology: Problems and Innovations”. Proceedings ICAE. Batumi, Georgia, 2015, pp.42-53

[11] Dzhanelidze Ch. P. Paleogeography Georgia during the Holocene. “Metsniereba”, Tb., 1980, 177 p. (in Russian)

[12] Rosenberg G., Brain D.P., Gelashvili D.B. Ecology. Elements of the theoretical constructions of modern ecology . ed. SAMNC, RAS, Samara, 1999, 397 p., (in Russian).

[13] Papashvili I.G. Restoration of the alongshore sediment transport for coastal protection. Abstracts "Geographical and economic problems of the study and development of the southern seas of the USSR", Leningrad, 1987, (in Russian)

[14] Peshkov V.M. Pebble beaches untidal seas. Krasnodar, 2005, 429 p., (in Russian)

[15] Kiknadze A.G. Dynamical systems and sediment budget along the Georgian sea coast. In the book The man and the environment. Publishing house "Alashara" , Sukhumi, 1977, 183 p., (in Russian).

[16] Lominadze G., Papashvili I., Khorava S., Kavlasvili G. Contemporery Changes of Beach Sediment’s Balance of Southern Part of Black Sea Coastal Line of Georgia. Abstractss of 8th International Conference of Asian Marine Geology, Jeju,Republic of Korea, 2015.

[17] Leontiev D.C. Saf’yanov G.A. Canyons under the sea. ed. “Misl”, Moscow, 261p. (in Russian)

[18] Lominadze G.J., Papashvili I.G., Khorava S.G. The Black Sea Kolkheti Coastal zone Submarine Canyons Erosive Development in the Epoch of Pleistocene-Holocene., Environment and Ecology in the Mediterranean region, Chapter 25, ed. Cambridge scholars Publ., 2014, pp. 295-305.

[19] Frencis P. Shepard. Submarine Geology, ed. Joana Cotler Books, 1973, 517 p.

[20] Makatsaria A.P. Causes and possible measures to eliminate the erosion of the coast from Poti. Proceedings Geographical Society Georgia, t. HII, 1973, pp. 34-47, (in Russian)

[21] Jaoshvili Sh.V. The river alluvium and the beach formation of the Georgian Black Sea coast. ed. “Sabchota Sakartvelo”, Tb., 1986, 155 p., (in Russian, English resume 5p.)

[22] Jaoshvili Sh.V. The rivers of the Black Sea. http//reports.eea.eu.int/technical.report_2002_71 Tb., 2003, 186 p.

[23] Sakvarelidze V. Determination of the longshore sediment flow The beach. Bulletin Academy of Sciences of the Georgian SSR, 93, № 1, 1979, pp. 13-21, (in Russian, with English Abstract).

გუმათის დავარციხის ჰესების გავლენა მდ. რიონის ახალი დელტის განვითარებაზე

გ. ლომინაძე, ი. პაპაშვილი, გ. ყავლაშვილი

რეზიუმე

მდინარე რიონის მიერ ზღვაში შემოტანილი ნატანის მოცულობის ცვლილების ანალიზის საფუძველზე მოხდა შავი ზღვის შესართავისპირა სანაპიროს მდგომარეობის შეფასება. შავი ზღვის სანაპირო ზონის რელიეფი და მისი დინამიკა დიდად არის დამოკიდებული

მდინარეების მიერ შემოტანილ ნატანზე. საქართველოში მდინარეების მიერ ზღვაში შემოტანილი ნატანის რაოდენობის შემცირება ძირითადად ტექნოგენური ფაქტორითაა გამოწვეული. ასევე მნიშვნელოვანია წყალქვეშა კანიონების ზეგავლენა ნაპირის მორფოლოგიასა და დინამიკაზე. მდ.რიონის ზღვის შესართავის აკუმულაციურ ნაპირებზე ტექნოგენური და ბუნებრივი ფაქტორების ზეგავლენის პროპორციის განსაზღვრა ყოველთვის რთული იყო.პროცესები გაანალიზდა რიონის დელტაში1939 წლის შემდგომ განვითარებული მოვლენების შესწავლის საუფძველზე.შემოთავაზებულია შავი ზღვის სანაპიროს მდ.რიონის შესართავისპირა მონაკვეთის განვითარების პროგნოზი.

Влияние Гумати и Варцихе ГЭС на развитие новой морской дельты реки Риони

Г.Дж. Ломинадзе, И.Г. Папашвили, Г.И. Кавлашвили

Резюме

На основе анализа изменения объема наносов, транспортируемых р. Риони к морю, произведена оценка состояния и предложен прогноз развития приустьевого участка реки. Уменьшение объема материала, приносимого реками на побережье Грузии, в основном вызвано техногенными причинами. В морфодинамике береговой зоны Черного моря Грузии существенным также является фактор подводных каньонов. Оределение соотношения влияния техногенных и природных факторов на исследуемые аккумулятивные берега всегда было сложной задачей. Реальная оценка процессов стала возможной на основе анализа явлений, имевших местов дельте р. Риони после 1939 г., в связи с перераспределением ее стока. Предложен прогноз равития участка Черноморского побережья в дельте р. Риони.

Journal of the Georgian Geophysical Society,
Issue B. Physics of Atmosphere, Ocean and Space Plasma, v.19B, 2016, pp. 59-65

Comparative Characteristics of the Changeability of Atmospheric Pressure in the Meteorological Stations in the Tbilisi Airport, Tortoise Lake and in Cosmic Rays Observatory of M. Nodia Institute of Geophysics

Teimuraz S. Bakradze, Paata A. Barbakadze, Nugzar Ya. Ghlonti, Irakli I. Tuskia

M. Nodia Institute of Geophysics of I. Javakhishvili Tbilisi State University, e-mail: irakli.tuskia@gmail.com

ABSTRACT

The paper considers the comparative analysis of the changeability of atmospheric pressure in the meteorological stations in the Tbilisi airport, the Tortoise Lake and in the Cosmic Rays Observatory of M. Nodia Institute of Geophysics during June 2015. The measurements of pressure at the meteorological stations are conducted once in every three hours, and in the observatory of cosmic rays - hourly. In particular, based on the example of the intensive local convective process of June 13-14, 2015 it becomes obvious that the hourly measurements of atmospheric pressure are more sensitive to their variations than three-hour measurements. It is proposed to use data of observatory about the atmospheric pressure for studying different processes in the environment.

Key words: atmospheric pressure variation.

Introduction

Variations in the atmospheric pressure are connected both with the global (cyclones, anticyclones, atmospheric fronts, etc.) and the local (air-mass clouds, etc.) atmospheric processes. On the territory of Caucasus the weather conditions (as well as atmospheric pressure variation) are formed a result of intensive impact of those large-scale circulation processes, which start on the Eurasian continent, in the North Atlantic and its neighbouring arctic basin [1]. Examples of the local variations of the atmospheric pressure connected with the influence of convective cloudiness are given in [2].

Many processes, which take place in the environment, are connected with the changeability of atmospheric pressure (the level of underwater water [3], flux of radon from the soil [4], etc.). Variations in the atmospheric pressure substantially influence on the health of people [5,6].

During several decades the hourly measurements of variations in the atmospheric pressure have been conducted in the Cosmic Rays Observatory of M. Nodia Institute of Geophysics. The data are used for the correction of the results of monitoring the intensity of neutron component of galactic cosmic rays.

For studying different processes, which take place in the atmosphere, these data have not had any wide application so far except the preliminary studies of the influence of variations of atmospheric pressure on the health of the population of Tbilisi city [6].

The purpose of this work is the development of the advantage of the hourly measurements of variations in the atmosphere in comparison with the three-hour measurement during the study of local atmospheric processes, which are conducted at standard meteorological stations.

Material and methods

In the work, besides the data of the Cosmic Rays Observatory, the data of the meteorological stations, located in the Tortoise Lake and in Tbilisi Airport are used (https://rp5.ru/Weather_in_Georgia). The coordinates of the points of measurement and distance between them are given in Table 1.

Table 1

Coordinates of the points of the measurement of atmospheric pressure in Tbilisi.

No St.	Points of the measurement (Stations)	LAT, N	LON, E	Height a.s.l., m	Distance from stations, km		
					1	2	3
1	Turtle Lake	41.70°	44.75°	425	0	16.9	3.3
2	Airport	41.67°	44.95°	472	16.9	0	18.5
3	Cosmic Rays Observatory	41.73°	44.74°	510	3.3	18.5	0

The comparison of variations in the atmospheric pressure in three indicated points of measurement is carried out for June, 2015. In the first half of the month unstable rainy weather was observed in Tbilisi. On June 13-14 in Tbilisi recorded the well known catastrophic flood, provoked by intensive rain with the subsequent landslide in the environments of Akhaldaba [7,8].

A relative variation of the atmospheric pressure ΔP with respect to its mean monthly value P_{mean} was studied:

$$\Delta P = 100 \cdot (1 - P/P_{mean}), \%$$

where P is atmospheric pressure.

In the proposed work the analysis of data is carried out with the use of the standard statistical analysis methods and methods of mathematical statistics for the time-series of observations [9,10].

The following designations will be used below: Min – minimal values, Max - maximal values, Range - variational scope, σ - standard deviation, σ_m - standard error (68% - confidence interval of mean values), 95%(+/-) - 95% - confidence interval of mean values, R - coefficient of linear correlation, R^2 – coefficient of determination, R_a - autocorrelation coefficient.

Results and discussion

The results are given in Tables 2, 3 and Fig. 1-5.

Table 2

The statistical characteristics of relative values of atmospheric pressure in 3 measurement points in June, 2015 in Tbilisi

Parameter	Tortoise Lake	Airport	Cosmic Rays Observatory
Min	-1.39	-1.34	-1.35
Max	0.95	0.76	0.85
Range	2.34	2.10	2.20
St Dev	0.48	0.45	0.47
σ_m	0.03	0.03	0.02
95%(+/-)	0.06	0.06	0.03
Correlation Matrix, (R)			
Tortoise Lake	1	0.97	0.98
Airport	0.97	1	0.97
Cosmic Rays Observatory	0.98	0.97	1

According to Table 2 and Fig. 1 high correlation is observed between the values ΔP in all points of measurements. The statistical parameters weakly differ from each other, except the standard error. The sensitivity of measurements ΔP in the Cosmic Rays Observatory is higher than at two remaining stations.

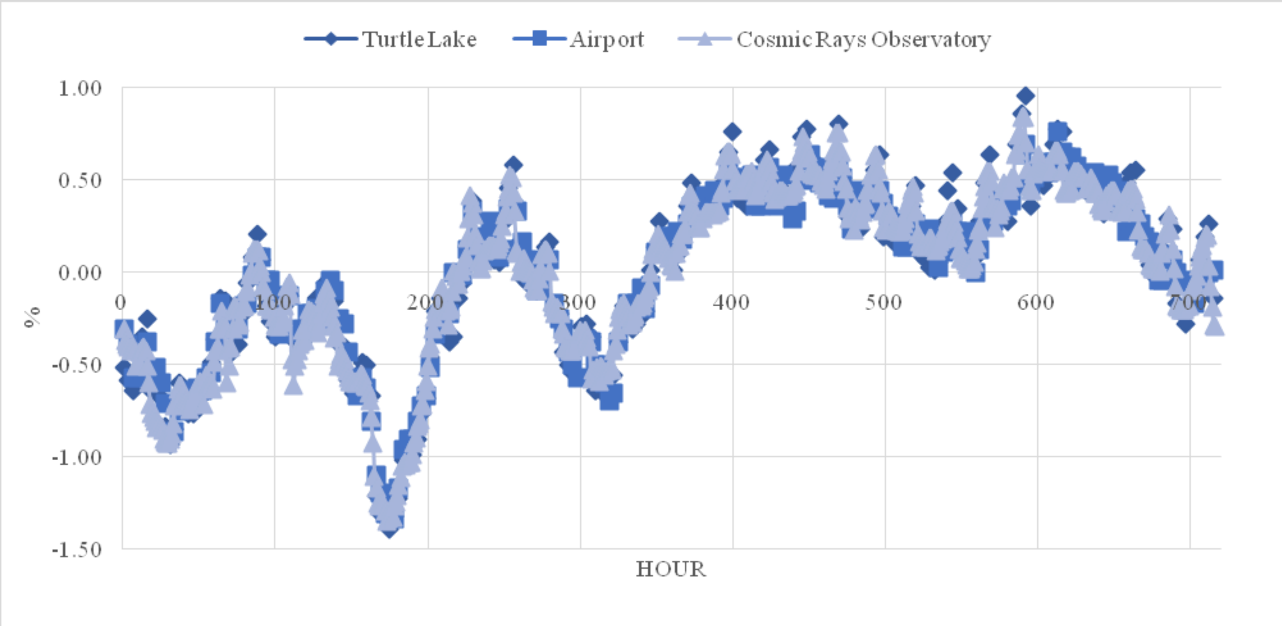


Fig. 1. Changeability of relative values of atmospheric pressure in 3 measurement points in June 2015 in Tbilisi.

As it was noted above, in the first half of June unstable rainy weather was observed in Tbilisi. This is well illustrated by means of the time variations of the values ΔP. They, in essence, have negative values in the first half of the month.

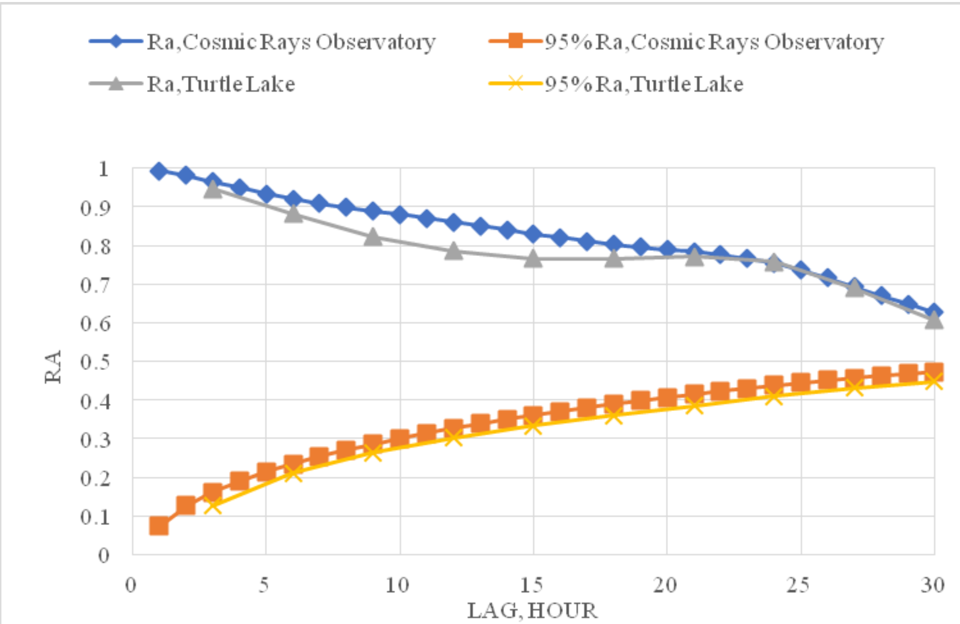


Fig. 2. Autocorrelation function of atmospheric pressure in 2 measurement points in June 2015 in Tbilisi.

Time series of ΔP are strongly auto-correlative (Fig. 2). Autocorrelation of time series of ΔP obtained at the Cosmic Rays Observatory is somewhat higher than that obtained at the station at the Tortoise Lake. In both cases the autocorrelation is meant at least to the Lag of 30 hours.

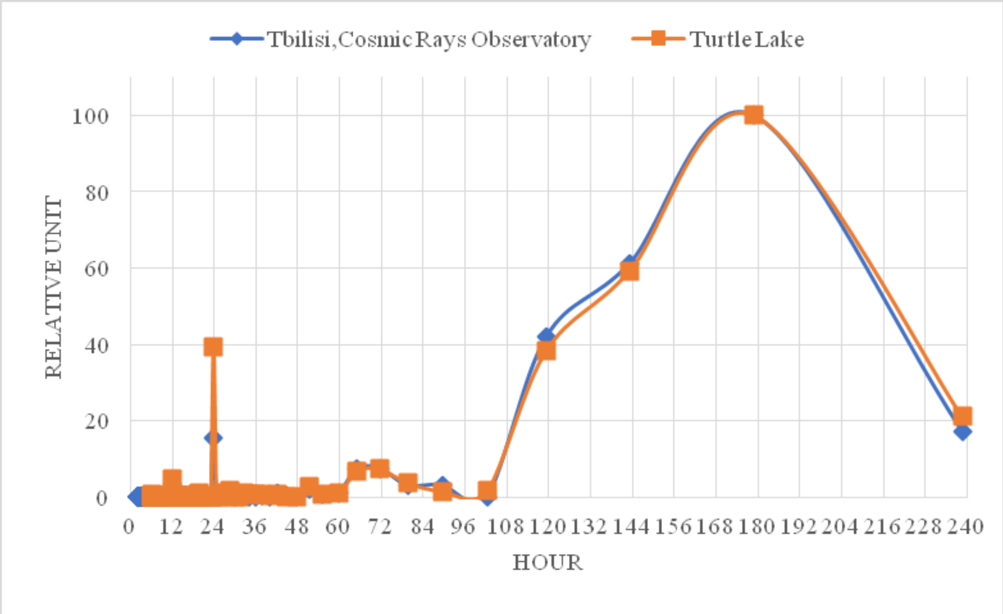


Fig. 3. Periodicity of atmospheric pressure in 2 measurement points
in June 2015 in Tbilisi.

The periodicity of values ΔP has the basic peak, which fit approximately to 180 hours (7.5 days) and two auxiliary - about 72 hours (3 days) and 24 hours (Fig. 3).

Let us examine the special features of changeability ΔP at all stations during catastrophic flood on June 13-14, 2015 in Tbilisi (Table 3, Fig. 4,5).

In the indicated interval of time the rain cloud was located in one and the same place for almost five hours. Process was air-mass. Precipitation intensity at the separate moments of time was found in the range 100-200 mm/h. Distance from the center of cloud to the points of measurement comprised: Tortoise Lake - 6 km, Cosmic Rays Observatory - 8.5 km, Tbilisi Airport - 20 km [7,8].

Table 3

The statistical characteristics of relative values of atmospheric pressure in 3 measurement points
from June 13, 19:00 to June 14, 04:00 in Tbilisi.

Parameter	Tortoise Lake	Airport	Cosmic Rays Observatory
Mean	-0.48	-0.44	-0.50
Min	-0.64	-0.50	-0.59
Max	-0.28	-0.36	-0.36
Range	0.36	0.14	0.23
St Dev	0.19	0.08	0.09
σ_m	0.11	0.04	0.03
95%(+/-)	0.22	0.09	0.06

Table 3 clearly demonstrates the influence of local cloud processes on the variation of the atmospheric pressure depending on distance during this process. The greatest variations in the values ΔP were observed at station Tortoise Lake, which was the closest from the cloud (Range = 0.36%), the smallest - in the Airport (Range = 0.14%).

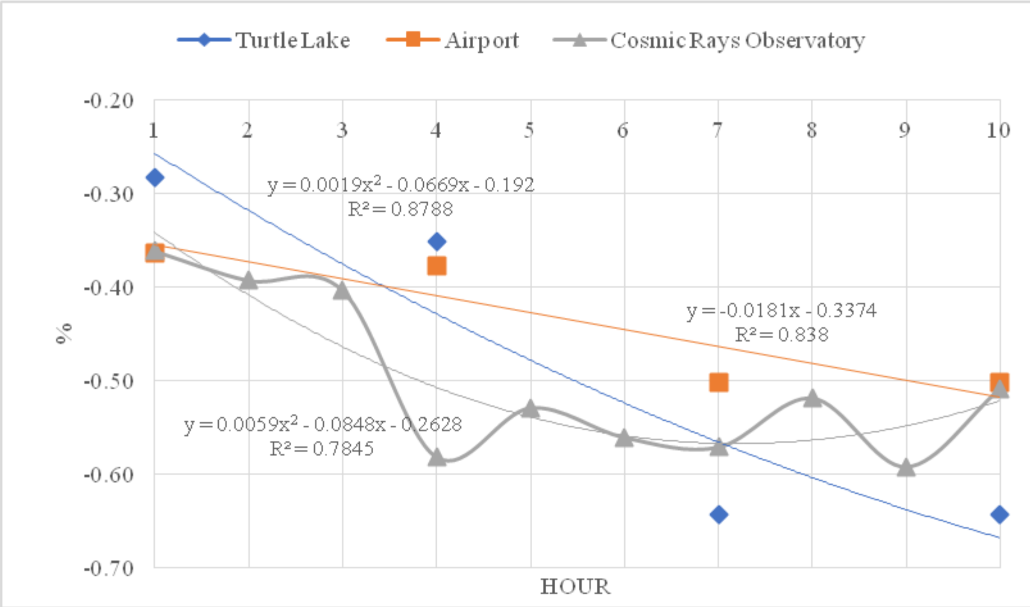


Fig. 4. Changeability of relative values of atmospheric pressure in 3 measurement points from June 13, 19:00 to June 14, 04:00 in Tbilisi.

Changeability in the time of values ΔP at station Tortoise Lake and Cosmic Rays Observatory satisfactorily described by second power polynomial, and in airport - linear (Fig. 4).

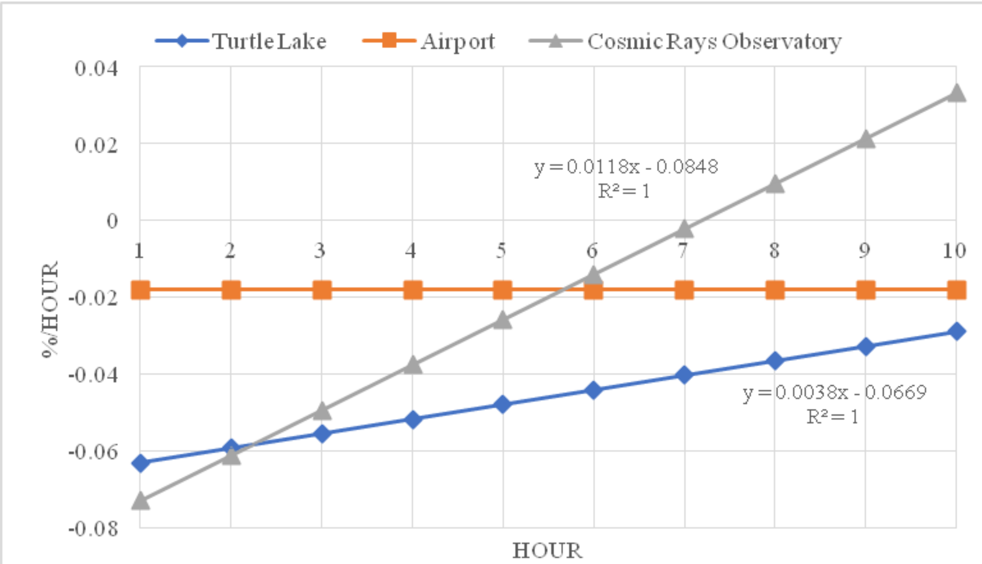


Fig.5. Changeability of speed of change of relative values of atmospheric pressure in 3 measurement points from June 13, 19:00 to June 14, 04:00 in Tbilisi.

Finally, Fig. 5 clearly demonstrates the higher sensitivity of hourly measurements in comparison with the three-hour measurement. Rate of change in the time of values ΔP in Cosmic Rays Observatory (0.0118 %/hour) is three times higher than at the station Tortoise Lake (0.0038 %/hour). In Tbilisi Airport this speed is constant (practically, the station did not react to the process).

In the future, by analogy with [2], it is possible to investigate the variability of atmospheric pressure under the passing clouds recorded by the radar used in the anti-hail service [7,11,12]

Conclusions

During the local atmospheric processes the hourly measurements of the atmospheric pressure, which are conducted in Cosmic Rays Observatory of M. Nodia Institute of Geophysics, are more sensitive to their variations than three-hour measurements, which are conducted at usual meteorological stations. Atmospheric pressure is an exogenous factor, which is infused on the Earth and water level in boreholes. It causes water level variation in boreholes together with tidal factors. Amplitude of their variation was changing depending tensor- sensitivity of boreholes and aquifer area totally. At the same time, it is one of the important factors for assessment of geodynamic processes. Using and developing this kind of observations and organization real-time monitoring of atmospheric pressure will be a support for forecasting geodynamic events. It is also possible to investigate the variability of atmospheric pressure under the passing clouds recorded by the radar used in the anti-hail service.

References

[1] Budagashvili T., Karchava J., Gunia G., Intskirveli L., Kuchava T., Gurgenidze M., Amiranashvili A., Chikhladze T. Inventory of Greenhouse Gas Emissions and Sinks. Georgia's Initial National Communication on Under the United Nations FrameworkConvection on Climate Change, Project GEO/96/G31, Tb., 1999, 137 p.

[2] BibilashviliN.Sh., Ivanov G.I., Kovalchuk A.N. Raspredelenie meteoelementov pod kuchevo-dozhdevimi oblakami po dannim nazemnoi meteoseti. Tr. Visokogornogo Geofizicheskogo Instituta, vip. 44, M., Gidrometeoizdat, 1979, s. 23-27.

[3] Melikadze G., Jimsheladze T., Kobzev G., Tchankvetadze A., Devidze M. Hydrodynamic and geomagnetic anomalies related with preparation of earthquakes in Caucasus. Journ.of Georgian Geophysical Soc., Iss.(A), Physics of Solid Earth, v. 19A, Tb., 2016, pp. 84-103.

[4] Schery S. D.,Gaeddert D. H. Measurements of the effect of cyclic atmospheric pressure variation on the flux of ^{222}Rn from the soil. Geophysical Research Letter, v. 9, iss. 8, August 1982, pp. 835–838.

[5] Sharafi R., Bogdanov V.B., Gorlov D.S., Gorgo Y.P. The influences of meteorological factors on the health and functional state of human. Health, v.5, No.12, 2013, pp. 2068-2076, http://dx.doi.org/10.4236/health.2013.512281

[6] Amiranashvili A., Bliadze T., Chikhladze V. Photochemical smog in Tbilisi. Monograph, Trans. of Mikheil Nodia institute of Geophysics, ISSN 1512-1135, v. 63, Tb., 2012,160 p., (in Georgian).

[7] Amiranashvili A.G., Chikhladze V.A., Dzodzuashvili U.V., Ghlonti N.Ya., Sauri I.P. Reconstruction of Anti-Hail System in Kakheti (Georgia). Journ. of the Georgian Geophysical Society, Iss. B. Physics of Atmosphere, Ocean and Space Plasma, v. 18B, Tb., 2015, pp. 92-106.

[8] Banetashvili V., Gelovani G., Grebentsova A., Javakhishvili N., Iobadze K., Mitin M., Saginashvili N., Samkharadze I., Khurtsidze G., Tsereteli A., Tskhvediashvili G., Chkhaidze B. Some examples of strong precipitation in eastern Georgia according to the data of radar surveillance of 2015. Trans. of Mikheil Nodia institute of Geophysics, ISSN 1512-1135, v. 66, Tb., 2016, pp. 75-83, (in Russian).

[9] Kobisheva N., Narovlianski G. Climatological processing of the meteorological information, Leningrad, Gidrometeoizdat, 1978, 294, (in Russian).

[10] Kendall M.G. Time-series, Moscow, 1981, 200 p., (in Russian).

[11] Amiranashvili A., Burnadze A., Dvalishvili K., Gelovani G., Ghlonti N., Dzodzuashvili U., Kaishauri M., Kveselava N., Lomtadze J., Osepashvili A., Sauri I., Telia Sh., ChargaziaKh., Chikhladze V. Renewal works of anti-hail service in Kakheti. Transactions of Mikheil Nodia Institute of Geophysics, v. 66, ISSN 1512-1135, Tb., 2016, pp. 14-27, (in Russian).

[12] Abaiadze O., Avlokhashvili Kh., Amiranashvili A., Dzodzuashvili U., Kiria J., Lomtadze J., Osepashvili A., Sauri I., Telia Sh., Khetashvili A., Tskhvediashvili G., Chikhladze V. Radar providing of anti-hail service in Kakheti. Transactions of Mikheil Nodia Institute of Geophysics, v. 66, ISSN 1512-1135, Tb., 2016, pp. 28-38, (in Russian).

ატმოსფერული წნევის ცვალებადობის ფარდობითი მახასიათებლები მეტეოროლოგიურ სადგურებზე თბილისის აეროპორტში, კუს ტბაზე და მ. ნოდიას სახ. გეოფიზიკის ინსტიტუტის კოსმოსური სხივების ობსერვატორიაში

ტ.ბაქრაძე, პ.ბარბაქაძე, ნ.ღლონტი, ი.ტუსკია

რეზიუმე

თბილისის აეროპორტში და კუს ტბაზე განლაგებულ მეტეოროლოგიურ სადგურებზე და მ.ნოდიას სახ. გეოფიზიკის ინსტიტუტის კოსმოსური სხივების ობსერვატორიაში 2015 წლის ივნისში დაკვირვებული ატმოსფერული წნევის ცვალებადობის შედარებითი ანალიზია მოყვანილი. წნევის გაზომვა მეტეოროლოგიურ სადგურებზე წარმოებდა ყოველ სამ საათში ერთხელ, ხოლო კოსმოსური სხივების ობსერვატორიაში-ყოველ საათს. კერძოდ, 2015 წლის 13-14 ივნისის ინტენსიური ლოკალური პროცესის მაგალითზე მიღებულია, რომ ატმოსფერული წნევის ყოველსაათიანი გაზომვები უფრო მგრძნობიარეა მათ ვარიაციებზე, ვიდრე სამსაათიანები. შემოთავაზებულია გამოყენებული იქნას ობსერვატორიის მონაცემები ატმოსფერულ წნევაზე გარემოში მიმდინარე სხვადასხვა პროცესების შესწავლისათვის.

Сравнительные характеристики изменчивости атмосферного давления на метеорологических станциях в Тбилисском аэропорту, Черепашьем озере и в обсерватории космических лучей Института геофизики им. М. Нодиа

Т.С. Бакрадзе, П.А. Барбакадзе, Н.Я. Глонти, И.И. Туския

Резюме

Приводится сравнительный анализ изменчивости атмосферного давления на метеорологических станциях в Тбилисском аэропорту, Черепашьем озере и в обсерватории космических лучей Института геофизики им. М. Нодиа в июне 2015 г. Измерения давления на метеорологических станциях проводится каждые три часа, а в обсерватории космических лучей – ежечасно. В частности, на примере интенсивного локального конвективного процесса 13-14 июня 2015 г. получено, что ежечасные измерения атмосферного давления более чувствительны к их вариациям, чем трехчасовые. Предлагается использовать данные обсерватории об атмосферном давлении для изучения различных процессов в окружающей среде.

Journal of the Georgian Geophysical Society,
Issue B. Physics of Atmosphere, Ocean and Space Plasma, v.19B, 2016, pp. 66-72

Vertical Distribution of the Monthly Mean Values of the Air Temperature above the Territory of Kakheti (Georgia) in the Central Months of the Year 2012-2016

[1]Nino K. Jamrishvili, [2]Khatia Z. Tavidashvili

[1]Iakob Gogebashvili Telavi State University
[2]Ivane Javakhishvili Tbilisi State University

ABSTRACT

The data about the changeability of the mean five-year values of the daily values of the air temperature above Kakheti for the central months of year for the period from 2012 through 2016 are cited. The statistical characteristics of the air temperature at the different levels in the range of heights from 0.54 to 27 km are represented. In particular, are cited: the data about the vertical distribution of the average monthly values of the air temperature during January, April, July and October; the mean value of the gradient of air temperature for the indicated months in the layer of the atmosphere from 0.54 to 8.5 km; the average monthly values of height of zero isotherm. It is noted, that heights of zero isotherm for July and October into 2012-2016 respectively by 0.215 and 0.506 km are higher than the same values in 1958-1961.

Key words: aerological sounding of atmosphere, air temperature vertical distribution.

Introduction

Studies of the vertical distribution of the air temperature in the atmosphere have great value for the solution of different problems of meteorology and climatology (meteorological forecast of showers, thunderstorms and hail [1-3], the determination of different characteristics of clouds according to the data of radar measurements [1, 4-7], weather modification [1, 8-11], estimation of climate change [12], etc.). From the end of May 2015 in Kakheti after 25- year interruption the work of anti-hail service was restored [13,14]. Therefore, in connection with climate change, the need for the detailed study of the contemporary regime of the vertical distribution of the air temperature above this territory arose [12,15-17]. These studies were begun in 2015 year [18].

In this work the results of investigating the vertical distribution of the average monthly values of air temperature above the territory of Kakheti in 2012-2016 during January, April, July and October in the range of heights from 0.543 to 27 km above sea level are given.

Material and methods

At present in Georgia the aerological sounding of the atmosphere is not conducted. Therefore, for the solution of the problem presented was carried out information processing about the daily vertical profiles of the air temperature in the atmosphere from the earth's surface to the height of 27 km above Kakheti (Telavi) for four periods of observations (4, 10, 16 and 22 hours on the local time, https://www.ready.noaa.gov/READYcmet.phpand https://rp5.ru/Weather_in_Georgia).

Results and discussion

The results of studies in tables 1-3 and figures 1-4 are clearly demonstrated.

