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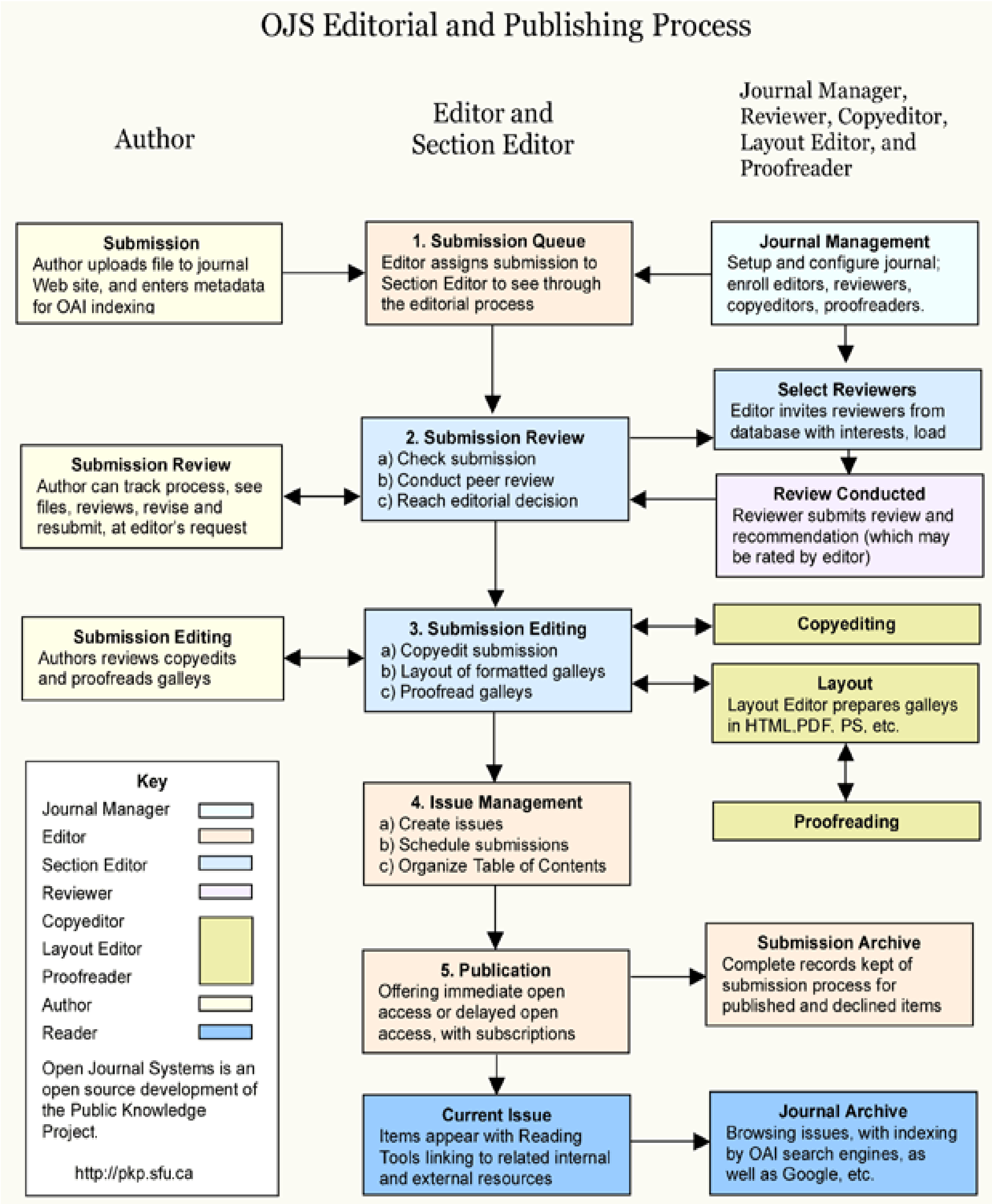

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Combined Geophysical Studies with Carried out in the Area of the Main Building of Power Project Narvani-HES on the River Narovani

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ABSTRACT

In addition to various standard problems of Engineering Geophysics we often deal with cases that are less known in the literature, but can be quite easily solved by geophysical methods. In such cases it is important to choose an appropriate method and a convenient way to apply it.
The paper describes one of such issues.
The territories of the dam construction and other engineering structures connected to the river mostly cover the areas of the river gorges, which are basically presented with pebbles and rocks filling the sand. One of the most important tasks during the study of the conditions of foundation placement is to determine the bedrock depths. The pebbly rocks covering the area create great difficulties during drilling operations and geophysical surveys.
In cases where the river bed is bordered by steep cliffs, both geophysical methods become difficult due to impossibility of extending communication cables to the required lengths. It is noteworthy that a part of the mentioned problems can be considered as a contributing factor for the method proposed by us in this article.
Key words*: seismic profiling, elastic wave.*

Preamble

The article considers the results of the geophysical survey carried out on the territory of the main building of power project Narvani-HES (Hydroelectric power station) on the river Narovani.

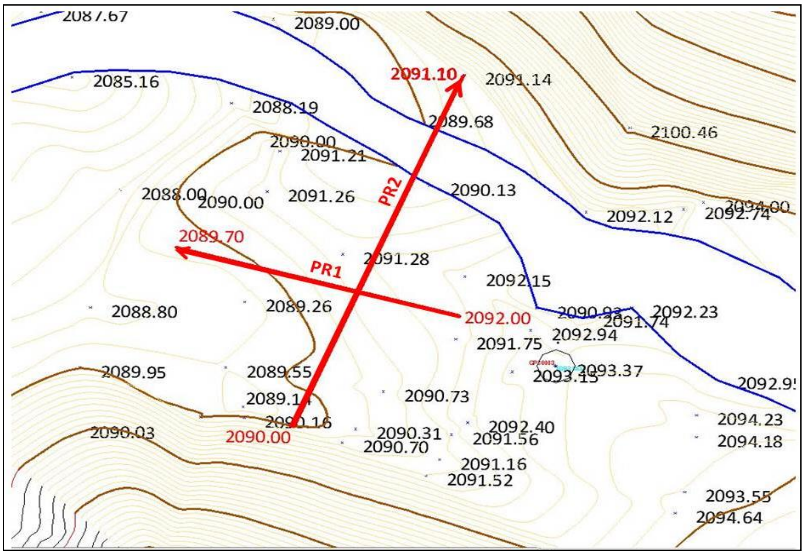

Fig. 1. Study area, seismic profiling and combined survey scheme.

The study area and the layout of the seismic profiles are shown in Fig. 1.

We conducted Seismic Profiling (Refracted Wave Method) and constructed a corresponding seismologic section, determined the propagation speeds of the elastic longitudinal wave and estimated the values of the densities. The paper presents Profile 1. Seismic profiling is often quite difficult due to the difficult relief of a study area. Therefore, it is necessary to conduct a combined geophysical survey in a difficult profile area.

Seismic Profiling

We conducted seismic profiling (Fig. 1) by Refracted Wave Method, on the basis of which we determine the velocity values of the elastic longitudinal wave propagation, constructed corresponding cuts and estimated the corresponding density values.

Refracted Waves Method makes it possible to determine the capacities of the surface and deeper layers and the propagation velocities of the elastic waves in them. The method is based on determining the arrival times of longitudinal wave fronts from the source of the longitudinal waves into the geophones displayed in one line. We also defined the density values [1-3].

The seismic profiling works were carried out with 10 Hz geophones, which were located in 1 meter distance from one another, while the seismic waves were generated by striking a 10 kg hammer on a special plastic plate in Z-Z orientation. We used a 5 shock point system, which contained 2 shocks at the head and bottom of the profile, one shock in the middle and two shocks transferred out of the profile.

The waves were registered with a 24-channel engineering seismic station produced by ***GEOMETRICS, ltd***. Depending on the type of a wave the direction of the shock was also changed.

We analyzed the obtained data, constructed corresponding sections and evaluated the values of the relevant physical-mechanical parameters. The display of the profile is shown in Fig. 1.

The Study Results

A seismic profile with a length of 23 m was constructed (Fig. 1).

According to the values of geophysical parameters, three main layers are distinguished on the seismic profile:

Layer 1 – intensively unloaded river gorge with natural moisture;

Layer 2 – river gorge saturated with water;

Layer 3 – heavily weathered bedrock.

The obtained seismic section is shown in Fig. 2.

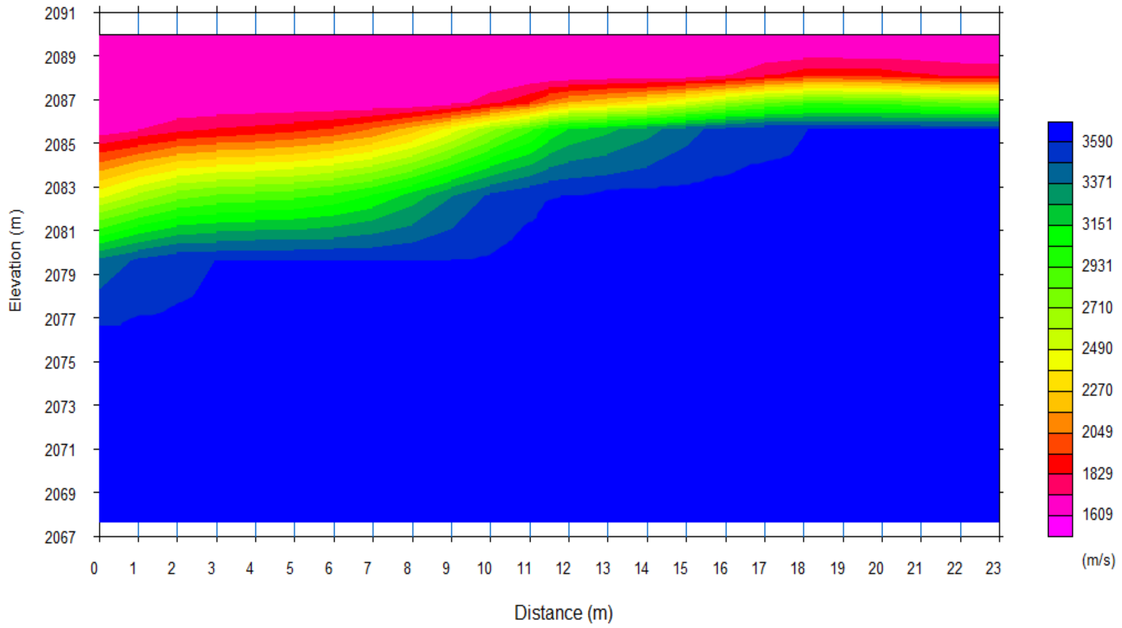

Fig. 2. Seismic Profile 1.

Seismic Profile 1

Layer 1 extends from the surface to an average depth of 4 m with the average value of longitudinal elastic wave speed Vp=1650 m/s, the average value of density ρ=1.98 g/cm^3.

Further comes **Layer 2** with thickness of 4m with the average value of longitudinal elastic wave speed Vp=2800 m/s, the average value of density ρ=2.26 g/cm^3.

Layer 3 is observed averagely to the depth of 22 m, the average value of longitudinal elastic wave speed is Vp=3590 m/s and the average value of density ρ=2.4 g/cm^3.

The combined study of the river gorge

The works on **Profile 2** were carried out by a combined method, during which the following values were taken into consideration:

- the distance between the rocky banks of the river gorge:
  L=35 m
- wave travel time on the rocky bottom of the gorge from shore to shore:
  T=0.0296 s
- the average speed of an elastic wave propagation in a rock
  Vp=1700 m/s
- the bending angles of the rocky banks:
  the left bank: φ=57°
  the right bank: φ=57°

Taking these values into account, the average depth of the river gorge was calculated:

$H_{average}$ ≈14 m.

The average width of the lower terrace of the river gorge:

C=17 m.

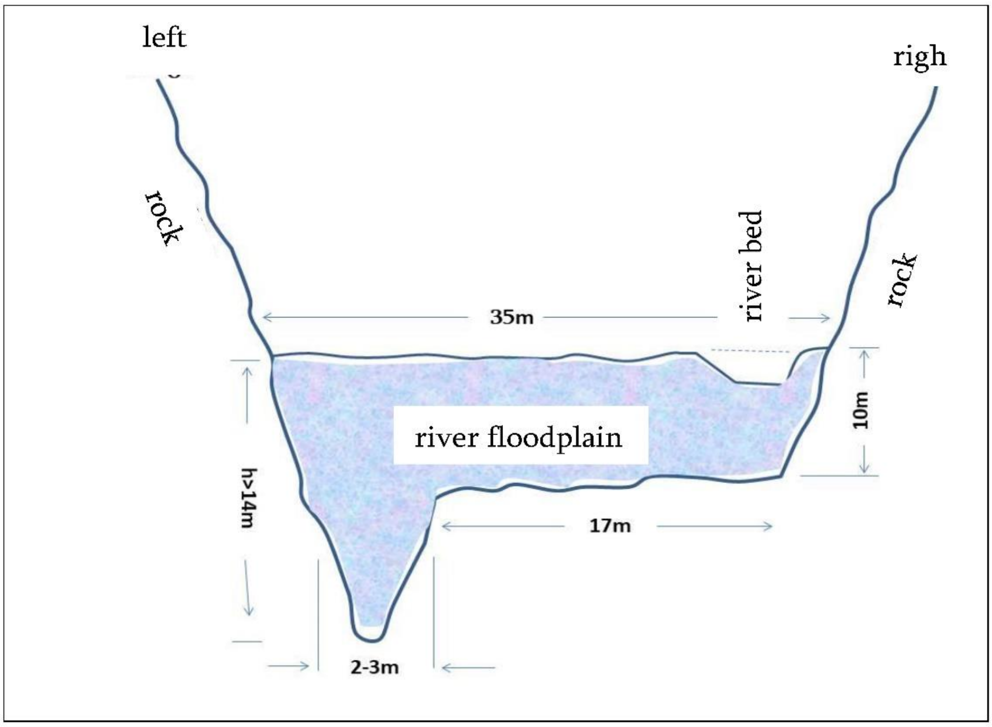

Fig. 3. A combined cut crossing the river gorge.

Taking into account the specificity of the obtained seismograms, it can be assumed that there is a sharp maximum deepening of the rocky bottom near the left rocky slope of the river bed. In the 2-3 meter section of the cut H exceeds 24 m, and in the rest of the section along the cut, H is of 10 m order.

Conclusion

Taking into account all the above said and the cut of Profile 1 we can build a model of a combined cut crossing the river gorge in the study area (Fig. 3).

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მდინარე ნაროვანზე მშენებარე ნარვანი ჰესის სათავე ნაგებობების უბანზე ჩატარებული კომბინირებული გეოფიზიკური კვლევები

მ. გიგიბერია, ჯ. ქირია, ნ. ღლონტი

რეზიუმე

საინჟინრო გეოფიზიკის სხვადასხვა სახის სტანდარტული ტიპის ამოცანების გარდა ხშირად საქმე გვაქვს ლიტერატურაში ნაკლებად ცნობილ, მაგრამ გეოფიზიკური მეთოდებით საკმაოდ ადვილად გადასაწყვეტ შემთხვევებთან. ამ დროს მნიშვნელოვანია სათანადო მეთოდისა და მისი გამოყენების მოხერხებული გზის ამორჩევა.

სწორედ ერთ–ერთ ასეთ შემთხვევას ეძღვნება წარმოდგენილი ნაშრომი.

კაშხლებისა და მდინარეებთან დაკავშირებული სხვა საინჟინრო ნაგებობების მშენებლობის ტერიტორიები უმრავლეს შემთხვევაში შეიცავს მდინარის ჭალის უბნებს, რომლებიც ძირითადად წარმოდგენილია ქვიშის შემავსებლიანი კენჭნარით და ლოდნარით. საძირკვლის განთავსების პირობების შესწავლის დროს ერთერთი უმთავრესი ამოცანაა ძირითადი ქანების ჩაწოლის სიღრმეების განსაზღვრა. მათი დამფარავი კენჭნარის ტიპის ქანები კი დიდ სირთულეებს ქმნიან საბურღი სამუშაოებისა და გეოფიზიკური კვლევების ჩატარების დროს.

იმ შემთხვევებში, როდსაც მდინარის კალაპოტი ნაპირებიდან შემოფარგლულია ციცაბო კლდეებით, ორივე გეოფიზიკური მეთოდისათვის იქმნება მნიშვნელოვანი პრობლმა საკომუნიკაციო კაბელების საჭირო სიგრძეებზე გაშლის შეუძლებლობის გამო. ნიშანდობლივია,რომ ამ სტატიაში ჩვენს მიერ შემოთავაზებული მეთოდისათვის აღნიშნული პრობლემების ნაწილი შეიძლება ხელისშემწყობ ფაქტორად განვიხილოთ.

საკვანძო სიტყვები: სეისმური პროფილირება, ელასტიური ტალღა.

Комплексные геофизические исследования, проведенные в районе основных сооружений строящейся Нарвани ГЭС на реке Наровани

М.Г. Гигиберия, Дж. К. Кирия, Н.Я. Глонти

Резюме

Помимо различных стандартных задач инженерной геофизики, мы часто имеем дело со случаями, мало известными в литературе, но достаточно легко решаемыми геофизическими методами. В это время важно выбрать подходящий метод и удобный способ его использования.

Представленная статья посвящена одному из таких случаев.

Участки строительства плотин и других инженерных сооружений речной связи в большинстве случаев содержат поймы рек, которые в основном представлены засыпанными песком галькой и валунами. Одной из важнейших задач при изучении условий закладки фундамента является определение глубины залегания коренных пород. Покрывающие их галечные породы создают большие трудности при буровых работах и геофизических исследованиях.

В тех случаях, когда русло реки ограничено отвесными скалами с берегов, для обоих геофизических методов создается существенная проблема из-за невозможности прокладки кабелей связи на требуемые длины. Показательно, что часть упомянутых проблем можно рассматривать как способствующие развитию метода, предложенного нами в данной статье.

Ключевые слова: сейсмопрофилирование, упругая волна.

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The Anomalous Magnetic Field of "Kaprovani" Settlement Territory and its Geological Interpretation

Robert A. Gogua, Jemal K. Kiria, Nugzar Ya. Ghlonti

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ABSTRACT

As a result of the geomagnetic studies conducted on the territory of Kaprovani we determined the magnetic absorption intensity of the anomalous magnetic field and the sand of the territory, percentage of ferromagnetic minerals in the sand and the source of the anomalous magnetic field.

Key words: *magnetic field, magnetic anomaly, magnetic absorption.*

The Black Sea area of Georgia, its sand saturated with magnetic minerals, is of universal interest due to its effective healing value. Nevertheless, detailed geomagnetic surveys of the area have not been conducted until recently. In order to solve this problem, we carried out geomagnetic surveys in the area with modern digital equipment (proton magnetometer G-856, susceptimeter KM-7) and determined the composition of the magnetic minerals in the sand samples in a laboratory.

The magnetic field of the study area was planned for 30 profiles in meridian direction (parallel to the sea coast) in 1:1000 scale. The vertical gradient of the magnetic field was determined in several areas of the territory.

The anomalous magnetic field map of the studied area is shown in *Figure 1*.

As the map shows, the anomalous magnetic field of the territory is intense and inhomogeneous. According to the intensity of the anomalies, the territory can be divided into three zones.

The first zone covers the territory from the sea shore including Profiles 1, 2, 3, where the intensity of the anomaly is 400-500 nT.

The second zone includes Profiles 4 - 14, where the anomaly of the magnetic field varies within 250-400 nT.

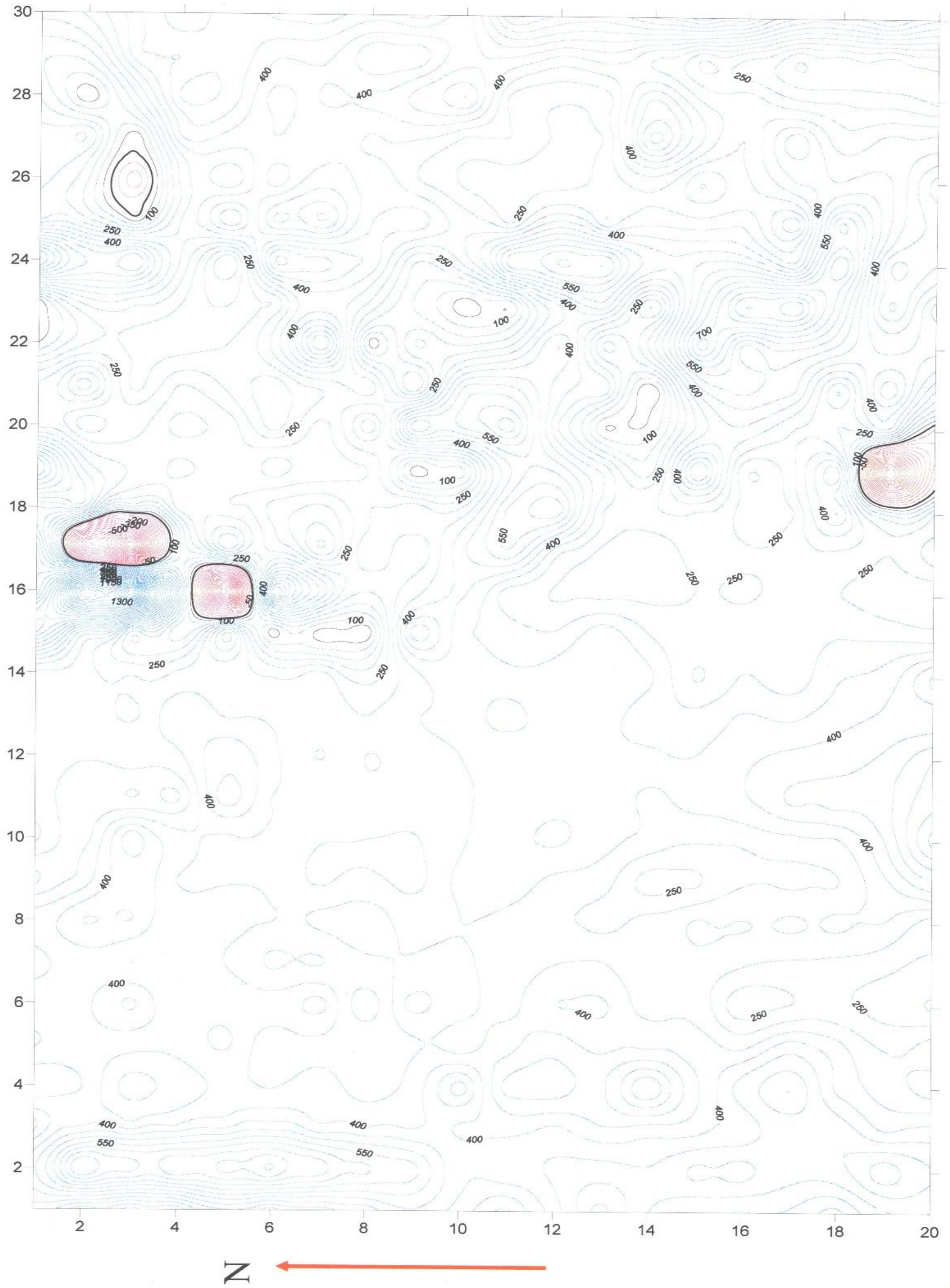
The third zone is significantly different from the previous two zones, both in terms of magnetic field intensity and nature. Starting from Profile 15 to Profile 18, the magnetic field anomaly is negative.

In the eastern part of the territory (Profiles 20-30), the magnetic field is quite varied and changes within 250-550 nT.

The studies of the vertical gradient of the magnetic field at 0.5m, 1m, 1.5m and 2m heights show that the anomaly decreases rapidly with height.

As the laboratory studies of the sand samples taken in the area show the main ferromagnetic minerals in the sand are magnetite and titanomagnetite. Their total amount in the sand is 10%.

Number of profiles



Number of points

Fig. 1.

Conclusion

The field investigations conducted on the territory of settlement “Kaprovani” showed that the anomalous magnetic field of the area is intense and changes within the range of 250-550 nT.

A rapid decrease in the vertical gradient of the magnetic field means that the source of the magnetic field is close to the diurnal surface. Besides, the laboratory analysis of the sand samples revealed that the value of ferromagnetic mineral composition in the sand is high. All above said confirms that the main source of the anomalous magnetic field in the investigated area is the sand spread over it, while strongly disturbed values of the magnetic field in some areas of the territory are caused by technogenic reasons.

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რ. გოგუა, ჯ. ქირია ნ. ღლონტი

რეზიუმე

„კაპროვანის“ ტერიტორიაზე ჩატარებული გეომაგნიტური კვლევების შედეგად დადგენილია: ტერიტორიის ანომალური მაგნიტური ველის და ქვიშის მაგნიტური შემთვისებლობის ინტენსივობა, ქვიშის ფერომაგნიტური მინერალების პროცენტული რაოდენობა და ანომალური მაგნიტური ველის წყარო.

საკვანძო სიტყვები: მაგნიტური ველი, მაგნიტური ანომალია, მაგნიტური შთანთქმა.

Аномальное магнитное поле района поселка «Капровани» и его геологическая интерпретация

Р.А. Гогуа, Д.К. Кириа, Н.Я. Глонти

Резюме

В результате геомагнитных исследований, проведенных на территории «Капровани», установлены: напряженность аномального магнитного поля и магнитное свойство песка, процентное содержание ферромагнитных минералов в песке и источник аномального магнитного поля.

Ключевые слова: магнитное поле, магнитная аномалия, магнитное поглощение.

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The results of the Research of Machavariani Street Landslide by Electroprospecting and Seismic Methods

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ABSTRACT

By means of geophysical methods (seismic and electromagnetic methods) it is possible to determine various characteristics of the geological environment. Seismic methods allow us to determine the elastic parameters of the environment (density, Poisson's ratio, Young's dynamic modulus, etc.), and with the help of electroprospecting methods electromagnetic characteristics of the geological environment (resistance, conductivity, etc.). From the results of the complex search, we can draw conclusions about the structure and humidity of the subsurface of the studied area. The paper presents the results of the studies conducted on the landslide that developed on Machavariani street in Tbilisi. Seismic surveys were conducted using the method of refracted waves and seismic tomography, and electrical surveys were conducted using the methods of vertical electrical sounding and natural electric field. Based on the analysis of the received results, conclusions have been made about the depths of the landslide scarps, the mechanical condition of rocks, their humidity and the possible presence of underground water flows.

Key words: *longitudinal waves, transverse waves, seismic tomography, electroprospecting, vertical electrical sounding, natural electric field*

Introduction

In today's world, the extensive development of urbanization and construction contributes to the increase of both environmental hazards and risk, as well as seismic risk. In this regard, the city Tbilisi is no exception. In terms of ecological risk and safety assessment, scientific assessment of geodynamic processes is necessary. Based on the above, it becomes clear that for the correct assessment of ecological risk and safety, geophysical studies using modern methods are of crucial importance [1,2].

