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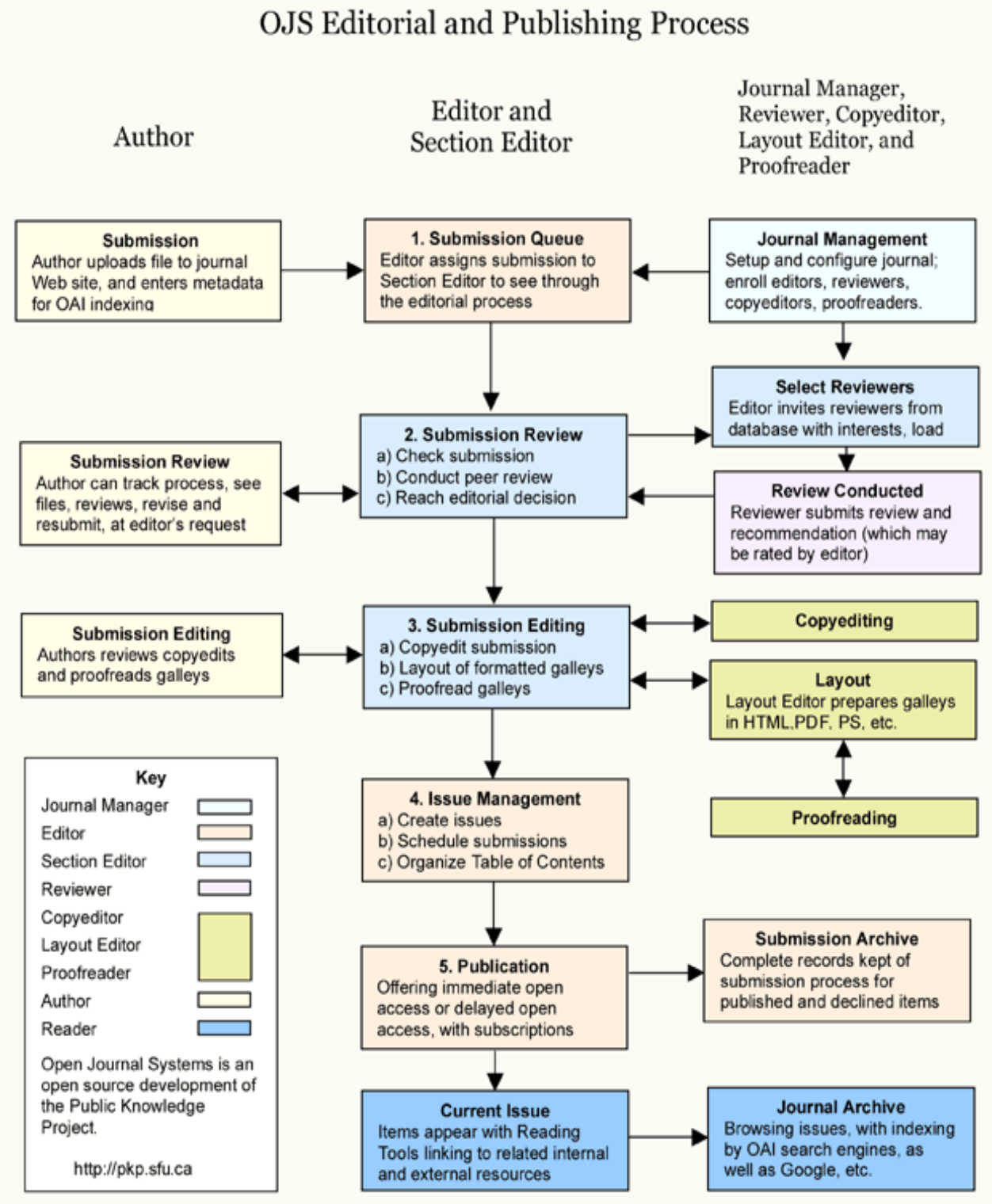

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Principles of Natural Hazards Catalogs Compiling and Magnitude Classification

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ABSTRACT

A systematic inventory of natural hazard (NH) events over the Georgia is valuable for estimating expected hazard and risk, human and economic losses, quantifying the relationship between NH occurrences and climate variations and for evaluating prediction new efforts. Therefore, it is planned to compile the catalogs of the 5 types of NHs (landslide, debris flow, flash flood, hurricane wind and hail) causing significant economic losses and casualties in Georgia throughout the historical time, drawing upon old and new reports, scholarly articles and other hazard databases. This article develops a principles of NH data collection, the basics of magnitude classification of NH events, which will be used in the process of cataloging and magnitude harmonization of these events.

Keywords: *Extreme natural event, natural hazard, natural disaster, natural disaster risk, magnitude, parametric catalog.*

1 Introduction

Georgia is prone to the natural disasters. In the last 30 years here, more than 700 people died and the economic losses amounted to $6.6 billion; this whole country is within the category of medium and high risk [16]. For example, only in the Georgian capital Tbilisi in 2002 occurred earthquake during which 5 people died and economic damage amounted to $350 million, and in 2015, as a result of a landslide in the Vere river-bed and then a flash flood and debris flow was inflicted severe damage to the Tbilisi, more than 20 people died, and estimated damage cost were more than $50 million. By UNDP, Georgia relates to the countries with medium and high level risk. In addition, in the 90s of the last century, in Georgia due to political, economic and environmental problems was increased urbanization at large towns and the associated increase in population density. As a result, urban elements prone to NHs have appeared with ever-increasing risks, which accordingly contribute to the transition from hazards to disasters.

An extreme natural event is simply an unusual event; it does not necessarily cause harm. If a natural event does not pose any risk to human property or lives, it is simply a natural event.

A NH is distinguished from an extreme event. A NH is a threat of a naturally occurring event will have a negative effect on humans. NHs (and the resulting disasters) are the result of naturally occurring processes that have operated throughout Earth's history [12]. Hazard assessment is when scientists study natural events to determine characteristics of various hazards. Hazard Assessment consists of determining the following:

- When and where hazardous processes have occurred in the past.
- The magnitude of past hazardous processes.

- The frequency of occurrence of hazardous processes.
- Probable effects of different hazardous processes depending upon the magnitude.

A NH escalates into a natural disaster when an extreme event caused harm in significant amounts and overwhelms the capability of people to cope and respond. A natural disaster is a hazard that has already occurred. A natural disaster has severe adverse impacts on human lives and livelihoods. Such events result from natural processes in the geospher, hydrosphere or atmosphere [7].

Natural disaster risk assessment involves not only the assessment of hazards from a scientific point of view, but also the socio-economic impacts of a hazardous event. Risk is a statement of probability that an event will cause a statement of the economic loss in monetary terms.

The global sequence of natural disasters is irregular, but it shows a trend toward increases in the number and size of events of all kinds (Fig. 1). Preliminary studies related to the occurred and spread of natural disasters in Georgia [16] showed that the most common are 12 types of natural disasters: earthquake, landslide, snow avalanche, flash flood, debris flow, drought, hurricane wind, lightning, hail, freezing, frost, fog. But the most significant economic losses and casualties are related with six types of this disasters: earthquake, landslide, flash flood, debris flow, hurricane wind and hail. As a result, the natural disasters in Georgia have to be considered as a standing negative factor for the development process of the country. As a result, the natural disasters in Georgia have to be considered as a standing negative factor for the development process of the country. The importance and relevance of the issues discussed above stimulates an active investigation of the parameters of NHs that induce natural disasters. It was revealed that various effects caused by different natural disasters, their complex interaction with the environment, and geophysical, geological and other processes, cause some deficits in the current knowledge. The assessment of vulnerability of the element at risk to hazards is very important for an effective and proper assessment of risk. In order to assess hazard information about its parameters, such as magnitude and intensity of an event, the size of the exposed area and information of damages to elements at risk caused by theses hazards are necessary. It was still unclear what should be considered as the magnitude or recurrence period of the event of a given magnitude, and how these parameters could be estimated [16]. Hence, it was impossible to establish trends change in number of all and separate types recorded natural disasters events in Georgia. Since, on a global scale, the rise in the number of natural disasters is predominantly attributable to weather-related events, and while global warming will continue in the coming decades, its contribution to increasing natural disasters number and losses will become more prominent [8].

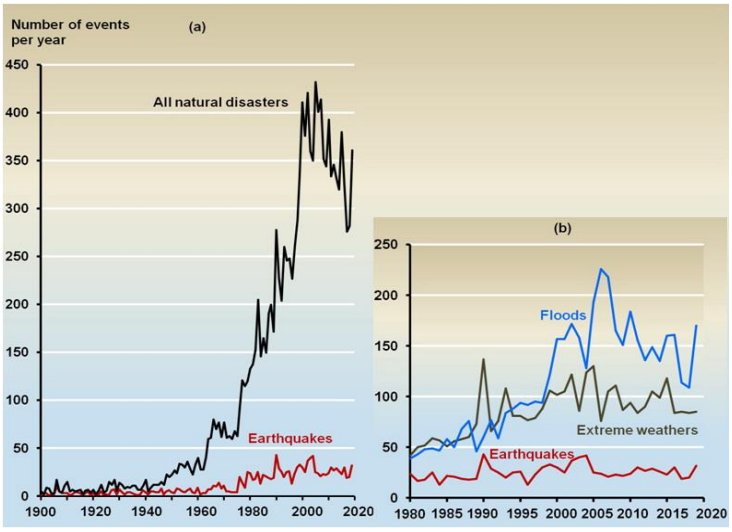

Fig. 1. Trends in number of recorded natural disaster events worldwide: (a) All natural disasters; (b) Earthquake versus hydrological and meteorological disasters ([6], [14], [15]).

The importance of the described issues requires studying the trends and characteristics of the factors of most common and destructive NHs in Georgia, which will be based on the most completeness parametric catalogs of these NHs, homogenized with the appropriate magnitude classification.

2 Principles of natural hazards cataloging

Assessment of NH, investigation of their regularities and many other related issues are mainly based on input data. Along with the development of the field of science of NH, the requirements for source information are increasing. This is especially true for tasks that require statistical approaches.

Thus, it is necessary to create NH parametric catalogs of events occurring in the territory of Georgia. It should be noted that in the reality of Georgia, there is no printed or electronic published parametric catalog for any type of NH events other than earthquakes.

To solve this task, first of all, the principles of compiling catalogs should be established:

- Only unified parameters should be included in the NH catalogs, i.e. the catalogs should include all searched historical events, starting from ancient times to the present day. All events must be classified in a single system, while the main parameters are defined for events of different magnitudes and different times.
- Magnitude classification should be performed for each type of NH events and corresponding catalogs should be harmonized according to one type of magnitude.
- For each event of NH, the most probable values of the main parameters, determined from the set of all available data, should be selected. Main parameter values should have error estimates.
- In the preparation of NH catalogs for each event, it is necessary to use all the available information (bulletins of various types, publications and manuscripts, articles and researches dedicated to individual strong events, extracts from geographical descriptions of travelers and local experts, reports from newspapers and journals, etc.). In this process, we should not limit ourselves to using the main, well-known sources. It is necessary to search for additional data, to conduct search works in print and electronic mass media in various archives, etc., which will allow us to significantly increase the amount of information and discover many new events.
- The preparation of materials for NH catalogs should be carried out in several stages: in the first stage, the data will be collected and systematized, then the initial processing of the existing data will be carried out, the preparation of the materials ends with the compilation of a chronological basis, in which all the prepared data must be entered in a strict order, as well as the results of their initial processing. Then the work will begin - analysis of the collected data, parametrization of NH events and assessment of the accuracy of the obtained values of NH main parameters.

The type and list of the unified main parameters of NH have been established. They will be listed in the catalogs. Each event will have two column allocated in the catalogs (except for the "Comments " and "Sources" columns). In the first column, the values of the main parameters will be placed, in the second column - actual error. Brackets in all graphs mean approximate values of given parameters.

The main parameters are: date (year, month, day), time of occurrence (hour), coordinates of the epicenter (latitude, longitude), magnitude, intensity, damage area (in terms of km^2), scale of natural disaster (number of killed, loss in terms of thousands USA dollars). In addition, there will be "Comments" and "Sources" columns.

3 Magnitude classification of natural hazards

In spite of the substantial differences between the different types of NHs, they require at last three main characteristics for a scientific assessment. First, it has to be principally possible to identify the specific

geographical coordinates. Second, it has to be possible to identify the recurrence period for each type of hazard and third, the magnitude of an event has to be reliably estimated.

The magnitude of a NH event is related to the energy released by the event. It is distinguished from intensity which is related to the effects at a specific location or area. The magnitude of a NH event varies in its frequency of occurrence over time in an inverse power relationship, or in other words, the larger and the more energetic the event, the rarer it is in time [11].

Landslides have become one of the most deadly natural disasters on earth, not only due to a significant increase in extreme climate change caused by global warming, but also rapid economic development in topographic relief areas [10].

Landslide magnitude is the measure of the landslide size. It may be quantitatively described by its volume or (indirectly) by its area. The latter descriptors may refer to the landslide scar, the landslide deposit, or both [2].

Taking into account the available data on landslides in Georgia, we believe that its volume V_{LL} (the mass that has been moved along the main scarp) is the most suitable measure of the landslide size in terms of m^3. And considering that this volume sometimes reaches millions of m^3, it is better to take the logarithm of the landslide volume (in term of m^3) as the landslide magnitude (M_{LL}).

$$M_{LL}=LogV_{LL} \qquad (1)$$

Debris flows represent an important NH process in mountain areas. The main elements required for a practical hazard assessment include the following steps: (i) estimation of potential initiation zones and sediment sources, (ii) establishment of a relation between the magnitude and frequency of expected future debris-flow events, and (iii) assessment of the flow behavior and delineation of areas potentially endangered by flowing debris [13].

A catalogue of past events is an important basis for the hazard assessment. The magnitude of an estimated debris flow event is typically assessed based both on information about magnitude of past events and on geomorphological investigations in the catchment [13].

The estimation of debris flow size, i.e. the maximum volume of debris material discharged during a single event, is a basic step toward the assessment of debris flow hazard [3].

Debris flow magnitude is a measure of the debris flow size, which can be quantified determined by the logarithm of the maximum volume in terms of m^3 of debris material discharged during a single event.

$$M_{DF}=LogV_{DF} \qquad (2)$$

Flash floods cause some of the most severe natural disasters around the world. In Georgia, intense snowmelt and rainfalls in the comparatively small catchments of many rivers, especially in the mountainous regions, cause flash floods.

Flash floods are basically extreme form of hydrological phenomena and it generated by the natural or anthropogenic causes [4].

Flash floods likely to result in significant geomorphic change are those that produce discharges many times above that normally experienced by the river, that is, those with high maximum peak discharge to mean annual discharge [9].

Flash flood magnitude **is** a measure of the flash flood size, which can be quantified determined by the logarithm logarithm of the maximum water discharge in terms of m^3/sec.

$$M_{FF}=LogW_{FF} \qquad (3)$$

By hurricane wind is considered an extreme meteorological event, during which the wind speed exceeds 30 m/s. Hurricane winds can cause catastrophic damage to its distribution area. Moving or airborne debris can break windows and doors and allow high winds and rain inside a home or business. In some hurricane winds, wind alone can cause extensive damage such as downed trees and power lines, collapsing weak areas of homes, businesses or other buildings. Additionally, hurricane winds can create storm surges along the coast and cause extensive damage from heavy rainfall. Floods and flying debris from the excessive winds are often the deadly and destructive results of these weather events.

On the territory of Georgia, hurricane winds are mainly western or eastern direction. Hurricane winds can have a moderate negative impact in the central part of the Colchis lowland with adjacent sub-mountainous and mountainous areas, as well as the South Georgian Highlands and Kvemo Kartli. Here the maximum wind speed can be 43-49 m/s. The zone of significant impact of hurricane wind occupies small areas of the territory of the South Georgian Highlands and Kvemo Kartli. In these areas, the maximum hurricane wind speed can exceed 50 m/s [5].

Hurricane wind magnitude is a measure of the hurricane wind size which can be quantified determined by the hurricane wind speed (in terms of m/s) divided by 10.

$$M_{HR}=S_{HR}/10 \quad (4)$$

The severity of hail events range based on the size of hail, winds, and structures in the path of a hailstorm. Storms that produce high winds in addition to hail are most damaging and can result in numerous broken windows and damaged siding. Hailstorms can cause extensive property damage affecting both urban and rural landscapes. Fortunately, most hailstorms produce marble-size or smaller hailstones. These can cause damage to crops, but they normally do not damage buildings or automobiles. Larger hailstones can destroy crops, livestock and wildlife and can cause extensive damage to buildings. A major hailstorm can easily cause damage amounting into the of millions monetary units.

Georgia is one of the most hail-hazardous countries in the world. Therefore, the problem of hail in this country is devoted to numerous works covering a wide range of studies, such as climatology of hail, radar observation on hail processes, theoretical and experimental studies of the mechanisms of hail formation, methods of impact on hail processes, analysis of impact results, etc. [1].

Hail magnitude is a measure of the hail size which can be quantified determined by the hail grain size in terms of mm.

$$M_{HL}=D_{HL}/10 \quad (5)$$

4 Conclusions

The studies related to the occurred and spread of natural disasters in Georgia showed that the most common are 12 types of natural disasters. But the most significant economic losses and casualties are related with six types of this disasters: earthquake, landslide, flash flood, debris flow, hurricane wind and hail. Thus, is required studying the trends and characteristics of the factors of most common and destructive NH in Georgia, which will be based on the most completeness parametric catalogs of these NHs, homogenized with the appropriate magnitude classification. It should be noted that in Georgia there is no published parametric catalog for any type of NH events, other than earthquakes.

In this article, the principles of compiling NH catalogs are established, which will become the basis for the inventory of NH recorded in the historical past in Georgia, as well as their parameterization and magnitude classification. To implement the latter, the concept of magnitude and the possibility of its quantitative calculation for all considered types of BS were defined.

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ც. ბასილაშვილი, ა. ამირანაშვილი

რეზიუმე

ბუნებრივი საშიშროების (ბს) მოვლენების სისტემატური ინვენტარიზაცია მთელს საქართველოში აუცილებელია მოსალოდნელი საშიშროების და რისკის, ადამიანური და ეკონომიკური ზარალის შესაფასებლად, ბს-ის წარმოქმნასა და კლიმატის ცვლილებას შორის რაოდენობრივი კავშირის დასადგენად და მათი პროგნოზირების ახალი ძალისხმევის შესაფასებლად. ამიტომ დაგეგმილია საქართველოში მნიშვნელოვანი ეკონომიკური ზარალისა და მსხვერპლის მომტანი 5 ტიპის ბუნებრივი საშიშროების: მეწყრის, წყალმოვარდნის, ღვარცოფის, გრიგალური ქარისა და სეტყვის მთელი ისტორიული დროის განმავლობაში მომხდარი მოვლენების კატალოგირება, მოძიებული ძველი და ახალი ანგარიშების, სამეცნიერო სტატიებისა და სხვა საშიშროების მონაცემთა ბაზების საფუძველზე. ამ სტატიაში შემუშავებულია ბს მონაცემების შეგროვებისა პრინციპები, ბს მოვლენების მაგნიტუდური კლასიფიკაციის საფუძვლები, რომელებიც გამოყენებულ იქნება ამ მოვლენების კატალოგების შედგენისა და მაგნიტუდური ჰარმონიზაციის პროცესში.

Принципы составления каталогов природных опасностей и магнитудная классификация

О. Ш. Варазанашвили, Г. М. Гаприндашвили, Е. Ш. Елизбарашвили, Ц. З. Басилашвили, А. Г. Амиранашвили

Резюме

Систематическая инвентаризация природных опасностей (ПО) в Грузии имеет важное значение для оценки ожидаемых опасностей и рисков, человеческих и экономических потерь, количественного определения взаимосвязи между явлениями ПО и изменениями климата, а также для оценки новых усилий по прогнозированию. Поэтому планируется составить каталоги 5 типов ПО (оползень, селевой поток, паводок, ураганный ветер и град), вызвавших значительный экономический ущерб и человеческие жертвы в Грузии на протяжении всего исторического времени, на основе старых и новых отчетов, научных статей и других баз данных об опасностях. В данной статье разработаны принципы сбора данных по ПО, основы магнитудной классификации событий ПО, которые будут использоваться в процессе каталогизации и магнитудной гармонизации этих событий.