Table 1

Statistical characteristics of the five years mean of diurnal values of the air temperature on the different heights above Kakheti during January and April 2012-2016

Param.	January					Param.	April				
H, km	Mean	Min	Max	Range	St Dev	H, km	Mean	Min	Max	Range	St Dev
0.54	2.5	-0.3	5.8	6.1	1.50	0.54	12.9	8.1	16.9	8.8	2.11
1.5	-2.5	-4.5	-0.8	3.7	1.14	1.5	6.7	1.5	10.6	9.1	2.27
2.0	-4.5	-6.9	-2.0	5.0	1.29	2.0	3.6	-1.1	7.3	8.4	2.18
2.5	-6.6	-9.3	-3.9	5.4	1.30	2.5	0.7	-3.6	4.1	7.6	2.04
3.0	-9.1	-12.0	-6.6	5.4	1.28	3.1	-2.4	-6.5	0.6	7.1	1.91
3.6	-12.3	-15.3	-9.9	5.4	1.29	3.6	-6.0	-10.0	-3.2	6.7	1.78
4.2	-16.0	-19.2	-13.7	5.5	1.32	4.3	-10.0	-13.8	-7.4	6.4	1.64
4.8	-20.2	-23.5	-18.1	5.4	1.33	4.9	-14.4	-18.0	-12.1	5.8	1.51
5.5	-25.2	-28.3	-23.0	5.3	1.34	5.6	-19.4	-22.7	-17.4	5.3	1.42
6.3	-31.0	-33.6	-28.6	5.0	1.33	6.4	-25.2	-28.2	-23.1	5.1	1.34
7.1	-37.4	-39.7	-35.2	4.5	1.30	7.3	-31.8	-34.7	-29.7	4.9	1.25
8.0	-44.6	-47.0	-42.5	4.4	1.20	8.2	-39.2	-42.1	-37.2	4.8	1.15
9.0	-51.7	-53.3	-49.3	4.0	0.98	9.2	-47.3	-49.8	-45.7	4.2	0.97
10.2	-57.1	-59.0	-54.4	4.6	1.22	10.4	-54.6	-56.4	-52.2	4.2	1.07
11.6	-57.9	-62.4	-53.6	8.8	1.98	11.8	-56.9	-60.2	-54.2	6.0	1.53
13.4	-56.7	-59.8	-54.3	5.5	1.37	13.7	-55.5	-57.4	-53.6	3.9	1.10
16.0	-58.9	-61.5	-57.7	3.8	1.12	16.2	-58.3	-59.9	-56.5	3.4	0.95
20.3	-60.8	-64.1	-56.5	7.6	1.80	20.6	-59.4	-60.8	-58.2	2.7	0.66
26.0	-57.6	-64.4	-50.4	14.0	3.79	26.3	-53.8	-56.7	-50.9	5.8	1.46

Table 2

Statistical characteristics of the five years mean of diurnal values of the air temperature on the different heights above Kakheti during July and October 2012-2016

Param.	July					Param.	October				
H, km	Mean	Min	Max	Range	St Dev	H, km	Mean	Min	Max	Range	St Dev
0.54	23.5	21.9	25.6	3.7	0.87	0.54	13.1	8.8	17.7	8.9	2.34
1.5	17.7	16.2	19.3	3.1	0.81	1.5	6.7	2.5	11.1	8.6	2.17
2.0	13.9	12.6	15.5	3.0	0.80	2.0	4.0	0.4	8.4	8.0	2.11
2.6	10.5	9.1	12.2	3.1	0.80	2.5	1.7	-1.7	6.3	8.0	2.12
3.1	7.6	6.4	9.4	3.0	0.77	3.1	-0.9	-4.1	3.7	7.8	2.04
3.7	4.3	3.1	5.8	2.8	0.76	3.7	-4.1	-7.2	0.4	7.6	1.95
4.4	0.4	-0.7	1.8	2.5	0.76	4.3	-7.8	-10.5	-3.3	7.2	1.87
5.1	-4.0	-5.2	-2.5	2.7	0.80	5.0	-11.8	-14.6	-7.6	7.0	1.82
5.8	-8.7	-10.1	-7.0	3.1	0.88	5.7	-16.6	-19.6	-12.4	7.2	1.81
6.6	-13.9	-15.4	-11.9	3.5	0.93	6.5	-22.2	-25.5	-17.9	7.6	1.82
7.5	-19.5	-21.3	-16.9	4.4	1.10	7.4	-28.6	-32.1	-24.2	7.9	1.86
8.5	-25.6	-28.0	-22.5	5.5	1.46	8.3	-36.0	-39.7	-31.6	8.1	1.87
9.6	-32.2	-35.7	-28.1	7.5	1.97	9.3	-44.2	-47.8	-40.4	7.5	1.81
10.9	-38.4	-41.3	-35.1	6.3	1.50	10.5	-52.1	-54.4	-48.9	5.5	1.75
12.4	-45.7	-47.0	-44.9	2.1	0.58	12.0	-57.4	-62.4	-53.7	8.7	2.18
14.2	-55.8	-57.9	-54.5	3.4	0.84	13.8	-59.0	-63.5	-55.5	7.9	1.98
16.8	-64.7	-66.8	-62.0	4.8	1.22	16.3	-61.2	-63.2	-58.7	4.5	1.18
21.0	-58.7	-59.5	-57.4	2.1	0.57	20.6	-60.8	-63.0	-59.2	3.8	0.98
26.9	-47.5	-47.9	-47.1	0.8	0.21	26.4	-53.4	-55.5	-50.1	5.4	1.28

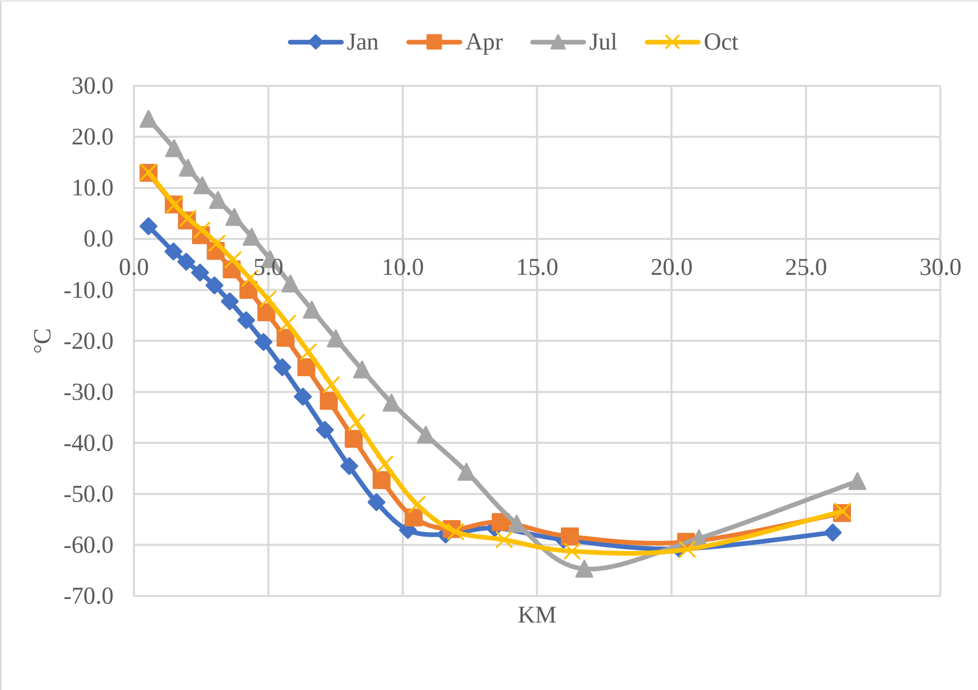


Fig. 1. Vertical distribution of the mean monthly values of the air temperature above the territory of Kakheti during January, April, July and October 2012-2016.

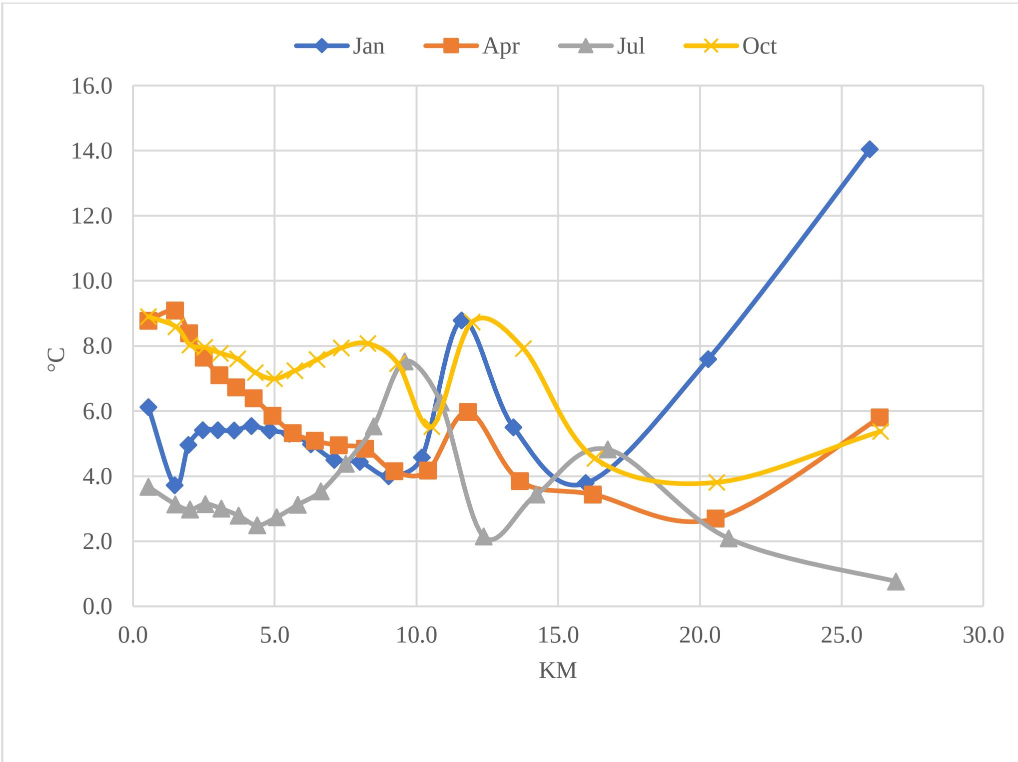


Fig. 2. Vertical distribution of a difference of the maximum and minimum mean diurnal values of the air temperature above the territory of Kakheti during January, April, July and October 2012-2016.

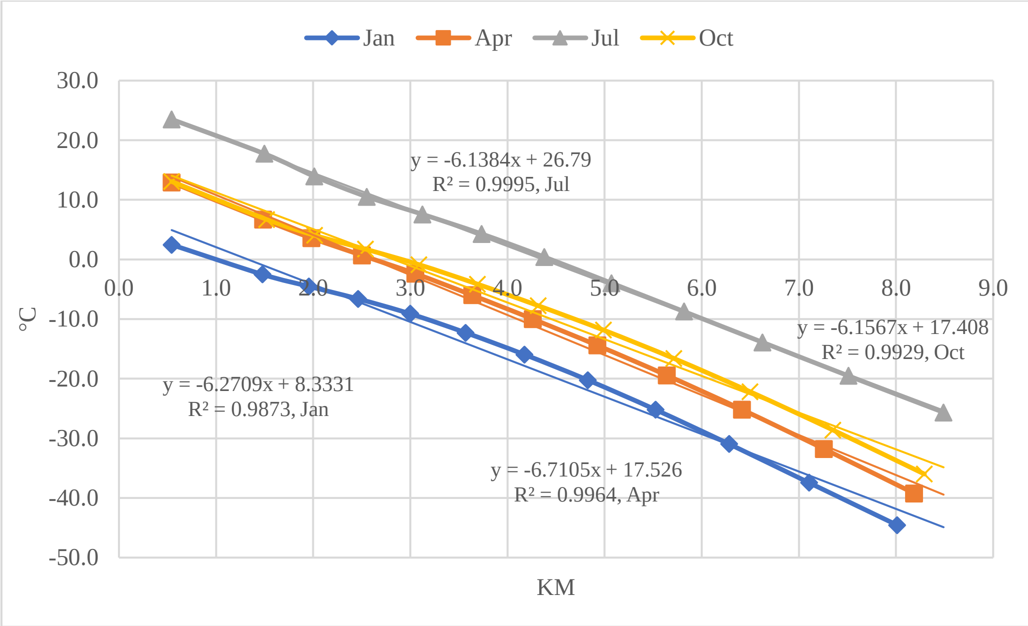


Fig. 3. Gradient of the vertical distribution of the average monthly values of the air temperature of above the territory of Kakheti during January, April, July and October 2012-2016.

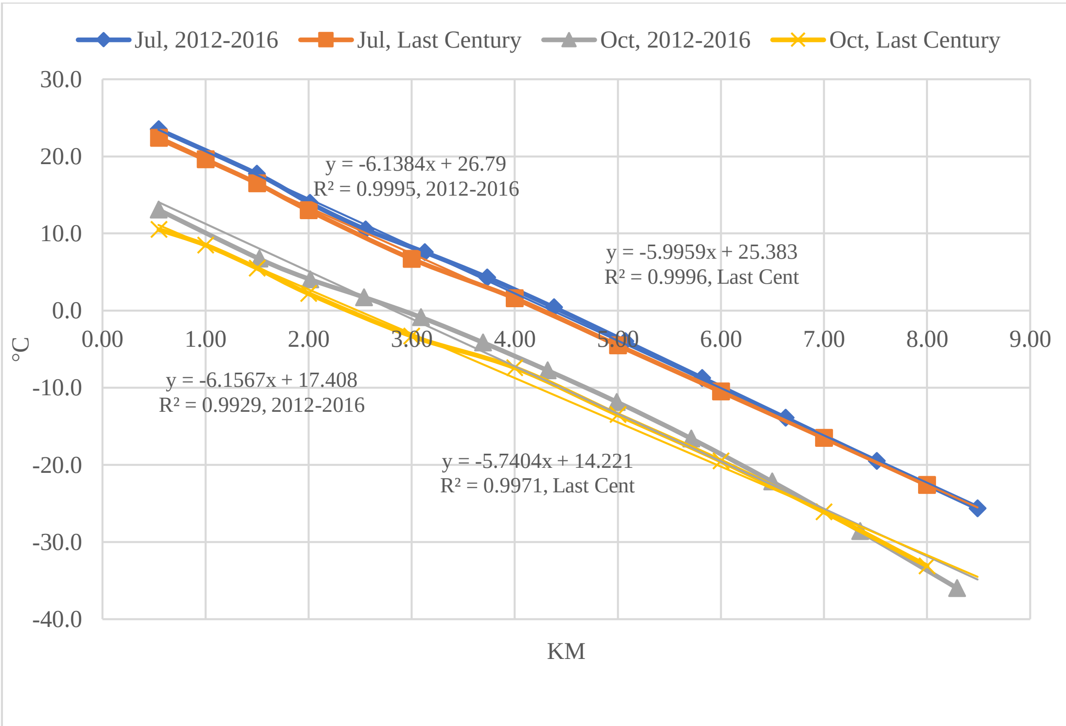


Fig. 4. Gradient of the vertical distribution of the average monthly values of the air temperature of above the territory of Kakheti during July and October 2012-2016 and 1958-1961 [2, 16].

As it follows from Table 1 and Fig. 1 during January the monthly average air temperature (T) linearly diminishes with 2.5 °C (range from -0.3 to 5.8 °C) on the earth's surface to -57.1 °C (range: -59.0 - -54.4°C) at the height of 10.2 km, then little it changes up to the height of 26 km (T = -57.6 °C, range: -64.4 -

-50.4 °C). In April the values of T linearly diminishes with 12.9 °C (range from 8.1 to 16.9°C) on the earth's surface to -54.6 °C (range: -56.4 - -52.2°C) at the height of 10.4 km, then little it changes up to the height of 26.3 km (T = -53.8 °C, range: -56.7 - -50.9°C).

As it follows from Table 2 and Fig. 1 in July the values of T linearly diminishes with 23.5 °C (range from 21.9 to 25.6°C) to -64.7 °C (range: -66.8- -62.0°C) at the height of 16.8 km, then it grows to -47.5 °C (range: -47.9 - -47.1°C) at the height of 26.9 km. In October the values of T linearly diminishes with 13.1 °C (range from 8.8 to 17.7°C) on the earth's surface to -57.4 °C (range: -62.4 - -53.7°C) at the height of 12.0 km, then little it changes up to the height of 20.6 km (T= -60.8 °C, range: -63.0 --59.2°C) °C) and then it grows to -53.4 °C (range: -55.5- -50.1°C) at the height of 26.4 km.

Vertical distribution of a difference of the maximum and minimum mean diurnal values of the air temperature above the territory of Kakheti in Fig. 2 are presented. As it follows from this figure maximum variations in the air temperature during January at the height of 26 km (14.0 °C), and minimum – in July at the height of 26.9 km (0.8°C) are observed.

Table 3

Average gradient of the vertical distribution of monthly values of the air temperature and mean height of zero isotherm above the territory of Kakheti

Parameter	January	April	July	October
Gradient, °/km	6.27	6.71	6.14	6.16
Ho, km	1.02	2.63	4.43	2.84

Average gradients of the vertical distribution of monthly values of the air temperature and mean height of zero isotherm above the territory of Kakheti in the Fig. 4 and Table 3 are presented. During July and October the monthly average height of zero isotherm is 4.43 and 2.84 km, which correspondingly is higher on 0.17 and 0.44 km than in 1958-1961. In July the average gradient of vertical distribution of monthly values of the air temperature during 2012-2016 is 6.14 °/km, and in 1958-1961 – 6.0 °/km. In October, these values respectively comprise 6.16 and 5.74 °/km. Thus, at present as at the end of the past century [12] also is observed the influence of the process of warming on the vertical distribution of the air temperature in eastern Georgia, on which on a small quantity of data it was noted in [18].

Conclusion

In the near future is planned conducting more detailed studies changeability of the vertical distribution of air temperature above Kakheti for all months of year, including decade, daily and hour variations. In particular, the indicated information is necessary for the optimum selection of rocket means with the works on the weather modification (fight with the hail, the regulation of atmospheric precipitations, etc.), construction of the detailed maps of the distribution of potential damage from the hail of agricultural crops, etc. taking into account the dimensions of hailstones in the clouds according to the data of radar measurements and height of locality.

Acknowledgement: This work is done by Shota Rustaveli National Science Foundation Master project grant MMR_2016_1_160.

The authors of work thank the head of the atmospheric physics department of M. Nodia Institute of Geophysics of I. Javakhishvili Tbilisi State University A. Amiranashvili for the management of the work and useful advice for its implementation.

References

[1] Abshaev A.M., Abshaev M.T., Barekova M.V., Malkarova A.M. Rukovodstvo po organizacii I provedeniu protivogradovih rabot. ISBN 978-5-905770-54-8, Nalchik, Pechatni dvor, 2014, 500 s., (in Russian).

[2] Nikolaishvili G.V. Aerologicheskaia harakteristika polia meteorologicheskih elementov nad Alazanskoi dolinoi. Trudi Vsesoiun. Sovesh. po aktivnim vozdeistviam na gradovie processi. Institut Geofiziki AN Gruzii, Tb., 1964, s. 71-89, (in Russian).
[3] Amiranashvili A., Dzodzuashvili U., Lomtadze J., Sauri I., Chikhladze V. Some Characteristics of Hail Processes in Kakheti. Trans. of Mikheil Nodia institute of Geophysics, ISSN 1512-1135, v. 65, Tb., 2015, pp. 77 – 100, (in Russian).
[4] Salukvadze T.G. Radiolokacionnie harakteristiki gradovih oblakov s uchetom ih sezonnogo hoda. Trudi Instituta Geofiziki AN Gruzii, t. 32., Tb., “Mecniereba”, 1973, s. 129-138, (in Russian).
[5] Amiranashvili A., Dzodzuashvili U., Lomtadze J., Sauri I., Chikhladze V. Meteorological Radar and Radar Ensuring Active Impacts on Atmospheric Processes in Kakheti. Trans. of Mikheil Nodia institute of Geophysics, ISSN 1512-1135, v. 65, Tb., 2015, pp. 101 – 112, (in Russian).
[6] Abaiadze O., Avlokhashvili Kh., Amiranashvili A., Dzodzuashvili U., Kiria J., Lomtadze J., Osepashvili A., Sauri I., Telia Sh., Khetashvili A., Tskhvediashvili G., Chikhladze V. Radar providing of anti-hail service in Kakheti. Transactions of Mikheil Nodia Institute of Geophysics, v. 66, ISSN 1512-1135, Tb., 2016, pp. 28-38, (in Russian).
[7] Avlokhashvili Kh., Banetashvili V., Gelovani G., Javakhishvili N., Kaishauri M., Mitin M., Samkharadze I., Tskhvediashvili G., Chargazia Kh., Khurtsidze G. Products of meteorological radar «METEOR 735CDP10». Transactions of Mikheil Nodia Institute of Geophysics, v. 66, ISSN 1512-1135, Tb., 2016, pp. 60-65, (in Russian).
[8] Kartsivadze A.I., SalukvadzeT.G., LapinskasV.A. Nekotorie voprosi metodiki vozdeistvia na gradovie processi s ispolzovaniem protivogradovoi sistemi “Alazani”. Trudi Instituta Geofiziki AN Gruzii, t. 36., 1975, s. 13-27, (in Russian).
[9] Amiranashvili A., Dzodzuashvili U., Chikhladze V. Anti-Hail Rockets of the Surface-to Air Type. Trans. of Mikheil Nodia institute of Geophysics, ISSN 1512-1135, v. 64, Tb., 2013, pp. 151 – 159, (in Russian).
[10] Amiranashvili A., Barekchian I., Dvalishvili K., Dzodzuashvili U., Lomtadze J., Osepashvili A., Sauri I., Tatishvili G., Telia Sh., Chikhladze V. Characteristics of ground means action on hail process in Kakheti. Transactions of Mikheil Nodia Institute of Geophysics, v. 66, ISSN 1512-1135, Tb., 2016, pp. 39-52, (in Russian).
[11] Amiranashvili A. G., Chikhladze V. A., Dzodzuashvili U. V., Jincharadze G. A., Pipia M. G., Sauri I. P., Telia Sh. O. On the Use of Anti-Hail Rockets "Trayal D 6- B" in the Work of Anti-Hail System in Kakheti (Georgia). Journal of the Georgian Geophysical Society, Issue B. Physics of Atmosphere, Ocean and Space Plasma, v.19B, Tb., 2016, pp. 73-78.
[12] Tavartkiladze K., Begalishvili N., Kharchilava J., Mumladze D., Amiranashvili A., Vachnadze J., Shengelia I., Amiranashvili V. Contemporary climate change in Georgia. Regime of some climate parameters and their variability. Monograph, ISBN 99928-885-4-7, Tb., 2006, 177 p., (in Georgian).
[13] Amiranashvili A.G., Chikhladze V.A., Dzodzuashvili U.V., Ghlonti N.Ya., Sauri I.P. Reconstruction of Anti-Hail System in Kakheti (Georgia). Journal of the Georgian Geophysical Society, Issue B. Physics of Atmosphere, Ocean and Space Plasma, v.18B, Tb., 2015, pp. 92-106.
[14] Amiranashvili A., Burnadze A., Dvalishvili K., Gelovani G., Ghlonti N., Dzodzuashvili U., Kaishauri M., Kveselava N., Lomtadze J., Osepashvili A., Sauri I., Telia Sh., ChargaziaKh., Chikhladze V. Renewal works of anti-hail service in Kakheti. Transactions of Mikheil Nodia Institute of Geophysics, v. 66, ISSN 1512-1135, Tb., 2016, pp. 14-27, (in Russian).
[15] Budagashvili T., Karchava J., Gunia G., Intskirveli L., Kuchava T., Gurgenidze M., Amiranashvili A., Chikhladze T. Inventory of Greenhouse Gas Emissions and Sinks. Georgia’s Initial National Communication on Under the United Nations Framework Convection on Climate Change, Project GEO/96/G31, Tb., 1999, 137 p.
[16] Amiranashvili A., Chikhladze V., Kartvelishvili L. Expected Change of Average Semi-Annual and Annual Values of Air Temperature and Precipitation in Tbilisi. Journ. of Georgian Geophysical Soc., Issue B. Physics of Atmosphere, Ocean and Space Plasma, ISSN 1512-1127, v. 13B, Tb., 2009, pp. 50 – 54.
[17] Amiranashvili A., Matcharashvili T., Chelidze T. Climate change in Georgia: Statistical and nonlinear dynamics predictions. Journ. of Georgian Geophysical Soc., Iss. (A), Physics of Solid Earth, v.15A, Tb., 2011-2012, pp. 67-87.
[18] Bliadze T., Jamrishvili N., Iobadze K., Tavidashvili Kh. Changeability of height of zero isotherm in Kakheti into the season of the anti-hail works of 2015. Transactions of Mikheil Nodia Institute of Geophysics, v. 66, ISSN 1512-1135, Tb., 2016, pp. 90-95, (in Russian).

ჰაერის ტემპერატურის ვერტიკალური განაწილების საშუალოთვიური მნიშვნელობები 2012-2016 წლების ცენტრალურითვეებისთვის კახეთის (საქართველო) ტერიტორიაზე

ნ. ჯამრიშვილი, ხ. თავიდაშვილი

რეზიუმე

მოყვანილია მონაცემები კახეთის ტერიტორიაზე 2012-2016 წლების ცენტრალური თვეებისთვის ჰაერის ტემპერატურის დღე-ღამური სიდიდეების მნიშვნელობების ხუთწლიანი საშუალო მონაცემების ცვალებადობის შესახებ. წარმოდგენილია ჰაერის ტამპერატურის სტატისტიკური მახასიათებლები სხავადასხვა დონეზე 0.54კმ-დან 27კმ-მდე სიმაღლეთა დიაპაზონში. კერზოდ, მოყვანილია ჰაერის ტემპერატურის ვარტიკალური განაწილების საშუალოთვიური მონაცემები იანვარში, აპრილში, ივლისსი და ოქტომბერში; ჰაერის საშუალო ტემპერატურის გრადიენტის მნიშვნელობები მითითებული თვეებისთვის ატმოსფერის ფენაში 0.54კმ-დან 8,5კმ-მდე; ნულოვანი იზოთერმის სიმაღლის საშუალოთვიური მნიშვნელობა. შედეგად მივიღეთ, რომ 2012-2016 წლებში ივლისის და ოქტომბრის თვეებისთვის ნულოვანი იზოთერმის სიმაღლე შესაბამისად 0.215 და 0.506კმ-ით მაღლაა 1958-1961 წლებთან შედარებით.

Вертикальное распределение среднемесячных значений температуры воздуха над территорией Кахетии (Грузия) в центральные месяцы года 2012-2016 гг.

Н.К. Джамришвили, Х.З. Тавидашвили

Резюме

Приводятся данные об изменчивости средних пятилетних значений суточных величин температуры воздуха над Кахетией для центральных месяцев года для периода с 2012 по 2016 гг. Представлены статистические характеристики температуры воздуха на разных уровнях в диапазоне высот от 0.54 до 27 км. В частности, приведены данные о вертикальном распределении среднемесячных значений температуры воздуха в январе, апреле, июле и октябре; среднем значении градиента температуры воздуха для указанных месяцев в слое атмосферы от 0.54 до 8.5 км; среднемесячных значениях высоты нулевой изотермы. Отмечено, что высоты нулевой изотермы для июля и октября месяцев в 2012-2016 соответственно на 0.215 и 0.506 км выше тех же величин в 1958-1961 гг.

Journal of the Georgian Geophysical Society,
Issue B. Physics of Atmosphere, Ocean and Space Plasma, v.19B, 2016, pp. 73-78

On the Use of Anti-Hail Rockets "Trayal D 6- B" in the Work of Anti-Hail System in Kakheti (Georgia)

[1]Avtandil G. Amiranashvili, [1]Victor A. Chikhladze, [2]Ucha V. Dzodzuashvili, [3]Gocha A. Jincharadze, [3]Mikheil G. Pipia, [2]Ioseb P. Sauri, [2]Shmagi O. Telia

[1]M. Nodia Institute of Geophysics of I. Javakhishvili Tbilisi State University,
e-mail:avtandilamiranashvili@gmail.com
[2]Military Scientific-Technical Center "DELTA"
[3]Institute of Hydrometeorology ofGeorgian Technical University

ABSTRACT

In the Kakheti region of Georgia in the work of anti-hail system anti-hail rockets "Trayal D 6-B" of the production of Serbia from September 2016 are used. Some results of the calculations of the optimum areas of cloud seeding by the crystallizing reagent for 83 points of action located on the protected territory in Kakheti are given.

Key Words: Weather modification, anti-hail rockets.

Introduction

Georgia is one of the hail-dangerous countries of world. Large-scale work on the weather modification in the Soviet period prior to the end of the eightieth years of past century in eastern Georgia, including fight with the hail was conducted [1,2]. Taking into account importantly this problem with the support of the government of Georgia, to the active operation of Scientific-Technical center "Delta", the collaborators of institute of geophysics and institute of hydrometeorology, the work of anti-hail service in Kakheti in the end of May 2015 was restored [3-6].

At present the anti-hail service works in the test regime. From the set of anti-hail items [2,7,8] in 2015 year it was possible to acquire the anti-hail rockets SK-6 of the productions of Macedonia [2,5,9], which were used until August 2016. From September 2016 for dealing with the hail anti-hail rockets "Trayal D 6- B" of the production of Serbia are used [10].

Some results of the calculations of the optimum areas of cloud seeding by the crystallizing reagent for 83 points of action located on the protected territory in Kakheti are given below.

Material and methods

To protect the whole region of Kakheti (650 thousand hectares) in 2016 year 83 launching points were used. There is a rocket launching device, solar panel, grounding and security systems installed on the launching site. The launching device carries 26 anti-hail rockets, aims to any given direction and fires [5,6,8,9]. The launchers at the heights from 205 to 1775 m above sea level placed. In the range of heights from 205 to 500 m located 34 launchers, from 501 to 700 m - 35 launchers, from 701 to 1000 m - 12 launchers, from 1100 to 1775 m - 2 launchers (Fig. 1).

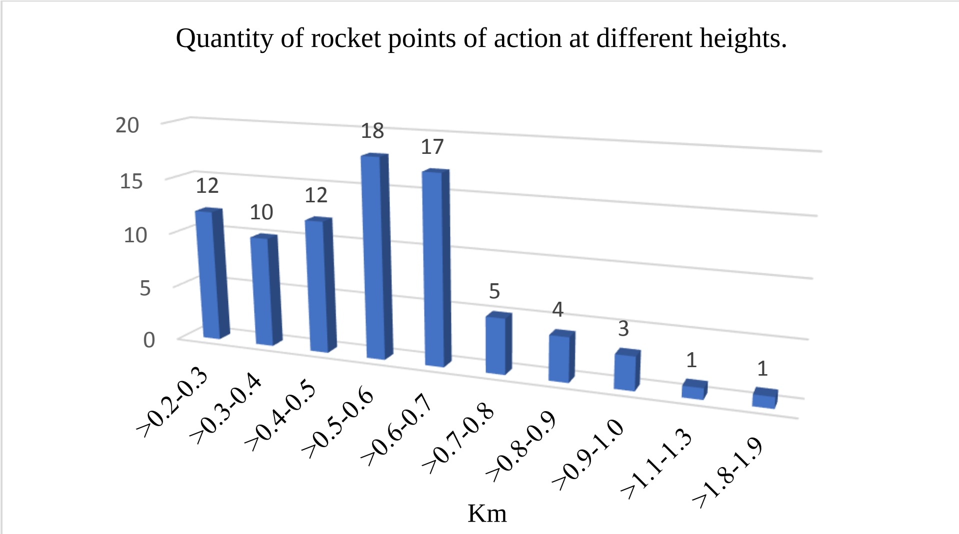


Fig. 1. Quantity of rocket points of action at different heights in Kakheti in 2016. In all - 83 points.

The anti-hail rocket „Trayal D-6B“ the production of Serbia (fig. 2) is an unguided, 55 mm rocket, which carries $4.0 \cdot 10^{15}$ particles of silver iodide reagent and disperses it for 29 seconds [10]. Some parameters of anti-hail rocket „Trayal D-6B“ represented lower. The number of rockets needed during one year estimated to be 5000-6000 units.

Fig. 2. Anti-hail Rockets „Trayal D-6B“ in the container for the transport (http://www.valjevskaposla.info/wp-content/uploads/2017/04/rakete.jpg).

Anti-hail rocket „Trayal D-6B“ parameters.

- Rocket quantity in launching device SD-26 or SD-52: 26-52 rockets
- Elevation: 55-80°
- Traverse: 360°
- Rocket diameter: 55 mm
- Rocket length: 840 mm
- Rocket weight: 3550 gram
- Rocket maximum velocity: 600 m/sec
- Shoot maximum distance (elevation 55°): 7400 meter
- The maximum from sea level (elevation 80°): 5600 meter
- The outlet of reagent from the rocket at a temperature -10°C – $4.0 \cdot 10^{15}$ particles

The calculations of the optimum areas of cloud seeding by the crystallizing reagent it was carried out taking into account level of the zero isotherm (and isotherm -6.0 °C), which as a result of the warming of climate [11-14] grew by several hundred meters [15,16], and also heights of the arrangement of launchers.

Results and discussion

The results of calculations on Fig. 3 and 4 are presented.

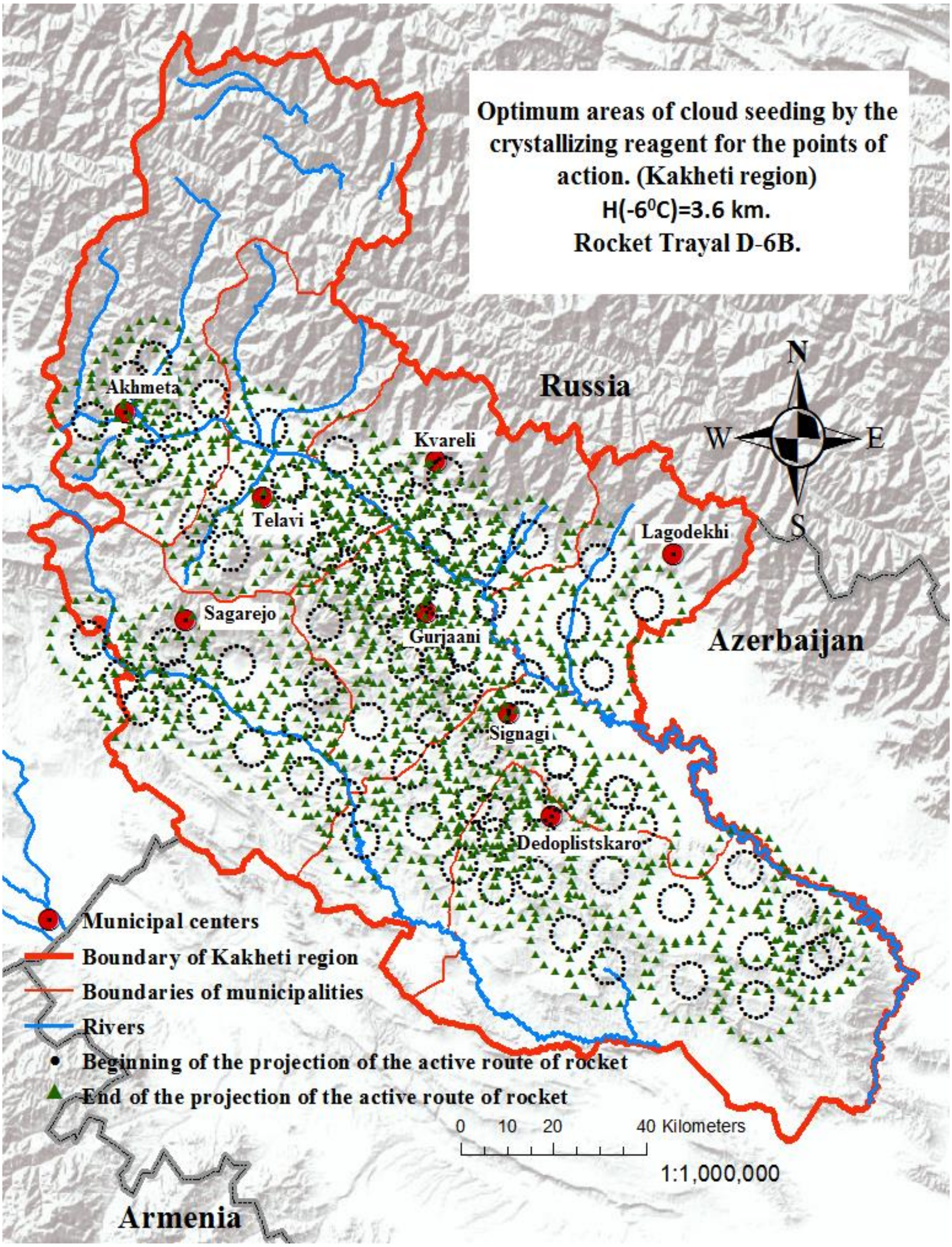


Fig. 3. Optimum areas of cloud seeding by the crystallizing reagent for the points of action by anti-hail rockets "Trayal D-6B" in the protected territory in Kakheti. Height of the isotherm -6°C = 3.6 km.