The paper presents St. The results of the geophysical (electrical and seismic) survey of the landslide that developed on Machavariani Street in Tbilisi. The landslide is developed in the sediments of Oligocene age.

a. **b.**

Fig. 1. a) Machavariani landslide photographed by drone, b) one of the ruptures of Machavariani landslide

Oligocene sediments are intensively fissured and represented by alternations of clays, argillites and sandstones. Machavariani street landslide is a typical block landslide (Fig.1). The surface area of the moving landslide body is about 1.5 hectares, and the volume is 225 thousand cubic meters. Its formation is related to intensively fissured rocks.

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Complex geophysical studies (electric prospecting, seismic profiling, seismic tomography) were conducted to assess the depth structure, geometry, lithology, humidity, watering and its danger of the block landslide. The methods of electroresearch are quite powerful and experienced means for studying the geometry, lithology, humidity of landslides [1,3,5,14]. During the study of landslides, electro-research methods are always assigned an important role. Geophysical methods are indispensable for determining the depth structure of the landslide, the elastic parameters of the underground rocks, the depths of the cracks on the landslide [7,11,13].

Electroprospecting works. On March 29, 2021, on the landslide located on Machavariani street (Tbilisi, Georgia), electroprospecting works were carried out using the method of vertical electrical sounding.

Fig. 2. Positioning points of vertical electrical sounding in landslide body area.

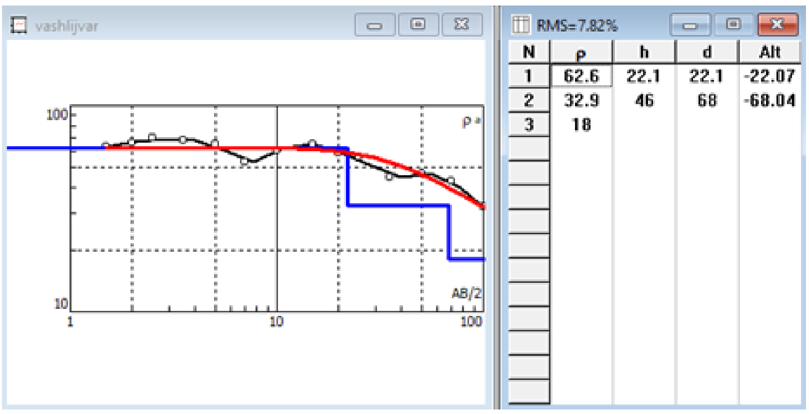
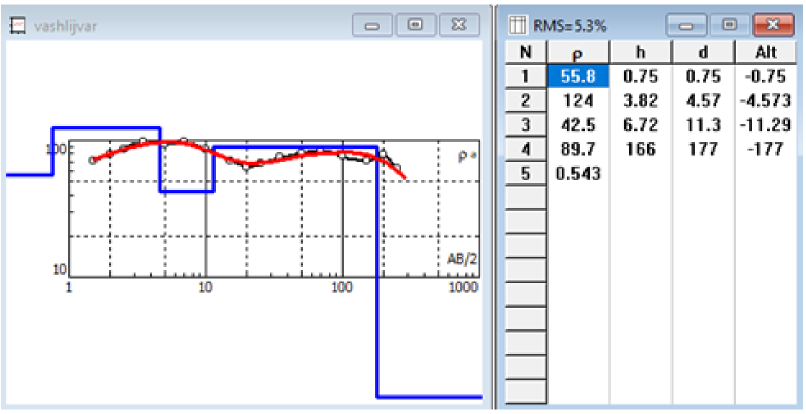


Fig. 3. Vertical electrical sounding curve obtained as a result of measurements near the landslide toe.

The first measurement was made near the landslide tongue, on Machavariani Street (Fig. 2). The measurement was performed by the vertical electrical sounding method. The maximum extension of the current electrodes was 100 meters. The corresponding vertical electrical sensing (VEZ) curve is presented in Fig. at 3. The figure shows the curve obtained as a result of resistance measurements in black, the theoretical curve in red, and the layers separated by inversion in blue. The analysis of the VES curve allows us to assume that the clay layer starts from a depth of about 25-30 meters. This result is in some agreement with the results obtained by coring wells in the vicinity of vertical electrical sounding points.

The second measurement was made on the landslide body, about 500 meters away from the first point (Fig. 4). The measurement was also performed using the vertical electrical sensing method. The maximum extension of the current electrodes was 250 meters.



N	ρ	h	d	Alt
1	55.8	0.75	0.75	-0.75
2	124	3.82	4.57	-4.573
3	42.5	6.72	11.3	-11.29
4	89.7	166	177	-177
5	0.543			

Fig. 4. Vertical electrical sounding curve obtained as a result of measurements on a landslide body.

The corresponding vertical electrical sounding curve is presented in Fig. 4. Potentially humidity layers are separated on the VES. However, the analysis of the vertical electrical sensing curve allows us to assume that the entire investigated subsurface is characterized by high humidity, which may indicate the inflow of water from certain areas.

Works of natural electric field measurement. The natural electric field was measured in the vicinity of the vertical electric sounding point (Vashlichvari2, Fig. 2). The measurement was carried out by the potential method. One electrode was fixed at the center of a stationary circle, and the other electrode, connected to it by a 25-meter cable, moved around the circle by at an 90 degrees step. The potential difference was measured at each step [6]. Measurements of the natural electric field allow determining the possible presence and direction of groundwater flow. Based on the asymmetry of the diagram, it can be assumed that there is movement of underground water. By analyzing the presented diagram (Fig. 5), we can assume the direction of groundwater flow [6].

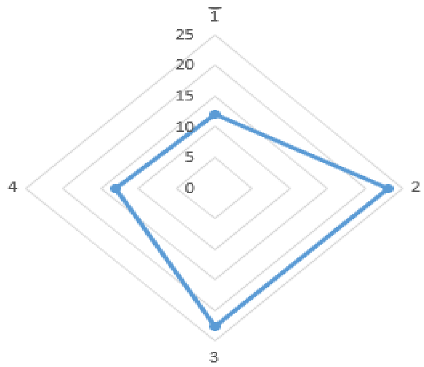


Fig. 5. Natural field measurement result with circular (90° angle) rotation.

Seismic profiling and seismic tomography. In order to investigate the state of the landslide developed in the vicinity of Machavariani Street, 4 seismic profiles of different lengths were conducted using the method of refracted waves and seismic tomography [8,9,10]. Figure 6 shows the scheme of the profiles, and also Table 1 gives the corresponding coordinates. Profile N 1 is oriented along the fault and crosses it, and profiles N 2 and N 3 - parallel to the fault. However, profile N 3 also crosses the fault. Profile N 4 is also directed in the direction of the rupture. Profiles N 2 are conducted in the upper, relatively stable zone of the landslide area, and profile N 3 - directly on the body of the landslide. Additionally, both longitudinal and transverse wave velocities were determined for all profiles, and corresponding physical-mechanical parameters were estimated for each layer.

The following physical-mechanical parameters were determined:

1	**Vp m/sec**	Longitudinal wave velocity
2	**Vs m/sec**	Shear wave velocity
3	**Vs/Vp**	Velocitys ratios
4	**ρ gr/cm^3**	density
5	**μ**	Poisson's ratio
6	**Ed Mpa**	Young's Dynamic modulus
7	**Gd MPa**	Dynamic shear modulus
8	**KdMpa**	Dynamic bulk modulus
9	**D Mpa**	General deformation modulus
10	**τ Mpa**	Hardness limit by compression

Note. 1-3 of the mentioned parameters are obtained as a result of research, 5-8 are calculated based on known theoretical assumptions, and 4, 9, 10 are obtained using empirical connections available to us.

After obtaining accurate geological information, it will be possible to determine the identification of separated layers and determine the relevant physical-mechanical parameters with greater accuracy [8,9,10,12].

Fig.6. Layout scheme of seismic profiles. N s indicates the beginning of the profile, and N e - the end of the profile.

Seismic slice N 1 is particularly informative, showing that in the southwestern part a lenticular depression of the third layer is observed, which should lead to a relatively stable condition, but since nearby, the exposure in the area adjacent to this street shows a newly observed fault with a displacement of up to 0.5 meters, obviously that this area is also experiencing active deformations.

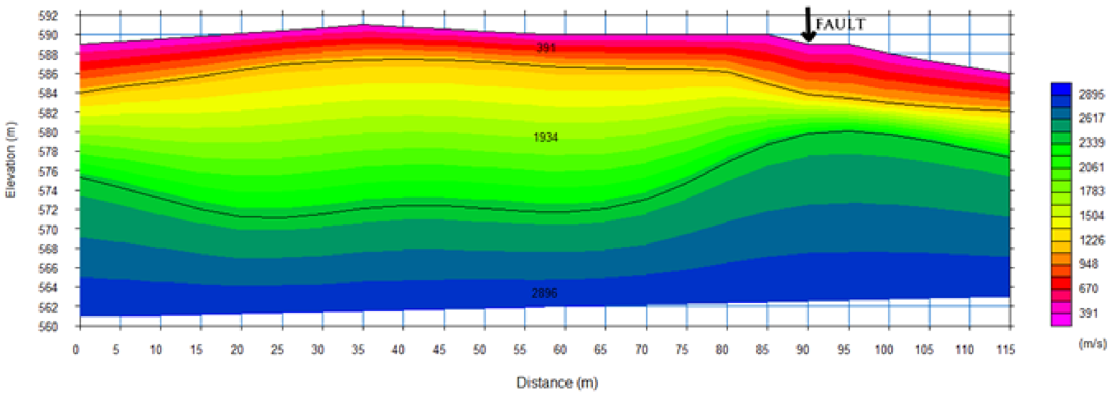


Fig. 7. Seismic cross section N 1.

In its northeastern part, to the right of the fault, (right of the fault indicated in Fig. 6) there is a slope of the existing layers, which is one of the main factors for the development of the landslide event. Based on the above, in order to obtain more complete information, we consider it expedient to cover the entire area of landslide occurrences and its adjacent zones with a network of complex geophysical surveys.

Table 1. Values of physical-mechanical parameters for profile N 1.

Layer N	Parameters	Parameter description	values
1	**Vp m/sec**	Longitudinal wave velocity	391
	Vs m/sec	Shear wave velocity	268
	Vs/Vp	Velocitys ratios	0.69
	ρ gr/cm^3	Density	1.43
	μ	Poisson's ratio	0.06
	Ed Mpa	Young's Dynamic modulus	220
	Gd MPa	Dynamic shear modulus	103
	KdMpa	Dynamic bulk modulus	817.82
	D Mpa	General deformation modulus	3.30
	τ Mpa	Hardness limit by compression	-
2	**Vp m/sec**	Longitudinal wave velocity	1934
	Vs m/sec	Shear wave velocity	1189
	Vs/Vp	Velocitys ratios	0.61
	ρ gr/cm^3	Density	2.14
	μ	Poisson's ratio	0.20
	Ed Mpa	Young's Dynamic modulus	7220
	Gd MPa	Dynamic shear modulus	3019
	KdMpa	Dynamic bulk modulus	39619.25
	D Mpa	General deformation modulus	793.89
	τ Mpa	Hardness limit by compression	4.95
3	**Vp m/sec**	Longitudinal wave velocity	2896

	Vs m/sec	Shear wave velocity	1236
	Vs/Vp	Velocitys ratios	0.43
	ρ gr/cm^3	density	2.36

μ	Poisson's ratio	0.39
Ed Mpa	Young's Dynamic modulus	10020
Gd MPa	Dynamic shear modulus	3609
KdMpa	Dynamic bulk modulus	149993.20
D Mpa	General deformation modulus	1328.50
τ Mpa	Hardness limit by compression	5.92

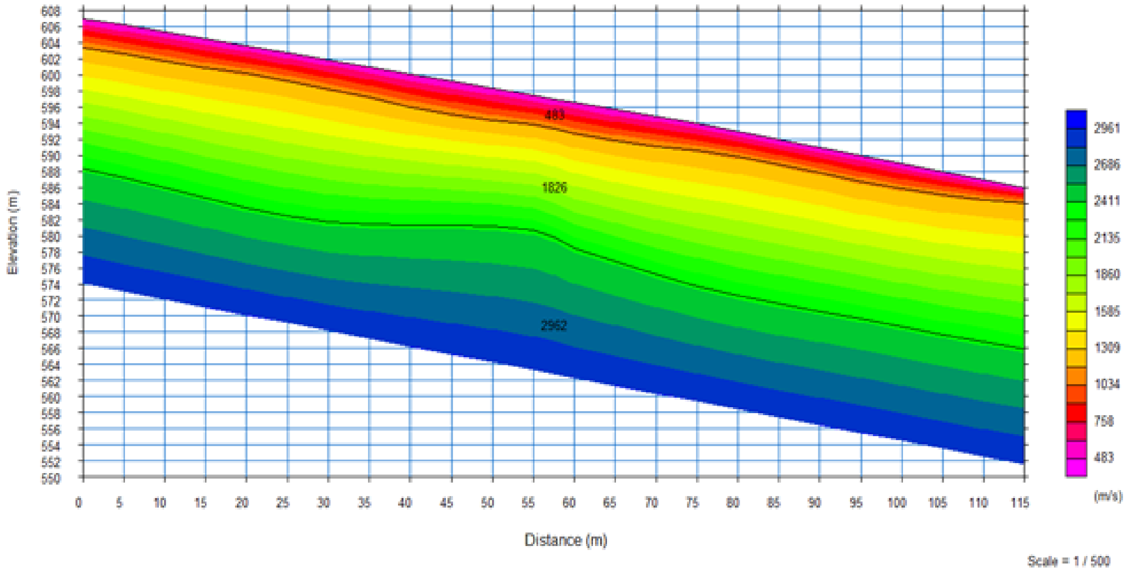


Fig. 8. Seismic cross section N 2.

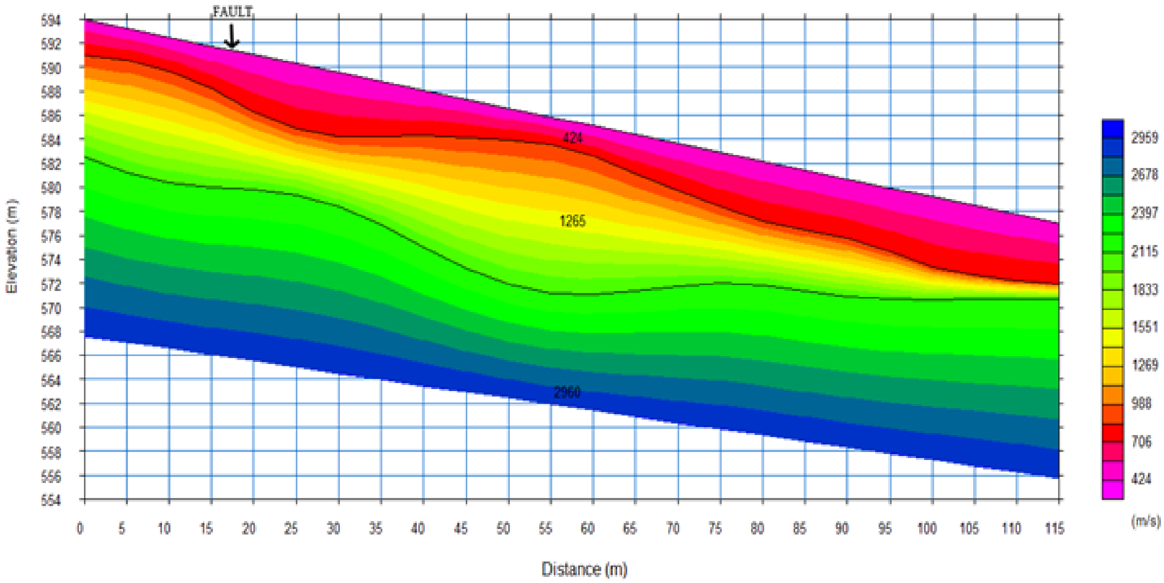


Fig. 9. Seismic cross section N 3.

Table 2. Values of physical-mechanical parameters for profile N 2.

Layer N	Parameters	Parameter description	values
1	**Vp m/sec**	Longitudinal wave velocity	483
	Vs m/sec	Shear wave velocity	339
	Vs/Vp	Velocitys ratios	0.70
	ρ gr/cm^3	Density	1.51
	μ	Poisson's ratio	0.01
	Ed Mpa	Young's Dynamic modulus	350
	Gd MPa	Dynamic shear modulus	173
	KdMpa	Dynamic bulk modulus	1208.55
	D Mpa	General deformation modulus	6.83
	τ Mpa	Hardness limit by compression	-
2	**Vp m/sec**	Longitudinal wave velocity	1826
	Vs m/sec	Shear wave velocity	1103
	Vs/Vp	Velocitys ratios	0.60
	ρ gr/cm^3	Density	2.10
	μ	Poisson's ratio	0.21
	Ed Mpa	Young's Dynamic modulus	6210
	Gd MPa	Dynamic shear modulus	2561
	KdMpa	Dynamic bulk modulus	36038.60
	D Mpa	General deformation modulus	626.54
	τ Mpa	Hardness limit by compression	4.20
3	**Vp m/sec**	Longitudinal wave velocity	2962
	Vs m/sec	Shear wave velocity	1234
	Vs/Vp	Velocitys ratios	0.42
	ρ gr/cm^3	Density	2.38
	μ	Poisson's ratio	0.39
	Ed Mpa	Young's Dynamic modulus	10090
	Gd MPa	Dynamic shear modulus	3617
	KdMpa	Dynamic bulk modulus	160181.33
	D Mpa	General deformation modulus	1343.11
	τ Mpa	Hardness limit by compression	5.93

Table 3. Values of physical-mechanical parameters for profile N 4.

Layer N	Parameters	Parameter description	values
1	**Vp m/sec**	Longitudinal wave velocity	268
	Vs m/sec	Shear wave velocity	188
	Vs/Vp	Velocitys ratios	0.70
	ρ gr/cm^3	Density	1.30
	μ	Poisson's ratio	0.02
	Ed Mpa	Young's Dynamic modulus	90

	Gd MPa	Dynamic shear modulus	46
	KdMpa	Dynamic bulk modulus	321.78
	D Mpa	General deformation modulus	0.81
	τ Mpa	Hardness limit by compression	-
2	**Vp m/sec**	Longitudinal wave velocity	1035
	Vs m/sec	Shear wave velocity	630
	Vs/Vp	Velocitys ratios	0.61
	ρ gr/cm^3	Density	1.83
	µ	Poisson's ratio	0.21
	Ed Mpa	Young's Dynamic modulus	1750
	Gd MPa	Dynamic shear modulus	725
	KdMpa	Dynamic bulk modulus	9899.43
	D Mpa	General deformation modulus	85.67
	τ Mpa	Hardness limit by compression	1.19
3	**Vp m/sec**	Longitudinal wave velocity	2433
	Vs m/sec	Shear wave velocity	1023
	Vs/Vp	Velocitys ratios	0.42
	ρ gr/cm^3	Density	2.26
	µ	Poisson's ratio	0.39
	Ed Mpa	Young's Dynamic modulus	6590
	Gd MPa	Dynamic shear modulus	2367
	KdMpa	Dynamic bulk modulus	102311.68
	D Mpa	General deformation modulus	687.81
	τ Mpa	Hardness limit by compression	3.88

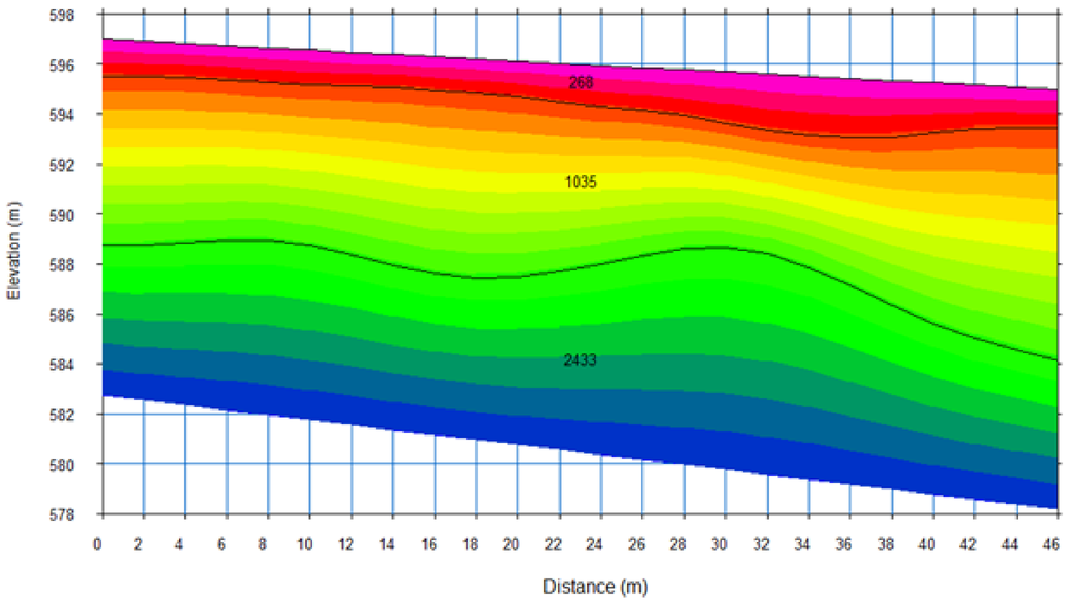


Fig. 10. Seismic cross section N 4.

Along with this, an experimental investigation of its depth was conducted in the area of the rupture. Based on the mathematical analysis of the received seismograms, it was determined that the depth of the open part of the fault is about 16 m. At the same time, the possible continuation of the opened part in depth is not excluded.

Conclusion:

1.The surface area of the moving landslide body is about 1.5 hectares, and the volume is about 225 thousand cubic meters.
2.The main rupture plane in the Main scarp of the landslide body is approximately 14-16 m deep;
3.The amount of horizontal displacement of the block landslide is about 2.30-2.40 m;
4.The analysis of the vertical electrical sounding curve allows us to assume that the clay layer begins at a depth of about 25-30 meters. This result is in quite good agreement with the results obtained by coring wells in the vicinity of VES.
5.Potentially humidity layers are separated on the presented vertical electrical sounding curve. In addition to the watered layers, the analysis of the vertical electrical sounding curve allows us to assume that the entire investigated underground space is characterized by high humidity, which may indicate the inflow of water from certain areas in the landslide body. Additional studies are needed to achieve high reliability of the results.
6. It is advisable to organize monitoring of unstable sections with different geological and geophysical methods in order to determine the speed of different sections of the landslide.
7. On the most moving block, it is advisable to install the patented, telemetric automatic multi-sensor early warning system created at the Institute of Geophysics (4). We consider installation of the system a must, because in the case of seasonally increased rainfall, activation of landslides is not excluded;
8. It is necessary to determine the underground water supply, for which it is necessary to continue the research using the natural electric field method and also conduct isotope analysis of the water moving in the landslide body.
9. It is necessary to avoid the landslide body as much as possible from the inflow of underground and surface waters, for which it is necessary to make an appropriate engineering decision (it may be a drainage arrangement). In order to effectively solve this task, it is necessary to determine the geometry of the groundwater feeding the landslide body. And, in order to determine the geometry of underground waters, it is necessary to conduct complex geophysical studies.

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მაჭავარიანის ქუჩის მეწყრის ელექტროსაძიებო და სეისმური მეთოდებით კვლევის შედეგები

ნ. ვარამაშვილი, მ. გიგიბერია, ჯ. ქირია, ნ. ღლონტი

რეზიუმე

გეოფიზიკური მეთოდების (სეისმური და ელექტრომაგნიტური) საშუალებით შესაძლებელია გეოლოგიური გარემოს სხვადასხვა მახასიათებლების დადგენა. სეისმური მეთოდები საშუალებას გვაძლევს დავადგინოთ გარემოს დრეკადი პარამეტრები (სიმკვრივე, პუასონის კოეფიციენტი, იუნგის დინამიური მოდული და ა.შ...), ხოლო ელექტრომიების მეთოდების საშუალებით შესაძლებელია გეოლოგიური გარემოს ელექტრომაგნიტური მახასიათებლების (წინააღმდეგობა, გამტარობა და ა.შ.) დადგენა. კომპლექსური ძიების შედეგებიდან შეიძლება გავაკეთოთ დასკვნები შესწავლილი ტერიტორიის აგებულების და დატენიანების შესახებ. ნაშრომში წარმოდგენილია ქ. თბილისში, მაჭავარიანის ქუჩაზე განვითარებულ მეწყერზე ჩატარებული კვლევების შედეგები. სეისმური კვლევები ჩატარდა გარდატეხილი ტალღების და სეისმური ტომოგრაფიის მეთოდით, ხოლო ელექტრული კვლევები - ვერტიკალური ელექტრული ზონდირების და ბუნებრივი ელექტრული ველის მეთოდებით. მიღებული შედეგების ანალიზის საფუძველზე, გაკეთებულია დასკვნები ქანების ბზარების სიღრმეების, ქანების მექანიკური მდგომარეობის, მათი გაწყლიანების და ასევე მიწისქვეშა წყლების ნაკადების შესაძლო არსებობის შესახებ.

საკვანძო სიტყვები: გრძივი ტალღები, განივი ტალღები, სეისმური ტომოგრაფია, ელექტრომიება, ვერტიკალური ელექტრული ზონდირება, ბუნებრივი ელექტრული ველი.

Результаты исследования оползня на улице Мачавариани методами электроразведки и сейсморазведки

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Резюме

С помощью геофизических методов (сейсмических и электромагнитных) можно определять различные характеристики геологической среды. Сейсмические методы позволяют определить упругие параметры среды (плотность, коэффициент Пуассона, динамический модуль Юнга и др.), а с помощью электроразведочных методов электромагнитные характеристики геологической среды (сопротивление, электропроводность и др.). По результатам комплексного поиска можно сделать выводы о структуре и влажности недр изучаемой территории. В статье представлены результаты исследований оползня, образовавшегося на улице Мачавариани в Тбилиси. Сейсморазведочные работы проводились методом преломленных волн и сейсмотомографии, а электроразведка – методами вертикального электрического зондирования и естественного электрического поля. На основании анализа полученных результатов сделаны выводы о глубинах залегания оползневых уступов, механическом состоянии горных пород, их влажности и возможном наличии потоков подземных вод.

Ключевые слова: продольные волны, поперечные волны, сейсмическая томография, электроразведка, вертикальное электрическое зондирование, естественное электрическое поле.

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Heavy Snow and Avalanches on the Territory of Georgia in 2014-2018

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ABSTRACT

Heavy snow and avalanches are frequent in Georgia during the cold period of the year. The development of these natural disasters is causing significant damage to the country's economy. Heavy snow and avalanches cause road closures and delays, damage to infrastructure, endanger human health.
The paper examines cases of heavy snow and avalanches for the period 2014-2018. Based on the data of the National Environment Agency, a table of cases of heavy snow and avalanches has been compiled by regions of Georgia.
Based on the table, a geo-information map of heavy snowfall and avalanches has been compiled for the study period, showing the municipalities where natural disasters occurred.
Cases of damage caused by heavy snow and avalanches in 2014-2018 are reviewed and described.