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The Possibility of Electroprospecting Methods in the Assessment of Subsurface Humidity and Groundwater Flow in a Landslide Area

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ABSTRACT

Electrical prospecting is a branch of geophysical methods that studies electromagnetic fields of various nature. The purpose of electroprospecting is to determine the electromagnetic characteristics of the geological environment (resistance, conductivity, polarization, etc.), from which we can draw conclusions about the structure of the studied area. Electrical study can be divided into two groups: passive and active methods. The first of them is called natural electric field methods, and the second - artificial electric field methods. The materials presented in our paper were obtained by the method of resistance (vertical electric sensing) and the method of natural electric field. The article presents a study of rock humidity and the possible existence of underground water flows.

Key words: *Electroprospecting, vertical electrical sounding (VES), natural electrical field*

Introduction

Electroprospecting (Vertical Electrical Sounding)

In electroprospecting (resistance method) is used artificial power source. The electricity reaches the ground through the power electrodes and the difference between the arised potentials is measured by the receiving electrodes on the earth surface. If the environment is homogeneous, the resistance method gives us true conductivity, which will not depend on the configuration of electrodes and the position of electrodes on the surface of the earth, since the true conductivity is a constant. In electric resistivity imaging (ERI) electric currents are injected into the ground and the resulting potential differences are measured at the surface, yielding information about the distribution of electrical resistivity below the surface. Finally this gives an indication of the lithological and structural variation of the subsoil (since resistivity depends on sediment porosity and pore water). In the shallow subsurface, the presence of water controls much of the conductivity variation. Measurement of resistivity is, in general, a measure of water saturation and connectivity of pore space (1,2,3,5). This is because water has a low resistivity and electric current will follow the path of least resistance. Increasing saturation, increasing salinity of the underground water, increasing porosity of rock (water-filled voids) and increasing number of fractures (water-filled) all tend to decrease measured resistivity. Increasing compaction of soils or rock units will expel water and effectively increase resistivity. In environment ΔV, and therefore impedance ρ should be dependent on the configuration and location of electrodes, as secondary fields influence on the primary field [2]. Therefore, the measured ρ value in nonhomogenous environments is called an apparent resistivity and is signed as ρa. The coefficient of reaccount for uneven environment depends on the configuration of electrodes. Different configurations of the electrodes are used according to the type of

problem. In our tasks we used the Schumerberger method. Receiver MN electrodes are fixed in the center of the device, while the distance between the current AB electrodes increases gradually [3].

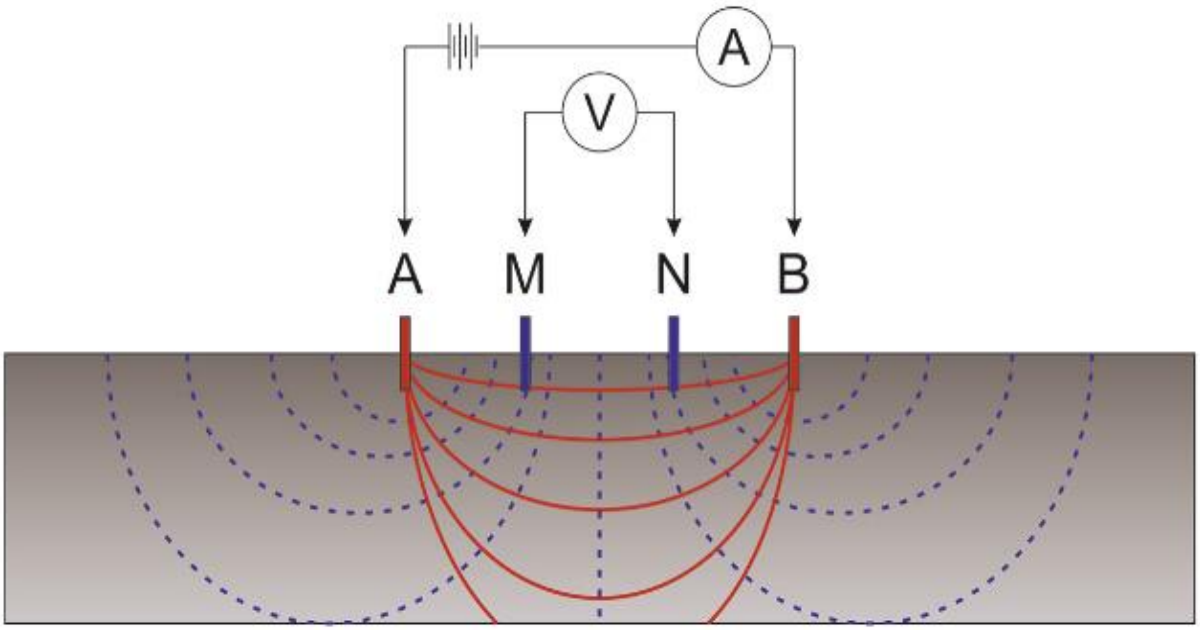


Fig.1. Schlumberger method of vertical electrical sounding

The vertical electrical sounding (VES) method relies on the fact that the greater is the distance between of current electrodes (AB), deeper penetrating the current, than from more deep layers we receivs information by measured potential on the electrode.

The works were carried out by the Italian electrometer equipment (Earth Resistivity Meter PASI 16GL-N). Data processing was done through a certified IPI2WIN program.

Electrical resistance table for some of the rocks

The name of the rock	Electrical resistivity (ohm.m)		
	min	typical	max
Clay	5	10	15
loam	10	30	50
sand clay	30	50	80
Water-saturated sands	50	80	200
Sands slightly moist	100	150	500
Dry sands	200	500	10000
Carbonate rocks weakly cracked	500	1000	5000
Intrusive rocks weakly fractured	1000	2000	10000
Bulk	30	50	500
Permafrost rocks of various ice content	500		80000
Ores minerals conductors(in mostly sulphides)	0,001		1-5

As we see from this table [2], the electrical resistance is different for different rocks that allow us to be more confident about the definition of rocks, the water content in them, and to overcome various geophysical tasks.

A study entitled slope stability analysis for landslides natural disaster mitigation by means of geoelectrical resistivity data in Gedangan of South Malang, East Java, Indonesia has been conducted [12]. The research was conducted using geoelectrical resistivity method by applying a vertical electrical sounding (VES) model and Wenner-Schlumberger configuration. From the data as a result of field data acquisition, processing and interpretation are carried out to obtain landslide parameters. By merging each vertical electrical sounding (VES) point, physical parameters will be obtained as the basis for local landslide analysis [12].

Landslide, as a geohazard issue, causes enormous threats to human lives and properties. In order to characterize the subsurface prone to the landslide which is occurred in the Tehran-North freeway, Iran, a comprehensive study focused on geological field observations, and a geoelectrical survey as a cost-effective and fast, non-invasive geophysical measurement was conducted in the area [13]. The Vertical Electrical Sounding (VES) investigation in the landslide area has been carried out by the Schlumberger array for data acquisition, implementing eight survey profiles varying in length between 60 and 130 m [13]. Electrical resistivity values above 150 Ωm indicate a basement of weathered marlstone and sand. Values between 15 and 150 Ωm illustrate a shale-content layer with outcrops in the area that is the reason for movement. The sliding surface is at a depth of about 12 m. The method used in this study is a good candidate to investigate the risk of landslides in this region and can be applied to other landslide areas where borehole exploration is inefficient and expensive due to local complications [13].

Natural electric field (NF) method

In the lithosphere, there are diverse natural electric fields that differ in their nature, nature and scale of manifestation. Among them, a special place is occupied by the electrochemical fields of natural electronic conductors, also called fields of redox or ore nature. One of the methods of electrical exploration is based on the study of fields of this type - the natural electric field method (SP method), which is used to search for and explore mineral deposits and map certain types of rocks.

The self-potential method enables non-intrusive assessment and imaging of disturbances in electrical currents of conductive subsurface materials. It has an increasing number of applications. Laboratory investigations undertaken, the inverse problem and seismoelectric coupling, and concludes with the application of the self-potential method to geohazards, water resources and hydrothermal systems [8].

Landslides present a latent danger to lives and infrastructure worldwide. Often such mass movements are caused by increasing pore pressure. The electrical self-potential (SP) method has been applied in a broad range of monitoring studies. When fluid flow is involved the most relevant source of SP is the streaming potential, caused by the flow of an electrolyte through porous media with electrically charged internal surfaces [9].

The trigger factor of landslide in Pasanggrahan, Indonesia is the increase of water content in the slope and the slip plane. The slip plane began to actively to turn on when the rainy season arrives. The infiltration of rainwater into slopes as an avalanche trigger can be detected by Self Potential (SP) method. SP measurements were performed to determine changes in subsurface water flow [10].

The major factor that triggered the landslide is the combination of the heavy rainfall and the existing weak zones. The electrical resistivity and self-potential profiling are invaluable tools for providing subsurface information in landslide investigation [11].

Fig. 2. Dry unpolarizable electrodes for self potentials measurement - PMS 9000

In the natural electric field method, two methods of observation are used: the gradient method and the potential method. When using the gradient method, the potential difference between adjacent points of the profile is measured. This method is indispensable in cases where it is not possible to use long wires, for example, in settlements or in areas of intense industrial interference. On the other hand, measurements by the gradient method are often accompanied by the accumulation of a large error, and the results require additional processing. The most commonly used and simplest for processing is the shooting of the EP according to the potential scheme, when one electrode is fixed, and using the second identical electrode, the potential difference between the fixed electrode and the rest points of the space is measured.

Measurements of the natural electric field were carried out by means of non-polarizable electrodes of French production (Unpolarizable electrodes for self potentials measurement - PMS 9000).

Field measurements and processing methods

Electroprospecting works. On March 29, 2021, on the landslide located on Machavariani street, electroprospecting works were carried out using the method of vertical electric sounding. Measurements were performed with modern Italian (PASI GL-15N) equipment. The measurement was performed at two points (Fig. 3). The data was processed using the certified program IPI2Win.

The first measurement was made near the landslide tongue, on Machavariani Street (Fig. 3). The measurement was performed by the vertical electrical sounding, with Schlumberger method. The maximum distance between the current electrodes was 100 meters. The corresponding vertical electrical sounding (VES) curve is presented in Fig. 4. The figure shows the curve obtained as a result of resistivity measurements in black, the theoretical curve in red, and the layers, separated by inversion method, in blue. The analysis of the

imaginary 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 carotage of wells in the vicinity of VES point.

Fig. 3. Positioning of vertical electrical sounding points in landslide body areas.

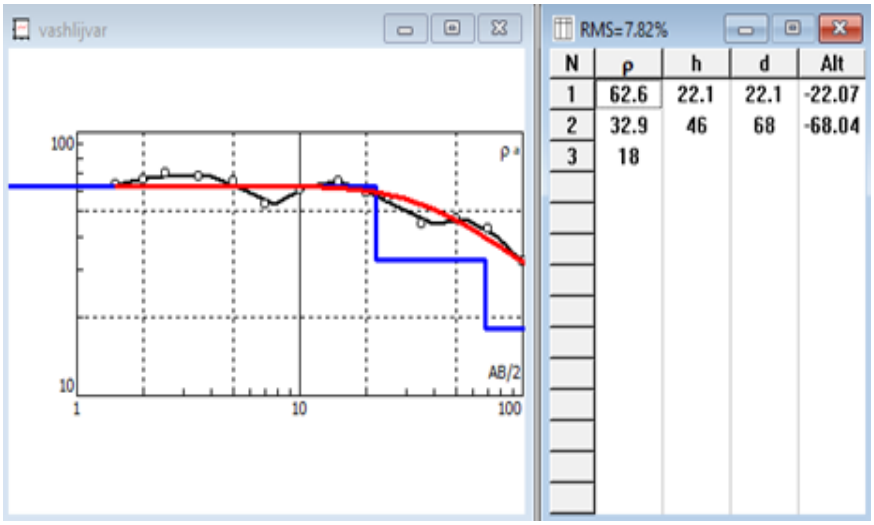
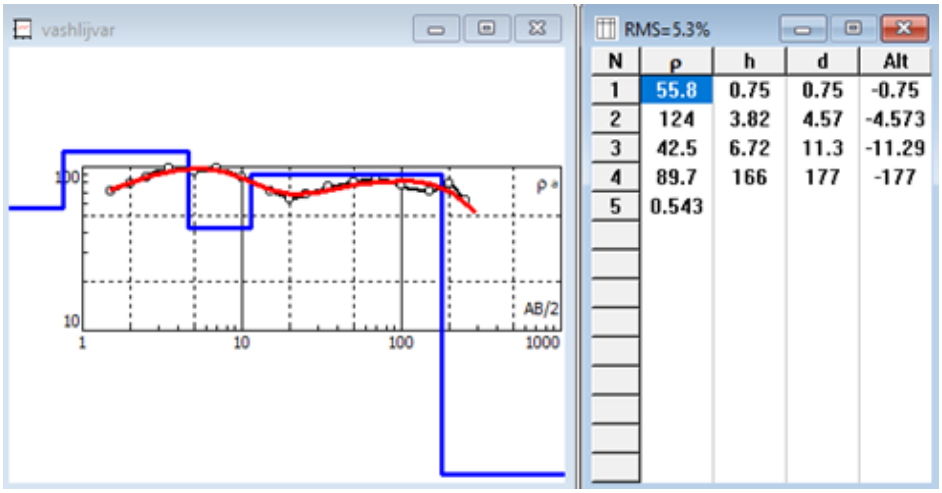


Fig. 4. Vertical electrical sounding curve obtained as a result of measurements near the landslide tongue.

The second measurement was made on the landslide body, about 500 meters away from the first point (Fig. 5). The measurement was also performed using the vertical electrical sounding method with Schlumberger extension. The maximum distance between the current electrodes was 250 meters.

The corresponding vertical electrical sounding curve is presented in at Fig.5. 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 underground space is characterized by high humidity, which may indicate the inflow of water from certain areas.



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. 5. Vertical electrical sounding curve obtained as a result of measurements on the landslide body.

Works of natural electric field. The measurement of the natural electric field was carried out in the vicinity of the second point of vertical electric sounding (vashlijvari2) (Fig.3). The measurement was carried out by method of the potential (Fig.6). One electrode was fixed stationary in the center of the circle, while the other electrode, connected to it by a 25-meter cable, moved around the circle at a 90-degree angle step. The potential difference was measured on each step. Measurements of the natural electric field allow determining the presence and direction of groundwater flow. From the asymmetry of the diagram, it can be assumed that there is movement of underground water. By analyzing the presented diagram (Fig.7), the direction of groundwater flow can be assumed. Most likely, the movement of underground water flow occurs in the direction of small to large potential difference.

Fig. 6. Non-polarizable electrodes PMS 9000

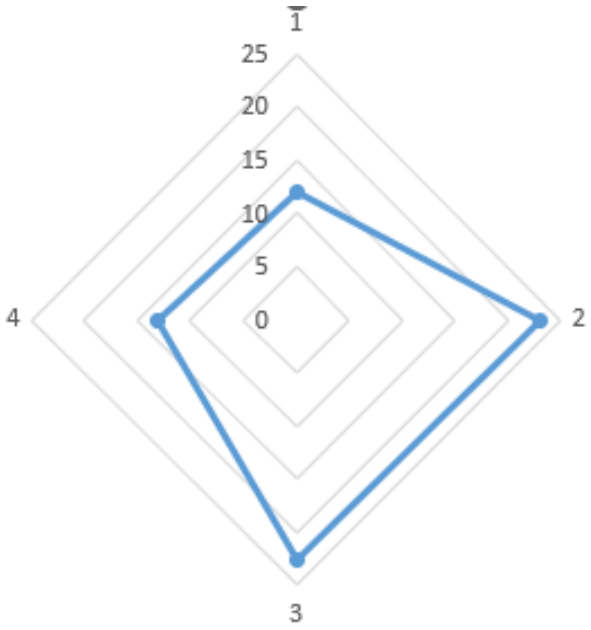


Fig. 7. Result of measurement of the natural field by circular (90° angle) rotation

Conclusion

1.Vertical electrical sounding method is effective in determining groundwater levels, lithology of subsurface and estimating moisture of the subsurface rock. Also, to evaluate the thickness of moistened areas.
2. Measurements of the natural electric field allow determining the presence and direction of groundwater flow.
3. Each of these methods has its own area of application. In the complex they complement each other and can be used for more useful information.
4. However, it should be noted that the work done is not sufficient to study the issue in depth. Further studies are needed.

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ელექტროძიების მეთოდების შესაძლებლობა მეწყრულ არეში ქვეზედაპირის დატენიანების და მიწისქვეშა წყლის ნაკადის შეფასებაში

ნ. ვარამაშვილი, ჯ. ქირია, ა. თარხან-მოურავი, ნ. ღლონტი

რეზიუმე

ელექტროძიება არის გეოფიზიკური მეთოდების მიმართულება, რომელიც სწავლობს სხვადასხვა ბუნების ელექტრომაგნიტურ ველებს. ელექტროძიების მიზანია გეოლოგიური გარემოს ელექტრომაგნიტური მახასიათებლების დადგენა (წინააღმდეგობა, გამტარობა, პოლარიზაცია და ა.შ.), საიდანაც შეიძლება გავაკეთოთ დასკვნები შესწავლილი ტერიტორიის აგებულების შესახებ. ელექტრული გამოკვლევა შეიძლება დაიყოს ორ ჯგუფად: პასიური და აქტიური მეთოდები. პირველ მათგანს ბუნებრივი ელექტრული ველის (ბევ) მეთოდებს უწოდებენ, ხოლო მეორეს - ხელოვნური ელექტრული ველის მეთოდებს. ჩვენს ნაშრომში წარმოდგენილი მასალები მიღებულია წინააღმდეგობის (ვერტიკალური ელექტრული ზონდირების) მეთოდით და ბუნებრივი ელექტრული ველის მეთოდით. სტატიაში წარმოდგენილია ქანების გაწყლიანების და მიწისქვეშა წყლების ნაკადების შესაძლო არსებობის კვლევა.

Возможности электроразведочных методов в оценке подземной влаги и подземного потока воды в оползневой зоне

Н.Д. Варамашвили, Д.К. Кирия, А.Г. Тархан-Моурави, Н.Я. Глонти

Резюме

Электроразведка — раздел геофизических методов, изучающий электромагнитные поля различной природы. Целью электроразведки является определение электромагнитных характеристик геологической среды (сопротивление, электропроводность, поляризация и др.), по которым можно сделать выводы о строении изучаемой территории. Электрические исследования можно разделить на две группы: пассивные и активные методы. Первый из них называется методами естественного электрического поля, а второй - методами сопротивления. Материалы, представленные в нашей статье, были получены методом сопротивления (вертикальное электрическое зондирование) и методом естественного электрического поля. В статье представлено исследование дренирования горных пород и возможного существования подземных водотоков.

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Determining the Presence and Structure of a Subsurface Radioactive Burial when Interpreting the Results of the GPR Method by Analyzing a Three-Dimensional Rotating Radio Image

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ABSTRACT

The state of burial sites for radioactive and other toxic substances poses an environmental hazard, when there are no schemes for their placement and the technical arrangement of their structures is unknown. Thus, it is necessary to determine the condition and structure of underground structures by non-invasive methods. One of the most non-invasive methods in terms of information content and minimization of threats in research is the GPR method [1, 2]. Based on the foregoing, we present two-dimensional and three-dimensional radio images of the underground repository. Rotating radio images at different angles, it is possible to determine the structure of an object located under the daylight surface.
Field georadar work was carried out using the Zond 12e georadar and the interpretation of the results was carried out using the Prism-2.5 and Voxler-4 programs [3, 4].

Key words: *Georadiolocation, 2D and 3D radio images, radioactive burial.*

Introduction

The Scientific Research Institute of Radiation Agronomy of Plants was located and functioned on the Georgia territory of Anaseuli, Chokhatauri region since the 60s of the last century. At present, the remains of the institute building, the remains of the perimeter of the foundation, the remains of a number of demolished objects have been preserved. In the collapsed building of the institute and around it, there were signs of radiation contamination, the sources of which could be located under the daytime surface of the soil, in more or less protected places.