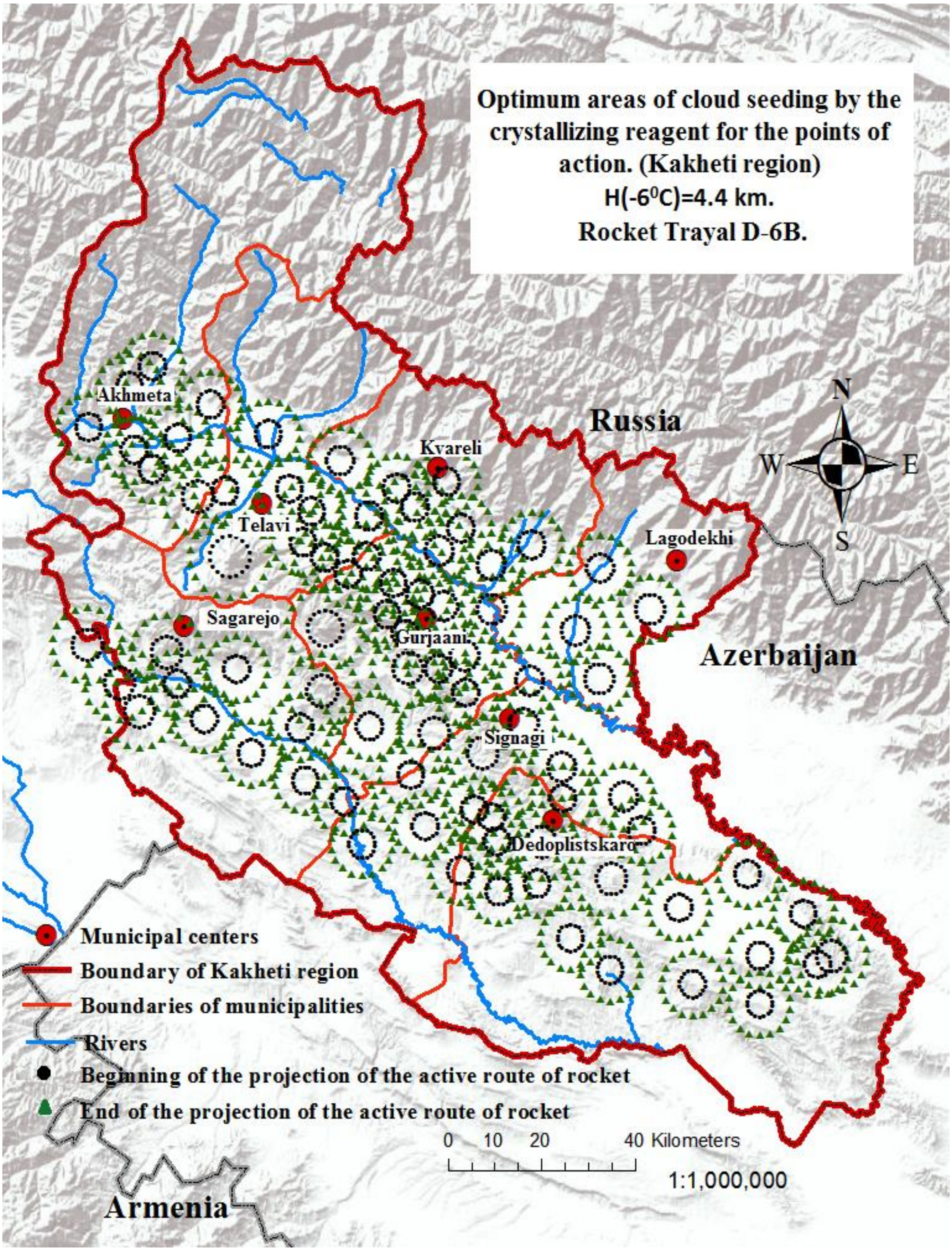


Fig. 4. Optimum areas of cloud seeding by the crystallizing reagent for the points of action by anti-hail rockets “Trayal D-6B” in the protected territory in Kakheti. Height of the isotherm -6°C = 4.4 km.

Optimum areas of cloud seeding by the crystallizing reagent depend on the height of the arrangement of launchers and level of isotherm -6°C (Fig. 3,4). As follows from these figures distribution of the optimum areas of cloud seeding by reagent is unevenly. Basic reason for this - the insufficiently long courses of the rocket "Trayal D-6B". Therefore, in near future the production of anti-hail rockets with the improved ballistic characteristics is planned (increase in the effective radius of action, etc.).

Conclusions

The Anti-hail service in Kakheti for several years will be function in test regime. In this period of time it is planned to improve means and methods of anti-hail protection in connection with local conditions and possibilities of obtaining the means of action and tracking of the hail clouds. The newly created distance automatic system of action on the clouds will be simultaneously improved, a question about the organization of own production of anti-hail rockets will be examined, etc.

References

[1] Amiranashvili A., Dzodzuashvili U., Lomtadze J., Sauri I., Chikhladze V. Some Characteristics of Hail Processes in Kakheti. Trans. of Mikheil Nodia institute of Geophysics, ISSN 1512-1135, v. 65, Tb., 2015, pp. 77 – 100, (in Russian).

[2] Abshaev A.M., Abshaev M.T., Barekova M.V., Malkarova A.M. Rukovodstvo po organizacii I provedeniu protivogradovih rabot. ISBN 978-5-905770-54-8, Nalchik, Pechatni dvor, 2014, 500 s, (in Russian).

[3] Amiranashvili A., Ghlonti N., Dzodzuashvili U., Lomtadze J., Chikhladze V. On the renewal of anti-hail works in Georgia. Int. Conf. "Advanced Problems in Geophysics". Reports, presented on the Scientific Conference "80 years of the M. Nodia Institute of Geophysics". Tb., 2014, pp. 208-212, (in Russian).

[4] Amiranashvili A., Ghlonti N., Dzodzuashvili U., Lomtadze J., Chikhladze V. O vosstanovlenii sluzhby bor'by s gradom v Kakhetinskom regione Gruzii. Doklady Vserossiyskoy otkrytoy konferentsii po fizike oblakov i aktivnym vozdeystviyam na gidrometeorologicheskiye protsessy, posvyashchennoy 80-letiyu El'brusskoy vysokogornoy kompleksnoy ekspeditsii AN SSSR, 7-9 oktyabrya 2014 g., chast' 2, FGBU «Vysokogorniy Geofizicheskiy Institut», Nal'chik, 2015, s. 132-139, (in Russian).

[5] Amiranashvili A.G., Chikhladze V.A., Dzodzuashvili U.V., Ghlonti N.Ya., Sauri I.P. Reconstruction of Anti-Hail System in Kakheti (Georgia). Journal of the Georgian Geophysical Society, Issue B. Physics of Atmosphere, Ocean and Space Plasma, v.18B, Tb., 2015, pp. 92-106.

[6] Amiranashvili A., Burnadze A., Dvalishvili K., Gelovani G., Ghlonti N., Dzodzuashvili U., Kaishauri M., Kveselava N., Lomtadze J., Osepashvili A., Sauri I., Telia Sh., Chargazia Kh., Chikhladze V. Renewal works of anti-hail service in Kakheti. Trans. of Mikheil Nodia institute of Geophysics, ISSN 1512-1135, v. 66, Tb., 2016, pp. 14 – 27, (in Russian).

[7] Amiranashvili A., Dzodzuashvili U., Chikhladze V. Anti-Hail Rockets of the Surface-to Air Type. Trans. of Mikheil Nodia institute of Geophysics, ISSN 1512-1135, v. 64, Tb., 2013, pp. 151 – 159, (in Russian).

[8] Amiranashvili A., Dzodzuashvili U., Lomtadze J., Sauri I., Chikhladze V. Means of action on atmospheric processes in Kakheti. Trans. of Mikheil Nodia institute of Geophysics, ISSN 1512-1135, v. 65, Tb., 2015, pp. 113 – 120, (in Russian).

[9] Amiranashvili A., Barekchian I., Dvalishvili K., Dzodzuashvili U., Lomtadze J., Osepashvili A., Sauri I., Tatishvili G., Telia Sh., Chikhladze V. Characteristics of ground means action on hail process in Kakheti. Trans. of Mikheil Nodia institute of Geophysics, ISSN 1512-1135, v. 66, Tb., 2016, pp. 39 – 52, (in Russian).

[10] Anti-hail Rocket "Trayal D-6B" Technical Description. TRAYAL Corporation Factory for Production Explosives and Pyrotechnics. Ševac, Serbia, 2016, 20 p.

[11] Budagashvili T., Karchava J., Gunia G., Intskirveli L., Kuchava T., Gurgenidze M., Amiranashvili A., Chikhladze T. Inventory of Greenhouse Gas Emissions and Sinks. Georgia's Initial National Communication on Under the United Nations Framework Convection on Climate Change, Project GEO/96/G31, Tb., 1999, 137 p.

[12] Amiranashvili A., Chikhladze V., Kartvelishvili L. Expected Change of Average Semi-Annual and Annual Values of Air Temperature and Precipitation in Tbilisi. Journ. of Georgian Geophysical Soc., Issue B. Physics of Atmosphere, Ocean and Space Plasma, ISSN 1512-1127, v. 13B, Tb., 2009, pp. 50 – 54.
[13] Amiranashvili A., Matcharashvili T., Chelidze T. Climate change in Georgia: Statistical and nonlinear dynamics predictions. Journ. of Georgian Geophysical Soc., Iss.(A), Physics of Solid Earth, v.15A, Tb., 2011-2012, pp. 67-87.
[14] Tavartkiladze K., Begalishvili N., Kharchilava J., Mumladze D., Amiranashvili A., Vachnadze J., Shengelia I., Amiranashvili V. Contemporary climate change in Georgia. Regime of some climate parameters and their variability. Monograph, ISBN 99928-885-4-7, Tb., 2006, 177 p., (in Georgian
[15] Bliadze T., Jamrishvili N., Iobadze K., Tavidashvili Kh. Changeability of height of zero isotherm in Kakheti into the season of the anti-hail works of 2015. Transactions of Mikheil Nodia Institute of Geophysics, v. 66, ISSN 1512-1135, Tb., 2016, pp. 90-95, (in Russian).
[16] Jamrishvili N. K., Tavidashvili Kh. Z. Vertical distribution of the monthly mean values of the air temperature above the territory of Kakheti (Georgia) in the central months of the year 2012-2016. Journal of the Georgian Geophysical Society, Issue B. Physics of Atmosphere, Ocean and Space Plasma, v.19B, Tb., 2016, pp. 66-72.

კახეთის (საქართველო) სეტყვასაწინაათმდეგო სისტემის მუშაობაში “Trayal D 6-B” ტიპის სეტყვასაწინააღმდეგო რაკეტების გამოყენების შესახებ

ა.ამირანაშვილი, ვ.ჩიხლაძე, უ.ძოძუაშვილი, გ.ჯინჭარაძე,
მ.ფიფია, ი. საური, შ. თელია

რეზიუმე

2016 წლის სექტემბრიდან საქართველოში კახეთის რეგიონში სეტყვასაწინააღმდეგო სამსახურში გამოიყენება სერბეთის წარმოების “Trayal D 6-B” ტიპის სეტყვასაწინააღმდეგო რაკეტები. კახეთში დასაცავ ტერიტორიაზე განლაგებული ზემოქმედების 83 პუნქტისთვის მაკრისტალიზებელი რეაგენტით ღრუბლების ჩათესვის ოპტიმალური ფართობების გათვლების ზოგიერთი შედეგია მოყვანილი.

Об использовании противоградовых ракет “Trayal D 6-B” в работе противоградовой системы в Кахетии (Грузия)

**А.Г. Амиранашвили, В.А. Чихладзе, У.В. Дзодзуашвили,
Г.А. Джинчарадзе, М.Г. Пипиа, И.П. Саури, Ш.О. Телия**

Резюме

С сентября 2016 года в Кахетинском регионе Грузии в работе противоградовой системы используются противоградовые ракеты “Trayal D 6-B” производства Сербии. Приводятся некоторые результаты расчетов оптимальных площадей засева облаков кристаллизующим реагентом для 83 пунктов воздействия, расположенных на защищаемой территории в Кахетии.

Journal of the Georgian Geophysical Society,
Issue B. Physics of Atmosphere, Ocean and Space Plasma, v.19B, 2016, pp. 79-89

Long Term Trends in Climate Variability of Caucasus Region

[1]Bakhram S. Nurtaev, [2]Lali Nurtaev

[1]Institute of Helioclimatology. Germany
[2]Cologne University of Applied Sciences. Germany
Email: nurtaev@gmx.net

ABSTRACT

Over the period 1855–1996 was observed a long-term increase trend of solar activity, that leads to temperature rise. In the Caucasus region it is also observed a warming trend. The main goal of this study is to identify contribution of the Sun on climate variability of Caucasus Mountains and long term prediction of future climate trend in the region for sustainable development.

Key words: climate change, solar activity.

1. Introduction

Solar radiation is the major source of heat for the Earth. The sun provides light and warmth. In fact 99. 97% of energy budget of the earth arrives from the Sun [1]. This energy to the atmosphere is the primary driver of the Earth's weather.

Its motions through the sky cause day and night, the passage of the seasons, and earth's varied climates. The added hours of daylight are one reason why summer is warmer than winter. Another reason that's even more important: the angle of the mid-day sun.

Global atmospheric circulation strongly affected by the amount of solar radiation received at Earth. That amount changes based on the Earth's albedo, that is how much radiation is reflected back from the Earth's surface and clouds. The amount of radiation given off by the Sun is changing with solar activity like sunspots and total solar irradiance.

A reconstruction of total solar irradiance since 1610 to the present estimated by various authors an increase in the total solar irradiance since the Maunder Minimum of about 1.3 W/m² [2]. This is a huge amount of energy, taking into account the Earth's total land mass.

Currently, our civilization consumes around 17.7 Terawatts of power taken from all sources of energy, namely oil, coal, natural gas and alternative energies. Every second the Earth's surface receives about 100 times more energy from the Sun.

During the period 1855-1996 was observed an increase in temperature in the Northern Hemisphere. The averaged sunspot number risen about 40% and temperature change on – 4%-10%.

The atmosphere in temperate regions continues to receive more heat than it gives up to space, a situation that lasts a month or more, depending on the latitude.

Climate of the Earth's has been changed over the 4, 5 billion years of the Earth's geological history. There have been periods of warming and there have been ice ages.

The Holocene Climate Optimum was a warm period during roughly the interval 9,000 to 5,000 years Before Present. The Holocene Climate Optimum warm event consisted of increases of up to 4 °C.

The Medieval Warm Period or Medieval Climate Optimum is generally thought to have occurred from about 950–1250.

The Little Ice Age was a period of cooling that occurred after the Medieval Warm Period (Fig. 1). Global warming has happened repeatedly over time: periodical cooling cycles alternated with warming.

The modern Warm Period has been occurred in the period 1880 to 2012, as can be seen from Fig. 2 [3].

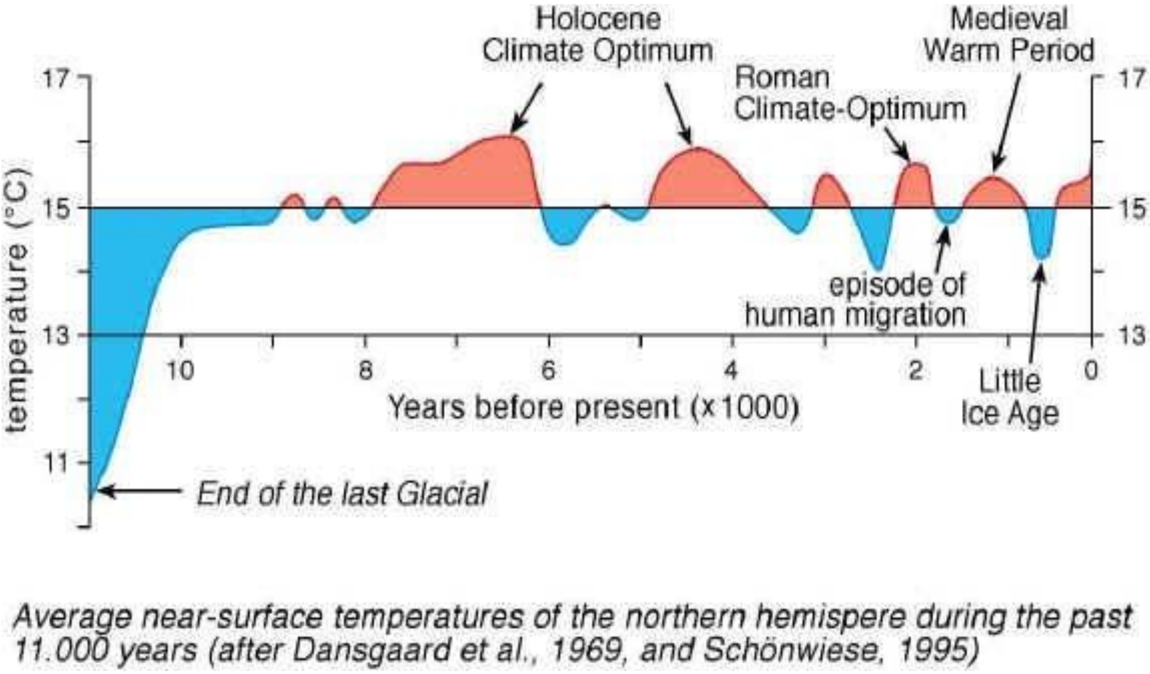


Fig. 1. Holocene climate variability over the period of 11.000 years

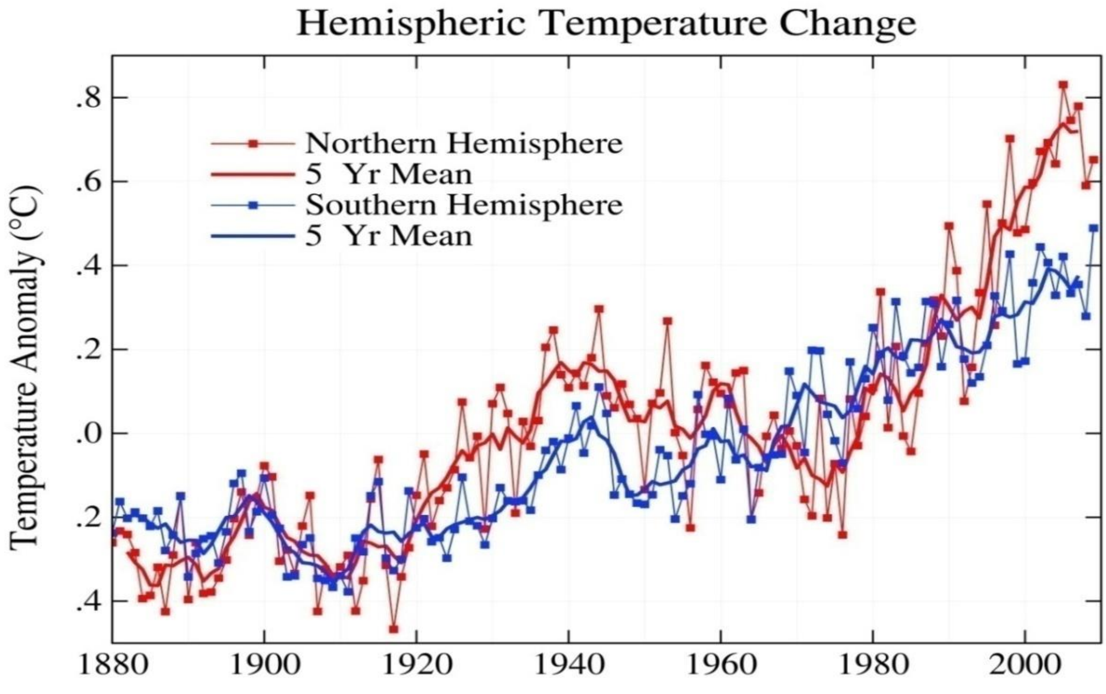
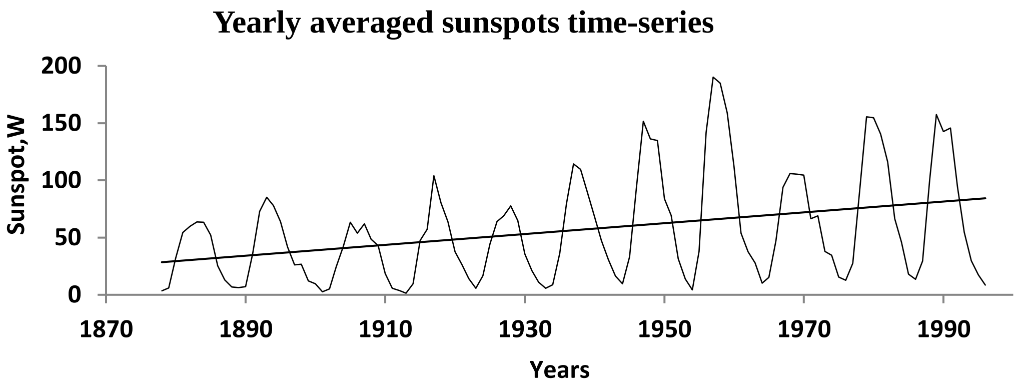


Fig. 2. Temperature change (NASA/GISS) http://www.giss.nasa.gov/research/news/20100121/

2. Background

Climate variability in the Caucasus region has to be considered in the context of global climate change. Common global climate change experience shows heterogeneous effect across regions of the world. Climate change and associated impacts differs from region to region around the globe. Anticipated effects include warming global temperature, rising sea levels, changing precipitation, and expansion of deserts in the subtropics.

Increase of solar activity in the last time has led to increase of air temperature, atmospheric carbon dioxide and global sea level (Fig. 3 - 7).



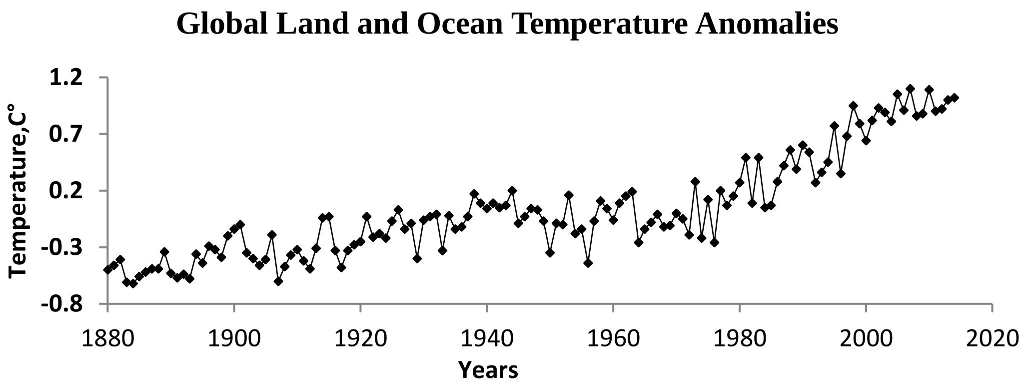


Fig. 3. Long-term increase trend of solar activity and temperature anomaly over the period 1880–1996.

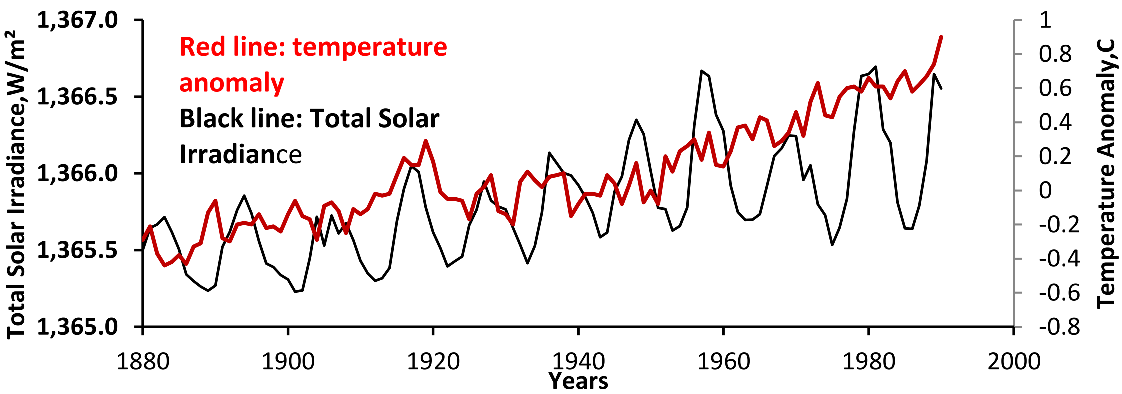


Fig. 4. Temperature Anomaly Data of NOAA's National Centers for Environmental Information (NCEI) and Total Solar Irradiance over the period of 1880-2008.

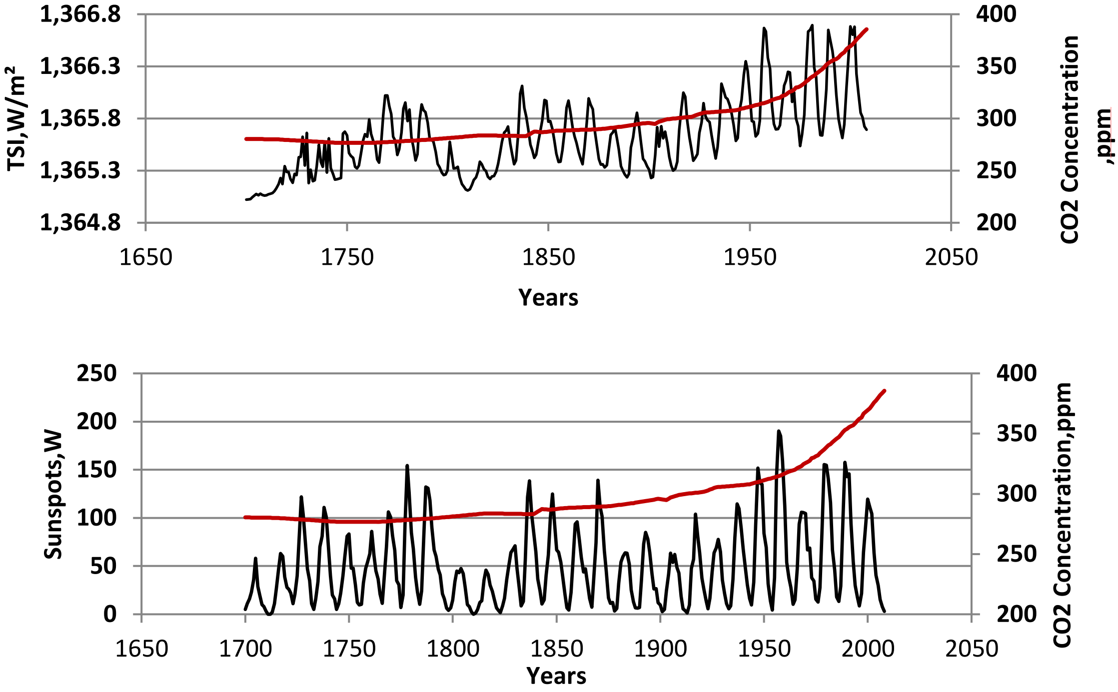


Fig. 5. The atmospheric carbon dioxide and solar activity (red line CO_2 concentration).

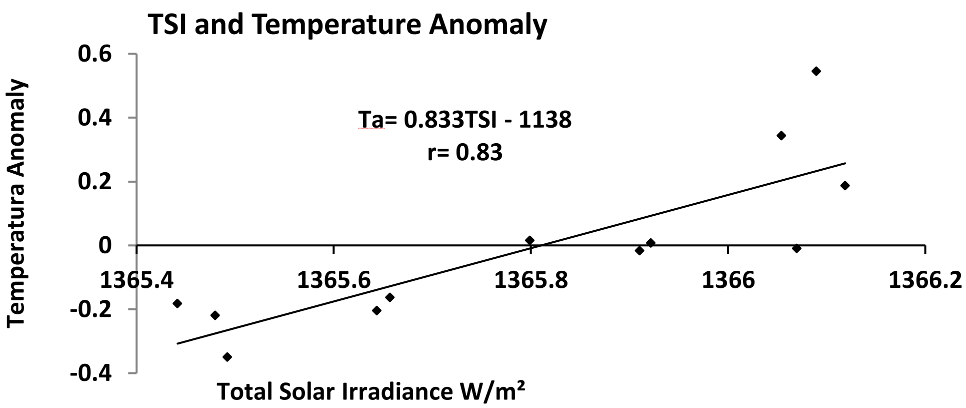


Fig. 6. Temperature Anomaly Data and solar activity.

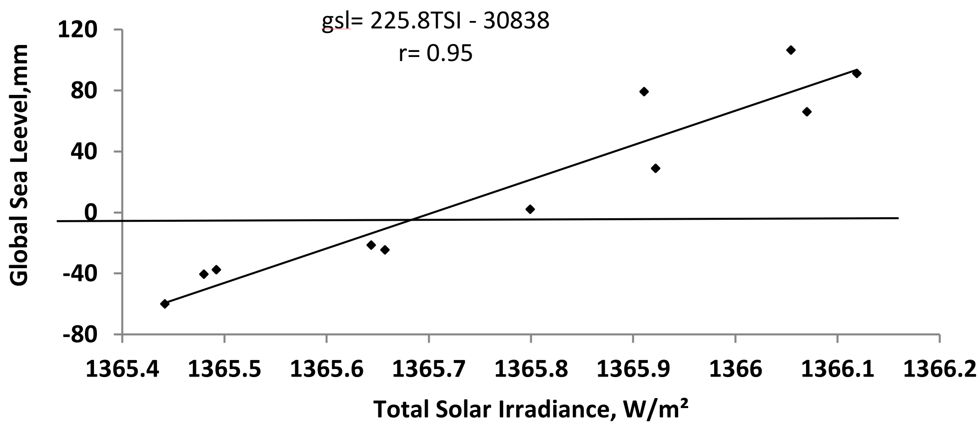


Fig. 7. Global Sea Level (gsl) in dependence from TSI over observed period 1878-2008.

3. Long term trends in climate variability of Caucasus region

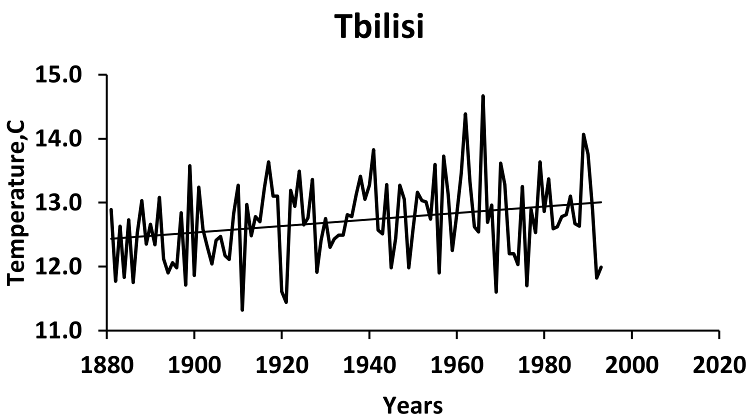
The Caucasus is a region located between the Black and Caspian Seas. The Greater Caucasus range moderates local climate by serving as a barrier against cold air from the north. Lesser Caucasus Mountains partially protect the region from the influence of dry and hot air masses from the south as well [4].

Regional climates in the Caucasus region are largely influenced by distance from the Black and Caspian Seas and the orography of the Greater and Lesser Caucasus. The prevailing west winds from the Black Sea loose most of their moisture when crossing the Surami ridge that connects the Greater with the Lesser Caucasus as a result of orographic lift. Dry winds descend into the Kura valley which therefore has a more arid character with warm to hot and dry summers and cold winters. Climate change is ambiguous here - warming in eastern Georgia and cooling in the west [5,6].

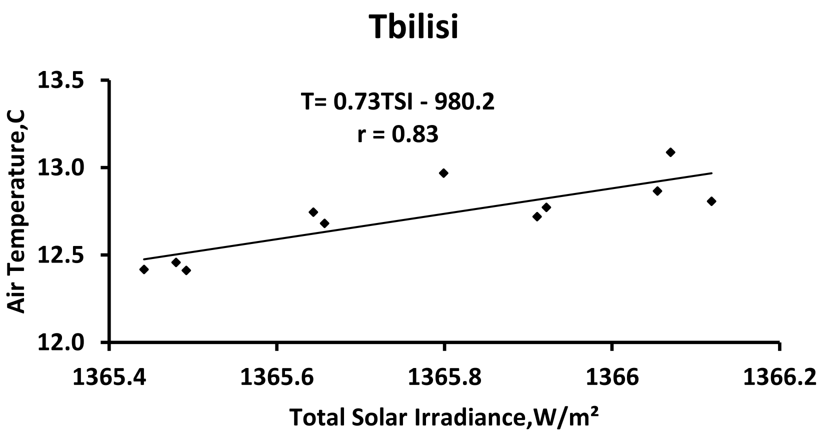
Mountains receive less solar radiation than adjacent foothills and plains located a short distance away. Winds blowing against mountains force some of the air to rise, and clouds form from the moisture in the air as it cools.

Smoothed Total Solar Irradiance (TSI) values were compared with smoothed weather parameters over the same period. Our calculations show that temperature change in the region closely depends on Total Solar Irradiance (TSI). For example temperature in Tbilisi over the period 1878-1996 can be written as:

$$T = 0.73TSI - 980.2 \qquad r=0.83 \qquad (1)$$



a



b

Fig. 8. Air temperature time series (a) in Tbilisi over the period 1881-1996 and relationship of temperature from solar irradiance (b).

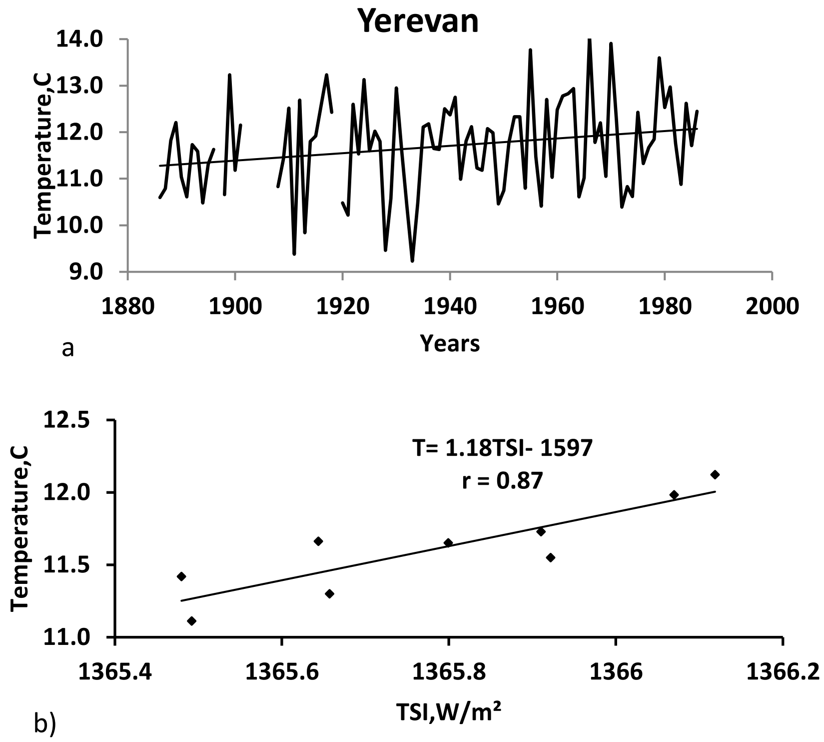


Fig. 9. Air temperature time series (a) in Yerevan over the period 1890-2008 and relationship of temperature from solar irradiance (b).

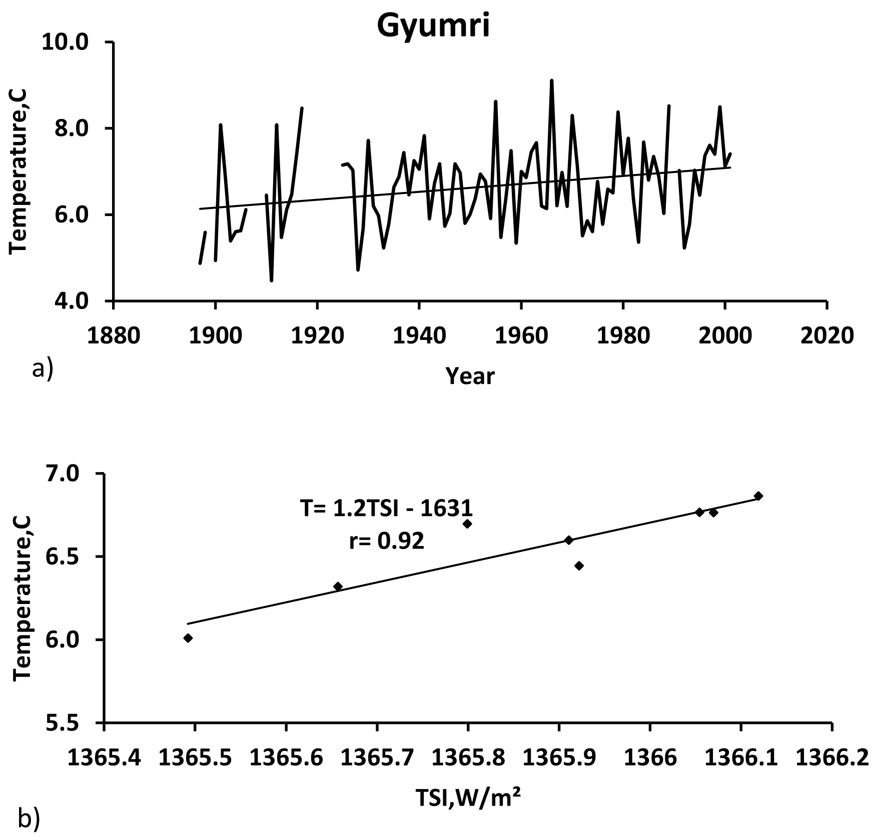


Fig. 10. Air temperature time series (a) in Gyumri over the period 1902-2001 and relationship of temperature from solar irradiance (b).