Key words: *Avalanche, heavy snow, natural disasters, geoinformation map.*

Introduction

Natural phenomena in Georgia are not so rare at any time of the year. Especially noteworthy is the winter period. It is a known fact that most of the territory of Georgia features mountainous and mountainous regions. Therefore, such natural phenomena as heavy snowfalls and avalanches cause significant damage to mountainous areas - they damage infrastructure, impede movement, and threaten civilians' health [1; 2]. The study of heavy snowfalls and avalanches is vital, given that developing winter resorts is one of the priority areas of the Georgian economy. Their position is especially noteworthy in recent times. Against the backdrop of climate change, which has been developing since the second half of the 20th century.

One can observe the activation of various natural phenomena. There are documents and studies dedicated to heavy snowfalls and avalanches, both now and in the past [3-5]. Preventing damage to them has always been on the agenda.

Materials and methods

This article briefly considers cases of heavy snowfalls and avalanches on the territory of Georgia in 2014-2018. Based on the available study, some characteristics of these cases are analyzed.
The data was provided by the National Environment Agency.
The study is processed using proven methods of mathematical statistics and probability theory in climatology.

Results

Heavy snowfalls and avalanches developed on the territory of Georgia with varying frequency and intensity in 2014-2018. All these cases are classified according to the regions and municipalities. They are present in a corresponding chart (Table 1). Table 1 also indicates the settlements and areas where heavy snowfall and avalanche cases have been recorded. As well as the processes during which the catastrophe developed.

Table 1. Distribution of heavy snowfall and avalanche cases in 2014-2018 on the territory of Georgia

Region	Municipality	Populated area	Causing process
Abkhazia	-	-	-
Adjara	Batumi, Khulo, Shuakhevi, Kbuleti, Khelvachauri, keda.	Batumi, Khulo, Shuakhevi, Goderdzi pass, Kobuleti, Khelvachauri, Bodzauri, Peria, Zeda gantiadi, Tsablana, 1 May, Zvare, Pushrukauli, Iakobidzeebi, Oshinakhevi, Khabelashvilebi	Western process, Cycle process
Imereti	Tskaltubo, Tkhibuli, Kharagauli	Tskaltubo, Naqerali pass, Moliti	Western process
Samegrelo-upper Svaneti	Mestia	Ushguli (Chdjashi), Djvari-khaishi part, Tetnulda	-
Racha-lechkhumi Lower Svaneti	Ambrolauri, Tsageri, Lentekhi, Oni	Tkhibuli-Ambrolauri road, Tsageri, Lentekhi, Oni-Shovi 15th km	Cycle process
Guria	Chokhatauri, Ozurgeti	Bakhmaro, Ozurgeti	Western process
Shida Qartli	-	-	-
Qvemo Qartli	-	-	-
Samtskhe-Javakheti	Ninotsminda, Akhaltsikhe, Adigeni	Akhaltsikhe, Ninotsminda, Adigeni.	Cycle process, Western process
Mtskheta-Mtianeti	Dusheti, Stepantsminda	Jinvali-barisakho road, Pshavi (chargali), Ananuri, Pasanauri, Gudauri, Nabeglavi, Mleta, Djuta, Khanobi, Jvari pass besides the Traverta, Arakhvneti, Kobi- 1 and 2 inbetween tunnels, Kobigudauri kobi, Mleta, Bedoni.	Cycle process, Increase of the snow height intensively, Thermal process, Dramatic increas of the temperature
Kakheti	Akhmeta	Tusheti road	East process

Table 1 shows that, compared to other regions in Georgia in the Adjara and Racha-Lechkhum Kvemo Svaneti, cases of heavy snowfalls and avalanches are more frequent.

During the study period, natural disasters were registered in all municipalities. Western processes in the area were the main causes of heavy snowfalls and avalanches area. Dusheti and Stepantsminda municipalities of the Mtskheta-Mtianeti region are also exceptional on the mentioned topic, where natural disasters were observed in dozens of places, on central and internal highways, passes, and crossings. Within all the processes that cause heavy snowfalls and avalanches, The research contains a sharp increase in temperature, a thermal process, intense snowfall, etc. records For the Mtskheta-Mtianeti region.

Based on Table 1, we have compiled a geoinformation map (. 1), which shows the distribution of cases of heavy snowfalls and avalanches in 2014-2018. by municipalities in the territory of Georgia.

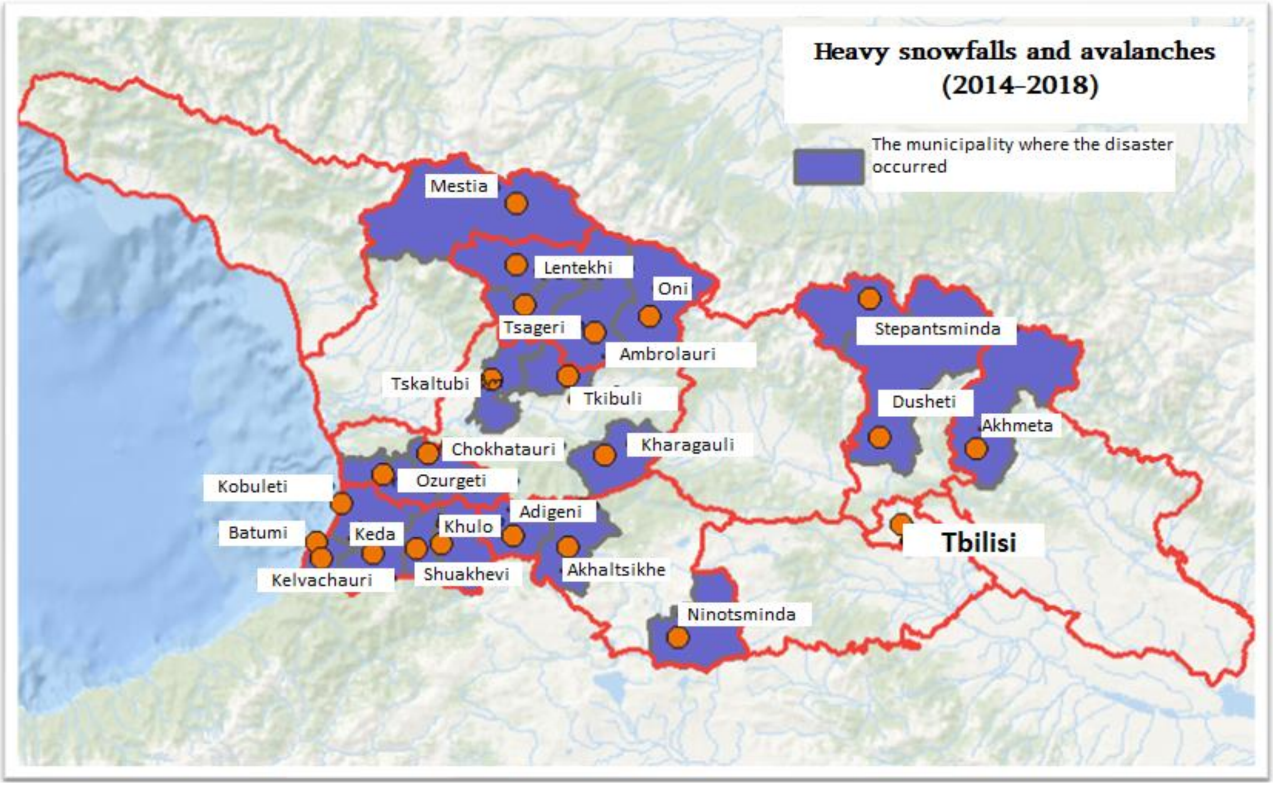

Fig.1. Heavy snowfalls and avalanches, according to municipalities from 2014-2018 years

The map represents territories and municipalities with heavy snowfalls and avalanches recordings in 2014-2018. In some cases of which, heavy snowfalls and avalanches caused damage to settlements or road infrastructure. Accordingly, the Geoinformation map is built with this exact information. As mentioned, heavy snowfalls and avalanches are among the natural disasters that destroy infrastructure, cause loss of life, causing significant damage and loss to the country, especially to municipalities in mountainous and high mountain areas. The list of such cases is numerous, from 2014-2018. Here is a description of some cases, provided by the National Environment Agency:

Five extremists got caught, and unfortunately, four of them passed away during the avalanche in the municipality of the Mestia (Chadjimi) in 2014 on 7 march;

Four civilians got caught during the avalanche in the Chokhatauri municipality, the disaster caused the death of one of them sadly;

In 2016 on 12 December, an avalanche in the Svaneti caused the death of one civilian, the disaster took place at the connecting road of Khashimi and Jvari, a local civilian was driving the minibus when he got caught in the avalanche.;

In 2017 on the 2nd of January, heavy masses of snow demolished the house of a local and caused an unfortunate death;

In 2017 on 13 March, the extrimist got caught under the masses of snow caused by an avalanche and passed away, tragedy took place in Khazbegi municipality;

In 2017 on 14 May, one civilian passed away due to an avalanche in Tusheti, on the 43km road of Pshaveli-Omali;

In 2018 on the 4th of January, extremists got caught in an avalanche and passed away in Tetnuldi mountain resort.

In 2016, on 24 January in Batumi snow coat was one meter high. The seaside town was practically paralyzed transportation was hardly possible on main roads only with specific automobiles. In Adjara, Heavy snowfall caused electron energy blackouts for about 1500 locals. The light source got cut out for the Batumi and Khelvachauri regions as well.

2017s heavy snowfall on the 1st of January caused the village Zemo Peria, Municipality of Khelvachauri, a fatal tragedy the civilian got caught up in the ruins of his house and passed away.

The cases described and the damage from natural disasters that are shown in these cases indicates, how important it is to take various preventive measures and reduce the consequences of expected heavy snowfalls and avalanches.

Conclusion

A study that covers the 2014-2018 years of analysis of the heavy snowfalls and, avalanches, shows natural disaster circulates in Adjara and Racha-Lechkhumi Qvemo Svaneti most of the time when it comes to western Georgian regions, but for the eastern regions of Georgia Mtskheta-Mtianeti region, especially in Dusheti and Kazbegi municipalities.

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The study report was represented at the II International Scientific Conference Landscape Dimension of Sustainable Development: Science, CartoGis, Planning, Governance, which was held on September 12-16 in Tbilisi, st. Javakhishvili of Tbilisi State University, and was dedicated to the 75th anniversary of the birth of the outstanding Georgian geographer-cartographer, Professor Nikoloz (Niko) Beruchashvilis' 75th anniversary of his birth. The abstract of the article is published in the collection of conference abstracts (pp. 211-212), in Georgian and English languages. (https://icldscartogis.tsu.ge/assets/media/uploads/images/abstracts_book_2022.pdf).

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დიდთოვლობა და ზვავები საქართველოს ტერიტორიაზე 2014-2018 წლებში

ნ. ბეგლარაშვილი, ს. გორგიჯანიძე, ნ. კობახიძე, მ. ფიფია, ვ. ჩიხლაძე, ი. ჯანელიძე, გ. ჯინჭარაძე

რეზიუმე

საქართველოს ტერიტორიაზე დიდთოვლობა და ზვავები წელიწადის ცივ პერიოდში ხშირი მოვლენაა. ამ სტიქიური მოვლენების განვითარება იწვევს მნიშვნელოვან ზარალს ქვეყნის ეკონომიკისთვის. დიდთოვლობა და ზვავები იწვევს გზების გადაკეტვასა და გადაადგილების შეფერხებას, ინფრასტრუქტურის დაზიანებას, საფრთხის ქვეშ აყენებს ადამიანთა ჯანმრთელობას.

ნაშრომში შესწავლილია დიდთოვლობისა და ზვავების შემთხვევები 2014-2018 წლების პერიოდისთვის. გარემოს ეროვნული სააგენტოს მონაცემების საფუძველზე შედგენილია დიდთოვლობისა და ზვავების შემთხვევათა ცხრილი საქართველოს რეგიონების მიხედვით.

ცხრილზე დაყრდნობით, საკვლევი პერიოდისთვის შედგენილია დიდთოვლიანობისა და ზვავების გეოინფორმაციული რუკა, რომელიც ასახავს იმ მუნიციპალიტეტებს სადაც განვითარდა სტიქიური მოვლენები.

განხილულია და აღწერილია 2014-2018 წლებში დიდთოვლობისა და ზვავების შედეგად მიყენებული ზარალისა და ზიანის შემთხვევები.

საკვანძო სიტყვები: ზვავი, ძლიერი თოვლი, სტიქიური უბედურებები, გეოინფორმაციული რუკა.

Сильные снегопады и лавины на территории Грузии в 2014-2018 гг.

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Резюме

На территории Грузии в холодный период года нередки сильные снегопады и сход лавин. Развитие этих природных явлений наносит значительный ущерб экономике страны. Сильные снегопады и лавины приводят к перекрытию дорог и нарушению движения, повреждению инфраструктуры, созданию опасности для здоровья людей.

В работе рассмотрены случаи сильных снегопадов и лавин за период 2014-2018 гг. На основании данных Национального агентства по окружающей среде составлена таблица случаев сильных снегопадов и сходов лавин по регионам Грузии.

На основании таблицы составлена геоинформационная карта обильных снегопадов и лавин за исследуемый период, на которой отмечены муниципальные образования, где происходили стихийные бедствия.

Обсуждаются и описываются случаи убытков и повреждений, вызванных обильными снегопадами и лавинами в 2014-2018 гг.

Ключевые слова: лавина, сильный снегопад, стихийные бедствия, геоинформационная карта.

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Study of Tbilisi City Atmosphere Pollution with PM2.5 and PM10-Microparticles During COVID-19 Pandemic Period

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ABSTRACT

Temporal and spatial variations of PM2.5 and PM10 concentrations in Tbilisi city atmosphere during pandemic period (2020-2021) are studied through analysis of routine observations, experimental measurement data, and numerical modeling. Maximum, minimum and average monthly values of concentrations are determined. It is shown that hourly variation of concentration is characterized with two maximums in the intervals between 9-10 and 18-21 hours and by one minimum from 0 to 6 h. It is established that measures related to "Lockdown" cause significant reduction of microaerosols concentration in urban air. It is shown that a change of their concentrations varies near the average values peculiar for automobile roads. Sharp increase of concentration values is observed at some road sections that is caused by local ecological conditions. Kinematics of PM2.5 and PM10 concentration changes induced by motor transport at Tbilisi city territory is explored using 3D model of admixture transfer-diffusion in the atmosphere. Diurnal pattern of dust spatial distribution is studied. Concentration values obtained via modeling are within the limits of values received through routine observations. It is established that a disposition of heavily polluted areas depends on motor transport traffic intensity, highways location, and local circulation systems formed by the dynamic influence of terrain and diurnal change of thermal regime at the underlying surface.

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Key words: *atmosphere, pollution, numerical modeling, concentration, PM*

Introduction

PM2.5 and PM10 microparticles are the main ingredients of environment pollution with high risk factor for human health. Prolonged presense of dust and microparticles in the atmosphere causes not only significant deterioration of human health, but also millions of deaths. Atmospheric air pollution with PM2.5 and PM10 particles is especially dangerous under conditions of COVID-19 pandemic. Scientific investigations show that microaerosols as COVID-19 virus carriers with great permeability into human organism are very hazardous for public health [1-7].

Negative impact of PM2.5 and PM10 is particularly strong in large cities and industrial centers, where a potential of atmosphere pollution with aerosols is very high. Though, Tbilisi is not ranked among the 500 most contaminated cities of the world [8], but according to data of National Environmental Agency of Georgia [9] PM2.5 and PM10 concentrations in Tbilisi city atmosphere reach and in some cases even exceed the values of maximum permissible concentrations (MPC). Presumably, a high mortality level caused by viral diseases in 2020-2021 in Georgia is partly resulted from this circumstance. Therefore, the study of temporal variation and spatial distribution of PM2.5 and PM10 in Tbilisi city atmosphere is of great importance for elaboration of practical measures aimed to human health and environment protection.

Research method

Some issues of temporal and spatial variation of dust propagation in Tbilisi city atmosphere are discussed in the works [10-13]. The impact of restrictions on the movement of road transport on air pollution in Tbilisi in the spring of 2020 due to the COVID-19 coronavirus pandemic is discussed in [14]. Due to small size and very low precipitation rate (<1 mm/sec) of PM2.5 and PM10, atmospheric distribution of microparticles under complex terrain conditions differs from dust propagation. The current work deals with the problems of atmospheric pollution of Tbilisi city and adjacent territories with PM2.5 and PM10 under conditions of restrictions related to COVID-19 pandemic by means of analysis of routine observations, experimental measurements data, and numerical modeling.

Research results

In Fig. 1 there are shown monthly absolute maximum, minimum and average PM concentrations in Tbilisi city atmosphere in 2020, which are obtained according to data of operating supervision carried out by the National Environmental Agency of the Ministry of Environmental Protection and Agriculture of Georgia [9]. It is seen from Fig. 1, that as a rule, concentrations of PM2.5 particles in Tbilisi atmosphere are 2-4-times less than PM10 concentrations, and their change curve behaviour is similar (Fig. 1). In case of routine pace of everyday life, maximum values of concentration almost always exceed the corresponding MPCs, minimum concentrations are always less than MPC, while average values surpass the respective MPCs in winter period only.

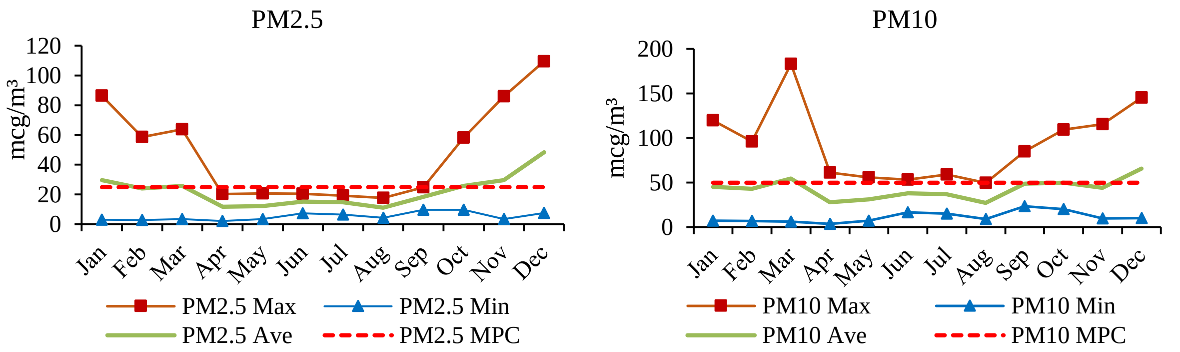

Fig. 1. Monthly absolute maximum, minimum and average PM2.5 and PM10 concentrations in Tbilisi city atmosphere in 2020.

Fig. 2 shows the diagram of hourly motion for last 5 days of November 2020. It is seen from Fig. 2 that from 26 to 28 day of the month inclusive, low concentrations are registered. Concentration drop is related to measures foreseen by the Lockdown (during the second pandemic wave) that were introduced starting from November 24: motor transport traffic restriction, closing of stores, shift to remote working for many public services etc. On November 29, so-called "Black Friday", transport traffic was sharply increased that respectively caused the rise in microparticles concentrations. Maximum PM2.5 concentration reached 136.59 mcg/m^3 within 2 days, while PM10 concentration – 186.54 mcg/m^3, that 4- and 5-times exceeds their respective MPCs.

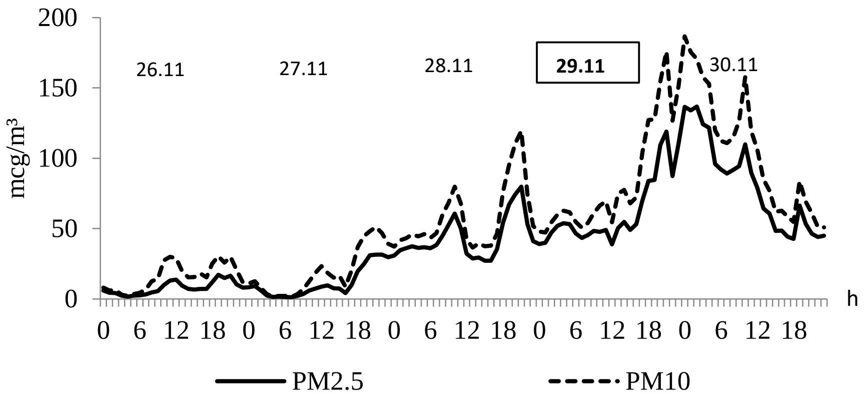

Fig. 2. Hourly motion of PM2.5 and PM10 concentrations on November 26-30, 2020 at observation point of monitoring situated at Tsereteli Avenue.

Experimental route measurement of PM2.5 and PM10 concentrations were conducted at main trunk roads of Tbilisi and its adjacent territories. Concentration values were determined using portable devices

„Aeroqual Series 500“ and „TROTEC PC220“ with 10 minute averaging. In Fig. 3 there are shown average values of concentrations obtained through measurements carried out in summer period of 2020 and 2021 from 9AM to 10PM.

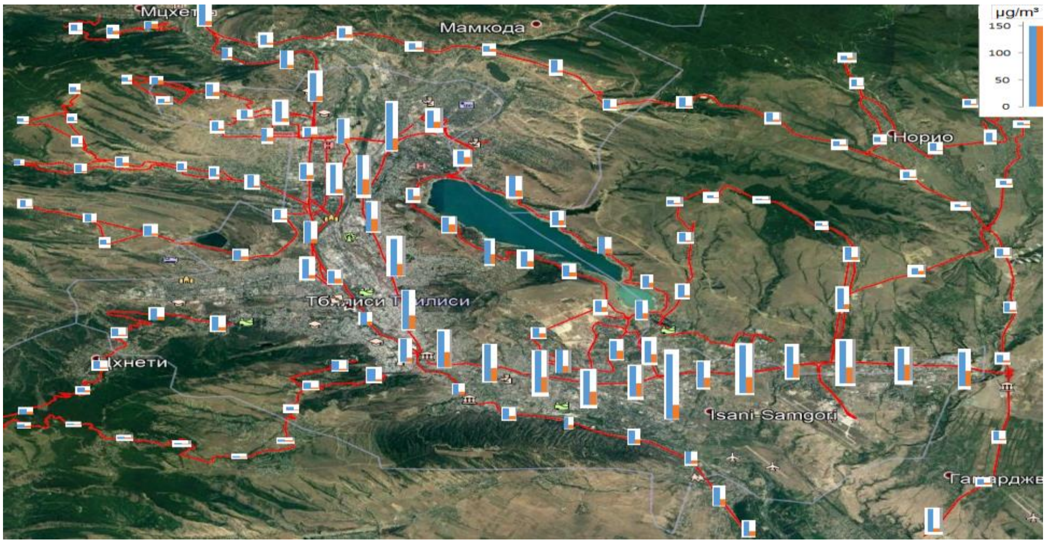

Fig. 3. Column-type diagram of PM2.5 and PM10 concentrations obtained via field measurements in Tbilisi city and adjacent territories (dark blue – PM10, red – PM2.5)

It is seen from Fig. 3 that microaerosols concentrations in daylight hours are high throughout the length of the central part of the city, in the surroundings of trunk roads, passing along Mtkvari River embankment, as well as Kakheti Highway, and Vake-Saburtalo, Gldani, TEMKA, Ortachala districts. Relatively fewer concentrations are obtained in the neighborhood of Tbilisi Sea. Concentration values in the high pollution area reach 1 MPC, while at less urbanized territories located out of the city, concentrations are less than 0.3 MPC.

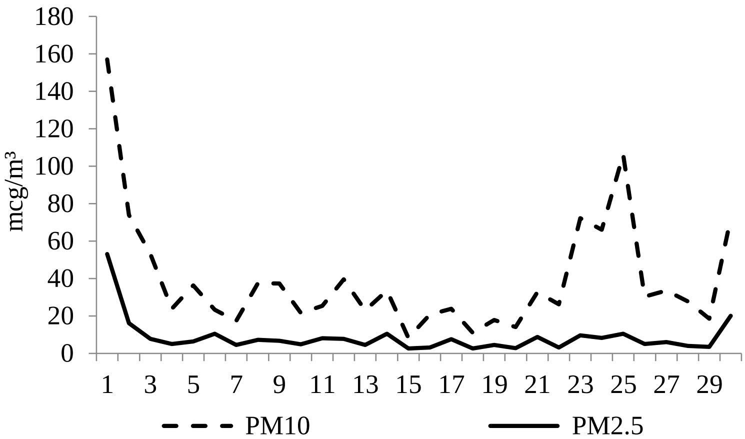

Fig. 4. PM2.5 and PM10 concentration values at the automobile road: Gldani bridges, Beliashvili Str., Vakhushti Bridge, Gagarin Str., Gelovani Ave., hospitals, Didi Digomi, on 21.10.2020 (N – sequential number of a measurement point)

Microaerosols concentration along some automobile roads depends on both motor transport traffic intensity and local peculiarities. Fig. 4 shows a concentration change at the road connecting Gldani bridges with Didi Digomi. It is seen from Fig. 4 that microaerosols concentration at major part of the road is less than MPC and varies within average values, and concentrations are especially high in the vicinity of Gldani bridges and Didi Digomi (Gelovani Highway). High concentration values at the mentioned sections are caused by “rush-hour”-like situation existing at the moment of observation, and by current repair and construction works.

Microaerosols concentrations change within the similar limits in the neighborhood of other main trunk road of Tbilisi, depending on respective local peculiarities.

In order to investigate the temporal and spatial evolution of microaerosols, PM2.5 and PM10 distribution in Tbilisi and adjacent territories is modeled by means of 3D numerical model [11]. Numerical grid of high resolution ability with 300 and 400 m horizontal steps along parallel and meridian is used. Vertical step varies from 0.5 to 15 m in the 100 m thick surface layer of the atmosphere, while in the atmospheric boundary layer and free atmosphere a vertical step is equal to 300 m. As far as there are no atmosphere-polluting large industrial enterprizes in Tbilisi city, it is assumed that a main source of atmosphere contamination is represented by microparticles generated and sprayed due to motor transport traffic. PM2.5 and PM10 concentrations change is modeled for 72 hours in cases of meteorological situations peculiar for the region.

Numerical modeling showed that in summer, during light background south air, a spatial distribution of PM2.5 in the atmosphere in 0-6 h time interval is not uniform. Its concentration at the major part of the city is within 0.001-0.1 mcg/m^3 at 2 m height from the Earth surface. In the city center, at the territories of Vake, Saburtalo districts, in the neighborhood of Tsereteli Avenue, Kakheti Highway and trunk roads connecting Tbilisi and Rustavi, PM2.5 concentrations vary from 1 to 5 mcg/m^3. Above 100 m, concentration reduction takes place and its value at 600 m altitude doesn't exceed 1 mcg/m^3.