Instrumental part and environment

The purpose of the georadar study was to determine the position, shape and location of radio images of possible underground objects in pre-designated areas (five areas). Georadar work was carried out by the Zond 12 georadar with standard antennas at frequencies of 150 MHz and 75 MHz, data collection and processing was carried out using its Prism-2.5 software. The work was carried out in the area, the soil of which consists of red soil, is common in the southwestern part of the humid subtropics zone (Adzharia, Guria) at an altitude of about 100-300 m above sea level and occupies a hilly-mountainous area. Red soil is characterized by heavy clay, clay and heavy clay with a mechanical composition. The red color is due to the content of ferric iron.

On the territory of the former Soviet Union, including former Soviet Georgia, near-surface radiation repositories were created. Their structure is more or less diverse in shape and partitions made of materials

with different ability to reflect electromagnetic waves that create different cavities. The fig. 1 shows exemplary types of radioactive burial sites for underground structures consisting of various protective layers. Numbers on the fig.1 indicate the radioactive storage burial grounds that are isolated from the external environment with layers of various types of material composition (concrete, clay, sand, inert materials, etc.).

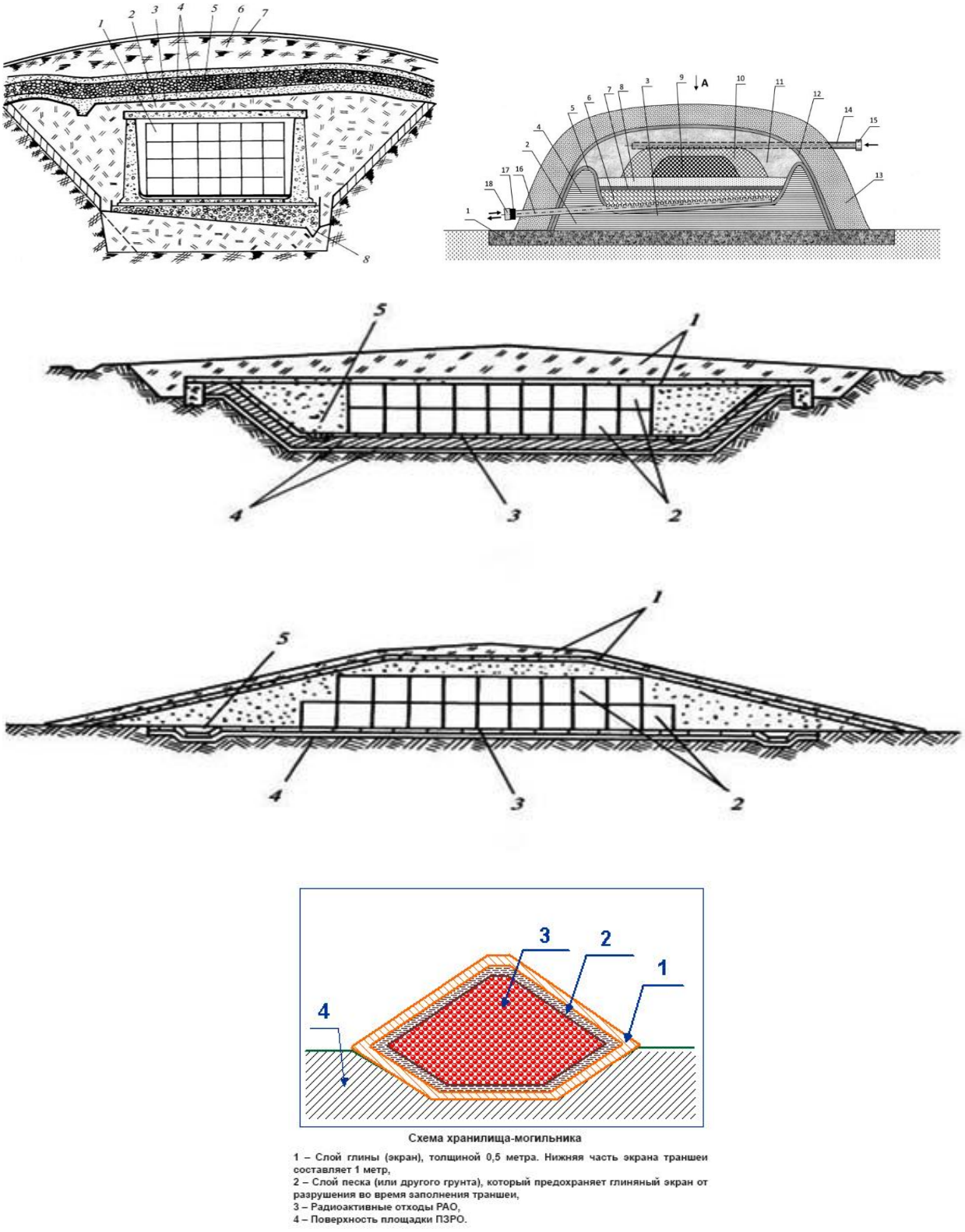

Fig.1. Simple and complex type of some radiation burials.

Results and discussion

Results in fig. 2-8 are presented.

Fig.2. Photo shows the region of the study area-5. The directions of GPR profiles (5a and 5b) are marked with white lines, marking their completion by the arrows.

We present GPR data of the fifth survey site and their two- and three-dimensional radio images.

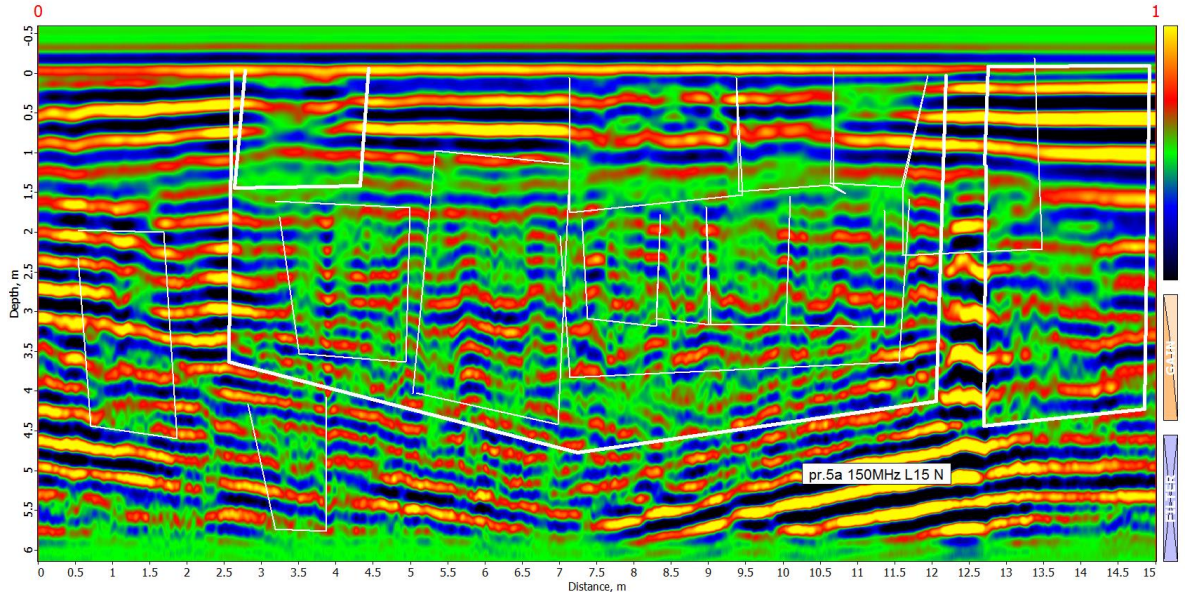

Fig.3. GPR- section with a depth of 6 m and a length of 15 m, presented on the radargram (profile 5a-3647), was made by the Zond 12e georadar with a standard 150 MHz dipole antenna.

The fig. 3 and fig. 4 show the corresponding radargrams of two-dimensional intersecting GPR profiles.

In the center of profile-5a is noted an approximate cavity about 4.5-5 m from the surface. Individual approximate cavities are outlined with white lines at distances of 2.5-12 m and 13-14 m. The radio image of the object at distances of 5.5-7.5 m with a thickness of 2.5-4 m is defined as a "box-shaped" [5, 6]. At distances of 7-12 m is noted a complex, folded radio image of a three-chamber object. Under the large cavity is clearly distinguished a conical base with a tip at a distance of 7.5 m.

From the surface of the tile in depth there are cavities 1.5 m thick [7, 8] (possibly filled with demolished material), under the tile there are cavities at a distance of 2.5-4.5 m, 7.5-9.5 and 10.5-12 m, these are possible traces of destruction.

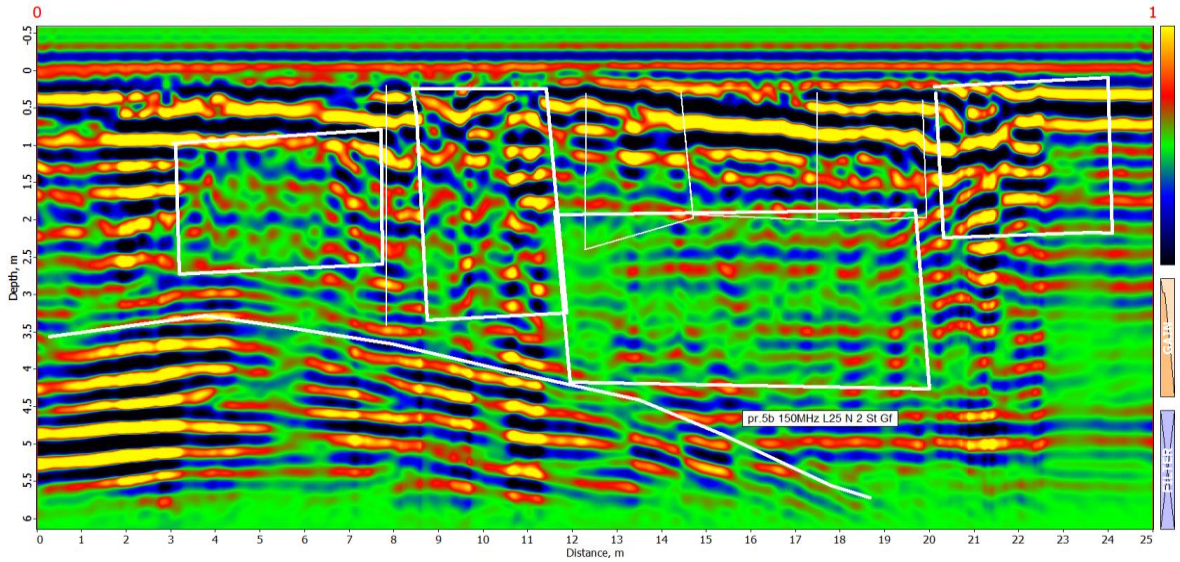

Fig. 4. GPR-section (profile 5b-3648) with a depth of 6 m and a length of 25 m, made by the Zond-12e georadar with a standard 150 MHz dipole antenna.

Profile 5b clearly shows cavities marked with white lines at distances of 3-7 and 12-20. A radio image of the "bow-tie" type is determined at a distance of 8-11 m from a depth of 0.5 m to 3.5-4 m. A cavity was also noted at 20-24 distances. The inverted cone-shaped part of the base was clearly distinguished at distances of 0–18, which is in good agreement with the results of profile 5a. Generally, profile-5a and profile-5b are in good agreement with each other and complement each other.

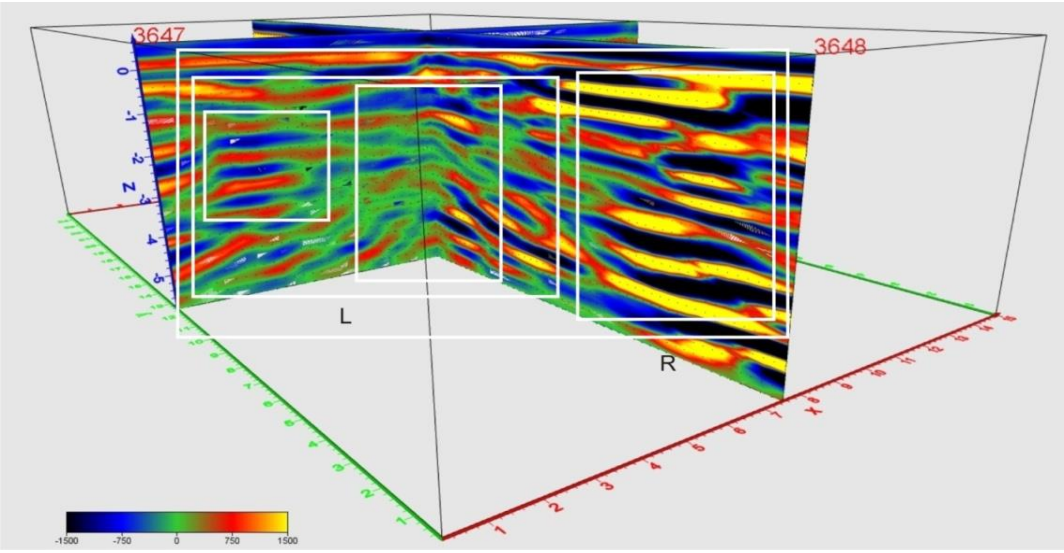

Fig.5. 3D radio image, created from profile-5a and profile-5b radargrams GPR-section. The lengths of the profiles are measured along the axes: Prof-5a length -15 m and Prof-5b length -25 m, which are built with GPR files-3647 "front" and file-3648 "rear". The selected segment of the electromagnetic wave amplitude is set according to the legend.

To represent the radio image in a 3D image, the software Prism-2.5 and Voxler-4 were used, they made it possible to see the radio image of the object in three dimensions [3, 4], by selecting the amplitude segment of the electromagnetic wave and using the appropriate rotation option.

Figures 5, 6, 7, 8 show views of the radio image of the object at different angles of rotation from the vertical axis of the intersection of the profiles.

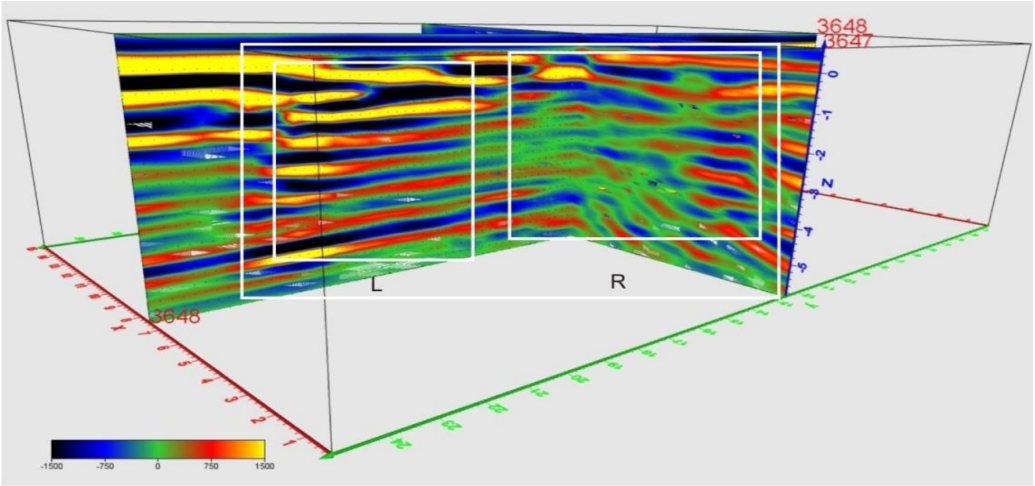

Fig. 6. 3D radio image created with profile 5a and profile 5b radargrams. The lengths of the profiles were measured along the axes: Prof-5a length 15 m, Prof-5b length 25 m. The radio image was rotated at an angle of 90 degrees from the axis of the intersection of the profiles.

Three-dimensional coordinates of the radio image are marked in meters. The left side is marked (L) and the right side is marked (R), special areas of the radio image are marked with white rectangles. The left side of the radio image consists of two main shapes with partial overlaps. In the center of the radio image is the so-called "bow-tie" with its characteristic arrangement of the in-phase axes, complicated by the horizontal axes of the in-phase of the left, rectangular overlapped object. The left large rectangular area of the radio image common-mode is read as a complexity of a "pit" type complex with vertical walls. The right rectangle is distinguished by a more reflexively located uneven-walled wall, it is horizontally covered by a possible reinforced concrete slab and has a pronounced base. As a wall material, it was possible to use brick or concrete-block masonry, separated from the environment by a clay-like material.

Thus, the interior of the burial ground consists of a distinctly isolated three-dimensional cavity, complicated by horizontal rectangular non-uniform partition inserts.

On the fig. 6 the angle of the radio image, twisted at an angle of about 90 degrees. Clearly distinguishes the left wall with a bounding vertical partition, turning into the radio image of the "pit" type object, file-3647 "rear part".

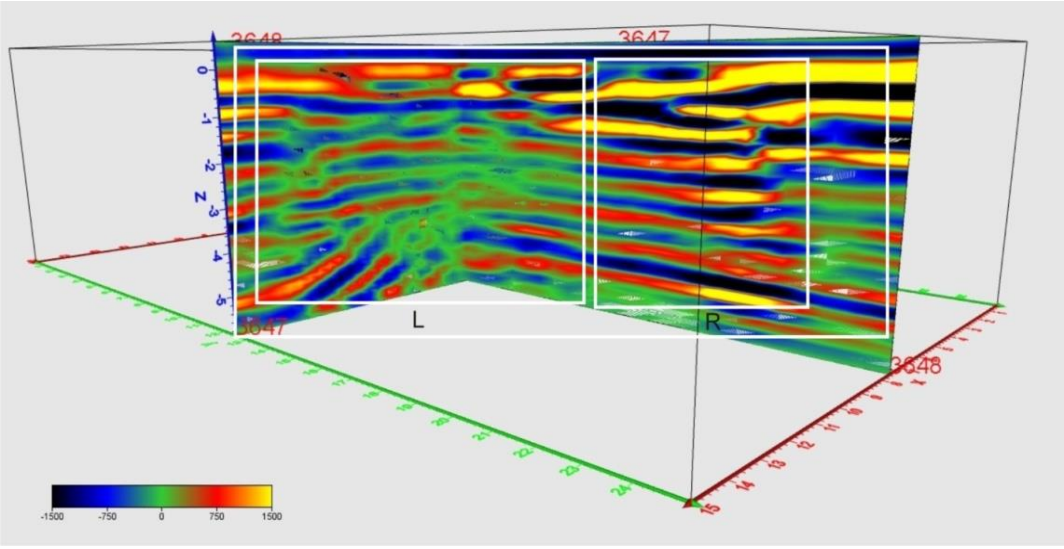

Fig.7. 3D radio image created with profile 5a and profile 5b radargrams. Profile lengths are measured along the Prof-5a axes at -15m, and Prof-5b at -25m. It consists of a "rear" file 3647 and a "rear" file 3648.

Have been identified the "Bow-tie", complicated by horizontal surfaces and space created by a wall of highly reflective material.

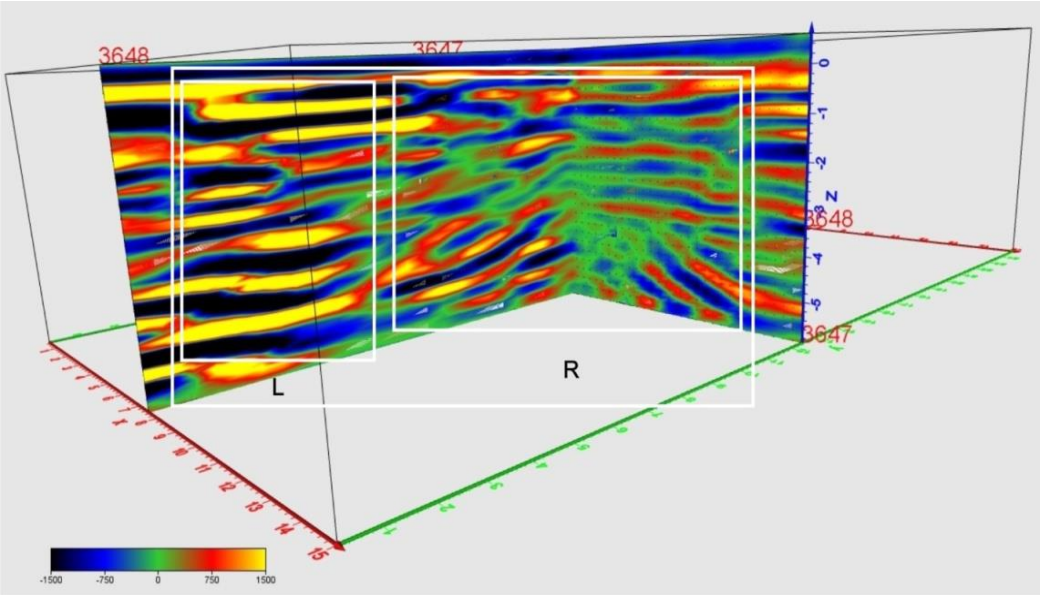

Fig. 8. 3D radio image created using profiles 5a and 5b radargrams. The lengths of the profiles are measured along the axes: Prof-5a length 15 m and Prof-5b - 25 m.