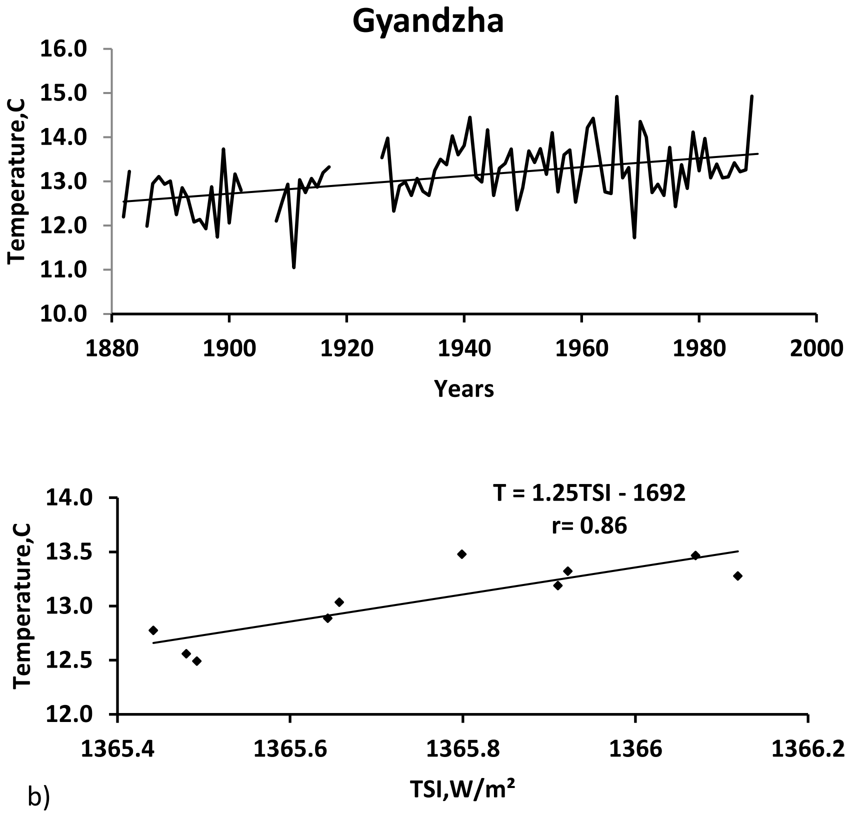


Fig. 11. Air temperature time series (a) in Gyandzha (Kirovobad) over the period 1882-1996 and relationship of temperature from solar irradiance (b).

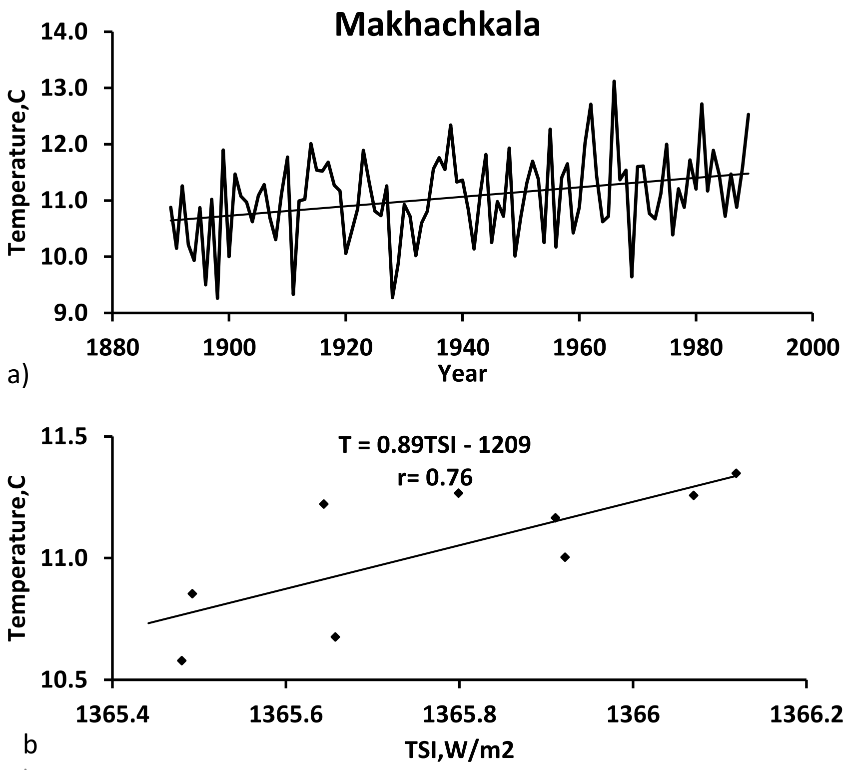


Fig. 12. Air temperature time series (a) in Makhachkala over the period 1890-1986 and relationship of temperature from solar irradiance (b).

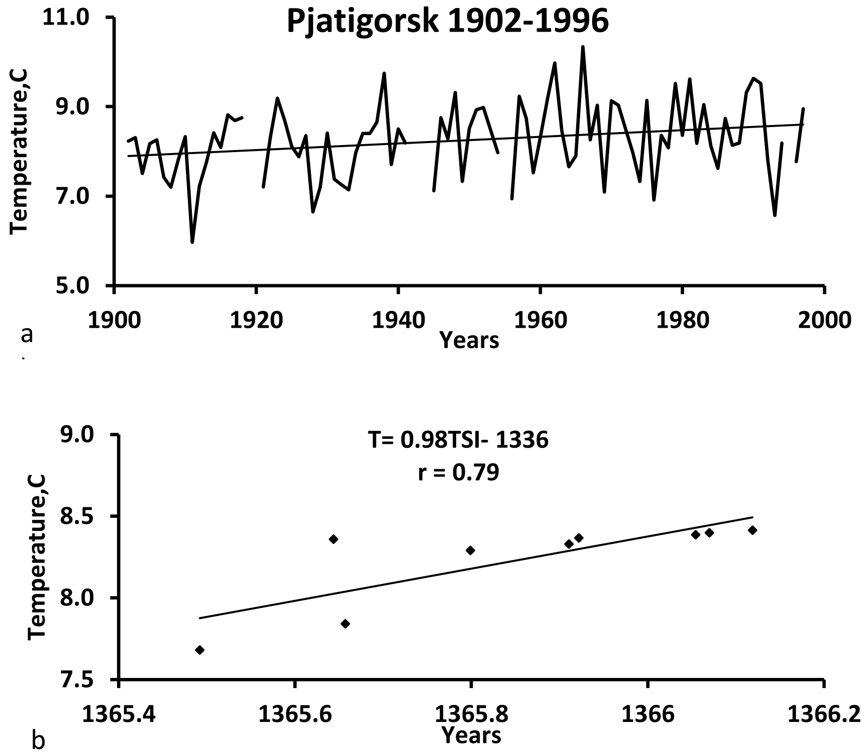


Fig. 13. Air temperature time series (a) in Piatigorsk over the period 1902-1996 and relationship of temperature from solar irradiance (b).

Temperatures are increasing over entire region and the annual mean amount of precipitation is tending to decrease.

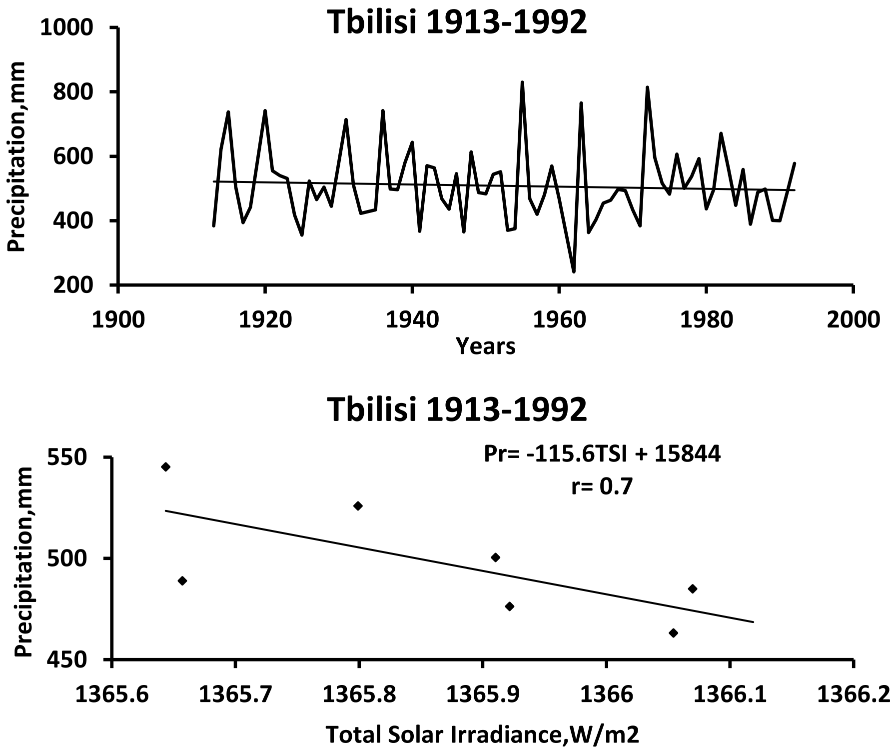


Figure 14. Precipitation time series (a) and decrease trend in Tbilisi over the period 1913-1992 in dependence from solar irradiance (b).

The same trend shows time series of Yerevan and Makhachkala station precipitation (Fig. 15).

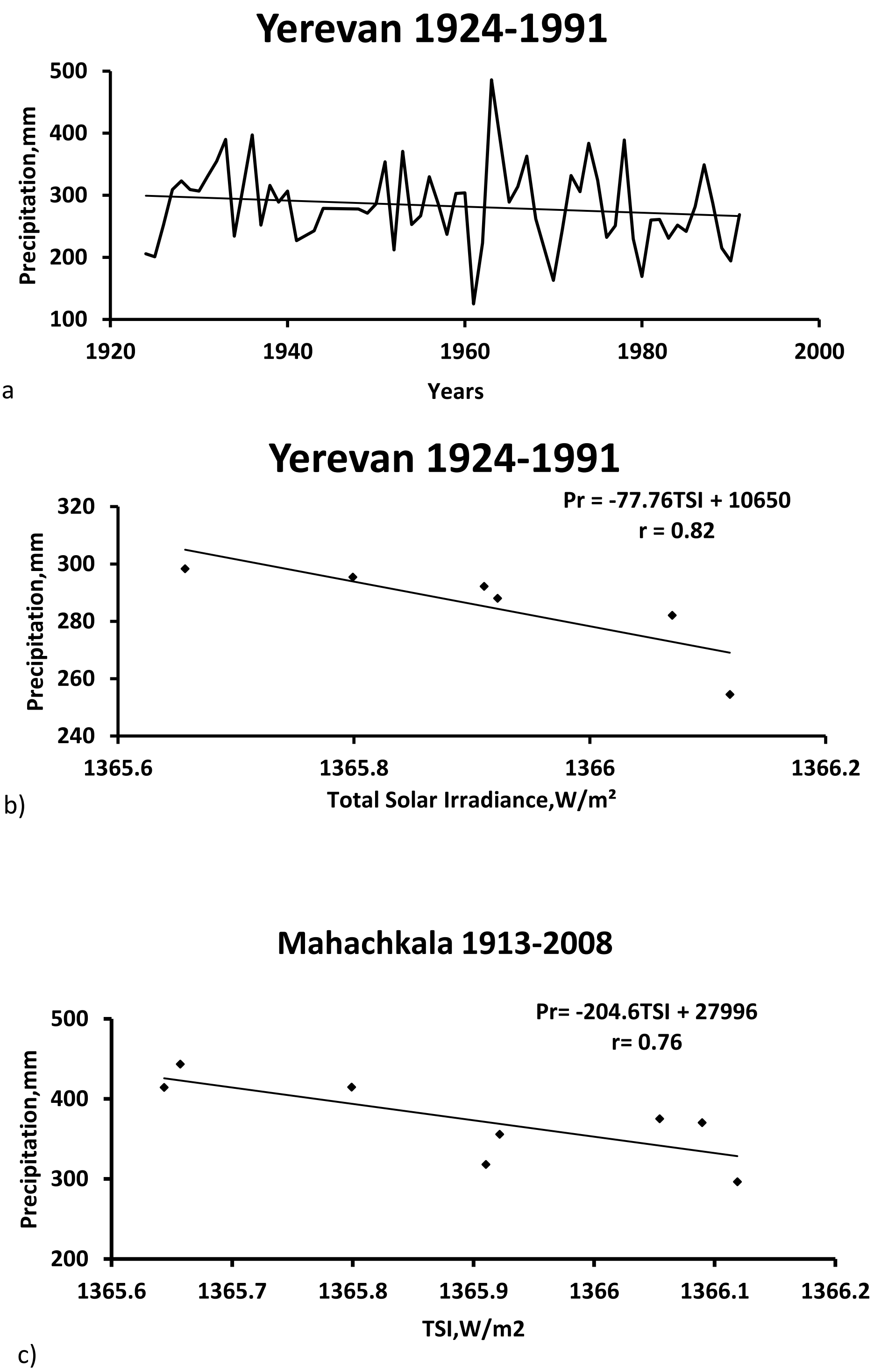


Fig. 15. Precipitation time series (a) and decrease trend in Yerevan (b) over the period 1924-1991 and Makhachkala (c) over the period 1913-2008 in dependence from solar irradiance.

This precipitation trend is typical for rain shadow located on the side of a mountain range that is protected from the prevailing winds [7]. The mountains block the passage of rain-producing weather systems and cast a "shadow" of dryness behind them. Wind and moist air is drawn by the prevailing winds towards the top of the mountains, where it condenses and precipitates before it crosses the top.

Table 1

Comparison of Caucasus weather stations altitudes show different temperature change.

Weather station	Altitude	Observed period	Air °C increase
Gumri	1523 m	1902-1996	0.70
Yerevan	907 m	1890-1996	0.70
Tbilisi	490 m	1878-1996	0.45
Kirovobad	408 m	1878-1996	0.50
Makhachkala	32 m	1890-1986	0.78
Pjatigorsk	538m	1902-1996	0.70

Temperature change in Tbilisi points out good correlation with temperature variability in Geneva (Switzerland) altitude 420 m, although temperature increase over the same period 1878-1996 more high - 1.7 °C (Fig. 17).This can be explained more intensive prevailing west winds from the Atlantic Ocean, that more weak in the Caucasus region.

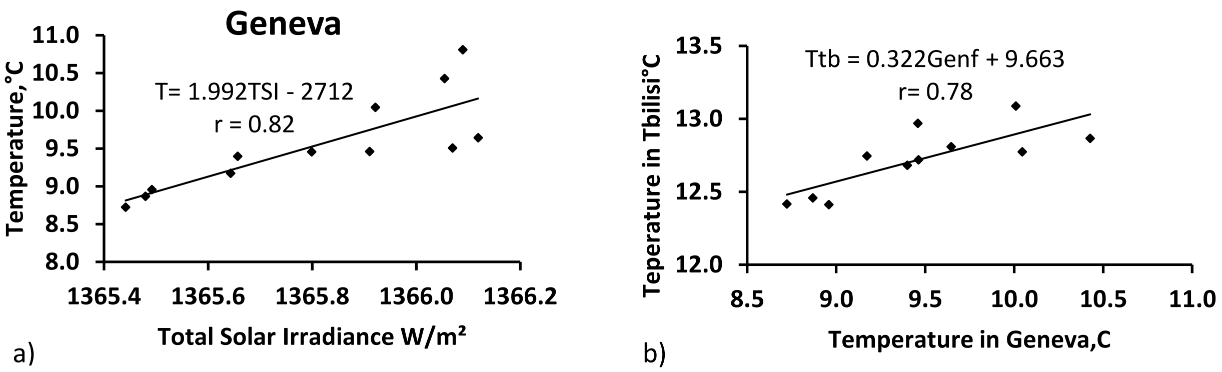


Fig. 16. Dependence of air temperature in Geneva from Total Solar Activity (a) and air temperature in Tbilisi (Ttb) from temperature in Geneva (Genf) over the period 1878-1996.

Moderate temperature increase trend in the Caucasus region can be connected with mountainous topography. The southern slopes of the Caucasus Mountain Range receive more solar irradiance.

Amount of Total Solar Irradiance on the different slopes varies in mountain disposition south/north - ratio -1.62, south/east- ratio 1.54, south /west ratio -1.56 [8]. In the Northern hemisphere, south-facing slopes receive more direct sunlight and have a warmer climate than those facing north.

Conclusion

More sunspots deliver more energy to the atmosphere, by way of increased brightness of the Sun and solar wind what tend to warm the Earth. Solar activity affects the Earth in many ways, some which we are still coming to understand.

In accordance with National Geophysical Data Center (NGDC) forecasting the solar cycles 24 and 25 will be very weak: averaged sunspot numbers W-35 for the solar cycle 24 and for the solar cycle 25 less than W-35 , NGDC (2009). Total Solar Irradiance will equal -1365,48. (23 cycle -1366,09).

This actually will lead to a decrease of the temperature on 0.5-0. 7 C in both averaged solar cycles, in Geneva will decrease to 1.5 C. Temperature of air will be lower in the Northern Hemisphere. Precipitation rate in Caucasus will be more in average on 100-150 mm in dependence from location.

The World Ocean level also will be lower, due to more snow and glacier accumulation on continents.

References

[1] Taylor F. W. Elementary Climate Physics. Oxford University Press, Oxford, 2005, 232 p.
[2] Krivova N. A., Vieira L. E. A., Solanki S. K. Reconstruction of solar spectral irradiance since the Maunder Minimum. Journal of Geophysical Research (Space Physics), 115, A12112, 2010, 11 p.
[3] NASA/GISS) http://www.giss.nasa.gov/research/news/20100121/
[4] Bondyrev I., Davitashvili Z.,Vijay P. Singh. The Geography of Georgia: Problems and Perspectives. Springer, 2015, 228 p.
[5] Budagashvili T., Karchava J., Gunia G., Intskirveli L., Kuchava T., Gurgenidze M., Amiranashvili A., Chikhladze T. Inventory of Greenhouse Gas Emissions and Sinks. Georgia's Initial National Communication on Under the United Nations Framework Convection on Climate Change, Project GEO/96/G31, Tb., 1999, 137 p.
[6] Amiranashvili A., Matcharashvili T., Chelidze T. Climate change in Georgia: Statistical and nonlinear dynamics predictions. Journ. of Georgian Geophysical Soc., Iss.(A), Physics of Solid Earth, v.15A, Tb., 2011-2012, pp. 67-87.
[7] Bakhram B. Impact of Solar Activity on Hydrological Cycle of the Himalayan and Indian Peninsula Rivers. Modern Environmental Science and Engineering. doi:10.15341/mese (2333-2581)/03.01.2015/003 Published online:11/19/2015(http://www.academicstar.us/issueshow.asp?daid=1323)
[8] Chandel S.S. , Aggarwal R. A. Estimation of Hourly Solar Radiation on Horizontal and Inclined Surfaces in Western Himalayas. Smart Grid and Renewable Energy, 2, 2011, pp. 45-55, doi:10.4236/sgre.2011.21006 Published Online February 2011 (http://www.SciRP.org/journal/sgre)

კლიმატის ცვალებადობის მრავალწლიური ტრენდები კავკასიის რეგიონში

ბ. ნურტაევი, ლ. ნურტაევი

რეზიუმე

1855-1996 წლებში დაიკვირვებოდა მზის აქტივობის მატების გრძელვადიანი ტრენდი, რაც იწვევდა ტემპერატურის მატებას. კავკასიის რეგიონში ასევე დაიკვირვება დათბობის ტენდენცია. ამ გამოკვლევის მთავარი მიზანია - მზის წვლილის განსაზღვრა კავკასიის მთების კლიმატის ცვლილებაში და მომავალი კლიმატური ტენდენციის გრძელვადიანი პროგნოზირება რეგიონში მისი მდგრადი განვითარებისათვის.

Долговременные тренды изменчивости климата в Кавказском регионе

Б.С. Нуртаев, Л. Нуртаев

Резюме

В период 1855-1996 гг. наблюдался долгосрочный тренд роста солнечной активности, что приводило к повышению температуры. В Кавказском регионе также наблюдается тенденция к потеплению. Основная цель этого исследования - определить вклад Солнца в изменчивость климата гор Кавказа и долгосрочное прогнозирование будущей климатической тенденции в регионе для устойчивого развития.

Journal of the Georgian Geophysical Society,
Issue B. Physics of Atmosphere, Ocean and Space Plasma, v.19B, 2016, pp. 90-100

Improvement of Ecological Fon in Georgian Cities

[1] Zurab A. Ezugbaia, [2] Inga R. Iremashvili

[1]Georgian Technical University
[2]Ts. Mirtskhulava Water Management Institute of Georgian Technical University

ABSTRACT

The article deals with the issues relating to the innovative technologies of green coverage arrangement on the roofs of the buildings and structures.there are widely represented the cover types and detailed characteristics of their structures.The appropriate conclusions are made, which describe the technical and environmental advantages of the green pavement arrangement. They show both, positive (Ecological, economic, psychological, business, security and aestheticism) and negative sides.

Key Words: *roof; green coverage; green plants; ecology.*

Introduction

The human and nature relationship starts from the very biginning. Since then, people not only accepted surroundings but they have started its tranformation: cutting down forests, cultivated land, made build roads and bridges, new towns and so on. The big sities population growing and the science and technology developement made it easier for people to use nature.

Recently, a lot of houses were built and the most of them were built in the prestigious districts.

The density of constructions has distroyed the green areas. Dramatically increased the number of cars. The Sidewalks turned into car parkings. A large number of vehicles caused the air pollution.

Due to the multi-storey building density they shade each-other and lighting standards are violated and many flats have no enough sunlight. Super urbanization has led to the deterioration of the living conditions of the people and the climate [1-5]. Especially heavy situation in Tbilisi city and environments of the city [6-9], where there is only an small quantity of recreational zones [10-12].

An integral part of urban life – parks and squares. Recreational areas around the city are deplorable. Extensive analysis of the environmental situation are not done. Ongoing constructions in the recreation areas, green zones and especially the prestigious districts (photo 1, 2, 3) start without environmental impact assessment documents. Nobody measures the noize, and no one discusses the greenery and ventilation issues. Considering this situation the urban planning ecology issue is becoming increasingly important. Moreover, the we talk about the million-city, which ecological situationis in a critical situation [8,13].

a) b)

Photo 1. Tbilisi Sports Palace surrounding area:
a) XX century 80-s and b) Now

a)

b)

Photo 2. The former Hippodrome a) XX century, in the 80-s and b) now

a)

b)

Photo 3. The construction boom in Kipshidze street:
a) view from the river Vere gorge; b) view from Chavchavadze Avenue

MAIN PART

At present situation of the ecological environment deterioration in big cities, it is very important the improvement of building design and construction.

In the big blocks of flats,where people feel themselves far from the nature there is possible to arrange the recreation area with plants, that can improve the buildings ecological situation [14].

In order to live more comfortable in the houses people used to build houses with green covering from the herbaceous plants that provided the protection of the microclimate of the houses.

In ancient times, gardens and small grass lawn leisure facilities were built 2,500 years ago in Assyrian and Babylon. The most obvious example is the Hanging Gardens of Semiramida. Gradually Hanging Gardens and green areas cultivation have begun not only in Asia, but also in Europe.

Scandinavian countries, particularly Norway, practice grass-covered areas over several centuries.

The green environment can make life comfortable conditions, which lead to ecological situation improvement (Improving the air, creating a micro-climate) As well as psychological and emotional rehabilitation capacity expansion.

Along with the growth of cities is becoming the one of the equally important aspects of the architecture - “the fifth facade" of buildings. The great problem of big cities is the Lack of free land and a big price. Green roofs are particularly important for the economic and ecological point of view.

In 1960 the German architect arranged the recreation area on the roof and called it “the green roof”. Of course, the green roof is better than the traditional roof from the aesthetic and architectural points of view. Because, as a rule, the traditional roofs are not arranged in order to be aesthetic.

On the background of global climate change the developed countries such as North America and European countries, especially in metropolises (photo 4), have in their eco programs the green coverage arrangement. For example, the green roof is actively developing in cities such as Copenhagen, Paris, London, Berlin, New York, Chicago and others. There are many examples in Asia-Thailand, China and so on.

Photo 4. Green coverage examples

It’s well known green coverage vegetation types, structures and diversity. Green coverage consists of 6 main layers: 1. Plant layer; 2. Soil substrates; 3. Filtration layer; 4. Drainage system; 5. waterproofing layer; 6. The insulation layer. In some cases, the composition or the material may be different (photo 5) [15,16].

The number of layers can change and be more in different cases due to the technologies (fig.1, 2).

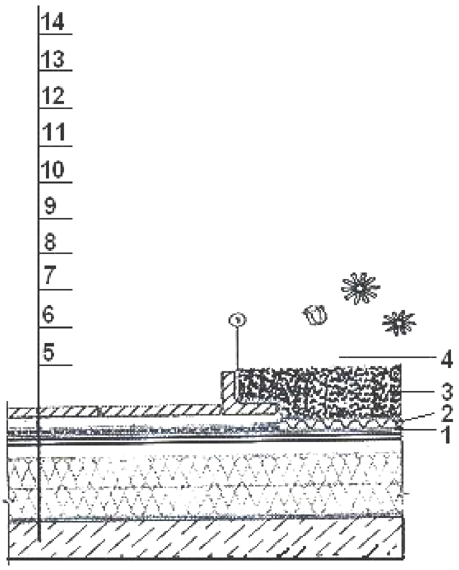


Fig. 1. The cover construction of greenery:
1 – geotextile 350-400 g / m^2; 2 - Planter life; 3 - ground; 4 - Greening; 5 - roofing tile; 6 - Steam insulation; 7 - hitter; 8 - reinforced cement-sand crust; 9 - bitumen primer; 10 –hydro isolation 2 layer; 11 -plastic layer;12 - Drainage component; 13 - reinforced cement-sand crust; 14 - sidewalks or floor tiles

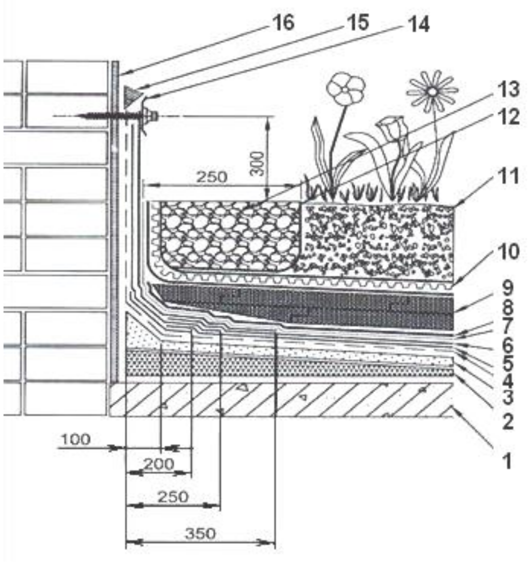


Fig. 2. green cover assent to wall:
1 - roofing tile; 2 - lightweight concrete layer; 3 - reinforced cement-sand crust;4- primaries;5, 6 - 2 insulating layer; 7, 8 - geotextile;9 - foam polystyrene; 10 - drainage membrane; 11 - soil; 12 - Geotextile; 13 – Gravel a fraction 20-40 mm;14 - Marginal metal backed sealing strip; 15 - hermetick; 16 - plaster layer.

2 kinds of geen coverage is known in modern desighn: extensive and inverted [3].

The extensive coverage (photo 5) is not used for walking. You can only walk on special places of this kind of coverage. The soil layer is not more than 0,07–0,15mm. Which gives us the chance to plant only small plants. Onli special kinds of greenery or moss can be planted here in the spesial capacities.

The plant must have the horizontal root system. The estensive coverage in water saturated condition is 80-100 kg/m^2 ·we can plant varety of small, drought resistant plants.The soil is saturated with essential minerals. There are 80% of extensive green coverage in Germany because it can easily return the investment back and can bring great ecological and floodin protection benefits to the densely populated city.

Photo 5. Green extensive roofs

Green intensive(inversive) roof –is a construction, where we can arrange not only the lawn, but also the gardens with trees and bushes and maybe with fountains and pools (photo 6) the intensive roofs must have parapets minimal height 1.2 m and the soil height – 0.2 – 0.6 m.

Photo 6. Green intensive roofs

Green, intensive coverage other items (pools, fountains, benches, trees and so on) and the soil thickness usually increases the load on the roof bearing elements. Because of this they take into account the green coverage structure on the stage of designing. It must be accounted the weight of the construction.

Here is some of the structural composition of green coverage [17]:

1. Green coverage plants selection must be provided individually and depends on the environment, green coverage location, soil thickness and the customer's wish. They usually choose moss or grass for the green coverage, meadow flowers and mountain flowers depending on the building location and the climate conditions

2. Soil Substrate. For soil it's used the substrate, which is much lighter, than the soil (peat or something else). This can significantly reduce base load. The lightened green coverage construction is particularly relevant for intensive coverage arrangement.

3. Filter layer usually consists of geo textile and root protective shell. The geo textile is used as filtering layer to avoid leak of soil particles in drainage and avoid congestion (photo 7).

Photo7. Geotextiles

For the green coverage it's used the thermally hardened geo textile, the construction is made so that it practically can't be sledged and has a great operation period in given conditions. The root protective layer is arranged after the geo textile (photo 8), (preferably made of nonwoven polypropylene).It is not recommended concrete or asphalt-concrete layer for the root protected layer.

4. Drainage systemcan be performed in some options:

- Perforated drainage layer with using water pipes;
- Perforated polystyrene tiles;
- Gravel;
- Drainage layer (photo 9).

Photo 8. Root protective layer **Photo 9. Drainage layer**

The perforated high strength polystirol or plastic pipes made of high pressure are used as drainage pipes. During the drainage system arrangement the soil depth and average rainfall amount should be considered. The soil layer thickness is measured considering the plant layer root deepening. When we arrange the extensive covering, the root deepening is about 20 cm and the deep drainage is not necessary.

5. Waterproofing layer – is protecting the green coverage from water and moisture liking into the building or the building walls outer surface. The variety of membranes is used for the green coverage waterproof layer arrangement. For example,

- Polymer waterproofing membranes on bitumen base and anti-root protection (ecological material), photo 10;

Photo 10. Polymer waterproofing membranes on bitumen base

- Polymer- with anti-root protection based on synthetic (operating period of 60 years), photo 11;

Photo11. Polymer waterproof membrane arrangement on the synthetic base

- Aluminum or copper foil with additional protective membrane;
- With liquid resins;

As rule, the waterproof layer on the flat roofs is arranged with 3-5% inclination.

6. Insulation layer. It’s recommended to arrange the insulation layer from the glass foam or perlite sand. The glass-foam does not conduct the moisture and it is not toxic for plants and soil micro flora. The extruded polystyrene foam tiles and mineral wadding is used for hitting. They also put the soil into the small plastic boxes (0.5x0.5m) to simplify the job (photo 12).

Photo 12. Plastic boxes for soil and the box arrangement

Intensive green coverage differs from extensive one by the soil thickness and hitters placement- its situated on the waterproof layer, not under it. This can protect it from mechanical damage.

Photo 13 presents the chart which determines the roof load size dependence on soil layer thickness.

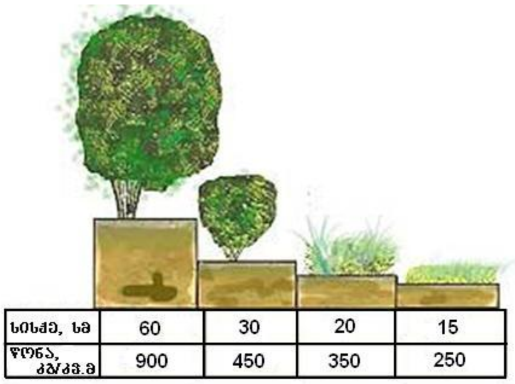


Photo 13. The size of the load on the roof of green cover soil layer thickness and plant diversity

The table below shows the relative data of two green coverages. The table shows, that the extensive coverage is better than intensive one:

- Relatively low price;
- less load on the coverage bearings;
- Easy storage and maintenance.

Table

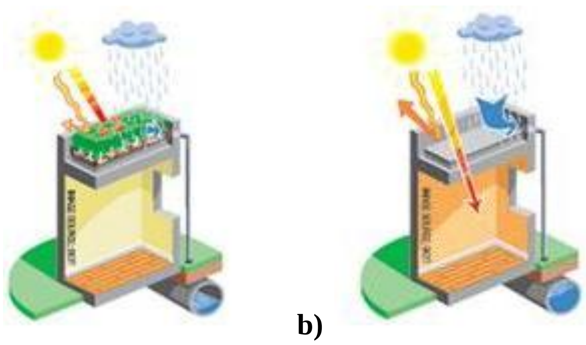
Extensive greening	Intensive greening
Does not provide being people on the covering	Gives possibility to arrange the garden on the green coverage, where people can walk
Plant monotony	Variety of bushes and trees
Don’t need frequent watering and special care	It needs special care and watering as normal garden
Don’t need frequent technical services	Needs good technical services
The coverage arrangement is possible on the roofs of various inclination	Gives possibility to locate flowers, bushes, trees, leisure zones, and pools on the roof.
Small weight	Medium and large weight
Possible arrangement on the existed buildings	Must be developed on the building design stage
Cheapness	High price

Conclusion

The positive sides of green coverage arrangement – ecological, economical, psychological, business, security and aestheticism:

1. **Ecological situation improvement -** the plants of the green coverage reduce harmful substances in the air due CO_2 absorption and oxygen gas emissions. It's calculated, that 150 $m^2$of green cover age allocates the oxygen that is enough for 100 people in a year. The green coverage plants neutralize the big amount of dust and harmful air, created favorable bioclimate [10-12,18,19]. 1000 m^2 of extensive green coverage can absorb 8 kg dust in a year, and air near the green coverage is fresh and includes the 37%-less SO_2 and 21%-less CO;
2. **Reduces the noise impact** (up to 8-10 dcb). The soil can absorb the low- frequency sounds and the plants can absorb the high-frequency sounds;
3. The green coverage also **moist air**. The coverage can deter or partially absorb 50-70% of rain water;
4. It 3-4 times **increases the coverage construction validity** because of the sun's ultraviolet rays and overheating protection (sun rays can hit the coverage up to 80ºC). The green coverage arrangement can prolong the ordinary flat coverage life up to 60%. It's known, that the green coverage usage can save our expenses up to 60%;
5. Green coverage on the roofs is **fire prevention**;
6. Green coverage performs a natural function of the thermal insulation on this base **the energy costs reduce for heating and cooling of buildings;**
7. Green coverage can be used for vegetable or fruit **gardens, Industrial greenhouses or for the leisure zone; It can be arranged the football stadiums, Children's playground, cafe, restaurant, Terraced places for business meetings. All this can give extra income;**
8. This kind of coverage is very **aesthetically beautiful** – the green coverage of houses with beautiful flowers and green balconies can create the daily comfort;
9. The status will rise and will increase the value of real estate–Ecological house and a beautiful view **will increase the house price;**
10. Green cover **improves the microclimate** in the building too;
11. **It is important in terms of employment** because It's needed not only builders, architect and workers, but It is important to botanists, gardeners and environmental ists involvement;
12. If the green coverage design is high quality, and the construction is made due all the rules, than we can say that the green roofs **will return the investment** we put into the coverage and at the and, it will be much more cheaper than traditional roofing;
13. **The green coverage operational period length –** It's well known, that the temperature is very high on the traditional roof in summer. Hit often damages the insulating layer and we have to change them. In Georgia it's recommended to change the roof every 10-15 years but the green roofs operation length is about 50-70 years because of plants protection from sun rays and other kind of damages;
14. Existing channels in our cities can't provide a large amount of water to drain during heavy rains because there is no more greenery in our towns. We have huge buildings everywhere instead of gardens and parks. Large amount of water comes from the building roofs and joins torrents which become more affluent. At the same time, the drainage channels are polluted and the household waste, leaves and so on fall into the wells. All these damage ecosystem.

    Regrettably, in Georgia, there is no study on loosing that carry the torrents but the fact is that heavy rains damage vehicles, electric wires, flats, people…For example, in 2010-2011, in Tbilisi children have died because of flooding. **One of the cheap ways** for the problem solving is green coverage. Green roof can absorb the rainfall and filter the water, as a result, there is a little amount of clean water in the drainage systems (photo 14).



a) b)

Photo 14. Water amount in the drainage system:
a) in case of green coverage; b)in case of traditional roofing

15. Very often the planting of greenery is done by using the lawn rolls. There are some organizations in USA and European countries which have their own fields and they supplying stadiums, parks, yards and firms that organize green roofs of buildings. They make lawn rolls in the fields and than transport those into a construction work site (photo 15).