Fig. 5 shows the fields of wind velocity and PM2.5 concentration obtained through numerical integration at 2, 100 and 600 m height above ground level at t = 9, 12, and 15h in case of light background south air. It was obtained that after 6AM, PM2.5 concentration increases at the entire territory of the city with increase of motor transport traffic intensity. Concentration growth is not uniform. It is especially high in the city center, in Vake and Saburtalo districts. At these territories, at 9AM, concentration value at 2 m height in the surface layer of the atmosphere varies within the limits of 25-35 mcg/m^3. After 9AM, concentration reduces in the main pollution areas and quazi-stationary distribution of microaerosols establishes. A slight positive vertical gradient is characteristic for obtained distribution at 100 m thick boundary layer, and a slight negative gradient – above 100 m altitude.

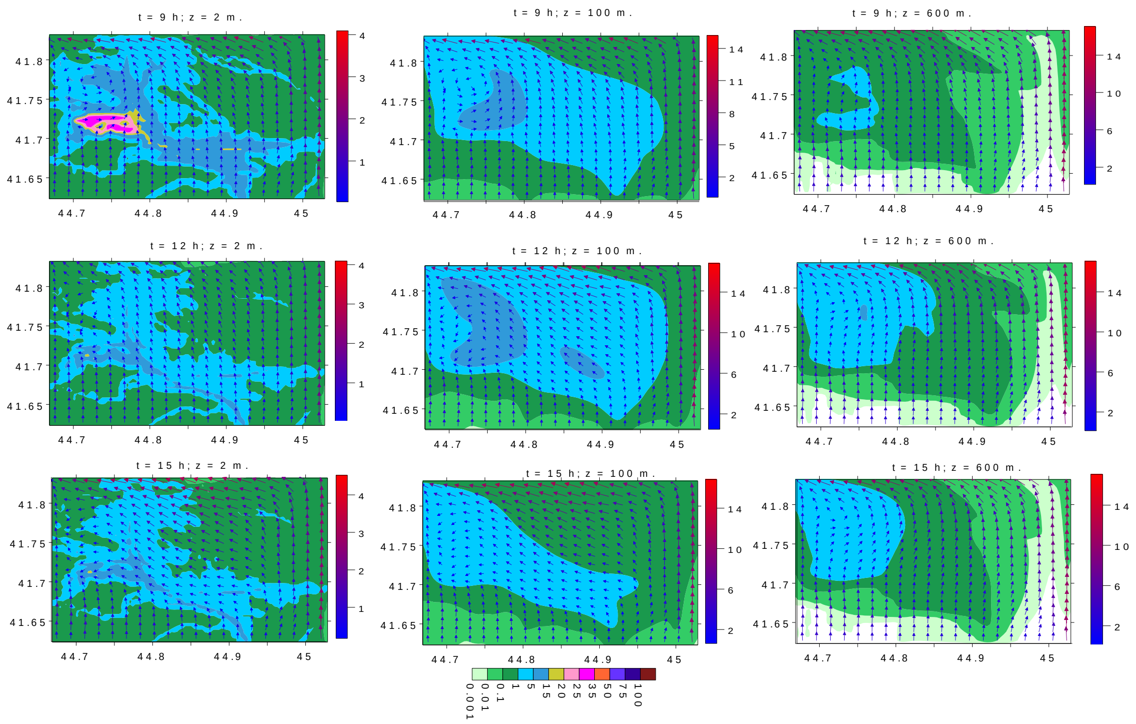

Fig. 5. Wind velocity (m/sec) and PM2.5 concentration (mcg/m^3) fields in summer, in the surface and boundary layers of the atmosphere, when t = 9, 12, and 15 h.

In the time interval from t = 15h to 21 h, takes place a sharp increase of PM2.5 concentration, which is caused by the second "rush-hour"-like situation of motor transport traffic (Fig. 6). Concentration increase at

2 m height from the Earth surface at t = 18h is obtained in Vake and Saburtalo districts. Concentration changes within the limits of 25-35 mcg/m^3. Concentration rise is relatively lesser at some small-size areas of Rustaveli and Gorgasali Avenues, Kakheti and Rustavi Highways, Ortachala and Ponichala. From t = 18h to 21 h, PM2.5 concentration is getting smaller at relatively highly polluted areas. Vertical turbulent and convective diffusion of aerosol particles occurs with ground-level concentration increase and, as a result, PM2.5 content increases at 100 and 600 m heights. At these levels, maximum concentration values by t = 18h become equal to 20 and 15 mcg/m^3. After t = 18 h, at 2 m height a slow reduction of concentration begins and at 100 m height its rise lasts. When t = 24h, such a vertical distribution of microaerosols establishes, during which PM2.5 concentration at 100 m height is higher than those obtained at 2 and 600 m altitude. As for time variation of pollution, the process repeats on a quasi-periodic basis after t = 24h.

A vertical distribution of PM2.5 concentration in the surface layer of the atmosphere, in three vertical cross-sections made along the parallel, is shown in Fig. 7, from where is seen that in the period from t = 3h to 6 h, PM2.5 concentration in the surface layer of the atmosphere is less than 5 mcg/m^3 and is characterized by slight reduction trend. After t = 6 h, aerosol concentration in the surface layer is getting higher with motor transport traffic intensity growth and by t = 9 h, average and high pollution zones form. They have quite large vertical and horizontal sizes and include almost entire surface layer. From t = 9h to 15 h time period, despite a fixed amount (9-12 h) and small reduction (12-15 h) of aerosols, entering into the atmosphere, takes place substantial reduction of concentration and air quality improvement. Sharp increase of ground-level concentration is registered in t = 16-21 h time interval. In this timespan, maximum value of concentration near the earth ground reaches 50 mcg/m^3 at small area. Through analysis of vertical distribution of PM2.5 concentration at various points of time one can conclude that in case of light background air the prevailing mechanism of aerosol propagation is represented by vertical and horizontal diffusion into the surface layer of the atmosphere. Turbulent flows take aerosols away from the surface layer to the boundary layer, where an advective transfer causes pollution dispersing at large areas and air self-purification. In high pollution zone, in the second half of a day, an important role is played by convective transfer, during which a heated air mass starts an intensive ordered relocation upward vertically from the earth ground and takes along available microparticles.

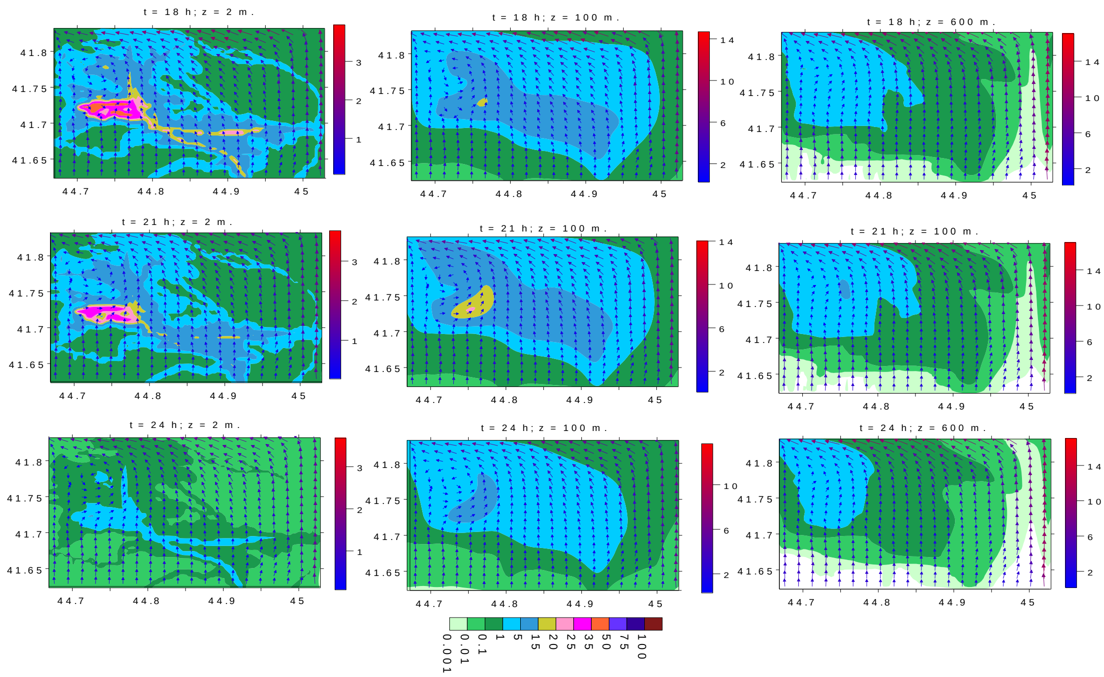

Fig. 6. Wind velocity (m/sec) and PM2.5 concentration (mkg/m^3) fields in summer, in the surface and boundary layers of the atmosphere, when t = 18, 21, and 24 h.

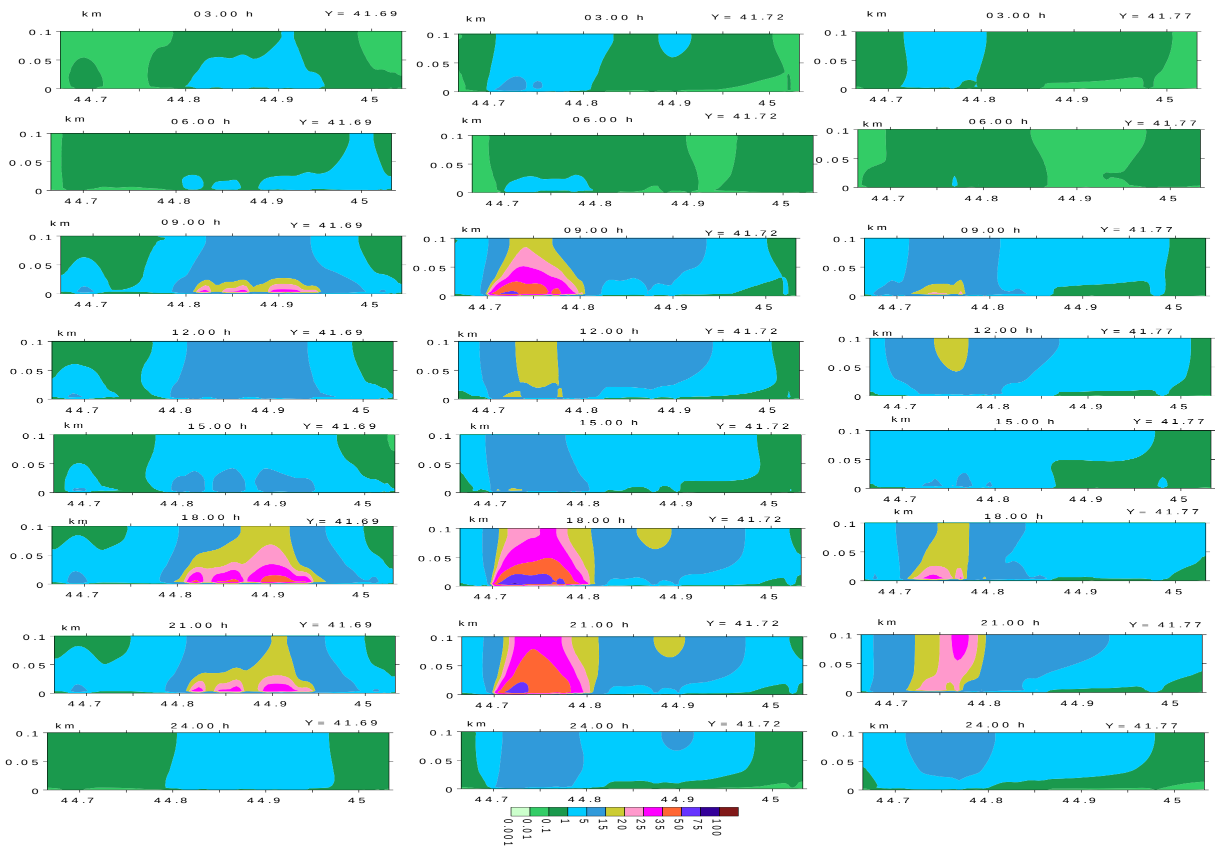

Fig. 7. PM2.5 concentration isolines in three vertical cross-sections made along the parallel in the lower 100 m thick atmospheric layer.

The picture similar from the viewpoint of temporal change and significantly different according to spatial distribution was obtained in winter, during numerical modeling of PM10 distribution in case of light background south air. The similarity lies in the pattern of concentration's temporal variation. In particular, it was established that a pollution level is minimal in time interval from t = 0 h to 6 h and maximal – during rush-hour situations (t = 9-10 h and 18-21 h).

When t = 9h, concentration is relatively high at 2 m height above ground level, both at main trunk road and urbanized territories, and in the suburbs. 25-40 mcg/m^3 concentration is obtained in the neighborhood of Vake, Saburtalo, Gldani, TEMKA districts and near Guramishvili Avenue, Kakheti and other highways. Pollution level increase takes place at 100 m altitude from the earth surface, as well, and in relatively small amount at 600 m height. Concentration values at 100 and 600 m heights are within the limits of 20-30 mcg/m^3 and 10-15 mcg/m^3.

In time interval from t = 9 h to 15 h a slight reduction of concentration is obtained. It is related to reduction of transport traffic intensity and to approach of formed local anticyclonic whirl center to the sources of pollution. The same situation occurs at 100 and 600 m height above ground level. Calculations showed that maximum values of PM10 concentration are equal to 20-25, 10-15 and 5-10 mcg/m^3 at 2, 100 and 600 m altitudes from earth surface, respectively. At 100 m height from earth surface, the difference between concentration distributions at t = 9h and 12 h is very small.

After t = 16h the ground-level concentration starts to rise. This increase is primarily noticeable at 2 m height. At 100 and 600 m altitudes concentration growth virtually has no place. By t = 18h PM10 concentration at 2 m height from earth surface equals to 35-40 mcg/m^3 in the vicinity of Vazha-Pshavela, Chavchavadze, Rustaveli avenues, Liberty and Erekle squares. Near other central avenues, concentration reaches 30 mcg/m^3 (Fig. 8).

Especially rapid growth of atmosphere pollution with PM10 takes place after t = 18h. Intensive growth of pollution occurs not only in the central part of the city, but also on the periphery: Gldani and TEMKA districts, surroundings of Ortachala and Ponichala, Rustavi and Kakheti highways etc. When t = 21 h, maximum concentration values are high at some small-size areas of polluted territory and they vary within 80-100 mkg/m^3, while at other heavily polluted territories – in the range of 50-70 mcg/m^3.

Ground-level concentration rise is accompanied with its growth in the upper surface layer and lower boundary layer of the atmosphere. When t = 21h, concentration values equal to 20-25 mcg/m^3 and 5-10 mcg/m^3 at 100 and 600 m height above ground level, respectively. The area of increased pollution is of horseshoe-shaped (U-shaped) form and covers large territory of the central and northern parts of the city. At 600 m height, the area of increased pollution occupies an eastern part of modeling area. After t = 21 h, a rapid decrease of ground-level pollution begins, due to which the ground-level concentration value drops to 5 mcg/m^3. The similar process takes place at 100 and 600 m altitudes, as well.

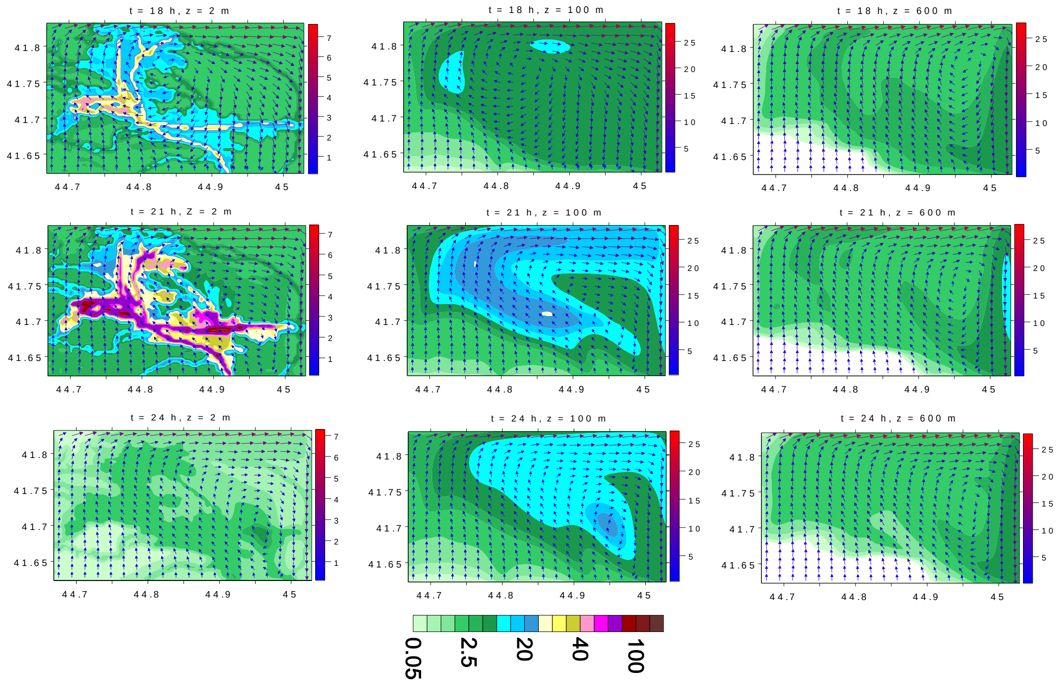

Fig. 8. Wind velocity (m/sec) and PM10 concentration (mcg/m^3) fields in winter, in the surface and boundary layers of the atmosphere, when t = 18, 21, and 24 h

Conclusion

Temporal and spatial variation of PM2.5 and PM10 concentrations in the surface and boundary layers of atmospheric air at main trunk roads of Tbilisi city and adjacent territories in 2020 and 2021 is studied through analysis of routine observations and experimental measurement data. Monthly values of maximum, minimum and average concentration are determined. It is shown that hourly variation of concentration is characterized by two maximums in t = 9-10 h and 18-21 h time intervals. It is established that measures related to Lockdown cause significant reduction of microaerosols concentration in urban air. The pattern of concentration change along the main automobile roads of the city is determined. It is shown that concentration values oscillate near the average magnitudes peculiar for the automobile road. Sharp increase of concentration values is registered in some places that is associated with particular local conditions created at the time of measurement (traffic jam, repair and construction works etc.).

Kinematics of PM2.5 and PM10 concentration change generated by motor transport at the territory of Tbilisi city under summer and winter conditions, in case of light background south air is explored through numerical modeling. Diurnal pattern of dust spatial distribution is studied. Concentration values are determined via modeling, and they are within the limits of values obtained through routine observations. It is established that a spatial distribution of heavily polluted areas depends on motor transport traffic intensity, trunk roads location, on one hand, and on dynamic impact of terrain and on local circulation systems formed by diurnal change of thermal regime at the underlying surface.

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ქ. თბილისის ატმოსფეროს PM2.5 და PM10 -მიკრონაწილაკებით დაბინძურების გამოკვლევა COVID-19-ის პანდემიის პერიოდში

ვ. კუხალაშვილი, მ. ფიფია, ნ. გიგაური,
ა. სურმავა, ლ. ინწკირველი

რეზიუმე

რეგულარული დაკვირვებების და ექსპერიმენტული გაზომვების მონაცემების ანალიზით შესწავლილია 2020 და 2021 წლებში ქ. თბილისის ძირითადი ტრასებზე და მიმდებარე ტერიტორიებზე ატმოსფერული ჰაერის მიწისპირა და სასაზღვრო ფენაში PM2.5 და PM10-ის

კონცენტრაციების დროსა და სივრცეში ცვლილება. ნაჩვენებია, რომ კონცენტრაციის საათობრივ ცვლილებას ახასიათებს ორი მაქსიმუმი დღის 9-10 სთ და 18-21 სთ-ის ინტერვალში. მიღებულია , რომ ,,Lockdown“-თან დაკავშირებული ღონისძიებები იწვევს ქალაქის ჰაერში მიკროაეროზოლების კონცენტრაციის მნიშვნელოვან შემცირებას. ნაჩვენებია, რომ კონცენტრაციების სიდიდეები ირხევიან ტრასისათვის მახასიათებელი საშუალო მნიშვნელობების მახლობლობაში.
რიცხვითი მოდელირებით შესწავლილია მტვრის სივრცული განაწილების დღეღამური სურათი ზაფხულის და ზამთრის პირობებში, სამხრეთის სუსტი ქარის დროს. მიღებულია კონცენტრაციების მნიშვნელობები, რომლებიც რეგულარული დაკვირვებებით მიღებული სიდიდეების ფარგლებშია. დადგენილია, რომ ძლიერად დამტვერიანებული არეების სივრცული განაწილება დამოკიდებულია: ავტოტრანსპორტის მოძრაობის ინტენსივობაზე, ავტომაგისტრალების მდებარეობაზე, რელიეფის დინამიკური ზემოქმედებით და ქვეფენილ ზედაპირზე თერმული რეჟიმის დღეღამური ცვლილებით ფორმირებულ ლოკალურ ცირკულაციურ სისტემებზე.

საკვანძო სიტყვები: ატმოსფერო, დაბინძურება, რიცხვითი მოდელირება, კონცენტრაცია, PM

Исследование загрязнения атмосферы г.Тбилиси микрочастицами PM2.5 и PM10 в период пандемии COVID-19

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Резюме

На основе анализа данных регулярных наблюдений и экспериментальных измерений в 2020-21 годах изучено изменение во времени и пространстве концентраций PM2.5 и PM10 в приземном слое атмосферного воздуха на основных автомагистралях г. Тбилиси и прилегающих территориях. Показано, что почасовое изменение концентрации характеризуется двумя максимумами в интервале 9-10 и 18-21 часов. Получено, что мероприятия, связанные с ,,Lockdown“-ом, приводят к значительному снижению концентрации микроаэрозолей в воздухе города. Показано, что уровни их концентраций колеблются в районе средних значений, характерных для автомагистралей.
Методом численного моделирования изучена суточная картина пространственного распределения пыли в летних и зимних условиях, при слабых южных ветрах. Полученые значения концентраций находятся в пределах значений, полученных при регулярных наблюдениях. Определено, что пространственное распределение сильно запыленных участков зависит от интенсивности движения автотранспорта, расположения автомобильных дорог, динамического воздействия рельефа и суточной смены термического режима на подстилающей поверхности.

Ключевые слова: атмосфера, загрязнение, численное моделирование, концентрация, PM.

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Some Results of a Study of the Relationship Between the Mean Annual Sum of Atmospheric Precipitation and Re-Activated and New Landslide Cases in Georgia Taking into Account of Climate Change

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ABSTRACT

Some results of statistical analysis of long-term variations of annual amount of atmospheric precipitation for 21 meteorological stations of Georgia (P) located in areas with landslides, average annual amount of precipitation for these stations (P_a), relationship between the P_a and number of re-activated and new cases of landslides (LS), and the estimated values of LS up to 2045 using predictive data on P_a are presented. Data from the Environmental Agency of Georgia on the P in period 1936 - 2020 and data on LS in period 1996 – 2018 are used.
The forecast of P_a using the AAA version of the Exponential Smoothing (ETS) algorithm was carried out.
In particular, the following results are obtained.
The correlations between the annual amounts of P at each of the meteorological stations with averaged data for all 21 stations P_a are established.
In 1981-2020, compared with 1936-1975, no significant variability of the mean P values is observed at 11 stations, an increase - at 6 stations, and a decrease - at 4 stations. The P_a value do not change during the indicated time periods.
The forecast of the P_a value up to 2040 were estimated taking into account the periodicity of precipitation variability, which is 11 years.
A cross-correlation analysis of the time series of the P_a and LS values showed that the best correlation between the indicated parameters is observed with a five-year advance of precipitation data. With this in mind, a linear regression equation was obtained between the five-year moving average of the P_a and the five-year moving average of the LS values.
Using this equation and predictive P_a data, five-year moving averages of re-activated and new landslides cases up to 2045 were estimated.

Key words: *atmospheric precipitation, landslides, climate change.*

Introduction

Landslides are one type of disaster. Landslide processes are widespread almost everywhere and are dangerous due to damage, often accompanied by human casualties [1,2]. This problem is also very relevant for Georgia, where the number of landslides included in the cadastre reaches 7000 [3]. Therefore, special attention has always been paid to the study of landslide processes in this area [4–10].

Landslide phenomena depend on many separate and complex processes, in particular, on atmospheric precipitation [3,11,12]. At the same time, the time scale of the influence of atmospheric precipitation on the provocation of landslides has a wide range - from several tens of minutes to several days, months and years (climatic time scale). Thus, in [13], it was found that in Georgia, with an increase in the annual amount of atmospheric precipitation, there is a tendency for an increase in the number of landslides in accordance with the second degree of the polynomial. In another work [14], in particular, it was found that with an increase in the monthly amount of precipitation, a linear trend of an increase in the number of landslides is observed.

This work is a continuation of previous studies [13,14]. Below are the results of a study of the relationship between the average annual precipitation (Pa) for 21 meteorological stations and the number of re-activated and new landslides (LS) in Georgia, and an assessment of the LS values until 2045 using predictive data on Pa.

Study Area, Materials and Methods

Study Area – Georgia. Data from the Environmental Agency of Georgia on the annual amount of atmospheric precipitation for 21 meteorological stations of Georgia located in areas with landslides (fig. 1) and data on re-activated and new landslides cases (fig. 2) are used. Period of observation: for atmospheric precipitation from 1936 to 2020, for re-activated and new landslides cases from 1996 to 2018.

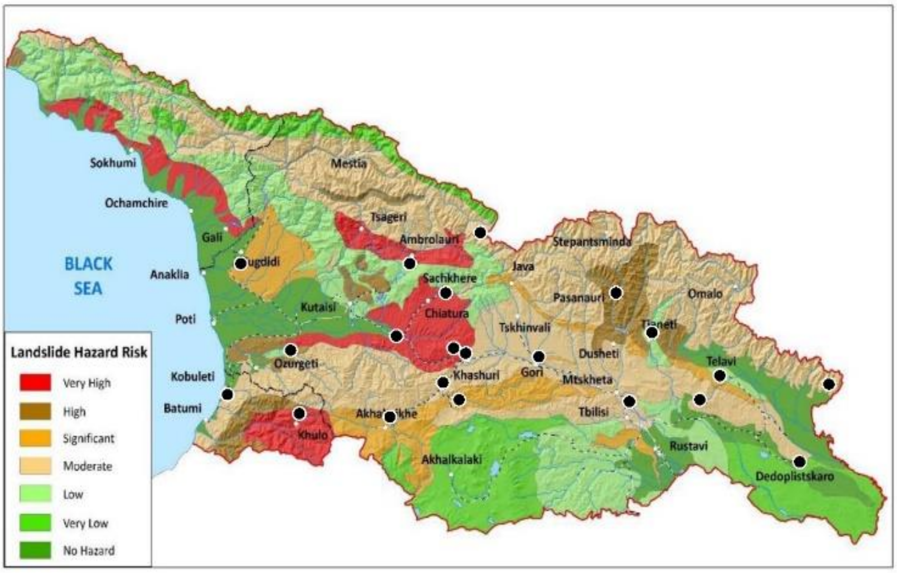

Fig 1. Location of 21 meteorological stations on the landslide risk zones map of Georgia by probability and damage.