The space was clearly represented by a radio image, “bow-tie” complicated by radio images superimposed by horizontal inclusions at depths of 2-4 m.

Conclusion

Fragmentary GPR studies conducted in Ozurgeti, at the previously designated sites of the Research Institute of Radiation Agronomy of Plants, revealed a variety of 2D-dimensional radio images [7, 8, 9], indicating the existence of different types of radioactive insects [10, 11, 12].

Rotation shapes of 3D radio images of underground objects were analyzed to determine the location and shape of the object. In particular, the angles of rotation of the three-dimensional radio face of the "Plot-5" object were used to clarify the internal spatial cavity of the burial ground, to delineate the space marked with "bow-tie" and complicated by horizontally located inclusions.

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გეორადიოლოკაციური მეთოდის შედეგების ინტერპრეტაციისას სამგანზომილებიანი მობრუნებითი რადიოსახის ანალიზი, ახლოქვეზედაპირული განთავსების რადიოაქტიური სამარხ-საცავის არსებობისა და მისი აგებულების დადგენა

დ. ოდილავაძე, თ. ჭელიძე, ნ. ღლონტი, ო. იავოლოვსკაია

რეზუმე

ჯვარედინად გატარებული გეორადიოლოკაციური კვეთების (Prism 2.5) მიხედვით აგებული პროფილების შედეგად მიღებული შედეგების მიხედვით გაკეთებული ინტერპრეტაციის დასაზუსტებლად საჭირო ხდება დამატებით ,,Voxler 4“ პროგრამის გამოყენება, რათა დაზუსტდეს რადიოსახის გვაროვნება, მაშინ როდესაც ის მკაფიოდ არ იკვეთება. ჩვენს შემთხვევაში კვეთებზე (Prism 2.5) მიღებული შედეგების მიხედვით არ გამოიკვეთა მკაფიოდ სიღრუის დამაფიქსირებელი ,,ბოუ-თაის“ ტიპის რადიოსახე. ,,Voxler4 ,, პროგრამული უზრუნველყოფის გამოყენების შედეგად , მკაფიოდ დაფიქსირდა ,,ბოუ-თაის “ ტიპის 3D რადიოსახე, ხოლო პროფილთა გადაკვეთის ღერძის გარშემო ბრუნვითი რაკურსების შედეგად დადასტურდა რადიოსახის არსებობა. ამრიგად, შეიძლება ჩვენს მიერ მოყვანილი მაგალითი გამოდგეს პარადიგმად გეორადიოლოკაციური ინტერპრეტაციისას პრობლემურ პირობებში შედეგების მეტი ინფორმატულობით წარმოდგენისთვის.

Определение наличия и структуры подповерхностного радиоактивного захоронения при интерпретации результатов георадарного метода по анализу трехмерного вращающегося радиоизображения

Д.Т. Одилавадзе, Т.Л. Челидзе, Н.Я. Глонти, О.В. Яволовская

Резюме

Для уточнения интерпретации результатов, полученных по профилям, построенным по поперечным георадиолокационным разрезам (Prism 2.5), желательно использовать дополнительную программу " Voxler 4" для уточнения наименования радиообраза, когда его не видно. В нашем случае результаты, полученные на пересечениях (Prism 2.5), не выявили радиоизображения типа «боу-тай», четко определяющего глубину. В результате использования программного обеспечения Voxler было четко идентифицирован 3D радиообраз типа боу-тай, а наличие радиообраза было подтверждено углами поворота вокруг оси пересечения профиля.

Приведенный нами пример можно использовать как парадигму интерпретации георадиолокации для более информативного представления результата в проблемных условиях.

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Comparison of the Distribution of Radionuclides and Heavy Metals in Georgian Soils

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ABSTRACT

Environmental pollution is an undesirable process of loss of substances and energy caused by human economic activities, such as the extraction and processing of raw materials, which is accompanied by the separation and dispersal of waste in the biosphere. The long-term threat of contamination of agricultural areas (decades or more) is associated with a drop in long-lived biologically active radionuclides of 90Sr and 137Cs. The data from the last round of our survey showed that in 2013-2018 the land area we surveyed reduced the 137Cs pollution density to 3.1% on Makhata Mountain. In Gardabani - 5.4%, in Rustavi - 31.9%, in Zestafoni - 55.4%. We will continue monitoring and will offer you the following in new article.

Keywords: *Radionuclides, heavy metals, forest brown soils.*

Introduction

The natural radioactivity of the biosphere is due to the origin of galactic (GCR) and solar (SCR) cosmic rays and radioactive isotopes (nuclides) - natural radionuclides contained in the Earth's crust, atmosphere and hydrosphere. Natural radiation background is constantly present in the biosphere.v.i. Vernadsky noted the enormous role of element radioactivity in evolution and the existence of the biosphere [1].

Environmental pollution is an undesirable process of loss of substances and energy caused by human economic activities, such as the extraction and processing of raw materials, which is accompanied by the separation and dispersal of waste in the biosphere. A comprehensive tool for studying different anthropogenic impacts on the environment is its comprehensive analysis [2]. In the event of a nuclear accident, adequate protection of society and the Measurement of radiation dose and radioactive contamination in the environment is essential for the optimization and decision-making process of radiation protection. However, in the early phase, such measurements are rarely available or sufficient. environment requires timely assessment of short-term and long-term radiological impacts. To compensate for the lack of monitoring data during nuclear emergencies, especially in the early stages of an emergency, mathematical models are often used to estimate the temporal and spatial distribution of radioactive substances. Which we have used in our works and the relevant results are in the case of Rustavi-Zestafoni [3].

Results

Radioactive contamination of agricultural lands is classified as areas of intensive agricultural production. The long-term threat of contamination of agricultural areas (decades or more) is associated with a drop in long-lived biologically active radionuclides of 90Sr and 137Cs (Fig.2).

Agricultural land in the mentioned district. The study of the natural radiation background of the soils of Gardabani district was carried out, where the highest annual dose was recorded at 120 ng / h, 1.06 mW/year [3,4]. It is known that the so-called The average data of the "normal" regions is 0.7 mSv / year. If we compare this figure with the data of the Gardabani zone, wewill see that the Gardabani region is one of the regions of the increased radiation zone Part of the agricultural land in Gardabani district has the highest dose of 137Cs pollution. And from heavy metals the most overdose is fixed to the metal ***Zn, Pb, Fe*** as for Rustavi and Zestafoni, the level of radiation pollution is not alarming (Table 1, Table 2).

Table. 1. Heavy metal content in soils of district.

Place of sampling	Heavy metal content in soils of district		
	Zn	Pb	Fe
Gardabani	770	360	3492
Rustavi	260	320	3426
Zestafoni	920	280	3105
Makhata Mountain	650	220	2988
MPN	300	130	420

Table.2. Doses of radiation elements in the examined areas.

Regions	Radionuclide Cs -137	Radionuclide Sr-90	MPN Beck/kg Cs -137	MPN Beck/kg Sr-90
Gardabani	47	18,1	50	20
Rustavi	11	27,4	50	20
Zestafoni	31	27	50	20
Makhata Mountain	27	16	50	20

Agricultural production in these areas was carried out on thousands of hectares, of which 3% had 137Cs pollution levels above 37 kW / m². Land pollution by 90Sr was negligible except for the interior of the Rustavi Metallurgical Plant, so the rest of the areas do not require protective measures. However requires monitoring. Thirty years after the Chernobyl accident, the radiation situation has improved significantly [5].

As a result of the radioactive decay of 137 Cs, the area of contaminated agricultural land in certain areas was reduced by the contamination density by 33.7%. We have tried to review the radiation situation around the existing enterprises, such as Zestafoni Ferro and Rustavi Metallurgical Plants, to ensure radiation safety, which is reflected in our published works (Fig. 1).

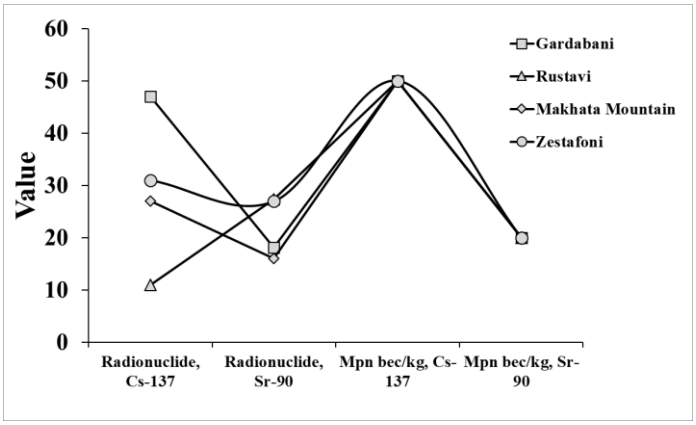

Fig.1. Distribution of Cs -137 and Sr-90 in soil.

Compare in this work with Gardabani, Rustavi and Makhata mountains the radiation factor in terms of its potential threat to life. Has a more balanced character. In terms of both radionuclides and heavy metals. Comparison of these data confirms the absence of harmful consequences of the Fukushima tragedy in Georgia. We will touch on the agrochemical characteristics of the soil in small volumes. Study zone in terms of climate and other conditions. Presented in the above strip loamy, forest brown soils and transitional forms

between field-type soils. Mostly loamy soils of different thicknesses are common. They are developed on the products of sandstones, porphyries and andesite's.

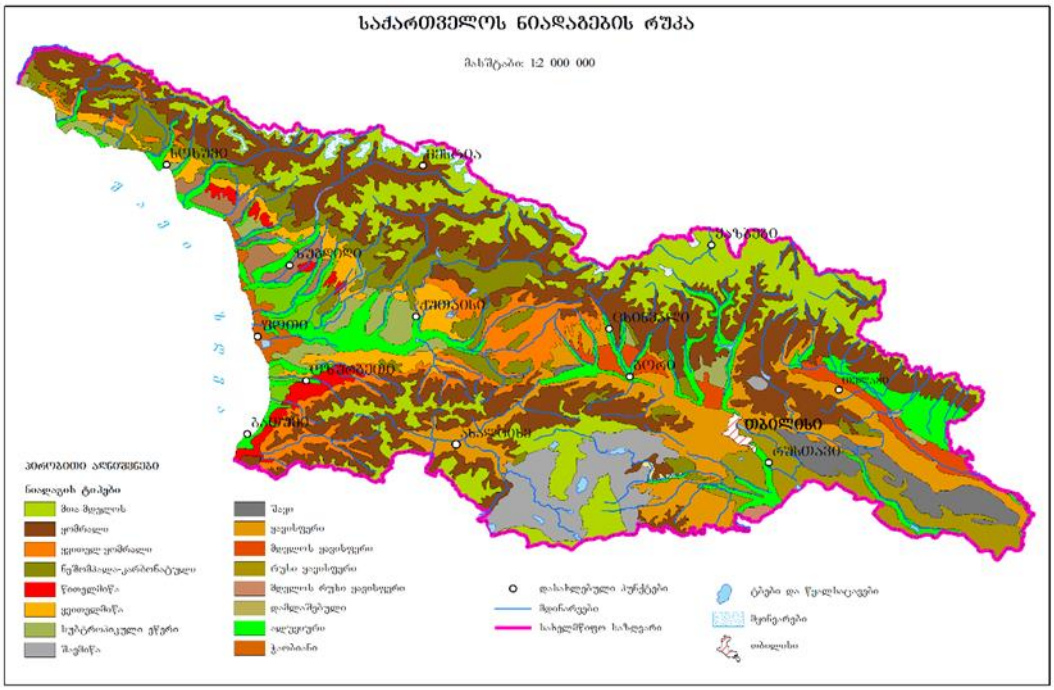

Fig. 2. Geological section of forest brown soils.

Loamy, forest brown soils and transitional forms between field-type soils. Mostly loamy soils of different thicknesses are common. They are developed on the products of sandstones, porphyries and sites (Fig. 2).

Fig.3. Georgian soils.

Due to the slope of the terrain, the soils have different profile thicknesses and mostly small thickness soils are common. The brown soils of the forest are characterized by a well-defined humus layer, strong waterproof structure, absorption capacity and carbonate content over almost the entire profile and carbonate content over almost the entire profile (Fig.3).

Conclusion

The data from the last round of our survey showed that in 2013-2018 the land area we surveyed reduced the 137Cs pollution density to 3.1% on Makhata Mountain. In Gardabani - 5.4%, in Rustavi - 31.9%, in Zestafoni - 55.4%. We will continue monitoring and will offer you the following in new article.

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რადიონუკლიდების და მძიმე მეტალების გავრცელების შედარება საქართველოს ნიადაგებში

ს. მათიაშვილი,ზ. ჩანქსელიანი, ე. მეფარიძე

რეზიუმე

გარემოს დაბინძურება არის ნივთიერებებისა და ენერგიის დაკარგვის არასასურველი პროცესი, რომელიც გამოწვეულია ადამიანის ეკონომიკური საქმიანობით, როგორიცაა ნედლეულის მოპოვება და გადამუშავება, რასაც თან ახლავს ბიოსფეროში ნარჩენების გამოყოფა და გაფანტვა. სასოფლო-სამეურნეო ტერიტორიების დაბინძურების გრძელვადიანი საფრთხე (ათწლეულები ან მეტი) დაკავშირებულია 90Sr და 137Cs ხანგრძლივი ბიოლოგიურად აქტიური რადიონუკლიდების ვარდნასთან. ჩვენი კვლევის ბოლო რაუნდის მონაცემებმა აჩვენა, რომ 2013-2018 წლებში ჩვენმიერ გამოკვლეულმა მიწის ფართობზე შემცირდა 137Cs დაბინძურების სიმკვრივე მახათას მთაზე 3.1%-მდე. გარდაბანში - 5,4%, რუსთავში - 31,9%, ზესტაფონში - 55,4%. ჩვენ გავაგრძელებთ მონიტორინგს და შემოგთავაზებთ შემდეგს კვლევებს ახალ შრომაში.

Сравнение распределения радионуклидов и тяжелых металлов в почвах Грузии

С.Б. Матиашвили, З.Дж. Чанкселиани, Е.В. Мепаридзе

Резюме

Загрязнение окружающей среды - нежелательный процесс потери веществ и энергии, вызванный хозяйственной деятельностью человека, такой как добыча и переработка сырья, который сопровождается разделением и рассеиванием отходов в биосфере. Многолетняя угроза загрязнения сельскохозяйственных угодий (десятилетия и более) связана с падением уровня долгоживущих биологически активных радионуклидов 90Sr и 137Cs. Данные последнего раунда нашего исследования показали, что в 2013-2018 годах на обследованной нами территории плотность загрязнения цезием-137 снизилась до 3,1% на горе Махата, в Гардабани — 5,4 %, в Рустави — 31,9 %, в Зестафони — 55,4 %. Мы продолжим мониторинг и представим результаты в следующей статье.

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Numerical Study of the Distribution of Floating Debris in the Coastal Zone of the Black Sea of Georgia

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ABSTRACT

Numerical modeling of the distribution of floating marine debris in the coastal waters of the Black Sea of Georgia using marine litter monitoring data is presented. The monitoring was carried out in Poti and Batumi nearshore water areas during September 2019 under the framework of EU project RedMarLitter. To simulate floating marine debris a 2D nonstationary advection-diffusion model is used, which is coupled with the regional model of the Black Sea dynamics of Institute of Geophysics of I. Javakhishvili Tbilisi State University (RM-IG), The RM-IG is a core of the regional forecasting system for the easternmost part of the Black Sea and is based on a full system of ocean hydrothermodynamics equations written in a Cartesian coordinate system. The modeling results showed the important role of advection and diffusion processes in the spatial-temporal distribution of floating solid waste.

Key words: *Circulation, marine litter, modeling system, advection-diffusion equation.*

1. Introduction

At the present stage of human development, environmental pollution with different anthropogenic impurities has become a global problem, the study of which is one of the main issues of modern environmental sciences. Among the environmental pollution problems, the pollution of the seas and oceans by solid waste (marine litter) has become one of the most important challenges for the world. Studies show that the world ocean is heavily polluted with debris – plastic bags, rubber, bottles, paper/cardboard, etc., which have a very negative impact on the marine ecosystem [1-4]. Some of them float on the sea surface, but most of marine litter sink and accumulate on the seabed. Marine litter enters the marine environment from both land- and sea-based sources. The source of this kind of waste is the garbage discharged from the ships, the household waste dumps along the banks of rivers, that are discharged into the rivers during floods, the waste accumulated on the sea coasts during the holiday season, etc. Most marine debris is plastics, which tends to break down into small particles and is often ingested through food and leads to various adverse health effects [2, 3]. Furthermore, plastics are a source of toxic chemicals, very dangerous for marine life. By estimation of some experts, 6.4 million tons of litter are entering the oceans each year [3].

Monitoring of solid waste in the seas and oceans is an important part of the marine environment monitoring in general and is a prerequisite for maintaining the ecological safety of marine systems and sustainable development of society. This problem is highlighted in the EU Marine Strategy Framework Directive (MSFD), where among 11 descriptors providing for good environmental status of the sea environment, descriptor 10 considers the survey of marine litter in marine environment (properties and quantities of marine litter).

Over the last two decades, a lot of works on marine litter monitoring have been conducted at sea beaches, at the sea surface and at the seabed in order to estimate and study litter spatial distribution, its composition and to identify the sources (e. g., [1-9]). In [1] beach litter was considered as a threat to beach tourism and studies have focused on the quantification and classification of marine litter on the beach of the City of Ensenada (Baja California, Mexico). During the monitoring, which was carried out on April-August 2000, the beach of Ensenada revealed a total of 16474 objects, including 2686 plastics (16,3%).

Spatial and temporal variability of the floating debris was studied in [2] based on data collected during oceanographic cruises in 1997 and 2000 in the north-western Mediterranean sea. A debris density in 1997 was 15-25 objects km^{-2}, while for the 2000 data, a lower density of the order 3 – 1.5 km^{-2} was found. This result indicates a significant time variability in the debris concentration in the Mediterranean basin. According to the authors, possible reasons for the observed variability are meteorological forcing, marine currents or debris input variability.

In [3] a rather detailed study of the distribution of marine debris in the waters of the European seas was carried out based on the analysis of data collected during 588 video and trawl surveys across 32 sites in European waters. In the Mediterranean Sea, which is an inland sea like the Black Sea, several hotspots were discovered. The hotspot with a maximum litter density 21-40 $kg.ha^{-1}$ was observed near the Spain shore. One of the conclusions of this study is that the highest litter density occurs in submarine canyons, whilst the lowest density can be found on continental shelves and on ocean ridges. It turned out that the most prevalent litter item found on the seafloor.

In [4] benthic marine litter were investigated during the period January-March 2013 in five study areas from the Eastern Mediterranean and Black Seas (Constanta Bay). Plastics were predominant in all study areas ranging from 45.2% to 95%. In total 5398 marine litter items were collected from all the study areas. The highest density was found in the Saronikos Gulf (1211 ±594 items/km^2), in the Constanta bay 291±237 items/km^2 litter density was found.

Like the world ocean, the Black Sea pollution with marine litter has become very relevant in the last two decades [5-9], which has a very negative impact on the marine ecosystem. Studies have shown that the bottom of the Black Sea coastal zones is often filled with municipal solid waste - bottles, banks, plastic materials, and more. The number of start-ups has been established for processing and recycling the plastic debris from environment, including the marine area (e. g. Tene Ltd.- https://www.facebook.com/TeneUSB/)

Following MFSD requirements, monitoring of marine litter has been conducted on 3 selected beach sections (Ureki, Kobuleti and Sarpi beaches) of Georgia within EC-UNDP funded project EMBLAS I/II in the period from 2015 to 2017 [6]. As a result of the monitoring work carried out, the authors conclude that the litter on the surveyed sections of beaches is generated from land-based sources. Monitoring results showed that Ureki beach is more loaded by litter, the volume of plastic in total amount of litter is 95-96 %.