Photo 15. Lawn rolls making abroad

Roof arrangement in this way is a **quite effective business** in countries, where green roofs set aside for the construction legislation. Purchasing ready-made rolls, firm saves the time on plant growing and has green coverage arranging possibility at any time of year. But gardeners and botanists decide which the best time for sowing is.

References

[1] Budagashvili T., Karchava J., Gunia G., Intskirveli L., Kuchava T., Gurgenidze M., Amiranashvili A., Chikhladze T. Inventory of Greenhouse Gas Emissions and Sinks. Georgia's Initial National Communication on Under the United Nations Framework Convection on Climate Change, Project GEO/96/G31, Tb., 1999, 137 p.
[2] Amiranashvili A.G., Amiranashvili V.A., Gzirishvili T.G., Kharchilava J.F., Tavartkiladze K.A. Modern Climate Change in Georgia. Radiatively Active Small Atmospheric Admixtures. Institute of Geophysics. Monograph. Trans. of M. Nodia Institute of Geophysics of Georgian Acad. of Sc., ISSN 1512-1135, v. LIX, Tb., 2005, 128 p.
[3] Tavartkiladze K., Begalishvili N., Kharchilava J., Mumladze D., Amiranashvili A., Vachnadze J., Shengelia I., Amiranashvili V. Contemporary climate change in Georgia. Regime of some climate parameters and their variability. Monograph, ISBN 99928-885-4-7, Tb., 2006, 177 p., (in Georgian).

[4] Amiranashvili A., Chikhladze V., Kartvelishvili L. Expected Change of Average Semi-Annual and Annual Values of Air Temperature and Precipitation in Tbilisi. Journ. of Georgian Geophysical Soc., Issue B. Physics of Atmosphere, Ocean and Space Plasma, ISSN 1512-1127, v. 13B, Tb., 2009, pp. 50 – 54.
[5] Amiranashvili A., Matcharashvili T., Chelidze T. Climate change in Georgia: Statistical and nonlinear dynamics predictions. Journ. of Georgian Geophysical Soc., Iss.(A), Physics of Solid Earth, v.15A, Tb., 2011-2012, pp. 67-87.
[6] Stankevich S., Titarenko O., Amiranashvili A., Chargazia Kh. Determination of Atmospheric Aerosol Optical Depth over Territory of Georgia during Different Regimes of Cloudiness Using the Satellite and Ground-Based Measurements Data Bulletin of the Georgian National Academy of sciences, vol. 9, No. 3, 2015, pp. 91-95.
[7] Stankevich S., Titarenko O., Amiranashvili A., Chargazia Kh. Modeling of Ozone Content Distribution in Lower Troposphere over the Territory of Georgia Using the Data of Satellite and Ground Observations. Bulletin of the Georgian National Academy of sciences, vol. 9, No. 2, 2015, pp. 54-58.
[8] Amiranashvili A., Bliadze T., Chikhladze V. Photochemical smog in Tbilisi. Monograph, Trans. of Mikheil Nodia institute of Geophysics, ISSN 1512-1135, v. 63, Tb., 2012, 160 p., (in Georgian).
[9] Amiranashvili A., Chargazia Kh. Intra-Annual and Seasonal Variations of Sub-Micron Aerosols Concentration and their Connection with Radon Content in Surface Boundary Layer of Tbilisi City. Bulletin of the Georgian National Academy of Sciences, vol. 10, N 2, 2016, p. 72-78.
[10] Amiranashvili A.G., Bliadze T.G., Chikhladze V.A., Saakashvili N.M., Tarkhan-Mouravi I.D., Sikharulidze Sh.A., Lachashvili N.I. National Botanical Garden of Georgia – Recreational – Sanitation Oasis of Tbilisi City. Trans. of the Institute of Hydrometeorology at the Georgian Technical University, v. 117, ISSN 1512-0902, Tb., 2011, pp. 94-96.
[11] Amiranashvili A., Bliadze T., Chikhladze V., Machaidze Z., Melikadze G., Saakashvili N., Khatiashvili E., Tarkhan-Mouravi I., Sikharulidze Sh., Nakaidze T., Tavartkiladze M. New Data About the Aeroionization Characteristics of the Territory of National Botanical Garden of Georgia as the Factor of the Expansion of its Sanitation Properties for the Visitors. Journ. of Georgian Geophysical Soc., Iss. (B), Physics of Atmosphere, Ocean and Space Plasma, vol.16b, Tbilisi, 2013, pp. 24-30.
[12] Amiranashvil A.G., Amiranashvil V.A., Bliadze T.G., Tarkhan-Mouravi I.D., Chikhladze V.A. Content of Light Aeroions in Some Health Resort and Tourist Zones in Borjomi and Tbilisi. Actual Problems of Pathology, Therapy and Medical Rehabilitation, Collection of Scientific Articles, ISBN 978-9941-0-6499-9, Tbilisi-Moscow: TBR-RAM-TS, 2014, pp. 69-74.
[13] Amiranashvili A., Khurodze T., Shavishvili P., Beriashvili R., Iremashvili I. Dinamics of the Mortality of the Population of Tbilisi City and its Connection with the Surface Ozone Concentration. Journ. of Georgian Geophysical Soc., Iss. (B), Physics of Atmosphere, Ocean and Space Plasma, vol.16b, Tbilisi, 2013, pp. 31-38.
[14] TECHNISCHE REGELN. abc der Bitumenbehnen. Germany. Frankfurt/main, 2002, p. 83.
[15] TECHNISCHE REGELN. abc der Bitumenbehnen. Germany. Frankfurt/main, 2007, p. 103-112.
[16] Jordania T., Ezugbaia Z., Gvinefadze R. Roofs. Green coverage arranging technology. GTU, 2009, p. 225-227.
[17] Catalog of the materials. Technonikol. Moscow, 2008, p. 255-257.
[18] Amiranashvili A.G., Chikhladze V.A. Saakashvili N.M., Tabidze M. Sh., Tarkhan-Mouravi I.D. Bioclimatic Characteristics of Recreational Zones – Important Component of the Passport of the Health Resort – Tourist Potential of Georgia. Trans. of the Institute of Hydrometeorology at the Georgian Technical University, v. 117, ISSN 1512-0902, Tb., 2011, pp. 89-92.
[19] Amiranashvili A.G., Bliadze T.G., Chikhladze V.A., Saakashvili N.M., Tarkhan-Mouravi I.D., Sikharulidze Sh.A., Lachashvili N.I. National Botanical Garden of Georgia – Recreational – Sanitation Oasis of Tbilisi City. Trans. of the Institute of Hydrometeorology at the Georgian Technical University, v. 117, ISSN 1512-0902, Tbilisi, 2011, pp. 94-96.

ეკოლოგიური ფონის გაუმჯობესება საქართველოს დიდ ქალაქებში

ზ. ეზუგბაია, ი. ირემაშვილი

რეზიუმე

სტატიაში განხილულია საკითხები, რომლებიც ეხება შენობების და ნაგებობების სახურავებზე მწვანე საფარის მოწყობის ნოვაციურ ტექნოლოგიებს. ფართოდ არის წარმოდგენილი ასეთი საფარის სახეები, დეტალურადაა მოცემული მათი კონსტრუქციული მახასიათებლები. ნაშრომში გაკეთებული შესაბამისი დასკვნები, რომლებიც ახასიათებენ ასეთი ბურულების მოწყობის ტექნიკურ და ეკოლოგიურ უპირატესობებს ჩვეულებრივ ბურულებთან შედარებით.

საკვანძო სიტყვები: სახურავი, ბურული, მწვანე საფარი, მწვანე ნარგავები, ეკოლოგია.

УЛУЧШЕНИЕ ЭКОЛОГИЧЕСКОГО ФОНА В КРУПНЫХ ГОРОДАХ ГРУЗИИ

З.А. Езугбая, И.Р. Иремашвили

Резюме

В статье рассмотрены вопросы касающиеся инновационной технологии по устройству зелёных покрытий на крышах зданий и сооружений. Широко представлены виды таких покрытий, в деталях даны их конструктивные характеристики. Сделаны соответствующие выводы, которые характеризуют технические и экологические преимущества таких кровель над обычными.

Ключевые слова: крыша, кровля, зеленое покрытие, зеленые насаждения, экология.

Journal of the Georgian Geophysical Society,
Issue B. Physics of Atmosphere, Ocean and Space Plasma, v.19B, 2016, pp. 101-110

The Preliminary Results of the Chemical-radiological Investigations of the Soils on the Territory of the Makhata Mountain

Sophiko B. Matiashvili

M. Nodia Institute of Geophysics at Iv. Javakhishvili Tbilisi State University,1 M Alexsidze Str 0160, Tbilisi, Georgia, sophiko_79@mail.ru

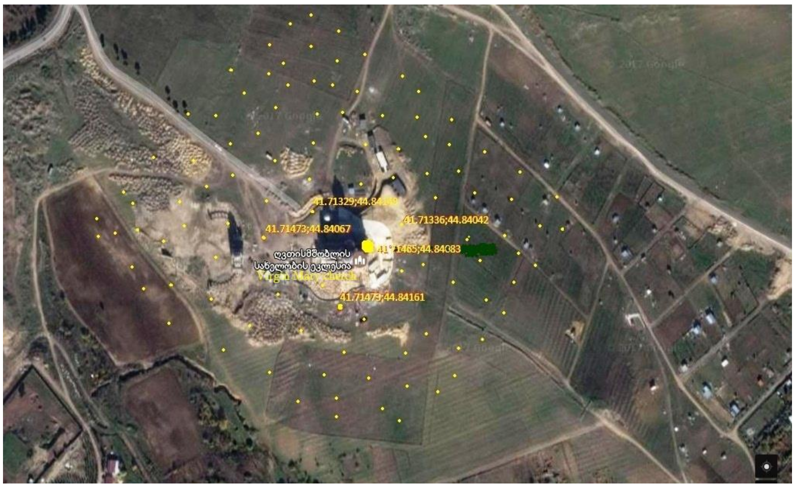
ABSTRACT

A detailed environmental study of any section of the city of Tbilisi on the subject of environmental hazards is a particularly urgent issue. From this point of view, the area of Mount Mahat is special, because Here for several years now operates the Church of Virgin Mary of Iberia Cathedral. 2012-13 years. A radioecological and agrochemical study was conducted on that site in the territory of Mount Makhata, where the Church of the Iberian Mother of God will be located. Laboratory studies of soil samples taken from this area were carried out at the research center of the Ministry of Agriculture. According to the initial data of environmental monitoring, it can be considered that the investigated territory is either a polluted medium level or a little polluted. Here the criterion is the content of a specific pollutant element, which should be less than the maximum permissible concentration of radionuclide in excess of the former Soviet standards. The background of agrochemical contamination on the investigated site is also not alarming. However, in spite of the fact that the radiation monitoring did not reveal significant contamination with radiation spots or point sources, periodic ecological monitoring of the investigated territory should continue to be continued in the future.

***Key words*: Radiation monitoring, agrochemical monitoring, heavy metals, Makhata mount

Preface

The Makhata Mountain is located on the left bank of the river Mtkvari, to the north of the central part of Tbilisi city, between the eastern edge of the city and the Tbilisi Sea (reservoir), at ≈600 m above sea level (Pic. 1). Nowadays the territory is a part of the ex-terrace of the mountain. The Makhata Mountain is built of upper Eocene clay and sand covered with the Quaternary alluvial sediments. It is characterized with flat top, slanting eastern and southern slopes and steep western and northern slopes.



Pic. 1
Virgin Mary church and surrounding Makhata mountain of area.

In 2012 on the Makhata Mountain the building process of the Church of Virgin Mary of Iberia was launched. The foundation was blessed by Catholicos-Patriarch of All Georgia Ilia II. The Makhata territory is of special significance regarding both its historical past and current meaning. It is natural that like other residential areas the site must be ecologically safe for the population. In this regard in 2012-2013 radio-ecological and agro-chemical investigations were carried out on the mountain area for the Church of Virgin Mary of Iberia. The soil samples taken from the territory were studied at Scientific-Research Center of Agriculture.

Actuality, novelty and formulation of the task

As a rule, detailed investigation of any area of Tbilisi regarding ecological safety is an especially important issue. In this view point the Makhata territory is of great significance as far as the Cathedral has been functioning for several years at this place. As the Cathedral was being built the relevant infrastructures were developed simultaneously: roads, buildings for rite, different auxiliary facilities and communications were built. Thus, the Makhata area, which is already densely urbanized, nowadays includes religious buildings of the Sameba Cathedral and the Church of Virgin Mary of Iberia, which are public places for a large quantity of people. Taking into consideration that during the Soviet period several important military facilities were located on the territory it is natural that ecological safety of such places is of the most significant issues.

Extremely high pollution of environment caused due to unsystematic industrialization was a problem characteristic of the last century. Its dramatic results were deteriorated by the Soviet military facilities. Nowadays many military objects have been replaced with civil ones. Therefore, ecological investigation (especially radiation monitoring) of these places is quite necessary in certain cases. It is considered that among civil factors for environment pollution the most significant reasons are industry and agriculture [1-6]. One more factor is natural erosion of soil. This factor is especially strong at the places of probable deep contamination of rocks, e.g. near mines and quarries. Saturation of the soil with chemicals plays the most minor role in the contamination of such places. Different artificial radioactive sources also often take part in environment pollution, e.g. before the 70-s of the 20th century massive environmental radioactive contamination was caused due to nuclear weapons tests in the atmosphere, also dissipation of radionuclides and spillage of radioactive water out into the environment from some nuclear electric power station. Besides the direct effects on ecosystem, natural and artificial radionuclides have indirectly environmental effects (acceleration of the formation of secondary aerosols, influence on the clouds microphysics, atmospheric precipitation, etc.) [7-9].

In this regard disastrous ecological results of several nucleus accidents are well known for public, for example, the Chernobyl Disaster was followed by especially widespread contamination caused by radionuclides, whereas during the Fukushima Disaster great quantity of radioactive water was spread into the environment [10,11]. Besides, as we have mentioned above, the environment is significantly contaminated by mining and transport fumes, as a result of which great quantity of radionuclides and heavy metals appear in the soil.

Besides the above mentioned civil pollution sources, the territory of Georgia was significantly contaminated by the former Soviet military facilities. Unfortunately, the most of them were located in urban areas in the centre of Tbilisi as well as in its vicinity, for example, several significant facilities (munition-factory *Arsenal*, headquarters of air forces, arsenal) were located on the Makhata Mountain. As it appeared after the collapse of the Soviet Union there had been no radiation control kept on many of the military facilities. Namely, contamination of environment and buildings by radionuclides and point radioactive sources was observed at many places of Georgia. Very often the radioactive contamination was followed by pollution with heavy metals, e.g. on the Makhata Mountain at the site of the former Soviet facilities the soil was contaminated by radiation. As a rule, it was caused by point radioactive sources, the significant quantity of which in the past was kept at military facilities (munition-factory *Arsenal*, headquarters of air forces, arsenal) located on the territory of the Makhata Mountain. These facilities were investigated within the framework of a special international programme (NATO grant G564 – **Complex monitoring of military bases in Georgia** 2002-2004). According to the specification of the programme this preliminary (2002) investigation included observations of only the areas of former and active military facilities and their surrounding territories. Thus, we may state that detailed radioecological monitoring of the civil (urban) part of the Makhata Mountain has not taken place if not taken into account the not quite detailed air monitoring of Tbilisi during the last years of the Communist period. Perfect ecological monitoring has neither been fulfilled during the building process of the cathedral. In this period the building area underwent significant technologic pressure. Huge masses of soil were cut off and flattened. At this time contaminating elements must have been distributed on the surface from the local foci (in the case of their existence). Consequently, we may suppose that since the Soviet period the building area has probably been contaminated with radionuclides regarding its nearness to the munition-factory. Thus, we once again state actuality of our task, the goal of which, first of all, is to verify radioecological safety of the territory and surroundings of the Cathedral and the Tsminda Ioane Church (Church of Saint John).

It is obvious that such task must include radiation monitoring in front of the Makhata Mountain slope, which is adjacent to a very densely populated area and also quite a large territory to the north of the cathedral (so called Arsenal settlement) to the Tbilisi Sea. Like at any other places, in this area any kind of radioactive influence on humans and the environment from any kind of radiation source should be excluded. The level of contamination of the soil with heavy metals (radioactive elements) should be also determined, which is much more labour-intensive task compared to surface radiation monitoring. Exactly this is the goal of the 2012-2018 special research programme, the part of which is our research. This programme includes preliminary ecological monitoring at the areas of probable radioactive pollution. Such investigations are essential for obtaining data on the background states in case of revealing probable serious contamination of the soil in the Makhata area and its adjacent territory. Otherwise, it would be impossible to determine the measures of improvement of the soil conditions in case it is required. As a rule, new background states must correspond to the permissible concentration of contaminating elements, though nowadays there is some ambiguity regarding this issue [12,13]. It is clear that requirements of ecological safety must be properly fulfilled for agricultural lands and urban areas. In this regard it is obvious that we consider the Makhata territory as one of the special zones of Tbilisi. In 2012-2013 the soil parameters on the building territory and the area adjacent to the Church of the Virgin Mary of Iberia were measured for three times. At certain points selected, according to due rules, together with soil composition the natural radiation background in the atmosphere was determined on the whole territory of Makhata including the yard of the Sameba Cathedral. The natural radiation background varied within the permissible levels: /0-20/ microSv. This result was expected as far as unlike West Georgia the natural radiation background in East Georgia has mainly been within the permissible limits during the whole period of instrumental measurements even after the Chernobyl Disaster. However, it is known that even before the Chernobyl Disaster artificial radionuclides had penetrated into the territory of Georgia as a result of nuclear weapons tests taking place before 1963 in the Earth’s atmosphere. We suppose that exactly this is the reason for probable difference in radionuclide concentration in various types of soils adjacent to one another that is accepted according to radiation-hygiene and sanitary standards.

In this viewpoint the most interesting is radionuclide Cs^{137}, which appeared in a big amount in the radioactive cloud after the Chernobyl Disaster. At the same time the Institute of Physics and Technology of Sokhumi on its own initiation carried out radiation monitoring of the Abkhazian coastline [1,13]. The monitoring results showed that the Cs^{137} concentration was especially high. Generally, according to the evaluation system of that time, radioactivity measured at different places varied within interval (2-5 curie/km^2), which must have been considered alarming. In 1991 the contamination level was verified at some places. It showed decrease in radioactivity, which must have been a result of decrease only in radionuclides, namely, in the Cesium concentration. Naturally, this effect is connected with atmospheric precipitations, which are especially frequent in West Georgia, namely in Abkhazia, compared to those of East Georgia. Despite the relatively weak diffusion effect nowadays in East Georgia the level of contamination by Cesium may not be higher than contamination by other elements, e.g. Potassium and Phosphorus. We consider the Cesium contamination level, which was recorded thirty years ago in East Georgia, namely in Tbilisi [10,14,15] as a basis for such claiming. That time Tbilisi city appeared in a Cesium contamination zone by isoline 0.1 curie/km^2. Volumetric radioactivity as 22 Bq/kg approximately corresponded to such surface radioactivity. Taking into account the diffusion effect and the time period, which has passed after the measurement, the volumetric radioactivity measured earlier must have been halved. This means that the role of Cesium, compared to other radioactive elements, in the contamination of territory of the Makhata Mountain must be relatively lower nowadays.

Thus, as a result of the analysis of the soil samples obtained on the Makhata territory (not less than 100 samples obtained during each field work) we determined the level of contamination with radioactive and chemical elements. The samples were removed without a grid, while the sample points were selected randomly and the distance between neighbouring points was 10-12 m. The agrochemical analysis was made by approved standard methodology. Approximately 1000 points were checked during each field work of the radiation monitoring process. For the radiation investigations military field radiation dosemeter РП was used. The monitoring process did not reveal any artificial point radiation source.

In table 1, which corresponds to the territory of Tsminda Ioane Church, the results of the agrochemical analysis are shown. This site is characterized with dark grey soil, [16] which is homogenous here on a quite large area; N1 denotes datum of the soil sample obtained from the foundation. The sample is a mixed soil. This means that the obtained datum is average. The data, which correspond to the samples taken from the angles of the 50m side square shape territory around the church foundation (digging depth – 0-60 cm, interval – 20 cm; N1-N5) are also average.

Table 1

Main agrochemical data of the soil composition. Iveeri's Monastery Complex Church

Depth in cm	Humus-%	Nitrogen		Phosphorus		Potassium	$PH(H_2O)$	$CaCO_3$%
		General %	Hydro g/kg per g soil	Total %	absorbed g/kg in soil	General %		
Average 0-60	3.2	0.19	7.2	3.2	7.3	1.29	6.3	None
0-20 20-40 40-60	4.9 3.0 1.3	0.27 0.18 0.14	9.9 6.9 3.8	5.2 3.1 1.4	11.4 7.2 3.4	1.38 1.31 1.20	6.3 6.2 6.4	None
0-20 20-40 40-60	5.0 2.6 1.3	0.21 0.12 0.08	11.4 6.2 4.8	5.2 3.1 1.7	11.2 5.3 3.2	1.52 1.44 1.38	7.3 7.3 7.5	2.8 2. 6.9
0-20 20-40 40-60	5.2 1.8 1.2	0.26 0.18 0.13	15.8 7.9 6.3	5.2 3.1 1.9	12.1 8.9 5.1	1.51 1.45 1.39	7.7 7.9 8.0	18.8 21.6 38.3
0-20 20-40 40-60	4.9 3.1 1.1	0.19 0.11 0.07	14.2 7.4 3.2	5.3 3.3 1.2	12.7 7.9 4.6	1.45 1.38 1.35	7.4 7.5 7.7	9.9 11.3 14.7

Besides chemical analysis, by means of the samples taken from the points constituting Table 1 we carried out radiological analysis (table 2) and analysis of heavy metal concentration in the soil (table 3).

Table 2

Iveeris Monastery Complex					
Radionuclide(Bq/kg); (Averaged 0-60 cm)	№1 44.84083; 41.71465	№2 44.84149; 41.71329	№3 44.84042; 41.71336	№4 44.84161; 41.71473	№5 44.84067; 41.71473
^{40}K	493	481	404	465	264
^{226}Ra	12	5	9	15	5
^{208}Tl	5.9	9.2	13	11	9.5
^{224}Ra	208	369	191	280	275

Table 3

Heavy metals - Iveeris Monastery Complex mg/kg						
1	Fe	590.135	582.21	307.27	438.96	479.70
2	Mn	13.31	937	826	1040	1034
3	Ni	10.7	12.7	0.1	12.7	9.0
4	Cu	82.9	72.7	64.1	77.2	74.2
5	Pb	102	123	129	146	125
6	Zn	244	202	154	286	199
7	Co	7.7	5.8	-	0.7	3.05

As seen from the above tables, the laboratory analysis, besides the church foundations and its adjacent dark grey soil, shows sufficient material for general agrochemical characterizing of all the types of soils on the Makhata Mountain. Indeed, Table 4 indicates that the Makhata territory contains dark grey, forest brown and field type soils and mixed soils between them, though here mainly dark grey soils of different thicknesses are met. They have developed on eroded products of sandstone, porphyry and andesite. Besides, the soils here have different profile thickness in accordance with the relief sloping.

Table 4

№	Soil types.	Depth cm	Humus %	Nitrogen		Phosphorus		Potassium		PHH_2O	$CaCO_3$%
				General % 100 g soil	Hydro mg per 100 g soil	Total % 100 g soil	Absorbed mg in 100 g soil	General % 100 g soil	Exchanged mg in 100 g soil		
1	Dark grey	0-20 20-40 40-60	5.2 3.1 1.4	2.7 1.8 1.4	10.3 7.2 4.1	0.52 0.31 0.14	11.4 7.2 3.4	1.38 1.31 1.20	38.2 34.0 28.7	6.3 6.2 6.4	None
2	Dark grey	0-20 20-40 40-60	2.7 2.1 1.7	2.2 1.8 1.5	12.1 6.0 3.7	0.52 0.31 0.15	8.9 5.3 3.0	1.41 1.30 1.21	39.9 36.2 30.0	6.0 6.2 6.5	None
3	Forest brown soil	0-20 20-40 40-60	3.7 2.4 1.3	2.1 1.2 0.8	11.4 6.2 4.8	0.52 0.31 0.17	12.2 5.3 3.3	1.52 1.44 1.38	32.4 28.7 21.4	7.3 7.3 7.5	2.8 2.5 6.9
4	Humus-carbonate soil	0-20 20-40 40-60	3.5 1.7 1.1	2.6 1.8 1.3	15.2 7.8 6.2	5.2 3.1 1.9	13.2 9.4 5.5	1.54 1.51 1.49	42.1 38.5 34.0	7.7 7.9 8.0	18.8 21.6 38.3
5	Meadow alluvial soil	0-20 20-40 40-60	2.6 1.2 0.8	1.9 1.1 0.7	14.2 7.4 3.2	5.2 3.1 1.10	12.7 7.9 4.6	1.25 1.18 1.15	27.7 22.5 20.1	7.4 7.5 7.7	9.9 11.3 14.7

6	Black soil	0-20	3.2	2.5	14.2	5.2	17.6	1.86	36.5	7.1	2.8
		20-40	1.9	2.1	9.9	3.1	12.0	1.74	33.0	7.4	2.4
		40-60	1.2	1.8	7.2	1.11	8.4	1.49	28.4	7.4	18.3

Thus, on the basis of the preliminary study we may consider that at the monitoring sites the level of the agrochemical contamination in the soils of Makhata territory is not significant. It is obvious that such conclusion is correct only in case of fulfilling soil purity criteria, according to which the concentration level of a concrete contaminating element must be less than the maximum concentration limit established for this element. However, it is known that determination of a maximum concentration limit for some elements is a world-wide problem, which makes it very difficult to assess ecological hazards. In order to prove this, e.g., we can present some former Soviet standards, which, due to absence of new standards in Georgia, are considered permissible even nowadays [17]:

Lead: approximate safe level for this element in clay carbonated soils is 65 mg/kg. Consequently, according to Table 4 in some soil samples obtained by us the level of contamination by lead (1.92-1.59 times) exceeds the approximate safe level.

Nickel: Unlike lead, the level of contamination by this element in our samples appeared much lower than the Soviet approximate safe level 40 mg/kg. Namely, in this case the contamination level is (4-500 times) less than the approximate safe level.

Copper: The level of contamination by this element is near the approximate safe level – 66 mg/kg (1.25-0.97 times).

Regarding that our goal is general assessment of the level of contamination in the Makhata territory soils we suppose that Table 5 is quite useful. It shows concentration of chemical elements in soils at randomly selected sites. Table 6 is compiled in the same way. It shows concentration of radioactive elements and heavy metals in some of those 100 samples, the analysis of which was done. It is obvious that the absolute values of the data in this table is insignificantly changed compared to the data in the tables 2 and 3 ($\Delta(max) \approx 40\text{-}50$ %).

Table 5

Coordinates	Points dispersed in any direction, Bq/kg								
	K^{40}	Ra^{226}	Tl^{208}	Ra^{224}	Cs^{137}	Bi^{211}	Pb^{214}	Pb^{212}	Th^{228}
Lat 44,84083 Long 41,71465	493				27				
Lat 44,84149 Long 41,71329	441				12	57			–
Lat 44,84042 Long 41,71336	292	12		221	5		13		–
Lat 44,84067 Long 41,71473	395		9.2	369					–
Lat 44,84161 Long 41,71473	404	12		191	9.2	19			–
Lat 44,83991 Long 41,71546	465		13		15	16		21	–
Lat 44,8398 Long 41,7144	432	15		280			15		–
Lat 44,83755 Long 41,71601	466			275	8.7		19	32	–

Lat 44,85752 Long 41,71612	377	15	5.9	155		19	21		–
Lat 44,85746 Long 41,75460	364	17	9.5	271		10	16		–
Lat 44,86601 Long 41,76560	542		11	313			23		–
Lat 44,86612 Long 41,75532	497	23		267		18	33	18	–

Table 6 is a simple illustration of the fact connected with the differences of national ecological-sanitary standards in different countries [17]. Namely, there are no universally permissible limits for soil contamination by radioactive elements. Therefore, we have received certain degree of freedom regarding exceedance in permissible concentration (EPC). This parameter practically determines the value of exceeding the maximum permissible concentration (MPC) of some element in soil in order to consider it life-threatening. Therefore, it is considered that for assessment of ecological hazards and evaluation of life-threatening concentration we may use the following formula: $A=EPC \cdot MPC$, where MPC is a measured concentration. As a rule, it is obvious that for a concrete contaminating element the theoretical value must be compared to the results of the laboratory analysis. Besides, by analogy with heavy metals for various radioactive elements the EPC must be different. It is also noteworthy that, compared to radioactive elements, reliability of assessment of contamination by heavy metals is higher as far as for metals practically all EPC-s are known. This parameter varies according the class a heavy metal belongs to: 1. very hazardous; 2. moderately hazardous; 3. less hazardous. According to this classification in various countries different standards of EPC are established. Table 6 is an illustration of such standards and enables comparing EPC standards in Netherlands [17] and the EPC standards in the former Soviet Union. The comparative analysis shows that, e.g., in Netherlands the concentration of lead in sand, sandstone and some soils may 55-times exceed MPC, the established value of which for this country was 6.0 mg/kg. Consequently, in Netherlands the moderately hazardous for life concentration is considered 330 mg/kg, whereas in the former Soviet Union the maximum permissible concentration was MPC=32-130 mg/kg for all kinds of soil. Same parameters in Netherlands, e.g., for copper is MPC 3 mg/kg and approximate safe level is 10.5 mg/kg (EPC= 3.5). According to the standards of the former Soviet Union the corresponding values are MPC =3 mg/kg and approximate safe level is 66 mg/kg (EPC=22). These two samples show the measures of differences in the standards of various countries. Therefore, taking into consideration the reality in the country it is quite difficult task for Georgia to elaborate national standards.

Table 6

Heavy Metals	MPC, mg/kg	EPC, mg/kg	EPC for Georgia, mg/kg
Ni	4	2.6	4
Cu	3	3.5	6
Co	5	24	5
Zn	23	16	23
Pb	6.0	55	65

Conclusion. According to the data of the preliminary ecological monitoring on the contamination by agroecological and radioactive elements of some part of the Makhata Mountain territory we may generally consider that the territory is moderately or less contaminated [18]. This statement is based on the laboratory analysis of the soil samples randomly taken mainly from the foundation of the Church of Virgin Mary of Iberia and its adjacent territory. If we extrapolate from the obtained data, we may suppose that the agrochemical pollution level in the soils of the Makhata Mountain territory is not serious. Despite the radiation monitoring has not revealed contamination of the site by radiation spots or point sources the territory should be monitored periodically in future as well, as far as several significant military facilities were located in this area in the Soviet period.

The author thanked Professor Zaur Chankseliani for guidance and Professor Zurab Kereselidze for useful advice.

References

[1] Eisenberg M. Radioactivity of the environment. Translated from English under editorship of P.P. Lyarskii M., Atomizdat, 1967, (in Russian).
[2] Chankseliani Z., Zardalishvili O. Ecological Principles of Agro-chemistry. (a book). Tbilisi, 1992, 107 p. (in Georgian).
[3] Budagashvili T., Karchava J., Gunia G., Intskirveli L., Kuchava T., Gurgenidze M., Amiranashvili A., Chikhladze T. Inventory of Greenhouse Gas Emissions and Sinks. Georgia's Initial National Communication on Under the United Nations Framework Convection on Climate Change, Project GEO/96/G31, Tb., 1999, 137 p.
[4] Amiranashvili A.G., Amiranashvili V.A., Gzirishvili T.G., Kharchilava J.F., Tavartkiladze K.A. Modern Climate Change in Georgia. Radiatively Active Small Atmospheric Admixtures. Institute of Geophysics, Monograph. Trans. of M. Nodia Institute of Geophysics of Georgian Acad. of Sc., ISSN 1512-1135, v. LIX, Tb., 2005, 128 p.
[5] Tavartkiladze K., Begalishvili N., Kharchilava J., Mumladze D., Amiranashvili A., Vachnadze J., Shengelia I., Amiranashvili V. Contemporary climate change in Georgia. Regime of some climate parameters and their variability. Monograph, ISBN 99928-885-4-7, Tb., 2006, 177 p., (in Georgian).
[6] Amiranashvili A., Bliadze T., Chikhladze V. Photochemical smog in Tbilisi. Monograph, Trans. of Mikheil Nodia institute of Geophysics, ISSN 1512-1135, v. 63, Tb., 2012, 160 p., (in Georgian).
[7] Amiranashvili A.G., Gzirishvili T.G., Chumburidze Z.A. On the role of artificial ice forming reagents and radioactive intermixtures in the variation of convective clouds thunderstorm and hail activity. Proc. 12th Int. Conf. on Clouds and Pricipitation, Zurich, Switzerland, August 19-23, v. 1, 1996, 267-270.
[8] Amiranashvili A.G. Increasing Public Awareness of Different Types of Geophysical Catastrophes, Possibilities of Their Initiation as a Result of Terrorist Activity, Methods of Protection and Fight With Their Negative Consequences. Engaging the Public to Fight Consequences of Terrorism and Disasters. NATO Science for Peace and Security Series E: Human and Societal Dynamics, v. 120. IOS Press, Amsterdam•Berlin•Tokyo•Washington, DC, ISSN 1874-6276, 2015, pp.155-164. http://www.nato.int/science; http://www. springer.com; http://www.iospress.nl
[9] Amiranashvili A., Chargazia Kh. Intra-Annual and Seasonal Variations of Sub-Micron Aerosols Concentration and their Connection with Radon Content in Surface Boundary Layer of Tbilisi City. Bulletin of the Georgian National Academy of Sciences, vol. 10, N 2, 2016, p. 72-78.
[10] Fesenko S.V., Aleksakhin R.M., Sanzharova N.I., Lisyanskii K.V. Analysis of strategy for the application of protective measures in agriculture after the accident in the Chernobyl Nuclear Power Plant. Radiation biology. Radio-ecology. Vol. 38, 5, 1988, (in Russian).
[11] Berman X. The basics of radiology (Fukushima accident). "Education", Tbilisi, 2015, pp 17-19.
[12] Intervention Criteria in a Nuclear or Radiation Emergency. International atomic Energy. Vienna, 1994, pp. 78-87.
[13] Gelashvili K. Radiation safety norms. "Education", Tbilisi, 2000; p. 221.

[14] Tsitskishvili M.S., Gachechiladze G.A,. Katamadze N.M, Intskirveli L.N., Kurtanidze S.R. Impact of the Cernobyl disaster on the radio on the ecological situation in the ecowavay. Radionuclide echo of Cernobyl in Georgia. Radiation studies VI, “Education”, Tbilisi, 1991, pp. 132-150, (in Georgian).
[15] Mosulishvili D., Shonia N., Katamadze N., Ginturi E., Some data of radionuclide monitoring in Georgia after the Chernobyl disaster. Radiation studies VI, “Education”, Tbilisi, 1991, pp. 221-240, (in Georgian).
[16] Talaxadze G. Georgian basic soil norms. “Education”, Tbilisi, 1964, pp. 217.
[17] Standarts for the content of heavy metals and metalloids in soil. Soil science, №3, 2012, pp.368-375.
[18] Gelashvili K. Radiation Hygine. “Education”, Tbilisi, 1976, pp. 222.