In the proposed work the analysis of data is carried out with the use of the standard statistical analysis methods.

The following designations will be used below: Mean – average values; Max - maximal values; Min – minimal values; Range – Max-Min; St Dev - standard deviation; St Err - standard error; Cv – coefficient of variation = 100·St Dev/Mean, %; Conf. Lev. - confidence level of the mean; Low and Upp – lower and upper levels of the confidence interval of the mean; R – coefficient of linear correlation; CR - coefficient of cross correlation; α - the level of significance; P - annual sum of atmospheric precipitation for separated meteorological station; Pa - mean annual sum of atmospheric precipitation for 21 meteorological stations; LS - re-activated and new landslides cases. Difference between mean annual sum of atmospheric precipitation in two periods of time was determined with the use of Student's criterion. The forecast of P_a using the AAA version of the Exponential Smoothing (ETS) algorithm was carried out [16]. Programs Excel 16 and Mesosaur for calculation were used.

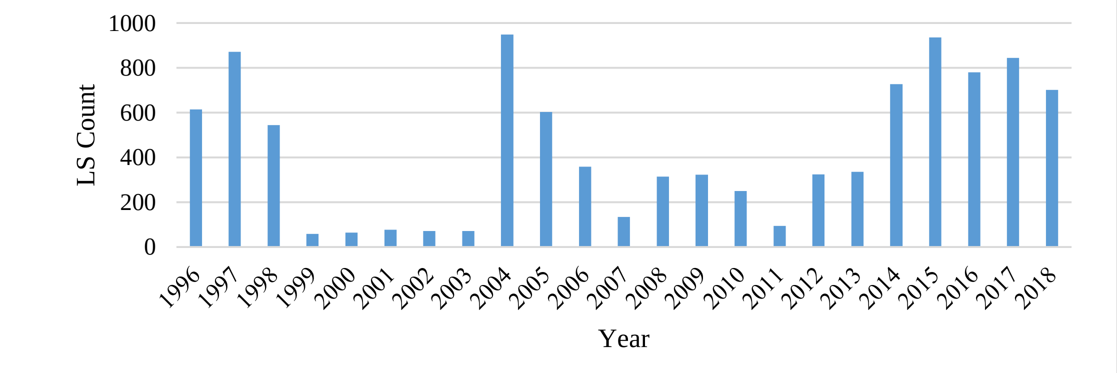

Fig 2. Changeability of re-activated and new landslides cases in Georgia from 1996 to 2018.

Results and Discussions

Results of statistical analysis of long-term variations of annual amount of atmospheric precipitation for 21 meteorological stations of Georgia (P) located in areas with landslides, average annual amount of precipitation for these stations (P_a), relationship between the P_a and number of re-activated and new cases of landslides (LS), and the estimated values of LS up to 2045 using predictive data on P_a are presented below in Table 1-3 and Fig. 3-8.

Table 1. Statistical characteristics of LS cases in Georgia in 1996-2018.

Parameter	Mean	Max	Min	Range	St Err	St Dev	Cv, %	Conf. Lev. , 95.0%
LS	437	949	58	891	66	316	72.2	136

Table 1 presents the statistical characteristics of LS cases in Georgia in 1996-2018. On average, 437 cases of LS were recorded per year with a range of changes from 58 to 949 cases. Significant variations in the amount of LS were observed in the specified time period (Cv = 72.2%, Conf. Lev. = 136).

Table 2 presents the statistical characteristics of the annual sum of atmospheric precipitations for 21 meteorological stations and the average annual sum precipitation for all these stations in 1936-2020.

Table 2. Statistical characteristics of annual sum of atmospheric precipitation for 21 meteorological stations of Georgia from 1936 to 2020, mm.

Location	Mean	Max	Min	Range	St Err	St Dev	Cv, %	Conf. Int., 95.0%
Akhaltsikhe	540	853	319	534	11	100	18.5	21.5
Ambrolauri	1038	1443	621	822	20	188	18.1	40.4
Bakuriani	854	1315	556	759	14	130	15.2	28.0
Borjomi	659	949	402	547	12	113	17.1	24.3
Chokhatauri	1793	2628	1059	1569	35	319	17.8	68.9
Dedoplistskaro	591	1001	332	669	14	131	22.2	28.3
Gori	517	758	303	456	10	96	18.5	20.7

Khashuri	621	920	380	540	13	120	19.4	25.9
Khulo	1346	1945	678	1267	31	290	21.5	62.5
Kobuleti	2376	3456	1648	1808	40	367	15.4	79.1
Lagodekhi	1076	1842	660	1182	27	246	22.8	53.0
Mta-sabueti	1165	1670	705	965	24	226	19.4	48.7
Pasanauri	992	1496	437	1059	20	183	18.5	39.5
Sachkhere	950	1385	656	730	18	161	17.0	34.8
Sagarejo	781	1332	433	899	18	163	20.9	35.3
Shovi	1173	1816	700	1116	21	198	16.9	42.7
Tbilisi	513	818	240	578	12	113	22.1	24.4
Telavi	777	1260	529	732	15	137	17.7	29.6
Tianeti	773	1180	299	881	19	179	23.1	38.6
Zestafoni	1296	1806	787	1019	24	224	17.3	48.4
Zugdidi	1798	2440	1158	1282	30	275	15.3	59.3
Average, 21 station	**1030**	**1313**	**773**	**540**	**13**	**120**	**11.6**	**25.9**

As follows from Table 2, the minimum value of the annual sum precipitation was recorded in Tbilisi (240 mm), the maximum - in Kobuleti (3456 mm). The average values of the annual sum of atmospheric precipitation for the entire observation period vary from 513 mm (Tbilisi) to 2376 mm (Kobuleti), the coefficient of variation changes from 15.2% (Bakuriani) to 23.1% (Tianeti).

The average annual precipitation for all observation stations is 1030 mm, the range of change is from 773 mm to 1313 mm, the coefficient of variation is 11.6%.

Fig. 3 presents data on the values of the linear correlation coefficient for the annual sum of atmospheric precipitation between each of the meteorological stations with average values of the annual sum of precipitation for all meteorological stations.

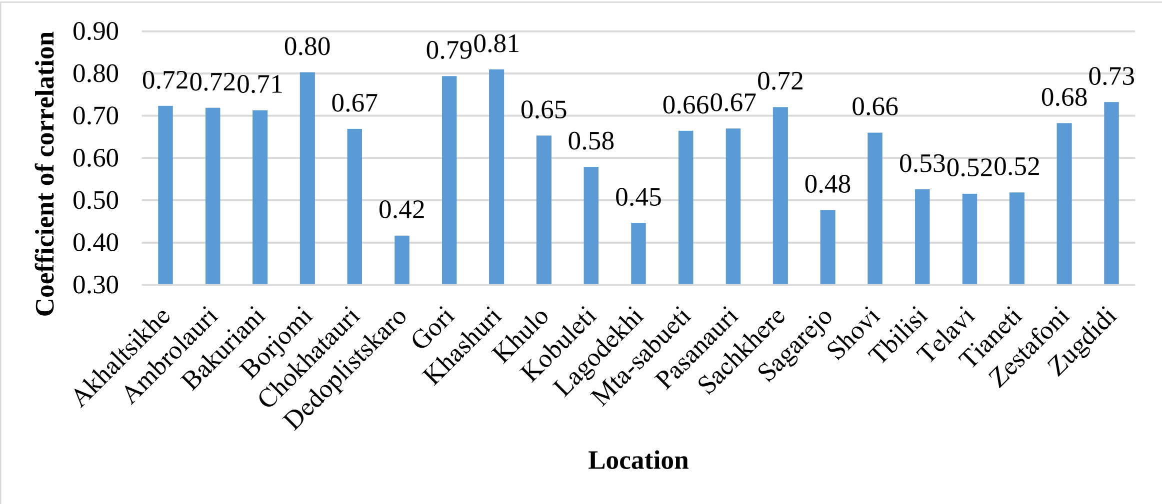

Fig 3. The correlation between the annual amounts of precipitation at each of the meteorological stations with averaged data for all 21 stations on 1936-2020, α<0.005.

As follows from Fig. 3, the R value changes from 0.42 (Dedoplistskaro, low correlation) to 0.81 (Khashuri, high correlation). In general, a high correlation ($0.7 \leq R < 0.9$) is observed between the indicated parameters in 38.1% of cases, a moderate correlation ($0.5 \leq R < 0.7$) in 47.6% of cases, and a low correlation ($0.3 \leq R< 0.5$) in 14.3% of cases. Thus, in general, the values of the annual sum of atmospheric precipitation averaged over all meteorological stations are sufficiently representative to compare them with the variations in the annual number of landslides on the territory of Georgia. Note that the representativeness of individual stations in terms of the annual sum of atmospheric precipitation varies from 19 km (Kobuleti, Mta-Sabueti) to 46 km (Gori) around them and averages is 31 km in accordance with [17].

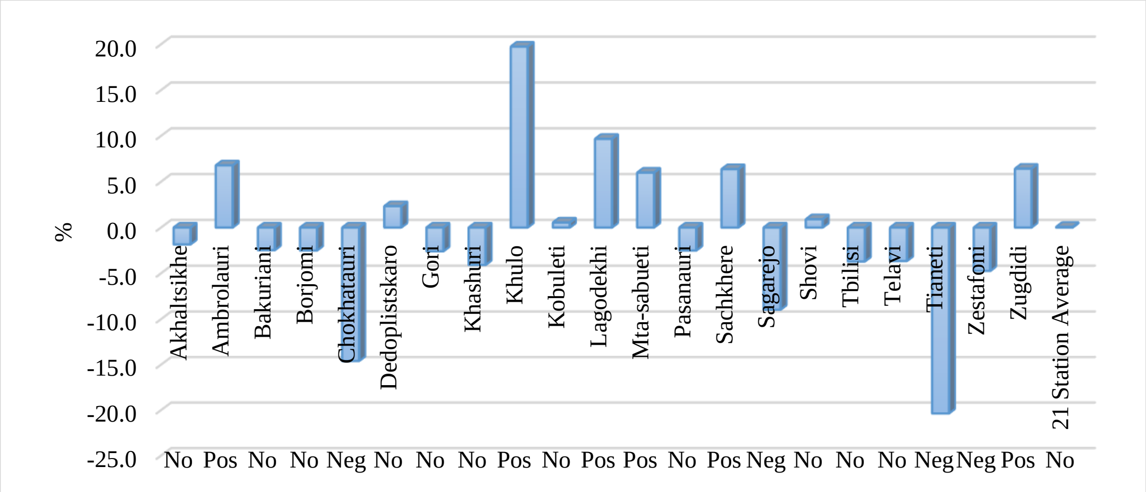

Fig 4. Variability of mean annual sum precipitation for 21 weather stations in 1981-2020 compared with 1936-1975 in relation to the average value of the sum precipitation in 1936-2020 at these stations, %, $\alpha \leq 0.2$.

Fig. 4 presents data on the change in the average annual precipitation in 1981-2020 compared to 1936-1975. The difference is normalized to the average annual precipitation in 1936-2020, %.

As follows from Fig. 4 as a result of climate change the variability of the average sum of precipitation in the second period of time compared to the first one for different measurement points is different. So, for 6 measurement points there is an increase in precipitation, for 4 points - a decrease, for 11 points - an insignificant change. For those averaged over all stations, the variability of the annual sum precipitation in the second period of time compared to the first is insignificant. Note that the periodicity of variability of the average annual precipitation per one meteorological station is 11 years (calculated using the Mesosaur program).

Let us consider the nature of the relationship between the annual number of re-activated and new landslides and the annual sum of precipitations. Fig. 5 shows the cross-correlation between values of P_a and the LS cases.

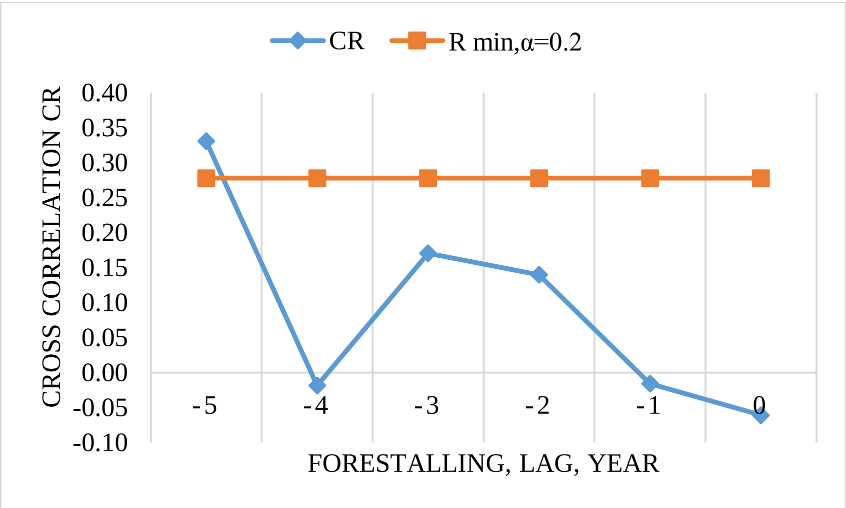

Fig 5. Cross-correlation between the P_a and LS values.

As follows from this figure, a significant correlation between the studied parameters is observed in the fifth lag before the landslide phenomena.

Another Fig. 6 shows the cross-correlation between the moving average of the P_a values and the moving average of the LS cases.

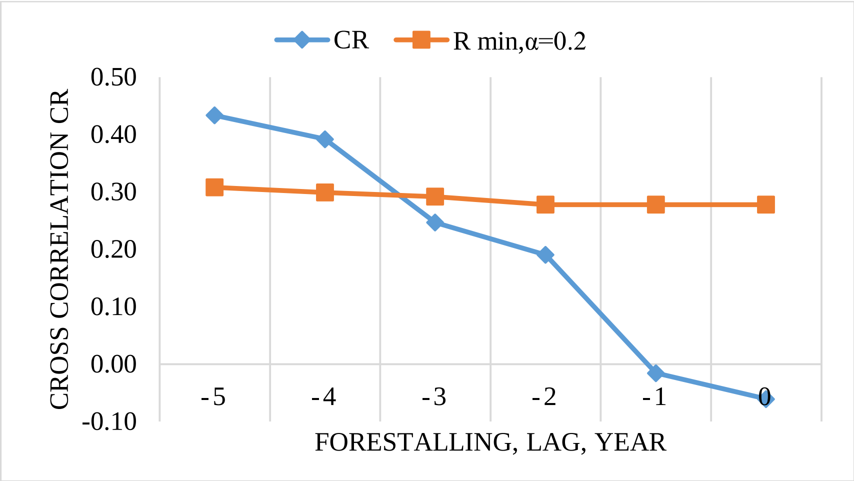

Fig 6. Cross-correlation between the five-year moving average of the P_a and five-year moving average of the LS values.

As follows from Fig. 6, a significant relationship between the studied parameters is observed in the fourth and fifth lags before the landslides. Comparison fig. 5 and 6 shows that in the second case the relationship between P_a values and LS number is more representative than in the first case. Taking into account that in the fifth lag before the onset of landslides, the correlation coefficient is higher than in the fourth lag, a linear regression was built between the five-year moving averages of P_a values and the five-year moving averages of LS number (Fig. 7).

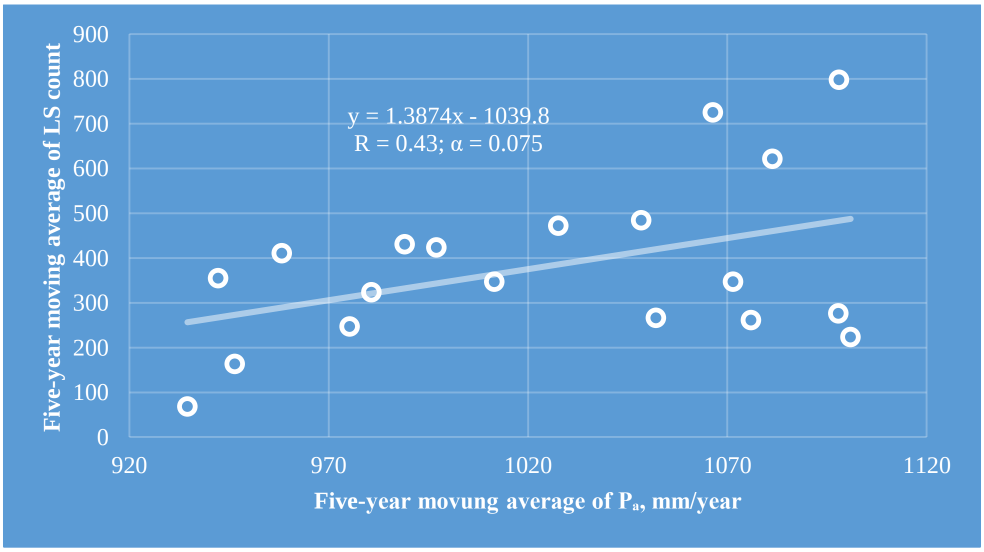

Fig 7. Linear correlation and regression between the five-year moving average of the P_a (1991-1995, 1992-1996, …, 2009-2013) and the five-year moving average of the LS (1996-2000, 2001-2005 ,…, 2014-2018) values.

As follows from Fig. 7, there is a significant direct linear relationship between the values of these parameters, which can be used to predict five-year moving averages of LS cases from the forecast values of the average annual sum precipitation per one meteorological station.

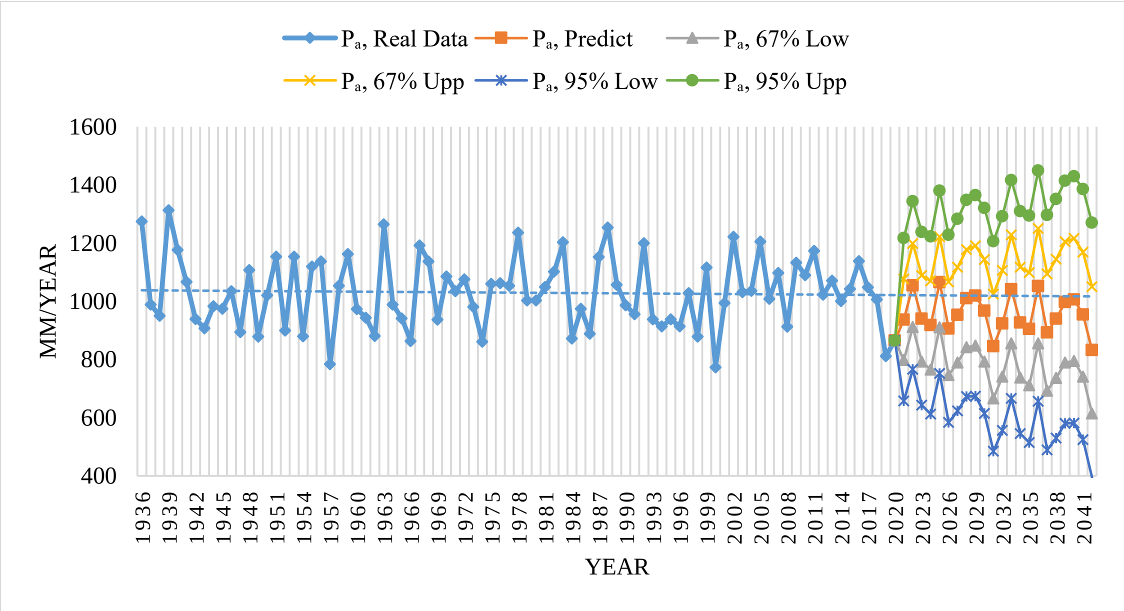

Fig 8. Changeability of average annual amount of precipitation for 21 meteorological stations (P_a) from 1936 to 2020 and its prediction to 2040.

Fig. 8 shows the forecast values of the average annual sum of precipitation per one meteorological station up to 2040, taking into account the eleven-year periodicity in the time-series of observation. Fig. 9 shows data on the expected five-year moving average of re-activated and new landslides cases up to 2041-2045, calculated according to the formula presented in Fig. 7 with using the data of Fig. 8.

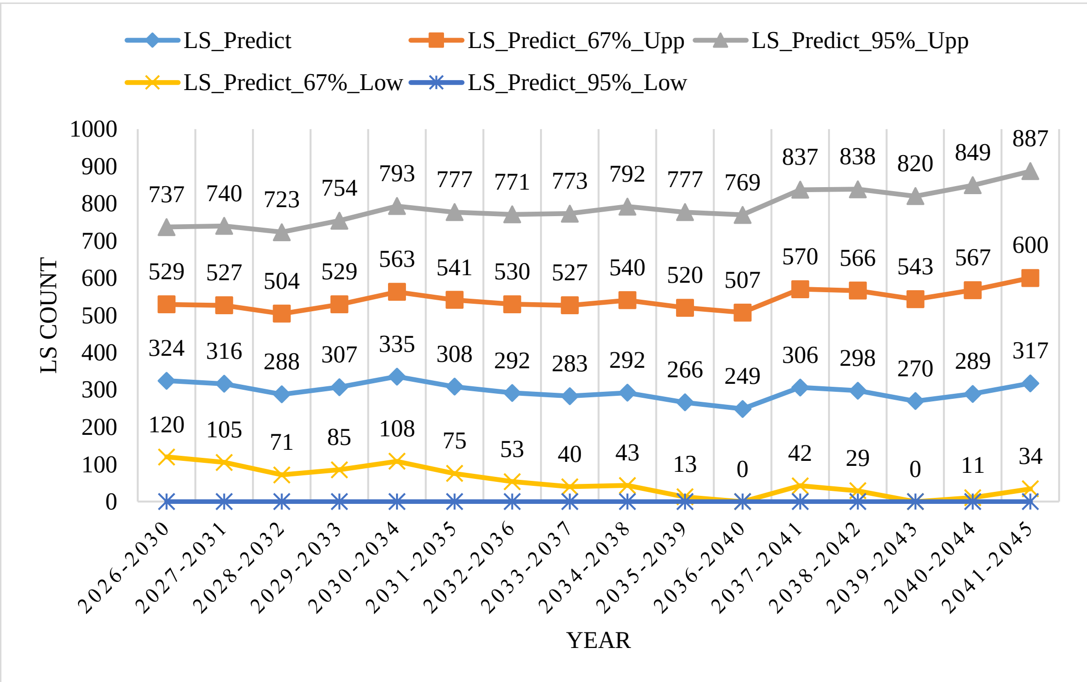

Fig 9. Interval prediction of five-year moving averages of re-activated and new landslides cases from 2026 up to 2045.

Graphs in Fig. 9 represent the center points of the forecast of the number of landslides (LS_Predict), as well as the lower and upper confidence levels of this forecast (LS_Predict_67%_Low, LS_Predict_67%_Upp, etc.). Note that all values of LS_Predict_95%_Low = 0.

Table 3 shows the comparative statistical characteristics of predicted (2026-2045) and real (1996-2018) five-year moving averages of re-activated and new landslides cases.

Table 3. Statistical characteristics of predicted (2026-2045) and real (1996-2018) five-year moving averages re-activated and new landslides cases in Georgia.

Period	2026-2045				1996-2018
Parameter	LS_Predict_ 67%_Low	LS_Predict	LS_Predict_ 67%_Upp	LS_Predict_ 95%_Upp	LS_Real
Mean	52	296	542	790	381
Max	120	335	600	887	798
Min	0	249	504	723	68
Range	120	87	96	164	730
St Err	9.7	5.7	6.4	11.3	42.1
St Dev	39	23	26	45	184
Cv, %	74.4	7.7	4.7	5.7	48.2
Conf. Lev., 95.0%	21	12	14	24	89

As follows from this Table, the average LS_Real values fall within the range of values between LS_Predict and LS_Predict_67%_Upp (296<381<542). The maximum values of LS_Real fall within the range of values between LS_Predict_67%_Upp and LS_Predict_95%_Upp (600<798<887). The minimum values of LS_Real fall within the range of values between LS_Predict and LS_Predict_67%_ Low (0<68<249). Thus, in general, in the next two decades, one should not expect a significant intensification of landslide processes in Georgia due to the expected variability of the annual sum of atmospheric precipitation. However, in certain regions of Georgia, where a significant increase in precipitation is observed (for example, in the vicinity of Khulo, Fig. 4), a significant activation of landslide phenomena is quite possible.

Conclusion

In the near future, we plan to continue similar studies both for the territory of Georgia as a whole and for its individual landslide-prone regions.

Note

This work was presented as a report at the International Eurasia Climate Change Congress "EURACLI – 2022", 29 September 2022 - 01 October 2022, Van,Turkey. http://webportal.yyu.edu.tr/euracli

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საქართველოში ატმოსფერული ნალექების საშუალო წლიური ჯამებისა და რე-აქტივიზებული და ახალი მეწყერების შემთხვევებს შორის კავშირის კვლევის ზოგიერთი შედეგი კლიმატის ცვლილების გათვალისწინებით

ამირანაშვილი ა., ჭელიძე თ., სვანაძე დ., წამალაშვილი თ., თვაური გ.

რეზიუმე

მოყვანილია საქართველოში 21 მეტეოროლოგიურ სადგურზე წლიური ჯამური ატმოსფერული ნალექების საშუალოსა (P) და რეაქტივირებული და ახალი მეწყერების შემთხვევების რაოდენობას (LS) შორის კავშირის გამოკვლევის შედეგები და აგრეთვე მოყვანილია LS მნიშვნელობის შეფასება 2045 წლამდე P-ს პროგნოსტული მონაცემების მიხედვით. ნაშრომში გამოყენებულია საქართველოს გარემოს სააგენტოს მონაცემები წლიური ჯამური ატმოსფერული ნალექებისა იმ 21 მეტეოროლოგიურ სადგურზე, რომლებიც განლაგებულია მეწყრულ ზონებში 1936 -დან 2020 წლამდე პერიოდისათვის და აგრეთვე მონაცემები LS -ს შესახებ 1996 -დან 2018 წწ. პერიოდში. მონაცემების ანალიზი ტარდებოდა სტანდარტული მათემატიკური სტატისტიკის მეთოდების გამოყენებით. წლიური ჯამური ატმოსფერული ნალექების სამომავლო ცვლილებების პროგნოზი პერიოდულობის გათვალისწინებით ხორციელდებოდა AAA version of the Exponential Smoothing (ETS) algorithm -ის გამოყენებით.

კერძოდ მიღებულია შემდეგი :

1981-2020 წლებში 1936-1975 წლებთან შედარებით 11 სადგურზე P-ს საშუალო სიდიდეების მნიშვნელოვანი ცვლილება არ შეინიშნება, 6 სადგურზე დაიკვირვება ჯამური ნალექების მატება და 4- ზე შემცირება. აღნიშნულ პერიოდში ყველა სადგურის P –ს საშუალო მნიშვნელობები ცვლილებას არ განიცდიან.