At present, numerical (mathematical) modeling is widely used to study the features of the floating marine litter distribution in the world ocean. A rather large number of publications are devoted to this issue (e. g., [10-18]).

The use of mathematical modeling methods allows to estimate the scales of marine litter distribution and contribution of different factors (sea circulation, atmospheric wind, etc) to floating litter dispersion process, providing better understanding litter dispersion processes. Distribution of floating marine debris in marine environment largely depends on the sea circulation parameters, which are calculated from ocean circulation models. In [10] different numerical models of ocean circulation are described, the output of which can be applied to simulate drifting of marine debris. These models are: the Navy Layered Ocean Mode (NLOM), the Navy Coastal Ocean Model (NCOM), the Hybrid Coordinate Ocean Model (HYCOM), etc.

Most of publications on numerical modeling consider a particle-tracking method to describe the distribution of floating debris by virtual particles. In [11] a global ocean circulation model HYCOM were coupled to the Lagrangian particle-tracking model Pol3DD to simulate 30 years of transport and accumulation of floating debris in the world ocean. The model outputs showed the formation of 5 accumulation zones in the subtropical latitudes. In terms of numerical modeling, considerable interest is [12], where modeling the distribution and accumulation of floating debris entering the ocean in large quantities as a result of well-known Tohoku tsunami by the 11 March 2011 is presented. This disaster has generated a massive influx of debris washed from the coastline into the ocean. To simulate the transport of flouting debris a modeling system is applied consisting of a global ocean circulation model HYCOM and a Lagrangian particle-tracking model Pol3DD. The model Pol3DD grid covered a part of the North Pacific and comprised 1551 x 701 grid nodes with 7 km spacing. In [13] the drift of marine litter in the southern North Sea was simulated with the Lagrangian particle-tracking model PELETS-2D for a nine year period 2000-2008. The model was coupled to pre-calculated current and wind fields based on the 3D operational circulation model BSHcmod of the Federal Maritime and Hidrographic Agency of Germany (for more information reference to [10]) .

In [16] overview of models of floating marine debris focusing on marine micro-plastics (< 5 mm diameter) is presented and some ways to improve modeling of transport of marine debris in a future are discussed. The authors are of the opinion that presently used ocean circulation models, commonly having 10

km horizontal and 10 m vertical resolution, require 10 m details or even finer grid, which is associated with the exponentially growing computer power.

It should be mentioned the model, recently elaborated by researchers from Naval Academy (Burgas, Bulgaria) within the EU funded project "Innovative Techniques and Methods for Reducing Marine Litter in the Black Sea Coastal Areas – BSB552 RedMarLitter", which is based on consideration of the trajectory of individual floating objects (https://map.redmarlitter.eu/en/waste-flow-modelling).

The present paper provides numerical modeling of the distribution of floating marine debris in the coastal waters of the Black Sea of Georgia using data of litter monitoring conducted in Poti and Batumi nearshore water area during September, 2019 (within the EU/UNDP project "Improving Environmental Monitoring in the Black Sea-Selected Measures – EMBLAS Plus" and EU funded project "Innovative Techniques and Methods for Reducing Marine Litter in the Black Sea Coastal Areas - BSB552 RedMarLitter"). There is considered advection-diffusion approach based on numerical solution of 2D nonstationary advection-diffusion equation. Unlike the particle-tracking method, within this approach we do not track the movement of every solid object floating on the sea surface, but use the concept of the average density of marine litter (concentration), that is, mass per unit area of the sea surface.

2. Description of the modeling system

The distribution process of floating solid debris entering the sea by rivers or otherwise discharged into the marine environment is a complex problem and largely depends on the sea currents, turbulent diffusion, atmospheric wind speed and direction, surface waves. To simulate and study this process, we considered a coupled modeling system consisting of two subsystems. The first subsystem represents a hydrodynamic block based on a high-resolution regional model of sea dynamics developed at M. Nodia Institute of Geophysics of I. Javakhishvili Tbilisi State University (RM-IG). The second one is a numerical model of marine litter transport based on the solution of a 2D non-stationary advection-diffusion equation.

Fig.1.Modeling and forecasting area in the easternmost part of the Black Sea marked with a rectangle. The numbers show amount of grid points of numerical model on the horizons.

The RM-IG is a core of the marine regional forecasting system for the easternmost part of the Black Sea [19-23], which covers the Georgian sector of the Black Sea and the adjacent water area with sizes about 215 x 340 km (Fig. 1). The study area is limited from the west by liquid boundary coinciding with the meridian $39{,}08^0$E passing near the city of Tuapse (Russia). The regional forecasting system is one of the components of the Black Sea basin-scale Nowcasting/Forecasting System [24, 25, 26].

2.1 Regional model of sea dynamics

The RM-IG is based on a full system of ocean hydrothermodynamics equations in hydrostatic and incompressible fluid approximations [19] and is a high-resolution version of the basin-scale model [27], adapted to the easternmost part of the Black Sea. The model equation system is written in z coordinates for

deviations of temperature, salinity and pressure from their standard vertical profiles. Atmospheric forcing is taken into account by upper boundary conditions by given of wind stress components, heat flux, evaporation and atmospheric precipitation on the sea surface, which is considered as a rigid surface. This model with 1 km spatial resolution is nested in the basin-scale model of the Black Sea dynamics of the Marine Hydrophysical Institute (MHI, Sevastopol) with 5 km spatial resolution [26] using one-way nesting method, which provides forcing of open sea processes on the regional processes via the liquid boundary. All required input data for initial and boundary conditions are available from MHI via ftp site, providing integration of equations of RM-IG for 4 days.

To solve the model equation system with corresponding initial and boundary conditions, a two-cycle splitting method with respect of physical processes, coordinate planes, and lines is applied [28, 29]. The splitting method enables solution of nonstationary 3D equation system of ocean hydrothermodynamics to reduce to solving of relatively simple 1D and 2D problems.

The sea surface current field calculated from the RM-IG with use of real input data is used in the 2D numerical advection-diffusion model of marine litter distribution.

2.2 Advection-diffusion model of marine litter transport

If we consider the transport of small floating debris, the size and shape of which can be neglected, then this process can be described by a 2D nonstationary advection-diffusion equation, similar to the transfer of an oil slick (the x axis is directed to the east, y - to the north)

$$\frac{\partial C}{\partial t}+\frac{\partial uC}{\partial x}+\frac{\partial \mathrm{v}C}{\partial y}=\frac{\partial}{\partial x}\mu_c\frac{\partial C}{\partial x}+\frac{\partial}{\partial y}\mu_c\frac{\partial C}{\partial y}+f(x,y,t). \qquad (1)$$

Here C is the concentration (density) of solid waste (kg / m^2), μ_c is the turbulent diffusion coefficient, the function *f*, generally, describes a temporal-spatial distribution of source power, which can be represented by δ-function in a particular case of a point source

$$f=Q\delta(x-x_0)(y-y_0),\quad .$$

where Q is the amount of solid waste getting into the whole area per unit time, x_0 and y_0 are the source coordinates.

The velocity components u, v along x and y axes consist of two terms

$$u = u_s + \alpha u_w,\quad \mathrm{v} = v_s + \alpha v_w,$$

where u_s and v_s are the components of the sea current velocity along the x and y axes calculated from the regional model of sea dynamics; u_w and v_w are velocity components of atmospheric wind along the x and y axes, respectively.α is the wind drift coefficient which, defines contribution of the atmospheric wind to drift of solid waste on the sea surface.

The diffusion coefficient was calculated on each time level by the formula, offered in [30]

$$\mu_\varphi=\gamma\Delta x\Delta y\sqrt{2\left(\frac{\partial u_s}{\partial x}\right)^2+\left(\frac{\partial u_s}{\partial y}+\frac{\partial v_s}{\partial x}\right)^2+2\left(\frac{\partial v_s}{\partial y}\right)^2},$$

where Δx and Δy are grid steps along x and y axes, respectively; γ is some constant depending on the average size of floating objects. To clarify this dependence further research is required.

The equation (1) is solved using the following boundary and initial conditions. If the lateral boundary (solid or liquid) is far from the source, zero litter density is assumed, but if the boundary Γ is close to the source location, in general, we can write

$$\partial C/\partial n=\beta C \quad \text{on} \quad \Gamma,$$

where β is the factor describing release of solid material ashore, *n* is a normal to the solid boundary.

$$C = C_0 \qquad \text{at} \quad t = 0,$$

where C_0 is the initial density distribution of marine litter.

A finite-difference method –the two-cycle splitting method by x and y coordinates is used to solve the equation (1) with appropriate initial and boundary conditions. With this purpose, we divide the entire integration time interval (0, T) by the 2τ step intervals, where $\tau = t_j - t_{j-1}$. Within every 2τ time step interval ($t_{j-1} \le t \le t_{j+1}$) we make the two-cycle splitting by coordinates of the equation (1), resulting in the solution of the problem in the following three steps:

1. at time interval $t_{j-1} \le t \le t_j$ the advection-diffusion equation along the axis x is solving

$$\frac{\partial C_1}{\partial t} + \frac{\partial uC_1}{\partial x} = \frac{\partial}{\partial x}\mu_c \frac{\partial C_1}{\partial x}$$

with initial condition

$$C_1^{j-1} = C_3^{j+1}$$

2. at time interval $t_{j-1} \le t \le t_{j+1}$the advection-diffusion equation along the axis y is solving

$$\frac{\partial C_2}{\partial t} + \frac{\partial vC_2}{\partial y} = \frac{\partial}{\partial y}\mu_c \frac{\partial C_2}{\partial y} + f(x,y,t)$$

with initial condition

$$C_2^{j-1} = C_1^j ,$$

3. at time interval $t_j \le t \le t_{j+1}$ the advection-diffusion equation along the axis x is solving again

$$\frac{\partial C_3}{\partial t} + \frac{\partial uC_3}{\partial x} = \frac{\partial}{\partial x}\mu_c \frac{\partial C_3}{\partial x}$$

with initial condition

$$C_3^j = C_2^{j+1}.$$

At each stage, the Krank-Nicholson scheme is applied for time approximation, and the derivatives by x and y are approximated with central finite differences. The obtained algebraic equations are solved using the factorization method. In general, numerical method of the problem solving approximates the task with second-order accuracy with respect to spatial and temporal variables.

The software of the developed coupled modeling system is a integrated software package elaborated in the algorithm language “Fortran”.This unified package contains a solid waste distribution software package as a separate module. If the solid waste enters the sea from rivers, ships, etc., then computer realization of this module requires to input source coordinates, the amount of solid material entering the sea and the duration of entering. If the initial distribution of litter density is given and we are interested in further evolution of the density field, to input above data is not needed.

Thus, the present model describes the distribution process of floating solid waste at the sea surface, which is caused by the advection, turbulent diffusion, wind speed and direction, source action.

3. Model outputs and discussion

3.1 Input parameters

For the purpose of computational realization of the numerical models involved in the modeling system the modeling area is covered by a spatial grid whose parameters are: in the RM-IG 30 calculated levels on a vertical with non-uniform vertical steps with a minimum step of 2 m at the sea surface and a maximum step of 100 m at the seabottom. The number of grid points on each horizon is 215x347 with the spatial horizontal resolution 1 km; The time step is 0.5 h. $\gamma = 0.5$, $\alpha = 0$.

With the purpose of validating the RM-IG, the computed sea surface temperature and surface flow fields were compared with satellite observational data showing the ability of the model to really reflect the hydrophysical processes occurring in the easternmost coastal zone of the Black Sea [19, 22, 23].

3.2 Main features of the regional circulation

Marine circulation is one of the main factors that largely determines the drift of solid floating debris on the sea surface. Studies based on the RM-IG with use of real input data show that the easternmost water area of the Black Sea is characterized by very high dynamic activity, where mesoscale and submesoscale vortex formations are continuously generated and evolve throughout the year [31, 32]. Such vortex formations obviously play an important role in the distribution of various impurities in the sea, including solid waste. One of the general features is that the structure of the sea surface circulation is characterized by significant seasonal and interannual variability and differs significantly in the warm and cold seasons. During the warm season, the main element of the regional circulation is often the anticyclonic eddy, which is known as the Batumi eddy. For the last decade, the Batumi eddy has been the most stable and intense formation in the summer and early autumn of 2010, covering an area of about 200 km in diameter [19, 20]. The process of spreading solid waste into the sea coming from land-sources depends significantly on the nature of the nearshore sub mesoscale circulation structure. The results of our modeling show that in a narrow strip 15-20 km wide along the coastline of Georgia, the formation of very small coastal unstable eddy structures with a lifetime of about 2-3 days is often observed. Here the current has a pronounced non-stationary character and in a short period of time the directions of the current change sharply.

3.3 Modeling of floating marine litter

Modeling of the distribution of floating marine litter in the Georgian coastal waters was carried out with taken into consideration the results of the monitoring conducted by the Georgian research team in Poti and Batumi nearshore waters within the EU project "**RedMarLitter**" during September 2019. The monitoring was carried out from the boat – at the coast of Poti on the area 42.12^0– 42.20^0N, 41.65^0– 41.62^0E during 10:09-11:53 (local time) on September 4 and at the coast of Batumi on the area 41.66-41.67N, 41.65-41.68E during 11:21-13.59 (local time) on September 5.

Modeling of solid waste propagation was carried out under the conditions of the real sea circulation mode for the period from 4 to 12 September 2019 calculated on the basis of the RM-IG using the corresponding real input data. Monitoring results were used to determine the initial field of litter density.

During observations 75 floating objects were found on the Poti transect along a length of 50 m and 29 solid objects were observed on the Batumi transect along a length of 30 m. The average size of solid objects ranged from 5 to 20 cm.

Assuming that the average mass of an object was 100-150 g, we could approximately estimate the initial densities of the litter (in kg per unit square) near Poti and Batumi coasts. At the initial moment t = 0, litter density was zero throughout the modeling area, except for one grid point near the Poti and Batumi coast, which approximately corresponded to the geographical coordinates of the monitoring. Based on the above data, in the first numerical experiment, we obtained the initial concentration of solid waste equal to 0.0033 kg/m^2 in the point with grid coordinates 212Δx, 124Δy (Δx = Δy = 1 km) near the Poti shore. In the second one, the initial density was 0.0024 kg/m^2 in the point with grid coordinates 208Δx, 88Δy near the Batumi shore. These points approximately corresponded to the geographical coordinates of the monitoring. In the first numerical experiment, the start of integration of the advection-diffusion equation was 08:00 GMT, September 4, 2019, which approximately corresponds to the monitoring time period in Poti coastal waters, but in the second one, the start of integration was 10:00 GMT, September 5, 2019 corresponding to the monitoring time period in Batumi coastal waters.

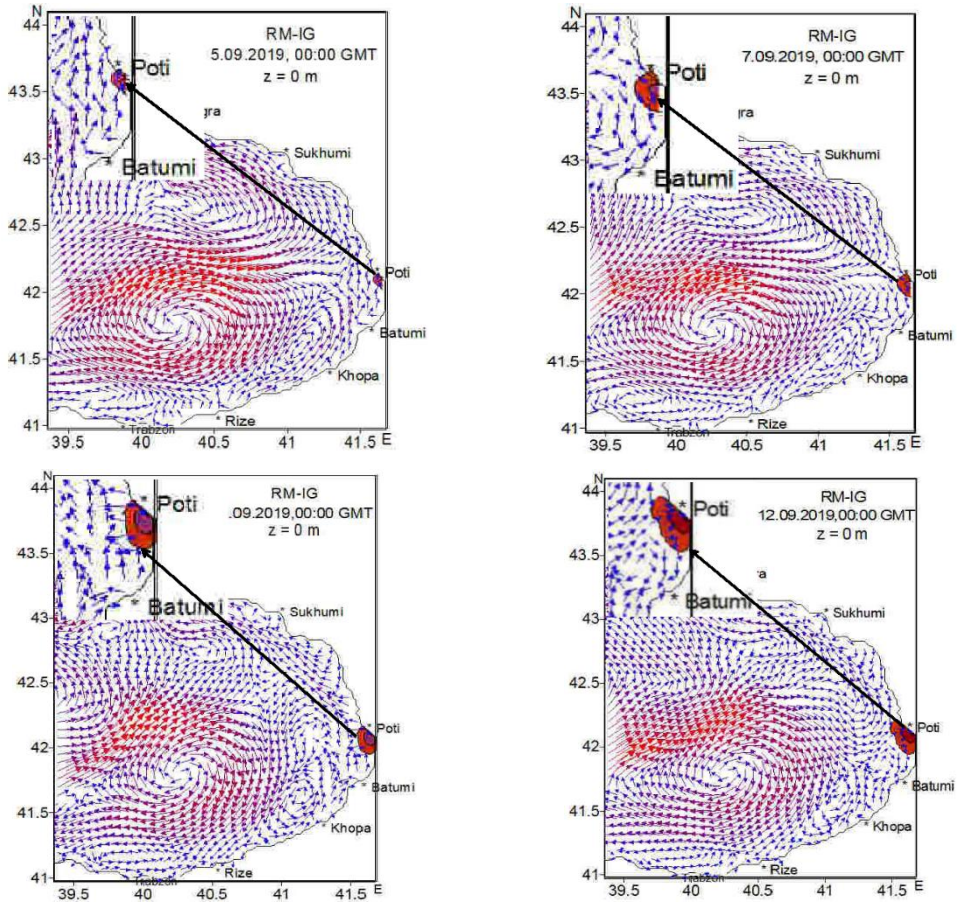

Fig.2. Modelled surface circulation field and solid waste distribution area for the time moments shown in the Figure in September 2019. The initial density of the waste was at the grid point near the Poti coast on September 4, 2019, 08:00 GMT.

In Fig. 2 the sea surface circulation field and the area of solid waste distribution at different times of September 2019 are demonstrated, when the initial concentration of waste was given near the coast of Poti.

Similar pictures are shown in Fig.3, when the initial litter density was given near the Batumi coast. For better visualization, the coastal circulation and distribution of solid waste in the Poti-Batumi waters are shown in an enlarged form in the upper left corner of the Figs 2 and 3.

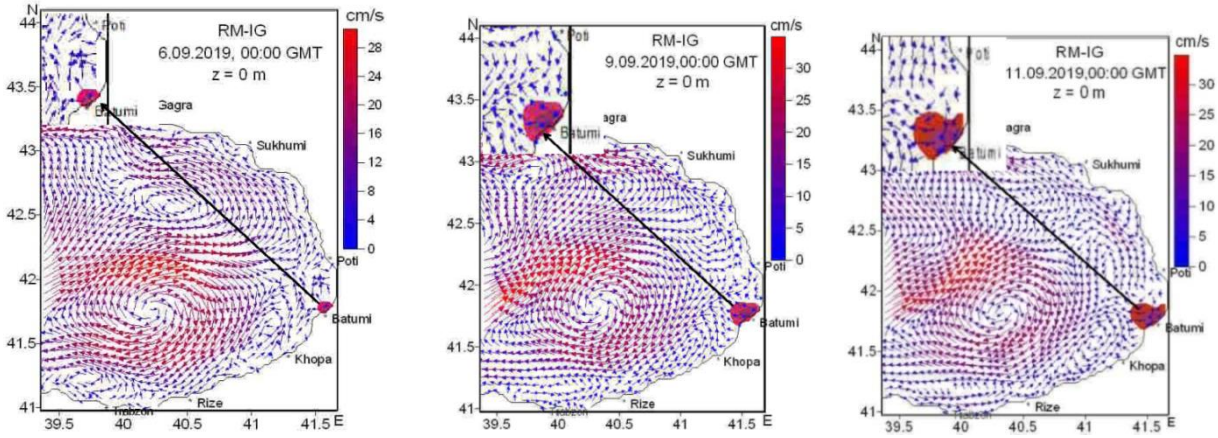

Fig.3. The same as in Fig.2, but the initial density of the waste was given close to Batumi beach on September 5, 2019, 10:00 GMT.