მახათას მთის ტერიტორიაზე ნიადაგების ქიმიურ რადიოლოგიური გამოკვლევის პირველადი შედეგები

ს. მათიაშვილი

რეზიუმე

თბილისის ნებისმიერი უბნის დეტალური გამოკვლევა ეკოლოგიურ უსაფრთხოების მიზნით განსაკუთრებით აქტუალურ საკითხად ითვლება.ამ თვალსაზრისით მახათას უბანი მაინც განსაკუთრებულია,რადგან ამ არეში უკვე რამდენიმე წელიწადია მოქმედებს საკათედრო ტაძარი.კერძოდ, 2012-2013 წლებში მოხდა მახათას მთის იმ უბნის რადიოეკოლოგიური და აგროქიმიური გამოკვლევა, სადაც განთავსდა ივერიის ღვთისმშობლის ეკლესია.ამ ტერიტორიიდან აღებული ნიადაგის ნიმუშების ლაბორატორიული კვლევა ჩატარდა სსიპ სოფლის მეურნეობის აგრარული რადიოლოგიისა და ეკოლოგიის სამეცნიერო- კვლევით ცენტრში. მახათას მთის ტერიტორიის აგროეკოლოგიური და რადიაქტიური ელემენტებით დაბინძურების პირველადი ეკოლოგიური მონიტორინგის მონაცემების მიხედვით გამოკვლეული ტერიტორია შესაძლებელია ზოგადად მივიჩნიოთ, როგორც საშუალო დონეზე ან უფრო ნაკლებად დაბინძურებულად. კრიტერიუმად მიღებული იყო, რომ კონკრეტული დამაბინძურებელი ელემენტების შემცველობა არ აჭარბებდა კონცენტრაციის ზღვრულად დასაშვები გადაჭარბების ყოფილ საბჭოთა ნორმას.ამიტომ გარკვეული სიზუსტით შეიძლება განვაცხადოთ, რომ მახათას ტერიტორიის ნიადაგებში აგროქიმიური დაბინძურების ფონი საგანგაშო არ არის. თუმცა მიუხედავად იმისა, რომ რადიაციულმა მონიტორინგმა არ გამოავლინა ამ ადგილის დაბინძურება რადიაციული ლაქებით ან წერტილოვანი წყაროებით, პერიოდული ეკოლოგიური მონიტორინგი ამ ტერიტორიაზე მომავალშიც უნდა გაგრძელდეს.

Первичные результаты химико-радиологических исследований почв на территории горы Махата

С. Б. Матиашвили

Резюме

Детальное экологическое исследование любого участка города Тбилиси на предмет экологической опасности является особенно актуальным вопросом. С данной точки зрения район горы Махата является особенным, т.к. на этом участке уже несколько лет действует кафедральный собор Самеба. В 2012-13 гг. было проведено радиоэкологическое и агрохимическое исследования того участка территории горы Махата, на котором будет располагаться церковь Иверской Богоматери. Лабораторные исследования образцов почвы, взятых с данной территории, были проведены в научно –исследовательском центре Министерства сельского хозяйства. Согласно первичным данным экологического мониторинга, можно считать, что исследованная территория является либо загрязненной среднего уровня, либо мало загрязненной. Тут критерием используется содержание конкретного загрязняющего элемента, которое должно быть меньше предельного превышения допустимой концентрации радионуклида по бывшим советским нормам. Фон агрохимического загрязнения на исследованном участке также не является тревожным. Однако, несмотря на то, что радиационный мониторинг не выявил значительного загрязнения радиационными пятнами или точечными источниками, периодический экологический мониторинг исследованной территории должен быть продолжен и в будущем.

Journal of the Georgian Geophysical Society,
Issue B. Physics of Atmosphere, Ocean and Space Plasma, v.19B, 2016, pp. 111-119

Thunderstorm and Hail Processes over Georgian Territory Against Global Climate Change Background

Marika R. Tatishvili, Liana G. Kartvelishvili, Irine P. Mkurnalidze

Institute of Hydrometeorology ofGeorgian Technical University
marika.tatishvili@yahoo.com

ABSTRACT

Hail and thunderstorm processes are very often phenomena over Globe. But the mechanism of their origin isn't completely understood yet. According NASA information their frequency and intensity has been increased for last period. Caucasus region is distinguished by mentioned phenomena. Hail and thunderstorm processes have been investigated based on 1960-2014 year period meteorological observation data for Georgian territory in presented article. The conducted statistical analysis revealed that those processes have increasing tendency over Georgian territory. Constructed GIS maps revealed that these processes cover whole territory. Especially there exist some local areas in west, east and south part where they are especially intensified.

Key words: Thunderstorm and hail processes, statistical analysis, geoinformation mapping.

Introduction

Georgian relief may be characterized by three sharply expressed orographic elements: in north Caucasus, in south – Georgian south uplands and lowland located between those two risings or intermountain depression (Fig. 1). This begins from the Black Sea shore by triangular Kolkheti Lowland and spreads up to eastern Georgia like narrow strip. Between those two uplands small scaled orographic elements can be allocated. Such complicated relief has definite influence on air masses movement in atmosphere lower layers. Mainly west and eastern atmospheric processes prevailed over Georgian territory**.**

Fig.1. Climatic zones of Caucasus region

Due to complex orographic conditions and influence of the Black Sea Georgia is one of most problematic country by natural disasters. Here exist most of Earths climatic types, from marine wet subtropical climate of west Georgia and steppe continental climate of east Georgia up to eternal snow and glaciers of high mountain zone of Great Caucasus, and also approximately 40% of observed landscapes. Current geodynamics and orographic properties of Georgia play an important role in occurrence of geological (earthquake), geomorphologic (landslide, mudflow, snow avalanche), hydro (flashflood) and meteorological (drought, hurricane, lightning, hail, fog, frost, ice) hazards.

There are old traditions of a study of the thunderstorm and hail processes in Georgia. The regular observation period on hail process covers 100 year [1,2].

During this period quantitative measurements, hail climatology research have been carried and also physical parameters of hailstones (density, structure, radios, etc) were studied. Also radiolocation parameters of convective clouds were studied and on this base radiolocation criteria of hail hazard have been identified in east and west parts of Georgia. Together with those investigations thunderstorm data have been processed.

Studies of thunderstorm electricity, thunderstorm and hail processes in the recent three decades within the framework of the study of climate change in Georgia were even more activated [3-7]. To the indicated studies the works on the study of the influence of the anthropogenic pollution of the atmosphere and works on the weather modification on these processes were added [8,9].

Statistical structure and spatial-temporary characteristics of the number of days with the thunderstorm and hail [10-18], the connection of duration of thunderstorms with the number of days with the thunderstorms [19-21], the special feature of the long-term dynamics of the intensity of hail processes on the territory of Georgia are studied [10,13,14,22,23].

The special features of thunderstorm activity in Kakheti, connection of the electrical and radar parameters of thunderstorm clouds are investigated. Taking into account of these connections and data about the radar parameters of convective clouds the map of the distribution of ground-based lightning discharges for Kakheti is built [24-26].

A study of changes in atmospheric precipitations, thunderstorm and hail processes in the conditions of eastern Georgia and their connections with the anthropogenic pollution of the atmosphere is carried out. The statistical models of the connection of thunderstorm activity with the aerosol pollution of atmosphere are developed. In particular it is obtained that the intensity of thunderstorm and hail processes depends substantially on the aerosol pollution of the atmosphere (including radioactive), although this dependence has fairly complicated nature. As a whole an increase in the nonradioactive aerosol pollution of the atmosphere led to the intensification of the intensity of hail damages and respectively to the decrease of the effectiveness of the action of anti-hail works [8, 27-32].

In recent years, before the renewal of works on the weather modification, special attention was given to detailed studies of damage from the dangerous weather phenomena and to questions of the prevention of natural catastrophes in the conditions of Georgia [9,22,23,33,34].

Study area and Methods

The main hail character is hailstone size. For most cases small intensive hail (70%), middle (20-30mm) and large (>30mm) is typical for Caucasus region. Hail repeatability is 25-30%. In most cases hail diameter doesn't exceeds 20mm. Hailstone with 50-70 mm diamter is rare phenomena [17,22]. Hail duration changes from minutes to several hours. Damaged area covers 20-50 km^2. The main negative hail impact is mainly connected with agriculture, construction,communication damages and human losses.

Thunderstors are dangerous natural phenomena and created on the result of such atmospheric processes that lead the formation of strong convective clouds. Lighting falls off the Earth 8-10^6 time per day, the covered area varies from $40 \cdot 10^4$ km^2 at 4 o'clock till $110 \cdot 10^4$ km^2 at 14-20 o'clock [18,33].

Georgia is considered as one of most dangeous thunderable region, as mean annual thunderstorm day number (N) reaches 35-90. Such a large diapason is explained by Georgian climate variability, conditioned by its complex mountinous relief. Especially Surami and Arsiani Ridges are important, as they are perpendicular to west wet air masses.

To identify mean annual thunderstorm day number temporal-spatial distribution in west and east Georgian regions 1960-2012 meteostation data have been used. The following statistical parameters were calculated: observation period, max., min., and mean values, standard deviations, modal values, asimetry, excess and variation members. Thunderstorm mean day number maximum comose 53 day, mean-32, modal-25 for west Geogia and for east those values are as following: N-61, aver.-39, mod-38. The distribution has normal characted as assymetry and excess values don't exceed 1 for all observation station. Variation members are vithin 30% range. Statistical provision has been checked by their correlation with standard deviationas for thunderstorm as for hail day number. Determining members are

$R_l^2 = 0,5977$ $R_{el}^2 = 0,4177$

respectively. Consequently for Georgia thundersorm minimal observation period is 10-15 years. To identify thundersorm duration in western regions emphiric-statistical equation has been used, that became in good converged with observation data.

Between thunderstorm day number and duration there exists high correlation. For investigation 33 (12 in west and 21 in east regions) meteostation 50 year period thundersorm day number data have been used.

Thundersorm mean annual duration has been calculated using the following equation:

$$D = 3.3 \cdot (N - 10) \qquad (1)$$

for stations where N < 40.

$$D = 0.14 \cdot N^{1.7} \qquad (2)$$

for stations where N > 40.

where N - mean annual thunderstorm day number, D mean annual duration (hr.). Obtained results are presented in table 1.

Table1

Thunderstorm multiyear mean duration (D), thunderstorm day number (N), station elevation (H), thunderstorm process mean duration (K)

	№	Meteostation	H (m)	N	D (hr)	K=D/N
West Georgia	1	Anaklia	3	25	50	2
	2	Batumi	10	41	102	2.5
	3	Lanchkhuti	20	28	59	2.1
	4	Chaqvi	30	51	112	2.2
	5	Kutaisi	114	37	89	2.4
	6	Zugdidi	117	41	102	2.5
	7	Qeda	256	20	33	1.7
	8	Tsageri	474	39	96	2.5
	9	Ambrolauri	544	41	102	2.5
	10	Sairme	910	25	50	2
	11	Shovi	1507	40	99	2.5
	12	Bakhmaro	1926	28	59	2.1
		average			79	2.3

East Georgia	13	Lagodekhi	362	44	87	2
	14	Gurjaani	410	37	65	1.8
	15	Khvareli	443	40	74	1.9
	16	Tbilisi	490	36	62	1.7
	17	Bolnisi	534	49	105	2.1
	18	Mukhrani	550	46	94	2
	19	Telavi	568	48	101	2.1
	20	KhaSuri	690	45	90	2
	21	Dedoflistskaro	800	35	82	2.3
	22	Dusheti	922	44	87	2
	23	Axaltsixe	982	55	127	2.3
	24	Pasanauri	1070	43	84	2
	25	Aspinza	1098	46	94	2
	26	Tetritskaro	1140	54	123	2.3
	27	Manglisi	1194	56	131	2.4
	28	Abastumani	1265	51	112	2.2
	29	Bakuriani	1665	52	116	2.2
	30	Akhalqalaqi	1716	54	123	2.3
	31	Stepantsminda	1744	22	40	1.9
	32	Paravani	2100	55	127	2.3
	33	Gudauri	2194	49	105	2.1
		average			97	2.1

Results

Hail mean anual and warm period (IV-IX months) distribution are presented on geoinformation maps (Fig. 1,2), based on 1962-2014 year period observation data. As it is obvious from mean annual map hail processes cover Georgian whole territory.

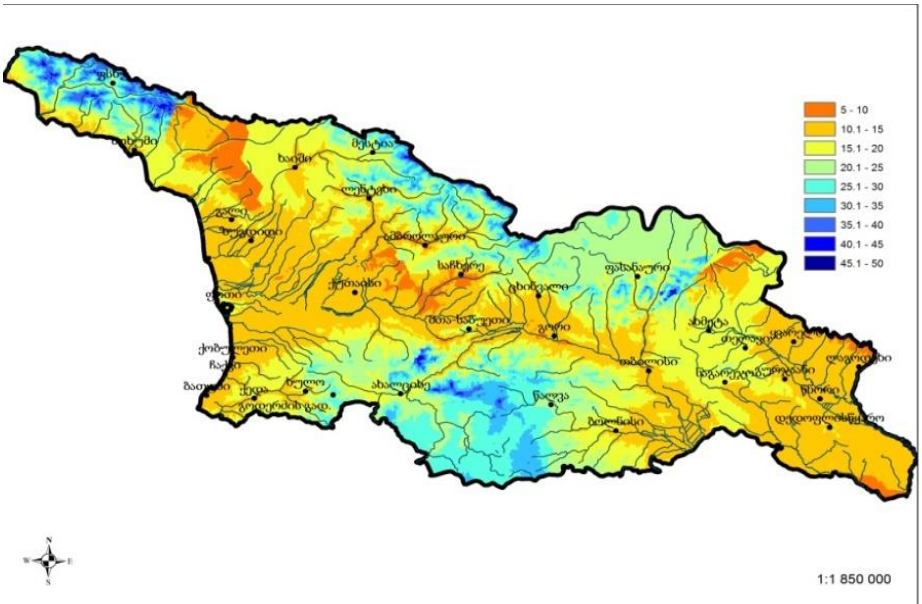


Fig.2. Hail annual distriburion over Georgian territory for 1962-2014 year period

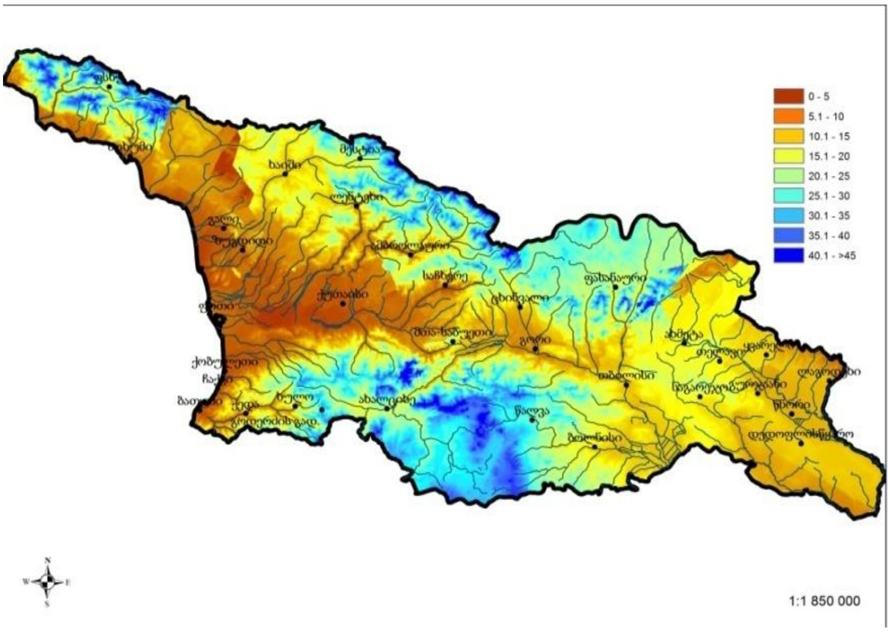


Fig.3. Hail l distriburion for warm period (IV-IX months) over Georgian territory for 1962-2014 year period.

Main hail centres are Kvemo Kartli, Kakheti, Svaneti, Dusheti regions. Hail processes are intensive in subtropical zones too, but they are dangerous for Kakheti region especially for vineyards and grape harvest, as this area is known as vinery region [21].

The other important hail processes parameter is its repeatability. To represent repeatability in the course of time 1962-2014 year data were used (Fig.3).

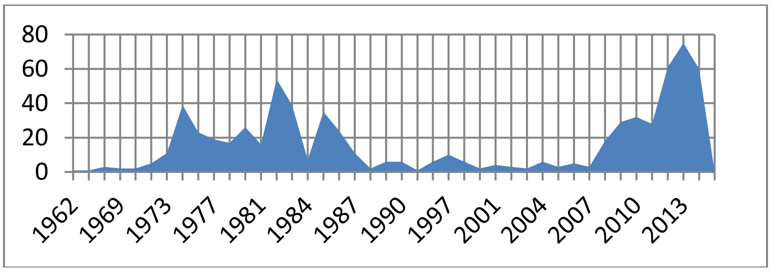


Fig.4. Hail repeatability over Georgian territory for 1962-2014 year period.
As it is revealed hail repeatability has been increased in last years.

As it reveals from table in west Georgia thunderstorm duration is less than in east part. The dependence of thunderstorm duration on elevation is presented on Fig. 5,6.

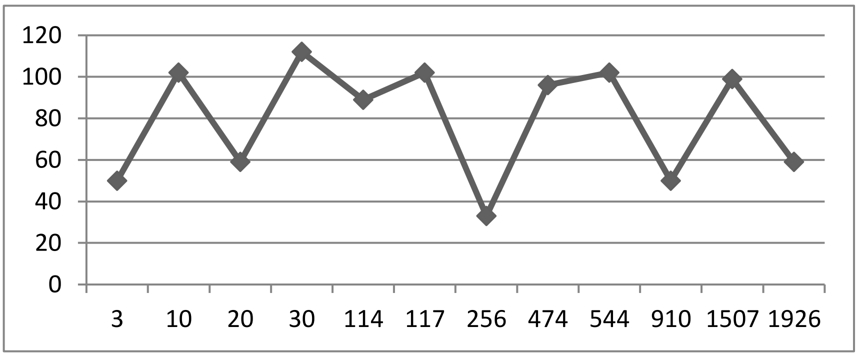


Fig.5. Dependence of thunderstorm duration (hr) on elevation (m) in west Georgia

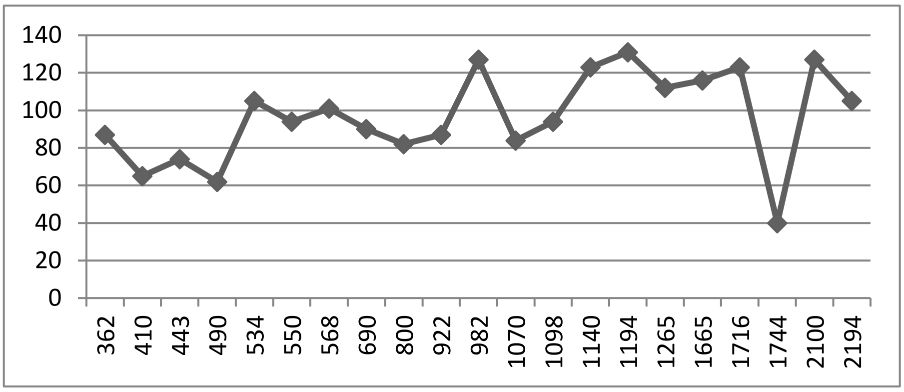


Fig.6. Dependence of thunderstorm duration (hr) on elevation (m) in east Georgia

As it is clear from charts the dependence has heterogeneous character. As for K member that represents duration of single thunderstorm process, in west Georgia it is higher. This confirms the fact that in western Georgian territory frontal thunderstorms prevails and in eastern part thunderstorms are mainly inner-massive.

The thunderstorm mean annual distribution is presented on geoinformation map, and it reveals thunderstorm intensive propagation centers.

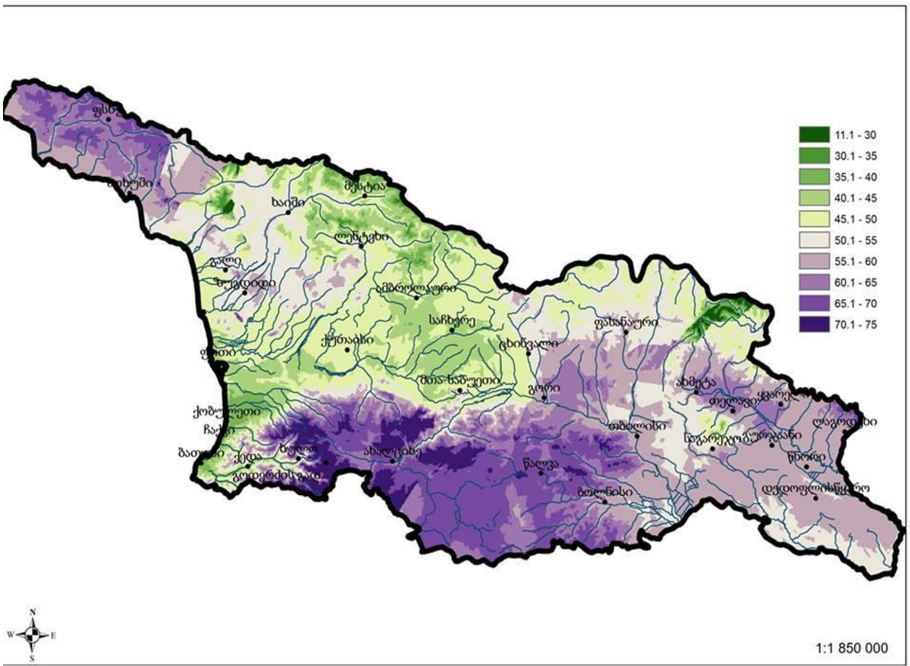


Fig.7. Thundersorm annual distribution over Georgian territory for 1960-2012 year period.

The obtained results may be used in different weather and climate models and also in lighting protecting measues. As it is known that if durable process is the higher is the probability of induced potential penetreats building communication, that may cause various damages.

Let us note in conclusion, that the intensity of hail processes have been increased over various regions of the Globe as in Georgia too. This investigation will be useful for planning of the expansion of works on the weather modification in Georgia [35,36].

References

[1] Gunia S.U. Grozovie protsessi v usloviyakh Zakavkaz'ya. L., Gidrometeoizdat, 1960, 123 s., (in Russian).

[2] Gigineishvili V.M. Gradobitia v vostochnoi Gruzii. Leninhrad, Gidrometeoizdat, 1960, 123 s., (in Russian).

[3] Budagashvili T., Karchava J., Gunia G., Intskirveli L., Kuchava T., Gurgenidze M., Amiranashvili A., Chikhladze T. Inventory of Greenhouse Gas Emissions and Sinks. Georgia's Initial National Communication on Under the United Nations Framework Convection on Climate Change, Project GEO/96/G31, Tb., 1999, 137 p.

[4] Tavartkiladze K., Begalishvili N., Kharchilava J., Mumladze D., Amiranashvili A., Vachnadze J., Shengelia I., Amiranashvili V. Contemporary climate change in Georgia. Regime of some climate parameters and their variability. Monograph, ISBN 99928-885-4-7, Tb., 2006, 177 p., (in Georgian).

[5] Amiranashvili A., Chikhladze V., Kartvelishvili L. Expected Change of Average Semi-Annual and Annual Values of Air Temperature and Precipitation in Tbilisi. Journ. of Georgian Geophysical Soc., Issue B. Physics of Atmosphere, Ocean and Space Plasma, ISSN 1512-1127, v. 13B, Tb., 2009, pp. 50 – 54.

[6] Amiranashvili A., Matcharashvili T., Chelidze T. Climate change in Georgia: Statistical and nonlinear dynamics predictions.Journ. of Georgian Geophysical Soc., Iss. (A), Physics of Solid Earth, v.15A, Tb., 2011-2012, pp. 67-87.

[7] Tatishvili M., Bolashvili N., Mkurnalidze I. Climate and causes of its variability. Transactions of Institute of Hydrometeorology, v. 119, Tbilisi, 2013, pp. 38-43.

[8] Amiranashvili A.G., Gzirishvili T.G., Chumburidze Z.A. On the role of artificial ice forming reagents and radioactive intermixtures in the variation of convective clouds thunderstorm and hail activity. Proc. 12th Int. Conf. on Clouds and Pricipitation, Zurich, Switzerland, August 19-23, v. 1, 1996, 267-270.

[9] Amiranashvili A., Dzodzuashvili U., Lomtadze J., Sauri I., Chikhladze V. Some Characteristics of Hail Processes in Kakheti. Trans. of Mikheil Nodia institute of Geophysics, ISSN 1512-1135, v. 65, Tb., 2015, pp. 77 – 100, (in Russian).

[10] Amiranashvili A.G., Beritashvili B.Sh., Mkurnalidze I.P. Long-Term Variation of Days with Thunderstorm in the East Georgia. Trans. of Vakhushti Bagrationi Institute of Geography Acad. of Sc. of Georgia, v. 21, USSN 11512-1224, Tbilisi, 2003, pp. 134-149, (in Georgian).

[11] Amiranashvili A.G., Amiranashvili V.A, Beritashvili B.Sh., Mkurnalidze I.P., Chumburidze Z.A. Some Characteristics of a Thunderstorm Activity in Georgia. Proc. 12th Int. Conf. on Atmospheric Electricity, Versailles, France, 9-13 June , v.1, 2003, pp. 711-714.

[12] Amiranashvili A.G., Nodia A.G., Toronjadze A.F., Khurodze T.V. Some Statistical Characteristics of the Number of Days with Hail into the Warm Half-Year in Georgia in 1941-1990, Trans. of Institute of Geophysics of Acad. of Sc. of Georgia, ISSN 1512-1135, v. 58, 2004, pp. 133-141, (in Russian).

[13] Amiranashvili A.G., Nodia A.G., Toronjadze A.F., Khurodze T.V. The Changeability of the Number of Days with the Hail in Georgia in 1941-1990, Trans. of Institute of Geophysics of Acad. of Sc. of Georgia, ISSN 1512-1135, v. 58, 2004, pp. 127-132, (in Russian).

[14] Amiranashvili A.G., Amiranashvili V.A., Nodia A.G. Khurodze T.V., Toronjadze A.F., Bibilashvili T.N. Spatial-Temporary Characteristics of Number of Days with a Hails in the Warm Period of Year in Georgia. Proc. 14thInternational Conference on Clouds and Precipitation, Bologna, Italy, 18-23 July 2004, pp. 2_2_215.1-2_2_215.2.

[15] Amiranashvili A., Varazanashvili O., Nodia A., Tsereteli N., Mkurnalidze I. Characteristics of Thunderstorm Activity in Georgia. Trans. of the Institute of Hydrometeorology, No 115, ISSN 1512-0902, Tb., 2008, pp. 284 – 290, (in Russian).

[16] Amiranashvili A., Varazanashvili O., Nodia A., Tsereteli N., Khurodze T. Statistical Characteristics of the Number of Days With Hail Per Annum in Georgia. Trans. of the Institute of Hydrometeorology, No 115, ISSN 1512-0902, Tb., 2008, pp. 427 – 433, (in Russian).

[17] Tatishvili M., Mkurnalidze I. Variations of thunder and hail processes over Georgian territory. Transactions of International Electronic Conference "Geography and Modern Environmental Problems", http://sou.edu.ge/index.php?lang_id=GEO&sec_id=408&info_id=1368

[18] Tatishvili M., Mkurnalidze I. Thunderstorm occurrence probability over Georgian territory. Transactions of International scientific conference dedicated to the 90th anniversary of Georgian Technical

University (II),“Basic paradigms in science and technology development for the 21th century”, Tbilisi, 2012, pp.248-253
[19] Amiranashvili A.G., Beritashvili B. Sh., Mkurnalidze I.P. Correlation Between Number of Thunder-Days and Duration of Thunderstorm Activity in Eastern Georgia. Proc. 14thInternational Conference on Clouds and Precipitation, Bologna, Italy,18-23 July 2004, pp. 2_1_214.1-2_1_214.4.
[20] Beritashvili B.Sh., Mkurnalidze I.P., Amiranashvili A.G. Study of Spatial-Temporary Changes of the Number of Days with the Thunderstorm on the Territory of Georgia. Collection of Articles, Questions of Clouds Physics, Cloud, Precipitation and Thunderstorm Electricity, A.I. Voyeykov Main Geophysical Observatory, Gidrometeoizdat, St.-Petersburg, 2004, pp.155-168, (in Russian).
[21] Tatishvili M., Mkurnalidze I. Duration of thunderstorm processes on Georgian territory. Institute of Geography of Tbilisi State University, Tbilisi, 2015, pp. 119-202.
[22] Varazanashvili O., Tsereteli N., Amiranashvili A., Tsereteli E., Elizbarashvili E., Dolidze J., Qaldani L., Saluqvadze M., Adamia Sh., Arevadze N., Gventcadze A. Vulnerability, Hazards and Multiple Risk Assessment for Georgia, Natural Hazards, v. 64, N. 3, 2012, pp. 2021-2056, DOI: 10.1007/s11069-012-0374-3, http://www.springerlink.com/content/ 9311p18582143662/fulltext.pdf
[23] Elizbarashvili E. Sh., Amiranashvili A. G., Varazanashvili O. Sh., Tsereteli N. S., Elizbarashvili M. E., Elizbarashvili Sh. E., Pipia M. G. Hailstorms in the Territory of Georgia. European Geographical Studies, v.2, № 2, ISSN: 2312-0029, 2014, DOI: 10.13187/egs.2014.2.55, www.ejournal9.com, pp. 55-69, (in Russian).
[24] Amiranashvili A., Amiranashvili V., Doreuli R., Khurodze T., Kolesnikov Yu. Some Characteristics of Hail Processes in the Kakheti Region of Georgia. Proc.13th Int. Conf. on Clouds and Precipitation, Reno, Nevada, USA, August 14-18, v.2, 2000, pp. 1085-1087.
[25] Amiranashvili A, Amiranashvili V., Bibilashvili T., Chumburidze Z., Gzirishvili T., Doreuli R., Nodia A., Khorguani F., Kolesnikov Yu. Distribution of Convective Clouds and Lightning Discharges of the Earth Surface in Kakheti Region of Georgia. Proc.13th Int. Conf. on Clouds and Precipitation, Reno, Nevada, USA, August 14-18, v. 2, 2000,1050-1052.
[26] Amiranashvili A.G., Amiranashvili V.A., Bliadze T.G., Nodia A.G., Chikhladze V.A., Bakhsoliani M.G., Khurodze T.V. Peculiarities of Many-Year Variabilities of Hailstorms in Kakheti. Trans. of Vakhushti Bagrationi Institute of Geography Acad. of Sc. of Georgia, v. 21, USSN 11512-1224, Tb., 2003, pp. 58-79, (in Georgian).
[27] Amiranashvili A.G., Amiranashvili V.A., Bachiashvili L.L., Bibilashvili T.N., Supatashvili G.D. Influence of the Anthropogenic Pollution of the Atmosphere and Thunderstorms on the Precipitations Regime and their Chemical Composition in Alazani Valley Conditions. Proc. 14thInternational Conference on Clouds and Precipitation, Bologna, Italy,18-23 July 2004, pp. 2_3_216.1-2_3_216.2.
[28] Amiranashvili A., Nodia A., Khurodze T., Kartvelishvili L., Chumburidze Z., Mkurnalidze I., Chikhradze N. Variability of Number of Hail and Thunderstorm Days in the Regions o Georgia with Active Influence on Atmospheric Processes. Bull. of the Georgian Acad. of Sc., 172, N3, 2005, pp. 484-486.
[29] Amiranashvili A. Connection Between the Characteristics of Thunderstorm Activity and Air Pollution in Kakheti Region of Georgia, Proc. of IX Int. Symposium on Lightning Protection, Foz do Iguaçu, Brazil, 26-30 November 2007.
[30] Amiranashvili A. Statistical Models of Connection of Lightning Activity with Aerosol Pollution of Atmosphere. Proc. of X Int. Symposium on Lightning Protection, Curitiba, Brazil, 9-13 November 2009, pp. 261-266.
[31] Amiranashvili A. Connection of Lightning Activity with Air Electrical Conductivity in Dusheti. Proc. of the XIth Int. Symp. of Lightning Protection, SIPDA, Fortaleza, Brazil, October 3-7, 2011, http://ws9.iee.usp.br/.
[32] Adzhiev A.Kh., Amiranashvili A.G., Chargazia Kh.Z. Vlianie aerozol'nogo zagriaznenia atmosferi na effektivnost' protivogradovikh rabot v Kakhetii i na Severnom Kavkaze. Dokladi Vserossiyskoi konferentsii po fizike oblakov i aktivnim vozdeistviam na gidrometeorologicheskie protsessi, posviashchennoi 80-letiu El'brusskoi visokogornoi kompleksnoi ekspeditsii AN SSSR, 7-9 oktiabria 2014 g., chast' 2, FGBU «Visokogorni Geofizicheski Institut», Nal'chik, 2015, s. 387-395, (in Russian).
[33] Tatishvili M., Elizbarashvili E., Elizbarashvili Sh., Meskhia R., Elizbarashvili M. Natural hydrometeorological disasters, their causes and prevention measures. The Macrotheme Review. A multidisciplinary journal of global macro trends. A Macrotheme Capital Management, LLC Academic Publication, v. 2, iss. 1, ISSN 1848-4735, France, Winter 2013 (January), pp. 148-154.
[34] Amiranashvili A.G. Increasing Public Awareness of Different Types of Geophysical Catastrophes, Possibilities of Their Initiation as a Result of Terrorist Activity, Methods of Protection and Fight With Their

Negative Consequences. Engaging the Public to Fight Consequences of Terrorism and Disasters. NATO Science for Peace and Security Series E: Human and Societal Dynamics, v. 120. IOS Press, Amsterdam•Berlin•Tokyo•Washington, DC, ISSN 1874-6276, 2015, pp.155-164. http://www.nato.int/science; http://www. springer.com; http://www.iospress.nl
[35] Amiranashvili A.G., Chikhladze V.A., Dzodzuashvili U.V., Ghlonti N. Ya., Sauri I.P. Reconstruction of Anti-Hail System in Kakheti (Georgia). Journal of the Georgian Geophysical Society, Issue B. Physics of Atmosphere, Ocean and Space Plasma, v.18B, Tb., 2015, pp. 92-106.
[36] Amiranashvili A., Burnadze A., Dvalishvili K., Gelovani G., Ghlonti N., Dzodzuashvili U., Kaishauri M., Kveselava N., Lomtadze J., Osepashvili A., Sauri I., Telia Sh., ChargaziaKh., Chikhladze V. Renewal works of anti-hail service in Kakheti. Transactions of Mikheil Nodia Institute of Geophysics, v. 66, ISSN 1512-1135, Tb., 2016, pp. 14-27, (in Russian).

სეტყვისა და ელჭექური პროცესები საქართველოს ტერიტორიაზე კლიმატის გლობალური ცვლილების ფონზე

მ. ტატიშვილი, ლ. ქართველიშვილი, ი. მკურალიძე

რეზიუმე

სეტყვის და ელჭექის პროცესები გავრცელებული მოვლენაა მთელს დედამიწაზე. თუმცა მათი წაარმოქმნის მექანიზმი სრულად გარკვეული ჯერ კიდევ არარის. *NASA* ინფორმაციის მიხეევით ამ პროცესების სიხშირე და ინტენსივობა ბოლო პერიოდში გაზრდილია. ამ მოვლენით გამორჩეულია კავკასიის რეგიონი. წარმოდგენილ ნაშრომში ეს პროცესები გამოკვლეულია 1960-2014 წლების მეტეოროლოგიური დაკვირვების მონაცემების გამოყენებით. ჩატარებულმა სტატისტიკურმა ანალიზმმა აჩვენა, რომ საქართველოს ტერიტორიაზე ამ პროცესებს აქვს ზრდის ტენდენცია. გეოსაინფორმაციო რუკებიდან ცხადად ჩანს, რომ ისინი ფარავენ მთელს ტერიტორიას. არსებობს ლოკალური ცენტრები სამხრეთ, დასავლეთ და აღმოსავლეთ ნაწილებში, სადაც ეს პროცესები განსაკუთრებით ინტენსიურია.

Градо-грозовые процессы на территории Грузии на фоне глобального изменения климата

М.Р. Татишвили, Л.Г. Картвелишвили, И.П. Мкурналидзе

Резюме

Градо-грозовые процессы частые явления на Земле. Но механизмы их возникновения еще не полностью изучены. По информации *NASA* их частота и интенсивность возросла за последний период. Кавказский регион отличается упомянутыми явлениями. В представленной статье на территории Грузии градо-грозовые процессы были исследованы на основе данных метеорологических наблюдений 1960-2014 г.г. Проведенный статистический анализ показал, что эти процессы имеют возрастающую тенденцию на территории Грузии. Построенные карты ГИС показали, что эти процессы охватывают всю территорию. Существуют некоторые локальные районы в западной, восточной и южной части, где они особенно активизировались.