ჩატარებულია ყველა სადგურის საშუალო მნიშვნელობების პროგნოსტული შეფასება 2045 წლამდე ნალექების ცვლილებების პერიოდულობის გათვალისწინებით, რომელიც შეადგენს 11 წელს.

ყველა სადგურის P საშუალოს მნიშვნელობების და LS-ის კროს-კორელაციურმა ანალიზმა აჩვენა, რომ ყველაზე კარგი კორელაციური კავშირი აღნიშნულ პარამეტრებს შორის არსებობს ნალექების მონაცემების ხუთწლიანი წინსწრების დროს. ამის გათვალისწინებით მიღებულია წრფივი რეგრესიის განტოლება ხუთწლიანი მცოცავი ატმოსფერული ჯამური ნალექების საშუალოსა და რე-აქტივირებული და ახალი მეწყერების შემთხვევების ხუთწლიანი მცოცავი საშუალო მნიშვნელობას შორის.

ამ განტოლებისა და P -ს პროგნოსტული მნიშვნელობების გამოყენებით ჩატარებულია LS -ის ხუთწლიანი მცოცავი საშუალო მნიშვნელობების შეფასება 2045 წლამდე.

საკვანძო სიტყვები: ნალექი, მეწყერი, კლიმატის ცვლილება.

Некоторые результаты исследования связи между среднегодовой суммой атмосферных осадков и количеством ре-активированных и новых случаев оползней в Грузии с учетом изменения климата

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Резюме

Приводятся результаты исследования связи между средней для 21 метеорологических станций годовой суммой атмосферных осадков (P) и количеством ре-активированных и новых случаев оползней (LS) в Грузии, а также проведена оценка значений LS до 2045 года по прогностическим данным о P. В работе использованы данные агентства по окружающей среде Грузии о годовой сумме атмосферных для 21 метеорологических станций, расположенных в зонах с оползнями, в период с 1936 по 2020 гг., а также данные о LS в период с 1996 по 2018 гг. Анализ данных проводился с использованием стандартных методов математической статистики. Прогноз будущих изменения годовой суммы осадков с учетом периодичности осуществлялся с использованием AAA version of the Exponential Smoothing (ETS) algorithm.
В частности, получены следующие результаты.
В 1981-2020 по сравнению с 1936-1975 на 11 станциях не наблюдается значимой изменчивости средних значений P, на 6 станциях наблюдается рост суммы осадков и на 4 – уменьшение. Средние по всем станциям значения P в указанные периоды времени изменений не претерпевают.
Проведена оценка прогностических значений среднего по всем станциям значения P до 2045 года с учетом периодичности изменчивости осадков, составляющей 11 лет.
Кросс-корреляционный анализ временных рядов среднего по всем станциям величин P и значений LS показал, что наилучшая корреляционная связь между указанными параметрами наблюдается при пятилетнем упреждении данных об осадках. С учетом этого получено уравнение линейной регрессии между пятилетней скользящей средней суммой атмосферных осадков и пятилетней скользящей средней значений ре-активированных и новых случаев оползней.
С использованием этого уравнения и данных о прогностических значениях P проведена оценка пятилетних скользящих средних значений LS до 2045 года.

Ключевые слова: атмосферные осадки, оползни, изменение климата.

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Changeability the Monthly Mean Values of Air Effective Temperature on Missenard in Batumi in 1956-2015

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ABSTRACT

Results of a statistical analysis of monthly average of the values of air effective temperature on Missenard (ET) in Batumi from 1956 to 2015 are presented. The intra-annual distribution of ET values in three time periods was studied: 1956-1985, 1956-2015, 1986-2015; their repetition of occurrence by ET categories in the specified time periods was obtained, etc. The influence of climate change on ET values was revealed.

In particular, it is shown that in 1986-2015, compared with 1956-1985, the repetition of ET values for the category "Very cold" decreased from 1.7% to 1.1%, "Cold" - decreased from 23.9% to 22.8%, "Cool" - increased from 35.0% to 35.8%, " Comfortable " - decreased from 22.2% to 17.8%, " Warm " - increased from 12.5% to 13.9%, "Hot" - increased from 4.7% to 8.6%.

The results of the study can find practical application for planning the development of the resort and tourism industry in Adjara, taking into account climate change.

Key Words: *Bioclimatic index, thermal comfort, bioclimatic stress, meteorological parameters.*

Introduction

To determine the degree of comfort or discomfort of the human environment for his health, various simple and complex thermal indices are often used.

Simple thermal indices include more than one meteorological parameter and take into account the combined effects on the human body of air temperature, humidity, wind speed, etc. Complex thermal indices are based on models of the energy budget and heat balance of the human body [1-14].

There are about 200 thermal indexes of varying complexity. Each index has its own numerical scale with the corresponding verbal description of the heat sensation of the human body, understandable to a wide range of the population (for example, "cold", "comfortable", "warm", etc.) [1-4].

The impact on the human body of the above factors can manifest itself both instantly and within hours, days, weeks, months and a longer period of time [1,5,7,15-21].

For the bioclimatic zoning of the area in order to establish its resort and tourist potential, the average monthly values of these indices are often used. One of the most popular indices is the Missenard air effective temperature (ET). This is a simple thermal indicator and is a combination of temperature, relative humidity and wind speed [22,23]. ET studies for different regions of Georgia are presented in [21,24,]. In particular, in [21] values of 8 simple thermal indices were calculated with the use of mean monthly and mean monthly for 13 hour data of meteorological elements. Between all studied simple thermal indices practically direct functional connection with the coefficient of linear correlation not lower than 0.86 is observed. The possibility of using the standard scales and categories of the indicated indices as the bioclimatic indicator in monthly time scale is studied. As a whole, all indices adequately correspond to the degree of the bioclimatic comfort of environment for the people - with an increase in the level of comfort the mortality diminishes. Most representative for this purpose is Missenard air effective temperature in 13 hours.

This work is a continuation of previous research and presents the results of a statistical analysis of monthly average values of ET in Batumi from 1956 to 2015. The intra-annual distribution of ET values in three time periods was studied: 1956-1985, 1956-2015, 1986-2015; their repetition of occurrence by ET categories in the specified time periods was obtained, etc. The influence of climate change on ET values was revealed.

Material and methods

Data of agency on the environment of Georgia about the monthly mean max values of air temperature - T (°C), monthly mean min values air relative humidity – RH (%), and monthly mean wind speed - V (m/sec) for Batumi during the 1956-2015 were used in the work.

The analysis of data with the aid of the standard methods of mathematical statistics was conducted. All 720 cases were analyzed (months). The difference between the two means was determined using Student's t-test with a significance level $\alpha \leq 0.2$.

Information about formula for calculating the air effective temperature according to Missenard (ET), its scale and category in Table 1 is presented. °C in this Table is so-called perceptible temperature.

Table 1. Formula for calculating the air effective temperature according to Missenard, its scale and category.

Air Effective Temperature on Missenard [22,23]: $ET = 37-(37-T)/(0.68-0.0014 \cdot RH+1/(1.76+1.4 \cdot V^{0.75})) -0.29 \cdot T \cdot (1-0.01 \cdot RH)$, °C	
<1	Very cold (ძალიან ცივა)
1-9	Cold (ცივა)
9-17	Cool (გრილა)
17-21	Comfortable (კომფორტი)
21-23	Warm (თბილა)
23-27	Hot (ცხელა)
>27	Very Hot (ძალიან ცხელა)

Results and discussion

Results in Table 2-4 and Fig. 1-10 are presented.

In Fig. 1-3 data about changeability of mean annual values of meteorological components of air effective temperature on Missenard in Batumi in 1956-2015 are presented. As follows from these figures, trends of all three mean annual components of ET have the form of the third power polynomial.

The range of changes in the mean annual real values of these components is as follows: T - from 16.8 to 21.5 °C, mean value – 18.7 °C; RH - from 64.4 to 72.8%, mean value – 69.3%; V - from 0.8 to 2.8 m/sec, mean value – 1.8 m/sec. The range of changes in the mean annual of trends component of these meteorological parameters is as follows: T - from 18.3 to 20.4 °C, mean value – 18.7 °C; RH - from 68.0 to 71.8%, mean value – 69.3%; V -from 1.0 to 2.7 m/sec, mean value – 1.8 m/sec.

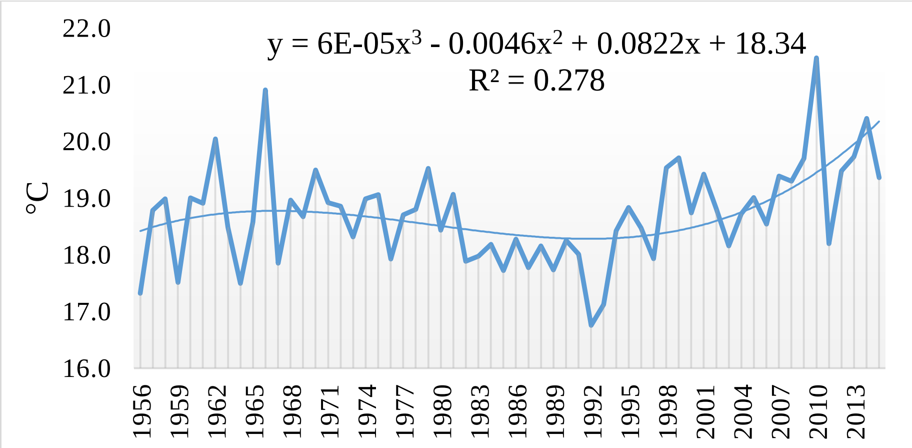


Fig.1. Trend of mean max annual values of air temperature in Batumi in 1956-2015.

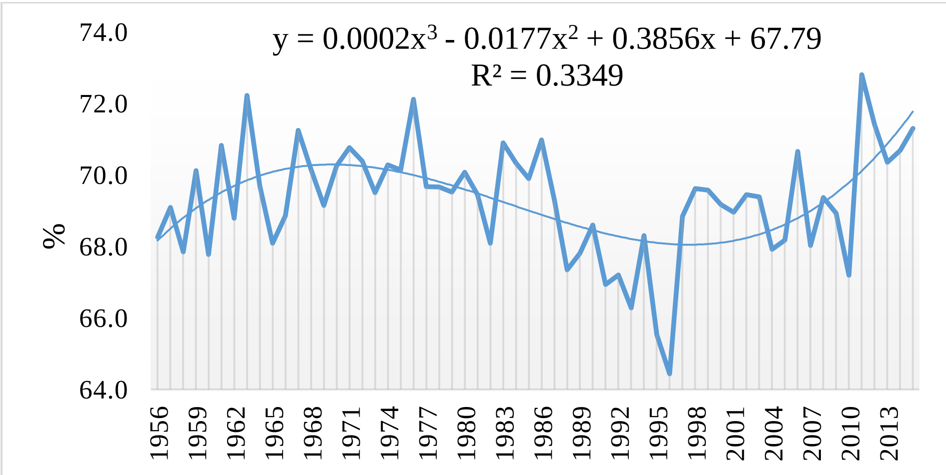


Fig. 2. Trend of mean min annual values of air relative humidity in Batumi in 1956-2015.

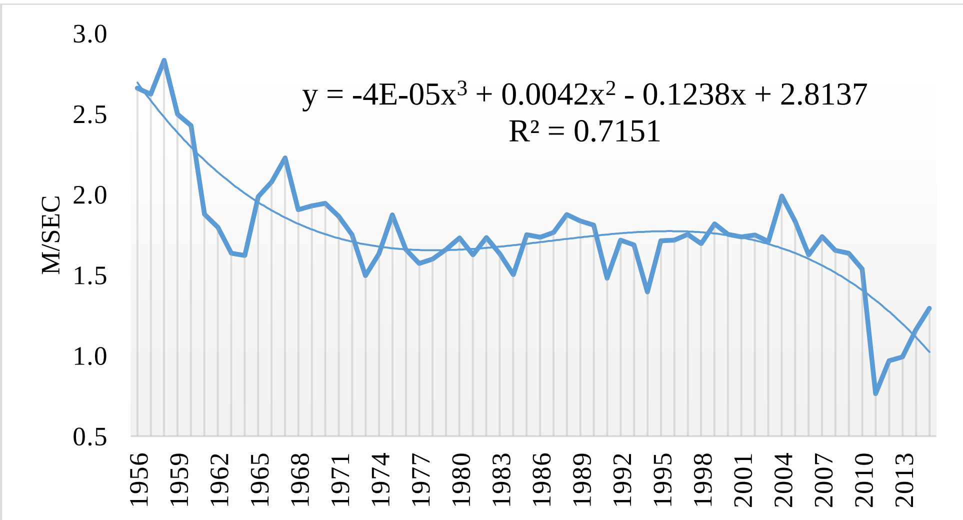


Fig. 3. Trend of mean annual values of wind speed in Batumi in 1956-2015.

Data analysis also showed that the range of changes of the mean monthly values of the indicated meteorological parameters in 1956-2015 is as follows: T - from 4.8 to 30.5 °C, RH - from 48.4 to 82.1 %, V - from 0.0 to 3.6 m/sec.

In Table 2 and 3 data about difference between mean monthly, in cold, warm periods and annual values of meteorological parameters in Batumi in 1986-2015 and 1956-1985.

Table 2. Difference between mean monthly, in cold period and annual values of meteorological parameters in Batumi in 1986-2015 and 1956-1985 (ΔT, ΔRH and ΔV).

Variable	Jan	Feb	Mar	Oct	Nov	Dec	Cold	Year
ΔT	-0.4	-0.1	0.1	0.5	-0.6	-0.5	-0.2	0.1
α(ΔT)	no sign	no sign	no sign	0.2	0.2	no sign	no sign	no sign
ΔRH	2.3	-0.7	-2.2	-0.7	-1.4	1.2	-0.2	-1.0
α(ΔRH)	0.1	no sign	0.12	no sign	no sign	no sign	no sign	0.01
ΔV	-0.5	-0.6	-0.2	-0.3	-0.3	-0.4	-0.4	-0.3
α(ΔV)	<0.01	<0.01	0.05	<0.01	<0.01	<0.01	<0.01	<0.01

Table 3. Difference between mean monthly and in warm period values of meteorological parameters in Batumi in 1986-2015 and 1956-1985 (ΔT, ΔRH and ΔV).

Variable	Apr	May	Jun	Jul	Aug	Sep	Warm
ΔT	0.0	-0.2	0.3	0.8	1.1	0.7	0.4
α(ΔT)	no sign	no sign	no sign	<0.01	<0.01	0.05	<0.01
ΔRH	-1.4	-1.5	0.0	-1.9	-2.4	-2.8	-1.7
α(ΔRH)	0.2	0.12	no sign	0.04	<0.01	<0.01	<0.01
ΔV	-0.3	-0.3	-0.2	-0.2	-0.1	-0.1	-0.2
α(ΔV)	<0.01	0.03	0.05	0.06	0.15	0.20	0.04

As follows from these tables, the variability of the meteorological parameters, determining the value of ET, in 1986-2015 compared to 1956-1985 is as follows.

- ΔT - growth in October, from July to September and in the warm half of the year; decrease - only in November.
- ΔRH - decrease in March, April, May from July to September, in the warm half of the year and in general for the year; growth in January only.
- ΔV - decrease in all months and seasons of the year.

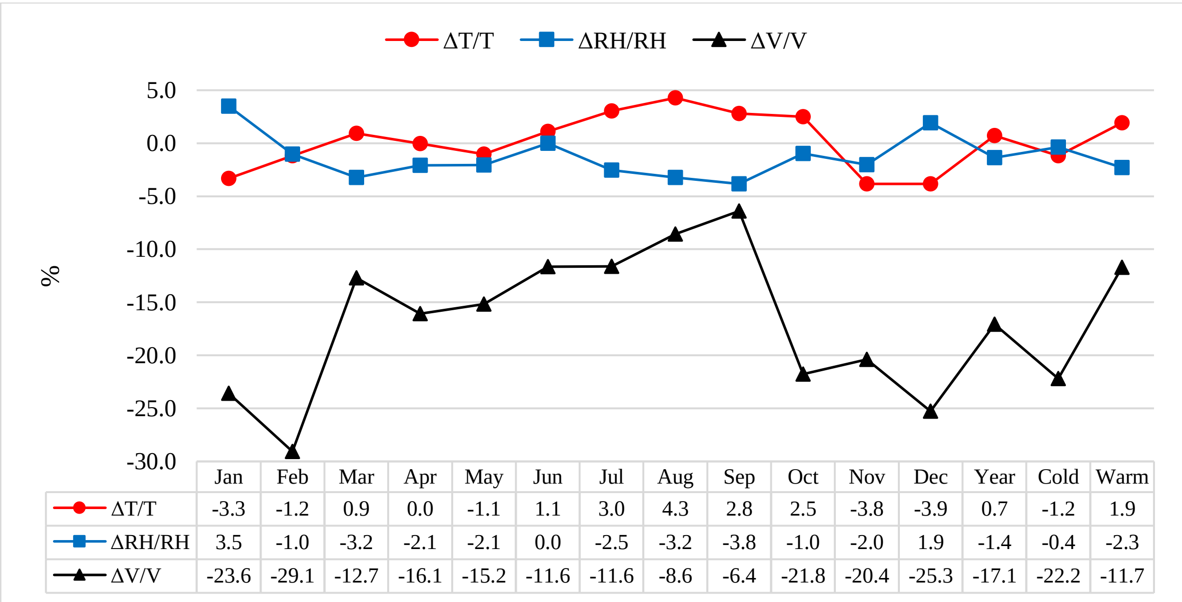


Fig. 4. Intra-annual distribution relative differences of mean monthly values of T, RH and V in Batumi in 1956-1985 and 1986-2015. ΔT/T=100·[T(2015-1986)-T(1956-1985)]/T(1956-2015), % etc.

In fig. 4, for clarity, data on the relative difference of the indicated meteorological parameters in different months and seasons of the year are presented. As follows from this figure, the variability of ΔV/V (decreasing) is much more significant than ΔT/T and ΔRH/RH changeability.

Results of analysis of data on ET values (Fig. 5) and its variability (Fig. 6-9, Table 4) in Batumi in 1956-2015 are presented below.

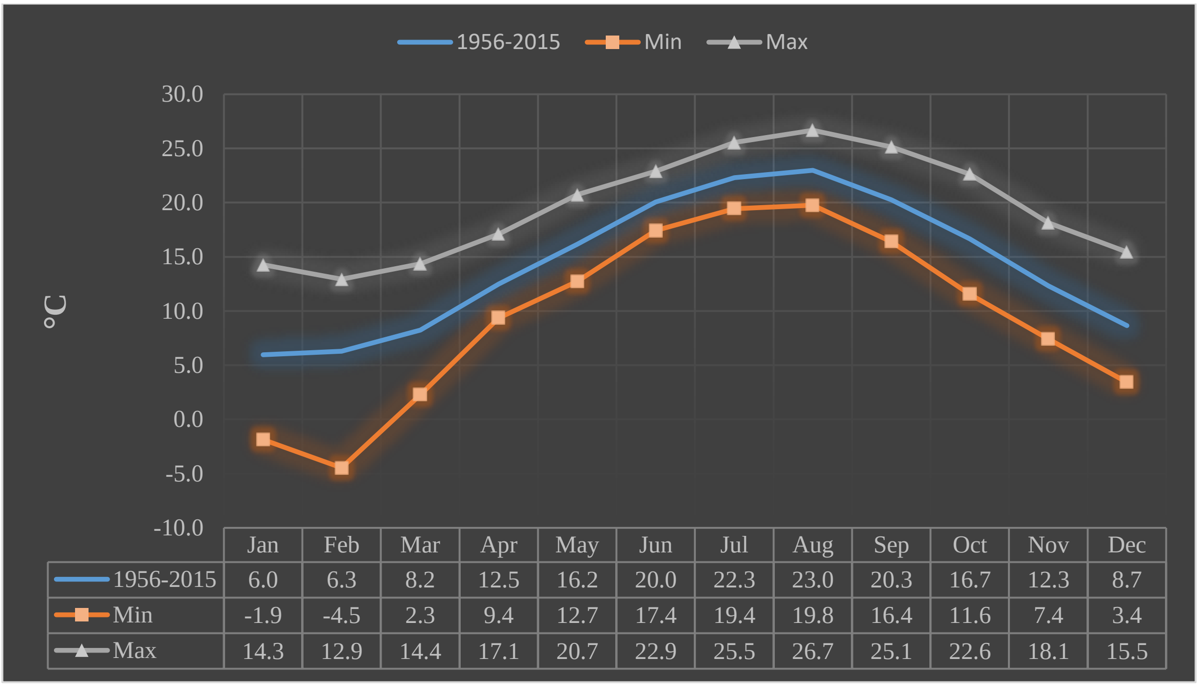


Fig. 5. Intra-annual distribution of Min, Max and mean monthly values of ET in Batumi in 1956-2015.

As follows from Fig. 5 monthly values of ET vary from -4.5 °C (February, category “Very cold”) to 26.7 °C (August, category ”Hot”). The mean monthly values of ET from 1956 to 2015 vary from 6.0 °C (January, category “Cold”) to 23.0 °C (August, category ”Hot”).

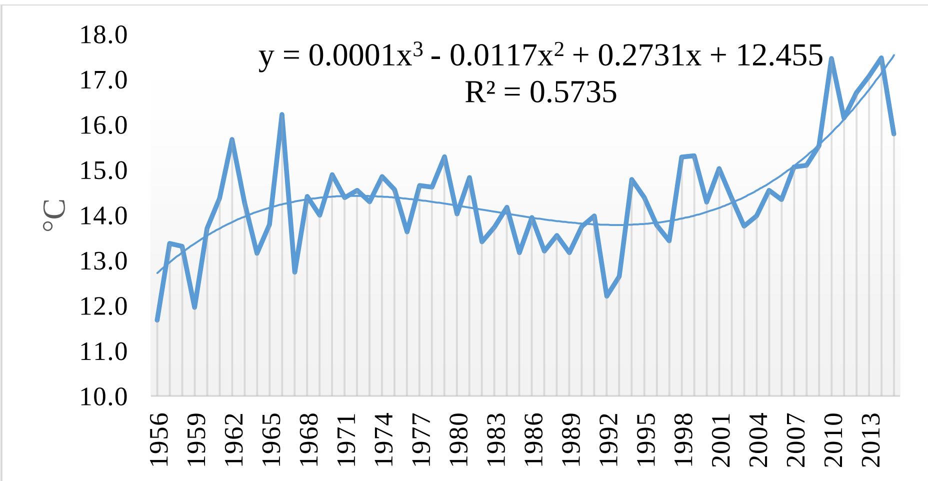
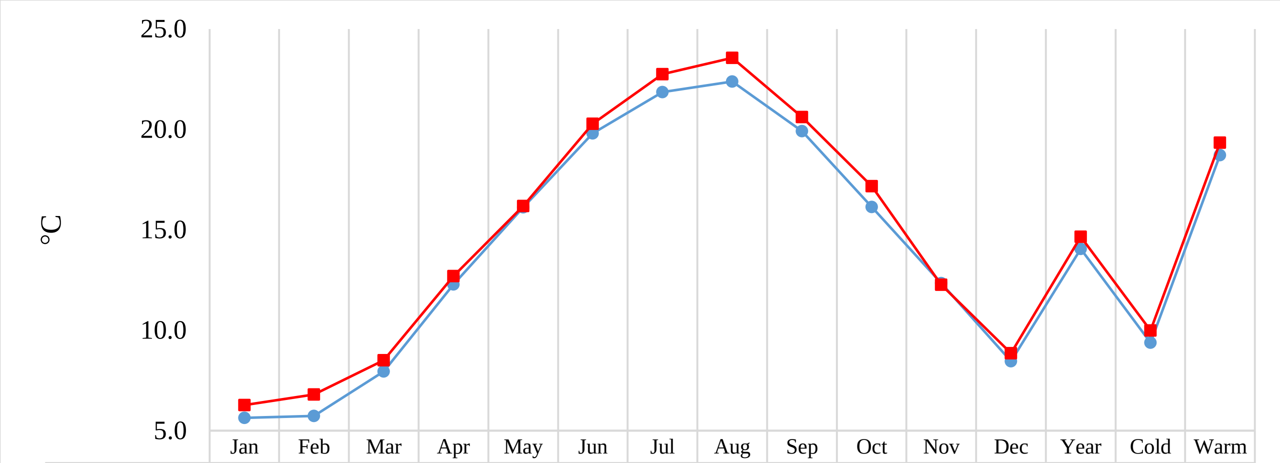


Fig. 7. Trend of mean annual values of air effective temperature on Missenard in Batumi in 1956-2015.

Trend of mean annual values of air effective temperature on Missenard in Batumi in 1956-2015 as T, RH and V, have the form of the third power polynomial (Fig. 7). The range of changes in the mean annual real values of ET is 11.7 °C (category “Cool”) ÷ 17.5 °C (category “Comfortable”); the range of changes in the mean annual of trends component of ET is 12.7 °C (category “Cool”) ÷ 17.5 °C (category “Comfortable”).

Data on intra-annual distribution of mean monthly and seasonal values of ET in Batumi in 1956-1985 and 1986-2015 in Fig. 7 are presented. In Fig. 8 difference between mean monthly and seasonal values of ET in Batumi in 1986-2015 and 1956-1985 are presented.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Cold	Warm
1956-1985	5.6	5.7	7.9	12.3	16.1	19.8	21.9	22.4	19.9	16.1	12.3	8.5	14.1	9.4	18.7
1986-2015	6.3	6.8	8.5	12.7	16.2	20.3	22.8	23.6	20.6	17.2	12.3	8.9	14.7	10.0	19.4

Fig. 7. Intra-annual distribution of mean monthly and seasonal values of ET in Batumi in 1956-1985 and 1986-2015.