It is clear from Figs. 2 and 3, that the coastal microcirculation at Poti and Batumi nearshore for the considered period is characterized by significant non-stationarity, where the dominated current direction does not observed and flow directions change dramatically over a short period of time. For example, in Fig.2, it is clearly shown that within two days from 5th to 7th September the current's direction changed from north to south. Calculations showed low speeds equal to 2-4 cm/s near Poti-Batumi coastline. Such character of the flow field has a direct impact on the floating solid waste distribution. The modeling results show that during the 7-8 days since initial time moment, solid objects can spread from the shore at a distance not more than of 8-10 km from the shore under the conditions of the mentioned microcirculation regime. Under the influence of advection and diffusion processes, the distance between floating objects increases over time and their distribution area takes up significantly more space. In our case, the diameter of the area occupied by solid waste is about 10-12 km.

If we take into consideration that the alternation of different circulation modes is often observed in the Georgian sector of the Black Sea, it is of important scientific and practical interest to evaluate the influence of the sea surface circulation on the process of floating solid waste distribution. For this purpose, computational experiments were conducted under different circulation modes in conditions of the same initial marine litter density field.

Fig.4 shows the results of modeling the surface circulation and distribution of marine litter after 24, 48 and 72 hours, when the initial density of marine litter at Poti coastline was the same as in the first numerical experiment (Fig.2), but in this case the sea circulation was stationary and characterized by strong current along the Georgian coastline directed to the north-west with a maximum speed of 60 cm/s. The flow field corresponding to December 9, 2014 was calculated from the RM-IG using real input data. Comparison of Figs.2 and 4 shows that despite the same initial conditions, the process of spreading solid waste in these two cases is completely different. In Fig. 4 it is clearly seen that under the influence of the sea current and diffusion the solid waste moves to the north-west and the area covered by the waste takes an elongated shape along the sea current direction.

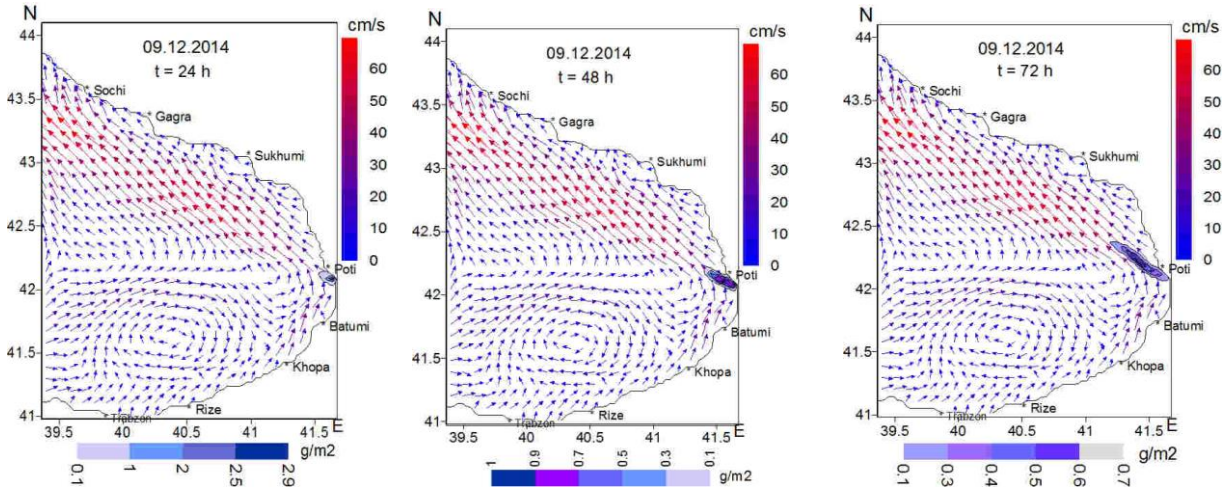

Fig. 4. Simulated surface current for 9 December 2014 and solid waste drift in the Georgian coastal zone in the indicated moments of time after the initial moment. Initial waste density was in the point near Poti shoreline.

Computational experiments have shown that the structure of the microcirculation in the area occupied with solid waste after entering the sea environment, may significantly determine the process of waste distribution.To illustrate this fact, In the next numerical experiment the circulation mode was the same as in the previous numerical experiment (corresponding to December 9, 2014), but initial location of marine waste was different – it located near the Batumi shoreline as in the second numerical experiment (Fig.3).

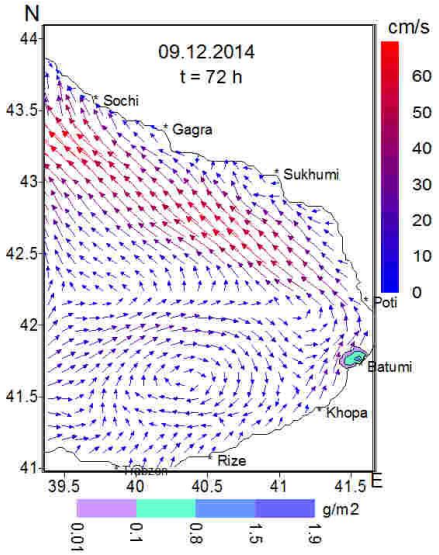

Fig. 5. Same as in Fig.4, but at the initial moment waste density was given in the point near Batumi shoreline.

in Fig.5 the marine litter distribution is shown at t = 72 h after the initial state. Comparison of Figs. 4 and 5 shows a large difference in the litter distribution. Unlike the previous case (Fig.4), where the area occupied by solid waste took an elongated shape along the flow direction having pronounced north-west direction, in this case, the shape of the area occupied by solid waste was approximately oval and does not move significantly from the shorline for three days.

4. Conclusions

For the purpose of mathematical modeling of floating solid debris in the Georgian Black Sea coast, a coupled modeling system has been considered, consisting of the RM-IG and floating marine litter distribution model. The RM-IG is a high-resolution z-level model based on a full system of ocean hydrothermodynamics and is nested in the basin-scale model of Black Sea dynamics of MHI (Sevastopol). Our approach to the simulation floating marine litter is based on a solution of a 2D nonstationary advection-diffusion equation, which is coupled with the RM-IG. The advection-diffusion model uses nonstationary sea flow field calculated from the RM-IG on each time level.

The mathematical modeling system makes it possible to simulate the spread of solid waste in the marine environment under various real modes of surface circulation with 1 km spatial resolution. If the solid waste enters the sea environment from ships, rivers and other land-based sources, then computer realization requires to input source coordinates, the amount of solid material entering the sea (in kilograms) and the duration of entering. If the initial litter density (kilogram per unit square) is given and we are interested in further evolution of the litter density field, to input above data is not needed.

Computational experiments were conducted to simulate and study the peculiarities of the spatial-temporal distribution of solid waste in the Georgian coastal waters with taken into consideration the data of the monitoring conducted in Poti and Batumi coastal waters in September 2019 within the EU project "**RedMarLitter**".

The numerical experiments have shown that water circulation mode and the initial position of solid waste entering the sea environment largely predetermine the main peculiarities of the marine litter propagation process.

Calculations have shown a significant role of advection and diffusion processes in the process of spatial-temporal propagation of solid waste floating on the sea surface. The general pattern is that the area covered with solid waste at the initial time, undergoes transformation over time - the area expands, that is the

distance between different objects gradually increases and occupies more area, which is mainly due to the turbulent nature of the flow. At the same time, the marine litter is drifted under the influence of advection processes. The specific features of this process are expressed differently under different circulation modes.

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საქართველოს შავი ზღვის სანაპირო ზონაში მცურავი მყარი ნარჩენების გავრცელების რიცხვითი გამოკვლევა

დ. დემეტრაშვილი, კ. ბილაშვილი, ნ. მაჩიტაძე, ნ. ცინცაძე, ვ. გვახარია, ნ. გელაშვილი, ვ. ტრაპაიძე, ი. კუზანოვა

რეზიუმე

წარმოდგენილია საქართველოს შავი ზღვის სანაპირო წყლებში მცურავი საზღვაო ნარჩენების განაწილების რიცხვითი მოდელირება ზღვის ნარჩენების მონიტორინგის მონაცემების გამოყენებით. მონიტორინგი განხორციელდა ფოთისა და ბათუმის სანაპირო წყლებში 2019 წლის სექტემბერში ევროკავშირის პროექტის RedMarLitter-ის ფარგლებში. მცურავი საზღვაო ნარჩენების მოდელირებისათვის გამოყენებულია 2D არასტაციონარული ადვექციურ-დიფუზიური მოდელი, რომელიც შეწყვილებულია ი.ჯავახიშვილის სახელობის თბილისის სახელმწიფო უნივერსიტეტის გეოფიზიკის ინსტიტუტის შავი ზღვის დინამიკის რეგიონალურ მოდელთან (RM-IG). RM-IG არის შავი ზღვის განაპირა აღმოსავლეთი ნაწილის რეგიონული პროგნოზული სისტემის ბირთვი და ეფუძნება ოკეანის ჰიდროთერმოდინამიკის განტოლებათა სრულ სისტემას, რომელიც დაწერილია დეკარტის კოორდინატთა სისტემაში. მოდელირების შედეგებმა აჩვენა ადექციური და დიფუზიური პროცესების მნიშვნელოვანი როლი მცურავი მყარი ნარჩენების სივრცით-დროით განაწილებაში.

Численное исследование распространения плавающих твердых отходов в прибрежной зоне Черного моря Грузии

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Резюме

Представлено численное моделирование распространения плавучего морского мусора в прибрежных водах Черного моря Грузии с использованием данных мониторинга морского мусора. Мониторинг проводился в прибрежных акваториях Поти и Батуми в течение сентября 2019 года в рамках проекта ЕС RedMarLitter. Для моделирования плавающих твердых отходов используется двумерная нестационарная адвективно-диффузионная модель, связанная с региональной моделью динамики Черного моря Института геофизики Тбилисского государственного университета им. И. Джавахишвили (RM-IG). RM-IG является ядром региональной прогностической системы для самой восточной части Черного моря и базируется на полной системе уравнений гидротермодинамики океана, записанных в декартовой системе координат. Результаты моделирования показали важную роль процессов адвекции и диффузии в пространственно-временном распределении плавающих твердых отходов.

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The Use of Structured Data for Drought Evaluation in Georgia

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ABSTRACT

The drought is frequent phenomena in Georgia. The SPI and SPEI drought indices were calculated to analyse drought frequency and intensity on the territory of Georgia in 1991-2020 period. The structured data of hydrometeorological observation net have been used to calculate following statistical parameters: Pearson correlation, mean deviation, and absolute deviation, both for the entire period and for months. The programs R and R-instat are used to calculate and visualize these parameters. The correlation coefficient is in good agreement for all cases, and the absolute deviation shows data scattering, which should be related to the complex relief of Georgia, as well as the heterogeneity of data series. The study is important for climate change assessment, hydrometeorological disaster early warning system, as the territory of Georgia is under the risk of this phenomenon.

Keywords: *Structural data, statistical analysis, drought indices, early warning system.*

Introduction

The term Big Data has spread due to new technologies and innovations that have emerged over the past decade given the demand for the analysis of large amounts of and rapidly generated diverse data, therefore, collection and processing takes place at a high speed, which is difficult to implement with calcareous analytical tools. Big Data is a rapidly generated amount of information from a variety of sources and in a different format. Data analysis is the examination and transformation of raw data into interpretable information, while data science is a multidisciplinary field of various analyses, programming tools, and algorithms, forecasting analysis statistics as well as machine learning that aim to recognize and extract patterns in raw data. The applicability of Big Data techniques is also significantly enhanced by the novel tools that support data collection and integration. The interoperability of the systems can be improved by data warehouses and the related **ETL** (extract, transform, and load) functionalities that can also be used to gather information from multiple models and data sources. Artificial intelligence (**AI**) and machine learning (**ML**) are also the key enabler technologies of big data analysis [1]. Analysis of Big Data combines traditional methods of statistical analysis with computational approaches. The analysis of Big Data is a synthesis of quantitative and qualitative analyses. Climate computing combines multidisciplinary researches in regard to climatic, data and system sciences to efficiently capture and analyze climate-related Big Data as well as to support socio-environmental efforts.

The significance of Big Data in climate-related studies is greatly recognized and its techniques are widely used to observe and monitor changes on a global scale. It facilitates understanding and forecasting to support adaptive decision-making as well as optimize models and structures. The Big Data classifies of three types: **Structured**; Semi-Structured and Unstructured Data. In presented paper Structured Data is used. The

structure of the data is the key to not only how to go about working with it, but also what insights it can produce. It is successfully used in weather, climate and environmental issues.

Study area

The complex orographic conditions and influence of the Black Sea preconditioned the formation of great variety of climate and landscapes in Georgia. Here exist most of Earths climatic types, from marine wet subtropical climate of west Georgia and steppe continental climate of east Georgia up to eternal snow and glaciers of high mountain zone of Great Caucasus, and also approximately 40% of observed landscapes. Territory of country lies between of the Major Caucasian Ridge and the Lesser Caucasus mountains. About 85 percent of the total land area occupies complex mountain ranges divided with river's valleys and ravines of different exposition. For most of these rivers spring is high water period thus ¾ of Georgia's territory is especially vulnerable to foods, flash floods and mudflows. Georgia's orography and its interaction with airflows are the basic spotting factors of synoptic processes spread in the country. Peculiarities of locally developed weather phenomena at any time a year are often characterized with diversity and extremity. Convective storms, with attendant phenomena; fog and low clouds; locally forced precipitation events; wintertime weather (snow, ice, glazed frost, avalanches) this is a short list of synoptic processes nowcasting (**NWC**) and very short range forecast (**VSRF**) of which has a great importance for Georgia [9]. The natural disasters in Georgia have to be considered as the standing negative factor for the sustainable development of the state. The importance of aroused problems from listed hazards stimulates the active investigation of reasons and physical processes involved in [5].

In the analysis of hazard and risk geo-information science and earth observation plays an increasingly important role. Remote Sensing is nowadays an essential tool in monitoring changes in the earth's surface, oceans and atmosphere, and is increasingly used as the basis for early warning for hazardous events [6].

Drought is a frequent phenomenon in eastern Georgia. Its frequency in some areas exceeded 40% in the 80-ies of the last century by certain early estimates. As a result of frequent droughts accompanying the global warming in past decades transformation of many types of natural landscapes has been observed. The desertification probability of steppe and semi-desert landscape of eastern Georgia by the end of the twentieth century has reached 25-30%. According to official figures, by the result of intense droughts area of over than 200 000 ha is strongly affected for present [4]. Property damage caused by drought is very significant.

The main meteorological factors for drought formation are dry weather, high temperature and lack of soil producing moisture. The average time of rainless period with precipitation less than 5 mm most important for agriculture is not more than 10-15 days. Besides, the mean rainfall is not more than 200-300 mm during vegetation period on the lowlands. Nevertheless, producing moisture supply is 50-200 mm per one meter of soil that corresponds to the zone of capillary agro-hydrological humidification and full spring rainfall penetration. At the same time active air temperatures sum exceeds 4000° over 10° times, and the mean duration of continuous high temperatures more than 30°C is longer than 4 hours [2].

Temperature change velocity is greatly depended on region physical-geographical conditions and seasons. Due to complex relief, mainly orographic and landscape-climatic conditions temperature change has heterogenic –mosaic character in Georgia The strong warming centers were located in east and also on west parts of Georgia. Strong warming centers were spread in moderately dry and dry subtropical semi-arid and dry step regions of eastern Georgia. During intense warming period (1975-2010) temperature annual trend has been significantly increased and on Black Sea region amounts 0.034^0C (Poti), Colchis Lowland -0.025^0C and on Dedoplistskaro-0.09-^{0}C, Gori-0.05^0C, in Khashuri and Telavi-0.06^0C.

Drought genesis in Georgia is depending on cyclonic and anticyclone motions. In first case rainy days are frequent and in second dry periods, with high temperature and low humidity of different durations have been taken place. If air masses directed from Arctic are dry and cold. They spread over long territories

and stable anticyclone system is established on east-south parts of Europe. During such situation dry period happens in Georgia. If air masses are invading from east high temperature and low humidity dry weather is standing. Such periods are more brutal and dangerous [**3**].

The observation analysis shows that various degree drought may take place all over the Georgian territory. The event frequency is expected mainly on spring, summer and fall seasons. During winter due to frequent cyclonic and frontal periods dry day duration is less. The drought day number and dry period frequency increase from the Black Sea regions through east or in direction of continental climate [10].

Based on historical records Georgian territory is under drought 60% repeatability. The most drought regions are Kvemo Kartli, Shiraki and Eldari lowlands and other low parts of eastern parts of Georgia. Those regions are characterized by productive humidity shortage in soils. Two types of productive humidity stocks are common for those places: capillary moisturizing and complete spring wetting. In the first case the productive humidity stock in 1m. soil layer composes 100-200mm, and in other- 50-150mm, while in western Georgia the humidity stock doesn't exceed 400mm. Except natural factors (windy erosion and precipitation decreasing) the anthropogenic loading has significant effect on desertification process too. Namely: unmanaged use of soil, forest and water resources, soil salting.

Method

Understanding of the natural environment is increasingly important to respond to the climate change negative impacts and anthropogenic pressures on finite natural resources, and their impacts on water, energy and food security, infrastructure, human health, natural hazards. This is also a major cross-disciplinary challenge involving almost all scientific fields

In 2013, the UK government announced large-scale investment in Big Data infrastructure for science, particularly in the environmental sector starting funding for a program called CEMS (Climate and Environmental Monitoring from Space). This allowed for the creation of larger databases to cope with the upcoming Big Data revolution and to allow research partner organizations to work with more data and produce more results. With a specific focus on climate change and planetary monitoring, CEMS storage removed the need to download enormous data sets while reducing the cost of access. Along with Cloud data, this is now the standard globally for some of the world's top research institutes.

Environmental data comes from a wide variety of sources and this is increasingly rapidly with new innovations in data capture:

1. Large volumes of data are collected via remote sensing, typically from satellite sensing or aircraft-borne sensing devices, including an increasing use of drones. This includes passive sensing, such as photography or infrared imagery, and active sensing, e.g., RADAR/LIDAR. The increasing availability of open satellite data is a major trend in earth and environmental sciences. For example, the EU Copernicus program and the associated Sentinel missions, or NASA's Earth Observing System satellites, LandSat archive are regularly mined for data for a variety of applications [6,10].
2. Other data are collected via earth monitoring systems, which consist of a range of sensor technologies measuring various physical entities. Namely weather stations and monitoring systems
3. Model output is also a significant generator of environmental data with results from previous model runs often stored for subsequent analysis

There are a number of issues deserve special attention:

1. Scarcity of in-situ observations.

2. Data heterogeneity: neighboring pixels in the dataset may have been acquired at different times of day and thus are not directly comparable. In addition, there are no observations during periods of cloud cover, and it is not possible to assume these data are simply "missing for statistical modeling purposes

After data receiving we conduct inventory, which means its visualization, in order to better estimate the transmitting break, for all this we use the program R-studio and R-Instat, R-Instat is a free, open source statistical software that is easy to use, even with low computer literacy. It encourages good statistical practices and learning, by opening the door to training to emphasize concepts rather than the theory.