Journal of the Georgian Geophysical Society,
Issue B. Physics of Atmosphere, Ocean and Space Plasma, v.19B, 2016, pp.120-123

Atmosphere Self-Rectification from Aerosols

Marat S. Tsitskishvili

Georgian Academy of the Ecological Science, Georgia

ABSTRACT

"Self-rectification's velocity", dry "sedimentation" and "washing" by atmospheric sediments. For different climatic regions and seasons, the values of the developed parameter that is of great importance for ecologically sound atmospheric protection.

Key words: air pollution, atmospheric aerosol, atmospheric protection.

All types of industrial activities require following the norms of air basin protection, preserving its pollution and degradation. At the same time, the environment protection itself constitutes an industrial activity, so the separation of these activities is symbolic. Nevertheless, let follow the tradition; thus the above-mentioned industrial and protective activities will develop and become perfect due to scientific progress and the design of programmes aimed at reducing the pollution and improving environmental quality. The occurred political changes and economic development caused by them have altered the ways of enhancement of such programmes. For such country as Georgia it is impossible to carry out the similar programmes by its own sources without transnational economic instruments such as pollution permits tradable at the international level environmental cost - benefit analysis, large investments into special programmes Development of common economic area of countries of the Black Sea basin an increase of integration processes makes possible to carry out a number of political and economical measures. Common industries activities connected with joint enterprises require creating unified regulatory mechanisms. Man juridical, technological, economical and political regulatory mechanisms permitting to reduce harmful anthropogenic influence on environment are based on stand arts adopted by the state committee on environment protection.

Development of common economic area of countries of the Caucasus and Black Sea basin an increase of integration processes makes possible to carry out a number of political and economical measures. Common industries activities connected with joint enterprises require creating unified regulatory mechanisms.

The solid or liquid microscopic particles, suspended in atmosphere differ from atmospheric dust having long "life" time in atmosphere. These particles constitute atmospheric aerosols. Their chemical and dispersive composition has a wide range of changeability recently a lot of researches have been dedicated to the study of physicochemical qualities of atmospheric aerosols. It was conditioned by if climatic and ecological great significance. The results of research of radioactive and no radioactive aerosols in atmosphere are summarized in many articles and monographs, including in Georgia [1-9]. The research results of atmospheric aerosolise component for Transcaucasia are summarized in our work. Here, also, was showed the "climatic stability" of atmosphere's lower layer **"self-rectification's velocity"**. The methodology of its experimental definition became possible after the determination of simple gauzed manifold catching effectiveness which is used widely in Georgian Hydrometnetwork i.e. the effectively of atmospheric sediment collectors.

In the process of theoretical analysis, we have found the total index for the atmospheric aerosol summary beta-radioactivity. That gives us the possibility tot learn integrally the dynamics of atmospheric **"self-rectification's velocity"** rectification for various aerosols, which are different in dispersion and composition. We defined average velocities of self-rectification for the lower troposphere in months for big towns of the Volga region and the Caucasian Daily data about sediments, which were collected during 10 years by gazed manifolds on the surface of ground, were worked out in approximately forty thousands of measurements and the same measurement about aerosol's concentration in the preground layer. The simple analysis of the measurement shows that any relation of the stream's admixture to its concentration is the velocity. The physical essence of this velocity is in the given unity of time, given corpulence of lower layer of atmosphere is completely cleared from the aerosol.

The geophysical essence of obtained characteristics is:

- It comes out, that seaside regions are characterized by high velocities of **“self-rectification’s velocity”**, compared with regions, which are far from the sea (Tbilisi, Yerevan, and Rostov).
- Conventionally, we can say that for the given region there is "three types" (groups) of atmospheres **“self-rectification’s velocity”** according to the following gradation:
- Continental (Tbilisi, Yerevan) wet velocities up to ~ 0.5 transitional up to 2.0 Km/24 hours (Rostov):
- And seaside (Volgograd, Astrakhan, Sokhumi, Baku), where velocities exceed 2.4 Km/24 hours.

Note that according to the data of the aircraft measurements of the vertical distribution of the radon decay products and solid aerosols in the lower troposphere that average rate of deposition of aerosols with a radius from 0.35 to > 2.0 μm was 0.21 - 0.45 cm/sec (0.18-0.49 Km/24 hour) [6].

Various kinds of admixtures (solid, liquid or gaseous) getting in atmosphere stay there for definite time. It depends on many processes: the turbulent calculation, sedimentation or coagulation with particles of clouds, their washing by atmospheric sediments. During the study of geo-ecological aspects of the atmosphere soiling, processes of the admixtures sedimentation from the atmosphere are divided conventionally into two groups: dry "sedimentation" and "washing" by atmospheric sediments ("dry" and "wet" sedimentation). The conventionality of such division of clear, if we go deep into physical and chemical mechanisms of processes, which go on in the atmosphere. Simple analysis shows us, that gravity and elementary forces as well as the turbulence, moisture and density of gas (in this case different layers of the atmosphere) always take part in each process (in the case of loaded particles). In spite of the conventionality of such division, it gives us the possibility to reveal regional geophysical peculiarities in processes of the same admixture (or pollution's) sedimentation from the atmosphere. It's a well-known fact, that during the sedimentation of aerosolise particles from the atmosphere, there are much more "wet" sediments, than "dry" ones, but it's difficult to make the correct numerical estimation, in spite of huge number of experimental and theoretical data.

The whole region is characterized by:

Annual washing:

Cold season: $10.0 \cdot 10^{-5}$ sec^{-1};

Warm season: $4.12 \cdot 10^{-5}$ sec^{-1};

Average annual: $7.03 \cdot 10^{-5}$ sec^{-1}.

For comparison, we note that in the works [9-13] give the data about the processes of the accumulation of natural radioactive aerosols in the convective clouds, and also about the values of the parameter of the washing out of aerosols with the cloud drops Λ (Λ of order 10^{-4} sec^{-1}). According to the data of laboratory experiments [8] the values of the coefficient of the washing out of aerosols by a diameter of about 1 μm by the drops of fog by diameter about 20 μm composed (9-23) $\cdot 10^{-4}$ sec^{-1}. For drops of water with diameter of approximately 70 μm it is obtained, that with the washing out of aerosols with diameter about 0.6 μm the value $\Lambda \approx 2.5 \cdot 10^{-4}$ sec^{-1}, and for aerosols with diameter about 4.2 μm, $\Lambda \approx 24 \cdot 10^{-4}$ sec^{-1} [8]. Laboratory experiments in the cloud chambers of the M. Nodia Institute of Geophysics were carried out [14,15].

The hypothesis of "ergoannualitical" can be approved by the prognostical modelling of admixtures content and composition. The revealing of such dependence constitutes the special problem. We showed that the characteristics of statistical fields of pollution do not satisfy this condition and their self-correlation and interstructural functions are non-statistical and demands the appliament of other statistical model [1, 2].

We have worked out the physical and statistical method of air pollution prognosis for cold and warm seasons for the city with average population ranges of 1-3 mln · inhabitants. The scheme is tested and reported at many scientific forums and meetings. Real prospects exist to better this number of experimental parameters for different conditions of the Black Sea regions. That should be done under the international programme. The scheme of prognosis is substantially précised by introduction of an inertial parameter Pi-1 (for the previous day), the reproducibility of such scheme is about 75-80%, that allows effectively adjust the loadings on the atmosphere and environment in whole during the unfavourable meteorological conditions and realize the principles of ICZM (Integral Costal Son Management).

Studies of the last decade give us the opportunity to introduce the number of new experimental parameters that allow describing the process of admixtures' sedimentation from the lower layers of atmosphere [1-3]. Calculates according the long-term experiments studying the introduced climatologic parameter characterizing the selt~c1eaning ability of lower layers of atmosphere for different regions and speed of cleaning. As one can see given parameters differ twice or three times, that is substantial for standardization of limits of exhausts set up within the ranges of atmosphere protection, the ICZM scheme. It should be mentioned that even in the period of the Second World war the American scientists outlined the physical meaning of the given parameter, that may be stated by simple analysis of the dimension ratio of admixture's flow value on the earth surface off the lower atmospheric layers per unit of time to concentration is velocity and is physically equal to the atmospheric layer that is cleaned per unit of time. Long-term investigations proved that this value is climatologically stable and may be used in practice for standardization of toxic exhausts in atmosphere.

Processes of atmosphere self-rectification are much more intensive, our estimation = 7 $\cdot 10^{-5}$ sec^{-1} is much higher than the results, which are given by other researchers.

It is noticeable that estimations, gived for each season, warm and cold, twofold differ from each other and a how correctness of the existing mechanisms of atmosphere self-rectification.

Given experimental estimations, give us the possibility to use scientific conditioned planning measures for atmosphere protection.

Thus, the state independence and free market economics, made actual not only creation of juridical basis, but international unification as well. Climatic unification may be made according the following scheme 1) coastal regions with high humidity, 2) regions with average humidity, 3) highlands, 4) regions with low humidity and deserftIike climate. Such rejoining for standardization needs sources and a lot of time.

In this sphere, the international cooperation may be very effective. On the other hand, from the standpoint of the international unification of the standards there is also a need to consider ways in which economic instruments may be employed as policy tools for improving atmosphere quality, especially in the most cost effective manner, possible under free market economics that will improve regional economic situation.

References

[1] Tsitskishvili M.S. Prognosis of Atmospheric Pollution of Large Cities and Industrial Centres Located in Caucasian Region. IH All union conference on Aerosols - M. SU GKNT, 1977, pp. 65-66.

[2] Tsitskishvili M.S. Air Pollution and Prognosis of Expected Increase of Some Harmful Admixtures in Tbilisi Region. Works of Caucasian Inst. of Hydrometeorology, is. 66-72. Hydromeotizdat. L., 1980, pp. 3-17.

[3] Tsitskishvili M.S. Integrated characteristics in models aerosol transfer in atmosphere. ISTC Russian – Canadian Workshop “Modelling Atmospheric Dispersion of Weapons Agents. June 19-21, 2006, Moscow, pp. 102 -104.

[4] Tsitskishvili M.S., Ninua T.L., Mikeladze M.O. Regional parameterization by atmospheric transfer for reduction radioactive pollution. “Radiological and agroecological Researches”, v. VI. The complete works consist of the materials of the International Conference devoted to XXX Anniversary of the Institute establishment, ISSN 1512-2786, Tbilisi, 2009, pp.181-185.

[5] Kozmanashvili A., Liparteliani M., Tsitskishvili M., Bibiluri E.. Radiational problems about the security of the production in conditions of contemporary technogenesis in the Agroecosphere of Georgia. Int. Conference “Protection of Agrobiodiversity and Sustainable Development of Agriculture”, ISSN 978-9941-17-143-7, November 24 –25, 2010, Tbilisi, Georgia, pp. 228 – 231, (In Georgian).

[6] Styra B., Amiranashvili A. Aerosol Distribution above Georgia Investigations. Trans., Institute of Physics of the Academy of Sciences of the Lithuanian SSR, Atmospheric Physics, ISSN 0135-1419, v. 8., “Mokslas”, Vilnius, 1983, pp. 18-24, (in Russian).

[7] Amiranashvili A.G., Gzirishvili T.G., Kartsivadze A.I., Nodia A.G. Aircraft investigations of the distribution of aerosols in the lower troposphere, Proc. 9th Int. Conf. on Atmospheric Aerosols, Condensation and Ice Nuclei, Budapest, Hungary, 3-8 September, v.1, 1984, 148-153.

[8] Amiranashvili A., Gzirishvili T. Aerosols and Ice Crystals in the Atmosphere. Tbilisi, Metsniereba, 1991, 113 p., (in Russian).

[9] Amiranashvili A., Amiranashvili V., Chochishvili K., Kirkitadze D. The Distribution of Aerosols Over the Georgian Territory in the Lower Troposphere, Journal of Georgian Geophysical Society, ISSN 1512-1127, Issue B. Physics of Atmosphere, Ocean and Space Plasma, v. 8 B, 2003, pp. 70-75.
[10] Styro B., Amiranashvili A., Gamkhitashvili L., Khundzua T. On Vertical Non-Stationary Natural Radioactivity Distribution in Cumuli Clouds. Trans., Institute of Physics of the Academy of Sciences of the Lithuanian SSR, Atmospheric Physics, ISSN 0135-1419, v. 5., "Mokslas", Vilnius, 1979, pp. 18-24, (in Russian).
[11] Styro B., Amiranashvili A. Some Results of the Investigation of Cumuli Clouds Natural Radioactivity. Trans., Institute of Physics of the Academy of Sciences of the Lithuanian SSR, Atmospheric Physics, ISSN 0135-1419, v. 5., "Mokslas", Vilnius, 1979, pp. 25-42, (in Russian).
[12] Styro B., Amiranashvili A. Investigation of the Natural Radioactivity of Cumuli Clouds in the Process of their Development and Disintegration. Trans., Institute of Physics of the Academy of Sciences of the Lithuanian SSR, Atmospheric Physics, ISSN 0135-1419, v. 5., "Mokslas", Vilnius, 1979, pp. 42-50, (in Russian).
[13] Styra B., Amiranashvili A. On the Cloud Drops Radioactivation. Trans., Institute of Physics of the Academy of Sciences of the Lithuanian SSR, Atmospheric Physics, ISSN 0135-1419, v. 7., "Mokslas", Vilnius, 1981, pp. 25-29, (in Russian).
[14] Amiranashvili A.G., Bliadze T.G., Chiabrishvili N.G., Gzirishvili T.G., Kirkitadze D.D., Nodia A.G., Odisharia M.A., Okujava A.M. Laboratory modelling of the transformation of microphysical and electrical properties of artificial water fogs, Proc.1st Int. Conf. on Fog and Fog Collection, Vancouver, Canada, July 19-24, 1998, pp. 333-335.
[15] Amiranashvili A., Bliadze T., Chiabrishvili N., Chikhladze V., Gzirishvili T., Kirkitadze D., Nodia A., Odisharia M., Okujava A. Complex for laboratory modelling of microphysical and electrical properties of aero-disperse formations, Proc. Int. Conf. Dedicated to Memory of Prof. A. Sutugin, Moscow, Russia, June 26-30, 2000, pp. 54-55.

ატმოსფეროს თვითგაწმენდა აეროზოლებისაგან

მ. ციცქიშვილი

რეზიუმე

„ატმოსფეროს თვითგაწმენდის სიჩქარე“, მშრალი გამოლექვა და ნალექებით გამორეცხვა. სხვა და სხვა კლიმატური რეგიონისა და სეზონისათვის განსაზღვრულია შემუშავებული პარამეტრის მნიშვნელობები, რასაც უდიდესი მნიშვნელობა აქვს ატმოსფეროს ეკოლოგიურად დასაბუთებული დაცვისათვის.

Самоочистка атмосферы от аэрозолей

М.С. Цицкишвили

Резюме

„Скорость самоочистки атмосферы“, сухое оседание и вымывание атмосферными осадками. Для разных климатических регионов и сезонов определены величины разработанного параметра, что имеет большое значение для экологически обоснованной защиты атмосферы.

Journal of the Georgian Geophysical Society,
Issue B. Physics of Atmosphere, Ocean and Space Plasma, v.19B, 2016, pp. 124-127

Improvement of Ecological Education in Georgia

Marat S. Tsitskishvili

Georgian Academy of the Ecological Science, Georgia

ABSTRACT

Intergovernmental Tbilisi Conference UNESCO 1977 has signified a transition on qualitative new level environmental education. Root of modern ecological crisis in unfaithful approaches to the nature-use and environment protect that puts particular problems before the formation system. Things going not only practical questions to unifications of scholastic programs for preparing the specialists to different specialization to high qualifications, regional coordinating and cooperation and etc., as well as fundamental questions ecological formation in general, joint development new "Concepts of ecological formation", in which must be approved in respect of to the "nature moral principles" in the counter-weight utilitarian, replaced ideological dogma and anthropocentric orientation on ethical value and egocentric glances, with provision for regional particularities, history experience and conditions of our countries.

Key words: ecology, ecological education

The problems of ecology and saving biodiversity are some of the important in the contemporary world, including in Georgia [1-5]. It's accomplished over 30 years anniversary of the having historical meaning UNESCO Conference of Nature Care Education - UNESCO Tbilisi International Conference of 1977 year marks new quality of ecologic education world wide. Till nowadays decisions of UNESCO Tbilisi Conference are widely cited and serve as guideline documents for the purposes of ecological and nature care education world wide. All other programs and guideline documents of nature care education are founded on discussions of Tbilisi Conference and among them national directive documents in Georgia.

Appropriated positive experience is already accumulated. In turn are next common steps – unification and normalization of nature-save acts, juridical efforts to support trans-boarder eco-tourism in the region etc. This all demands the existence of specialist ecologists with high qualification with wide profile with trust-worthy and unified basic education It's been for 10 years that at the Georgian Technical University exists specialized and the only in region "Board of UNESCO of Nature-Use Education". Must realize and coordinate such regional elaborations.

During the time from breakdown of the USSR at the Caucasus were accomplished important international projects of nature-care profile. Main result of accomplished projects in the social-political mean is formation of high-qualified united trans-state creative collective of executors well-equipped working groups, which consist of staff of governmental structures and NGO-s. This Formed collective can accomplish not only scientific research and problem analysis, but also elaboration of concrete decisions and to bring it appropriate structures and a well lobby issues in legislative and executive structures.

In the report of 19-th special session of UNITED NATIONS in June 1977 for latter quarter of century were made prognosis of more frequent "Ecological conflicts and deepening of Ecological Stress".

After "World Summit Rio-10" in Johannesburg, it is clear lack mainly financial investments and institution character of process.

Root of ecological crises is in the non-correct approach methods of Nature Use and Nature Care. For the years passed after Tbilisi Conference of UNESCO "Earth Summit" in Rio claimed interdependency and indivisibility of the peace, development and Care of the Environment stable development course. Conception of Education may be considered as factor stimulating Union of the international community. Academician N.N. Moiseev call main and fundamental condition of the stable development of the Human Society – ecological education. There is need in new ecological concepts of nature care education based on ethical principles. It means that Natural Environment can't be considered as only source of good and to care for it in the purpose of the more intensive exploitation. In the practice of teaching Nature Care fundamentals, Confession of the value of all its parts, independently from benefit for men must lay in basement and serve as motivation method - minimal challenge in the natural Environment: "Planet is balancing at the edge of abyss and time to make economical and political choice, to prevent catastrophe is passing to past". In the May 2004 at the State Technical University of Georgia (Tbilisi) is planned to held conference "Problems of Nature and Education in the light of the sustainable Development in the Caucasus" with participation of Regional educational boards of the network "UNITWIN" of the UNESCO. It is motivated and proved as chronologically – there is 25 years after Tbilisi Intergovernmental Conference of UNESCO, and geographically as well – Caucasus region is unique with natural biodiversity. Region had gone hard historical way, but saved global perception of problems is just at the beginning of making concise possible ways of the stable development. It is necessary to apply all forces to create realization of the principle "from ecological stability to political"

Board UNESCO at the Georgian Technical University (Founded in 1995 member of world Network of by brotherhood joined Universities - "UNITWIN"); is head methodical regional center on the issues of methods ecological ecological-environmental education at the Caucasus, Implementing common, mandatory continuing education for all University students of technical and humanitarian faculties. Board develops unified programs, methodical recommendations and prints methodical indices, practical manuals Educational literature. In the Board are prepared studying materials handbooks collections of scientific issues "Issues on Ecology" (regional 3-lingual complete), "Colloquium on Ecology") etc.

On the Conference must be considered not only practical issues of the unification, regional coordination and collaboration, highest qualification specialists studying courses for education in different specialties, etc. but also fundamental issues of ecological-environmental education in general, evaluated possibility of the new "Conception of Ecological Education", which must prove ethical principles towards nature, against utilitarianism, changed ecological dogmas and anthropocentric attitudes on the ethical values and eco-central views and foreseen regional peculiarities and historical experience and conditions of our countries.

Elaboration of the "Concept of Ecological Education", "Problem of Ecological Education and "Ecology of Education of XXI Century" must create necessary fundament for harmonization of relations between Men and Nature, best understanding between people, and at end formation of the "Concept of Stable Development" of the region. In the realities of XXI century modern ecology – multidisciplinary scientific field – basis of strategy and tactics for saving life on the Earth, must be mandatory educational discipline for future specialists of any specialization Now in Georgia works glorious plead of scientists-Ecologists. Georgian authors have many significant works in Ecology. Among these world famous monographs and periodical issues on the different on the different private theoretical and applied issues of the modern Ecology. Nevertheless, till nowadays there doesn't exist modern manuals in Georgian for training at the High Education System of specialists in the field of Ecology with wide profile for any of two grades of Education in the Universities. Existing separate works of the narrow biological profile can't serve for non-biological specialties for these purposes.

Education qualified national specialists of different specialties with engineering educational basis in the Caucasus Countries serve as guarantors of ecological prosperity. So, issues pertained with highest grade ecological education are most important and has highest priority. Work in this direction at the leading Universities of the country, headed by world-known scientists, tutors of qualified specialists, and activity of the "Ecological Education Block", Commission on Biosphere and ecological research at the presidium of Georgian Academy of Sciences are directly correlated and coordinated and go in the several directions:

- Informational supply provided with new investigations in the field of methodic of new and traditional study courses and disciplines
- Development of thematic programs, educational plans, organization of new environmental specialties, profiles, improvement of coordination between universities, faculties etc.
- Preparation of Manuals, tutorials, reference and methodical publications.
- Implementation of distant learning and modern audio-visual educational programs foreseen foreign experience.

All this work is conducted in tight contacts with colleagues from Caucasus countries and foreign partners. Must serve as example Georgian-language and 3-lingual periodical publications "Problems of Ecology", "Conversations about Ecology" etc. issued by Georgian Technical University together with several Academies of Georgia.

On the basis of elaborated studying materials, special and facultative courses, by which nowadays is putting into practice training specialists with high qualification of ecological profile at the Georgian Technical University. It's necessary to prepare unified, inter-faculty program of the "Applied Ecology" – discipline, which may serve as basis of fundamental manual for ecological profile and specialty for non-biological profile in the region. Must be considered that is not published appropriate tutorial in the Georgian language "Fundamentals of Applied Ecology" already prepared by us long time ago. Signed by President of Georgia 18 December 2002 edict #538 "Of State Program of People Ecological Education." Must guarantee practical realization on legislated in Georgia principle of common mandatory ecological education.

It means improvement of fully inadmissible today situation characteristic not only for Georgia.

- If we compare study programs and plans to prepare specialists of ecological profile in several Universities can't be find common for everyone essential profile, essential studying discipline with unified structure and program.
- Nevertheless authors from Georgia, just as their colleagues from Armenia and Azerbaijan, taking part in creation of most interesting foreign tutorials of different profiles, levels and content, can't accomplish work of creation of tutorial which must contain all 3 parts: "Fundamentals of General Ecology", "Fundamentals of Applied Ecology", "Environment Defense and Rational Use of Natural Resources"; and at the same time represent regional peculiarities, traditions of nature-use and suit world standards. There exist mandatory demand of common development of such "region-wide" manual – we are obliged by realities of today:
- Great Trans border regional project requiring common efforts from ecologists of Caucasus to obtain real ecological security of building and exploitation of this project.
- Necessity of common development of trans-boarder environmental projects – Nature don't confess boarders; save of rear and endemic species of faun and flora is real without trans-boarder regional approach.

Appropriated positive experience is already accumulated. In turn are next common steps – unification and normalization of nature-save acts, juridical efforts to support trans-boarder eco-tourism in the region etc. This all demands the existence of specialist ecologists with high qualification with wide profile with trust-worthy and unified basic education It's been for 10 years that at the Georgian Technical University exists specialized and the only in region "Board of UNESCO of Nature-Use Education". Must realize and coordinate such regional elaborations.

Existing elaborations, experience of work of "Board of UNESCO for Nature-use Education" which give us possibility to have full information of the world tendencies on this issue, about existing manuals and learning programs, on conditions of issue not only in the region but CIS, UIS allow us to prove that planned positive result would be achieved. Main guarantees of success is that Russian language manuals with our co-authority were twice published at Moscow and Tbilisi; gained high positive estimation of specialists in the region and got recommendation for UNESCO system.

During the time from breakdown of the USSR at the Caucasus were accomplished important international projects of nature-care profile. Main result of accomplished projects in the social-political mean is formation of high-qualified united trans-state creative collective of executor's well-equipped working groups, which consist of staff of governmental structures and NGO-s. This Formed collective can accomplish not only scientific research and problem analysis, but also elaboration of concrete decisions and to bring it appropriate structures and a well lobby issues in legislative and executive structures.

- Achievement of understanding of indivisibility issues of biodiversity saving and social-economical problems of region, necessity of unified approach in the aspect of guarantee stable development of whole Caucasus region and its separate parts as well.
- Prepared ground and elaborated mechanisms for execution of projects of concrete, inter-state character, the end result of which would be not only implementation of progressive forms of biodiversity saving in concrete eco-regions, but significant social-economical drives for native population, among other in educational sphere (as well as formal and informal education), which at the end result diminishes social-economical and consequently political tension.

Problem of saving biodiversity of the unique Caucasus region in the first order is pertained with mobilization of educational, informatics and professional means. It's pertained as well with economical problems of existence of appropriate founding and not least with forming necessary public opinions, creation right drives and motives with understanding worldwide importance of problem and role of Caucasus community in its decision.

References

[1] Kosigin J.A. Limits of thinking. J. “Vestnik RAN”, N 3, 1992, pp 53-58, (in Russian).
[2] Barcel A. Meaning of technological culture and technoethics. “Alma Mater”, J. ”Vestnik shkoli” N 12, December 1991, pp. 54-58, (in Russian).
[3] Amiranashvili A.G., Chikhladze V.A. Saakashvili N.M., Tabidze M.Sh., Tarkhan-Mouravi I.D. Bioclimatic Characteristics of Recreational Zones – Important Component of the Passport of the Health Resort – Tourist Potential of Georgia. Trans. of the Institute of Hydrometeorology at the Georgian Technical University, v. 117, ISSN 1512-0902, Tb., 2011, pp. 89-92.
[4] Amiranashvili A.G., Bliadze T.G., Chikhladze V.A., Saakashvili N.M., Tarkhan-Mouravi I.D., Sikharulidze Sh.A., Lachashvili N.I. National Botanical Garden of Georgia – Recreational – Sanitation Oasis of Tbilisi City. Trans. of the Institute of Hydrometeorology at the Georgian Technical University, v. 117, ISSN 1512-0902, Tbilisi, 2011, pp. 94-96.
[5] Amiranashvili A., Bliadze T., Chikhladze V. Photochemical smog in Tbilisi. Monograph, Trans. of Mikheil Nodia institute of Geophysics, ISSN 1512-1135, v. 63, Tb., 2012, 160 p., (in Georgian).

გარემოსდაცვითი განათლების სრულყოფისათვის საქართველოში

მ. ციცქიშვილი

რეზიუმე

საქართველოში გარემოსდაცვითი – ეკოლოგიური განათლების დიდი ხნის ტრადიციები არსებობს, დაწყებული “დედა ენის” პირველივე პწკარებიდან ვაჟასეული მინდიას ბუნების წვდომის მსოფლიო შედევრებამდე. Mმსოფლიო განვითარების თანამედროვე ეტაპი, რომელიც მძაფრი ეკოლოგიური კრიზისით ხასიათდება, განსაკუთრებულ მოთხოვნებს უყენებს განათლების სისტემას. საჭიროა ახალი “ეკოლოგიური განათლების კონცეფციის” შემუშავება. მასში განცხადებული უნდა იყოს, რეგიონალური თავისებურებების გათვალისწინებით, ანტროპოცენტრული შეხედულებების საწინააღმდეგოთ, მორალურ-ზნეობრივი პრინციპები ბუნებისადმი მიმართებაში, კაცობრიობის წინაშე მდგარი “მდგრადი განვითარების”-აკენ გადასვლის ამოცანების გათვალისწინებით.

К совершенствованию природоохранного образования в Грузии

М.С. Цицкишвили

Резюме

Природоохранное или экологическое образование имеет в Грузии давние традиции, начинаясь с первых слов «Деда ена» и до шедевров познания природы Миндией Важа Пшавелы. Современный экологический кризис ставит особые задачи перед системой образования. Необходим переход на качественно новый уровень природоохранного образования, разработка новой «Концепции экологического образования», в которой должно быть утверждены в отношении к природе моральные принципы в противовес утилитарным, заменены идеологические догмы и антропоцентрические установоки на этические ценности и экоцентрические взгляды, с учетом региональных особенностей, исторического опыта и условий наших стран.

Journal of the Georgian Geophysical Society,
Issue B. Physics of Atmosphere, Ocean and Space Plasma, v.19B, 2016, pp. 128-134

On the Connection between Annual Variations of the Intensity of Galactic Cosmic Rays and the Changeability of Cloudiness and Air Temperature in Tbilisi

[1]Avtandil G. Amiranashvili, [1]Teimuraz S. Bakradze, [1]Nugzar Ya. Ghlonti, [2]Tamila V. Khurodze, [1]Irakli I. Tuskia

M. Nodia Institute of Geophysics of I. Javakhishvili Tbilisi State University, e-mail:
avtandilamiranashvili@gmail.com
[2]N. Muskhelishvili Institute of Applied Mathematics of Georgian Technical University

ABSTRACT

The paper considers the results of the study of the connection between annual variations of intensity of galactic cosmic rays and the changeability of cloudiness and air temperature in 1963-1990 in Tbilisi. The statistical characteristics of the indicated parameters (trends, random component, linear correlations between real and random components, etc.) are studied. In particular, we established that the correlation of the real values of cosmic ray intensity with the real values of total cloudiness is positive, with lower cloudiness – is not significance, with air temperature – is negative. The correlation of the random components of the intensity of cosmic ray intensity with the random components of lower and total cloudiness – are positive, with the air temperature - is negative. Within the variation range the contribution of the studied parameters to air temperature variability is as follows: real values of total cloudiness- 5.0%, random components of lower cloudiness – 1.0%, real values and random components of cosmic ray intensity - 3.0% and 4.1%, respectively.

Key Words: Climate change, galactic cosmic rays, cloudiness, air temperature, statistical analysis.

Introduction

Large-scale studies of contemporary climate change in Georgia began in 1996 and they are continued nowadays. First of all, the inventory of greenhouse gases in Georgia [1,2] was carried out, spatial-temporary variations of the fields of air temperature and precipitations [1,3-6], cloudiness [7], solar radiation [8,9], aerosol air pollution [2,3,10], atmospheric ozone [2,3,11] and other climate-forming parameters were studied.

One of the factors, which influence on climate change, is cosmic radiation [2,12,13]. The effect of cosmic rays on climate could be expressed in three ways: (a) through changes in the concentration of cloud condensation nuclei, (b) thunderstorm electrizacation and (c) ice formation in cyclones. The concentration of cloud condensation nuclei depends on the light ions produced during cosmic ray ionization.

Galactic and solar cosmic rays influence physical-chemical process (reactions) in the lower atmosphere including cloudiness, density changes and atmosphere cloud coverage and thus, control the variability of atmosphere transparency and thereby affect solar radiation flax reaching the lower atmosphere. Clouds reflect both the incoming solar radiation flux upward and the Earth's thermal radiation back to it, thereby control thermal energy input in the lower atmosphere, thus establishing a link between cosmic rays and temperature.

There are two mechanisms, which link cosmic rays with cloud. In the first mechanism cosmic ray-produced ions influence the production of new aerosol particles in the troposphere, which may grow and eventually increase the number of cloud condensation nuclei. These nuclei act as seeds for the cloud droplet formation. In the second mechanism cosmic ray-produced ionization modulates the global electric current, which influences cloud properties through charge effects at cloud surface on droplet freezing and other microphysical processes [2,12,13].

In Georgia studies of the climatic effects on cosmic rays also began recently. In particular, in the works [14-16] the effects of cosmic radiation on the formation in the atmosphere of the secondary aerosols, which have an effect on cloudiness [2,12,13], are studied. In the works [17,18] the inter-annual distributions of cloudless days and cloudless nights in Abastumani Astrophysical Observatory (41.75 N, 42.82 E), at various helio-geophysical conditions, and their coupling with cosmic factors were studied.

This work is the continuation of our foregoing studies

Material and methods

The data of the Hydrometeorological Department of Georgia about the annual values of total (G) and lower (g) cloudiness and air temperature (T) in Tbilisi are used. Information about annual values of intensity of neutron component of galactic cosmic rays (CR) is obtained at the Cosmic Rays Observatory of M. Nodia institute of geophysics. The period of observation is 1963 - 1990.

In the proposed work the analysis of data is carried out with the use of the standard statistical analysis methods of random events and methods of mathematical statistics for the non accidental time-series of observations [19, 20].

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, Res – residual component, α - the level of significance, 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 coefficient of determination and such values of K_{DW}, with which the residual values are accidental.

A background component usually enters into the curve of trend. The value of background component is most frequently unknown. From the physical aspect, 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 the value of background component is known, the min Rand will be = Back). Accordingly, Trend+Back (sum of the trend and background components of time series) will be a curve of equation of the regression of the connection of the investigated parameter and the time minus absolute value of the min value of Res. So, Real = (Trend+Back) + Res.

Results and discussion

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

Table 1

Characteristics of trend of G, g, T and CR in Tbilisi in 1963-1990.

Variable	Form of the equation of regression	R^2 (with year)	K_{DW}
G	Fifth power polynomial	0.44 (α =0.001)	2.0 (α =0.05)
g	Fifth power polynomial	0.62 (α =0.0001)	1.96 (α =0.05)
T	Linear	0.047 (α =0.25)	2.23 (α =0.05)
CR	Tenth power polynomial	0.93 (α =0.0001)	1.98 (α =0.05)

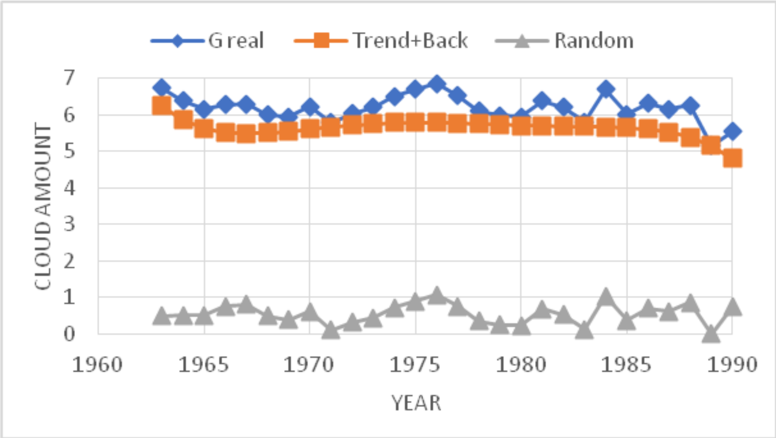


Fig. 1. Trend of the total average annual cloudiness in Tbilisi in 1963-1990.

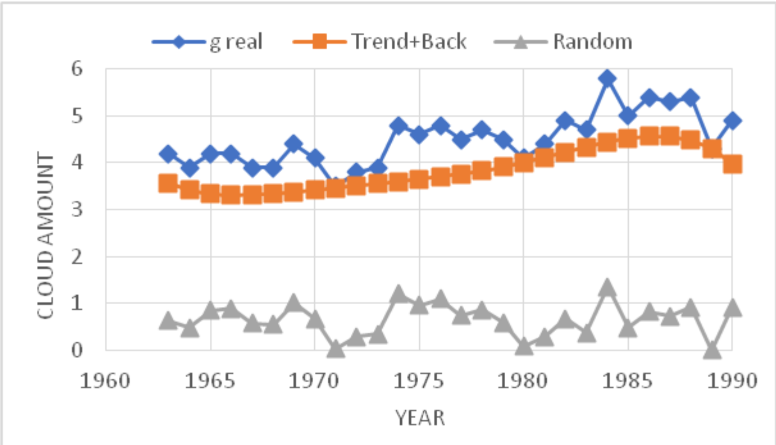


Fig. 2. Trend of the average lower annual cloudiness in Tbilisi in 1963-1990.