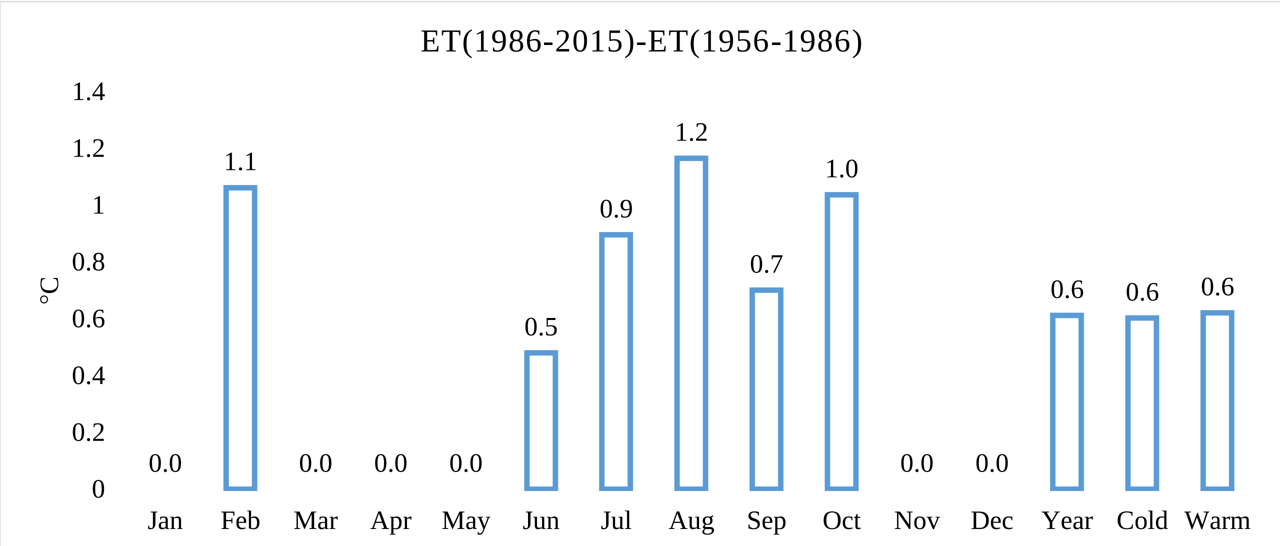


Fig. 8. Difference between mean monthly and seasonal values of ET in Batumi in 1986-2015 and 1956-1985 (0.0 – insignificant difference).

As follows from Fig. 7 and 8 in general, in 1986–2015, compared with 1956–1986, there was an increase of ET values for all months and seasons of the year. At the same time, a significant increase of ET values was noted in February, from June to October, in the cold and warm half-years, and in the whole year.

In Fig. 9 data about repetition of monthly values of ET in Batumi in 1986-2015 and 1956-1985 on its categories are presented.

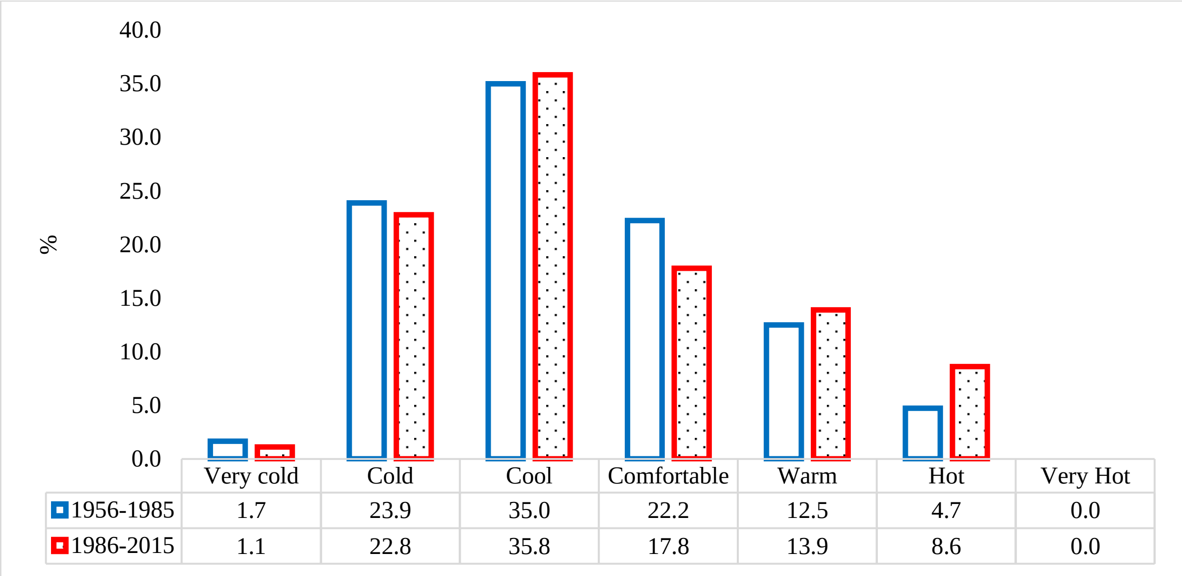


Fig. 9. Repetition of monthly values of ET in Batumi in 1986-2015 and 1956-1985.

As follows from Fig. 9 in 1986-2015, compared with 1956-1985, repetition of ET values for the category “Very cold” decreased from 1.7% to 1.1%, “Cold” - decreased from 23.9% to 22.8%, “Cool” - increased from 35.0% to 35.8%, "Comfortable" - decreased from 22.2% to 17.8% (reduction by 1.25 times), "Warm" - increased from 12.5% to 13.9%, “Hot" - increased from 4.7% to 8.6%. For categories "Warm" ÷ “Hot" repetition of ET values increase from 17.2% до 22.5 % (growth by 1.3 times). Thus, the increase of repetition of ET values for the "Warm" ÷ “Hot" categories mainly occurred due to a decrease of repetition of ET values for the "Comfortable" category. In accordance with Fig. 2 of [21], such a shift in the repetition of ET values towards warming should be favorable for human health (in terms of cardiovascular diseases). However, this statement requires further research, since the work [21] was carried out for Tbilisi conditions

Finally, Table 4 provides information on categories of mean monthly and seasonal values of ET in Batumi in 1986-2015 and 1956-1985.

Table 4. Category of mean monthly and seasonal values of ET in Batumi in 1986-2015 and 1956-1985.

Year/ Month	Jan	Feb	Mar	Apr	May	Jun	Jul	**Aug**	Sep	**Oct**	Nov	Dec	Year	Cold	Warm
1956-1985	Cold	Cold	Cold	Cool	Cool	Comf.	Warm	**Warm**	Comf.	**Cool**	Cool	Cold	Cool	Cool	Comf.
1986-2015	Cold	Cold	Cold	Cool	Cool	Comf.	Warm	**Hot**	Comf.	**Comf.**	Cool	Cold	Cool	Cool	Comf.

As follows from this Table, in the second period of time, compared with the first, the change in the categories of ET values occurred only in August (“Warm” → “Hot”) and October (“Cool” → "Comfortable").

Conclusion

In the future, we will continue such studies. Particular attention will be paid to predicting the variability of various bioclimatic indicators for several decades to come. The results of these studies can find practical application for planning the development of the resort and tourism industry both in Adjara and in other regions of Georgia, taking into account climate change.

Note

This work was presented as a report at the International Scientific Conference Black Sea Region at the Crossroads of Civilizations "BSRCC", 5-6 July, 2022, Batumi, Georgia. https://bsu.edu.ge/main/page/16543/index.html

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მისენარდის მიხედვით ჰაერის საშუალო თვიური ეფექტური ტემპერატურის ცვალებადობა ბათუმში 1956-2015 წწ.

ა. ამირანაშვილი, ნ. ჯაფარიძე, ლ. ქართველიშვილი,
კ. ხაზარაძე, ა. რევიშვილი

რეზიუმე

წარმოდგენილია ბათუმში 1956 - 2015 წლებში მისენარდის მიხედვით ჰაერის ეფექტური ტემპერატურის საშუალო თვიური მნიშვნელობების (ET) სტატისტიკური ანალიზის შედეგები. შესწავლილი იქნა ET-ს მნიშვნელობების შიდაწლიური განაწილება დროის სამ პერიოდში: 1956-1985, 1956-2015, 1986-2015 წწ.; მიღებულ იქნა მათი განმეორადობა ET-ს კატეგორიების მიხედვით

მითითებულ დროში და სხვ. გამოვლინდა კლიმატის ცვლილების გავლენა ET-ს მნიშვნელობებზე.
კერძოდ, ნაჩვენებია, რომ 1986-2015 წწ. 1956-1985 წლებთან შედარებით ET-ს მნიშვნელობების განმეორადობა "Very cold" კატეგორიისთვის შემცირდა 1.7%-დან 1.1%-მდე, "Cold" - შემცირდა 23.9%-დან 22.8%-მდე, "Cool" - გაიზარდა 35.0%-დან 35.8%-მდე, "Comfortable " - შემცირდა 22.2%-დან 17.8%-მდე, „Warm" - გაიზარდა 12.5%-დან 13.9%-მდე, „Hot" - გაიზარდა 4.7%-დან 8.6%-მდე.
კვლევის შედეგებს შეუძლია ჰქონდეს პრაქტიკული გამოყენება აჭარაში საკურორტო და ტურისტული ინდუსტრიის განვითარების დაგეგმვისთვის, კლიმატის ცვლილების გათვალისწინებით.

საკვანძო სიტყვები: ბიოკლიმატური ინდექსი, თერმული კომფორტი, ბიოკლიმატური სტრესი, მეტეოროლოგიური პარამეტრები.

Изменчивость среднемесячных значений эффективной температуры воздуха по Миссенарду в Батуми в 1956-2015 гг.

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Резюме

Представлены результаты статистического анализа среднемесячных значений эффективной температуры воздуха по Миссенарду (ET) в Батуми с 1956 по 2015 гг. Изучено внутригодовое распределение значений ET в три периода времени: 1956-1985, 1956-2015, 1986-2015 гг.; получена их повторяемость по категориям ET в указанные периоды времени и др. Выявлено влияние изменения климата на значения ET.
В частности, показано, что в 1986-2015 гг. во сравнению с 1956-1985 гг. повторяемость значений ET для категории " Very cold" уменьшилась с 1.7% до 1.1%, "Cold" - уменьшилась с 23.9% до 22.8%, "Cool" - увеличилась с 35.0% до 35.8%,, "Comfortable" - уменьшилась с 22.2 % до 17.8%, "Warm" - увеличилась с 12.5% до 13.9%, "Hot" - увеличилась с 4.7% до 8.6%.
Результаты исследования могут найти практическое применение для планирования развития курортно-туристической индустрии в Аджарии с учетом изменения климата.

Ключевые слова: биоклиматический индекс, тепловой комфорт, биоклиматический стресс, метеорологические параметры.

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Preliminary Results of a Study on the Impact of Some Simple Thermal Indices on the Spread of COVID-19 in Tbilisi

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ABSTRACT

The results of a study of the influence of diurnal values of separate components of simple thermal indices (temperature and air relative humidity, wind speed) on the infection positivity rate with coronavirus COVID-19 (IR) of the population of Tbilisi from September 1, 2020 to May 31, 2021 are presented. It was found that IR values are inversely correlated with air temperature and wind speed, and positively correlated with air relative humidity.

The effect of four different thermal indices (air effective temperature and Wet-Bulb-Globe-Temperature) on the IR values averaged over the scale ranges of their categories was studied. It has been found that an increase of the air effective temperature leads to a decrease of the IR values. In the latter case, the level of significance of the relationship between thermal indices and IR values is much higher than in the case of the relationship between IR and separate components of these indices.

Key Words: *Bioclimatic index, air effective temperature, meteorological parameters, COVID-19, infection positive rate.*

Introduction

Three years have passed since the outbreak of the new coronavirus (COVID-19) in China, which was recognized on March 11, 2020 as a pandemic due to its rapid spread in the World [1]. During this period of time, despite the measures taken (including vaccination), several strains of this virus appeared (the last one is omicron). The overall level of morbidity and mortality is currently decreasing significantly, although in many countries of the world it remains quite high.

For example, according data to the National Center for Disease Control and Public Health of Georgia [http://data.ncdc.ge/?LangID=en] from February 27, 2020 to September 30, 2022 in Georgia 1785137 new cases of COVID-19 infection were registered; died - 16912 people. Due to the sharp decline in coronavirus infection in Georgia after September 30, 2022, official statistics on COVID-19 are not published.

Scientists and specialists from various disciplines from all over the world, together with epidemiologists and doctors, have joined in intensive research on this unprecedented phenomenon (including in Georgia [2-11]), providing all possible assistance to them. In particular, in our work [9], it was noted works on statistical analysis, forecasting, forecasting systematization, spatial-temporary modelling of the spread of the new coronavirus etc. was actively continuing in 2021. Similar work is also continued in 2022 [10-13].

In our latest work [14] results of a statistical analysis of daily, total by days of the week and monthly data on officially reported deaths cases from the new coronavirus COVID-19 in the countries of the South Caucasus (Armenia, Azerbaijan, Georgia) from March 12, 2020 to May 31, 2022 are presented.

A significant number of papers are devoted to studies of the influence of various meteorological factors on the COVID-19 pandemic [15-21].

In particular, in study [20], the influence of several meteorological factors in the transmission of COVID-19 cases in six cities in Saudi Arabia was investigated using the Spearman and Kendall rank tests. For this purpose, the reported COVID-19 data from these cities in Saudi Arabia for the period between 26 March 2020 to 10 August 2021 was used along with such meteorological factors, as the average, maximum, and minimum values of air temperatures, air pressure, wind speed, relative humidity, dew point temperatures, and the average values of absolute humidity. The results for all the cities revealed that air temperature (average, minimum, and maximum) are positively associated with the daily number of COVID-19 cases reported in these cities. However, relative humidity and atmospheric pressure (averages, minimum, and maximum) are anticorrelated with the number of daily COVID-19 cases. For the rest of the variables, the correlation, strength, and significance with regard to the COVID-19 cases were different from one city to another. The findings presented in this paper are in total agreement with some of the previously established studies and are in contradiction either partially or entirely with others conducted at several locations around the world. The obtained results showed that the meteorological variables, significantly, affect the spread of COVID-19.

In [21] results of modelled the impact of selected meteorological factors on the daily number of new cases of the coronavirus disease 2019 (COVID-19) at the Hospital District of Helsinki and Uusimaa in southern Finland from August 2020 until May 2021 are resented. Authors applied a DLNM (distributed lag non-linear model) with and without various environmental and non-environmental confounding factors. The relationship between the daily mean temperature or absolute humidity and COVID-19 morbidity shows a non-linear dependency, with increased incidence of COVID-19 at low temperatures between 0 to −10 °C or at low absolute humidity (AH) values below 6 g/m³. It is noted that, the outcomes need to be interpreted with caution, because the associations found may be valid only for the study period in 2020–2021. Longer study periods are needed to investigate whether severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has a seasonal pattern similar such as influenza and other viral respiratory infections. The influence of other non-environmental factors such as various mitigation measures are important to consider in future studies. Knowledge about associations between meteorological factors and COVID-19 can be useful information for policy makers and the education and health sector to predict and prepare for epidemic waves in the coming winters.

We are also involved in similar studies. Preliminary results of the study of influence of some simple thermal indices on the positive rate of infection of the population of Tbilisi city with the COVID-19 virus from September 1, 2020 to May 31, 2021 to are presented below.

Material and methods

Data of agency on the environment of Georgia about the daily mean and max values of air temperature - T (°C), air relative humidity – RH (%), and daily mean wind speed - V (m/sec) for Tbilisi during September 1, 2020 to May 31, 2021 were used in the work. For the same days, data of National Center for Disease Control and Public Health of Georgia about infection positivity rate with coronavirus COVID-19 (IR) of the population of Tbilisi were used (IR = Confirmed Coronavirus Cases/Test Number, %).

The paper compares the daily values of the indicated meteorological elements with the IR values, as well as compares four thermal indices (effective air temperature and Wet-Bulb-Globe-Temperature) with the IR values averaged over the scale ranges of their categories. (Table 1, [26]). To calculate thermal indices, data on max daily air temperature, min values of relative air humidity, and average wind speed were used.

Table 1. Four simple thermal indices formula, scales and category.

Equivalent-Effective Temperature [27,28]: $EET = 125 \cdot Lg(1+0.02 \cdot T+0.0001 \cdot (T-8) \cdot (RH-60)-0.0045 \cdot (33-T) \cdot V^{0.5})$, °C		Effective Temperature [29,30]: $ET = 37-(37-T)/(0.68-0.0014 \cdot RH+1/(1.76+1.4 \cdot V^{0.75})) -0.29 \cdot T \cdot (1-0.01 \cdot RH)$, °C	
<1	Sharply coldly	<1	Very cold
1-8	Coldly	1-9	Cold
9-16	Moderately coldly	9-17	Cool
17-22	Comfortably	17-21	Comfortable
23-27	Warmly	21-23	Warm
>27	Hotly	23-27	Hot
		>27	Very Hot
Effective Temperature [31-33]: $TE = T-0.4 \cdot (T-10) \cdot (1-RH/100)$, °C		Wet-Bulb-Globe-Temperature [34]: $WBGT = 0.567 \cdot T+0.393 \cdot e+3.94$, °C	
< 16.1	Cool	<18	Comfortable
16.1-20	Comfortable	18÷24	Warm
20.1-24	Slightly humid	24÷28	Hot
> 24	Humid	28÷30	Very hot
		>30	Extreme hot
T – air temperature, °C; RH – air relative humidity, %; V - wind speed, m/sec; °C in this Table is so-called perceptible temperature.			

Results and discussion

Results in Fig. 1-9 are presented.

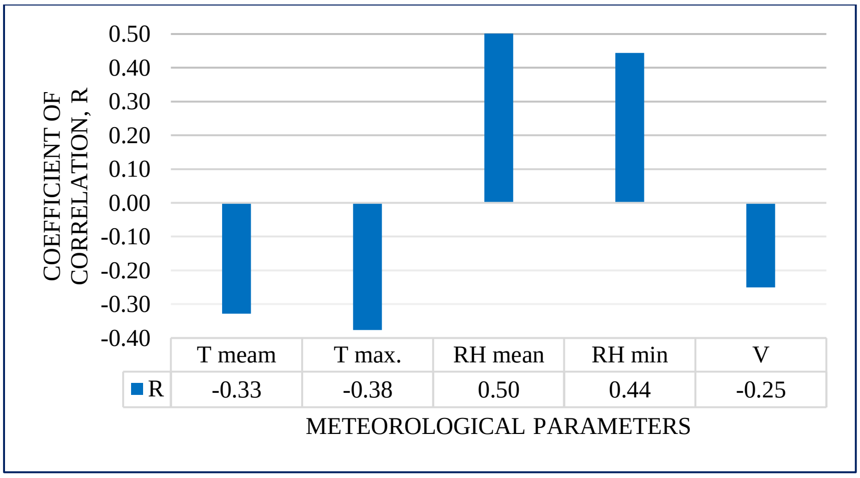

Fig. 1. Linear correlation between daily values of COVID-19 Infection Rate and meteorological parameters in Tbilisi from September 1, 2020 to May 31, 2021 (α<0.005).

In Fig. 1 data about coefficient of linear correlation R between daily values of COVID-19 Infection Rate and meteorological parameters in Tbilisi from September 1, 2020 May 31, 2021 are presented.

As follows from Fig. 1, value of coefficient of correlation T mean, T max and V with IR is negative (-0.33, -0.38 and -0.25 respectively). Value of coefficient of correlation RH mean and RH min with IR is positive (0.50 and 0.44 respectively).

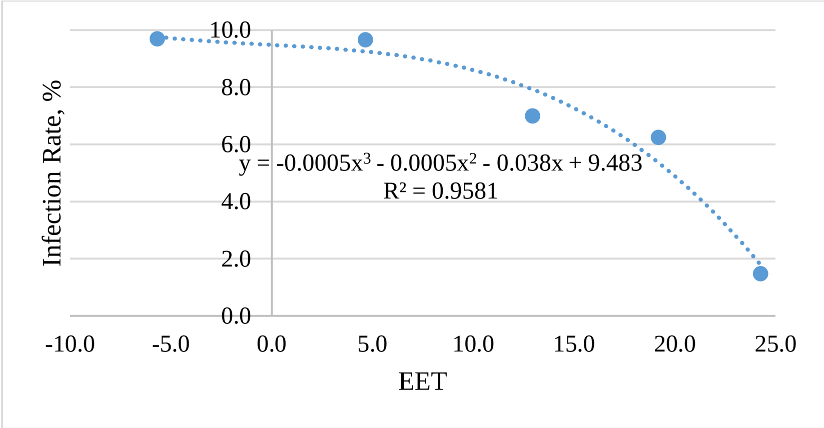

Fig. 2. Connection of COVID-19 Infection Rate with Air Equivalent-Effective Temperature (EET).

Connection of COVID-19 Infection Rate with Air Equivalent-Effective Temperature has the form of a third power polynomial (Fig. 2). As the EET values increase, the IR values decrease non-linearly.

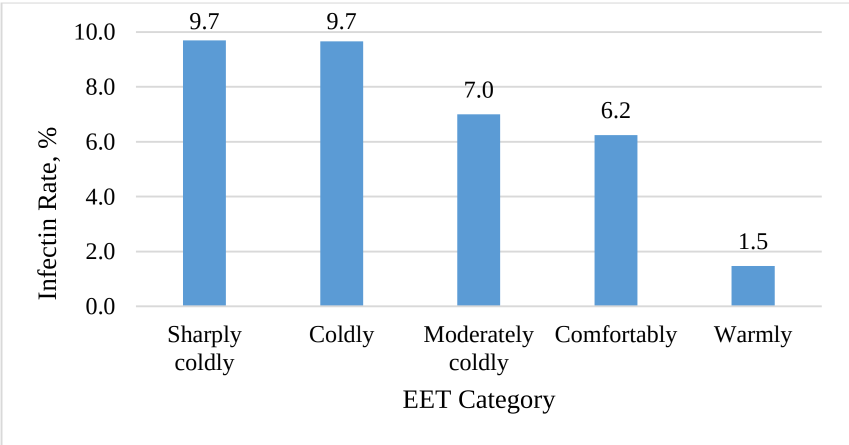

Fig. 3. Values of COVID-19 Infection Rate under different categories of Air Equivalent-Effective Temperature (EET).

As follows from Fig. 3 values of COVID-19 Infection Rate under different categories of Air Equivalent-Effective Temperature (EET) decreases from 9.7% ("Sharply coldly", "Coldly") to 1.5% ("Warmly").

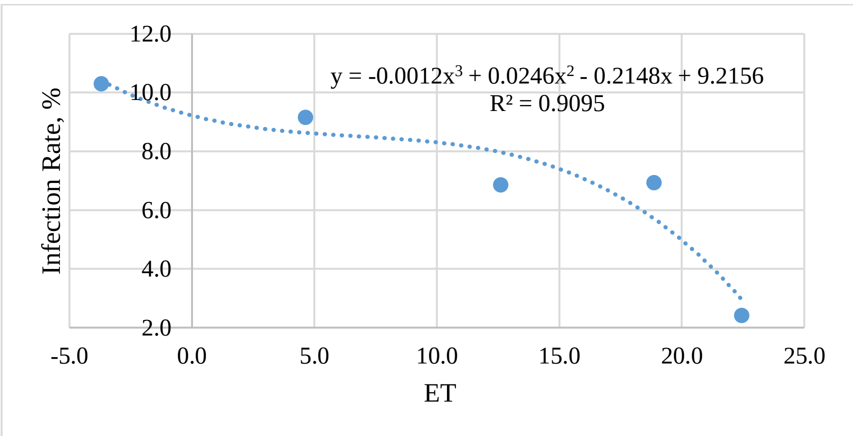

Fig. 4. Connection of COVID-19 Infection Rate with Missenard Air Effective Temperature (ET).

As in the previous case connection of COVID-19 Infection Rate with Missenard Air Effective Temperature has the form of a third power polynomial (Fig. 4).

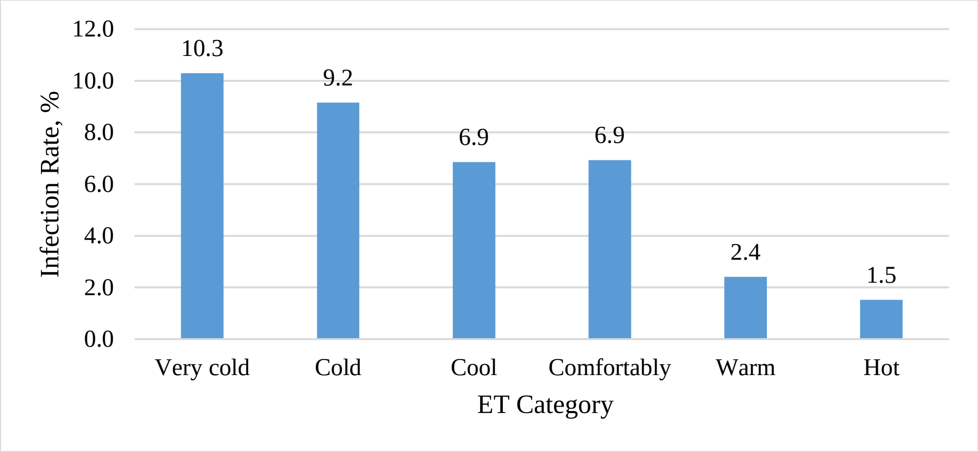

Fig. 5. Values of COVID-19 Infection Rate under different categories of Missenard Air Effective Temperature (ET).

As seen from Fig. 5 values of IR under different categories of Air Effective Temperature (ET) decreases from 10.3% ("Very cold") to 1.5% ("Hot").

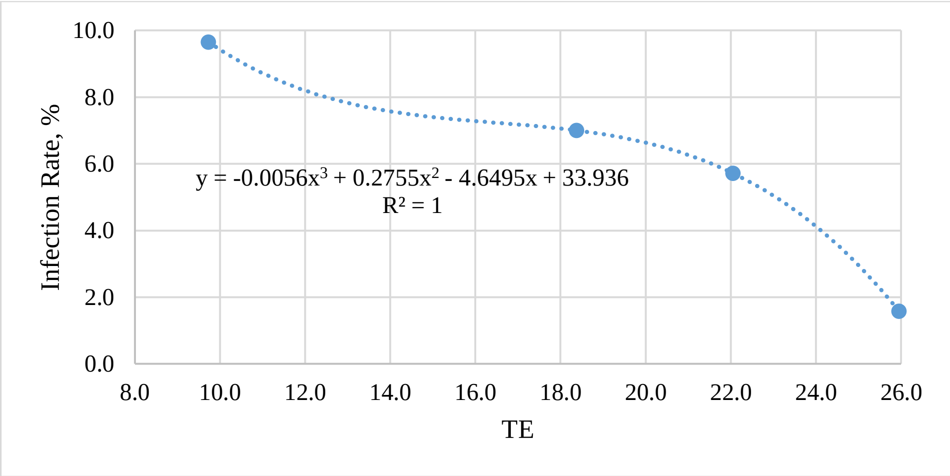

Fig. 6. Connection of COVID-19 Infection Rate with Air Effective Temperature (TE).

Connection of COVID-19 Infection Rate with Air Effective Temperature (TE) also has the form of a third power polynomial (Fig. 6). In this case, the decrease of IR values with increasing TE occurs monotonically.