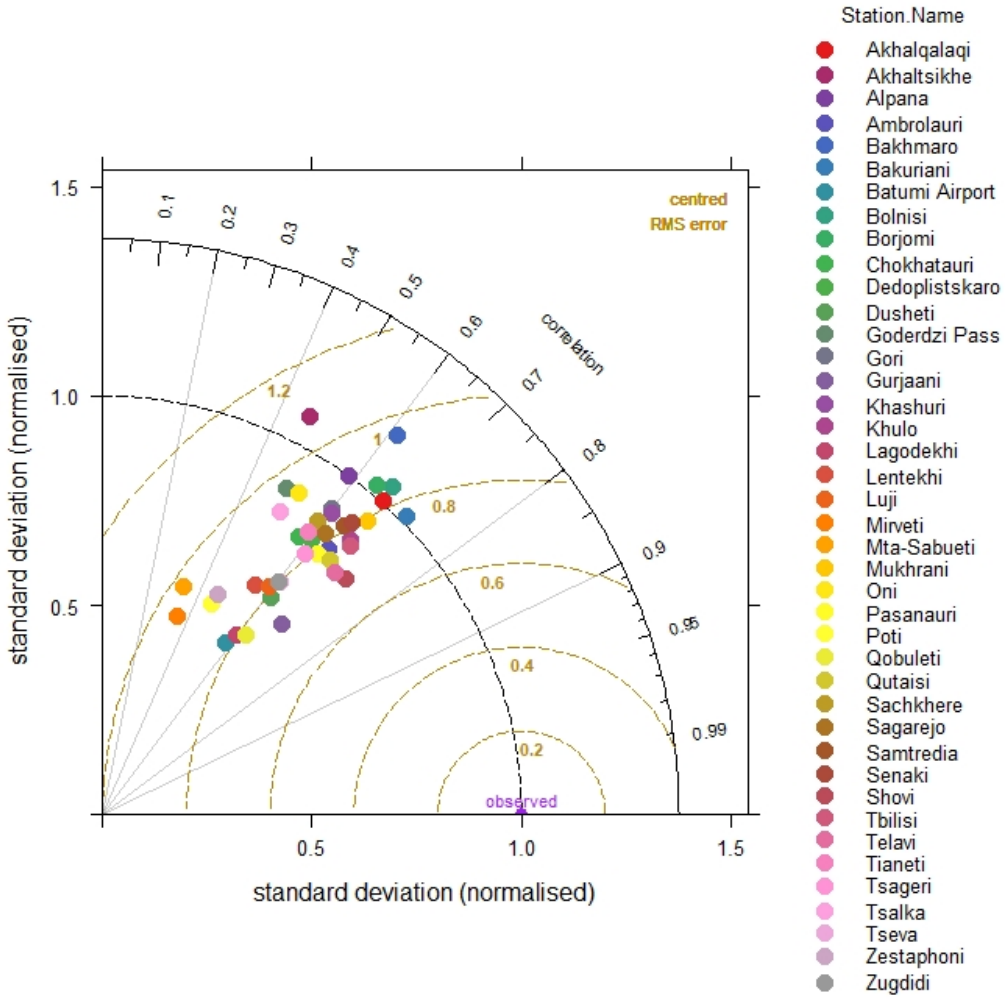

Fig.1. Taylor diagram of standard deviation (normalized) of processed stations

The standardized indices **SPI** and **SPE**I classify the precipitation and water balance anomalies with respect to the long term records. The index values directly indicate how frequent the current situation is expected to occur at the location and season of interest given the long term observations. The **SPI** (standardized precipitation index) classifies the precipitation sums on a particular date with respect to the sums of the same month in all years of the measurement record. For this purpose, the precipitation sums of the whole record within one month around the respective date are transformed into a standard normal distribution around zero. The SPI is nothing else than these transformed precipitation sums. The **SPI** value hence directly indicates the frequency of the observed precipitation amount in the corresponding month as estimated from the whole observation record. The **SPEI** (standardized precipitation evapotranspiration index) is calculated in analogy to the SPI, using the cumulative water balance instead of precipitation sums. The SPEI hence represents the standard-normal distributed water balance[8].

From above discussed stations several have been chosen for 1991-2020 year period drought research. Those stations satisfy all requirements and also are most vulnerable to draught phenomenon to calculate draught indices and conduct statistical analysis. Those stations are the following Dedoplistskaro, Gori, Khashuri, Telavi. By using the calculated indices it became possible to evaluate drought degree and intensity.

The evolution of SPI and SPEI drought indices in 1991-2020 year period are presented on the plots (Fig.2,3).

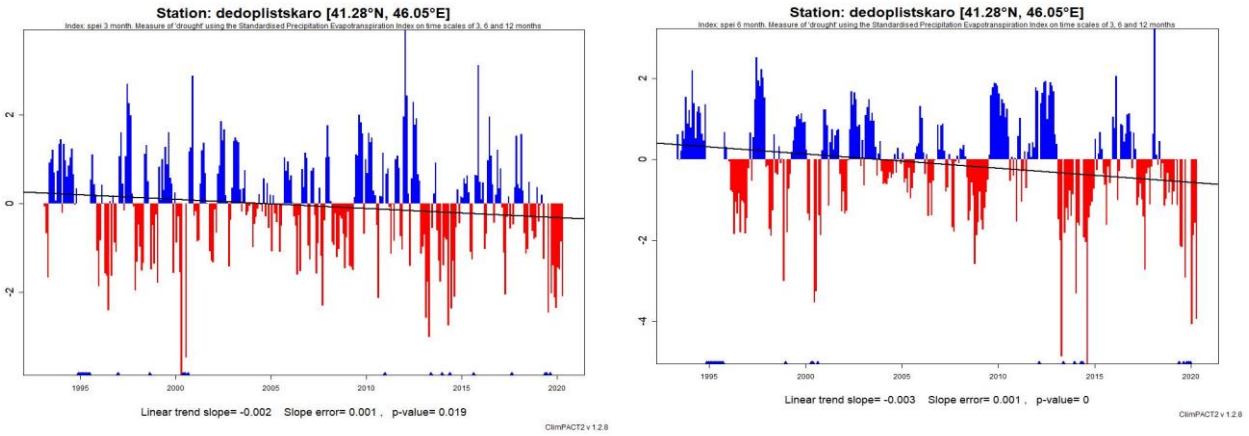

Fig.2. SPEI 3and 6 month Dedoplistskaro station

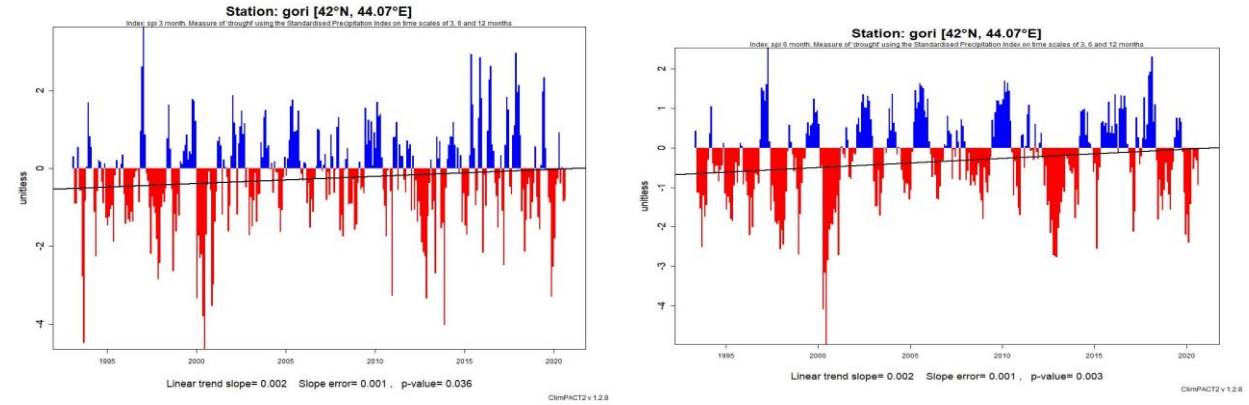

Fig.3. SPI 3and 6 month Gori station

In study Pearson correlation coefficient (PCC), determination coefficient (R^2), and root mean square error (RMSE) criteria, which are among the strong statistical criteria, were used. R^2 ranges from 0 to 1, with higher values indicating less error variance. The **RMSE** is the square root of the variance of the residuals. It indicates the absolute fit of two data set and lower the RMSE the better performance is.

In order to compare drought indices, scatter diagrams of indices were drawn and statistically evaluated. For this, R^2 and the RSME were used. Correlation between data sets is a measure of how well they are related. The most common measure of correlation in stats is the Pearson Correlation. It shows the linear relationship between two sets of data (3month) PCC, which shows linear relationship between SPI-SPEI is quite high, RMSE (SPI-SPEI) is low especially for Khashuri and Telavi; RMSE (SPI-EDI), (Tab.1)

Table1.Statistical parameters of SPI3-SPEI3 for selected stations

Station	Pearson	Pearson	Pearson	R^2-SPI	R^2-SPEI	RMSE(SPI_SPE)
Dedoplistskaro	0.935369	0.056465	0.068697	0.0233	0.0785	0.017053
Gori	0.916488	0.049104	0.114851	0.0034	0.0315	0.010956
Khashuri	0.918664	0.111081	0.130188	0.0064	0.0918	0.005407
Telavi	0.949467	0.051841	0.078509	0.0013	0.0263	0.005885

(12month) PCC for SPI-SPEI is high. R^2 is low for all stations. RMSE (SPI-SPEI) is low which means perfect fitting, (Tab.2).

The strongest relationship was observed among the indices in the same time periods. As time lag increases, the relationship between variables has weakened. Among the indices, the strongest correlation coefficient (0.94) was observed between SPI-12.

Table 2. Statistical parameters of SPI12-SPEI12 for selected stations

Station	Pearson	Pearson	Pearson	R^2-SPI	R^2-SPEI	RMSE(SPI_SPE)
Dedoplistaskaro	0.924953	0.065094	0.102553	0.0705	0.2187	0.016993
Gori	0.84161	0.055709	0.14224	0.0046	0.1264	0.010384
Khashuri	0.898084	0.13671	0.084106	0.0465	0.2861	0.005174
Telavi	0.945912	0.116814	0.148417	0.0023	0.0383	0.018411

DISCUSSION

In Europe the Global Monitoring for Environment and Security (GMES) initiative of the European Commission and the European Space Agency (ESA) is actively supporting the use of satellite technology in disaster management, with projects such as PREVIEW (Prevention, Information and Early Warning pre-operational services to support the management of risks), LIMES (Land and Sea Integrated Monitoring for Environment and Security), GMOSS (Global Monitoring for Security and Stability), SAFER (Services and Applications For Emergency Response), and GMOSAIC

(GMES services for Management of Operations, Situation Awareness and Intelligence for regional Crises). The United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER, 2010) has been established by the UN to ensure that all countries have access to and develop the capacity to use space- based information to support the disaster management cycle. They are working on a space application matrix that will provide the satellite-based approaches for each type of hazard and each phase of the disaster management cycle [7].

WMO has signed the Emergency Alerting Call to Action as part of its ongoing Global Multi-hazard Alert System (GMAS) development and its collaboration with governmental, non-governmental, and commercial organizations to achieve the broadest adoption of CAP worldwide. The Call to Action was launched at a special event during the Humanitarian Networks and Partnerships Weeks 2021.

For further researches application of satellite imaginary with ground observation data will be useful to construct drought hazard risk map for entire territory of Georgia.

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სტრუქტურირებული მონაცემების გამოყენება გვალვის შეფასებისთვის საქართველოში

მ. ტატიშვილი, ა. ფალავანდიშვილი, მ. ციცაგი, ნ. სუქნიძე

რეზიუმე

საქართველოში გვალვა ხშირი მოვლენაა. SPI და SPEI გვალვის ინდექსები გამოთვლილია გვალვის სიხშირისა და ინტენსივობის გასაანალიზებლად საქართველოს ტერიტორიაზე 1991-2020 წლებში. ჰიდრომეტეოროლოგიური დაკვირვების ქსელის სტრუქტურირებული მონაცემები გამოყენებულია შემდეგი სტატისტიკური პარამეტრების გამოსათვლელად: პირსონის კორელაცია, საშუალო გადახრა და აბსოლუტური გადახრა, როგორც მთელი პერიოდისთვის, ასევე თვეების განმავლობაში. პროგრამები R და R-instat გამოიყენება ამ პარამეტრების გამოსათვლელად და ვიზუალიზაციისთვის. კორელაციის კოეფიციენტი კარგად შეესაბამება ყველა შემთხვევისთვის, ხოლო აბსოლუტური გადახრა აჩვენებს მონაცემთა გაფანტვას, რაც დაკავშირებული უნდა იყოს როგორც საქართველოს კომპლექსურ რელიეფთან, ასევე მონაცემთა სერიების ჰეტეროგენურობასთან. კვლევა მნიშვნელოვანია კლიმატის ცვლილების შეფასებისთვის, ჰიდრომეტეოროლოგიური კატასტროფების ადრეული გაფრთხილების სისტემისთვის, რადგან საქართველოს ტერიტორია ამ მოვლენის საფრთხის ქვეშ იმყოფება.

Использование структурированных данных для оценки засухи в Грузии

М.Р. Татишвили, А.М. Палавандишвили, М.Б. Цицаги, Н.Е. Сукнидзе

Резюме

Засуха частое явление в Грузии. Индексы засухи SPI и SPEI рассчитаны для анализа повторяемости и интенсивности засух на территории Грузии в период 1991-2020 гг. По структурированным данным сети гидрометеорологических наблюдений рассчитаны следующие статистические параметры: корреляция Пирсона, среднее отклонение и абсолютное отклонение как за весь период, так и по месяцам. Для расчета и визуализации этих параметров используются программы R и R-instat. Коэффициент корреляции хорошо согласуется для всех случаев, а абсолютное отклонение показывает разброс данных, что должно быть связано со сложным рельефом Грузии, а также с неоднородностью рядов данных. Исследование важно для оценки изменения климата, системы раннего предупреждения о гидрометеорологических катастрофах, так как территория Грузии находится под угрозой этого явления.

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On the Physiological Effect of the Tskaltsminda-Ureki Magneto-Electrical Anomaly

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ABSTRACT

Before the industrial era the natural electro-magnetic background was formed by so called space weather and radioactive dissolution process taking place inside the Earth. Nowadays, due to sustainably increasing anthropogenic load, a process of overall change is observed in the parameters of the environment we live in. The process takes place all over the Earth, especially in areas of dense urbanization, where negative sociological and physiological influences of the technical progress on the global population as well as on individual groups of people are especially felt. This global problem has many aspects and among them is the study of adaptation ability of the population living in the conditions of unnatural changes of the electromagnetic background, the essential element of which is a comparative analysis of background diseases of population, for example, it is already well known that the correlation effect of geomagnetic storms, which is one of the global impact of rapid change in the space weather, has an influence on the deterioration of the health state in population with cardiovascular pathologies. In our opinion, revealing physiological mechanism of this correlation, together with the effects of the processes taking place on the surface of the sun, requires to study physiological effects of the locally variable natural electromagnetic background caused by the influence of geomagnetic anomalies on the Earth. In this regard a comparative analysis of the preliminary medical data of the aboriginal population of the resort area of Tskaltsminda-Ureki local geomagnetic anomaly zone and the population of Telavi region, which is a calmer area in geomagnetic point of view, appears deeply interesting. According to the obtained results the combination of the characteristics of the Tskaltsminda-Ureki geomagnetic anomaly area with the cosmic factors characteristic of the sea coast, probably has a positive influence on the population. According to extrapolation of this conclusion we can generally speak on positive therapeutic effect on the people, who make short-term visits to the Tskaltsminda-Ureki resort zone for recreation and treating purposes.

Keywords: *Magneto-electrical anomaly, physiological effect, Tskaltsminda-Ureki resort.*

Preamble. We may imagine the Earth as a homogenous sphere, on the surface of which perturbations of its own magnetic field (so called "geomagnetic dynamo") induction permanently takes place. This effect is caused by various geological and cosmic mechanisms, which provide conditions for local, regional and global geomagnetic anomalies. Therefore, generally, the magnetic field of the Earth is a superposition of normal and anomalous magnetic fields. Except rare cases the intensity of the first, i.e. the regular component of geomagnetic field considerably exceeds the intensity of the other. The exception is some big anomalies, the geological structures of which are provided by the existence of vast fragments of iron ores. The field of a homogenously magnetized sphere plus continental scale anomalous field (e.g., magnetic fields in polar areas) is called the normal, i.e. the main magnetic field of the Earth. This field is characterized by so called normal

gradients of geomagnetic field in dipole approximation, for example, East Europe is characterized by normal horizontal component gradient $\approx [2-7]$ nT/km.

Significant deviation from normal geomagnetic field refers to existence of regional or local geomagnetic anomaly. Their classification is to some extent conditional and is firstly evaluated according to the area of the anomaly. Therefore, the value of the regional magnetic anomaly of Georgia is commensurable to the local magnetic anomaly characteristic of Russia. Thus, the local magnetic anomaly in Georgia corresponds to micro anomalies in Russia, Kazakhstan or Canada, i.e., any country that coves a vast territory. The value and orographic properties of a magnetic anomaly depend on the degree of rock magnetization, which is determined by physical properties of rocks. Therefore, as a rule, magnetic anomalies are caused by existence of fragments of rocks with different magnetic absorption. The magnetic field of the Earth is characterized by so called century movement, i.e., normal geomagnetic field induction in a given space point varies along time that is associated with magnetic pole drift as well as the variation of the "geomagnetic dynamo" parameters inside the Earth. Besides the century movement, which has its characteristic value $\approx [20 \div 140]$ nT and characteristic time interval – several decades, geomagnetic field shows short-term variations that are caused by external, i.e., cosmic factors. These variations are expressed as sporadic magnetic storms and regular annual, diurnal and short-term (from seconds to 2-10 minutes) periodic oscillations with intensities /1-10/ nT.

It is known that the natural low frequency electromagnetic background is formed by various type waves generated in the near-Earth cosmic space. The intensity and conditions of distributing over the Earth surface of these waves depend on the geomagnetic activity. In calm and less perturbed conditions the self-oscillation frequency spectrum of the Earth magnetosphere, the gigantic magnetic layer, is clearly manifested practically without any distortion. Individual modes constituent of integral wave spectrum of the geomagnetic field variation on the Earth are separated as regular and irregular geomagnetic pulsations and ultra low frequency (ULF) and very low frequency (VLF) electromagnetic oscillations. It is known that geomagnetic pulsation frequency spectrum is composed of six basic regular pulsations Pc1 – Pc6 and each of them has a frequency interval with its maximum probable value characteristic of the given latitude line, for example, appearance of regular short-term pulsations, which belong to Pc1- Pc3, is more probable in low and medium latitudes than in high latitudes. Besides, distribution of the shortest-term Pc1 regular geomagnetic pulsations from the ionospheric levels to the Earth surface in calm conditions is maximally probable in the sea coastline area, where the wave-conductive system Ionosphere-Earth is especially effective [1].

Unlike geomagnetic pulsations, which can be considered as manifestation of magneto-hydrodynamic self-oscillations of magnetosphere resonator, the source of generation of very low or ultra low electromagnetic waves is kinetic effect, which develops as a result of cyclotron instability of the plasma medium inside the magnetosphere. Activity of magnetospheric resonator may be caused due to a rapid change of solar wind pressure, i.e., a global mechanical impulse, whereas in inner magnetospheric plasma it is sufficient to satisfy certain criteria for activation of cyclotron oscillations. Usually, it occurs in some radiation belt of the plasma reservoir of the magnetosphere, e.g., ionosphere. The same phenomenon can serve as a generator of electromagnetic waves. However, as it turned out, appearance of ULF (VLF) waves inside the magnetosphere is rarer than activation of geomagnetic pulsations. Moreover, very low frequency electromagnetic radiation is usually modulated by short-term geomagnetic pulsations [1].