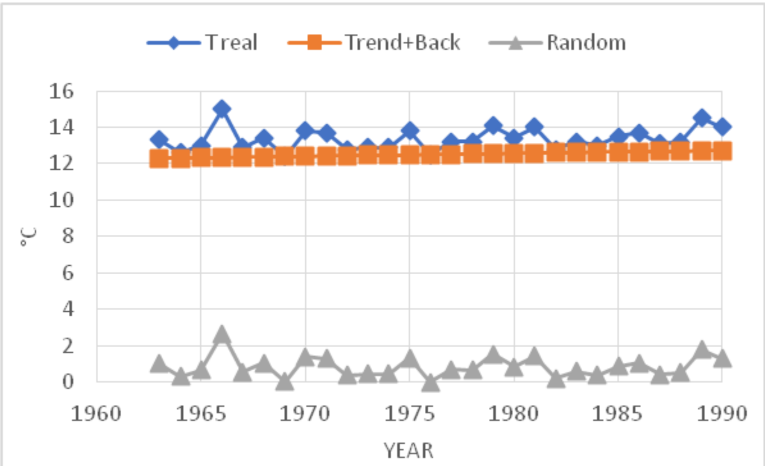


Fig. 3. Trend of the average annual air temperature in Tbilisi in 1963-1990.

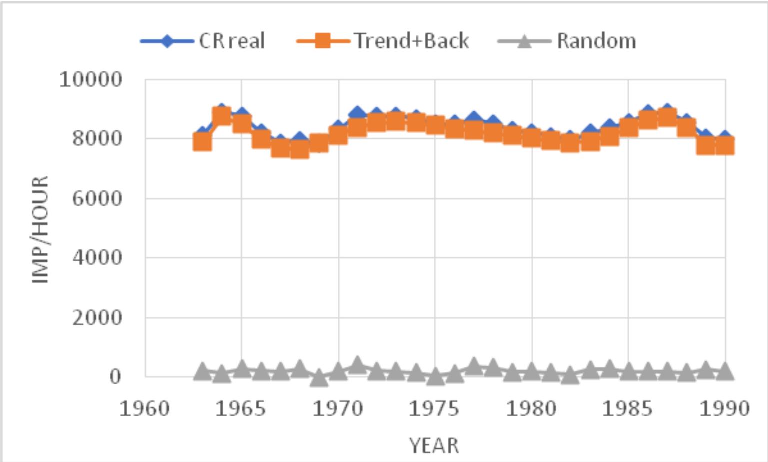


Fig. 4. Trend of the average annual intensity of galactic cosmic rays in Tbilisi in 1963-1990.

According to Table 1 and Fig. 1-4, trends of G and g takes the form of fifth power polynomial, trend of T is linear and trend of CR take the form of tenth power polynomial.

Table 2 shows the statistical characteristics of real data of G, g, T and CR in Tbilisi.

Table 2

The statistical characteristics of real data of G, g, T and CR in Tbilisi in 1963-1990.

Variable	G, cloud amount	g, cloud amount	T, °C	CR, imp/hour
Max	6.9	5.8	15.0	8910
Min	5.2	3.5	12.4	7867
Range	1.7	2.3	2.6	1043
Average	6.2	4.5	13.4	8409
St Dev	0.4	0.6	0.6	336
Correlation Matrix				
	G	g	T	CR
G	1	0.23 (α=0.22)	-0.36 (α=0.06)	0.26 (α=0.17)
g	0.23 (α=0.22)	1	-0.06 (not sign)	0.09 (not sign)
T	-0.36 (α=0.06)	-0.06 (not sign)	1	-0.23 (α=0.22)
CR	0.26 (α=0.17)	0.09 (not sign)	-0.23 (α=0.22)	1

According to Table 2, the values of G vary from 6.9 to 5.2 (average = 6.2), values of g – from 5.8 to 3.5 (average = 4.5), values of T – from 15.0 to 12.4 (average = 13.4) and CR - from 8910 to 7867 (average = 8409).

The significant linear correlation between the following investigated parameters is observed: G with g (positive), T (negative) and CR (positive); g with G (positive); T with G (negative) and CR (negative); CR with G (positive) and T (negative).

In Table 3 the statistical characteristics of the random components of G, g, T and CR in Tbilisi are presented.

According to Table 3, max and average values of random components of investigation parameters are respectively equal: G - 1.1 and 0.6, g - 1.4 and 0.7, T – 2.7 and 0.8, CR – 425 and 210.

The significant linear correlation between the following investigated parameters is observed (table 3): G with g (positive) and CR (negative); g with G (positive), with T (negative) and CR (negative); T with g (negative) and CR (positive); CR with G and g (negative), and with T (positive).

Table 3

The statistical characteristics of random components of G, g, T and CR in Tbilisi in 1963-1990.

Variable	G, cloud amount	G, cloud amount	T, °C	CR, imp/hour
Max	1.1	1.4	2.7	425
Range	1.1	1.4	2.7	425
Average	0.6	0.7	0.8	210
St Dev	0.3	0.3	0.6	88
Correlation Matrix				
	G	g	T	CR
G	1	0.76	-0.16	-0.26 (α=0.17)
g	0.76 (α=0.001)	1	-0.26 (α=0.17)	-0.29 (α=0.12)
T	-0.16 (not sign)	-0.26 (α=0.17)	1	0.20 (α=0.29)
CR	-0.26 (α=0.17)	-0.29 (α=0.12)	0.20 (α=0.29)	1

Shares of the average values of random components in the average values of the real values of the studied parameters (fig. 1-4, table 2 and 3) constitute: for G – 9.0%, for g – 14.6 %, for T – 6.3 % and for CR – 2.5 %.

The equation of the multiple linear regression of the connection of air temperature and G_{real}, g_{rand}, CR_{real} and CR_{rand} is represented below:

$$\mathbf{T = -0.3956 \cdot G_{real} - 0.09313 \cdot g_{rand} - 0.0003825 \cdot CR_{real} + 0.0012956 \cdot CR_{rand} + 18.807}$$

R^2 = 0.185 (α =0.03), R between T_{real} and CR_{rand} = 0.19 (α=0.30)

Table 4 shows the data about contribution of variations in the values of G_{real}, g_{rand}, CR_{real} and CR_{rand} to the changeability of T.

Table 4

Contribution of variations in the values of G_{real}, g_{rand}, CR_{real} and CR_{rand} to the changeability of T.

Variable	In the limits of Range (%)	In the limits of St Dev (%)
G_{real}	5.0	2.2
g_{rand}	1.0	0.5
CR_{real}	3.0	1.9
CR_{rand}	4.1	1.7

According to Table 3, within the variation range, the contribution of the studied parameters to air temperature variability is as follows: real values of total cloudiness- 5.0%, random components of lower cloudiness – 1.0%, real values and random components of cosmic ray intensity - 3.0% and 4.1%, respectively.

Conclusion

In the future, for the comparison of the obtained results, similar works will be carried out for other stations of the observation (Telavi, Tsalka, Anaseuli, etc.), and also other, more contemporary periods of measurement.

References

[1] Budagashvili T., Karchava J., Gunia G., Intskirveli L., Kuchava T., Gurgenidze M., Amiranashvili A., Chikhladze T. Inventory of Greenhouse Gas Emissions and Sinks. Georgia's Initial National Communication on Under the United Nations Framework Convection on Climate Change, Project GEO/96/G31, Tb., 1999, 137 p.

[2] Amiranashvili A.G., Amiranashvili V.A., Gzirishvili T.G., Kharchilava J.F., Tavartkiladze K.A. Modern Climate Change in Georgia. Radiatively Active Small Atmospheric Admixtures, Institute of Geophysics, Monograph, Trans. of M. Nodia Institute of Geophysics of Georgian Acad. of Sc., ISSN 1512-1135, v. LIX, 2005, 128 p.
[3] Tavartkiladze K., Begalishvili N., Kharchilava J., Mumladze D., Amiranashvili A., Vachnadze J., Shengelia I., Amiranashvili V. Contemporary climate change in Georgia. Regime of some climate parameters and their variability. Monograph, ISBN 99928-885-4-7, Tb., 2006, 177 p., (in Georgian).
[4] Amiranashvili A., Matcharashvili T., Chelidze T. Climate change in Georgia: Statistical and nonlinear dynamics predictions. Journ. of Georgian Geophysical Soc., Iss.(A), Physics of Solid Earth, ISSN 1512-1127, v.15A, Tb., 2011-2012, pp. 67-87.
[5] Amiranashvili A., Chikhladze V., Kartvelishvili L. Expected Change of Average Semi-Annual and Annual Values of Air Temperature and Precipitation in Tbilisi. Journ. of Georgian Geophysical Soc., Issue B. Physics of Atmosphere, Ocean and Space Plasma, ISSN 1512-1127, v. 13B, Tb., 2009, pp. 50 – 54.
[6] Amiranashvili A.G. Special Features of Changeability of Daily Sum of Precipitation in Tbilisi in 1957-2006. Journal of the Georgian Geophysical Society, Issue B. Physics of Atmosphere, Ocean and Space Plasma, ISSN 1512-1127, v.18B, Tbilisi, 2015, pp.81-91.
[7] Amiranashvili A., Amiranashvili V., Gzirishvili T., Kolesnikov Yu., Tavartkiladze K. Spatial-Temporary Variations of Total and Lower Layer Cloudiness Over the Georgian Territory. Proc.13th Int. Conf. on Clouds and Precipitation, Reno, Nevada, USA, August 14-18, v.2, 2000, pp. 1159-1162.
[8] Amiranashvili A., Amiranashvili V., Tavartkiladze K. Influence of Cloudiness Trends on the Total Solar Radiation in Tbilisi. Proc.13th Int. Conf. on Clouds and Precipitation, Reno, Nevada, USA, August 14-18, vol.2, 2000, pp. 876-877.
[9] Amiranashvili A.G., Amiranashvili V.A., Tavartkiladze K.A. Influence of Cloudiness and Aerosol Pollution Trends on the Total Solar Radiation in Some Non Industrial Regions of Georgia. Proc. 14th Int. Conf. on Clouds and Precipitation, Bologna, Italy, July 18-23, 2004, pp. 3_1_217.1-3_1_217.2.
[10] Stankevich S., Titarenko O., Amiranashvili A., Chargazia Kh. Determination of Atmospheric Aerosol Optical Depth over Territory of Georgia during Different Regimes of Cloudiness Using the Satellite and Ground-Based Measurements Data. Bulletin of the Georgian National Academy of Sciences, v. 9, No. 3, 2015, pp. 91-95.
[11] Stankevich S., Titarenko O., Amiranashvili A., Chargazia Kh. Modeling of Ozone Content Distribution in Lower Troposphere over the Territory of Georgia Using the Data of Satellite and Ground Observations. Bulletin of the Georgian National Academy of Sciences, v. 9, No. 2, 2015, pp. 54-58.
[12] Devendraa Siingh, Singh R. P. The role of cosmic rays in the Earth's atmospheric processes. Pramana, Journ. of Physics, Indian Academy of Sciences, v. 74, No 1, 2010, pp. 153 - 168, http://www.ias.ac.in/ article/fulltext/pram/074/ 01/0153-0168.
[13] Carslaw K. Atmospheric physics: Cosmic rays, clouds and climate. Nature, 460, 7253, 2009, pp. 332-333.
[14] Amiranashvili A.G. On the Role of Cosmic and Radioactive Radiation on the Formation of the Secondary Aerosols in Atmosphere. Int. Conference "Near-Earth Astronomy 2007", Abstract, Terskol, Russia, September 3-7, 2007, p. 85.
[15] Amiranashvili A.G., Amiranashvili V.A., Bakradze T.S., Chikhladze V.A., Glonti N. Ya., Kharchilava J.F., Tuskia I.I On the Influence of Cosmic Rays on the Secondary Aerosols Formation in the Atmosphere. 7th Int. Conference "Problems of Geocosmos", Abstract, St. Petersburg, Russia, May 26 - 30, 2008.
[16] Amiranashvili A., Bliadze T., Chikhladze V. Photochemical smog in Tbilisi. Monograph, Trans. of Mikheil Nodia institute of Geophysics, ISSN 1512-1135, v. 63, Tb., 2012, 160 p., (in Georgian).
[17] Didebulidze G.G., Todua M. Investigation of presence of cosmic factors in the inter-annual distributions of cloudless days and nights in Abastumani. Sun and Geosphere, v.10, No.1, 2015, pp. 59-63.
[18] Todua M., Didebulidze G. G. Cosmic factors influence on the inter-annual variations of the green 557.7 Nm line and red 630.0 Nm line nightglow intensities and their possible coupling with cloud covering at Abastumani (41.75°N, 42.82°E). Acta Geophysica, v. 62, iss. 2, 2014, pp.381-399.
[19] Kobisheva N., Narovlianski G. Climatological processing of the meteorological information, Leningrad, Gidrometeoizdat, 1978, 294 p., (in Russian).
[20] Kendall M.G. Time-series, Moscow, 1981, 200 p., (in Russian).

გალაქტიკური კოსმოსური სხივების ინტენსივობის წლიური ვარიაციების ღრუბლიანობის და ჰაერის ტემპერატურის ცვალებადობასთან კავშირების კვლევის შედეგები თბილისში

ა.ამირანაშვილი, თ. ბაქრაძე, ნ. ღლონტი, თ. ხუროძე, ი. ტუსკია

რეზიუმე

წარმოდგენილია გალაქტიკური კოსმოსური სხივების ინტენსივობის წლიური ვარიაციების ღრუღლიანობის და ჰაერის ტემპერატურის ცვალებადობასთან კავშირების კვლევის შედეგები თბილისში 1963-1990 წლებში. შესწავლილია აღნიშნული პარამეტრების სტატისტიკური მახასიათებლები (ტრენდები, შემთხვევითი მდგენელები, კორელაციური კავშირები რეალურ მონაცემებსა და შემთხვევით მდგენელებს შორის და სხვა). კერძოდ მიღებულია, რომ კოსმოსური სხივების ინტენსივობის რეალურ მონაცემებსა და საერთო ღრუბლიანობის რეალურ მონაცემებს შორის წრფივი კორელაცია დადებითია, ქვედა ღრუბლიანობისათვის – არ არსებობს, ჰაერის ტემპერატურისათვის – უარყოფითია. კოსმოსური სხივების ინტენსივობის შემთხვევითი კომპონენტების კორელაცია ქვედა და საერთო ღრუბლიანობის შემთხვევით კომპონენტებთან –დადებითია, ჰაერის ტემპერატურასთან – უარყოფითია. ვარიაციული განშლადობის ფარგლებში გამოსაკვლევი პარამეტრების წვლილი ჰაერის ტემპერატურის ცვალებადობაში შემდეგია: საერთო ღრუბლიანობის რეალური მონაცემებისა – 5.0%, ქვედა ღრუბლიანობისათვის შემთხვევითი კომპონენტებისა - 1.0 %, კოსმოსური სხივების ინტენსივობის რეალური მნიშვნელობებისა და შემთხვევითი კომპონენტებისა –3.0% და 4.1% შესაბამისად.

О связи годовых вариаций интенсивности галактических космических лучей с изменчивостью облачности и температуры воздуха в Тбилиси

А.Г. Амиранашвили, Т.С. Бакрадзе, Н.Я. Глонти, Т.В. Хуродзе, И.И. Туския

Резюме

Представлены результаты исследования связи годовых вариаций интенсивности галактических космических лучей с изменчивостью облачности и температуры воздуха в Тбилиси в 1963-1990 гг. Изучены статистические характеристики указанных параметров (тренды, случайные составляющие, корреляционные связи между реальными данными и случайными компонентами и др.). В частности, получено, что линейная корреляция реальных значений интенсивности космических лучей с реальными значениями общей облачности положительная, нижней облачности – отсутствует, температуры воздуха – отрицательная. Корреляция случайных компонент интенсивности космических лучей со случайными компонентами нижней и общей облачности – положительная, температуры воздуха – отрицательная. В пределах вариационного размаха вклад исследуемых параметров в изменчивость температуры воздуха: реальных значений общей облачности – 5.0 %, случайных компонент нижней облачности - 1.0 %, реальных значений и случайных компонент интенсивности космических лучей – 3.0 % и 4.1 % соответственно.

Journal of the Georgian Geophysical Society,
Issue B. Physics of Atmosphere, Ocean and Space Plasma, v.19B, 2016, pp.135-143

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}).

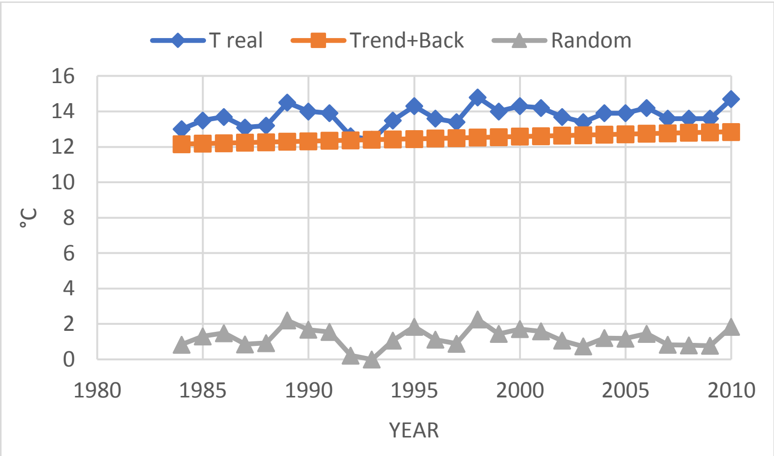


Fig. 1. Trend of the average annual air temperature in Tbilisi in 1984-2010.

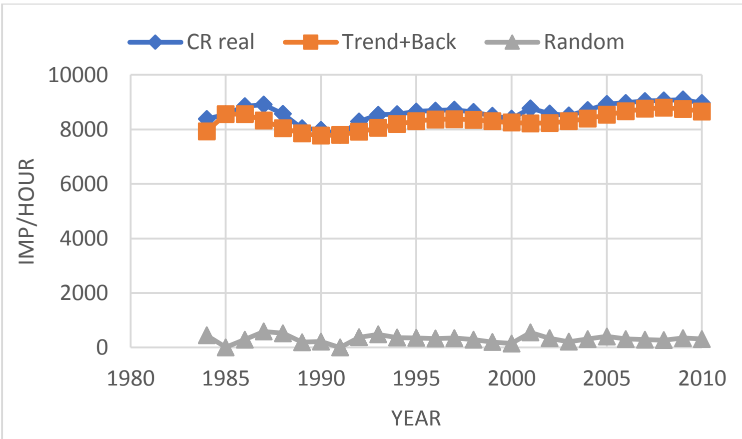


Fig. 2. Trend of the average annual intensity of galactic cosmic rays in Tbilisi in 1984-2010.

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:

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

$R^2 = 0.30$ ($\alpha=0.01$).

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.

References

[1] Bunker A., Wildenhain J., Vandenbergh A., Henschke N., Rocklöv J., Hajat Sh., Sauerborn R. Effects of Air Temperature on Climate-Sensitive Mortality and Morbidity Outcomes in the Elderly; a Systematic Review and Meta-analysis of Epidemiological Evidence. EbioMedicine, v. 6, 2016, pp. 258–268.

[2] Turner, L.R., Barnett, A.G., Connell, D., Tong, S. Ambient temperature and cardio respiratory morbidity: a systematic review and meta-analysis. Epidemiology, v. 23, 2012, pp. 594–606.

[3] Zhou X., Zhao A., Meng X., Chena R., Kuang X., Duan X., Kan H. Acute effects of diurnal temperature range on mortality in 8Chinese cities. Science of the Total Environment, v. 493, 2014, pp. 92–97.

[4] Wang X.Y., Barnett A.G., Hu W., Tong S. Temperature variation and emergency hospital admissions for stroke in Brisbane, Australia, 1996–2005. Int. J. Biometeorol., v. 53, 2009, pp. 535–541. doi:10.1007/s00484-009-0241-4

[5] Kyobutungi C., Grau A., Stieglbauer G., Becher H. Absolute temperature, temperature changes and stroke risk: a case-crossover study. Eur. J. Epidemiol., v. 20, 2005, pp. 693–698. doi:10.1007/s10654-005-0703
[6] Zaninović K., Matzarakis A. Impact of heat waves on mortality in Croatia. Int. J. Biometeorol., v. 58, iss. 6, 2014, pp. 1135–1145.
[7] Gomez-Acebo I., Llorca J., Dierssen T. Cold-related mortality due to cardiovascular diseases, respiratory diseases and cancer: a case-crossover study. Public Health, v. 127, 2013, pp. 252–258.
[8] Amiranashvili A., Chikhladze V., Kartvelishvili L., Khazaradze K. Expected Change of the Extremal Air Temperature and its Influence on the Mortality (Based on the Example to Tbilisi City). International Cooperation Network for East European and Central Asian Countries: EECA Conference, Yerevan, Armenia, October 7-8, 2010, http://be.sci.am/.
[9] Davis R.E., Knappenberger P.C., Novicoff W.M., Michaels P.J. Decadal changes in heat-related human mortality in the eastern United States. Clim. Res., v. 22, 2002, pp. 175–184.
[10] Huynen M.M.T.E., Martens P., Schram D., Weijenberg M.P., Kunst A.E. The Impact of Heat Waves and Cold Spells on Mortality Rates in the Dutch Population. Environmental Health Perspectives, v.109, N 5, 2001, pp. 463 – 470.
[11] Davis R.E., Gregor G.R., Enfield K.B. Humidity: A review and primer on atmospheric moisture and human health. Environmental Research, v. 144, Part A, January 2016, pp. 106-116.
[12] Amiranashvili A.G., Gogua R.A., Matiashvili T.G., Kirkitadze D.D., Nodia A.G., Khazaradze K.R., Kharchilava J.F., Khurodze T.V., Chikhladze V.A. The Estimation of the Risk of Some Astro-Meteo-Geophysical Factors for the Health of the Population of the City of Tbilisi. Int. Conference "Near-Earth Astronomy 2007" Abstract, Terskol, Russia, 3-7 September 2007, p. 86.
[13] Shaposhnikov D., Revich B., Gurfinkel Yu., Naumova E. The influence of meteorological and geomagnetic factors on acute myocardial infarction and brain stroke in Moscow, Russia. Int. J. of Biometeorology, v. 58, iss. 5, 2014, pp. 799–808.
[14] Azcárate T., Mendoza B., Levi J.R. Influence of geomagnetic activity and atmospheric pressure on human arterial pressure during the solar cycle 24. Advances in Space Research, v. 58, iss. 10, 2016, pp. 2116-2125.
[15] Palmer S., Rycroft M., Cermack M. Solar and geomagnetic activity, extremely low frequency magnetic and electric fields and human health at the Earth's surface. Surv. Geophys., v. 27, 2006, pp. 557–595. doi:10.1007/s10712-006-9010-7
[16] Caswell J.M., Carniello T.N., Murugan N.J. Annual incidence of mortality related to hypertensive disease in Canada and associations with heliophysical parameters. Int. J. Biometeorol., v. 60, 2015, pp. 9–20. doi:10.1007/s00484-015-1000-3
[17] Alexander L.T., Atawi N.S.A.l., Mostafa H.M.A. Space Weather Effects on Humans in Tabuk City, KSA. Int. J. of Applied Science and Technology, v. 6, N 1, February 2016, pp. 47-57.
[18] Zenchenko T.A., Dimitrova S., Stoilova I., Breus T.K. Individual responses of arterial pressure to geomagnetic activity in practically healthy subjects. Klin. Med., v. 87(4), 2009, pp.18–24.
[19] Amiranashvili A., Bliadze T., Chikhladze V. Photochemical smog in Tbilisi. Monograph, Trans. of Mikheil Nodia institute of Geophysics, ISSN 1512-1135, v. 63, Tb., 2012, 160 p., (in Georgian).
[20] Hori A., Hashizume M., Tsuda Y., Tsukahara T., Nomiyama T. Effects of weather variability and air pollutants on emergency admissions for cardiovascular and cerebrovascular diseases. Int. J. Environ Health Res., v. 22(5),2012, pp.416–430. doi:10.1080/09603123.2011.650155
[21] Amiranashvili A., Matiashvili T., Nodia A., Nodia Kh., Kharchilava J., Khunjua A., Khurodze T., Chikhladze V. Air Electrical Conductivity Changeability as the Factor of Atmosphere Purity. Trans. of M. Nodia Institute of Geophysics, ISSN 1512-1135, v. 60, Tb., 2008, pp. 186 – 194, (in Russian).
[22] Amiranashvili A., Chikhladze V., Bliadze T. Contemporary State of a Question About the Spatial-Temporary Distribution of Photochemical Smog and Ozone. Trans. of M. Nodia Institute of Geophysics, v. LXI, ISSN 1512-1135, Tb., 2009, pp. 179-186, (in Russian).

[23] Amiranashvili A., Bliadze T., Melikadze G., Tarkhan-Mouravi I., Chikhladze V. Content of Light Aeroions as Factor of the Air Purity of Some Health Resorts of Georgia. Modern Problems of Using of Health Resort Resources, Collection of Scientific Works of International Conference, Sairme, Georgia, June 10-13, 2010, ISBN 978-9941-0-2529-7, Tbilisi, 2010, pp. 145-151, (in Russian).
[24] Amiranashvili A., Chikhladze V., Bliadze T. Contemporary State of a Question About the Action of Photochemical Smog and Surface Ozone on Human Health. Trans. of M. Nodia Institute of Geophysics, v. LXII, ISSN 1512-1135,Tbilisi, 2010, pp. 177-188,(in Russian).
[25] Amiranashvili A., Khurodze T., Shavishvili P., Beriashvili R. Iremashvili I. Dinamics of the Mortality of the Population of Tbilisi City and its Connection with the Surface Ozone Concentration. Journ. of Georgian Geophysical Soc., Iss. (B), Physics of Atmosphere, Ocean and Space Plasma, ISSN 1512-1127, v.16b, Tbilisi, 2013, pp. 31-38.
[26] Amiranashvili A.G. Increasing Public Awareness of Different Types of Geophysical Catastrophes, Possibilities of Their Initiation as a Result of Terrorist Activity, Methods of Protection and Fight With Their Negative Consequences. Engaging the Public to Fight Consequences of Terrorism and Disasters. NATO Science for Peace and Security Series E: Human and Societal Dynamics, v. 120. IOS Press, Amsterdam•Berlin•Tokyo•Washington, DC, ISSN 1874-6276, 2015, pp.155-164. http://www.nato.int/science; http://www. springer.com; http://www.iospress.nl
[27] Amiranashvili A., Amiranashvili V., Kartvelishvili L., Nodia Kh., Khurodze T. Influence of Air Effective Temperature and Geomagnetic Storms on the Population of Tbilisi City. Trans. of the Institute of Hydrometeorology, v. No 115, ISSN 1512-0902, Tbilisi, 2008, pp. 434 – 437, (in Russian).
[28] Amiranashvili A., Mirianashvili K., Fedorova N., Levit V., Fabiana Medeiros Carnaúba, Aliton Oliveira da Silva. Comparative analysis of air equivalent - effective temperature in some cities of Georgia and Brazil, Proc. of Int. Conf. "Environment and Global Warming", Dedicated to the 100th Birthday Anniversary of Academician F. Davitaya, Collected Papers New Series, N 3(82), ISSN 2333-3347, Tbilisi, 2011, pp. 105-110.
[29] Amiranashvili A., Danelia R., Mirianashvli K., Nodia A., Khazaradze K.,Khurodze T., Chikhladze V. On the Applicability of the Scale of Air Equivalent-Effective Temperature in the Conditions of Tbilisi City.Trans. of M. Nodia Institute of Geophysics, v. LXII, ISSN 1512-1135,Tbilisi, 2010, pp. 216-220, (in Russian).
[30] Farajzadeh H., Saligheh M., Alijani B., Matzarakis A. Comparison of selected thermal indices in the northwest of Iran. Natural Environment Change, v. 1, N 1, 2015, pp. 1- 20.
[31] Amiranashvili A.G., Chikhladze V.A. Saakashvili N.M., Tabidze M.Sh., Tarkhan-Mouravi I.D. Bioclimatic Characteristics of Recreational Zones – Important Component of the Passport of the Health Resort – Tourist Potential of Georgia. Trans. of the Institute of Hydrometeorology at the Georgian Technical University, v. 117, ISSN 1512-0902, Tbilisi, 2011, pp. 89-92.
[32] Amiranashvili A.G., Bliadze T.G., Chikhladze V.A., Saakashvili N.M., Tarkhan-Mouravi I.D., Sikharulidze Sh.A., Lachashvili N.I. National Botanical Garden of Georgia – Recreational – Sanitation Oasis of Tbilisi City. Trans. of the Institute of Hydrometeorology at the Georgian Technical University, v. 117, ISSN 1512-0902, Tbilisi, 2011, pp. 94-96.
[33] Matzarakis A., Rudel E., Zygmuntowski M., Koch E. Bioclimatic maps for tourism purposes. Physics and Chemistry of the Earth, v. 35, 2010, pp. 57–62.
[34] Davis R.E., Knight D., Hondula D., Knappenberger P.C. A comparison of biometeorological comfort indices and human mortality during heat waves in the United States. Paper presented at Human biometeorology: The heat 17th conference on biometeorology and aerobiology, San Diego, CA, 2006, https://ams.confex.com/ams/BLTAgFBioA/techprogram/paper_110867.htm
[35] Ketterer Ch., Matzarakis A. Human-biometeorological assessment of the urban heat island in a city with complex topography – The case of Stuttgart, Germany. Urban Climate, v. 10, Part 3, December 2014, pp. 573-584.

[36] Urban A., Kyselý J. Comparison of UTCI with Other Thermal Indices in the Assessment of Heat and Cold Effects on Cardiovascular Mortality in the Czech Republic. Int. J. Environ. Res. Public Health, vol. 11, 2014, pp. 952-967.
[37] Amiranashvili A.G., Cornélissen G., Amiranashvili V., Gheonjian L., Chikhladze V.A., Gogua R.A., Matiashvili T.G., Paatashvili T., Kopytenko Yu.A., Siegelova J., Dusek J., Halberg F. Circannual and circadecennian stages in mortality from cardiovascular causes in Tbilisi, Republic of Georgia (1980-1992). Scriptamedica (Brno), 75, 2002, pp. 255-260.
[38] Marti-Soler H., Gonseth S., Gubelmann C., Stringhini S., Bovet P., Chen P-Ch., Wojtyniak B., Paccaud F., Tsai D-H., Zdrojewski T., Marques-Vidal P. Seasonal variation of overall and cardiovascular mortality: A study in 19 countries from different geographic locations. PLOS ONE, v.9 (11), 2014, http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0113500
[39] Amiranashvili A., Chargazia Kh., Chikhladze V., Japaridze N., Khazaradze K. The monthly variations in mortality from the cardiovascular diseases in Tbilisi. Georgian Medical News, N 5 (242), 2015, pp. 53-59.
[40] Kharchilava J., Chikhladze V., Chochishvili K., Chkhaidze G. Changeability of Surface Ozone Concentration in Tbilisi in 1984-2010. Proc. Int. Sc. Conference on “Environment and Global Warming”, Tbilisi, Georgia, 15-17 September 2011, Vakhushti Bagrationi Institute of Geography, Collected Papers, New Series, N 3(82), ISSN 2233-3347, Tbilisi, 2011, pp. 111–116.
[41] Kobisheva N., Narovlianski G. Climatological processing of the meteorological information, Leningrad, Gidrometeoizdat, 1978, 294 p., (in Russian).
[42] Kendall M.G. Time-series, Moscow, 1981, 200 p., (in Russian).
[43] Amiranashvili A.G, Bakradze T.S, Ghlonti N.Ya, Khurodze T.V., Tuskia I.I. On the Connection of Annual Variations of the Intensity of Galactic Cosmic Rays with the Changeability of Cloudiness and Air Temperature in Tbilisi. Journ. of Georgian Geophysical Soc., Iss. (B), Physics of Atmosphere, Ocean and Space Plasma, ISSN 1512-1127, v.19b, Tbilisi, 2016, pp. 128-134.
[44] Nurtaev B.S., Nurtaev L. Long Term Trends in Climate Variability of Caucasus Region. Journ. of Georgian Geophysical Soc., Iss. (B), Physics of Atmosphere, Ocean and Space Plasma, ISSN 1512-1127, v.19b, Tbilisi, 2016, pp. 79-89.
[45] Budagashvili T., Karchava J., Gunia G., Intskirveli L., Kuchava T., Gurgenidze M., Amiranashvili A., Chikhladze T. Inventory of Greenhouse Gas Emissions and Sinks. Georgia’s Initial National Communication on Under the United Nations Framework Convection on Climate Change, Project GEO/96/G31, Tb., 1999, 137 p.
[46] Amiranashvili A., Matcharashvili T., Chelidze T. Climate change in Georgia: Statistical and nonlinear dynamics predictions. Journ. of Georgian Geophysical Soc., Iss.(A), Physics of Solid Earth, v.15A, Tb., 2011-2012, pp. 67-87.
[47] Amiranashvili A., Chikhladze V., Kartvelishvili L. Expected Change of Average Semi-Annual and Annual Values of Air Temperature and Precipitation in Tbilisi. Journ. of Georgian Geophysical Soc,, Iss. (B), Physics of Atmosphere, Ocean and Space Plasma, ISSN 1512-1127, v. 13B, Tbilisi, 2009, pp. 50 – 54.
[48] Amiranashvili A., Kartvelishvili L., Trofimenko L., Khurodze T. Statistical Structure of Mean Annual Air Temperature in Tbilisi and St.-Petersburg in 1850-2012. Proc. of Int. Conf. “Modern Problems of Geography”, Dedicated to the 80th Anniversary Since the Fondation of Vakhushti Bagrationi Institute of Geography, Collected Papers New Series, N 5(84), ISSN 2233-3347, Tbilisi, 2013, pp. 160-163.

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.

Information for contributors

Papers intended for the Journal should be submitted in two copies to the Editor-in-Chief. Papers from countries that have a member on the Editorial Board should normally be submitted through that member. The address will be found on the inside front cover.

1. Papers should be written in the concise form. Occasionally long papers, particularly those of a review nature (not exceeding 16 printed pages), will be accepted. Short reports should be written in the most concise form not exceeding 6 printed pages. It is desirable to submit a copy of paper on a diskette.
2. A brief, concise abstract in English is required at the beginning of all papers in Russian and in Georgian at the end of them.
3. Line drawings should include all relevant details. All lettering, graph lines and points on graphs should be sufficiently large and bold to permit reproduction when the diagram has been reduced to a size suitable for inclusion in the Journal.
4. Each figure must be provided with an adequate caption.
5. Figure Captions and table headings should be provided on a separate sheet.
6. Page should be 20 x 28 cm. Large or long tables should be typed on continuing sheets.
7. References should be given in the standard form to be found in this Journal.
8. All copy (including tables, references and figure captions) must be double spaced with wide margins, and all pages must be numbered consecutively.
9. Both System of units in GGS and SI are permitted in manuscript
10. Each manuscript should include the components, which should be presented in the order following as follows:
    Title, name, affiliation and complete postal address of each author and dateline.
    The text should be divided into sections, each with a separate heading or numbered consecutively.
    Acknowledgements. Appendix. Reference.
11. The editors will supply the date of receipt of the manuscript.

CONTENTS

სარჩევი

საქართველოს გეოფიზიკური საზოგადოების ჟურნალი

სერია ბ. ატმოსფეროს, ოკეანესა და კოსმოსური პლაზმის ფიზიკა

ჟურნალი იბეჭდება საქართველოს გეოფიზიკური საზოგადოების პრეზიდიუმის დადგენილების საფუძველზე

ტირაჟი 100 ცალი

ЖУРНАЛ ГРУЗИНСКОГО ГЕОФИЗИЧЕСКОГО ОБЩЕСТВА

Серия Б. Физика Атмосферы, Океана и Космической Плазмы

Журнал печатается по постановлению президиума Грузинского геофизического общества

Тираж 100 экз

JOURNAL OF THE GEORGIAN GEOPHYSICAL SOCIETY

Issue B. Physics of Atmosphere, Ocean and Space Plasma

Printed by the decision of the Georgian Geophysical Society Board

Circulation 100 copies