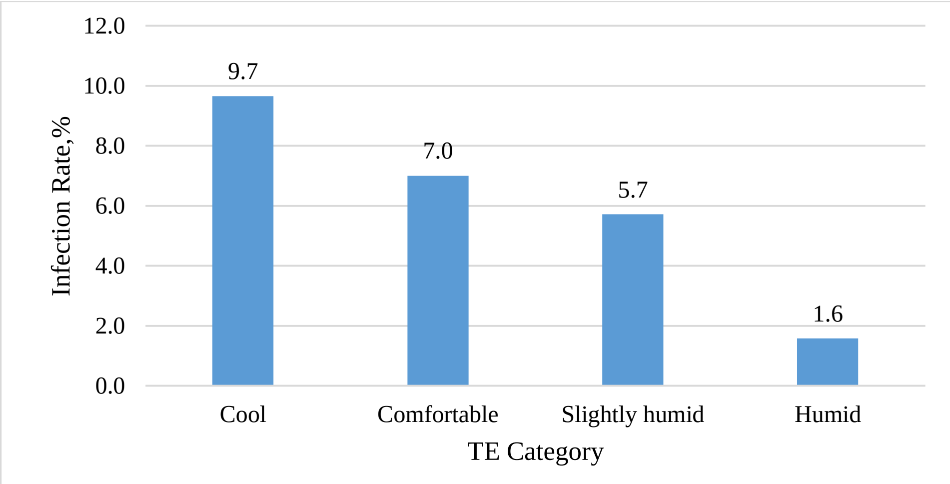

Fig. 7. Values of COVID-19 Infection Rate under different categories of Air Effective Temperature (TE).

Fig. 7 shows that values of IR under different categories TE decrease from 9.7 ("Cool") to 1.6 ("Humid")

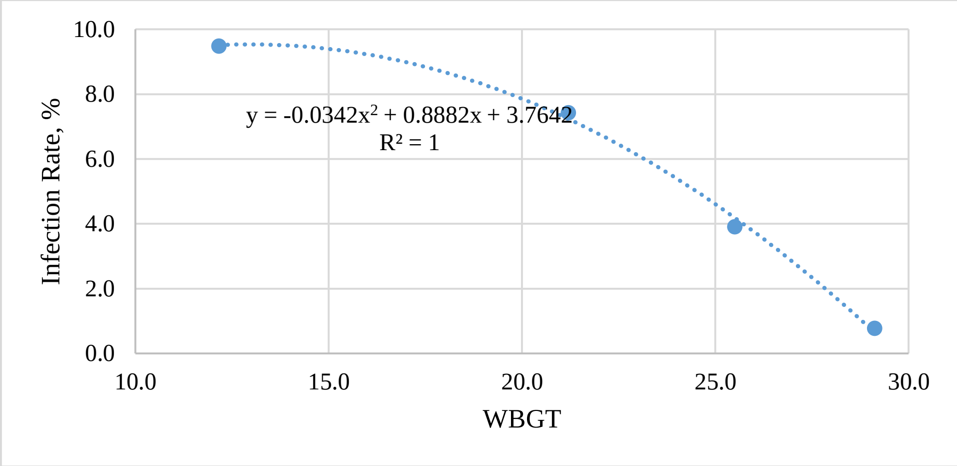

Fig. 8. Connection of COVID-19 Infection Rate with Wet-Bulb-Globe-Temperature (WBGT).

Connection of COVID-19 Infection Rate with Wet-Bulb-Globe-Temperature (WBGT) has the form of a two power polynomial (Fig. 8). As in the previous case the decrease of IR values with increasing WBGT occurs monotonically.

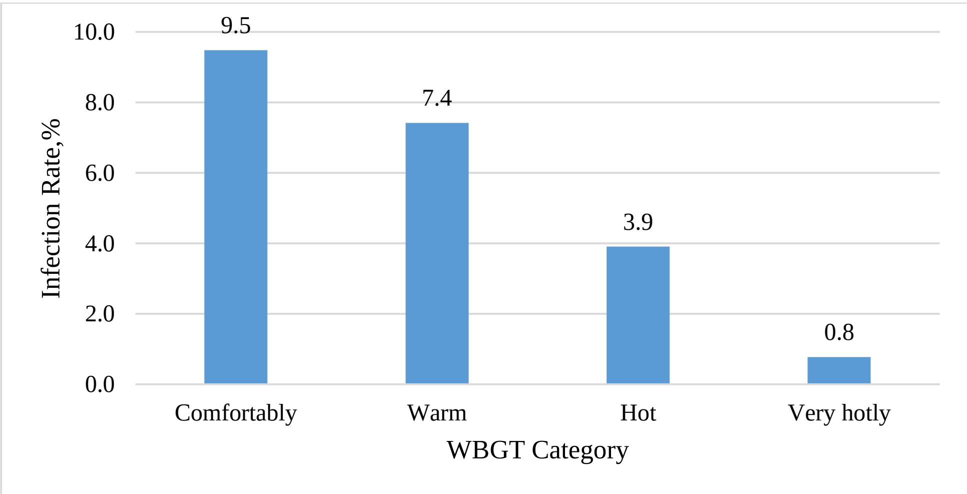

Fig. 9. Values of COVID-19 Infection Rate under different categories of Wet-Bulb-Globe-Temperature (WBGT).

Fig. 9 shows that values of IR under different categories WBGT decrease from 9.5 (“Comfortably”) to 0.8 (“Very hotly”)

As follows from Fig. 2, 4, 6 and 8 the most significant relationship is noted between IR and TE, IR and WBGT (coefficient of determination $R^2 = 1$, decrease of IR values with increasing of both thermal indexes occurs monotonically).

Thus it has been found that an increase of the air effective temperature leads to a decrease of the IR values. In the latter case, the level of significance of the relationship between thermal indices and IR values is much higher than in the case of the relationship between IR and separate components of these indices (Fig. 1, 2, 4, 6, 8). The reason for this may be that often with a small number of tests, overestimated IR values obtained (testing is carried out only for visitors with coronavirus symptoms). When data are averaged over the values of the categories of thermal indices, these shortcomings are smoothed out. Accordingly, the above results are obtained.

Conclusion

The spread of COVID-19 in Tbilisi, as well as in other locations of the world, significantly depends on both individual meteorological factors and their complexes (thermal indices). As many researchers note, this dependence is often due to local climatic and other specific conditions, the type of virus, etc. In the future, we will continue these studies both for Tbilisi and other regions of Georgia using more extensive material.

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თბილისში COVID-19-ის გავრცელებაზე ზოგიერთი მარტივი თერმული ინდექსის გავლენის კვლევის წინასწარი შედეგები

ა. ამირანაშვილი, ნ. ჯაფარიძე, ლ. ქართველიშვილი,
კ. ხაზარაძე, ა. რევიშვილი

რეზიუმე

წარმოდგენილია მარტივი თერმული ინდექსების ცალკეული კომპონენტების დღე-ღამური მნიშვნელობების (ტემპერატურა და ფარდობითი ტენიანობა, ქარის სიჩქარე) თბილისის მოსახლეობის კორონავირუსით ინფიცირების დადებითობის მაჩვენებელზე COVID-19 (IR) გავლენის კვლევის შედეგები 2020 წლის 1 სექტემბრიდან 2021 წლის 31 მაისამდე. მიღებულია, რომ IR მნიშვნელობები საპირისპირო კორელაციაშია ჰაერის ტემპერატურასა და ქარის სიჩქარესთან და დადებითად არის დაკავშირებული ჰაერის ფარდობით ტენიანობასთან.
შესწავლილი იქნა ოთხი განსხვავებული თერმული ინდექსის (ჰაერის ეფექტური ტემპერატურა და Wet-Bulb-Globe-Temperature) გავლენა IR მნიშვნელობებზე, რომლებიც გასაშუალებული არის მათი კატეგორიების მასშტაბის დიაპაზონში. აღმოჩნდა, რომ ჰაერის ეფექტური ტემპერატურის ზრდა იწვევს IR მნიშვნელობების შემცირებას. ამ უკანასკნელ შემთხვევაში, თერმულ ინდექსებსა და IR მნიშვნელობებს შორის ურთიერთკავშირის ნიშნადობის დონე გაცილებით მაღალია, ვიდრე IR -სა და ამ ინდექსების ცალკეულ კომპონენტებს შორის ურთიერკავშირის შემთხვევაში.

საკვანძო სიტყვები: ბიოკლიმატური ინდექსი, ჰაერის ეფექტური ტემპერატურა, მეტეოროლოგიური პარამეტრები, COVID-19, დადებითობის მაჩვენებელი.

Предварительные результаты исследования влияния некоторых простых термальных индексов на распространение COVID-19 в Тбилиси

А.Г. Амиранашвили, Н.Д. Джапаридзе, Л.Г. Картвелишвили, К.Р. Хазарадзе, А. А. Ревишвили

Резюме

Представлены результаты исследования влияния суточных значений отдельных составляющих простых термических индексов (температура и относительной влажность воздуха, скорость ветра) на показатель положительности инфицирования коронавирусом COVID-19 (IR) населения г. Тбилиси с 1 сентября 2020 г. по 31 мая 2021 г. Получено, что значения IR находятся в обратной корреляционной связи с температурой воздуха и скоростью ветра, и положительной – с относительной влажностью воздуха.

Изучено влияние четырех различных термических индексов (эффективная температура воздуха и Wet-Bulb-Globe-Temperature) на значения IR, осредненных по диапазонам шкал их категорий. Получено, что рост эффективной температуры воздуха приводит к уменьшению значений IR. В последнем случае уровень значимости связи термических индексов со значениями IR гораздо выше, чем в случае связи IR с отдельными составляющими этих индексов.

Ключевые слова: биоклиматический индекс, эффективная температура воздуха, метеорологические параметры, COVID-19, показатель положительности.

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Managing and Organizing

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ABSTRACT

The globalization of the business environment means that companies are moving to different parts of the world to serve different markets. Therefore, it was necessary to develop performance management (PM) functions that facilitate the development of processes and activities that, in turn, meet the goals and objectives of the organization. The study is devoted to the analysis of the prospects for PM in the modern business environment and the complexity of its implementation. At the same time, the commercialization of scientific achievements, in particular, geophysical research, support for economic activity and innovation in management has become of great importance. This article provides solutions to these problems.

Key words: *Business, management, geophysical data.*

Introduction

PM has engulfed most activities of the organizations in the modern days like in the case of the management of the suppliers, customers, employees etc. However, on a general rendition the discipline has been linked closely with the human resource management (HRM) that looks into the management of the employees (Aguinis, 2009).

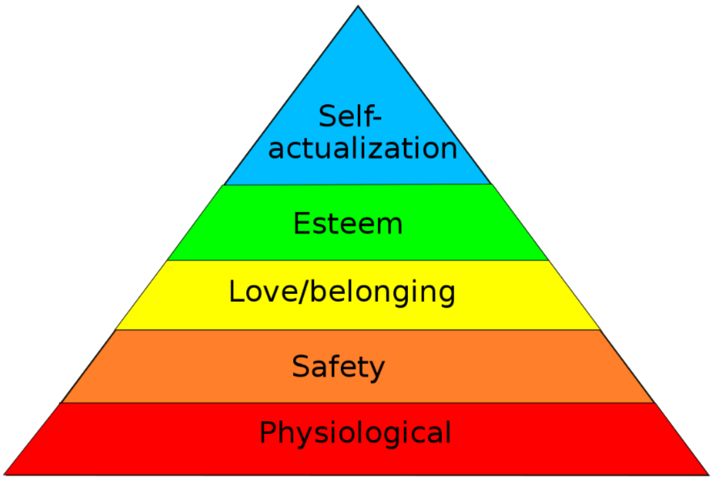
Performance management and its complexity

The major perspective of the subject has been to improve the performances of the organization and the management of the same. This has led to the growth of the discipline of PM from a narrow objective of performance measurement to a broader notion of performance development (Amaratunga and Baldry, 2002). The employees are integral for the better performance of the organizations – especially with and the growth of the service-related industries.

The stakeholder theory also suggests that the employees have been integral to the success of the organizations in the modern days. They are primary stakeholders in the organization and it has been important for the management to take care of their needs (Harrison and Wicks, 2013). Thus, catering to the needs employees has been integral for the companies in the present environment in order to develop the performance of the organizations. The PM functions will thus look into the development of a proper environment for the growth of the employees which in turn can also help in the development of the organizations. The main functions of PM can be stated as follows:

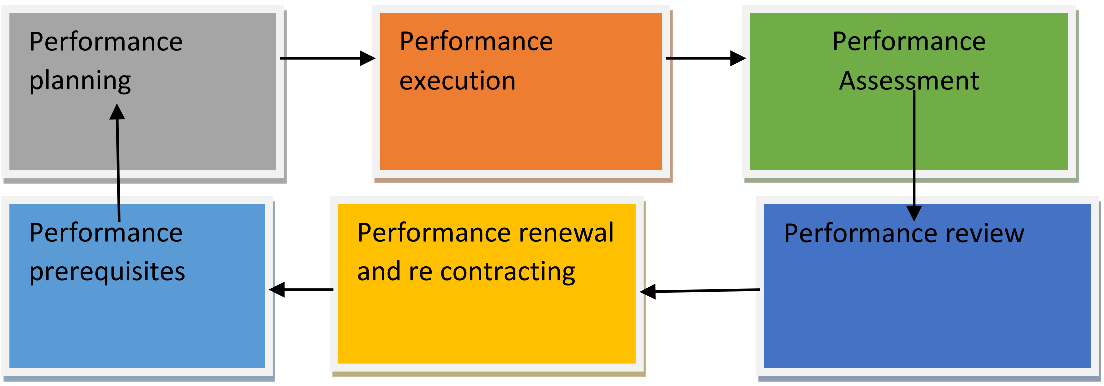
- Keeping record of the major stakeholders like employees;
- Analysis of their performance;
- Understanding the potential of the stakeholders and providing feedback to the management in regards to the same;
- Providing proper framework for the development of their potential; (McConnell, 2007: 186).

It will also be integral to look into the needs of the employees under the stakeholder principles to find out how the employees can be motivated. This can be stated with the help of the Maslow's hierarchy of needs as follows:



The hierarchy of needs model states that the employees can be motivated by the basic aspects of their need like money after which more emphasis has to be given to work environment as well as the relation between the management and the employees. There should be proper chances for the employees to learn, develop and grow in the organization as well (Lee and Hanna, 2015). The main emphasis of the model has been to create an environment where the employees can be provided an environment to grow and develop along with the organization. Therefore, it can be seen that PM functions have been linked to the growth and development of the employees which eventually caters to the development of the organization. Given the competitive nature of the business environment, quality employees have been scarce and therefore, proper emphasis has to be given to manage and retain them. A proper framework of PM can also help in the process (Fan, 2006).

How has this been possible and how would the PM aspects guarantee the growth of the employees? This can be done with the help of a proper framework that can be stated as follows:



Source: Aguinis and Pierce, 2008

The emphasis should be on proper development of performance prerequisites that cater to the development of proper facilities in the work environment. This will relate to proper performance planning related to the job and the execution as well as assessment of the same. The HRM is also engaged in the review of the performance which lead to the analysis of the best performers in the company who are rewarded (Gruman and Saks, 2011). This is in sync with the findings from the Maslow hierarchy model whereby the employees are to be motivated to perform according to the objectives set by the firms.

The study by Gruman and Saks (2011) has found that given the modern-day nature of the work environment, projects are developed according to the dynamic nature of the business environment and they change very frequently. Therefore, it has been difficult to motivate the employees in this context as there is not a standard aspect of the work process and thus the PM framework cannot be developed.

There has been the growth of another model called the Balanced Scorecard (BSC) that looks to compare the performances of the employees to the industry benchmark (Northcott and Taulapapa, 2012). Given the lack of stability of the work processes, this again has not feasible in developing proper PM prerogatives. The employees thus, find the performance measures not related to the project goals. In this context, Gruman and Saks (2011) have recommended the development of employee engagement (EE) perspectives whereby the employees can engage fully in the work environment and can fully express themselves with proper deployment of one's self. However, this is an intrinsic aspect that comes from within and the HRM can only develop the prerequisites for it. The study has also revealed that the main emphasis should be on following the *Job Demands – Resources* (JDR) model whereby the demands of the job are carefully ascertained and negotiated with the employees. The HRM then looks to provide the necessary resources for the fulfilment of the same (Gruman and Saks, 2011).

However, the use of the JDR model cannot cater to the motivational traits of the employees unless they are linked to the quantitative aspects of job performance which in turn disrespects the findings of the stakeholder theory. Catering to the needs of the stakeholders will require analysis of the performance and providing rewards to the employees in addition to increasing employee engagement. In the modern-day dynamic business environment this will be extremely difficult given the fact that work operations change constantly according to the changed objectives.

Conclusion

The study has revealed that PM has been an important prerogative in catering to the needs of the employees in the business organizations. The PM functions relate to the analysis of the performances of the employees and also assisting them to grow in the organization with suitable reward structure. However, with the changes in the business environment, more emphasis has been led to employee engagement whereby the motivational aspects of the employees are intrinsic in nature and cannot be measured. In this context, it has been very difficult to develop proper PM procedures and will require constant analysis of the same by HRM professionals. In particular, the results of the work can be useful in the implementation of certain business projects, taking into account the data of various geophysical studies (expected climate change, risks of natural and man-made disasters, etc. [11-15])

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მართვა და ორგანიზება

ი. ლოლაძე

რეზიუმე

ბიზნეს გარემოს გლობალიზაცია ნიშნავს, რომ კომპანიები გადაადგილდებიან მსოფლიოს სხვადასხვა კუთხეში, რათა მოემსახურონ სხვადასხვა ბაზრებს. აქედან გამომდინარე, აუცილებელი იყო შესრულების მართვის (PM) ფუნქციების შემუშავება, რაც ხელს უწყობს პროცესებისა და აქტივობების განვითარებას, რომლებიც, თავის მხრივ, აკმაყოფილებენ ორგანიზაციის მიზნებსა და მიზნებს. კვლევა ეხება PM-ის პერსპექტივების ანალიზს თანამედროვე ბიზნეს გარემოში და მისი განხორციელების სირთულეს. ამასთან ერთად მეტად მნიშვნელოვანი გახდა მეცნიერული მიღწევების, კერძოდ გეოფიზიკური კვლევების, კომერციალიზაცია, დამხმარე ეკონომიკური საქმიანობა და სიახლე მენეჯმენტში. ამ ნაშრომში მოყვანილია ამ პრობლემების გადაჭრის გზები.

საკვანძო სიტყვები: ბიზნესი, მენეჯმენტი, გეოფიზიკური მონაცემები.

Управление и организация

И. Н. Лоладзе

Резюме

Глобализация бизнес-среды означает, что компании перемещаются в разные части мира, чтобы обслуживать разные рынки. Поэтому необходимо было разработать функции управления эффективностью (PM), которые облегчают разработку процессов и видов деятельности, которые, в свою очередь, отвечают целям и задачам организации. Исследование посвящено анализу перспективы PM в современной бизнес-среде и сложности ее реализации. При этом большое значение приобрела коммерциализация научных достижений, в частности, геофизических исследований, поддержка экономической деятельности и инноваций в управлении. В данной статье представлены решения этих проблем.

Ключевые слова: Бизнес, управление, геофизические данные.

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Chronicle

International Conference of Young Scientists "Modern Problems of Earth Sciences"

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ABSTRACT

Information about the international conference of young scientists "Modern Problems of the Earth Sciences", which was held on November 21-22, 2022 at Ivane Javakhishvili Tbilisi State University is presented.The conference was dedicated to the challenges in the directions of Earth sciences and ways to solve them.

Key words: *Geophysical processes, natural disasters, earth ecology, mitigation.*

Introduction

On November 21-22, 2022, Ivane Javakhishvili Tbilisi State University hosted the International Conference of Young Scientists - "Modern Problems of the Earth Sciences".
More than 50 young researchers from 6 countries participated in the conference.
The objectives of the conference were the presentation of the results of many years of research in the field of earth science by young scientists at the plenary session (oral\stand\video). Also, presentation of reports selected by the scientific committee and their discussion at plenary, sectional sessions and in poster form.
The target group was Georgian and foreign scientific, educational, governmental and non-governmental organizations, which have direct contact with the theme of the conference (universities, research institutes, educational organizations, structures of emergency situations, etc.).
The collection of conference materials and all of its separate articles is available on the website of the National Scientific Library: http://openlibrary.ge/handle/123456789/10224

Goal of the Conference

- Discovering the potential of young scientists in the field of earth science;
- Establishing and strengthening ties between different generations of scientists;
- Defining the prospects for the development of scientific research;
- Identify opportunities for improving the scientific-educational field of secondary and higher education institutions in relation to the issues of the conference;
- Strengthening international scientific cooperation on conference topics;
- To acquaint the world scientific community, governmental structures, other interested organizations and individuals with the current state of the problems related to the fields of Earth Sciences.

Conference Organizers

The conference was organized by the Mikheil Nodia Institute of Geophysics of the Tbilisi State University and the Institute of Hydrometeorology of the Georgian Technical University.

Conference Supporting Organizations

The supporting organization of the conference was the Georgian Geophysical Association.

Scientific Committee and Editorial Board

Organizing Committee

Conference Themes – All Problems of the Earth Sciences

Expected Results

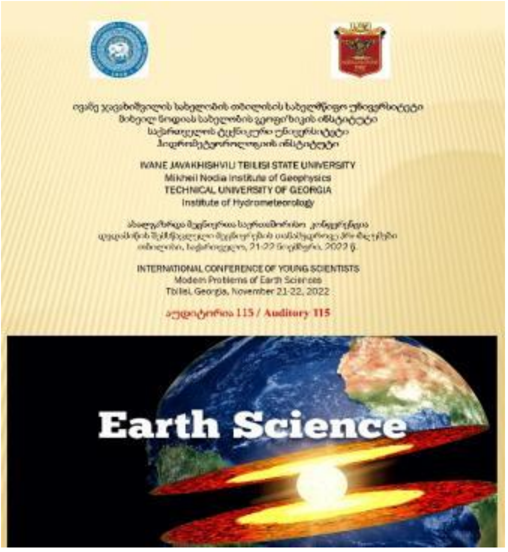
- Promoting historical and modern achievements in the field of Earth Sciences;
- To acquaint the world community with the current state of the problems related to the science of the Earth;
- Enhance international cooperation for the scientific and practical application of modern achievements related to the conference;
- Assess the social and economic risks associated with the conference topics and identify opportunities for joint action to prevent these risks;
- Identify opportunities to improve the scientific-educational base of secondary and higher education institutions in the field of Earth Sciences.

The conference was opened by the co-chairman of the scientific committee, the director of the Institute of Geophysics, Nugzar Ghlonti, who made a general overview of the modern problems of earth science and wished the conference participants fruitful work.
Another co-chairman of the scientific committee, director of the Institute of Hydrometeorology Tengiz Tsintsadze addressed the participants with a welcome speech, talked about the problems of hydrometeorological events and the need to involve young researchers in this field.
Avtandil Amiranashvili, the deputy editor-in-chief, head of the atmospheric physics sector of the Institute of Geophysics, addressed the participants with a closing speech and wished success to the young scientists in their future research activities.
A total of 43 oral and poster presentations were considered at the conference. 42 reports published (see References). One report, at the request of the authors, will be published in another edition (Vepkhvadze S., Malik P., Melikadze G., Todadze M., Ghlonti L., Chikadze T. Assessment karstic water origin along South slope of Grate Caucasus Mountain range).

The proceedings of this conference as a whole, as well as its individual works, are published and posted on the portal of the Institute of Geophysics, which are included in the international electronic library data base DSpace, indexed in Google Scholar and Publish or Perish.

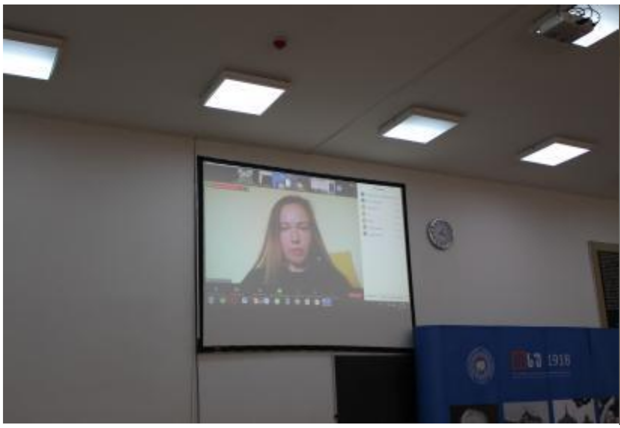
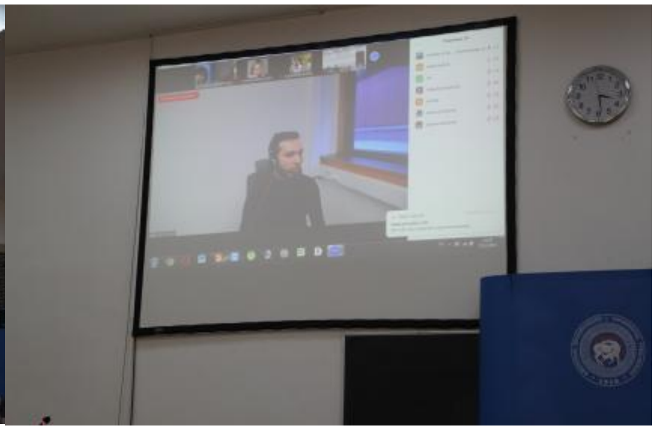
According to the results of the conference, a decision was made, in which the achievements and gaps in the directions of earth science are discussed. Future meetings with the participation of young scientists have been planned.

Photos from Conference





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ახალგაზრდა მეცნიერთა საერთაშორისო კონფერენცია "დედამიწის შემსწავლელი მეცნიერების თანამედროვე პრობლემები"

მ. ფიფია

რეზიუმე

წარმოდგენილია ინფორმაცია ახალგაზრდა მეცნიერთა საერთაშორისო კონფერენციის "დედამიწის შემსწავლელი მეცნიერების თანამედროვე პრობლემები" შესახებ, რომელიც ჩატარდა 2022 წლის 21-22 ნოემბერს ივანე ჯავახიშვილის სახელობის თბილისის სახელმწიფო უნივერსიტეტში. კონფერენცია მიეძღვნა დედამიწის შემსწავლელ მეცნიერებათა მიმართულებებში გამოწვევებს და მათი გადაჭრის გზებს.

საკვანძო სიტყვები: გეოფიზიკური პროცესები, სტიქიური უბედურებები, დედამიწის ეკოლოგია, შერბილება.

Международная научная конференция молодых ученых "Современные проблемы наук о Земле"

М.Г. Пипиа

Резюме

Представлена информация о международной конференции молодых ученых «Современные проблемы наук о Земле», которая состоялась 21-22 ноября 2022 года в Тбилисском государственном университете имени Иване Джавахишвили. Конференция была посвящена проблемам в направлениях наук о Земле и путям их решения.

Ключевые слова: Геофизические процессы, стихийные бедствия, экология Земли, смягчение последствий.

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CONTENTS - სარჩევი

საქართველოს გეოფიზიკური საზოგადოების ჟურნალი

მყარი დედამიწის, ატმოსფეროს, ოკეანისა და კოსმოსური პლაზმის ფიზიკა

ტომი 25 , № 2

ჟურნალი იბეჭდება საქართველოს გეოფიზიკური საზოგადოების პრეზიდიუმის დადგენილების საფუძველზე

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