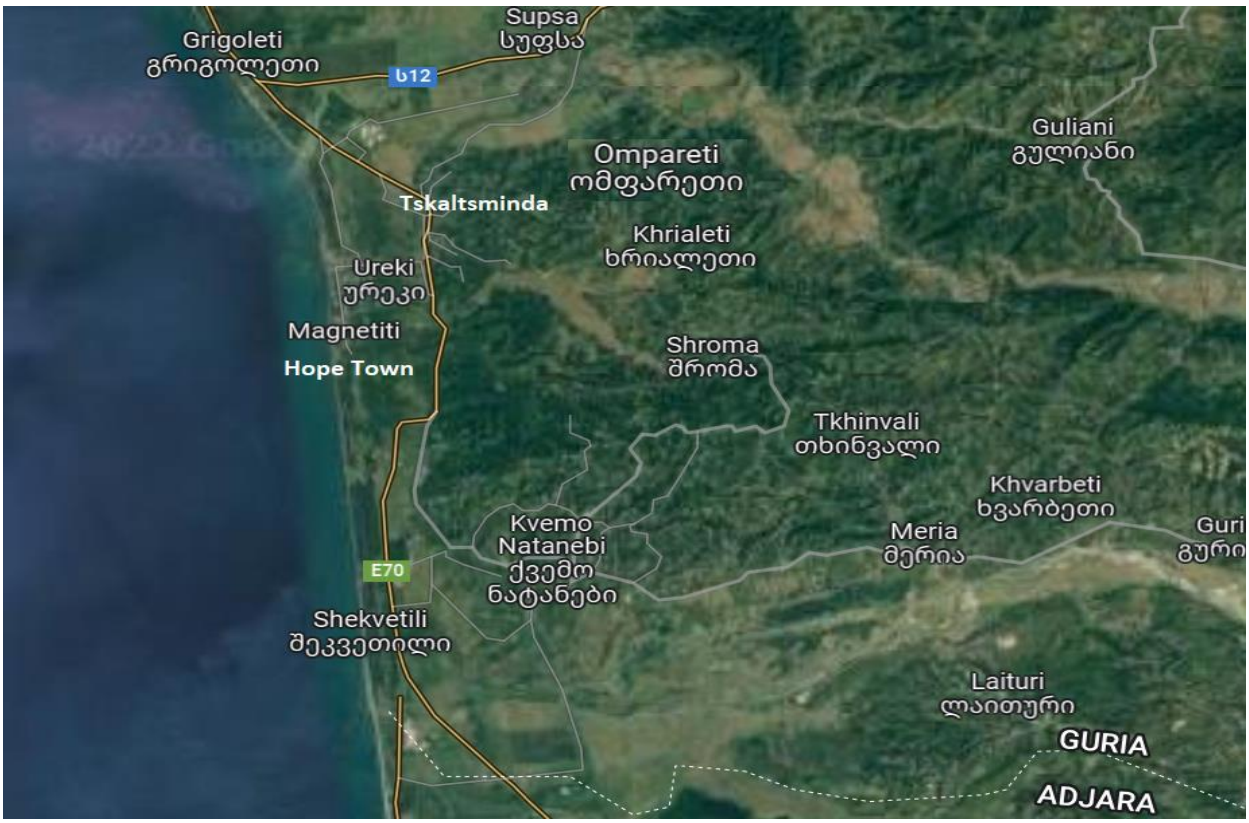
It is known that a certain interval of low frequency magnetospheric electromagnetic radiation spectrum /200-30000/ is practically compatible with the frequency diapason characteristic of human auditory perception

[2]. It is also interesting that the minimum of frequency spectrum of these waves only by half an order exceeds the frequency of industrial electromagnetic wave, which is 50 Hz. Therefore, we may consider that due to the influence of technological electromagnetic field with industrial frequency, the population actually has to be in environment similar to the one, where the inhabitants permanently live in the conditions with high probability that cosmic ULF and VLF radiation reaches the Earth surface. It is noteworthy that like Pc1-Pc2 geomagnetic pulsations, in the magnetospheric ULF and VLF electromagnetic wave spectrum as well, there are such oscillations, the frequencies of which coincide with some human endogenic rhythm. It is acceptable that by means of auditory sensors or via central nerve system they make influence on human organism. Therefore, we may consider that like geomagnetic pulsation, ULF and VLF electromagnetic waves may have a triggering function of vital processes taking place inside the human body [3].

The regional geomagnetic anomaly in Guria. On the territory of Georgia the value of normal geomagnetic field anomaly perturbation has the following classification: 1. weak magnetic anomaly, i.e., deviation from the main characteristic geomagnetic field induction value in interval by [100-500] nT; 2. medium magnetic anomaly – deviation by more than [500-1000] nT; 3. strong magnetic anomaly – deviation by more than 1000 nT. It is noteworthy that deviation from normal field may be both increasing as well as decreasing. In case deviation is positive the magnetic field induction expression takes place and when otherwise then depression is observed. On the territory of Georgia there have been revealed several such anomalies, among which are the regional geomagnetic anomalies of Adjara and Guria. The Tskaltsminda-Ureki-Ompareti local geomagnetic anomaly is a constituent part of the latter and it was for the first time discovered and studied by Prof. Mikheil Nodia. In the 30s of the past century he was heading several long-term geophysical expeditions with the purpose to prospect oil ores in Ompareti. The general results of the expedition were further proved by a large-scale geomagnetic aerial survey organized by the Oil Production Agency of the former USSR in 60-70s. It is natural that there had been no instrumental measurement data on the geomagnetic field of the mountain part of Adjara-Guria before the expedition lead by M. Nodia. Therefore, he had only historical information on the existence of iron and metal mines in Guria, namely in the areas of Chonchkhati dating back to the early era to the late medieval times. Similar information was about Mountainous Adjara, where weapon manufacture was well developed in some gorges. Naturally, it could not have been possible without having local metallurgical raw materials. Besides the historical data there was also a visible sign of high concentration of magnetite in the mountain rocks washed off by the river Supsa and it was visible all over the valley of the river Supsa from the very source to the estuary. Therefore, the first expedition, taking into account the geomagnetic equipment accuracy of that time, made a maximally detailed plan of the areas of the Supsa estuary and some territory of the sea coastline from Kobuleti to Grigoleti. During the first expedition only single, the vertical component of geomagnetic field was measured and further the horizontal component was also added. Due to the big size and insufficient stability during working process in field of so called Schmidt magnetic scales, a magnetometer of that time, a task of geomagnetic planning was very labour-intesive and required quite a substantial amount of time. In spite of that the Schmidt magnetometer accuracy appeared sufficient for quite clearly distinguishing the anomalous values of the geomagnetic field it turned out that the value characteristic of the magnetic anomaly exceeded the threshold of the equipment sensitivity approximately by at least two orders and more: ±10 nT. They mainly used the longitudinal profiling method with an interval of 100 m., though, in those areas, where it was possible to close rectangular frames, i.e., construct the main element of the grid method, Mikheil Nodia used the opportunity everywhere. Despite that, due to objective reasons mainly associated with swampiness of the coastline, the area of the territory

planned by the grid method turned out to be much less than that of the territory planned by longitudinal profiling method [4-6]. It is noteworthy that except rare cases in modern conditions it is practically impossible to repeat the geomagnetic profiles constructed by M. Nodia by modern equipment due to the population increase and building of different urban constructions, among them significant industrial structures, e.g., the Supsa Terminal in the Tskaltsminda-Ureki-Ompareti zone.

The local magneto-electrical anomaly in Tskaltsminda-Ureki. A long-term geomagnetic expedition organized by Institute of Geophysics on this territory began in 1991 and lasted during 1999-2006. During the expedition process a detailed planning of the local magnetic anomaly territories of Tskaltsminda-Ureki (nowadays "Hope Town") and Ompareti was conducted by areal grid method with interval 10 m (Pic.1).



Pic.1. The local magneto-electrical anomaly in Tskaltsminda-Ureki.

As a result of the boundary originated due to the urban changes the micro anomaly of Ompareti was considered as an individual segment of the main local geomagnetic anomaly. They used field magnetometer M-203, by which the absolute vector value $\boldsymbol{T}$ of the magnetic field induction of the Earth is measured. Besides determining the topological image of the geomagnetic field in the Tskaltsminda-Ureki zone, in order to reveal the deep geologic structure of the territory, at the last stage of the expedition a detailed electrometric survey by means of vertical sighting method was also conducted. It appeared that the central area of the geomagnetic anomaly (so called "Hope Town") is characterized with particular inhomogeneity in electric resistance that probably must have been caused due to large fragments of iron-bearing rocks in the sea coastline zone. Such a structure, taking into account sea water leakage into the porous medium, must be in high probability causing a permanent effect of electric polarization and physical phenomena associated with it. Therefore, we consider that this area is anomalous in regard to not only geomagnetic but also geo-electrical point of view. Consequently, the anomaly must be called a local magneto-geo-electrical anomaly. It is characterized with low

absolute intensity, though clear gradients of geomagnetic field together with variable geo-electrical field are also observed. Thus, all the above mentioned together with healthy climatic characteristics, apparently condition particular ecology of this zone. There is a joint activity of several natural factors, namely: sand rich in magnetite, taken down by the river Supsa from the mountains of Guria and Adjara to the porous medium of the beach area; leakage (hydration) of sea water into the coastline; possibility of magneto-hydro-dynamic (MHD) effect generation, as a result of which systematic generation of bound and free polarized charges becomes possible. Under the influence of the variable electrical field generated in such inhomogeneously polarized environment an effect of large-scale (integral) dipole electrical and magnetic moments may arise in the anomaly area. In the area, probably, relaxation of free charges may take place as a result of closing of telluric current circuit generated due to seismic processes developed under the sea in the anomalous zone. In such conditions very low frequency (VLF) surface electromagnetic radiation may generate in the anomaly area. Its characteristic frequency diapason, according to the measures of the anomalous area, must probably be /103-106/ Hz. It is not excluded that in certain cases VLF electromagnetic radiation can be so strong that it may cause local perturbation in the thermo-dynamical and electrical parameters of the atmosphere [7, 8].

The medico-biological aspect. The purpose of comparative analysis of background health data of population living at different places is to verify normal and pathological endemic criteria. In conditions of increasing technogenic load on the environment this issue is considered as a significant aspect of ecological problem for the mankind [9]. It is natural that in this regard, populations in big cities live in particular conditions, which are distinctly different from the usual natural conditions in pre-industrial era. However, population of some certain places might have been under same conditions as in big cities. In regards to electromagnetic background of the Tskaltsminda-Ureki magneto-geo-electrical anomaly zone, which is under high urban load, belongs to the list of such places. Probably, the unique geophysical characteristics determining its value as of a resort, make certain influence on the parameters characteristic of the health of the aborigine population.

It is known that the intensity of the signal that induces parametric resonance phenomenon, i.e., the trigger amplitude, does not have any real meaning. In the case of a living organism the parameter of the activation factor, e.g., electromagnetic wave, which is to coincide with some cyclic function characteristic of organism, is wave signal frequency [2, 10]. As a result of stochastic resonance inside a human body, desynchronization of internal biological rhythms may take place in order to reduce them to a single basic frequency. According to one of hypothesis, such an effect may turn out destructive for the human body, which is diseased or under stress. This is proved by the result obtained after statistical analysis of great number of medical data, which shows tight correlation between global magnetic storms and increased frequency of myocardial infarction, also cerebrovascular accident and lethal ends caused by them [10]. It is logical to assume that such correlation may take place due to anomalous changes in rhythmic process determining the living process of human body, like heart-beating and breathing frequencies. It is noteworthy that the frequencies characteristic of Pc1 - Pc2 geomagnetic pulsations /1 – 0.1/ Hz are in the frequency variation diapason of these very vital characteristics. Pc1 pulsations are sometimes observed in calm geomagnetic conditions, though they almost always accompany global geomagnetic storms, when negative conclusions of cardiovascular diseases are especially increased. Therefore, it is assumed that such type of pulsations may cause stochastic resonance effect in a human body [10]. It is noteworthy that in formation of natural electromagnetic background, besides geomagnetic pulsations, ULF and VLF electromagnetic waves with much higher frequency spectrum than pulsations have a great role and these waves are often modulated by geomagnetic pulsations.

The question whether natural geomagnetic radiation from environment is a permanent negative influence factor for the human body has two existential aspects: medico-physiological and social. Generally, the justice of such assumption must be proved by numerous and versatile research results. In our opinion one of certain cases of such assumption may be manifested by the comparative image based on comparative statistical analysis of the local medical information conducted by us. For this purpose we used the data of the Statistics Agency of Georgia on the Tskaltsminda-Ureki zone and highly populated Telavi region, which is geographically considerably distant and distinguished with its natural conditions from the former. At the same time, at both places, besides the statistical analysis of the preliminary medical information from the healthcare board, a sampling survey by a method of filling out a special questionnaire was conducted on the population. The results revealed quite complete general information involving both male and female aborigine population of all age groups. Namely, there were individual data from 200 residents in 2006 in Ureki. Similarly, by maintaining the correctness of the research method a sampling survey was carried out on the population of Telavi region. Further the results were reconciled with the data of medical archives. Finally, the database of both places included quite wide groups of individuals: Ureki -869 residents, Telavi – 42 789 residents.

Within the framework of the research special interest was taken on separation of the population with health problems within the aborigine residents without referring to degree of disease (low, medium, high). According to methodic the sum of individuals having any type of health problems was equal to 100%. The next step was determining the shares of the diseases, initiation or deterioration of which, with high probability, might associate with triggering effect of geomagnetic pulsations or very low frequency electromagnetic radiation. The diseases were classified in four groups: endocrine diseases, diseases of nervous and sensory system, cardiovascular diseases and respiratory system diseases. The comparative statistical analysis showed significant difference only in the correlation data of endocrine system diseases:

Diseases in the Tskaltsminda-Ureki zone:
- Endocrine system – 6.6 %
- Nervous system and sensory organs – 4.5 %
- Cardiovascular system – 15 %
- Respiratory organs – 13 %

Diseases in Telavi region:
- Endocrine system – 35 %
- Nervous system and sensory organs – 4.5 %
- Cardiovascular system – 15 %
- Respiratory organs – 20 %

At the same time, we used the correlation characteristics of the same disease groups for comparison for entire Georgia:
- Endocrine system – 8.76 %
- Nervous system and sensory organs – 10.29 %
- Cardiovascular system – 20 %
- Respiratory organs – 20.93 %

The obtained results clearly show that correlation statistical indicators of all groups determined according to all three databases, excluding one disease group, are similar. Namely, it turned out that the inhabitants of the magneto-geo-electrical anomaly zone of Tskaltsminda-Ureki, in regards to endocrine diseases are in a considerably better state than the population of Telavi region with calmer natural electromagnetic background. This result appeared to be unexpected as far as according to the opinion

distributed within the circle of medics any kind of electromagnetic radiation, like high-frequency (penetrating radiation) as well as ULF and VLF electromagnetic waves, must have extremely negative influence on functioning of cardiovascular and endocrine systems of human body.

Conclusion.

As a result of carrying out a many-year complex expedition, quite a vast complete database of observations was established by Institute of Geophysics. On the basis of interpretation of these data a theoretical model of the local magneto-geo-electrical anomaly of Tskaltsminda-Ureki, the physical image corresponding of which covers the whole resort zone between the estuaries of the rivers Supsa and Natanebi including the territories of Shekvetili and the camping area, was constructed [7, 8]. According to the model the area of the anomalous geophysical parameters are probably distributed also in the direction of the sea, where in early era a paleo-estuary of the river Supsa was located.

In the viewpoint of fundamental researches of human physiology, taking into account general characteristics of medical information and conditionality of individual data it would be probably reasonable to carry out long-term physiological and epidemiological monitoring of the constitution parameters and functional indicators, especially cardiovascular system as one of the main determinants of adaptation potentials of human organism among valid groups of the aboriginal healthy population of the resort zone.

Such local studies may reveal the physiological effect of permanent influence caused by apparent inhomogeneity of the geomagnetic field.

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წყალწმინდა-ურეკის მაგნიტო-ელექტრული ანომალიის ფიზიოლოგიურ ეფექტთან დაკავშირებით

ზ. კერესელიძე, მ. ლომოური, მ. ჩხიტუნიძე, ნ. ჟონჟოლაძე

რეზიუმე

ინდუსტრიულ ეპოქამდე ბუნებრივ ელექტრომაგნიტურ ფონს აყალიბებდა ე.წ. კოსმოსური ამინდი და რადიოაქტიური დაშლის პროცესი, მიმიდინარე დედამიწის შიგნით. დღეს, სისტემატურად მზარდი ანტროპოგენული დატვირთვის გამო ადგილი აქვს ადამიანების საცხოვრებელი გარემოს პარამეტრების საყოველთაო ცვლილებებს. ეს პროცესი ეხება მთელ დედამიწას, პირველ რიგში მაღალი ურბანიზაციის მქონე არეებს, სადაც განსაკუთრებით საგრძნობია ტექნიკური პროგრესის უარყოფითი სოციოლოგიურ-ფიზიოლოგიური გავლენა როგორც გლობალურად მთელ მოსახლეობაზე, ასევე ადამიანთა ცალკეულ ჯგუფებზე. ამ გლობალურ პრობლემას მრავალი ასპექტი გააჩნია, რომელთა შორის არის ელექტრომაგნიტური ფონის არაბუნებრივი ცვლილებების პირობებში მცხოვრებთა ადაპტაციური უნარების გამოკვლევა, რომლის მნიშვნელოვანი ელემენტია მოსახლეობის ფონური დაავადებიანობის შედარებითი ანალიზი. მაგალითად, უკვე საკმაოდ კარგად არის ცნობილი კოსმოსური ამინდის მკვეთრი ცვლილების ერთერთი გლობალური გამოვლინების, გეომაგნიტური ქარიშხლების კორელაციური ეფექტი გულ-სისხლძარღვთა პათოლოგიის მქონე ადამიანების ჯანმრთელობის მდგომარეობის გაუარესებას შორის. მიგვაჩნია, რომ ამ კავშირის ფიზიოლოგიური მექანიზმების გამოვლენა, მზეზე მიმდინარე პროცესების ეფექტების განხილვასთან ერთად, მოითხოვს აგრეთვე დედამიწაზე გეომაგნიტური ანომალიების გავლენით გამოწვეული ლოკალურად ცვლადი ბუნებრივი ელექტრომაგნიტური ფონის ფიზიოლოგიური ეფექტების შესწავლას. ამ თვალსაზრისით საინტერესო აღმოჩნდა წყალწმინდა-ურეკის ლოკალური გეომაგნიტური ანომალიის საკურორტო ზონაში მცხოვრები აბორიგენული მოსახლეობისა და გეომაგნიტური თვალსაზრისით უფრო წყნარ პირობებში მცხოვრები თელავის რაიონის მოსახლეობის პირველადი სამედიცინო მონაცემების შედარებითი ანალიზი. მიღებული სურათის თანახმად, ურეკი-წყალწმინდის გეომაგნიტური ანომალიის გარემოს მახასიათებლების კომბინაცია ზღვის სანაპიროსათვის დამახასიათებელ კოსმოსურ ფაქტორებთან, სავარაუდოდ, საკმაოდ

კეთილისმყოფელ გავლენას ახდენს აქ მცხოვრებ ადამიანებზე. ასეთი დასკვნის ექსტრაპოლაციიდან გამომდინარე, შეიძლება ზოგადად აიხსნას დადებითი თერაპიული ეფექტი იმ ადამიანებშიც, რომლებიც წყალწმინდა-ურეკის საკურორტო ზონაში მოკლევადიანად იმყოფებიან დასვენებისა და მკუნალობის მიზნით.

О связи с физиологическом эффектом магнито-электрической аномалии Цкалцминда-Уреки

З.А. Кереселидзе, М.А. Ломоури, М.С. Чхитунидзе, Н.И. Жонжоладзе

Резюме

До индустриальной эры естественный электромагнитный фон формировался так называемой космической погодой и процессом радиоактивного распада, происходящим внутри Земли. В настоящее время в связи с неуклонно возрастающей антропогенной нагрузкой наблюдается процесс общего изменения параметров окружающей среды, в которой мы живем. Этот процесс затрагивает всю землю, в первую очередь районы с высокой урбанизацией, где особенно существенно негативное социологическое и физиологическое воздействие технического прогресса как в глобальном масштабе на все население, так и на отдельные группы людей. Эта глобальная проблема имеет множество аспектов и среди них изучение адаптационных возможностей населения, проживающего в условиях неестественных изменений электромагнитного фона, неотъемлемым элементом которого является сравнительный анализ фоновых заболеваний населения, например, Уже хорошо известно, что корреляционный эффект геомагнитных бурь, являющийся одним из глобальных последствий быстрой смены космической погоды, оказывает влияние на ухудшение состояния здоровья населения с сердечно-сосудистыми патологиями. По нашему мнению, выявление физиологического механизма этой связи, наряду с влиянием процессов, происходящих на поверхности Солнца, требует изучения физиологических эффектов локально изменчивого природного электромагнитного фона, обусловленного влиянием геомагнитных аномалий на Земле. В связи с этим большой интерес представляет сравнительный анализ предварительных медицинских данных аборигенного населения курортной зоны Цкалцминда-Урекинской локальной геомагнитной аномальной зоны и населения более спокойного в геомагнитном отношении района Телави. Согласно полученным результатам, сочетание характеристик Цкалцминда-Урекской области геомагнитной аномалии с космическими факторами, характерными для морского побережья, вероятно, оказывает положительное влияние на население. Экстраполируя этот вывод, можно в целом говорить о положительном терапевтическом воздействии на людей, совершающих кратковременные посещения курортной зоны Цхалцминда-Уреки с лечебно-оздоровительными целями.

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